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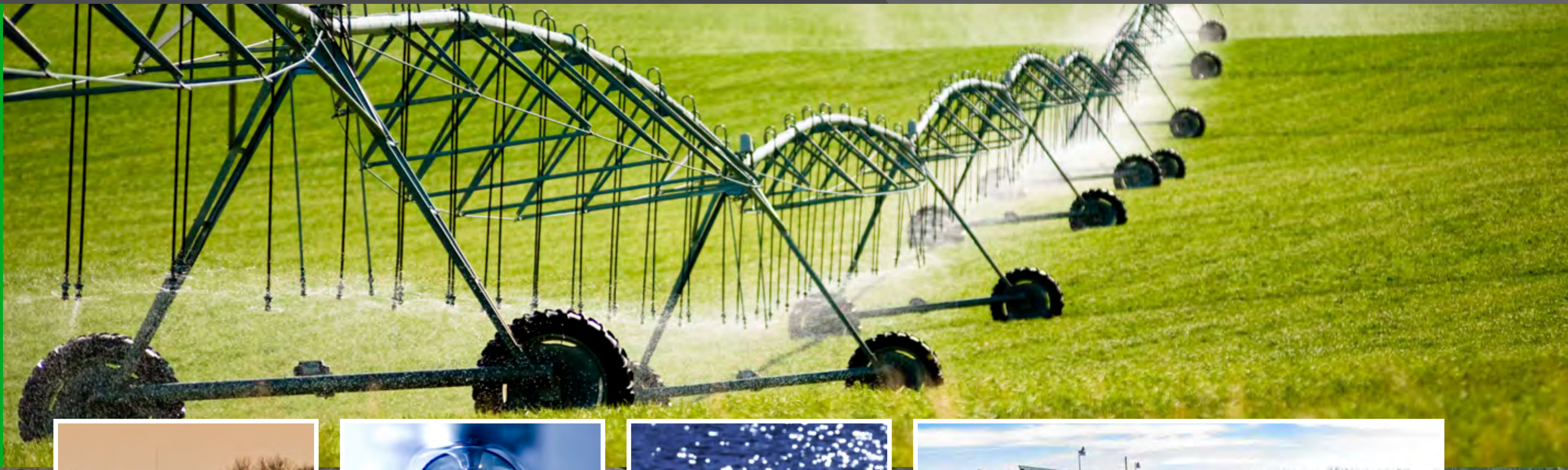
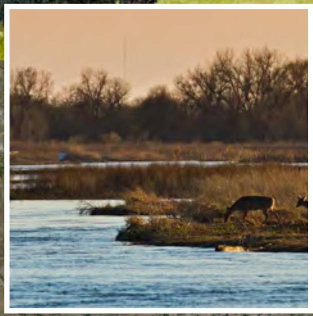




Basin-Wide Plan for Joint Integrated Water Resources Management of Overappropriated Portions of the Platte River Basin, Nebraska

SECOND INCREMENT (2019-2029)

CPNRD Central Platte Natural Resources District

North Platte Natural Resources District

South Platte Natural Resources District

Tri Basin Natural Resources District

Twin Platte Natural Resources District

Nebraska Dept. of Natural Resources

Table of Contents

APPENDICES

1.0 Introduction

The purpose of this Basin-Wide Plan (Plan) is to meet the requirements of *Nebraska Revised Statute* §46-715(5)(a) for those portions of the Upper Platte River Basin upstream of the Kearney Canal Diversion designated as overappropriated by the Nebraska Department of Natural Resources (NeDNR) on September 15, 2004. This area is defined in the NeDNR's 2004 Order, which also defines the area in which groundwater is hydrologically connected to the overappropriated surface water basin (see Figure 1). The overappropriated basin and the hydrologically connected area will hereinafter be referred to as the "overappropriated basin." The overappropriated basin encompasses portions of the Central Platte Natural Resources District (CPNRD), Tri-Basin Natural Resources District (TBNRD), Twin Platte Natural Resources District (TPNRD), South Platte Natural Resources District (SPNRD), and North Platte Natural Resources District (NPNRD).

As described in *Neb. Rev. Stat.* §46-715(5), NeDNR and the Natural Resources Districts (NRDs) have implemented an incremental approach to integrated water planning in the overappropriated area of the Upper Platte River Basin to sustain a balance between basin water uses and water supplies. Activities identified in the first ten-year increment plan (effective date of September 11, 2009) have been implemented over the past ten years, with the results of these efforts described in Section 3.0 of this Plan. This Plan includes goals, objectives, and action items for the second ten-year increment, which were developed utilizing the consultative and collaborative process described in *Neb. Rev. Stat.* §46-715(5)(b).

Vision Statement

The consultative and collaborative process utilized in developing the Plan included the formation of a single planning group (SPG) consisting of stakeholders representing surface water and groundwater interests from throughout the Basin, as described in Section 2.0. The SPG developed a list of shared values that guided the planning process, and ultimately the development of this Plan:

- ✓ Generational Stewardship
- ✓ Maintaining the good life
- ✓ There is a space for all; willingness and interest in working together; shared burden
- ✓ Looking beyond our own fences
- ✓ Others can make good use of the water we save
- ✓ We are making a difference!
- ✓ We have a long culture of adapting and changing with the times
- ✓ "Putting water back to the river without causing economic harm"

These values are represented in the following vision statement for the Plan: As generational stewards with a recognition that there is a space for all, and the willingness and interest in working together, we'll look beyond our own fences to develop a plan to sustain a balance between basin water uses and supplies without causing economic harm.

Effective Date and Time Frame of the Basin-Wide Plan

This second increment of the Upper Platte River Basin-Wide Plan became effective on [PLACEHOLDER FOR DATE}. The time frame to implement the Plan is ten years, spanning from the effective date of the Plan to no later than [PLACEHOLDER FOR TEN YEAR DURATION FROM PLAN ADOPTION].

Authority

Neb. Rev. Stat. §46-715(5) requires in any river basin that is designated as overappropriated, when the designated area lies within two or more natural resources districts, that NeDNR and the affected NRDs shall jointly develop and adopt a basin-wide plan for the area designated as overappropriated.

Purpose and Scope of Basin-Wide Plan and IMPs

This Plan is the result of a collaborative effort by NeDNR, CPNRD, TBNRD, TPNRD, NPNRD, SPNRD, and a basin-wide group of stakeholders that formed the Single Planning Group (SPG). This Plan is the second increment of the Upper Platte River Basin-Wide Plan and was developed to fulfill the requirements of *Neb. Rev. Stat.* §46-715(5) which requires NeDNR and the NRDs to jointly develop and adopt a plan to incrementally achieve the goals and objectives described in *Neb. Rev. Stat.* §46-715(2).

Collaborative integrated water management planning within the Upper Platte River Basin occurs at both the local (individual NRD) and regional (basin-wide) scales. Locally, individual integrated management plans (IMPs) are jointly developed and implemented by NeDNR and a single NRD. Under *Neb. Rev. Stat.* §46-715, an IMP is required for each of the five NRDs in the Basin (see Figure 1). Regionally, a basin-wide plan is jointly developed by NeDNR and the five NRDs.

Broadly, the Basin's required IMPs and Basin-Wide Plan support cooperation between NeDNR and the Basin's NRDs to ensure coordinated management of the Basin's hydrologically connected surface and groundwater supplies. Through the development and implementation of these planning processes, NeDNR, the NRDs, and local stakeholders foster better communication and collaboration concerning the Basin's water issues, which provides a foundation for more efficient, adaptable, and sustainable water management now and in years to come.

Many of the planning elements in required NRD IMPs and this Plan are shared, but a few conceptual and practical differences exist. The two following subsections describe the background and unique role for each type of plan, as well as how the two types of plans work together to improve integrated water management in the Basin.

Integrated Management Plans

In 2004 the State Legislature passed LB 962, which required IMPs be developed for NRDs or basins designated as overappropriated or fully appropriated. All five Upper Platte River NRDs in the designated overappropriated area adopted their first generation IMPs in 2009. CPNRD updated its IMP in 2012; TPNRD and NPNRD updated their IMPs in 2013. At the time of this Plan's adoption, each of the five NRDs are in the process of updating their IMPs. Through adaptive management, all of the NRD IMPs will continue to be updated as needed.

As described in *Neb. Rev. Stat.* § 46-715, a required IMP must contain clear goals and objectives intended to protect existing uses and manage for new uses for a sustainable balance between water uses and water supplies. It must also include a map of the plan's geographic area (which must include the portion of the NRD determined by NeDNR to be hydrologically connected, but may include the entire NRD), at least one groundwater control, at least one surface water control, and a plan for monitoring and data collection. Management actions initiated through IMPs must also comply with federal and state laws and interstate compacts and agreements. In addition, NeDNR and the NRD consult with water users in the affected area and offer those water users with an opportunity to provide input during development of an IMP. Each IMP is developed to uniquely suit the needs of the individual NRD, and thus monitoring protocols, actions, and controls are tailored to fit the differing goals and objectives of each plan.

The Platte River Basin-Wide Plan

The requirements for this Plan are described in *Neb. Rev. Stat.* § 46-715(5). Like the individual IMPs, this Plan contains goals and objectives; however, unlike IMPs, the Basin-Wide Plan does not require groundwater or surface water controls. Instead, this Plan provides clear goals and objectives for the entire Basin, to which the NRDs can then align the controls and actions of their IMPs to achieve.

For consistency across the Upper Platte Basin, this Plan also includes information on monitoring, data collection, and regular evaluation. The ongoing evaluation includes information on the overall difference between current and fully appropriated levels of development and determining progress toward meeting the Plan's goals and objectives.

Development of both the IMPs and the Basin-Wide Plan in the Upper Platte Basin involve a conscientious process of consultation and collaboration with stakeholders that rely on water from the affected area. Through consultation and collaboration, stakeholders are involved in formulating, evaluating, and recommending Plan details, including preferred solutions. Following statutory requirements, NeDNR and the NRDs work to reach agreement among all official participants.

Overall, this Plan provides a general framework, focusing on regional, cross-boundary issues and opportunities such as those related to hydrologic connectivity and management strategies that cross the NRDs' borders. This Plan also provides opportunities for consistency among all of the Basin's NRDs by offering an umbrella framework for the individual IMPs. Individual IMPs must be consistent with the Basin-Wide Plan, but contain additional goals, objectives, and controls that are tailored to local conditions, management issues, and opportunities found within the specific NRD.

Responsibilities and Authorities of NeDNR and NRDs

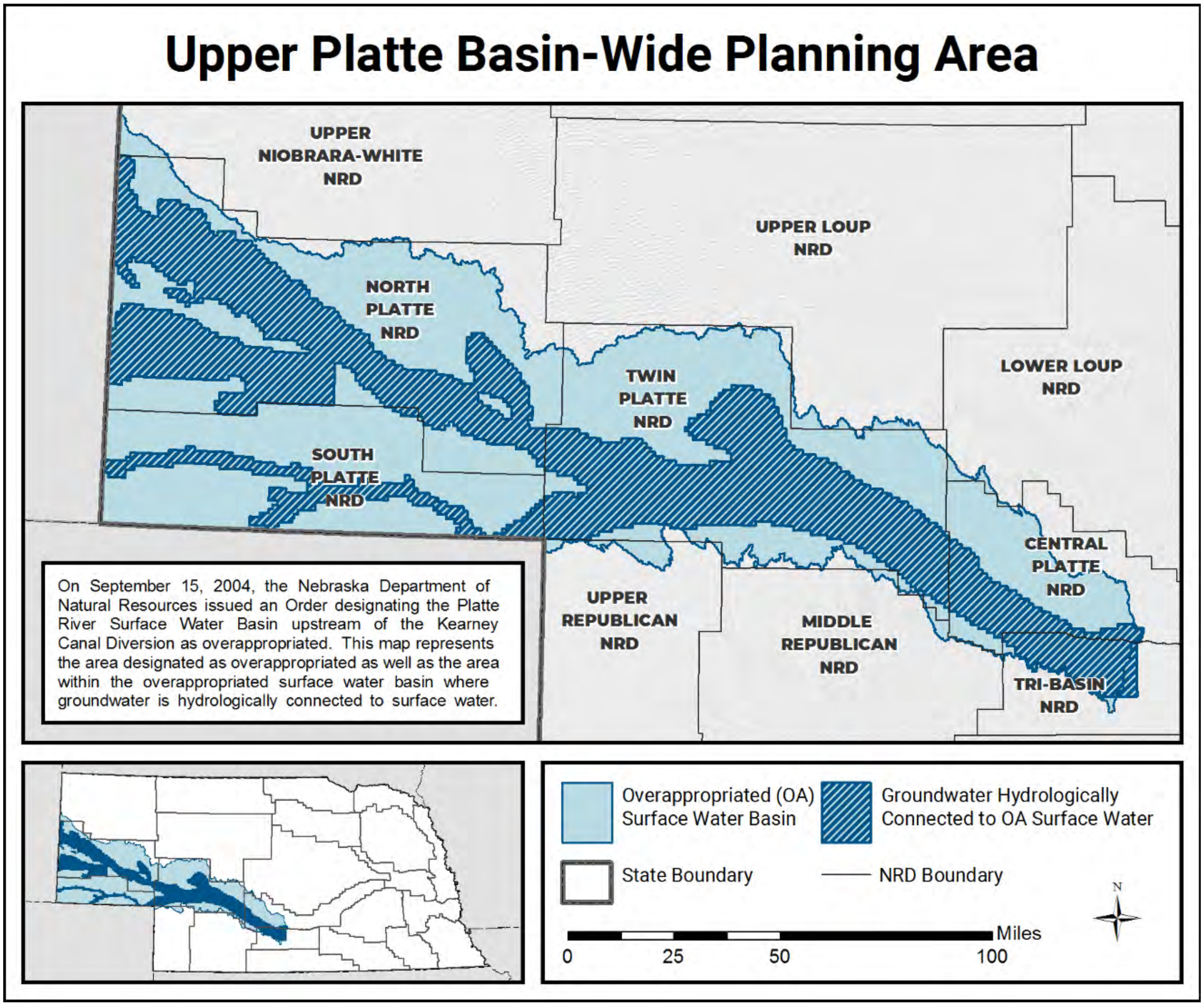
NeDNR is responsible for permitting and administering surface water rights for beneficial uses including, but not limited to storage, irrigation, hydropower, and instream flows. Among its duties, NeDNR registers wells, delineates hydrologically connected aquifers and flowing water, regulates dams, delineates floodplains, and provides technical and policy assistance. NeDNR also collaborates with all 23 NRDs to develop and manage integrated water management plans and basin-wide plans.

Among their other statutory authorities, NRDs are responsible for local development, management, utilization, and conservation of groundwater and surface water resources. NRDs manage groundwater use permitting and monitor and regulate groundwater quality. The NRDs have the legal authority to regulate groundwater use within their boundaries to ensure that irrigated agriculture remains an important industry to Nebraska in accordance with *Neb. Rev. Stat.* §§46-701 and 46-703(3). Additionally, NRDs are authorized, along with the Nebraska Game and Parks Commission to hold instream water rights for fish, wildlife, and recreation. The NRDs collaborate with NeDNR to develop and implement integrated water management plans and basin-wide plans.

Plan Area

The Plan addresses the overappropriated basin, illustrated in Figure 1, including the portion of the Upper Platte River Basin upstream of the Kearney Canal Diversion and hydrologically connected areas.

Figure 1. Overappropriated Basin of the Platte River



2.0 Planning Process

This Plan was jointly developed by NeDNR, CPNRD, TBNRD, TPNRD, NPNRD, SPNRD, and the Plan's stakeholder advisory committee. The inclusive process was guided by a shared vision statement, which was created based on the priorities and values identified throughout the planning process and development of the Plan. The vision statement is as follows:

> *As generational stewards with a recognition that there is a space for all, and the willingness and interest in working together, we'll look beyond our own fences to develop a plan to sustain a balance between basin water uses and supplies without causing economic harm.*

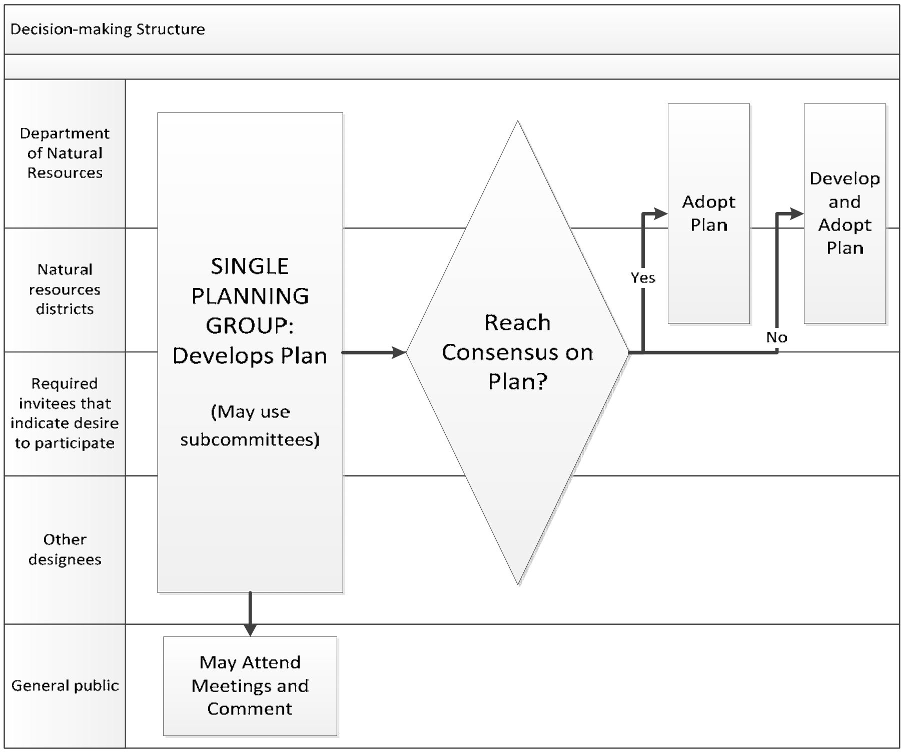
Public Participation Plan

In preparation of the development of the second increment Upper Platte Basin-Wide Plan, a committee made up of representatives from NeDNR, CPNRD, TBNRD, TPNRD, NPNRD, SPNRD, irrigation districts, and power districts worked collaboratively to create the Public Participation Plan (PPP) (Appendix G) to guide the process for developing the Plan. The PPP was created with the intent to provide an overall vision for how the basin-wide planning process was approached.

The committee's goal was to create a robust, understandable, transparent approach for the second increment planning. The PPP provided direction related to the required participants and their respective roles and responsibilities. The PPP outlined the decision-making structure, which called for representatives of all parties to form a single planning group to develop the Basin-Wide Plan (Figure 2).

The PPP also informed the planning process and timeline, which consisted of orientation and preparation; planning; approval; and adoption, set to be completed by September 2019. Finally, the PPP outlined the governance guidelines to address the following issues: meeting times and locations, communications, meeting notice and preparations.

Figure 2. Planning structure



Planning Activities

Single Planning Group

A Single Planning Group (SPG) of Upper Platte Basin stakeholders was formed and met twelve times from June 2016 – September 2018 to achieve consensus on the content of the second increment Plan. Approximately 55 primary and alternate stakeholders were invited via postcards and email invitations to each meeting, as well as staff members from participating NRDs and NeDNR. For the list of primary and alternative stakeholders, please see Appendix G.

Primary stakeholders were made up of representatives from the following affiliations:

AFFILIATION	NUMBER OF PRIMARY STAKEHOLDERS
Agriculture	4
Environment/Wildlife	1
Financial	2
Groundwater Irrigator	2
Ground Water User	2
Irrigation District	5
Municipality	6
Public Power District	2
Surface Water User	4

A summary of the SPG meeting dates and topics is as follows.

DATE	PURPOSE OF MEETING
June 16, 2016	Introduce stakeholders to the planning process and explain their roles.
July 20, 2016	Review first increment Basin-Wide Plan goals and objectives and implementation by each NRD.
September 21, 2016	Present on the hydrogeology of the Platte River Basin and discuss models used.
November 16, 2016	Review the First Increment, modeling, and Plan goals.
March 15, 2017	Discuss Second Increment and depletions.
May 17, 2017	Define additional elements to be incorporated into second increment and discuss the goal of economic viability of the Basin.
July 19, 2017	Agree on the values of the basin and discuss new goals and objectives.
September 20, 2017	Discuss Statute 46-715 interpretation and continue defining additional elements: safety, welfare, and social and environmental health.
January 17, 2018	Present first increment activities cost & benefits and the intent for the second increment.
March 21, 2018	Included special presentations explaining agricultural hydrology, drought mitigation, conjunctive water management, and conservation study.
May 16, 2018	Discuss elements of the draft second increment Plan and identify the second increment intent.
September 19, 2018	Review second increment and achieve consensus.

For meeting agendas, attendance lists, and detailed meeting notes, please refer to Appendix G. All meeting materials will be maintained for the second increment and can be found on the DNR website here: https://upbwp.nebraska.gov/

Single Planning Group Sub-Committee

In the course of the over two years of SPG meetings, NeDNR, the Upper Platte NRDs, and stakeholders representing hydropower interests held four additional meetings in order to more comprehensively discuss issues within the Basin that impact hydropower and could be addressed in the second increment Plan; as well as issues that lie outside of the scope of the Plan and may require further negotiation apart from the Basin-Wide planning process. Plan language proposals stemming from these hydropower sub-committee meetings were brought to the larger SPG for consideration and eventual vote. The additional discussions of this sub-committee assisted the planning process by ensuring that some of the more complicated issues impacting various interests within the Basin could be fully considered, while also allowing the larger planning process to stay on schedule.

Platte Basin Coalition

Throughout the planning process, the Platte Basin Coalition/Platte Overappropriated Area

Committee served as a general steering committee of the basin-wide planning effort. A portion of the agenda for their regular bi-monthly meeting was devoted to SPG meetings including setting agendas, reviewing meeting materials, and discussing the development of the Basin-Wide Plan. This group is made up of representatives from NeDNR, CPNRD, TBNRD, TPNRD, NPNRD, and SPNRD.

Public Involvement

The general public was invited to participate in the Basin-Wide Plan development throughout the planning process. Information was available through the Upper Platte Basin-Wide Planning website hosted by NeDNR, which contained information about the planning process and meeting materials. The public was notified of the meetings through public notices published in: Grand Island Independent; Scottsbluff Star Herald; Kearney Hub; North Platte Telegraph; and Sidney Sun-Telegraph. Notices were also posted at NRD offices and on the NeDNR website. All SPG meetings were open to the public and each agenda included the opportunity for public comment.

Pursuant to statute (*Neb. Rev. Stat.* §46-715 to 46-719), the following joint public hearings on the Basin-Wide Plan were conducted by NeDNR and the individual NRDs:

- NPNRD, July 18, 2019,
- SPNRD, July 17, 2019,
- TPNRD, July 16, 2019,
- CPNRD, July 15, 2019, and
- TBNRD, July 16, 2019.

Consensus

The decision-making process outlined in the PPP described that the SPG would be striving to reach agreement (consensus) on all sections of the Plan, if that could not be reached for all plan sections then DNR and the NRDs would move forward to resolve any areas where agreement was not reached by all parties. On September 19, 2018, the SPG met for the final review and approval of the Plan goals, objectives, and action items. Each goal, objective, and action item was reviewed and an initial vote on consensus for each goal (and supporting objectives and action items) as-is was taken. Unanimous consensus was achieved on Goal 4 during this initial vote. Goals 1, 2, 3, and 5, were then discussed in detail with the SPG. A final vote of approval for the Plan in its entirety was held, with one dissenting vote. Post-meeting discussions identified the concerns of the dissenter as related to the concept of the overall water budget as it relates to fully appropriated conditions, and not the goals of the Plan itself. These water budget concepts and water as a reusable resource have been addressed in the background discussion of Section 4. For meeting notes detailing discussion and votes on the Plan elements at the September 19, 2018, SPG meeting, see Appendix G.

3.0 Activities of First Increment

During implementation of the first increment of the Basin-Wide Plan, a primary focus was to offset depletions to streamflows for new and expanded uses initiated after July 1, 1997, consistent with *Neb. Rev. Stat.* §46-715(5)(d)(i). Table 1 summarizes the depletions offsets identified for each of the Upper Platte NRDs in the first increment of the Plan.

Table 1 – Post-1997 New Use Depletions from First Increment Plan

	Average Annual Depletion within entire NRD (AF)	Average Annual Depletion within Overappropriated Area (AF)
NPNRD	-8,000	-7,900
SPNRD	-700	-200
TPNRD	-7,700	-6,700
CPNRD	-3,400	-1,400
TBNRD	-5,000	-2,200
TOTAL	-24,800	-18,400

** From Table 1 of the first increment Basin-Wide Plan*

First Increment Achievements

Through a combination of retirements, leases, regulatory actions (certifying irrigated acres, restrictions on new uses and transfers, etc.), and conjunctive management projects, NeDNR and the NRDs achieved the first increment goal of offsetting the basin-wide average annual depletion, and in some NRDs, achieved progress toward offsetting pre-1997 use depletions. A general summary of approaches used to achieve these goals is provided below:

- NPNRD – combination of irrigated land retirements (permanent and lease), allocations on groundwater users, and intentional recharge to retime and augment baseflows.
- SPNRD – combination of irrigated land retirements (conservation easements), allocations on groundwater users, and intentional recharge to retime and augment baseflows.
- TPNRD – combination of intentional recharge to retime and augment baseflows, flow retiming (J2 Regulating Reservoir), and streamflow augmentation (NCORPE).
- CPNRD – combination of irrigated land retirements (conservation easements), purchase and operational changes to surface water canals (Thirty-mile and Orchard-Alfalfa canals), flow retiming (J2 Regulating Reservoir), and intentional recharge to retime and augment baseflows.
- TBNRD – combination of intentional recharge to retime and augment baseflows, flow

retiming (J2 Regulating Reservoir), and streamflow augmentation (North Dry Creek).

- NeDNR – Implemented the surface water controls identified in the individual IMPs, administered existing surface water uses, and as partners in the Basin-Wide Plan and the individual IMPs, participated in the NRD efforts, providing technical and financial assistance, as well as invested separately in the J2 Regulating Reservoir Project.

A more detailed description of individual NRD efforts can be found in the most recent annual reports (Appendix C).

In addition to offsetting depletions, NeDNR and the NRDs accomplished several additional activities that were identified in the goals and objectives of the first increment Plan:

- Conservation Measures Study - During implementation of the first increment Plan, Phase I and Phase II of a study of the effects of conservation measures on water supplies was completed. Phase I (Appendix E) focused on an overall evaluation of a wide spectrum of conservation measures across the Basin. The results of this study were used to inform and focus the evaluation of Phase II of the study. Phase II (Appendix F) focused on two types of conservation measures: 1) the effects of tillage practices and 2) irrigation efficiencies on available water supplies. Tillage practices and irrigation efficiencies are driven by producer choices and are considered part of the spectrum of producer practices. Current evaluation of the study results indicates that changes in tillage practices and irrigation efficiency changes over time have impacted available water supplies in varying degrees across the Basin. Further efforts identified for this increment of the Plan are identified in Action Item 1.4.3.1.
- Current to Fully Appropriated Study – Prior to development of the first increment Plan, as a preliminary step in developing the overall difference between current and fully appropriated conditions, representatives of NeDNR, the Central Nebraska Public Power and Irrigation District (CNPPID), Nebraska Public Power District (NPPD), and CPNRD performed a preliminary estimate of the changes in stream reach gains and surface water demands affected by such reach gain changes, *Preliminary Estimate of Historical Stream Flow Reductions in the Overappropriated Portion of the Platte River in Nebraska* (see Appendix D). An assessment of water supplies and water demands within the Basin was conducted during implementation of the first increment. This assessment generally followed the NeDNR INSIGHT methodology for determining the quantity of available hydrologically connected water supplies and the demands on those supplies. The analysis looked at supplies over a representative climate period taking into account wet and dry phases of the hydrologic cycle. Consumptive and non-consumptive surface water demands were considered as well as groundwater depletions and groundwater consumptive use. A description of the INSIGHT methodology as applied to the Upper Platte Basin is included in Appendix A. An analysis of Streamflow Impacts from Uses Initiated Prior to July 1, 1997, and after July 1, 1997, was also conducted. This study provides an estimate of total depletions to streamflows resulting from all groundwater development in the Upper Platte Basin. This is part of what statute says must be considered

when evaluating the difference between current and fully appropriated conditions. See Evaluation of the difference in stream flow impacts in the Upper Platte River Basin dude to water uses initiated prior to and after July 1, 1997 in Appendix I. Additional studies for this increment of the Plan are described in Action Item 1.4.3.2.

- Robust Review – As required by *Neb. Rev. Stat.* §46-715(5)(d)(iii) a technical analysis was conducted to determine the progress towards meeting first increment goals and objectives. The analysis evaluated the controls and management actions implemented by NeDNR and the NRDs during the first increment. The updated modeling tools and datasets jointly developed by NeDNR and the NRDs were used to estimate streamflow impacts resulting from gained and lost irrigated land, controls, expansion and contraction of municipal and industrial uses, managed recharge, stream augmentation and permitted uses. Additional evaluations of unpermitted uses (sand and gravel mining operations, small reservoirs [less than 15 AF in storage capacity], livestock and small-scale domestic uses) were also conducted through the first increment. The results of this analysis not only provide an update on progress achieved during the first increment, but inform the goals and objectives of the second increment. The results of the robust review are provided in Appendix B.
- Excess Flow Evaluation – A key tool utilized in offsetting depletions is conjunctive management of surface and groundwater resources, primarily diversion and storage/recharge of surface water when it is available. An evaluation to determine times, durations, and quantities of excess flows in the Upper Platte River Basin was conducted to assist in planning and evaluation of conjunctive management projects. The analysis developed daily natural flows in the Platte River from historic records and applied current surface water appropriations to determine if natural flow was available, i.e. "excess flow" was in the River and could potentially be used.
- Conjunctive Management Study – In 2011, HDR and The Flatwater Group, Inc. published the Conjunctive Management Study. The objectives of this study were to identify general elements, potential approaches, and constraints necessary for planning and evaluation of conjunctive management projects. Findings were then used to evaluate several hypothetical projects involving the Western Canal to illustrate the application of these concepts. Although the Western Canal, a 20-mile canal that diverts from the South Platte River, is located in SPNRD and TPNRD, the concepts from this case study were applicable basin-wide.
- Inventory of Sandpits and Small Reservoirs – As part of Nebraska's commitment to PRRIP, the NeDNR has been charged with estimating the cumulative impacts of new or expanded, unregulated surface water activities. Therefore, in 2013, NeDNR conducted an inventory and analysis of sandpits and reservoirs with capacity below 15 acre-feet throughout the Basin. Baseline data generated from 2005 multi-temporal aerial imagery were compared to 2010 imagery in order to identify changes in the overall surface areas of these unregulated water bodies within the Basin. Once these new or expanded water bodies were identified, the Natural Resources Conservation Service (NRCS) Evapo-Transpiration

(ET) calculator was used to estimate the resulting change in consumptive use due to ET. Ultimately, the NRCS analysis estimated that the increase in unregulated surface water acreage from 2005 to 2010 resulted in a net decrease in consumptive use of 678 acre-feet per year throughout the Basin.

- Data Collection and Modeling Tools – Significant data collection efforts focused on land uses, irrigation practices, evapotranspiration rates, and well meters to better understand water uses occurring in the Basin. Substantial improvements were made to the modeling tools used to predict water uses and their depletive effects. The Western Water Use Management Model (WWUMM) and Cooperative Hydrology Study (COHYST, the primary modeling tools employed in the Basin, were modified to integrate the surface water components, resulting in enhanced tools with the ability to simulate the full hydrologic cycle. These efforts provided a more realistic representation of the physical system and an improved ability to assess management actions and conjunctive management projects. In addition, the newly collected data was incorporated to inform and enhance the modeling tools, resulting in a much better representation of the Basin uses and overall hydrology.

Finally, the first increment actions of NeDNR and the NRDs provided mitigation for post-1997 new use depletions in lieu of retirement of these new uses. These actions allowed over 200,000 acres of irrigated land added within the Basin after July 1, 1997 (including over 50,000 acres within hydrologically connected areas of the Platte River) to remain in production - vital to the economy of the Basin and the region as a whole.

Costs Incurred for First Increment Activities

The first increment efforts were funded through the individual NRDs, state, and federal monies. The state and federal funds were administered by NeDNR and included funding from the general fund, Nebraska Environmental Trust (NET), Interrelated Water Management Plan Program (IWMPP), Environmental Quality Incentives Program (EQIP), Conservation Reserve Enhancement Program (CREP), and Platte Basin Habitat Enhancement Program (PBHEP). A summary of costs is included in Table 2 and specific costs by category summarized in Appendix H.

Table 2. First Increment Costs (through 2017)

	Projects	Retirements	Studies	Administration**	Total
NRD Costs	$34.8M	$8.5M	$4.1M	$10.0M (1.25M Annually)	$57.4M
NeDNR Costs*	$43.8M	$5.6M	$0.9M	$7.2M ($0.9M Annually)	$57.5M
Total Costs	$78.6M	$14.1M	$5.0M	$17.2M	$114.9M

*NeDNR Costs include funding from NeDNR general fund, NET, PBHEP, IWMPP, CREP, and EQIP

**NRD costs for regulation included in administration costs. Costs to producers and third party economic impacts due to regulation not monetized in table.

Many of the activities implemented in the first increment are long-term projects with monetary commitments that extend beyond the first increment (long-term agreements, continuing administration, operation and maintenance, etc.). Table 3 provides an estimate of these annual costs and financial commitments for first increment activities that extend into the second increment.

Table 3. Annual costs for first increment activities that extend into second increment

	Projects	Retirements	Studies	Administration**	Total
NRD Costs	$2.3M	$0.6M	-	$1.2M	$4.1M
NeDNR Costs*	-	-	-	$0.9M	$0.9M
Total Costs	$2.3M	$0.6M	-	$2.1M	$5.0M

*While new project costs are expected, no first increment projects will include maintenance costs from NeDNR

**NRD costs for regulation included in administration costs. Costs to producers and third party economic impacts due to regulation not monetized in table.

4.0 Goals, Objectives, and Action Items

The following excerpts from the *Nebraska Revised Statutes*, as of 2018, provide context for the development of goals, objectives, and action items for this Plan. To the extent that anything in this Plan could be interpreted as being in conflict or inconsistent with any state statute, any such statute prevails.

Integrated Management Plans

Neb. Rev. Stat. §46-715(2): "In developing an integrated management plan, the effects of existing and potential new water uses on existing surface water appropriators and ground water users shall be considered. An integrated management plan shall include the following: (a) Clear goals and objectives with a purpose of sustaining a balance between water uses and water supplies so that the economic viability, social and environmental health, safety, and welfare of the river basin, subbasin, or reach can be achieved and maintained for both the near term and the long term…."

Neb. Rev. Stat. §46-715(3): "In order to provide a process for economic development opportunities and economic sustainability within a river basin, subbasin, or reach, the integrated management plan shall include clear and transparent procedures to track depletions and gains to streamflows resulting from new, retired, or other changes to uses within the river basin, subbasin, or reach. The procedures shall:

(a) Utilize generally accepted methodologies based on the best available information, data, and science;
(b) Include a generally accepted methodology to be utilized to estimate depletions and gains to streamflows, which methodology includes location, amount, and time regarding gains to streamflows as offsets to new uses;
(c) Identify means to be utilized so that new uses will not have more than a de minimis effect upon existing surface water users or ground water users;
(d) Identify procedures the natural resources district and the department will use to report, consult, and otherwise share information on new uses, changes in uses, or other activities affecting water use in the river basin, subbasin, or reach;
(e) Identify, to the extent feasible, potential water available to mitigate new uses, including, but not limited to, water rights leases, interference agreements, augmentation projects, conjunctive use management, and use retirement;
(f) Develop, to the extent feasible, an outline of plans after consultation with and an opportunity to provide input from irrigation districts, public power and irrigation districts, reclamation districts, municipalities, other political subdivisions, and other water users to make water available for offset to enhance and encourage economic development opportunities and economic sustainability in the river basin, subbasin, or reach; and
(g) Clearly identify procedures that applicants for new uses shall take to apply for approval of a new water use and corresponding offset…"

Fully Appropriated Definition

Neb. Rev. Stat. §46-706(27): "Overall difference between the current and fully appropriated levels of development means the extent to which existing uses of hydrologically connected surface water and ground water and conservation activities result in the water supply available for purposes identified in subsection (3) of section 46-713 to be less than the water supply available if the river basin, subbasin, or reach had been determined to be fully appropriated in accordance with section 46-714.".

Neb. Rev. Stat. §46-713(3): "A river basin, subbasin, or reach shall be deemed fully appropriated if the department determines based upon its evaluation conducted pursuant to subsection (1) of this section and information presented at the hearing pursuant to subsection (4) of section 46-714 that then current uses of hydrologically connected surface water and ground water in the river basin, subbasin, or reach cause or will in the reasonably foreseeable future cause (a) the surface water supply to be insufficient to sustain over the long term the beneficial or useful purposes for which existing natural-flow or storage appropriations were granted and the beneficial or useful purposes for which, at the time of approval, any existing instream appropriation was granted, (b) the streamflow to be insufficient to sustain over the long term the beneficial uses from wells constructed in aquifers dependent on recharge from the river or stream involved, or (c) reduction in the flow of a river or stream sufficient to cause noncompliance by Nebraska with an interstate compact or decree, other formal state contract or agreement, or applicable state or federal laws."

Essence of the Statutes

The excerpts of statute above provide the overall guidance for the goals, objectives, and action items contained in this Plan. Specifically, the statutes:

1. Define the difference between over and fully appropriated as the condition where existing uses of surface water and groundwater result in the available water supply to be less than the water supply needed to sustain: a) the beneficial or useful purpose for which existing natural-flow or storage appropriations were granted, b) beneficial uses from wells constructed in aquifers dependent on recharge from the river or stream, c) compliance by Nebraska with an interstate agreement.
2. State that the integrated management plan (IMP) goals and objectives should strive for sustaining a balance between uses and supplies so that the economic viability, social and environmental health, safety, and welfare of the river basin, for both short-term and long-term, is maintained.

The goals and objectives of this Plan address the activities necessary to make progress from current to fully appropriated conditions, while considering the economic viability, social and environmental health, safety, and welfare of the Basin.

Water Supplies and Uses

The Platte Basin water supply is variable. The primary source of water in the Upper Platte River Basin is precipitation, which varies spatially and temporally across the region. In the mountains of Wyoming and Colorado, much of the precipitation falls as snow, which serves as a seasonal, natural reservoir, releasing water when snow melts in the late spring and summer. This natural, seasonal reservoir is supplemented across the Basin with human-made structures, such as Pathfinder Reservoir and Lake McConaughy. In addition to surface water runoff, precipitation also infiltrates and recharges the aquifers that provide baseflow to the Platte River. Aquifer recharge has also been enhanced due to the development and use of surface water canals, where a portion of flows conveyed through the canals seep into the aquifer. Through a combination of natural and human-made influences, three distinct time scales exist for precipitation contributions to the Platte River. Natural runoff from rainfall feeds river flows in a matter of hours to days. Runoff from snowfall and storage/releases from human-made surface water reservoirs typically occur on a seasonal scale. Finally, aquifer recharge and baseflow accretions to the Platte River occur over a period of months to years.

These natural and human-made storage options have enabled development of large-scale surface water agricultural irrigation during the otherwise dry later summer months in the western portions of the Upper Platte River Basin. In spite of the substantial basin water storage capacity, during extended drought periods water user needs can potentially exceed the ability of these storage options to fully mitigate drought, as observed during the 2003-2006 extended drought period.

Water use is also variable. Irrigation demands consistently peak during July and August, but the timing and amount of peak demand in one year can be substantially different from year to year at any particular location. Storage water is also used for hydroelectric power generation and for cooling steam-electric power plants. Both uses are dependent on regional power demands on any given day. Likewise, demands for other purposes such as municipal, industrial, and commercial uses also varies day to day.

Consumptive Use

By definition, consumptive use of water is that portion of the water that is taken out of a water source and not returned to the water system. The water you use to brush your teeth is returned to the water system, and is considered non consumptive. The water you use to water your plants or your lawn is not returned to the system, therefore; it is considered consumptive. It is this portion of used water that is critical to the integrated management planning effort. Evapotranspiration (ET) from a watershed's surface is the largest component of consumptive use and is the depletion or loss of water from the basin associated with plant water use.

Water diverted from its natural course through a canal, pipe, or other conveyance measure and applied as irrigation in excess of ET is not lost because it returns into the basin from which it was withdrawn via surface runoff or deep percolation to the aquifer. This water can be available to other users at other times in other locations. One user's water inefficiency often serves as the source of another user's water supply. A modeled representation of a basin's hydrology and water mass balance allows for quantification of these consumptive uses, and can account for return flows to the surface water system or aquifer, which then become available as supply for other uses.

Basin Water Budget

Generally, state statutes define a fully appropriated condition as one in which current uses will result in not having the water necessary to meet the beneficial purposes of existing surface water and groundwater uses in aquifers dependent upon recharge from the river or stream. A key element of evaluating this condition is determining the water budget for the basin using the best available information, data, and science, as required by statute. The models and other tools that are used to evaluate the hydrology of the basin represent the basin's water budget, considering all water inflows and outflows within the basin. The basin hydrology is based on the principle of water mass balance, defined in both 'flows' and 'stocks'.

The most important 'flows' tracked by the models include headwater flows, streamflows at the basin's important stream gauges, water diverted, water applied to crops, water depleted, reservoir releases, groundwater pumping, seepage to aquifers, return flows to streams, reservoir evaporation, and reservoir releases. The models include major functions that influence any of the flows described above.

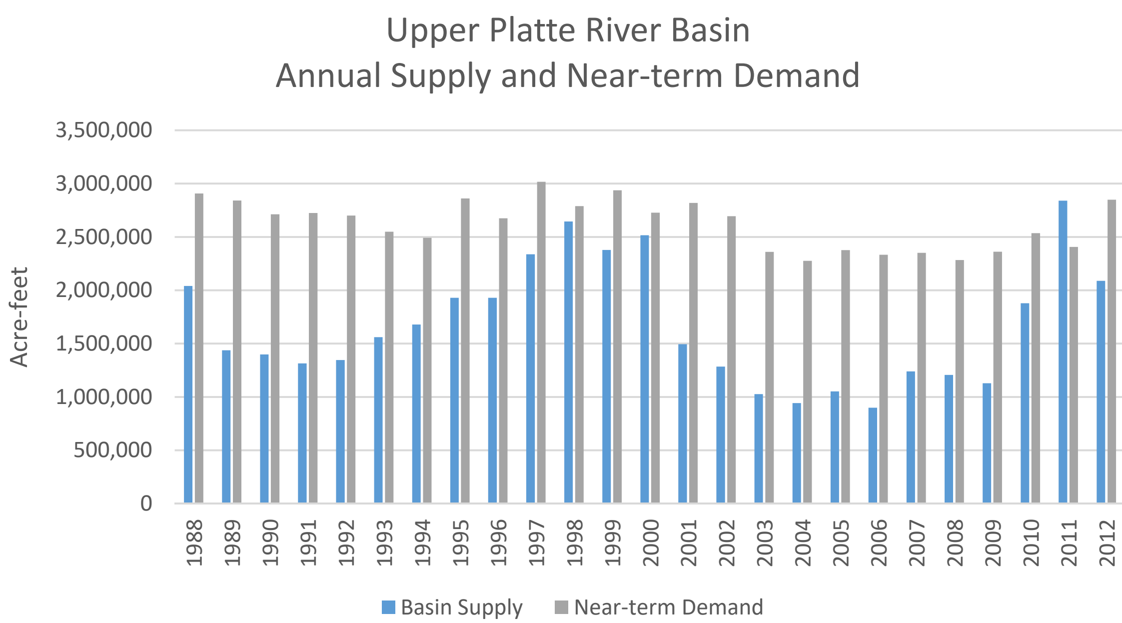
Important 'stocks' include reservoir and aquifer levels. A hydrologic mass balance for both surface water and groundwater is enforced for all flows and stocks. The mass balance for reservoir stocks is given by starting storage minus reservoir releases plus river inflows to the reservoir minus evaporation. Changes in any period's groundwater stock are represented through effects of seepage, water applied, and water pumped.

Both the supply side of the equation and the use side of the equation are variable spatially and temporally across the Upper Platte River Basin, so on any given day, the Basin could be in a fully appropriated condition with all the beneficial uses being met, or in an overappropriated condition with the beneficial uses not being met. Understanding that water uses cannot exceed water supplies (natural-flow and storage supplies), a balance will likely exist each year in the overappropriated basin. However, *water demand* can exceed water use when supplies are limited (for further information, see discussion in Appendix 1 of Appendix I). Table 4 and Figure 3 below summarize the results of the INSIGHT analysis conducted for the Basin above Odessa (for years 1988-2012) during the first Plan increment and illustrates this variability (see Appendix A). The INSIGHT analysis looks at the water supplies during a given year and the demands for water – both from surface water and hydrologically connected groundwater - in that same year. The years 1988-2012 represent a statistically unbiased representation of hydrological variability in the Basin.

Table 4. Summary of Supplies and Demands for the Platte Basin above Odessa – 1988-2012[1]

	Maximum Annual	Minimum Annual	Mean Annual
Supply	2.09M AF (2011)	0.9M AF (2006)	1.66M AF
Demand	3.02M AF (1997)	2.28M AF (2004)	2.62M AF

Figure 3. Summary of Supplies and Demands for the Platte Basin above Odessa – 1988-2012



Because of the variability of hydrologic conditions within this river system, spatially and temporally appropriate management actions must be developed, implemented, monitored, and regularly re-evaluated to ensure that existing beneficial uses are being protected, so that the

[1] The Basin Supply term represents an estimate of total water supply without human-made depletions and can be summarized as: Basin Supply = Streamflow + SW Consumptive Use +GW Depletions. The Near Term Demand represents an estimate of total basin demands and can be summarized as: Near Term Demand = GW Depletions + SW Demand + Net SW Loss + Non-Consumptive Use Demand. The Non-Consumptive Use term of the total demand recognizes that these types of demands are not cumulative, therefore the maximum of the non-consumptive uses (instream flow demand, hydropower, and downstream demand) is used.

economic viability, social and environmental health, safety, and welfare of the Basin can be maintained for both the near-term and the long-term. The focus of the management actions are not on mitigating shortages that may occur due to the natural variations in the hydrologic cycle. The prior appropriation doctrine used in Nebraska for administering surface water has provided and will continue to provide a mechanism for managing those shortages that can be expected due to variations in the hydrologic cycle. Rather, the management actions, and this Plan, are focused on mitigating human-made effects on surface water supplies to maintain beneficial uses of appropriations and provide adequate recharge to those aquifers dependent on streamflow during times of shortages in water supply.

Statute requires working towards a balance of water supply and water use, while considering impacts on the near- and long-term economic viability, social and environmental health, safety, and welfare of the Basin. Throughout the stakeholder process for the second increment, significant discussion occurred on this topic. Stakeholders identified economic viability in a number of ways, including:

- A steady income,
- water needed to provide for the beneficial uses of appropriators including the generation of hydropower,
- financial support to maintain benefits of surface water irrigation projects,
- cooling water for power generation,
- the sustainability of canal systems,
- resiliency to withstand drought,
- flexibility in the use of natural flow and stored water, and
- conjunctive management.

Stakeholders clearly believe that the most significant impact on the economic viability of users across the Basin occurs during times of drought. Therefore, the second increment Plan recognizes that a focus on drought planning and mitigating the effect of depletions that amplify effects of drought conditions, will be an important step toward consistently achieving a fully appropriated condition. In addition, more data and analyses of water supply and demands as related to economic viability, social and environmental health, safety, and welfare of the Basin, for both the short-term and long-term, are needed to develop a more targeted set of goals and objectives for achieving a fully appropriated condition for the long-term. Finally, much has been accomplished through implementation of the first increment Plan and individual NRD IMPs. Stakeholders recognized these successes and generally felt those elements should be retained for the second increment of the Plan.

The goals, objectives, and action items contained in this Plan were developed through extensive collaboration with the stakeholders of the Basin and define the activities to be accomplished in this increment, to the extent possible based on staffing and resource constraints.

Goals, Objectives, and Action Items

Goal 1: Incrementally achieve and sustain a fully appropriated condition while maintaining economic viability, social and environmental health, safety, and welfare of the Basin.

Objective 1.1: Maintain previous increment mitigation progress.

During the development of the first increment Plan, estimates of post-1997 use depletions requiring offset for each NRD were developed. Each of the NRDs met the identified depletion offset during implementation of the first increment Plan. A summary of first increment activities is included in Appendix B.

Models, tools, and overall understanding of the Basin hydrology were also improved during implementation of the first increment Plan and applied in the first increment robust review (process described in Objective 1.4). Application of these tools and understanding has resulted in refined estimates of post-1997 depletions, which are typically greater than the original estimates included in the first increment Plan. The robust review also provided estimates of the first increment offsets achieved by each of the NRDs.

Table 5 summarizes the results of the first increment robust review by NRD. Negative values in the table represent depletions to the stream and positive values represent accretions to the stream. The first column is the estimated impacts from all groundwater uses through time (pre-1997 and post-1997 uses). The second column is the portion of computed impacts due to those uses initiated before July 1, 1997, referred to as pre-1997. The third column is the portion of computed impacts from those uses initiated after July 1, 1997, referred to as post-1997. The fourth column is the current estimate of offsets achieved in 2019 from excess flow recharge events that occurred through 2013 in each NRD. The fifth column is the current estimate of the impacts that each NRD must either offset (if a depletion) or maintain (if an accretion). Finally, the last column displays the 2019 target accretions or depletions for each NRD based on the linear trend of modeled streamflow impacts. Because of year-to-year variability in modeled results due to modeled climate inputs, the average trend line of modeled results is used as the target in each NRD's IMP.

Table 5 First Increment Robust Review and Other Management Actions Summary

	Total Depletion in 2019 (AF)	Pre-1997 Use Depletion in 2019 (AF)	Post-1997 Use Depletion or Accretion in 2019 (AF)	Other Management Actions in place as of 2019[2] (AF)	Total 2019 Post-1997 Impacts (AF)	2019 Target[3] (AF)
NPNRD	-87,600	-108,700	20,800[4]	400	21,200	23,300
SPNRD	-37,400	-42,700	5,200[4]	100	5,300	4,500
TPNRD	-149,600	-127,200	-22,800	6,200	-16,600	-22,900
TBNRD	-35,800	-37,500	1,400	1,600	3,000	4,200
CPNRD	-101,100	-88,100	-13,700	3,100	-10,600	-10,500
Total			-9,100	11,400	2,300	

[2] The estimated 1st increment offsets achieved in 2019 include excess flow/recharge projects, NCORPE in TPNRD (5,600 af), North Dry Creek Augmentation Well in TBNRD (1,400 af), and Surface Water Retirements in the CPNRD (2,500 af).

[3] The Robust Review analysis, which generated the IMP targets for each NRD, did not include NCORPE in TPNRD (5,600 af), North Dry Creek Augmentation Well in TBNRD (1,400 af), and Surface Water Retirements in the CPNRD (2,500 af).

[4] Includes impacts from groundwater allocation management actions of the NRD.

Table 6 summarizes the total change in the number of groundwater-only irrigated acres since July 1, 1997, as well as the total number of groundwater-only irrigated acres in 2019, by NRD[5]. In addition, Table 6 displays the volume of groundwater pumping in 2019 attributed to groundwater-only irrigation and the volume of groundwater pumping in 2019 attributed to municipal and industrial uses.

Table 6 First Increment Robust Review Groundwater Irrigation and Pumping Summary

	Change in Groundwater-only Irrigated Acres 1997 to 2019 (AF)	Total Groundwater-only Irrigated Acres in 2019 (AF)	Groundwater-only Irrigation Pumping in 2019 (AF)	M&I Pumping in 2019 (AF)	Groundwater-only and M&I Pumping in 2019 (AF)
NPNRD	0	134,400	113,300	11,500	124,800
SPNRD	12,000	115,800	78,400	3,100	81,500
TPNRD	58,000	263,700	322,100	8,100	330,300
TBNRD	55,000	461,600	237,500	3,200	240,600
CPNRD	85,200	902,500	575,100	22,300	597,400

Progress made during the first increment will be maintained in this increment and keep the Basin moving toward achieving a long-term balance of water supplies and uses while maintaining economic viability, social and environmental health, safety, and welfare of the Basin.

Action Item 1.1.1: Keep policies, projects, and practices in place that provide offsets, or supply equivalent offsets, so that the current level of depletions is not exceeded.

Much progress toward reaching a fully appropriated condition was made in the first increment through implementation of various offsets and mitigation actions. This includes efforts to offset depletions from water uses initiated after July 1, 1997, and in some areas progress toward offsetting pre-1997 depletions. Many of these efforts capitalized on federally funded programs, like the Conservation

[5] Acres values were maintained at constant levels after 2013, with the exception of temporary retirements that were reincorporated into subsequent years when the retirements terminated.

Reserve Enhancement Program, and on state and local programs funded through NeDNR and the Upper Platte NRDs. Continued availability of these funding sources during the second increment of the Plan is uncertain and may affect management activities during the second increment. NeDNR and the NRDs will continue implementation of cost effective policies, projects, and practices to maintain the progress made during the first increment in this increment toward achieving a long-term balance of water supplies and uses while maintaining economic viability, social and environmental health, safety, and welfare of the Basin.

Objective 1.2: Offset impacts of streamflow depletions to (A) surface water appropriations and (B) water wells constructed in aquifers dependent on recharge from streamflow to the extent those depletions are due to water use initiated after July 1, 1997.

In accordance with statutes, to reach a fully appropriated condition, the first step is to ensure that depletions to streamflows from uses initiated after July 1, 1997, are offset. The action items under this objective outline the process and considerations for addressing these depletions during Plan implementation. Depletions associated with post-1997 levels of development are to be fully offset by the end of the second increment. The timetable for addressing the post-1997 use depletions during implementation of this Plan increment will be identified by the individual NRDs and included in the individual IMPs.

Neb. Rev. Stat. § 46-715(3) provides guidance on facilitating new development within overappropriated areas. The statutes call for procedures and processes to be identified in the individual IMPs for allowing new uses while ensuring that mitigation measures sufficient to offset those new depletions are put in place.

Action Item 1.2.1: The identification of pre- and post-1997 levels of development and associated depletions includes assessment of the following:

- changes in irrigated acres;
- changes in municipal and domestic uses of water;
- changes in livestock use of water;
- changes in industrial uses of water;
- changes in the amount of surface water and groundwater applied on commingled irrigated land; or
- any other relevant changes in water consumption that affect streamflow.

Estimates of pre- and post-1997 levels of development and associated depletions have been determined for each NRD and are illustrated in Table 5 The first step in this process involved using modeling tools to estimate depletions to streamflow from water uses initiated prior to July 1, 1997. This establishes a pre-1997 level of development condition. The second step in the process is to add the post-1997 uses to the pre-1997 level of development condition and simulate these conditions using the same modeling tools. Computed depletions from this simulation in excess of the pre-1997 condition are then required to be offset.

Appendix B contains a summary of estimated depletions and offsets requirements for the second increment, specifically:

- Computed streamflow depletions from the pre-1997 level of development
- Computed depletions including those resulting from post-1997 uses within each NRD and the Upper Platte River Basin as a whole.
- Current estimate of depletions within each NRD that must be offset.

As noted in Appendix B, the robust review results recognize the temporal variability in required depletion offsets – both from year to year, as well as seasonally within the year. The results of the robust review can be used to determine seasonal and monthly offset requirements. The seasonal variation is important as it illustrates the opportunity for active vs. passive management to meet depletion offset requirements. Examples of passive management projects are intentional recharge of excess flows using canals or recharge pits, where water seeps into the aquifer and baseflow accretions due to the additional recharge occur naturally throughout the year. Active management includes targeted mitigation projects such as augmentation projects, where water is pumped or released at a specific time to directly impact streamflow during times of shortage. The information contained in Appendix B can be used to determine appropriate targets for passive or active management approaches.

The depletion estimates presented in Appendix B are based on the most recent modeling efforts in support of the first increment robust review, completed in 2018 during development of the second increment Plan. These depletions estimates will be reviewed periodically using agreed upon modeling tools. Models, supporting data and information, and the understanding of the Basin's hydrology continue to evolve. As new tools, information, and understanding is applied, it is anticipated that the values for depletions presented in Appendix B may change. As new depletion information is developed and considered, the values presented in Appendix B may be updated and the Plan revised via a public hearing at the annual basin-wide meeting. While values for the level of allowable depletions and depletions requiring offsets may change during this increment of the Plan, Objective 1.1 calls for continuing, as appropriate, first increment activities to offset depletions.

Action Item 1.2.2: Identify, quantify, and proportion the source and quantity of water used on acres irrigated with both surface water and groundwater. Gather data on water use on such lands (both why and when irrigators use surface water or groundwater).

The impacts to water supply on lands with access to both surface water irrigation and groundwater irrigation, referred to as "commingled acres", need to be investigated. Data on when surface water or groundwater is used on commingled acres is important to fully understand the impact of irrigation of these lands on streamflow. Surface water irrigation and groundwater irrigation typically have different delivery and application efficiencies which affect the amount of water withdrawn to meet crop demands, and ultimately the fate of that water (seepage, evaporation, returns, consumptive use, etc.). The timing of impacts on streamflow is also affected by the source of water used: surface water diversion is an immediate depletion to streamflow, while use of groundwater has a time-lagged effect on streamflow.

Further understanding the sources of water used on commingled acres allows better representation of water usage in modeling tools and evaluations. For modeling purposes and to determine post-1997 depletions, it is important to know historically when acres may have changed from irrigation by surface water alone to commingled or groundwater-only irrigation.

Action Item 1.2.3: Continue to identify and implement projects that may be used to enhance water supply. These projects shall be pursued on a basin-wide level, when such projects will help achieve sustainable levels of supply and use and address water shortages in one NRD that affect more than one NRD.

Options for offsetting the impacts of post-1997 depletions can be either direct reduction of consumptive use (Action Item 1.2.4), enhancing existing water supplies in other ways, or projects that improve management of existing supplies in such a way that depletions can be either reduced or directly offset. Projects to offset depletions that affect more than one NRD will be coordinated and pursued at a basin-wide level. Platte River Recovery Implementation Program (PRRIP) Water Action Plan projects, if funded in part or wholly by the State or NRDs, can be used to meet post-1997 offset requirements or progress towards fully appropriated. If no State or NRD funding is used for a Water Action Plan project, the benefits of the project - depending on the location, timing, operation, etc. - may accrue as progress towards fully appropriated.

Action Item 1.2.4: Continue to reduce consumptive water use through retirement of irrigated lands, water use allocation, and/or other management options.

One option for offsetting the impacts of post-1997 depletions is reduction of consumptive water use. This can be accomplished through retirement of irrigated acres, water use allocations, and/or other management options. The analyses described in Action Items 1.4.2 and 1.4.3.1 are the basis for determining offsets provided by management activities aimed at reducing consumptive use. Crop types and producer practices may result in increases or decreases in consumptive use, so tracking current crop types and practices will be important to determine future estimates of consumptive use. Offsets that are accrued through consumptive use reductions are credited to the NRD in which they occur, and ultimately the Basin, in meeting the post-1997 offset requirements.

Action Item 1.2.5: Ensure that offsets of depletions occur at the appropriate time, amount, and location to mitigate the impact of the depletion. Allow for flexibility in providing offsets when appropriate.

The timing of the highest demand, and therefore potential impact of depletions, varies spatially across the Basin. It is important that depletion offsets identified in Action Items 1.2.3 and 1.2.4 provide a volume of water to the stream sufficient to make up for the associated depletions in the locations in which the depletions occur to effectively offset depletions. Preferably monthly, and at a minimum seasonally, offsets would occur in the same time and within the same reach as the depletions they are mitigating so as not to affect downstream users' access to water. The results of the robust review contained in Appendix B provide the timing, quantity, and location of required depletion offsets.

Action Item 1.2.6: Apply current methodologies, and continue to refine these methods of estimating depletions and accretions. Gather and evaluate data that could be used to estimate depletions and accretions to streamflow using tools as agreed on by NeDNR and the NRDs. Apply these methods for calculating depletions and offsets uniformly across the Basin.

Whenever an analysis is performed to determine compliance with this Basin-Wide Plan or any IMP subject to this Plan, the methods utilized will be conceptually consistent so that stream depletions estimated/calculated in one area of the Basin are an "apples to apples" comparison to stream depletions estimated/calculated in another area of the Basin.

Models, supporting data and information, and our understanding of Basin hydrology will continue to evolve during implementation of the Plan. As this information becomes available and is evaluated, NeDNR and the NRDs will refine the methodologies and tools used to estimate depletions and accretions throughout the Basin. This information will be shared as part of the annual reporting for this Plan described in Objective 5.1. Methods, tools, and data used will be made available to the stakeholders and the public. The process for incorporating new information and results into this Plan document and/or supporting appendices will include a public hearing at the annual meeting.

The term 'uniform' in this action item (and elsewhere in the Plan when referring to consistency in analysis) is not intended to dictate that same methods be used throughout the Basin, as differences in available data, water supply and uses, climate, etc. across the Basin will require differences in the methodologies employed. Rather the term 'uniform' is intended to indicate that the methodologies must be consistent in concept to provide an apples-to-apples comparison across the Basin.

Objective 1.3: Make progress toward a fully appropriated condition.

Objective 1.1 calls for maintaining first increment offset achievements and Objective 1.2 addresses post-1997 use depletions – a priority in making progress towards a fully appropriated condition. The intent of Objective 1.3 is to identify actions that assist in making progress towards fully appropriated conditions while maintaining the economic viability, social and environmental health, safety, and welfare of the Basin. Throughout the planning process and stakeholder discussions, it was understood that some of these elements are believed to be largely addressed through other activities in the Basin or will be addressed through implementation of this Plan and will not require specific additional actions. Namely:

- Social and environmental health: Addressed through implementation of the Platte River Recovery Implementation Program (See Objective 2.1) and continued protection of instream flow appropriations.
- Safety: Addressed by not limiting access to emergency water supplies, as well as the capture and conjunctive management of flood flows to reduce flooding.
- Welfare: Addressed through implementation of this Plan.

Economic viability was identified as a critical element that warranted the inclusion specific objectives in order to be fully addressed.

Based on examination of the water supplies and water demands in the Basin (INSIGHT analysis – see Appendix A) and extensive work done with the stakeholder group through the planning process to determine conditions where water users are economically vulnerable, cyclical supply variability due to both short and extended drought periods and natural geographic variation in precipitation distribution are significant factors affecting economic viability. Human-made depletions amplify dry periods of the cyclical supply variability. This goal is focused on maintaining the Basin's economic viability in the face of these variations in water supply and human-made depletion impacts.

The first three action items supporting this objective are organized in a logical progression—first, understanding and developing tools for determining economic impacts of supply variability (1.3.1), then approaches and protocols for assessing supplies, demands, and potential shortages and excesses[6] (1.3.2), and finally, developing approaches and solutions to maintain economic viability of water users in the Basin (1.3.3). Each action item determines the necessity and informs the action items of the subsequent objective. Action Item 1.3.4 is a focused effort to address shortages to water users during periods of drought. Many of the stakeholders identified droughts as the only time their water supply was affected. Addressing human-made depletion impacts during these shortages will be a step toward a fully appropriated condition.

Action Item 1.3.1: Understand the economic impacts of supply variability on water users.

Through the planning process conducted for the second increment, extensive discussion centered on vulnerabilities of stakeholders to the variable water supply. The action items related to this objective are geared toward developing a fundamental and quantitative understanding of the economic impacts on Basin water users from variability in water supply.

Action Item 1.3.1.1: Identify who is affected (hydrologically and economically), and to what extent, by water supply variability.

Conduct a study that identifies water users that are affected during cyclical variations in water supply. This hydrologic element analysis will be conducted by NeDNR and the NRDs by evaluating data such as stream gage and diversion records, and well hydrograph data. Focused surveys of, as well as meetings with Basin water users can be used to build on stakeholder input gathered throughout the planning process. Once impacted water users who are hydrologically affected by water

[6] The assessment of supplies and demands under Objection 1.3 are focused on current and future conditions.

supply variability are identified, economic impacts can be estimated as described in Action Items 1.3.1.2 and 1.3.1.3.

Action Item 1.3.1.2: Partner with impacted water users and other entities to gather data and study economic impacts of supply variability as well as regulatory and management actions.

NeDNR and the NRDs will collaborate with impacted water users and other entities to gather relevant economic data. Potential partners include economists and other subject matter experts familiar with the economic drivers of the Basin who can help identify data needs and formulate the tools and methodologies for assessing economic impacts. The tools and methodologies will be used to not only evaluate impacts of supply variability, but also evaluate human-made depletion impacts, management actions, regulatory actions, and potential projects or other activities considered during implementation that may affect water availability.

Action Item 1.3.2: Assess short- and long-term Basin water supply and demand.

This objective is focused on coordination and dissemination of information, not developing new methods or predictive tools. Many entities within the Basin currently assess and predict upcoming water supplies (CNPPID, NPPD, surface water irrigation districts, NRDs, etc.), with varying degrees of complexity in the methods used. Likewise, forecasting of short- and long-term demands under variable hydrologic conditions is also necessary. Basin water use and supply data, such as the INSIGHT analysis results, can be used as a reference for forecasting future supply and demands, Likewise modeling tools such as the CROPSIM model can be used to forecast demands in the short- and long-term. Timely coordination and information exchange amongst Basin stakeholders can further understanding of hydrologic conditions within the Basin and inform management decisions. This objective is targeted toward drought preparedness. Understanding potential for excess flows is as important as identifying potential droughts because management of excess supplies can build resiliency within the Basin to better withstand drought conditions.

Action Item 1.3.2.1: Evaluate expected natural flows of the Basin and available storage water.

Anticipated supplies for the coming year will be assessed, including consideration of factors such as mountain and plains snowpack, current reservoir storage levels, and current aquifer levels and prevailing trends. Communication and dissemination of this information provides a clear and consistent understanding of current and expected hydrologic conditions throughout the Basin.

Action Item 1.3.2.2: Identify specific locations and flow targets critical to water users in the Basin.

The results of action items 1.3.1.1 through 1.3.1.3 provide the basis for determining locations and flow thresholds critical to each water user in an effort to maintain the economic vitality of the Basin. The flow thresholds should consider variable demands and provide a range of anticipated demands based on variable hydrologic conditions. This information, coupled with anticipated supplies from action item 1.3.2.1, will inform management decisions.

Action Item 1.3.2.3: Forecast location and timing of shortage and excess within the Basin.

The anticipated supplies from action item 1.3.2.1, coupled with location and flow targets from action item 1.3.2.2, will inform management decisions in each year. In addition to seasonal or upcoming season forecasts of water supply, the feasibility of developing long-term forecasts of water supply (3-yr or 5-yr time frame) will be evaluated.

Action Item 1.3.2.4: Develop protocols for assessing and communicating available excess flows

The ability to capture and use excess flows is dependent on advanced notice of the availability of excess flows. NeDNR will develop a protocol for assessing, predicting, and communicating 1) the potential of excess flows to Basin water users, and 2) notice of actual availability of excess flows.

Action Item 1.3.3: Explore and implement potential measures to mitigate impacts (hydrologic and economic) of Basin supply variability due to human-made depletions on surface water and groundwater users.

This objective is focused on mitigating hydrologic and economic impacts of supply variability due to human-made depletions identified during completion of Action Items 1.3.1 and 1.3.2. Discussions with the stakeholder group through the planning process identified potential approaches (hydrologic, financial, etc.) for mitigating impacts. Action items 1.3.3.1 through 1.3.3.5 are to further evaluate these approaches for consideration.

Action Item 1.3.3.1: Evaluate options to maintain economic viability of surface water and groundwater infrastructure.

Potential strategies to mitigate economic impacts that may be considered include:

- Compensation, which may include financial, for lost hydropower production to the extent groundwater depletions may have impacted hydropower production
- Funding for surface water irrigation district canal infrastructure improvements (storage, efficiency, etc.)
- Funding for groundwater recharge projects

Action Item 1.3.3.2: Identify conjunctive management opportunities.

Potential conjunctive management strategies to mitigate hydrologic impacts that may be considered include:

- Aquifer recharge enhancement to mitigate water level declines
- Offsetting depletions to groundwater aquifers due to groundwater use or reduced surface water recharge to allow land to stay in production while maintaining or increasing available water supply

Action Item 1.3.3.3: Study potential for developing markets and transfer protocols for annual surface water and groundwater supplies.

A water market is an economic platform for temporary or permanent trades of the rights to use water (both surface water and groundwater, subject to NeDNR and NRD approval, respectively), where the price of water is determined by variable economic and market conditions. Much is still unknown about the logistics, framework, and interest of water users in such a market. Some questions to be addressed include if there is potential for market-driven water management approaches in the Basin and what might the physical, regulatory, and administrative framework of such a system look like for the Basin. This action item is focused on addressing these questions by working cooperatively with Basin water users in determining potential applicability and potential framework for a basin-wide water market. NeDNR and CPNRD's pilot study in 2016 and 2017 developed an algorithm and established a water market within CPNRD. Lessons learned from the pilot study can inform efforts under this action item.

Action Item 1.3.3.4: Study management options of storage water (both surface water reservoirs and aquifer storage; and existing and potential new storage) to provide flexibility and increase resiliency of water supplies.

The importance of storage to the resiliency of Basin water supply was a consistent theme during the stakeholder process. The ability to capture and store flow during times of excess, either in the aquifer or in surface water reservoirs, was identified as an important approach to improve the Basin's resiliency under variable hydrologic conditions.

Many of the existing surface water storage facilities within the Basin serve multiple purposes (irrigation, aquifer recharge, hydropower, environmental, recreation, etc.), increasing the complexity of operations. Within this context, new storage management approaches will be evaluated that could potentially improve the resiliency of the water supplies, while considering impacts to the multiple purposes currently served. Potential new storage opportunities, whether in new facilities or new storage allocations in existing facilities, will also be evaluated.

Opportunities for enhancing aquifer storage will also be studied. In addition to identifying supplies and recharge sites, effects on existing aquifer water quality and aquifer levels require consideration.

Action Item 1.3.3.5: Support diversity in revenue streams of water users within the Basin.

During the stakeholder process, diversification of revenue streams was identified by many of the participants as a means for maintaining economic viability. Examples included eco-tourism, crop diversification, changes in land use, etc. While these types of activities are solely at the discretion of the individual users, NeDNR and the NRDs can provide expertise and education in support of constituent activities that support the goals and objectives of this Plan and the individual NRD IMPs.

Action Item 1.3.4: Develop a Basin drought contingency plan for management of supplies during times of shortage.

The Basin drought contingency plan is part of the continuing efforts to reach fully appropriated conditions by addressing those shortages caused by short- and long-term drought conditions. The contingency plan discussed herein is to be completed within the first 3 to 5 years of this increment and address conditions under a basin-wide or regional drought condition, not a local (county or NRD level) drought condition.

The Basin drought contingency plan will focus on vulnerabilities identified through coordination with Basin water users in Action Item 1.3.1, and developing a monitoring and communication protocol for consistency across the Basin. The Basin drought contingency plan will serve as a guide for plans to be developed by each individual NRD as part of this action item. District-level mitigation measures and response actions corresponding to the drought conditions will be identified and implemented at the individual NRD level. Elements of a drought contingency plan include:

1. Vulnerabilities (Action Item 1.3.1)
2. Monitoring protocols (Basin-Wide Plan)
3. Triggers (individual NRD plans)
4. Mitigation actions (individual NRD plans – potentially basin-wide activities)
5. Response actions (individual NRD plans – potentially basin-wide activities)
6. Plan administration (individual NRD plans and Basin-Wide Plan)

Action Item 1.3.4.1: Develop a Basin drought monitoring protocol for defining and determining drought conditions.

This effort will focus on defining the severity of drought conditions (including identifying trigger points that will be linked to response actions) and determining the protocols for monitoring drought conditions at a basin level. The focus is on providing consistency and communication of Basin drought conditions. The monitoring protocol will identify information and an approach to determining Basin drought severity. Current monitoring activities and information utilized by Basin water managers and other agencies responsible for developing forecasts will be reviewed and considered during the development of the monitoring protocols. Examples of information that can be used include snowpack, streamflow, system storage, soil moisture, National Drought Mitigation Center reports, Standardized Precipitation Index reports, and aquifer levels.

The result of this effort is intended to be consistency in communicating drought conditions to users across the Basin.

Action Item 1.3.4.2: Identify potential basin-wide mitigation and response actions to drought conditions and opportunities for cooperation across the Basin (for example, management of storage water).

Each NRD will develop individual drought contingency plans. The individual NRD drought contingency plans will contain mitigation and response actions specific to each District. The responsibility for implementation of those activities will, therefore, lie with each District. The purpose of this action item is to identify potential mitigation and response actions that are basin-wide or near basin-wide in scale, and/or involve multiple entities within the Basin (NeDNR, NRDs, irrigation districts, power districts, etc.). Collaboration with Basin water managers and water users impacted by drought conditions is anticipated in the identification and development of potential mitigation measures.

Action Item 1.3.4.3: Conduct a drought simulation workshop with NeDNR, NRDs, and water users to assist in developing and testing of protocols during a drought.

The workshop will test the proposed monitoring and communication protocols, as well as potential mitigation and response actions through simulation of conditions from a historic drought period.

Action Item 1.3.4.4: Identify roles for administering and implementing Basin drought contingency plan.

The administration of the Basin drought contingency plan requires defining specific roles and responsibilities for monitoring, communication, and implementation activities at the basin level. In addition, protocols for updating the plan need to be developed for inclusion in the plan administration.

Objective 1.4: Conduct technical analyses to support and evaluate effectiveness of Plan and adequacy in sustaining progress toward a fully appropriated level of water use.

This objective focuses on the technical analyses of water supplies and uses to support plan implementation and evaluation. Specific activities include:

- An annual review of any permitted new or expanded uses of surface water and groundwater within the Basin and associated mitigations (Action Item 1.4.1)
- An evaluation (robust review) of pre- and post-July 1, 1997 development (Action Item 1.4.2)
- An evaluation of current and fully appropriated conditions (Action Item 1.4.3)
- Development of necessary tools and technical analyses to support the robust review (Action Item 1.4.4)

Action Item 1.4.1: NeDNR and the NRDs will continue to assemble and share data annually on any permitted new and expanded uses of surface and groundwater and any associated mitigations in the Basin.

Statute describes both an annual review (*Neb. Rev. Stat.* §46-715(5)(d)(ii)) and a second more robust review of new or expanded uses and associated mitigation actions (*Neb. Rev. Stat.* §46-715(5)(d)(iii)) (Action Item 1.4.2). NeDNR and the NRDs will annually share data on any permitted new or expanded uses of surface water and groundwater and any associated mitigations in the Basin. Data will be shared in accordance with the requirements of state statutes, including meeting compliance with the individual IMPs and the Nebraska New Depletion Plan. Data will be analyzed to assess the collective amount, timing, and locations of the depletions to streamflows resulting from new or expanded uses and the collective amount, timing, and locations of all mitigations put in place. These analyses will be done using the agreed upon methods and tools. The results of these analyses will be shared as part of the annual reporting for this Plan described in Objective 5.1. Methods and tools used will be available to the stakeholders and the public. Basin-wide data collected will then be trimmed to the relevant PRRIP area, analyzed, and used for required annual and periodic reporting for the Nebraska New Depletion Plan, helping facilitate Nebraska's compliance with the Nebraska New Depletion Plan (supporting Goal 2). Details of annual reporting requirements can be found within the Monitoring and Studies Chapter of each District's IMP. The most recent annual reports can be found on the Department's website. Recent reports are included as Appendix A.

Action Item 1.4.2: An evaluation (robust review) of the impact of pre- and post-July 1, 1997, development and progress towards Plan goals/objectives/action items shall be conducted for each plan increment.

The purpose of the robust review it two-fold: 1) Update estimates of depletions from pre- and post-July 1, 1997 development; and 2) Evaluate management actions taken and their overall effectiveness in making progress towards the goals and objectives outlined in the Plan. The latter purpose serves as the basis for determining the need for further increments, and if so, to inform the planning process for the next increment. The process for the evaluation is described in *Neb. Rev. Stat.* §46-715(5)(d)(iii) and will identify the following information:

- A 50-year estimate of the streamflow depletions associated with pre- and post-1997 levels of water use development within the hydrologically connected area of the overappropriated basin within each NRD and within the entirety of the NRD.
- A 50-year estimate of streamflow accretions associated with management actions implemented by each NRD and NeDNR within the hydrologically connected area of the overappropriated basin within each NRD and within the entirety of the NRD.
- A summary of the net streamflow depletions within the overappropriated basin resulting from groundwater pumping within each NRD.

The net streamflow depletions estimated may need to be adjusted based on actual hydrologic conditions to reflect the requirement to offset only those amounts needed to prevent depletions to (A) surface water appropriations; (B) water wells constructed in aquifers dependent on recharge from streamflow; and (C) ensure compliance by Nebraska with the New Depletion Plan included in PRRIP, for as long as the Program exists.

The data collected on an annual basis (Action Item 1.4.1) will be used to update land use datasets for the accepted modeling tools. The models will be used to assess impacts of the permitted activities as part of the robust review process. The robust review will also evaluate the effects of other actions taken to reduce consumptive use and enhance streamflows to meet the goals and objectives in the Plan.

During the first increment, the robust review and evaluation of depletions focused on the impacts to stream baseflows. The groundwater modeling tools are used to assess baseflow impacts. During the second increment of the Plan, more focus will be given to activities that may have broader impacts and the impacts to overall streamflows may be evaluated, which would require the use of integrated modeling tools that incorporate surface water. NeDNR and the

NRDs will agree upon when it may be appropriate to use integrated modeling tools, what methods should be used, and how evaluations will be done.

The general method for conducting the robust review will be as follows:

i. The groundwater models used for this process will be calibrated to streamflows/baseflows and groundwater levels in the area with the ability to assess the impacts on a monthly basis. The groundwater models will be updated periodically to simulate the management practices that have been implemented to date. The evaluation period of these models will be 50 years into the future.

ii. The following groundwater model runs will be conducted to measure the success toward reaching Objective 1.2:

   a. The 1997 Development Level Run. A model run that simulates holding the number of irrigated acres and crop types or mix in 1997 constant through the current date and the fifty-year projection period. It will assume the full crop irrigation requirement for the crop types or mix. The run will be conducted using climate data through the current date and will include a 50-year projection using an agreed to climate pattern.

   b. The Historical Run. A model run that simulates the actual annual changes of the irrigated acres, excess flow recharge events, retirements, allocation effects, augmentation projects, and other water management regulations or projects throughout the evaluation period starting in 1997 through the current date and the 50-year projection period. The 50-year projection period will repeat an agreed to land use, regulation, or project dataset. The model will use available flow meter data or, in the absence of flow meter data, assume the full crop irrigation requirement was met at all times. The run will be conducted using data through the current date and will include a 50-year projection using an agreed to climate pattern.

   c. Difference between the 1997 Development Level Run and the Historical Run. The simulated output from each model run will be compared to determine the difference in the baseflow that has resulted from post-1997 development.

   d. Surface Water Accretions and Other Uses not Covered by the Models. If surface water acres are retired to offset streamflow depletions due to new uses begun subsequent to July 1, 1997, accretions resulting from those retirements will be determined using agreed upon methodologies. This would include conjunctive management activities that are not otherwise captured in the models.

e. Evaluation Results. For Objective 1.2 to be considered achieved, the results of combining the difference between the 1997 Development Level Run and the Historical Run with the addition of surface water accretions and other uses not covered by the models must be greater than or equal to zero.

(simulated streamflow/baseflow from the Historical Run) - (simulated streamflow/baseflow from the 1997 Development Level Run) + (other Surface Water Accretions) = Net Depletions

(***Note: In equation above, streamflow/baseflow is positive)

iii. An additional groundwater model run will be conducted to measure total depletions. This will be the Pre-Development Run. The Pre-Development Run will simulate no groundwater development. The run will be conducted using climate data through the current date and will include a 50-year projection using the historical Run's agreed to climate pattern.

a. Total Depletions Evaluation.

(simulated streamflow/baseflow from the Historical Run) – (simulated streamflow/baseflow from the Pre-Development Run) = Total Depletions

(***Note: In equation above, streamflow/baseflow is positive)

iv. If integrated models are used to assess impacts to the total streamflow, the methods to be used will be developed jointly between NeDNR and the NRDs to properly design and constrain those analyses so that the results can be used to assess progress toward the goals and objectives of the Plan.

For Conjunctive Management Projects, or other management actions taken to meet the objectives and goals of the Plan, the conceptual basis for the analysis will be to compare the new water balance effect of the management action to the 1997 level of development water balance effect of the management action.

Activities such as conjunctive management projects, land use changes, retirement of irrigated acres, etc. can be represented in the modeling tools and compared to the 1997 level of development model results to evaluate the effects on water supply in the Basin in relation to the 1997 level of development and the effectiveness of those activities at offsetting post-1997 levels of depletions.

In other cases it may be necessary to compare the management activities to the historical run to assess their impacts, or to other model runs that may not be the same as the historical run or 1997 development level run described above. This will need to be assessed on a case-by-case basis to determine the best approach to appropriately evaluate the impacts and effectiveness.

Action Item 1.4.3: Continue to refine the methodology used to determine the difference between the current and fully appropriated levels of development in each NRD.

The evaluation of the difference between current and fully appropriated levels of development is tied to Nebraska Statute and the current rules of the NeDNR for declaring a basin fully appropriated. Statute requires that this evaluation will:

- take into account cyclical supply, including drought;
- identify the portion of the overall difference that is due to conservation measures;
- identify the portion of the overall difference that is due to water use initiated prior to July 1, 1997; and
- identify the portion of the overall difference that is due to water use initiated or expanded on or after July 1, 1997.

The current NeDNR rules for determining fully appropriated status includes evaluation of the most junior appropriator's access to water, adjustments for lag effect of groundwater depletions and accretions on water supplies, and consideration of instream flows, among other guidance for conducting the analysis. The rules also provide flexibility for NeDNR to "….utilize a standard of interference appropriate for the use, taking into account the purpose for which the appropriation was granted…."[7] for uses which are not defined in the rule. These include storage and hydropower appropriations, which are significant appropriators in the Upper Platte River Basin. NeDNR and the NRDs have and will continue to work with impacted water users on the process for determining the difference between the current and fully appropriated condition of the Basin.

Prior to development of the first increment Plan, as a preliminary step in developing the overall difference between fully and overappropriated conditions, representatives of NeDNR, the Central Nebraska Public Power and Irrigation District (CNPPID), Nebraska Public Power District (NPPD), and CPNRD

[7] Title 457, Chapter 24, Section 001.01B of the Nebraska Administrative Code, dated June 27, 2008.

performed a preliminary estimate of the changes in stream reach gains and surface water demands affected by such reach gain changes in, *Preliminary Estimate of Historical Stream Flow Reductions in the Overappropriated Portion of the Platte River in Nebraska* (see Appendix D).

Action Item 1.4.3.1: Continue to study the effects of conservation measures impacts on the overall difference between current and fully appropriated conditions.

During implementation of the first increment Plan, Phase I and Phase II of a study of the effects of conservation measures on water supplies was completed. Phase I (Appendix E) focused on an overall evaluation of a wide spectrum of conservation measures across the Basin. The results of this study were used to inform and focus the evaluation of Phase II of the study. Phase II (Appendix F) focused on two types of conservation measures: 1) the effects of tillage practices and 2) the effects of irrigation efficiencies on available water supplies. Tillage practices and irrigation efficiencies are driven by producer choices and are considered part of the spectrum of producer practices. Current evaluation of the study results indicates that changes in tillage practices and irrigation efficiency changes over time have impacted available water supplies in varying degrees across the Basin.

Additional studies, building on the results of what was learned in Phases I and II of the conservation measures study, will be conducted during the second increment to further evaluate the effects of conservation measures on the overall difference between current and fully appropriated conditions, including verification of appropriate representation of existing and proposed producer practices in modeling tools.

In the current modeling tools, current levels of consumptive use are established based on the current understanding of on-farm producer practices, crop types, and current water management regulations. Changes from the current level of consumptive water use due to changes in production practices (on-farm practices, crop type, etc.) and current water management regulations will be estimated and compared to the current level of consumptive uses to determine and track offsets.

Action Item 1.4.3.2: As part of understanding the difference between the current level of development and a fully appropriated level of development, an evaluation of the balance of water supplies and demands shall be conducted for each plan increment.

As part of understanding the difference between the current level of development and a fully appropriated level of development, an evaluation of the balance of water supplies and demands shall be conducted for each 10-year plan increment.

An assessment of water supplies and water demands within the Basin has been conducted during implementation of the first increment. This assessment generally followed the NeDNR INSIGHT methodology for determining the quantity of available hydrologically connected water supplies and the demands on those supplies. The analysis looks at supplies over a representative climate period taking into account wet and dry phases of the hydrologic cycle. Consumptive and non-consumptive surface water demands are considered as well as groundwater depletions and groundwater consumptive use. A description of the INSIGHT methodology as applied to the Upper Platte Basin is included in Appendix A. INSIGHT methodologies will continue to be revised as necessary during this plan increment and used to assess total supplies and total demands within the Basin and methodologies refined as necessary.

Action Item 1.4.4: The NRDs and NeDNR will continue to cooperate on the development of the necessary modeling tools or technical analyses that are aimed at providing updated or refined estimates for the robust review.

Throughout this Plan document the terms "agreed upon tools/models/analysis" are used. As this Basin-Wide Plan and the IMPs are joint plans between NeDNR and the NRDs, all tools, models, analyses used to evaluate the progress toward the goals and objectives of this Plan or the related IMPs must be jointly developed and agreed upon by NeDNR and the NRDs. Methods, tools, and data used will be made available to the stakeholders and the public.

Objective 1.5: Use available funds and actively pursue new funding opportunities to cost effectively offset depletions, as well as to develop, maintain and update data and analytical tools needed to implement this Plan.

NeDNR and the NRDs will identify and pursue funding opportunities to support plan implementation. Funding sources may include federal, state, and local partners in addition to NeDNR and NRD contributions. Funding priorities identified in the action items include:

- Reductions in consumptive use
- Enhancement of water supplies
- Maintaining existing and implementing proposed projects to meet goals of this Plan
- Data acquisition and maintenance, and model improvements for plan implementation

Action Item 1.5.1: Cooperate with the federal government to use programs such as the Conservation Reserve Enhancement Program and others that promote reductions in consumptive use and enhance water supplies.

Action Item 1.5.2: Encourage Upper Platte River Basin NRDs, agencies, and water users to participate in these programs.

Action Item 1.5.3: Work to secure necessary funding for existing and proposed projects that will advance the goals of this Plan.

Action Item 1.5.4: Maintain, improve, or acquire data and modeling tools, as agreed by NeDNR and the Upper Platte River Basin NRDs that will be useful for assessing progress and further implementing this Plan.

Objective 1.6: Update and continue implementing IMPs in each Upper Platte River Basin NRD.

This objective provides guidance for each individual Upper Platte River Basin NRD IMP and outlines its relation to this Basin-Wide Plan.

Action Item 1.6.1: Update individual NRD IMPs to be consistent with this Upper Platte River Basin-Wide Plan.

Each of the NRDs currently has an IMP that will be updated for consistency with this Basin-Wide Plan. In addition, each IMP will:

- Identify management options that will help to achieve the goals and objectives of this Plan.
- Management actions should take into account the cyclical nature of water supplies as well as the impact of conservation measures.
- Management options available to be used in the IMPs to address the objectives of the second and any subsequent increments are those found in *Neb. Rev. Stats.* §§ 46- 716 and 46-739. Other options that are not regulatory include, but are not limited to: augmentation and retiming projects; alternative management of canals; new storage reservoirs or underground storage; water banking; incentive programs for retiring irrigated acres or purchasing surface water; alternative management of existing reservoirs; and PRRIP water action plan projects. The Historical Run for the robust review described in Action Item 1.4.2 serves as the basis for evaluating management options and their effectiveness.
- Riparian and riverine vegetation control may be considered as a management option when a change in consumptive use can be scientifically estimated and there is a comprehensive assessment of changes in such vegetation over the development period.
- Ensure that depletions caused by new or expanded uses within each Upper Platte River Basin NRD are offset.
- Describe how progress toward the depletion reduction objective for that Upper Platte River Basin NRD is to be measured. Possible tools to use for such measurements include, but are not limited to the following:
    - tracking reductions in irrigated acres;
    - monitoring reductions in consumptive water uses; and
    - performing new model runs.
- Include actions that will offset depletive impacts of post- July 1, 1997, water uses outside the overappropriated area, to the extent that those new uses deplete streamflow within the overappropriated area.
- Allow for the transfer of certified acres within and across NRD boundaries, subject to NRD approval, while not increasing streamflow depletions to the Platte River.

Action Item 1.6.2: Monitor and amend individual IMPs as needed to keep the IMPs current.

During implementation of the IMPs, NeDNR and the NRDs will monitor IMP actions consistent with the analyses and methods contained in the Basin-Wide Plan and amend the IMP if activities are determined by the parties to not be capable of meeting goals. If NeDNR and an Upper Platte River Basin NRD determine that management actions have not provided the offsets required to meet the goals of the Plan, they will agree to increase offset activities to the extent possible and revise the individual NRD IMP, if necessary. These revisions may include additional controls, if needed, to meet goals of the Plan.

Action Item 1.6.3: As prescribed by *Nebraska Revised Statute* §46-715(5)(d)(iv), a consultative and collaborative process shall identify goals and objectives for subsequent increments, if necessary, of the individual NRD IMPs.

NeDNR and the individual NRDs will engage stakeholders in a consultative and collaborative process in the development of goals and objectives for subsequent increments (beyond the second increment) of the individual IMPs, if necessary. The need for subsequent increments will be determined through the robust review process completed at the end of the second increment and described in Action Item 1.4.2. Should a subsequent increment be necessary, the planning process will be initiated by NeDNR and each NRD developing a public participation plan that outlines the stakeholder engagement process for the NRD's IMP, including identification of participants/parties, definition of roles, decision-making protocols, planning processes, and timelines. This public participation plan serves as a reference guide for participants as well as the general public throughout the planning process. This effort is analogous to the basin-wide collaborative process described in Objective 5.3, but focused on the individual NRD stakeholder collaboration. The public participation plan that was developed for the second increment Plan is included in Appendix G for reference.

Goal 2: Prevent or mitigate human-induced reductions in the flow of a river or stream that would cause non-compliance with an interstate compact or decree or other formal state contract or agreement.

Maintaining compliance with *Neb. Rev. Stat.* §46-713(3), including commitments under compacts, decrees, and other formal agreements is a fundamental goal that must be considered throughout implementation of all goals, objectives, and action items identified in the Plan. This goal applies not only to those activities included in this Plan, but also to activities of the individual NRD IMPs.

Objective 2.1: Prevent human-induced streamflow depletions that would cause non-compliance by Nebraska with the Nebraska New Depletion Plan included within the Platte River Recovery Implementation Program, for as long as the Program exists.

Nebraska's New Depletion Plan (Attachment 5, Section 8 of the Platte River Recovery

Implementation Program (PRRIP) document) describes the actions Nebraska proposes to take to prevent or mitigate for new depletions to current United States Fish and Wildlife Service target flows and state protected flows as described in the Nebraska New Depletion Plan as part of the state's commitment to PRRIP. New depletions are defined as those uses started or expanded on or after July 1, 1997. The current United States Fish and Wildlife Service target flows were developed for the first increment of the PRRIP and considered the social and environmental health of the Platte River. The target flows are included in the PRRIP document and will be reevaluated during the extension of the first increment of PRRIP. Should the target flows change based on the reevaluation, the Nebraska New Depletion Plan will be updated accordingly.

This objective specifies that activities within the Basin during plan implementation must maintain compliance with the Nebraska New Depletion Plan, that is, depletions to United States Fish and Wildlife Service target flows and state protected flows, as described in the Nebraska New Depletion Plan, must be prevented or mitigated. In doing so, this objective addresses the requirements of *Neb. Rev. Stat.* §46-715(2) to maintain the social and environmental health of the Basin.

This objective recognizes that naturally occurring variations in the Basin's hydrologic cycle affects Basin water supplies; therefore, the focus of this objective is explicitly on impacts of human-induced depletions to water supplies.

Action Item 2.1.1: Ensure that the groundwater and surface water controls adopted in the individual NRD IMPs are sufficient to ensure that the State will remain in compliance with the Nebraska New Depletion Plan.

This action item specifies that during consideration and development of the controls for inclusion in the individual NRD IMPs, NeDNR or the NRDs will evaluate the net effects of the IMP controls to ensure they are adequate to prevent or mitigate depletions to as identified in the Nebraska New Depletion Plan.

Action Item 2.1.2: Collectively, as defined in the Nebraska New Depletion Plan, offset the new depletions caused by new uses within the Upper Platte River Basin NRDs.

In this context, the term offset is an action that either reduces water use or increases the water supply in an amount corresponding to the estimated volume of authorized new depletions. Depletive effects of new uses, as defined in the Nebraska New Depletion Plan, continue to accrue and must be offset to maintain compliance with the Nebraska New Depletion Plan. Statutory guidance regarding new depletions is provided in *Neb. Rev. Stat.* §46-715(3). Procedures for offsetting depletive effects of new uses are now and will continue to be identified and described in the individual NRD IMPs.

Action Item 2.1.3: Prepare reports to the Governance Committee of the Platte River Recovery Implementation Program on status and activities related to the Nebraska New Depletion Plan.

This action item is closely related to and coordinated with Objective 1.4 where technical analysis and reporting efforts for activities within the Basin are outlined. As outlined in Action Item 1.4.1, the annual reporting and data exchange efforts of NeDNR and NRDs will include portions of the Basin covered by PRRIP and will be used in preparing annual and other periodic reports to the Governance Committee as identified in the Nebraska New Depletion Plan.

Goal 3: Partner with municipalities and industries to maximize conservation and water use efficiency.

Municipal and industrial groundwater users are an important group of water users in the Basin. The availability of water to these users directly affects the social and environmental health, safety, and welfare of the Basin. Existing users must be protected while ensuring compliance with state laws and the Nebraska New Depletion Plan. *Nebraska Revised Statute* §46-715 (3) provides guidance and procedures that enable new development to occur with appropriate offsets, facilitating future growth while protecting existing uses.

Conservation and efficiency are needed for local populations to sustain water supplies and provide opportunity to grow and attract new industries. This objective is not intended to dictate development of conservation plans, but rather foster an understanding of current water usage and identify potential conservation measures that would benefit overall water supplies. The first step is to understand how water is being used by municipalities and industries and to understand the challenges they face.

Objective 3.1: Continue to collect data on water use and existing conservation plans of municipalities and industries within the Basin.

Action Item 3.1.1: To advance understanding of water usage by municipalities and industries, gather information on total pumping, consumptive use, and timing of any return flows and collect data on water use efficiency and conservation methods being employed.

Action Item 3.1.2: Uniformly assess consumptive use, impacts on streamflows, and requirements and responsibilities for offsets due to current and expanded municipal and industrial uses, using agreed upon modeling tools. Consistent methods for tracking municipal and industrial consumptive use will be specified in individual NRD IMPs.

Action Item 3.1.3: If any municipalities have formal conservation plans in place, review these for strategies that can be applied to other municipalities in the Basin.

Objective 3.2: Invite municipalities and industries to the annual meetings.

Action Item 3.2.1: To improve communication among all entities in the Basin regarding water uses and facilitate the sharing of data, all municipalities and industrial users in the Basin will be invited to the annual basin-wide meetings.

Action Item 3.2.2: Solicit feedback from municipalities and industries on impacts of water regulations, restrictions, and conservation on their development, ability to attract new industries and accommodate economic growth.

Action Item 3.2.3: Communicate to municipalities and industries the changes that will occur when relevant statutes change in 2026, making sure expectations and requirements are clear, and work with them to develop strategies.

Action Item 3.2.4: Keep open conversations going about what is being done and what can be done to conserve water and what impacts conservation has on streamflows.

Objective 3.3: Establish baseline water use levels for each municipal and industrial user by January 1, 2026.

Through the course of the first increment, NeDNR and the NRDs have developed a 1997 baseline for municipal and industrial uses that will continue to be used to determine whether or not there are increases or reductions in consumptive use relative to the 1997 baseline. This is separate from the baselines that may be used by each NRD to establish a municipal or industrial allocation under *Neb. Rev. Stat.* §46-740. Nothing in Objective 3.3 or its associated action items changes the obligation of the NRD and NeDNR to provide offsets for post-1997 increases in consumptive use. However, subsequent to January 1, 2026, baseline allocations may be set for each municipal or industrial user in accordance with *Neb. Rev. Stat.* §46-740. Should such allocations be established and the municipal or industrial user exceed those allocations, the NRD may require the municipal or industrial user to provide offsets for the expanded use.

Action Item 3.3.1: Use data collected from the municipalities and industries to track increases or decreases in consumptive use relative to the 1997 baseline.

Action Item 3.3.2: For purposes of *Neb. Rev. Stat.* §46-740, establish baselines that may be used to develop allocations, incorporating feedback and input received from the municipal and industrial users. In accordance with statute, the base amount of the allocation for a municipality shall be determined as the greater of either a) the amount of water authorized by a permit, or b) their greatest annual use of governmental, commercial, and industrial use prior to January 1, 2026, plus a per capita allowance. The base amount of the allocation for an industrial or commercial user is the greater of either a) the amount authorized by a permit, or b) the amount of water necessary to achieve the industrial or commercial use as long as the consumptive use is less than 25 million gallons annually. Further details and exceptions to developing baselines and setting allocations can be found in state statutes.

Action Item 3.3.3: In accordance with *Neb. Rev. Stat.* §46-740, the NRDs will continue to offset any new depletions that occur as a result of municipal and industrial consumptive use exceeding 1997 levels up to any allocation that may be established for municipal or industrial users, with the exception of new or expanded municipal and industrial uses greater than 25 million gallons per year. Any reductions in consumptive use by municipalities or industrial users that result in accretions to streamflow may be used to offset depletions from other water uses in that NRD or by the municipal or industrial user, subject to the rules established by each NRD.

Action Item 3.3.4: For purposes of *Neb. Rev. Stat.* §46-740, on and after January 1, 2026, after municipal and industrial baseline allocations have been established, the requirement to offset any new uses beyond the baseline allocation that cause depletions to streamflow may be addressed by municipal and industrial users. The specific requirements for municipal and industrial users will be established in the individual NRD IMPs and NeDNR rules and regulations.

Goal 4: Work cooperatively to identify and investigate disputes between groundwater users and surface water appropriators and, if determined appropriate, implement management solutions to address such issues.

There is a hydrologic connection of surface water and groundwater resources and the potential exists for uses to affect one another. NeDNR and the NRDs will work cooperatively with Basin water users to identify potential conflicts, evaluate those conflicts, and if appropriate, implement solutions to address conflicts.

Objective 4.1: Identify disputes between groundwater users and surface water appropriators.

The purpose of this objective is to identify potential conflicts between surface water and groundwater users, with Action Items 4.1.1 and 4.1.2 outlining the processes for identifying potential conflicts.

Action Item 4.1.1: Surface water appropriators or groundwater users may present data and other supporting information identifying the nature and scope of potential disputes at the annual meeting.

Any surface water or groundwater user in the Basin with a potential conflict may submit data and supporting information to NeDNR and the NRDs for consideration. The submittal should include a concise description of the potential conflict, as well as relevant information for NeDNR and the NRDs to use in their evaluation.

Action Item 4.1.2: The Upper Platte River Basin NRDs and NeDNR may present data and other supporting information identifying the nature and scope of potential disputes at the annual meeting.

This action item provides the opportunity for the NeDNR and the Upper Platte River Basin NRDs to provide information to Basin water users and the public on potential conflicts occurring within the Basin at the annual meeting.

Objective 4.2: Investigate and address issues between groundwater users and surface water appropriators, based on investigation results.

Once potential conflicts have been identified, Action Items 4.2.1 through 4.2.5 outline the approach and roles of NeDNR, the Basin NRDs, and affected users in evaluating and addressing conflicts.

Action Item 4.2.1: NeDNR and the Upper Platte River Basin NRDs shall determine whether specific disputes identified via Goal 5, Objective 1, have a hydrologic impact.

Action Item 4.2.2: NeDNR and the Upper Platte River Basin NRDs will investigate a given dispute to determine whether the issue should be addressed through modification of the Upper Platte River Basin-Wide Plan, individual NRD IMPs, or by other means.

Action Item 4.2.3: If it is determined, as a result of the investigation, that the issue is not a basin-wide issue, the issue will be turned over to the appropriate affected NRD(s) or NeDNR.

Action Item 4.2.4: NeDNR or the affected Upper Platte River Basin NRD(s), as determined in Action Item 4.2.3, working with the affected water user(s), shall develop management solutions, as appropriate, to address the issue(s).

Action Item 4.2.5: NeDNR and the affected Upper Platte River Basin NRD(s) shall update the Upper Platte River Basin-Wide Plan and/or individual IMP, as appropriate.

Goal 5: Keep the Upper Platte River Basin-Wide Plan current and keep stakeholders informed.

Objective 5.1: Meet at least annually to review progress toward achieving the goals and objectives of this Upper Platte River Basin-Wide Plan and those portions of individual NRD IMPs that implement this Plan.

Annual meetings will be held in June or July each year, unless agreed to otherwise, at a location designated by NeDNR and the NRDs. Discussion shall include, but not be limited to the following:

1. revisions to this Plan;
2. revisions to IMPs;
3. new data and information
4. disputes related to implementation of IMPs; and/or
5. any other topic which NeDNR and the Upper Platte Basin NRDs have mutually agreed to discuss.

A proposed agenda will be made available to the public, along with any available supporting documents, at least two weeks prior to the annual meeting. As a result of actions taken at the annual meeting, the Plan may be revised, if necessary.

Stakeholder and/or public feedback concerning the Basin-Wide Plan or individual IMPs will be considered in the following process:

1. Basin-Wide Plan
    a. Any groundwater user, surface water appropriator, NRD, or NeDNR may, at least 30 days before the annual review meeting between the NRDs and NeDNR, send a written request to NeDNR or an Upper Platte Basin NRD for revision to the Basin-Wide Plan.
        i. The affected Upper Platte Basin NRD(s) and NeDNR will review the proposed issues prior to the annual meeting.
        ii. Opportunity for input regarding the proposed issues will be provided to the party making the request during the annual meeting.
        iii. Written requestors will receive a written response, regardless of whether the NRDs and NeDNR agree to consider proposed Plan revisions.
    b. If NeDNR and the Upper Platte River Basin NRDs agree to consider potential revisions to the Plan, then the public will be notified of the potential revisions to the Plan, and input will be solicited at a minimum via a hearing.
        i. An advisory or stakeholder group may be convened, if the affected NRD(s) and NeDNR determine that the proposed changes warrant the formation of such a group.
    c. After receiving public comments, Plan revisions will be considered for adoption.
    d. If the NRD(s) and NeDNR agree on revisions to the Plan, then a hearing will be held to solicit formal comment. Following the public hearing, the proposed changes will be considered and may be adopted.
2. IMPs
    a. If the Basin-Wide Plan is revised, then revisions to the individual Upper Platte Basin IMPs will be made as necessary, in accordance with *Neb. Rev. Stat.* §46-715(4).
    b. If the Upper Platte River Basin NRD(s) and NeDNR agree on revisions to an IMP after the annual meeting, then a hearing will be held to solicit formal comment. The IMPs for each of the five Upper Platte Basin NRDs shall be provided to all

other NRDs in the overappropriated basin for comment before revisions are approved.

c. NeDNR and any Upper Platte Basin NRD may amend an IMP as more data and information become available, as provided in *Neb. Rev. Stat.* §46-715(4)(d)(ii).

Action Item 5.1.1: Regular presentations are anticipated to include an annual forecast of basin water supply and demand once a forecast is developed under action item 1.3.2, and other plan implementation updates.

Objective 5.2: Improve information sharing with interested stakeholders.

Action Item 5.2.1: Maintain a database of interested stakeholders; it is the responsibility of interested parties to keep their contact information current by notifying NeDNR or their respective NRD of changes.

Action Item 5.2.2: Send notice of annual meeting to interested stakeholders, municipalities, and industries.

Action Item 5.2.3: Send electronic notice when new reports pertinent to this Plan have been published to the internet.

Objective 5.3: Conduct planning for subsequent increments of the Plan, as necessary.

Action Item 5.3.1: As prescribed by Statute, a consultative and collaborative process shall identify goals and objectives for subsequent increments, if necessary, of the Basin-Wide Plan.

NeDNR and the NRDs will engage stakeholders in a consultative and collaborative process in the development of goals and objectives for subsequent increments of the Plan, if necessary. The need for subsequent increments will be determined through the robust review process described in Action Item 1.4.2. Should a subsequent increment be necessary, the planning process will be initiated by NeDNR and the NRDs by developing a public participation plan that outlines the stakeholder engagement process, including identification of participants/parties, definition of roles, decision-making protocols, planning processes, and timelines. This public participation plan serves as a reference guide for participants as well as the general public throughout the planning process. The public participation plan developed for the second increment Plan development process is included in Appendix G for reference.

5.0 Monitoring

During implementation of this increment of the Basin-Wide Plan, progress towards identified goals and objectives will be monitored, actions and/or plans revised as necessary, and Basin stakeholders kept informed of activities occurring within the Basin.

Reporting

Objective 5.1 requires the NeDNR and NRDs to meet annually and exchange reports on Plan progress. These reports will contain, but are not limited to, data and information about:

- Water supplies and uses in the Basin
- New or expanded uses within the Basin
- Water management activities in support of the Plan and individual IMPs
- Progress toward goals, objectives, and action items of the Plan

Copies of the 2018 annual reports can be found on the Department website: [add web address]. Reports will be made available to the public following annual meetings.

Annual Meeting

Annual meetings will be held in June or July each year, unless agreed to otherwise, at a location designated by NeDNR and the NRDs. The annual meeting will be open to the public and time allotted on the agenda for public comment. Discussion shall include, but not be limited to the following:

1. revisions to this Plan;
2. revisions to individual NRD IMPs;
3. new data and information,
4. disputes related to implementation of IMPs; and/or
5. any other topic which the NeDNR and the Upper Platte Basin NRDs have mutually agreed to discuss.

A proposed agenda will be made available to the public, along with any available supporting documents, at least two weeks prior to the annual meeting. To improve communication among all entities in the Basin regarding water uses and to facilitate the sharing of data, municipalities and industrial users in the Basin will be invited to the annual basin-wide meetings and feedback solicited on impacts of water regulations, restrictions, and conservation on their development, ability to attract new industries, and accommodate economic growth. As a result of actions taken at the annual meeting, the Plan may be revised, if necessary.

Technical Analyses

Technical analyses to support plan implementation and evaluation of progress are identified in Objective 1.4. Specific analyses identified include:

- An annual review of any permitted new and expanded uses of surface water and groundwater within the Basin and associated mitigations (Action Item 1.4.1)
- An evaluation (robust review) of pre- and post-July 1, 1997 development (Action Item 1.4.2)
- Continued evaluation of current and fully appropriated conditions (Action Item 1.4.3)
- Development of necessary tools and technical analyses to support the robust review (Action Item 1.4.4)

The referenced action items provide additional information related to the data collection, purposes, and analyses to inform status and progress towards identified Plan goals and objectives. During implementation of this Plan, NeDNR and the NRDs may identify and prioritize additional technical analyses in support of monitoring and achieving Plan goals and objectives.

Modifications to the Plan

If NeDNR and the Upper Platte River Basin NRDs agree to consider potential revisions to the Basin-Wide Plan, then the public will be notified of the potential revisions, and input will be solicited, at a minimum, via a hearing. An advisory or stakeholder group may be convened if the affected NRD(s) and NeDNR determine that the proposed changes warrant the formation of such a group. After receiving public comments, Plan revisions will be considered for adoption. If the NRD(s) and NeDNR agree on revisions to the Plan, then a hearing will be held to solicit formal comment. Following the public hearing, the proposed changes will be considered and may be adopted.

6.0 Glossary

<u>28 / 40 Area</u>: The area within the North Platte, South Platte, or Platte River watershed in which groundwater intentionally withdrawn for 40 years will result in a cumulative stream depletion to the North Platte, South Platte, or Platte River or a baseflow tributary greater than or equal to 28 percent of the total groundwater consumed as a result of the withdrawals.

<u>Accretion</u>: Addition to streamflow that results from an offset/mitigation action or project

<u>Acre-Foot (AF)</u>: Volume of water required to cover 1 acre of land (43,560 square feet) to a depth of 1 foot, equivalent to 325,851 gallons.

<u>Appropriation</u>: A permit granted by the NeDNR to use surface water for a beneficial use in a specific amount, purpose and location, and is based on first-in-time, first-in- right

<u>Aquifer</u>: A geological formation or structure of permeable rock or unconsolidated materials that stores and/or transmits water, such as to wells and springs

<u>Augmentation Well</u>: A groundwater well drilled to pump water into a stream to augment streamflows

<u>AWEP</u>: Agricultural Water Enhancement Program

<u>AWREP</u>: Agricultural Water Resources Enhancement Program

<u>BWP</u>: Basin-Wide Plan

<u>CFS / Cubic Feet per Second</u>: The flow rate or discharge equal to one cubic foot of water per second or about 7.5 gallons per second

<u>COHYST</u>: Cooperative Hydrology Study

<u>Conjunctive Management</u>: The coordinated and combined process that utilizes the connection between surface and groundwater to maximize water use, while minimizing impacts to streamflow and groundwater levels in an effort to increase the overall water supply of a region and improve the reliability of that supply.

<u>Consumptive Use</u>: The amount of water that is consumed under efficient practices, which satisfies the beneficial use without waste and does not return to a water resources system

CREP: Conservation Reserve Enhancement Program

Depletion: Reduction to streamflow that results from a new use of either groundwater or surface water

Drought: A deficiency of precipitation over an extended period of time (usually a season or more), resulting in a water shortage. The effects of this deficiency are often called drought impacts.

EQIP: Environmental Quality Incentives Program

Flood Control: Referring to water withdrawn from the surface water source for the purpose of protecting health and well-being of society

Fully Appropriated: From 46-713, subsection (3): A river basin, subbasin, or reach shall be deemed fully appropriated if the NeDNR determines based upon its evaluation conducted pursuant to subsection (1) of this section and information presented at the hearing pursuant to subsection (4) of section 46-714 that then current uses of hydrologically connected surface water and ground water in the river basin, subbasin, or reach cause or will in the reasonably foreseeable future cause (a) the surface water supply to be insufficient to sustain over the long term the beneficial or useful purposes for which existing natural-flow or storage appropriations were granted and the beneficial or useful purposes for which, at the time of approval, any existing instream appropriation was granted, (b) the streamflow to be insufficient to sustain over the long term the beneficial uses from wells constructed in aquifers dependent on recharge from the river or stream involved, or (c) reduction in the flow of a river or stream sufficient to cause noncompliance by Nebraska with an interstate compact or decree, other formal state contract or agreement, or applicable state or federal laws.

GDP / Gallons per Day: Referring to the approved amount of acre-feet of water legally allowed to be pumped from a surface water source, as long as all other conditions are met

Groundwater: Water which occurs in or moves, seeps, filters, or percolates through ground under the surface of the land, and shall include ground water which becomes commingled with waters from surface sources

Instream Use: Water that is appropriated for use within the stream and is not withdrawn from a surface water source

IWMPP: Interrelated Water Management Plan Program

LB 962: Bill passed by Nebraska Legislature in 2004. The amendment establishes a proactive approach to the integrated management of hydrologically connected groundwater and surface water and creates funds to direct money towards data gathering, research, conservation and implementation of integrated management plans in fully and overappropriated basins.

LB 1098: Passed in 2014, altered and created water sustainability funding opportunities

Moratorium: A legally authorized suspension of drilling of groundwater wells or approval of new surface water appropriations

NET: Nebraska Environmental Trust

NNDP: Nebraska New Depletion Plan

NSWCP: Nebraska Soil and Water Conservation Program (alternatively NSWCF - Nebraska Soil and Water Conservation Funds)

OAI: Ogallala Aquifer Initiative

Offset: A reduction in water use that corresponds with an increased use of water. An offset may be used as a management strategy to balance uses and supplies. The offset will have a corresponding amount, time, and location. Also referred to as mitigation.

Overappropriated: From 46-713, subsection (4a): A river basin, subbasin, or reach shall be deemed overappropriated if, on July 16, 2004, the river basin, subbasin, or reach is subject to an interstate cooperative agreement among three or more states and if, prior to such date, the NeDNR has declared a moratorium on the issuance of new surface water appropriations in such river basin, subbasin, or reach and has requested each natural resources district with jurisdiction in the affected area in such river basin, subbasin, or reach either (i) to close or to continue in effect a previously adopted closure of all or part of such river basin, subbasin, or reach to the issuance of additional water well permits in accordance with subdivision (1)(k) of section 46 -656.25 as such section existed prior to July 16, 2004, or (ii) to temporarily suspend or to continue in effect a temporary suspension, previously adopted pursuant to section 46-656.28 as such section existed prior to July 16, 2004, on the drilling of new water wells in all or part of such river basin, subbasin, or reach.

PBC: Platte Basin Coalition

PBHEP: Platte Basin Habitat Enhancement Program

PRRIP: Platte River Recovery Implementation Program

PRRIP Critical Habitat Reach: The reach of the Platte River from Lexington, NE, to Chapman, NE, which is of critical importance to the endangered target species

Recharge: A hydrologic process where water moves downward from surface water to groundwater, both naturally through the hydrologic cycle or through intentional practices

Replacement Well: A groundwater well drilled to replace an existing groundwater well which has become unusable. The replaced well must be decommissioned. No increase in irrigated acres is associated with a replacement well unless a variance is granted.

RCPP: Regional Conservation Partnership Program

Streamflow: The discharge that occurs in a natural channel of a surface stream course

Supplemental Well: A groundwater well drilled to either supplement an existing groundwater well or to augment surface water irrigation when surface water is not available. No increase in irrigated acres is associated with a supplemental well unless a variance is granted.

Surface Water: Water which occurs or moves on the surface of the planet such as in a stream, river, lake, wetland, or ocean

Telemetry: A process by which measurements and other data are collected at remote or inaccessible points and transmitted to receiving equipment for monitoring

Temporary RechargeA temporary (for one year) surface water permit issued for the purpose of diverting excess streamflow (unappropriated water) to recharge groundwater, intended to supply baseflow accretions back to the river

Transfer: To allow for the historic consumptive use of water to be changed, in location and/or purpose without causing an increase in depletions to the river or an impact to existing surface water or groundwater uses

USDA – NRCS: U.S. Department of Agriculture - Natural Resources Conservation Service

Use: The legally accepted use of the well or water appropriation

Variance: To allow an exception to the stay on new irrigated acres and new consumptive uses while providing adequate mitigations or transfers to assure that there is no net increase in depletions to the river or impacts to existing surface water or groundwater uses; any request that is contrary to existing rules or regulations will require a variance

WWUMM: Western Water Use Management Model

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Appendix A

UPPER PLATTE RIVER BASIN INSIGHT ANALYSIS

2019

Upper Platte Basin INSIGHT ANALYSIS

Table of Contents

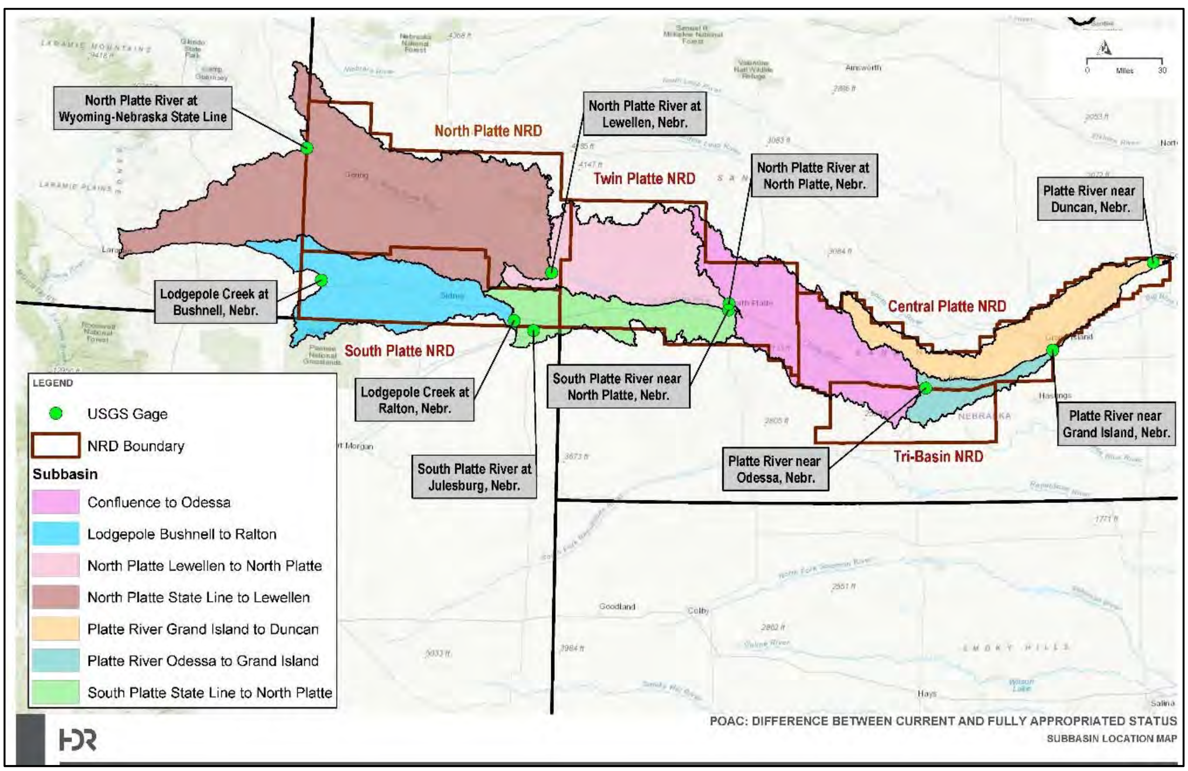
1.0 Introduction and Background

This report documents the application of the NeDNR INSIGHT methodology, with appropriate modifications described herein, to the Upper Platte River Basin. This effort was performed by HDR on behalf of the Platte Basin Coalition (PBC). The PBC was formed through an Interlocal Cooperation Agreement among the Nebraska Department of Natural Resources (NeDNR) and the following five Natural Resources Districts (NRDs) that encompass the Upper Platte River Basin:

- North Platte Natural Resources District (NPNRD)
- South Platte Natural Resources District (SPNRD)
- Tri-Basin Natural Resources District (TBNRD)
- Twin Platte Natural Resources District (TPNRD)
- Central Platte Natural Resources District (CPNRD)

The Upper Platte River Basin includes the North Platte River, South Platte River, and Platte River from the confluence to Duncan, as shown in Figure 1. It is noted that the Lodgepole Creek basin illustrated in Figure 1 was not explicitly included in this analysis as an individual subbasin. Lodgepole Creek flows through the southwest corner of the Nebraska Panhandle into Colorado, before joining the South Platte River upstream of the Julesburg, CO gage on the South Platte River. Supplies and demands of the Lodgepole Creek basin are included in the analysis of the South Platte River subbasin.

Figure 1: Subbasins in the Upper Platte River Basin Overlaid by NRD Boundaries



The HDR Team applied the NeDNR INSIGHT methodologies, with modifications as noted herein, to the Upper Platte River Basin to assist in evaluating the overall difference between the current and fully appropriated levels of development within the overappropriated portion of the Platte River Basin. The Act (*Neb. Rev. Stat.* § 46-713 (3)), defines that the overall difference between the current and fully appropriated levels of development to mean the extent to which existing uses of hydrologically connected surface water and ground water and conservation activities result in the water supply available for purposes identified in subsection (3) of section *Neb. Rev. Stat.* § 46-713 to be less than the water supply available if the river basin, subbasin, or reach had been determined to be fully appropriated in accordance with section *Neb. Rev. Stat.* § 46-714. This, in essence, suggests the overall difference between current and fully appropriated levels of development is determined through the rules and methods used by NeDNR to designate basins as fully appropriated.

The rules and methods used by NeDNR to designate a basin as fully appropriated in accordance with *Neb. Rev. Stat.* § 46-714 primarily rely on the evaluation of junior natural-flow surface water irrigation appropriations (see N.A.C. Title 457, Chapter 24 and Annual Evaluation of Availability of Hydrologically Connected Water Supplies, December 30, 2016). The rules further establish that in the event other natural-flow and storage appropriations need to be considered, NeDNR has the ability to utilize a standard of interference appropriate for the use in conducting its evaluation. Through the course of attempting to apply the rules and methods to the complexities of the Upper Platte River Basin, NeDNR and NRDs have agreed that further standards are necessary and have applied different methods (see INSIGHT, Preliminary Estimate of Historical Stream Flow Reductions in the Overappropriated Portion of the Platte River in Nebraska, 2009) to support the assessments. These alternative methods remain flexible to NeDNR and the NRDs and may be refined in subsequent evaluations.

The technical evaluations described in this report, in conjunction with other supporting data, are ultimately used to establish appropriate IMP goals and objectives. The IMPs must contain clear goals and objectives with a purpose of sustaining a balance between ***water uses*** and ***water supplies*** so that the economic viability, social and environmental health, safety, and welfare of the river basin, subbasin, or reach can be achieved and maintained for both the near term and the long term (*Neb. Rev. Stat.* § 46-715 (2)). Understanding that water uses cannot exceed water supplies (natural-flow and storage supplies), a balance will likely exist each year in the overappropriated basin. However, ***water demand*** can exceed water use when supplies are limited. Even if all water users have access to and are able to use water supplies, their total demand may not be met. It is important to review the distribution of the balance of water supply and water use among various water users to see which users might not be meeting their full demand. The distribution of water use among the different user groups in the basin and the degree to which the use meets the demand is what influences the economic viability, social and environmental health, safety, and welfare of the river basin. Therefore, establishing appropriate goals and objectives in the IMP requires careful consideration of this distribution, as well as the total water use and supply, in order to ensure that the balance recognizes the overall welfare of the basin.

The application of the NeDNR INSIGHT methodology to the Upper Platte River basin then provides information on water supplies, as well as the distribution of water use among the different user groups and the degree to which the use meets the demand.

2.0 INSIGHT - (Integrated Network of Scientific Information and GeoHydrologic Tools)

INSIGHT (Integrated Network of Scientific Information and GeoHydrologic Tools) is a web-based, interactive tool[1] developed by NeDNR in support of required and voluntary integrated water management planning efforts pursuant to Neb. Rev. Stat. § 46-715. INSIGHT consolidates data from several sources, including NeDNR, the United States Geological Survey (USGS), the United States Bureau of Reclamation (USBR), and local NRDs. The NeDNR uses that hydrologic data to conduct an analysis of the following items at the basin- and subbasin-level: 1) streamflow water supplies available for use, 2) the current amount of demand on these supplies, 3) the long-term demand on these water supplies due to current uses, 4) the projected long-term demand on these water supplies due to five percent growth in total use[2], and 5) the balance between these water supplies and demands. . The INSIGHT website displays the results of this analysis in various charts and graphs.

The NeDNR INSIGHT methodology examines a statistically unbiased period of record (see Section 2.1.6). The analysis evaluates basins and subbasins on both a seasonal and annual time-frame. The two sub-periods within the year are the "Peak Season" (June 1 through August 31) and the "Non-peak Season" (September 1 through May 31). If a basin's near-term demand and/or the long-term demand of hydrologically connected groundwater and surface water exceeds the basin water supplies (BWS) during either of the two sub-periods when summed over the time period utilized in the evaluation, then supplies may not be sufficient to sustain the demands over the long term.". The geographic area within which the NeDNR considers surface water and groundwater to be hydrologically connected for the purpose prescribed in *Neb. Rev. Stat.* §46-713(3) is the area within which pumping of a well for 50 years will deplete the river or a base flow tributary thereof by at least ten (10) percent of the amount pumped in that time. This area is also referred to as the 10/50 area or the hydrologically connected area.[3]

The components that make up the BWS, near-term demand and long-term demand are described in greater detail in the following sections.

2.1 Intrinsic Supply

The BWS is made up of four components: 1) streamflow reach-gain/ loss; 2) surface water consumptive use; 3) streamflow depletions from groundwater pumping (also referred to as groundwater depletions; and 4) required inflow (or the amount of water that is necessary to flow out of basins or subbasins upstream to a given location). Required inflow does not represent water that is required by law or permit, but rather the typical amount of water a basin or subbasin relies upon from upstream under the NeDNR INSIGHT methodology.

The intrinsic supply is the same as the BWS but does not include the required inflow term. It is necessary to calculate the intrinsic supply of the subbasins before the BWS can be computed because

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1 The INSIGHT interactive tool is available at https://nednr.nebraska.gov/INSIGHT/.

2 The projected growth in long-term demand was not applied in the Upper Platte River basin analysis as new uses are regulated

3 The Department determined hydrologically connected areas using the 10/50 area as established under Regulation 457 NAC 24.001.02. The analytical approach for determining the 10/50 area is described further in the INIGHT documentation.

the ratio of intrinsic supplies is used to proportion the supplies (the required inflow term) and demands (downstream demand term). Section 2.2.5 explains this proportioning in greater detail. Because of this, the required inflow term will be discussed separately in Section 2.6.6. The remainder of this section will focus on the components of the intrinsic supply.

2.1.1 Streamflow

The streamflow volumes represent the amount of water that originates within that particular subbasin or reach. If an upstream subbasin is present, only the streamflow reach-gain/loss is considered. USGS streamflow records and NeDNR streamflow records were used to determine the streamflow reach-gain/loss discussed. Table 1 lists the gage locations and the associated period-of-record used in this analysis.

Table 1: Stream Gage Locations

Gage	Gage Number	Period-of-Record Utilized
South Platte River at Julesburg, Co.	06764000	1988-10-01 to 2012-09-30 (USGS)
South Platte River at North Platte, Nebr.	06765500	1988-10-01 to 1994-09-30 (USGS); 1994-10-1 to 2012-9-30 (NeDNR)
Western Canal from South Platte River	147000	1988-10-01 to 2012-09-30 (NeDNR)
South Platte Supply Canal (Korty) from South Platte River	06764900	1988-10-01 to 2012-10-01 (NeDNR)
South Platte River at Paxton, Nebr.	06765000	1988-10-01 to 1970-04-30
North Platte River at Lewellen, Nebr.	06687500	1988-10-01 to 1991-09-30 (USGS); 1991-10-1 to 2012-9-30 (NeDNR)
North Platte River at North Platte, Nebr.	06693000	1988-10-01 to 1994-09-30 (USGS); 1994-10-1 to 2012-9-30 (NeDNR)
North Platte River at Keystone, Nebr.	06690500	1988-10-1 to 1994-09-30 (USGS); 1994-09-30 to 2012-9-30 (NeDNR)
Sutherland Power Return at South Platte River	140000	1988-10-1 to 2012-9-30 (NeDNR)
Tri-county Diversion	142000	1988-10-1 to 2012-9-30 (NeDNR)
Platte River near Odessa, Nebr.	06770000	1988-10-01 to 1991-09-30 (USGS); 1991-10-1 to 2012-9-30 (NeDNR)
Platte River near Grand Island, Nebr.	06770500	1988-10-01 to 2012-09-30 (USGS)
Platte River near Duncan, Nebr.	06774000	1988-10-01 to 2012-09-30 (USGS)

Additionally, to recognize that extreme flow events produce water that often cannot be utilized or stored in reservoir systems, the NeDNR INSIGHT methodology reduces the daily streamflow or reach-gain/loss values with an exceedance probability[4] of 5 percent or less to the value corresponding to the 5 percent exceedance probability, as shown in Figure 2.[5] It should be noted that no cap was applied to those stream gages upstream of Lake McConaughy as it was assumed that extreme flow events could be

4 The exceedance probability is the probability of occurrence for each flow level. Higher flows are exceeded less frequently and therefore have a lower exceedance probability

5 This analysis uses 5% to remain consistent with how NeDNR currently adjusts streamflow in INSIGHT. Specific values for each subbasin or basin may be incorporated into future evaluations. The streamflow gages upstream of Lake McConaughy were not capped as Lake McConaughy is large enough to capture extreme flow events.

captured in this reservoir. Table 2 below lists the daily caps for each gage location where these caps were applied.

Figure 2: Example of an Exceedance Plot and the Result from Capping Streamflows at 5 percent Exceedance Flow Probability (Source: "INSIGHT Methods" 2015)

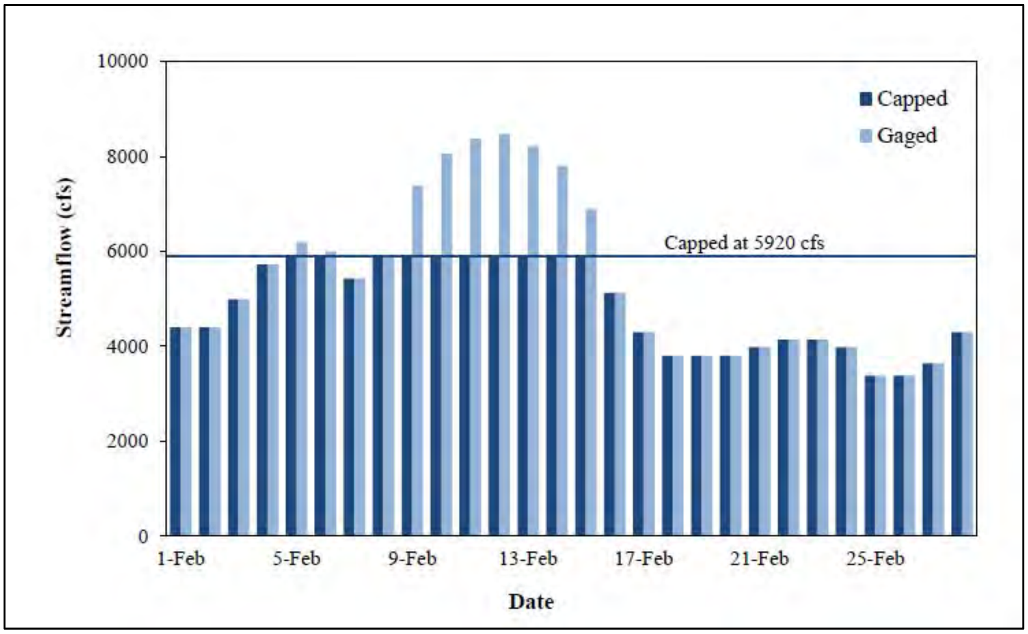

Table 2: Daily Streamflow Cap by Gage Location

Basin	Streamflow Cap, AF
North Platte River at Lewellen	N/A[1]
North Platte River at North Platte	4,198
South Platte River at South Platte	2,772
North Platte River at Keystone	4,673
Platte River at Confluence	9,583
Platte River at Odessa	9,207
Platte River at Grand Island	9,662
Platte River at Duncan	11,365

[1] The gages above Lake McConaughy were not capped. Unlike the extreme events below Lake McConaughy, the extreme events above Lake McConaughy could be captured and stored in the reservoir.

The confluence of the North and South Platte Rivers is not gaged and was estimated as follows:

Estimated Flow at Platte River Confluence = North Platte River at North Platte gage + South Platte River at North Platte gage + Sutherland Return

The South Platte River at Paxton gage was closed in 1970. The South Platte River at Paxton gage is necessary to determine the undepleted streamflow[6] in order to limit the Sutherland hydropower demand.[7] Thus, it was necessary to calculate a synthetic South Platte River at Paxton gage as follows[8]:

South Platte River at Paxton = South Platte at Roscoe gage + Streamflow Reach-gain/Loss (Roscoe to North Platte)

In order to remove the affect the Lake McConaughy operations has on the North Platte River, Lewellen to North Platte subbasin, the streamflow reach-gain/loss for the North Platte River, Lewellen to North Platte was estimated as follows:

Estimated Streamflow Reach-Gain/Loss North Platte Subbasin = North Platte River at North Platte gage – North Platte River at Keystone + 40 cfs

The streamflow reach- gain/loss term for the South Platte River, Julesburg to North Platte was calculated as follows:

Estimated Streamflow Reach-Gain/Loss South Platte Subbasin = South Platte River at North Platte gage + Korty Diversion

The streamflow reach-gain/loss term for the Platte River, Confluence to Odessa was calculated as follows:

Estimated Streamflow Reach-Gain/Loss Odessa Subbasin = Estimated Flow Platte River at Confluence + Kearney Diversion

2.1.2 Groundwater and Surface Water Models

2.1.3.1 Western Water Use Model (WWUM)

The WWUM covers the central and southern panhandle in Western Nebraska and extends east to include Lake McConaughy and a small portion of the South Platte River. The model is an integrated tool consisting of a surface water operations model, groundwater flow model, and soil-water balance model.

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6 Undepleted streamflow is a term coined by NeDNR to describe the cap used in the NeDNR INSIGHT methodology when capping a hydropower or instream flow demand. This is calculated as the gaged streamflow plus the groundwater depletions for that subbasin.

7 See sections 2.3.3.1 and 2.3.3.2 for further description of the undepleted streamflow and hydropower demand.

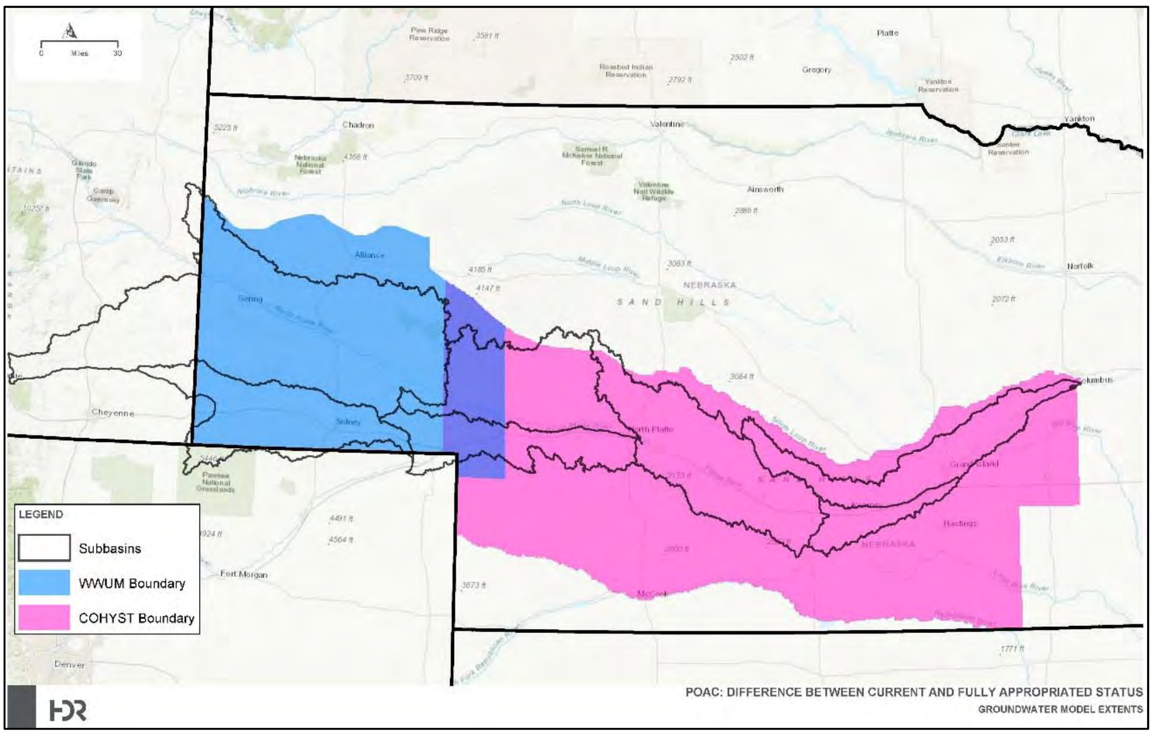
8 RGL obtained from ftp://dnrftp.dnr.ne.gov/Pub/cohystftp/2010Report/Section12_Linked%20Doc%20List/Linked_Documents/1984-2008_Reach_Gain_Loss.xlsx.

Groundwater depletion, groundwater consumptive use, surface water consumptive use, and seepage data from WWUM were used in this analysis.[9]

2.1.3.2 Cooperative Hydrology Study (COHYST)

The COHYST 2010 model covers the Platte River Basin from Lake McConaughy downstream to Chapman, Nebraska and takes into account surface water as well as groundwater. COHYST 2010 consists of three integrated modeling tools –watershed model for land, surface water model for the river (STELLA), and groundwater model for the aquifer. Groundwater depletion, groundwater consumptive use, surface water demand, and seepage data from COHYST were used in this analysis.[10]

Figure 3: Groundwater Model Extents



2.1.3 Surface Water Consumptive Use (SWCU)

Surface water consumptive use is defined as water that is used directly from the stream (or other surface water body) to make full beneficial use of an existing irrigation, municipal, or industrial use, accounting for limitations on the supply available. Surface water consumptive use is transpired, evaporated, or otherwise consumed and does not return to the stream.

The NeDNR INSIGHT methodology separates the surface water consumptive use (SWCU) into four main use categories: 1) irrigation; 2) municipal; 3) industrial; and 4) evaporation from large water bodies. In

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[9] Visit https://dnr.nebraska.gov/Western-Water-Use-Conjunctive-Use-Model for more information on the Western Water Use Model.

[10] Visit https://dnr.nebraska.gov/COHYST-Conjunctive-Use-Model for more information on the COHYST Model.

the WWUM and COHYST model areas, there are currently no municipal and industrial users that rely on direct surface water sources. Therefore, under the NeDNR INSIGHT methodology, irrigation and evaporation are the only surface water consumptive uses evaluated for this analysis. SWCU irrigation demand estimates were obtained from the WWUM and COHYST models and the reservoir evaporation was calculated separately. See Section 2.1.5 for further discussion of reservoir evaporation. The remainder of this section will focus only on the SWCU for irrigation.

SWCU estimates were readily available from the models described in Section 2.1.2. The WWUM SWCU estimates were used for the North Platte River above Lewellen. SWCU associated with the WWUM were provided by Adaptive Resources, Inc. (ARI) with the efficiency factor already incorporated; therefore, no further adjustment to reported results was necessary. Rather than using a constant efficiency factor, the WWUM varies the efficiency factor through time based on evolution of irrigation practices and seasonally based on flow-dependent system losses.[11]

The COHYST full surface water demand estimates were used for the North Platte River below Lewellen, the South Platte River subbasin, and the Platte River from the confluence to Duncan. Because COHYST reports the full surface water demand, these data were multiplied by a 0.65 (accounting for efficiency) to convert the full surface water demand to SWCU.[12] For purposes of this analysis (consistent with INSIGHT), the SWCU demands are assigned at their associated points of diversion. Table 3 indicates those surface water canals in the COHYST model area with surface water rights associated with this analysis. These canals are also illustrated in Figure 4.

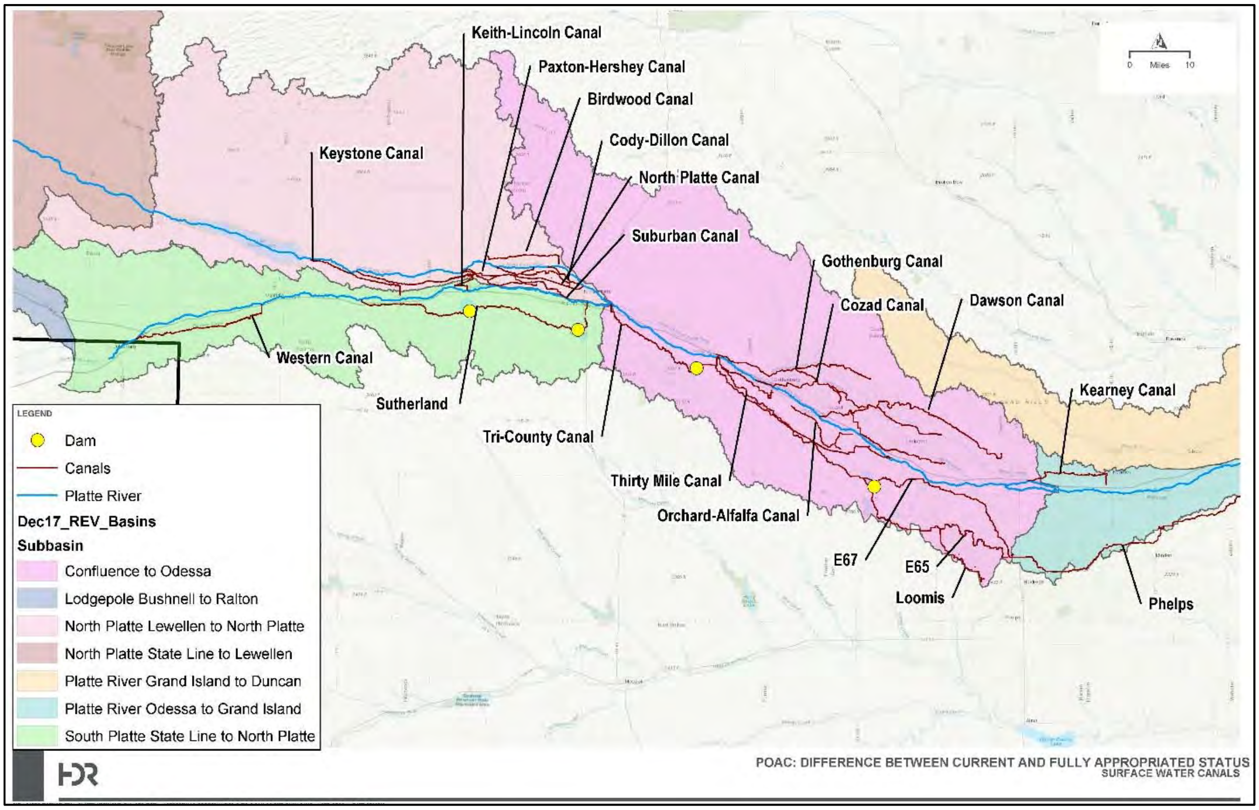
Table 3: STELLA Surface Water Canals that Serve Water Rights

Canal	Basin Demand Assigned To:
Western	South Platte River; State Line to North Platte
Keith-Lincoln	North Platte River; Lewellen to North Platte
North Platte	
Paxton-Hershey	
Suburban	
Cody-Dillon	
Tri-County/E65/E67/Phelps	Platte River; Confluence to Odessa
Gothenburg	
30 Mile	
6 Mile	
Cozad	
Orchard-Alfalfa	
Dawson	
Kearney	

11 Western Water Use Management Model Historical Crop Consumptive Use Analysis, Final Report, July 2014 by Wilson Water Group

12 Of the water applied, 65% is consumed via evaporation and transpiration by plants (Trenberth et al. 2007. Estimates of the Global Water Budget and Its Annual Cycle Using Observational and Model Data. Journal of Hydrometeorology 8:758-769). The remaining net diversion (100% - 65% = 35%) is assumed to have recharged to groundwater or field runoff.

Figure 4: STELLA Surface Water Canals



STELLA, the surface water operations model for the COHYST area, incorporates crop demands from CropSIM. The approach for incorporating irrigation demands for lands served by surface water canals is documented in *Section 6.6 Operational Rules* of the COHYST documentation[13]. In general, the annual irrigation demand is distributed to constant values for four distinct periods (June 16-30, July, August, and Sept 1-10) as shown in Table 4.

Table 4: Distribution of CropSIM Irrigation Demand in STELLA

Month	Percentage
June 16-30	7.4%
July	50.0%
August	35.9%
Sept 1-10	6.7%

[13] http://cohyst.nebraska.gov/

2.1.4 Groundwater Depletion (GWDP)

The depletions analysis consists of a comparison of two model runs: 1) one that represents historical pumping; and 2) another that represents the basin without pumping. The difference between these two model runs indicates the depletions to streamflow from groundwater pumping. The NeDNR INSIGHT methodology considers depletions from irrigation, municipal, and industrial groundwater withdrawals. Groundwater depletions (GWDP) are used as a component of BWS as well as to represent near-term demand of groundwater uses (see Section 2.4 for discussion on the near-term demand).

The above mentioned groundwater models as well as analytical results were used to estimate the groundwater depletions as part of this analysis. The COHYST depletion estimates were used for the South Platte River Julesburg to North Platte, North Platte Lewellen to North Platte, and Platte River confluence to Duncan reaches. The depletions estimates from the WWUM were provided by ARI for the North Platte River (Wyoming state line to the eastern boundary of the NPNRD), South Platte River (SPNRD along the South Platte River), Lodgepole Creek (Wyoming state line to Colorado state line), and Lake McConaughy (including North Platte River, Lake McConaughy, and tributaries).

2.1.5 Reservoir Evaporation (Res Evap)

The NeDNR INSIGHT methodology considers evaporation for reservoirs with a capacity greater than 32,000 acre-feet as a surface water consumptive use. The reservoirs included in this analysis were Sutherland Reservoir, Lake Maloney, Elwood Reservoir, Lake McConaughy, and the Inland Lakes.

Surface area and net evaporation for these reservoirs were calculated as part of the COHYST modeling. The surface areas for the reservoirs were calculated as a function of storage volumes using the equations shown in Tables 5 and 6.

Table 5: Lake McConaughy Surface Area Equations for STELLA Modeling

Volume Bounds	Surface Area Equation Y = area (acres) X = storage (AF)
80 AF to 53,900 AF	y = 0.085x + 526.27
53,900 AF to 104,900 AF	y = 0.047x + 2094.98
104,900 AF to 205,900 AF	y = 0.028x + 4168.00
205,900 AF to 310,100 AF	y = 0.021x + 5373.07
310,100 AF to 412,400 AF	y = 0.020x + 5680.17
412,400 AF to 501,100 AF	y = 0.017x + 6965.21
501,100 AF to 704,100 AF	y = 0.014x + 8764.34
704,100 AF to 1,273,900 AF	y = 0.011x + 10221.33
1,273,900 AF to 1,773,800 AF	y = 0.012x + 10225.93
1,773,800 AF to 2,315,500 AF	y = 0.010x + 12939.88

Table 6: Other Reservoir Surface Area Equations for STELLA Modeling

Reservoir	Surface Area Equation Y = area (acres) X = storage (AF)
Sutherland Reservoir	$y = -0.00000031x^2 + 0.054x + 1127.47$
Lake Maloney	$y= -0.00000197x^2 + 0.103x + 411.54$
Elwood Reservoir	$y = -0.00000023x^2 + 0.035x + 162.10$

These evaporative losses are estimated by accessing information on pan evaporation, surface area, and precipitation. The equation for calculation Reservoir Evaporation[14] is:

Reservoir Evaporation = [(Pan evaporation*0.7*surface area) – (precipitation*surface area)]

Following this formula, the net evaporation equations used in the STELLA Modeling are calculated using the formulas shown in Table 7.

Table 7: Reservoir Net Evaporation Equations for STELLA Modeling[15]

Reservoir	Surface Area Equation (acre-ft/day (AFD))
Lake McConaughy	((Kingsley_Dam_Pan_Evap_in/12) x 0.7 x LakeMac_Surface_Area_AC)-((Kingsley_Dam_Precip_in/12) x LakeMac_Surface_Area_AC)
Sutherland Reservoir	((North_Platte_Pan_Evap_in/12) x 0.7 x Suth_Res_SurfaceArea_ac)-((North_Platte_Precip_in/12) x Suth_Res_SurfaceArea_ac) + Suth_Res_heat_ind_evap_afd)
	STELL A uses the minimum of the equation above or 80 afd for Sutherland
Lake Maloney	((North_Platte_Pan_Evap_in/12) x 0.7 x Maloney_SurfaceArea_ac)-((North_Platte_Precip_in/12) x Maloney_SurfaceArea_ac)
Elwood Reservoir	(((Gothenburg_Pan_Evap_in/12) x 0.7)-(Gothenburg_Precip_in/12)) x Elwood_Res_Surface_Area_ac

National Weather Service data used in the analysis come from the University of Nebraska, High Plains Regional Climate Center (HPRCC): www.hprcc.unl.edu/index.php. The stations utilized are shown in Table 8.

14 The 0.7 is a multiplier to reduce pan evaporation to values more representative of a large water body (Farnsworth et al., 1982. Evaporation Atlas for the Contiguous 48 United States. NOAA Technical Report NWS 33).

15 The Kingsley Evaporation data was obtained from the HPRCC. Per discussions with HPRCC and NeDNR, the winter month evaporation estimates are inaccurate and were capped to the average daily evaporation by month.

Table 8: HPRCC Stations

Station	Used in Analysis	Notes
North Platte EXP FAR NE	Sutherland Reservoir and Lake Maloney Net Evaporation	Used in computing synthetic Gothenburg station
Grand Island WSO AP NE	N/A	Used in computing synthetic Gothenburg station
Synthetic Gothenburg Station*	Jeffrey Reservoir, Johnson Lake, and Elwood Reservoir Net Evaporation	Calculated as the average of the North Platte and Grand Island stations
Kingsley Dam, NE	Lake McConaughy Net Evaporation	NOAA NCDC gage post 2011

2.1.6 Period of Record

The evaluation utilizes the most recent period of record that represents naturally occurring wet/dry cycles in order to avoid bias between wet and dry periods and to accommodate non-stationarity in climate cycles. Suitability of the selected climatic period was evaluated by performing an autocovariance and Kendall Tau statistical analysis of the data. The period 1988 to 2012 was utilized for this analysis for the current analysis.

2.2 Demand Components

The total demand of water within a basin or subbasin is derived from seven main categories of water use:

1. Consumptive water demands for surface water uses
2. Consumptive water demands for hydrologically connected high capacity (greater than 50 gpm) groundwater well pumping
3. Net surface water loss (canal seepage losses)
4. Streamflow demands for hydropower operations
5. Streamflow demands to meet instream flow demands (accounting for all development in place at the time the appropriation was granted)
6. Downstream demands (the proportionate amount of BWS necessary to meet demands downstream of a given basin or subbasin)

Similar to required inflows, downstream demands do not represent demands that are required to be met by permit or statute, but rather water that is consistent with the NeDNR INSIGHT methodology and a way to provide more spatially refined evaluations.

The elements of total demand applicable to each subbasin is summarized in Table 9.

Table 9: Components of Demand by Subbasin

Subbasin	Ground-water Demand (GWDP or GWCU)	Surface Water Demand (SW Demand)	Net SW Loss	Non-Consumptive Use Demand (NonCU)		
				Instream Flow Demand	Hydro-power Demand	Down-stream Demand
North Platte River; State Line to Lewellen	X	X	X			X
North Platte River; Lewellen to North Platte	X	X	X		X	X
South Platte River; State Line to North Platte	X	X	X		X	X
Platte River; Confluence to Odessa	X	X	X	X	X	X
Platte River; Odessa to Grand Island	X			X		X
Platte River; Grand Island to Duncan	X			X		X

2.2.1 Surface Water Demand (SWDemand)

The surface water demand term is calculated in a similar manner as the surface water consumptive use (SWCU) for the BWS. Only irrigation and evaporation were included in the surface water demand, as there are no municipal or industrial surface water demands in the basin. The only differences were that for the surface water demand calculation, the full surface water demand was accounted for (rather than the historic demand). As described in Section 2.1.3, the surface water demand is applied at the point-of-diversion.

Surface water demands were readily available from the models described in Section 2.1.2. The COHYST full surface water demand estimates were used for the North Platte River below Lewellen, the South Platte River subbasin, and the Platte River from the confluence to Duncan[16].

Surface water demands associated with the WWUM were provided by ARI for the North Platte River above Lewellen. The WWUM surface water demands exclude the acres associated with the State line canals as these demands are served by diversions upstream of the State line. There are three years (1993, 1995 and 1999) that the WWUM modeled SWCU exceeds the surface water demand (which is counterintuitive as the historical use should not exceed the full permitted use). ARI has indicated that there are 1,500 acres included in the SWCU data that are outside the 10/50 area that should be included in the surface water demand for consistency with the NeDNR INSIGHT methodology as a possible cause. ARI has indicated that additional effort would be needed to refine the splits for groundwater and surface water consumptive use on comingled acres as well as including the these 1,500 additional acres in the surface water demand term. These refinements will be accomplished in the next update of the WWUM.s.

[16] From STELLA Model (HDR): Run 22A_13_21 (Feb 2014)

2.2.1.1 Redistributing the Surface Water Demand

Because the streamflow reach- gain/loss term (described in Section 2.1.1) is calculated as the downstream streamflow reach –gain/loss less the upstream streamflow reach-gain/loss, any water stored in a reservoir is not considered in the basin water supply term. Recognizing that the purpose of storage reservoirs is to store water during the non-peak season and make those flows available during the peak season, the peak season consumptive use demand is adjusted by the non-peak season change-in-storage[17] .[18]The adjustment is calculated as follows:

Adjustment = [Consumptive Use Demands] – {the minimum of [Non-peak Season Change-in-Storage Volume] – [Peak Season Releases] or [Consumptive Use Demands]}

Note: If the change-in-storage is less than the consumptive use demands, this formula would only reduce the consumptive use demands by the change-in-storage amount. If the change-in-storage exceeds the consumptive use demands, then it would reduce the consumptive use demands to zero.

2.2.2 Groundwater Consumptive Use Demand (GWCU)

Calculation of long-term groundwater demand relied upon the same raw data that was utilized to calculate groundwater depletions (Section 2.1.4).[19] The only difference was that the long-term groundwater demands considers groundwater consumption to be the total net irrigation requirement and removes the lag-effect as if all water consumed is immediately realized in the streamflow. Groundwater depletions are the lagged impacts of groundwater pumping on the stream. The assumption is that over time, within the hydrologically connected area, all groundwater pumping that goes to consumptive use will impact streamflows 100 percent.

COHYST was used to estimate the groundwater consumptive use (GWCU) demand for the North Platte River below Lewellen, South Platte River, and Platte River confluence to Duncan reaches. The model grid was obtained from The Flatwater Group, Inc. (TFG) and clipped down to the 10/50 area. It is important to note that the water balance data provided by TFG was provided on an annual time step. Annual groundwater consumptive uses were distributed 70 percent to the non-peak season and 30 percent to the peak season. The proportioning between the seasons was intended to match the observed seasonal pattern of groundwater depletions.[20]

[17] The non-peak season change is storage is calculated the May end-of-month volume (current year) less the August end-of-month volume (from the previous year)

[18] This adjustment is made on a year-by-year basis so that the reduction in demand does not exceed that year's change in storage.

[19] The long-term groundwater demand considers all groundwater irrigated acres (not what was historically irrigated as in the depletion term) and the full irrigation requirement.

[20] See *Water Matters: Stream Depletion and Groundwater Pumping Part One: The Groundwater Balance (No. 4, June 2010)* at https://dnr.nebraska.gov/sites/dnr.nebraska.gov/files/doc/water-planning/water-matters/WaterMatters_No4.pdf and *Stream Depletion and Groundwater Pumping Part Two: The Timing of Groundwater Depletions (No. 5, July 2010)* at https://dnr.nebraska.gov/sites/dnr.nebraska.gov/files/doc/water-planning/water-matters/WaterMatters_No5.pdf for more information.

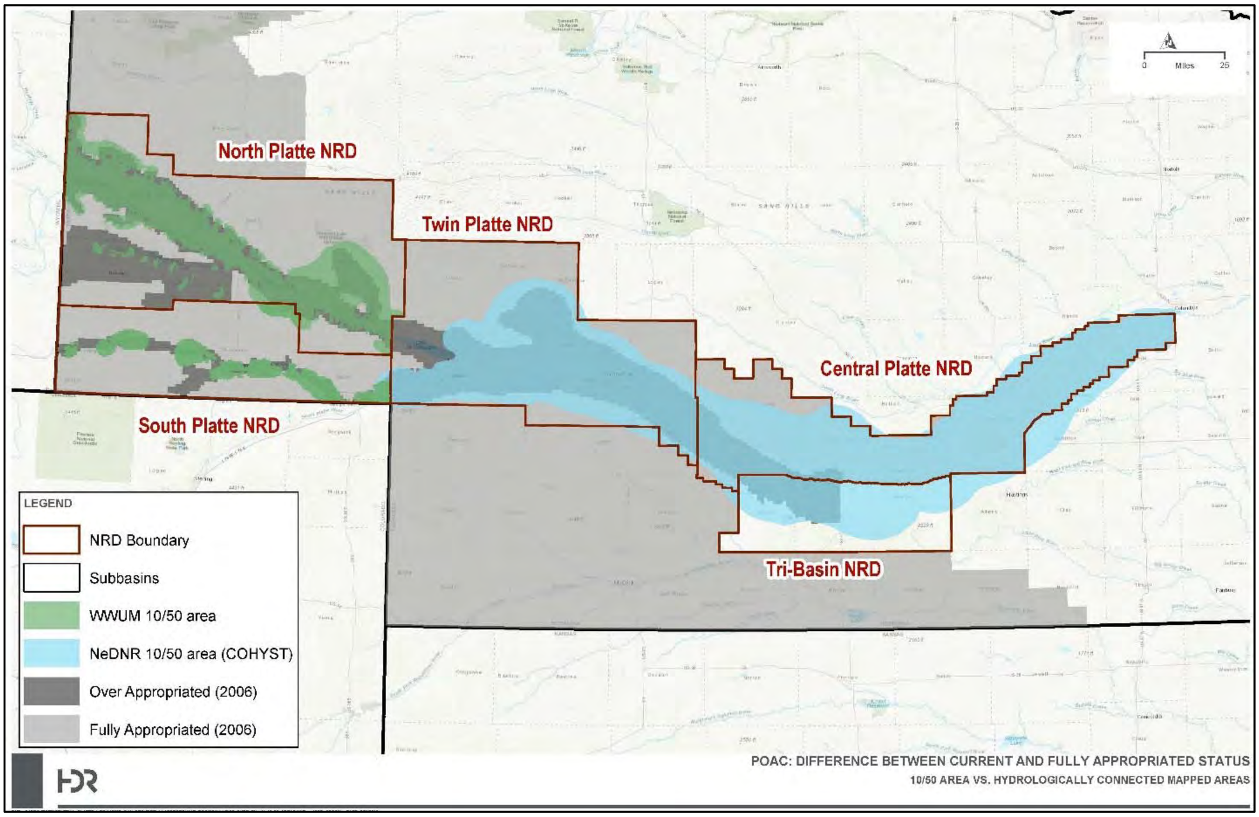
The WWUM GWCU estimates were provided by ARI for the North Platte River above Lewellen reach on a monthly time step. Monthly groundwater consumptive uses were summed on an annual basis and then distributed 70 percent to the non-peak season and 30 percent to the peak season to match the observed seasonal pattern in depletions.

It should be noted that there are occasions when the groundwater depletions exceeded the groundwater consumptive use in the Odessa to Grand Island subbasin (for select years) and State Line to Lewellen subbasin (all years). The occurrences in the Odessa to Grand Island reach appears to be a phenomenon during relatively wet years (1993, 1996, 1998, 1999, 2001, 2007 and 2008). This could be due to relatively high precipitation during the growing season, which would reduce the consumptive use demands on groundwater and surface water, but would not immediately affect groundwater depletions because of the lag effect.

In the State Line to Lewellen subbasin, groundwater depletions exceed groundwater consumptive use for every year. Similar to the surface water consumptive use demand discussion, additional effort may be necessary to refine the splits in this subbasin for groundwater and surface water consumptive use on comingled acres. In addition, depletions are estimated from the entire subbasin, where groundwater consumptive uses are limited to the 10/50 area. Further investigation of the differences and extent of groundwater irrigation use between these two limits may offer insight. These refinements could be accomplished in future analysis.

As an intermediate solution to allow completion of this study effort, the groundwater consumptive use demand was set equal to the groundwater depletions for purposes of this analysis. The effect of this is that the groundwater supply and demand terms cancel each other when comparing supplies and demands and represents a condition where the lag effect of groundwater usage has been removed and the full effect of pumping is being realized on streamflows.

Figure 5: Map of 10/50 Area in Study Area



2.2.3 Net Surface Water Loss (Net SW Loss)

Net surface water loss is the water lost through canal seepage after diversion from the stream, essentially the conveyance losses that occur from the point of diversion to delivery at the field turnout. While this water can be beneficial toward recharging the aquifer, the passive return of this water as baseflow does not occur within the same time period (lagged return). Therefore is represents an additional demand for water at the point of diversion to satisfy the downstream surface water demand. For this evaluation, it was assumed that the net surface water loss was the difference of the full diversion and the amount consumed for irrigation.

Canal seepage data from the STELLA model (part of the COHYST integrated model) were utilized as the net surface water loss term. The associated STELLA nodes from which seepage data was obtained are listed in Table 10.[21] Net surface water loss data for canal diversions above Lewellen were obtained from the WWUM and were provided by ARI.

[21] From STELLA Model (HDR): 'Canal_Res_Seepage_1950_2012.xlsx'; Run 22A_13_21 (Feb 2014)

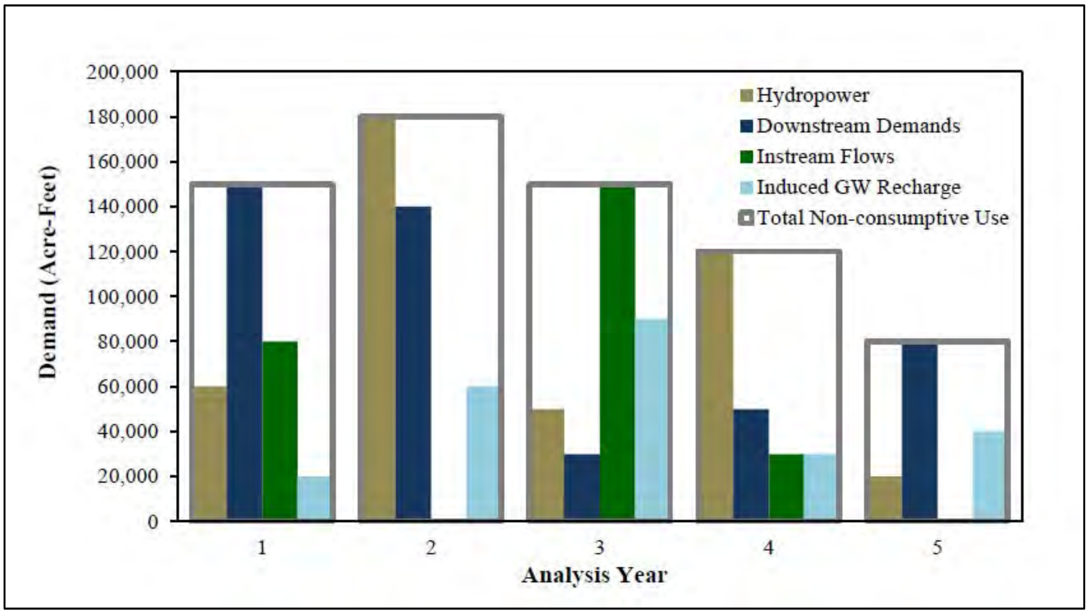
Table 10: STELLA Seepage Nodes Used for Seepage Estimate

STELLA Node	River Reach
Cody-Dillon	North Platte River; Lewellen to North Platte
Keith Lincoln	
North Platte Canal	
Paxton Hershey	
Suburban Canal	
Sutherland Canal below Res	
Sutherland Canal	
Sutherland Reservoir	
Sutherland Return	
Cozad Canal below Lateral 6	Platte River; Confluence to Odessa
Cozad Diversion	
Dawson Canal below Berquist	
Dawson Canal below French Creek	
Dawson Canal below Lateral 2	
Dawson Canal below Spring Creek	
Dawson Diversion	
E65 below Elwood Reservoir	
E65 Diversion	
E65 Lateral 23 7	
E65 Main/Loomis	
E67 Diversion	
Gothenburg Canal below Lake Helen	
Gothenburg Canal below Lateral 6	
Gothenburg Canal below Spring Creek	
Gothenburg Diversion	
Head gate to Jeffrey	
Kearney Canal below Cotton Mill Lake	
Kearney Canal below Turkey Creek	
Kearney Diversion	
Kearney Power Return	
Orchard Alfalfa	
Phelps below 29 8 (Junction)	
Phelps below E65	
Phelps Diversion	
Tri-County below 30 Mi Siphon	
Below J1	
Below Jeffrey Reservoir	
Below Jeffrey Return	
J2 Return	
6 Mi Canal	
30 Mile below Midway Lakes	
30 Mile below 30 Mi Siphon	
30 Mile Diversion	
30 Mile below 30 Mi Siphon	
30 Mile Diversion	
Western Canal	South Platte River; State Line to North Platte

2.2.4 Non-Consumptive Use Demands (NonCU)

Non-consumptive use demands (NonCU) are demands on the water supply that do not take water out of the stream or consume it therefore the water is available to meet other demands such as instream flow, induced recharge, or downstream demands for consumptive and/or non-consumptive uses. Non-consumptive use demands include hydropower demands, instream flow demands, induced groundwater recharge, and downstream demands. For non-consumptive use demands, the NeDNR INSIGHT methodology only applies the greater of the non-consumptive demands, i.e. the non-consumptive demands are not cumulative as the water is not consumed and available to meet downstream demands. For example, if hydropower demand exceeds instream flow demands or downstream demands, then the hydropower demand is applied to the basin in question, recognizing the returns will be adequate to serve the instream and downstream demands. Figure 6 shows a chart of how the maximum non-consumptive use is determined on an annual basis.

Figure 6: Example Plot Showing Maximum Non-Consumptive Use Demand (Source: "INSIGHT Methods", 2015)



2.2.4.1 Hydropower Demand

Multiple hydropower demands exist within the Upper Platte River Basin. The Central Nebraska Public Power and Irrigation District (CNPPID) owns and operates multiple hydropower facilities in the Upper Platte River Basin. CNNPID diverts water released from Lake McConaughy and/or the South Platte River into the Tri-County Canal, directs it through Jeffrey and Johnson lakes (regulating reservoirs), three hydroelectric plants (Jeffrey, J-1, J-2), and delivers it to the irrigation system (during the irrigation season) or back to the Platte River (non-irrigation season).[22]

[22] http://www.cnppid.com/operations/hydropower/

Nebraska Public Power District (NPPD), also operates multiple hydropower facilities in the Upper Platte River Basin, in addition to the Gerald Gentleman coal-fire plant that utilizes surface water as a cooling water source. NPPD operates diversions on the South Platte River (Korty Diversion) and the North Platte River (Keystone Diversion). Flows are conveyed through their supply canal to Sutherland Reservoir (cooling water source for the Gentleman Station), then through Lake Maloney near North Platte which serves as a regulating reservoir for NPPDs North Platte hydropower facility. The hydropower returns flows to the South Platte River just above the confluence with the North Platte River and CNPPID's Tri-County diversion. NPPD also has a hydropower facility in Kearney, served by the Kearney Canal Diversion. Table 11 describes these hydropower demands by analysis subbasin.

Table 11: Hydropower Demands by Subbasin

Hydropower Demand	Demand Applied:	Applied To Subbasin:
Kearney	Min[400 cfs or (Platte River Streamflow at Overton + ∑GWDP above Overton)]	Platte River; Odessa to Grand Island
J2/Jeffrey[A]	Min[2,250 cfs or (Platte River Streamflow at Confluence + ∑GWDP above Platte River Confluence)]	Platte River; Confluence to Odessa
Sutherland[B]	Min[1,900 cfs or (Synthetic South Platte River Streamflow at Paxton + ∑GWDP above Paxton)]	South Platte River; State Line to North Platte/ North Platte River; Lewellen to North Platte
McConaughy	N/A[C]	North Platte: Lewellen to North Platte

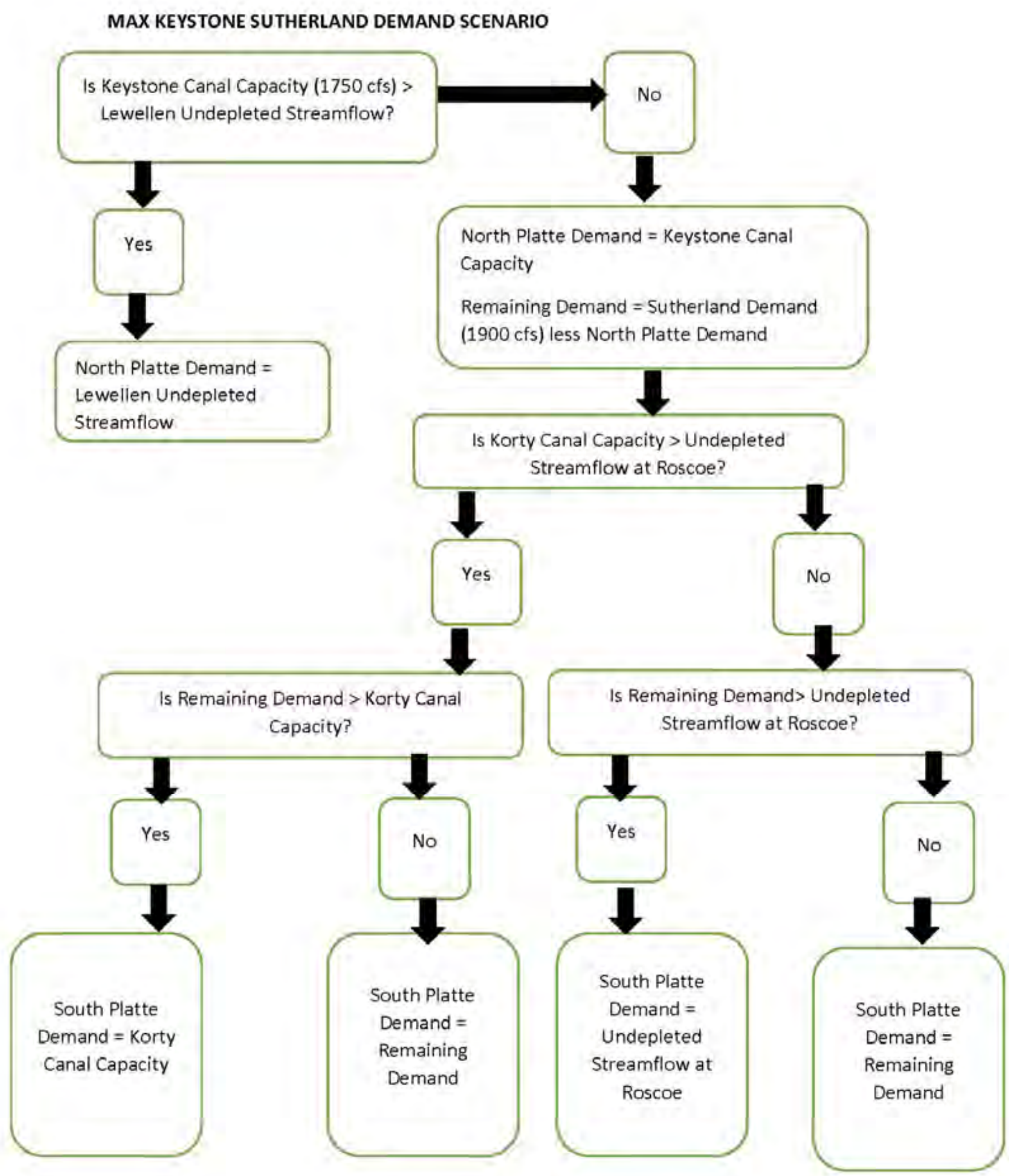
Notes:

A) The Tri-County Canal serves both surface water consumptive and non-consumptive use demands. In some cases, the surface water consumptive demands are located upstream of the non-consumptive use demands; therefore, it was necessary to consider the surface water consumptive and non-consumptive use demands separately for this canal. These demands were broken out as follow:

- Full Tri-County Demand = Minimum of [Canal losses above Brady + Max (surface water demands or CNPPID hydropower demand) OR Undepleted streamflow at Confluence of North Platte & South Platte Rivers]
- Tri-County Non-consumptive Use Demand = Full Tri-County Demand – Tri-County SW Demand – Tri-County Canal seepage

(B) The demand associated with Sutherland is unique in that the water right exceeds canal capacity. Therefore, two demand scenarios were evaluated for purposes of this analysis. The first scenario maximizes the contribution of the Sutherland demand from the South Platte River, Julesburg to North Platte subbasin by placing the 850 cfs Korty canal capacity capped to historic undepleted flow at Roscoe and assigning the remainder to the North Platte subbasin. The second demand scenario places a 1,750 cfs demand on the North Platte Lewellen to North Platte subbasin (the capacity of the Keystone Canal) capped to the undepleted historic streamflow at Lewellen and assigning the remainder of the Sutherland demand to the South Platte Julesburg to North Platte subbasin. In actuality, the demands assigned to these two subbasins will likely be somewhere in-between these two scenarios. An example of this methodology is shown in Figure 7.

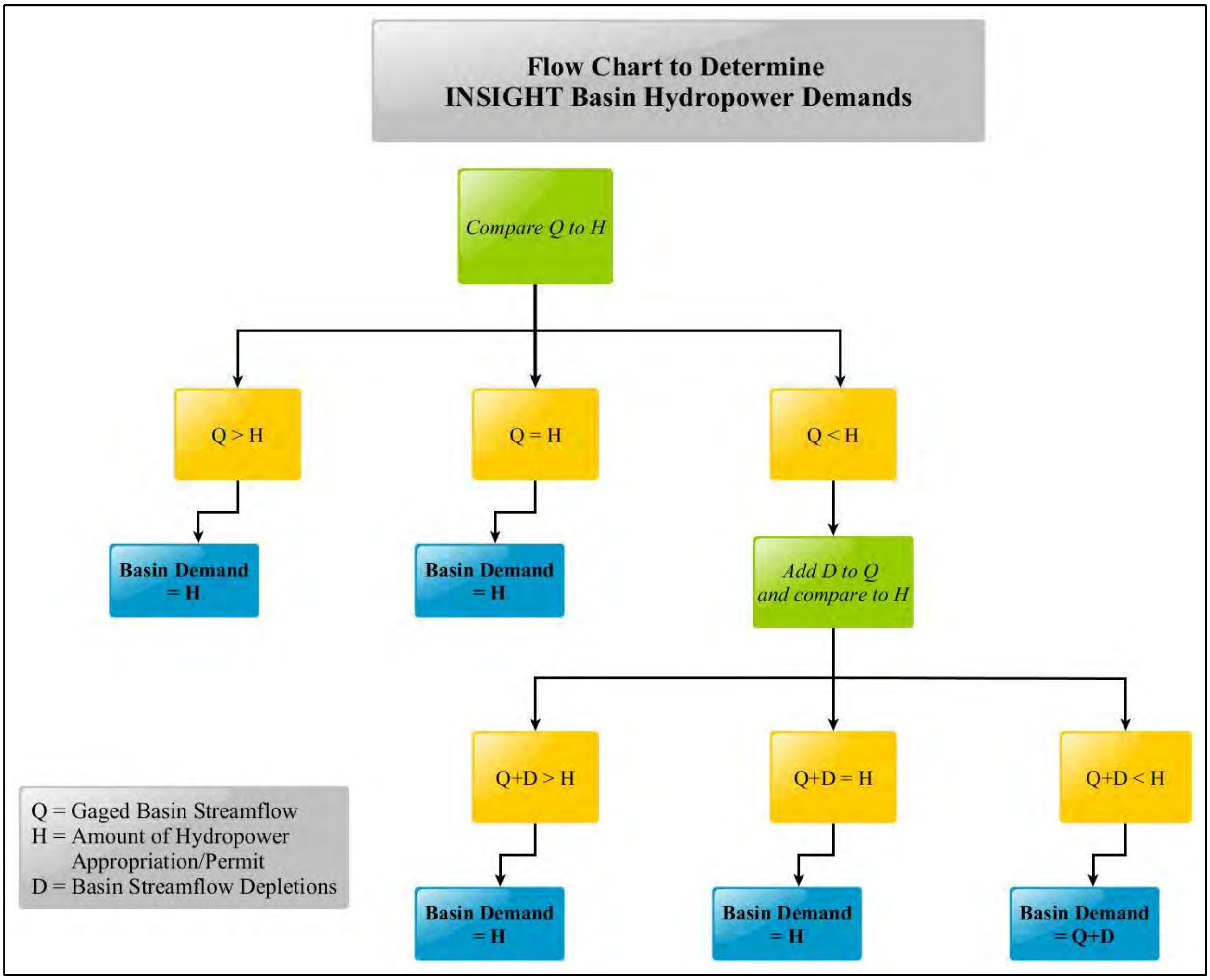
Figure 7: Example calculation where the contribution from the North Platte subbasin (Keystone Diversion) is maximized



Lake McConaughy is operated based on downstream demands; that is the Kingsley Hydropower unit at Lake McConaughy is not explicitly represented as a demand, but generates hydropower based on releases to serve the downstream demands. The CNPPID demand is assigned to upstream basins as a downstream demand.

The NeDNR INSIGHT methodology evaluates hydropower demands at the basin level. Hydropower demands are evaluated by comparing the daily streamflow through the hydropower plant to the permitted hydropower appropriation. If streamflow is greater than or equal to the hydropower appropriation, the demand is considered to be the amount of the appropriation, as that is the maximum amount of water permitted for that use and the demand cannot legally exceed that. If streamflow is less than the appropriation, then streamflow depletions from groundwater pumping will also be considered in order to determine if undepleted streamflow would have been available prior to impacts of groundwater uses. The depletions are added to the daily streamflow, resulting in the undepleted streamflow. This undepleted streamflow is compared to the hydropower appropriation. If the undepleted streamflow is greater than or equal to the hydropower appropriation, the demand is considered to be the amount of the appropriation. In the case that the undepleted streamflow available is not adequate to meet the appropriation, the demand for the basin is equal to the undepleted streamflow. Figure 8 illustrates the process used to determine daily hydropower demands for each basin.

Figure 8: Flow Chart to Determine INSIGHT Basin Hydropower Demands (Source: "INSIGHT Methods" 2015)



2.2.4.2 Instream Flow Demands

Instream flow appropriations exist in the Confluence to Odessa, Odessa to Grand Island, and Grand Island to Duncan reaches for the purpose of fish and wildlife needs. The appropriated instream flow rates are shown in Figure 9.[23] Like hydropower uses, instream flows represent a non-consumptive use demand.

Figure 9: Total Platte River Instream Flow Appropriations (Source: NeDNR)

Total Platte River Instream Flow Needs
For Purposes of Water Administration
All Quantities in CFS

Central Platte figures in blue (Priority date of 7-25-1990)
Game & Parks figures in red (Priority date of 11-30-1993)
Totals in black

TIME PERIOD	OVERTON GAGE	ODESSA GAGE	GRAND ISLAND GAGE	DUNCAN GAGE	NORTH BEND GAGE	LOUISVILLE GAGE
January	500	500	500	500	1,800	3,100
February	500	500	500	500	1,800	3,700
March	1,100	1,100	1,100	500	1,800	3,700
April 1-14	1,300	1,350 (1,300 + 50)	1,350 (1,300 + 50)	500	1,800	3,700
April 15-30	1,500	1,500	1,500	500	1,800	3,700
May 1-3	1,500	1,500	1,500	500	1,800	3,700
May 4-10	500	1,350 (includes 500)	1,350 (includes 500)	500	1,800	3,700
May 11-31	500	500	500	500	1,800	3,700
June 1-23	500	1,000 (500 + 500)	1,000 (500 + 500)	1,000 (500 + 500)	1,800	3,700
June 24-30	600	1,000 (600 + 400)	1,000 (600 + 400)	1,000 (600 + 400)	1,800	3,700
July 1-31	600	1,000 (600 + 400)	1,000 (600 + 400)	1,000 (600 + 400)	1,800	3,700
August 1-22	600	800 (600 + 200)	800 (600 + 200)	900 (600 + 300)	1,800	3,500
August 23-31	500	800 (500 + 300)	800 (500 + 300)	900 (500 + 400)	1,800	3,500
September	500	500	500	500	1,800	3,200
October 1-11	1,100	1,350 (includes 1,100)	1,350 (includes 1,100)	500	1,800	3,700
October 12-31	1,500	1,500	1,500	500	1,800	3,700
November 1-10	1,500	1,500	1,500	500	1,800	3,700
November 11-30	500	500	500	500	1,800	3,700
December	500	500	500	500	1,800	3,700

Because the instream flow demand is a non-consumptive use demand, the NeDNR INSIGHT methodology compares the instream flow demand to the undepleted streamflow similar to the way that the hydropower demands are evaluated. Consistent with the NeDNR INSIGHT methodology, if undepleted streamflow is greater than the instream flow appropriation, the demand is capped at the instream flow appropriation because the demand cannot exceed what is legally permitted.[24] Consistent with NeDNR INSIGHT methodology, if the undepleted streamflow does not meet the instream flow appropriation, then the instream flow demand is capped to the undepleted streamflow.

23 *Neb. Rev. Stat. § 46-2,115(1)*

24 Note this description only applies to the NeDNR INSIGHT methodology for evaluating demands in a river basin. This statement is not intended to reflect how surface water rights are actually administered with respect to the prior-appropriation doctrine.

Consistent with *Neb. Rev. Stat*. § 46-713(3) of the Ground Water Management and Protection Act, the NeDNR INSIGHT methodology further adjusts the instream flow demands by the level of groundwater development in place in 1993.[25] The adjustment to pre-1993 historic flows consists of reducing the observed historic flows by the consumptive use of those acres irrigated by groundwater in 1993. Conceptually, this adjustment incorporates the lag effect of groundwater irrigation in the pre-1993 period that had not yet resulted in depletions to the stream in 1993. Pre-1993 surface water development is inherently included by its ability to use water in priority.

Mathematically, the Instream Flow Demand applied in INSIGHT is as follows:

INSIGHT Instream Demand = Instream Flow Appropriation (Capped to Undepleted Flow) less 1993 Level of Groundwater Development

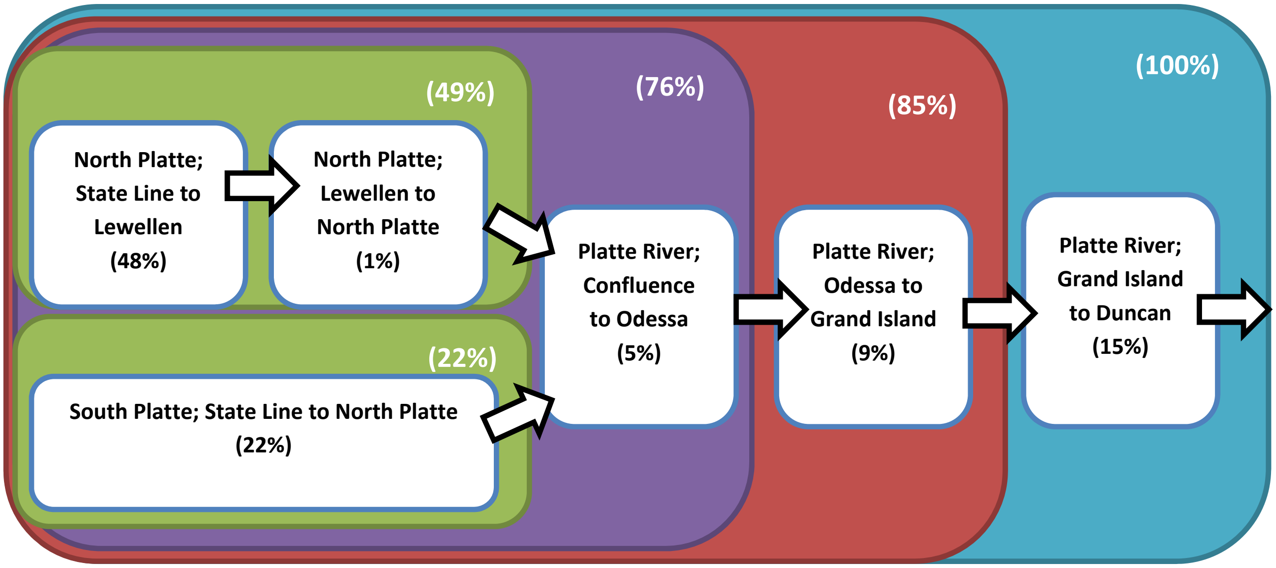
For this analysis, TFG applied the watershed model component of the COHYST integrated model using the period-of-analysis with 1993 land use held constant in order to estimate the impact that the 1993 level of groundwater development would have for each year (climatic cycles allowed to vary). TFG provided these consumptive use results to adjust the instream flow demands in each year at each instream flow location (Overton, Odessa, Grand Island, Duncan, North Bend, and Louisville).

2.2.5 Proportioning Supplies and Demands

As previously mentioned, it is necessary to calculate the intrinsic supply prior to calculating required inflows or downstream demands because the ratio of intrinsic supplies is used to proportion the supplies and demands to each subbasin. Figure 10 shows a simplified schematic for how basin proportioning in the Upper Platte River Basin would be calculated.

[25] The Nebraska Game and Parks Commission obtained instream flow appropriations for fish and wildlife purposes in 1993.

Figure 10: Schematic of Upper Platte River Basin Intrinsic Basin Water Supply
Note: ***Values included for example purposes only and actual results may vary.***



Several steps were necessary to determine the contributing proportion of each subbasin. The steps for calculating contributing proportions are as follows:

> **Step 1:** Calculate the intrinsic supply at the furthest downstream accounting point in a basin (total intrinsic supply).
>
> **Step 2:** Calculate the intrinsic supply at each subbasin confluence upstream.
>
> **Step 3:** Calculate the percent contribution for each subbasin relative to the total intrinsic BWS for the basin. This represents the proportion an upper basin contributes to the basin as a whole.

2.2.6 Required Inflow and Downstream Demand

The required inflow term is used to recognize the historic contribution of BWS from an upstream basin. Similarly, downstream demands are used to reflect the portion of mainstem surface water demand of a downstream subbasin that has historically been satisfied by water originating in an upstream basin. This is done because water development in a lower basin was based on water supply that was historically available at the time the surface water appropriation was granted. Because an upstream basin's water supply represents only a portion of the total downstream basin's total water supply, only a portion of the downstream basin's demand is applied to an upstream basin. The proportioning discussed in Section 2.2.5 is used to carry downstream demands to upstream basins as well as calculate required inflow from upstream basins to downstream basins. These terms cancel out at the whole basin level.

Downstream demands are those mainstem surface water consumptive use demands, non-consumptive use demands, and net surface water loss demands in downstream subbasins that have historically relied on water supply from an upstream basin. Downstream groundwater demands are not assigned to upstream basins as surface water flows cannot be expected to meet downstream groundwater demands. The following are the formulas used for calculating the required inflow and downstream demands in the Upper Platte River Basin.

<u>North Platte River, Lewellen to North Platte, Required Inflow</u>
(% Lewellen to North Platte) x
(Odessa Subbasin: Mainstem SW Demand + Net SW Loss + Max Non-consumptive Use Demand)

<u>Platte River, Confluence to Odessa, Required Inflow</u>
(% Lewellen to Odessa + % North Platte to Odessa + % South Platte to Odessa) x
(Odessa Subbasin: Mainstem SW Demand + Net SW Loss + Max Non-consumptive Use Demand)

<u>Platte River, Odessa to Grand Island, Required Inflow</u>
(% Lewellen to Grand Island + % North Platte to Grand Island + % South Platte to Grand Island + % Odessa to Grand Island) x
(Grand Island Subbasin: Max Non-consumptive Use Demand)

Note: There are no SW Demands or Net SW Loss Demands in the Grand Island Subbasin

<u>Platte River, Grand Island to Duncan, Required Inflow</u>
(% Lewellen to Duncan + % North Platte to Duncan + % South Platte to Duncan + % Odessa to Duncan + % Grand Island to Duncan) x
(Duncan Subbasin: Max Non-consumptive Use Demand)

Note: There are no SW Demands or Net SW Loss Demands in the Duncan Subbasin

<u>North Platte River, State Line to Lewellen, Downstream Demand</u>
% Lewellen to North Platte x (North Platte Subbasin: Mainstem SW Demand + Net SW Loss) +
% Lewellen to Odessa x (Odessa Subbasin: Mainstem SW Demand + Net SW Loss) +
% Lewellen to Lower Platte x (Lower Platte Subbasin: Mainstem SW Demand + Net SW Loss) +

MAX {% Lewellen to North Platte x North Platte Subbasin: Max Non-consumptive Use Demand,
% Lewellen to Odessa x Odessa Subbasin: Max Non-consumptive Use Demand,
% Lewellen to Grand Island x Grand Island Subbasin: Max Non-consumptive Use Demand,
% Lewellen to Duncan x Duncan Subbasin: Max Non-consumptive Use Demand,
% Lewellen to Lower Platte x Lower Platte Subbasin: Max Non-consumptive Use Demand}

Note: There are no SW Demands or Net SW Loss Demands in the Grand Island or Duncan Subbasins

North Platte River, Lewellen to North Platte, Downstream Demand

% North Platte to Odessa x (Odessa Subbasin: Mainstem SW Demand + Net SW Loss) +
% North Platte to Lower Platte x (Lower Platte Subbasin: Mainstem SW Demand + Net SW Loss) +

MAX {% North Platte to Odessa x Odessa Subbasin: Max Non-consumptive Use Demand,
% North Platte to Grand Island x Grand Island Subbasin: Max Non-consumptive Use Demand,
% North Platte to Duncan x Duncan Subbasin: Max Non-consumptive Use Demand,
% North Platte to Lower Platte x Lower Platte Subbasin: Max Non-consumptive Use Demand}

Note: There are no SW Demands or Net SW Loss Demands in the Grand Island or Duncan Subbasins

Platte River, Confluence to Odessa, Downstream Demand

% Odessa to Lower Platte x (Lower Platte Subbasin: Mainstem SW Demand + Net SW)

MAX {% Odessa to Grand Island x Grand Island Subbasin: Max Non-consumptive Use Demand,
% Odessa to Duncan x Duncan Subbasin: Max Non-consumptive Use Demand,
% Odessa to Lower Platte x Lower Platte Subbasin: Max Non-consumptive Use Demand}

Note: There are no SW Demands or Net SW Loss Demands in the Grand Island or Duncan Subbasins

Platte River, Odessa to Grand Island, Downstream Demand

% Grand Island to Lower Platte x (Lower Platte Subbasin: Mainstem SW Demand + Net SW Loss) +

MAX {% Grand Island to Duncan x Duncan Subbasin: Max Non-consumptive Use Demand,
% Grand Island to Lower Platte x Lower Platte Subbasin: Max Non-consumptive Use Demand}

Note: There are no SW Demands or Net SW Loss Demands in the Grand Island or Duncan Subbasins

Platte River, Grand Island to Duncan, Downstream Demand

% Duncan to Lower Platte x (Lower Platte Subbasin: Mainstem SW Demand + Net SW Loss + Max Non-consumptive Use Demand)

South Platte River, State Line to North Platte, Downstream Demand
% South Platte to Odessa x (Odessa Subbasin: Mainstem SW Demand + Net SW Loss) +
% South Platte to Lower Platte x (Lower Platte Subbasin: Mainstem SW Demand + Net SW Loss) +

MAX {% North Platte to Odessa x Odessa Subbasin: Max Non-consumptive Use Demand,
% North Platte to Grand Island x Grand Island Subbasin: Max Non-consumptive Use Demand,
% North Platte to Duncan x Duncan Subbasin: Max Non-consumptive Use Demand,
% North Platte to Lower Platte x Lower Platte Subbasin: Max Non-consumptive Use Demand}

Note: There are no SW Demands or Net SW Loss Demands in the Grand Island or Duncan Subbasins

2.3 Basin Water Supply

As discussed in Section 2.1, the BWS is made up of four components: 1) streamflow reach-gain/loss; 2) surface water consumptive use; 3) groundwater depletions; and 4) required inflow, which is the amount of water that is necessary to flow out of basins or subbasins upstream to a given location. Required inflow does not represent water that is required by law or permit, but rather the typical amount of water a basin or subbasin relies upon from upstream under the NeDNR INSIGHT methodology.

The intrinsic supply (Section 2.1) is the same as the BWS only less the required inflow term (intrinsic supply = streamflow reach-gain/loss + surface water consumptive use + groundwater depletions). It was necessary to calculate the intrinsic supply first because the ratio of intrinsic supplies is used to calculate the required inflow and downstream demand terms, as discussed in Section 2.2.6. With all terms calculated, the BWS can now be calculated. The formula for BWS is as follows:

BWS = Streamflow reach-gain/Loss + SWCU + GWDP + Required Inflow

Table 12: Components of BWS by Subbasin

Subbasin	Streamflow/ Reach-Gain/Loss	Surface water Consumptive Use (SWCU & Res Evap)	Groundwater Depletions (GWDP)	Required Inflow
North Platte River; State Line to Lewellen	X	X	X	
North Platte River; Lewellen to North Platte	X	X	X	X
South Platte River; State Line to North Platte	X	X	X	
Platte River; Confluence to Odessa	X	X	X	X
Platte River; Odessa to Grand Island	X		X	X
Platte River; Grand Island to Duncan	X		X	X

2.4 Near-Term Demand & Near-Term Balance

The NeDNR INSIGHT methodology used the BWS concept in conjunction with Total Demand (TD) to determine the balance of water supply and water use. The BWS recreates, at any defined timestep, the amount of streamflow water supply available for use, while the TD, at any defined timestep, recreates the total demand on streamflow water supplies, including those demands that may not always be met.

As previously discussed in Section 2.0, the NeDNR INSIGHT methodology evaluates the basin on both a seasonal and annual time frame. The two sub-periods within the year are the "Peak Season" (June 1 through August 31) and the "Non-peak Season" (September 1 through May 31). If a basin's near-term demand and/or the long-term demand of hydrologically connected groundwater and surface water exceeds the basin water supplies (BWS) during either of the two sub-periods when summed over the time period utilized in the INSIGHT evaluation, then supplies may not be sufficient to sustain the demands over the long term.

The difference between the near-term and long-term demands is that the near-term demand calculation considers the groundwater depletion (current effect of wells on the stream) while the long-term calculation considers the groundwater consumption (full impact of wells on a hydrologically connected stream). The formula for the near-term demand is as follows:

Near-term Demand = GWDP + SW Demand + Net SW Loss + Max Non-Consumptive Use Demand

Note: The max non-consumptive use demand includes the downstream demands

With the near-term demand calculated, the near-term balance is calculated using the following formula:

Near-term Balance = BWS – Near-term Demand

2.5 Long-Term Demand & Long-Term Balance

The difference between the near-term and long-term demands is that the near-term demand calculation considers the groundwater depletion (current effect of wells on the stream) while the long-term calculation considers the groundwater consumption (full impact of wells on a hydrologically connected stream). The formula for the long-term demand is as follows:

Long-term Demand = GWCU + SW Demand + Net SW Loss + Max Non-Consumptive Use Demand

Note: The max non-consumptive use demand includes the downstream demands

With the long-term demand calculated, the long-term balance is calculated using the following formula:

Long-term Balance = BWS – Long-term Demand

3.0 Results

This section presents the results of the basin accounting for the Upper Platte River Basin following the NeDNR INSIGHT Methodology. It should be noted that this NeDNR INSIGHT Methodology considers demands in their entirety (all surface and groundwater acres irrigated at full net irrigation requirement). The intent of this methodology is not to imply that all water demands would, could, or should be satisfied; rather its intent is to understand demands of the total surface water appropriations and groundwater permitted acres existing within the basin. Additionally, the reader should note that while the non-consumptive uses (hydropower and instream flow) are capped based on historically available flow, surface water uses, downstream demands, and required inflow are not. Future studies by the PBC and NeDNR could consider investigating surface water and groundwater demands in greater detail to better define an appropriate level of supplies and demands in the Upper Platte Basin. The data gathered and presented as part of this analysis serves as a starting point for any future investigation.

Figure 11 shows the 1988-2012 25-year average calculated supplies in the Upper Platte River Basin. Note that the supply only changes by Sutherland demand scenario (described in Section 2.2.3.1) for the Lewellen to North Platte subbasin. This is because the required inflow term for the Lewellen to North Platte subbasin changes based on which Sutherland demand (described in Section 2.2.3.1) is applied to the subbasin. Both the Lewellen to North Platte subbasin as well as Confluence to Odessa subbasin supplies are largely driven by the required inflow term which is based upon upstream subbasin contributions to the large CNPPID demand. The Odessa to Grand Island supply is driven by the required inflow term which is based upon upstream subbasin contributions to the Grand Island instream flow demand.

Figure 11: Annual Supply Plot for the Upper Platte River Basin

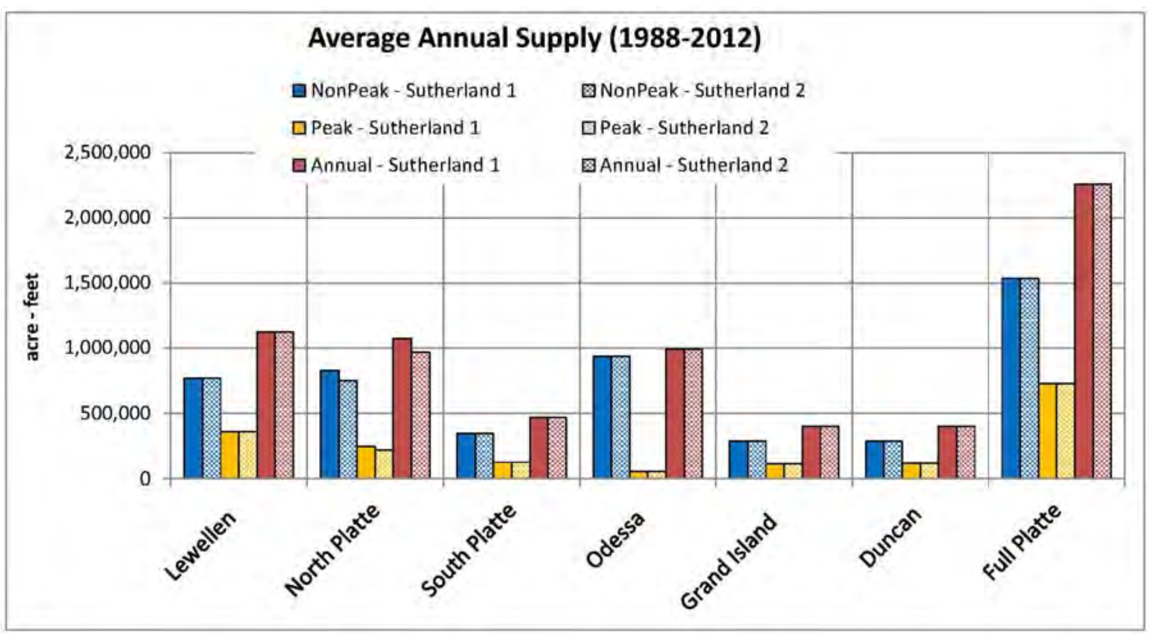


Figure 12 shows the 1988-2012 25-year average calculated near-term demands in the Upper Platte River Basin. Note that the demand only changes by Sutherland demand scenario (described in Section 2.2.3.1).

Figure 12: Annual Near-term Demand Plot for the Upper Platte River Basin

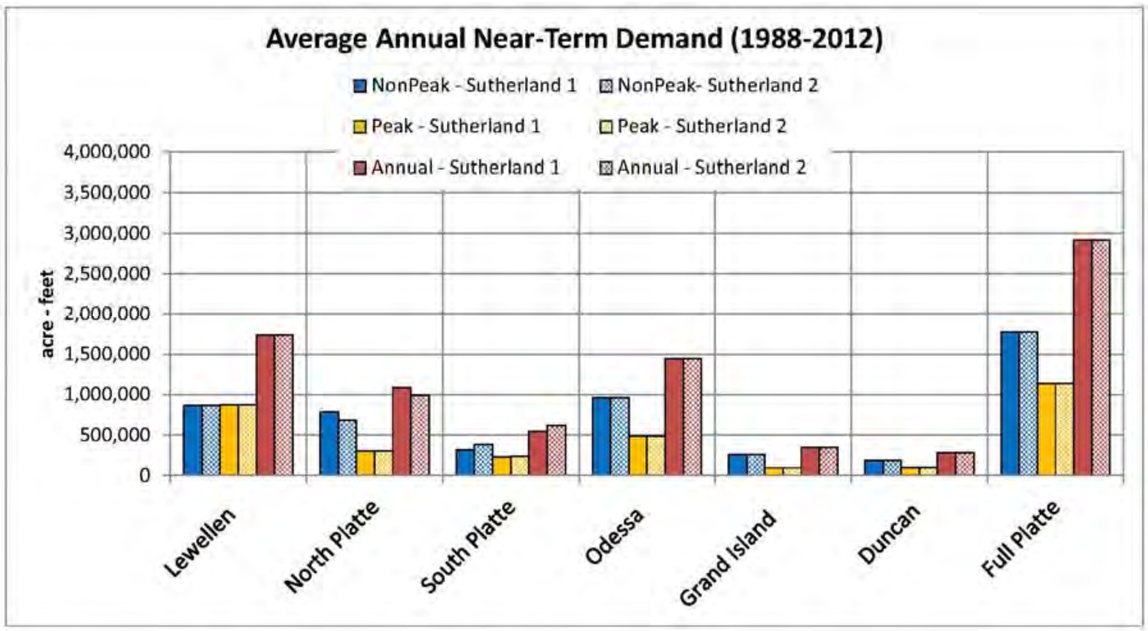
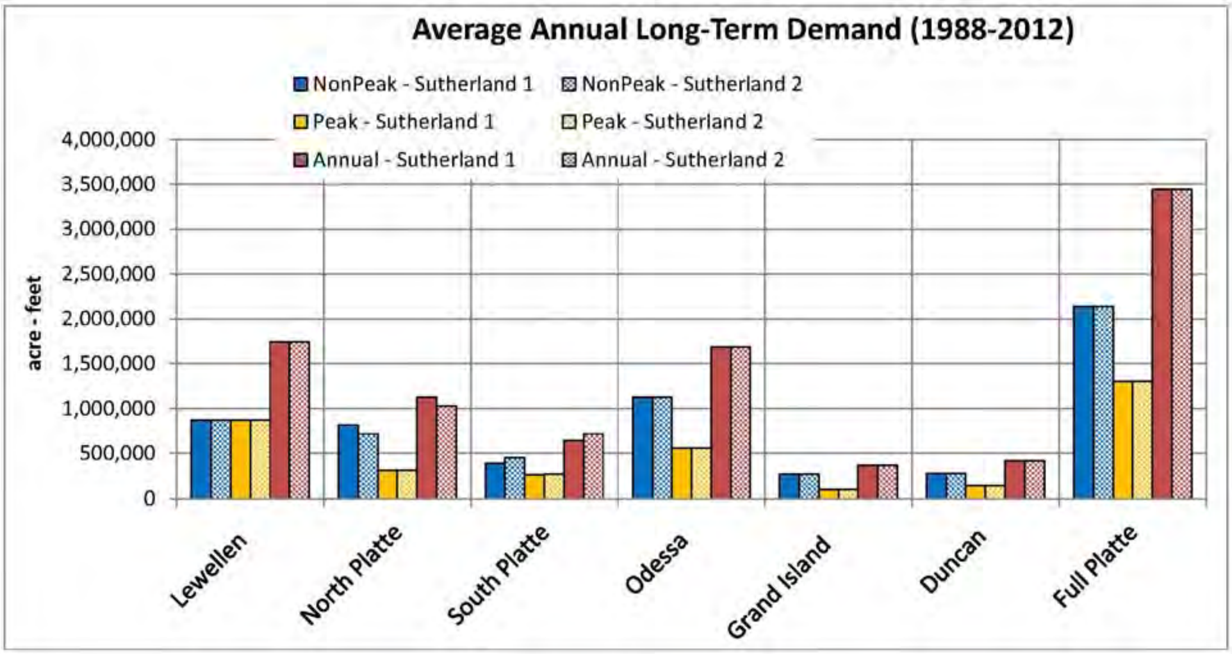


Figure 13 shows the 1988-2012 25-year average calculated long-term demands in the Upper Platte River Basin. Note that the demand only changes by Sutherland demand scenario (described in Section 2.2.3.1). The breakdown of supply and demand terms are described in further detail in the Nature and Extent of Use Section (Section 4.0).

Figure 13: Annual Long-term Demand Plot for the Upper Platte River Basin



With the supplies and demands calculated, the excess supplies were calculated as described in Section 2.5 and Section 2.6. Figure 14 shows the 1988-2012 25-year average calculated annual excess supply for the Upper Platte River Basin based on near-term demand while Figure 15 shows the 1988-2012 25-year average calculated annual excess supply for the Upper Platte River Basin based on long-term demand. Tables 13 and 14 corresponds to the annual excess supply numbers shown in Figures 14 and 15.

Figure 14: Annual Excess Supply (based on Near-term demand) for the Upper Platte River Basin

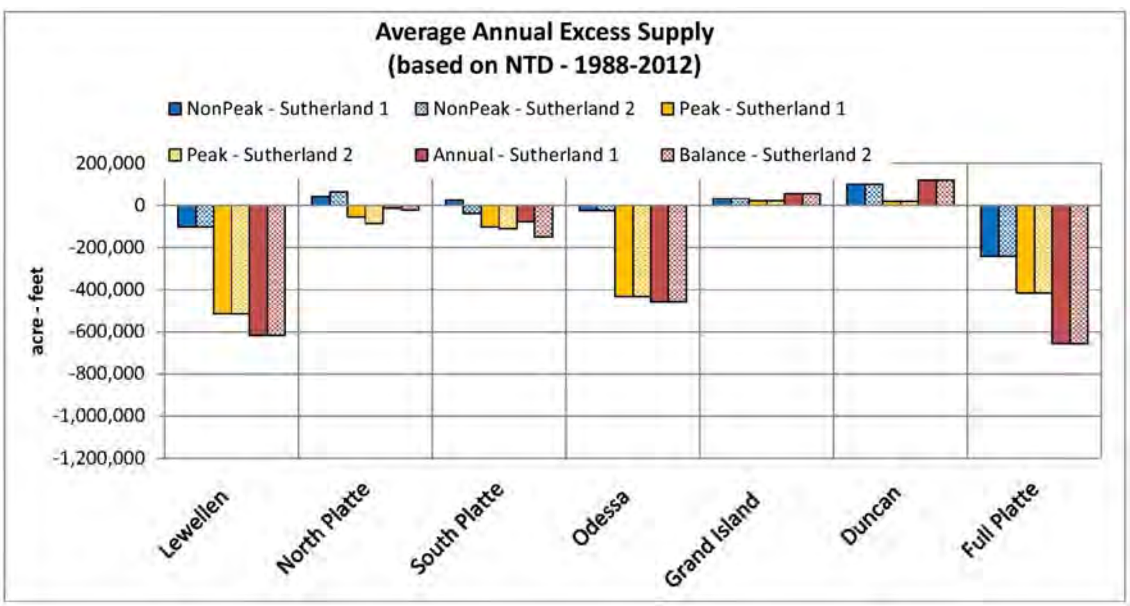


Figure 15: Annual Excess Supply (based on Long-term demand) for the Upper Platte River Basin

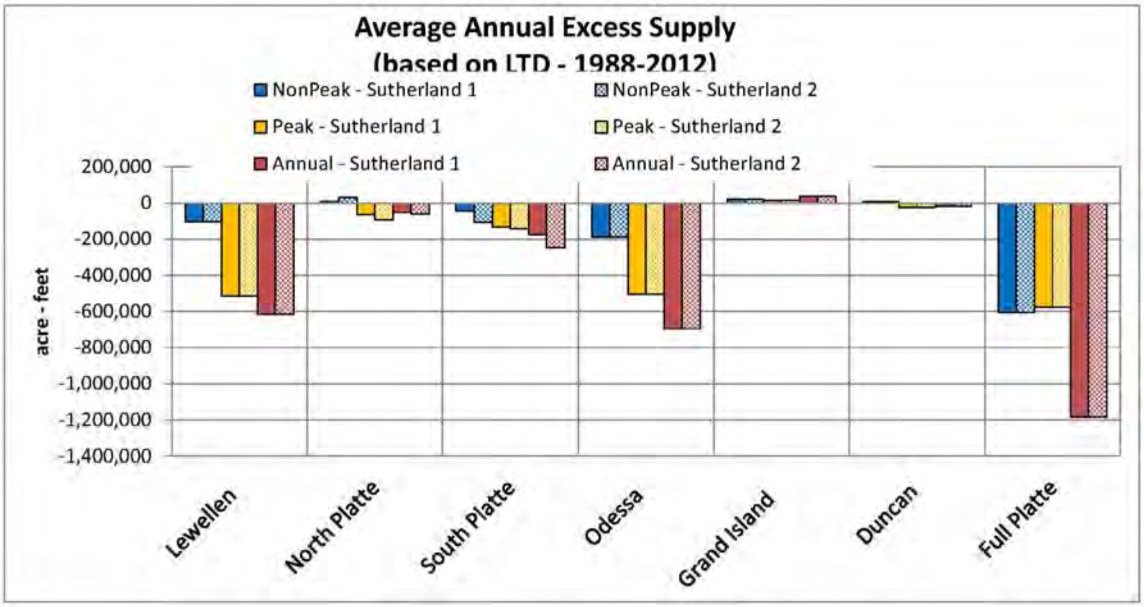


Table 13: Annual Excess Supply (based on Near-term demand) by Subbasin (AF)

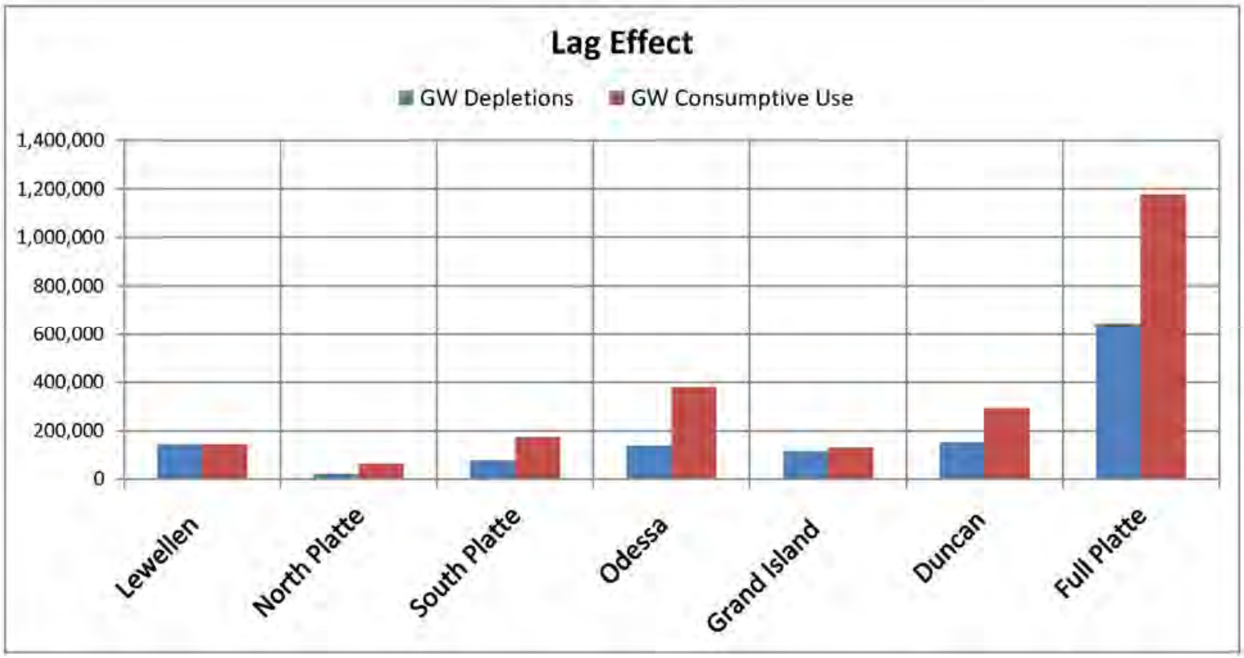
Subbasin	Sutherland Demand Scenario 1			Sutherland Demand Scenario 2		
	Non-peak	Peak	Annual	Non-peak	Peak	Annual
North Platte River, State Line to Lewellen	(102,302)	(514,616)	(616,918)	(102,302)	(514,616)	(616,918)
North Platte River, Lewellen to North Platte	41,935	(55,126)	(13,190)	62,754	(85,106)	(22,353)
South Platte River, State Line to North Platte	24,346	(102,400)	(78,053)	(38,366)	(112,142)	(150,508)
Platte River, Confluence to Odessa	(25,527)	(431,938)	(457,464)	(25,527)	(431,938)	(457,464)
Platte River, Odessa to Grand Island	32,445	21,670	54,114	32,445	21,670	54,114
Platte River, Grand Island to Duncan	99,396	20,802	120,198	99,396	20,802	120,198
Full Upper Platte River Basin	(241,025)	(415,308)	(656,333)	(241,025)	(415,308)	(656,333)

Table 14: Annual Excess Supply (based on Long-term demand) by Subbasin (AF)

Subbasin	Sutherland Demand Scenario 1			Sutherland Demand Scenario 2		
	Non-peak	Peak	Annual	Non-peak	Peak	Annual
North Platte River, State Line to Lewellen	(102,302)	(514,616)	(616,918)	(102,302)	(514,616)	(618,918)
North Platte River, Lewellen to North Platte	9,722	(62,169)	(52,477)	30,540	(95,150)	(61,610)
South Platte River, State Line to North Platte	(43,719)	(131,974)	(175,693)	(106,432)	(141,716)	(248,148)
Platte River, Confluence to Odessa	(189,530)	(506,073)	(695,602)	(189,530)	(506,073)	(695,602)
Platte River, Odessa to Grand Island	21,896	15,244	37,140	21,896	15,244	37,140
Platte River, Grand Island to Duncan	7,795	(24,173)	(16,378)	7,795	(24,173)	(16,378)
Full Upper Platte River Basin	(607,457)	(577,462)	(1,184,919)	(607,457)	(577,462)	(1,184,919)

As described in Section 2.5 and Section 2.6, the difference between near-term and long-term demand is in the groundwater demand term. The near-term demand uses the groundwater depletions while the long-term demand uses the full groundwater consumptive use and does not account for the lag-effects for the wells located within the hydrologically connected area. Figure 16 shows a comparison of the 25-year average groundwater depletions versus the 25-year average groundwater consumptive use.

Figure 16: Upper Platte River Basin, Lag Effect (based on 25-year averages)

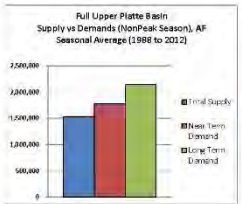


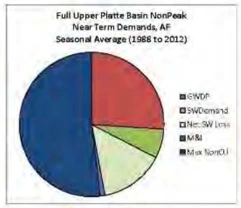
Because the only difference between near-term and long-term demands is the groundwater term, it holds that the only difference between the near-term excess supply and long-term excess supply is also the groundwater term. Therefore, the magnitude of difference between near-term and long-term demands (shown in Figure 16) is the same as the magnitude of difference between the near-term and long-term excess supplies.

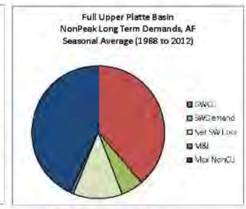
4.0 Nature and Extent of Use

The nature and extent of use are displayed in pie charts and provide information on the general distribution of water demands for a given basin. These pie charts provide information on the relative magnitude of each demand within a subbasin and easily identifies the driver of demands in a subbasin. This is another powerful informational tool as it can help target management or conservation efforts toward the demands where the biggest impact can be made. The pie charts also include a piece showing the excess supply. If the pie piece associated with the excess supply is gold in color, then the excess supply is a positive number and supplies exceed demands in the subbasin. If the pie piece associated with excess supply is black-hatched in color, then the excess supply is a negative number and the demands exceed the supply. Figures 17 through 23 show the nature and extent of use in each subbasin in the Upper Platte River Basin.

Figure 17: Nature and Extent of Use: Full Upper Platte Basin







Supply, AF

Streamflow (Gain)	981,120
GWDP	462,645
SWCU	90,271
Total Supply	1,534,036

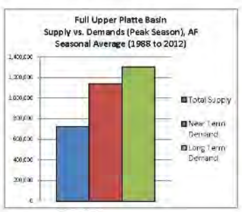
Total Supply	1,534,036
Near Term	1,775,061
Long Term	2,141,493

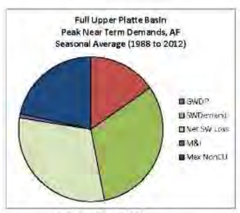
Near Term Demand, AF

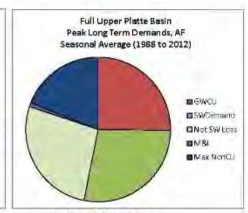
GWDP	462,645
SWDemand	115,791
Net SW Loss	256,399
M&I	18,579
Max NonCU	921,647
Excess Supply	(241,025)
Total Near Term Demand	1,775,061

Long Term Demand, AF

GWCU	829,077
SWDemand	115,791
Net SW Loss	256,399
M&I	18,579
Max NonCU	921,647
Excess Supply	(607,457)
Total Long Term Demand	2,141,493







Supply, AF

Streamflow (Gain)	305,186
GWDP	187,527
SWCU	231,647
Total Supply	724,359

Total Supply	724,359
Near Term	1,139,667
Long Term	1,301,821

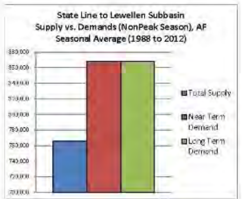
Near Term Demand, AF

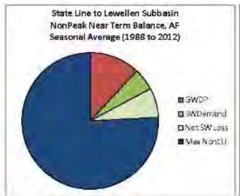
GWDP	187,527
SWDemand	389,304
Net SW Loss	375,817
M&I	11,080
Max NonCU	264,887
Excess Supply	(415,308)
MAC Storage Offset	(88,948)
Total Near Term Demand	1,139,667

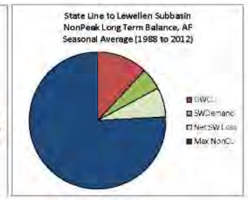
Long Term Demand, AF

GWCU	349,681
SWDemand	389,304
Net SW Loss	375,817
M&I	11,080
Max NonCU	264,887
Excess Supply	(577,462)
MAC Storage Offset	(88,948)
Total Long Term Demand	1,301,821

Figure 18: Nature and Extent of Use: North Platte River, State Line to Lewellen Subbasin







Supply, AF

Streamflow (Gain)	637,306
GWDP	103,772
SWCU	24,612
Total Supply	765,689

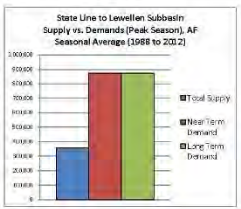
Near Term Demand; Sutherland Scenario 1, AF

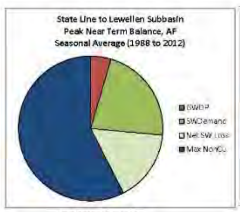
GWDP	103,772
SWDemand	45,258
Net SW Loss	60,561
Max NonCU	658,401
Excess Supply	(102,302)
Total Near Term Demand	867,991

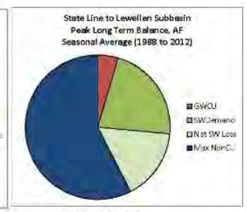
Long Term Demand; Sutherland Scenario 1, AF

GWCU	103,772
SWDemand	45,258
Net SW Loss	60,561
Max NonCU	658,401
Excess Supply	(102,302)
Total Long Term Demand	867,991

Total Supply	765,689
Near Term	867,991
Long Term	867,991







Supply, AF

Streamflow (Gain)	219,544
GWDP	39,794
SWCU	99,315
Total Supply	358,653

Near Term Demand; Sutherland Scenario 1, AF

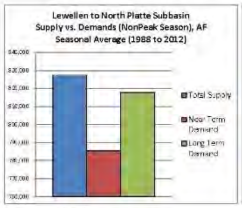
GWDP	39,794
SWDemand	191,258
Net SW Loss	139,854
Max NonCU	502,363
Excess Supply	(514,616)
Total Near Term Demand	873,269

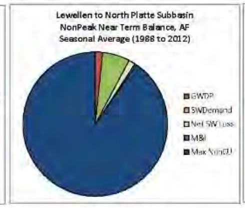
Long Term Demand; Sutherland Scenario 1, AF

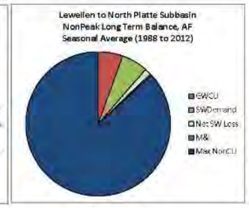
GWCU	39,794
SWDemand	191,258
Net SW Loss	139,854
Max NonCU	502,363
Excess Supply	(514,616)
Total Long Term Demand	873,269

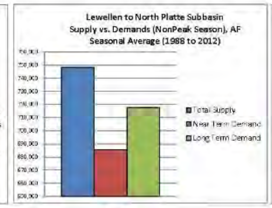
Total Supply	358,653
Near Term	873,269
Long Term	873,269

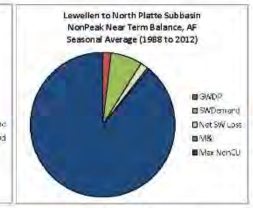
Figure 19: Nature and Extent of Use: North Platte River, Lewellen to North Platte Subbasin

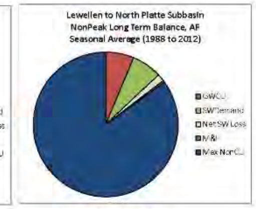












Supply; Sutherland Scenario 1, AF

Streamflow (Gain)	187,484
GWDP	12,912
SWCU	47,169
Req. Inflow	579,910
Total Supply	827,476

Total Supply	827,476
Near Term	785,541
Long Term	817,754

Near Term Demand; Sutherland Scenario 1, AF

GWDP	12,912
SWDemand	48,049
Net SW Loss	11,870
M&I	3,074
Max NonCU	709,635
Excess Supply	41,935
Total Near Term Demand	785,541

Long Term Demand; Sutherland Scenario 1, AF

GWCU	45,126
SWDemand	48,049
Net SW Loss	11,870
M&I	3,074
Max NonCU	709,635
Excess Supply	9,722
Total Long Term Demand	817,754

Supply; Sutherland Scenario 2, AF

Streamflow (Gain)	187,484
GWDP	12,912
SWCU	47,169
Req. Inflow	500,778
Total Supply	748,344

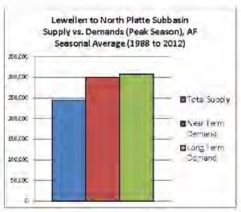
Total Supply	748,344
Near Term Demand	685,591
Long Term Demand	717,804

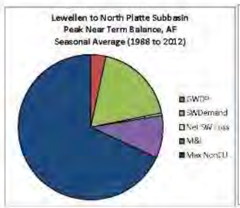
Near Term Demand; Sutherland Scenario 2, AF

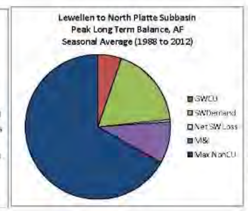
GWDP	12,912
SWDemand	48,049
Net SW Loss	11,870
M&I	3,074
Max NonCU	609,685
Excess Supply	62,754
Total Near Term Demand	685,591

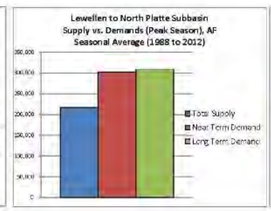
Long Term Demand; Sutherland Scenario 2, AF

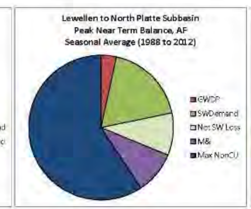
GWCU	45,126
SWDemand	48,049
Net SW Loss	11,870
M&I	3,074
Max NonCU	609,685
Excess Supply	30,540
Total Long Term Demand	717,804

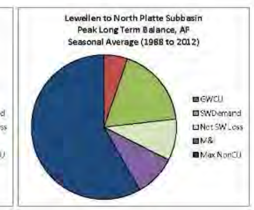












Supply; Sutherland Scenario 1, AF

Streamflow (Gain)	(11,421)
GWDP	12,343
SWCU	54,253
Req. Inflow	190,122
Total Supply	245,298

Total Supply	245,298
Near Term	300,423
Long Term Demand	307,467

Near Term Demand; Sutherland Scenario 1, AF

GWDP	12,343
SWDemand	66,507
Net SW Loss	1,852
M&I	34,366
Max NonCU	245,856
Excess Supply	(55,126)
MAC Storage Offset	(60,502)
Total Near Term Demand	300,423

Long Term Demand; Sutherland Scenario 1, AF

GWCU	19,387
SWDemand	66,507
Net SW Loss	1,852
M&I	34,366
Max NonCU	245,856
Excess Supply	(62,169)
MAC Storage Offset	(60,502)
Total Long Term Demand	307,467

Supply; Sutherland Scenario 2, AF

Streamflow (Gain)	(11,421)
GWDP	12,343
SWCU	54,253
Req. Inflow	162,013
Total Supply	217,189

Total Supply	217,189
Near Term Demand	302,295
Long Term Demand	309,339

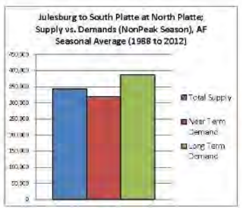
Near Term Demand; Sutherland Scenario 2, AF

GWDP	12,343
SWDemand	66,507
Net SW Loss	34,366
M&I	34,366
Max NonCU	215,213
Excess Supply	(85,106)
MAC Storage Offset	(60,502)
Total Near Term Demand	302,295

Long Term Demand; Sutherland Scenario 2, AF

GWCU	19,387
SWDemand	66,507
Net SW Loss	34,366
M&I	34,366
Max NonCU	215,213
Excess Supply	(97,150)
MAC Storage Offset	(60,502)
Total Long Term Demand	309,339

Figure 20: Nature and Extent of Use: South Platte River, State Line to North Platte Subbasin

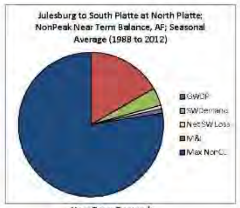


Supply, AF

Streamflow (Gain)	277,681
GWDP	53,189
SWCU	12,665
Total Supply	343,535

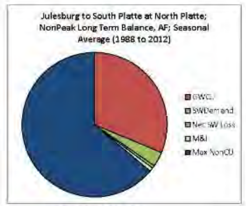
Sutherland Scenario 1, AF

Total Supply	343,535
Near Term	319,189
Long Term	387,255



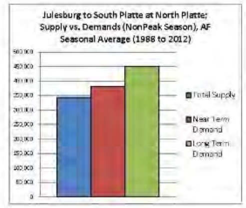
Near Term Demand; Sutherland Scenario 1, AF

GWDP	53,189
SWDemand	12,810
Net SW Loss	2,492
M&I	3,221
Max NonCU	247,476
Excess Supply	24,346
Total Near Term Demand	319,189



Long Term Demand; Sutherland Scenario 1, AF

GWCU	121,255
SWDemand	12,810
Net SW Loss	2,492
M&I	3,221
Max NonCU	247,476
Excess Supply	(43,719)
Total Long Term Demand	387,255

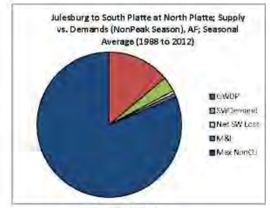


Supply, AF

Streamflow (Gain)	277,681
GWDP	53,189
SWCU	12,665
Total Supply	343,535

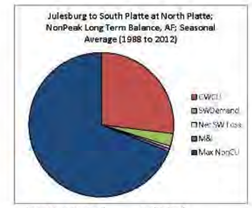
Sutherland Scenario 2, AF

Total Supply	343,535
Near Term Demand	381,901
Long Term Demand	449,967



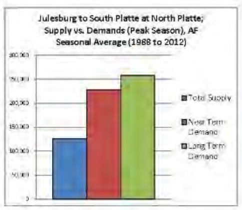
Near Term Demand; Sutherland Scenario 2, AF

GWDP	53,189
SWDemand	12,810
Net SW Loss	2,492
M&I	3,221
Max NonCU	310,189
Excess Supply	(38,366)
Total Near Term Demand	381,901



Long Term Demand; Sutherland Scenario 2, AF

GWCU	121,255
SWDemand	12,810
Net SW Loss	2,492
M&I	3,221
Max NonCU	310,189
Excess Supply	(106,432)
Total Long Term Demand	449,967

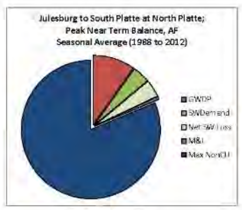


Supply, AF

Streamflow (Gain)	96,326
GWDP	22,392
SWCU	7,306
Total Supply	126,024

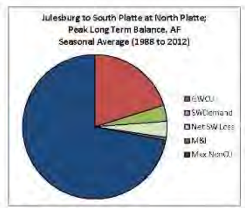
Sutherland Scenario 1, AF

Total Supply	126,024
Near Term	228,424
Long Term	257,998



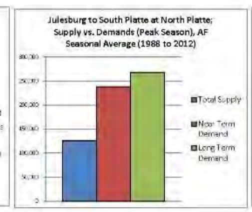
Near Term Demand; Sutherland Scenario 1, AF

GWDP	22,392
SWDemand	9,327
Net SW Loss	9,290
M&I	1,666
Max NonCU	185,748
Excess Supply	(102,400)
Total Near Term Demand	228,424



Long Term Demand; Sutherland Scenario 1, AF

GWCU	51,966
SWDemand	9,327
Net SW Loss	9,290
M&I	1,666
Max NonCU	185,748
Excess Supply	(131,974)
Total Long Term Demand	257,998

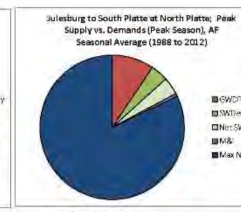


Supply, AF

Streamflow (Gain)	96,326
GWDP	22,392
SWCU	7,306
Total Supply	126,024

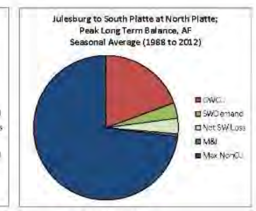
Sutherland Scenario 2, AF

Total Supply	126,024
Demand	238,166
Long Term Demand	267,740



Near Term Demand; Sutherland Scenario 2, AF

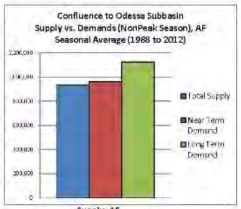
GWDP	22,392
SWDemand	9,327
Net SW Loss	9,290
M&I	1,666
Max NonCU	195,490
Excess Supply	(112,142)
Total Near Term Demand	238,166

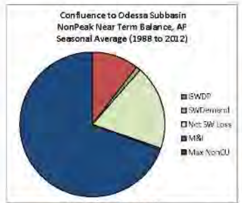


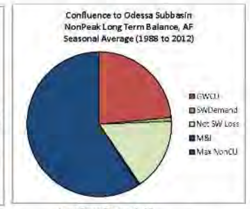
Long Term Demand; Sutherland Scenario 2, AF

GWCU	51,966
SWDemand	9,327
Net SW Loss	9,290
M&I	1,666
Max NonCU	195,490
Excess Supply	(141,716)
Total Long Term Demand	267,740

Figure 21: Nature and Extent of Use: Platte River, Confluence to Odessa Subbasin







Supply, AF

Streamflow (Gain)	64,579
GWDP	100,128
SWCU	5,825
Req. Inflow	764,521
Total Supply	935,053

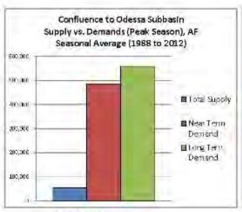
Total Supply	935,053
Near Term	960,580
Long Term	1,124,583

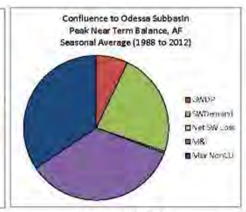
Near Term Demand, AF

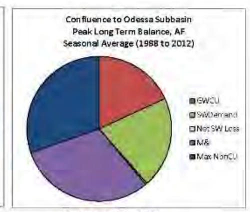
GWDP	100,128
SWDemand	9,673
Net SW Loss	181,476
M&I	3,812
Max NonCU	665,491
Excess Supply	(25,527)
Total Near Term Demand	960,580

Long Term Demand, AF

GWCU	264,131
SWDemand	9,673
Net SW Loss	181,476
M&I	3,812
Max NonCU	665,491
Excess Supply	(189,530)
Total Long Term Demand	1,124,583







Supply, AF

Streamflow (Gain)	(239,089)
GWDP	39,064
SWCU	74,137
Req. Inflow	179,559
Total Supply	53,672

Total Supply	53,672
Near Term	485,609
Long Term	559,744

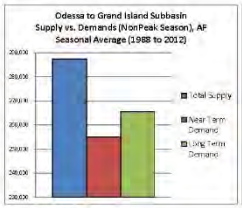
Near Term Demand, AF

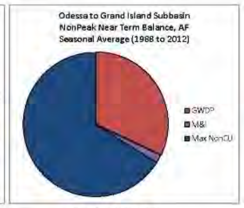
GWDP	39,064
SWDemand	127,732
Net SW Loss	2,088
M&I	192,306
Max NonCU	189,594
Excess Supply	(431,938)
Mac Offset	(65,175)
Total Near Term Demand	485,609

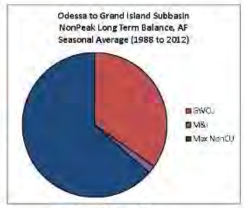
Long Term Demand, AF

GWCU	113,199
SWDemand	127,732
Net SW Loss	2,088
M&I	192,306
Max NonCU	189,594
Excess Supply	(506,073)
Mac Offset	(65,175)
Total Long Term Demand	559,744

Figure 22: Nature and Extent of Use: Platte River, Odessa to Grand Island Subbasin







Supply, AF

Streamflow (Gain)	51,795
GWDP	81,583
SWCU	0
Req. Inflow	154,073
Total Supply	287,451

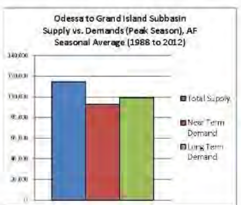
Total Supply	287,451
Near Term	255,007
Long Term	265,555

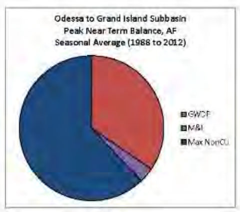
Near Term Demand, AF

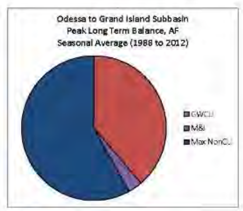
GWDP	81,583
SWDemand	0
M&I	4,667
Max NonCU	168,757
Excess Supply	32,445
Total Near Term Demand	255,007

Long Term Demand, AF

GWCU	92,132
SWDemand	0
M&I	4,667
Max NonCU	168,757
Excess Supply	21,896
Total Long Term Demand	265,555







Supply, AF

Streamflow (Gain)	43,136
GWDP	32,053
SWCU	0
Req. Inflow	39,347
Total Supply	114,535

Total Supply	114,535
Near Term	92,866
Long Term	99,292

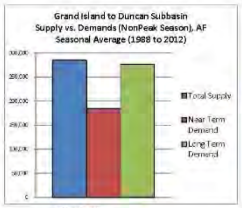
Near Term Demand, AF

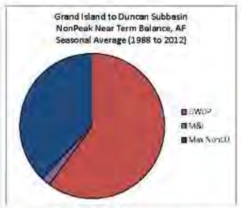
GWDP	32,053
SWDemand	0
M&I	3,117
Max NonCU	57,696
Excess Supply	21,670
Total Near Term Demand	92,866

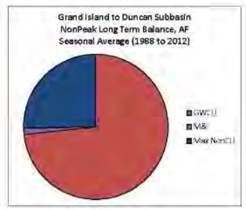
Long Term Demand, AF

GWCU	38,478
SWDemand	0
M&I	3,117
Max NonCU	57,696
Excess Supply	15,244
Total Long Term Demand	99,292

Figure 23: Nature and Extent of Use: Platte River, Grand Island to Duncan Subbasin







Supply, AF

Streamflow (Gain)	169,076
GWDP	111,061
SWCU	0
Req. Inflow	4,160
Total Supply	284,296

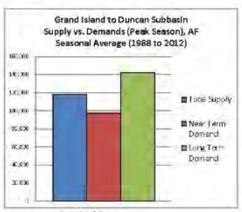
Total Supply	284,296
Near Term	184,900
Long Term	276,501

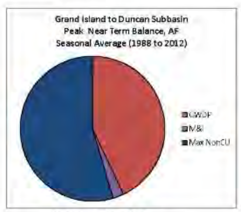
Near Term Demand, AF

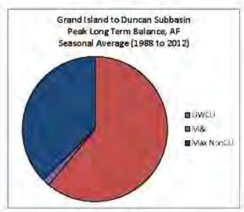
GWDP	111,061
SWDemand	0
M&I	3,806
Max NonCU	70,033
Excess Supply	99,396
Total Near Term Demand	184,900

Long Term Demand, AF

GWCU	202,662
SWDemand	0
M&I	3,806
Max NonCU	70,033
Excess Supply	7,795
Total Long Term Demand	276,501







Supply, AF

Streamflow (Gain)	62,912
GWDP	41,880
SWCU	0
Req. Inflow	13,479
Total Supply	118,271

Total Supply	118,271
Near Term	97,469
Long Term	142,444

Near Term Demand, AF

GWDP	41,880
M&I	2,357
Max NonCU	53,232
Excess Supply	20,802
Total Near Term Demand	97,469

Long Term Demand, AF

GWCU	86,855
M&I	2,357
Max NonCU	53,232
Excess Supply	(24,173)
Total Long Term Demand	142,444

APPENDIX A – SUMMARY OF KEY ASSUMPTIONS AND DEFINITIONS

Summary of Key Assumptions and Methods for Calculations in Support of Identifying the Overall Difference between the Current and Fully Appropriated Levels of Development

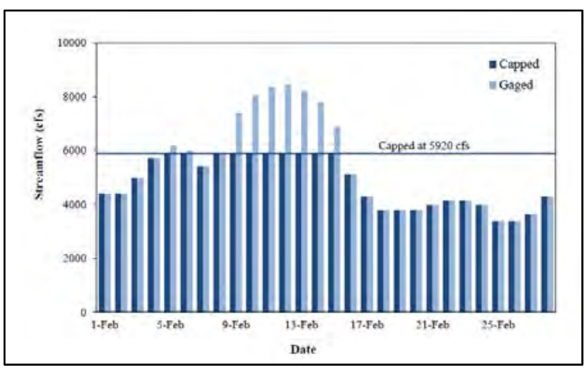
Water Supplies

For purposes of the evaluation methodology, the water supplies consist of the summation of streamflows, surface water consumptive uses, and groundwater depletions. Water supplies were tabulated for the period of 1988 – 2012 to represent naturally occurring wet and dry cycles. Required inflows are also included in the water supplies when evaluating individual sub-basins, but not when evaluating the entire overappropriated basin. Further description of each element of the water supply is provided below.

Streamflows– streamflows are the measured streamflow of the basin with the exception that mean daily flows in excess of the five-percent exceedance probability are capped at the five-percent exceedance value (see Figure 1)[1]. The streamflows for a sub-basin are calculated by subtracting the upstream gage from the downstream gage to establish the gain/loss in streamflow for each sub-basin. The exceptions are as follows:

- Lewellen Streamflow = Uncapped Lewellen gage
- South Platte Streamflow = Capped South Platte River at North Platte gage + Historic Korty Diversion
- North Platte Streamflow Gain = Capped North Platte gage + 40 cfs – Capped Keystone gage. (This was done to prevent Lake MAC operations from influencing the analysis.)
- Odessa Streamflow Gain = Capped Odessa gage – Capped "Streamflow at Confluence" of North Platte & South Platte Rivers + Kearney Diversion where the "Streamflow at Confluence" = North Platte River at North Platte + South Platte River at North Platte + Sutherland Return

Figure 1: Example of an Exceedance Plot and the Result from Capping Streamflows at the five-percent Exceedance Flow Probability (Source: "INSIGHT Methods" 2015)



[1] **Note: This is not done at Lewellen because Lake MAC does have the capacity to capture extreme events.**

Groundwater Depletions – Groundwater depletions within the overappropriated portion of the Platte River Basin were calculated using the COHYST and WWUM to estimate the total impact groundwater pumping has had on streamflows through the period of record evaluated in the analysis (1988-2012).

Historical groundwater pumping and surface water deliveries within the COHYST model area which determined based on crop demands. Groundwater was used to meet the portion of crop demand that could not be met by surface water deliveries.

Surface Water Consumptive Use[2] – The surface water consumptive use aims to identify the level of consumption that occurred as a result of surface water diversions for irrigation and evaporation from major reservoirs (Lake McConaughy, Lake Maloney, Elwood Reservoir, Jeffery Reservoir, and Johnson Reservoir). The surface water consumption that was calculated for each canal included in the analysis was generally estimated from crop irrigation demands and the acreage that is served by surface water within each irrigation district. Surface water consumption was calculated for all major canals in the overappropriated portion of the Platte River Basin with the exception of Pathfinder Irrigation District, Gering-Fort Laramie, Mitchell-Gering, and Tri-State canals that divert from the North Platte River in the proximity of the Nebraska-Wyoming state line. The surface water consumptive use from these canals was not included in the water supply calculations and was also excluded from the consumptive surface water demand calculations. The models used to estimate surface water consumptive use represent historic irrigation practices.

Required Inflows – Required inflows are included as part of the water supply for each sub-basin with the exception of the two sub-basins (North Platte River Stateline to Lewellen and South Platte River Stateline to North Platte) that initiate from the state line. Required inflows represent the portion of water supply that flows from upstream locations to assist in meeting a portion of demands in downstream locations. The process for determining the portion of demands that is met by required inflows is based on determining each upstream subbasins proportional contribution to the overall water supply available in the downstream subbasin.

Water Demands

For purposes of the evaluation methodology, the water demands consist of the summation of consumptive use demands for irrigation, municipal, and industrial uses that are served by groundwater or surface water, net surface water loss, hydropower, instream flows, and downstream demands. Further description of each element of the water demands is provided below.

[2] . Note: There are still three years (1993, 1995 and 1999) that the SW CU exceeds the demand in the WWUM. ARI would need more time to refine the splits for GW Pumping to CU on comingled acres versus the SW diversions to CU on comingled acres.

Consumptive Surface Water Demands[3] – The demands for surface water include those for irrigation and evaporation as no significant municipal or industrial uses occur in the area. The models used to estimate surface water demands assume commingled lands are irrigated with groundwater. The demands are calculated by multiplying the surface water irrigated acres by the consumptive use estimates (irrigation requirements). Additionally, the temporal distribution of surface water demands differs from surface water consumptive use in that surface water demands that have access to water stored in reservoirs are redistributed from the peak season (June – August) to the non-peak season (September – May). SWD has been defined as the greater of either SWCU or the product of surface water irrigated acreage and the NIR for corn. The COHYST utilized the BL001 run data which assumed that comingled acres were fully met by groundwater. Also, BL001 repeats year 2005 land use post 2005.

Consumptive Demands for Hydrologically Connected Groundwater (Long-Term Groundwater Demands)[4] – The demands for hydrologically connected groundwater are based on consumptive use estimates (irrigation requirements) multiplied by groundwater irrigated acres and commingled acres within the hydrologically connected area (10/50 area). The COHYST utilized the BL001 run data which assumed that comingled acres were fully met by groundwater. BL001 varies land use, acreage, and climate from year-to-year through 2005. Post 2005, BL001 repeats year 2005 land use and acreage but varies climate. For the WWUM area groundwater demands were set equal to groundwater depletions since groundwater depletions were often in excess of the groundwater demands[5]. The seasonal distribution of groundwater demands assigns 70% of the demands to the non-peak season (September – May) and 30% to the peak season (June – August). The split is current condition, and may shift in the future to more peak season depletions (60/40, 50/50, etc.) in coming years as aquifers are depleted.

Lake McConaughy Change-in-Storage- Non-peak season change-in-storage is used to reduce peak season uses that hold storage water rights in Lake MAC. These demands are not reassigned to the non-peak season (break from INSIGHT methodology)

Demands for Net Surface Water Loss – The demands for net surface water loss represent the seepage loss to the aquifer during transport of surface water through canal systems and losses at the field for surface water irrigated lands. This loss was estimated based on the difference between modeled head-gate diversions and surface water demands (the consumptive portion of diversions)[6].

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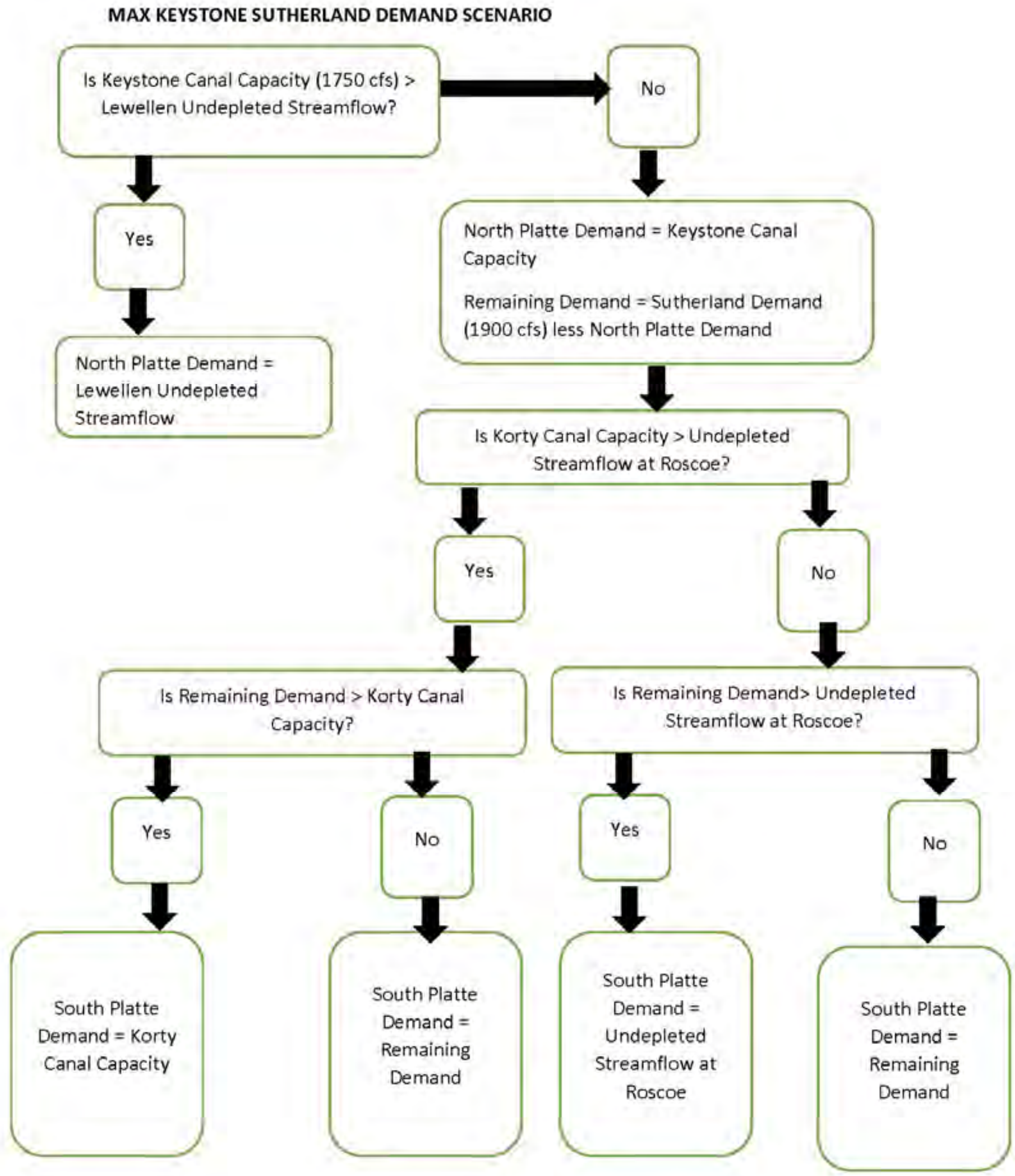
[3] In the COHYST area, SW demands for canals that may span more than one subbasin can be assigned to the point of diversion.
[4] ARI has indicated that M&I pumping has been included in the provided data. TFG has provided M&I as a separate dataset. The TFG M&I data only goes through 2005; therefore, 2005 was repeated through 2012.
[5] This was done because in some cases the GWDP > GWCU which was counterintuitive. This occurs more frequently in the WWUM area than the COHYST area. This issue could be investigated further in future analysis.
[6] Reservoir seepage was not considered as it is assumed this seepage is not a "demand" that must be satisfied in order to convey water in this System. Additionally, this seepage water returns to the System as baseflow/groundwater.

<u>Demands for Hydropower –</u> Hydropower demands are represented for the Sutherland hydropower facility, CNPPID hydropower facilities (Jeffery, J-1, and J-2, with the Kingsley Hydropower excluded)[7], and Kearney hydropower facility. The demands for hydropower are represented by summing the streamflow and groundwater depletions (undepleted streamflow) available at the point of diversion and comparing that value to the lesser of the canal capacity or water right. Once the lesser of the undepleted stream, canal capacity, or water right has been established, the final step in calculating the hydropower demand is to integrate the surface water irrigation demands with the hydropower demands to ensure that the combination of demands does not exceed the canal capacity. If the combined demands exceed the canal capacity then the hydropower demands are further reduced to the canal capacity.

Two Sutherland demands scenarios were considered in order to "bookend" the demands that could be placed on either the North Platte or South Platte subbasin. The Keystone demand scenario is shown below. The Korty Demand Scenario reverses this process.

[7] Lake McConaughy is assumed to operate to satisfy the CNPPID demand; therefore, the CNPPID downstream demand was applied to the North Platte Subbasin instead of applying the full Lake McConaughy hydropower demand.



Undepleted streamflow at Lewellen = Uncapped streamflow at Lewellen gage + GWDP above Lewellen gage.

Undepleted streamflow at Roscoe = [South Platte River at Paxton] + [Reach Gain Loss from Roscoe to North Platte] + [South Platte River GWDP].

Demands for Instream Flows – Instream flow demands are represented in a similar manner to that of hydropower demands. Similar to hydropower demands the daily undepleted streamflow is calculated at the instream flow location and capped at the daily instream flow appropriation value. If the daily undepleted streamflow does not meet the instream flow appropriation, then the daily instream flow demand is capped to the undepleted streamflow. The final adjustment is to subtract the volume of consumption associated with upstream groundwater development in place at the time the appropriation was granted (i.e., 1993) to create a final volume of instream flow demand.

Demands for Downstream Uses – Downstream demands for the overappropriated basin consist of a portion (based on the proportion of overappropriated basin water supplies relative to the water supplies at downstream locations) of downstream mainstem surface water and net surface water loss demands within the central and lower Platte River Basin plus a portion of the greater of instream flow or induced recharge appropriations located in the central and lower Platte River Basin. Downstream demands within the overappropriated basin vary based on location and the demands located downstream of that subbasin.

Tri-County Non-consumptive & Surface Water Demand Split: The Tri-County Canal serves both surface water and non-consumptive use demands. In some cases, the surface water demands are located upstream the non-consumptive use demands; therefore, it was necessary to consider the surface water and non-consumptive use demands separately for this canal. These demands were broken out as follow:

- **Full Tri-County Demand** = Minimum of [Canal losses above Brady + Max (surface water demands or CNPPID hydropower demand) OR Undepleted streamflow at Confluence of North Platte & South Platte Rivers]
- **Tri-County Non-consumptive Use Demand** = Full Tri-County Demand – Tri-County SW Demand – Tri-County Canal seepage

The Balance of Water Supplies and Water Demands

The evaluation methodology seeks to compare the water supplies and water demands for two periods throughout the year. The peak season (June – August) and non-peak season (September – May) are used to assess the balance in water supplies and water uses. These comparisons evaluate the average balance in water supplies and water demands over the most recent twenty-five year period of data (1988-2012) to assess how wet and dry cycles impact the balance in water supplies and water demands.

APPENDIX B – INSIGHT ANALYSIS DATA SOURCES

North Platte River, State Line to Lewellen (Lewellen Subbasin)

	Component	Dataset	Source	File Name
Basin Water Supply	Streamflow	• North Platte River at Wyoming – Nebraska State Line • Horse Creek at Lyman, NE • Fort Laramie Canal from North Platte River • Mitchell Gering from North Platte River • Interstate Canal from North Platte River • North Platte River at Lewellen, NE	• USGS 6674500 (1987 to 2009) • USGS/DNR 6677500 • DNR 52200 • DNR 101100 • DNR 71000 • USGS 6887500	Spreadsheets 'Diff_Curr_Fully_Gage_Data.xlsx' and 'StateLineFlows_042015.xlsx'
	Surface Water[2,3] Consumptive Use	Monthly surface water consumptive use from deliveries and stored surface water soil moisture	Adaptive Resources Inc. / Western Water Use Model	Spreadsheet 'WWUM_SWCU_InlandLakeEvap_ Diversions_NetSWLoss__20150514.xlsx'
	Groundwater Depletions[1,3]	Groundwater Depletions to Streamflow	Adaptive Resources Inc. / Western Water Use Model (2014 Extension Run & FA Depletions Run)	Spreadsheet 'WWUM_SWCU_InlandLakeEvap_ Diversions_NetSWLoss__20150514.xlsx'
	Evaporation	Inland Lakes (Lake Minatare, Lake Alice 1 and 2, and Winters Creek Lake) monthly evaporation	Adaptive Resources Inc. / Western Water Use Model	Spreadsheet 'WWUM_SWCU_InlandLakeEvap_ Diversions_NetSWLoss__20150514.xlsx'
	Required Inflow	N/A – no upstream Subbasins	---	---
Total Demand	Surface Water Demand[2,3]	Surface Water Irrigated Acres Net Crop Irrigation Requirement	• Adaptive Resources Inc. • The Flatwater Group	Spreadsheet '10_50_Summariesv7.xlsx'
	Groundwater Consumptive Use[1,3]	Groundwater Irrigated Acres Net Crop Irrigation Requirement	• Adaptive Resources Inc. • The Flatwater Group	Spreadsheet '10_50_Summariesv7.xlsx'
	Instream Flow Demand	N/A – no instream flow demands in this Subbasin	----	----
	Hydropower Demand	N/A – no hydropower operations in this Subbasin	----	----
	Net Surface Water Loss[2]	Canal conveyance loss	Adaptive Resources Inc. / Western Water Use Model	Spreadsheet 'WWUM_SWCU_InlandLakeEvap_Diversions_ NetSWLoss__20150514.xlsx'
	Proportionate Downstream Demand	Demands from downstream Subbasins along Platte River to Louisville	DNR Methodology	Spreadsheet 'POAC_Refinements_2016Dec12.xlsx'

(1) Adaptive Resources Inc. indicates that municipal and industrial pumping is included in the provided groundwater consumptive use data.

(2) The Surface Water Consumptive Use, Surface Water Demand, and Net Surface Water Loss terms do not include those canals/acres served by the state line canals (Interstate, Gering-Ft. Laramie, and Mitchell-Gering).

(3) WWUM land use was obtained from Leonard Rice Engineers

North Platte River, Lewellen to North Platte (North Platte Subbasin)

Component		Dataset	Source	File Name
Basin Water Supply	Streamflow	• North Platte River at Keystone, NE • North Platte River at North Platte, NE	• USGS 6690500 • USGS 6693000	Spreadsheets 'Diff_Curr_Fully_Gage_Data.xlsx'
	Surface Water Consumptive Use	• Annual surface water consumptive use by canal[1] • Land Use	• STELLA Model SW04Nov2013[2] • CropSIM	Spreadsheets 'STELLA_SWIRRDemandsAll_1950-1970.xlsx'; 'STELLA_SWIRRDemandsAll_1971-1984.xlsx'; 'STELLA_SWIRRDemandsAll_1985-2005.xlsx'; 'STELLA_SWIRRDemandsAll_2006-2012.xlsx'
	Groundwater Depletions	Groundwater Depletions to Streamflow	DNR	Spreadsheet '051315_SDA_1950to2012_Depletion.xlsx'
	Evaporation	Lake McConaughy monthly evaporation	HPRCC/NWS	Spreadsheet 'KingsleyDam_HPRCC_EVAP_1948-2014'
	Required Inflow	Required Inflow from upstream Subbasin (*Lewellen*)	DNR Methodology	Spreadsheet 'POAC_Refinements_2016Dec12.xlsx'
Total Demand	Surface Water Demand	• Surface Water Irrigated Acres & Net Crop Irrigation Requirement • Land Use	• COHYST BL001 • CALMIT	Thumb drive provided by The Flatwater Group
	Groundwater Consumptive Use	• Surface Water Irrigated Acres & Net Crop Irrigation Requirement • Land Use	• COHYST BL001 • CALMIT	Thumb drive provided by The Flatwater Group
	Instream Flow Demand	N/A – There are no instream flow demands in this Subbasin	----	----
	Hydropower Demand	Sutherland hydropower demand[3, 4]	----	----
	Net Surface Water Loss	Canal conveyance loss[5]	STELLA Model SW04Nov2013	Spreadsheet 'Canal_Res_Seepage_1950-2012.xlsx'
	Proportionate Downstream Demand	Demands from downstream Subbasins along Platte River to Louisville	DNR Methodology	Spreadsheet 'POAC_Refinements_2016Dec12.xlsx'

(1) 93.3% of the annual surface water consumptive use was applied to the peak season and 6.7% to the non-peak season.

(2) The STELLA model surface water deliveries are multiplied by 65% to calculate the Surface Water Consumptive Use term.

(3) Two demand scenarios were evaluated for the Sutherland hydropower demand. One scenario maximizes the Keystone Canal and the other demand scenario maximizes the Korty Canal to satisfy the Sutherland demand.

(4) The CNPPID hydropower demand is applied to the North Platte Subbasin as a downstream demand in lieu of the Lake McConaughy hydropower demand.

(5) Canals in the North Platte Subbasin include Keith-Lincoln, North Platte, Paxton-Hershey, Cody Dillon, and Suburban Canals.

South Platte River, Julesburg to North Platte (South Platte Subbasin)

	Component	Dataset	Source	File Name
Basin Water Supply	Streamflow	• South Platte River at Julesburg, CO • South Platte River at North Platte, NE • Korty Canal from South Platte River	• USGS 6764000 • USGS 6765500 • DNR 6764900	Spreadsheets 'Diff_Curr_Fully_Gage_Data.xlsx'
	Surface Water Consumptive Use	• Annual surface water consumptive use by canal[1] • Land Use	• STELLA Model SW04Nov2013[2] • CropSIM	Spreadsheets 'STELLA_SWIRRDemandsAll_1950-1970.xlsx'; 'STELLA_SWIRRDemandsAll_1971-1984.xlsx'; 'STELLA_SWIRRDemandsAll_1985-2005.xlsx'; 'STELLA_SWIRRDemandsAll_2006-2012.xlsx'
	Groundwater Depletions	Groundwater Depletions to Streamflow	DNR	Spreadsheet '051315_SDA_1950to2012_Depletion.xlsx'
	Evaporation	Monthly evaporation for Sutherland and Maloney Reservoirs	HDR	Spreadsheet '20131206_Reservoir_SA_NetEvap.xlsx'
	Required Inflow	N/A – There are no upstream Subbasins	----	----
Total Demand	Surface Water Demand	• Surface Water Irrigated Acres & Net Crop Irrigation Requirement • Land Use	• COHYST BL001 • CALMIT	Thumb drive provided by The Flatwater Group
	Groundwater Consumptive Use	• Surface Water Irrigated Acres & Net Crop Irrigation Requirement • Land Use	• COHYST BL001 • CALMIT	Thumb drive provided by The Flatwater Group
	Instream Flow Demand	N/A – There are no instream flow demands in this Subbasin	----	----
	Hydropower Demand	Sutherland hydropower demand[3]	----	----
	Net Surface Water Loss	Canal conveyance loss[4]	STELLA Model SW04Nov2013	Spreadsheet 'Canal_Res_Seepage_1950-2012.xlsx'
	Lake McConaughy	Change in Storage data for reducing peak-season demands for those canals with storage water rights	CNPPID	Spreadsheet 'Daily2.xlsx'
	Proportionate Downstream Demand	Demands from downstream Subbasins along Platte River to Louisville	DNR Methodology	Spreadsheet 'POAC_Refinements_2016Dec12.xlsx'

(1) 93.3% of the annual surface water consumptive use was applied to the peak season and 6.7% to the non-peak season.

(2) The STELLA model surface water deliveries are multiplied by 65% to calculate the Surface Water Consumptive Use term.

(3) Two demand scenarios were evaluated for the Sutherland hydropower demand. One scenario maximizes the Keystone Canal and the other demand scenario maximizes the Korty Canal to satisfy the Sutherland demand.

(4) The Western Canal is located in the South Platte Subbasin.

Platte River, Confluence to Odessa (Odessa Subbasin)

Component		Dataset	Source	File Name
Basin Water Supply	Streamflow	• North Platte River at North Platte, NE • South Platte River at North Platte, NE • Sutherland Return to South Platte River • Platte River at Odessa, NE • Kearney Canal from Platte River	• USGS 6693000 • USGS 6765500 • DNR 140000 • USGS 6770000 • DNR 73000	Spreadsheets 'Diff_Curr_Fully_Gage_Data.xlsx'
	Surface Water Consumptive Use	• Annual surface water consumptive use by canal[1] • Land Use	• STELLA Model SW04Nov2013[2] • CropSIM	Spreadsheets 'STELLA_SWIRRDemandsAll_1950-1970.xlsx'; 'STELLA_SWIRRDemandsAll_1971-1984.xlsx'; 'STELLA_SWIRRDemandsAll_1985-2005.xlsx'; 'STELLA_SWIRRDemandsAll_2006-2012.xlsx'
	Groundwater Depletions	Groundwater Depletions to Streamflow	DNR	Spreadsheet '051315_SDA_1950to2012_Depletion.xlsx'
	Evaporation	Monthly evaporation for Elwood Reservoir	HDR	Spreadsheet '20131206_Reservoir_SA_NetEvap.xlsx'
	Required Inflow	Required Inflow from upstream Subbasins (*South Platte, Lewellen, and North Platte*)	DNR Methodology	Spreadsheet 'POAC_Refinements_2016Dec12.xlsx'
Total Demand	Surface Water Demand	• Surface Water Irrigated Acres & Net Crop Irrigation Requirement • Land Use	• COHYST BL001 • CALMIT	Thumb drive provided by The Flatwater Group
	Groundwater Consumptive Use	• Surface Water Irrigated Acres & Net Crop Irrigation Requirement • Land Use	• COHYST BL001 • CALMIT	Thumb drive provided by The Flatwater Group
	Instream Flow Demand	Maximum of Overton or Odessa Instream Flow Demand	DNR Methodology	Spreadsheet 'POAC_Refinements_2016Dec12.xlsx'
	Hydropower Demand	Maximum of CNPPID Hydropower Demand or Kearney Hydropower Demand	Water Right and DNR Methodology[3]	Spreadsheet 'POAC_Refinements_2016Dec12.xlsx'
	Net Surface Water Loss	Canal conveyance loss[4]	STELLA Model SW04Nov2013	Spreadsheet 'Canal_Res_Seepage_1950-2012.xlsx'
	Proportionate Downstream Demand	Demands from downstream Subbasins along Platte River to Louisville	DNR Methodology	Spreadsheet 'POAC_Refinements_2016Dec12.xlsx'

(1) 93.3% of the annual surface water consumptive use was applied to the peak season and 6.7% to the non-peak season.
(2) The STELLA model surface water deliveries are multiplied by 65% to calculate the Surface Water Consumptive Use term.
(3) The hydropower demand is capped to the undepleted streamflow at the confluence of the North and South Platte rivers for the CNPPID hydropower demand or undepleted streamflow at Overton for the Kearney hydropower demand.
(4) Canals in the Odessa Subbasin include Tri-County, Kearney, Cozad, Dawson, Gothenburg, Orchard-Alfalfa, Six Mile, and Thirty Mile Canals.

Platte River, Odessa to Grand Island (Grand Island Subbasin)

	Component	Dataset	Source	File Name
Basin Water Supply	Streamflow	• Platte River at Odessa, NE • Platte River near Grand Island, NE	• USGS 6770000 • USGS 6770500	Spreadsheets ‘Diff_Curr_Fully_Gage_Data.xlsx’
	Surface Water Consumptive Use	N/A – There are no surface water demands in this Subbasin	----	----
	Groundwater Depletions	Groundwater Depletions to Streamflow	DNR	Spreadsheet ‘051315_SDA_1950to2012_Depletion.xlsx’
	Required Inflow	Required Inflow from upstream Subbasins (*South Platte, Lewellen, North Platte, and Odessa*)	DNR Methodology	Spreadsheet ‘POAC_Refinements_2016Dec12.xlsx’
Total Demand	Surface Water Demand	N/A – There are no surface water demands in this Subbasin	----	----
	Groundwater Consumptive Use	• Surface Water Irrigated Acres & Net Crop Irrigation Requirement • Land Use	• COHYST BL001 • CALMIT	Thumb drive provided by The Flatwater Group
	Instream Flow Demand	Grand Island Instream Flow Demand	Water Right & DNR Methodology	Spreadsheet ‘POAC_Refinements_2016Dec12.xlsx’
	Hydropower Demand	N/A – There are no hydropower demands in this Subbasin	----	----
	Net Surface Water Loss	N/A – There are no surface water canals in this Subbasin	----	----
	Proportionate Downstream Demand	Demands from downstream Subbasins along Platte River to Louisville	DNR Methodology	Spreadsheet ‘POAC_Refinements_2016Dec12.xlsx’

Platte River, Grand Island to Duncan (Duncan Subbasin)

	Component	Dataset	Source	File Name
Basin Water Supply	Streamflow	• Platte River near Grand Island, NE • Platte River near Duncan, NE	• USGS 6770500 • USGS 6774000	Spreadsheets 'Diff_Curr_Fully_Gage_Data.xlsx'
	Surface Water Consumptive Use	N/A – There are no surface water demands in this Subbasin	----	----
	Groundwater Depletions	Groundwater Depletions to Streamflow	DNR	Spreadsheet '051315_SDA_1950to2012_Depletion.xlsx'
	Required Inflow	Required Inflow from upstream Subbasins (*South Platte, Lewellen, North Platte, Odessa, and Grand Island*)	DNR Methodology	Spreadsheet 'POAC_Refinements_2016Dec12.xlsx'
Total Demand	Surface Water Demand	N/A – There are no surface water demands in this Subbasin	----	----
	Groundwater Consumptive Use	• Surface Water Irrigated Acres & Net Crop Irrigation Requirement • Land Use	• COHYST BL001 • CALMIT	Thumb drive provided by The Flatwater Group
	Instream Flow Demand	Duncan Instream Flow Demand	Water Right & DNR Methodology	Spreadsheet 'POAC_Refinements_2016Dec12.xlsx'
	Hydropower Demand	N/A – There are no hydropower demands in this Subbasin	----	----
	Net Surface Water Loss	N/A – There are no surface water canals in this Subbasin	----	----
	Proportionate Downstream Demand	Demands from downstream Subbasins along Platte River to Louisville	DNR Methodology	Spreadsheet 'POAC_Refinements_2016Dec12.xlsx'

B

Appendix B

ROBUST REVIEW ANALYSES

2019

Upper Platte Basin Robust Review

A REPORT ON MANAGEMENT ACTIVITIES AIMED AT FULFILLING THE GOALS AND OBJECTIVES OF THE UPPER PLATTE BASIN-WIDE PLAN, THE UPPER PLATTE BASIN INDIVIDUAL NRD IMPS, AND THE NEBRASKA NEW DEPLETIONS PLAN

Preface

The Nebraska Department of Natural Resources (NeDNR), working in conjunction with the five Upper Platte River Basin natural resources districts (Upper Platte Basin NRDs) through the Platte Overappropriated Area Committee (POAC), have published this report to provide an update on management activities aimed at fulfilling the goals and objectives of the *Basin-Wide Plan for Joint Integrated Water Resources Management of Overappropriated Portions of the Platte River Basin, Nebraska* (BWP); NRD-level integrated management plans (IMPs); and the Nebraska New Depletion Plan (NNDP) for the Platte River Recovery Implementation Program (PRRIP). This report is a comprehensive update to the report, *Estimated Stream Baseflow Depletions by Natural Resources District in Nebraska Platte Basin due to Gained or Lost Groundwater Irrigated Land after July 1, 1997* (Luckey, 2008), and reports provided to the PRRIP Governance Committee; and synthesizes the various activities (controls, regulations, incentives, new permits, unpermitted activities, and projects) that have been completed through 2013 during the first increment of the BWP. NeDNR and the Upper Platte Basin NRDs have developed and submitted a number of annual reports and updates in support of the BWP and NNDP implementation, and this evaluation is provided as a means of summarizing the combined outcomes of those activities through a "robust review." Detailed technical reports, memos, and supporting documentation describing further details of specific components of the analyses are included in Appendix A. The results of the robust review serve as the basis for establishing second increment (September 2019 to September 2029) goals and objectives that are included in the updated BWP and IMPs.

INTRODUCTION

NeDNR and the Upper Platte Basin NRDs adopted the first increment BWP and NRD-specific IMPs in 2009. Those plans contain a number of goals and objectives, chief among them are those related to addressing depletions in Upper Platte River streamflow due to new water uses developed after July 1, 1997. NeDNR and the Upper Platte Basin NRDs have carried out a number of controls and management actions to support the implementation of those goals and objectives. The NeDNR and Upper Platte Basin NRDs, in coordination with basin stakeholders, developed and updated a number of datasets and models to support the evaluation of first increment activities through 2013. Foremost among those updates were efforts to refine groundwater models, develop surface water operations models, and extend land use datasets, which were used as the primary tools to conduct this "robust review" evaluation.

This evaluation provides summarized estimates of the streamflow impacts resulting from increases or decreases in irrigated acres, controls (allocations and transfers), increases or decreases in municipal and industrial uses, managed recharge, stream augmentation, and permitted uses. Additional evaluations of unpermitted uses (e.g., sand and gravel mining operations, small reservoirs [less than 15 acre-feet in storage capacity], livestock uses, and small-scale domestic uses) were also conducted through the first increment. This report is a synthesis of all of these efforts, and also provides summarized updates of new targets that will be used to guide second increment planning goals and objectives.

A series of detailed technical memos and model reports containing further documentation and data are listed in Appendix A. The reader is referred to those technical memos and reports for details regarding the specifics of each model and evaluation component. The projections of future streamflow impacts will be reviewed and updated through the course of the second increment, with future evaluations guiding any necessary refinements and modifications to the planning goals, objectives, actions, and controls.

This evaluation represents the best data and information currently available for evaluating progress in achieving first increment goals and objectives, and for establishing second increment goals and objectives outlined in the planning documents. Various modeling and data updates are expected to be completed in the second increment, which may modify the results presented in this report. Furthermore, the technical memos listed in Appendix A outline specific limitations that may be associated with each analysis. Examples of limitations associated with the analyses include:

1) In the COHYST model, future projections are based on 2013 groundwater irrigated acres data, with the exception of temporary retirements, which were reincorporated into subsequent years until the retirements terminated. In the WWUM model, future projections are based on repeated 2009-2013 groundwater irrigated acres and metered pumping data;
2) Crop type data are held constant based on the distribution available in 2010 for the COHYST model, and repeating 2009-2013 crop typing data in the WWUM model;
3) Conservation measures, primarily tillage practices, may not fully reflect present-day practices and associated water supply benefits;
4) Management actions implemented after 2013 are excluded, including N-CORPE operations and conjunctive management operations in Central Platte NRD;
5) Water budget changes associated with modeled changes in on-field runoff have not been incorporated into the new depletions estimates;

6) Groundwater pumping in certain portions of the groundwater models is estimated and may be refined with the collection of measurement data;
7) Certain model areas exhibit dry cells that may limit the incorporation of pumping and recharge changes;
8) The regional nature of the models may not appropriately express the degree of connection between aquifers and streams for capturing smaller scale management actions;
9) Streamflow routing of runoff and diversions were not included and may warrant further evaluation of the impacts on results; and
10) Future projections are based on a single, repeating historical climate scenario and may not be representative of future climate conditions.

NeDNR and the Upper Platte Basin NRDs will continue to work to address these limitations through the second increment, and update the robust review as limitations are evaluated in the future.

Evaluation Procedures and Data

A broad description of this evaluation process is contained within each of the Upper Platte Basin NRDs' IMPs. This evaluation process serves to supplement and refine reviews conducted by NeDNR and each NRD on an annual basis. The IMPs require that a "robust review" is conducted to evaluate the progress made toward achieving the goals and objectives of each IMP for the first ten (10) year increment. The robust review process is described below.

Excerpt from the Twin Platte NRD's IMP:

(i) *The ground water models used for this process will be calibrated to baseflows and ground water levels in the area with sufficient temporal variability to assess the impacts on a monthly basis. The ground water models will be updated periodically to simulate the management practices that have been implemented to date. The evaluation period of these models will be 1998 through 2048 (fifty years).*

(ii) *The following two ground water model runs will be conducted to measure the success toward reaching the objectives of Goal I.A.1.a and Goal I.A.2.a:*

(ii.a.) The 1997 Development Level Run - A model run which simulates the number of irrigated acres in 1997 and the associated crop mix. It will incorporate the full crop irrigation requirement for the 1997 crop mix. This model run will serve as the baseline to which the evaluation run will be compared. The run will be conducted using data through the current date and will include an update from the current date through the year 2048 (fifty years into the future).

(ii.b.) The Evaluation Run - A model run which simulates the annual changes between the irrigated acres throughout the evaluation period and the irrigated acres in 1997. The model will use available flow meter data or, in the absence of flow meter data, assume the full crop irrigation requirement. The run will be conducted using data through the

current date and will include an update from the current date through the year 2048 (fifty years).

(ii.c.) Difference between the Evaluation Run and the 1997 Run - The simulated baseflow output from each model run will be compared to determine the difference.

(ii.d.) Surface Water Accretions and Other Uses not Covered by the Model - If surface water acres are retired to offset streamflow depletions due to new uses begun subsequent to July 1, 1997, accretions resulting from those retirements will be determined using agreed upon methodologies.

(ii.e.) Evaluation Results - For the first ten (10) year increment to be considered achieved, the results of combining the difference between the evaluation run and the 1997 development level run with the addition of surface water accretions and other uses not covered by the model will be less than or equal to zero. See the following equation.

(baseflow from the Evaluation Run) - (baseflow from the 1997 Development Level Run) + (Surface Water Accretions) = Net Depletions

This broad description of the evaluation process serves as the guidance under which the various data sets were developed and models simulated. Within this report, the Evaluation Run referenced in the IMP will be referred to as the **Historical Run** because it simulates historical development and management actions; and the 1997 Development Level Run will be referred to as the **1997 Development Run**. The post-1997 streamflow impacts referred to in this report are the depletions and accretions calculated as the difference in the baseflow between the Historical Run and baseflow in the 1997 Development Run (Net Depletions from the referenced IMP). Further details of the specific evaluation processes are contained in the POAC's detailed scope of work that supported completion of these evaluations for each NRD. Additional evaluations have been made through the first increment to determine the impacts of unpermitted activities (e.g., sand and gravel mining operations, small reservoirs [less than 15 acre-feet in storage capacity], livestock uses, and small-scale domestic uses). The results of those analyses were not updated as part of this evaluation, but those reports are included within Appendix A for reference.

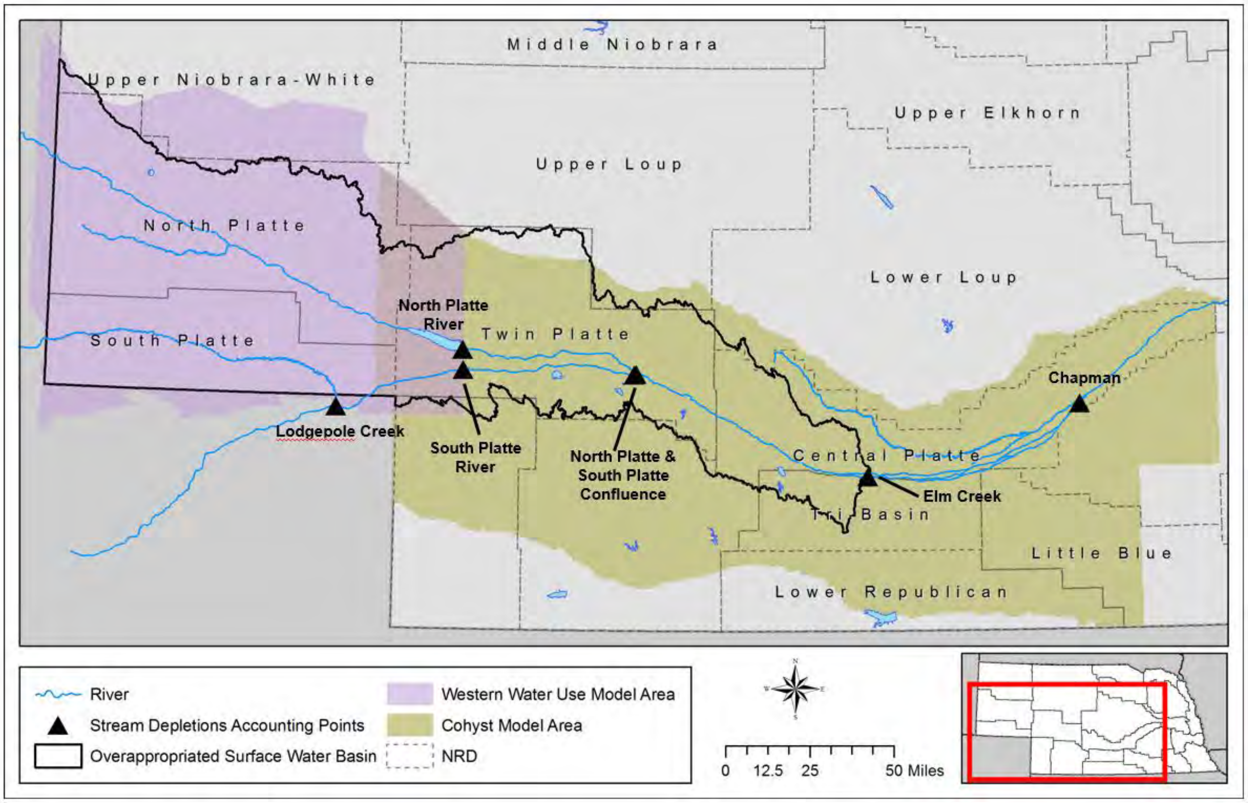


Figure 1. Upper Platte River Basin NRDs, Overappropriated Basin, accounting points, and model domains.

RESULTS

Previous analyses have been conducted throughout the first increment to evaluate compliance with IMP related triggers and the NNDP. Table 1 summarizes the most recent evaluation provided to the PRRIP Governance Committee on April 21, 2017, of the overall impacts to Upper Platte River streamflow resulting from depletive activities and mitigation measures, including all post-1997 new or expanded uses. The results of the 2017 evaluation indicated compliance with NNDP requirements and noted that the evaluation would be updated as part of this robust review.

The results of the robust review evaluation represent the impacts to streams in the Upper Platte River system (e.g., North Platte River, South Platte River, Lodgepole Creek, and the Platte River) and their extents within the Overappropriated Basin and/or upstream of Chapman, NE (Figure 1). The Overappropriated Basin (upstream of Kearney Canal Diversion) is an administrative area established by NeDNR and has significance within the context of Nebraska state law. The Upper Platte Basin upstream of Chapman, NE, is used as the reporting area for the NNDP because it represents the downstream end of the PRRIP Critical Habitat Reach. Analyses of groundwater pumping activities and their impacts to streamflow were conducted for each of the Upper Platte Basin NRDs. An additional analysis was conducted to evaluate the streamflow impacts caused by groundwater pumping changes in NRDs that are located outside of the Upper Platte Basin, but within the extent of the groundwater modeling domains.

Changes in groundwater irrigated acres and crop types subsequent to July 1, 1997, were identified through a variety of techniques, as described in Appendix A. Table 2 illustrates the total number of groundwater-only irrigated acres within each NRD for the years 1997, 2005, 2013, and 2023. Acres values were maintained at constant levels after 2013 in the COHYST model, with the exception of temporary retirements that were reincorporated into subsequent years until the retirements terminated. In the WWUM model, groundwater-only irrigated acres values repeated data from 2009-2013. Table 3 illustrates the changes in groundwater-only irrigated acres relative to 1997 levels of groundwater-only irrigated acres in each NRD.

Figures 2 through6 display the average annual change in net recharge by NRD, accounting for changes in groundwater-only irrigation pumping and related changes in recharge, and changes in municipal and industrial pumping, for the period 2014 – 2063. The average change in net recharge in the COHYST model area is based on 2013 land use conditions (with temporary retirements lapsing after 2023) with variable, but repeating, future climate conditions. In the WWUM model area, the average change in net recharge is based on the average of the repeating 2009-2013 land use data, 2009-2013 metered pumping data, and variable, but repeating, future climate conditions. Red areas indicate conditions where net recharge has decreased (increased withdrawal from the aquifer relative to 1997 conditions) and areas in blue indicate conditions where net recharge increased (decreased withdrawal from aquifer relative to 1997 conditions). Water budget data, including recharge, groundwater irrigation pumping, municipal and industrial groundwater pumping, and net recharge within each NRD area, are summarized in Tables 4 through 8.

The results of the groundwater modeling evaluation of impacts on streamflow due to post-1997 activities (post-1997 streamflow impacts) are summarized in Figures 7 through 22. In the figures, positive results represent accretions to streamflow and negative results represent depletions to streamflow. The results summarize the impacts (increase or decrease in streamflow relative to 1997 levels of development) based on changes within each of the Upper Platte Basin NRDs. In addition, Figure 23 depicts the impact to streamflow in the Upper Platte River Basin due to groundwater-only irrigation and municipal and industrial water uses in the areas that are outside of the five Upper Platte Basin NRDs, but within the modeling domain. Figure 24 shows the combined impact to streamflow due to changes within the five Upper Platte Basin NRDs, relative to 1997 levels of development; as well as the combined impact to streamflow due to changes in the modeled area, including areas within and outside of the Upper Platte Basin NRD's. The five stream reaches used in the analysis include: 1) Lodgepole Creek; 2) North Platte River; 3) South Platte River; 4) Platte River between the North Platte and South Platte confluence and Elm Creek; and 5) Platte River between Elm Creek and Chapman.

The results of the groundwater modeling evaluation have been combined with the results from evaluations of other post-1997 activities, such as permanent surface water retirements and augmentation pumping, to illustrate the total net streamflow impact for each Upper Platte Basin NRD. The streamflow impacts for the period 2014-2063 are modeled based on assumptions of a representative climate without additional management actions or changes in land use incorporated after 2013. Figures 7 through 22 include graphs with a linear fit applied to the modeled depletion values from 2014-2063 to illustrate a 50-year trend. The inter-annual variability of modeled streamflow impacts for 2014-2063 is shown as a band of the maximum residual, or difference between the modeled data and trend. The modeled streamflow impacts are not exactly periodic along the trend despite having explicit period climate inputs and constant land use. This result is primarily due to the inclusion of all management actions in the analysis prior to 2013 and discontinuing many of those management actions in the future projection (2014-2063). An additional summary of the annual estimates based on the linear trend is provided for the period 2019-2029 in Tables 9 through 13. The annual values contained in Tables 9 through 13 will be used to support second increment IMP planning goals, objectives, actions, and controls.

A variety of new outcomes can be observed within this evaluation. First, the results for both the North Platte NRD and South Platte NRD indicate that post-1997 depletions have been mitigated and the net effect of post-1997 activities, including regulatory limits on groundwater irrigation withdrawals (allocations), have had a significant positive impact to streamflow. Second, updates to modeling methods and data developed by COHYST have resulted in significant increases in groundwater depletion estimates associated with post-1997 groundwater irrigation development in the Twin Platte NRD and Central Platte NRD. This change was primarily the result of work performed on the COHYST model to address previously noted limitations outlined in the Luckey (2008) report. Third, management actions taken to recharge and retime excess flows have had positive impacts on streamflow throughout the Basin. Fourth, crop type conversions in certain areas of the Basin, most notably eastern portions of the Central Platte NRD and the Tri-Basin NRD, have trended toward lower consumption (corn to soybean conversions) through the period of this evaluation. Fifth, the impacts from groundwater pumping changes outside of the Upper Platte River Basin NRDs are projected to be positive (accretions) through the second increment (Table 14) and no additional mitigation is required at this time. Finally, the overall results (Table 15) indicate that significant progress has been made in the first increment toward addressing groundwater depletions, but that additional actions will be required in certain NRDs to meet second increment goals.

Summary

NeDNR and the Upper Platte Basin NRDs have worked extensively through the course of the first increment to implement a variety of actions in accordance with in each NRD's respective IMP, as well as the Upper Platte's BWP. Those actions have included a variety of regulatory and non-regulatory management actions aimed at addressing streamflow depletions associated with post-1997 activities. Additionally, NeDNR and the Upper Platte Basin NRDs have made considerable efforts to update the datasets and models used to evaluate progress toward meeting key IMP goals and objectives. The results of this robust review indicate that key first increment goals and objectives related to addressing post-1997 depletions were met in many areas, but that additional efforts will be necessary to address updated post-1997 depletions targets in the second increment.

A number of limitations associated with this analysis have been identified. Efforts will continue to be made toward refining the models, datasets, and methods used through the course of this evaluation to support future updates and address limitations. The NeDNR and Upper Platte Basin NRDs will continue to evaluate the impacts that increased field-level conservation practices and irrigation efficiencies may have on future evaluations. Landuse information will continue to be updated and refined, along with continued incorporation of metered and measured water use data to support updates reflective of various NRD management efforts. The integration of these activities will be noted when incorporated into future robust review evaluations. Unpermitted activities such as sand pits, small reservoirs, livestock uses, and non-municipal domestic uses have been previously evaluated and results indicate that these activities have not had an overall negative impact and are not projected to have an overall negative impact in the second increment. Efforts to further update and track details associated with unpermitted activities will be limited in the second increment. Municipal and industrial uses will continue to be tracked and incorporated into future updates.

Many planning goals and objectives in the Upper Platte River Basin will be refined as a result of this robust review. The IMPs of NRDs for which this evaluation indicated post-1997 depletions remain to be offset will contain goals and objectives aimed at ensuring that those depletions are addressed through the course of the second increment. The IMPs of NRDs for which this evaluation indicated post-1997 depletions have been addressed will continue to monitor those outcomes and use available resources to maintain the progress that has been made to date. The Twin Platte NRD will begin the use of the N-CORPE project at the beginning of the second increment to provide up to 5,600 acre-feet of annual depletion mitigation through the second increment. This project, in conjunction with other activities, will be implemented by the Twin Platte NRD to incrementally address remaining post-1997 groundwater depletions by the end of the second increment. The Central Platte NRD plans to use conjunctive management projects and other management actions to address remaining post-1997 groundwater depletions by the end of the second increment. Accretions resulting from the progress made by the other three NRDs will be used to bridge any remaining gap between post-1997 depletions and mitigation measures that are necessary to meet the terms of the NNDP. In all Upper Platte NRD's, it is acknowledged that when implementing or assessing management actions outlined in the IMPs, NeDNR and the NRDs need to consider when and where depletions occur and how they may impact current water users, as well as state-protected or PRRIP target flows. The NeDNR and NRDs will continue to provide annual reports and updates at the annual Upper Platte River BWP meetings and through the annual reports provided to PRRIP.

Change in Net Recharge Figures

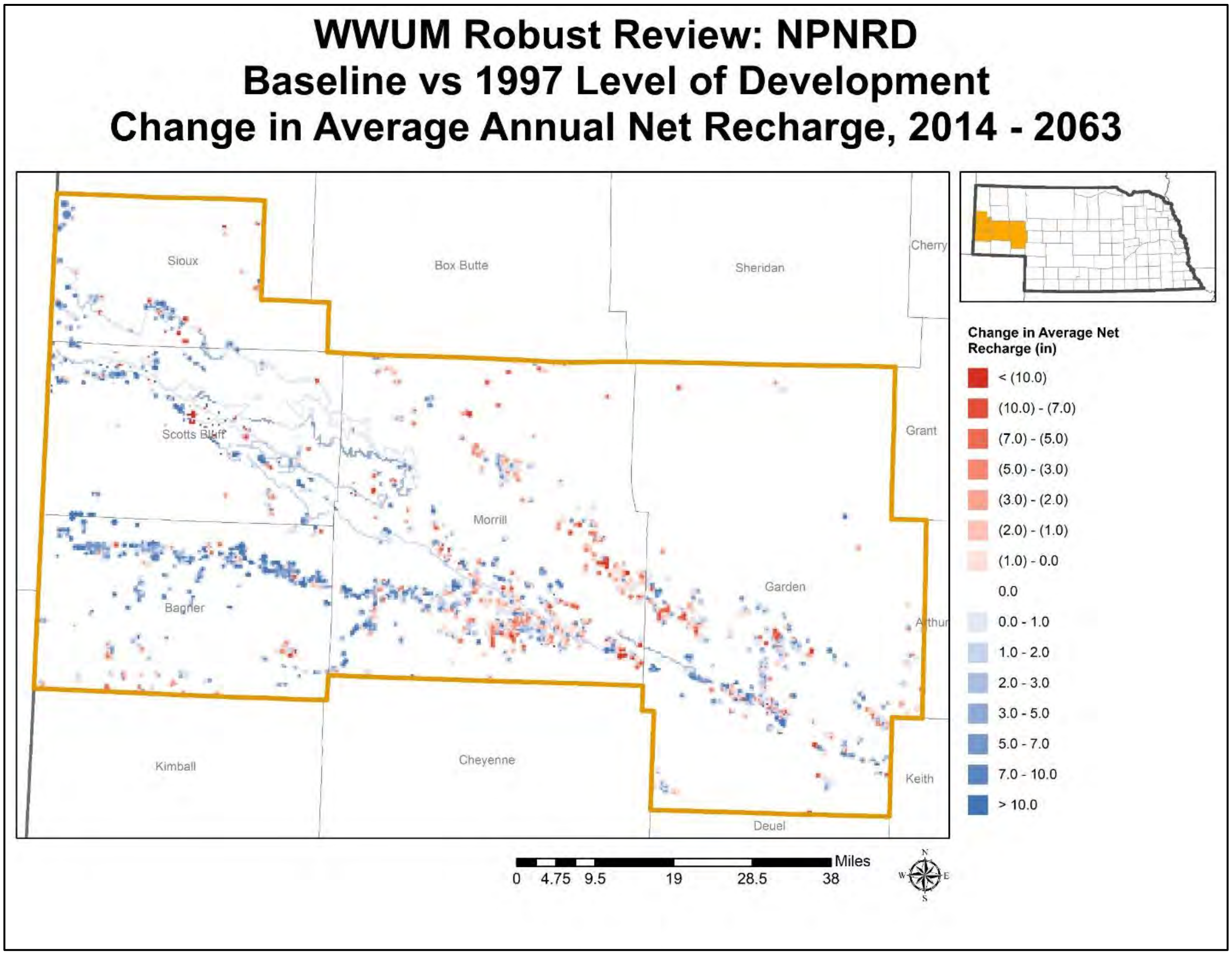


Figure 2. Historical Run minus 1997 Development Run. Change in average net recharge including change in M&I pumping from 2014 – 2063 within NPNRD.

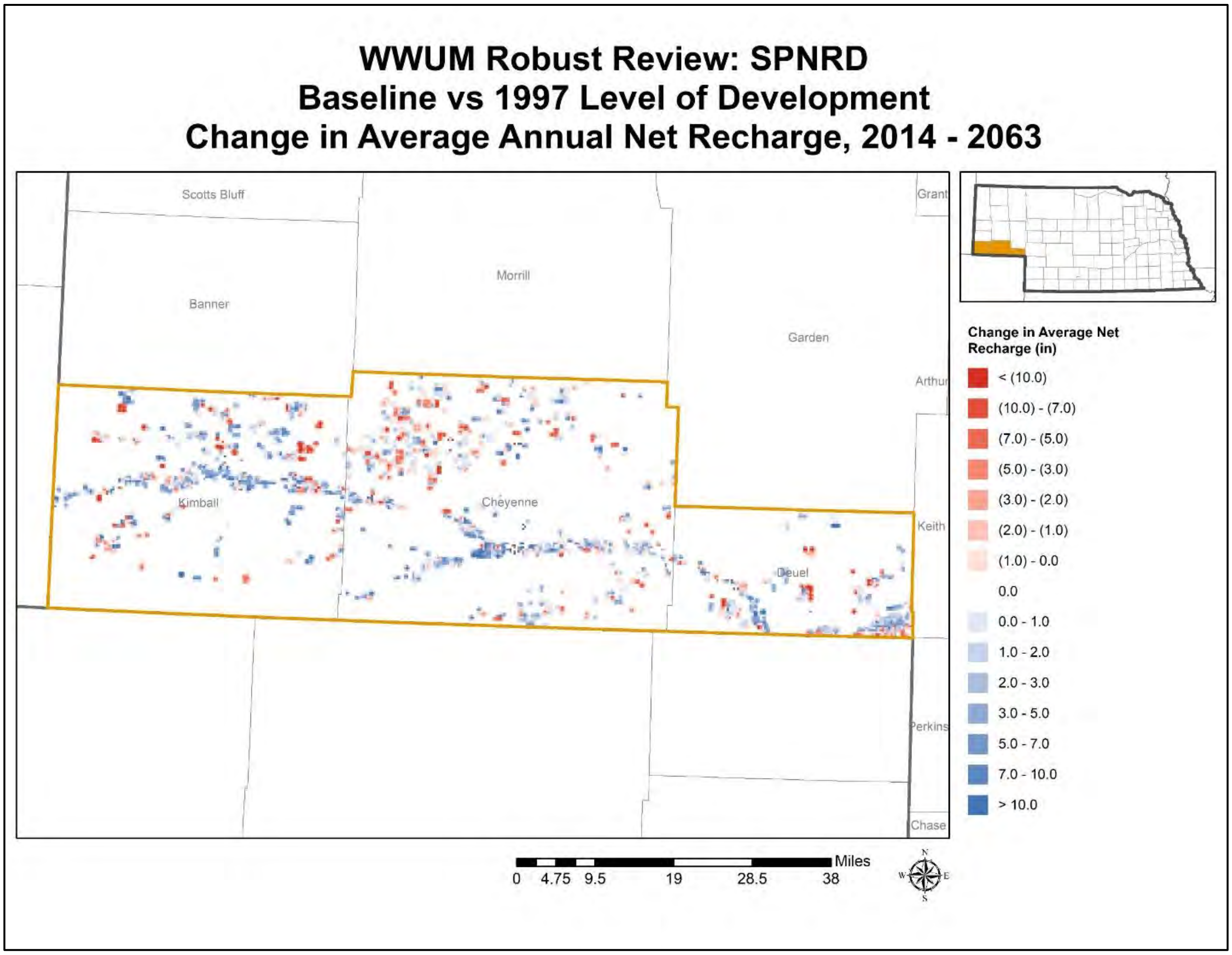


Figure 3. Historical Run minus 1997 Development Run. Change in average net recharge including change in M&I pumping from 2014 – 2063 within SPNRD.

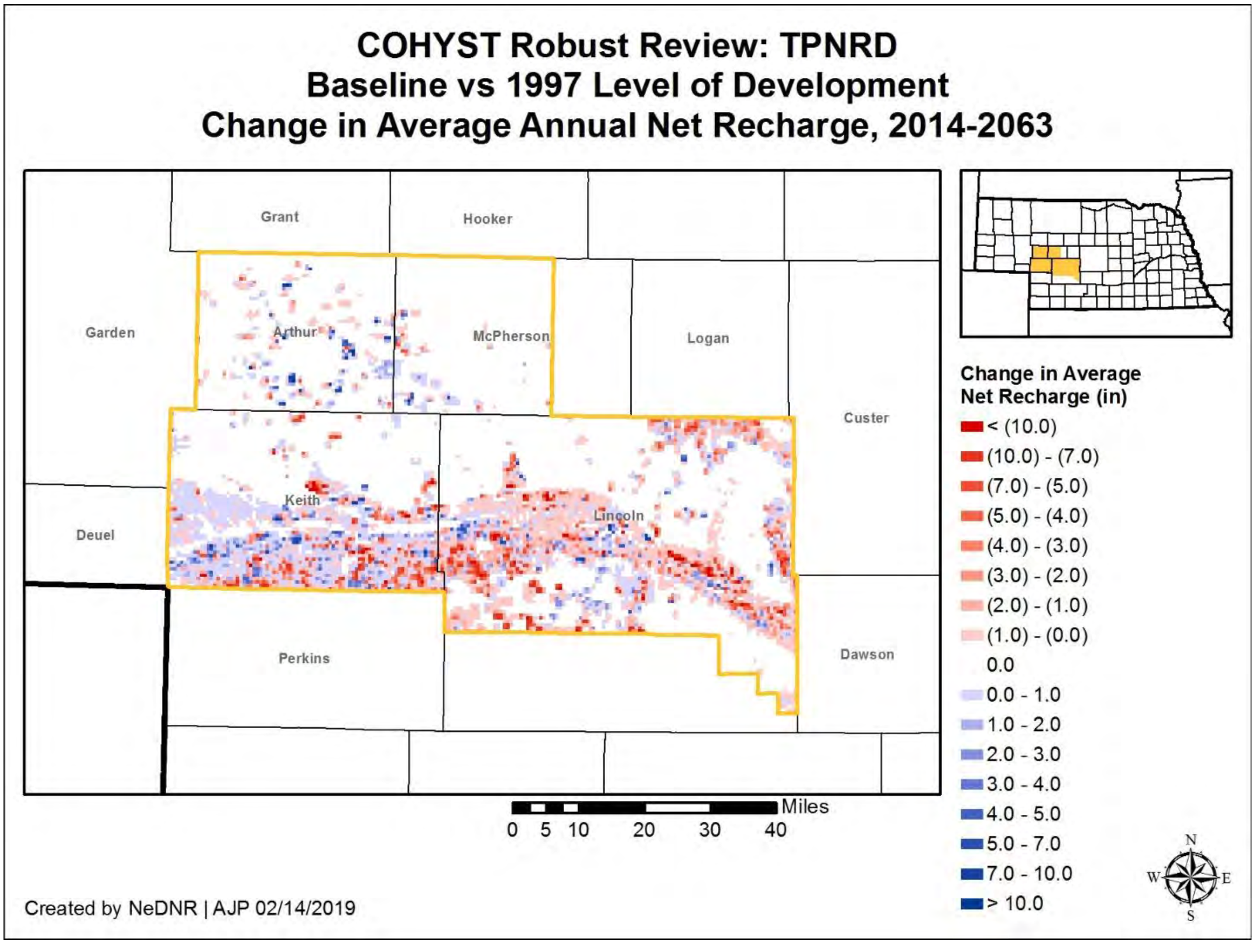


Figure 4. Historical Run minus 1997 Development Run. Change in average net recharge including change in M&I pumping from 2014 – 2063 within TPNRD.

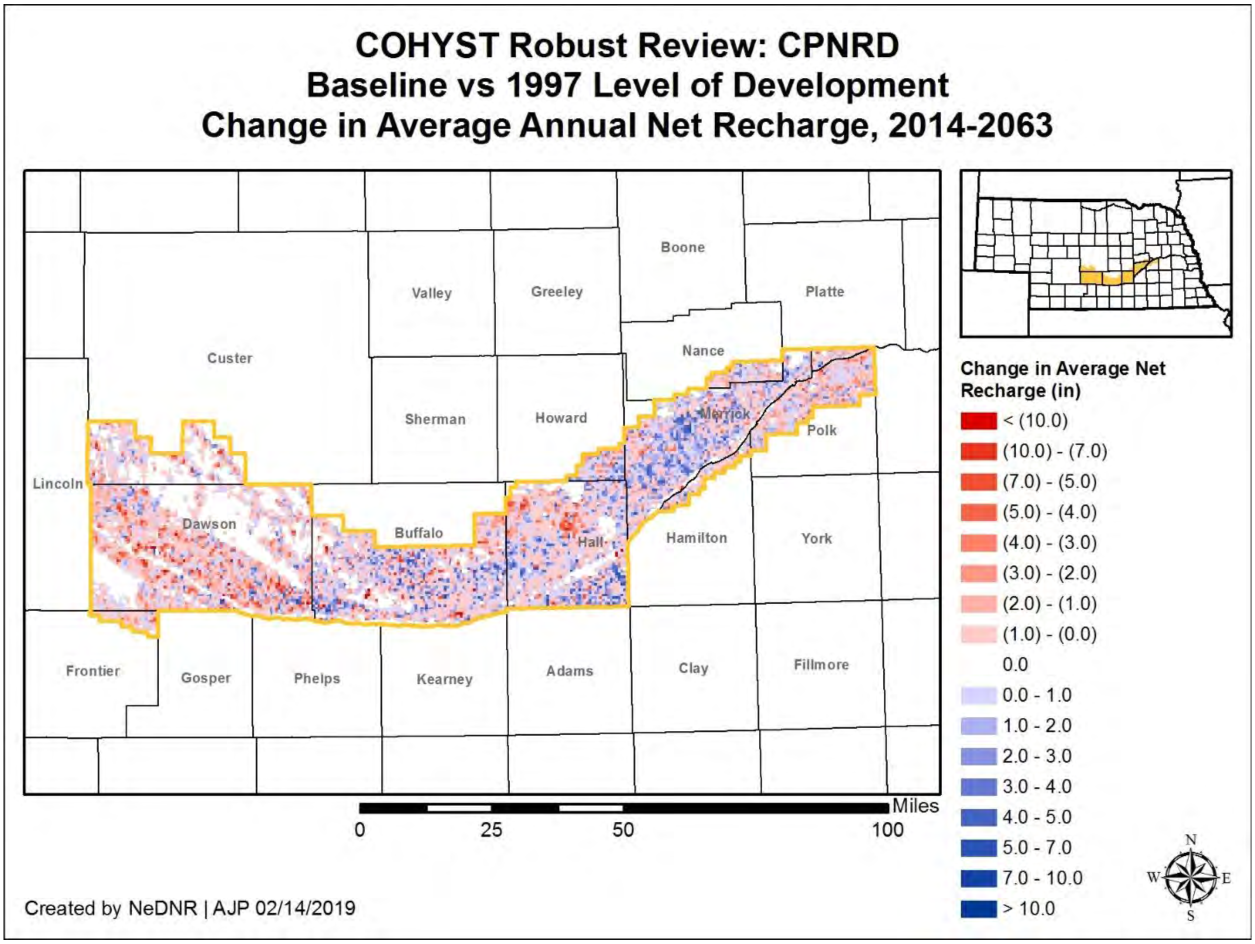


Figure 5. Historical Run minus 1997 Development Run. Change in average net recharge including change in M&I pumping from 2014 – 2063 within CPNRD.

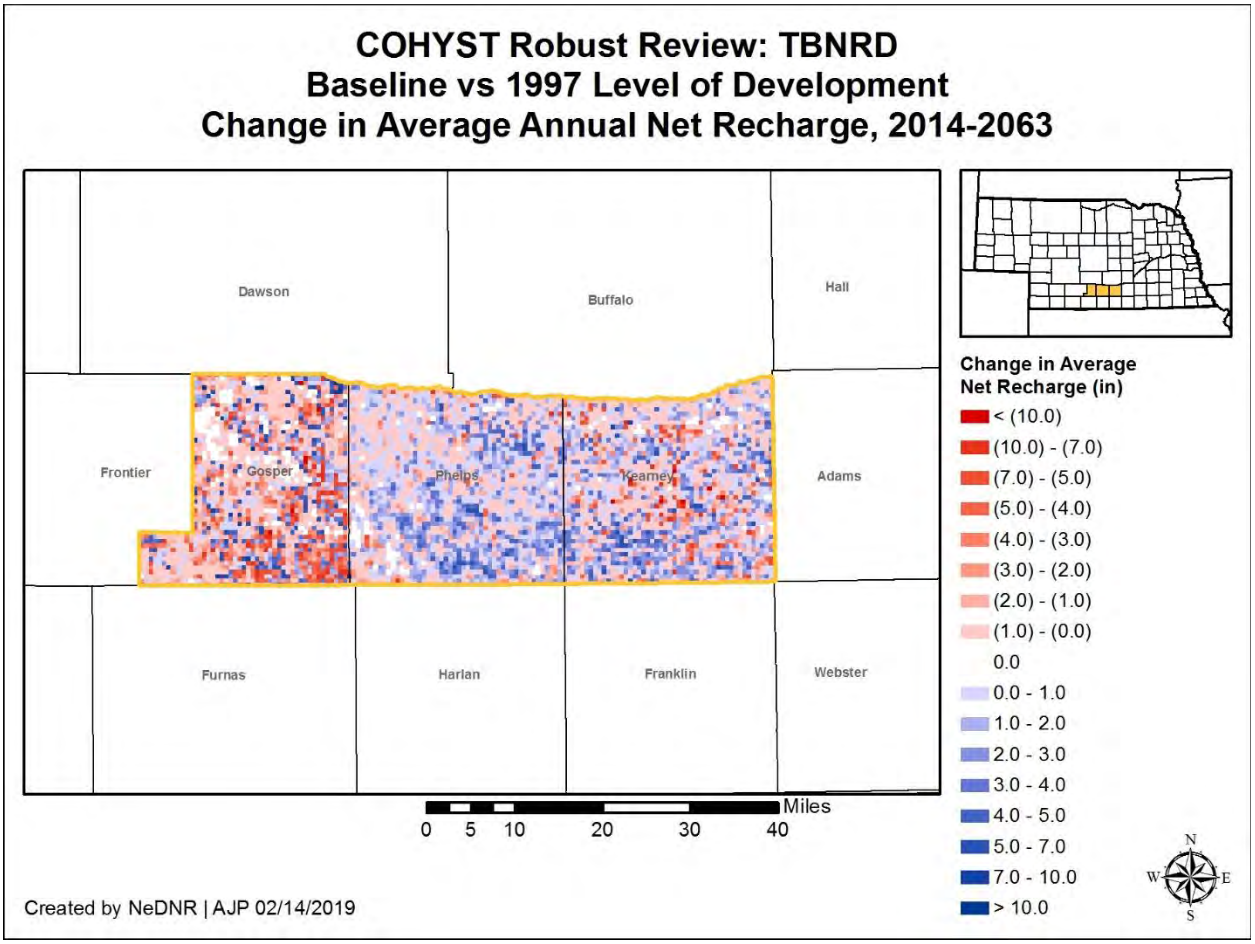


Figure 6. Historical Run minus 1997 Development Run. Change in average net recharge including change in M&I pumping from 2014 – 2063 within TBNRD.

STREAMFLOW DEPLETIONS FIGURES

North Platte NRD (NPNRD)

In Figure 7, the modeled post-1997 impacts to the North Platte River from groundwater-only irrigation and municipal and industrial development within the NPNRD are shown. Data shown in this figure also includes depletions-offsetting management actions including: allocations, groundwater irrigated acres retirements, and recharge projects on the North Platte River.

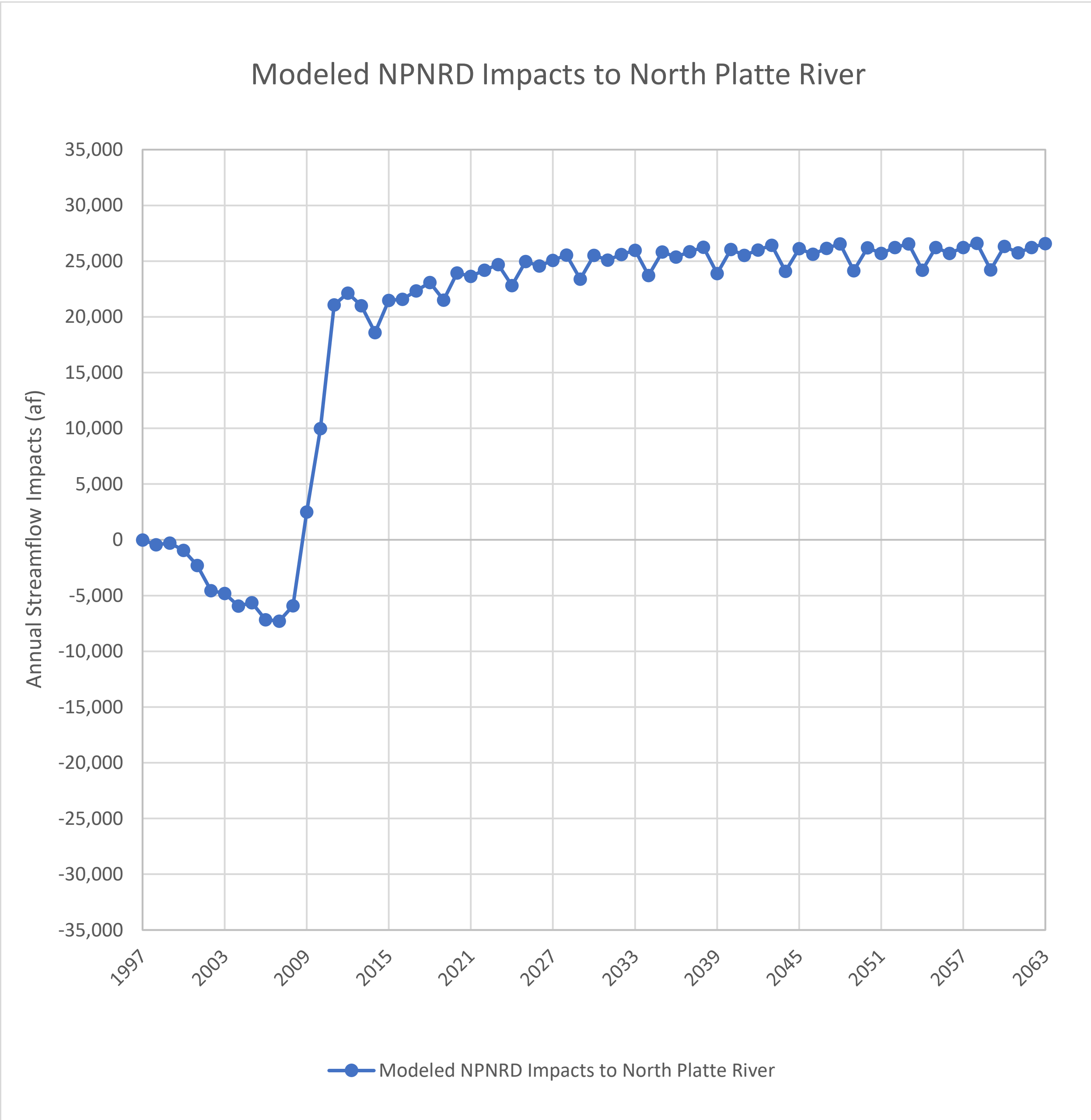


Figure 7. Modeled NPNRD post-1997 impacts to the North Platte River.

Figure 8 displays the same modeled post-1997 impacts of NPNRD to the North Platte River as that found in Figure 7 (including groundwater-only irrigation, municipal and industrial development, allocations, groundwater irrigated acres retirements, and recharge projects on the North Platte River), with the addition of the linear trend line of the modeled impacts from 2014-2063, and the inter-annual variability range of modeled impacts across the trend. The inset in Figure 8 shows the same data at a smaller scale.

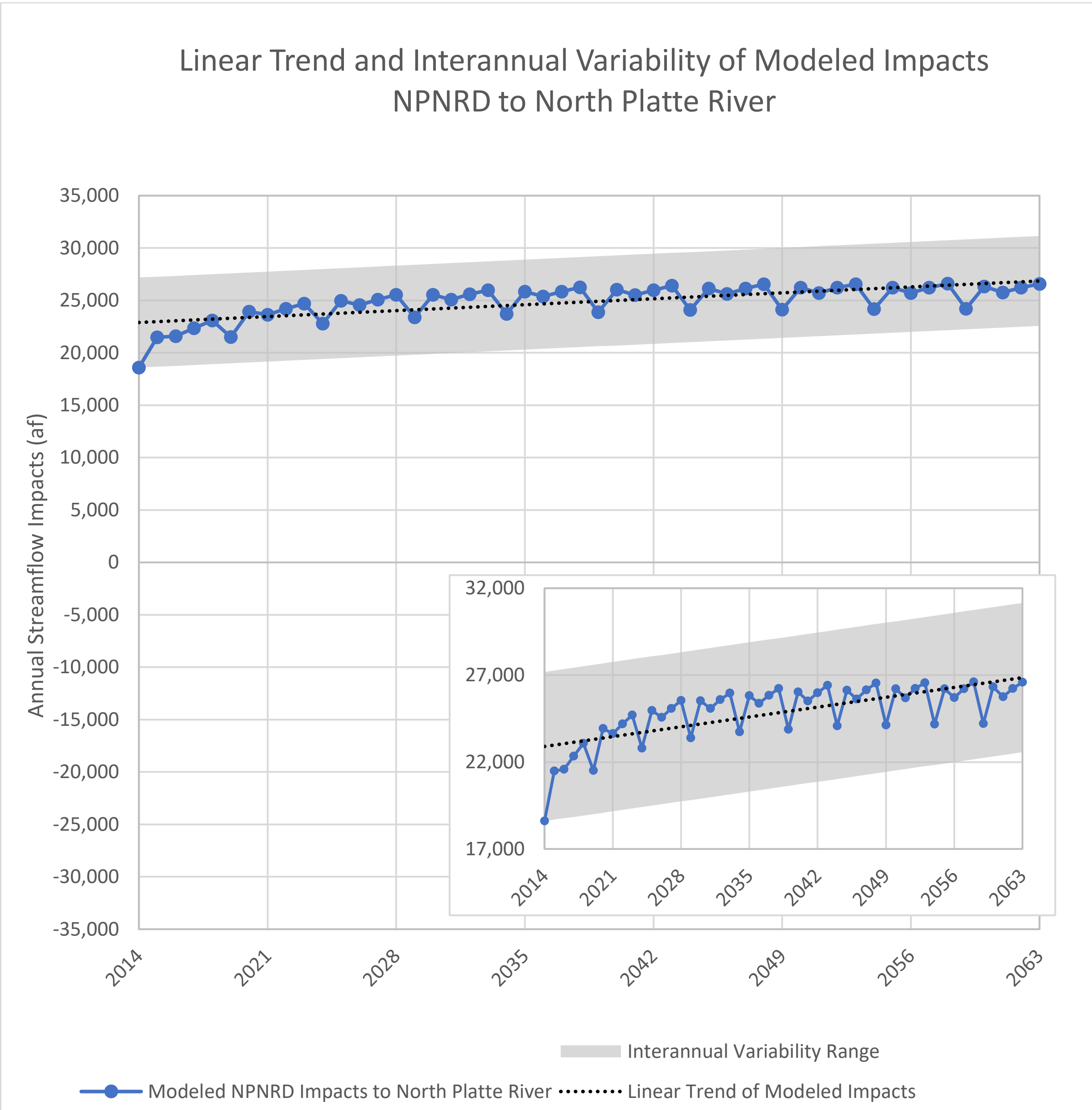


Figure 8. Modeled NPNRD post-1997 impacts to the North Platte River, the linear trend line of the modeled impacts from 2014-2063, and the inter-annual variability range of modeled impacts across the trend.

South Platte NRD (SPNRD)

In Figure 9, the modeled post-1997 impacts to the North Platte River, South Platte River, and Lodgepole Creek from groundwater-only irrigation and municipal and industrial development within SPNRD are shown. Data shown in this figure also includes depletions-offsetting management actions including: allocations, groundwater irrigated acres retirements, and recharge projects on the South Platte River. The inset in Figure 9 shows the same data at a smaller scale.

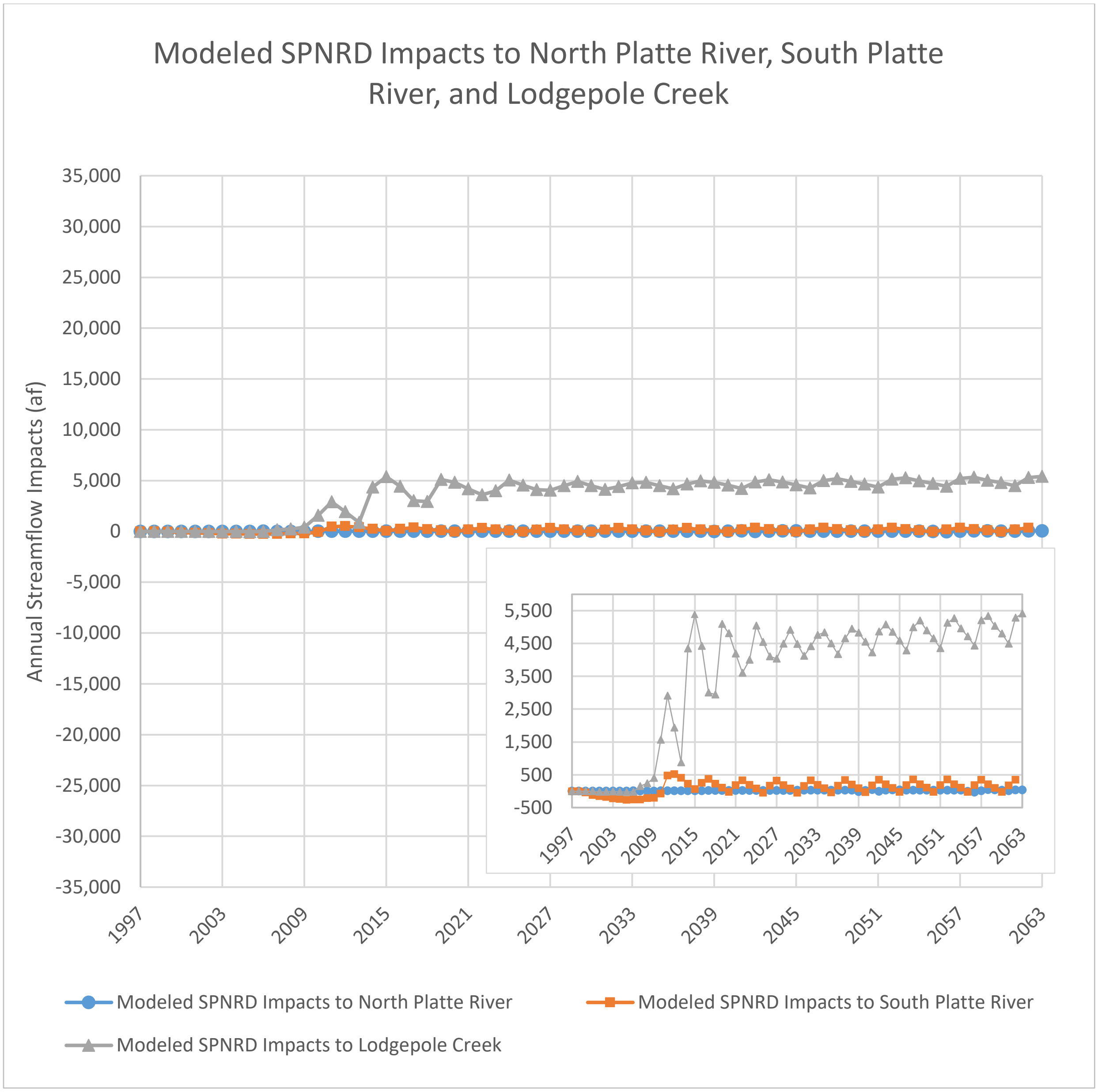


Figure 9. Modeled SPNRD post-1997 impacts to the North Platte River, South Platte River, and Lodgepole Creek.

Figure 10 displays the same modeled post-1997 impacts of SPNRD to the North Platte River as that found in Figure 9 (including groundwater-only irrigation, municipal and industrial development, allocations, and groundwater irrigated acres retirements), with the addition of the linear trend line of the modeled impacts from 2014-2063, and the inter-annual variability range of modeled impacts across the trend. The inset in Figure 10 shows the same data at a smaller scale.

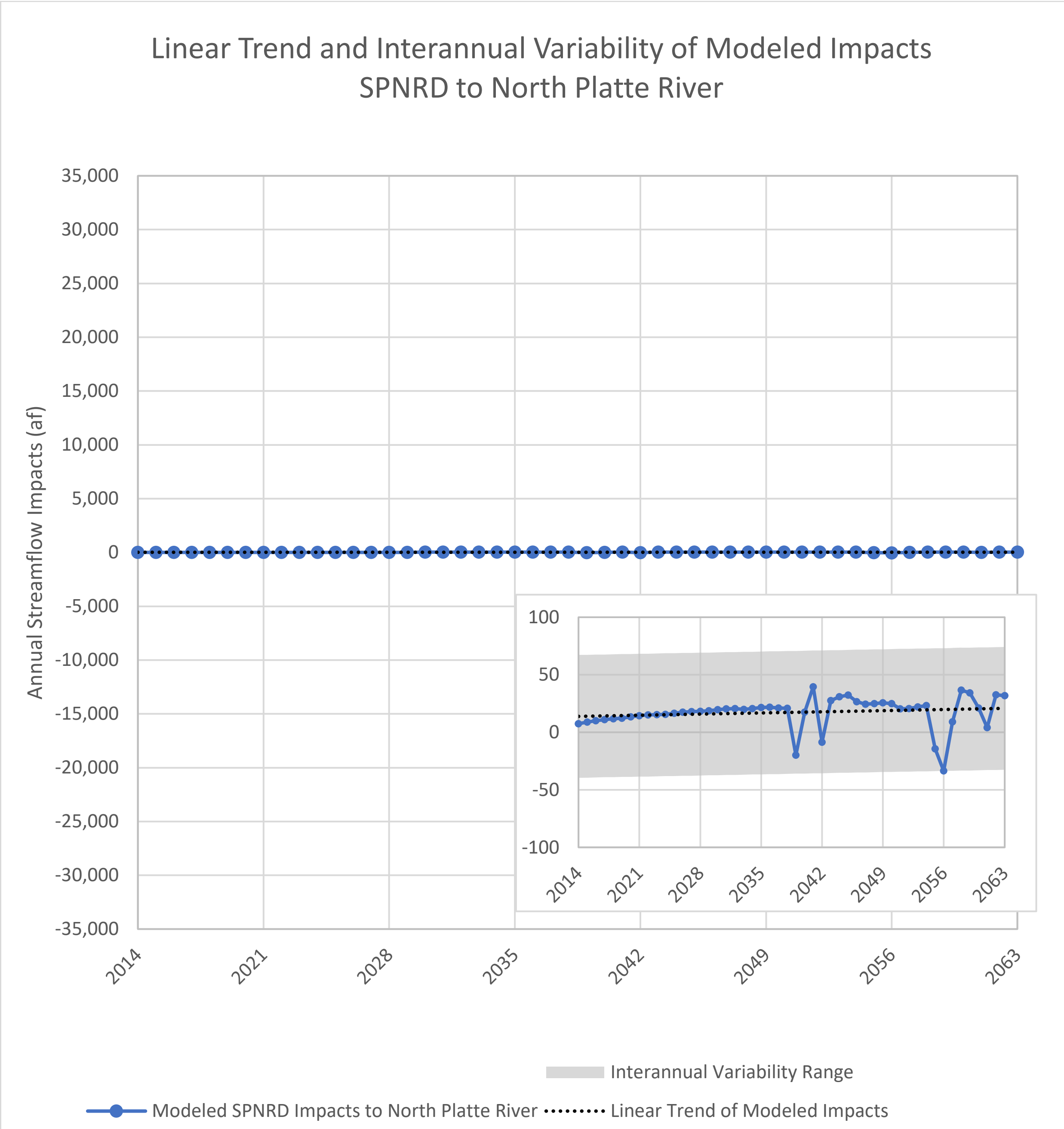


Figure 10. Modeled SPNRD post-1997 impacts to the North Platte River, the linear trend line of the modeled impacts from 2014-2063, and the inter-annual variability range of modeled impacts across the trend.

Figure 11 displays the same modeled post-1997 impacts of SPNRD to the South Platte River that were seen in Figure 9 (including groundwater-only irrigation, municipal and industrial development, allocations, groundwater irrigated acres retirements, and recharge projects on the South Platte River), with the addition of the linear trend line of the modeled impacts from 2014-2063, and the inter-annual variability range of modeled impacts across the trend. The inset in Figure 11 shows the same data at a smaller scale.

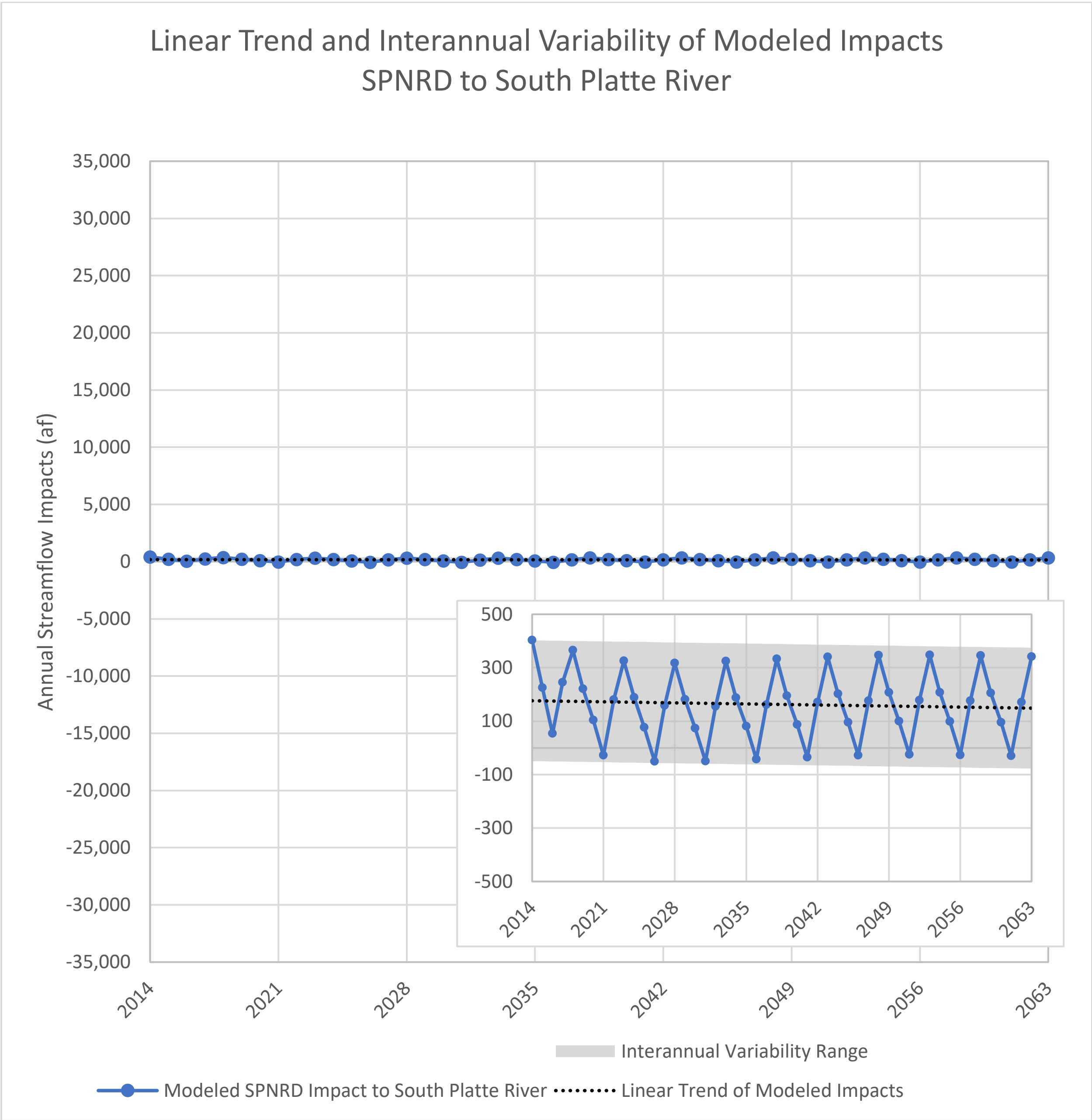


Figure 11. Modeled SPNRD post-1997 impacts to the South Platte River, the linear trend line of the modeled impacts from 2014-2063, and the inter-annual variability range of modeled impacts across the trend.

Figure 12 displays the same modeled post-1997 impacts of SPNRD to Lodgepole Creek that were seen in Figure 9 (including groundwater-only irrigation, municipal and industrial development, allocations, and groundwater irrigated acres retirements), with the addition of the linear trend line of the modeled impacts from 2014-2063, and the inter-annual variability range of modeled impacts across the trend. The inset in Figure 12 shows the same data at a smaller scale.

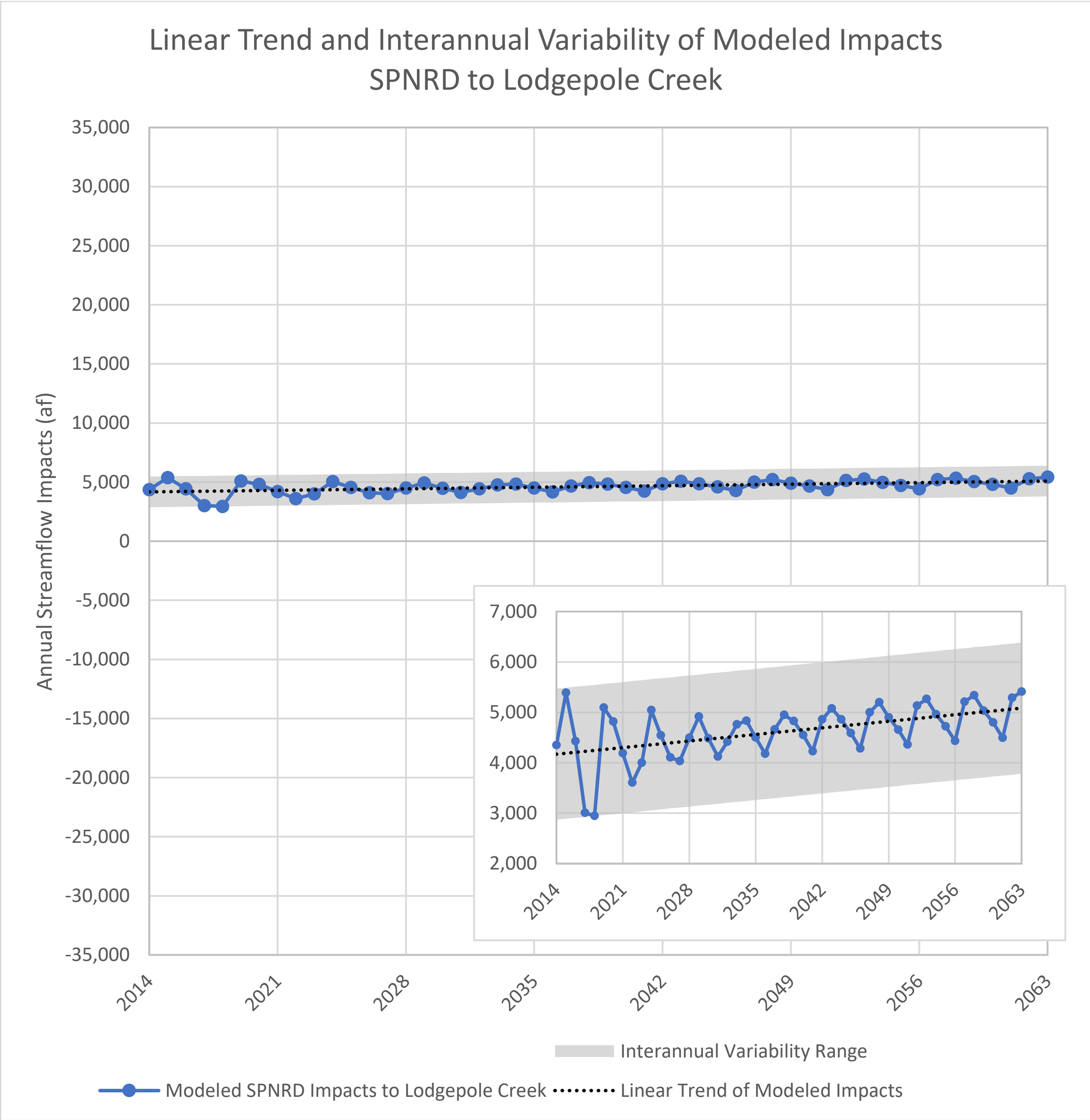


Figure 12: Modeled SPNRD post-1997 impacts to Lodgepole Creek, the linear trend line of the modeled impacts from 2014-2063, and the inter-annual variability range of modeled impacts across the trend.

Twin Platte NRD (TPNRD)

In Figure 13, the modeled post-1997 impacts to the South Platte River, North Platte River, and the Platte River upstream of Elm Creek from groundwater-only irrigation and municipal and industrial development within TPNRD are shown. Data shown in this figure also includes depletions-offsetting management actions, including groundwater irrigated acres retirements and recharge projects on the South Platte River and Platte River upstream of Elm Creek. The inset in Figure 13 shows the same data at a smaller scale.

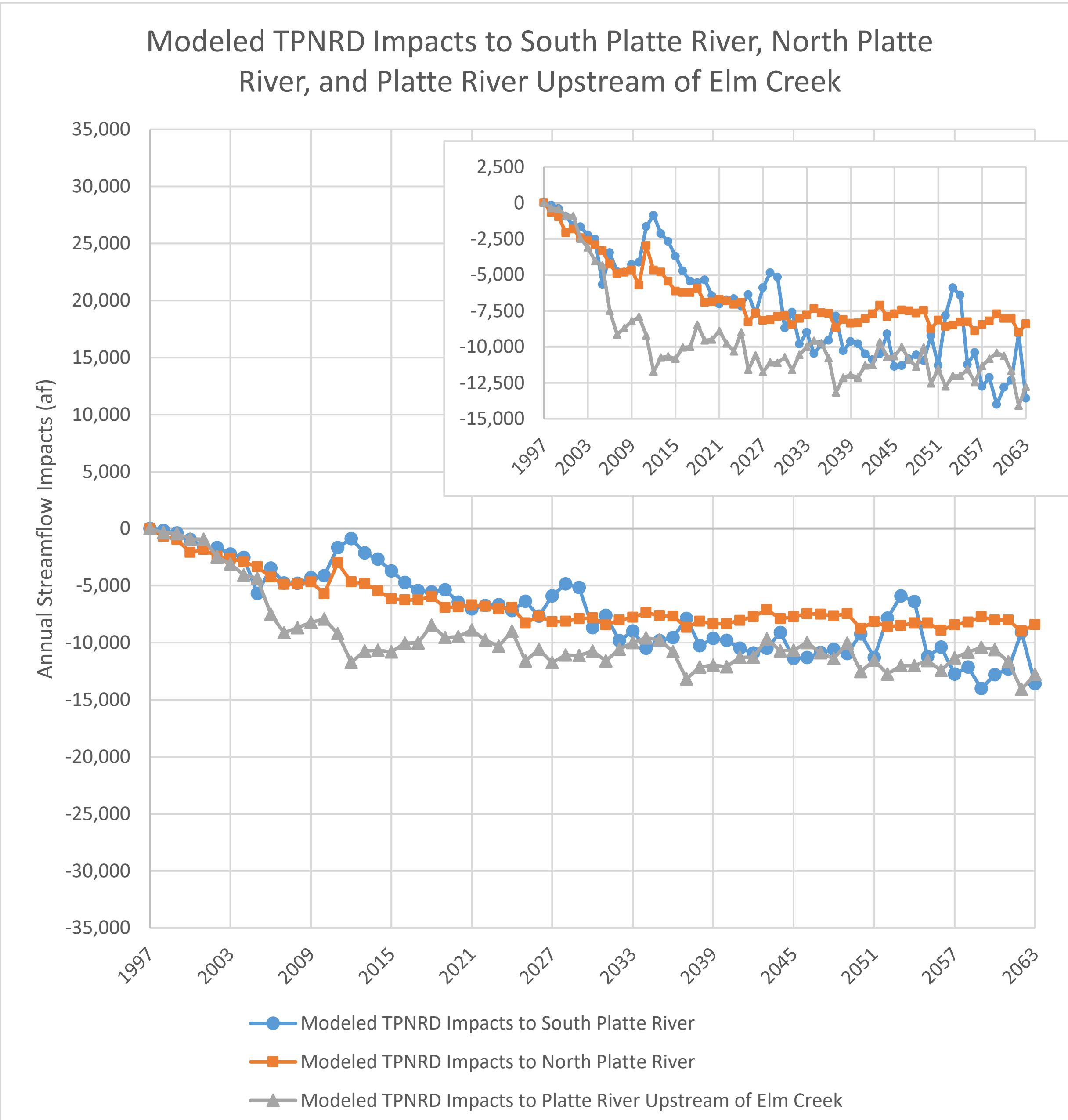


Figure 13: Modeled TPNRD post-1997 impacts to the South Platte River, North Platte River, and Platte River upstream of Elm Creek.

Figure 14 displays the same modeled post-1997 impacts of TPNRD to the South Platte River as that found in Figure 13 (including groundwater only irrigation, municipal and industrial development, groundwater irrigated acres retirements, and recharge projects on Western Canal), with the addition of the linear trend line of the modeled impacts from 2014-2063, and the inter-annual variability range of modeled impacts across the trend. The inset in figure 14 is the same data at a smaller scale.

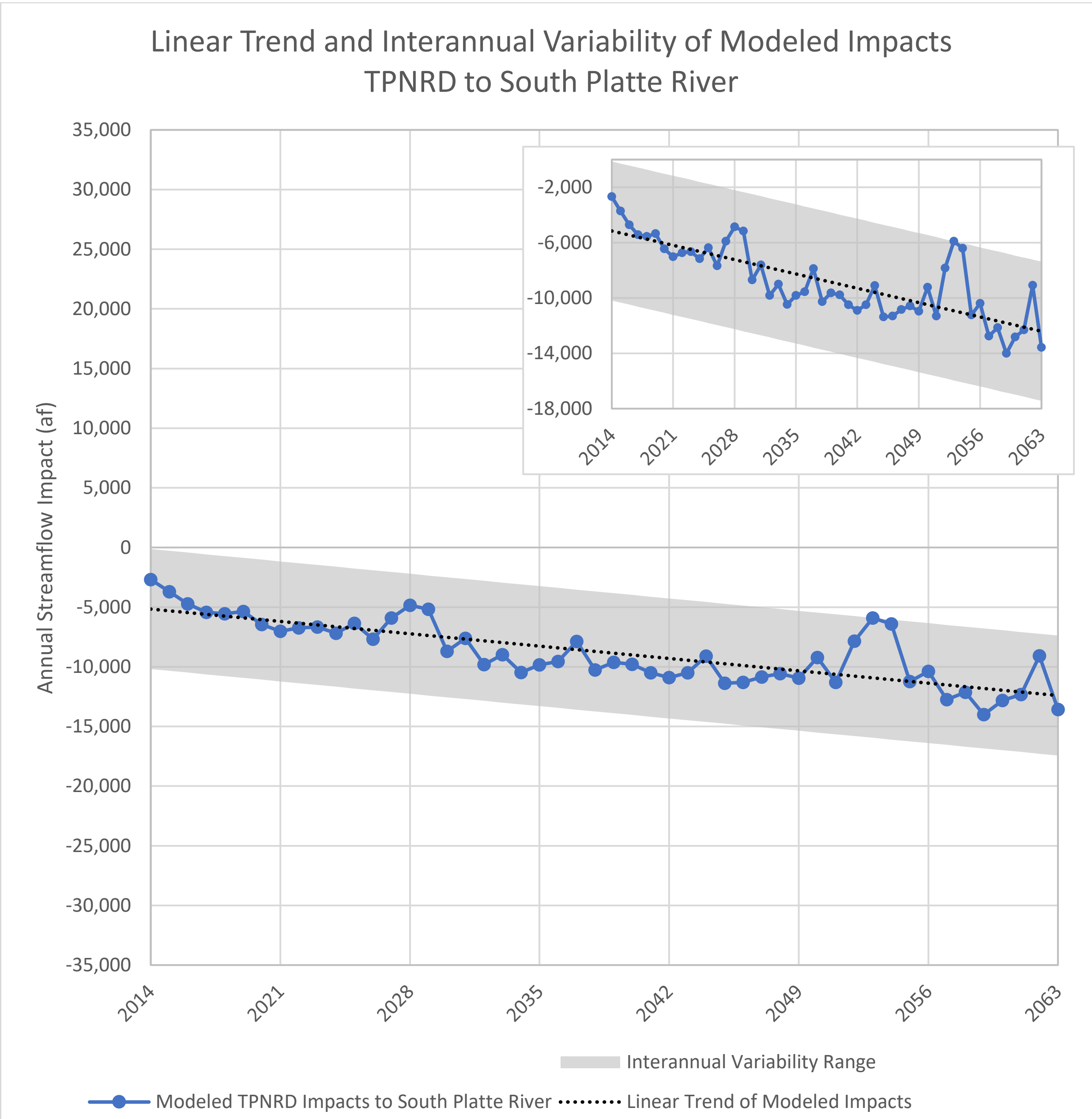


Figure 14: Modeled TPNRD post-1997 impacts to the South Platte River, the linear trend line of the modeled impacts from 2014-2063, and the inter-annual variability range of modeled impacts across the trend.

Figure 15 displays the same modeled post-1997 impacts of TPNRD to the North Platte River as that found in Figure 13 (including groundwater-only irrigation, municipal and industrial development, groundwater irrigated acres retirements, and recharge projects on Keith Lincoln Canal, North Platte Canal, Paxton Hershey Canal, and Suburban canal), with the addition of the linear trend line of the modeled impacts from 2014-2063, and the inter-annual variability range of modeled impacts across the trend. The inset in figure 15 shows the same data at a smaller scale.

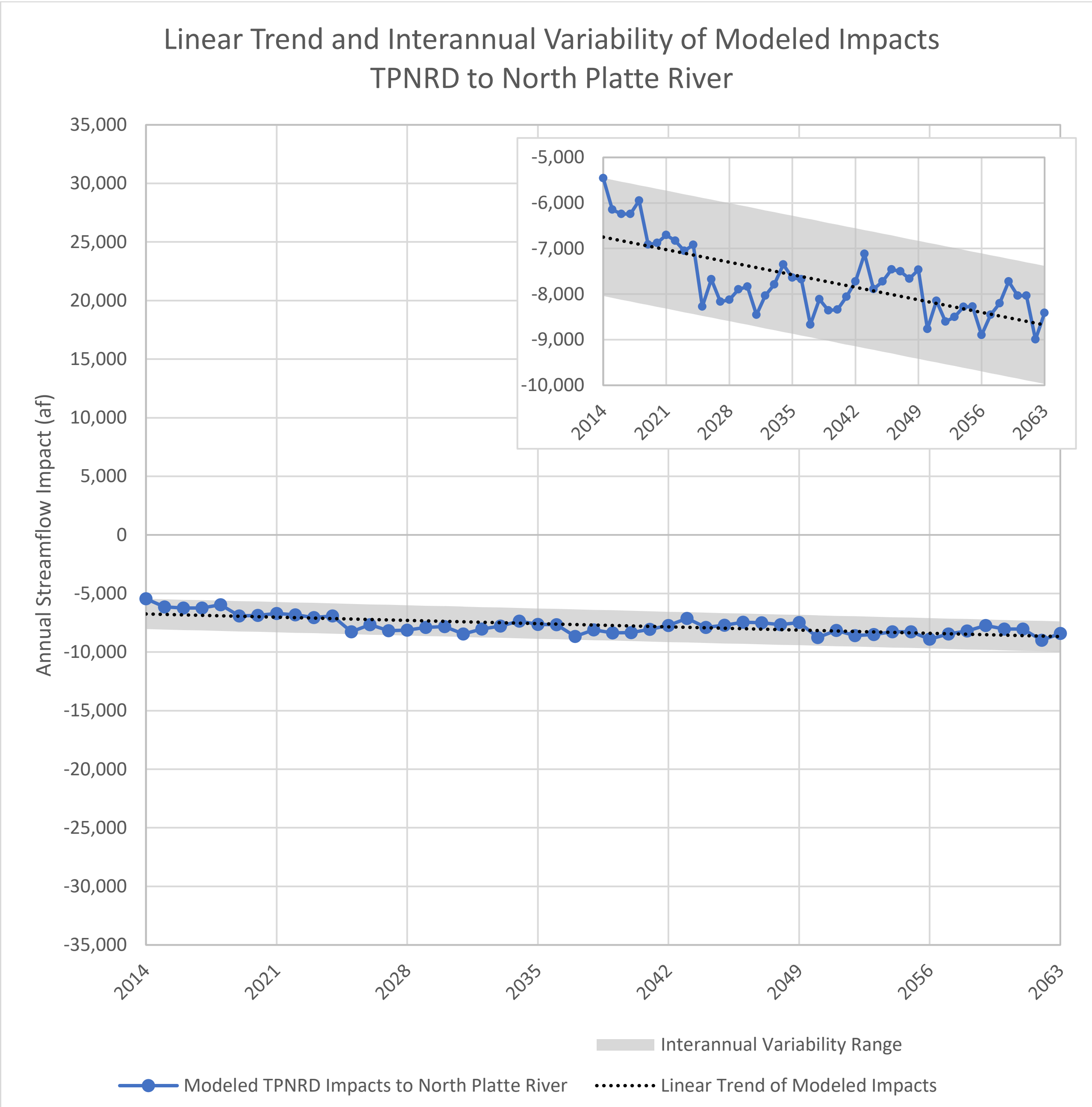


Figure 15: Modeled TPNRD post-1997 impacts to the North Platte River, the linear trend line of the modeled impacts from 2014-2063, and the inter-annual variability range of modeled impacts across the trend.

Figure 16 displays the same modeled post-1997 impacts of TPNRD to the Platte River upstream of Elm Creek as that found in Figure 13 (including groundwater only irrigation, municipal and industrial development, and groundwater irrigated acres retirements), with the addition of the linear trend line of the modeled impacts from 2014-2063, and the inter-annual variability range of modeled impacts across the trend. The inset in Figure 16 shows the same data at a smaller scale.

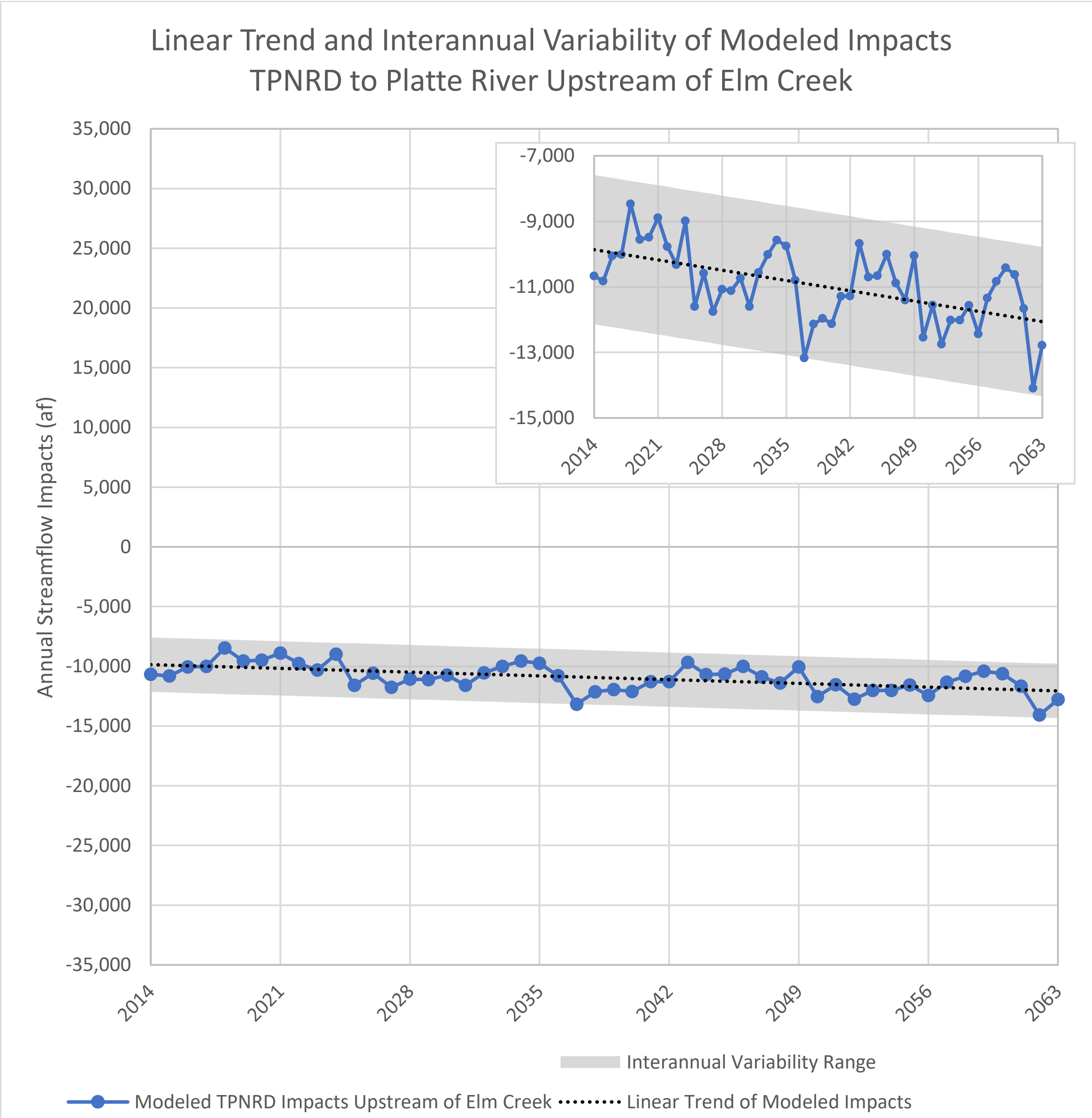


Figure 16: Modeled TPNRD post-1997 impacts to the Platte River upstream of Elm Creek, the linear trend line of the modeled impacts from 2014-2063, and the inter-annual variability range of modeled impacts across the trend.

Central Platte NRD (CPNRD)

In Figure 17, the modeled post-1997 impacts to the Platte River upstream of Elm Creek, and between Elm Creek and Chapman, from groundwater-only irrigation and municipal and industrial development within CPNRD are shown. Data shown in this figure also includes depletions-offsetting management actions, including groundwater irrigated acres retirements and recharge projects on the Platte River contracted by CPNRD.

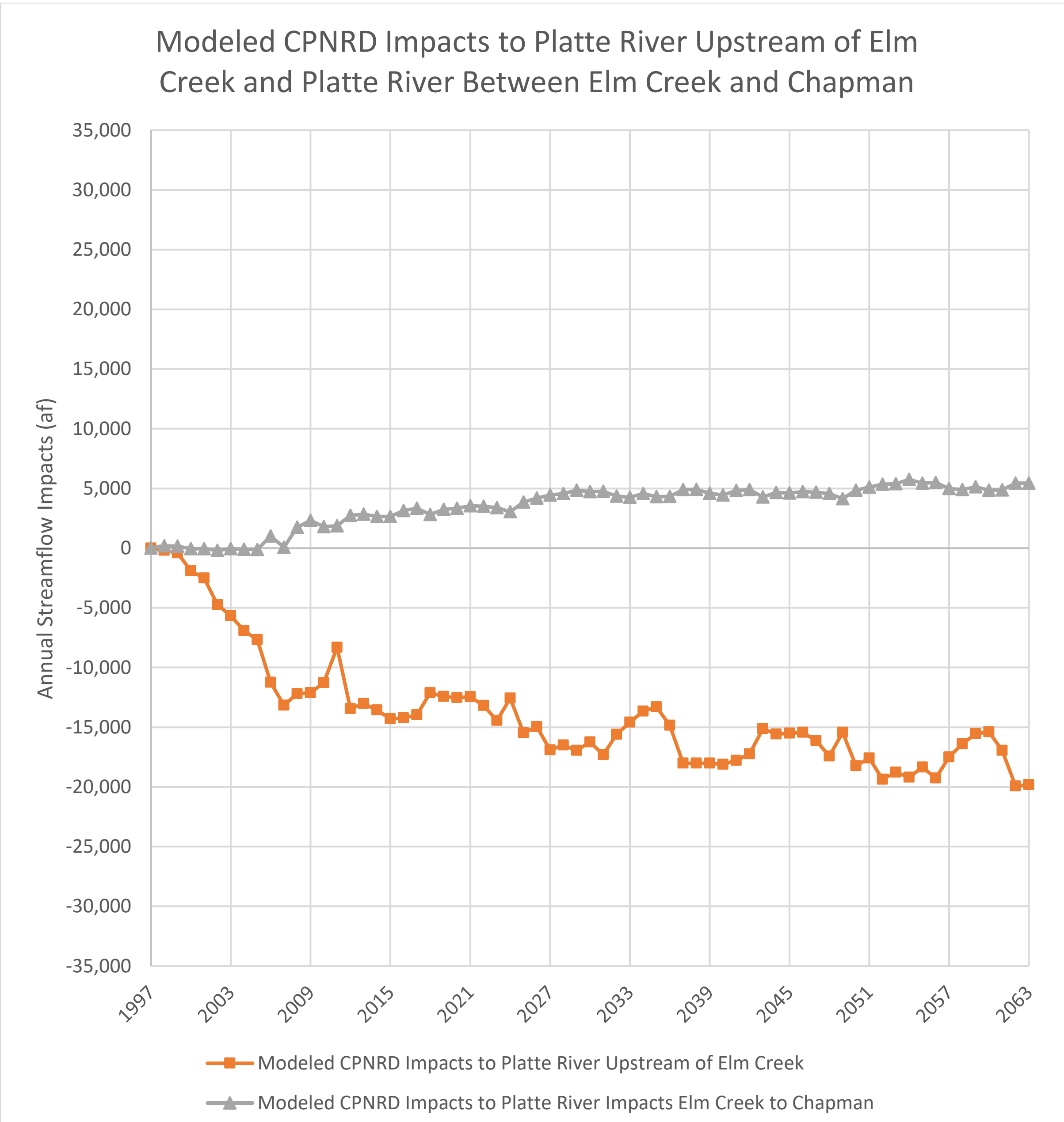


Figure 17: Modeled CPNRD post-1997 impacts to the Platte River Upstream of Elm Creek and the Platte River between Elm Creek and Chapman.

Figure 18 displays the same modeled post-1997 impacts of CPNRD to the Platte River upstream of Elm Creek as that found in Figure 17 (including groundwater-only irrigation, municipal and industrial development, groundwater irrigated acres retirements, and recharge projects on the Platte River contracted by CPNRD), with the addition of the linear trend line of the modeled impacts from 2014-2063, and the inter-annual variability range of modeled impacts across the trend. The inset in Figure 18 shows the same data at a smaller scale.

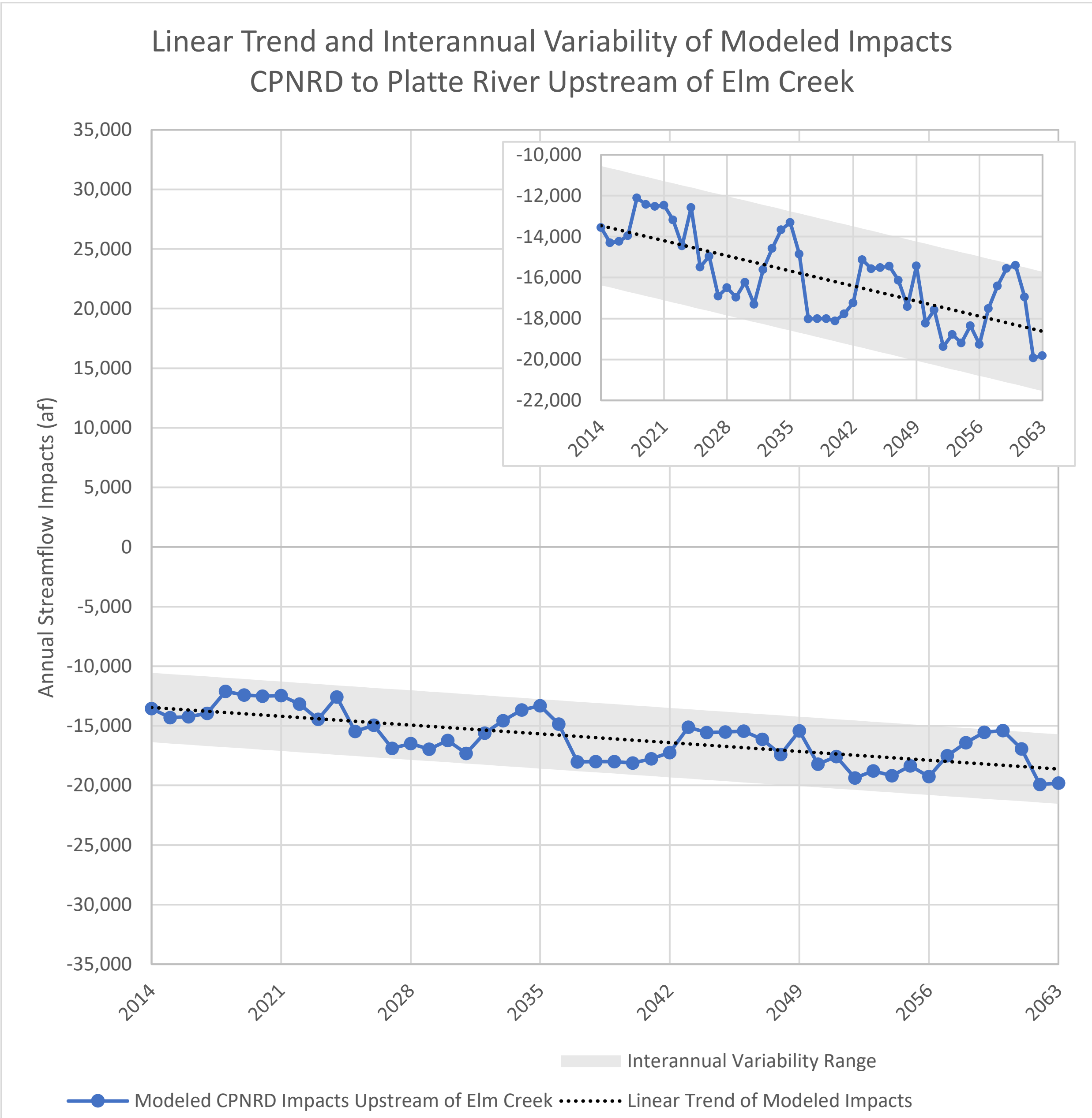


Figure 18: Modeled CPNRD post-1997 impacts to the Platte River upstream of Elm Creek, the linear trend line of the modeled impacts from 2014-2063, and the inter-annual variability range of modeled impacts across the trend.

Figure 19 displays the same modeled post-1997 impacts to the Platte River between Elm Creek and Chapman as that found in Figure 17 (including groundwater-only irrigation, municipal and industrial development, groundwater irrigated acres retirements, and recharge projects on the Platte River contracted by CPNRD), with the addition of the linear trend line of the modeled impacts from 2014-2063, and the inter-annual variability range of modeled impacts across the trend. The inset in Figure 19 shows the same data at a smaller scale.

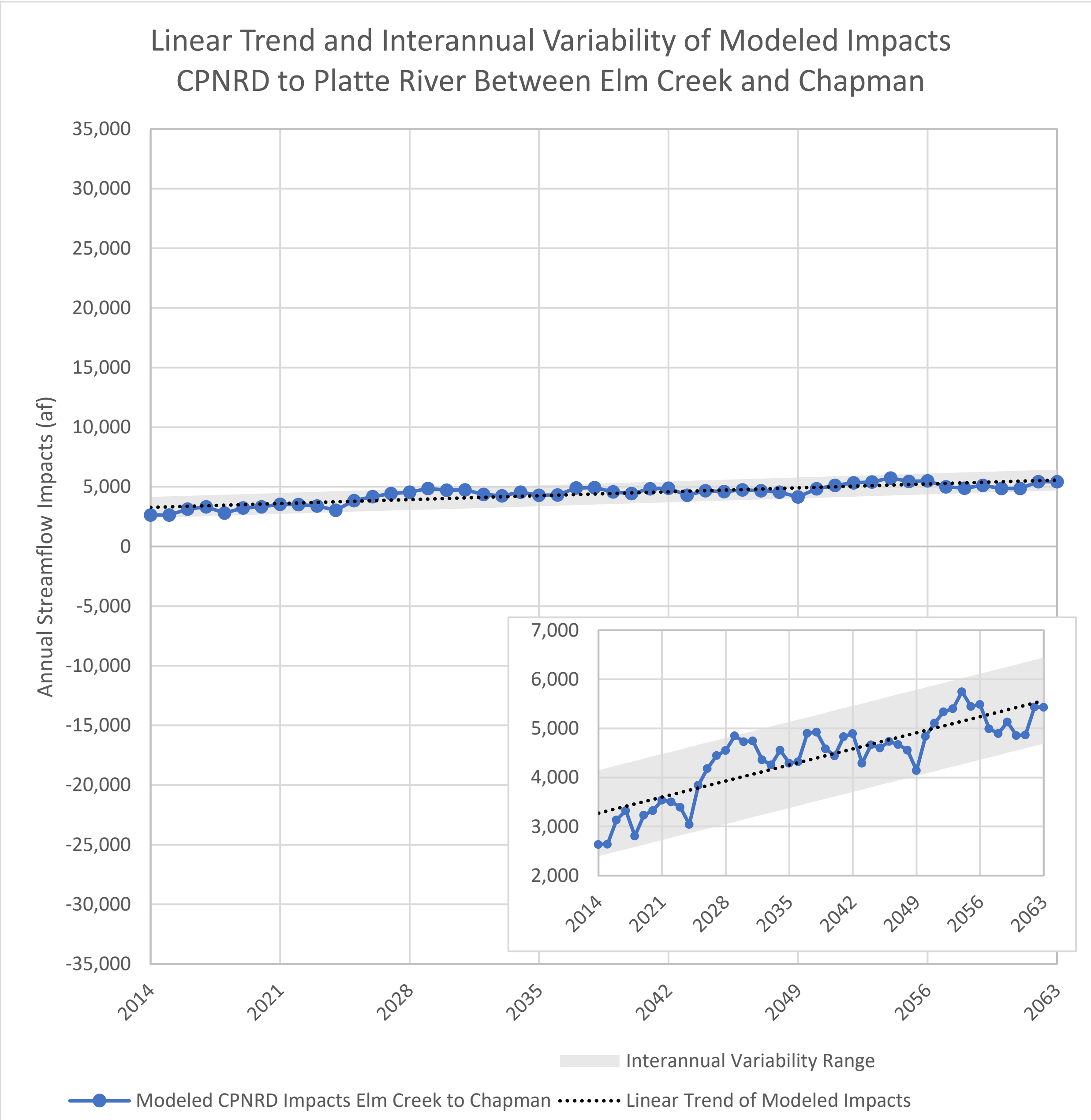


Figure 19: Modeled CPNRD post-1997 impacts to the Platte River between Elm Creek and Chapman, the linear trend line of the modeled impacts from 2014-2063, and the inter-annual variability range of modeled impacts across the trend.

Tri-Basin NRD (TBNRD)

In Figure 20, the modeled post-1997 impacts to the Platte River upstream of Elm Creek, and between Elm Creek and Chapman, from groundwater-only irrigation and municipal and industrial development within TBNRD are shown. Data shown in this figure also includes depletions-offsetting management actions, including groundwater irrigated acres retirements, recharge projects on the Platte River contracted by TBNRD, and streamflow augmentation.

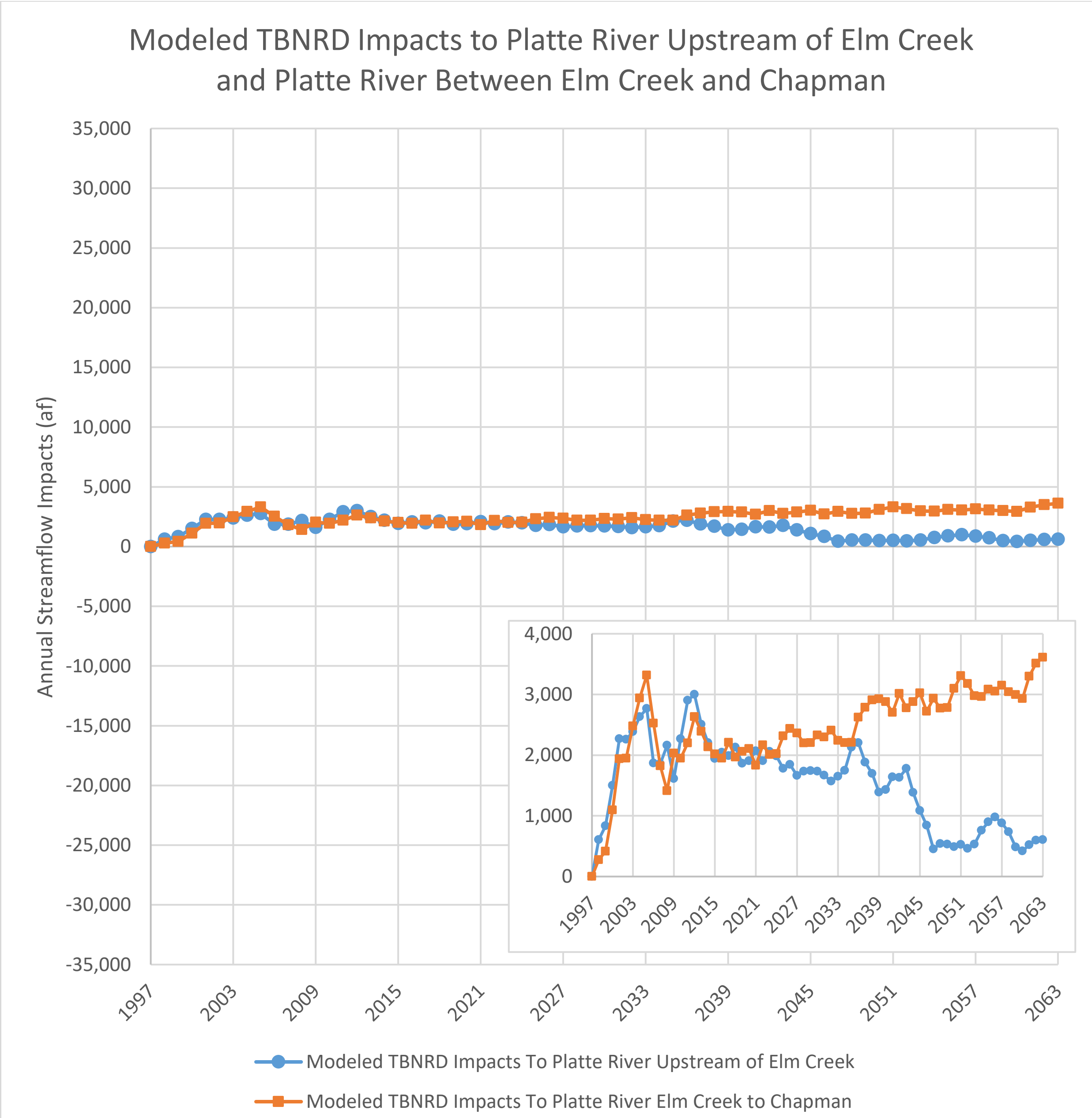


Figure 20: Modeled TBNRD post-1997 impacts to the Platte River upstream of Elm Creek and the Platte River between Elm Creek and Chapman.

Figure 21 displays the same modeled post-1997 impacts of TBNRD to the Platte River upstream of Elm Creek as that found in Figure 20 (including groundwater-only irrigation, municipal and industrial development, groundwater irrigated acres retirements, and recharge projects on the Platte River contracted by TBNRD), with the addition of the linear trend line of the modeled impacts from 2014-2063, and the inter-annual variability range of modeled impacts across the trend.

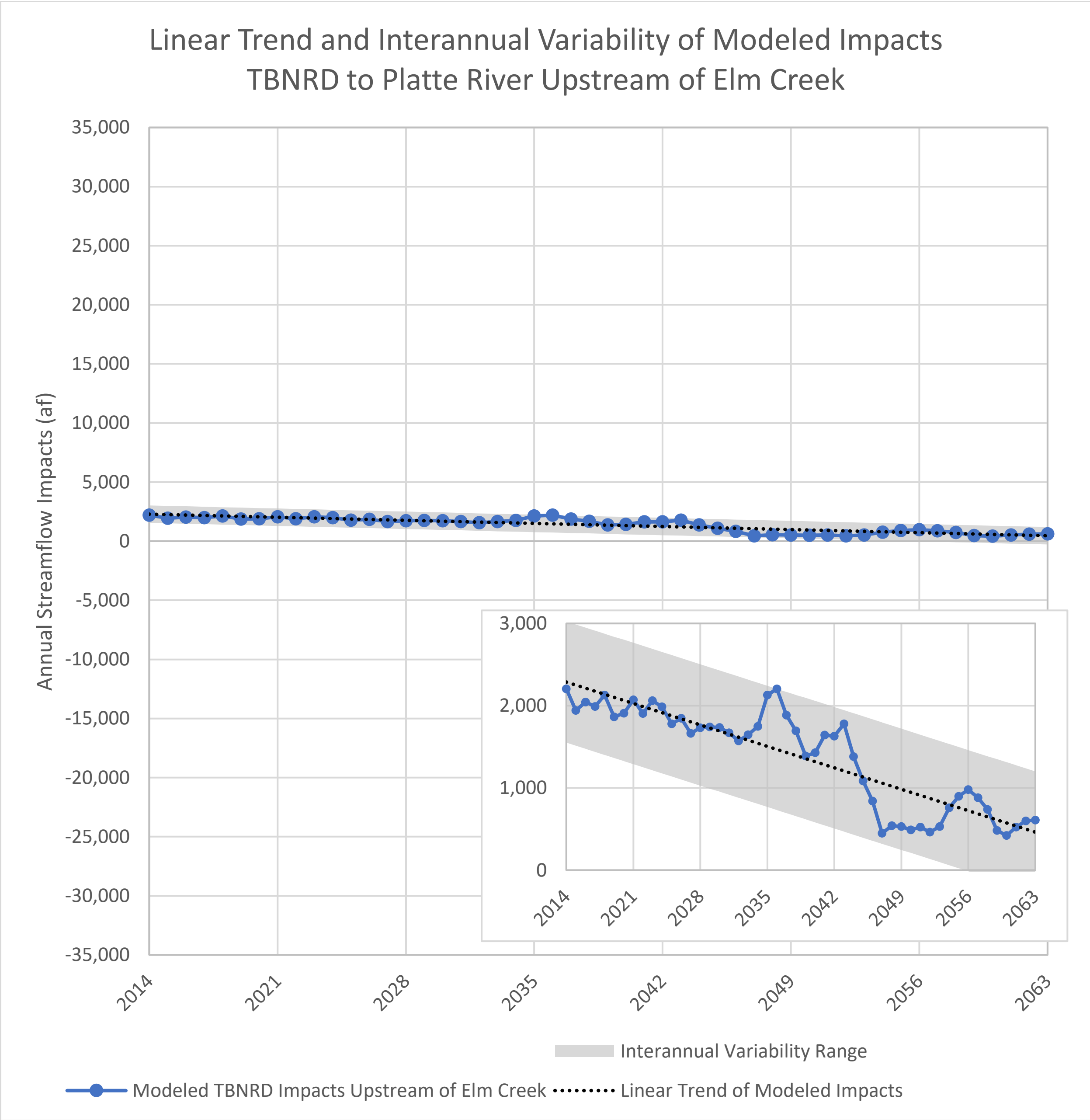


Figure 21: Modeled TBNRD post-1997 impacts to the Platte River upstream of Elm Creek, the linear trend line of the modeled impacts from 2014-2063, and the inter-annual variability range of modeled impacts across the trend.

Figure 22 displays the same modeled post-1997 impacts of TBNRD to the Platte River between Elm Creek and Chapman (including groundwater-only irrigation, municipal and industrial development, groundwater irrigated acres retirements, recharge projects on the Platte River contracted by TBNRD, and streamflow augmentation), with the addition of the linear trend line of the modeled impacts from 2014-2063, and the inter-annual variability range of modeled impacts across the trend.

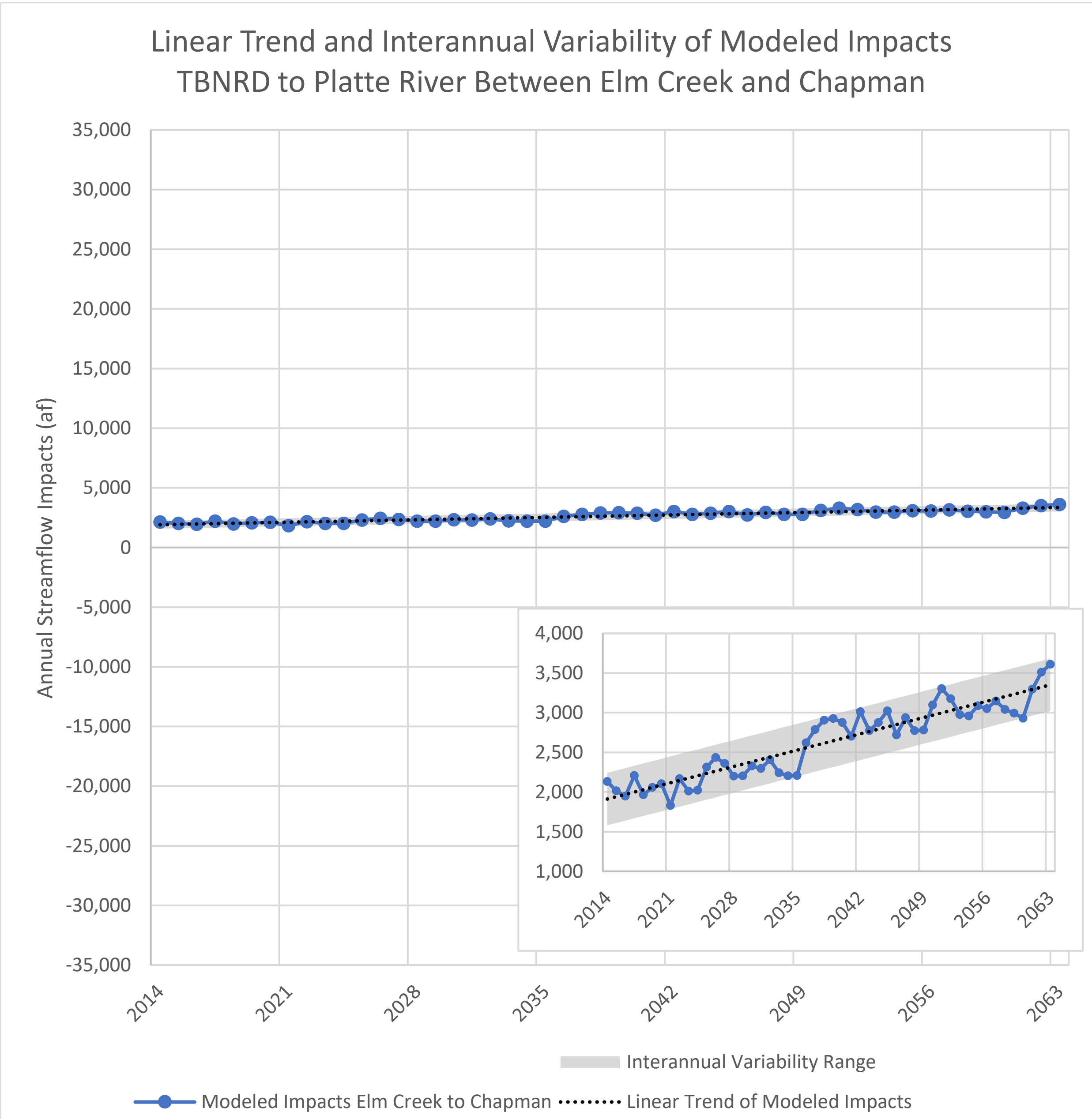


Figure 22: Modeled TBNRD post-1997 impacts to the Platte River between Elm Creek and Chapman, the linear trend line of the modeled impacts from 2014-2063, and the inter-annual variability range of modeled impacts across the trend.

Area Outside of the Five Upper Platte Basin NRDs

Figure 23 shows the modeled post-1997 impacts to the Platte River upstream of Chapman from groundwater-only irrigation and municipal and industrial development that occurred outside of the five Upper Platte Basin NRDs, but still within the model area.

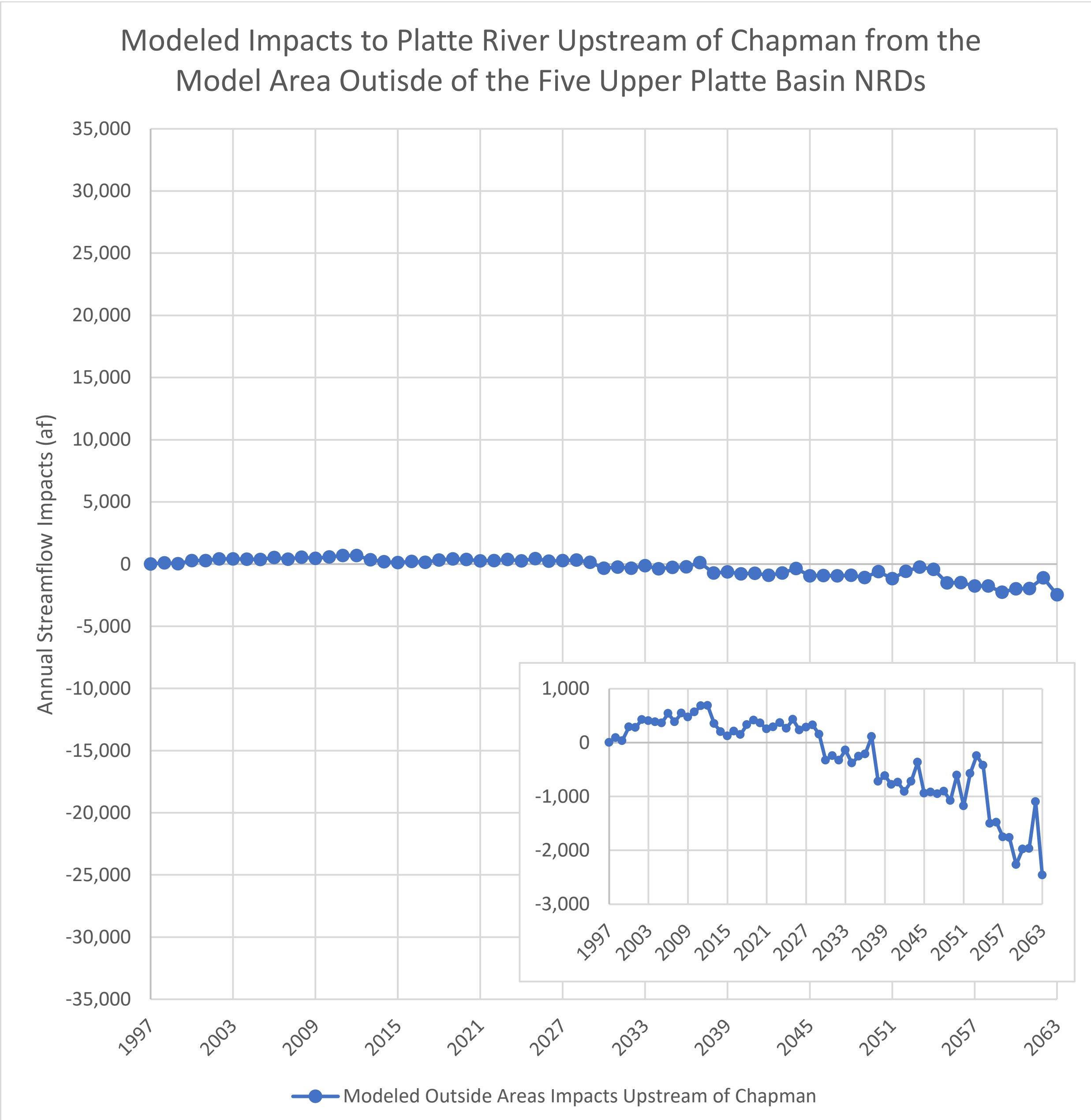


Figure 23: Modeled post-1997 impacts to the Platte River upstream of Chapman from the model area outside of the five Upper Platte Basin NRDs.

Five Upper Platte Basin NRDs and Total Model Area

Figure 24 shows the modeled post-1997 impacts to the Platte River upstream of Elm Creek from the five Upper Platte Basin NRDs (including groundwater-only irrigation, municipal and industrial development, groundwater irrigated acres retirements, recharge projects, and streamflow augmentation).

Also displayed in Figure 24 are the modeled post-1997 impacts (including groundwater-only irrigation, municipal and industrial development, groundwater irrigated acres retirements, recharge projects, and streamflow augmentation) to the Platte River upstream of Chapman from the entire model area, which includes but is not limited to, the area represented by the five Upper Platte Basin NRDs.

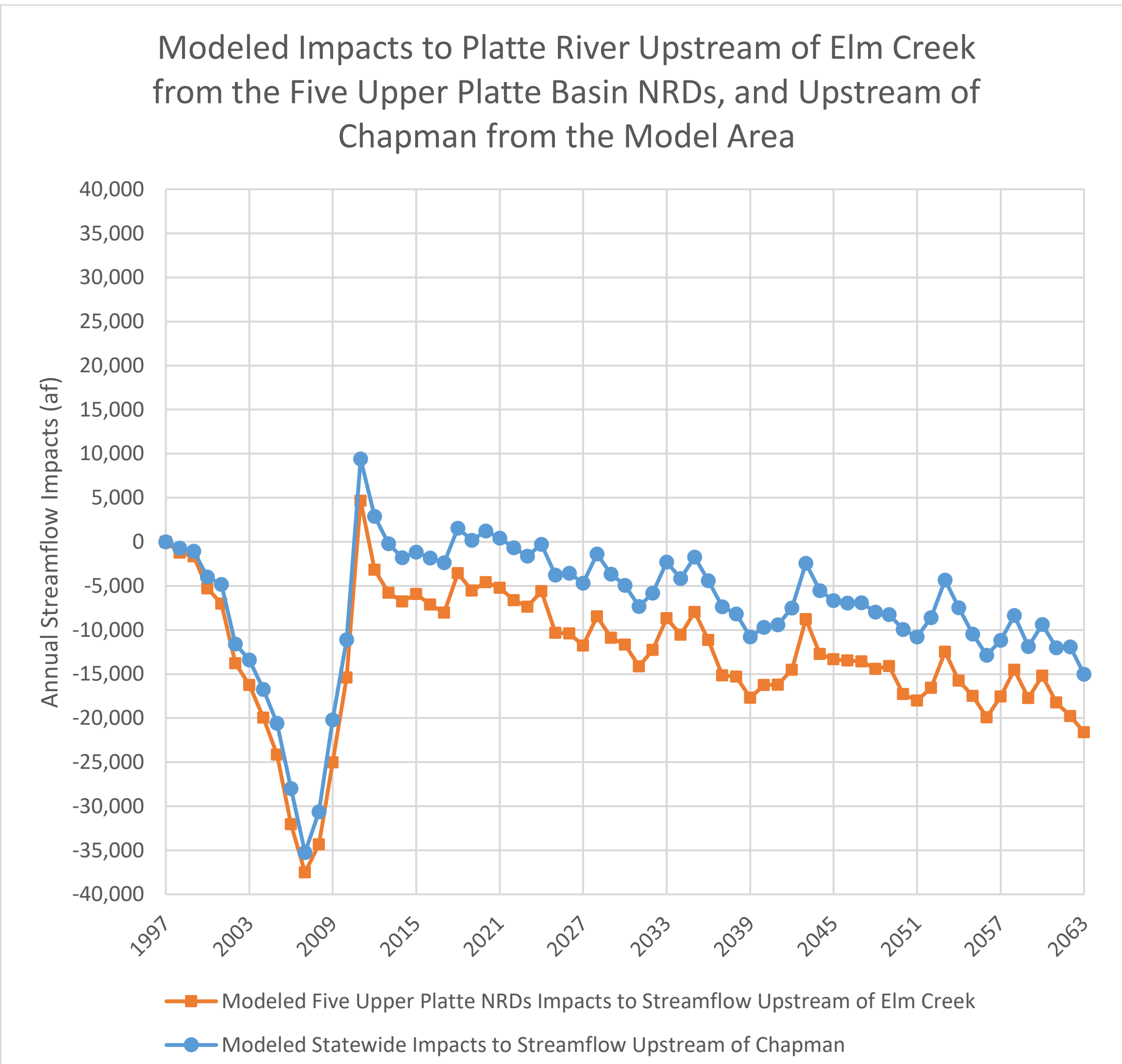


Figure 24: Modeled post-1997 impacts to the Platte River upstream of Elm Creek from the five Upper Platte Basin NRDs. Also, the modeled post-1997 impacts to the Platte River upstream of Chapman from the entire model area, including the Upper Platte Basin NRDs.

TABLES

Table 1: Net effect through 2019 of depletions and accretions. Values previously reported to PRRIP on April 21, 2017.

YEAR	NET EFFECT OF PERMITTED ACTIVITIES (af)	DEPLETIVE EFFECT FROM OTHER ACTIVITIES (af)	ACCRETIVE EFFECT FROM MITIGATION MEASURES (af)	TOTAL NET EFFECT (af)
2016	730	-20,400	23,710	4,040
2017	730	-20,800	23,540	3,470
2018	720	-21,300	23,080	2,500
2019	710	-21,600	22,980	2,090

Table 2: Total groundwater-only irrigated acres for each of the Upper Platte Basin NRDs and the Other NRDs within the model area used in the Robust Review analyses, rounded to the nearest hundred acres. Land use acres were held constant after 2023.

YEAR	NPNRD (acres)	SPNRD (acres)	TPNRD (acres)	CPNRD (acres)	TBNRD (acres)	OTHER NRDS (acres)
1997	134,400	103,800	205,700	817,300	406,600	1,590,400
2005	140,300	120,300	250,500	887,400	422,400	1,915,000
2013	131,100	119,000	263,100	902,200	461,300	2,055,700
2023	131,100	119,000	263,800	902,900	461,600	2,055,700

Table 3. Change in total groundwater-only irrigated acres for each of the Upper Platte NRDs and the Other NRDs within the model area used in the Robust Review analyses, rounded to the nearest hundred acres. Land use acres were held constant after 2023.

YEAR	NPNRD (acres)	SPNRD (acres)	TPNRD (acres)	CPNRD (acres)	TBNRD (acres)	OTHER NRDS (acres)
2005	5,900	16,500	44,800	70,100	15,900	324,700
2013	-3,400	15,300	57,500	84,900	54,700	465,300
2023	-3,400	15,300	58,100	85,700	55,000	465,300

Table 4: Average annual net recharge, irrigation groundwater pumping, net recharge (difference between recharge and irrigation groundwater pumping), and municipal and industrial pumping within NPNRD over 2014 to 2063 in acre-feet rounded to the nearest hundred.

NPNRD	HISTORICAL RUN (af)	1997 DEVELOPMENT RUN (af)	CHANGE DUE TO POST-1997 DEVELOPMENT (af)
AVERAGE RECHARGE	1,029,700	1,025,000	4,700
AVERAGE IRRIGATION GROUNDWATER PUMPING	198,900	233,500	-34,500
AVERAGE NET RECHARGE (Recharge - Irrigation Groundwater Pumping)	830,700	791,500	39,300
MUNICIPAL AND INDUSTRIAL PUMPING	11,500	14,100	-2,600

Table 5: Average annual net recharge, irrigation groundwater pumping, net recharge (difference between recharge and irrigation groundwater pumping), and municipal and industrial pumping within SPNRD over 2014 to 2063 in acre-feet rounded to the nearest hundred.

SPNRD	**HISTORICAL RUN** (af)	**1997 DEVELOPMENT RUN** (af)	**CHANGE DUE TO POST-1997 DEVELOPMENT** (af)
AVERAGE RECHARGE	160,200	157,300	3,000
AVERAGE IRRIGATION GROUNDWATER PUMPING	114,500	127,300	-12,800
AVERAGE NET RECHARGE (Recharge - Irrigation Groundwater Pumping)	45,700	29,900	15,700
MUNICIPAL AND INDUSTRIAL PUMPING	3,600	4,000	-400

Table 6: Average annual net recharge, irrigation groundwater pumping, net recharge (difference between recharge and irrigation groundwater pumping), and municipal and industrial pumping within TPNRD over 2014 to 2063 in acre-feet rounded to the nearest hundred.

TPNRD	**HISTORICAL RUN** (af)	**1997 DEVELOPMENT RUN** (af)	**CHANGE DUE TO POST-1997 DEVELOPMENT** (af)
AVERAGE RECHARGE	473,000	463,200	9,900
AVERAGE IRRIGATION GROUNDWATER PUMPING	358,600	293,600	64,900
AVERAGE NET RECHARGE (Recharge - Irrigation Groundwater Pumping)	114,500	169,500	-55,000
MUNICIPAL AND INDUSTRIAL PUMPING	8,100	6,700	1,400

Table 7: Average annual net recharge, irrigation groundwater pumping, net recharge (difference between recharge and irrigation groundwater pumping), and municipal and industrial pumping within CPNRD over 2014 to 2063 in acre-feet rounded to the nearest hundred.

CPNRD	**HISTORICAL RUN** (af)	**1997 DEVELOPMENT RUN** (af)	**CHANGE DUE TO POST-1997 DEVELOPMENT** (af)
AVERAGE RECHARGE	646,200	607,300	38,900
AVERAGE IRRIGATION GROUNDWATER PUMPING	716,000	664,300	51,700
AVERAGE NET RECHARGE (Recharge - Irrigation Groundwater Pumping)	-69,800	-56,900	-12,900
MUNICIPAL AND INDUSTRIAL PUMPING	22,300	18,400	3,900

Table 8: Average annual net recharge, irrigation groundwater pumping, net recharge (difference between recharge and irrigation groundwater pumping), and municipal and industrial pumping within TBNRD over 2014 to 2063 in acre-feet rounded to the nearest hundred.

TBNRD	**HISTORICAL RUN** (af)	**1997 DEVELOPMENT RUN** (af)	**CHANGE DUE TO POST-1997 DEVELOPMENT** (af)
AVERAGE RECHARGE	287,300	252,700	34,600
AVERAGE IRRIGATION GROUNDWATER PUMPING	386,900	362,400	24,500
AVERAGE NET RECHARGE (Recharge - Irrigation Groundwater Pumping)	-99,600	-109,700	10,100
MUNICIPAL AND INDUSTRIAL PUMPING	3,200	2,500	700

Table 9: Trend in modeled post-1997 streamflow impacts for 2019 to 2029 from groundwater-only irrigation development after 1997, expansion of municipal and industrial uses after 1997, and management activities through 2013 in NPNRD.

YEAR	**NPNRD IMPACT ON NORTH PLATTE RIVER** (af)
2019	23,300
2020	23,400
2021	23,500
2022	23,500
2023	23,600
2024	23,700
2025	23,800
2026	23,900
2027	23,900
2028	24,000
2029	24,100

The modeled impacts and inter-annual variability range about the trend presented in Table 9 are displayed in Figure 8.

Table 10: Trend in modeled post-1997 streamflow impacts for 2019 to 2029 from groundwater-only irrigation development after 1997, expansion of municipal and industrial uses after 1997, and management activities through 2013 in SPNRD.

YEAR	SPNRD IMPACT ON SOUTH PLATTE RIVER (af)	SPNRD IMPACT ON LODGEPOLE CREEK (af)	SPNRD IMPACT ON NORTH PLATTE RIVER (af)
2019	200	4,300	0
2020	200	4,300	0
2021	200	4,300	0
2022	200	4,300	0
2023	200	4,300	0
2024	200	4,400	0
2025	200	4,400	0
2026	200	4,400	0
2027	200	4,400	0
2028	200	4,400	0
2029	200	4,500	0

The modeled impacts and inter-annual variability range about the trend presented in Table 10 are displayed in Figures 10-12.

Table 11: Trend in modeled post-1997 streamflow impacts for 2019 to 2029 from groundwater-only irrigation development after 1997, expansion of municipal and industrial uses after 1997, and management activities through 2013 in TPNRD.

YEAR	TPNRD IMPACT ON SOUTH PLATTE RIVER (af)	TPNRD IMPACT ON NORTH PLATTE RIVER (af)	TPNRD IMPACT ON PLATTE RIVER UPSTREAM OF ELM CREEK (af)
2019	-5,900	-6,900	-10,100
2020	-6,000	-7,000	-10,100
2021	-6,200	-7,000	-10,200
2022	-6,300	-7,100	-10,200
2023	-6,500	-7,100	-10,300
2024	-6,600	-7,100	-10,300
2025	-6,800	-7,200	-10,400
2026	-6,900	-7,200	-10,400
2027	-7,100	-7,300	-10,400
2028	-7,200	-7,300	-10,500
2029	-7,400	-7,300	-10,500

The modeled impacts and inter-annual variability range about the trend presented in Table 11 are displayed in Figures 14-16.

Table 12: Trend in modeled post-1997 streamflow impacts for 2019 to 2029 from groundwater-only irrigation development after 1997, expansion of municipal and industrial uses after 1997, and management activities through 2013 in CPNRD.

YEAR	CPNRD IMPACT ON PLATTE RIVER UPSTREAM OF ELM CREEK (af)	CPNRD IMPACT ON PLATTE RIVER BETWEEN ELM CREEK AND CHAPMAN (af)
2019	-14,000	3,500
2020	-14,100	3,600
2021	-14,200	3,600
2022	-14,300	3,600
2023	-14,400	3,700
2024	-14,500	3,700
2025	-14,600	3,800
2026	-14,700	3,800
2027	-14,800	3,900
2028	-14,900	3,900
2029	-15,000	4,000

The modeled impacts and inter-annual variability range about the trend presented in Table 12 are displayed in Figures 18 and 19.

Table 13: Trend in modeled post-1997 streamflow impacts for 2019 to 2029 from groundwater-only irrigation development after 1997, expansion of municipal and industrial uses after 1997, and management activities through 2013 in TBNRD.

YEAR	TBNRD IMPACT ON PLATTE RIVER UPSTREAM OF ELM CREEK (af)	TBNRD IMPACT ON PLATTE RIVER ELM CREEK TO CHAPMAN (af)
2019	2,100	2,100
2020	2,100	2,100
2021	2,000	2,100
2022	2,000	2,100
2023	2,000	2,200
2024	1,900	2,200
2025	1,900	2,200
2026	1,800	2,300
2027	1,800	2,300
2028	1,800	2,300
2029	1,700	2,400

The modeled impacts and inter-annual variability range about the trend presented in Table 13 are displayed in Figures 21 and 22.

Table 14: Trend in modeled post-1997 streamflow impacts for 2019 to 2029 for areas outside of the five Upper Platte Basin Natural Resources Districts (other NRDs), but still within the model area.

YEAR	OTHER NRDS' IMPACT ON PLATTE RIVER UPSTREAM OF CHAPMAN (af)
2019	400
2020	300
2021	300
2022	300
2023	200
2024	200
2025	100
2026	100
2027	0
2028	0
2029	-100

Table 15: Summarized trended robust review results for the five Upper Platte Basin NRDs by stream segment for 2019 -2029 (second IMP increment).

YEAR	NORTH PLATTE RIVER (af)	SOUTH PLATTE RIVER (af)	LODGEPOLE CREEK (af)	PLATTE RIVER BETWEEN NORTH AND SOUTH PLATTE CONFLUENCE AND ELM CREEK (af)	PLATTE RIVER ELM CREEK TO CHAPMAN (af)	TOTAL UPSTREAM OF ELM CREEK (af)	TOTAL UPSTREAM OF CHAPMAN (af)
2019	16,400	-5,700	4,300	-22,000	5,600	-7,100	-1,500
2020	16,400	-5,900	4,300	-22,200	5,600	-7,300	-1,700
2021	16,500	-6,000	4,300	-22,400	5,700	-7,600	-1,900
2022	16,500	-6,200	4,300	-22,500	5,800	-7,900	-2,100
2023	16,500	-6,300	4,300	-22,700	5,900	-8,200	-2,300
2024	16,600	-6,500	4,400	-22,900	5,900	-8,400	-2,500
2025	16,600	-6,600	4,400	-23,100	6,000	-8,700	-2,700
2026	16,700	-6,800	4,400	-23,300	6,100	-9,000	-2,900
2027	16,700	-6,900	4,400	-23,500	6,200	-9,300	-3,100
2028	16,700	-7,100	4,400	-23,700	6,300	-9,600	-3,300
2029	16,800	-7,200	4,500	-23,900	6,300	-9,800	-3,500

The summary in Table 15 does not include any new management actions implemented subsequent to 2013, including Nebraska's participation in the J-2 Water Action Plan Project.

2019

Appendix A – Supplemental Technical Memos and Model Reports

Components of the Current Robust Review Analysis

- A. Components Analyzed in the Current Groundwater Model Evaluation
  - A.1 Cooperative Hydrology Study 2010 (COHYST2010) and Western Water Use Management (WWUM) Model Groundwater Model Analysis Methods
    - A.1.1 Robust Review Project Analysis Scope of Work
    - A.1.2 Memorandum on the COHYST2010 Watershed Model Update – Run029
    - A.1.3 Memorandum on COHYST2010 area Model Runs
    - A.1.4 Memorandums on Municipal, Industrial, and Domestic Use for COHYST2010
    - A.1.5 Memorandums on NRD Land Use Retirements, Transfers and Variances for COHYST2010
    - A.1.6 North Dry Creek pumping data excel spreadsheet
    - A.1.7 Memorandums on the Calculation of Excess Flows, Recharge Volumes and Percentages, and Discharge Volumes for Canal Recharge
    - A.1.8 Memorandum October 2018 Update: Post 97 Analysis WWUMM
    - A.1.9 Memorandums on Industrial and Municipal Pumping for WWUMM
    - A.1.10 Memorandum on NPNRD and SPNRD Ground Water Only Retirements
    - A.1.11 Memorandum on NPNRD and SPNRD Canal Excess Flow Diversion, Recharge Analysis Comparison, and Canal Loss Recommendation
- B. Components Not Analyzed in the Current Groundwater Model Evaluation
  - B.1 Evaluation of Livestock Uses
    - B.1.1 Cattle Analysis – COHYST
    - B.1.2 Confined Livestock Feeding Facility Pumping - WWUMM
  - B.2 Evaluation of Sandpits and Small Reservoirs

Components of the Current Robust Review Evaluation

A. Components analyzed in the current groundwater model evaluation

The 2019 Robust Review groundwater model evaluation was completed to provide a quantification of the NeDNR and NRDs management actions to meet the goals and objectives of the Integrated Management Plans in the Overappropriated Area of the Platte Basin. One piece of this evaluation was completed using groundwater models. The models included an estimate of changes in groundwater only irrigation use (via either landuse changes or metered use data), municipal use and industrial use, and certain management actions (recharge of excess flows via canals and recharge facilities, groundwater retirements, and streamflow augmentation). The processes for these activities are described in Section A of Appendix A. This current analysis replaces the previous analysis completed by Richard Luckey in 2008[1] which only included an evaluation of the changes in groundwater only irrigation use.

B. Components not analyzed in the current groundwater model evaluation

Livestock uses and the change in sandpits and small reservoirs were not evaluated within the groundwater models. Changes in the number of cattle since 1997 were evaluated by the NeDNR and the NRDs and the numbers have generally decreased over time, resulting in a net positive effect on water supplies in the Upper Platte Basin. Therefore, the determination was made that these uses did not need to be included in the groundwater model analysis. More details on the calculations of livestock numbers can be found in Section B.1 of Appendix A.

Sandpits and small reservoirs were previously analyzed by NeDNR in 2014. This analysis determined that the overall consumptive use of water from changes between 2010 and 2015 resulted in net decreases in consumptive use; consequently, resulting in a net positive effect on water supplies in the Upper Platte Basin. Therefore, the determination was made that no further analysis of this change was needed at this time. More details on the methodology for this analysis can be found in Section B.2 of Appendix A.

[1] Luckey, R.R. 2008. Estimated Stream Baseflow Depletion by Natural Resources District in the Nebraska Platte Basin due to Gained and Lost Groundwater Irrigated Land after July 1, 1997. *High Plains Hydrology, LLC*. https://dnr.nebraska.gov/sites/dnr.nebraska.gov/files/doc/water-planning/upper-platte/publications/Estimated%20Stream%20Baseflow%20Depletion%20by%20Natural%20Resources%20District%20in%20the%20Nebraska%20Platte%20Basin%20.pdf

A.1 Cooperative Hydrology Study 2010 (COHYST2010) Groundwater Model Analysis Methods

A.1 Cooperative Hydrology Study 2010 (COHYST2010) Groundwater Model Analysis Methods

I. Objective

The purpose of this modeling evaluation is to simulate depletions to streamflow from development of groundwater-only irrigated lands in the Cooperative Hydrology Study 2010 (COHYST2010) model area from after 1997 through 2013, including groundwater acre retirements through 2023, and development of municipal and industrial (M&I) pumping after 1997 through 2013, and ongoing (1997 – 2063) offsets from management actions (excess flow recharge and augmentation) taken between 1997 and 2013.

The specific results that were summarized in the report are acres and crop type changes on groundwater-only irrigated land by Natural Resources District (NRD); M&I pumping changes by NRD; excess flow recharge volumes by project and contracting NRD; augmentation pumping by NRD; and the combined streamflow impacts of the aforementioned by NRD.

For each NRD analysis, two model runs are necessary: a baseline simulation and an impact/scenario simulation. The baseline simulation is the representation of the historical condition. The scenario simulation is the representation of constant 1997 groundwater only irrigated acres and M&I pumping. The difference between these two runs provides an estimate of the streamflow impacts from development and management actions after 1997.

The documented model that is the basis for this analysis consists of the Regionalized Soil Water Balance (Watershed model) and Groundwater portions of the COHYST2010 integrated model. Further documentation of the COHYST model is available at https://cohyst.nebraska.gov/, including datasets at https://cohyst.nebraska.gov/pdf/04-Datasets.pdf. Version 29 of the Watershed model and Version 28 of the Groundwater model were used. The simulation period for these analyses is 1950 to 2063. The Platte Basin Coalition (PBC) scope of work documents for the design of this analysis are available as attachments (Appendix A.1.1). Model files are available at https://UPJointPlanning.nebraska.gov.

II. Baseline Model Setup – Historical

A. Baseline Watershed Model Setup

The Flatwater Group, Inc. (TFG) was contracted by PBC to complete Watershed model runs for the Robust Review. The Watershed model used for the Robust Review was based on COHYST 2010 Watershed Model Run029, an updated version of the documented COHYST watershed model, as described in the TFG memorandum on the COHYST2010 Watershed Model Update – Run029, dated June 15, 2018 (Appendix A.1.2). For the Robust Review, COHYST Watershed Model Run029 was updated with irrigated acres and M&I pumping through 2013 and extended back to 1950 and forward to 2063. Information on the documented COHYST2010 M&I pumping is available at https://cohyst.nebraska.gov/pdf/appendix/04R-MunicipalProcessing.pdf. The Flatwater Group Memorandum on COHYST2010 area Model Runs dated November 26, 2018 (Appendix A.1.3) documents the Watershed model setup. Details on updates to M&I pumping and land use used in this analysis are available as Appendices A.1.4 and A.1.5, respectively.

Watershed results for the Robust Review were provided from The Flatwater Group, Inc. to NeDNR include land use and water balance summaries and recharge (.rch) and pumping (.wel) MODFLOW groundwater model files.

B. Baseline Groundwater Model Setup

The groundwater model used for the Robust Review was based on the documented COHYST groundwater model updated with recharge and pumping files provided by the Watershed model update, as described in the previous section, and extended from 1950 to 2063. The following section describes changes made to the individual model files in setup of the Robust Review baseline model.

1. Pumping/.WEL

For the baseline run, the North Dry Creek augmentation pumping (NDC) was added to the Watershed output .WEL file. The pumping from the NDC augmentation well was obtained from a spreadsheet "NDC Augmentation Wells_SWLs.xls" tab "Aug Prod Well" provided by TBNRD. The NDC pumping data from the spreadsheet that are relevant to this analysis are provided as an attachment (Appendix A.1.6). The coordinates of the well (Lat: N40 38' 25.91700", Long: W99 06' 59.91771") were also obtained from this tab and were identified as model row-column 190-319. Only pumping through 2013 was used in this Robust Review. An email was exchanged with Nolan Little, TBNRD, on July 18, 2018, verifying these monthly pumped volumes:

Month	Year	Acre-Feet Pumped
7	2011	0.776667
10	2011	0.755833
6	2012	71.2375
7	2012	108.0308
8	2012	155.7767
9	2012	39.39333
5	2013	66.17667
6	2013	37.02333
7	2013	80.10083
8	2013	87.60417

2. Recharge

The documented COHYST2010 groundwater model is set up to take recharge arrays parameterized for seepage from surface water bodies (typically output data of the surface water model portion of the integrated COHYST2010 model) and recharge from precipitation and surface water irrigation and groundwater pumping (typically output data from the Watershed model).

The seepage values from canals and reservoirs are based on the surface water model portion of the Conservation Study. The Conservation Study reference documents can be found at https://UPJointPlanning.nebraska.gov. Seepage for 1950-2013 uses the values simulated from the Conservation Study baseline. Seepage for years 2014-2063 are represented by repeating 1989 to 2013 twice.

The excess flow canal and reservoir recharge was added to the historical surface water seepage recharge array. The excess flow recharge projects analyzed in this Robust Review are:

- Twin Platte excess flow canal recharge projects
- Central Platte excess flow canal recharge projects
- Phelps Canal excess flow recharge
- E65 Canal excess flow recharge
- Elwood excess flow recharge

The quantification of these projects are available in the memos on the Calculation of Excess Flows, Recharge Volumes and Percentages, and Discharge Volumes for Canal Recharge (Appendix A.1.7):

- From Margeaux Carter and Kari Burgert, NeDNR, to the POAC Technical Committee, dated March 15, 2018, revised June 12, 2018, revised June 7, 2019
- From Kari Burgert, NeDNR, to the POAC Technical Committee, dated June 14, 2018, revised October 11, 2018

For the second recharge array, the output from the baseline Watershed model run was used. The .RCH file from the Watershed output was reformatted into the array format by removing the time step header information.

All recharge multipliers used by the documented COHYST2010 groundwater model are set to 1.0.

3. Initial heads

The initial heads represented in the MODFLOW Basic package (.BAS) were changed to January 1950 levels created using pre-development groundwater level data and the methodology used to develop the starting heads for calibrated COHYST.

4. General head boundaries

There are four general head boundary arrays parameterized for the documented COHYST2010 groundwater model runs.

- The marginal heads developed for these runs are the same as calibrated.
- Lake McConaughy heads are based on the surface water model portion of the Conservation Study. Lake McConaughy heads for 1950-2013 use the end-of-month elevations from the Conservation Study. Lake McConaughy heads for years 2014-2063 are represented by repeating 1989 to 2013 twice.
- Hugh Butler Lake and Harry Strunk Lake heads for 1950-2013 use the end-of-month elevations from the U.S. Bureau of Reclamation (USBR) Hydromet database. Hugh Butler Lake and Harry Strunk Lake heads for years 2014-2063 are represented by repeating 1989 to 2013 twice.

5. Evapotranspiration

Phreatophyte evapotranspiration (EVT) represented in the .EVT package of the groundwater model is based on calibrated values. EVT values for 1985-2010 are calibrated values. Monthly 1950-1984 EVT are set to monthly 1985 values. Monthly 2011-2013 EVT are set to monthly 2010 values. To mimic the climate repetitions, 2014-2063 EVT are represented by repeating 1989 to 2013 twice.

6. Streams

The stream package in the integrated calibrated model of the latest version of COHYST2010 includes flows from inflows, diversions, returns, and watershed runoff. No diversions, returns, or watershed-modeled runoff are included in these simulations. Stress period inflows to the stream (90% of Sutherland reservoir seepage, inflow to the South Platte River at Julesburg, and inflow on the North Platte River below Keystone Dam) for 1950-2013 are taken from the surface water results of Conservation Study. Inflows for 2014-2063 are represented by repeating 1989 to 2013 values twice.

7. Drains

The documented model drain elevation and conductances were repeated for all periods.

8. Rivers

The documented model river stages, conductances, and elevations were repeated for all periods.

9. Baseline Groundwater Model Setup Summary

Pumping:	Watershed model to meet Net Irrigation Recharge (NIR) Historical M&I pumping North Dry Creek (NDC) pumping
Recharge:	
Watershed:	Watershed model
Surface water seepage:	1950-2013 from surface water model of Conservation Study 2014-2063 represented by repeating 1989 to 2013 twice Excess flow recharge
Multipliers:	No multipliers (multipliers of 1.0) were used for all zones
Initial heads:	Updated to January 1950 levels from previous NeDNR analysis
General head boundaries:	
Lake McConaughy:	1950-2013 from surface water model of Conservation Study 2014-2063 represented by repeating 1989 to 2013 twice
Hugh Butler & Harry Strunk:	1950-2013 from USBR Hydromet database 2014-2063 represented by repeating 1989 to 2013 twice
EVT:	1950-1984 represented by monthly 1985 values 1985-2010 from calibrated model 2011-2013 represented by monthly 2010 values 2014-2063 represented by repeating 1989 to 2013 twice
Streams:	Runoff, diversions, and returns are excluded for the entire period

Inflows:	1950-2013 from the surface water results of Conservation Study 2014-2063 represented by repeating 1989 to 2013 twice
Drains:	Documented values for all time periods
River:	Documented values for all time periods

III. Scenario Setup – Constant 1997 Conditions

The four scenarios for each of the three NRDs of Twin Platte NRD (TPNRD), Central Platte NRD (CPNRD), and Tri-Basin NRD (TBNRD) and the area outside of these three NRDs but part of the COHYST model area (Rest-of-Model Area) are to represent constant 1997 conditions as compared to the baseline that has historical groundwater-only irrigation and M&I conditions as well as management actions. This requires the scenario to be modified from the baseline both during the scenario watershed setup (land use and M&I pumping) and the scenario groundwater model setup (augmentation pumping and excess flow recharge). Only the recharge arrays and pumping volumes change between the baseline and scenario.

1. Scenario Watershed Model Setup

There was one run of the watershed model executed for the scenario simulation. The baseline inputs were modified by holding all groundwater-only irrigated acres and M&I pumping constant at 1997 levels through 2063. The Flatwater Group, Inc. Memorandum on COHYST2010 area Model Runs, (Appendix A.1.3) documents the Watershed model setup. The land use change and M&I pumping change was made for all areas of the model in a single watershed model run, and the resulting pumping and recharge impacts will be isolated by management area in the scenario groundwater model setup. The watershed results for the Constant-97 scenario were provided from The Flatwater Group, Inc. to NeDNR include land use and water balance summaries and recharge (.rch) and pumping (.wel) MODFLOW groundwater model files.

2. Scenario Groundwater Model Setup

For each management area scenario, the scenario watershed model recharge and pumping values were used for the management area, and the baseline watershed model recharge and pumping values were used for the other NRDs and remainder of the model area. North Dry Creek pumping and excess flow recharge volumes were added to the scenarios for the management areas in which they did not occur (e.g., NDC pumping was added to TPNRD, CPNRD, and Rest-of-Model Area scenarios but not TBNRD scenario). All other groundwater model data are the same as in the baseline. The following table summarizes the four groundwater model runs for the Robust Review scenarios.

Table 1. Robust review scenarios representing constant 1997 conditions for comparison to the baseline scenario representing historical development and management actions.

Scenario Management Area	Scenario Description	Change to baseline well file	Change to baseline watershed recharge array	Change to baseline surface water seepage array
TPNRD	Historical without TPNRD GWO and M&I development after 1997 and without Twin Platte canals excess flow recharge	Constant97 scenario pumping in TPNRD	Constant97 scenario recharge in TPNRD	Does not include Twin Platte canals excess flow recharge
CPNRD	Historical without CPNRD GWO and M&I development after 1997 and without CPNRD and NPPD canals excess flow recharge	Constant97 scenario pumping in CPNRD	Constant97 scenario recharge in CPNRD	Does not include CPRND nor NPPD canals excess flow recharge
TBNRD	Historical without TBNRD GWO and M&I development after 1997, without NDC pumping, without E65 canals excess flow recharge	Constant97 scenario pumping in TBNRD and no NDC pumping	Constant97 scenario recharge in TBNRD	No change
Rest-of-Model Area	Historical without Rest-of-Model Area GWO and M&I development after 1997	Constant97 scenario pumping in Rest-of-Model	Constant97 scenario recharge in Rest-of-Model	No change

IV. Component Scenarios

The Post-1997 NRD impacts can be broken down further to determine the separate impacts of individual historical changes and management actions and the impacts from those in different management areas of an NRD. The individual component scenarios considered in the Robust Review are:

- Retired groundwater irrigated acres by NRD and hydrologically connected areas
- Change in groundwater-only irrigated acres after 1997 by NRD and hydrologically connected areas
- Change in groundwater-only irrigated acres and M&I pumping after 1997 by NRD and hydrologically connected areas (no management actions considered)
- North Dry Creek Augmentation Project pumping
- TPNRD-contracted excess flow recharge from 2011-2013
- CPNRD-contracted excess flow recharge from 2011-2013 , including separate analyses for:
    - The sum of Cozad, Orchard-Alfalfa, and Thirty-mile canals
    - The sum of Dawson County, Gothenburg, and Kearney canals
- TBNRD-contracted excess flow recharge individually:
    - E65 Canal in 2013
    - Elwood Reservoir from 2006-2013
    - Phelps Canal from 2011-2013

For the retired groundwater irrigated acres analysis, a scenario was developed with the Watershed model where the acres that were identified as retired from irrigation, were restored to groundwater irrigated. The watershed results for the unretired scenario (MOD001) were provided from The Flatwater Group, Inc. to NeDNR include land use and water balance summaries and recharge (.rch) and pumping (.wel)

MODFLOW groundwater model files. The groundwater model scenario setup followed the same processes as identified in the last section.

For the remaining component scenarios, combinations of the historical and constant 1997 scenario recharge and well values were used to create scenarios in which the component of interest was removed from the historical scenario. The M&I pumping is an auxiliary term to the watershed modeled pumping. The Flatwater Group, Inc. provided a Constant-97 pumping file that included historical M&I development, i.e., only 1997 groundwater-only irrigated acres were held constant, which will be referred to as Constant97HistMI. The groundwater model scenario setup followed the same processes as identified in the last section, unless otherwise described in the following table.

Table 2. Robust review component scenarios representing individual historical changes and management actions in differing management areas for comparison to the baseline scenario representing historical development and management actions.

Scenario Run	**Change to baseline well file**	**Change to baseline watershed recharge array**	**Change to baseline surface water seepage array**
1. Historical without TPNRD retired lands	MOD001 well values in TPNRD	MOD001 recharge values in TPNRD	no change
2. Historical without TPNRD OA area retired lands	MOD001 well values in TPNRD OA	MOD001 recharge values in TPNRD OA	no change
3. Historical without CPNRD retired lands	MOD001 well values in CPNRD	MOD001 recharge values in CPNRD	no change
4. Historical without CPNRD OA area retired lands	MOD001 well values in CPNRD OA	MOD001 recharge values in CPNRD OA	no change
5. Historical without CPNRD HC area retired lands	MOD001 well values in CPNRD HC	MOD001 recharge values in CPNRD HC	no change
6. Historical without TBNRD retired lands	MOD001 well values in TBNRD	MOD001 recharge values in TBNRD	no change
7. Historical without TBNRD OA area retired lands	MOD001 well values in TBNRD OA	MOD001 recharge values in TBNRD OA	no change
8. Historical without TBNRD HC area retired lands	MOD001 well values in TBNRD HC	MOD001 recharge values in TBNRD HC	no change
9. Historical without TPNRD GWO development after 1997	Constant97HistMI well values in TPNRD	Constant97 recharge values in TPNRD	no change
10. Historical without TPNRD OA area GWO development after 1997	Constant97HistMI well values in TPNRD OA	Constant97 recharge values in TPNRD OA	no change
11. Historical without CPNRD GWO development after 1997	Constant97HistMI well values in CPNRD	Constant97 recharge values in CPNRD	no change
12. Historical without CPNRD OA area GWO development after 1997	Constant97HistMI well values in CPNRD OA	Constant97 recharge values in CPNRD OA	no change

Scenario Run	Change to baseline well file	Change to baseline watershed recharge array	Change to baseline surface water seepage array
13. Historical without CPNRD HC area GWO development after 1997	Constant97HistMI well values in CPNRD HC	Constant97 recharge values in CPNRD HC	no change
14. Historical without TBNRD GWO development after 1997	Constant97HistMI well values in TBNRD	Constant97 recharge values in TBNRD	no change
15. Historical without TBNRD OA area GWO development after 1997	Constant97HistMI well values in TBNRD OA	Constant97 recharge values in TBNRD OA	no change
16. Historical without TBNRD HC area GWO development after 1997	Constant97HistMI well values in TBNRD HC	Constant97 recharge values in TBNRD HC	no change
17. Historical without TPNRD GWO and M&I development after 1997	Constant97 well values in TPNRD	Constant97 recharge values in TPNRD	no change
18. Historical without TPNRD OA area GWO and M&I development after 1997	Constant97 well values in TPNRD OA	Constant97 recharge values in TPNRD OA	no change
19. Historical without CPNRD GWO and M&I development after 1997	Constant97 well values in CPNRD	Constant97 recharge values in CPNRD	no change
20. Historical without CPNRD OA area GWO and M&I development after 1997	Constant97 well values in CPNRD OA	Constant97 recharge values in CPNRD OA	no change
21. Historical without CPNRD HC area GWO and M&I development after 1997	Constant97 well values in CPNRD HC	Constant97 recharge values in CPNRD HC	no change
22. Historical without TBNRD GWO and M&I development after 1997	Constant97 well values in TBNRD	Constant97 recharge values in TBNRD	no change
23. Historical without TBNRD OA area GWO and M&I development after 1997	Constant97 well values in TBNRD OA	Constant97 recharge values in TBNRD OA	no change
24. Historical without TBNRD HC area GWO and M&I development after 1997	Constant97 well values in TBNRD HC	Constant97 recharge values in TBNRD HC	no change
25. Historical without North Dry Creek augmentation pumping	No NDC pumping; Baseline well file from the Watershed model	no change	no change
26. Historical without Twin Platte canals excess flow recharge	no change	no change	Does not include Twin Platte canals excess flow recharge

Scenario Run	Change to baseline well file	Change to baseline watershed recharge array	Change to baseline surface water seepage array
27. Historical without Phelps Canal excess flow recharge	no change	no change	Does not include Phelps Canal excess flow recharge
28. Historical without E65 Canal excess flow recharge	no change	no change	Does not include E65 Canal excess flow recharge
29. Historical without Elwood Reservoir excess flow recharge	no change	no change	Does not include Elwood Reservoir excess flow recharge
30. Historical without CPNRD canals excess flow recharge	no change	no change	Does not include CPRND canals excess flow recharge
31. Historical without NPPD canals excess flow recharge	no change	no change	Does not include NPPD canals excess flow recharge

V. Model Output and Post-processing

1. Watershed Model Outputs

The Watershed land use and water balance summaries were used to generate the summaries of acres by irrigation type and crop type. The accounting points and NRD area zone files described later in the groundwater model output post-processing were used to create these reports. The following differences in the annual number of acres by irrigation source or crop type were used:

Post-97 developed acres = Historical/Baseline acres – Constant97cenario acres
Retired acres = Historical/Baseline acres – Unretired/MOD001 acres

The land use and water balance summaries were also used to QA/QC the pumping and recharge differences that were calculated in groundwater model post-processing.

2. Groundwater Model Outputs

a. Process model results by NRD zone

The cell-by-cell outputs of the groundwater model runs were processed through ZoneBudget with a zone file representing the management areas, detailed in the following Zone files section. The difference between the pumping and recharge between the scenario and the baseline were summarized annually and compared to the watershed model outputs for QA/QC.

b. Process model results by accounting zone

The cell-by-cell output of the groundwater model was run through ZoneBudget with a zone file representing the delineations of the stream accounting points. For the purpose of the report, the zones were combined to account for the North Platte River, South Platte River, Platte River Upstream of Elm Creek, and Platte River from Elm Creek to Chapman, as further detailed in the Zone files section. The stream leakage terms from the ZoneBudget outputs are summarized on an annual basis. Net stream leakage is calculated as the difference between the volumes of water that went from the aquifer to the stream and from the stream to the aquifer. The difference between the scenario and baseline net stream leakage are the scenario impacts. As calculated, negative impacts are depletions and positive impacts are accretions.

c. Adjustments for management activities

In order to account for the total impact to streamflow the Constant97 impacts needed to be adjusted for the following:

- TPNRD
  - The addition of streamflow from the Western Canal excess flow recharge volumes modeled with the WWUM model and shared with SPNRD on the South Platte River.
- CPNRD
  - The reduction in accretions from the CPNRD excess flow events that were purchased by Platte River Recovery Implementation Program (PRRIP).
- TBNRD
  - The addition of streamflow from the North Dry Creek augmentation between Elm Creek and Chapman.
  - Addition of accretions from the Elwood Reservoir, E65 Canal, and Phelps Canal excess flow events that are attributed to TBNRD.

The entirety of the Western Canal recharge project areas (the canal and recharge pits) are covered by the WWUM model. Therefore, that model was used to determine the accretions associated with Western Canal recharge. TPNRD and SPNRD contracted a 70%/30% split on the Western Canal recharge events from 2011-2013. For the Robust Review, the entire volume of recharge was applied to the WWUM model, and the accretions were split 70%/30%. The accretions occurred on the South Platte River and were added to the TPNRD impacts to that zone.

CPNRD impacts were discounted for accretions from 2011-2013 excess flow recharge events from CPNRD canals, Cozad, Orchard-Alfalfa, and Thirty-Mile that were purchased by PRRIP through 2018. The separate model run that subtracted only the excess flow recharge events on these canals from the baseline was completed, and accretions were calculated as described previously. The accretions purchased by PRRIP were discounted from CPNRD impacts annually from the Platte River Upstream of Elm and Platte River from Elm Creek to Chapman accounting zones in the same annual proportions that they occurred.

North Dry Creek enters the Platte River south of Kearney. All of the augmentation was added to the TBNRD impacts for the accounting zone Platte River from Elm Creek to Chapman.

The 2011-2013 Phelps Canal excess flow recharge events were contracted 50%/50% between the TBNRD and PRRIP. For this reason, half of the accretions resulting from these recharge events belong to the PRRIP and half belong to the TBNRD. To separate the accretions between PRRIP and TBNRD, first, an impact model run was completed by subtracting 100% of the excess flow recharge events on Phelps Canal from the baseline with 100% of the accretions being calculated from this change. Then, fifty percent of the 2011-2013 Phelps Canal excess flow recharge accretions were included in the TBNRD impacts.

Elwood Reservoir and E65 excess flow events were included in both the baseline and Constant97 TBNRD runs. The separate model runs that subtracted only the excess flow recharge events on these areas from the baseline were completed, and accretions were calculated as described previously and were added to the TBNRD impacts.

d. Streamflow Impact trend and uncertainty

The streamflow impacts for the period 2014-2063 are modeled based on assumptions of a representative climate without additional management actions or changes in land use incorporated after 2013. A linear fit is applied to the modeled depletions 2014-2063 to illustrate the 50-year trend. The inter-annual variability of modeled streamflow impacts for 2014-2063 is shown as a band of the maximum residual, or difference between the modeled data and trend. The modeled streamflow impacts are not exactly periodic about the trend despite having explicit period climate inputs and constant land use. This result is primarily due to the inclusion of all management actions in the analysis prior to 2013 and discontinuing many of those management actions in the future projection (2014-2063).

3. Zone Files

For the COHYST model, one zone file delineated the model area into accounting points: 1) North Platte River; 2) South Platte River; 3) Platte River between the North Platte and South Platte confluence and Elm Creek; 4) Platte River between Elm Creek and Chapman; 5) Below Chapman; and 6) Elsewhere. The file was developed by assigning attributes to model grid cells using ArcGIS spatial join by centroid to HUC10 basins, with some small adjustments to match the COHYST stream cell locations. For comparison to the Luckey (2006) report, the model grid cell assigned to the Tri-County diversion is the cell identified by the confluence in the HUC10 dataset, although geographically Tri-County is downstream of the confluence. The confluence through Chapman accounting zones based on the HUC10 were visually inspected and adjusted by individual grid cells to better reflect the model stream cell locations and accepted National Hydrography Dataset (NHD) flow lines.

The second zone file delineated the model file into management areas: 1. CPNRD; 2. CPNRD HC; 3. CPNRD OA; 4. TBNRD; 5. TBNRD HC; 6. TBNRD OA; 7. TPNRD; 8. TPNRD OA; 9. LBNRD; 10. LBNRD HC; 11. UBBNRD; 12. UBBNRD HC; 13. other NRD; 14. other HC; 15. NPNRD and SPNRD. Regions are defined as inside or outside the relevant NRDs, and then inside or outside the over-appropriated or hydrologically connected (28/40) management areas. For the purpose of the total impacts for each NRD and the rest-of-model area, the following zones were combined as: TPNRD = zones 7 and 8; CPNRD = zones 1, 2, and 3; TBNRD = zones 4, 5, and 6; Rest-of-Model area = zones 9, 10, 11, 12, 13, and 14. The management areas zone file was developed by assigning attributes to model grid cells using ArcGIS spatial join by centroid to NRDs, the Platte Basin Over-Appropriated Area, HUC10, and section polygons, and by direct transfer of calculated SDF values using the results from the model run beginning in 1950 and conducted in June 2018. NRDs and the Over-Appropriated Area are explicitly defined as the regions encapsulated in the spatial join. The hydrologically connected (28/40) region was defined as the cells with SDF greater than or equal to 0.28, within the Platte Basin, following the HUC10 basin boundary, and east of the Over-Appropriated Area. Because the Over-Appropriated Area and newly developed hydrologically connected area are offset North-to-South at their intersection, the southern hydrologically connected boundary was extended, and the northern extent reduced to smooth the boundary. Additionally, the Upper Big Blue NRD Over-Appropriated Management Area, which is defined by section in their IMP, was explicitly classified based on the join by centroid of the model cells within UBBNRD and the IMP sections. The Little Blue NRD Over-Appropriated Management Area, which has not been agreed upon in an IMP but will likely be defined by quarter sections, was explicitly classified in a similar manner, as cells in LBNRD with centers in quarter sections which fall within the Platte Basin and have an SDF of at least 0.28.

VI. Results

The acres changes, pumping and recharge differences, and resulting differences in stream leakage are summarized in four spreadsheets – one for each NRD/area. These spreadsheets are available at https://UPJointPlanning.nebraska.gov.

VII. Additional/Further Investigations

The results of this analysis are subject to the limitations of the modeling processes outlined in this documentation. Further investigations may be necessary to test the assumptions of this analysis and to assess the impacts of other management actions. Below is a short list of recommended further investigations:

- The sensitivity of annual depletions resulting from different climate representations
- The sensitivity of depletions to different crop type conversions on groundwater-only irrigated acres historically and when converting between groundwater only to dryland
- The sensitivity of annual and accounting point depletions to including runoff and diversions and returns
- Updating conservation practices/more accurate representation of current farming practices
- Hydraulic conductivity and initial head sensitivity in the vicinity of Plum Creek

This documentation describes the updates, modifications, and methods used by NeDNR to conduct the specific model simulations associated with the robust review evaluation for the COHYST model area.

A.1 Western Water Use Management (WWUM) Model Groundwater Model Analysis Methods

A.1 Western Water Use Management (WWUM) Model Groundwater Model Analysis Methods

I. Objective

The purpose of this modeling evaluation is to simulate depletions to streamflow from development of groundwater-only irrigated lands and municipal and industrial (M&I) pumping in North Platte Natural Resources District (NPNRD) and South Platte Natural Resources District (SPNRD) after 1997 through 2013, including impacts from groundwater acre retirements, allocated uses starting in 2009, and excess flow recharge. The specific results summarized in the Robust Review report are acres and crop type changes on groundwater-only irrigated land by NRD; M&I pumping changes by NRD; excess flow recharge volumes by project and contracting NRD; and the combined streamflow impacts of the aforementioned by NRD.

For each NRD analysis, two model runs are necessary: a baseline simulation and an impact/scenario simulation. The baseline simulation is the representation of the historical condition including metered irrigation pumping. The scenario simulation is the representation of constant 1997 groundwater only irrigated acres and M&I pumping. The difference between these two runs provides an estimate of the streamflow impacts from development and management actions after 1997.

The documented model that is the basis for this analysis consists of the Regionalized Soil Water Balance (Watershed model) and Groundwater portions of the WWUM model, available at http://www.spnrd.org/Html/WWUM.html. Version 28 of the Watershed model and the 1953 to 2013 update of the Groundwater model were used. The simulation period for these analyses is May 1953 to 2063. The Platte Basin Coalition scope of work documents for the design of this analysis are available as attachments (Appendix A.1.1). Model files are available at https://UPJointPlanning.nebraska.gov.

II. Baseline Model Setup – Historical

A. Baseline Watershed Model Setup

The Flatwater Group, Inc. (TFG) was contracted by the Platte Basin Coalition (PBC) to complete Watershed model runs for the Robust Review. The Watershed model used for the Robust Review was based on the calibrated WWUM Watershed Model Run028 extended forward to 2063. The Flatwater Group, Inc. Memorandum on October 2018 Update: Post 97 Analysis WWUMM , dated October 11, 2018, (Appendix A.1.8) documents the Watershed model setup. Details on updates to M&I pumping and land use used in this analysis are available as Appendix A.1.9 and A.1.10, respectively.

Watershed results for the Robust Review were provided from The Flatwater Group, Inc. to NeDNR include land use and water balance summaries and recharge (.rch) and pumping (.wel) MODFLOW groundwater model files.

B. Baseline Groundwater Model Setup

The groundwater model used for the Robust Review was based on the documented WWUM groundwater model updated with recharge and pumping files provided by the Watershed model update, as described in the previous section, and extended to 2063. The following section describe changes made to the individual model files in setup of the Robust Review baseline model.

1. Pumping/.WEL

For the baseline run, the pumping file from the Watershed model that allowed historical development of groundwater only irrigated acres and metered pumping and M&I pumping was used. No additional modifications were made.

2. Recharge

Excess flow recharge was added to the historical recharge file provided by The Flatwater Group, Inc. Adaptive Resources, Inc. (ARI) provided NeDNR with the rates and cell locations of excess flow recharge to include in the analysis in the file *rr_excess_flow_11092018.csv*, available at https://UPJointPlanning.nebraska.gov. The excess flow recharge projects analyzed in this Robust Review are:

- Western Canal and pits excess flow recharge
- North Platte canals excess flow recharge, includes the canals of: Belmont, Castle Rock, Central, Chimney Rock, Enterprise, Farmers, Lisco, Nine Mile, Minatare, Pathfinder and Winters Creek.

The quantification of these projects are available in:

- A memorandum on NPNRD and SPNRD Canal Excess Flow Diversion, Recharge Analysis Comparison, and Canal Loss Recommendation from Thad Kuntz, P.G., Joe Reedy G.I.T., and Jason Yuill to John Berge, General Manager NPNRD, Rod L. Horn, General Manager SPNRD, and Platte Basin Water Project Coalition, dated March 10, 2017 (Appendix A.1.11)
- A zipped file of Western canal excess flow data available at https://UPJointPlanning.nebraska.gov.

3. General head boundaries

The last 12 months of the calibrated model general head boundaries were repeated 51 times to extend the model to 2063.

4. Evapotranspiration

Phreatophyte evapotranspiration (EVT) represented in the .EVT package of the groundwater model is based on calibrated values. The last 12 months of the calibrated model EVT rates were repeated 51 times to extend the model to 2063.

5. Streams

The last 12 months of the calibrated model streamflows were repeated 51 times to extend the model to 2063.

6. Drains

The last 12 months of the calibrated model drain flows were repeated 51 times to extend the model to 2063.

7. Baseline Groundwater Model Setup Summary

Pumping:	Watershed model, metered pumping and 5-year climate repeat Historical M&I pumping

Recharge:	Watershed model, calibrated surface water model seepage values modified by ARI and supplied as ancillary to Watershed model output, excess flow recharge
Initial heads:	No change from calibrated
General head boundaries:	
May 1953-2013:	Calibrated
2013- Dec. 2063:	Last 12 months of calibrated
Streamflows:	
May 1953-2013:	Calibrated
2013- Dec. 2063:	Last 12 months of calibrated
Drains:	
May 1953-2013:	Calibrated
2013- Dec. 2063:	Last 12 months of calibrated

III. Scenario Setup – Constant 1997 Conditions

One scenario for each of NPNRD and SPNRD represent constant 1997 conditions as compared to the baseline that has historical groundwater-only irrigation and M&I conditions as well as management actions. This requires the scenario to be modified from the baseline both during the scenario watershed setup (land use and M&I pumping) and the scenario groundwater model setup (excess flow recharge). Only the recharge and pumping volumes change between the baseline and scenario.

1. Scenario Watershed Model Setup

There was one run of the watershed model executed for the scenario simulation. The baseline inputs were modified by holding all groundwater-only irrigated acres and M&I pumping constant at 1997 levels through 2063. The Flatwater Group, Inc. Memorandum on October 2018 Update: Post 97 Analysis (Appendix A.1.8) dated October 11, 2018, documents the Watershed model setup. The land use change and M&I pumping change were made for SPNRD and NPNRD in a single watershed model run, and the resulting pumping and recharge impacts will be isolated by management area in the scenario groundwater model setup. The watershed results for the Constant-97 scenario were provided from The Flatwater Group, Inc. to NeDNR include land use and water balance summaries and recharge (.rch) and pumping (.wel) MODFLOW groundwater model files.

2. Scenario Groundwater Model Setup

For each management area scenario run, the scenario watershed model recharge and pumping values were used for the management area, and the baseline watershed model recharge and pumping values were used for the other NRDs and remainder of the model area. Due to potential discrepancies in how commingled acres were handled in the land use files used in the Watershed model, baseline values were used for the Western Canal Service Area for all scenarios. Excess flow recharge volumes were added to the scenarios for the management areas in which they did not occur. All other groundwater model data are the same as in the baseline. The following table summarizes the two groundwater model runs for the Robust Review scenarios.

Table 1. Robust review scenarios representing constant 1997 conditions for comparison to the baseline scenario representing historical development and management actions.

Scenario Management Area	Scenario Description	Change to baseline well file	Change to baseline recharge file
NPNRD	Historical without NPNRD GWO and M&I development after 1997 and without North Platte canals excess flow recharge	Constant97 scenario pumping in NPNRD	- Constant97 scenario recharge in NPNRD - Does not include North Platte canals excess flow recharge
SPNRD	Historical without CPNRD GWO and M&I development after 1997	Constant-97 scenario pumping in SPNRD, except in the Western Canal Service Area	Constant97 scenario recharge in SPNRD, except in the Western Canal Service Area

IV. Component Scenarios

The Post-1997 NRD impacts can be broken down further to determine the separate impacts of individual historical changes and management actions and the impacts from those in different management areas of an NRD. The individual component scenarios considered in the Robust Review are:

- Change in groundwater-only irrigated acres after 1997 by NRD and OA areas
- Change in groundwater-only irrigated acres and M&I pumping after 1997 by NRD and OA areas (no management actions considered)
- NPNRD-contracted excess flow recharge from 2011-2013
- Western Canal and pits excess flow recharge from 2011-2013

Combinations of the historical and constant 1997 scenario recharge and well values were used to create scenarios in which the component of interest was removed from the historical scenario. The M&I pumping is an auxiliary term to the watershed modeled pumping. The Flatwater Group, Inc. provided a Constant-97 pumping file that included historical M&I development, i.e., only 1997 groundwater-only irrigated acres were held constant, which will be referred to as Constant97HistMI. The groundwater model scenario setup followed the same processes as identified in the last section, unless otherwise described in the following table.

Table 2. Robust review component scenarios representing individual historical changes and management actions in differing management areas for comparison to the baseline scenario representing historical development and management actions.

Scenario Run	Change to baseline well file	Change to baseline recharge file
32. Historical without NPNRD GWO development after 1997	Constant97HistMI well values in NPNRD	Constant97 recharge values in NPNRD
33. Historical without NPNRD OA area GWO development after 1997	Constant97HistMI well values in NPNRD OA	Constant97 recharge values in NPNRD OA
34. Historical without SPNRD GWO development after 1997	Constant97HistMI well values in SPNRD except in the Western Canal Service Area	Constant97 recharge values in SPNRD except in the Western Canal Service Area
35. Historical without SPNRD OA area GWO development after 1997	Constant97HistMI well values in SPNRD OA except in the Western Canal Service Area	Constant97 recharge values in SPNRD OA except in the Western Canal Service Area
36. Historical without NPNRD GWO and M&I development after 1997	Constant97 well values in NPNRD	Constant97 recharge values in NPNRD
37. Historical without NPNRD OA area GWO and M&I development after 1997	Constant97 well values in NPNRD OA	Constant97 recharge values in NPNRD OA
38. Historical without SPNRD GWO and M&I development after 1997	Constant97 well values in SPNRD except in the Western Canal Service Area	Constant97 recharge values in SPNRD except in the Western Canal Service Area
39. Historical without SPNRD OA area GWO and M&I development after 1997	Constant97 well values in SPNRD OA except in the Western Canal Service Area	Constant97 recharge values in SPNRD OA except in the Western Canal Service Area
40. Historical without North Platte canals excess flow recharge	no change	Does not included North Platte canals excess flow recharge

Scenario Run	Change to baseline well file	Change to baseline recharge file
41. Historical without Western Canal and pits excess flow recharge	no change	Does not include Western Canal and pits excess flow recharge

V. Model Output and Post-processing

1. Watershed Model Outputs

The Watershed land use and water balance summaries were used to generate the summaries of acres by irrigation type and crop type. The NRD area zone files described later in the groundwater model output post-processing were used to create these reports. The following differences in the annual number of acres by irrigation source or crop type were used:

Post-97 developed acres = Historical/Baseline acres – Constant97scenario acres

The land use and water balance summaries were also used to QA/QC the pumping and recharge differences that were calculated in groundwater model post-processing.

2. Groundwater Model Outputs

a. Process model results by NRD zone

The cell-by-cell outputs of the groundwater model runs were processed through zonebudget with a zone file representing the management areas, detailed in the following Zone files section. The difference between the pumping and recharge between the scenario and the baseline were summarized annually and compared to the watershed model outputs for QA/QC.

b. Process model results by accounting zone

The cell-by-cell output of the groundwater model was run through ZoneBudget with a zone file representing the delineations of the stream accounting points. For the purpose of the report, the zones were combined to account for the North Platte River, South Platte River, and Lodgepole Creek, as further detailed in the Zone files section. The stream leakage terms from the ZoneBudget outputs are summarized on an annual basis. Net stream leakage is calculated as the difference between the volumes of water that went from the aquifer to the stream and from the stream to the aquifer. The difference between the scenario and baseline net stream leakage are the scenario impacts. As calculated, negative impacts are depletions and positive impacts are accretions.

c. Adjustments for management activities

In order to account for the total impact to streamflow the SPNRD Constant97 impacts needed to be adjusted for the portion of the Western Canal and pit accretions that were attributed to SPNRD contract.

The entirety of the Western Canal recharge project areas (the canal and recharge pits) are covered by the WWUM model. Therefore, this model was used to determine the accretions associated with Western Canal and pit recharge. TPNRD and SPNRD contracted a 70%/30% split on the Western Canal recharge events from 2011-2013. For the Robust Review, the entire volume of recharge was applied to the WWUM model, and the accretions were split 70%/30%. The accretions occurred on the South Platte River and were added to the SPNRD impacts to that zone.

d. Impacts trend and uncertainty

The streamflow impacts for the period 2014-2063 are modeled based on assumptions of a representative climate without additional management actions or changes in land use incorporated after 2013. A linear fit is applied to the modeled depletions 2014-2063 to illustrate the 50-year trend. The inter-annual variability of modeled streamflow impacts for 2014-2063 is shown as a band of the maximum residual, or difference between the modeled data and trend. The modeled streamflow impacts are not exactly periodic about the trend despite having explicit period climate inputs and constant land use. This result is primarily due to the inclusion of all management actions in the analysis prior to 2013 and discontinuing many of those management actions in the future projection (2014-2063).

3. Zone Files

For the WWUM model, one zone file delineated the model area into accounting points: 1) Out of Basin; 2) Out of State, North Platte River; 3) In State, North Platte River; 4) Out of State, Lodgepole Creek; 5) In State, Lodgepole Creek; 6) Out of State, South Platte River; and 7) In State, South Platte River. The file was developed by assigning attributes to model grid cells using ArcGIS spatial join by centroid to HUC10 basins

The second zone file delineated the model file into management areas: 1. Within Nebraska, not including NPRND or SPNRD; 2. TPNRD OA; 3. NPNRD; 4. NPNRD OA; 5. SPNRD; 6. SPNRD OA; 7. Western Canal Service Area; and 8. Out of State. Regions are defined as inside or outside the relevant NRDS, and then inside or outside the over-appropriated management areas. Western Canal Service area as defined in the documented model was delineated out of the SPNRD OA area. For the purpose of the total impacts for each NRD and the rest-of-model area, the following zones were combined as: NPNRD = zones 3 and 4 and SPNRD = zones 5 and 6. The management areas zone file was developed by assigning attributes to model grid cells using ArcGIS spatial join by centroid to NRDs and the Platte Basin Over Appropriated Area. NRDs and the Over Appropriated Area are explicitly defined as the regions encapsulated in the spatial join.

VI. Results

The acres changes, pumping and recharge differences, and resulting differences in stream leakage are summarized in two spreadsheets – one for each NRD/area. These spreadsheets are available at https://UPJointPlanning.nebraska.gov.

VII. Additional/Further Investigations

The results of this analysis are subject to the limitations of the modeling processes outlined in this documentation. Further investigations may be necessary to test the assumptions of this analysis and to assess the impacts of other management actions. Below is a short list of further investigations that we recommend:

- The sensitivity of annual depletions resulting from different climate representations

- The sensitivity of depletions to different crop type conversions on groundwater-only irrigated acres historically and when converting between groundwater only to dryland
- The sensitivity of annual and accounting point depletions to runoff and diversions and returns
- Updating conservation practices/more accurate representation of current farming practices

A.1.1 Robust Review Project Analysis Scope of Work

Exhibit A

Memo

To: POAC Technical Committee

From: Thad Kuntz (ARI) and Duane Woodward (CPNRD)

Date: 8/2/2016

Re: FINAL – Robust Review Project Analysis Scope of Work

Introduction

The Platte Overappropriated Area Committee (POAC) Technical Committee tasked Thad Kuntz from Adaptive Resources Inc. (ARI) and Duane Woodward from CPNRD to develop a scope of work for the Robust Review Analysis. The Districts included in this analysis are NPNRD, SPNRD, TPNRD, CPNRD, and TBNRD.

Robust Review General Scope of Work Description

A "change modeling" technique will be utilized for this analysis; this technique compares a baseline or reference model run (either the Western Water Use Management (WWUM) Model or Cooperative Hydrology Study (COHYST) Model) to a modified model run. The modified run introduces a change to a specific dataset in the baseline run and, when compared to the baseline, the difference is reflected in the stream baseflow, heads, or aquifer storage. The results from this technique do not represent actual estimates of future stream baseflow, streamflow, heads, or aquifer storage, but rather provide the estimated change in the stream baseflow, streamflow, heads, or aquifer storage.

Two phases of modeling will be completed to provide information for each District on post-1997 irrigated acreage development impacts, mitigation measures completed to offset those impacts, and effects of other water management actions each District has completed. Phase 1 modeling will encompass mitigation measures and management actions completed through 2013 while Phase 2 modeling will address additional analysis on surface water only and commingled acres, projects after 2013, and future water management planning for each District.

Phase 1 Modeling

The Phase I Robust Review modeling encompasses the post-1997 irrigated acreage development depletions and the management actions to mitigate these depletions. These actions include: excess flow canal recharge, ground water pumping allocations, certified acreage retirements, certified acreage transfers, surface water recharge projects, crop type changes, and municipal/industrial baseline changes. To complete Phase 1 Modeling, the POAC Technical Committee has identified the following baseline simulation and 7 individual analyses:

Baseline Run:

1. Existing Models
    a. WWUM Modeling
        i. Utilize the 1953 through 2014 Model
        ii. Only use 1997 through 2013 for the analysis
        iii. Modification to the Baseline Simulation
            1. Temporary retirements and transfers of certified ground water only irrigated acres occur in several NRDs and as a consequence the baseline simulation will need to be modified to

Memo

incorporate the reactivation or movement of these acres. To account for this affect, the baseline model will add these acres or move them to the original location, represented as irrigated corn, in the simulation when their temporary location expires.

iv. Repeat 2009 through 2013 climate into the future through 2063

v. Repeat the 2009 through 2013 pumping and recharge into the future through 2063

b. COHYST Modeling
   i. Utilize the 1950 through 2013 Model
   ii. Only use 1997 through 2013 for the analysis
   iii. Repeat 1988 through 2013 climate through 2063
      1. Hold the 2013 land use dataset (this is the 2010 land use dataset repeated through 2013) constant for the projection
c. Municipal, Industrial, and Livestock Pumping
   i. To complete the municipal, industrial, and livestock transfer and baseline analyses, both modeling efforts may need to revise the current estimates and locations of pumping and if not already in place, revise with actual pumping estimates for each category.
d. Canal Recharge Projects from Excess Flow
   i. The baseline models will need modified to incorporate the excess flow diversions for recharge.
   ii. To determine the amount of recharge from the diversion of excess flows a similar calculation to the NDNR Technical Memorandum for the 2011 Ground Water Recharge Demonstration Projects will need completed.

For all modified modeling analyses described below, each District will need to have separate analyses to determine their individual effects and compared to the baseline run described above. For the WWUM Modeling, each analysis using the regionalized soil water balance modeling will have only one run for both NPNRD and SPNRD. Post processing will split the run for each District.

Land Use Analysis:

1. *Increase in Post-1997 Irrigated Ground Water Only Acres*
   a. WWUM Modeling
      i. A set of model runs have been completed by ARI and the only additional work is two ground water model runs to separate out the effects of each NRD. No additional regionalized soil water balance modeling work will need to be completed. ARI will coordinate with NDNR, allowing NDNR to conduct the same analysis of increases in post-1997 irrigated groundwater only acres. NDNR will use the same input files and the same model version used by ARI to replicate the analysis, and the results of the two will be compared and evaluated to determine if the methods used meet the goals and objectives of the IMPs. This activity will take place as part of the Robust Review process.

b. COHYST Modeling
    i. To complete the analysis for CPNRD, TPNRD, and TBNRD individually, within each District the irrigation portion of the irrigated acres developed after 1997 will be removed from the land use dataset and ran through the watershed and ground water models to provide a streamflow value.

2. *Certified Irrigated Acreage Retirements (PBHEP, AWEP, CREP, EQUIP, NRD, etc.)*
    a. The retirement analyses will be completed separate from the Post-1997 depletions analysis. However, the effects from the retirements can be incorporated into the depletions analysis to provide the overall combined results.
    b. WWUM Modeling Area
        i. The retirement analysis will pump water at the retired parcel in the modified model each year using the projected pumping described in the baseline run.
            1. There is the possibility of double accounting for retirement effects if the lands were post-1997 developed lands. To mitigate this issue, the lands that were retired and developed after 1997 will not be analyzed in the retirement analysis. (SPNRD has no post-1997 retired acres, NPNRD estimates that 130 retired acres were post-1997 lands.)
    c. COHYST Modeling Area
        i. The retirement analysis will pump water at the retired parcel in the modified model each year as if the parcel grew corn from the retirement date to the end of the analysis.
            1. There is the possibility of double accounting for retirement effects if the lands were post-1997 developed lands. To mitigate this issue, the lands that were retired and developed after 1997 will not be analyzed in the retirement analysis.

3. *Certified Irrigated Acreage Transfers*
    a. The transfer analyses will also be completed separate from the Post-1997 depletions analysis. However, the effects from the transfers can be incorporated into the depletions analysis to provide the overall concept of combining the results.
    b. WWUM and COHYST Modeling Areas
        i. In the modified model:
            1. Water will be pumped at the pre-transferred location using the crop type and pumping amount of the post-transferred location. New irrigation recharge will be estimated will be provided for each pre-transferred location. The future projection will be completed as described in the baseline run.
            2. The post-transferred location will be converted to dryland pasture in the WWUM Modeling and dryland crop in the COHYST Modeling.
            3. If the transfer is to an industrial use, then the efficiency of that new use must be estimated for the simulation.

4. *Variances Granted Since July 1, 1997*

Memo

a. Each variance will need individually conceptualized and an analysis will need to be completed.
b. NDNR has compiled a list of the variances provided by the NRDs that have occurred over this timeframe. It is anticipated that each individual variance can be categorized into one of the previous categories: Increase in acres, retirements, or transfers.

Change in Crop Mix Analysis:

1. *Changes in Crop Consumptive Use from Changes in Crop Mix as Compared to 1997 Crop Mix*
   a. This phase of the project will investigate the changes in crop consumptive use since 1997. This will be completed by determining the annual total consumptive use and comparing it to the 1997 annual consumptive use.

Canal Recharge Projects Analysis:

1. *2011 Ground Water Recharge Demonstration Project*
   a. In the modified model, this will be completed by removing the amount of excess flow diversions and associated recharge.
2. *2013 South Platte River Flood Flow Diversion and Recharge*
   a. In the modified model, this analysis can be completed by removing the recharge from the diversion of excess flows.
3. Phelps County Canal Recharge Project
   a. In the modified model, this analysis can be completed by removing the recharge from the diversion of excess flows into Phelps canal during the winter months.
4. Elwood Reservoir Ground Water Recharge Project
   a. In the modified model, this analysis can be completed by removing the recharge from the diversion of excess flows into Elwood Reservoir.

Augmentation Project Analysis:

1. *North Dry Creek Augmentation Project*
   a. In the modified model, this analysis can be completed by removing the pumping into dry creek during the time period water was pumped.

Allocation Analysis (NPNRD and SPNRD Only):

1. *Ground Water Allocations (North Platte and South Platte NRDs Only)*
   a. A set of model runs have been completed by ARI and the only additional work is two ground water model runs to separate out the effects of each NRD. No additional regionalized soil water balance modeling work will need to be completed. ARI will coordinate with NDNR, allowing NDNR to conduct the same analysis evaluating the allocations. NDNR will use the same input files and the same model version used by ARI to replicate the analysis, and the results of the two will be compared and evaluated to determine if the methods used meet the goals and objectives of the IMPs. This activity will take place as part of the Robust Review process.

Memo

Municipal, Industrial, and Confined Livestock Feeding Operation Baseline and Transfer Analysis:

1. *Changes in Municipal, Industrial, and Confined Livestock Feeding Operations Consumptive Use and Location of Pumping as Compared to Their Baseline*
    a. In the modified model:
        i. For municipal baseline pumping from 1998 through 2013, the calculated baseline annual per capita consumptive use will be multiplied by the annual population of 1997 and will be compared to the baseline run's actual pumping amount.
        ii. For industrial baselines from 1998 through 2013, the 1997 estimates of pumping for each industry will be fixed to compare against the actual pumping in the baseline run.
        iii. For livestock baselines from 1998 through 2013, the average gallons/head/day will be multiplied against the 1997 cattle of feed for each NRD tracked livestock facility and compared to the baseline run's actual pumping.
    b. To determine the effect of municipal, industrial, or livestock transfers, in the modified model, the pre-transferred pumping locations will be used. The post-transferred pumping locations will be removed from the modified model.

Overall Robust Review Analysis:

1. Overall analysis will combine each analysis into a single run.
    a. The overall analysis will encompass the following changes:
        i. Land Use Analysis
        ii. Canal Recharge Projects Analysis
        iii. Augmentation Projects Analysis
        iv. Allocation Analysis (NPNRD and SPNRD Only)
        v. Municipal Baseline and Transfer Analysis
    b. **Some of these changes may not be able to be analyzed together so a composite of the combined and individual analyses may need to be utilized in order to complete this analysis.**

Documentation for All Analyses

The change results will be determined and presented for each of the individual analysis listed above (e.g. Land Use Analysis, Change in Crop Mix Analysis, etc.) and by District. Additionally, complete overall documentation for the process, assumptions, and results will be presented in a single document for the Platte Basin area.

Project Timeline

The Phase 1 modeling analyses need completed by December 31st, 2016. In early 2017, the information and draft documentation will be provided to the POAC Technical Committee and Administrators for review and discussion.

Memo

Phase 2 Modeling

The Phase II modeling will be completed to provide each District with information on the post-1997 irrigated acre development impacts, projects, and management actions that are in the in development after 2013 that will effect stream baseflow or streamflow through the first increment and into the future. The future projects and management actions include canal recharge, allocations, certified acreage retirements, certified acreage transfers, surface water recharge projects, idled certified acres, crop type changes, and municipal/industrial baseline changes. Additionally, different climatic conditions may exist in the future that may include wet and dry scenarios and modeling can be completed to help inform each District's water resource management planning. Additionally, commingled pumping will be addressed in Phase 2 Modeling. The Phase 1 Modeling will be used as the modeling or a template of the modeling needed for this phase of the Robust Review Analysis.

Below is a list of potential projects being considered for Phase II modeling:

- Temporary Surface Water Only and Commingled Land Retirements
- Climatic Conditions
- Change in Crop Mix (If Needed)
- Commingled Acres
- Canal Rehabilitation: Cozad, Orchard-Alfalfa, Thirty-Mile
- Nebraska Cooperative Republican Platte Enhancement Project
- J-2 Regulating Reservoir
- Elm Creek Reservoir Potential Excess Flow Storage
- Surface Water Transfer Recharge/Stream Augmentation Projects (NPNRD)
- Future High Flow Canal Recharge Projects (Similar to the 2011 and 2013/2014 Recharge Projects)
- Planned Projects (after 2013)
- Conversion from Surface Water Only Irrigation to Commingled Irrigation
- Conversion from Surface Water Only Irrigation to Ground Water Only Irrigation (CPNRD)

A.1.2 Memorandum on the COHYST2010 Watershed Model Update – Run029

COHYST2010 MODELING TOOL UPDATE
WATERSHED MODEL RUN029

TECHNICAL MEMORANDUM

TO: Nebraska DNR Technical Staff
FROM: Marc Groff
Isaac Mortensen
RE: COHYST2010 Watershed Model Update – Run029
DATE: 15 June 2018

Introduction

The COHYST modeling tool was initially developed in 1998 as part of the Cooperative Hydrology Study (COHYST) which is a hydrologic study focused on the Platte River drainage basin in Nebraska. The modeling tool has undergone several revisions since that time. The original 1998 model was comprised of three ground water models covering the area from the Wyoming border to approximately Duncan, NE. That tool evolved into the Western Water Use Model (WWUM), which covers the Nebraska Panhandle area, and COHYST2010, which covers the area from the Panhandle to Duncan, NE. Both the WWUM and COHYST2010 tools are integrated models comprised of a ground water model, a surface water operations model, and a watershed response model. Run028 was the version of the watershed response model described in the current COHYST2010 documentation (refer to http://cohyst.nebraska.gov/ for a copy of that documentation).

The purpose of this memorandum is to document a couple of updates being made to Run028 of the watershed response model in the COHYST2010 tool. The incorporation of these changes will result in a new watershed model version, Run029, which will be used within the COHYST2010 tool supporting the Robust Review modeling project.

Watershed Model Updates

As discussed in Section 5 of the COHYST2010 modeling report, the watershed model has four components: a climate model; a point source soil water balance model; spatial and temporal distribution routines; and a regionalized soil water balance model. The Run029 updates affect two of these components: the climate model; and the point source soil water balance model.

With respect to the climate model, the update reflects a change necessitated by changes in data availability. Specifically, two climate stations (Tryon and Arnold) are no longer supported. Therefore, the station located near Stapleton, NE (Stapleton_5W) was incorporated into the input dataset in their place. Figure 1 below (which is Figure 5.4 in Section 5 of the COHYST2010 modeling report) shows the locations of these stations.

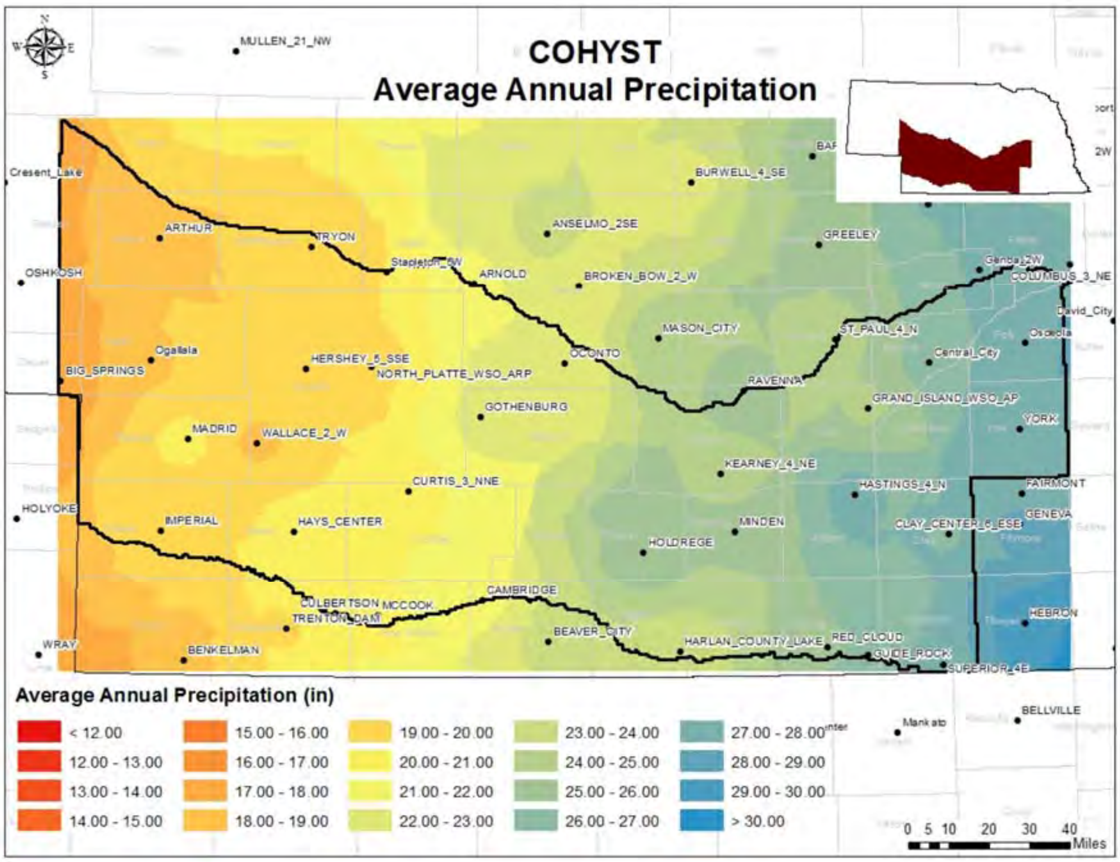


Figure 1: Climate Station Locations

With respect to the point source soil water balance model, the soil water balance model CropSim is used within the watershed response model. Run028 used CropSim version 7.9 and Run029 uses CropSim version 8.0. The version 8.0 update to CropSim addressed two coding issues: ensuring that a variable used to track the partitioning of soil water within CropSim's 10 layer soil model properly resets; and normalizing the numeric format of data being read and written to the data file which stores the initial water content in the soil profile prior to a simulation being run. The first coding update corrects an issue which occurred under wet conditions on irrigated lands that resulted in potentially more recharge being allowed out of the root zone than should have been. The general effect of implementing the update was a small reduction in recharge under the identified condition. The second issue updated coding statements such that data would be both read and written to three decimals of precision. Previously, data was being written to two decimals of precision.

Impacts to Modeling Results

In general, updating the watershed response model with COHYST2010 to Run029 has a minimal impact on the overall results from the watershed model. Table 1 below shows the change in long term average water balance values for select terms of interest. Table 1 is based on Table 5.4 in the current COHYST2010 documentation.

Table 1: Comparison of long term average water balance terms

Parameter	Run028	Run029	Change in Average
Precipitation	24,112,174	24,133,809	21,635
Surface Water Deliveries	221,170	221,341	171
Groundwater Pumping	2,448,889	2,461,605	12,716
Total Applied Water	26,782,233	26,816,756	34,522
Field Evapotranspiration	21,994,798	22,292,473	297,675
Field Recharge	2,647,784	2,507,367	(140,418)
Field Runoff	2,011,730	1,965,506	(46,223)
Surface Losses	129,080	129,721	641
Lateral Losses	15,038	15,039	1
Field Water Balance	(1,158)	(78,311)	(77,153)
Field Runoff Balance	2,011,730	1,965,506	(46,223)
Runoff Losses to Recharge	436,584	426,936	(9,648)
Runoff Contributions to Streamflow	1,138,562	1,111,635	(26,927)
Runoff Losses to Evapotranspiration	436,584	426,936	(9,648)
*Units are in Acre-Feet (AF)			

There are localized areas within the model domain which do reflect a greater response to the updates. A presentation developed by the technical staff at the Nebraska Department of Natural Resources (DNR) highlights the changes in these areas through an evaluation of relative water level changes and predicted streamflow changes output from COHYST 2010 when using Run029 versus Run028 of the watershed model . Even in these locations, it is TFG’s belief that the magnitude of change does not rise to the level of warranting any type of COHYST2010 recalibration.

Summary
The COHYST2010 toolset is comprised of several individual models and their associated datasets. This modular construction is a major advantage to keep COHYST2010 current with changing inputs and updated modeling tools. The updates discussed in the memorandum reflect proper model and input dataset maintenance. Incorporating these changes now will ensure that the Robust Review project is evaluated with the most current and up to date toolset available.

A.1.3 Memorandum on COHYST2010 area Model Runs

Memorandum

To: Kari Burgert, DNR

From: The Flatwater Group, Inc.

Subject: Robust Review – COHYST area Model Runs

Date: 11/26/2018

INTRODUCTION

The Flatwater Group, Inc. (TFG) was contracted by the Platte Basin Water Project Coalition through the Nebraska Department of Natural Resources (NDNR) to provide technical assistance for the Robust Review project. The purpose of the Robust Review project is to assess streamflow impacts resulting from management actions taken as part of the Basin-Wide Plan and/or Natural Resource District (NRD) Integrated Management Plans (MPs). The focus of this memorandum is to identify the scenario simulations created for the Robust Review project and define their setup.

The remaining discussion within this document is organized into four sections:

Section 0 of this memorandum describes the setup of the model TFG used to develop these files.

Section 0 describes the first iteration of the of the Robust Review scenarios and the inputs used to create the simulations. TFG's task originally consisted of developing three simulation runs, with multiple Municipal and Industrial (M&I) pumping scenarios. However, the groundwater land use modifications to the baseline and the unretired scenario were limited to Tri-Basin NRD and Twin Platte NRD.

0. Baseline Scenario
0. Unretired Scenario
0. Post 1997 Development Rollback Scenario
    0. 1997 level of M&I development
    0. Historical level of M&I development

Section D describes requested updates to land use and M&I pumping information made by the three Natural Resource Districts (NRDs) in the COHYST model domain area during the course of the Robust Review project.

Section E describes the updated Robust Review scenario simulations created to implement the changes described in Section D. It contains a list of the Robust Review simulations with a description of how each scenario was represented. Section E is organized as follows:

0. Baseline Scenario
    0. No M&I pumping
0. Unretired Scenario

0. Post 1997 Development Rollback Scenarios
    0. 1997 level of M&I development
    0. Historical level of M&I development
    0. No M&I pumping
0. No Groundwater Only Pumping Scenario

Section 0 described the updates to the Unretired Scenario land use data set to fix the acres unretired to account for post 2010 temporary retirements being implemented at twice the area of these retirements. This accounted for 40.8 acres in TPNRD and 111.3 acres in TBNRD.

Section 0 describes the updated Robust Review Unretired Scenario simulation created to implement the changes described in Section 0. It contains a list of the simulation with a description of who the scenario was represented. Section 0 is organized as follows:

A1. Unretired Scenario

MODEL SETUP

The watershed model utilized for the Robust Review was based upon the calibrated Cooperative Hydrology Study (COHYST) 2010 watershed model. Additional inputs were incorporated from the Conservation Study's Baseline (Base001). Several modifications were necessary to implement the scenarios through the watershed model.

A1. MODEL STRUCTURE

The Robust Review model runs include a historical period (1950-2013) and a projected period (2014-2063). The Watershed model was modified to draw Water Balance Parameter (WBP) data from two sets. The first set uses the traditional time trended WBPs that represent the change in farming practices over time. This set is applied to the historical period. The second set switches to the WBP developed using the most current set of farming practices. This set is applied to the projected period.

CLIMATE

The WBP input data sets implemented in the COHYST 2010 model were updated for the Robust Review in the COHYST model area. Two changes were made to the CROPSIM model (v8.0). The first change updated the recharge routine from precipitation on irrigated simulations during the irrigation season. A second change made the transfer of soil water content between subsequent years consistent on the number of decimals passed between variables.

The same COHYST weather stations were simulated for the circa 1950s, 1970s, and 2000s farming practices and then time trended over the historical period. The time trended information was spatially gridded to create the COHYST WBP data set Run002\Grid_TT for application in Robust Review's historical period. The Circa 2000s information was spatially gridded to create the COHYST WBP data set Run002\Grid98 for application in the Robust Review's projected period.

LAND USE

Multiple land use data sets were implemented in the Robust Review within the COHYST area to hand the different modeled scenarios.

BASELINE LAND USE (RR001\LU004_RR2013EXT)

The first step was to establish a baseline land use. The Robust Review Land Use used land use data sets for the period 1950 to 2013. The 1985-2010 land use was consistent with the land use used in COHYST 2010. The 1950-1984 land use was obtained from the 2013 FAB analysis. This was also consistent with the way land use was represented in the Conservation Study. The period 2011-2013 was created by adding and removing the NRD and DNR specified retirements, transfers, and variances from the 2010 land use file. The land use modifications were applied to groundwater only irrigated lands. Surface water only and comingled lands were not altered. With the exception of the 6 Mile canal which was converted completely to comingled and the GWC was set to 1.0 effectively making these lands groundwater only irrigated. The 2014-2023 period was further modified to accommodate temporary retirement contracts ending[1]. At the time of the first Robust Review Iteration the land use modifications were applied for Twin Platte NRD and Tri-Basin NRD.

Details about the modifications made to the Land use data sets can be found in the Land Use Memorandums[2]:

TBNRD_RR_Memo_20180713.docx
TPNRD_RobustReview_LU_20180713.docx

Unretired Scenario Land Use (RR001\LU004_rr2013mod)

The second set was to develop to capture the influence of the retired groundwater only irrigated acres. The baseline land use was modified to add back in the temporary and permanently retired groundwater only irrigated acres. No modifications were made to surface water only or comingled lands. At the time of the first Robust Review Iteration the land use modifications were applied for Twin Platte NRD and Tri-Basin NRD.

Details about the modifications made to the Land use data sets can be found in the Land Use Memorandums[3]:

TBNRD_RR_Memo_20180713.docx
TPNRD_RobustReview_LU_20180713.docx

[1] A ten-year temporary retirement would only be retire for 10 years as opposed to persisting throughout the projected period.

[2] The land use memos were updated to account for changes requested by the NRDs and the implementation of the CPNRD modifications.

[3] The land use memos were updated to account for changes requested by the NRDs and the implementation of the CPNRD modifications.

POST 1997 GROUNDWATER DEVELOPMENT ROLLBACK LAND USE (LU004P97)[4]

The post 97 data set was developed by making alterations to the baseline data set. For the years 1953 through 1997 the land use remained constant. Between the 1998 and 2013 surface water only and comingled lands were developed as seen in the Baseline Data Set, while groundwater only irrigated lands were kept at 1997 levels. The balance of the acres within a cell were handled one of three ways

- If the number of irrigated acres in the cell exceeded 160.0 acres[5], the excess acres irrigated acres remained in the model and the dryland acres were set to 0.0. The annual total of the excess acres never exceeded 10,000 acres. Averaging 2,100 acres from 1998-2005 and 9,200 acres from 2006-2013. The overwhelming majority of this acre imbalance occurred in the Republican River, Big Blue River, and Little Blue River Basins.
- IF the irrigated acres were less than 40.0 acres, but the irrigated acres plus the dry acres were greater than 160.0 acres; acres were removed from the dryland crops until the total number of acres was equal to 160.0.
- If the irrigated acres plus the dryland acres was less than 40.0 acres, the balance was added as dryland corn.

IRRIGATION ESTIMATES

All groundwater only irrigation estimates were simulated to meet a target NIR.

The Robust Review used the Surface Water Irrigation District surface water deliveries from the Conservation Study[6]. This deliveries data set spanned from 1950 through 2013. For the projected period (2014-2063) the total canal deliveries were copied to match the climate year. This total was then divided among the acres to receive surface water as specified by the simulation year land use file[7]. For surface water only and comingled lands not in the surface water operations model, the irrigation volumes were simulated to meet a target NIR.

Comingled pumping was implemented in the same manner as the COHYST 2010 model. A portion of the target NIR designated by the Groundwater Concentration Factor (GWC) is meet by pumping. Additionally, if the surface water deliveries were insufficient to meet the demanded deliveries (1-GWC), pumping was applied to make up the deficit.

The same surface water deliveries and comingled pumping were applied to each scenario.

CANAL RECHARGE

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[4]All of the NRD and DNR specified modifications to the groundwater irrigated acres happened in1999 or later. This means that the post 1997 groundwater development rollback land use data set was not altered by these changes.

[5]Irrigated acres are defined as the total of the land use file year's surface water only and comingled irrigated acres plus the 1997 groundwater only irrigated acres.

[6]The Robust Review was not running the COHYST Surface Water Operations Model.

[7] Example: In 2014 Cozad Canal would receive the 1989 volume of deliveries which would be divided over the 2014 surface water only and comingled lands serviced by the Cozad Canal.

The Robust Review used the Republican River canal recharge from the COHYST 2010 model. The 1950-1984 canal recharge was copied from 1985. The 2011-2013 canal recharge was copied from 2010 which was in turn originally copied from 2005. (RRcnl001)

Municipal and Industrial (M&I) Pumping

The Robust Review used the M&I pumping from the Statewide M&I data set in the COHYST model area (MI001).

ROBUST REVIEW SCENARIOS (ITERATION 1)

Using the setup and updates described in Section 0, the watershed model was used to simulate a variety of scenarios for the Robust Review and create the corresponding inputs for the groundwater model. Section 0 contains a list of these simulations with a description of how the scenario was represented.

A1. BASELINE SCENARIO (BASE001)

Deliverable: RobustReview_Base001_20180711.zip

Date: 7/11/2018

Simulated Period (1950-2013)

Climate:	1950 – 2013
Land Use:	Baseline Extension (RR001\LU004_rr2013ext)
Groundwater Pumping:	Simulated to meet a target NIR
Surface Water Deliveries:	Copied from the Conservation Study Baseline
Comingled Pumping:	Simulated to meet a target NIR and supplement deficient comingled deliveries
Comingled Deliveries:	Copied from the Conservation Study Baseline to match simulated climate year
Canal Recharge:	Yes
M&I Pumping:	Yes

Simulated Period (2014-2063)

Climate:	1989 – 2013 repeated twice
Land Use:	Baseline Extension (RR001\LU004_rr2013ext)
Groundwater Pumping:	Simulated to meet a target NIR
Surface Water Deliveries:	Copied from the Conservation Study Baseline to match simulated climate year
Comingled Pumping:	Simulated to meet a target NIR and supplement deficient comingled deliveries
Comingled Deliveries:	Copied from the Conservation Study Baseline to match simulated climate year

Canal Recharge:	Yes – match simulated year
M&I Pumping:	Yes – Uses the 2013 estimate

Unretired Scenario (MOD001)

Deliverable: RobustReview_MOD001_20180711.zip

Date: 7/11/2018

Simulated Period (1950-2013)

Climate: 1950 – 2013

Land Use: Unretire Acres (RR001\LU004_rr2013mod)

Groundwater Pumping: Simulated to meet a target NIR

Surface Water Deliveries: Copied from the Conservation Study Baseline

Comingled Pumping: Simulated to meet a target NIR and supplement deficient comingled deliveries

Comingled Deliveries: Copied from the Conservation Study Baseline to match simulated climate year

Canal Recharge: Yes

M&I Pumping: Yes

Simulated Period (2014-2063)

Climate: 1989 – 2013 repeated twice

Land Use: Unretire Acres (RR001\LU004_rr2013mod)

Groundwater Pumping: Simulated to meet a target NIR

Surface Water Deliveries: Copied from the Conservation Study Baseline to match simulated climate year

Comingled Pumping: Simulated to meet a target NIR and supplement deficient comingled deliveries

Comingled Deliveries: Copied from the Conservation Study Baseline to match simulated climate year

Canal Recharge: Yes – match simulated year

M&I Pumping: Yes – Uses the 2013 estimate

Post 1997 Groundwater Development Rollback Scenario (dP97_001)

Post 197 Groundwater Development Rollback Scenario 1997 Level of M&I

Deliverable: RobustReview_dP97_001_20180720.zip

Date: 7/20/2018

Simulated Period (1950-1997)

Climate: 1950 – 1997

Land Use: Post 97 GW Scenario Land Use (LU004p97)

Groundwater Pumping: Simulated to meet a target NIR

Surface Water Deliveries: Copied from the Conservation Study Baseline

Comingled Pumping: Simulated to meet a target NIR and supplement deficient comingled deliveries

Comingled Deliveries: Copied from the Conservation Study Baseline to match simulated climate year

Canal Recharge: Yes

M&I Pumping: Yes (MI001)

Simulated Period (1998-2013)

Climate: 1998 – 2013

Land Use: Post 97 GW Scenario Land Use (LU004p97)

Groundwater Pumping: Simulated to meet a target NIR

Surface Water Deliveries: Copied from the Conservation Study Baseline

Comingled Pumping: Simulated to meet a target NIR and supplement deficient comingled deliveries

Comingled Deliveries: Copied from the Conservation Study Baseline to match simulated climate year

Canal Recharge: Yes

M&I Pumping: Yes – At 1997 levels of pumping (MI001)

Simulated Period (2014-2063)

Climate: 1989 – 2013 repeated twice

Land Use: Post 97 GW Scenario 2013 Land Use (LU004p97)

Groundwater Pumping: Simulated to meet a target NIR

Surface Water Deliveries: Copied from the Conservation Study Baseline to match simulated climate year

Comingled Pumping: Simulated to meet a target NIR and supplement deficient comingled deliveries

Comingled Deliveries: Copied from the Conservation Study Baseline to match simulated climate year

Canal Recharge: Yes – match simulated year

M&I Pumping: Yes – At 1997 levels of pumping (MI001)

POST 197 GROUNDWATER DEVELOPMENT ROLLBACK SCENARIO WITH HISTORIC LEVELS OF M&I

Deliverable: RobustReview_dP97_001_20180716.zip

Date: 7/16/2018

Simulated Period (1950-1997)

Climate: 1950 – 1997

Land Use: Post 97 GW Scenario Land Use (LU004p97)

Groundwater Pumping: Simulated to meet a target NIR

Surface Water Deliveries: Copied from the Conservation Study Baseline

Comingled Pumping: Simulated to meet a target NIR and supplement deficient comingled deliveries

Comingled Deliveries: Copied from the Conservation Study Baseline to match simulated climate year

Canal Recharge: Yes

M&I Pumping: Yes (MI001)

Simulated Period (1998-2013)

Climate: 1998 – 2013

Land Use: Post 97 GW Scenario Land Use (LU004p97)

Groundwater Pumping: Simulated to meet a target NIR

Surface Water Deliveries: Copied from the Conservation Study Baseline

Comingled Pumping: Simulated to meet a target NIR and supplement deficient comingled deliveries

Comingled Deliveries: Copied from the Conservation Study Baseline to match simulated climate year

Canal Recharge: Yes

M&I Pumping: Yes (MI001)

Simulated Period (2014-2063)

Climate:	1989 – 2013 repeated twice
Land Use:	Post 97 GW Scenario 2013 Land Use (LU004p97)
Groundwater Pumping:	Simulated to meet a target NIR
Surface Water Deliveries:	Copied from the Conservation Study Baseline to match simulated climate year
Comingled Pumping:	Simulated to meet a target NIR and supplement deficient comingled deliveries
Comingled Deliveries:	Copied from the Conservation Study Baseline to match simulated climate year
Canal Recharge:	Yes – match simulated year
M&I Pumping:	Yes – At 2014 estimate levels of pumping (MI001)

*The output of this run is no longer on the TFG server. Only the results provided to DNR remain. The output was replaced with 1997 level of M&I pumping before it was determined that both sets of information were desired. This run could be replicated, but the subsequent Post 1997 runs would replace this run in the Robust Review Analysis.

Robust Review COHYST Area Updates

A second iteration of the Robust Review was completed to accommodate the changes to groundwater only irrigated acres in the Central Platte NRD. Furthermore, the requested changes from TPNRD and TBNRD were also implemented. The following changes were made:

A1. Land Use

The Baseline Land Use data set and the Unretired Scenario Land use data sets were updated as follows:

- The CPNRD retirements, transfers, and variances were implemented into both data sets
- The TBNRD temporary retirement '*Pheasants Forever*' contract term was changed from 4 years to 5 years

This information was combined with the previous modifications to create new data sets:

Baseline Land Use (RR002\LU004_rr2013ext_002)
Unretired Scenario Land Use (RR002\LU004_rr2013mod_002)

Details about the modifications made to the baseline and unretired scenario land use data sets can be found in the Land Use Memorandums[8]:

CPNRD_RR_LUmemo_LU20181017.pdf
TBNRD_RR_Memo_LU20181017.pdf
TPNRD_RobustReview_LU20181017.pdf

No Groundwater Pumping Scenario Land Use (RR002\LU004_rr2013ext_002_ngwp)

The No Groundwater Pumping Scenario land use converted all groundwater only irrigated acres in the Baseline Land Use Data Set (RR002\LU_rr2013ext_002) to dryland acres of the same crop mix. Surface water only and comingled land use remained unchanged.

Municipal and Industrial (M&I) Pumping

The industrial pumping from the Gerald Gentleman Power Station (GGS) in the TPNRD was modified to use estimates developed by Nebraska Public Power District (NPPD) in their annual reports. The COHYST M&I data set (MI001) was modified by moving the GGS pumping data to their own set of inputs:

Details about the modifications made to the M&I data sets can be found in the M&I Memorandum:

GGS_update_20181022.docx

[8] The land use memos were updated to account for changes requested by the NRDs and the implementation of the CPNRD modifications.

COHYST M&I for the Robust Review (MIRR001)

Contains the information from the COHYST M&I data set (MI001) sans the GGS pumping estimates.

Gerald Gentleman Station Pumping (GGSRR_002)

Contains the new pumping estimates for GGS.

ROBUST REVIEW SCENARIOS (ITERATION 2)

The newly updated inputs developed in Section 0 were implemented into the watershed model to create a new set of Robust Review scenario simulations and the corresponding inputs for the groundwater model. Section 0 contains a list of these simulations with a description of how the scenario was represented.

A1. BASELINE SCENARIO (BASE002)

Deliverable: RobustReview_COHYST_Base002_20180831.zip
Date: 8/31/2018

Simulated Period (1950-2013)

Climate: 1950 – 2013

Land Use: Baseline Extension (RR002\LU004_rr2013ext_002)

Groundwater Pumping: Simulated to meet a target NIR

Surface Water Deliveries: Copied from the Conservation Study Baseline

Comingled Pumping: Simulated to meet a target NIR and supplement deficient comingled deliveries

Comingled Deliveries: Copied from the Conservation Study Baseline to match simulated climate year

Canal Recharge: Yes

M&I Pumping: Yes

Simulated Period (2014-2063)

Climate: 1989 – 2013 repeated twice

Land Use: Baseline Extension (RR002\LU004_rr2013ext_002)

Groundwater Pumping: Simulated to meet a target NIR

Surface Water Deliveries: Copied from the Conservation Study Baseline to match simulated climate year

Comingled Pumping: Simulated to meet a target NIR and supplement deficient comingled deliveries

Comingled Deliveries: Copied from the Conservation Study Baseline to match simulated climate year

Canal Recharge: Yes – match simulated year

M&I Pumping: Yes – Uses the 2014 estimate

Baseline Scenario – No Municipal and Industrial Pumping (Base002_SansMI)

Deliverable: RobustReview_COHYST_Base002_sansMI_20180905.zip

Date: 9/5/2018

Simulated Period (1950-2013)

Climate:	1950 – 2013
Land Use:	Baseline Extension (RR002\LU004_rr2013ext_002)
Groundwater Pumping:	Simulated to meet a target NIR
Surface Water Deliveries:	Copied from the Conservation Study Baseline
Comingled Pumping:	Simulated to meet a target NIR and supplement deficient comingled deliveries
Comingled Deliveries:	Copied from the Conservation Study Baseline to match simulated climate year
Canal Recharge:	Yes
M&I Pumping:	No

Simulated Period (2014-2063)

Climate:	1989 – 2013 repeated twice
Land Use:	Baseline Extension (RR002\LU004_rr2013ext_002)
Groundwater Pumping:	Simulated to meet a target NIR
Surface Water Deliveries:	Copied from the Conservation Study Baseline to match simulated climate year
Comingled Pumping:	Simulated to meet a target NIR and supplement deficient comingled deliveries
Comingled Deliveries:	Copied from the Conservation Study Baseline to match simulated climate year
Canal Recharge:	Yes – match simulated year
M&I Pumping:	No

Unretired Scenario (Mod002)

Deliverable: RobustReveiw_COHSYT_MOD002_20180831.zip

Date: 8/31/2018

Simulated Period (1950-2013)

Climate: 1950 – 2013

Land Use: Unretired Acres (RR002\LU004_rr2013mod_002)

Groundwater Pumping: Simulated to meet a target NIR

Surface Water Deliveries: Copied from the Conservation Study Baseline

Comingled Pumping: Simulated to meet a target NIR and supplement deficient comingled deliveries

Comingled Deliveries: Copied from the Conservation Study Baseline to match simulated climate year

Canal Recharge: Yes

M&I Pumping: Yes

Simulated Period (2014-2063)

Climate: 1989 – 2013 repeated twice

Land Use: Unretired Acres (RR002\LU004_rr2013mod_002)

Groundwater Pumping: Simulated to meet a target NIR

Surface Water Deliveries: Copied from the Conservation Study Baseline to match simulated climate year

Comingled Pumping: Simulated to meet a target NIR and supplement deficient comingled deliveries

Comingled Deliveries: Copied from the Conservation Study Baseline to match simulated climate year

Canal Recharge: Yes – match simulated year

M&I Pumping: Yes – Uses the 2014 estimate

Post 1997 Groundwater Development Rollback Scenario (dP97_001)

These runs use the same agricultural pumping and recharge from the *Post 1997 Groundwater Development Rollback Scenario (dP97_001)* from Section 0. The difference between the runs is the municipal and industrial pumping data sets which were applied and the way they were applied.

Post 1997 Groundwater Development Rollback Scenario with 1997 Level of M&I

*Updated with new M&I data sets

Deliverable: RobustReview_dP97_001_MIrr001_20180904.zip

Date: 9/4/2018

Simulated Period (1950-1997)

Climate: 1950 – 1997

Land Use: Post 97 GW Scenario Land Use (LU004p97)

Groundwater Pumping: Simulated to meet a target NIR

Surface Water Deliveries: Copied from the Conservation Study Baseline

Comingled Pumping: Simulated to meet a target NIR and supplement deficient comingled deliveries

Comingled Deliveries: Copied from the Conservation Study Baseline to match simulated climate year

Canal Recharge: Yes

M&I Pumping: Yes (MIrr_001, GGSrr_002)

Simulated Period (1998-2013)

Climate: 1998 – 2013

Land Use: Post 97 GW Scenario Land Use (LU004p97)

Groundwater Pumping: Simulated to meet a target NIR

Surface Water Deliveries: Copied from the Conservation Study Baseline

Comingled Pumping: Simulated to meet a target NIR and supplement deficient comingled deliveries

Comingled Deliveries: Copied from the Conservation Study Baseline to match simulated climate year

Canal Recharge: Yes

M&I Pumping: Yes – At 1997 levels of pumping (MIrr_001, GGSrr_002)

Simulated Period (2014-2063)

Climate: 1989 – 2013 repeated twice

Land Use: Post 97 GW Scenario 2013 Land Use (LU004p97)

Groundwater Pumping: Simulated to meet a target NIR

Surface Water Deliveries: Copied from the Conservation Study Baseline to match simulated climate year

Comingled Pumping: Simulated to meet a target NIR and supplement deficient comingled deliveries

Comingled Deliveries: Copied from the Conservation Study Baseline to match simulated climate year

Canal Recharge: Yes – match simulated year

M&I Pumping: Yes – At 1997 levels of pumping (MIrr_001, GGSrr_002)

POST 1997 GROUNDWATER DEVELOPMENT ROLLBACK SCENARIO WITH HISTORICAL LEVELS OF M&I

*Updated with new M&I data sets

Deliverable: RobustReview_dP97_001_MIrr001HistDev_20180905.zip

Date: 9/5/2018

Simulated Period (1950-1997)

Climate: 1950 – 1997

Land Use: Post 97 GW Scenario Land Use (LU004p97)

Groundwater Pumping: Simulated to meet a target NIR

Surface Water Deliveries: Copied from the Conservation Study Baseline

Comingled Pumping: Simulated to meet a target NIR and supplement deficient comingled deliveries

Comingled Deliveries: Copied from the Conservation Study Baseline to match simulated climate year

Canal Recharge: Yes

M&I Pumping: Yes (MIrr_001, GGSrr_002)

Simulated Period (1998-2013)

Climate: 1998 – 2013

Land Use: Post 97 GW Scenario Land Use (LU004p97)

Groundwater Pumping: Simulated to meet a target NIR

Surface Water Deliveries: Copied from the Conservation Study Baseline

Comingled Pumping: Simulated to meet a target NIR and supplement deficient comingled deliveries

Comingled Deliveries: Copied from the Conservation Study Baseline to match simulated climate year

Canal Recharge: Yes

M&I Pumping: Yes (MIrr_001, GGSrr_002)

Simulated Period (2014-2063)

Climate:	1989 – 2013 repeated twice
Land Use:	Post 97 GW Scenario 2013 Land Use (LU004p97)
Groundwater Pumping:	Simulated to meet a target NIR
Surface Water Deliveries:	Copied from the Conservation Study Baseline to match simulated climate year
Comingled Pumping:	Simulated to meet a target NIR and supplement deficient comingled deliveries
Comingled Deliveries:	Copied from the Conservation Study Baseline to match simulated climate year
Canal Recharge:	Yes – match simulated year
M&I Pumping:	Yes – At 2014 estimate levels of pumping (MIrr_001, GGSrr_002)

Post 1997 Groundwater Development Rollback Scenario with No M&I

Deliverable: RobustReview_dP97_001_MIrr001_none_20180904.zip

Date: 9/4/2018

Simulated Period (1950-1997)

Climate: 1950 – 1997

Land Use: Post 97 GW Scenario Land Use (LU004p97)

Groundwater Pumping: Simulated to meet a target NIR

Surface Water Deliveries: Copied from the Conservation Study Baseline

Comingled Pumping: Simulated to meet a target NIR and supplement deficient comingled deliveries

Comingled Deliveries: Copied from the Conservation Study Baseline to match simulated climate year

Canal Recharge: Yes

M&I Pumping: No

Simulated Period (1998-2013)

Climate: 1998 – 2013

Land Use: Post 97 GW Scenario Land Use (LU004p97)

Groundwater Pumping: Simulated to meet a target NIR

Surface Water Deliveries: Copied from the Conservation Study Baseline

Comingled Pumping: Simulated to meet a target NIR and supplement deficient comingled deliveries

Comingled Deliveries: Copied from the Conservation Study Baseline to match simulated climate year

Canal Recharge: Yes

M&I Pumping: No

Simulated Period (2014-2063)

Climate: 1989 – 2013 repeated twice

Land Use: Post 97 GW Scenario 2013 Land Use (LU004p97)

Groundwater Pumping: Simulated to meet a target NIR

Surface Water Deliveries: Copied from the Conservation Study Baseline to match simulated climate year

Comingled Pumping: Simulated to meet a target NIR and supplement deficient comingled deliveries

Comingled Deliveries: Copied from the Conservation Study Baseline to match simulated climate year

Canal Recharge: Yes – match simulated year

M&I Pumping: No

No Groundwater Only Pumping Scenario (nGWP_003)

Deliverable: RobustReview_nGWP_003_20180906.zip

Date: 9/6/2018

Simulated Period (1950-2013)

Climate:	1950 – 2013
Land Use:	Baseline Extension No Groundwater Only Lands (Lu004_rr2013ext_002_ngwp)
Groundwater Pumping:	None
Surface Water Deliveries:	Copied from the Conservation Study Baseline
Comingled Pumping:	Simulated to meet a target NIR and supplement deficient comingled deliveries
Comingled Deliveries:	Copied from the Conservation Study Baseline to match simulated climate year
Canal Recharge:	Yes
M&I Pumping:	No

Simulated Period (2014-2063)

Climate:	1989 – 2013 repeated twice
Land Use:	Baseline Extension No Groundwater Only Lands (RR002\LU004_rr2013ext_002_ngwp)
Groundwater Pumping:	None
Surface Water Deliveries:	Copied from the Conservation Study Baseline to match simulated climate year
Comingled Pumping:	Simulated to meet a target NIR and supplement deficient comingled deliveries
Comingled Deliveries:	Copied from the Conservation Study Baseline to match simulated climate year
Canal Recharge:	Yes – match simulated year
M&I Pumping:	No

Robust Review COHYST Area Updates (Iteration 2.1)

The second iteration of the Robust Review was modified after identifying a data discrepancy between the unretired acres scenario and the cumulative retirements. It was determined that the temporary retirements after 2010 were being added back in at double the rate they should have been. This resulted in 40.8 additional GW only acres in TPNRD and 111.3 additional GW only acres in the TBNRD. The land use data set for the Unretired Scenario was rebuilt to remove the additional unretire acres. No other changes were made.

A1. This created the land use data set:

Unretired Scenario Land Use (RR002\LU004_rr2013mod_002.1)

This land use dataset was created with the same method and inputs as 0; the only exception was that the post 2010 temporary retirements were not added back into the data set. This was not necessary as the modified data set was extended from the 2010 land use from COHYST 2010; as opposed to the modification being made to the extended baseline dataset. Details about the modified data sets can be found in the Land Use Memorandums[9]:

CPNRD_RR_LUmemo_LU20181121.pdf

TBNRD_RR_Memo_LU20181121.pdf

TPNRD_RobustReview_LU20181121.pdf

[9] The land use memos were updated to account for the removal of the double addition of unretired acres.

Robust Review Scenario (Iteration 2.1)

The newly updated inputs developed in Section 0 were implemented into the watershed model to create a new Unretired Scenario simulation and the corresponding inputs for the groundwater model. Section 0 summarizes the inputs used to represent the scenario within the model.

A1. Unretired Scenario (Mod002)

Deliverable: RobustReveiw_COHSYT_MOD002.1_20181121.zip
Date: 11/26/2018

Simulated Period (1950-2013)

Climate: 1950 – 2013

Land Use: Unretired Acres (RR002\LU004_rr2013mod_002.1)

Groundwater Pumping: Simulated to meet a target NIR

Surface Water Deliveries: Copied from the Conservation Study Baseline

Comingled Pumping: Simulated to meet a target NIR and supplement deficient comingled deliveries

Comingled Deliveries: Copied from the Conservation Study Baseline to match simulated climate year

Canal Recharge: Yes

M&I Pumping: Yes

Simulated Period (2014-2063)

Climate: 1989 – 2013 repeated twice

Land Use: Unretired Acres (RR002\LU004_rr2013mod_002.1)

Groundwater Pumping: Simulated to meet a target NIR

Surface Water Deliveries: Copied from the Conservation Study Baseline to match simulated climate year

Comingled Pumping: Simulated to meet a target NIR and supplement deficient comingled deliveries

Comingled Deliveries: Copied from the Conservation Study Baseline to match simulated climate year

Canal Recharge:	Yes – match simulated year
M&I Pumping:	Yes – Uses the 2014 estimate

A.1.4 Memorandums on Municipal, Industrial, and Domestic Use for COHSYT2010

Appendix 4-R

Processing Municipal, Industrial, and Domestic Withdrawals and Discharge

Appendix 4-R.
COHYST M & I
Municipal, Industrial, and Domestic Withdrawals and Discharge
Data Acquisition, Estimation, and Incorporation into the COHYST Grid.

To:	COHYST Group
From:	The Flatwater Group
Subject:	M & I write up
Date:	9/19/2011

This memo describes the production of municipal, domestic, and industrial datasets by The Flatwater Group, Inc., for use in the COHYST 2010 numerical ground water model from 1985 to 2010. Using available sources of withdrawals, returns, and population, "baseline" conditions were developed monthly for each entity in the region. Domestic consumptive use was determined from pumping withdrawals and returns converted to a per capita volume, and trended according to annual population estimates. The Industrial consumptive use baseline was developed using data acquired from the surveys mailed to industrial water users. When calculating consumptive use, large industrial uses were separated from municipal uses.

The databases were combined and applied to the COHYST grid in GIS with a descriptive rate of acre-feet per month. Data sources and method used to estimate municipal, industrial, and domestic withdrawals and returns within the eastern and central portions of the COHYST model region are described below.

DATA Sources

Data used in estimating the industrial and municipal withdrawals for the eastern and central portions of the COHYST area were acquired from several locations. The Department of Natural Resources (DNR), local natural resource districts (NRD) (Central Platte NRD, Tri-Basin NRD, Twin Platte NRD), and the United States Geological Survey (USGS) provided pumping measurements and estimates. DNR, NRDs, and the Nebraska Department of Environmental Quality (DEQ) provided discharge measurements and estimates. Information on population and demographics was acquired from the DNR and combined with data from the United States Census Bureau and USGS. The spatial location of the wells was attained from DNR.

DNR circulated two types of water use surveys to industries throughout the COHYST area. In addition, DNR provided population estimates for the COHYST counties and municipalities during several inter-census years. Finally, the DNR provided spatial information on the location of municipal, domestic and industrial wells across the area in the form of the registered groundwater wells database.

The first survey type was titled “Historical Surveys”. Many of the industries surveyed receive their water source from municipal water supplies. This was reported in the upper right-hand section of the first page of the survey. Requested information included industry type, method of discharge, location of discharge if into a stream, DEQ NPDES permits, and the technique used to acquire the annual or monthly data (metered or estimated).

A second DNR water use survey was sent to owners of registered industrial wells. The survey included a list of wells used at an industrial location and requested information on any other wells that were used to supply water to the industry. The survey requested information on the industry type, well, DEQ NPDES permits, and the location where waste water was discharged into the stream, along with monthly or annual pumping and discharge values or estimates and the technique used to arrive at these estimates.

The USGS prepares withdrawal estimates in the form of a USGS water use circular titled “Estimated use of Water in the United States”. These Water use estimates are published every 5 years. Electronic data on a county-level were available from 1985 to the most current publication in 2005. USGS’s water use circular includes withdrawal estimates from publicly supplied water sources, self-supplied domestic water use, self-supplied industrial water use, irrigation, livestock production, mining, thermoelectric power production, and withdrawal totals on a statewide basis, with background data available on a county-level. The water use circulars also include estimates of total population, self-supplied population and publicly supplied population.

For the USGS circulars, the source of all self-supplied domestic withdrawals in Nebraska is assumed to be groundwater. A county’s self-supplied population was calculated as the difference between the total county population and the estimated publicly-supplied population. Withdrawals were estimated based upon the self-supplied population and the average zonal[1] residential delivery per-capita rate based on the results from the public water system survey. Data sources for the self-supplied domestic withdrawals in the 2005 water use circular include the following: a public water supply

[1] As defined by the USGS estimation methods for the self-supplied domestic population withdrawals.

database maintained by the Nebraska Department of Health and Human Services System; a DNR 2005 Public Water System Survey; USGS Water Use in Nebraska, 2000 (USGS); DNR 1995 Water Use Report, and a U.S. Bureau of Census, 2006, 2000-2005 County Population Estimates report.

Besides information on withdrawals, estimates of returns were also obtained. Municipal and Industrial water users who discharge waste water into the streams are required to submit discharge monitoring reports (DMR) to the DEQ. These discharge reports were obtained, when available, to confirm the amount of wastewater discharged by the industry or municipality.

United States Census Bureau records were also used to acquire population estimates for the municipalities and counties that were in the eastern and central portions of the COHYST area. Population estimates from the census were available on a ten-year basis.

Industrial Data and Estimates

The data supplied by the industry contacts came in several different formats. Industries typically provided monthly or annual data based upon metered pumping data, while a few provided summaries of utilities statements. However, many of the industries did not have meters on either their water source or discharge point, and several cited this as the reason they were unable to report their water use. Other industries attempted to make good-faith estimates of either monthly or annual values based on their instantaneous pumping rates, consumption rates, or other methods.

Industries that possessed a DEQ NPDES permit often did not include discharge data, and instead referred to the DMRs submitted to the DEQ. Discharge data were acquired for sites with NPDES permits to match the time period for which the industry supplied withdrawal records.

The metered and estimated data, as well as the DEQ DMR discharge values, were compiled into a database for each surveyed location. While the scope of the project was to investigate municipal and industrial water use from 1985-2010, none of the industrial records were complete for the entire time period. To account for these limitations, estimation techniques were developed to fill in the gaps.

Partially completed set of monthly data points for a year

This first technique was used for those situations where there were unknown monthly water withdrawal values in partially reported years. Water use was not consistent throughout the year for many industries; there were periods where withdrawals were relatively higher or relatively lower. This may be due to a variety of reasons, but when estimating unknown values, it was important that an attempt be made to account for these temporal patterns.

Using years where a complete set of monthly data was available, the monthly distribution for each year was developed by calculating the average proportion of the annual withdrawals that occurred during each month. Using this average monthly distribution, the total amount of withdrawals were estimated by averaging the quantity of the known monthly value divided by the average monthly withdrawal proportion for those months where withdrawal data were available.

$$\widetilde{W_a} = \frac{\sum_{i=1}^{n} \frac{W_i}{\overline{P_i}}}{n}$$

$\widetilde{W_a}$ Estimated annual withdrawals

W_i Known monthly withdrawal for month i

$\overline{P_i}$ Average monthly proportion of the annual distribution of withdrawals $\left(\sum_{i=1}^{12} \overline{P}_i = 1.0\right)$

n Number of months with available monthly withdrawal data

The unknown monthly values were estimated by multiplying the estimated annual withdrawals by the corresponding average monthly proportion of the annual distribution of withdrawals. This same technique was applied to the discharge values to estimate missing monthly data points in an incomplete year.

Missing annual and monthly data

For some industrial withdrawal records, entire years' worth of records were missing. For these situations, annual withdrawal data were estimated, using an established procedure. The industries were investigated to ensure that they were operational during the investigation period, and that if they had private wells, that those wells were present during a given year. If the industry had multiple wells, and one or more of those wells was completed during the investigation time period, the estimated withdrawals by the industry were prorated according to the pumping capacity of active wells compared to total pumping capacity for the years prior to the completion date of the well or wells in question. If the industry used a consistent amount of water each year, it was assumed that the pattern for the known period persisted during periods with missing records, and this annual amount was then applied to all the missing years.

Withdrawals for industries that saw fluctuating annual amounts were estimated by considering the average portion of non-irrigation pumping within a respective county that could be attributed to the particular industry. Using the supporting data from the USGS circulars for the years 1985-2005, estimates for the total irrigation withdrawals and the total county withdrawals were obtained. Irrigation encompasses the majority of the total withdrawals for most of the counties of interest. By removing the irrigation estimate from the total estimate, an estimate of the non-irrigation withdrawals was developed. The non-irrigation annual withdrawals for the year 2010 were estimated as either the average of 1985-2005 withdrawals if the volume of water being withdrawn was fluctuating up and down over time, or using a linear regression trend if there was a persistent growth or decline over the time period. Linear interpolation was used to determine the intermediate values.

$$W_t = W_a + (W_z - W_a)\left(\frac{Y_t - Y_a}{Y_z - Y_a}\right)$$

W_t	Estimated non-irrigated withdrawals for a year between Y_z and Y_a
W_a	Estimated non-irrigated withdrawals for a known year prior to the year of interest
W_z	Estimated non-irrigated withdrawals for a known year following the year of interest
Y_t	Year of interest
Y_a	Year of available data prior to the year of interest
Y_z	Year of available data following the year of interest

Initially, the USGS industrial withdrawals estimate was considered as the benchmark for comparisons. However, the USGS water use circulars do not always have a consistent format from publication to publication, and some categories have been eliminated and/or combined to form other categories. This appears to have been the case for industries that use a municipal source. Occasionally, withdrawal estimates obtained for a single industry within the DNR survey data exceeded the annual self-supplied industrial water use estimates in the USGS circular. Because of these circumstances, non-irrigation withdrawal values were developed instead.

These estimates were derived by removing the major source of withdrawals (irrigation) from total USGS county withdrawal estimates. Having estimated the county's non-irrigation withdrawal, the proportion of non-irrigation withdrawals associated with a given industry was determined for each year in which industry withdrawal data were available. These annual proportions were then averaged across all years of available records. This average proportion was then used to estimate annual pumping volumes for each unknown year in the period of interest by multiplying that fraction by the USGS non-irrigation withdrawal value for each year with missing data. The final step was to distribute the annual value to monthly values, which was done by using the average monthly distribution.

The self-supplied industrial withdrawals were geospatially referenced by assigning those values to the COHYST cells where their wells were located. If an industry acquired its water from a municipal supply, the industrial withdrawals were applied to the cell representing the centroid of the municipality. Several municipalities contained multiple industrial sites, in which case the withdrawal values were simply summed and applied to that location.

Estimating Discharge

When discharge values were present in conjunction with the withdrawal values, the annual ratio of discharge to withdrawals was computed. The average relationship was then applied to the years when no annual estimates or values were present, by multiplying the annual withdrawals by this average ratio. This process was undertaken to approximate the annual discharge in unknown years, including years where the withdrawals were estimated. Once the annual amounts had been estimated they were partitioned using the average monthly discharge proportion of total discharge.

Some industry sites included only annual values or estimates. If there were industries that served the same purposes (i.e. two alfalfa pelleting plants) and only one of them had monthly values, the monthly distributions for that industry were applied to the industry that included only annual values. Otherwise the withdrawals or discharges were spread uniformly across the year.

The discharge values were assigned to the COHYST cell that contained the location of discharge, but only if the industry had a known discharge location into a stream. If no discharge locations were identified, it was assumed that the industry had a zero-discharge facility.

Municipal Data and Estimates

Municipal withdrawals and discharges were acquired for 36 communities and estimated for an additional 12 communities in the COHYST model area. Monthly withdrawal and/or discharge data were provided by the Twin Platte NRD, Central Platte NRD, and the Tri-Basin NRD. Supplemental discharge data were acquired from the DEQ DMRs.

Municipal pumping estimates were heavily dependent on the size of the municipal population. Population estimates supplied by the DNR for the years 1994-1999 and 2005 were combined with data from the U.S. Census Bureau from 1980, 1990, 2000, and 2010 to estimate the population for each year during the investigation period. Linear interpolation between two known annual population values was used between the known data points.

Once the population was estimated, the per capita withdrawals or discharges were calculated on a monthly basis for the years with available data. For years with missing data, a moving average of the previously calculated per capita withdrawals or discharges was used to calculate the monthly withdrawal or discharge by multiplying the moving average with the estimated population.

$$\widetilde{W}_{m,y} = \frac{P_y \sum_k C_{m,k}}{n}$$

$\widetilde{W}_{m,y}$	Estimated withdrawal or discharge for the municipality for a given month and year.
$C_{m,k}$	Per Capita withdrawals for a given month (m) and year (k).
P_y	Estimated Population of the municipality during a given year y
n	Number of years in the moving average. An 8 year moving average was used except for those cases with less than 8 years of available data.
m	The month being estimated
k	The years being used in the moving average (n years total).

The next step was to remove the municipally supplied industrial withdrawals from the municipal withdrawals, which was done on a city-by-city basis. Lexington, NE, municipal withdrawals were approximately half of the withdrawals used by Tyson Fresh Meats, the largest industrial user. While the Tyson Fresh Meats water use survey from DNR states that Tyson's water source was from the municipal supply, it was assumed that the industrial withdrawals have already been removed from the municipal withdrawals in Lexington. The municipal withdrawals were then assigned to the COHYST cell containing the centroid of the municipality.

Estimating discharge when no data were present

If no discharge data were available, the annual discharge was estimated as a proportion of withdrawals. The proportion used was calculated in different ways, depending upon the population of the municipality. For municipalities smaller than 1,500, between 1,500 and 10,000, and greater than 10,000, ratios of .341, 0.438, and 0.630 were used to estimate discharge, respectively.

The annual discharge was then distributed by using distributions calculated for other nearby municipalities or municipalities with similar populations. For each town that lacked discharge data, the average monthly discharge distribution for the four closest towns was compared to the average monthly discharge distribution of the four towns with similar population size regardless of location (with the caveat that the towns used to calculate the averages needed to have discharge data available). The difference between these two discharge distribution estimates was rarely greater than 1%, and often below 0.5%. With this in consideration, estimates were made using the distribution of similar sized towns.

Blank values for partial years were estimated using the same procedure explained for the industries. If only the annual amount was reported, it was distributed according to the average distribution based upon municipalities of similar size.

Discharge values were assigned to the COHYST cell at the location where the municipality discharged into a stream. For municipal discharges with no known discharge locations, it was assumed that they employed zero-discharge wastewater facilities.

Domestic Self-Supplied Withdrawal Estimates

Self-supplied domestic withdrawals were calculated based upon the USGS water use circulars published in 1985, 1990, 1995, 2000, and 2005. A value for 2010 was estimated using either 1) the average over the period 1985-2005 if there were sigmoidal fluctuations (Figure 1) every five years or 2) a linear regression model if there was a persistent rise (Figure 2) or decline in the withdrawal rate. Withdrawal rates for years between USGS circulars were estimated using linear interpolation. The monthly distribution developed for a municipality with a population less than 1,500 residents was used to partition the annual withdrawals into monthly values.

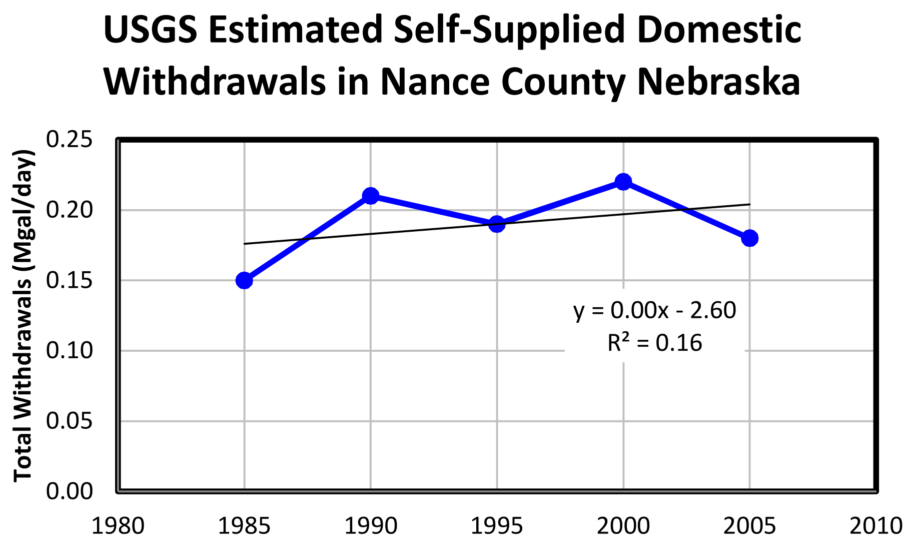


Figure 1. Fluctuating self-supplied domestic withdrawals in Nance County, Nebraska.

A list of all domestic wells with their geographic location was acquired from the DNR registered groundwater well database. The monthly self-supplied domestic withdrawal values were then assigned to the COHYST cells based upon the number of wells present in each cell. A uniform quantity of water withdrawals was assigned to each well and the cumulative amount was assigned to the cell. This process was done for 32 counties wholly or partially contained in the middle and eastern sections of the COHYST model area.

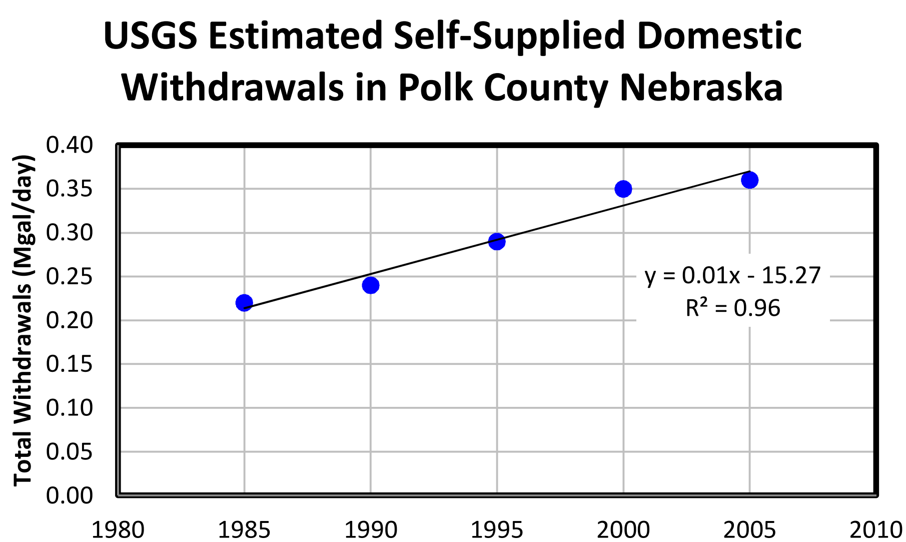


Figure 2. Upward trending self-supplied domestic withdrawals in Polk County, Nebraska.

The maximum level of withdrawals in any given cell was 275,000 gallon pumped in a single month. This occurred during January, 2005, in cell 85066, which was located in Hall County, Nebraska, and contains 49 domestic wells. If the pumps were run 24 hours a day for the entire month, the combined capacity of the 49 wells would need to be less than 6.4 gpm, or 0.13 gpm per well. Assuming the wells were active a quarter of the time, the combined capacities of the well would need to be 25.5 gpm, or 0.52 gpm per well. These values appear to be within the pumping capabilities for a typical domestic well.

Municipal and Industrial Pumping

Prepared By:
The Flatwater Group, Inc

1. Introduction

1.1. Authorization

The Flatwater Group, Inc. (TFG) has prepared this as authorized in the contract between the Nebraska Department of Natural Resources (DNR) and TFG originally dated 9 August 2010.

1.2. Purpose and Scope

Municipal and industrial (M&I) pumping is a small but significant element crucial to the acumen of a robust conjunctive management model. While not encompassing as much spatial area as other parts of the Regionalized Soil Water Balance model (RSWB); the impact of M&I pumping can be substantial in localized area. The M&I development process is shown in figure 1.

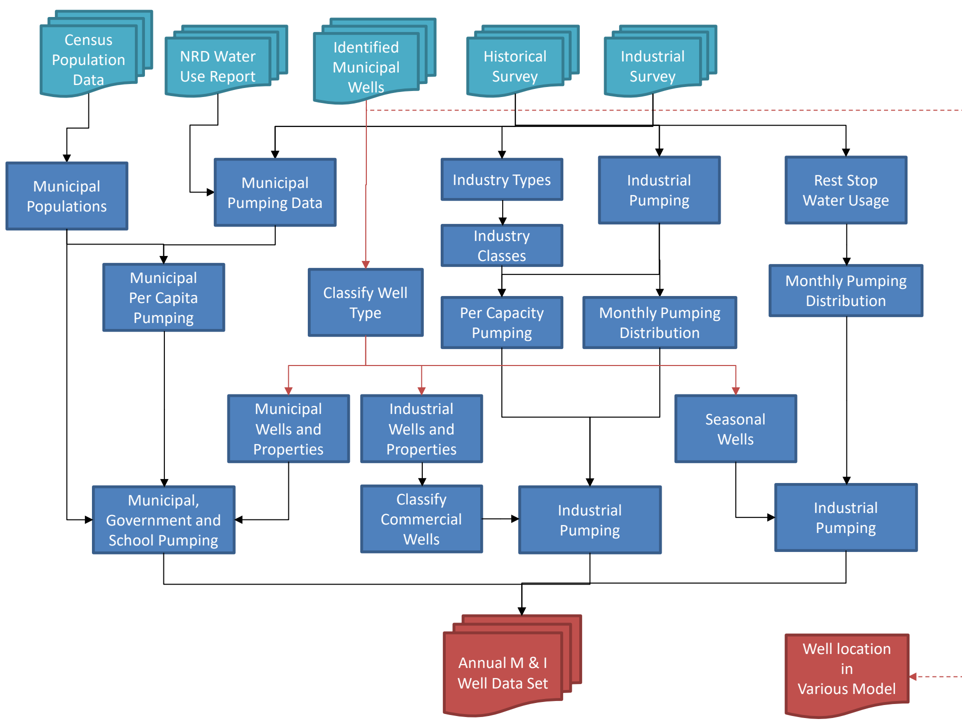


Figure 1. The development process for the M&I state-wide data set.

TFG received a statewide shapefile of registered groundwater wells designated as either Commercial (C) or Public (P or U) from the Nebraska Department of Natural Resources (NDNR). The process to develop the industrial and municipal withdrawals included drawing on data from multiple sources. The Department of Natural Resources (DNR) and the natural resource districts (NRDs) in the COHYST model area (Central Platte NRD, Tri-Basin NRD, Twin Platte NRD) provided pumping measurements and estimates; and additionally the spatial location of the wells. United States Census Bureau data was downloaded from the Nebraska Department of Economic Development website.

DNR circulated two types of water use surveys to industries throughout the COHYST model area. The first type was title “Historical Surveys”. Information contained in the surveys includes the industry type, monthly and or annual pumping, and the technique used to acquire the data (metered or estimated). Many of the industries surveyed received their water source from municipal water supplies; however, this information provided valuable insight into the volume of water that was withdrawn by the industry.

A second type of water use survey was sent to owners of registered industrial wells; “Industrial Surveys”. The survey included a list of wells used at an industrial location; with the request for information on all pumping from any other wells supplying water to the industry. Additionally, the survey requested information on the type of industry, well properties, and the technique used to arrive at the reported pumping totals.

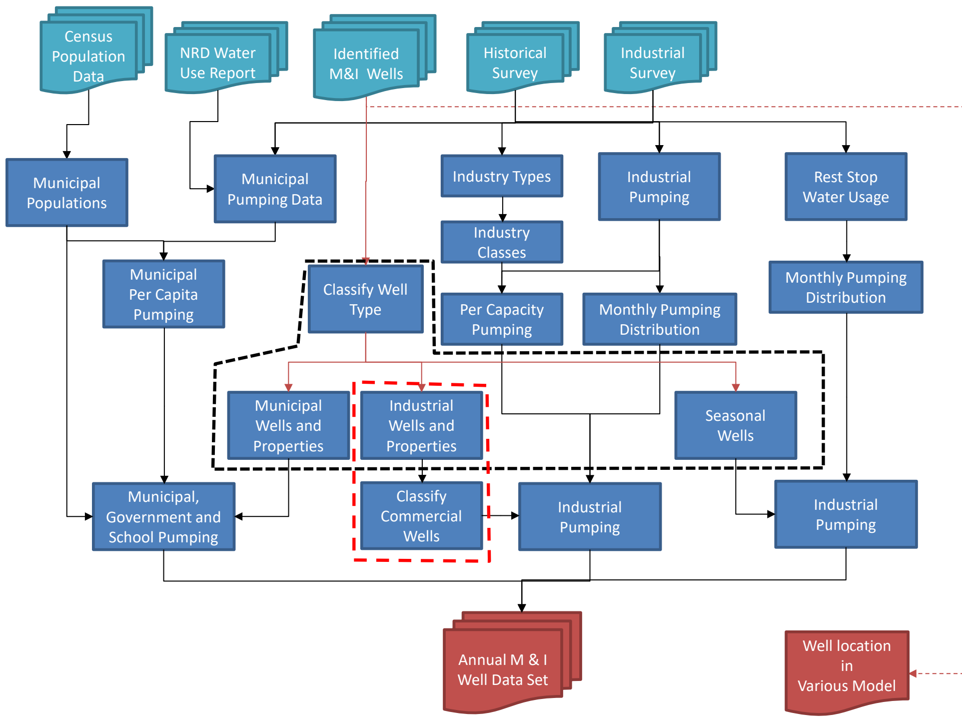
The inclusion of municipal pumping information in either the industrial or historical surveys was sparse. To supplement this limited information, data used in the development of the 2010 NRD water use reports from the TPNRD, CPNRD, and TBNRD was incorporated into the development of the M&I pumping data set.

The populations of the municipalities were acquired from the US Census Bureau for the years 1930-2010.

The statewide well coverage was overlaid with the 6 water basin model grids individually as well as the statewide model grid to determine the grid cells each well resided within. This tabular data was imported into a database where it is combined with the population data based on municipality. The total well capacity of a municipality is calculated to be used in the distribution process. A separate municipal well capacity is also calculate based on the model grid which the wells are located in. For instance, if a municipality has several wells located in one model grid and others located within another model grid, a separate capacity is calculated for each group of wells and associated with the appropriated model grid id.

This data was used in various forms to develop three different datasets depicting pumping estimates from municipalities and industries based upon the characteristics of the well and the type of industry using the well.

2. Well Classification



The first step was to classify all of the identified wells. Six different types of wells were readily identifiable based upon the owner of the well; public, commercial, seasonal, governmental, public interest, and educational.

- Public wells were defined as those wells that fed the municipalities.
- Commercial wells were owned by individual or companies whose was deemed as neither agricultural nor domestic in use. Examples included private business, power production facilities, golf courses, etc…
- The seasonal classification consisted of wells that provided water for items such as campgrounds or the Nebraska Game and Parks Commission.
- The governmental class includes wells for governmental services associated with public safety. These items include prisons, military installations, and law enforcement centers.
- Public Interest well mainly consisted of wells to meet the needs of the travellers and transportation. These wells included those owned by the Nebraska Department of Roads and the wells used to operate rest stops.
- Educational wells were wells that were owned by school districts or institutions of high learning.

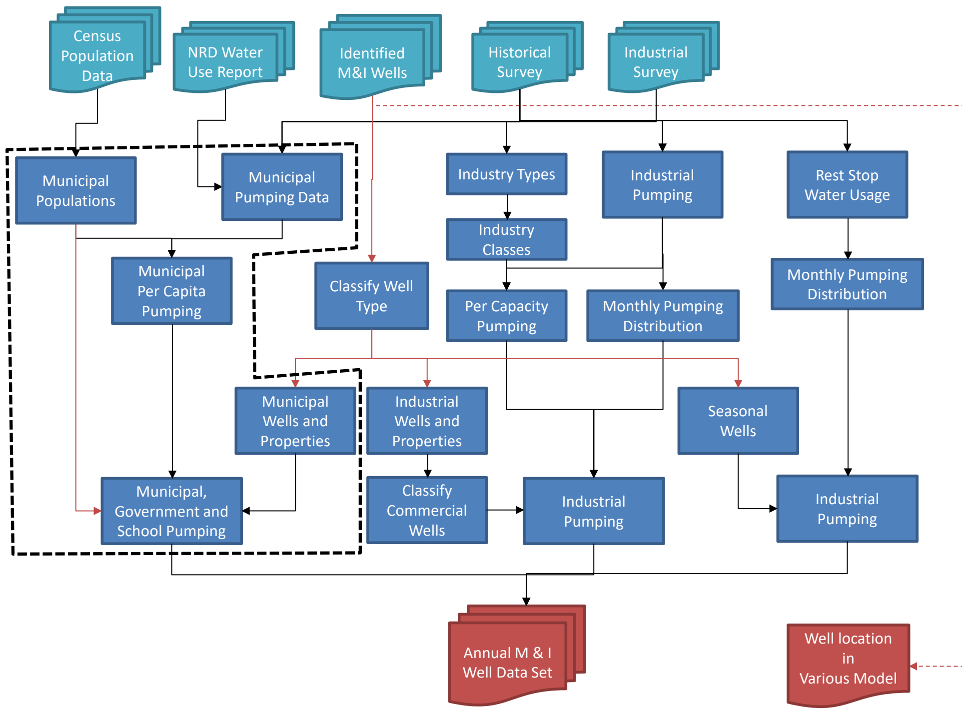
Unfortunately, this level of classification was not sufficient to match the well information with the available information from the data sources. To account for this these classes were further combined into three groups.

The educational and the governmental wells were combined with the public wells to form the municipal well group. Data limitations failed to provided enough information to independently develop estimates for the water usage by the entities described in the governmental or educational well classes. However, the presences of similar entities potentially exist within the constructs of the users of the public wells used to develop municipal pumping estimates.

Seasonal and public interest wells were combined as they were both deemed dependent upon the number of users with small amounts of net consumptive use.

The commercial wells are the only group included in the industrial well data set.

3. The Estimation of Municipal Pumping



The estimated pumping for municipal, governmental, and educational wells was developed using a per capita pumping values for the municipality to which the well belongs. By interpolating between the decadal populations retrieved from the 10 year census, an annual population was developed. The population in 2011-2012 was the product of extrapolating each town's population trend between 2000 and 2010.

$$pop_i = pop_1 + (pop_2 - pop_1)\left(\frac{year_i - year_1}{year_2 - year_1}\right)$$

pop	population
year	year
i	pertaining to the estimated year
1	first interpolating/extrapolating point
1	second interpolating/extrapolating point

Next, the municipal pumping data was organized by municipality. Using the annual population estimates, the per capita pumping was determined by dividing each monthly pumping value by the annual population. An average per capita pumping for each month was taken over the period of available pumping data. This process was repeated for each municipality. The list of municipalities is shown located in Appendix A.

An average monthly per capacity pumping distribution was developed for three groups based upon population. These however, did not differ significantly from a simple average over the entire set of municipalities. Therefore, the single average monthly per capita pumping distribution was utilized. The distribution is shown in Table 1.

Having developed the monthly per capita pumping distribution and annual population estimates, the total volume of water pumped by the municipality can be estimated. This amount is then split between all active wells feeding the municipality, weighted by the relative capacity of the well.

$$P_{well,i} = Pop_j * P_{pc,i} * \frac{Cap_{well}}{Cap_{muni,j}}$$

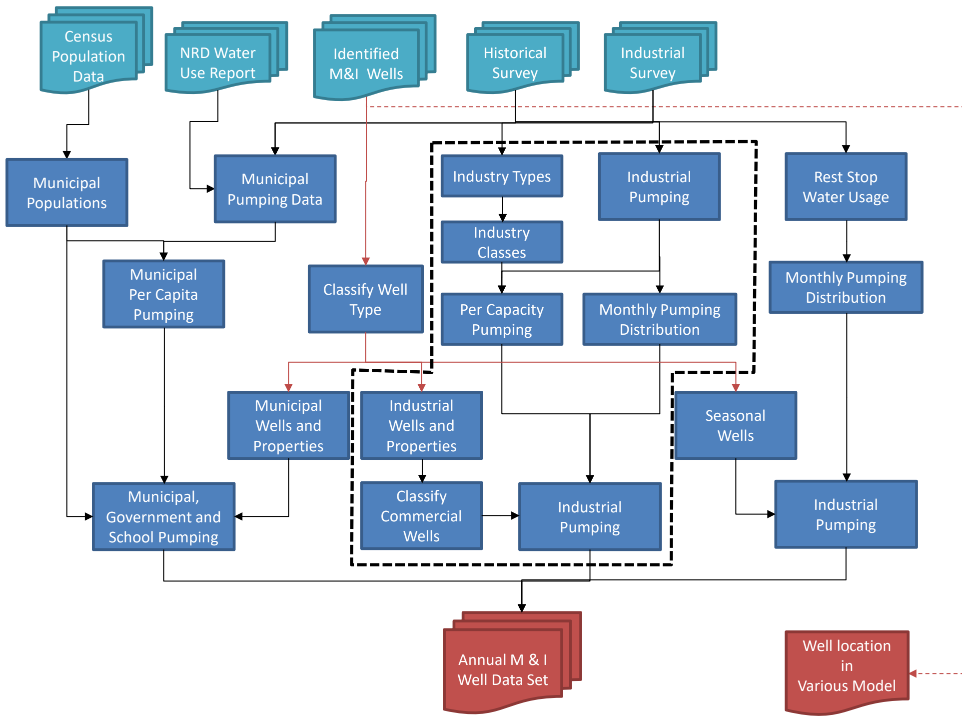
$P_{well,i}$	Pumping for the well in month i
Pop_j	Population for the municipality in Year j
$P_{pc,i}$	Pumping per capita in month i
Cap_{well}	Capacity of the well
$Cap_{muni,j}$	Total capacity of the municipality in year j

Table 1. Monthly Per Capita Pumping

Month	Per Capita Pumping (Mgal/person)
Jan	0.0053
Feb	0.0048
Mar	0.0057
Apr	0.0066
May	0.0095
Jun	0.0119
Jul	0.0161
Aug	0.0134
Sep	0.0110
Oct	0.0079
Nov	0.0057
Dec	0.0054

The towns of Yankton, SD; Julesburg, CO; and Bern, KS all had water sources within the state of Nebraska. However, total pumping capabilities for these municipalities was unknown. Therefore, the populations were adjusted to 10%, 25%, and 25% respectively.

4. The Estimation of Industrial Pumping



Using the data collected by DNR in the Historical and Industrial Surveys, the following technique was developed to estimate industrial pumping volumes for the state-wide M&I dataset. The survey results provided water use information for 50 different industrial sites. The average annual volume of water usage and the average monthly pumping distribution were compiled for each industrial site. Also, when available the pumping capacity of the individual industry was obtained. This information was augmented with data relating to the industry from the Nebraska Well Registry.

The next step was to create and assigned different industrial categories to group similar types of water users. Twelve different classes were developed. Additionally two large water users, Western Sugar Cooperative and the Sutherland coal power plant, remained as unique groups. The different industrial classes are:

1. Western Sugar Cooperative
2. Ethanol Production
3. Golf Courses
4. Meat Packing and Animal Byproduct Manufacturing
5. Sand and Gravel
6. Confined Animal Feeding Operations (CAFO)
7. Construction
8. Power Plants

9. Small Manufacturing
10. Medium Manufacturing
11. Large Manufacturing
12. Small Business
13. Raceways
14. The Sutherland Coal Power Plant

As with any water user, even within an industry, the amount of water that is consumed varies for several reasons including: size, product, etc... Therefore, a technique was developed to estimate the per capacity annual pumping for each defined industrial class. This was accomplished first by determining the average annual volume of water used for each industrial class. Next the average total capacity per industrial class was computed. The industrial class per capacity pumping was the result of dividing the average industrial pumping by the average industrial capacity.

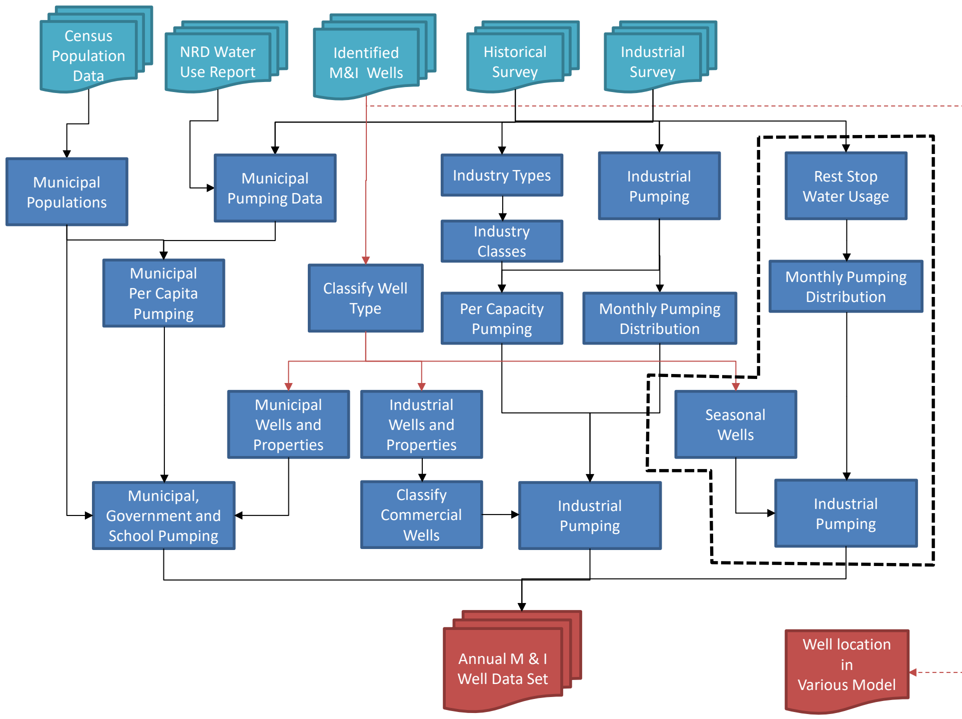
Finally the monthly distribution for each industry class was determined by averaging the distribution for each industry. Two exceptions existed, CAFO and power plant. All CAFOs reported that they were using the same volume of water throughout the year. Therefore, the CAFO water use was evenly distributed between the months. The power plant monthly distribution was developed using the monthly power production distribution from US Energy Information Administration for 2011-2012.

The next step was to assign the various industries within the well file to the corresponding industrial class. A short internet search was performed on each individual company. The results were used to classify the company to the correct group. Unfortunately, the sample of industries in the historical and industrial surveys was not sufficient to cover all types of industries within the state. Therefore, some rules were developed to classify the remaining businesses.

- Mining and Fossil Fuel extraction was classified as large industrial
- Agriculture production types were classified as golf course (nurseries, vegetable, etc…)
- Well drilling was classified with sand and gravel
- Game and Parks wells were classified as golf courses
- Unknown Business types were classified by total well capacity (gpm):
    - 0 – 350 small business
    - 350 – 600 small manufacturing
    - 600 – 1250 medium manufacturing
    - 1250 + large manufacturing

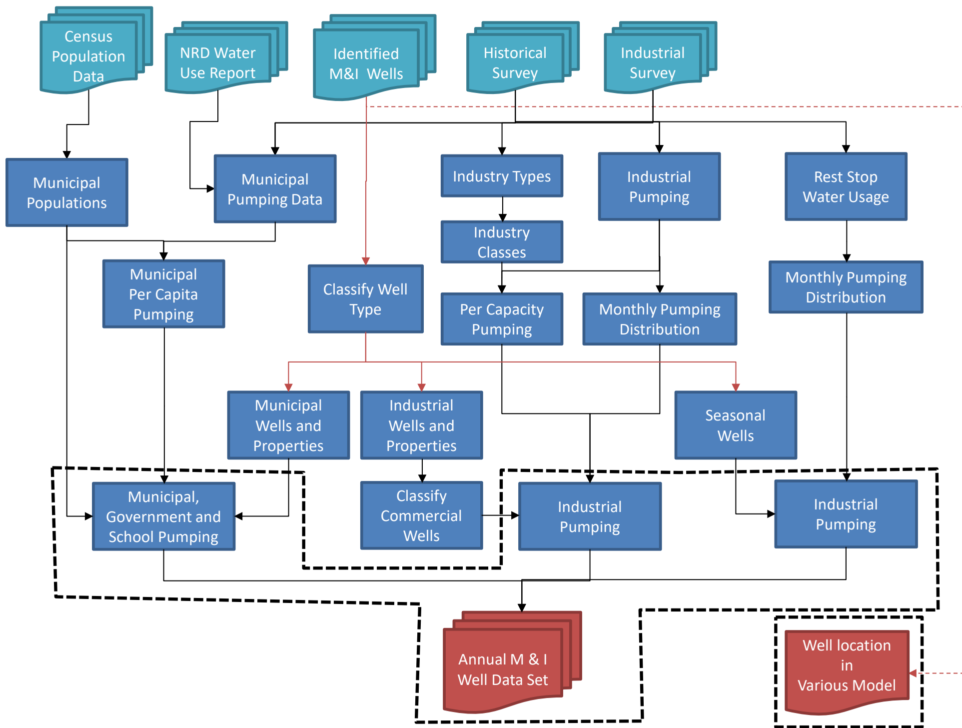
The appropriate per capacity pumping and monthly distribution was applied to each well to develop the industrial pumping data set from industrial wells.

5. The Estimation of Seasonal Industrial Pumping



The seasonal industrial pumping data set was developed based upon the results of the Rest Stop Water Usage from the Industrial Survey. The rest stop water data was developed based upon the per visitor water usage, with each visitor using 2.5 gal. The total monthly water usage was estimated for each rest area in the sample population. The monthly average over all sample rest areas was used to define the monthly pumping distribution for the seasonal industrial wells. The distribution was then applied to all seasonal wells to create the Seasonal Industrial Pumping data set.

6. Process Results



The results from the municipal pumping, industrial pumping, and seasonal industrial pumping are compiled to create the Annual M&I state wide data base. This file contains the well, the years and the volume of pumping that occurs from the well each month.

The Annual M&I state wide data base is to be used in combination with the well location file. The well location file contains the model cell ID for each RSWB model and the state-wide grid; Western Water Use Model (WWUM), Upper Niobrara White Model (UNW), the Central Nebraska Model (CNEB), the Blue Basin Model (BBM), COHYST, and the Missouri Tribs; in which the well is located.

Appendix A

The municipalities used to create the per capita pumping distribution are listed in Table A.1. Each month contains the average per capita pumping for each town over the time period when pumping records were available. The average population is also depicted over this same time period.

Table A.1. Municipality average per capita pumping values used to create the municipal per capita pumping distribution.

#	city	Ave Pop	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	Brady	396	0.005	0.006	0.005	0.007	0.014	0.017	0.028	0.022	0.016	0.009	0.005	0.005
2	Brule	367	0.005	0.004	0.004	0.006	0.010	0.013	0.016	0.014	0.010	0.006	0.004	0.005
3	Maxwell	311	0.004	0.004	0.005	0.005	0.006	0.009	0.010	0.008	0.005	0.005	0.003	0.004
4	Ogallala	4771	0.004	0.003	0.004	0.005	0.009	0.010	0.013	0.012	0.009	0.005	0.004	0.003
5	Paxton	554	0.004	0.004	0.005	0.006	0.009	0.010	0.014	0.014	0.010	0.007	0.005	0.004
6	Sutherland	1223	0.005	0.005	0.006	0.006	0.007	0.010	0.012	0.012	0.011	0.007	0.005	0.005
7	North Platte	24097	0.005	0.005	0.005	0.007	0.009	0.012	0.014	0.014	0.012	0.009	0.005	0.005
8	Axtell	711	0.005	0.004	0.005	0.006	0.009	0.012	0.019	0.015	0.011	0.008	0.005	0.005
9	Bertrand	778	0.005	0.005	0.005	0.007	0.012	0.014	0.024	0.017	0.015	0.009	0.006	0.005
10	Elwood	720	0.006	0.005	0.006	0.008	0.011	0.013	0.017	0.015	0.012	0.009	0.007	0.006
11	Funk	194	0.011	0.007	0.010	0.008	0.005	0.011	0.014	0.013	0.014	0.013	0.006	0.011
12	Loomis	382	0.004	0.005	0.005	0.008	0.014	0.020	0.029	0.021	0.016	0.008	0.005	0.004
13	Smithfield	62	0.004	0.004	0.005	0.005	0.007	0.008	0.012	0.012	0.010	0.012	0.005	0.005
14	Alda	631	0.004	0.004	0.004	0.004	0.007	0.010	0.012	0.010	0.008	0.005	0.004	0.004
15	Amherst	257	0.010	0.009	0.011	0.013	0.015	0.020	0.027	0.020	0.021	0.020	0.012	0.012
16	Cairo	786	0.004	0.004	0.004	0.005	0.008	0.010	0.015	0.012	0.009	0.006	0.004	0.004
17	Central City	2929	0.005	0.006	0.006	0.007	0.010	0.010	0.010	0.014	0.011	0.010	0.009	0.009
18	Cozad	4185	0.006	0.006	0.017	0.009	0.014	0.018	0.023	0.018	0.015	0.009	0.006	0.006
19	Doniphan	773	0.006	0.006	0.006	0.007	0.009	0.013	0.018	0.014	0.012	0.008	0.006	0.006
20	Duncan	346	0.006	0.003	0.003	0.009	0.012	0.010	0.011	0.009	0.007	0.005	0.003	0.003
21	Elm Creek	873	0.006	0.005	0.006	0.007	0.011	0.014	0.020	0.015	0.013	0.008	0.006	0.006
22	Eustis	427	0.006	0.005	0.005	0.008	0.014	0.018	0.025	0.019	0.017	0.010	0.006	0.005

#	city	Ave Pop	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
23	Farnam	213	0.004	0.004	0.004	0.005	0.007	0.009	0.013	0.013	0.011	0.007	0.006	0.006
24	Gibbon	1785	0.006	0.005	0.006	0.006	0.005	0.009	0.011	0.009	0.008	0.008	0.007	0.004
25	Grand Island	44164	0.008	0.007	0.008	0.008	0.011	0.013	0.017	0.015	0.012	0.010	0.008	0.008
26	Gothenburg	3606	0.005	0.005	0.006	0.008	0.012	0.014	0.019	0.016	0.013	0.009	0.006	0.005
27	Kearney	28722	0.004	0.004	0.004	0.005	0.007	0.009	0.012	0.010	0.009	0.006	0.005	0.004
28	Lexington	9840	0.005	0.004	0.006	0.006	0.010	0.010	0.013	0.010	0.008	0.006	0.005	0.005
29	Overton	650	0.002	0.003	0.003	0.004	0.005	0.005	0.007	0.005	0.003	0.003	0.002	0.002
30	Riverdale	206	0.004	0.004	0.004	0.005	0.007	0.009	0.011	0.008	0.006	0.005	0.013	0.004
31	Shelton	1085	0.005	0.004	0.004	0.005	0.007	0.008	0.013	0.011	0.008	0.006	0.004	0.004
32	Wood River	1217	0.005	0.005	0.006	0.007	0.009	0.012	0.015	0.013	0.011	0.007	0.005	0.005

Appendix B

The list of industries from the historical or industrial surveys used to create the industrial classes and their distributions are shown in Table B.1.

Table B.1. Industrial sites used to create the industrial pumping data.

#	Name	Industrial Class
1	Gothenburg Feed Products Co	10
2	Chief Fabrication	10
3	Chief Buildings	10
4	Chief Agri Industrial	10
5	Chief Custom Products	10
6	Chief Automotive Systems Inc	12
7	Tyson Fresh Meats, Inc.	4
8	Diamond Plastics Corp	10
9	Pennington Seed, Inc	9
10	Consolidated Concrete, Co	5
11	Masonite Internatinoal Corp	9
12	Eilers Machine and Welding	9
13	L & S Industries, Inc	9
14	G Tech, Inc	9
15	Archer Daniels Midland Co.	9
16	Dy-NA Tool & Mold, Inc	10
17	Sutherland Industries	12
18	Monroe Auto Equipment Co	10
19	Consolidated Blenders Inc.	5
20	Island Dehy Co Inc.	10
21	Hornady Manufacturing Company	11
22	Orthman Manufacturing, Inc	9
23	West Company Inc.	11
24	Veetronix, Inc.	12
25	Electronic Display Systems	9
26	Baldwin Filters, Inc	10
27	Baldwin Filters	11
28	Big Flag Farm Supply Inc.	12
29	Western Sugar Cooperative	1
30	Werner	5
31	Wood Drive Dairy	6
32	Werner Construction	7
33	US 30 Speedway, LLC	13
34	KCC Feeding Inc.	6

#	Name	Industrial Class
35	Brown Sheep Company Inc	10
36	Alma Golf Course	3
37	Procter & Gamble	11
38	Nebraska Public Power District	8
39	Philips - Golf Course	3
40	Halimage Farms LLC	6
41	Nebraska Energy LLC	2
42	Agriculture Services Inc	10
43	Simon Contractors	5
44	Petersons Supermarket	12
45	Nitro Construction	7
46	Abengoa Bioenergy	2
47	Gibbon Packing Inc	4
48	Island Land Handlers	5
49	Nutra-Flo Company	10
50	Miscellaneous Ethanol Plant*	2

*By request of the ownership and to protect trade secrets, this name is being withheld from publication.

Appendix C

The list of industrial classes is shown in Table C.1. The table includes the average class annual pumping, the average class per capacity pumping, and the average portion of the annual pumping that occurs during each month.

#	Industrial Class	Annual Pumping (Mgal)	Per Capacity Pumping (gal/gpm)	Average Distribution of Annual Pumping											
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	Western Sugar Cooperative	1,463.786	221,786	0.107	0.084	0.096	0.055	0.038	0.037	0.050	0.063	0.081	0.142	0.120	0.126
2	Ethanol	311.029	112,150	0.083	0.073	0.080	0.082	0.083	0.084	0.091	0.087	0.085	0.090	0.081	0.081
3	Golf Course	17.390	53,922	-	-	0.038	0.066	0.085	0.094	0.131	0.192	0.178	0.160	0.056	-
4	Meat Packing and Animal ByProducts	614.104	372,185	0.081	0.079	0.084	0.074	0.081	0.088	0.085	0.093	0.087	0.084	0.083	0.080
5	Sand and Gravel	29.450	26,652	0.051	0.051	0.058	0.074	0.092	0.099	0.095	0.102	0.147	0.098	0.076	0.058
6	CAFO	39.541	36,111	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.083
7	Construction	0.110	109	-	-	0.044	0.108	0.108	0.216	0.201	0.137	0.137	0.049	-	-
8	Power Plant	6.760	193,143	0.084	0.084	0.080	0.089	0.098	0.112	0.108	0.090	0.083	0.082	0.090	-
9	Small Manufacturing	0.426	2,131	0.087	0.087	0.077	0.068	0.074	0.082	0.079	0.086	0.091	0.083	0.079	0.107
10	Medium Manufacturing	3.057	1,703	0.053	0.054	0.076	0.058	0.069	0.123	0.121	0.103	0.124	0.077	0.064	0.078
11	Large Manufacturing	78.822	43,912	0.093	0.090	0.095	0.077	0.076	0.077	0.079	0.082	0.080	0.083	0.080	0.088
12	Small Business	0.233	4,673	0.023	0.021	0.021	0.027	0.050	0.093	0.117	0.172	0.149	0.144	0.119	0.065
13	Raceway	0.120	400	-	-	0.038	0.066	0.085	0.094	0.131	0.192	0.178	0.160	0.056	-
14	Sutherland Power Plant	4,353.780	72,989	0.084	0.084	0.080	0.089	0.098	0.112	0.108	0.090	0.083	0.082	0.090	-

Appendix D

The seasonal industrial pumping is dependent upon the rest stop water use. The rest stops listed in Table D.1. were included in the development of the rest stop pumping distribution.

Table D.1. Rest stops included in the creation of the seasonal pumping distribution.

Station	County	City
Melia Hill	Sarpy	Gretna
Platte River	Cass	Greenwood
Lincoln Solar	Lancaster	Lincoln
York WB	York	York
York EB	York	York
Grand Island WB	Hall	Grand Island
Grand Island EB	Hall	Grand Island
Sutherland WB	Lincoln	Sutherland
Sutherland EB	Lincoln	Sutherland
Brady WB	Lincoln	Brady
Brady EB	Lincoln	Brady
Chappell WB	Duel	Chappell
Chappell EB	Duel	Chappell
Sidney WB	Cheyenne	Sidney
Sidney EB	Cheyenne	Sidney
Kimball EB	Kimball	Kimball
Kimball WB	Kimball	Kimball
Ogallala EB	Keith	Ogallala
Ogallala WB	Keith	Ogallala
Cozad EB	Dawson	Cozad
Cozad WB	Dawson	Cozad
Kearney EB	Buffalo	Kearney
Kearney WB	Buffalo	Kearney
Goehner WB	Seward	Goehner
Blue River EB	Seward	Milford

Table D.2. Monthly distribution of seasonal industrial pumping.

Mon	Pumping (gal)
Jan	30,799
Feb	29,426
Mar	43,174
Apr	48,037
May	61,025
Jun	69,021
Jul	84,227
Aug	65,488
Sep	57,772
Oct	54,188
Nov	44,495
Dec	37,589

Memorandum

To: Ann Dimmitt – TPNRD; Kari Burgert – NDNR
From: The Flatwater Group, Inc.
CC: Michael Krondak - NPPD
Date: 10/22/2018
Subject: COHYST Area Robust Review: Gerald Gentleman Station M&I Pumping

Project Background and Workflow

The Flatwater Group, Inc. (TFG) was contracted by the Platte Basin Water Coalition through the Nebraska Department of Natural Resources (NDNR) to provide technical assistance for the Robust Review project. The purpose of the Robust Review project is to assess streamflow impacts resulting from management actions taken as part of the Basin-Wide Plan and/or Natural Resource District (NRD) Integrated Management Plans (IMPs). The focus of this memorandum is to document changes to the Municipal and Industrial (M&I) Pumping at the Gerald Gentleman Station (GGS) within the Twin Plate NRD (TPNRD).

TFG's primary task was to modify the GGS M&I pumping by replacing the estimated GGS pumping developed as part of the Statewide M&I efforts[1] with the values from the Nebraska Public Power District (NPPD) annual reports to NDNR. The new M&I data sets are to be used in the Robust Review Scenarios.

Data Collection

TPNRD and TFG reached out to NPPD, who provided TFG with the monthly pumping volumes from 2005 forward. NPPD provided three files:

1. GGS Industrial Well Report for 2013.pdf
2. GGS Industrial Well Report for 2012.pdf
3. Historical GGS Well Field Monthly pumping from Isaac Mortensen modeling.xlsx

The GGS pumping is divided between two well fields. One well field (Well Field 1) is used to meet the plant operation needs. Well field 1 is comprised of 5 wells, but unmetered. The pumping for the Well Field 1 was estimated by NPPD based upon their typical annual usage. This amounted to 873 AF/year. The pumping was split evenly throughout the year based upon NPPD's description of typical usage.

The second well field (Well Field 2) is part of the cooling water system. Well Field 2 has 38 wells, of which 27 are currently being utilized. Monthly pumping volumes for Well Field 2 were provided from commencement of operations in 2005 through 2013 (Table 1). To project the M&I pumping into the future, an average of the last 6 years of reported data was used[2].

To estimate the net effect operation of the Well Field 1 & 2 have on the aquifer, it was assumed that 50% of the total pumping was consumed with the other 50% returning eventually to the aquifer. This

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[1] Details on the Statewide M&I efforts are documented in: ftp://dnrftp.dnr.ne.gov/Pub/INSIGHTDocumentation/2015/DataAndDocumentation/AdditionalBackUpData/MunicipalAndIndustrialPumping/MunicipalAndIndustrialPumping_TFG2014.pdf

[2] The initial GGS pumping estimates were based upon the M&I Survey performed by NDNR. NPPD provided pumping volumes for the years 2005-2007 for that survey. The 6-year average was used to reflect more current operating procedures.

assumption is consistent with the approach taken in developing the Statewide M&I dataset. This assumption was incorporated by applying a multiplier of 0.5 to the estimates of total pumping discussed above. This yielded 436.5 AF/year from Well Field 1, while the net pumping estimates from Well Field 2 are shown in Table 2.

Table 1. GGS Well Field 2 reported pumping volumes.

Year	Annual Pumping	January	February	March	April	May	June	July	August	September	October	November	December
2005	4,210.9	-	-	-	-	-	-	1,551.3	2,165.2	490.7	3.7	-	-
2006	3,442.4	-	-	-	-	1.2	43.4	957.3	2,440.5	-	-	-	-
2007	8,194.0	-	-	-	-	4.0	870.9	1,705.3	5,406.2	207.6	-	-	-
2008	426.1	-	-	-	-	5.2	167.7	94.5	158.7	-	-	-	-
2009	3,241.1	-	-	-	1.0	11.4	1,243.5	1,391.0	587.7	-	6.5	-	-
2010	1,127.0	-	-	-	-	7.1	589.2	530.7	-	-	-	-	-
2011	13.3	-	-	-	-	5.0	1.0	1.0	0.4	5.5	0.4	-	-
2012	47.0	-	-	-	-	5.0	-	13.0	-	-	21.0	8.0	-
2013	116.0	-	-	-	-	-	9.0	-	1.0	100.0	5.0	1.0	-
Projected	828.4	-	-	-	0.2	5.6	335.1	338.4	124.6	17.6	5.5	1.5	-

Table 2. GGS Well Field 2 net M&I pumping volumes.

Year	Annual Pumping	January	February	March	April	May	June	July	August	September	October	November	December
2005	2,105.5	-	-	-	-	-	-	775.7	1,082.6	245.4	1.9	-	-
2006	1,721.2	-	-	-	-	0.6	21.7	478.7	1,220.3	-	-	-	-
2007	4,097.0	-	-	-	-	2.0	435.5	852.7	2,703.1	103.8	-	-	-
2008	213.1	-	-	-	-	2.6	83.9	47.3	79.4	-	-	-	-
2009	1,620.6	-	-	-	0.5	5.7	621.8	695.5	293.9	-	3.3	-	-
2010	563.5	-	-	-	-	3.6	294.6	265.4	-	-	-	-	-
2011	6.7	-	-	-	-	2.5	0.5	0.5	0.2	2.8	0.2	-	-
2012	23.5	-	-	-	-	2.5	-	6.5	-	-	10.5	4.0	-
2013	58.0	-	-	-	-	-	4.5	-	0.5	50.0	2.5	0.5	-
Projected	414.2	-	-	-	0.1	2.8	167.5	169.2	62.3	8.8	2.7	0.8	-

Creation of the new Watershed Model M&I Pumping input files

The new input data sets were developed by beginning with the original COHYST M&I dataset: *MI001*. Returning to the statewide M&I dataset list of industrial well locations, the COHYST model cells containing GGS wells were identified. The M&I pumping within these cells was removed to create the M&I data set: *MIrr_001*[3].

The GGS pumping was used to create a separate M&I dataset: *GGSrr_002*. The GGS well field volumes were split between the individual wells based upon the relative well capacity compared to the total capacity of all actively utilized wells in the respective well field. The pumping was spatially placed in the COHYST model grid using the location of the wells.

Results

By switching from the initial GGS estimates to the reported values, the net pumping for GGS was reduced by ~6,500 AF/year after well field 2 was completed. Total GGS pumping from both well fields in the projected period reduced by just under 7,000 AF/year.

Table 3 provides an overview of the annual M&I pumping used in the first (Baseline 001[4]; Column A) and second (Baseline 002; Columns B-D) iterations of the robust review baseline. The information used for the second iteration of the baseline contains a summary of the GSS pumping (D) and the balance of the COHYST M&I pumping (C). These volumes are combined to arrive at the total M&I pumping (B). Finally, Table 3 continues with a summation of the resultant change in M&I as a result of the changes to the GGS pumping.

Table 3. M&I Pumping in the Robust Review

	Baseline 001	Baseline 002			
Year	(A) M&I Pumping (MI001)	(B) = C + D Total M&I Pumping	(C) M&I Pumping (MIrr_001)	(D) Gerald Gentlemen Station (GGSrr_002)	(E) = B - A Change in M&I Pumping
1950	14,790	14,790	14,790	-	-
1951	14,898	14,898	14,898	-	-
1952	15,183	15,183	15,183	-	-
1953	16,165	16,165	16,165	-	-
1954	17,594	17,594	17,594	-	-
1955	17,824	17,824	17,824	-	-
1956	19,085	19,085	19,085	-	-
1957	19,548	19,548	19,548	-	-
1958	19,736	19,736	19,736	-	-
1959	19,840	19,840	19,840	-	-
1960	20,024	20,024	20,024	-	-
1961	20,756	20,756	20,756	-	-
1962	21,288	21,288	21,288	-	-

[3] TFG checked for additional M&I wells not belonging to GGS in these cells and found none.

[4] The same M&I pumping used in Baseline 001 was also used in the documented COHYST 2010 Run028.

Table 3. M&I Pumping in the Robust Review

Year	Baseline 001 (A) M&I Pumping (MI001)	Baseline 002 (B) = C + D Total M&I Pumping	(C) M&I Pumping (MIrr_001)	(D) Gerald Gentlemen Station (GGSrr_002)	(E) = B - A Change in M&I Pumping
1963	22,498	22,498	22,498	-	-
1964	23,612	23,612	23,612	-	-
1965	24,352	24,352	24,352	-	-
1966	25,042	25,042	25,042	-	-
1967	25,623	25,623	25,623	-	-
1968	26,225	26,225	26,225	-	-
1969	26,693	26,693	26,693	-	-
1970	27,551	27,551	27,551	-	-
1971	27,847	27,847	27,847	-	-
1972	28,873	28,873	28,873	-	-
1973	29,171	29,171	29,171	-	-
1974	29,887	29,947	29,510	437	60
1975	30,812	30,576	30,139	436	(236)
1976	31,955	31,719	31,283	436	(236)
1977	33,029	32,792	32,356	436	(236)
1978	33,345	33,108	32,672	436	(236)
1979	33,635	33,398	32,962	436	(236)
1980	34,061	33,736	33,299	436	(325)
1981	34,437	34,112	33,675	436	(325)
1982	34,720	34,394	33,958	436	(325)
1983	35,120	34,795	34,358	436	(325)
1984	35,265	34,940	34,503	436	(325)
1985	35,339	35,014	34,577	436	(325)
1986	35,400	35,075	34,638	436	(325)
1987	35,903	35,577	35,141	436	(325)
1988	36,433	35,752	35,316	436	(681)
1989	37,291	36,610	36,173	436	(681)
1990	38,155	37,474	37,038	436	(681)
1991	38,528	37,847	37,411	436	(681)
1992	38,867	38,186	37,749	436	(681)
1993	39,253	38,572	38,135	436	(681)
1994	39,880	39,199	38,762	436	(681)
1995	40,850	40,169	39,733	436	(681)
1996	41,239	40,558	40,121	436	(681)
1997	42,001	41,320	40,884	436	(681)
1998	43,068	42,387	41,951	436	(681)

Table 3. M&I Pumping in the Robust Review

Year	Baseline 001 (A) M&I Pumping (MI001)	Baseline 002 (B) = C + D Total M&I Pumping	(C) M&I Pumping (MIrr_001)	(D) Gerald Gentlemen Station (GGSrr_002)	(E) = B - A Change in M&I Pumping
1999	43,547	42,866	42,430	436	(681)
2000	44,177	43,451	43,015	436	(725)
2001	44,606	43,881	43,444	436	(725)
2002	44,786	44,061	43,625	436	(725)
2003	45,564	44,839	44,402	436	(725)
2004	52,490	45,084	44,648	436	(7,406)
2005	53,217	47,916	45,374	2,542	(5,301)
2006	54,051	48,366	46,208	2,158	(5,685)
2007	55,404	52,095	47,561	4,534	(3,309)
2008	55,738	48,544	47,895	649	(7,193)
2009	56,104	50,319	48,262	2,057	(5,786)
2010	56,312	49,469	48,469	1,000	(6,843)
2011	56,494	49,095	48,651	443	(7,399)
2012	56,658	49,276	48,816	460	(7,383)
2013	56,658	49,310	48,816	494	(7,348)
Projected	56,658	49,666	48,816	851	(6,992)

Summary

New M&I pumping data for NPPD's GGS power station was implemented into the Robust Review in the COHYST area. The GGS pumping estimates from the Statewide M&I efforts were replaced with the records from NPPD reports to NDNR. This resulted in a reduction of the average GGS M&I net pumping estimates in the Robust Review of just under 7,000 AF/year for the period after Well Field 2 began operations in 2005.

A.1.5 Memorandums on NRD Land Use Retirements, Transfers and Variances for COHYST2010

Memorandum

To:	Tammy Fahrenbruch - Tri-Basin NRD; Kari Burgert – NDNR
From:	The Flatwater Group, Inc.
Date:	7/13/2018
Subject:	COHYST Area Robust Review: TBNRD Land Use Retirements, Transfers, and Variances

Project Background and Workflow

The Flatwater Group, Inc. (TFG) was contracted by the Nebraska Department of Natural Resources (NDNR) on the COHYST Area Robust Review project. The Robust Review project's purpose is to evaluate the impacts of land use changes to streamflow. To account for transfers, retirements, and variances within TBNRD, TFG's primary work tasks included evaluating and summarizing the transfers, retirements, and variances; then spatially placing these transactions within the constructs of the COHYST 2010 watershed model's land use files to extend the baseline land use through 2013 and create a new land use data set for the unretired scenario.

For the first step in the process, TFG worked with NDNR and TBNRD to gather the land use data (retirements, transfers, variances) into summary tables by land use type. After the summary data was organized by land use type, TFG's next step was to perform a geospatial analysis to identify the location of each land use transaction (I.e. retirement, transfer, variance). The geospatial analysis included a proximity function to determine the closest available model cells capable of accommodating land use changes. ArcGIS and custom script were used for the analysis and the results were organized into Tables 11-15

This memo presents summary tables of retirement acres (temporary and permanent) and transferred acres within TBNRD, outlines the spatial analysis methodology, and then summarizes the resultant land use files. Spatial data was provided in shapefile format and spatially analyzed using ArcGIS and custom FORTRAN programs. Land use changes were provided in spreadsheet form; which were analyzed and assimilated by TFG into the COHYST land use files.

Land Use Summary Tables

The Flatwater Group, Inc. (TFG) has compiled a final summary of the retirements, transfers, and variances for the Tri-Basin Natural Resources District (TBNRD) from the information provided by TBNRD and the Nebraska Department of Natural Resources (DNR). This information was used to modify the land use data set in the COHYST 2010 model to investigate the effects of these land use changes on streamflow as part of the larger Robust Review effort. Table 1 shows an overview summary of retirements and transfers in the TBNRD as provided by TBNRD and DNR. Tables 2-5 show summaries of the individual categories used to create Table 1 and serve as a reference for the description of each of the data sources.

Table 1. Summary of TBNRD acres changes for implementation into the Robust Review.

Year	Temporary Retirements	Reinstated Temporary Retirements	Permanent Retirements	Transfers To	Transfers Away	Change
Baseline Change	(-)	(+)	(-)	(+)	(-)	
1999	1.9	-	-	-	-	(1.9)
2000	293.6	-	-	-	-	(293.6)
2001	408.6	-	-	-	-	(408.6)
2002	-	-	-	-	-	-
2003	-	-	-	-	-	-
2004	77.5	7.0	-	-	-	(70.5)
2005	259.4	-	-	-	-	(259.4)
2006	163.9	-	-	-	-	(163.9)
2007	219.8	-	-	-	-	(219.8)
2008	697.8	77.5	73.1	-	-	(693.4)
2009	167.9	244.7	-	-	-	76.8
2010	127.3	420.5	-	-	-	293.2
2011	111.3	619.4	-	178.7	246.7	440.1
2012	-	413.5	-	118.3	118.3	413.5
2013	-	452.2	-	229.4	245.6	436.0
2014	-	127.3	-	-	-	127.3
2015	-	127.9	-	-	-	127.9
2016	-	-	-	-	-	-
2017	-	39.0	-	-	-	39.0

Table 2. Summary of temporary retirement retired acres in the TBNRD

Year	Conservation Corners	Buffer Strips	Pheasants Forever	TBNRD EQIP	CRP Reinstatements	DNR CREP/EQIP	Temporary Retirements
1999	-	1.9	-	-	-	-	1.9
2000	-	28.3	7.0	-	258.3	-	293.6
2001	-	-	-	-	408.6	-	408.6
2002	-	-	-	-	-	-	-
2003	-	-	-	-	-	-	-
2004	-	-	-	77.5	-	-	77.5
2005	-	16.6	21.0	221.8	-	-	259.4
2006	-	-	17.9	116.0	-	30.0	163.9
2007	-	9.0	27.0	183.8	-	-	219.8
2008	126.8	-	13.0	400.5	-	157.5	697.8
2009	-	-	14.8	153.1	-	-	167.9
2010	-	-	-	127.3	-	-	127.3
2011	-	-	-	111.3	-	-	111.3
2012	-	-	-	-	-	-	-
2013	-	-	-	-	-	-	-
Total	126.8	55.8	100.7	1,391.3	666.9	187.5	2,529.0

Table 3. Summary of permanent retirement acres in the TBNRD

Year	Conservation Easements	Permanent Retirements
1999	-	-
2000	-	-
2001	-	-
2002	-	-
2003	-	-
2004	-	-
2005	-	-
2006	-	-
2007	-	-
2008	73.1	73.1
2009	-	-
2010	-	-
2011	-	-
2012	-	-
2013	-	-
Total	73.1	73.1

Table 4. Summary of temporary retirement reinstated acres in the TBNRD

Year	Conservation Corners	Buffer Strips	Pheasants Forever	TBNRD EQIP	CRP Reinstatements	DNR CREP/EQIP	Temporary Retirements
1999	-	-	-	-	-	-	-
2000	-	-	-	-	-	-	-
2001	-	-	-	-	-	-	-
2002	-	-	-	-	-	-	-
2003	-	-	-	-	-	-	-
2004	-	-	7.0	-	-	-	7.0
2005	-	-	-	-	-	-	-
2006	-	-	-	-	-	-	-
2007	-	-	-	-	-	-	-
2008	-	-	-	77.5	-	-	77.5
2009	-	1.9	21.0	221.8	-	-	244.7
2010	-	28.3	17.9	116.0	258.3	-	420.5
2011	-	-	27.0	183.8	408.6	-	619.4
2012	-	-	13.0	400.5	-	-	413.5
2013	126.8	-	14.8	153.1	-	157.5	452.2
2014	-	-	-	127.3	-	-	127.3
2015	-	16.6	-	111.3	-	-	127.9
2016	-	-	-	-	-	-	-
2017	-	9.0	-	-	-	30.0	39.0
Total	126.8	55.8	100.7	1,391.3	666.9	187.5	2,529.0

Table 5. Summary of transfer acres in the TBNRD

Year	Transfer To	Transfer Away	Conversions	Total Transfer Away
2011	178.7	178.7	67.9	246.7
2012	118.3	118.3	-	118.3
2013	229.4	245.6	-	245.6
Total	526.4	542.7	67.9	610.6

The TBNRD provided updated information to TFG in three files on 7/17/2017:

TBNRD AppendixI_Conservation practices.xlsx
Platte_CIA_Permits_Changes_updates.xlsx
Robust_COHYST_Platte_data.xlsx

Within the file *TBNRD Appenidx I_Conservation practices.xlsx* there were several categories of temporary retirements.

Conservation Corners (C Corners SI)

- Robust Review Assignment: Temporary Retirements
- Contract are for 5 years
- 11 entries
- Table 2 & Table 4

Buffer Strips (Buffer Strips)

- Robust Review Assignment: Temporary Retirements
- Contract are for 10 years
- 6 entries
- Table 2 & Table 4

Pheasants Forever (P Forever)

- Robust Review Assignment: Temporary Retirements
- Contract appears to be for 4 years
- 15 entries
- Table 2 & Table 4

Conservation Easements (Cons Easements)

- Robust Review Assignment: Permanent Retirements
- 2 entries
- Table 3

EQIP

- Robust Review Assignment: Temporary Retirements
- Contract appears to be for 4 years
- 95 entries
- Table 2 & Table 4

CREP

- Robust Review Assignment: Temporary Retirement
- 1 entry
- The CREP entry was for 30 acres for the period 2006-2016. This entry was also in the DNR data set. The DNR data set was used due to the accompanying shape file.

From the file *Platte_CIA_Permits_Changes_updates.xlsx*

There were two types of transfers. The first type of transfer involves moving the source of the irrigation water, but the irrigated field remains in the same location. This type of transfer did not require any action to be taken for the robust review. These transfers were listed in the sheets 'G Water Transf_Exsisting' and 'G Water Transfers'.

The second transfer type involves moving the irrigated field to a new location. These transfers were listed in the sheet 'Acres Transfers'. There were 109 records in this sheet. Of these records 25 were incorporated into the robust review. These 25 records were identified to occur in the timeframe that would affect the 2011-2013 irrigation season. This means that the transfer occurred on or after July 1, 2010 and before July 1, 2013. This was based upon the 'Date Approved' field in the table. If the transfer occurred after July 1, it was likely that the original field was still irrigated in the transfer year; as the late year transfers happened in the fall (October-December). While the spring transfers, prior to July 1, had an opportunity to irrigate in the transfer year. Table 6 begins with the same values as the table from Jessie Strom 11/14/2017. The table next illustrates how the transfer acres are split between the record year and the next year based upon the month the transfer took place. Finally, Table 7 show the new distribution of transfer acres which were place in Table 5.

Acres Transfer

- Robust Review Assignment: Transfer Away and Transfer To
- Action is considered permanent
- Contains a transfer from and a transfer to
- 25 entries
- Table 5

Table 6. Summary of transfer acres in the TBNRD

TBNRD			To		From	
Year	To	From	Current Year	Next Year	Current Year	Next Year
2010	74.4	75.7	48.7	25.7	50.0	25.7
2011	158.0	158.0	153.0	5.0	153.0	5.0
2012	188.4	194.1	113.3	75.1	113.3	80.8
2013	234.3	250.8	154.3	80.0	164.8	86.0

Table 7. Summary of transfer acres in the TBNRD adjusted for timing within the year.

Adjusted		
Year	To	From
2011	178.7	178.7
2012	118.3	118.3
2013	229.4	245.6

The sheet 'Variances' includes the TBNRD variances. These changes tended to be administrative rather than identifying acreage changes. It was decided in the August 2017 meeting that the robust review did not need to consider variances.

The sheet 'Corrections' contained 36 entries. These entries can be divided into two sets. The first set is administrative changes in the number of irrigated acres rather than changes to the acre location. No action was taken for these entries.

The second set is the CRP reinstated acres. The table only includes the reinstatement of the acres, it does not include when the land went into the program. CRP contracts typically enroll land for 10-15 years. For the Robust Review, it was assumed each contract was for 10 years.

CRP Acre Reinstatement

- Robust Review Assignment: Temporary Retirements
- Contract are for 10 years
- 4 entries
- Table 2 & Table 4

The sheet 'Conversion' contains 4 entries for the conversion of irrigation to watering livestock. Two of these entries occurred in the 2011-2013 timeframe. These transactions were treated as transfers.

Conversions

- Robust Review Assignment: Transfer away
- 2 entries
- Table 5

DNR provided the shape file *CREP* on 8/17/2017. It was supplemented by *20170829_COHYSTAreaMissingDates.xlsx* provide on 8/29/2017.

This shape file included the updated list of CREP and EQIP contracts. This file included CREP, EQIP, and TBEQIP parcels. The data in the CREP shape file was clipped to the TBNRD resulting in 114. The information was limited to contracts initiated prior to the end of 2013. Furthermore, the information was limited to the drainage area to the Platte River. Next the records were limited to contracts on groundwater only lands. Finally, the records were compared to the EQIP records from *TBNRD Appendix I_Conservation practices.sxlsx* sheet 'EQIP D land' and sheet 'CREP Acres'. The location timing of the 'EQIP D land' records did not overlap and records in CREP shape file. The entry from 'CREP Acres' matched a record in the CREP shapefile. The entry from the CREP shape file was used. This resulted in 21 parcels being applied to the robust review.

Table 8. DNR CREP and EQIP temporary retirements.

Year	CREP	EQIP	TBEQIP
2005	-	169.7	-
2006	1,029.8	-	-
2007	416.7	-	-
2008	16.6	-	380.1
2009	-	-	-
2010	2.6	-	-
Total	1,465.7	169.7	380.1

Table 9. DNR CREP and EQIP temporary retirements within the Platte River drainage Basin.

Year	CREP	TBEQIP	End Year
2005	-	-	
2006	30.0	-	2017
2007	-	-	
2008	-	157.4	2013
2009	-	-	
2010	-	-	
Total	30.0	167.9	

The CREP shape file was missing contract beginning and ending dates. DNR provided the contract dates in the supplementary file.

DNR CREP/EQIP

- Robust Review Assignment: Temporary Retirement
- 21 entries
- Table 2 & Table 4 & Table 9

SPATIAL ANALYSIS METHODOLOGY

ArcGIS was used to link the retirements, transfers and variances to the COHYST model grid. This was accomplished either by overlaying the parcels' shape file with the model grid. Or linking the parcels' legal description to model cells.

Step 1: Assigning land use change location

Each of the transactions provided by TBNRD included a legal description. These descriptions typically included the quarter section in which the transaction took place. This information needed to be linked to the COHYST 2010 model grid. COHYST uses a 160 acre grid; but, the cell boundaries and the section lines do not overlap. To accommodate this, the section shape file was spatially joined with the cell centroid. Typically, this would result in 4 cells being assigned to a section. Using the quarter section identifier, the cell which best represented the spatial location of the transaction was assigned the placement.[1]

Table 10. Approach used to link legal descriptions to model cell locations.

Cell Index	Row	Column	Quarter
Cell	x	y	NW
Cell + 1	x	y + 1	NE
Cell + 504	x + 1	y	SW
Cell + 505	x + 1	y + 1	SE

[1] For irregular sections, the cell-section relationship and professional judgement was used to place the transaction acres as close as possible to the defined location.

DNR provided a shape file for their retirements. The union function within ArcGIS was applied to the CREP shapefile and the model grid to determine the cell location. The polygon area within each cell was then computed using the calculate geometry function within ArcGIS.

Step 2: Building the Baseline Land Use Update

The next step was to build the 2011-2013 land use files incorporating the identified transfers and retirements. The beginning condition for this update is the 2010 land use file from the COHYST 2010 model. Each of the 2011 transactions were applied to the 2010 land use to create the 2011 land use file; which in turn became the basis for applying the 2012 transactions. This continued through 2013. One of the key points of investigation is the effect of retirements on the system. Given that many of the retirements were temporary in nature and knowing their contract end dates, the land use file building process was continued through 2023 to be able to add back in all the temporarily retire acres.[2]

Acres were to be added or removed from their assigned cells. If there was insufficient space[3] for new acres or an insufficient amount of groundwater only acres[4] to be retired within the cell, the addition or subtraction of acres was applied to nearby cells which exhibit the appropriate characteristics[5]. This spatial process entails radiating outward from the identified cell until the acres had been placed. During this process acres are placed or removed from the lowest priority cell which meets the appropriate criteria. If more than one cell has the same priority and meets criteria, the acres are split evenly between the multiple cells. Unless an even split would exceed the available space within the cell; at which time the placed acres would be limited to the available space and the remaining acres would be split among the other priority cells. The priority pattern for the first two rings around the assignment cell can be seen in Figure 1. This process was implemented using a custom piece of FORTRAN script.

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[2] 2023 was identified as the year the last TPNRD temporary retirement would be actively irrigated again for the first time

[3] Example: transferring 30 groundwater only acres to a cell where there was only 20 non-irrigated acres

[4] Example: retiring 30 groundwater only acres from a cell where there was only 20 groundwater only acres

[5] The cell needed to be active, in the same NRD, and have a sufficient amount of groundwater only acres to retire or non-irrigated acres to convert

5 (r-2, c-2)	4 (r-2, c-1)	3 (r-2, c+0)	4 (r-2, c+1)	5 (r-2, c+2)
4 (r-1, c-2)	2 (r-1, c-1)	1 (r-1, c+0)	2 (r-1, c+1)	4 (r-1, c+2)
3 (r+0, c-2)	1 (r+0, c-1)	0 (r+0, c+0)	1 (r+0, c+1)	3 (r+0, c+2)
4 (r+1, c-2)	2 (r+1, c-1)	1 (r+1, c+0)	2 (r+1, c+1)	4 (r+1, c+2)
5 (r+2, c-2)	4 (r+2, c-1)	3 (r+2, c+0)	4 (r+2, c+1)	5 (r+2, c+2)

Figure 1. Priority of search pattern to place or remove acres when the assigned cell has insufficient non-irrigated or groundwater only acres.

The results of Step 2 are shown in Table 11, which match the results summarized in Table 1 for the years 2011-2017. The exception being 2013. The location of two transactions placed them in cells designated CPNRD. This accounted for 77.1 acres from the transfer away data set being in CPNRD (58.6 in Dawson County, 18.5 in Buffalo County).

It should be noted again that the cell boundaries do not necessarily overlap with the legal boundaries, either county or NRD. For these summaries each cell was assigned to an NRD and county based upon the location of the cell centroid.

Table 11. Change in groundwater only irrigated acres within the TBNRD for the Robust Review baseline.

Year	Groundwater Only Irrigated Acres	Annual Change in Groundwater Only Irrigated Acres in TBNRD vs 2010	Change in Groundwater Only Irrigated Acres not in TBNRD
2010	459,902.8	-	
2011	460,343.0	440.2	
2012	460,756.3	413.3	
2013	461,269.2	512.9	(77.1)
2014	461,396.5	127.3	
2015	461,524.4	127.9	
2016	461,524.4	-	
2017	461,563.4	39.0	

Step 3: Building the Unretired Acres Scenario Modified Land Use

Similarly, a new set of land use files were created for the unretired scenario. In this scenario the permanently and temporarily retired acres were never retired.

- The transfers were applied.
- For the post 2010 period no retirements were applied.
- For permanent retirements, irrigated acres were added back into the modified land use files for all future years.
- For temporary retirements, the acres were added back during their contracted period. If the temporary retirement ended after 2010, the temporarily retire acres added back in 2011 and remain moving forward.

Tables 12-13 show that given a summary of the modified land use files, one can trace back changes to the summary of transactions applied to create the files.

Table 12 shows the changes between the COHYST 2010 land use and the unretired retirements scenario. The difference between the two data sets shows the cumulative change over time. However, looking at the change in the cumulative total one arrives at the retired acres shown in Table 1.

Table 12. Change in Groundwater Only Irrigated Acres in the TBNRD comparing the COHYST 2010 land use to Unretired Retirements Scenario land use; years 1999-2010.

	Groundwater Only Irrigated Acres		Change in Groundwater Only Irrigated Acres	
Year	COHYST 2010	Modified Land Use	Cumulative	Annual
1999	408,126	408,128.2	1.9	1.9
2000	409,469	409,764.4	295.5	293.6
2001	409,418	410,122.3	704.1	408.6
2002	421,829	422,533.2	704.1	0.0
2003	422,302	423,006.6	704.2	0.1
2004	423,360	424,134.9	774.8	70.6
2005	422,424	423,457.7	1,033.9	259.1
2006	439,644	440,841.7	1,197.9	164.0
2007	464,704	466,122.4	1,418.0	220.1
2008	444,988	447,099.2	2,111.4	693.4
2009	471,247	473,281.1	2,034.0	(77.4)
2010	459,903	461,643.7	1,740.9	(293.1)
		Cumulative		1,740.9

Table 13 show the changes between the COHYST 2010 2010 land use file and the unretired retirement scenario land use for the robust review. The table shows you the annual modified land use's groundwater only irrigated lands. The next column shows the modified land use's groundwater only irrigated lands minus the COHYST 2010's 2010 land use and the cumulative effect of unretiring acres. For the values in this column on must consider: the retired acres to be unretired prior to 2011, retired acres which were reinstated prior to 2011, and finally the cumulative retirements and net transfers away after 2010 but prior to the relevant year. The value in the third column is the also the retirements plus the transfers away minus the transfers to and minus those transfers away which were not in the summary area. By taking the transfers from Table 1 and the bit of information from Table 11 about the transfer away acres falling outside the TPNRD summary area we can get back to the post 2010 retirements shown in Table 1.

Table 13. Change in Groundwater Only Irrigated Acres in the TBNRD comparing the COHYST 2010 land use to Unretired Retirements Scenario land use; years 2011-2017.

Year	Groundwater Only Irrigated Acres	Difference in Groundwater only Acres from 2010 minus cumulative prior retirements	Transfers Away	Transfers to	Non TBNRD Transfers Away	Net Transfers Away	Cumulative Net Transfers Away	Retirements
2011	461,687.1	43.4	246.7	178.7	-	67.9	67.9	111.3
2012	461,687.0	(0.1)	118.3	118.3	-	-	67.9	(0.1)
2013	461,747.8	60.8	245.6	229.4	77.1	(60.9)	7.1	(0.1)
2014	461,747.8	(7.1)	-	-	-	-	7.1	-
2015	461,747.8	(7.1)	-	-	-	-	7.1	-
2016	461,747.8	(7.1)	-	-	-	-	7.1	-
2017	461,747.8	(7.1)	-	-	-	-	7.1	-

Finally, Tables 14-15 show the annual area of groundwater only irrigated land for each county in the TBNRD.

Table 14. TBNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Gosper	Kearney	Phelps
1950	-	2,242	2,537
1951	-	3,998	2,777
1952	-	6,293	2,809
1953	-	8,593	3,749
1954	-	10,124	5,131
1955	-	14,150	6,346
1956	-	18,843	8,376
1957	-	23,410	11,750
1958	-	27,870	11,977
1959	1,164	32,496	13,060
1960	2,200	32,722	13,549
1961	3,082	32,987	14,450
1962	3,945	33,235	15,066
1963	4,905	33,438	17,833
1964	5,881	33,921	20,393
1965	8,366	41,783	27,825
1966	11,024	49,365	35,927
1967	13,803	56,675	43,969
1968	16,191	64,484	52,068
1969	19,136	72,225	60,374
1970	21,712	77,738	66,486
1971	24,407	83,602	71,898
1972	27,234	89,777	78,063
1973	29,769	95,315	84,101
1974	32,514	102,037	90,857
1975	37,209	108,257	100,749
1976	41,646	115,304	109,914
1977	46,247	121,588	120,074
1978	50,109	128,065	128,097
1979	53,225	133,332	133,288
1980	53,940	140,155	138,302
1981	55,494	145,561	140,783
1982	55,887	150,993	144,299
1983	56,187	149,122	144,750
1984	56,761	147,856	143,892

Table 15. TBNRD county summary of groundwater only irrigated lands robust review Unretired Scenario land use data set

Year	Gosper	Kearney	Phelps
1950	-	2,242	2,537
1951	-	3,998	2,777
1952	-	6,293	2,809
1953	-	8,593	3,749
1954	-	10,124	5,131
1955	-	14,150	6,346
1956	-	18,843	8,376
1957	-	23,410	11,750
1958	-	27,870	11,977
1959	1,164	32,496	13,060
1960	2,200	32,722	13,549
1961	3,082	32,987	14,450
1962	3,945	33,235	15,066
1963	4,905	33,438	17,833
1964	5,881	33,921	20,393
1965	8,366	41,783	27,825
1966	11,024	49,365	35,927
1967	13,803	56,675	43,969
1968	16,191	64,484	52,068
1969	19,136	72,225	60,374
1970	21,712	77,738	66,486
1971	24,407	83,602	71,898
1972	27,234	89,777	78,063
1973	29,769	95,315	84,101
1974	32,514	102,037	90,857
1975	37,209	108,257	100,749
1976	41,646	115,304	109,914
1977	46,247	121,588	120,074
1978	50,109	128,065	128,097
1979	53,225	133,332	133,288
1980	53,940	140,155	138,302
1981	55,494	145,561	140,783
1982	55,887	150,993	144,299
1983	56,187	149,122	144,750
1984	56,761	147,856	143,892

Table 14. TBNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Gosper	Kearney	Phelps
1985	56,971	157,806	150,247
1986	56,297	157,629	149,714
1987	49,352	156,719	148,311
1988	50,724	159,107	150,150
1989	52,238	161,324	152,772
1990	53,033	163,587	155,668
1991	54,907	166,242	157,356
1992	56,348	169,870	160,700
1993	56,797	171,421	161,580
1994	57,368	173,074	162,570
1995	57,916	174,916	163,327
1996	59,029	177,751	164,645
1997	59,906	180,190	166,474
1998	62,384	179,627	166,025
1999	63,178	179,325	165,623
2000	64,020	179,822	165,627
2001	64,705	179,524	165,188
2002	65,456	187,438	168,936
2003	66,229	187,575	168,498
2004	67,007	187,705	168,648
2005	67,899	187,429	167,096
2006	70,272	196,922	172,450
2007	85,141	200,533	179,031
2008	74,647	198,594	171,748
2009	91,432	200,132	179,683
2010	83,058	197,888	178,957
2011	83,049	198,307	178,987
2012	83,156	198,370	179,231
2013	83,198	198,502	179,570
2014	83,272	198,502	179,623
2015	83,272	198,518	179,734
2016	83,272	198,518	179,734
2017	83,272	198,518	179,773
2018	83,272	198,518	179,773
2019	83,272	198,518	179,773
2020	83,272	198,518	179,773
2021	83,272	198,518	179,773
2022	83,272	198,518	179,773

Table 15. TBNRD county summary of groundwater only irrigated lands robust review Unretired Scenario land use data set

Year	Gosper	Kearney	Phelps
1985	56,971	157,806	150,247
1986	56,297	157,629	149,714
1987	49,352	156,719	148,311
1988	50,724	159,107	150,150
1989	52,238	161,324	152,772
1990	53,033	163,587	155,668
1991	54,907	166,242	157,356
1992	56,348	169,870	160,700
1993	56,797	171,421	161,580
1994	57,368	173,074	162,570
1995	57,916	174,916	163,327
1996	59,029	177,751	164,645
1997	59,906	180,190	166,474
1998	62,384	179,627	166,025
1999	63,178	179,327	165,623
2000	64,020	180,099	165,646
2001	64,705	180,210	165,207
2002	65,456	188,123	168,955
2003	66,229	188,261	168,517
2004	67,007	188,468	168,660
2005	67,906	188,232	167,320
2006	70,330	197,742	172,769
2007	85,216	201,384	179,523
2008	74,828	199,550	172,721
2009	91,654	201,080	180,547
2010	83,304	198,543	179,797
2011	83,278	198,523	179,886
2012	83,278	198,523	179,886
2013	83,272	198,592	179,884
2014	83,272	198,592	179,884
2015	83,272	198,592	179,884
2016	83,272	198,592	179,884
2017	83,272	198,592	179,884
2018	83,272	198,592	179,884
2019	83,272	198,592	179,884
2020	83,272	198,592	179,884
2021	83,272	198,592	179,884
2022	83,272	198,592	179,884

Table 14. TBNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Gosper	Kearney	Phelps
2023	83,272	198,518	179,773
2024	83,272	198,518	179,773
2025	83,272	198,518	179,773
2026	83,272	198,518	179,773
2027	83,272	198,518	179,773
2028	83,272	198,518	179,773
2029	83,272	198,518	179,773
2030	83,272	198,518	179,773
2031	83,272	198,518	179,773
2032	83,272	198,518	179,773
2033	83,272	198,518	179,773
2034	83,272	198,518	179,773
2035	83,272	198,518	179,773
2036	83,272	198,518	179,773
2037	83,272	198,518	179,773
2038	83,272	198,518	179,773
2039	83,272	198,518	179,773
2040	83,272	198,518	179,773
2041	83,272	198,518	179,773
2042	83,272	198,518	179,773
2043	83,272	198,518	179,773
2044	83,272	198,518	179,773
2045	83,272	198,518	179,773
2046	83,272	198,518	179,773
2047	83,272	198,518	179,773
2048	83,272	198,518	179,773
2049	83,272	198,518	179,773
2050	83,272	198,518	179,773
2051	83,272	198,518	179,773
2052	83,272	198,518	179,773
2053	83,272	198,518	179,773
2054	83,272	198,518	179,773
2055	83,272	198,518	179,773
2056	83,272	198,518	179,773
2057	83,272	198,518	179,773
2058	83,272	198,518	179,773
2059	83,272	198,518	179,773
2060	83,272	198,518	179,773

Table 15. TBNRD county summary of groundwater only irrigated lands robust review Unretired Scenario land use data set

Year	Gosper	Kearney	Phelps
2023	83,272	198,592	179,884
2024	83,272	198,592	179,884
2025	83,272	198,592	179,884
2026	83,272	198,592	179,884
2027	83,272	198,592	179,884
2028	83,272	198,592	179,884
2029	83,272	198,592	179,884
2030	83,272	198,592	179,884
2031	83,272	198,592	179,884
2032	83,272	198,592	179,884
2033	83,272	198,592	179,884
2034	83,272	198,592	179,884
2035	83,272	198,592	179,884
2036	83,272	198,592	179,884
2037	83,272	198,592	179,884
2038	83,272	198,592	179,884
2039	83,272	198,592	179,884
2040	83,272	198,592	179,884
2041	83,272	198,592	179,884
2042	83,272	198,592	179,884
2043	83,272	198,592	179,884
2044	83,272	198,592	179,884
2045	83,272	198,592	179,884
2046	83,272	198,592	179,884
2047	83,272	198,592	179,884
2048	83,272	198,592	179,884
2049	83,272	198,592	179,884
2050	83,272	198,592	179,884
2051	83,272	198,592	179,884
2052	83,272	198,592	179,884
2053	83,272	198,592	179,884
2054	83,272	198,592	179,884
2055	83,272	198,592	179,884
2056	83,272	198,592	179,884
2057	83,272	198,592	179,884
2058	83,272	198,592	179,884
2059	83,272	198,592	179,884
2060	83,272	198,592	179,884

Table 14. TBNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Gosper	Kearney	Phelps
2061	83,272	198,518	179,773
2062	83,272	198,518	179,773
2063	83,272	198,518	179,773

Table 15. TBNRD county summary of groundwater only irrigated lands robust review Unretired Scenario land use data set

Year	Gosper	Kearney	Phelps
2061	83,272	198,592	179,884
2062	83,272	198,592	179,884
2063	83,272	198,592	179,884

Memorandum

To:	Ann Dimmit – TPNRD; Kari Burgert – DNR
From:	The Flatwater Group, Inc.
Date:	7/13/2018
Subject:	COHYST Area Robust Review: TPNRD Land Use Retirements, Transfers, and Variances

Project Background and Workflow

The Flatwater Group, Inc. (TFG) was contracted by the Nebraska Department of Natural Resources (DNR) on the COHYST area Robust Review project. The Robust Review project's purpose is to evaluate the impacts of land use changes to streamflow. To account for transfers, retirements, and variances within the Twin Platte Natural Resources District (TPNRD), TFG's primary work tasks include evaluating and summarizing the transfers, retirements, and variances; then spatially placing these transactions within the constructs of the COHYST 2010 watershed model's land use files to extend the baseline land use through 2013 and create a new land use data set for the unretired scenario.

For the first step in the process, TFG worked with DNR and TPNRD to gather the land use data (retirements, transfers, and variances) into summary tables by land use type. TFG's next step was to perform a geospatial analysis to identify the location of each transaction. The geospatial analysis included a proximity function to determine the closest available model cells capable of accommodating land use changes. ArcGIS and custom script were used for the analysis and the results were organized into Tables 4-8.

This memo presents summary tables of retirement acres and transfer acres within the TPNRD, outlines the spatial analysis methodology, and then summarizes the resultant land use files. Spatial analysis was provided in shapefile format and spatially analyzed using ArcGIS and custom FORTRAN programs.

Land Use Summary Tables

TFG has compiled a final summary of the retirements, transfers, and variances for the TPNRD from the information provided by TPNRD and the DNR. This information was used to modify the land use data set in the COHYST 2010 model to investigate the effects of these action as part of the larger Robust Review effort. Table 1 shows an overview summary of retirements and transfers in the TPNRD. Tables 2-3 show summaries of the individual categories used to create Table 1 and serve as a reference fro the description of each data source.

Table 1. Summary of TPNRD acres changes for implementation into the Robust Review.

Year	Temporary Retirements	Reinstated Temporary Retirements	Transfers To	Transfers Away	Change
Baseline Change	(-)	(+)	(+)	(-)	
2006	595.6	-	-	-	(595.64)
2007	27.4	-	-	-	(27.40)
2008	-	-	-	-	-
2009	-	-	-	-	-
2010	-	-	-	-	-
2011	-	-	833.0	815.7	17.27
2012	40.8	28.8	1,569.3	1,635.4	(78.10)
2013	-	-	1,865.7	1,840.6	25.10
2014	-	-	-	-	-
2015	-	-	-	-	-
2016	-	-	-	-	-
2017	-	594.2	-	-	594.24
2018	-	-	-	-	-
2019	-	-	-	-	-
2020	-	-	-	-	-
2021	-	-	-	-	-
2022	-	-	-	-	-
2023	-	40.8	-	-	40.80
Total	663.8	663.8	4,268.0	4,291.7	(23.7)

The TPNRD provided updated changes land change files on 8/8/2017 in the form of shape files:

TPNRD_Acres_Decertified_Implemented_through_2013

TPNRD_New_Acres_implemented_through_2013

These two files contain the spatial location and area of the transfers within the TPNRD.

Decertified Acres

- 229 entries
- 149 occurred between 2011 and 2013
- Timing was based upon the implementation year
- In 2013, 234.3 acres of provided decertified acres were located outside the COHYST 2010 active model domain. They were not considered when modifying the land use.
- Table 2

New Acres

- 187 entries
- 131 occurred between 2011 and 2013
- Timing was based upon the implementation year
- Table 2

Table 2. Summary of transfer acres in the TPNRD

	TPNRD Updated			
Year	New Acres	Decertified Acres	Decertified Acres in Non-Active Cells	Modeled Decertified Acres
2011	833.0	815.7	-	815.7
2012	1,569.3	1,635.4	-	1,635.4
2013	1,865.7	2,074.9	234.3	1,840.6
Total	4,268.0	4,526.0	234.3	4,291.7

DNR provided the *CREP* shape file on 8/17/2017

This shape file included the updated list of CREP and EQIP contracts. The data was clipped to the TPNRD resulting in 59 polygons totaling 1641 acres. The information was limited to groundwater only irrigated (Irrigation = 1), trimming the area to 14 polygons and 905 acres. Finally, the polygons were reduced to those which were initiated prior to the 2013 irrigation season. This left the data set with 11 entries with 664 acres. Each of these 11 entries were CREP contracts. Contracts lengths were either 5, 10, or 11 years (Table 3).

To be considered for the current year, the retirement needed to be initiated or ended prior to July of the current year; otherwise, the transaction will have its first effect in the next year. The rationale is that if the action was taken prior to July, the transaction could influence the irrigation season in the current year. However, if the transaction occurred later, the land would finish up the current growing season in the same state.

Table 3. Summary of temporary retirements and reinstated retirement acres in the TPNRD

Year	Temporary Retirements	Year	Reinstated Retirements
2006	595.6	2006	-
2007	27.4	2007	-
2008	-	2008	-
2009	-	2009	-
2010	-	2010	-
2011	-	2011	-
2012	40.8	2012	28.8
2013	-	2013	-
2014	-	2014	-
2015	-	2015	-
2016	-	2016	-
2017	-	2017	594.2
2018	-	2018	-
2019	-	2019	-
2020	-	2020	-
2021	-	2021	-
2022	-	2022	-
2023	-	2023	40.8
Total	663.8	Total	663.8

All transactions in the TPNRD were provide in shape files. These polygons were overlaid on the COHYST 2010 model grid with the union function in ArcGIS. This returned the number of acres in each cell for each transaction.

SPATIAL ANALYSIS METHODOLOGY

ArcGIS was used to link the retirements, transfers, and variances to the COHYST model grid. This was accomplished by overlaying the parcels' shapefiles with the model grid.

Step 1: Assigning land use change location

DNR and TPNRD provided shape files for their retirements and transfers. The union function within ArcGIS was applied to the shapefiles to determine the cell location. The polygon area within each cell was then computed using the calculate geometry function within ArcGIS.

Step 2: Building the Baseline Land Use

The next step is to build the 2011-2013 land use files incorporating the identified transfers and retirements. The beginning condition for this update is the 2010 land use file from the COHYST 2010 model. Each of the 2011 transactions were applied to the 2010 land use to create the 2011 land use file; which in turn became the basis for applying the 2012 transactions. This continued through 2013. One of the key points of the investigation is the effect of retirements on the system. Given that many of the retirements were temporary in nature and knowing their contract end dates, the land use file building process was continued through 2023 to be able to add back in all the temporarily retired acres. [1]

Acres were to be added or removed from their assigned cells. If there was insufficient space[2] for new acres or an insufficient amount of groundwater only acres[3] to be retired within the cell, the addition or subtraction of acres was applied to nearby cells which exhibit the appropriate characteristics[4]. This spatial process entails radiating outward from the identified cell until the acres had been placed. During this process acres are placed or removed from the lowest priority cell which meets the appropriate criteria. If more than one cell has the same priority and meets criteria, the acres are split evenly between the multiple cells. Unless an even split would exceed the available space within the cell; at which time the placed acres would be limited to the available space and the remaining acres would be split among the other priority cells. The priority pattern for the first two rings around the assignment cell can be seen in Figure 1. This process was implemented using a custom piece of FORTRAN script.

5 (r-2, c-2)	4 (r-2, c-1)	3 (r-2, c+0)	4 (r-2, c+1)	5 (r-2, c+2)
4 (r-1, c-2)	2 (r-1, c-1)	1 (r-1, c+0)	2 (r-1, c+1)	4 (r-1, c+2)
3 (r+0, c-2)	1 (r+0, c-1)	0 (r+0, c+0)	1 (r+0, c+1)	3 (r+0, c+2)
4 (r+1, c-2)	2 (r+1, c-1)	1 (r+1, c+0)	2 (r+1, c+1)	4 (r+1, c+2)
5 (r+2, c-2)	4 (r+2, c-1)	3 (r+2, c+0)	4 (r+2, c+1)	5 (r+2, c+2)

Figure 1. Priority of search pattern to place or remove acres when the assigned cell has insufficient non-irrigated or groundwater only acres. The center cell represents the cell identified as the location of the land use transaction. 'r' and 'c' indicate the row column index of the cell.

[1] 2023 was identified as the year the last TPNRD temporary retirement would be actively irrigated again for the first time

[2] Example: transferring 30 groundwater only acres to a cell where there was only 20 non-irrigated acres

[3] Example: retiring 30 groundwater only acres from a cell where there was only 20 groundwater only acres

[4] The cell needed to be active, in the same NRD, and have a sufficient amount of groundwater only acres to retire or non-irrigated acres to convert

The results of Step 2 are shown in Table 4 which match the results summarized in Table 1 for the years 2011-2023. The exceptions being in 2011 and 2012. In 2011, the location of a couple of transaction were placed in cells designated CPNRD or URNRD; 11.4 new acres were placed in the URNRD in Perkins County, while 1.6 acres were removed from CPNRD in Dawson County. Likewise, in 2012, 3.8 acres were removed from CPNRD in Dawson County. These placements were from the New Acres and Decertified Acres data sets.

It should be noted that the cell boundaries do not necessarily overlap with the legal boundaries either for the county or NRD. For these summaries each cell was assigned to an NRD and county based upon the location of the cell centroid.

Table 4. Change in groundwater only irrigated acres within the TPNRD for the Robust Review baseline.

Year	Groundwater Only Irrigated Acres	Annual Change in Groundwater Only Irrigated Acres in TPNRD vs 2010	Change in Groundwater Only Irrigated Acres not in TPNRD
2010	263,165.7	-	-
2011	263,173.8	8.1	9.8
2012	263,099.6	(74.2)	(3.8)
2013	263,124.4	24.8	-
2014	263,124.4	-	-
2015	263,124.4	-	-
2016	263,124.4	-	-
2017	263,718.3	593.9	-
2018	263,718.3	-	-
2019	263,718.3	-	-
2020	263,718.3	-	-
2021	263,718.3	-	-
2022	263,718.3	-	-
2023	263,759.1	40.8	-

Step 3: Building the Unretired Acres Scenario Modified Land Use

A new set of land use files were created for the unretired scenario. In this scenario the permanently and temporarily retired acres were never retired.

- The transfers were applied.
- For the post 2010 period no retirements were applied.
- For permanent retirements, irrigated acres were added back into the modified land use files for all future years.
- For temporary retirements, the acres were added back during their contracted period. If the temporary retirement ended after 2010, the temporarily retire acres added back in 2011 and remain moving forward.

Tables 5-6 show that given a summary of the modified land use files, one can trace back change to the summary of transactions applied to create these files.

Table 5 shows the changes between the COHYST 2010 land use and the unretired retirements scenario. The difference between the two data sets shows the cumulative change over time. However, looking at the change in the cumulative total one arrives at the retired acres shown in Table 1.

Table 5. Change in Groundwater Only Irrigated Acres in the TPNRD comparing the COHYST 2010 land use to Unretired Retirements Scenario land use; years 1999-2010.

	Groundwater Only Irrigated Acres		Change in Groundwater Only Irrigated Acres	
Year	Run029	Modified Land Use	Cumulative	Annual
1999	208,718	208,718.0	-	-
2000	210,934	210,933.7	-	-
2001	213,311	213,311.4	-	-
2002	221,892	221,892.1	-	-
2003	233,442	233,442.3	-	-
2004	245,508	245,507.7	-	-
2005	250,480	250,479.6	-	-
2006	258,475	259,070.3	595.4	595.4
2007	267,919	268,541.2	622.6	27.2
2008	265,482	266,104.8	622.7	0.1
2009	267,862	268,485.1	622.7	-
2010	263,166	263,788.4	622.7	0.0
		Cumulative		622.7

Table 6 show the changes between the COHYST 2010's 2010 land use file and the unretired retirement scenario land use for the robust review. The table shows you the annual modified land use's groundwater only irrigated lands. The next column shows the modified land use's groundwater only irrigated lands minus the COHYST 2010's 2010 land use and the cumulative effect of unretiring acres. For the values in this column one must consider: the retired acres to be unretired prior to 2011, retired acres which were reinstated prior to 2011, and finally the cumulative retirements and net transfers away after 2010 but prior to the relevant year. The value in the third column is the also the retirements plus the transfers away minus the transfers to and minus those transfers away which were not in the summary area. By taking the transfers from Table 2 and the transfer acres falling outside the TPNRD from Table 4 about the transfer acres falling outside the TPNRD summary area we can get back to the post 2010 retirements shown in Table 1.

Table 6. Change in Groundwater Only Irrigated Acres in the TPNRD comparing the COHYST 2010 land use to Unretired Retirements Scenario land use; years 2011-2017.

Year	Groundwater Only Irrigated Acres	Difference in Groundwater only Acres from 2010 minus cumulative prior retirements	Transfers Away	Transfers to	Non TPNRD Transfers Away	Net Transfers Away	Cumulative Net Transfers Away	Retirements
2011	263,796.5	8.1	815.7	833.0	(9.8)	(7.5)	(7.5)	0.6
2012	263,775.2	(21.3)	1,635.4	1,569.3	3.8	62.3	54.8	41.0
2013	263,800.0	24.8	1,840.6	1,865.7	-	(25.1)	29.7	(0.3)
2014	263,800.0	-	-	-	-	-	29.7	-
2015	263,800.0	-	-	-	-	-	29.7	-
2016	263,800.0	-	-	-	-	-	29.7	-
2017	263,800.0	-	-	-	-	-	29.7	-
2018	263,800.0	-	-	-	-	-	29.7	-
2019	263,800.0	-	-	-	-	-	29.7	-
2020	263,800.0	-	-	-	-	-	29.7	-
2021	263,800.0	-	-	-	-	-	29.7	-
2022	263,800.0	-	-	-	-	-	29.7	-
2023	263,800.0	-	-	-	-	-	29.7	-

Finally, Tables 7-8 show the annual area of groundwater only irrigated land for each county in the TPNRD within the Robust Review's baseline and Unretirement Scenarios.

Table 7. TPNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Arthur	Keith	Lincoln	Logan	McPherson
1950	-	3,940	2,329	-	-
1951	-	5,100	2,338	-	-
1952	-	6,508	2,496	-	-
1953	-	7,848	3,049	-	-
1954	-	8,869	4,411	-	140
1955	259	9,516	6,515	-	140
1956	235	9,873	8,285	-	140
1957	280	10,202	10,006	-	140
1958	237	10,809	11,681	-	140
1959	259	11,064	13,596	-	140
1960	280	12,154	13,940	-	140
1961	358	12,975	13,933	-	280
1962	365	14,036	14,258	-	280
1963	336	15,026	14,721	-	420
1964	330	15,865	14,864	-	420
1965	420	18,019	17,328	-	420
1966	399	19,825	19,369	-	420
1967	549	22,606	21,894	-	420
1968	906	24,595	23,982	-	700
1969	1,159	26,818	26,102	-	840
1970	1,400	28,644	31,203	-	980
1971	1,839	30,082	35,802	-	980
1972	1,818	31,813	40,612	-	980
1973	1,933	33,438	45,704	-	1,260

Table 8. TPNRD county summary of groundwater only irrigated lands robust review Unretired Scenario land use data set

Year	Arthur	Keith	Lincoln	Logan	McPherson
1950	-	3,940	2,329	-	-
1951	-	5,100	2,338	-	-
1952	-	6,508	2,496	-	-
1953	-	7,848	3,049	-	-
1954	-	8,869	4,411	-	140
1955	259	9,516	6,515	-	140
1956	235	9,873	8,285	-	140
1957	280	10,202	10,006	-	140
1958	237	10,809	11,681	-	140
1959	259	11,064	13,596	-	140
1960	280	12,154	13,940	-	140
1961	358	12,975	13,933	-	280
1962	365	14,036	14,258	-	280
1963	336	15,026	14,721	-	420
1964	330	15,865	14,864	-	420
1965	420	18,019	17,328	-	420
1966	399	19,825	19,369	-	420
1967	549	22,606	21,894	-	420
1968	906	24,595	23,982	-	700
1969	1,159	26,818	26,102	-	840
1970	1,400	28,644	31,203	-	980
1971	1,839	30,082	35,802	-	980
1972	1,818	31,813	40,612	-	980
1973	1,933	33,438	45,704	-	1,260

Table 7. TPNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Arthur	Keith	Lincoln	Logan	McPherson
1974	2,203	35,177	50,349	-	1,540
1975	2,881	40,123	57,650	-	1,540
1976	3,068	46,074	62,725	-	1,540
1977	3,912	52,163	69,618	-	1,820
1978	5,277	57,650	76,349	-	2,940
1979	5,602	59,990	78,875	-	3,560
1980	6,470	62,452	82,621	-	4,158
1981	7,300	65,245	85,496	-	4,387
1982	7,653	67,611	88,954	-	4,746
1983	7,551	67,158	88,061	-	4,972
1984	7,670	67,173	85,653	-	5,350
1985	10,496	59,997	98,168	-	4,987
1986	10,513	60,079	97,769	-	5,094
1987	10,691	59,892	96,995	-	5,263
1988	10,714	61,442	97,483	-	5,323
1989	10,824	63,871	98,705	-	5,380
1990	10,845	65,847	99,915	-	5,438
1991	10,868	67,211	100,718	-	5,494
1992	10,906	68,534	102,556	-	5,573
1993	10,929	69,355	103,469	-	5,561
1994	11,067	71,249	104,183	-	5,550
1995	11,209	72,978	105,622	-	5,545
1996	11,461	75,348	108,418	-	5,541
1997	11,506	78,805	109,820	-	5,541
1998	11,206	79,530	111,194	70	5,226
1999	10,793	80,715	112,136	87	4,987
2000	10,471	82,230	113,302	104	4,826

Table 8. TPNRD county summary of groundwater only irrigated lands robust review Unretired Scenario land use data set

Year	Arthur	Keith	Lincoln	Logan	McPherson
1974	2,203	35,177	50,349	-	1,540
1975	2,881	40,123	57,650	-	1,540
1976	3,068	46,074	62,725	-	1,540
1977	3,912	52,163	69,618	-	1,820
1978	5,277	57,650	76,349	-	2,940
1979	5,602	59,990	78,875	-	3,560
1980	6,470	62,452	82,621	-	4,158
1981	7,300	65,245	85,496	-	4,387
1982	7,653	67,611	88,954	-	4,746
1983	7,551	67,158	88,061	-	4,972
1984	7,670	67,173	85,653	-	5,350
1985	10,496	59,997	98,168	-	4,987
1986	10,513	60,079	97,769	-	5,094
1987	10,691	59,892	96,995	-	5,263
1988	10,714	61,442	97,483	-	5,323
1989	10,824	63,871	98,705	-	5,380
1990	10,845	65,847	99,915	-	5,438
1991	10,868	67,211	100,718	-	5,494
1992	10,906	68,534	102,556	-	5,573
1993	10,929	69,355	103,469	-	5,561
1994	11,067	71,249	104,183	-	5,550
1995	11,209	72,978	105,622	-	5,545
1996	11,461	75,348	108,418	-	5,541
1997	11,506	78,805	109,820	-	5,541
1998	11,206	79,530	111,194	70	5,226
1999	10,793	80,715	112,136	87	4,987
2000	10,471	82,230	113,302	104	4,826

Table 7. TPNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Arthur	Keith	Lincoln	Logan	McPherson
2001	9,487	84,154	115,231	122	4,318
2002	9,272	86,334	121,088	122	5,077
2003	9,507	89,925	128,681	122	5,207
2004	9,732	94,959	135,355	122	5,339
2005	10,096	95,166	139,304	123	5,791
2006	10,232	95,184	147,506	126	5,427
2007	11,112	98,022	152,349	126	6,310
2008	10,687	97,668	150,662	126	6,339
2009	10,113	98,320	152,749	126	6,554
2010	9,180	97,947	150,323	132	5,583
2011	9,180	97,885	150,394	132	5,583
2012	9,180	97,901	150,304	132	5,583
2013	8,613	97,725	151,061	132	5,593
2014	8,613	97,725	151,061	132	5,593
2015	8,613	97,725	151,061	132	5,593
2016	8,613	97,725	151,061	132	5,593
2017	8,613	98,291	151,088	132	5,593
2018	8,613	98,291	151,088	132	5,593
2019	8,613	98,291	151,088	132	5,593
2020	8,613	98,291	151,088	132	5,593
2021	8,613	98,291	151,088	132	5,593
2022	8,613	98,291	151,088	132	5,593
2023	8,613	98,291	151,129	132	5,593
2024	8,613	98,291	151,129	132	5,593
2025	8,613	98,291	151,129	132	5,593
2026	8,613	98,291	151,129	132	5,593
2027	8,613	98,291	151,129	132	5,593

Table 8. TPNRD county summary of groundwater only irrigated lands robust review Unretired Scenario land use data set

Year	Arthur	Keith	Lincoln	Logan	McPherson
2001	9,487	84,154	115,231	122	4,318
2002	9,272	86,334	121,088	122	5,077
2003	9,507	89,925	128,681	122	5,207
2004	9,732	94,959	135,355	122	5,339
2005	10,096	95,166	139,304	123	5,791
2006	10,232	95,779	147,506	126	5,427
2007	11,112	98,617	152,376	126	6,310
2008	10,687	98,263	150,690	126	6,339
2009	10,113	98,915	152,776	126	6,554
2010	9,180	98,543	150,351	132	5,583
2011	9,180	98,480	150,421	132	5,583
2012	9,180	98,467	150,413	132	5,583
2013	8,613	98,291	151,170	132	5,593
2014	8,613	98,291	151,170	132	5,593
2015	8,613	98,291	151,170	132	5,593
2016	8,613	98,291	151,170	132	5,593
2017	8,613	98,291	151,170	132	5,593
2018	8,613	98,291	151,170	132	5,593
2019	8,613	98,291	151,170	132	5,593
2020	8,613	98,291	151,170	132	5,593
2021	8,613	98,291	151,170	132	5,593
2022	8,613	98,291	151,170	132	5,593
2023	8,613	98,291	151,170	132	5,593
2024	8,613	98,291	151,170	132	5,593
2025	8,613	98,291	151,170	132	5,593
2026	8,613	98,291	151,170	132	5,593
2027	8,613	98,291	151,170	132	5,593

Table 7. TPNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Arthur	Keith	Lincoln	Logan	McPherson
2028	8,613	98,291	151,129	132	5,593
2029	8,613	98,291	151,129	132	5,593
2030	8,613	98,291	151,129	132	5,593
2031	8,613	98,291	151,129	132	5,593
2032	8,613	98,291	151,129	132	5,593
2033	8,613	98,291	151,129	132	5,593
2034	8,613	98,291	151,129	132	5,593
2035	8,613	98,291	151,129	132	5,593
2036	8,613	98,291	151,129	132	5,593
2037	8,613	98,291	151,129	132	5,593
2038	8,613	98,291	151,129	132	5,593
2039	8,613	98,291	151,129	132	5,593
2040	8,613	98,291	151,129	132	5,593
2041	8,613	98,291	151,129	132	5,593
2042	8,613	98,291	151,129	132	5,593
2043	8,613	98,291	151,129	132	5,593
2044	8,613	98,291	151,129	132	5,593
2045	8,613	98,291	151,129	132	5,593
2046	8,613	98,291	151,129	132	5,593
2047	8,613	98,291	151,129	132	5,593
2048	8,613	98,291	151,129	132	5,593
2049	8,613	98,291	151,129	132	5,593
2050	8,613	98,291	151,129	132	5,593
2051	8,613	98,291	151,129	132	5,593
2052	8,613	98,291	151,129	132	5,593
2053	8,613	98,291	151,129	132	5,593
2054	8,613	98,291	151,129	132	5,593

Table 8. TPNRD county summary of groundwater only irrigated lands robust review Unretired Scenario land use data set

Year	Arthur	Keith	Lincoln	Logan	McPherson
2028	8,613	98,291	151,170	132	5,593
2029	8,613	98,291	151,170	132	5,593
2030	8,613	98,291	151,170	132	5,593
2031	8,613	98,291	151,170	132	5,593
2032	8,613	98,291	151,170	132	5,593
2033	8,613	98,291	151,170	132	5,593
2034	8,613	98,291	151,170	132	5,593
2035	8,613	98,291	151,170	132	5,593
2036	8,613	98,291	151,170	132	5,593
2037	8,613	98,291	151,170	132	5,593
2038	8,613	98,291	151,170	132	5,593
2039	8,613	98,291	151,170	132	5,593
2040	8,613	98,291	151,170	132	5,593
2041	8,613	98,291	151,170	132	5,593
2042	8,613	98,291	151,170	132	5,593
2043	8,613	98,291	151,170	132	5,593
2044	8,613	98,291	151,170	132	5,593
2045	8,613	98,291	151,170	132	5,593
2046	8,613	98,291	151,170	132	5,593
2047	8,613	98,291	151,170	132	5,593
2048	8,613	98,291	151,170	132	5,593
2049	8,613	98,291	151,170	132	5,593
2050	8,613	98,291	151,170	132	5,593
2051	8,613	98,291	151,170	132	5,593
2052	8,613	98,291	151,170	132	5,593
2053	8,613	98,291	151,170	132	5,593
2054	8,613	98,291	151,170	132	5,593

Table 7. TPNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Arthur	Keith	Lincoln	Logan	McPherson
2055	8,613	98,291	151,129	132	5,593
2056	8,613	98,291	151,129	132	5,593
2057	8,613	98,291	151,129	132	5,593
2058	8,613	98,291	151,129	132	5,593
2059	8,613	98,291	151,129	132	5,593
2060	8,613	98,291	151,129	132	5,593
2061	8,613	98,291	151,129	132	5,593
2062	8,613	98,291	151,129	132	5,593
2063	8,613	98,291	151,129	132	5,593

Table 8. TPNRD county summary of groundwater only irrigated lands robust review Unretired Scenario land use data set

Year	Arthur	Keith	Lincoln	Logan	McPherson
2055	8,613	98,291	151,170	132	5,593
2056	8,613	98,291	151,170	132	5,593
2057	8,613	98,291	151,170	132	5,593
2058	8,613	98,291	151,170	132	5,593
2059	8,613	98,291	151,170	132	5,593
2060	8,613	98,291	151,170	132	5,593
2061	8,613	98,291	151,170	132	5,593
2062	8,613	98,291	151,170	132	5,593
2063	8,613	98,291	151,170	132	5,593

Memorandum

To:	Brandi Flyr – Central Platte NRD; Kari Burgert – NDNR
From:	The Flatwater Group, Inc.
Date:	10/17/2018
Subject:	COHYST Area Robust Review: CPNRD Land Use Retirements, Transfers, and Variances

Project Background and Workflow

The Flatwater Group, Inc. (TFG) was contracted by the Platte Basin Water Project Coalition through the Nebraska Department of Natural Resources (NDNR) to provide technical assistance for the Robust Review project. The purpose of the Robust Review project is to assess streamflow impacts resulting from management actions taken as part of the Basin-Wide Plan and/or Natural Resource District (NRD) Integrated Management Plans (IMPs). The focus of this memorandum is to document land use changes related to acreage transfers, retirements, and variances within the Central Platte NRD (CPNRD).

To evaluate changes to land use within the CPNRD, TFG's primary work tasks included compiling available acreage change information; spatially processing the compiled information to ensure unique datasets; developing land use summary tables to facilitate review of the provided information; placing the acreage change transactions into the constructs of the COHYST 2010 watershed model's land use files in order to extend the baseline land use dataset through 2013; and finally to then create a new land use data set for the Robust Review's unretired scenario.

Data Collection and Spatial Processing

For the first step in the process, TFG worked with NDNR and CPNRD to gather available land use change information. Ultimately, CPNRD provided four ArcGIS® shape files and NDNR provide one ArcGIS® shape file and an Excel spreadsheet upon which the analyses for CPNRD were based. The shape files from CPNRD were named:

- *Acres_Added_2_13_2018.shp*
  - Contains spatial locations of areas where irrigation was transferred to
  - Comprised of 2,925 entries
  - 970 of those entries occurred between 2011 and 2013
- *Acres_Offset_2_13_2018.shp*
  - Contains spatial location of areas where irrigation was transferred from
  - Comprised of 3,287 entries
  - 725 of those entries occurred between 2011 and 2013
- *CPNRD_2004_CIA_2018_02_13.shp*
  - 2004 certified acreage coverage
- *WB_PURCHASES.shp*
  - Spatial location of permanent retirements initiated through CPNRD's water bank.
  - Contained 71 entries

NDNR provided the following files:

- *CREP.shp*
  - Contains spatial locations of retirements funded with either CREP or EQIP funds and tracked by NDNR

- *20180829_COHYSTAreaMissing Dates.xlsx*
  - Provided supplementary contract starting and end dates for parcels included in *CREP.shp*.

To ensure that the spatial information provided was unique and did not reflect overlapping polygons, the information was linked to the COHYST 2010 model grid. COHYST 2010 uses a grid of 160-acre sized model cells. Cells are assigned to counties, NRDs, and/or drainage basins based on the location of the cell's centroid. This results in a model cell being assigned a single value for a given feature class. For example, if the border of an NRD passes through a model cell, whichever NRD the cell's centroid is within determines which NRD the cell is assigned to within the model. For this reason, it is possible to have an activity which occurs within a cell along a feature border to be enacted by one entity that shares the border, but for the model to summarize the activity to the other entity which shares the border.

After joining the provided spatial information to the COHYST 2010 model grid, the following observations were made:

1. There were multiple overlapping parcels within the *Acres_Added_2_13_2018.shp* and *Acres_Offset_2_13_2018.shp* datasets
   a. This led to potential changes in ground water only irrigated lands greater than the number of acres within a cell
2. There were irrigated acres to be offset that did not have an underlying entry in the *CPNRD_2004_CIA_2018_02_13.shp* dataset.
3. The majority of the parcels identified in *WB_PURCHASES.shp* were also included in the *Acres_Offset_2_13_2018.shp dataset*
   a. There was one completely unique WB entry
4. The *WB_PURCHASES.shp* dataset included transactions for surface water and comingled acres as well as ground water only acres

With respect to item 1 above, to account for the overlapping parcels within the acreage transfer datasets, the shape files were dissolved by the transfer year using the software ArcGIS®. This eliminated the ability to add or remove the same acres multiple time in a single year but allowed for transfers to and from in subsequent years. The 'Union' function within ArcGIS® was used to associate the transfer and retirement shape file information to the COHYST model grid.

After discussion with CPNRD regarding item 2, the offset acreage parcels which did not have an underlying entry in the certified acreage dataset were identified and returned to CPNRD. CPNRD determined if the parcels were truly offset acres; ultimately providing TFG with their recommendations on which parcels to omit from the analysis. TFG removed these parcels from the dataset moving forward.

After additional discussions with CPNRD about item 3, it was determined that the *Acres_Offset_2_13_2018.shp* dataset included both transfers away and permanent retirements (which were initially believed to be contained in the *WB_PURCHASES.shp* dataset). The *WB_PURCHASES.shp* coverage was spatially queried against the *Acres_Offset_2_13_2018.shp* dataset to determine which offset transactions were retirements. The *Acres_Offset_2_13_2018.shp* dataset was then divided into two sets: offset transfers and offset retirements.

Item 4 was noted due to the Robust Review being focused on ground water only transactions. The offset acreage transactions which had a designation of surface water only or comingled were therefore removed.

Land Use Summary Tables

Using information provided by CPNRD, NDNR, and other basin NRDs, TFG compiled a final summary of the retirements, transfers, and variances occurring within the CPNRD assigned model domain. This information was used to modify the land use data set in the COHYST 2010 model to investigate the effects of these actions as part of the larger Robust Review effort. Tables 1-7 below summarize the information provided to TFG. Tables 8-14 summarize the distribution of that information into the modeling input files.

Table 1 provides an overall summary of the retirement and transfer acreage source information relevant to the CPNRD received by TFG. Columns A through E on Table 1 summarize the information provided by CPNRD and NDNR. Column F summarizes information tracked by other basin NRDs, but whose spatial location upon distribution to the model placed acreage within the model domain assigned to the CPNRD. Subsequent tables define the source(s) of this information.

Table 1. Summary of CPNRD acreage changes for implementation into the Robust Review.

	CPNRD Data					Non-CPNRD Data	
Year	(A) Temporary Retirements	(B) Reinstated Temporary Retirements	(C) Permanent Retirements	(D) Transfers To	(E) Transfers Away	(F) Transfers Away	(G) Change
Baseline Change	(-)	(+)	(-)	(+)	(-)	(-)	
1999	-	-	-	-	-	-	-
2000	-	-	-	-	-	-	-
2001	-	-	-	-	-	-	-
2002	-	-	-	-	-	-	-
2003	-	-	-	-	-	-	-
2004	-	-	-	-	-	-	-
2005	304.4	-	-	-	-	-	(304.4)
2006	260.7	-	150.1	-	-	-	(410.8)
2007	111.9	-	-	-	-	-	(111.9)
2008	52.2	-	-	-	-	-	(52.2)
2009	6.9	-	1,513.8	-	-	-	(1,520.7)
2010	-	-	317.8	-	-	-	(317.8)
2011	-	-	430.8	1,087.2	683.5	1.6	(28.7)
2012	-	-	211.3	4,397.8	1,021.6	3.8	3,161.1
2013	-	-	19.1	4,255.3	1,440.0	77.1	2,719.1
2014	-	-	-	-	-	-	-
2015	-	-	-	-	-	-	-
2016	-	-	-	-	-	-	-
2017	-	-	-	-	-	-	-
2018	-	282.7	-	-	-	-	282.7
2019	-	21.5	-	-	-	-	21.5
2020	-	39.7	-	-	-	-	39.7
2021	-	196.4	-	-	-	-	196.4
2022	-	125.0	-	-	-	-	125.0
2023	-	70.8	-	-	-	-	70.8
Total	736.1	736.1	2,642.9	9,740.3	3,145.1	82.5	3,869.8

<u>Data Source Discussion for Table 1 Columns A-B</u>

The CREP related information provided by NDNR was the source of the temporary retirement information summarized in Column A of Table 1. The *CREP.shp* file included the most up to date list of CREP and EQIP contracts available from NDNR. TFG queried the data spatially in the shape file to obtain only the parcels located within the CPNRD. That query returned 58 polygons totaling 1,640 acres. The information was then limited to parcels irrigated only with ground water and which were initiated prior to the 2013 irrigation season. This reduced the number of acres to 876.4.

A spatial comparison of the CREP/EQIP information provided by NDNR and the permanent retirement information provided by CPNRD (via *WB_PURCHASES.shp*) revealed a small amount of overlap between the two datasets. The overlapping acres were removed from the *CREP.shp* dataset and retained in the in the CPNRD provided information; however, the date the retirements were initiated was changed to reflect the initial temporary retirement year (from 2009 to 2006). This resulted in 140.3 acres being converted from temporarily retired to permanently retired. Reducing the remaining 876.4 CREP/EQIP retirement acres by the 140.3 acres yields 736.1 acres within the CPNRD area (and an additional 0.7 acres in the TBNRD area due to the cell assignment procedures discussed earlier). Table 2 summarizes these values. Note that Column 'CPNRD' on Table 2 is the source of the information populated into Column A of Table 1.

Table 2. Summary of CPNRD CREP and EQIP temporary retirements.

Year	Total	CPNRD	TBNRD
2005	304.4	304.4	-
2006	260.7	260.7	-
2007	111.9	111.9	-
2008	52.2	52.2	-
2009	7.6	6.9	0.7
2010	-	-	-
2011	-	-	-
2012	-	-	-
2013	-	-	-
Total	736.8	736.1	0.7

Based on the contract start and end dates contained in *CREP.shp* and *20180829_COHYSTAreaMissing Dates.xlsx*, the year the temporary retirements end was computed. This information is shown on Table 3. Note that Column 'CPNRD' on Table 3 is the source of the information populated into Column B of Table 1.

Table 3. Summary of CPNRD CREP and EQIP temporary retirements reinstatements.

Year	Total	CPNRD	TBNRD
2018	282.7	282.7	-
2019	21.5	21.5	-
2020	40.4	39.7	0.7
2021	196.4	196.4	-
2022	125.0	125.0	-
2023	70.8	70.8	-
Total	736.8	736.1	0.7

Data Source Discussion for Table 1 Column C

Table 4 summarizes the permanent retirement information provided in the datasets from CPNRD. Similar to the CREP/EQIP acreage, some permanent retirements occurred in cells assigned to neighboring NRDs. Note that Column A of Table 4 is the source of the information populated into Column C of Table 1.

Table 4. Summary of CPNRD permanent retirement acreage.

Year	(A) = B + C CPNRD Retirements	(B) Water Bank Only	(C) Water Bank And Offset Acres	LLNRD	TBNRD
2006	150.1	-	150.1	-	-
2007	-	-	-	-	-
2008	-	-	-	-	-
2009	1,513.8	75.0	1,438.8	0.4	149.1
2010	317.8	-	317.8	-	-
2011	430.8	-	430.8	-	-
2012	211.3	-	211.3	-	-
2013	19.1	-	19.1	-	-
Total	2,642.9	75.0	2,567.9	0.4	149.1

Note:
LLNRD – Lower Loup Natural Resources District
TBNRD – Tri-Basin Natural Resources District
(B) represents the data found only in the WB Purchases shapefile
(C) represents the intersection of the Acres Offset data set and the WB Purchases shapefiles limited to groundwater only transactions

The 140.3 acres converted from temporary to permanent as discussed in the Section above are reflected in this table.

Data Source Discussion for Table 1 Columns D and E

Table 5 summarizes the amount of new irrigated acreage resulting from CPNRD transfers, while Table 6 summarizes the amount of irrigated acreage reduced as a result of transfers occurring in the CPNRD.

Table 5. Summary of CPNRD added acres.

Year	Total	CPNRD	UBBNRD	LBNRD	LLNRD	LPNNRD	TBNRD
2011	1,107.4	1,087.2	5.1	10.6	4.5	-	-
2012	4,455.9	4,397.8	4.4	2.5	49.4	1.8	-
2013	4,268.9	4,255.3	10.0	-	2.2	-	1.4
Total	9,832.2	9,740.3	19.5	13.1	56.1	1.8	1.4

Table 6. Summary of CPNRD offset acres.

Year	Total	CPNRD	UBBNRD	LLNRD	LPNNRD
2011	698.3	683.5	4.3	10.5	-
2012	1,037.9	1,021.6	5.3	9.2	1.8
2013	1,445.2	1,440.0	2.9	2.3	-
Total	3,181.4	3,145.1	12.5	22.0	1.8

Note for Tables 5 and 6:
UBBNRD – Upper Big Blue Natural Resources District
LBNRD – Little Blue Natural Resources District
LLNRD – Lower Loup Natural Resources District
LPNNRD – Lower Platte North Natural Resources District
TBNRD – Tri-Basin Natural Resources District

Columns 'CPNRD' in Tables 5 and 6 are the sources for the information populated into Columns D and E, respectively, of Table 1. The tables also reflect a small amount of acreage attributed to cells assigned to neighboring NRDs due to the cell assignment process previously discussed.

<u>Data Source Discussion for Table 1 Column F</u>

Table 7 reflects, similar to how acreage modifications tracked by the CPNRD were located within cells assigned to other NRDs within the model, a small number of transactions tracked by the TPNRD (5.4 acres) and TBNRD (77.1 acres) that were placed into model cells which were assigned to the CPNRD. These transactions were all transfers away. The information in Column 'Total' of Table 7 is the source of the information populated into Column F of Table 1.

Table 7. Acreage summary of Non-CPNRD transactions which occurred within the CPNRD assigned cells.

Year	TPNRD	TBNRD	Total
2011	1.6	-	1.6
2012	3.8	-	3.8
2013	-	77.1	77.1
Total	5.4	77.1	82.5

Spatial Analysis Method

ArcGIS® was used to link the retirement, transfer, and variance information provided by CPNRD and NDNR to the COHYST 2010 model grid. This was accomplished by overlaying the parcels' shapefiles with the model grid.

Step 1: Assigning land use change location

NDNR and CPNRD provided retirement and transfer acreage information in the form of shape files. The parcel information within the shape files was dissolved by year to remove duplicate areas. The offset acreage information was divided between transfers away and permanent retirements. The union function within ArcGIS® was applied to each shapefile to determine the cell location. The polygon area within each cell was then computed using the calculate geometry function within ArcGIS®.

Step 2: Building the Baseline Land Use

The next step was to build the 2011-2013 land use files incorporating the identified transfers and retirements. The beginning condition for this update was the 2010 land use file from the COHYST 2010 model. Each of the 2011 transactions were applied to the 2010 land use to create the 2011 land use file; which in turn became the basis for applying the 2012 transactions. This continued through 2013. One of the key points of the investigation was the effect of retirements on the system. Given that many of the retirements were temporary in nature and knowing their contract end dates, the land use file building process was continued through 2023 to be able to add back in all of the temporarily retired acres.

Acres were to be added or removed from their assigned cells. If there was insufficient space[1] for new acres or an insufficient amount of groundwater only acres[2] to be retired within the cell, the addition or subtraction of acres was applied to nearby cells which exhibit the appropriate characteristics[3]. This spatial process entails radiating outward from the identified cell until the acres had been placed. During this process acres are placed or removed from the lowest priority cell which meets the appropriate criteria. If more than one cell has the same priority and meets criteria, the acres are split evenly between the multiple cells. Unless an even split would exceed the available space within the cell; at which time the placed acres would be limited to the available space and the remaining acres would be split among the other priority cells. The priority pattern for the first two rings around the assignment cell can be seen in Figure 1. This process was implemented using a custom piece of FORTRAN script.

[1] Example: transferring 30 groundwater only acres to a cell where there was only 20 non-irrigated acres
[2] Example: retiring 30 groundwater only acres from a cell where there was only 20 groundwater only acres
[3] The cell needed to be active, in the same NRD, and have a sufficient amount of groundwater only acres to retire or non-irrigated acres to convert

5 (r-2, c-2)	4 (r-2, c-1)	3 (r-2, c+0)	4 (r-2, c+1)	5 (r-2, c+2)
4 (r-1, c-2)	2 (r-1, c-1)	1 (r-1, c+0)	2 (r-1, c+1)	4 (r-1, c+2)
3 (r+0, c-2)	1 (r+0, c-1)	0 (r+0, c+0)	1 (r+0, c+1)	3 (r+0, c+2)
4 (r+1, c-2)	2 (r+1, c-1)	1 (r+1, c+0)	2 (r+1, c+1)	4 (r+1, c+2)
5 (r+2, c-2)	4 (r+2, c-1)	3 (r+2, c+0)	4 (r+2, c+1)	5 (r+2, c+2)

Figure 1. Priority of search pattern to place or remove acres when the assigned cell has insufficient non-irrigated or groundwater only acres. The center cell represents the cell identified as the location of the land use transaction. 'r' and 'c' indicate the row column index of the cell.

The results of step 2 are shown in Table 8. As intended, the values in Column B of Table 8 match (sans de minimis rounding resulting from the distribution process) the original source information summarized in Column G of Table 1 for the years 2011-2023. This indicates that the acreage values provided by CPNRD and NDNR were the quantities by which the modeling input files were adjusted.

Table 8 also includes the changes attributable to the CPNRD which occur in cells assigned to its neighboring NRDs. Column C represents the total impact of Table 3 (Columns: TBNRD), Table 5 (Columns: UBBNRD, LBNRD, LLNRD, LPNNRD, & TBNRD), and Table 6 (Columns UBBNRD, LLNRD, & LPNNRD). It should be noted that the cell boundaries do not necessarily overlap with the legal boundaries either for the county or NRD. For these summaries each cell was assigned to an NRD and county based upon the location of the cell centroid.

Table 8. Change in groundwater only irrigated acres within the CPNRD for the Robust Review baseline.

Year	(A) Groundwater Only Irrigated Acres in CPNRD	(B) Annual Change in TPNRD Groundwater Only Irrigated Acres in the CPNRD	(C) Change in CPNRD Groundwater Only Irrigated Acres not in the CPNRD
2010	896,869.5	-	-
2011	896,840.8	(28.7)	5.4
2012	900,002.3	3,161.5	41.8
2013	902,721.3	2,719.0	8.4
2014	902,721.3	-	-
2015	902,721.3	-	-
2016	902,721.3	-	-
2017	902,721.3	-	-
2018	903,004.1	282.8	-
2019	903,025.6	21.5	-
2020	903,065.3	39.7	0.7
2021	903,261.7	196.4	-
2022	903,386.7	125.0	-
2023	903,457.5	70.8	-

Step 3: Building the Unretired Acres Scenario Modified Land Use

A new set of land use files were created for the unretired scenario. In this scenario the permanently and temporarily retired acres were never retired. Other key elements of the scenario include:

- The transfers were applied.
- For the post 2010 period no retirements were applied.
- For permanent retirements, irrigated acres were added back into the modified land use files for all future years.
- For temporary retirements, the acres were added back during their contracted period. If the temporary retirement ended after 2010, the temporarily retired acres were added back in 2011 and remain moving forward.

Table 9 shows the change between the COHYST 2010 land use file and the unretired retirements scenario. The difference between the two data sets shows the cumulative change over time. Again, as intended, the annual change in ground water only irrigated acres shown on Table 8 Column D match (sans de minimis rounding resulting from the distribution process) the original source information shown in Column G of Table 1 for the years 1999 through 2010 (the sign reversal indicates removal (unretirement) of the acreage). This indicates that the acreage values provided by the CPNRD and NDNR were the quantities by which the modeling input files were adjusted.

Table 9. Change in Groundwater Only Irrigated Acres in the TPNRD comparing the COHYST 2010 land use to Unretired Retirements Scenario land use; years 1999-2010.

	Groundwater Only Irrigated Acres		Change in Groundwater Only Irrigated Acres within the CPNRD	
Year	(A) Run029	(B) Modified Land Use	(C) Cumulative	(D) Annual
1999	828,559	828,559	(0.0)	(0.0)
2000	834,741	834,741	-	0.0
2001	843,080	843,080	-	-
2002	854,133	854,133	0.0	0.0
2003	866,690	866,690	(0.0)	(0.0)
2004	878,324	878,324	-	0.0
2005	887,953	888,258	304.4	304.4
2006	883,622	884,337	715.1	410.7
2007	914,684	915,511	826.6	111.5
2008	877,717	878,597	879.5	52.9
2009	907,031	909,431	2,400.1	1,520.6
2010	896,870	899,587	2,717.9	317.8
		Cumulative		2,717.9

Table 10 shows the changes between the COHYST 2010 land use file and the land use file developed for the "unretired" condition within the Robust Review's retirement scenario. Column A in the table presents the annual acreage irrigated only with ground water from 2011 through 2023 for the "unretired" land use data set. Column B summarizes the acreage changes made to arrive at values presented in Column A. Columns C through I present the information used in the computation of the Column B values.

SUMMARY

Tables 8 through 10 summarize the background information as to how the land use files for the Robust Review will be populated. Comparisons back to Table 1 confirm the information provided to TFG by CPNRD, NDNR and other entities referenced in the memorandum were fully included in the model input files. The retirement scenario within the Robust Review involves two land use datasets: the Baseline Set; and the Unretired Set.

For the Baseline Set:

- For the years through 1998: The existing COHYST 2010 land use data set will be used
- For the years 1999 through 2010: Values from Column A in Table 9 will be used
- For the years 2011 through 2023 and forward: Values from Column A in Table 8 will be used

For the Unretired Set:

- For the years through 1998: The existing COHYST 2010 land use data set will be used
- For the years 1999 through 2010: Values from Column B in Table 9 will be used
- For the years 2011 through 2023 and forward: Values from Column A in Table 10 will be used

Table 10. Change in Groundwater Only Irrigated Acres in the TPNRD comparing the COHYST 2010 land use to Unretired Retirements Scenario land use; years 2011-2023.

Year	(A) Groundwater Only Irrigated Acres	(B) Difference in Ground Water Only Acres from 2010 minus cumulative prior retirements and transfers	(C) Transfers Away	(D) Transfers To	(E) Non Area Transfers Away	(F) Non Area Transfers To	(G) Net Transfers Away	(H) Cumulative Net Transfers Away	(I) Retirements
2011	899,989.5	402.1	683.5	1,087.2	1.6		(402.1)	(402.1)	(0.0)
2012	903,362.3	3,372.8	1,021.6	4,397.8	3.8		(3,372.4)	(3,774.5)	0.4
2013	906,100.4	2,738.1	1,440.0	4,255.3	77.1		(2,738.2)	(6,512.7)	(0.1)
2014	906,100.4	-					-	(6,512.7)	-
2015	906,100.4	-					-	(6,512.7)	-
2016	906,100.4	-					-	(6,512.7)	-
2017	906,100.4	-					-	(6,512.7)	-
2018	906,100.4	-					-	(6,512.7)	-
2019	906,100.4	-					-	(6,512.7)	-
2020	906,100.4	-					-	(6,512.7)	-
2021	906,100.4	-					-	(6,512.7)	-
2022	906,100.4	-					-	(6,512.7)	-
2023	906,100.4	-					-	(6,512.7)	-

Tables 11 and 12 show the annual area of groundwater only irrigated land for each county in the CPNRD within the Robust Review baseline and unretirement scenarios. Finally, Tables 13 and 14 show the annual area of groundwater only irrigated land for each county in the CPNRD and Platte River Drainage basin within the Robust Review's baseline and unretirement scenarios.

Table 11. CPNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
1950	37,762	403	27,603	-	38,694	883	253	20,701	168	128	2,030
1951	38,107	596	26,837	-	40,090	897	220	18,343	170	118	1,864
1952	38,472	459	26,426	-	41,482	904	185	15,963	165	106	1,703
1953	38,638	665	26,443	-	42,875	781	120	13,606	160	84	1,541
1954	38,818	773	27,725	-	44,267	616	86	11,236	155	81	1,175
1955	42,204	1,217	35,398	58	51,750	915	233	16,096	202	143	2,394
1956	45,745	1,496	43,244	169	59,229	1,346	394	20,960	302	225	3,174
1957	49,510	1,920	50,498	281	66,706	2,042	554	25,719	402	308	3,861
1958	53,516	2,174	56,649	320	74,185	2,510	727	30,563	488	399	4,869
1959	57,358	2,538	64,005	467	81,662	2,990	891	35,406	552	463	5,867
1960	58,532	2,713	64,363	539	84,161	3,249	1,104	39,426	738	571	7,673
1961	59,699	2,720	64,418	743	86,660	3,536	1,307	43,459	922	697	9,349
1962	60,893	2,832	64,716	736	89,163	3,816	1,551	47,494	1,084	811	11,036
1963	62,188	2,897	65,266	757	91,656	4,062	1,823	51,508	1,218	960	12,692
1964	63,155	2,999	65,219	692	94,156	4,388	2,070	55,499	1,394	1,037	14,087
1965	67,131	4,116	67,466	1,321	98,490	4,867	3,070	60,697	1,750	1,245	16,472
1966	71,398	5,058	69,448	1,622	102,777	5,283	4,020	65,832	2,070	1,457	19,161
1967	75,375	5,991	71,862	1,604	107,112	5,667	4,808	70,912	2,482	1,747	21,573
1968	79,317	6,844	74,296	1,882	111,447	6,017	5,605	75,955	2,817	2,023	23,798
1969	83,508	7,897	76,595	1,952	115,722	6,698	6,275	80,999	3,128	2,247	26,254
1970	88,978	8,703	86,595	2,361	122,556	7,308	6,529	85,769	3,245	2,435	27,857
1971	94,430	9,677	96,852	2,716	129,273	7,958	7,032	90,528	3,276	2,591	29,419
1972	99,125	10,412	107,389	2,779	136,031	8,434	7,235	95,280	3,461	2,692	30,849
1973	104,220	11,069	117,907	3,115	142,807	8,882	7,548	99,922	3,715	2,769	32,414
1974	109,536	11,863	129,601	3,299	149,581	9,553	8,112	104,690	4,163	2,883	34,222
1975	116,243	12,546	132,081	3,729	156,915	10,270	8,995	111,897	4,829	3,245	36,893
1976	122,587	13,248	132,581	3,880	164,283	11,296	9,733	118,796	5,188	3,529	39,541
1977	129,105	14,362	135,105	4,265	171,636	11,780	10,114	125,820	5,644	3,975	42,361

Table 11. CPNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
1978	136,078	15,494	136,151	4,481	178,967	12,647	10,967	132,888	6,213	4,204	44,679
1979	138,896	16,663	140,172	4,258	180,519	12,768	11,283	134,209	6,188	4,171	43,948
1980	142,065	17,443	145,645	4,369	182,018	12,827	11,613	135,467	6,268	4,117	42,961
1981	146,078	18,135	150,431	4,153	183,565	12,864	11,917	136,665	6,223	4,290	42,138
1982	149,224	18,722	155,109	4,352	184,999	12,810	12,157	137,922	6,293	4,277	41,025
1983	146,691	18,607	152,394	4,299	181,499	12,558	11,695	135,549	6,363	4,338	41,255
1984	143,647	17,959	149,510	4,114	177,862	12,243	11,303	133,139	6,457	4,412	41,345
1985	144,075	20,445	169,085	4,968	193,563	10,446	13,046	166,376	9,633	5,195	35,947
1986	144,745	20,080	166,815	4,908	193,519	10,344	12,745	166,499	9,564	5,214	36,157
1987	145,080	19,556	163,289	4,806	193,173	10,167	12,162	166,554	9,521	5,265	36,535
1988	146,473	19,684	163,270	4,856	194,271	10,219	12,616	167,318	9,446	5,278	36,357
1989	148,972	19,834	163,121	4,799	196,204	10,366	13,056	168,747	9,464	5,271	36,223
1990	150,649	20,009	163,019	4,738	197,294	10,424	13,501	170,202	9,556	5,280	36,063
1991	152,280	20,234	162,930	4,677	198,631	10,575	13,924	171,093	9,479	5,314	35,917
1992	154,498	20,827	163,529	4,657	200,312	10,817	14,723	172,140	9,447	5,388	35,536
1993	155,474	20,929	163,200	4,622	200,857	10,898	14,949	172,900	9,478	5,442	37,142
1994	156,701	21,061	162,887	4,588	201,279	10,984	15,203	173,400	9,534	5,495	38,749
1995	157,797	21,224	162,749	4,556	201,806	11,078	15,406	173,634	9,612	5,552	40,378
1996	159,570	21,437	163,209	4,545	203,009	11,177	15,653	174,129	9,791	5,615	42,052
1997	161,837	21,763	163,006	4,525	203,597	11,383	15,991	174,679	10,061	5,735	45,241
1998	162,219	21,787	167,423	4,818	203,667	11,425	16,038	174,203	10,129	5,900	45,809
1999	162,685	21,745	171,542	5,087	203,704	11,578	16,043	173,630	10,146	6,015	46,385
2000	163,257	21,718	175,831	5,334	204,223	11,686	16,186	173,201	10,178	6,203	46,924
2001	162,813	21,556	183,747	5,915	204,341	11,663	16,476	172,389	10,331	6,343	47,507
2002	164,295	22,660	186,859	6,214	205,180	11,707	16,511	174,074	10,446	6,470	49,718
2003	165,455	25,163	191,481	6,250	206,046	11,772	17,140	174,294	10,686	6,632	51,769
2004	166,787	26,266	195,741	6,499	207,343	11,986	17,765	174,759	10,936	6,664	53,578
2005	167,084	27,724	200,234	6,497	207,622	12,185	18,098	174,951	11,189	6,695	55,675

Table 11. CPNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
2006	165,041	21,503	200,516	5,741	210,252	12,325	18,183	175,802	11,521	6,727	56,011
2007	171,270	26,613	211,532	6,538	213,805	12,740	19,019	177,883	12,213	6,862	56,209
2008	163,245	25,823	203,209	5,725	204,290	12,239	17,559	173,374	10,627	6,568	55,060
2009	170,387	27,559	211,181	6,394	208,849	12,622	18,390	176,557	11,693	6,801	56,597
2010	169,215	26,607	203,177	6,555	210,204	12,577	18,557	177,058	10,960	6,534	55,426
2011	169,132	26,591	202,848	6,551	210,356	12,714	18,650	177,059	10,978	6,534	55,427
2012	169,260	26,553	202,671	6,548	211,511	12,883	18,681	178,350	11,007	6,562	55,978
2013	169,508	26,552	202,627	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2014	169,508	26,552	202,627	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2015	169,508	26,552	202,627	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2016	169,508	26,552	202,627	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2017	169,508	26,552	202,627	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2018	169,508	26,552	202,910	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2019	169,508	26,552	202,931	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2020	169,508	26,552	202,971	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2021	169,508	26,552	203,167	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2022	169,508	26,552	203,292	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2023	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2024	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2025	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2026	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2027	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2028	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2029	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2030	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2031	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2032	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2033	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811

Table 11. CPNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
2034	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2035	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2036	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2037	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2038	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2039	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2040	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2041	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2042	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2043	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2044	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2045	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2046	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2047	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2048	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2049	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2050	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2051	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2052	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2053	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2054	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2055	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2056	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2057	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2058	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2059	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2060	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2061	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811

Table 11. CPNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
2062	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2063	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811

Table 12. CPNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
1950	37,762	403	27,603	-	38,694	883	253	20,701	168	128	2,030
1951	38,107	596	26,837	-	40,090	897	220	18,343	170	118	1,864
1952	38,472	459	26,426	-	41,482	904	185	15,963	165	106	1,703
1953	38,638	665	26,443	-	42,875	781	120	13,606	160	84	1,541
1954	38,818	773	27,725	-	44,267	616	86	11,236	155	81	1,175
1955	42,204	1,217	35,398	58	51,750	915	233	16,096	202	143	2,394
1956	45,745	1,496	43,244	169	59,229	1,346	394	20,960	302	225	3,174
1957	49,510	1,920	50,498	281	66,706	2,042	554	25,719	402	308	3,861
1958	53,516	2,174	56,649	320	74,185	2,510	727	30,563	488	399	4,869
1959	57,358	2,538	64,005	467	81,662	2,990	891	35,406	552	463	5,867
1960	58,532	2,713	64,363	539	84,161	3,249	1,104	39,426	738	571	7,673
1961	59,699	2,720	64,418	743	86,660	3,536	1,307	43,459	922	697	9,349
1962	60,893	2,832	64,716	736	89,163	3,816	1,551	47,494	1,084	811	11,036
1963	62,188	2,897	65,266	757	91,656	4,062	1,823	51,508	1,218	960	12,692
1964	63,155	2,999	65,219	692	94,156	4,388	2,070	55,499	1,394	1,037	14,087
1965	67,131	4,116	67,466	1,321	98,490	4,867	3,070	60,697	1,750	1,245	16,472
1966	71,398	5,058	69,448	1,622	102,777	5,283	4,020	65,832	2,070	1,457	19,161
1967	75,375	5,991	71,862	1,604	107,112	5,667	4,808	70,912	2,482	1,747	21,573
1968	79,317	6,844	74,296	1,882	111,447	6,017	5,605	75,955	2,817	2,023	23,798
1969	83,508	7,897	76,595	1,952	115,722	6,698	6,275	80,999	3,128	2,247	26,254

Table 12. CPNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
1970	88,978	8,703	86,595	2,361	122,556	7,308	6,529	85,769	3,245	2,435	27,857
1971	94,430	9,677	96,852	2,716	129,273	7,958	7,032	90,528	3,276	2,591	29,419
1972	99,125	10,412	107,389	2,779	136,031	8,434	7,235	95,280	3,461	2,692	30,849
1973	104,220	11,069	117,907	3,115	142,807	8,882	7,548	99,922	3,715	2,769	32,414
1974	109,536	11,863	129,601	3,299	149,581	9,553	8,112	104,690	4,163	2,883	34,222
1975	116,243	12,546	132,081	3,729	156,915	10,270	8,995	111,897	4,829	3,245	36,893
1976	122,587	13,248	132,581	3,880	164,283	11,296	9,733	118,796	5,188	3,529	39,541
1977	129,105	14,362	135,105	4,265	171,636	11,780	10,114	125,820	5,644	3,975	42,361
1978	136,078	15,494	136,151	4,481	178,967	12,647	10,967	132,888	6,213	4,204	44,679
1979	138,896	16,663	140,172	4,258	180,519	12,768	11,283	134,209	6,188	4,171	43,948
1980	142,065	17,443	145,645	4,369	182,018	12,827	11,613	135,467	6,268	4,117	42,961
1981	146,078	18,135	150,431	4,153	183,565	12,864	11,917	136,665	6,223	4,290	42,138
1982	149,224	18,722	155,109	4,352	184,999	12,810	12,157	137,922	6,293	4,277	41,025
1983	146,691	18,607	152,394	4,299	181,499	12,558	11,695	135,549	6,363	4,338	41,255
1984	143,647	17,959	149,510	4,114	177,862	12,243	11,303	133,139	6,457	4,412	41,345
1985	144,075	20,445	169,085	4,968	193,563	10,446	13,046	166,376	9,633	5,195	35,947
1986	144,745	20,080	166,815	4,908	193,519	10,344	12,745	166,499	9,564	5,214	36,157
1987	145,080	19,556	163,289	4,806	193,173	10,167	12,162	166,554	9,521	5,265	36,535
1988	146,473	19,684	163,270	4,856	194,271	10,219	12,616	167,318	9,446	5,278	36,357
1989	148,972	19,834	163,121	4,799	196,204	10,366	13,056	168,747	9,464	5,271	36,223
1990	150,649	20,009	163,019	4,738	197,294	10,424	13,501	170,202	9,556	5,280	36,063
1991	152,280	20,234	162,930	4,677	198,631	10,575	13,924	171,093	9,479	5,314	35,917
1992	154,498	20,827	163,529	4,657	200,312	10,817	14,723	172,140	9,447	5,388	35,536
1993	155,474	20,929	163,200	4,622	200,857	10,898	14,949	172,900	9,478	5,442	37,142
1994	156,701	21,061	162,887	4,588	201,279	10,984	15,203	173,400	9,534	5,495	38,749
1995	157,797	21,224	162,749	4,556	201,806	11,078	15,406	173,634	9,612	5,552	40,378
1996	159,570	21,437	163,209	4,545	203,009	11,177	15,653	174,129	9,791	5,615	42,052
1997	161,837	21,763	163,006	4,525	203,597	11,383	15,991	174,679	10,061	5,735	45,241

Table 12. CPNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
1998	162,219	21,787	167,423	4,818	203,667	11,425	16,038	174,203	10,129	5,900	45,809
1999	162,685	21,745	171,542	5,087	203,704	11,578	16,043	173,630	10,146	6,015	46,385
2000	163,257	21,718	175,831	5,334	204,223	11,686	16,186	173,201	10,178	6,203	46,924
2001	162,813	21,556	183,747	5,915	204,341	11,663	16,476	172,389	10,331	6,343	47,507
2002	164,295	22,660	186,859	6,214	205,180	11,707	16,511	174,074	10,446	6,470	49,718
2003	165,455	25,163	191,481	6,250	206,046	11,772	17,140	174,294	10,686	6,632	51,769
2004	166,787	26,266	195,741	6,499	207,343	11,986	17,765	174,759	10,936	6,664	53,578
2005	167,084	27,724	200,538	6,497	207,622	12,185	18,098	174,951	11,189	6,695	55,675
2006	165,051	21,503	201,221	5,741	210,252	12,325	18,183	175,802	11,521	6,727	56,011
2007	171,281	26,613	212,348	6,538	213,805	12,740	19,019	177,883	12,213	6,862	56,209
2008	163,255	25,823	204,078	5,725	204,290	12,239	17,559	173,374	10,627	6,568	55,060
2009	170,742	27,559	213,010	6,394	209,065	12,622	18,390	176,557	11,693	6,801	56,597
2010	169,571	26,607	205,256	6,555	210,432	12,577	18,557	177,113	10,960	6,534	55,426
2011	169,536	26,597	205,255	6,551	210,633	12,714	18,650	177,114	10,978	6,534	55,427
2012	169,707	26,559	205,247	6,548	211,787	12,883	18,681	178,405	11,007	6,562	55,978
2013	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2014	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2015	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2016	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2017	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2018	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2019	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2020	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2021	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2022	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2023	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2024	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2025	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811

Table 12. CPNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
2026	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2027	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2028	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2029	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2030	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2031	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2032	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2033	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2034	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2035	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2036	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2037	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2038	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2039	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2040	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2041	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2042	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2043	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2044	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2045	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2046	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2047	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2048	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2049	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2050	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2051	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2052	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2053	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811

Table 12. CPNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
2054	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2055	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2056	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2057	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2058	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2059	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2060	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2061	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2062	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2063	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811

Table 13. CPNRD county summary of groundwater only irrigated lands robust review baseline land use data set within the Platte River drainage basin.

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
1950	37,762	403	27,603	-	37,736	883	253	20,580	147	128	1,993
1951	38,107	596	26,837	-	38,967	897	220	18,220	151	118	1,798
1952	38,427	459	26,426	-	40,282	848	185	15,861	147	106	1,643
1953	38,597	665	26,443	-	41,454	732	120	13,497	142	84	1,492
1954	38,666	773	27,722	-	42,551	581	86	11,113	141	81	1,130
1955	41,954	1,217	35,370	58	49,528	801	233	15,930	171	143	2,320
1956	45,461	1,496	43,159	169	56,170	1,009	394	20,720	269	225	3,061
1957	49,047	1,920	50,373	281	62,398	1,414	537	25,320	332	308	3,654
1958	53,017	2,174	56,490	320	69,341	1,734	684	30,108	402	399	4,614
1959	56,831	2,538	63,779	467	76,263	2,064	839	34,889	461	463	5,564
1960	58,002	2,713	64,133	539	78,417	2,243	1,042	38,829	618	571	7,274
1961	59,070	2,720	64,176	743	80,640	2,437	1,231	42,804	777	697	8,867

Table 13. CPNRD county summary of groundwater only irrigated lands robust review baseline land use data set within the Platte River drainage basin.

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
1962	60,251	2,832	64,471	736	82,921	2,627	1,464	46,798	924	811	10,471
1963	61,508	2,897	65,015	757	85,219	2,794	1,726	50,688	1,055	960	12,021
1964	62,477	2,999	64,950	692	87,092	3,013	1,967	54,585	1,186	1,037	13,377
1965	66,237	4,116	67,193	1,321	90,683	3,336	2,934	59,623	1,479	1,245	15,514
1966	70,468	5,058	69,130	1,622	94,197	3,589	3,854	64,682	1,746	1,457	17,938
1967	74,334	5,991	71,527	1,604	97,700	3,941	4,620	69,571	2,128	1,747	20,017
1968	78,123	6,844	73,929	1,882	101,499	4,196	5,374	74,403	2,344	2,023	22,083
1969	82,200	7,897	76,229	1,952	105,122	4,571	6,004	79,254	2,629	2,247	24,402
1970	87,492	8,703	86,185	2,361	111,092	5,086	6,264	83,830	2,763	2,435	25,756
1971	92,693	9,677	96,303	2,716	116,659	5,494	6,653	88,377	2,817	2,591	27,204
1972	97,300	10,303	106,747	2,779	122,400	5,927	6,868	92,665	2,997	2,692	28,564
1973	102,091	10,972	117,177	3,115	128,025	6,208	7,180	97,095	3,239	2,769	29,910
1974	107,137	11,682	128,835	3,299	134,016	6,529	7,745	101,782	3,701	2,883	31,597
1975	113,477	12,343	131,307	3,729	140,112	7,102	8,629	108,551	4,351	3,245	33,686
1976	119,342	13,080	131,715	3,880	145,777	7,761	9,305	115,018	4,703	3,529	36,078
1977	125,234	14,189	134,265	4,265	151,367	8,165	9,700	121,795	5,013	3,975	38,676
1978	131,712	15,294	135,229	4,481	157,612	8,790	10,515	128,568	5,552	4,204	40,768
1979	134,109	16,383	139,184	4,258	158,836	8,821	10,721	129,758	5,521	4,118	40,194
1980	136,916	17,154	144,644	4,369	160,116	8,885	11,049	130,886	5,535	4,072	39,334
1981	140,740	17,830	149,214	4,153	161,744	8,916	11,280	132,063	5,515	4,060	38,683
1982	143,696	18,401	153,794	4,352	162,727	8,875	11,506	133,142	5,602	4,049	37,629
1983	141,431	18,283	151,087	4,299	160,240	8,682	11,062	130,910	5,657	4,100	37,832
1984	138,674	17,680	148,292	4,114	157,198	8,518	10,718	128,660	5,748	4,180	37,916
1985	136,892	20,044	167,652	4,968	164,849	7,076	12,491	159,367	8,353	4,601	32,525
1986	137,539	19,686	165,401	4,908	164,844	7,009	12,207	159,463	8,300	4,618	32,716
1987	137,860	19,173	161,908	4,806	164,424	6,891	11,651	159,519	8,269	4,663	33,058
1988	139,189	19,298	161,898	4,856	165,411	6,922	12,088	160,269	8,208	4,649	32,902

Table 13. CPNRD county summary of groundwater only irrigated lands robust review baseline land use data set within the Platte River drainage basin.

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
1989	141,513	19,445	161,755	4,799	166,906	7,086	12,511	161,685	8,244	4,643	32,802
1990	143,133	19,617	161,661	4,738	167,819	7,123	12,947	162,973	8,355	4,653	32,667
1991	144,709	19,839	161,577	4,677	168,815	7,142	13,356	163,767	8,293	4,646	32,489
1992	146,861	20,421	162,174	4,657	170,202	7,228	14,126	164,798	8,275	4,614	32,151
1993	147,684	20,520	161,850	4,622	170,367	7,279	14,342	165,307	8,303	4,660	33,606
1994	148,773	20,652	161,543	4,588	170,656	7,333	14,596	165,575	8,352	4,705	35,069
1995	149,833	20,813	161,411	4,556	171,142	7,392	14,799	165,806	8,419	4,755	36,563
1996	151,466	21,029	161,880	4,545	172,077	7,454	15,043	166,300	8,594	4,809	38,025
1997	153,438	21,351	161,687	4,525	172,431	7,594	15,376	166,805	8,835	4,911	40,738
1998	153,705	21,350	166,075	4,818	172,379	7,688	15,424	166,293	8,909	5,024	41,170
1999	153,876	21,310	170,164	5,087	172,366	7,796	15,435	165,758	8,923	5,121	41,716
2000	154,472	21,287	174,425	5,334	172,745	7,855	15,322	165,360	8,952	5,298	42,152
2001	154,078	21,135	182,288	5,915	172,816	7,842	15,601	164,534	9,087	5,416	42,703
2002	155,328	22,224	185,387	6,214	173,663	7,867	15,643	166,170	9,211	5,535	44,593
2003	156,124	24,687	189,865	6,250	174,370	7,913	16,280	166,310	9,426	5,563	46,421
2004	156,962	25,772	194,100	6,499	175,299	8,107	16,838	166,791	9,655	5,590	48,099
2005	157,177	26,801	198,563	6,497	175,586	8,276	17,153	166,989	9,879	5,615	49,947
2006	154,900	20,584	199,009	5,741	178,511	7,959	17,187	166,481	10,006	5,660	49,706
2007	160,930	25,670	209,739	6,538	181,168	8,353	18,012	168,783	10,608	5,795	49,821
2008	153,153	24,885	201,452	5,725	174,109	8,007	16,653	164,037	9,180	5,501	48,657
2009	160,080	26,603	209,434	6,394	176,127	8,264	17,444	167,098	10,120	5,734	50,122
2010	158,798	25,652	201,420	6,555	177,806	8,207	17,572	167,891	9,470	5,467	49,036
2011	158,711	25,636	201,095	6,551	177,827	8,226	17,663	167,880	9,488	5,467	49,037
2012	158,839	25,598	200,918	6,548	178,849	8,366	17,694	169,017	9,517	5,494	49,507
2013	158,977	25,597	200,871	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2014	158,977	25,597	200,871	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2015	158,977	25,597	200,871	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184

Table 13. CPNRD county summary of groundwater only irrigated lands robust review baseline land use data set within the Platte River drainage basin.

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
2016	158,977	25,597	200,871	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2017	158,977	25,597	200,871	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2018	158,977	25,597	201,154	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2019	158,977	25,597	201,175	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2020	158,977	25,597	201,215	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2021	158,977	25,597	201,411	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2022	158,977	25,597	201,536	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2023	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2024	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2025	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2026	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2027	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2028	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2029	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2030	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2031	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2032	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2033	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2034	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2035	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2036	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2037	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2038	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2039	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2040	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2041	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2042	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184

Table 13. CPNRD county summary of groundwater only irrigated lands robust review baseline land use data set within the Platte River drainage basin.

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
2043	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2044	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2045	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2046	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2047	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2048	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2049	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2050	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2051	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2052	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2053	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2054	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2055	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2056	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2057	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2058	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2059	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2060	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2061	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2062	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2063	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184

Table 14. CPNRD county summary of groundwater only irrigated lands robust review Unretired Scenario land use data set within the Platte River drainage basin

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
1950	37,762	403	27,603	-	37,736	883	253	20,580	147	128	1,993
1951	38,107	596	26,837	-	38,967	897	220	18,220	151	118	1,798
1952	38,427	459	26,426	-	40,282	848	185	15,861	147	106	1,643
1953	38,597	665	26,443	-	41,454	732	120	13,497	142	84	1,492
1954	38,666	773	27,722	-	42,551	581	86	11,113	141	81	1,130
1955	41,954	1,217	35,370	58	49,528	801	233	15,930	171	143	2,320
1956	45,461	1,496	43,159	169	56,170	1,009	394	20,720	269	225	3,061
1957	49,047	1,920	50,373	281	62,398	1,414	537	25,320	332	308	3,654
1958	53,017	2,174	56,490	320	69,341	1,734	684	30,108	402	399	4,614
1959	56,831	2,538	63,779	467	76,263	2,064	839	34,889	461	463	5,564
1960	58,002	2,713	64,133	539	78,417	2,243	1,042	38,829	618	571	7,274
1961	59,070	2,720	64,176	743	80,640	2,437	1,231	42,804	777	697	8,867
1962	60,251	2,832	64,471	736	82,921	2,627	1,464	46,798	924	811	10,471
1963	61,508	2,897	65,015	757	85,219	2,794	1,726	50,688	1,055	960	12,021
1964	62,477	2,999	64,950	692	87,092	3,013	1,967	54,585	1,186	1,037	13,377
1965	66,237	4,116	67,193	1,321	90,683	3,336	2,934	59,623	1,479	1,245	15,514
1966	70,468	5,058	69,130	1,622	94,197	3,589	3,854	64,682	1,746	1,457	17,938
1967	74,334	5,991	71,527	1,604	97,700	3,941	4,620	69,571	2,128	1,747	20,017
1968	78,123	6,844	73,929	1,882	101,499	4,196	5,374	74,403	2,344	2,023	22,083
1969	82,200	7,897	76,229	1,952	105,122	4,571	6,004	79,254	2,629	2,247	24,402
1970	87,492	8,703	86,185	2,361	111,092	5,086	6,264	83,830	2,763	2,435	25,756
1971	92,693	9,677	96,303	2,716	116,659	5,494	6,653	88,377	2,817	2,591	27,204
1972	97,300	10,303	106,747	2,779	122,400	5,927	6,868	92,665	2,997	2,692	28,564
1973	102,091	10,972	117,177	3,115	128,025	6,208	7,180	97,095	3,239	2,769	29,910
1974	107,137	11,682	128,835	3,299	134,016	6,529	7,745	101,782	3,701	2,883	31,597
1975	113,477	12,343	131,307	3,729	140,112	7,102	8,629	108,551	4,351	3,245	33,686
1976	119,342	13,080	131,715	3,880	145,777	7,761	9,305	115,018	4,703	3,529	36,078

Table 14. CPNRD county summary of groundwater only irrigated lands robust review Unretired Scenario land use data set within the Platte River drainage basin

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
1977	125,234	14,189	134,265	4,265	151,367	8,165	9,700	121,795	5,013	3,975	38,676
1978	131,712	15,294	135,229	4,481	157,612	8,790	10,515	128,568	5,552	4,204	40,768
1979	134,109	16,383	139,184	4,258	158,836	8,821	10,721	129,758	5,521	4,118	40,194
1980	136,916	17,154	144,644	4,369	160,116	8,885	11,049	130,886	5,535	4,072	39,334
1981	140,740	17,830	149,214	4,153	161,744	8,916	11,280	132,063	5,515	4,060	38,683
1982	143,696	18,401	153,794	4,352	162,727	8,875	11,506	133,142	5,602	4,049	37,629
1983	141,431	18,283	151,087	4,299	160,240	8,682	11,062	130,910	5,657	4,100	37,832
1984	138,674	17,680	148,292	4,114	157,198	8,518	10,718	128,660	5,748	4,180	37,916
1985	136,892	20,044	167,652	4,968	164,849	7,076	12,491	159,367	8,353	4,601	32,525
1986	137,539	19,686	165,401	4,908	164,844	7,009	12,207	159,463	8,300	4,618	32,716
1987	137,860	19,173	161,908	4,806	164,424	6,891	11,651	159,519	8,269	4,663	33,058
1988	139,189	19,298	161,898	4,856	165,411	6,922	12,088	160,269	8,208	4,649	32,902
1989	141,513	19,445	161,755	4,799	166,906	7,086	12,511	161,685	8,244	4,643	32,802
1990	143,133	19,617	161,661	4,738	167,819	7,123	12,947	162,973	8,355	4,653	32,667
1991	144,709	19,839	161,577	4,677	168,815	7,142	13,356	163,767	8,293	4,646	32,489
1992	146,861	20,421	162,174	4,657	170,202	7,228	14,126	164,798	8,275	4,614	32,151
1993	147,684	20,520	161,850	4,622	170,367	7,279	14,342	165,307	8,303	4,660	33,606
1994	148,773	20,652	161,543	4,588	170,656	7,333	14,596	165,575	8,352	4,705	35,069
1995	149,833	20,813	161,411	4,556	171,142	7,392	14,799	165,806	8,419	4,755	36,563
1996	151,466	21,029	161,880	4,545	172,077	7,454	15,043	166,300	8,594	4,809	38,025
1997	153,438	21,351	161,687	4,525	172,431	7,594	15,376	166,805	8,835	4,911	40,738
1998	153,705	21,350	166,075	4,818	172,379	7,688	15,424	166,293	8,909	5,024	41,170
1999	153,876	21,310	170,164	5,087	172,366	7,796	15,435	165,758	8,923	5,121	41,716
2000	154,472	21,287	174,425	5,334	172,745	7,855	15,322	165,360	8,952	5,298	42,152
2001	154,078	21,135	182,288	5,915	172,816	7,842	15,601	164,534	9,087	5,416	42,703
2002	155,328	22,224	185,387	6,214	173,663	7,867	15,643	166,170	9,211	5,535	44,593
2003	156,124	24,687	189,865	6,250	174,370	7,913	16,280	166,310	9,426	5,563	46,421

Table 14. CPNRD county summary of groundwater only irrigated lands robust review Unretired Scenario land use data set within the Platte River drainage basin

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
2004	156,962	25,772	194,100	6,499	175,299	8,107	16,838	166,791	9,655	5,590	48,099
2005	157,177	26,801	198,867	6,497	175,586	8,276	17,153	166,989	9,879	5,615	49,947
2006	154,910	20,584	199,713	5,741	178,511	7,959	17,187	166,481	10,006	5,660	49,706
2007	160,941	25,670	210,555	6,538	181,168	8,353	18,012	168,783	10,608	5,795	49,821
2008	153,163	24,885	202,321	5,725	174,109	8,007	16,653	164,037	9,180	5,501	48,657
2009	160,434	26,603	211,264	6,394	176,315	8,264	17,444	167,098	10,120	5,734	50,122
2010	159,154	25,652	203,499	6,555	178,006	8,207	17,572	167,946	9,470	5,467	49,036
2011	159,116	25,642	203,502	6,551	178,075	8,226	17,663	167,935	9,488	5,467	49,037
2012	159,286	25,604	203,493	6,548	179,097	8,366	17,694	169,072	9,517	5,494	49,507
2013	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2014	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2015	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2016	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2017	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2018	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2019	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2020	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2021	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2022	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2023	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2024	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2025	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2026	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2027	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2028	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2029	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2030	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184

Table 14. CPNRD county summary of groundwater only irrigated lands robust review Unretired Scenario land use data set within the Platte River drainage basin

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
2031	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2032	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2033	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2034	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2035	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2036	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2037	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2038	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2039	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2040	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2041	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2042	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2043	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2044	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2045	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2046	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2047	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2048	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2049	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2050	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2051	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2052	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2053	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2054	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2055	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2056	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2057	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184

Table 14. CPNRD county summary of groundwater only irrigated lands robust review Unretired Scenario land use data set within the Platte River drainage basin

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
2058	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2059	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2060	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2061	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2062	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2063	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184

Memorandum

To: John Thorburn – Tri-Basin NRD; Kari Burgert – NDNR
From: The Flatwater Group, Inc.
Date: 10/17/2018
Subject: COHYST Area Robust Review: TBNRD Land Use Retirements, Transfers, and Variances

Project Background and Workflow

The Flatwater Group, Inc. (TFG) was contracted by the Platte Basin Water Project Coalition through the Nebraska Department of Natural Resources (NDNR) to provide technical assistance for the Robust Review project. The purpose of the Robust Review project is to assess streamflow impacts resulting from management actions taken as part of the Basin-Wide Plan and/or Natural Resource District (NRD) Integrated Management Plans (MPs). The focus of this memorandum is to document land use changes related to acreage transfers, retirements, and variances within the Tri-Basin NRD (TBNRD).

To account for transfers, retirements, and variances within TBNRD, TFG's primary work tasks included evaluating and summarizing the available datasets related to transfers, retirements, and variances; then spatially placing these transactions within the constructs of the COHYST 2010 watershed model's land use files to extend the baseline land use through 2013; and to then create a new land use data set for the unretired acreage scenario. For the first step in the process, TFG worked with NDNR and TBNRD to gather the land use data (retirements, transfers, and variances) and place it into summary tables by land use type. TFG's next steps were to perform geospatial analyses using ArcGIS to identify the location of each transaction. The geospatial analysis included a proximity function in the form of a custom Fortran program to determine the closest available model cells capable of accommodating the specified land use change.

This memorandum presents a series of tables which summarize the annual number of acres retired or transferred within the TBNRD, outlines the spatial analysis methodology, and ultimately summarizes the resultant land use files.

Land Use Summary Tables

Using information provided by TBNRD, NDNR, and other basin NRDs, TFG compiled a final summary of the retirements, transfers, and variances occurring within the TPNRD assigned model domain. This information was used to modify the land use data set in the COHYST 2010 model to investigate the effects of these actions as part of the larger Robust Review effort. Tables 1-10 below summarize the information provided to TFG. Tables 11-20 summarize the distribution of that information into the modeling input files.

Table 1 provides an overall summary of the retirement and transfer acreage source information relevant to the TBNRD received by TFG. Columns A through E on Table 1 summarize the information provided by TBNRD and NDNR. Columns F through I summarize information tracked by other basin NRDs, but whose spatial location upon distribution to the model placed acreage within the model domain assigned to the TBNRD. Subsequent tables will define the source(s) of this information.

Table 1. Summary of TBNRD acreage changes for implementation into the Robust Review.

	TBNRD Data					Non-TBNRD Data				
Year	(A) Temporary Retirements	(B) Reinstated Temporary Retirements	(C) Permanent Retirements	(D) Transfers To	(E) Transfers Away	(F) Temporary Retirements	(G) Reinstated Temporary Retirements	(H) Permanent Retirements	(I) Transfers To	(J) Change
Baseline Change	(-)	(+)	(-)	(+)	(-)	(-)	(+)	(-)	(+)	
1999	1.9	-	-	-	-	-	-	-	-	(1.9)
2000	293.6	-	-	-	-	-	-	-	-	(293.6)
2001	408.6	-	-	-	-	-	-	-	-	(408.6)
2002	-	-	-	-	-	-	-	-	-	-
2003	-	-	-	-	-	-	-	-	-	-
2004	77.5	-	-	-	-	-	-	-	-	(77.5)
2005	259.4	7.0	-	-	-	-	-	-	-	(252.4)
2006	163.9	-	-	-	-	-	-	-	-	(163.9)
2007	219.8	-	-	-	-	-	-	-	-	(219.8)
2008	697.8	77.5	73.1	-	-	-	-	-	-	(693.4)
2009	167.9	223.7	-	-	-	0.7	-	149.1	-	(94.0)
2010	127.3	423.6	-	-	-	-	-	-	-	296.3
2011	111.3	610.3	-	178.7	246.7	-	-	-	-	431.0
2012	-	427.5	-	118.3	118.3	-	-	-	-	427.5
2013	-	450.4	-	229.4	168.5	-	-	-	1.4	512.7
2014	-	142.1	-	-	-	-	-	-	-	142.1
2015	-	127.9	-	-	-	-	-	-	-	127.9
2016	-	-	-	-	-	-	-	-	-	-
2017	-	39.0	-	-	-	-	-	-	-	39.0
2018	-	-	-	-	-	-	-	-	-	-
2019	-	-	-	-	-	-	-	-	-	-
2020	-	-	-	-	-	-	-	-	-	-

Table 1. Summary of TBNRD acreage changes for implementation into the Robust Review.

	TBNRD Data					Non-TBNRD Data				
Year	(A) Temporary Retirements	(B) Reinstated Temporary Retirements	(C) Permanent Retirements	(D) Transfers To	(E) Transfers Away	(F) Temporary Retirements	(G) Reinstated Temporary Retirements	(H) Permanent Retirements	(I) Transfers To	(J) Change
2021	-	-	-	-	-	-	0.7	-	-	0.7
2022	-	-	-	-	-	-	-	-	-	-
2023	-	-	-	-	-	-	-	-	-	-
Total	2,529.0	2,529.0	73.1	526.4	533.5	0.7	0.7	149.1	1.4	(227.9)

Data Source Discussion for Table 1 Columns A through C

The TBNRD provided several spreadsheets containing information which were used to populate Table 1. Ultimately, two spreadsheets provided by the TBNRD on 7/17/2017 to TFG served as the TBNRD source information for the table:

TBNRD AppendixI_Conservation practices.xlsx

Platte_CIA_Permits_Changes_updates.xlsx

A third spreadsheet, *Robust_COHYST_Platte_data.xlsx*, was also provided to TFG; however, information relevant to the Robust Review that was contained in that spreadsheet was also contained in the two above spreadsheets and thus *Robust_COHYST_Platte_data.xlsx* was not used as an independent source of information by TFG.

The spreadsheets summarized information related to multiple conservation programs and categorized information accordingly. For the purposes of the Robust Review, TFG needed to designate those categories as being either a retirement (either temporary or permanent) or a transfer. Tables 2-4 below provide a mapping of the categories which were assigned to either temporary or permanent retirements in Table 1. The column headers in the tables indicate the TBNRD assigned category mapped to the Table 1 column indicated by the title of the table. Those table titles are:

Table 2: Summary of temporary retirement acreage in the TBNRD - This is Column A in Table 1

Table 3: Summary of permanent retirement acreage in the TBNRD - This is Column C in Table 1

Table 4: Summary of temporary retirement acreage reinstated in the TBNRD - This is Column B in Table 1

Table 2. Summary of temporary retirement acreage in the TBNRD

Year	Conservation Corners	Buffer Strips	Pheasants Forever	TBNRD EQIP	CRP Reinstatements	DNR CREP/EQIP	Temporary Retirements
1999	-	1.9	-	-	-	-	1.9
2000	-	28.3	7.0	-	258.3	-	293.6
2001	-	-	-	-	408.6	-	408.6
2002	-	-	-	-	-	-	-
2003	-	-	-	-	-	-	-
2004	-	-	-	77.5	-	-	77.5
2005	-	16.6	21.0	221.8	-	-	259.4
2006	-	-	17.9	116.0	-	30.0	163.9
2007	-	9.0	27.0	183.8	-	-	219.8
2008	126.8	-	13.0	400.5	-	157.5	697.8
2009	-	-	14.8	153.1	-	-	167.9
2010	-	-	-	127.3	-	-	127.3
2011	-	-	-	111.3	-	-	111.3
2012	-	-	-	-	-	-	-
2013	-	-	-	-	-	-	-
Total	126.8	55.8	100.7	1,391.3	666.9	187.5	2,529.0

Table 3. Summary of permanent retirement acreage in the TBNRD

Year	Conservation Easements	Permanent Retirements
1999	-	-
2000	-	-
2001	-	-
2002	-	-
2003	-	-
2004	-	-
2005	-	-
2006	-	-
2007	-	-
2008	73.1	73.1
2009	-	-
2010	-	-
2011	-	-
2012	-	-
2013	-	-
Total	73.1	73.1

Table 4. Summary of temporary retirement acreage reinstated in the TBNRD

Year	Conservation Corners	Buffer Strips	Pheasants Forever	TBNRD EQIP	CRP Reinstatements	DNR CREP/EQIP	Temporary Retirements
2005	-	-	7.0	-	-	-	7.0
2006	-	-	-	-	-	-	-
2007	-	-	-	-	-	-	-
2008	-	-	-	77.5	-	-	77.5
2009	-	1.9	-	221.8	-	-	223.7
2010	-	28.3	21.0	116.0	258.3	-	423.6
2011	-	-	17.9	183.8	408.6	-	610.3
2012	-	-	27.0	400.5	-	-	427.5
2013	126.8	-	13.0	153.1	-	157.5	450.4
2014	-	-	14.8	127.3	-	-	142.1
2015	-	16.6	-	111.3	-	-	127.9
2016	-	-	-	-	-	-	-
2017	-	9.0	-	-	-	30.0	39.0
Total	126.8	55.8	100.7	1,391.3	666.9	187.5	2,529.0

The information under the column names on Tables 2-4 all originated in the spreadsheets provided by the TBNRD with the exception of "DNR CREP/EQIP" which summarized processed information from NDNR. The spreadsheet *TBNRD AppendixI_Conservation practices .xlsx* contained the only reference to a category TFG assigned to permanent retirements. Key elements regarding that category along with a reference to the table the category is considered in are shown below.

Conservation Easements
- 2 entries
- Table 3

With regards to temporary retirement information from the TBNRD, following are a few key elements regarding each of those categories along with a reference to which table number(s) the category is considered. With the exception of the category "CRP Reinstatements", information for all categories was taken from the file *TBNRD AppendixI_Conservation practices .xlsx*. As indicated below, the "CRP Reinstatements" information was taken from *Platte_CIA_Permits_Changes_updates.xlsx.*

Conservation Corners
- Contracts are for 5 years
- 11 entries
- Table 2 & Table 4

Buffer Strips
- Contracts are for 10 years
- 6 entries
- Table 2 & Table 4

Pheasants Forever
- Contract are for 5 years
- 15 entries
- Table 2 & Table 4

CRP Reinstatements – (Note data source was *Platte_CIA_Permits_Changes_updates.xlsx*)
- Assumed 10 year contract duration – provided information only specified when the acres were reinstated. No contract start date information was provided.
- 4 entries
- Table 2 & Table 4

CREP
- 1 entry
- The CREP entry was for 30 acres for the period 2006-2016. This entry was also in the DNR data set. The DNR data set was used due to the accompanying shape file.
- Table 2

TBNRD EQIP (EQIP)
- Contracts appears to be for 4 years
- 95 entries. Entries were cross referenced with information provided by NDNR to ensure acreage was neither double accounted for nor overlooked.
- Table 2 & Table 4

With regards to the CREP and EQIP programs, as indicated in the above discussion TFG received information from both the TBNRD and NDNR. To supplement the information provided by TBNRD, NDNR provided the shape file *CREP* on 8/17/2017. It was augmented by the spreadsheet *20170829_COHYSTAreaMissingDates.xlsx* provided on 8/29/2017 which provided additional contract start/end dates that were missing from the shape file attribute information.

This shape file included the most up to date list of CREP and EQIP contracts available from NDNR at that time. TFG spatially queried the data in the CREP shape file to obtain only the parcels located within the TBNRD. That query returned 114 parcels. Those parcels all had designations of either CREP, EQIP, or TBEQIP. Table 5 shows the number of acres represented by those 114 parcels.

Table 5. DNR CREP and EQIP temporary retirements within the TBNRD.

Year	CREP	EQIP	TBEQIP
2005	-	169.7	-
2006	1,029.8	-	-
2007	416.7	-	-
2008	16.6	-	380.1
2009	-	-	-
2010	2.6	-	-
Total	1,465.7	169.7	380.1

For inclusion in the Robust Review. the information was further limited to:

- Contracts initiated prior to the end of 2013
- Parcels located within the drainage area of the Platte River
- Contracts referencing acreage only irrigated with ground water

As a final QC step, the remaining records were compared to the information contained in the TBNRD spreadsheet *TBNRD AppendixI_Conservation practices.xlsx,* sheets 'EQIP D land' and 'CREP Acres'. The location and contract timing of the 'EQIP D land' records did not overlap with records in CREP shape file. The entry from 'CREP Acres', however, did match a record in the CREP shapefile. TFG elected to use the entry from the CREP shape file due to the spatial definition provided in the shapefile.

At the conclusion of this process, 21 parcels remained and were considered in the Robust Review. Table 6 below shows the number of acres represented by those parcels and are the values shown in columns "DNR CREP/EQIP" on Tables 2 and 4.

Table 6. DNR CREP and EQIP temporary retirements within the Platte River Basin area of the TBNRD.

Year	CREP	TBEQIP	End Year
2005	-	-	
2006	30.0	-	2017
2007	-	-	
2008	-	157.5	2013
2009	-	-	
2010	-	-	
Total	30.0	157.5	

Data Source Discussion for Table 1 Columns D and E

The information presented in Columns D and E of Table 1 represents the available acreage transfer information which was all provided to TFG in the spreadsheet *Platte_CIA_Permits_Changes_updates.xlsx*.

The spreadsheet contained information regarding two types of transfers. The first type of transfer involved moving the source of the irrigation water, while the field where the irrigation water was applied remains unchanged. This type of transfer did not require any action to be taken for the Robust Review. These transfers were listed in the sheets 'G Water Transf_Exsisting' and 'G Water Transfers' within *Platte_CIA_Permits_Changes_updates.xlsx.*

The second type of transfer involved transferring the location of where the irrigation water was applied. These types of transfers were recorded on sheet 'Acres Transfers' in spreadsheet *Platte_CIA_Permits_Changes_updates.xlsx*. The spreadsheet listed records for 109 such transfers. Of these, 25 occurred within a time frame that could have potentially impacted the 2011-2013 irrigation seasons. These records were compared to information on file at NDNR and TFG received confirmation on 11/14/2017 via email from NDNR that the TBNRD and NDNR information was in general agreement. Columns A and B in Table 7 below summarize that information.

Table 7. Summary of transfer acres in the TBNRD

TBNRD			To		From	
Year	(A) To	(B) From	(C) Current Year	(D) Next Year	(E) Current Year	(F) Next Year
2010	74.4	75.7	48.7	25.7	50.0	25.7
2011	158.0	158.0	153.0	5.0	153.0	5.0
2012	188.4	194.1	113.3	75.1	113.3	80.8
2013	234.3	250.8	154.3	80.0	164.8	86.0

The transfers represented on Table 7 occurred on or after July 1, 2010 and before July 1, 2013. This was based upon the 'Date Approved' field in the spreadsheet (*Platte_CIA_Permits_Changes_updates.xlsx*) information. For the purposes of inclusion in the Robust Review, it was decided that If the transfer occurred after July 1, it was likely that the original field was still irrigated in the transfer year; as the late year transfers typically happened in the fall (October-December). For transfers occurring on or before July 1, it was assumed that irrigation water was applied in the alternate (transfer) location. Columns C through F on Table 7 present a breakdown of the acreage based on the July 1 implementation date. Columns C and D partition the "Transfer To" acreage (Column A) while Columns E and F partition the "Transfer From" acreage (Column B). Table 8 presents summarizes the transfer acreage amounts after the July 1 timing criteria is applied.

Table 8. Summary of transfer acres in the TBNRD adjusted for timing within the year.

Adjusted		
Year	To	From
2011	178.7	178.7
2012	118.3	118.3
2013	229.4	245.6

The spreadsheet *Platte_CIA_Permits_Changes_updates.xlsx* also contained information on wells converted for use for irrigation to use for watering livestock. The tab 'Conversion' in the spreadsheet contained four such entries, two of which occurred in the 2011-2013 timeframe. For the purposes of the Robust Review, those transactions were considered to be transfers. Table 9 incorporates these conversions with the Table 8 transfer information to provide the total Transfer To (Column A) and Transfer Away (Column D) values reflected on Table 1.

Table 9. Summary of transfer acres in the TBNRD

Year	(A) Transfer To	(B) Transfer Away	(C) Conversions	(D) Total Transfer Away
2011	178.7	178.7	67.9	246.7
2012	118.3	118.3	-	118.3
2013	229.4	168.5[1]	-	168.5
Total	526.4	465.6	67.9	533.5

Data Source Discussion for Table 1 Columns F through I

In addition to the information provided by TBNRD, the Central Platte Natural Resources District (CPNRD) identified retirements, transfers, and variances which were placed in cells assigned to the TBNRD in the Platte Basin. This information included transfers to (CPNRD Acres Added), permanent retirements (CPNRD Acres Offset WB), and temporary retirements (CPNRD CREP). The scope of these transactions is defined in Table 10, and depict the Non-TBNRD data in Table 1.

Table 10. DNR CREP and EQIP temporary retirements within the Platte River drainage Basin.

Year	CPNRD Acres Added	CPNRD Acres Offset WB	CPNRD CREP Retirement	CPNRD CREP Reinstatement
2009	-	149.1	0.7	-
2010	-	-	-	-
2011	-	-	-	-
2012	-	-	-	-
2013	1.4	-	-	-
2014	-	-	-	-
2015	-	-	-	-
2016	-	-	-	-
2017	-	-	-	-
2018	-	-	-	-
2019	-	-	-	-
2020	-	-	-	-
2021	-	-	-	0.7

[1] Transfer acres were subject to the same limitations as CREP/EQIP acreage. Table 13 traces the source of the 168.5 value for 2013.

Other Information Provided By TBNRD

The spreadsheet *Platte_CIA_Permits_Changes_updates.xlsx* contained some additional information which was not included into the current Robust Review. The sheet 'Variances' summarized actions taken by the TBNRD which categorized as Variances. These actions tended to be administrative in nature rather than identifying acreage type changes. The POAC group decided in August 2017 to not consider these types of actions in the current Robust Review project.

The same spreadsheet also contained a sheet named 'Corrections' which contained a set of information regarding administrative changes related to the number of irrigated acres rather than changes to acreage locations. No action was taken on these entries.

SPATIAL ANALYSIS METHODOLOGY

ArcGIS was used to link the retirements, transfers and variances to the COHYST model grid. This was accomplished either by overlaying the parcels' shape file with the model grid or linking the parcels' legal description to model cells.

Step 1: Assigning land use change locations within the model

Each of the transactions provided by TBNRD included a legal description. These descriptions typically included the quarter section in which the transaction took place. This information was linked to the COHYST 2010 model grid. COHYST uses a grid of 160-acre sized model cells; but, the cell boundaries and the section lines do not overlap. To accommodate this, the section shape file was spatially joined with the cell centroid. Typically, this would result in 4 cells being assigned to a section as represented on Table 11. Using the quarter section identifier, the cell which best represented the spatial location of the transaction was assigned the placement.[2]

Table 11. Approach used to link legal descriptions to model cell locations.

Cell Index	Row	Column	Quarter
Cell	x	y	NW
Cell + 1	x	y + 1	NE
Cell + 504	x + 1	y	SW
Cell + 505	x + 1	y + 1	SE

In a similar way the model cells were assigned to counties, NRDs, and drainage basins. In general, features were assigned to cells based on the location of the cell's centroid in relation to the border of interest. This results in a model cell being assigned a single value for a given feature class. For example, if the border of an NRD passes through a model cell, whichever NRD the cell's centroid is within determines which NRD the cell is assigned to within the model. For this reason, it is possible to have an activity which occurs within a cell along a feature border to be enacted by one entity that shares the border, but for the model to summarize the activity to the other entity which shares the border.

The data on Table 12 below illustrates just that type of effect. The acreage retirement information in Column A of Table 12 matches that shown in the 'TBNRD EQIP' column of Table 2. These again are retirements related to the EQIP program initiated by the TBNRD within the Platte Basin area of the District. However, when these actions are assigned within the model, a small number of acres are assigned to cells which have been assigned to a river basin outside of the Platte Basin. Columns B and C in Table 12 present the effect of this distribution within the model (Column B – acreage distributed to cells assigned within the model to be in the Platte Basin drainage area; Column C – acreage distributed to cells assigned within the model to a drainage basin outside of the Platte Basin). Likewise, Column D matches the acreage reinstatement information shown in the 'TBNRD EQIP' column of Table 4. Columns E and F reflect the distribution of that acreage inside of and outside of the Platte Basin, respectively.

[2] For irregular sections, the cell-section relationship and professional judgement was used to place the transaction acres as close as possible to the defined location.

Table 12. Distribution of the TBNRD EQIP acres between the Platte River Basin and the rest of the NRD[3].

Year	(A) Total EQUP TBNRD Retirements	(B) EQIP TBNRD Platte Basin Retirements	(C) EQIP TBNRD Non-Platte Basin Retirements	(D) Total EQUP TBNRD Reinstatements	(E) EQIP TBNRD Platte Basin Reinstatements	(F) EQIP TBNRD Non-Platte Basin Reinstatements
2004	77.5	50.0	27.5	-	-	-
2005	221.8	221.8	-	-	-	-
2006	116.0	116.0	-	-	-	-
2007	183.8	183.8	-	-	-	-
2008	400.5	400.5	-	77.5	50.0	27.5
2009	153.1	116.1	37.0	221.8	221.8	-
2010	127.3	127.3	-	116.0	116.0	-
2011	111.3	111.3	-	183.8	183.8	-
2012	-	-	-	400.5	400.5	-
2013	-	-	-	153.1	116.1	37.0
2014	-	-	-	127.3	127.3	-
2015	-	-	-	111.3	111.3	-
Total	1,391.3	1,326.8	64.5	1,391.3	1,326.8	64.5

The distribution of the Transfer Acres summarized in Table 8 encountered a similar issue. The acreage values in Column A on Table 13 matches those shown in the column 'From' in Table 8. Columns B and C in Table 13 reflect the distribution of those acres to cells defined as being either within the CPNRD (Column B) or the TBNRD (Column C). The acreage listed in Column C is then summarized based on whether the distribution placed the acreage within cells identified as being within either the Platte Basin (Column D) or outside of the Platte Basin (Column E) areas of the TBNRD.

Table 13. Distribution of TBNRD transfers away between applied NRDs and river basins[4].

Year	(A) Transfer Away Total	(B) Applied in CPNRD	(C) Applied In TBNRD	(D) TBNRD Platte	(E) TBNRD Non-Platte
2011	178.7	-	178.7	178.7	-
2012	118.3	-	118.3	118.3	-
2013	245.6	77.1	168.5	160.3	8.2

[3]TBNRD only provided EQIP contracts acreage for the Platte River Basin. However, some of these acres, while in the Platte Basin, were assigned to cells which were not in the Platte Basin. This is caused by the drainage boundary differing from cell boundaries.

[4] TBNRD only provided transfer acreage for the Platte River Basin. However, some of these acres, while in the Platte Basin, were assigned to cells which were not in the Platte Basin. This is caused by the drainage boundary differing from cell boundaries.

Step 2: Building the Baseline Land Use Update

The next step was to build the 2011-2013 land use files incorporating the identified transfers and retirements. The beginning condition for this update is the 2010 land use file from the COHYST 2010 model. Each of the 2011 transactions were applied to the 2010 land use to create the 2011 land use file; which in turn became the basis for applying the 2012 transactions. This continued through 2013. One of the key points of investigation is the effect of retirements on the system. Given that many of the retirements were temporary in nature and knowing their contract end dates, the land use file building process was continued through 2023 to be able to add back in all the temporarily retired acres.[5]

Acres were to be added or removed from their assigned cells. If there was insufficient space[6] for new acres or an insufficient amount of groundwater only acres[7] to be retired within the cell, the addition or subtraction of acres was applied to nearby cells which exhibit the appropriate characteristics[8]. This spatial analysis process entails radiating outward from the identified cell until the acres had been placed. During this process acres are placed or removed from the lowest priority cell which meets the appropriate criteria. If more than one cell has the same priority and meets criteria, the acres are split evenly between the multiple cells. This occurs unless an even split would exceed the available space within a given cell at which time the placed acres would be limited to the available space and the remaining acres would be evenly split among the other priority cells. The priority pattern for the first two rings around the assignment cell can be seen in Figure 1. This process was implemented using a custom FORTRAN script.

5 (r-2, c-2)	4 (r-2, c-1)	3 (r-2, c+0)	4 (r-2, c+1)	5 (r-2, c+2)
4 (r-1, c-2)	2 (r-1, c-1)	1 (r-1, c+0)	2 (r-1, c+1)	4 (r-1, c+2)
3 (r+0, c-2)	1 (r+0, c-1)	0 (r+0, c+0)	1 (r+0, c+1)	3 (r+0, c+2)
4 (r+1, c-2)	2 (r+1, c-1)	1 (r+1, c+0)	2 (r+1, c+1)	4 (r+1, c+2)
5 (r+2, c-2)	4 (r+2, c-1)	3 (r+2, c+0)	4 (r+2, c+1)	5 (r+2, c+2)

Figure 1. Priority of search pattern to place or remove acres when the assigned cell has insufficient non-irrigated or groundwater only acres.

[5] 2023 was identified as the year the last temporary retirement would be actively irrigated again for the first time
[6] Example: transferring 30 groundwater only acres to a cell where there was only 20 non-irrigated acres
[7] Example: retiring 30 groundwater only acres from a cell where there was only 20 groundwater only acres
[8] The cell needed to be active, in the same NRD, and have a sufficient amount of groundwater only acres to retire or non-irrigated acres to convert

The results of Step 2 are shown in Table 14. As intended, the values in Column B of Table 14 match (sans de minimis rounding resulting from the distribution process) the original source information shown in Column J of Table 1 for the years 2011-2023. This indicates that the acreage values provided by TBNRD and NDNR were the quantities by which the modeling input files were adjusted. The value in Column C of Table 14 matches the value in Column B of Table 13 which again indicates that the model input files were adjusted by the intended values based on the results of the spatial distribution assignments made to the provided input data from TBNRD. As an aside, the distribution routines placed 58.6 of the 77.1 acres shown in Table 14 Column C into Dawson county and the remaining 18.5 acres into Buffalo county.

Table 14. Change in groundwater only irrigated acres within the TBNRD for the Robust Review baseline.

Year	(A) Groundwater Only Irrigated Acres in TBNRD	(B) Annual Change in TBNRD Groundwater Only Irrigated Acres in the TBNRD	(C) Change in TBNRD Groundwater Only Irrigated Acres not in the TBNRD
2010	459,902.8	-	-
2011	460,333.9	431.1	-
2012	460,761.2	427.3	-
2013	461,273.7	512.5	(77.1)
2014	461,415.8	142.1	-
2015	461,543.7	127.9	-
2016	461,543.7	-	-
2017	461,582.7	39.0	-
2018	461,582.7	-	-
2019	461,582.7	-	-
2020	461,582.7	-	-
2021	461,583.4	0.7	-
2022	461,583.4	-	-
2023	461,583.4	-	-

Step 3: Building the Unretired Acres Scenario Modified Land Use

Similarly, a new set of land use files were created for the unretired scenario. In this scenario the permanently and temporarily retired acres were never retired. Other key elements of the scenario include:

- The transfers were applied.
- For the post 2010 period no retirements were applied.
- For permanent retirements, irrigated acres were added back into the modified land use files for all future years.
- For temporary retirements, the acres were added back during their contracted period. If the temporary retirement ended after 2010, the temporarily retired acres added back in 2011 remain moving forward.

Table 15 shows the changes between the COHYST 2010 land use data set (Column A) and the unretired retirements scenario data set (Column B). The difference between the two data sets is a result of incorporating the retirement and transfer acreage information into the model. Again as intended, the annual change in ground water only acres shown on Table 15 (Column D) match (sans de minimis rounding resulting from the distribution process) the original source information shown in Column J of Table 1 for the years 2009-2010 (the sign reversal indicates removal (unretirement) of the acreage). This indicates that the acreage values provided by TBNRD and NDNR were the quantities by which the modeling input files were adjusted.

Table 15. Change in Groundwater Only Irrigated Acres in the TBNRD comparing the COHYST 2010 land use to Unretired Retirements Scenario land use; years 1999-2010.

	Groundwater Only Irrigated Acres		Change in Groundwater Only Irrigated Acres	
Year	(A) Run029	(B) Modified Land Use	(C) Cumulative	(D) Annual
1999	408,126	408,128	1.9	1.9
2000	409,469	409,764	295.5	293.6
2001	409,418	410,122	704.1	408.6
2002	421,829	422,533	704.1	0.0
2003	422,302	423,007	704.2	0.1
2004	423,360	424,142	781.8	77.6
2005	422,424	423,458	1,033.9	252.1
2006	439,644	440,842	1,197.9	164.0
2007	464,704	466,122	1,418.0	220.1
2008	444,988	447,099	2,111.4	693.4
2009	471,247	473,452	2,204.8	93.4
2010	459,903	461,811	1,908.6	(296.2)
		Cumulative		1,908.6

Table 16 shows the changes between the annual COHYST 2010 land use files and the land use files developed for the "unretired" condition within the Robust Review's retirement scenario. Column A in the table presents the annual acreage irrigated only with ground water from 2011 through 2023 for the "unretired" land use data set. Column B summarizes the acreage changes made to arrive at values presented in Column A. Columns C through J present the information used in the computation of the Column B values.

SUMMARY

Tables 14 through 16 summarize the background information as to how the land use files for the Robust Review will be populated. Comparisons back to Table 1 confirm the information provided to TFG by TBNRD, NDNR and other entities referenced in the memorandum were fully included in the model input files. The retirement scenario within the Robust Review involves two land use datasets: the Baseline Set; and the Unretired Set.

For the Baseline Set:

- For the years through 1998: The existing COHYST 2010 land use data set will be used
- For the years 1999 through 2010: Values from Column A in Table 15 will be used
- For the years 2011 through 2023 and forward: Values from Column A in Table 14 will be used

For the Unretired Set:

- For the years through 1998: The existing COHYST 2010 land use data set will be used
- For the years 1999 through 2010: Values from Column B in Table 15 will be used
- For the years 2011 through 2023 and forward: Values from Column A in Table 16 will be used

Table 16. Change in Groundwater Only Irrigated Acres in the TBNRD comparing the COHYST 2010 land use to Unretired Retirements Scenario land use; years 2011-2017.

Year	(A) Groundwater Only Irrigated Acres	(B) =I-G+J Difference in Groundwater only Acres from 2010 minus cumulative prior retirements and transfers	(C) Transfers Away (Table 9, Col D And Table 13, Col D)	(D) Transfers to (Table 9, Col A)	(E) Non Area Transfers Away (Table 13, Col E)	(F) Non Area Transfers To (Table 10)	(G) Net Transfers Away	(H) Cumulative Net Transfers Away	(I) Reinstated Temporary Retirements (Table 2)	(J) Residuals
2011	461,854.8	43.8	246.7[9]	178.7	-	-	67.9	67.9	111.3	0.4
2012	461,854.7	(0.1)	118.3[10]	118.3	-	-	-	67.9	-	(0.1)
2013	461,916.9	62.2	160.3[11]	229.4	8.2	1.4	(62.3)	5.7	-	(0.1)
2014	461,916.9	-					-	5.7		-
2015	461,916.9	-					-	5.7		-
2016	461,916.9	-					-	5.7		-
2017	461,916.9	-					-	5.7		-
2018	461,916.9	-					-	5.7		-
2019	461,916.9	-					-	5.7		-
2020	461,916.9	-					-	5.7		-
2021	461,916.9	-					-	5.7		-
2022	461,916.9	-					-	5.7		-
2023	461,916.9	-					-	5.7		-

[9] Table 9, Column D
[10] Table 9, Column D
[11] Table 13, Column D

Tables 17 and 18 show the annual area of groundwater only irrigated land for each county in the TBNRD within the Robust Review's baseline and unretirement scenarios. Finally, Tables 19 and 20 show the annual area of groundwater only irrigated land for each county in the TBNRD within the Platte River Drainage basin.

Table 17. TBNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Gosper	Kearney	Phelps
1950	-	2,242	2,537
1951	-	3,998	2,777
1952	-	6,293	2,809
1953	-	8,593	3,749
1954	-	10,124	5,131
1955	-	14,150	6,346
1956	-	18,843	8,376
1957	-	23,410	11,750
1958	-	27,870	11,977
1959	1,164	32,496	13,060
1960	2,200	32,722	13,549
1961	3,082	32,987	14,450
1962	3,945	33,235	15,066
1963	4,905	33,438	17,833
1964	5,881	33,921	20,393
1965	8,366	41,783	27,825
1966	11,024	49,365	35,927
1967	13,803	56,675	43,969
1968	16,191	64,484	52,068
1969	19,136	72,225	60,374
1970	21,712	77,738	66,486
1971	24,407	83,602	71,898
1972	27,234	89,777	78,063
1973	29,769	95,315	84,101
1974	32,514	102,037	90,857
1975	37,209	108,257	100,749
1976	41,646	115,304	109,914
1977	46,247	121,588	120,074
1978	50,109	128,065	128,097
1979	53,225	133,332	133,288
1980	53,940	140,155	138,302
1981	55,494	145,561	140,783

Table 18. TBNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set

Year	Gosper	Kearney	Phelps
1950	-	2,242	2,537
1951	-	3,998	2,777
1952	-	6,293	2,809
1953	-	8,593	3,749
1954	-	10,124	5,131
1955	-	14,150	6,346
1956	-	18,843	8,376
1957	-	23,410	11,750
1958	-	27,870	11,977
1959	1,164	32,496	13,060
1960	2,200	32,722	13,549
1961	3,082	32,987	14,450
1962	3,945	33,235	15,066
1963	4,905	33,438	17,833
1964	5,881	33,921	20,393
1965	8,366	41,783	27,825
1966	11,024	49,365	35,927
1967	13,803	56,675	43,969
1968	16,191	64,484	52,068
1969	19,136	72,225	60,374
1970	21,712	77,738	66,486
1971	24,407	83,602	71,898
1972	27,234	89,777	78,063
1973	29,769	95,315	84,101
1974	32,514	102,037	90,857
1975	37,209	108,257	100,749
1976	41,646	115,304	109,914
1977	46,247	121,588	120,074
1978	50,109	128,065	128,097
1979	53,225	133,332	133,288
1980	53,940	140,155	138,302
1981	55,494	145,561	140,783

Table 17. TBNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Gosper	Kearney	Phelps
1982	55,887	150,993	144,299
1983	56,187	149,122	144,750
1984	56,761	147,856	143,892
1985	56,971	157,806	150,247
1986	56,297	157,629	149,714
1987	49,352	156,719	148,311
1988	50,724	159,107	150,150
1989	52,238	161,324	152,772
1990	53,033	163,587	155,668
1991	54,907	166,242	157,356
1992	56,348	169,870	160,700
1993	56,797	171,421	161,580
1994	57,368	173,074	162,570
1995	57,916	174,916	163,327
1996	59,029	177,751	164,645
1997	59,906	180,190	166,474
1998	62,384	179,627	166,025
1999	63,178	179,325	165,623
2000	64,020	179,822	165,627
2001	64,705	179,524	165,188
2002	65,456	187,438	168,936
2003	66,229	187,575	168,498
2004	67,007	187,705	168,648
2005	67,899	187,429	167,096
2006	70,272	196,922	172,450
2007	85,141	200,533	179,031
2008	74,647	198,594	171,748
2009	91,432	200,132	179,683
2010	83,058	197,888	178,957
2011	83,049	198,313	178,972
2012	83,156	198,376	179,230
2013	83,199	198,508	179,567
2014	83,274	198,508	179,634
2015	83,274	198,524	179,746
2016	83,274	198,524	179,746
2017	83,274	198,524	179,785
2018	83,274	198,524	179,785
2019	83,274	198,524	179,785

Table 18. TBNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set

Year	Gosper	Kearney	Phelps
1982	55,887	150,993	144,299
1983	56,187	149,122	144,750
1984	56,761	147,856	143,892
1985	56,971	157,806	150,247
1986	56,297	157,629	149,714
1987	49,352	156,719	148,311
1988	50,724	159,107	150,150
1989	52,238	161,324	152,772
1990	53,033	163,587	155,668
1991	54,907	166,242	157,356
1992	56,348	169,870	160,700
1993	56,797	171,421	161,580
1994	57,368	173,074	162,570
1995	57,916	174,916	163,327
1996	59,029	177,751	164,645
1997	59,906	180,190	166,474
1998	62,384	179,627	166,025
1999	63,178	179,327	165,623
2000	64,020	180,099	165,646
2001	64,705	180,210	165,207
2002	65,456	188,123	168,955
2003	66,229	188,261	168,517
2004	67,007	188,468	168,667
2005	67,906	188,232	167,320
2006	70,330	197,742	172,769
2007	85,216	201,384	179,523
2008	74,828	199,550	172,721
2009	91,811	201,080	180,561
2010	83,454	198,549	179,809
2011	83,428	198,529	179,898
2012	83,428	198,529	179,898
2013	83,423	198,598	179,896
2014	83,423	198,598	179,896
2015	83,423	198,598	179,896
2016	83,423	198,598	179,896
2017	83,423	198,598	179,896
2018	83,423	198,598	179,896
2019	83,423	198,598	179,896

Table 17. TBNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Gosper	Kearney	Phelps
2020	83,274	198,524	179,785
2021	83,274	198,524	179,785
2022	83,274	198,524	179,785
2023	83,274	198,524	179,785
2024	83,274	198,524	179,785
2025	83,274	198,524	179,785
2026	83,274	198,524	179,785
2027	83,274	198,524	179,785
2028	83,274	198,524	179,785
2029	83,274	198,524	179,785
2030	83,274	198,524	179,785
2031	83,274	198,524	179,785
2032	83,274	198,524	179,785
2033	83,274	198,524	179,785
2034	83,274	198,524	179,785
2035	83,274	198,524	179,785
2036	83,274	198,524	179,785
2037	83,274	198,524	179,785
2038	83,274	198,524	179,785
2039	83,274	198,524	179,785
2040	83,274	198,524	179,785
2041	83,274	198,524	179,785
2042	83,274	198,524	179,785
2043	83,274	198,524	179,785
2044	83,274	198,524	179,785
2045	83,274	198,524	179,785
2046	83,274	198,524	179,785
2047	83,274	198,524	179,785
2048	83,274	198,524	179,785
2049	83,274	198,524	179,785
2050	83,274	198,524	179,785
2051	83,274	198,524	179,785
2052	83,274	198,524	179,785
2053	83,274	198,524	179,785
2054	83,274	198,524	179,785
2055	83,274	198,524	179,785
2056	83,274	198,524	179,785
2057	83,274	198,524	179,785

Table 18. TBNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set

Year	Gosper	Kearney	Phelps
2020	83,423	198,598	179,896
2021	83,423	198,598	179,896
2022	83,423	198,598	179,896
2023	83,423	198,598	179,896
2024	83,423	198,598	179,896
2025	83,423	198,598	179,896
2026	83,423	198,598	179,896
2027	83,423	198,598	179,896
2028	83,423	198,598	179,896
2029	83,423	198,598	179,896
2030	83,423	198,598	179,896
2031	83,423	198,598	179,896
2032	83,423	198,598	179,896
2033	83,423	198,598	179,896
2034	83,423	198,598	179,896
2035	83,423	198,598	179,896
2036	83,423	198,598	179,896
2037	83,423	198,598	179,896
2038	83,423	198,598	179,896
2039	83,423	198,598	179,896
2040	83,423	198,598	179,896
2041	83,423	198,598	179,896
2042	83,423	198,598	179,896
2043	83,423	198,598	179,896
2044	83,423	198,598	179,896
2045	83,423	198,598	179,896
2046	83,423	198,598	179,896
2047	83,423	198,598	179,896
2048	83,423	198,598	179,896
2049	83,423	198,598	179,896
2050	83,423	198,598	179,896
2051	83,423	198,598	179,896
2052	83,423	198,598	179,896
2053	83,423	198,598	179,896
2054	83,423	198,598	179,896
2055	83,423	198,598	179,896
2056	83,423	198,598	179,896
2057	83,423	198,598	179,896

Table 17. TBNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Gosper	Kearney	Phelps
2058	83,274	198,524	179,785
2059	83,274	198,524	179,785
2060	83,274	198,524	179,785
2061	83,274	198,524	179,785
2062	83,274	198,524	179,785
2063	83,274	198,524	179,785

Table 18. TBNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set

Year	Gosper	Kearney	Phelps
2058	83,423	198,598	179,896
2059	83,423	198,598	179,896
2060	83,423	198,598	179,896
2061	83,423	198,598	179,896
2062	83,423	198,598	179,896
2063	83,423	198,598	179,896

*Up to 70 acres occur in a cell assigned to TBNRD and Frontier County. This data was combined into the Gosper County total.

Table 19. TBNRD county summary of groundwater only irrigated lands robust review baseline land use data set limited to the Platte Basin

Year	Gosper	Kearney	Phelps
1950	-	1,451	2,284
1951	-	2,756	2,526
1952	-	4,471	2,559
1953	-	5,672	3,353
1954	-	6,037	4,573
1955	-	8,107	5,669
1956	-	9,964	7,426
1957	-	11,608	10,599
1958	-	13,579	10,809
1959	695	15,597	11,822
1960	1,305	15,765	12,299
1961	1,826	15,948	13,191
1962	2,290	15,959	13,547
1963	2,819	16,120	15,229
1964	3,262	16,387	16,483
1965	4,568	19,419	20,599
1966	6,203	21,983	25,050
1967	7,199	24,714	28,886
1968	8,025	26,725	32,380
1969	8,997	29,610	36,325
1970	9,808	31,757	38,917
1971	10,618	34,429	41,562
1972	10,753	37,051	45,541

Table 20. TBNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set limited to the Platte Basin

Year	Gosper	Kearney	Phelps
1950	-	1,451	2,284
1951	-	2,756	2,526
1952	-	4,471	2,559
1953	-	5,672	3,353
1954	-	6,037	4,573
1955	-	8,107	5,669
1956	-	9,964	7,426
1957	-	11,608	10,599
1958	-	13,579	10,809
1959	695	15,597	11,822
1960	1,305	15,765	12,299
1961	1,826	15,948	13,191
1962	2,290	15,959	13,547
1963	2,819	16,120	15,229
1964	3,262	16,387	16,483
1965	4,568	19,419	20,599
1966	6,203	21,983	25,050
1967	7,199	24,714	28,886
1968	8,025	26,725	32,380
1969	8,997	29,610	36,325
1970	9,808	31,757	38,917
1971	10,618	34,429	41,562
1972	10,753	37,051	45,541

Table 19. TBNRD county summary of groundwater only irrigated lands robust review baseline land use data set limited to the Platte Basin

Year	Gosper	Kearney	Phelps
1973	11,543	38,343	48,751
1974	12,240	40,953	53,046
1975	13,730	43,895	58,392
1976	15,050	46,039	62,503
1977	15,785	47,810	67,858
1978	16,792	50,036	71,705
1979	17,321	52,080	75,671
1980	17,678	55,399	79,706
1981	18,191	57,014	81,229
1982	18,530	58,737	83,636
1983	18,829	58,430	84,575
1984	18,824	57,783	84,309
1985	18,855	56,061	82,805
1986	18,668	55,868	82,479
1987	16,997	55,412	81,675
1988	17,219	56,116	82,625
1989	17,767	56,887	84,145
1990	18,190	57,348	85,113
1991	18,662	58,639	85,833
1992	19,290	60,028	87,456
1993	19,225	60,647	88,224
1994	19,512	61,398	88,644
1995	19,482	61,940	89,048
1996	19,777	62,572	89,715
1997	19,826	63,559	90,195
1998	21,061	63,366	90,027
1999	21,145	63,384	89,796
2000	21,261	63,445	89,849
2001	21,240	63,304	89,638
2002	20,818	66,058	91,450
2003	20,419	65,563	91,187
2004	20,024	65,338	90,602
2005	19,739	66,054	90,123
2006	20,443	67,863	93,694
2007	23,309	69,246	96,783
2008	19,770	67,654	94,781
2009	24,102	68,433	97,068

Table 20. TBNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set limited to the Platte Basin

Year	Gosper	Kearney	Phelps
1973	11,543	38,343	48,751
1974	12,240	40,953	53,046
1975	13,730	43,895	58,392
1976	15,050	46,039	62,503
1977	15,785	47,810	67,858
1978	16,792	50,036	71,705
1979	17,321	52,080	75,671
1980	17,678	55,399	79,706
1981	18,191	57,014	81,229
1982	18,530	58,737	83,636
1983	18,829	58,430	84,575
1984	18,824	57,783	84,309
1985	18,855	56,061	82,805
1986	18,668	55,868	82,479
1987	16,997	55,412	81,675
1988	17,219	56,116	82,625
1989	17,767	56,887	84,145
1990	18,190	57,348	85,113
1991	18,662	58,639	85,833
1992	19,290	60,028	87,456
1993	19,225	60,647	88,224
1994	19,512	61,398	88,644
1995	19,482	61,940	89,048
1996	19,777	62,572	89,715
1997	19,826	63,559	90,195
1998	21,061	63,366	90,027
1999	21,145	63,386	89,796
2000	21,261	63,722	89,867
2001	21,240	63,990	89,657
2002	20,818	66,744	91,469
2003	20,419	66,248	91,206
2004	20,024	66,076	90,621
2005	19,746	66,831	90,346
2006	20,501	68,656	94,013
2007	23,384	70,069	97,274
2008	19,952	68,610	95,747
2009	24,444	69,381	97,937

Table 19. TBNRD county summary of groundwater only irrigated lands robust review baseline land use data set limited to the Platte Basin

Year	Gosper	Kearney	Phelps
2010	23,088	68,924	96,526
2011	23,080	69,349	96,541
2012	23,186	69,411	96,793
2013	23,192	69,552	97,129
2014	23,267	69,552	97,196
2015	23,267	69,568	97,307
2016	23,267	69,568	97,307
2017	23,267	69,568	97,346
2018	23,267	69,568	97,346
2019	23,267	69,568	97,346
2020	23,267	69,568	97,346
2021	23,268	69,568	97,346
2022	23,268	69,568	97,346
2023	23,268	69,568	97,346
2024	23,268	69,568	97,346
2025	23,268	69,568	97,346
2026	23,268	69,568	97,346
2027	23,268	69,568	97,346
2028	23,268	69,568	97,346
2029	23,268	69,568	97,346
2030	23,268	69,568	97,346
2031	23,268	69,568	97,346
2032	23,268	69,568	97,346
2033	23,268	69,568	97,346
2034	23,268	69,568	97,346
2035	23,268	69,568	97,346
2036	23,268	69,568	97,346
2037	23,268	69,568	97,346
2038	23,268	69,568	97,346
2039	23,268	69,568	97,346
2040	23,268	69,568	97,346
2041	23,268	69,568	97,346
2042	23,268	69,568	97,346
2043	23,268	69,568	97,346
2044	23,268	69,568	97,346
2045	23,268	69,568	97,346
2046	23,268	69,568	97,346

Table 20. TBNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set limited to the Platte Basin

Year	Gosper	Kearney	Phelps
2010	23,447	69,584	97,371
2011	23,421	69,565	97,459
2012	23,421	69,565	97,459
2013	23,417	69,641	97,458
2014	23,417	69,641	97,458
2015	23,417	69,641	97,458
2016	23,417	69,641	97,458
2017	23,417	69,641	97,458
2018	23,417	69,641	97,458
2019	23,417	69,641	97,458
2020	23,417	69,641	97,458
2021	23,417	69,641	97,458
2022	23,417	69,641	97,458
2023	23,417	69,641	97,458
2024	23,417	69,641	97,458
2025	23,417	69,641	97,458
2026	23,417	69,641	97,458
2027	23,417	69,641	97,458
2028	23,417	69,641	97,458
2029	23,417	69,641	97,458
2030	23,417	69,641	97,458
2031	23,417	69,641	97,458
2032	23,417	69,641	97,458
2033	23,417	69,641	97,458
2034	23,417	69,641	97,458
2035	23,417	69,641	97,458
2036	23,417	69,641	97,458
2037	23,417	69,641	97,458
2038	23,417	69,641	97,458
2039	23,417	69,641	97,458
2040	23,417	69,641	97,458
2041	23,417	69,641	97,458
2042	23,417	69,641	97,458
2043	23,417	69,641	97,458
2044	23,417	69,641	97,458
2045	23,417	69,641	97,458
2046	23,417	69,641	97,458

Table 19. TBNRD county summary of groundwater only irrigated lands robust review baseline land use data set limited to the Platte Basin

Year	Gosper	Kearney	Phelps
2047	23,268	69,568	97,346
2048	23,268	69,568	97,346
2049	23,268	69,568	97,346
2050	23,268	69,568	97,346
2051	23,268	69,568	97,346
2052	23,268	69,568	97,346
2053	23,268	69,568	97,346
2054	23,268	69,568	97,346
2055	23,268	69,568	97,346
2056	23,268	69,568	97,346
2057	23,268	69,568	97,346
2058	23,268	69,568	97,346
2059	23,268	69,568	97,346
2060	23,268	69,568	97,346
2061	23,268	69,568	97,346
2062	23,268	69,568	97,346
2063	23,268	69,568	97,346

Table 20. TBNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set limited to the Platte Basin

Year	Gosper	Kearney	Phelps
2047	23,417	69,641	97,458
2048	23,417	69,641	97,458
2049	23,417	69,641	97,458
2050	23,417	69,641	97,458
2051	23,417	69,641	97,458
2052	23,417	69,641	97,458
2053	23,417	69,641	97,458
2054	23,417	69,641	97,458
2055	23,417	69,641	97,458
2056	23,417	69,641	97,458
2057	23,417	69,641	97,458
2058	23,417	69,641	97,458
2059	23,417	69,641	97,458
2060	23,417	69,641	97,458
2061	23,417	69,641	97,458
2062	23,417	69,641	97,458
2063	23,417	69,641	97,458

Memorandum

To: Ann Dimmit – TPNRD; Kari Burgert – NDNR
From: The Flatwater Group, Inc.
Date: 10/17/2018
Subject: COHYST Area Robust Review: TPNRD Land Use Retirements, Transfers, and Variances

Project Background and Workflow

The Flatwater Group, Inc. (TFG) was contracted by the Platte Basin Water Project Coalition through the Nebraska Department of Natural Resources (NDNR) to provide technical assistance for the Robust Review project. The purpose of the Robust Review project is to assess streamflow impacts resulting from management actions taken as part of the Basin-Wide Plan and/or Natural Resource District (NRD) Integrated Management Plans (IMPs). The focus of this memorandum is to document land use changes related to acreage transfers, retirements, and variances within the Twin Platte NRD (TPNRD).

To account for transfers, retirements, and variances within the TPNRD, TFG's primary work tasks included evaluating and summarizing the available datasets related to transfers, retirements, and variances; then spatially placing these transactions within the constructs of the COHYST 2010 watershed model's land use files to extend the baseline land use through 2013; and to then create a new land use data set for the unretired acreage scenario. For the first step in the process, TFG worked with NDNR and TPNRD to gather the land use data (retirements, transfers, and variances) and place into summary tables by land use type. TFG's next steps were to perform geospatial analyses using ArcGIS to identify the location of each transaction. The geospatial analysis included a proximity function in the form of a custom Fortran program to determine the closest available model cells capable of accommodating the specified land use change.

This memorandum presents a series of tables which summarize the annual number of acres retired or transferred within the TPNRD, outlines the spatial analysis methodology, and ultimately summarizes the resultant land use files.

Land Use Summary Tables

Using information provided by TPNRD and the NDNR, TFG compiled a final summary of the retirements, transfers, and variances for the TPNRD. This information was used to modify the land use data set in the COHYST 2010 model to investigate the effects of these actions as part of the larger Robust Review effort. Tables 1-4 below summarize the information provided to TFG. Tables 5-11 summarize the distribution of that information into the modeling input files.

Table 1 shows an overview summary of retirements and transfers in the TPNRD. Tables 2, 3, and 4 show summaries of the individual categories used to create Table 1 and serve as a reference for the description of each data source.

Table 1. Summary of TPNRD acreage changes for implementation into the Robust Review.

Year	Temporary Retirements	Reinstated Temporary Retirements	Transfers To	Transfers Away	Change
Baseline Change	(-)	(+)	(+)	(-)	
2006	595.5	-	-	-	(595.5)
2007	27.4	-	-	-	(27.4)
2008	-	-	-	-	-
2009	-	-	-	-	-
2010	-	-	-	-	-
2011	-	-	833.2	815.6	17.6
2012	40.8	28.8	1,569.5	1,635.5	(78.0)
2013	-	-	1,865.3	1,840.5	24.8
2014	-	-	-	-	-
2015	-	-	-	-	-
2016	-	-	-	-	-
2017	-	594.1	-	-	594.1
2018	-	-	-	-	-
2019	-	-	-	-	-
2020	-	-	-	-	-
2021	-	-	-	-	-
2022	-	-	-	-	-
2023	-	40.8	-	-	40.8
Total	663.7	663.7	4,268.0	4,291.6	(23.6)

The TPNRD provided two shape files on 8/8/2017 which summarized acreage transfers in the District:
TPNRD_Acres_Decertified_Implemented_through_2013 – (Transfers Away)
TPNRD_New_Acres_implemented_through_2013 – (Transfers To)
These two files provided the spatial location of the acreage transfers within the TPNRD.

Key elements from the information provided related to Decertified Acres (Transfers Away in Table 1):

- 229 entries
- 149 of the 229 entries occurred between 2011 and 2013
- Timing was based upon the implementation year
- In 2013, 234.3 decertified acres were located outside the COHYST 2010 active model domain. They were not considered when modifying the land use.
- 5.4 decertified acres were removed from cells assigned to the CPNRD; 1.6 acres in 2011 and 3.8 acres in 2012
- Table 2 summarizes the model areas impacted by the provided information

Key Elements form the information provided related to New Acres (Transfers To in Table 1):
- 187 entries
- 131 of the 187 entries occurred between 2011 and 2013
- Timing was based upon the implementation year
- 11.4 acres were added to cells assigned to the URNRD. All 11.4 acres were added in 2011.
- Table 3 summarizes the model areas impacted by the provided information

Table 2. Summary of decertified transfer acres in the TPNRD

Year	Decertified Acres	Decertified Acres in Non-Active Cells	Modeled Decertified Acres	Removed from TPNRD	Removed From CPNRD
2011	815.6	-	815.6	814.0	1.6
2012	1,635.5	-	1,635.5	1,631.7	3.8
2013	2,074.8	234.3	1,840.5	1,840.5	-
Total	4,525.9	234.3	4,291.6	4,286.2	5.4

Table 3. Summary of new transfer acres in the TPNRD

Year	New Acres	Added To TPNRD	Added to URNRD
2011	833.2	821.8	11.4
2012	1,569.5	1,569.5	-
2013	1,865.3	1,865.3	-
Total	4,268.0	4,256.6	11.4

Temporary retirement information recorded on Table 1 was based on information NDNR provided on 8/17/2017 in the form of a shape file which summarized CREP and EQIP contract information.

This shape file included the updated list of CREP and EQIP contracts. The data was clipped to the TPNRD resulting in 59 polygons totaling 1,641 acres. The information was limited to groundwater only irrigated (Irrigation = 1) lands which trimmed the area to 14 polygons and 905 acres. Finally, the polygons were reduced to those which were initiated prior to the 2013 irrigation season. This left the data set with 11 entries with 663.7 acres. Each of these 11 entries were CREP contracts. Contract lengths were either 5, 10, or 11 years (Table 4).

To be considered for the current year, the retirement needed to be initiated or ended prior to July of the current year; otherwise, the transaction will have its first effect in the next year. The rationale is that if the action was taken prior to July, the transaction could influence the irrigation season in the current year. However, if the transaction occurred later, the land would finish up the current growing season in the same state.

Table 4. Summary of temporary retirements and reinstated retirement acres in the TPNRD

Year	Temporary Retirements	Reinstated Retirements
2006	595.5	-
2007	27.4	-
2008	-	-
2009	-	-
2010	-	-
2011	-	-
2012	40.8	28.8
2013	-	-
2014	-	-
2015	-	-
2016	-	-
2017	-	594.1
2018	-	-
2019	-	-
2020	-	-
2021	-	-
2022	-	-
2023	-	40.8
Total	663.7	663.7

As discussed above, the acreage summarized in Table 1 (developed from the information in Tables 2-4) was provided in a series of GIS shape files. Using standard GIS practices, the acreage polygons within these coverages were unioned with the COHYST 2010 model grid to determine the number of acres in each model grid cell for each transaction. The following section provides additional detail on this process.

SPATIAL ANALYSIS METHODOLOGY

ArcGIS was used to link the retirements, transfers, and variances to the COHYST model grid. This was accomplished by overlaying the parcels' shapefiles with the model grid.

Step 1: Assigning land use change location

NDNR and TPNRD provided shape files for their retirements and transfers. The union function within ArcGIS was applied to the shapefiles to determine the cell location. The polygon area within each cell was then computed using the calculate geometry function within ArcGIS.

Step 2: Building the Baseline Land Use

The next step was to build the 2011-2013 baseline land use files incorporating the identified transfers and retirements. The beginning condition for this update was the 2010 land use file from the COHYST 2010 model. Each of the transactions occurring in 2011 were applied to the existing 2010 land use file to create the 2011 land use file; which in turn became the basis for applying the transactions occurring in 2012. This continued through 2013. One of the key points of the investigation is the effect of retirements on the system. Given that many of the retirements were temporary in nature and knowing their contract end dates, the land use file building process was continued through 2023 in order to accurately reflect the temporary nature of the retirements. [1]

In the process of distributing the GIS polygon information to the model cells, the existing acreage within a given cell in the year 2010 (as modified moving forward through 2013 as discussed above) was considered. If there was insufficient space[2] for new acres or an insufficient amount of groundwater only acres[3] to be retired within a given cell, the addition or subtraction of acres was applied to nearby cells which exhibited the appropriate characteristics[4]. This spatial analysis process entails radiating outward from the identified cell until the acres had been placed. During this process acres are placed or removed from the lowest priority cell which meets the appropriate criteria. If more than one cell has the same priority and meets criteria, the acres are split evenly between the multiple cells. Unless an even split would exceed the available space within the cell; at which time the placed acres would be limited to the available space and the remaining acres would be split among the other priority cells. The priority pattern for the first two rings around the assignment cell can be seen in Figure 1. This process was implemented using a custom FORTRAN script.

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[1] 2023 was identified as the year the last TPNRD temporary retirement would be actively irrigated again for the first time

[2] Example: transferring 30 groundwater only acres to a cell where there was only 20 non-irrigated acres available

[3] Example: retiring 30 groundwater only acres from a cell where there was only 20 groundwater only acres identified

[4] The cell needed to be active, in the same NRD, and have a sufficient amount of groundwater only acres to retire or non-irrigated acres to convert

5 (r-2, c-2)	4 (r-2, c-1)	3 (r-2, c+0)	4 (r-2, c+1)	5 (r-2, c+2)
4 (r-1, c-2)	2 (r-1, c-1)	1 (r-1, c+0)	2 (r-1, c+1)	4 (r-1, c+2)
3 (r+0, c-2)	1 (r+0, c-1)	0 (r+0, c+0)	1 (r+0, c+1)	3 (r+0, c+2)
4 (r+1, c-2)	2 (r+1, c-1)	1 (r+1, c+0)	2 (r+1, c+1)	4 (r+1, c+2)
5 (r+2, c-2)	4 (r+2, c-1)	3 (r+2, c+0)	4 (r+2, c+1)	5 (r+2, c+2)

Figure 1. Priority of search pattern to place or remove acres when the assigned cell has insufficient non-irrigated or groundwater only acres. The center cell represents the cell identified as the location of the land use transaction. 'r' and 'c' indicate the row column index of the cell.

Table 5 presents the results of Step 2 above. The values in Table 5 were generated by summarizing information from the model land use input files (created as described above) developed for the baseline (full representation of all acreage retirements/transfers) Robust Review model run. Comparing Table 5 to Table 1 shows how the provided information was ultimately represented in the model for the years 2011 – 2023. Discrepancies between the tables are generally related to a particular cell's NRD assignment within the model. In 2011, the location of a couple of transactions were placed in cells designated CPNRD or URNRD; 11.4 new acres were placed in the URNRD in Perkins County, while 1.6 acres were removed from CPNRD in Dawson County. Likewise, in 2012, 3.8 acres were removed from CPNRD in Dawson County. These placements were from the New Acres(Transfers To in Table 1) and Decertified Acres (Transfers Away in Table 1) data sets.

It should be noted that the cell boundaries do not necessarily overlap with the legal boundaries either for the county or NRD. For these summaries each cell was assigned to an NRD and county based upon the location of the cell centroid.

Table 5. Change in groundwater only irrigated acres within the TPNRD for the Robust Review baseline.

Year	(A) Groundwater Only Irrigated Acres in TPNRD	(B) Annual Change in TPNRD Groundwater Only Irrigated Acres in the TPNRD	(C) Change in TPNRD Groundwater Only Irrigated Acres not in the TPNRD
2010	263,165.7	-	-
2011	263,173.8	8.1	9.8
2012	263,099.6	(74.2)	(3.8)
2013	263,124.4	24.8	-
2014	263,124.4	-	-
2015	263,124.4	-	-
2016	263,124.4	-	-
2017	263,718.3	593.9	-
2018	263,718.3	-	-
2019	263,718.3	-	-
2020	263,718.3	-	-
2021	263,718.3	-	-
2022	263,718.3	-	-
2023	263,759.1	40.8	-

Step 3: Building the Unretired Acres Scenario Modified Land Use

Step 3 was taken to develop a new set of land use files for the unretired scenario within the Robust Review. Key elements related to the construction of this scenario include:

a) Acreage transfers were applied as the historically occurred.
b) Post 2010, no acreage retirement activities were incorporated.
c) For temporary and permanent retirements initiated prior to 2010, irrigated acres were added back into the modified land use files starting with the first retirement year (e.g. if a retirement started in 2008, the retired acres were added back into the model starting in 2008).

Regarding c) above, Table 6 shows the changes between the COHYST 2010 land use (column “Run029” in Table 6) and the unretired retirements scenario (column “Modified Land Use” in Table 6). The difference between the two data sets shows the cumulative change over time. These values match those shown in Table 1 subject to rounding resulting from the distribution process.

Table 6. Change in Groundwater Only Irrigated Acres in the TPNRD comparing the COHYST 2010 land use to Unretired Retirements Scenario land use; years 1999-2010.

	Groundwater Only Irrigated Acres		Change in Groundwater Only Irrigated Acres within the TPNRD	
Year	Run 029	Modified Land Use	Cumulative	Annual
1999	208,718	208,718	-	-
2000	210,934	210,934	-	-
2001	213,311	213,311	-	-
2002	221,892	221,892	-	-
2003	233,442	233,442	-	-
2004	245,508	245,508	-	-
2005	250,480	250,480	-	-
2006	258,475	259,070	595.4	595.4
2007	267,919	268,541	622.6	27.2
2008	265,482	266,105	622.7	0.1
2009	267,862	268,485	622.7	(0.0)
2010	263,166	263,788	622.7	0.0
		Cumulative		622.7

With regards to b) under Step 3, Table 7 show the changes referenced to the year 2010 between the COHYST 2010 land use file and the unretired acres represented in the retirement scenario land use file for the Robust Review. The table presents an annual summary for the years 2011 – 2023 of the modifications made to the number of acres irrigated only with ground water based on the 2010 acreage.

Column (A) of Table 7 presents a summary taken from the model input files of the total number of acres irrigated only with ground water represented within the NRD in the “unretired condition” of the retirement scenario. This column can be contrasted with Column (A) of Table 5 to see the total annual acreage change represented in the model between the baseline (all retirements included) condition (Table 5) and the “unretired” scenario condition (Table 7) for the years 2011 through 2023.

Column (B) of Table 7 presents the annual change made to the preceding year’s acreage total for determining a given year’s adjusted acreage value. Column (B) was calculated using the values in Columns (C) through (J).

Table 7. Change in Groundwater Only Irrigated Acres in the TPNRD comparing the COHYST 2010 land use to Unretired Retirements Scenario land use; years 2011-2023.

Year	(A) Groundwater Only Irrigated Acres	(B) =-((G)-(I)-(J)) Difference in Groundwater only Acres from 2010 minus cumulative prior retirements and transfers	(C) Transfers Away (Table 2)	(D) Transfers to (Table 3)	(E) Non Area Transfers Away	(F) Non Area Transfers To	(G) =(C)–(D) Net Transfers Away	(H) Cumulative Net Transfers Away	(I) Reinstated Temporary Retirements (Table 4)	(J) Rounding Residuals
2011	263,796.5	8.1	814.0	821.8			(7.8)	(7.8)	-	0.3
2012	263,775.2	(21.3)	1,631.7	1,569.5			62.2	54.4	40.8	0.1
2013	263,800.0	24.8	1,840.5	1,865.3			(24.8)	29.6	-	(0.0)
2014	263,800.0	-					-	29.6	-	-
2015	263,800.0	-					-	29.6	-	-
2016	263,800.0	-					-	29.6	-	-
2017	263,800.0	-					-	29.6	-	-
2018	263,800.0	-					-	29.6	-	-
2019	263,800.0	-					-	29.6	-	-
2020	263,800.0	-					-	29.6	-	-
2021	263,800.0	-					-	29.6	-	-
2022	263,800.0	-					-	29.6	-	-
2023	263,800.0	-					-	29.6	-	-

Tables 8 and 9 show the annual area of groundwater only irrigated land for each county in the TPNRD within the Robust Review's baseline and unretirement scenarios. Finally, Tables 10 and11 show the annual area of groundwater only irrigated land for each county in the TPNRD and Platte River Drainage basin within the Robust Review's baseline and unretirement scenarios.

Table 8. TPNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Arthur	Keith	Lincoln	McPherson
1950	-	3,940	2,329	-
1951	-	5,100	2,338	-
1952	-	6,508	2,496	-
1953	-	7,848	3,049	-
1954	-	8,869	4,411	140
1955	259	9,516	6,515	140
1956	235	9,873	8,285	140
1957	280	10,202	10,006	140
1958	237	10,809	11,681	140
1959	259	11,064	13,596	140
1960	280	12,154	13,940	140
1961	358	12,975	13,933	280
1962	365	14,036	14,258	280
1963	336	15,026	14,721	420
1964	330	15,865	14,864	420
1965	420	18,019	17,328	420
1966	399	19,825	19,369	420
1967	549	22,606	21,894	420
1968	906	24,595	23,982	700
1969	1,159	26,818	26,102	840
1970	1,400	28,644	31,203	980
1971	1,839	30,082	35,802	980
1972	1,818	31,813	40,612	980

Table 9. TPNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set

Year	Arthur	Keith	Lincoln	McPherson
1950	-	3,940	2,329	-
1951	-	5,100	2,338	-
1952	-	6,508	2,496	-
1953	-	7,848	3,049	-
1954	-	8,869	4,411	140
1955	259	9,516	6,515	140
1956	235	9,873	8,285	140
1957	280	10,202	10,006	140
1958	237	10,809	11,681	140
1959	259	11,064	13,596	140
1960	280	12,154	13,940	140
1961	358	12,975	13,933	280
1962	365	14,036	14,258	280
1963	336	15,026	14,721	420
1964	330	15,865	14,864	420
1965	420	18,019	17,328	420
1966	399	19,825	19,369	420
1967	549	22,606	21,894	420
1968	906	24,595	23,982	700
1969	1,159	26,818	26,102	840
1970	1,400	28,644	31,203	980
1971	1,839	30,082	35,802	980
1972	1,818	31,813	40,612	980

Table 8. TPNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Arthur	Keith	Lincoln	McPherson
1973	1,933	33,438	45,704	1,260
1974	2,203	35,177	50,349	1,540
1975	2,881	40,123	57,650	1,540
1976	3,068	46,074	62,725	1,540
1977	3,912	52,163	69,618	1,820
1978	5,277	57,650	76,349	2,940
1979	5,602	59,990	78,875	3,560
1980	6,470	62,452	82,621	4,158
1981	7,300	65,245	85,496	4,387
1982	7,653	67,611	88,954	4,746
1983	7,551	67,158	88,061	4,972
1984	7,670	67,173	85,653	5,350
1985	10,496	59,997	98,168	4,987
1986	10,513	60,079	97,769	5,094
1987	10,691	59,892	96,995	5,263
1988	10,714	61,442	97,483	5,323
1989	10,824	63,871	98,705	5,380
1990	10,845	65,847	99,915	5,438
1991	10,868	67,211	100,718	5,494
1992	10,906	68,534	102,556	5,573
1993	10,929	69,355	103,469	5,561
1994	11,067	71,249	104,183	5,550
1995	11,209	72,978	105,622	5,545
1996	11,461	75,348	108,418	5,541
1997	11,506	78,805	109,820	5,541
1998	11,206	79,530	111,264	5,226
1999	10,793	80,715	112,223	4,987

Table 9. TPNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set

Year	Arthur	Keith	Lincoln	McPherson
1973	1,933	33,438	45,704	1,260
1974	2,203	35,177	50,349	1,540
1975	2,881	40,123	57,650	1,540
1976	3,068	46,074	62,725	1,540
1977	3,912	52,163	69,618	1,820
1978	5,277	57,650	76,349	2,940
1979	5,602	59,990	78,875	3,560
1980	6,470	62,452	82,621	4,158
1981	7,300	65,245	85,496	4,387
1982	7,653	67,611	88,954	4,746
1983	7,551	67,158	88,061	4,972
1984	7,670	67,173	85,653	5,350
1985	10,496	59,997	98,168	4,987
1986	10,513	60,079	97,769	5,094
1987	10,691	59,892	96,995	5,263
1988	10,714	61,442	97,483	5,323
1989	10,824	63,871	98,705	5,380
1990	10,845	65,847	99,915	5,438
1991	10,868	67,211	100,718	5,494
1992	10,906	68,534	102,556	5,573
1993	10,929	69,355	103,469	5,561
1994	11,067	71,249	104,183	5,550
1995	11,209	72,978	105,622	5,545
1996	11,461	75,348	108,418	5,541
1997	11,506	78,805	109,820	5,541
1998	11,206	79,530	111,264	5,226
1999	10,793	80,715	112,223	4,987

Table 8. TPNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Arthur	Keith	Lincoln	McPherson
2000	10,471	82,230	113,406	4,826
2001	9,487	84,154	115,353	4,318
2002	9,272	86,334	121,210	5,077
2003	9,507	89,925	128,803	5,207
2004	9,732	94,959	135,478	5,339
2005	10,096	95,166	139,426	5,791
2006	10,232	95,184	147,632	5,427
2007	11,112	98,022	152,475	6,310
2008	10,687	97,668	150,789	6,339
2009	10,113	98,320	152,875	6,554
2010	9,180	97,947	150,456	5,583
2011	9,180	97,885	150,526	5,583
2012	9,180	97,901	150,436	5,583
2013	8,613	97,725	151,193	5,593
2014	8,613	97,725	151,193	5,593
2015	8,613	97,725	151,193	5,593
2016	8,613	97,725	151,193	5,593
2017	8,613	98,291	151,221	5,593
2018	8,613	98,291	151,221	5,593
2019	8,613	98,291	151,221	5,593
2020	8,613	98,291	151,221	5,593
2021	8,613	98,291	151,221	5,593
2022	8,613	98,291	151,221	5,593
2023	8,613	98,291	151,262	5,593
2024	8,613	98,291	151,262	5,593
2025	8,613	98,291	151,262	5,593
2026	8,613	98,291	151,262	5,593

Table 9. TPNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set

Year	Arthur	Keith	Lincoln	McPherson
2000	10,471	82,230	113,406	4,826
2001	9,487	84,154	115,353	4,318
2002	9,272	86,334	121,210	5,077
2003	9,507	89,925	128,803	5,207
2004	9,732	94,959	135,478	5,339
2005	10,096	95,166	139,426	5,791
2006	10,232	95,779	147,632	5,427
2007	11,112	98,617	152,503	6,310
2008	10,687	98,263	150,816	6,339
2009	10,113	98,915	152,903	6,554
2010	9,180	98,543	150,483	5,583
2011	9,180	98,480	150,553	5,583
2012	9,180	98,467	150,545	5,583
2013	8,613	98,291	151,303	5,593
2014	8,613	98,291	151,303	5,593
2015	8,613	98,291	151,303	5,593
2016	8,613	98,291	151,303	5,593
2017	8,613	98,291	151,303	5,593
2018	8,613	98,291	151,303	5,593
2019	8,613	98,291	151,303	5,593
2020	8,613	98,291	151,303	5,593
2021	8,613	98,291	151,303	5,593
2022	8,613	98,291	151,303	5,593
2023	8,613	98,291	151,303	5,593
2024	8,613	98,291	151,303	5,593
2025	8,613	98,291	151,303	5,593
2026	8,613	98,291	151,303	5,593

Table 8. TPNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Arthur	Keith	Lincoln	McPherson
2027	8,613	98,291	151,262	5,593
2028	8,613	98,291	151,262	5,593
2029	8,613	98,291	151,262	5,593
2030	8,613	98,291	151,262	5,593
2031	8,613	98,291	151,262	5,593
2032	8,613	98,291	151,262	5,593
2033	8,613	98,291	151,262	5,593
2034	8,613	98,291	151,262	5,593
2035	8,613	98,291	151,262	5,593
2036	8,613	98,291	151,262	5,593
2037	8,613	98,291	151,262	5,593
2038	8,613	98,291	151,262	5,593
2039	8,613	98,291	151,262	5,593
2040	8,613	98,291	151,262	5,593
2041	8,613	98,291	151,262	5,593
2042	8,613	98,291	151,262	5,593
2043	8,613	98,291	151,262	5,593
2044	8,613	98,291	151,262	5,593
2045	8,613	98,291	151,262	5,593
2046	8,613	98,291	151,262	5,593
2047	8,613	98,291	151,262	5,593
2048	8,613	98,291	151,262	5,593
2049	8,613	98,291	151,262	5,593
2050	8,613	98,291	151,262	5,593
2051	8,613	98,291	151,262	5,593
2052	8,613	98,291	151,262	5,593
2053	8,613	98,291	151,262	5,593

Table 9. TPNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set

Year	Arthur	Keith	Lincoln	McPherson
2027	8,613	98,291	151,303	5,593
2028	8,613	98,291	151,303	5,593
2029	8,613	98,291	151,303	5,593
2030	8,613	98,291	151,303	5,593
2031	8,613	98,291	151,303	5,593
2032	8,613	98,291	151,303	5,593
2033	8,613	98,291	151,303	5,593
2034	8,613	98,291	151,303	5,593
2035	8,613	98,291	151,303	5,593
2036	8,613	98,291	151,303	5,593
2037	8,613	98,291	151,303	5,593
2038	8,613	98,291	151,303	5,593
2039	8,613	98,291	151,303	5,593
2040	8,613	98,291	151,303	5,593
2041	8,613	98,291	151,303	5,593
2042	8,613	98,291	151,303	5,593
2043	8,613	98,291	151,303	5,593
2044	8,613	98,291	151,303	5,593
2045	8,613	98,291	151,303	5,593
2046	8,613	98,291	151,303	5,593
2047	8,613	98,291	151,303	5,593
2048	8,613	98,291	151,303	5,593
2049	8,613	98,291	151,303	5,593
2050	8,613	98,291	151,303	5,593
2051	8,613	98,291	151,303	5,593
2052	8,613	98,291	151,303	5,593
2053	8,613	98,291	151,303	5,593

Table 8. TPNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Arthur	Keith	Lincoln	McPherson
2054	8,613	98,291	151,262	5,593
2055	8,613	98,291	151,262	5,593
2056	8,613	98,291	151,262	5,593
2057	8,613	98,291	151,262	5,593
2058	8,613	98,291	151,262	5,593
2059	8,613	98,291	151,262	5,593
2060	8,613	98,291	151,262	5,593
2061	8,613	98,291	151,262	5,593
2062	8,613	98,291	151,262	5,593
2063	8,613	98,291	151,262	5,593

Table 9. TPNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set

Year	Arthur	Keith	Lincoln	McPherson
2054	8,613	98,291	151,303	5,593
2055	8,613	98,291	151,303	5,593
2056	8,613	98,291	151,303	5,593
2057	8,613	98,291	151,303	5,593
2058	8,613	98,291	151,303	5,593
2059	8,613	98,291	151,303	5,593
2060	8,613	98,291	151,303	5,593
2061	8,613	98,291	151,303	5,593
2062	8,613	98,291	151,303	5,593
2063	8,613	98,291	151,303	5,593

*Due to the construct of the model, up to 132 groundwater acres in the TPNRD are located in cells classified as Logan County. This is caused by cell boundaries and legal boundaries not being congruent. The cell is the smallest unit of the model. Each cell was assigned a county designation by the location of the cell centroid. Even if a cell is bisected by the county boundary, the entire cell is assigned to one county. The same process was used to assign each cell an NRD designation.

Table 10. TPNRD county summary of groundwater only irrigated lands robust review baseline land use data set within the Platte River drainage basin.

Year	Arthur	Keith	Lincoln	McPherson
1950	-	3,940	2,329	-
1951	-	5,100	2,338	-
1952	-	6,508	2,496	-
1953	-	7,848	3,049	-
1954	-	8,869	4,411	140
1955	259	9,516	6,515	140
1956	235	9,818	8,263	140
1957	280	10,146	9,979	140
1958	237	10,757	11,654	140
1959	259	11,005	13,561	140
1960	280	12,094	13,907	140
1961	358	12,915	13,899	280
1962	365	13,965	14,224	280
1963	336	14,932	14,688	420
1964	330	15,801	14,834	420
1965	420	17,898	17,282	420
1966	399	19,714	19,328	420
1967	549	22,527	21,819	420
1968	790	24,513	23,841	700
1969	1,042	26,573	25,977	840
1970	1,165	28,357	31,009	980
1971	1,581	29,789	35,502	980
1972	1,465	31,546	40,067	980
1973	1,607	33,154	45,177	1,260
1974	1,907	34,313	49,581	1,540
1975	2,517	39,056	56,459	1,540

Table 11. TPNRD county summary of groundwater only irrigated lands robust review Unretired Scenario land use data set within the Platte River drainage basin.

Year	Arthur	Keith	Lincoln	McPherson
1950	-	3,940	2,329	-
1951	-	5,100	2,338	-
1952	-	6,508	2,496	-
1953	-	7,848	3,049	-
1954	-	8,869	4,411	140
1955	259	9,516	6,515	140
1956	235	9,818	8,263	140
1957	280	10,146	9,979	140
1958	237	10,757	11,654	140
1959	259	11,005	13,561	140
1960	280	12,094	13,907	140
1961	358	12,915	13,899	280
1962	365	13,965	14,224	280
1963	336	14,932	14,688	420
1964	330	15,801	14,834	420
1965	420	17,898	17,282	420
1966	399	19,714	19,328	420
1967	549	22,527	21,819	420
1968	790	24,513	23,841	700
1969	1,042	26,573	25,977	840
1970	1,165	28,357	31,009	980
1971	1,581	29,789	35,502	980
1972	1,465	31,546	40,067	980
1973	1,607	33,154	45,177	1,260
1974	1,907	34,313	49,581	1,540
1975	2,517	39,056	56,459	1,540

Table 10. TPNRD county summary of groundwater only irrigated lands robust review baseline land use data set within the Platte River drainage basin.

Year	Arthur	Keith	Lincoln	McPherson
1976	2,648	44,393	61,489	1,540
1977	3,492	50,259	67,666	1,820
1978	4,857	55,248	73,851	2,940
1979	5,193	57,314	75,932	3,560
1980	6,067	59,598	79,123	4,158
1981	6,841	62,163	80,738	4,387
1982	7,188	64,269	82,255	4,746
1983	7,149	63,644	81,798	4,972
1984	7,267	63,585	79,110	5,350
1985	9,901	56,403	90,075	4,987
1986	9,918	56,495	89,710	5,094
1987	10,096	56,326	89,000	5,263
1988	10,118	57,462	89,449	5,323
1989	10,227	59,711	90,637	5,380
1990	10,247	61,259	91,808	5,438
1991	10,268	62,572	92,572	5,494
1992	10,305	63,804	94,330	5,573
1993	10,326	64,581	95,231	5,561
1994	10,464	66,004	95,934	5,550
1995	10,605	67,724	97,373	5,545
1996	10,857	69,868	100,180	5,541
1997	10,899	72,742	101,466	5,541
1998	10,618	73,239	102,532	5,226
1999	10,227	74,435	103,200	4,987
2000	9,934	75,965	104,291	4,826
2001	9,000	77,152	105,988	4,318

Table 11. TPNRD county summary of groundwater only irrigated lands robust review Unretired Scenario land use data set within the Platte River drainage basin.

Year	Arthur	Keith	Lincoln	McPherson
1976	2,648	44,393	61,489	1,540
1977	3,492	50,259	67,666	1,820
1978	4,857	55,248	73,851	2,940
1979	5,193	57,314	75,932	3,560
1980	6,067	59,598	79,123	4,158
1981	6,841	62,163	80,738	4,387
1982	7,188	64,269	82,255	4,746
1983	7,149	63,644	81,798	4,972
1984	7,267	63,585	79,110	5,350
1985	9,901	56,403	90,075	4,987
1986	9,918	56,495	89,710	5,094
1987	10,096	56,326	89,000	5,263
1988	10,118	57,462	89,449	5,323
1989	10,227	59,711	90,637	5,380
1990	10,247	61,259	91,808	5,438
1991	10,268	62,572	92,572	5,494
1992	10,305	63,804	94,330	5,573
1993	10,326	64,581	95,231	5,561
1994	10,464	66,004	95,934	5,550
1995	10,605	67,724	97,373	5,545
1996	10,857	69,868	100,180	5,541
1997	10,899	72,742	101,466	5,541
1998	10,618	73,239	102,532	5,226
1999	10,227	74,435	103,200	4,987
2000	9,934	75,965	104,291	4,826
2001	9,000	77,152	105,988	4,318

Table 10. TPNRD county summary of groundwater only irrigated lands robust review baseline land use data set within the Platte River drainage basin.

Year	Arthur	Keith	Lincoln	McPherson
2002	8,796	79,165	111,189	5,077
2003	9,018	82,477	118,006	5,207
2004	9,232	87,078	124,383	5,339
2005	9,577	87,274	128,022	5,791
2006	9,784	86,962	134,677	5,427
2007	10,646	89,800	139,541	6,310
2008	10,296	89,452	137,752	6,339
2009	9,599	90,077	140,367	6,554
2010	8,722	89,812	137,454	5,583
2011	8,722	89,740	137,524	5,583
2012	8,722	89,756	137,434	5,583
2013	8,155	89,580	138,005	5,593
2014	8,155	89,580	138,005	5,593
2015	8,155	89,580	138,005	5,593
2016	8,155	89,580	138,005	5,593
2017	8,155	90,146	138,032	5,593
2018	8,155	90,146	138,032	5,593
2019	8,155	90,146	138,032	5,593
2020	8,155	90,146	138,032	5,593
2021	8,155	90,146	138,032	5,593
2022	8,155	90,146	138,032	5,593
2023	8,155	90,146	138,073	5,593
2024	8,155	90,146	138,073	5,593
2025	8,155	90,146	138,073	5,593
2026	8,155	90,146	138,073	5,593
2027	8,155	90,146	138,073	5,593

Table 11. TPNRD county summary of groundwater only irrigated lands robust review Unretired Scenario land use data set within the Platte River drainage basin.

Year	Arthur	Keith	Lincoln	McPherson
2002	8,796	79,165	111,189	5,077
2003	9,018	82,477	118,006	5,207
2004	9,232	87,078	124,383	5,339
2005	9,577	87,274	128,022	5,791
2006	9,784	87,557	134,677	5,427
2007	10,646	90,395	139,568	6,310
2008	10,296	90,047	137,779	6,339
2009	9,599	90,672	140,394	6,554
2010	8,722	90,407	137,481	5,583
2011	8,722	90,335	137,551	5,583
2012	8,722	90,322	137,543	5,583
2013	8,155	90,146	138,114	5,593
2014	8,155	90,146	138,114	5,593
2015	8,155	90,146	138,114	5,593
2016	8,155	90,146	138,114	5,593
2017	8,155	90,146	138,114	5,593
2018	8,155	90,146	138,114	5,593
2019	8,155	90,146	138,114	5,593
2020	8,155	90,146	138,114	5,593
2021	8,155	90,146	138,114	5,593
2022	8,155	90,146	138,114	5,593
2023	8,155	90,146	138,114	5,593
2024	8,155	90,146	138,114	5,593
2025	8,155	90,146	138,114	5,593
2026	8,155	90,146	138,114	5,593
2027	8,155	90,146	138,114	5,593

Table 10. TPNRD county summary of groundwater only irrigated lands robust review baseline land use data set within the Platte River drainage basin.

Year	Arthur	Keith	Lincoln	McPherson
2028	8,155	90,146	138,073	5,593
2029	8,155	90,146	138,073	5,593
2030	8,155	90,146	138,073	5,593
2031	8,155	90,146	138,073	5,593
2032	8,155	90,146	138,073	5,593
2033	8,155	90,146	138,073	5,593
2034	8,155	90,146	138,073	5,593
2035	8,155	90,146	138,073	5,593
2036	8,155	90,146	138,073	5,593
2037	8,155	90,146	138,073	5,593
2038	8,155	90,146	138,073	5,593
2039	8,155	90,146	138,073	5,593
2040	8,155	90,146	138,073	5,593
2041	8,155	90,146	138,073	5,593
2042	8,155	90,146	138,073	5,593
2043	8,155	90,146	138,073	5,593
2044	8,155	90,146	138,073	5,593
2045	8,155	90,146	138,073	5,593
2046	8,155	90,146	138,073	5,593
2047	8,155	90,146	138,073	5,593
2048	8,155	90,146	138,073	5,593
2049	8,155	90,146	138,073	5,593
2050	8,155	90,146	138,073	5,593
2051	8,155	90,146	138,073	5,593
2052	8,155	90,146	138,073	5,593
2053	8,155	90,146	138,073	5,593

Table 11. TPNRD county summary of groundwater only irrigated lands robust review Unretired Scenario land use data set within the Platte River drainage basin.

Year	Arthur	Keith	Lincoln	McPherson
2028	8,155	90,146	138,114	5,593
2029	8,155	90,146	138,114	5,593
2030	8,155	90,146	138,114	5,593
2031	8,155	90,146	138,114	5,593
2032	8,155	90,146	138,114	5,593
2033	8,155	90,146	138,114	5,593
2034	8,155	90,146	138,114	5,593
2035	8,155	90,146	138,114	5,593
2036	8,155	90,146	138,114	5,593
2037	8,155	90,146	138,114	5,593
2038	8,155	90,146	138,114	5,593
2039	8,155	90,146	138,114	5,593
2040	8,155	90,146	138,114	5,593
2041	8,155	90,146	138,114	5,593
2042	8,155	90,146	138,114	5,593
2043	8,155	90,146	138,114	5,593
2044	8,155	90,146	138,114	5,593
2045	8,155	90,146	138,114	5,593
2046	8,155	90,146	138,114	5,593
2047	8,155	90,146	138,114	5,593
2048	8,155	90,146	138,114	5,593
2049	8,155	90,146	138,114	5,593
2050	8,155	90,146	138,114	5,593
2051	8,155	90,146	138,114	5,593
2052	8,155	90,146	138,114	5,593
2053	8,155	90,146	138,114	5,593

Table 10. TPNRD county summary of groundwater only irrigated lands robust review baseline land use data set within the Platte River drainage basin.

Year	Arthur	Keith	Lincoln	McPherson
2054	8,155	90,146	138,073	5,593
2055	8,155	90,146	138,073	5,593
2056	8,155	90,146	138,073	5,593
2057	8,155	90,146	138,073	5,593
2058	8,155	90,146	138,073	5,593
2059	8,155	90,146	138,073	5,593
2060	8,155	90,146	138,073	5,593
2061	8,155	90,146	138,073	5,593
2062	8,155	90,146	138,073	5,593
2063	8,155	90,146	138,073	5,593

Table 11. TPNRD county summary of groundwater only irrigated lands robust review Unretired Scenario land use data set within the Platte River drainage basin.

Year	Arthur	Keith	Lincoln	McPherson
2054	8,155	90,146	138,114	5,593
2055	8,155	90,146	138,114	5,593
2056	8,155	90,146	138,114	5,593
2057	8,155	90,146	138,114	5,593
2058	8,155	90,146	138,114	5,593
2059	8,155	90,146	138,114	5,593
2060	8,155	90,146	138,114	5,593
2061	8,155	90,146	138,114	5,593
2062	8,155	90,146	138,114	5,593
2063	8,155	90,146	138,114	5,593

Memorandum

To: Brandi Flyr – Central Platte NRD; Kari Burgert – NDNR
From: The Flatwater Group, Inc.
Date: 11/21/2018
Subject: COHYST Area Robust Review: CPNRD Land Use Retirements, Transfers, and Variances

Project Background and Workflow

The Flatwater Group, Inc. (TFG) was contracted by the Platte Basin Water Project Coalition through the Nebraska Department of Natural Resources (NDNR) to provide technical assistance for the Robust Review project. The purpose of the Robust Review project is to assess streamflow impacts resulting from management actions taken as part of the Basin-Wide Plan and/or Natural Resource District (NRD) Integrated Management Plans (IMPs). The focus of this memorandum is to document land use changes related to acreage transfers, retirements, and variances within the Central Platte NRD (CPNRD).

To evaluate changes to land use within the CPNRD, TFG's primary work tasks included compiling available acreage change information; spatially processing the compiled information to ensure unique datasets; developing land use summary tables to facilitate review of the provided information; placing the acreage change transactions into the constructs of the COHYST 2010 watershed model's land use files in order to extend the baseline land use dataset through 2013; and finally to then create a new land use data set for the Robust Review's unretired scenario.

Data Collection and Spatial Processing

For the first step in the process, TFG worked with NDNR and CPNRD to gather available land use change information. Ultimately, CPNRD provided four ArcGIS® shape files and NDNR provide one ArcGIS® shape file and an Excel spreadsheet upon which the analyses for CPNRD were based. The shape files from CPNRD were named:

- *Acres_Added_2_13_2018.shp*
    - Contains spatial locations of areas where irrigation was transferred to
    - Comprised of 2,925 entries
    - 970 of those entries occurred between 2011 and 2013
- *Acres_Offset_2_13_2018.shp*
    - Contains spatial location of areas where irrigation was transferred from
    - Comprised of 3,287 entries
    - 725 of those entries occurred between 2011 and 2013
- *CPNRD_2004_CIA_2018_02_13.shp*
    - 2004 certified acreage coverage
- *WB_PURCHASES.shp*
    - Spatial location of permanent retirements initiated through CPNRD's water bank.
    - Contained 71 entries

NDNR provided the following files:

- *CREP.shp*
    - Contains spatial locations of retirements funded with either CREP or EQIP funds and tracked by NDNR

- *20180829_COHYSTAreaMissing Dates.xlsx*
  - Provided supplementary contract starting and end dates for parcels included in *CREP.shp*.

To ensure that the spatial information provided was unique and did not reflect overlapping polygons, the information was linked to the COHYST 2010 model grid. COHYST 2010 uses a grid of 160-acre sized model cells. Cells are assigned to counties, NRDs, and/or drainage basins based on the location of the cell's centroid. This results in a model cell being assigned a single value for a given feature class. For example, if the border of an NRD passes through a model cell, whichever NRD the cell's centroid is within determines which NRD the cell is assigned to within the model. For this reason, it is possible to have an activity which occurs within a cell along a feature border to be enacted by one entity that shares the border, but for the model to summarize the activity to the other entity which shares the border.

After joining the provided spatial information to the COHYST 2010 model grid, the following observations were made:

1. There were multiple overlapping parcels within the *Acres_Added_2_13_2018.shp* and *Acres_Offset_2_13_2018.shp* datasets
   a. This led to potential changes in ground water only irrigated lands greater than the number of acres within a cell
2. There were irrigated acres to be offset that did not have an underlying entry in the *CPNRD_2004_CIA_2018_02_13.shp* dataset.
3. The majority of the parcels identified in *WB_PURCHASES.shp* were also included in the *Acres_Offset_2_13_2018.shp dataset*
   a. There was one completely unique WB entry
4. The *WB_PURCHASES.shp* dataset included transactions for surface water and comingled acres as well as ground water only acres

With respect to item 1 above, to account for the overlapping parcels within the acreage transfer datasets, the shape files were dissolved by the transfer year using the software ArcGIS®. This eliminated the ability to add or remove the same acres multiple time in a single year but allowed for transfers to and from in subsequent years. The 'Union' function within ArcGIS® was used to associate the transfer and retirement shape file information to the COHYST model grid.

After discussion with CPNRD regarding item 2, the offset acreage parcels which did not have an underlying entry in the certified acreage dataset were identified and returned to CPNRD. CPNRD determined if the parcels were truly offset acres; ultimately providing TFG with their recommendations on which parcels to omit from the analysis. TFG removed these parcels from the dataset moving forward.

After additional discussions with CPNRD about item 3, it was determined that the *Acres_Offset_2_13_2018.shp* dataset included both transfers away <u>and</u> permanent retirements (which were initially believed to be contained in the *WB_PURCHASES.shp* dataset). The *WB_PURCHASES.shp* coverage was spatially queried against the *Acres_Offset_2_13_2018.shp* dataset to determine which offset transactions were retirements. The *Acres_Offset_2_13_2018.shp* dataset was then divided into two sets: offset transfers and offset retirements.

Item 4 was noted due to the Robust Review being focused on ground water only transactions. The offset acreage transactions which had a designation of surface water only or comingled were therefore removed.

Land Use Summary Tables

Using information provided by CPNRD, NDNR, and other basin NRDs, TFG compiled a final summary of the retirements, transfers, and variances occurring within the CPNRD assigned model domain. This information was used to modify the land use data set in the COHYST 2010 model to investigate the effects of these actions as part of the larger Robust Review effort. Tables 1-7 below summarize the information provided to TFG. Tables 8-14 summarize the distribution of that information into the modeling input files.

Table 1 provides an overall summary of the retirement and transfer acreage source information relevant to the CPNRD received by TFG. Columns A through E on Table 1 summarize the information provided by CPNRD and NDNR. Column F summarizes information tracked by other basin NRDs, but whose spatial location upon distribution to the model placed acreage within the model domain assigned to the CPNRD. Subsequent tables define the source(s) of this information.

Table 1. Summary of CPNRD acreage changes for implementation into the Robust Review.

Year	CPNRD Data					Non-CPNRD Data	(G) Change
	(A) Temporary Retirements	(B) Reinstated Temporary Retirements	(C) Permanent Retirements	(D) Transfers To	(E) Transfers Away	(F) Transfers Away	
Baseline Change	(-)	(+)	(-)	(+)	(-)	(-)	
1999	-	-	-	-	-	-	-
2000	-	-	-	-	-	-	-
2001	-	-	-	-	-	-	-
2002	-	-	-	-	-	-	-
2003	-	-	-	-	-	-	-
2004	-	-	-	-	-	-	-
2005	304.4	-	-	-	-	-	(304.4)
2006	260.7	-	150.1	-	-	-	(410.8)
2007	111.9	-	-	-	-	-	(111.9)
2008	52.2	-	-	-	-	-	(52.2)
2009	6.9	-	1,513.8	-	-	-	(1,520.7)
2010	-	-	317.8	-	-	-	(317.8)
2011	-	-	430.8	1,087.2	683.5	1.6	(28.7)
2012	-	-	211.3	4,397.8	1,021.6	3.8	3,161.1
2013	-	-	19.1	4,255.3	1,440.0	77.1	2,719.1
2014	-	-	-	-	-	-	-
2015	-	-	-	-	-	-	-
2016	-	-	-	-	-	-	-
2017	-	-	-	-	-	-	-
2018	-	282.7	-	-	-	-	282.7
2019	-	21.5	-	-	-	-	21.5
2020	-	39.7	-	-	-	-	39.7
2021	-	196.4	-	-	-	-	196.4
2022	-	125.0	-	-	-	-	125.0
2023	-	70.8	-	-	-	-	70.8
Total	736.1	736.1	2,642.9	9,740.3	3,145.1	82.5	3,869.8

Data Source Discussion for Table 1 Columns A-B

The CREP related information provided by NDNR was the source of the temporary retirement information summarized in Column A of Table 1. The *CREP.shp* file included the most up to date list of CREP and EQIP contracts available from NDNR. TFG queried the data spatially in the shape file to obtain only the parcels located within the CPNRD. That query returned 58 polygons totaling 1,640 acres. The information was then limited to parcels irrigated only with ground water and which were initiated prior to the 2013 irrigation season. This reduced the number of acres to 876.4.

A spatial comparison of the CREP/EQIP information provided by NDNR and the permanent retirement information provided by CPNRD (via *WB_PURCHASES.shp*) revealed a small amount of overlap between the two datasets. The overlapping acres were removed from the *CREP.shp* dataset and retained in the in the CPNRD provided information; however, the date the retirements were initiated was changed to reflect the initial temporary retirement year (from 2009 to 2006). This resulted in 140.3 acres being converted from temporarily retired to permanently retired. Reducing the remaining 876.4 CREP/EQIP retirement acres by the 140.3 acres yields 736.1 acres within the CPNRD area (and an additional 0.7 acres in the TBNRD area due to the cell assignment procedures discussed earlier). Table 2 summarizes these values. Note that Column 'CPNRD' on Table 2 is the source of the information populated into Column A of Table 1.

Table 2. Summary of CPNRD CREP and EQIP temporary retirements.

Year	Total	CPNRD	TBNRD
2005	304.4	304.4	-
2006	260.7	260.7	-
2007	111.9	111.9	-
2008	52.2	52.2	-
2009	7.6	6.9	0.7
2010	-	-	-
2011	-	-	-
2012	-	-	-
2013	-	-	-
Total	736.8	736.1	0.7

Based on the contract start and end dates contained in *CREP.shp* and *20180829_COHYSTAreaMissing Dates.xlsx*, the year the temporary retirements end was computed. This information is shown on Table 3. Note that Column 'CPNRD' on Table 3 is the source of the information populated into Column B of Table 1.

Table 3. Summary of CPNRD CREP and EQIP temporary retirements reinstatements.

Year	Total	CPNRD	TBNRD
2018	282.7	282.7	-
2019	21.5	21.5	-
2020	40.4	39.7	0.7
2021	196.4	196.4	-
2022	125.0	125.0	-
2023	70.8	70.8	-
Total	736.8	736.1	0.7

Data Source Discussion for Table 1 Column C

Table 4 summarizes the permanent retirement information provided in the datasets from CPNRD. Similar to the CREP/EQIP acreage, some permanent retirements occurred in cells assigned to neighboring NRDs. Note that Column A of Table 4 is the source of the information populated into Column C of Table 1.

Table 4. Summary of CPNRD permanent retirement acreage.

Year	(A) = B + C CPNRD Retirements	(B) Water Bank Only	(C) Water Bank And Offset Acres	LLNRD	TBNRD
2006	150.1	-	150.1	-	-
2007	-	-	-	-	-
2008	-	-	-	-	-
2009	1,513.8	75.0	1,438.8	0.4	149.1
2010	317.8	-	317.8	-	-
2011	430.8	-	430.8	-	-
2012	211.3	-	211.3	-	-
2013	19.1	-	19.1	-	-
Total	2,642.9	75.0	2,567.9	0.4	149.1

Note:
LLNRD – Lower Loup Natural Resources District
TBNRD – Tri-Basin Natural Resources District
(B) represents the data found only in the WB Purchases shapefile
(C) represents the intersection of the Acres Offset data set and the WB Purchases shapefiles limited to groundwater only transactions

The 140.3 acres converted from temporary to permanent as discussed in the Section above are reflected in this table.

Data Source Discussion for Table 1 Columns D and E

Table 5 summarizes the amount of new irrigated acreage resulting from CPNRD transfers, while Table 6 summarizes the amount of irrigated acreage reduced as a result of transfers occurring in the CPNRD.

Table 5. Summary of CPNRD added acres.

Year	Total	CPNRD	UBBNRD	LBNRD	LLNRD	LPNNRD	TBNRD
2011	1,107.4	1,087.2	5.1	10.6	4.5	-	-
2012	4,455.9	4,397.8	4.4	2.5	49.4	1.8	-
2013	4,268.9	4,255.3	10.0	-	2.2	-	1.4
Total	9,832.2	9,740.3	19.5	13.1	56.1	1.8	1.4

Table 6. Summary of CPNRD offset acres.

Year	Total	CPNRD	UBBNRD	LLNRD	LPNNRD
2011	698.3	683.5	4.3	10.5	-
2012	1,037.9	1,021.6	5.3	9.2	1.8
2013	1,445.2	1,440.0	2.9	2.3	-
Total	3,181.4	3,145.1	12.5	22.0	1.8

Note for Tables 5 and 6:
UBBNRD – Upper Big Blue Natural Resources District
LBNRD – Little Blue Natural Resources District
LLNRD – Lower Loup Natural Resources District
LPNNRD – Lower Platte North Natural Resources District
TBNRD – Tri-Basin Natural Resources District

Columns 'CPNRD' in Tables 5 and 6 are the sources for the information populated into Columns D and E, respectively, of Table 1. The tables also reflect a small amount of acreage attributed to cells assigned to neighboring NRDs due to the cell assignment process previously discussed.

Data Source Discussion for Table 1 Column F

Table 7 reflects, similar to how acreage modifications tracked by the CPNRD were located within cells assigned to other NRDs within the model, a small number of transactions tracked by the TPNRD (5.4 acres) and TBNRD (77.1 acres) that were placed into model cells which were assigned to the CPNRD. These transactions were all transfers away. The information in Column 'Total' of Table 7 is the source of the information populated into Column F of Table 1.

Table 7. Acreage summary of Non-CPNRD transactions which occurred within the CPNRD assigned cells.

Year	TPNRD	TBNRD	Total
2011	1.6	-	1.6
2012	3.8	-	3.8
2013	-	77.1	77.1
Total	5.4	77.1	82.5

Spatial Analysis Method

ArcGIS® was used to link the retirement, transfer, and variance information provided by CPNRD and NDNR to the COHYST 2010 model grid. This was accomplished by overlaying the parcels' shapefiles with the model grid.

Step 1: Assigning land use change location

NDNR and CPNRD provided retirement and transfer acreage information in the form of shape files. The parcel information within the shape files was dissolved by year to remove duplicate areas. The offset acreage information was divided between transfers away and permanent retirements. The union function within ArcGIS® was applied to each shapefile to determine the cell location. The polygon area within each cell was then computed using the calculate geometry function within ArcGIS®.

Step 2: Building the Baseline Land Use

The next step was to build the 2011-2013 land use files incorporating the identified transfers and retirements. The beginning condition for this update was the 2010 land use file[1] from the COHYST 2010 model. Each of the 2011 transactions were applied to the 2010 land use to create the 2011 land use file; which in turn became the basis for applying the 2012 transactions. This continued through 2013. One of the key points of the investigation was the effect of retirements on the system. Given that many of the retirements were temporary in nature and knowing their contract end dates, the land use file building process was continued through 2023 to be able to add back in all of the temporarily retired acres.

Acres were to be added or removed from their assigned cells. If there was insufficient space[2] for new acres or an insufficient amount of groundwater only acres[3] to be retired within the cell, the addition or subtraction of acres was applied to nearby cells which exhibit the appropriate characteristics[4]. This spatial process entails radiating outward from the identified cell until the acres had been placed. During this process acres are placed or removed from the lowest priority cell which meets the appropriate criteria. If more than one cell has the same priority and meets criteria, the acres are split evenly between the multiple cells. Unless an even split would exceed the available space within the cell; at which time the placed acres would be limited to the available space and the remaining acres would be split among the other priority cells. The priority pattern for the first two rings around the assignment cell can be seen in Figure 1. This process was implemented using a custom piece of FORTRAN script.

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[1] While the 'Certified Irrigated Acres' (CIA) provided by CPNRD was considered as the starting point for the land use update, it was decided to use the land use data set developed by Riverside for COHYST 2010. The CIA coverage represents the maximum potential groundwater irrigated acres. The Riverside coverage identified the groundwater only irrigated acres which were actively being irrigated in 2010.

[2] Example: transferring 30 groundwater only acres to a cell where there was only 20 non-irrigated acres

[3] Example: retiring 30 groundwater only acres from a cell where there was only 20 groundwater only acres

[4] The cell needed to be active, in the same NRD, and have a sufficient amount of groundwater only acres to retire or non-irrigated acres to convert

5 (r-2, c-2)	4 (r-2, c-1)	3 (r-2, c+0)	4 (r-2, c+1)	5 (r-2, c+2)
4 (r-1, c-2)	2 (r-1, c-1)	1 (r-1, c+0)	2 (r-1, c+1)	4 (r-1, c+2)
3 (r+0, c-2)	1 (r+0, c-1)	0 (r+0, c+0)	1 (r+0, c+1)	3 (r+0, c+2)
4 (r+1, c-2)	2 (r+1, c-1)	1 (r+1, c+0)	2 (r+1, c+1)	4 (r+1, c+2)
5 (r+2, c-2)	4 (r+2, c-1)	3 (r+2, c+0)	4 (r+2, c+1)	5 (r+2, c+2)

Figure 1. Priority of search pattern to place or remove acres when the assigned cell has insufficient non-irrigated or groundwater only acres. The center cell represents the cell identified as the location of the land use transaction. ‘r’ and ‘c’ indicate the row column index of the cell.

The results of step 2 are shown in Table 8. As intended, the values in Column B of Table 8 match (sans de minimis rounding resulting from the distribution process) the original source information summarized in Column G of Table 1 for the years 2011-2023. This indicates that the acreage values provided by CPNRD and NDNR were the quantities by which the modeling input files were adjusted.

Table 8 also includes the changes attributable to the CPNRD which occur in cells assigned to its neighboring NRDs. Column C represents the total impact of Table 3 (Columns: TBNRD), Table 5 (Columns: UBBNRD, LBNRD, LLNRD, LPNNRD, & TBNRD), and Table 6 (Columns UBBNRD, LLNRD, & LPNNRD). It should be noted that the cell boundaries do not necessarily overlap with the legal boundaries either for the county or NRD. For these summaries each cell was assigned to an NRD and county based upon the location of the cell centroid.

Table 8. Change in groundwater only irrigated acres within the CPNRD for the Robust Review baseline.

Year	(A) Groundwater Only Irrigated Acres in CPNRD	(B) Annual Change in CPNRD Groundwater Only Irrigated Acres in the CPNRD	(C) Change in CPNRD Groundwater Only Irrigated Acres not in the CPNRD
2010	896,869.5	-	-
2011	896,840.8	(28.7)	5.4
2012	900,002.3	3,161.5	41.8
2013	902,721.3	2,719.0	8.4
2014	902,721.3	-	-
2015	902,721.3	-	-
2016	902,721.3	-	-
2017	902,721.3	-	-
2018	903,004.1	282.8	-
2019	903,025.6	21.5	-
2020	903,065.3	39.7	0.7
2021	903,261.7	196.4	-
2022	903,386.7	125.0	-
2023	903,457.5	70.8	-

Step 3: Building the Unretired Acres Scenario Modified Land Use

A new set of land use files were created for the unretired scenario. In this scenario the permanently and temporarily retired acres were never retired. Other key elements of the scenario include:

- The transfers were applied.
- For the post 2010 period no retirements were applied.
- For permanent retirements, irrigated acres were added back into the modified land use files for all future years.
- For temporary retirements, the acres were added back during their contracted period. If the temporary retirement ended after 2010, the temporarily retired acres were added back in 2011 and remain moving forward.

Table 9 shows the change between the COHYST 2010 land use file and the unretired retirements scenario. The difference between the two data sets shows the cumulative change over time. Again, as intended, the annual change in ground water only irrigated acres shown on Table 8 Column D match (sans de minimis rounding resulting from the distribution process) the original source information shown in Column G of Table 1 for the years 1999 through 2010 (the sign reversal indicates removal (unretirement) of the acreage). This indicates that the acreage values provided by the CPNRD and NDNR were the quantities by which the modeling input files were adjusted.

Table 9. Change in Groundwater Only Irrigated Acres in the CPNRD comparing the COHYST 2010 land use to Unretired Retirements Scenario land use; years 1999-2010.

Year	Groundwater Only Irrigated Acres		Change in Groundwater Only Irrigated Acres within the CPNRD	
	(A) Run029	(B) Modified Land Use	(C) Cumulative	(D) Annual
1999	828,559	828,559	(0.0)	(0.0)
2000	834,741	834,741	-	0.0
2001	843,080	843,080	-	-
2002	854,133	854,133	0.0	0.0
2003	866,690	866,690	(0.0)	(0.0)
2004	878,324	878,324	-	0.0
2005	887,953	888,258	304.4	304.4
2006	883,622	884,337	715.1	410.7
2007	914,684	915,511	826.6	111.5
2008	877,717	878,597	879.5	52.9
2009	907,031	909,431	2,400.1	1,520.6
2010	896,870	899,587	2,717.9	317.8
		Cumulative		2,717.9

Table 10 shows the changes between the COHYST 2010 land use file and the land use file developed for the "unretired" condition within the Robust Review's retirement scenario. Column A in the table presents the annual acreage irrigated only with ground water from 2011 through 2023 for the "unretired" land use data set. Column B summarizes the acreage changes made to arrive at values presented in Column A. Columns C through I present the information used in the computation of the Column B values.

SUMMARY

Tables 8 through 10 summarize the background information as to how the land use files for the Robust Review will be populated. Comparisons back to Table 1 confirm the information provided to TFG by CPNRD, NDNR and other entities referenced in the memorandum were fully included in the model input files. The retirement scenario within the Robust Review involves two land use datasets: the Baseline Set; and the Unretired Set.

For the Baseline Set:

- For the years through 1998: The existing COHYST 2010 land use data set will be used
- For the years 1999 through 2010: Values from Column A in Table 9 will be used
- For the years 2011 through 2023 and forward: Values from Column A in Table 8 will be used

For the Unretired Set:

- For the years through 1998: The existing COHYST 2010 land use data set will be used
- For the years 1999 through 2010: Values from Column B in Table 9 will be used
- For the years 2011 through 2023 and forward: Values from Column A in Table 10 will be used

Table 10. Change in Groundwater Only Irrigated Acres in the CPNRD comparing the COHYST 2010 land use to Unretired Retirements Scenario land use; years 2011-2023.

Year	(A) Groundwater Only Irrigated Acres	(B) Difference in Ground Water Only Acres from 2010 minus cumulative prior retirements and transfers	(C) Transfer s Away	(D) Transfers To	(E) Non Area Transfers Away	(F) Non Area Transfers To	(G) Net Transfers Away	(H) Cumulative Net Transfers Away	(I) Residuals
2011	899,989.5	402.1	683.5	1,087.2	1.6		(402.1)	(402.1)	(0.0)
2012	903,362.3	3,372.8	1,021.6	4,397.8	3.8		(3,372.4)	(3,774.5)	0.4
2013	906,100.4	2,738.1	1,440.0	4,255.3	77.1		(2,738.2)	(6,512.7)	(0.1)
2014	906,100.4	-					-	(6,512.7)	-
2015	906,100.4	-					-	(6,512.7)	-
2016	906,100.4	-					-	(6,512.7)	-
2017	906,100.4	-					-	(6,512.7)	-
2018	906,100.4	-					-	(6,512.7)	-
2019	906,100.4	-					-	(6,512.7)	-
2020	906,100.4	-					-	(6,512.7)	-
2021	906,100.4	-					-	(6,512.7)	-
2022	906,100.4	-					-	(6,512.7)	-
2023	906,100.4	-					-	(6,512.7)	-

Tables 11 and 12 show the annual area of groundwater only irrigated land for each county in the CPNRD within the Robust Review baseline and unretirement scenarios. Finally, Tables 13 and 14 show the annual area of groundwater only irrigated land for each county in the CPNRD and Platte River Drainage basin within the Robust Review's baseline and unretirement scenarios.

Table 11. CPNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
1950	37,762	403	27,603	-	38,694	883	253	20,701	168	128	2,030
1951	38,107	596	26,837	-	40,090	897	220	18,343	170	118	1,864
1952	38,472	459	26,426	-	41,482	904	185	15,963	165	106	1,703
1953	38,638	665	26,443	-	42,875	781	120	13,606	160	84	1,541
1954	38,818	773	27,725	-	44,267	616	86	11,236	155	81	1,175
1955	42,204	1,217	35,398	58	51,750	915	233	16,096	202	143	2,394
1956	45,745	1,496	43,244	169	59,229	1,346	394	20,960	302	225	3,174
1957	49,510	1,920	50,498	281	66,706	2,042	554	25,719	402	308	3,861
1958	53,516	2,174	56,649	320	74,185	2,510	727	30,563	488	399	4,869
1959	57,358	2,538	64,005	467	81,662	2,990	891	35,406	552	463	5,867
1960	58,532	2,713	64,363	539	84,161	3,249	1,104	39,426	738	571	7,673
1961	59,699	2,720	64,418	743	86,660	3,536	1,307	43,459	922	697	9,349
1962	60,893	2,832	64,716	736	89,163	3,816	1,551	47,494	1,084	811	11,036
1963	62,188	2,897	65,266	757	91,656	4,062	1,823	51,508	1,218	960	12,692
1964	63,155	2,999	65,219	692	94,156	4,388	2,070	55,499	1,394	1,037	14,087
1965	67,131	4,116	67,466	1,321	98,490	4,867	3,070	60,697	1,750	1,245	16,472
1966	71,398	5,058	69,448	1,622	102,777	5,283	4,020	65,832	2,070	1,457	19,161
1967	75,375	5,991	71,862	1,604	107,112	5,667	4,808	70,912	2,482	1,747	21,573
1968	79,317	6,844	74,296	1,882	111,447	6,017	5,605	75,955	2,817	2,023	23,798
1969	83,508	7,897	76,595	1,952	115,722	6,698	6,275	80,999	3,128	2,247	26,254
1970	88,978	8,703	86,595	2,361	122,556	7,308	6,529	85,769	3,245	2,435	27,857
1971	94,430	9,677	96,852	2,716	129,273	7,958	7,032	90,528	3,276	2,591	29,419
1972	99,125	10,412	107,389	2,779	136,031	8,434	7,235	95,280	3,461	2,692	30,849
1973	104,220	11,069	117,907	3,115	142,807	8,882	7,548	99,922	3,715	2,769	32,414
1974	109,536	11,863	129,601	3,299	149,581	9,553	8,112	104,690	4,163	2,883	34,222
1975	116,243	12,546	132,081	3,729	156,915	10,270	8,995	111,897	4,829	3,245	36,893
1976	122,587	13,248	132,581	3,880	164,283	11,296	9,733	118,796	5,188	3,529	39,541
1977	129,105	14,362	135,105	4,265	171,636	11,780	10,114	125,820	5,644	3,975	42,361

Table 11. CPNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
1978	136,078	15,494	136,151	4,481	178,967	12,647	10,967	132,888	6,213	4,204	44,679
1979	138,896	16,663	140,172	4,258	180,519	12,768	11,283	134,209	6,188	4,171	43,948
1980	142,065	17,443	145,645	4,369	182,018	12,827	11,613	135,467	6,268	4,117	42,961
1981	146,078	18,135	150,431	4,153	183,565	12,864	11,917	136,665	6,223	4,290	42,138
1982	149,224	18,722	155,109	4,352	184,999	12,810	12,157	137,922	6,293	4,277	41,025
1983	146,691	18,607	152,394	4,299	181,499	12,558	11,695	135,549	6,363	4,338	41,255
1984	143,647	17,959	149,510	4,114	177,862	12,243	11,303	133,139	6,457	4,412	41,345
1985	144,075	20,445	169,085	4,968	193,563	10,446	13,046	166,376	9,633	5,195	35,947
1986	144,745	20,080	166,815	4,908	193,519	10,344	12,745	166,499	9,564	5,214	36,157
1987	145,080	19,556	163,289	4,806	193,173	10,167	12,162	166,554	9,521	5,265	36,535
1988	146,473	19,684	163,270	4,856	194,271	10,219	12,616	167,318	9,446	5,278	36,357
1989	148,972	19,834	163,121	4,799	196,204	10,366	13,056	168,747	9,464	5,271	36,223
1990	150,649	20,009	163,019	4,738	197,294	10,424	13,501	170,202	9,556	5,280	36,063
1991	152,280	20,234	162,930	4,677	198,631	10,575	13,924	171,093	9,479	5,314	35,917
1992	154,498	20,827	163,529	4,657	200,312	10,817	14,723	172,140	9,447	5,388	35,536
1993	155,474	20,929	163,200	4,622	200,857	10,898	14,949	172,900	9,478	5,442	37,142
1994	156,701	21,061	162,887	4,588	201,279	10,984	15,203	173,400	9,534	5,495	38,749
1995	157,797	21,224	162,749	4,556	201,806	11,078	15,406	173,634	9,612	5,552	40,378
1996	159,570	21,437	163,209	4,545	203,009	11,177	15,653	174,129	9,791	5,615	42,052
1997	161,837	21,763	163,006	4,525	203,597	11,383	15,991	174,679	10,061	5,735	45,241
1998	162,219	21,787	167,423	4,818	203,667	11,425	16,038	174,203	10,129	5,900	45,809
1999	162,685	21,745	171,542	5,087	203,704	11,578	16,043	173,630	10,146	6,015	46,385
2000	163,257	21,718	175,831	5,334	204,223	11,686	16,186	173,201	10,178	6,203	46,924
2001	162,813	21,556	183,747	5,915	204,341	11,663	16,476	172,389	10,331	6,343	47,507
2002	164,295	22,660	186,859	6,214	205,180	11,707	16,511	174,074	10,446	6,470	49,718
2003	165,455	25,163	191,481	6,250	206,046	11,772	17,140	174,294	10,686	6,632	51,769
2004	166,787	26,266	195,741	6,499	207,343	11,986	17,765	174,759	10,936	6,664	53,578
2005	167,084	27,724	200,234	6,497	207,622	12,185	18,098	174,951	11,189	6,695	55,675

Table 11. CPNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
2006	165,041	21,503	200,516	5,741	210,252	12,325	18,183	175,802	11,521	6,727	56,011
2007	171,270	26,613	211,532	6,538	213,805	12,740	19,019	177,883	12,213	6,862	56,209
2008	163,245	25,823	203,209	5,725	204,290	12,239	17,559	173,374	10,627	6,568	55,060
2009	170,387	27,559	211,181	6,394	208,849	12,622	18,390	176,557	11,693	6,801	56,597
2010	169,215	26,607	203,177	6,555	210,204	12,577	18,557	177,058	10,960	6,534	55,426
2011	169,132	26,591	202,848	6,551	210,356	12,714	18,650	177,059	10,978	6,534	55,427
2012	169,260	26,553	202,671	6,548	211,511	12,883	18,681	178,350	11,007	6,562	55,978
2013	169,508	26,552	202,627	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2014	169,508	26,552	202,627	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2015	169,508	26,552	202,627	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2016	169,508	26,552	202,627	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2017	169,508	26,552	202,627	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2018	169,508	26,552	202,910	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2019	169,508	26,552	202,931	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2020	169,508	26,552	202,971	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2021	169,508	26,552	203,167	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2022	169,508	26,552	203,292	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2023	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2024	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2025	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2026	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2027	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2028	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2029	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2030	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2031	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2032	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2033	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811

Table 11. CPNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
2034	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2035	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2036	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2037	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2038	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2039	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2040	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2041	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2042	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2043	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2044	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2045	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2046	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2047	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2048	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2049	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2050	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2051	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2052	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2053	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2054	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2055	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2056	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2057	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2058	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2059	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2060	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2061	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811

Table 11. CPNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
2062	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811
2063	169,508	26,552	203,363	6,541	211,990	12,980	18,814	179,305	11,023	6,570	56,811

Table 12. CPNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
1950	37,762	403	27,603	-	38,694	883	253	20,701	168	128	2,030
1951	38,107	596	26,837	-	40,090	897	220	18,343	170	118	1,864
1952	38,472	459	26,426	-	41,482	904	185	15,963	165	106	1,703
1953	38,638	665	26,443	-	42,875	781	120	13,606	160	84	1,541
1954	38,818	773	27,725	-	44,267	616	86	11,236	155	81	1,175
1955	42,204	1,217	35,398	58	51,750	915	233	16,096	202	143	2,394
1956	45,745	1,496	43,244	169	59,229	1,346	394	20,960	302	225	3,174
1957	49,510	1,920	50,498	281	66,706	2,042	554	25,719	402	308	3,861
1958	53,516	2,174	56,649	320	74,185	2,510	727	30,563	488	399	4,869
1959	57,358	2,538	64,005	467	81,662	2,990	891	35,406	552	463	5,867
1960	58,532	2,713	64,363	539	84,161	3,249	1,104	39,426	738	571	7,673
1961	59,699	2,720	64,418	743	86,660	3,536	1,307	43,459	922	697	9,349
1962	60,893	2,832	64,716	736	89,163	3,816	1,551	47,494	1,084	811	11,036
1963	62,188	2,897	65,266	757	91,656	4,062	1,823	51,508	1,218	960	12,692
1964	63,155	2,999	65,219	692	94,156	4,388	2,070	55,499	1,394	1,037	14,087
1965	67,131	4,116	67,466	1,321	98,490	4,867	3,070	60,697	1,750	1,245	16,472
1966	71,398	5,058	69,448	1,622	102,777	5,283	4,020	65,832	2,070	1,457	19,161
1967	75,375	5,991	71,862	1,604	107,112	5,667	4,808	70,912	2,482	1,747	21,573
1968	79,317	6,844	74,296	1,882	111,447	6,017	5,605	75,955	2,817	2,023	23,798
1969	83,508	7,897	76,595	1,952	115,722	6,698	6,275	80,999	3,128	2,247	26,254

Table 12. CPNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
1970	88,978	8,703	86,595	2,361	122,556	7,308	6,529	85,769	3,245	2,435	27,857
1971	94,430	9,677	96,852	2,716	129,273	7,958	7,032	90,528	3,276	2,591	29,419
1972	99,125	10,412	107,389	2,779	136,031	8,434	7,235	95,280	3,461	2,692	30,849
1973	104,220	11,069	117,907	3,115	142,807	8,882	7,548	99,922	3,715	2,769	32,414
1974	109,536	11,863	129,601	3,299	149,581	9,553	8,112	104,690	4,163	2,883	34,222
1975	116,243	12,546	132,081	3,729	156,915	10,270	8,995	111,897	4,829	3,245	36,893
1976	122,587	13,248	132,581	3,880	164,283	11,296	9,733	118,796	5,188	3,529	39,541
1977	129,105	14,362	135,105	4,265	171,636	11,780	10,114	125,820	5,644	3,975	42,361
1978	136,078	15,494	136,151	4,481	178,967	12,647	10,967	132,888	6,213	4,204	44,679
1979	138,896	16,663	140,172	4,258	180,519	12,768	11,283	134,209	6,188	4,171	43,948
1980	142,065	17,443	145,645	4,369	182,018	12,827	11,613	135,467	6,268	4,117	42,961
1981	146,078	18,135	150,431	4,153	183,565	12,864	11,917	136,665	6,223	4,290	42,138
1982	149,224	18,722	155,109	4,352	184,999	12,810	12,157	137,922	6,293	4,277	41,025
1983	146,691	18,607	152,394	4,299	181,499	12,558	11,695	135,549	6,363	4,338	41,255
1984	143,647	17,959	149,510	4,114	177,862	12,243	11,303	133,139	6,457	4,412	41,345
1985	144,075	20,445	169,085	4,968	193,563	10,446	13,046	166,376	9,633	5,195	35,947
1986	144,745	20,080	166,815	4,908	193,519	10,344	12,745	166,499	9,564	5,214	36,157
1987	145,080	19,556	163,289	4,806	193,173	10,167	12,162	166,554	9,521	5,265	36,535
1988	146,473	19,684	163,270	4,856	194,271	10,219	12,616	167,318	9,446	5,278	36,357
1989	148,972	19,834	163,121	4,799	196,204	10,366	13,056	168,747	9,464	5,271	36,223
1990	150,649	20,009	163,019	4,738	197,294	10,424	13,501	170,202	9,556	5,280	36,063
1991	152,280	20,234	162,930	4,677	198,631	10,575	13,924	171,093	9,479	5,314	35,917
1992	154,498	20,827	163,529	4,657	200,312	10,817	14,723	172,140	9,447	5,388	35,536
1993	155,474	20,929	163,200	4,622	200,857	10,898	14,949	172,900	9,478	5,442	37,142
1994	156,701	21,061	162,887	4,588	201,279	10,984	15,203	173,400	9,534	5,495	38,749
1995	157,797	21,224	162,749	4,556	201,806	11,078	15,406	173,634	9,612	5,552	40,378
1996	159,570	21,437	163,209	4,545	203,009	11,177	15,653	174,129	9,791	5,615	42,052
1997	161,837	21,763	163,006	4,525	203,597	11,383	15,991	174,679	10,061	5,735	45,241

Table 12. CPNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
1998	162,219	21,787	167,423	4,818	203,667	11,425	16,038	174,203	10,129	5,900	45,809
1999	162,685	21,745	171,542	5,087	203,704	11,578	16,043	173,630	10,146	6,015	46,385
2000	163,257	21,718	175,831	5,334	204,223	11,686	16,186	173,201	10,178	6,203	46,924
2001	162,813	21,556	183,747	5,915	204,341	11,663	16,476	172,389	10,331	6,343	47,507
2002	164,295	22,660	186,859	6,214	205,180	11,707	16,511	174,074	10,446	6,470	49,718
2003	165,455	25,163	191,481	6,250	206,046	11,772	17,140	174,294	10,686	6,632	51,769
2004	166,787	26,266	195,741	6,499	207,343	11,986	17,765	174,759	10,936	6,664	53,578
2005	167,084	27,724	200,538	6,497	207,622	12,185	18,098	174,951	11,189	6,695	55,675
2006	165,051	21,503	201,221	5,741	210,252	12,325	18,183	175,802	11,521	6,727	56,011
2007	171,281	26,613	212,348	6,538	213,805	12,740	19,019	177,883	12,213	6,862	56,209
2008	163,255	25,823	204,078	5,725	204,290	12,239	17,559	173,374	10,627	6,568	55,060
2009	170,742	27,559	213,010	6,394	209,065	12,622	18,390	176,557	11,693	6,801	56,597
2010	169,571	26,607	205,256	6,555	210,432	12,577	18,557	177,113	10,960	6,534	55,426
2011	169,536	26,597	205,255	6,551	210,633	12,714	18,650	177,114	10,978	6,534	55,427
2012	169,707	26,559	205,247	6,548	211,787	12,883	18,681	178,405	11,007	6,562	55,978
2013	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2014	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2015	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2016	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2017	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2018	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2019	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2020	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2021	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2022	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2023	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2024	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2025	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811

Table 12. CPNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
2026	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2027	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2028	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2029	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2030	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2031	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2032	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2033	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2034	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2035	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2036	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2037	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2038	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2039	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2040	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2041	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2042	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2043	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2044	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2045	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2046	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2047	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2048	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2049	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2050	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2051	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2052	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2053	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811

Table 12. CPNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
2054	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2055	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2056	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2057	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2058	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2059	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2060	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2061	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2062	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811
2063	169,955	26,558	205,222	6,541	212,267	12,980	18,814	179,360	11,023	6,570	56,811

Table 13. CPNRD county summary of groundwater only irrigated lands robust review baseline land use data set within the Platte River drainage basin.

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
1950	37,762	403	27,603	-	37,736	883	253	20,580	147	128	1,993
1951	38,107	596	26,837	-	38,967	897	220	18,220	151	118	1,798
1952	38,427	459	26,426	-	40,282	848	185	15,861	147	106	1,643
1953	38,597	665	26,443	-	41,454	732	120	13,497	142	84	1,492
1954	38,666	773	27,722	-	42,551	581	86	11,113	141	81	1,130
1955	41,954	1,217	35,370	58	49,528	801	233	15,930	171	143	2,320
1956	45,461	1,496	43,159	169	56,170	1,009	394	20,720	269	225	3,061
1957	49,047	1,920	50,373	281	62,398	1,414	537	25,320	332	308	3,654
1958	53,017	2,174	56,490	320	69,341	1,734	684	30,108	402	399	4,614
1959	56,831	2,538	63,779	467	76,263	2,064	839	34,889	461	463	5,564
1960	58,002	2,713	64,133	539	78,417	2,243	1,042	38,829	618	571	7,274
1961	59,070	2,720	64,176	743	80,640	2,437	1,231	42,804	777	697	8,867

Table 13. CPNRD county summary of groundwater only irrigated lands robust review baseline land use data set within the Platte River drainage basin.

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
1962	60,251	2,832	64,471	736	82,921	2,627	1,464	46,798	924	811	10,471
1963	61,508	2,897	65,015	757	85,219	2,794	1,726	50,688	1,055	960	12,021
1964	62,477	2,999	64,950	692	87,092	3,013	1,967	54,585	1,186	1,037	13,377
1965	66,237	4,116	67,193	1,321	90,683	3,336	2,934	59,623	1,479	1,245	15,514
1966	70,468	5,058	69,130	1,622	94,197	3,589	3,854	64,682	1,746	1,457	17,938
1967	74,334	5,991	71,527	1,604	97,700	3,941	4,620	69,571	2,128	1,747	20,017
1968	78,123	6,844	73,929	1,882	101,499	4,196	5,374	74,403	2,344	2,023	22,083
1969	82,200	7,897	76,229	1,952	105,122	4,571	6,004	79,254	2,629	2,247	24,402
1970	87,492	8,703	86,185	2,361	111,092	5,086	6,264	83,830	2,763	2,435	25,756
1971	92,693	9,677	96,303	2,716	116,659	5,494	6,653	88,377	2,817	2,591	27,204
1972	97,300	10,303	106,747	2,779	122,400	5,927	6,868	92,665	2,997	2,692	28,564
1973	102,091	10,972	117,177	3,115	128,025	6,208	7,180	97,095	3,239	2,769	29,910
1974	107,137	11,682	128,835	3,299	134,016	6,529	7,745	101,782	3,701	2,883	31,597
1975	113,477	12,343	131,307	3,729	140,112	7,102	8,629	108,551	4,351	3,245	33,686
1976	119,342	13,080	131,715	3,880	145,777	7,761	9,305	115,018	4,703	3,529	36,078
1977	125,234	14,189	134,265	4,265	151,367	8,165	9,700	121,795	5,013	3,975	38,676
1978	131,712	15,294	135,229	4,481	157,612	8,790	10,515	128,568	5,552	4,204	40,768
1979	134,109	16,383	139,184	4,258	158,836	8,821	10,721	129,758	5,521	4,118	40,194
1980	136,916	17,154	144,644	4,369	160,116	8,885	11,049	130,886	5,535	4,072	39,334
1981	140,740	17,830	149,214	4,153	161,744	8,916	11,280	132,063	5,515	4,060	38,683
1982	143,696	18,401	153,794	4,352	162,727	8,875	11,506	133,142	5,602	4,049	37,629
1983	141,431	18,283	151,087	4,299	160,240	8,682	11,062	130,910	5,657	4,100	37,832
1984	138,674	17,680	148,292	4,114	157,198	8,518	10,718	128,660	5,748	4,180	37,916
1985	136,892	20,044	167,652	4,968	164,849	7,076	12,491	159,367	8,353	4,601	32,525
1986	137,539	19,686	165,401	4,908	164,844	7,009	12,207	159,463	8,300	4,618	32,716
1987	137,860	19,173	161,908	4,806	164,424	6,891	11,651	159,519	8,269	4,663	33,058
1988	139,189	19,298	161,898	4,856	165,411	6,922	12,088	160,269	8,208	4,649	32,902

Table 13. CPNRD county summary of groundwater only irrigated lands robust review baseline land use data set within the Platte River drainage basin.

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
1989	141,513	19,445	161,755	4,799	166,906	7,086	12,511	161,685	8,244	4,643	32,802
1990	143,133	19,617	161,661	4,738	167,819	7,123	12,947	162,973	8,355	4,653	32,667
1991	144,709	19,839	161,577	4,677	168,815	7,142	13,356	163,767	8,293	4,646	32,489
1992	146,861	20,421	162,174	4,657	170,202	7,228	14,126	164,798	8,275	4,614	32,151
1993	147,684	20,520	161,850	4,622	170,367	7,279	14,342	165,307	8,303	4,660	33,606
1994	148,773	20,652	161,543	4,588	170,656	7,333	14,596	165,575	8,352	4,705	35,069
1995	149,833	20,813	161,411	4,556	171,142	7,392	14,799	165,806	8,419	4,755	36,563
1996	151,466	21,029	161,880	4,545	172,077	7,454	15,043	166,300	8,594	4,809	38,025
1997	153,438	21,351	161,687	4,525	172,431	7,594	15,376	166,805	8,835	4,911	40,738
1998	153,705	21,350	166,075	4,818	172,379	7,688	15,424	166,293	8,909	5,024	41,170
1999	153,876	21,310	170,164	5,087	172,366	7,796	15,435	165,758	8,923	5,121	41,716
2000	154,472	21,287	174,425	5,334	172,745	7,855	15,322	165,360	8,952	5,298	42,152
2001	154,078	21,135	182,288	5,915	172,816	7,842	15,601	164,534	9,087	5,416	42,703
2002	155,328	22,224	185,387	6,214	173,663	7,867	15,643	166,170	9,211	5,535	44,593
2003	156,124	24,687	189,865	6,250	174,370	7,913	16,280	166,310	9,426	5,563	46,421
2004	156,962	25,772	194,100	6,499	175,299	8,107	16,838	166,791	9,655	5,590	48,099
2005	157,177	26,801	198,563	6,497	175,586	8,276	17,153	166,989	9,879	5,615	49,947
2006	154,900	20,584	199,009	5,741	178,511	7,959	17,187	166,481	10,006	5,660	49,706
2007	160,930	25,670	209,739	6,538	181,168	8,353	18,012	168,783	10,608	5,795	49,821
2008	153,153	24,885	201,452	5,725	174,109	8,007	16,653	164,037	9,180	5,501	48,657
2009	160,080	26,603	209,434	6,394	176,127	8,264	17,444	167,098	10,120	5,734	50,122
2010	158,798	25,652	201,420	6,555	177,806	8,207	17,572	167,891	9,470	5,467	49,036
2011	158,711	25,636	201,095	6,551	177,827	8,226	17,663	167,880	9,488	5,467	49,037
2012	158,839	25,598	200,918	6,548	178,849	8,366	17,694	169,017	9,517	5,494	49,507
2013	158,977	25,597	200,871	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2014	158,977	25,597	200,871	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2015	158,977	25,597	200,871	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184

Table 13. CPNRD county summary of groundwater only irrigated lands robust review baseline land use data set within the Platte River drainage basin.

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
2016	158,977	25,597	200,871	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2017	158,977	25,597	200,871	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2018	158,977	25,597	201,154	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2019	158,977	25,597	201,175	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2020	158,977	25,597	201,215	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2021	158,977	25,597	201,411	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2022	158,977	25,597	201,536	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2023	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2024	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2025	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2026	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2027	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2028	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2029	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2030	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2031	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2032	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2033	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2034	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2035	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2036	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2037	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2038	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2039	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2040	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2041	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2042	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184

Table 13. CPNRD county summary of groundwater only irrigated lands robust review baseline land use data set within the Platte River drainage basin.

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
2043	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2044	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2045	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2046	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2047	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2048	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2049	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2050	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2051	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2052	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2053	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2054	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2055	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2056	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2057	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2058	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2059	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2060	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2061	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2062	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184
2063	158,977	25,597	201,607	6,541	179,329	8,458	17,809	169,965	9,553	5,503	50,184

Table 14. CPNRD county summary of groundwater only irrigated lands robust review Unretired Scenario land use data set within the Platte River drainage basin

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
1950	37,762	403	27,603	-	37,736	883	253	20,580	147	128	1,993
1951	38,107	596	26,837	-	38,967	897	220	18,220	151	118	1,798
1952	38,427	459	26,426	-	40,282	848	185	15,861	147	106	1,643
1953	38,597	665	26,443	-	41,454	732	120	13,497	142	84	1,492
1954	38,666	773	27,722	-	42,551	581	86	11,113	141	81	1,130
1955	41,954	1,217	35,370	58	49,528	801	233	15,930	171	143	2,320
1956	45,461	1,496	43,159	169	56,170	1,009	394	20,720	269	225	3,061
1957	49,047	1,920	50,373	281	62,398	1,414	537	25,320	332	308	3,654
1958	53,017	2,174	56,490	320	69,341	1,734	684	30,108	402	399	4,614
1959	56,831	2,538	63,779	467	76,263	2,064	839	34,889	461	463	5,564
1960	58,002	2,713	64,133	539	78,417	2,243	1,042	38,829	618	571	7,274
1961	59,070	2,720	64,176	743	80,640	2,437	1,231	42,804	777	697	8,867
1962	60,251	2,832	64,471	736	82,921	2,627	1,464	46,798	924	811	10,471
1963	61,508	2,897	65,015	757	85,219	2,794	1,726	50,688	1,055	960	12,021
1964	62,477	2,999	64,950	692	87,092	3,013	1,967	54,585	1,186	1,037	13,377
1965	66,237	4,116	67,193	1,321	90,683	3,336	2,934	59,623	1,479	1,245	15,514
1966	70,468	5,058	69,130	1,622	94,197	3,589	3,854	64,682	1,746	1,457	17,938
1967	74,334	5,991	71,527	1,604	97,700	3,941	4,620	69,571	2,128	1,747	20,017
1968	78,123	6,844	73,929	1,882	101,499	4,196	5,374	74,403	2,344	2,023	22,083
1969	82,200	7,897	76,229	1,952	105,122	4,571	6,004	79,254	2,629	2,247	24,402
1970	87,492	8,703	86,185	2,361	111,092	5,086	6,264	83,830	2,763	2,435	25,756
1971	92,693	9,677	96,303	2,716	116,659	5,494	6,653	88,377	2,817	2,591	27,204
1972	97,300	10,303	106,747	2,779	122,400	5,927	6,868	92,665	2,997	2,692	28,564
1973	102,091	10,972	117,177	3,115	128,025	6,208	7,180	97,095	3,239	2,769	29,910
1974	107,137	11,682	128,835	3,299	134,016	6,529	7,745	101,782	3,701	2,883	31,597
1975	113,477	12,343	131,307	3,729	140,112	7,102	8,629	108,551	4,351	3,245	33,686
1976	119,342	13,080	131,715	3,880	145,777	7,761	9,305	115,018	4,703	3,529	36,078

Table 14. CPNRD county summary of groundwater only irrigated lands robust review Unretired Scenario land use data set within the Platte River drainage basin

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
1977	125,234	14,189	134,265	4,265	151,367	8,165	9,700	121,795	5,013	3,975	38,676
1978	131,712	15,294	135,229	4,481	157,612	8,790	10,515	128,568	5,552	4,204	40,768
1979	134,109	16,383	139,184	4,258	158,836	8,821	10,721	129,758	5,521	4,118	40,194
1980	136,916	17,154	144,644	4,369	160,116	8,885	11,049	130,886	5,535	4,072	39,334
1981	140,740	17,830	149,214	4,153	161,744	8,916	11,280	132,063	5,515	4,060	38,683
1982	143,696	18,401	153,794	4,352	162,727	8,875	11,506	133,142	5,602	4,049	37,629
1983	141,431	18,283	151,087	4,299	160,240	8,682	11,062	130,910	5,657	4,100	37,832
1984	138,674	17,680	148,292	4,114	157,198	8,518	10,718	128,660	5,748	4,180	37,916
1985	136,892	20,044	167,652	4,968	164,849	7,076	12,491	159,367	8,353	4,601	32,525
1986	137,539	19,686	165,401	4,908	164,844	7,009	12,207	159,463	8,300	4,618	32,716
1987	137,860	19,173	161,908	4,806	164,424	6,891	11,651	159,519	8,269	4,663	33,058
1988	139,189	19,298	161,898	4,856	165,411	6,922	12,088	160,269	8,208	4,649	32,902
1989	141,513	19,445	161,755	4,799	166,906	7,086	12,511	161,685	8,244	4,643	32,802
1990	143,133	19,617	161,661	4,738	167,819	7,123	12,947	162,973	8,355	4,653	32,667
1991	144,709	19,839	161,577	4,677	168,815	7,142	13,356	163,767	8,293	4,646	32,489
1992	146,861	20,421	162,174	4,657	170,202	7,228	14,126	164,798	8,275	4,614	32,151
1993	147,684	20,520	161,850	4,622	170,367	7,279	14,342	165,307	8,303	4,660	33,606
1994	148,773	20,652	161,543	4,588	170,656	7,333	14,596	165,575	8,352	4,705	35,069
1995	149,833	20,813	161,411	4,556	171,142	7,392	14,799	165,806	8,419	4,755	36,563
1996	151,466	21,029	161,880	4,545	172,077	7,454	15,043	166,300	8,594	4,809	38,025
1997	153,438	21,351	161,687	4,525	172,431	7,594	15,376	166,805	8,835	4,911	40,738
1998	153,705	21,350	166,075	4,818	172,379	7,688	15,424	166,293	8,909	5,024	41,170
1999	153,876	21,310	170,164	5,087	172,366	7,796	15,435	165,758	8,923	5,121	41,716
2000	154,472	21,287	174,425	5,334	172,745	7,855	15,322	165,360	8,952	5,298	42,152
2001	154,078	21,135	182,288	5,915	172,816	7,842	15,601	164,534	9,087	5,416	42,703
2002	155,328	22,224	185,387	6,214	173,663	7,867	15,643	166,170	9,211	5,535	44,593
2003	156,124	24,687	189,865	6,250	174,370	7,913	16,280	166,310	9,426	5,563	46,421

Table 14. CPNRD county summary of groundwater only irrigated lands robust review Unretired Scenario land use data set within the Platte River drainage basin

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
2004	156,962	25,772	194,100	6,499	175,299	8,107	16,838	166,791	9,655	5,590	48,099
2005	157,177	26,801	198,867	6,497	175,586	8,276	17,153	166,989	9,879	5,615	49,947
2006	154,910	20,584	199,713	5,741	178,511	7,959	17,187	166,481	10,006	5,660	49,706
2007	160,941	25,670	210,555	6,538	181,168	8,353	18,012	168,783	10,608	5,795	49,821
2008	153,163	24,885	202,321	5,725	174,109	8,007	16,653	164,037	9,180	5,501	48,657
2009	160,434	26,603	211,264	6,394	176,315	8,264	17,444	167,098	10,120	5,734	50,122
2010	159,154	25,652	203,499	6,555	178,006	8,207	17,572	167,946	9,470	5,467	49,036
2011	159,116	25,642	203,502	6,551	178,075	8,226	17,663	167,935	9,488	5,467	49,037
2012	159,286	25,604	203,493	6,548	179,097	8,366	17,694	169,072	9,517	5,494	49,507
2013	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2014	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2015	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2016	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2017	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2018	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2019	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2020	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2021	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2022	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2023	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2024	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2025	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2026	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2027	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2028	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2029	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2030	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184

Table 14. CPNRD county summary of groundwater only irrigated lands robust review Unretired Scenario land use data set within the Platte River drainage basin

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
2031	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2032	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2033	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2034	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2035	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2036	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2037	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2038	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2039	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2040	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2041	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2042	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2043	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2044	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2045	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2046	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2047	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2048	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2049	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2050	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2051	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2052	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2053	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2054	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2055	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2056	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2057	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184

Table 14. CPNRD county summary of groundwater only irrigated lands robust review Unretired Scenario land use data set within the Platte River drainage basin

Year	Buffalo	Custer	Dawson	Frontier	Hall	Hamilton	Howard	Merrick	Nance	Platte	Polk
2058	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2059	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2060	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2061	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2062	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184
2063	159,424	25,603	203,466	6,541	179,577	8,458	17,809	170,020	9,553	5,503	50,184

Memorandum

To:	John Thorburn – Tri-Basin NRD; Kari Burgert – NDNR
From:	The Flatwater Group, Inc.
Date:	11/21/2018
Subject:	COHYST Area Robust Review: TBNRD Land Use Retirements, Transfers, and Variances

Project Background and Workflow

The Flatwater Group, Inc. (TFG) was contracted by the Platte Basin Water Project Coalition through the Nebraska Department of Natural Resources (NDNR) to provide technical assistance for the Robust Review project. The purpose of the Robust Review project is to assess streamflow impacts resulting from management actions taken as part of the Basin-Wide Plan and/or Natural Resource District (NRD) Integrated Management Plans (MPs). The focus of this memorandum is to document land use changes related to acreage transfers, retirements, and variances within the Tri-Basin NRD (TBNRD).

To account for transfers, retirements, and variances within TBNRD, TFG's primary work tasks included evaluating and summarizing the available datasets related to transfers, retirements, and variances; then spatially placing these transactions within the constructs of the COHYST 2010 watershed model's land use files to extend the baseline land use through 2013; and to then create a new land use data set for the unretired acreage scenario. For the first step in the process, TFG worked with NDNR and TBNRD to gather the land use data (retirements, transfers, and variances) and place it into summary tables by land use type. TFG's next steps were to perform geospatial analyses using ArcGIS to identify the location of each transaction. The geospatial analysis included a proximity function in the form of a custom Fortran program to determine the closest available model cells capable of accommodating the specified land use change.

This memorandum presents a series of tables which summarize the annual number of acres retired or transferred within the TBNRD, outlines the spatial analysis methodology, and ultimately summarizes the resultant land use files.

Land Use Summary Tables

Using information provided by TBNRD, NDNR, and other basin NRDs, TFG compiled a final summary of the retirements, transfers, and variances occurring within the TPNRD assigned model domain. This information was used to modify the land use data set in the COHYST 2010 model to investigate the effects of these actions as part of the larger Robust Review effort. Tables 1-10 below summarize the information provided to TFG. Tables 11-20 summarize the distribution of that information into the modeling input files.

Table 1 provides an overall summary of the retirement and transfer acreage source information relevant to the TBNRD received by TFG. Columns A through E on Table 1 summarize the information provided by TBNRD and NDNR. Columns F through I summarize information tracked by other basin NRDs, but whose spatial location upon distribution to the model placed acreage within the model domain assigned to the TBNRD. Subsequent tables will define the source(s) of this information.

Table 1. Summary of TBNRD acreage changes for implementation into the Robust Review.

Year	TBNRD Data					Non-TBNRD Data				
	(A) Temporary Retirements	(B) Reinstated Temporary Retirements	(C) Permanent Retirements	(D) Transfers To	(E) Transfers Away	(F) Temporary Retirements	(G) Reinstated Temporary Retirements	(H) Permanent Retirements	(I) Transfers To	(J) Change
Baseline Change	(-)	(+)	(-)	(+)	(-)	(-)	(+)	(-)	(+)	
1999	1.9	-	-	-	-	-	-	-	-	(1.9)
2000	293.6	-	-	-	-	-	-	-	-	(293.6)
2001	408.6	-	-	-	-	-	-	-	-	(408.6)
2002	-	-	-	-	-	-	-	-	-	-
2003	-	-	-	-	-	-	-	-	-	-
2004	77.5	-	-	-	-	-	-	-	-	(77.5)
2005	259.4	7.0	-	-	-	-	-	-	-	(252.4)
2006	163.9	-	-	-	-	-	-	-	-	(163.9)
2007	219.8	-	-	-	-	-	-	-	-	(219.8)
2008	697.8	77.5	73.1	-	-	-	-	-	-	(693.4)
2009	167.9	223.7	-	-	-	0.7	-	149.1	-	(94.0)
2010	127.3	423.6	-	-	-	-	-	-	-	296.3
2011	111.3	610.3	-	178.7	246.7	-	-	-	-	431.0
2012	-	427.5	-	118.3	118.3	-	-	-	-	427.5
2013	-	450.4	-	229.4	168.5	-	-	-	1.4	512.7
2014	-	142.1	-	-	-	-	-	-	-	142.1
2015	-	127.9	-	-	-	-	-	-	-	127.9
2016	-	-	-	-	-	-	-	-	-	-
2017	-	39.0	-	-	-	-	-	-	-	39.0
2018	-	-	-	-	-	-	-	-	-	-
2019	-	-	-	-	-	-	-	-	-	-
2020	-	-	-	-	-	-	-	-	-	-

Table 1. Summary of TBNRD acreage changes for implementation into the Robust Review.

Year	TBNRD Data					Non-TBNRD Data				
	(A) Temporary Retirements	(B) Reinstated Temporary Retirements	(C) Permanent Retirements	(D) Transfers To	(E) Transfers Away	(F) Temporary Retirements	(G) Reinstated Temporary Retirements	(H) Permanent Retirements	(I) Transfers To	(J) Change
2021	-	-	-	-	-	-	0.7	-	-	0.7
2022	-	-	-	-	-	-	-	-	-	-
2023	-	-	-	-	-	-	-	-	-	-
Total	2,529.0	2,529.0	73.1	526.4	533.5	0.7	0.7	149.1	1.4	(227.9)

<u>Data Source Discussion for Table 1 Columns A through C</u>

The TBNRD provided several spreadsheets containing information which were used to populate Table 1. Ultimately, two spreadsheets provided by the TBNRD on 7/17/2017 to TFG served as the TBNRD source information for the table:

TBNRD AppendixI_Conservation practices.xlsx

Platte_CIA_Permits_Changes_updates.xlsx

A third spreadsheet, *Robust_COHYST_Platte_data.xlsx*, was also provided to TFG; however, information relevant to the Robust Review that was contained in that spreadsheet was also contained in the two above spreadsheets and thus *Robust_COHYST_Platte_data.xlsx* was not used as an independent source of information by TFG.

The spreadsheets summarized information related to multiple conservation programs and categorized information accordingly. For the purposes of the Robust Review, TFG needed to designate those categories as being either a retirement (either temporary or permanent) or a transfer. Tables 2-4 below provide a mapping of the categories which were assigned to either temporary or permanent retirements in Table 1. The column headers in the tables indicate the TBNRD assigned category mapped to the Table 1 column indicated by the title of the table. Those table titles are:

Table 2: Summary of temporary retirement acreage in the TBNRD - This is Column A in Table 1

Table 3: Summary of permanent retirement acreage in the TBNRD - This is Column C in Table 1

Table 4: Summary of temporary retirement acreage reinstated in the TBNRD - This is Column B in Table 1

Table 2. Summary of temporary retirement acreage in the TBNRD

Year	Conservation Corners	Buffer Strips	Pheasants Forever	TBNRD EQIP	CRP Reinstatements	DNR CREP/EQIP	Temporary Retirements
1999	-	1.9	-	-	-	-	1.9
2000	-	28.3	7.0	-	258.3	-	293.6
2001	-	-	-	-	408.6	-	408.6
2002	-	-	-	-	-	-	-
2003	-	-	-	-	-	-	-
2004	-	-	-	77.5	-	-	77.5
2005	-	16.6	21.0	221.8	-	-	259.4
2006	-	-	17.9	116.0	-	30.0	163.9
2007	-	9.0	27.0	183.8	-	-	219.8
2008	126.8	-	13.0	400.5	-	157.5	697.8
2009	-	-	14.8	153.1	-	-	167.9
2010	-	-	-	127.3	-	-	127.3
2011	-	-	-	111.3	-	-	111.3
2012	-	-	-	-	-	-	-
2013	-	-	-	-	-	-	-
Total	126.8	55.8	100.7	1,391.3	666.9	187.5	2,529.0

Table 3. Summary of permanent retirement acreage in the TBNRD

Year	Conservation Easements	Permanent Retirements
1999	-	-
2000	-	-
2001	-	-
2002	-	-
2003	-	-
2004	-	-
2005	-	-
2006	-	-
2007	-	-
2008	73.1	73.1
2009	-	-
2010	-	-
2011	-	-
2012	-	-
2013	-	-
Total	73.1	73.1

Table 4. Summary of temporary retirement acreage reinstated in the TBNRD

Year	Conservation Corners	Buffer Strips	Pheasants Forever	TBNRD EQIP	CRP Reinstatements	DNR CREP/EQIP	Temporary Retirements
2005	-	-	7.0	-	-	-	7.0
2006	-	-	-	-	-	-	-
2007	-	-	-	-	-	-	-
2008	-	-	-	77.5	-	-	77.5
2009	-	1.9	-	221.8	-	-	223.7
2010	-	28.3	21.0	116.0	258.3	-	423.6
2011	-	-	17.9	183.8	408.6	-	610.3
2012	-	-	27.0	400.5	-	-	427.5
2013	126.8	-	13.0	153.1	-	157.5	450.4
2014	-	-	14.8	127.3	-	-	142.1
2015	-	16.6	-	111.3	-	-	127.9
2016	-	-	-	-	-	-	-
2017	-	9.0	-	-	-	30.0	39.0
Total	126.8	55.8	100.7	1,391.3	666.9	187.5	2,529.0

The information under the column names on Tables 2-4 all originated in the spreadsheets provided by the TBNRD with the exception of "DNR CREP/EQIP" which summarized processed information from NDNR. The spreadsheet *TBNRD AppendixI_Conservation practices .xlsx* contained the only reference to a category TFG assigned to permanent retirements. Key elements regarding that category along with a reference to the table the category is considered in are shown below.

Conservation Easements

- 2 entries
- Table 3

With regards to temporary retirement information from the TBNRD, following are a few key elements regarding each of those categories along with a reference to which table number(s) the category is considered. With the exception of the category "CRP Reinstatements", information for all categories was taken from the file *TBNRD AppendixI_Conservation practices .xlsx*. As indicated below, the "CRP Reinstatements" information was taken from *Platte_CIA_Permits_Changes_updates.xlsx.*

Conservation Corners

- Contracts are for 5 years
- 11 entries
- Table 2 & Table 4

Buffer Strips

- Contracts are for 10 years
- 6 entries
- Table 2 & Table 4

Pheasants Forever

- Contract are for 5 years
- 15 entries
- Table 2 & Table 4

CRP Reinstatements – (Note data source was *Platte_CIA_Permits_Changes_updates.xlsx*)

- Assumed 10 year contract duration – provided information only specified when the acres were reinstated. No contract start date information was provided.
- 4 entries
- Table 2 & Table 4

CREP

- 1 entry
- The CREP entry was for 30 acres for the period 2006-2016. This entry was also in the DNR data set. The DNR data set was used due to the accompanying shape file.
- Table 2

TBNRD EQIP (EQIP)

- Contracts appears to be for 4 years
- 95 entries. Entries were cross referenced with information provided by NDNR to ensure acreage was neither double accounted for nor overlooked.
- Table 2 & Table 4

With regards to the CREP and EQIP programs, as indicated in the above discussion TFG received information from both the TBNRD and NDNR. To supplement the information provided by TBNRD, NDNR provided the shape file *CREP* on 8/17/2017. It was augmented by the spreadsheet *20170829_COHYSTAreaMissingDates.xlsx* provided on 8/29/2017 which provided additional contract start/end dates that were missing from the shape file attribute information.

This shape file included the most up to date list of CREP and EQIP contracts available from NDNR at that time. TFG spatially queried the data in the CREP shape file to obtain only the parcels located within the TBNRD. That query returned 114 parcels. Those parcels all had designations of either CREP, EQIP, or TBEQIP. Table 5 shows the number of acres represented by those 114 parcels.

Table 5. DNR CREP and EQIP temporary retirements within the TBNRD.

Year	CREP	EQIP	TBEQIP
2005	-	169.7	-
2006	1,029.8	-	-
2007	416.7	-	-
2008	16.6	-	380.1
2009	-	-	-
2010	2.6	-	-
Total	1,465.7	169.7	380.1

For inclusion in the Robust Review. the information was further limited to:

- Contracts initiated prior to the end of 2013
- Parcels located within the drainage area of the Platte River
- Contracts referencing acreage only irrigated with ground water

As a final QC step, the remaining records were compared to the information contained in the TBNRD spreadsheet *TBNRD AppendixI_Conservation practices.xlsx,* sheets 'EQIP D land' and 'CREP Acres'. The location and contract timing of the 'EQIP D land' records did not overlap with records in CREP shape file. The entry from 'CREP Acres', however, did match a record in the CREP shapefile. TFG elected to use the entry from the CREP shape file due to the spatial definition provided in the shapefile.

At the conclusion of this process, 21 parcels remained and were considered in the Robust Review. Table 6 below shows the number of acres represented by those parcels and are the values shown in columns "DNR CREP/EQIP" on Tables 2 and 4.

Table 6. DNR CREP and EQIP temporary retirements within the Platte River Basin area of the TBNRD.

Year	CREP	TBEQIP	End Year
2005	-	-	
2006	30.0	-	2017
2007	-	-	
2008	-	157.5	2013
2009	-	-	
2010	-	-	
Total	30.0	157.5	

Data Source Discussion for Table 1 Columns D and E

The information presented in Columns D and E of Table 1 represents the available acreage transfer information which was all provided to TFG in the spreadsheet *Platte_CIA_Permits_Changes_updates.xlsx*.

The spreadsheet contained information regarding two types of transfers. The first type of transfer involved moving the source of the irrigation water, while the field where the irrigation water was applied remains unchanged. This type of transfer did not require any action to be taken for the Robust Review. These transfers were listed in the sheets 'G Water Transf_Exsisting' and 'G Water Transfers' within *Platte_CIA_Permits_Changes_updates.xlsx.*

The second type of transfer involved transferring the location of where the irrigation water was applied. These types of transfers were recorded on sheet 'Acres Transfers' in spreadsheet *Platte_CIA_Permits_Changes_updates.xlsx*. The spreadsheet listed records for 109 such transfers. Of these, 25 occurred within a time frame that could have potentially impacted the 2011-2013 irrigation seasons. These records were compared to information on file at NDNR and TFG received confirmation on 11/14/2017 via email from NDNR that the TBNRD and NDNR information was in general agreement. Columns A and B in Table 7 below summarize that information.

Table 7. Summary of transfer acres in the TBNRD

TBNRD			To		From	
Year	(A) To	(B) From	(C) Current Year	(D) Next Year	(E) Current Year	(F) Next Year
2010	74.4	75.7	48.7	25.7	50.0	25.7
2011	158.0	158.0	153.0	5.0	153.0	5.0
2012	188.4	194.1	113.3	75.1	113.3	80.8
2013	234.3	250.8	154.3	80.0	164.8	86.0

The transfers represented on Table 7 occurred on or after July 1, 2010 and before July 1, 2013. This was based upon the 'Date Approved' field in the spreadsheet (*Platte_CIA_Permits_Changes_updates.xlsx*) information. For the purposes of inclusion in the Robust Review, it was decided that If the transfer occurred after July 1, it was likely that the original field was still irrigated in the transfer year; as the late year transfers typically happened in the fall (October-December). For transfers occurring on or before July 1, it was assumed that irrigation water was applied in the alternate (transfer) location. Columns C through F on Table 7 present a breakdown of the acreage based on the July 1 implementation date. Columns C and D partition the "Transfer To" acreage (Column A) while Columns E and F partition the "Transfer From" acreage (Column B). Table 8 presents summarizes the transfer acreage amounts after the July 1 timing criteria is applied.

Table 8. Summary of transfer acres in the TBNRD adjusted for timing within the year.

Adjusted		
Year	To	From
2011	178.7	178.7
2012	118.3	118.3
2013	229.4	245.6

The spreadsheet *Platte_CIA_Permits_Changes_updates.xlsx* also contained information on wells converted for use for irrigation to use for watering livestock. The tab 'Conversion' in the spreadsheet contained four such entries, two of which occurred in the 2011-2013 timeframe. For the purposes of the Robust Review, those transactions were considered to be transfers. Table 9 incorporates these conversions with the Table 8 transfer information to provide the total Transfer To (Column A) and Transfer Away (Column D) values reflected on Table 1.

Table 9. Summary of transfer acres in the TBNRD

Year	(A) Transfer To	(B) Transfer Away	(C) Conversions	(D) Total Transfer Away
2011	178.7	178.7	67.9	246.7
2012	118.3	118.3	-	118.3
2013	229.4	168.5[1]	-	168.5
Total	526.4	465.6	67.9	533.5

<u>Data Source Discussion for Table 1 Columns F through I</u>

In addition to the information provided by TBNRD, the Central Platte Natural Resources District (CPNRD) identified retirements, transfers, and variances which were placed in cells assigned to the TBNRD in the Platte Basin. This information included transfers to (CPNRD Acres Added), permanent retirements (CPNRD Acres Offset WB), and temporary retirements (CPNRD CREP). The scope of these transactions is defined in Table 10, and depict the Non-TBNRD data in Table 1.

Table 10. DNR CREP and EQIP temporary retirements within the Platte River drainage Basin.

Year	CPNRD Acres Added	CPNRD Acres Offset WB	CPNRD CREP Retirement	CPNRD CREP Reinstatement
2009	-	149.1	0.7	-
2010	-	-	-	-
2011	-	-	-	-
2012	-	-	-	-
2013	1.4	-	-	-
2014	-	-	-	-
2015	-	-	-	-
2016	-	-	-	-
2017	-	-	-	-
2018	-	-	-	-
2019	-	-	-	-
2020	-	-	-	-
2021	-	-	-	0.7

[1] Transfer acres were subject to the same limitations as CREP/EQIP acreage. Table 13 traces the source of the 168.5 value for 2013.

Other Information Provided By TBNRD

The spreadsheet *Platte_CIA_Permits_Changes_updates.xlsx* contained some additional information which was not included into the current Robust Review. The sheet 'Variances' summarized actions taken by the TBNRD which categorized as Variances. These actions tended to be administrative in nature rather than identifying acreage type changes. The POAC group decided in August 2017 to not consider these types of actions in the current Robust Review project.

The same spreadsheet also contained a sheet named 'Corrections' which contained a set of information regarding administrative changes related to the number of irrigated acres rather than changes to acreage locations. No action was taken on these entries.

SPATIAL ANALYSIS METHODOLOGY

ArcGIS was used to link the retirements, transfers and variances to the COHYST model grid. This was accomplished either by overlaying the parcels' shape file with the model grid or linking the parcels' legal description to model cells.

Step 1: Assigning land use change locations within the model

Each of the transactions provided by TBNRD included a legal description. These descriptions typically included the quarter section in which the transaction took place. This information was linked to the COHYST 2010 model grid. COHYST uses a grid of 160-acre sized model cells; but, the cell boundaries and the section lines do not overlap. To accommodate this, the section shape file was spatially joined with the cell centroid. Typically, this would result in 4 cells being assigned to a section as represented on Table 11. Using the quarter section identifier, the cell which best represented the spatial location of the transaction was assigned the placement.[2]

Table 11. Approach used to link legal descriptions to model cell locations.

Cell Index	Row	Column	Quarter
Cell	x	y	NW
Cell + 1	x	y + 1	NE
Cell + 504	x + 1	y	SW
Cell + 505	x + 1	y + 1	SE

In a similar way the model cells were assigned to counties, NRDs, and drainage basins. In general, features were assigned to cells based on the location of the cell's centroid in relation to the border of interest. This results in a model cell being assigned a single value for a given feature class. For example, if the border of an NRD passes through a model cell, whichever NRD the cell's centroid is within determines which NRD the cell is assigned to within the model. For this reason, it is possible to have an activity which occurs within a cell along a feature border to be enacted by one entity that shares the border, but for the model to summarize the activity to the other entity which shares the border.

The data on Table 12 below illustrates just that type of effect. The acreage retirement information in Column A of Table 12 matches that shown in the 'TBNRD EQIP' column of Table 2. These again are retirements related to the EQIP program initiated by the TBNRD within the Platte Basin area of the District. However, when these actions are assigned within the model, a small number of acres are assigned to cells which have been assigned to a river basin outside of the Platte Basin. Columns B and C in Table 12 present the effect of this distribution within the model (Column B – acreage distributed to cells assigned within the model to be in the Platte Basin drainage area; Column C – acreage distributed to cells assigned within the model to a drainage basin outside of the Platte Basin). Likewise, Column D matches the acreage reinstatement information shown in the 'TBNRD EQIP' column of Table 4. Columns E and F reflect the distribution of that acreage inside of and outside of the Platte Basin, respectively.

[2] For irregular sections, the cell-section relationship and professional judgement was used to place the transaction acres as close as possible to the defined location.

Table 12. Distribution of the TBNRD EQIP acres between the Platte River Basin and the rest of the NRD[3].

Year	(A) Total EQUP TBNRD Retirements	(B) EQIP TBNRD Platte Basin Retirements	(C) EQIP TBNRD Non-Platte Basin Retirements	(D) Total EQUP TBNRD Reinstatements	(E) EQIP TBNRD Platte Basin Reinstatements	(F) EQIP TBNRD Non-Platte Basin Reinstatements
2004	77.5	50.0	27.5	-	-	-
2005	221.8	221.8	-	-	-	-
2006	116.0	116.0	-	-	-	-
2007	183.8	183.8	-	-	-	-
2008	400.5	400.5	-	77.5	50.0	27.5
2009	153.1	116.1	37.0	221.8	221.8	-
2010	127.3	127.3	-	116.0	116.0	-
2011	111.3	111.3	-	183.8	183.8	-
2012	-	-	-	400.5	400.5	-
2013	-	-	-	153.1	116.1	37.0
2014	-	-	-	127.3	127.3	-
2015	-	-	-	111.3	111.3	-
Total	1,391.3	1,326.8	64.5	1,391.3	1,326.8	64.5

The distribution of the Transfer Acres summarized in Table 8 encountered a similar issue. The acreage values in Column A on Table 13 matches those shown in the column 'From' in Table 8. Columns B and C in Table 13 reflect the distribution of those acres to cells defined as being either within the CPNRD (Column B) or the TBNRD (Column C). The acreage listed in Column C is then summarized based on whether the distribution placed the acreage within cells identified as being within either the Platte Basin (Column D) or outside of the Platte Basin (Column E) areas of the TBNRD.

Table 13. Distribution of TBNRD transfers away between applied NRDs and river basins[4].

Year	(A) Transfer Away Total	(B) Applied in CPNRD	(C) Applied In TBNRD	(D) TBNRD Platte	(E) TBNRD Non-Platte
2011	178.7	-	178.7	178.7	-
2012	118.3	-	118.3	118.3	-
2013	245.6	77.1	168.5	160.3	8.2

[3]TBNRD only provided EQIP contracts acreage for the Platte River Basin. However, some of these acres, while in the Platte Basin, were assigned to cells which were not in the Platte Basin. This is caused by the drainage boundary differing from cell boundaries.

[4] TBNRD only provided transfer acreage for the Platte River Basin. However, some of these acres, while in the Platte Basin, were assigned to cells which were not in the Platte Basin. This is caused by the drainage boundary differing from cell boundaries.

Step 2: Building the Baseline Land Use Update

The next step was to build the 2011-2013 land use files incorporating the identified transfers and retirements. The beginning condition for this update is the 2010 land use file from the COHYST 2010 model. Each of the 2011 transactions were applied to the 2010 land use to create the 2011 land use file; which in turn became the basis for applying the 2012 transactions. This continued through 2013. One of the key points of investigation is the effect of retirements on the system. Given that many of the retirements were temporary in nature and knowing their contract end dates, the land use file building process was continued through 2023 to be able to add back in all the temporarily retired acres.[5]

Acres were to be added or removed from their assigned cells. If there was insufficient space[6] for new acres or an insufficient amount of groundwater only acres[7] to be retired within the cell, the addition or subtraction of acres was applied to nearby cells which exhibit the appropriate characteristics[8]. This spatial analysis process entails radiating outward from the identified cell until the acres had been placed. During this process acres are placed or removed from the lowest priority cell which meets the appropriate criteria. If more than one cell has the same priority and meets criteria, the acres are split evenly between the multiple cells. This occurs unless an even split would exceed the available space within a given cell at which time the placed acres would be limited to the available space and the remaining acres would be evenly split among the other priority cells. The priority pattern for the first two rings around the assignment cell can be seen in Figure 1. This process was implemented using a custom FORTRAN script.

5 (r-2, c-2)	4 (r-2, c-1)	3 (r-2, c+0)	4 (r-2, c+1)	5 (r-2, c+2)
4 (r-1, c-2)	2 (r-1, c-1)	1 (r-1, c+0)	2 (r-1, c+1)	4 (r-1, c+2)
3 (r+0, c-2)	1 (r+0, c-1)	0 (r+0, c+0)	1 (r+0, c+1)	3 (r+0, c+2)
4 (r+1, c-2)	2 (r+1, c-1)	1 (r+1, c+0)	2 (r+1, c+1)	4 (r+1, c+2)
5 (r+2, c-2)	4 (r+2, c-1)	3 (r+2, c+0)	4 (r+2, c+1)	5 (r+2, c+2)

Figure 1. Priority of search pattern to place or remove acres when the assigned cell has insufficient non-irrigated or groundwater only acres.

[5] 2023 was identified as the year the last temporary retirement would be actively irrigated again for the first time
[6] Example: transferring 30 groundwater only acres to a cell where there was only 20 non-irrigated acres
[7] Example: retiring 30 groundwater only acres from a cell where there was only 20 groundwater only acres
[8] The cell needed to be active, in the same NRD, and have a sufficient amount of groundwater only acres to retire or non-irrigated acres to convert

The results of Step 2 are shown in Table 14. As intended, the values in Column B of Table 14 match (sans de minimis rounding resulting from the distribution process) the original source information shown in Column J of Table 1 for the years 2011-2023. This indicates that the acreage values provided by TBNRD and NDNR were the quantities by which the modeling input files were adjusted. The value in Column C of Table 14 matches the value in Column B of Table 13 which again indicates that the model input files were adjusted by the intended values based on the results of the spatial distribution assignments made to the provided input data from TBNRD. As an aside, the distribution routines placed 58.6 of the 77.1 acres shown in Table 14 Column C into Dawson county and the remaining 18.5 acres into Buffalo county.

Table 14. Change in groundwater only irrigated acres within the TBNRD for the Robust Review baseline.

Year	(A) Groundwater Only Irrigated Acres in TBNRD	(B) Annual Change in TBNRD Groundwater Only Irrigated Acres in the TBNRD	(C) Change in TBNRD Groundwater Only Irrigated Acres not in the TBNRD
2010	459,902.8	-	-
2011	460,333.9	431.1	-
2012	460,761.2	427.3	-
2013	461,273.7	512.5	(77.1)
2014	461,415.8	142.1	-
2015	461,543.7	127.9	-
2016	461,543.7	-	-
2017	461,582.7	39.0	-
2018	461,582.7	-	-
2019	461,582.7	-	-
2020	461,582.7	-	-
2021	461,583.4	0.7	-
2022	461,583.4	-	-
2023	461,583.4	-	-

Step 3: Building the Unretired Acres Scenario Modified Land Use

Similarly, a new set of land use files were created for the unretired scenario. In this scenario the permanently and temporarily retired acres were never retired. Other key elements of the scenario include:

- The transfers were applied.
- For the post 2010 period no retirements were applied.
- For permanent retirements, irrigated acres were added back into the modified land use files for all future years.
- For temporary retirements, the acres were added back during their contracted period. If the temporary retirement ended after 2010, the temporarily retired acres added back in 2011 remain moving forward.

Table 15 shows the changes between the COHYST 2010 land use data set (Column A) and the unretired retirements scenario data set (Column B). The difference between the two data sets is a result of incorporating the retirement and transfer acreage information into the model. Again as intended, the annual change in ground water only acres shown on Table 15 (Column D) match (sans de minimis rounding resulting from the distribution process) the original source information shown in Column J of Table 1 for the years 1999-2010 (the sign reversal indicates removal (unretirement) of the acreage). This indicates that the acreage values provided by TBNRD and NDNR were the quantities by which the modeling input files were adjusted.

Table 15. Change in Groundwater Only Irrigated Acres in the TBNRD comparing the COHYST 2010 land use to Unretired Retirements Scenario land use; years 1999-2010.

Year	Groundwater Only Irrigated Acres		Change in Groundwater Only Irrigated Acres	
	(A) Run029	(B) Modified Land Use	(C) Cumulative	(D) Annual
1999	408,126	408,128	1.9	1.9
2000	409,469	409,764	295.5	293.6
2001	409,418	410,122	704.1	408.6
2002	421,829	422,533	704.1	0.0
2003	422,302	423,007	704.2	0.1
2004	423,360	424,142	781.8	77.6
2005	422,424	423,458	1,033.9	252.1
2006	439,644	440,842	1,197.9	164.0
2007	464,704	466,122	1,418.0	220.1
2008	444,988	447,099	2,111.4	693.4
2009	471,247	473,452	2,204.8	93.4
2010	459,903	461,811	1,908.6	(296.2)
		Cumulative		1,908.6

Table 16 shows the changes between the annual COHYST 2010 land use files and the land use files developed for the “unretired” condition within the Robust Review’s retirement scenario. Column A in the table presents the annual acreage irrigated only with ground water from 2011 through 2023 for the “unretired” land use data set. Column B summarizes the acreage changes made to arrive at values presented in Column A. Columns C through I present the information used in the computation of the Column B values.

SUMMARY

Tables 14 through 16 summarize the background information as to how the land use files for the Robust Review will be populated. Comparisons back to Table 1 confirm the information provided to TFG by TBNRD, NDNR and other entities referenced in the memorandum were fully included in the model input files. The retirement scenario within the Robust Review involves two land use datasets: the Baseline Set; and the Unretired Set.

For the Baseline Set:

- For the years through 1998: The existing COHYST 2010 land use data set will be used
- For the years 1999 through 2010: Values from Column A in Table 15 will be used
- For the years 2011 through 2023 and forward: Values from Column A in Table 14 will be used

For the Unretired Set:

- For the years through 1998: The existing COHYST 2010 land use data set will be used
- For the years 1999 through 2010: Values from Column B in Table 15 will be used
- For the years 2011 through 2023 and forward: Values from Column A in Table 16 will be used

Table 16. Change in Groundwater Only Irrigated Acres in the TBNRD comparing the COHYST 2010 land use to Unretired Retirements Scenario land use; years 2011-2013.

Year	(A) Groundwater Only Irrigated Acres	(B) =I-G Difference in Groundwater only Acres from 2010 minus cumulative prior retirements and transfers	(C) Transfers Away (Table 9, Col D And Table 13, Col D)	(D) Transfers to (Table 9, Col A)	(E) Non Area Transfers Away (Table 13, Col E)	(F) Non Area Transfers To (Table 10)	(G) Net Transfers Away	(H) Cumulative Net Transfers Away	(I) Residuals
2011	461,743.5	(67.9)	246.7[9]	178.7	-	-	67.9	67.9	0.4
2012	461,743.4	(0.1)	118.3[10]	118.3	-	-	-	67.9	(0.1)
2013	461,805.6	62.2	160.3[11]	229.4	8.2	1.4	(62.3)	5.7	(0.1)
2014	461,805.6	-					-	5.7	-
2015	461,805.6	-					-	5.7	-
2016	461,805.6	-					-	5.7	-
2017	461,805.6	-					-	5.7	-
2018	461,805.6	-					-	5.7	-
2019	461,805.6	-					-	5.7	-
2020	461,805.6	-					-	5.7	-
2021	461,805.6	-					-	5.7	-
2022	461,805.6	-					-	5.7	-
2023	461,805.6	-					-	5.7	-

[9] Table 9, Column D
[10] Table 9, Column D
[11] Table 13, Column D

Tables 17 and 18 show the annual area of groundwater only irrigated land for each county in the TBNRD within the Robust Review's baseline and unretirement scenarios. Finally, Tables 19 and 20 show the annual area of groundwater only irrigated land for each county in the TBNRD within the Platte River Drainage basin.

Table 17. TBNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Gosper	Kearney	Phelps
1950	-	2,242	2,537
1951	-	3,998	2,777
1952	-	6,293	2,809
1953	-	8,593	3,749
1954	-	10,124	5,131
1955	-	14,150	6,346
1956	-	18,843	8,376
1957	-	23,410	11,750
1958	-	27,870	11,977
1959	1,164	32,496	13,060
1960	2,200	32,722	13,549
1961	3,082	32,987	14,450
1962	3,945	33,235	15,066
1963	4,905	33,438	17,833
1964	5,881	33,921	20,393
1965	8,366	41,783	27,825
1966	11,024	49,365	35,927
1967	13,803	56,675	43,969
1968	16,191	64,484	52,068
1969	19,136	72,225	60,374
1970	21,712	77,738	66,486
1971	24,407	83,602	71,898
1972	27,234	89,777	78,063
1973	29,769	95,315	84,101
1974	32,514	102,037	90,857
1975	37,209	108,257	100,749
1976	41,646	115,304	109,914
1977	46,247	121,588	120,074
1978	50,109	128,065	128,097
1979	53,225	133,332	133,288
1980	53,940	140,155	138,302
1981	55,494	145,561	140,783

Table 18. TBNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set

Year	Gosper	Kearney	Phelps
1950	-	2,242	2,537
1951	-	3,998	2,777
1952	-	6,293	2,809
1953	-	8,593	3,749
1954	-	10,124	5,131
1955	-	14,150	6,346
1956	-	18,843	8,376
1957	-	23,410	11,750
1958	-	27,870	11,977
1959	1,164	32,496	13,060
1960	2,200	32,722	13,549
1961	3,082	32,987	14,450
1962	3,945	33,235	15,066
1963	4,905	33,438	17,833
1964	5,881	33,921	20,393
1965	8,366	41,783	27,825
1966	11,024	49,365	35,927
1967	13,803	56,675	43,969
1968	16,191	64,484	52,068
1969	19,136	72,225	60,374
1970	21,712	77,738	66,486
1971	24,407	83,602	71,898
1972	27,234	89,777	78,063
1973	29,769	95,315	84,101
1974	32,514	102,037	90,857
1975	37,209	108,257	100,749
1976	41,646	115,304	109,914
1977	46,247	121,588	120,074
1978	50,109	128,065	128,097
1979	53,225	133,332	133,288
1980	53,940	140,155	138,302
1981	55,494	145,561	140,783

Table 17. TBNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Gosper	Kearney	Phelps
1982	55,887	150,993	144,299
1983	56,187	149,122	144,750
1984	56,761	147,856	143,892
1985	56,971	157,806	150,247
1986	56,297	157,629	149,714
1987	49,352	156,719	148,311
1988	50,724	159,107	150,150
1989	52,238	161,324	152,772
1990	53,033	163,587	155,668
1991	54,907	166,242	157,356
1992	56,348	169,870	160,700
1993	56,797	171,421	161,580
1994	57,368	173,074	162,570
1995	57,916	174,916	163,327
1996	59,029	177,751	164,645
1997	59,906	180,190	166,474
1998	62,384	179,627	166,025
1999	63,178	179,325	165,623
2000	64,020	179,822	165,627
2001	64,705	179,524	165,188
2002	65,456	187,438	168,936
2003	66,229	187,575	168,498
2004	67,007	187,705	168,648
2005	67,899	187,429	167,096
2006	70,272	196,922	172,450
2007	85,141	200,533	179,031
2008	74,647	198,594	171,748
2009	91,432	200,132	179,683
2010	83,058	197,888	178,957
2011	83,049	198,313	178,972
2012	83,156	198,376	179,230
2013	83,199	198,508	179,567
2014	83,274	198,508	179,634
2015	83,274	198,524	179,746
2016	83,274	198,524	179,746
2017	83,274	198,524	179,785
2018	83,274	198,524	179,785
2019	83,274	198,524	179,785

Table 18. TBNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set

Year	Gosper	Kearney	Phelps
1982	55,887	150,993	144,299
1983	56,187	149,122	144,750
1984	56,761	147,856	143,892
1985	56,971	157,806	150,247
1986	56,297	157,629	149,714
1987	49,352	156,719	148,311
1988	50,724	159,107	150,150
1989	52,238	161,324	152,772
1990	53,033	163,587	155,668
1991	54,907	166,242	157,356
1992	56,348	169,870	160,700
1993	56,797	171,421	161,580
1994	57,368	173,074	162,570
1995	57,916	174,916	163,327
1996	59,029	177,751	164,645
1997	59,906	180,190	166,474
1998	62,384	179,627	166,025
1999	63,178	179,327	165,623
2000	64,020	180,099	165,646
2001	64,705	180,210	165,207
2002	65,456	188,123	168,955
2003	66,229	188,261	168,517
2004	67,007	188,468	168,667
2005	67,906	188,232	167,320
2006	70,330	197,742	172,769
2007	85,216	201,384	179,523
2008	74,828	199,550	172,721
2009	91,811	201,080	180,561
2010	83,454	198,549	179,809
2011	83,428	198,529	179,786
2012	83,428	198,529	179,786
2013	83,423	198,598	179,785
2014	83,423	198,598	179,785
2015	83,423	198,598	179,785
2016	83,423	198,598	179,785
2017	83,423	198,598	179,785
2018	83,423	198,598	179,785
2019	83,423	198,598	179,785

Table 17. TBNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Gosper	Kearney	Phelps
2020	83,274	198,524	179,785
2021	83,274	198,524	179,785
2022	83,274	198,524	179,785
2023	83,274	198,524	179,785
2024	83,274	198,524	179,785
2025	83,274	198,524	179,785
2026	83,274	198,524	179,785
2027	83,274	198,524	179,785
2028	83,274	198,524	179,785
2029	83,274	198,524	179,785
2030	83,274	198,524	179,785
2031	83,274	198,524	179,785
2032	83,274	198,524	179,785
2033	83,274	198,524	179,785
2034	83,274	198,524	179,785
2035	83,274	198,524	179,785
2036	83,274	198,524	179,785
2037	83,274	198,524	179,785
2038	83,274	198,524	179,785
2039	83,274	198,524	179,785
2040	83,274	198,524	179,785
2041	83,274	198,524	179,785
2042	83,274	198,524	179,785
2043	83,274	198,524	179,785
2044	83,274	198,524	179,785
2045	83,274	198,524	179,785
2046	83,274	198,524	179,785
2047	83,274	198,524	179,785
2048	83,274	198,524	179,785
2049	83,274	198,524	179,785
2050	83,274	198,524	179,785
2051	83,274	198,524	179,785
2052	83,274	198,524	179,785
2053	83,274	198,524	179,785
2054	83,274	198,524	179,785
2055	83,274	198,524	179,785
2056	83,274	198,524	179,785
2057	83,274	198,524	179,785

Table 18. TBNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set

Year	Gosper	Kearney	Phelps
2020	83,423	198,598	179,785
2021	83,423	198,598	179,785
2022	83,423	198,598	179,785
2023	83,423	198,598	179,785
2024	83,423	198,598	179,785
2025	83,423	198,598	179,785
2026	83,423	198,598	179,785
2027	83,423	198,598	179,785
2028	83,423	198,598	179,785
2029	83,423	198,598	179,785
2030	83,423	198,598	179,785
2031	83,423	198,598	179,785
2032	83,423	198,598	179,785
2033	83,423	198,598	179,785
2034	83,423	198,598	179,785
2035	83,423	198,598	179,785
2036	83,423	198,598	179,785
2037	83,423	198,598	179,785
2038	83,423	198,598	179,785
2039	83,423	198,598	179,785
2040	83,423	198,598	179,785
2041	83,423	198,598	179,785
2042	83,423	198,598	179,785
2043	83,423	198,598	179,785
2044	83,423	198,598	179,785
2045	83,423	198,598	179,785
2046	83,423	198,598	179,785
2047	83,423	198,598	179,785
2048	83,423	198,598	179,785
2049	83,423	198,598	179,785
2050	83,423	198,598	179,785
2051	83,423	198,598	179,785
2052	83,423	198,598	179,785
2053	83,423	198,598	179,785
2054	83,423	198,598	179,785
2055	83,423	198,598	179,785
2056	83,423	198,598	179,785
2057	83,423	198,598	179,785

Table 17. TBNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Gosper	Kearney	Phelps
2058	83,274	198,524	179,785
2059	83,274	198,524	179,785
2060	83,274	198,524	179,785
2061	83,274	198,524	179,785
2062	83,274	198,524	179,785
2063	83,274	198,524	179,785

Table 18. TBNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set

Year	Gosper	Kearney	Phelps
2058	83,423	198,598	179,785
2059	83,423	198,598	179,785
2060	83,423	198,598	179,785
2061	83,423	198,598	179,785
2062	83,423	198,598	179,785
2063	83,423	198,598	179,785

*Up to 70 acres occur in a cell assigned to TBNRD and Frontier County. This data was combined into the Gosper County total.

Table 19. TBNRD county summary of groundwater only irrigated lands robust review baseline land use data set limited to the Platte Basin

Year	Gosper	Kearney	Phelps
1950	-	1,451	2,284
1951	-	2,756	2,526
1952	-	4,471	2,559
1953	-	5,672	3,353
1954	-	6,037	4,573
1955	-	8,107	5,669
1956	-	9,964	7,426
1957	-	11,608	10,599
1958	-	13,579	10,809
1959	695	15,597	11,822
1960	1,305	15,765	12,299
1961	1,826	15,948	13,191
1962	2,290	15,959	13,547
1963	2,819	16,120	15,229
1964	3,262	16,387	16,483
1965	4,568	19,419	20,599
1966	6,203	21,983	25,050
1967	7,199	24,714	28,886
1968	8,025	26,725	32,380
1969	8,997	29,610	36,325
1970	9,808	31,757	38,917
1971	10,618	34,429	41,562
1972	10,753	37,051	45,541

Table 20. TBNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set limited to the Platte Basin

Year	Gosper	Kearney	Phelps
1950	-	1,451	2,284
1951	-	2,756	2,526
1952	-	4,471	2,559
1953	-	5,672	3,353
1954	-	6,037	4,573
1955	-	8,107	5,669
1956	-	9,964	7,426
1957	-	11,608	10,599
1958	-	13,579	10,809
1959	695	15,597	11,822
1960	1,305	15,765	12,299
1961	1,826	15,948	13,191
1962	2,290	15,959	13,547
1963	2,819	16,120	15,229
1964	3,262	16,387	16,483
1965	4,568	19,419	20,599
1966	6,203	21,983	25,050
1967	7,199	24,714	28,886
1968	8,025	26,725	32,380
1969	8,997	29,610	36,325
1970	9,808	31,757	38,917
1971	10,618	34,429	41,562
1972	10,753	37,051	45,541

Table 19. TBNRD county summary of groundwater only irrigated lands robust review baseline land use data set limited to the Platte Basin

Year	Gosper	Kearney	Phelps
1973	11,543	38,343	48,751
1974	12,240	40,953	53,046
1975	13,730	43,895	58,392
1976	15,050	46,039	62,503
1977	15,785	47,810	67,858
1978	16,792	50,036	71,705
1979	17,321	52,080	75,671
1980	17,678	55,399	79,706
1981	18,191	57,014	81,229
1982	18,530	58,737	83,636
1983	18,829	58,430	84,575
1984	18,824	57,783	84,309
1985	18,855	56,061	82,805
1986	18,668	55,868	82,479
1987	16,997	55,412	81,675
1988	17,219	56,116	82,625
1989	17,767	56,887	84,145
1990	18,190	57,348	85,113
1991	18,662	58,639	85,833
1992	19,290	60,028	87,456
1993	19,225	60,647	88,224
1994	19,512	61,398	88,644
1995	19,482	61,940	89,048
1996	19,777	62,572	89,715
1997	19,826	63,559	90,195
1998	21,061	63,366	90,027
1999	21,145	63,384	89,796
2000	21,261	63,445	89,849
2001	21,240	63,304	89,638
2002	20,818	66,058	91,450
2003	20,419	65,563	91,187
2004	20,024	65,338	90,602
2005	19,739	66,054	90,123
2006	20,443	67,863	93,694
2007	23,309	69,246	96,783
2008	19,770	67,654	94,781
2009	24,102	68,433	97,068

Table 20. TBNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set limited to the Platte Basin

Year	Gosper	Kearney	Phelps
1973	11,543	38,343	48,751
1974	12,240	40,953	53,046
1975	13,730	43,895	58,392
1976	15,050	46,039	62,503
1977	15,785	47,810	67,858
1978	16,792	50,036	71,705
1979	17,321	52,080	75,671
1980	17,678	55,399	79,706
1981	18,191	57,014	81,229
1982	18,530	58,737	83,636
1983	18,829	58,430	84,575
1984	18,824	57,783	84,309
1985	18,855	56,061	82,805
1986	18,668	55,868	82,479
1987	16,997	55,412	81,675
1988	17,219	56,116	82,625
1989	17,767	56,887	84,145
1990	18,190	57,348	85,113
1991	18,662	58,639	85,833
1992	19,290	60,028	87,456
1993	19,225	60,647	88,224
1994	19,512	61,398	88,644
1995	19,482	61,940	89,048
1996	19,777	62,572	89,715
1997	19,826	63,559	90,195
1998	21,061	63,366	90,027
1999	21,145	63,386	89,796
2000	21,261	63,722	89,867
2001	21,240	63,990	89,657
2002	20,818	66,744	91,469
2003	20,419	66,248	91,206
2004	20,024	66,076	90,621
2005	19,746	66,831	90,346
2006	20,501	68,656	94,013
2007	23,384	70,069	97,274
2008	19,952	68,610	95,747
2009	24,444	69,381	97,937

Table 19. TBNRD county summary of groundwater only irrigated lands robust review baseline land use data set limited to the Platte Basin

Year	Gosper	Kearney	Phelps
2010	23,088	68,924	96,526
2011	23,080	69,349	96,541
2012	23,186	69,411	96,793
2013	23,192	69,552	97,129
2014	23,267	69,552	97,196
2015	23,267	69,568	97,307
2016	23,267	69,568	97,307
2017	23,267	69,568	97,346
2018	23,267	69,568	97,346
2019	23,267	69,568	97,346
2020	23,267	69,568	97,346
2021	23,268	69,568	97,346
2022	23,268	69,568	97,346
2023	23,268	69,568	97,346
2024	23,268	69,568	97,346
2025	23,268	69,568	97,346
2026	23,268	69,568	97,346
2027	23,268	69,568	97,346
2028	23,268	69,568	97,346
2029	23,268	69,568	97,346
2030	23,268	69,568	97,346
2031	23,268	69,568	97,346
2032	23,268	69,568	97,346
2033	23,268	69,568	97,346
2034	23,268	69,568	97,346
2035	23,268	69,568	97,346
2036	23,268	69,568	97,346
2037	23,268	69,568	97,346
2038	23,268	69,568	97,346
2039	23,268	69,568	97,346
2040	23,268	69,568	97,346
2041	23,268	69,568	97,346
2042	23,268	69,568	97,346
2043	23,268	69,568	97,346
2044	23,268	69,568	97,346
2045	23,268	69,568	97,346
2046	23,268	69,568	97,346

Table 20. TBNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set limited to the Platte Basin

Year	Gosper	Kearney	Phelps
2010	23,447	69,584	97,371
2011	23,421	69,565	97,348
2012	23,421	69,565	97,348
2013	23,417	69,641	97,346
2014	23,417	69,641	97,346
2015	23,417	69,641	97,346
2016	23,417	69,641	97,346
2017	23,417	69,641	97,346
2018	23,417	69,641	97,346
2019	23,417	69,641	97,346
2020	23,417	69,641	97,346
2021	23,417	69,641	97,346
2022	23,417	69,641	97,346
2023	23,417	69,641	97,346
2024	23,417	69,641	97,346
2025	23,417	69,641	97,346
2026	23,417	69,641	97,346
2027	23,417	69,641	97,346
2028	23,417	69,641	97,346
2029	23,417	69,641	97,346
2030	23,417	69,641	97,346
2031	23,417	69,641	97,346
2032	23,417	69,641	97,346
2033	23,417	69,641	97,346
2034	23,417	69,641	97,346
2035	23,417	69,641	97,346
2036	23,417	69,641	97,346
2037	23,417	69,641	97,346
2038	23,417	69,641	97,346
2039	23,417	69,641	97,346
2040	23,417	69,641	97,346
2041	23,417	69,641	97,346
2042	23,417	69,641	97,346
2043	23,417	69,641	97,346
2044	23,417	69,641	97,346
2045	23,417	69,641	97,346
2046	23,417	69,641	97,346

Table 19. TBNRD county summary of groundwater only irrigated lands robust review baseline land use data set limited to the Platte Basin

Year	Gosper	Kearney	Phelps
2047	23,268	69,568	97,346
2048	23,268	69,568	97,346
2049	23,268	69,568	97,346
2050	23,268	69,568	97,346
2051	23,268	69,568	97,346
2052	23,268	69,568	97,346
2053	23,268	69,568	97,346
2054	23,268	69,568	97,346
2055	23,268	69,568	97,346
2056	23,268	69,568	97,346
2057	23,268	69,568	97,346
2058	23,268	69,568	97,346
2059	23,268	69,568	97,346
2060	23,268	69,568	97,346
2061	23,268	69,568	97,346
2062	23,268	69,568	97,346
2063	23,268	69,568	97,346

Table 20. TBNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set limited to the Platte Basin

Year	Gosper	Kearney	Phelps
2047	23,417	69,641	97,346
2048	23,417	69,641	97,346
2049	23,417	69,641	97,346
2050	23,417	69,641	97,346
2051	23,417	69,641	97,346
2052	23,417	69,641	97,346
2053	23,417	69,641	97,346
2054	23,417	69,641	97,346
2055	23,417	69,641	97,346
2056	23,417	69,641	97,346
2057	23,417	69,641	97,346
2058	23,417	69,641	97,346
2059	23,417	69,641	97,346
2060	23,417	69,641	97,346
2061	23,417	69,641	97,346
2062	23,417	69,641	97,346
2063	23,417	69,641	97,346

Memorandum

To: Ann Dimmit – TPNRD; Kari Burgert – NDNR
From: The Flatwater Group, Inc.
Date: 11/21/2018
Subject: COHYST Area Robust Review: TPNRD Land Use Retirements, Transfers, and Variances

Project Background and Workflow

The Flatwater Group, Inc. (TFG) was contracted by the Platte Basin Water Project Coalition through the Nebraska Department of Natural Resources (NDNR) to provide technical assistance for the Robust Review project. The purpose of the Robust Review project is to assess streamflow impacts resulting from management actions taken as part of the Basin-Wide Plan and/or Natural Resource District (NRD) Integrated Management Plans (IMPs). The focus of this memorandum is to document land use changes related to acreage transfers, retirements, and variances within the Twin Platte NRD (TPNRD).

To account for transfers, retirements, and variances within the TPNRD, TFG's primary work tasks included evaluating and summarizing the available datasets related to transfers, retirements, and variances; then spatially placing these transactions within the constructs of the COHYST 2010 watershed model's land use files to extend the baseline land use through 2013; and to then create a new land use data set for the unretired acreage scenario. For the first step in the process, TFG worked with NDNR and TPNRD to gather the land use data (retirements, transfers, and variances) and place into summary tables by land use type. TFG's next steps were to perform geospatial analyses using ArcGIS to identify the location of each transaction. The geospatial analysis included a proximity function in the form of a custom Fortran program to determine the closest available model cells capable of accommodating the specified land use change.

This memorandum presents a series of tables which summarize the annual number of acres retired or transferred within the TPNRD, outlines the spatial analysis methodology, and ultimately summarizes the resultant land use files.

Land Use Summary Tables

Using information provided by TPNRD and the NDNR, TFG compiled a final summary of the retirements, transfers, and variances for the TPNRD. This information was used to modify the land use data set in the COHYST 2010 model to investigate the effects of these actions as part of the larger Robust Review effort. Tables 1-4 below summarize the information provided to TFG. Tables 5-11 summarize the distribution of that information into the modeling input files.

Table 1 shows an overview summary of retirements and transfers in the TPNRD. Tables 2, 3, and 4 show summaries of the individual categories used to create Table 1 and serve as a reference for the description of each data source.

Table 1. Summary of TPNRD acreage changes for implementation into the Robust Review.

Year	Temporary Retirements	Reinstated Temporary Retirements	Transfers To	Transfers Away	Change
Baseline Change	(-)	(+)	(+)	(-)	
2006	595.5	-	-	-	(595.5)
2007	27.4	-	-	-	(27.4)
2008	-	-	-	-	-
2009	-	-	-	-	-
2010	-	-	-	-	-
2011	-	-	833.2	815.6	17.6
2012	40.8	28.8	1,569.5	1,635.5	(78.0)
2013	-	-	1,865.3	1,840.5	24.8
2014	-	-	-	-	-
2015	-	-	-	-	-
2016	-	-	-	-	-
2017	-	594.1	-	-	594.1
2018	-	-	-	-	-
2019	-	-	-	-	-
2020	-	-	-	-	-
2021	-	-	-	-	-
2022	-	-	-	-	-
2023	-	40.8	-	-	40.8
Total	663.7	663.7	4,268.0	4,291.6	(23.6)

The TPNRD provided two shape files on 8/8/2017 which summarized acreage transfers in the District:

TPNRD_Acres_Decertified_Implemented_through_2013 – (Transfers Away)

TPNRD_New_Acres_implemented_through_2013 – (Transfers To)

These two files provided the spatial location of the acreage transfers within the TPNRD.

Key elements from the information provided related to Decertified Acres (Transfers Away in Table 1):

- 229 entries
- 149 of the 229 entries occurred between 2011 and 2013
- Timing was based upon the implementation year
- In 2013, 234.3 decertified acres were located outside the COHYST 2010 active model domain. They were not considered when modifying the land use.
- 5.4 decertified acres were removed from cells assigned to the CPNRD; 1.6 acres in 2011 and 3.8 acres in 2012
- Table 2 summarizes the model areas impacted by the provided information

Key Elements form the information provided related to New Acres (Transfers To in Table 1):
- 187 entries
- 131 of the 187 entries occurred between 2011 and 2013
- Timing was based upon the implementation year
- 11.4 acres were added to cells assigned to the URNRD. All 11.4 acres were added in 2011.
- Table 3 summarizes the model areas impacted by the provided information

Table 2. Summary of decertified transfer acres in the TPNRD

Year	Decertified Acres	Decertified Acres in Non-Active Cells	Modeled Decertified Acres	Removed from TPNRD	Removed From CPNRD
2011	815.6	-	815.6	814.0	1.6
2012	1,635.5	-	1,635.5	1,631.7	3.8
2013	2,074.8	234.3	1,840.5	1,840.5	-
Total	4,525.9	234.3	4,291.6	4,286.2	5.4

Table 3. Summary of new transfer acres in the TPNRD

Year	New Acres	Added To TPNRD	Added to URNRD
2011	833.2	821.8	11.4
2012	1,569.5	1,569.5	-
2013	1,865.3	1,865.3	-
Total	4,268.0	4,256.6	11.4

Temporary retirement information recorded on Table 1 was based on information NDNR provided on 8/17/2017 in the form of a shape file which summarized CREP and EQIP contract information.

This shape file included the updated list of CREP and EQIP contracts. The data was clipped to the TPNRD resulting in 59 polygons totaling 1,641 acres. The information was limited to groundwater only irrigated (Irrigation = 1) lands which trimmed the area to 14 polygons and 905 acres. Finally, the polygons were reduced to those which were initiated prior to the 2013 irrigation season. This left the data set with 11 entries with 663.7 acres. Each of these 11 entries were CREP contracts. Contract lengths were either 5, 10, or 11 years (Table 4).

To be considered for the current year, the retirement needed to be initiated or ended prior to July of the current year; otherwise, the transaction will have its first effect in the next year. The rationale is that if the action was taken prior to July, the transaction could influence the irrigation season in the current year. However, if the transaction occurred later, the land would finish up the current growing season in the same state.

Table 4. Summary of temporary retirements and reinstated retirement acres in the TPNRD

Year	Temporary Retirements	Reinstated Retirements
2006	595.5	-
2007	27.4	-
2008	-	-
2009	-	-
2010	-	-
2011	-	-
2012	40.8	28.8
2013	-	-
2014	-	-
2015	-	-
2016	-	-
2017	-	594.1
2018	-	-
2019	-	-
2020	-	-
2021	-	-
2022	-	-
2023	-	40.8
Total	663.7	663.7

As discussed above, the acreage summarized in Table 1 (developed from the information in Tables 2-4) was provided in a series of GIS shape files. Using standard GIS practices, the acreage polygons within these coverages were unioned with the COHYST 2010 model grid to determine the number of acres in each model grid cell for each transaction. The following section provides additional detail on this process.

SPATIAL ANALYSIS METHODOLOGY

ArcGIS was used to link the retirements, transfers, and variances to the COHYST model grid. This was accomplished by overlaying the parcels' shapefiles with the model grid.

Step 1: Assigning land use change location

NDNR and TPNRD provided shape files for their retirements and transfers. The union function within ArcGIS was applied to the shapefiles to determine the cell location. The polygon area within each cell was then computed using the calculate geometry function within ArcGIS.

Step 2: Building the Baseline Land Use

The next step was to build the 2011-2013 baseline land use files incorporating the identified transfers and retirements. The beginning condition for this update was the 2010 land use file from the COHYST 2010 model. Each of the transactions occurring in 2011 were applied to the existing 2010 land use file to create the 2011 land use file; which in turn became the basis for applying the transactions occurring in 2012. This continued through 2013. One of the key points of the investigation is the effect of retirements on the system. Given that many of the retirements were temporary in nature and knowing their contract end dates, the land use file building process was continued through 2023 in order to accurately reflect the temporary nature of the retirements. [1]

In the process of distributing the GIS polygon information to the model cells, the existing acreage within a given cell in the year 2010 (as modified moving forward through 2013 as discussed above) was considered. If there was insufficient space[2] for new acres or an insufficient amount of groundwater only acres[3] to be retired within a given cell, the addition or subtraction of acres was applied to nearby cells which exhibited the appropriate characteristics[4]. This spatial analysis process entails radiating outward from the identified cell until the acres had been placed. During this process acres are placed or removed from the lowest priority cell which meets the appropriate criteria. If more than one cell has the same priority and meets criteria, the acres are split evenly between the multiple cells. Unless an even split would exceed the available space within the cell; at which time the placed acres would be limited to the available space and the remaining acres would be split among the other priority cells. The priority pattern for the first two rings around the assignment cell can be seen in Figure 1. This process was implemented using a custom FORTRAN script.

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[1] 2023 was identified as the year the last TPNRD temporary retirement would be actively irrigated again for the first time

[2] Example: transferring 30 groundwater only acres to a cell where there was only 20 non-irrigated acres available

[3] Example: retiring 30 groundwater only acres from a cell where there was only 20 groundwater only acres identified

[4] The cell needed to be active, in the same NRD, and have a sufficient amount of groundwater only acres to retire or non-irrigated acres to convert

5 (r-2, c-2)	4 (r-2, c-1)	3 (r-2, c+0)	4 (r-2, c+1)	5 (r-2, c+2)
4 (r-1, c-2)	2 (r-1, c-1)	1 (r-1, c+0)	2 (r-1, c+1)	4 (r-1, c+2)
3 (r+0, c-2)	1 (r+0, c-1)	0 (r+0, c+0)	1 (r+0, c+1)	3 (r+0, c+2)
4 (r+1, c-2)	2 (r+1, c-1)	1 (r+1, c+0)	2 (r+1, c+1)	4 (r+1, c+2)
5 (r+2, c-2)	4 (r+2, c-1)	3 (r+2, c+0)	4 (r+2, c+1)	5 (r+2, c+2)

Figure 1. Priority of search pattern to place or remove acres when the assigned cell has insufficient non-irrigated or groundwater only acres. The center cell represents the cell identified as the location of the land use transaction. 'r' and 'c' indicate the row column index of the cell.

Table 5 presents the results of Step 2 above. The values in Table 5 were generated by summarizing information from the model land use input files (created as described above) developed for the baseline (full representation of all acreage retirements/transfers) Robust Review model run. Comparing Table 5 to Table 1 shows how the provided information was ultimately represented in the model for the years 2011 – 2023. Discrepancies between the tables are generally related to a particular cell's NRD assignment within the model. In 2011, the location of a couple of transactions were placed in cells designated CPNRD or URNRD; 11.4 new acres were placed in the URNRD in Perkins County, while 1.6 acres were removed from CPNRD in Dawson County. Likewise, in 2012, 3.8 acres were removed from CPNRD in Dawson County. These placements were from the New Acres(Transfers To in Table 1) and Decertified Acres (Transfers Away in Table 1) data sets.

It should be noted that the cell boundaries do not necessarily overlap with the legal boundaries either for the county or NRD. For these summaries each cell was assigned to an NRD and county based upon the location of the cell centroid.

Table 5. Change in groundwater only irrigated acres within the TPNRD for the Robust Review baseline.

Year	(A) Groundwater Only Irrigated Acres in TPNRD	(B) Annual Change in TPNRD Groundwater Only Irrigated Acres in the TPNRD	(C) Change in TPNRD Groundwater Only Irrigated Acres not in the TPNRD
2010	263,165.7	-	-
2011	263,173.8	8.1	9.8
2012	263,099.6	(74.2)	(3.8)
2013	263,124.4	24.8	-
2014	263,124.4	-	-
2015	263,124.4	-	-
2016	263,124.4	-	-
2017	263,718.3	593.9	-
2018	263,718.3	-	-
2019	263,718.3	-	-
2020	263,718.3	-	-
2021	263,718.3	-	-
2022	263,718.3	-	-
2023	263,759.1	40.8	-

Step 3: Building the Unretired Acres Scenario Modified Land Use

Step 3 was taken to develop a new set of land use files for the unretired scenario within the Robust Review. Key elements related to the construction of this scenario include:

a) Acreage transfers were applied as the historically occurred.
b) Post 2010, no acreage retirement activities were incorporated.
c) For temporary and permanent retirements initiated prior to 2010, irrigated acres were added back into the modified land use files starting with the first retirement year (e.g. if a retirement started in 2008, the retired acres were added back into the model starting in 2008).

Regarding c) above, Table 6 shows the changes between the COHYST 2010 land use (column "Run029" in Table 6) and the unretired retirements scenario (column "Modified Land Use" in Table 6). The difference between the two data sets shows the cumulative change over time. These values match those shown in Table 1 subject to rounding resulting from the distribution process.

Table 6. Change in Groundwater Only Irrigated Acres in the TPNRD comparing the COHYST 2010 land use to Unretired Retirements Scenario land use; years 1999-2010.

	Groundwater Only Irrigated Acres		Change in Groundwater Only Irrigated Acres within the TPNRD	
Year	Run 029	Modified Land Use	Cumulative	Annual
1999	208,718	208,718	-	-
2000	210,934	210,934	-	-
2001	213,311	213,311	-	-
2002	221,892	221,892	-	-
2003	233,442	233,442	-	-
2004	245,508	245,508	-	-
2005	250,480	250,480	-	-
2006	258,475	259,070	595.4	595.4
2007	267,919	268,541	622.6	27.2
2008	265,482	266,105	622.7	0.1
2009	267,862	268,485	622.7	(0.0)
2010	263,166	263,788	622.7	0.0
		Cumulative		622.7

With regards to b) under Step 3, Table 7 show the changes referenced to the year 2010 between the COHYST 2010 land use file and the unretired acres represented in the retirement scenario land use file for the Robust Review. The table presents an annual summary for the years 2011 – 2023 of the modifications made to the number of acres irrigated only with ground water based on the 2010 acreage.

Column (A) of Table 7 presents a summary taken from the model input files of the total number of acres irrigated only with ground water represented within the NRD in the “unretired condition” of the retirement scenario. This column can be contrasted with Column (A) of Table 5 to see the total annual acreage change represented in the model between the baseline (all retirements included) condition (Table 5) and the “unretired” scenario condition (Table 7) for the years 2011 through 2023.

Column (B) of Table 7 presents the annual change made to the preceding year’s acreage total for determining a given year’s adjusted acreage value. Column (B) was calculated using the values in Columns (C) through (I).

Table 7. Change in Groundwater Only Irrigated Acres in the TPNRD comparing the COHYST 2010 land use to Unretired Retirements Scenario land use; years 2011-2023.

Year	(A) Groundwater Only Irrigated Acres	(B) =-((G)-(I)) Difference in Groundwater only Acres from 2010 minus cumulative prior retirements and transfers	(C) Transfers Away (Table 2)	(D) Transfers to (Table 3)	(E) Non Area Transfers Away	(F) Non Area Transfers To	(G) =(C)–(D) Net Transfers Away	(H) Cumulative Net Transfers Away	(I) Rounding Residuals
2011	263,796.5	8.1	814.0	821.8			(7.8)	(7.8)	0.3
2012	263,734.4	(62.1)	1,631.7	1,569.5			62.2	54.4	0.1
2013	263,759.2	24.8	1,840.5	1,865.3			(24.8)	29.6	(0.0)
2014	263,759.2	-					-	29.6	-
2015	263,759.2	-					-	29.6	-
2016	263,759.2	-					-	29.6	-
2017	263,759.2	-					-	29.6	-
2018	263,759.2	-					-	29.6	-
2019	263,759.2	-					-	29.6	-
2020	263,759.2	-					-	29.6	-
2021	263,759.2	-					-	29.6	-
2022	263,759.2	-					-	29.6	-
2023	263,759.2	-					-	29.6	-

Tables 8 and 9 show the annual area of groundwater only irrigated land for each county in the TPNRD within the Robust Review's baseline and unretirement scenarios. Finally, Tables 10 and11 show the annual area of groundwater only irrigated land for each county in the TPNRD and Platte River Drainage basin within the Robust Review's baseline and unretirement scenarios.

Table 8. TPNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Arthur	Keith	Lincoln	McPherson
1950	-	3,940	2,329	-
1951	-	5,100	2,338	-
1952	-	6,508	2,496	-
1953	-	7,848	3,049	-
1954	-	8,869	4,411	140
1955	259	9,516	6,515	140
1956	235	9,873	8,285	140
1957	280	10,202	10,006	140
1958	237	10,809	11,681	140
1959	259	11,064	13,596	140
1960	280	12,154	13,940	140
1961	358	12,975	13,933	280
1962	365	14,036	14,258	280
1963	336	15,026	14,721	420
1964	330	15,865	14,864	420
1965	420	18,019	17,328	420
1966	399	19,825	19,369	420
1967	549	22,606	21,894	420
1968	906	24,595	23,982	700
1969	1,159	26,818	26,102	840
1970	1,400	28,644	31,203	980
1971	1,839	30,082	35,802	980
1972	1,818	31,813	40,612	980

Table 9. TPNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set

Year	Arthur	Keith	Lincoln	McPherson
1950	-	3,940	2,329	-
1951	-	5,100	2,338	-
1952	-	6,508	2,496	-
1953	-	7,848	3,049	-
1954	-	8,869	4,411	140
1955	259	9,516	6,515	140
1956	235	9,873	8,285	140
1957	280	10,202	10,006	140
1958	237	10,809	11,681	140
1959	259	11,064	13,596	140
1960	280	12,154	13,940	140
1961	358	12,975	13,933	280
1962	365	14,036	14,258	280
1963	336	15,026	14,721	420
1964	330	15,865	14,864	420
1965	420	18,019	17,328	420
1966	399	19,825	19,369	420
1967	549	22,606	21,894	420
1968	906	24,595	23,982	700
1969	1,159	26,818	26,102	840
1970	1,400	28,644	31,203	980
1971	1,839	30,082	35,802	980
1972	1,818	31,813	40,612	980

Table 8. TPNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Arthur	Keith	Lincoln	McPherson
1973	1,933	33,438	45,704	1,260
1974	2,203	35,177	50,349	1,540
1975	2,881	40,123	57,650	1,540
1976	3,068	46,074	62,725	1,540
1977	3,912	52,163	69,618	1,820
1978	5,277	57,650	76,349	2,940
1979	5,602	59,990	78,875	3,560
1980	6,470	62,452	82,621	4,158
1981	7,300	65,245	85,496	4,387
1982	7,653	67,611	88,954	4,746
1983	7,551	67,158	88,061	4,972
1984	7,670	67,173	85,653	5,350
1985	10,496	59,997	98,168	4,987
1986	10,513	60,079	97,769	5,094
1987	10,691	59,892	96,995	5,263
1988	10,714	61,442	97,483	5,323
1989	10,824	63,871	98,705	5,380
1990	10,845	65,847	99,915	5,438
1991	10,868	67,211	100,718	5,494
1992	10,906	68,534	102,556	5,573
1993	10,929	69,355	103,469	5,561
1994	11,067	71,249	104,183	5,550
1995	11,209	72,978	105,622	5,545
1996	11,461	75,348	108,418	5,541
1997	11,506	78,805	109,820	5,541
1998	11,206	79,530	111,264	5,226
1999	10,793	80,715	112,223	4,987

Table 9. TPNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set

Year	Arthur	Keith	Lincoln	McPherson
1973	1,933	33,438	45,704	1,260
1974	2,203	35,177	50,349	1,540
1975	2,881	40,123	57,650	1,540
1976	3,068	46,074	62,725	1,540
1977	3,912	52,163	69,618	1,820
1978	5,277	57,650	76,349	2,940
1979	5,602	59,990	78,875	3,560
1980	6,470	62,452	82,621	4,158
1981	7,300	65,245	85,496	4,387
1982	7,653	67,611	88,954	4,746
1983	7,551	67,158	88,061	4,972
1984	7,670	67,173	85,653	5,350
1985	10,496	59,997	98,168	4,987
1986	10,513	60,079	97,769	5,094
1987	10,691	59,892	96,995	5,263
1988	10,714	61,442	97,483	5,323
1989	10,824	63,871	98,705	5,380
1990	10,845	65,847	99,915	5,438
1991	10,868	67,211	100,718	5,494
1992	10,906	68,534	102,556	5,573
1993	10,929	69,355	103,469	5,561
1994	11,067	71,249	104,183	5,550
1995	11,209	72,978	105,622	5,545
1996	11,461	75,348	108,418	5,541
1997	11,506	78,805	109,820	5,541
1998	11,206	79,530	111,264	5,226
1999	10,793	80,715	112,223	4,987

Table 8. TPNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Arthur	Keith	Lincoln	McPherson
2000	10,471	82,230	113,406	4,826
2001	9,487	84,154	115,353	4,318
2002	9,272	86,334	121,210	5,077
2003	9,507	89,925	128,803	5,207
2004	9,732	94,959	135,478	5,339
2005	10,096	95,166	139,426	5,791
2006	10,232	95,184	147,632	5,427
2007	11,112	98,022	152,475	6,310
2008	10,687	97,668	150,789	6,339
2009	10,113	98,320	152,875	6,554
2010	9,180	97,947	150,456	5,583
2011	9,180	97,885	150,526	5,583
2012	9,180	97,901	150,436	5,583
2013	8,613	97,725	151,193	5,593
2014	8,613	97,725	151,193	5,593
2015	8,613	97,725	151,193	5,593
2016	8,613	97,725	151,193	5,593
2017	8,613	98,291	151,221	5,593
2018	8,613	98,291	151,221	5,593
2019	8,613	98,291	151,221	5,593
2020	8,613	98,291	151,221	5,593
2021	8,613	98,291	151,221	5,593
2022	8,613	98,291	151,221	5,593
2023	8,613	98,291	151,262	5,593
2024	8,613	98,291	151,262	5,593
2025	8,613	98,291	151,262	5,593
2026	8,613	98,291	151,262	5,593

Table 9. TPNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set

Year	Arthur	Keith	Lincoln	McPherson
2000	10,471	82,230	113,406	4,826
2001	9,487	84,154	115,353	4,318
2002	9,272	86,334	121,210	5,077
2003	9,507	89,925	128,803	5,207
2004	9,732	94,959	135,478	5,339
2005	10,096	95,166	139,426	5,791
2006	10,232	95,779	147,632	5,427
2007	11,112	98,617	152,503	6,310
2008	10,687	98,263	150,816	6,339
2009	10,113	98,915	152,903	6,554
2010	9,180	98,543	150,483	5,583
2011	9,180	98,480	150,553	5,583
2012	9,180	98,467	150,504	5,583
2013	8,613	98,291	151,262	5,593
2014	8,613	98,291	151,262	5,593
2015	8,613	98,291	151,262	5,593
2016	8,613	98,291	151,262	5,593
2017	8,613	98,291	151,262	5,593
2018	8,613	98,291	151,262	5,593
2019	8,613	98,291	151,262	5,593
2020	8,613	98,291	151,262	5,593
2021	8,613	98,291	151,262	5,593
2022	8,613	98,291	151,262	5,593
2023	8,613	98,291	151,262	5,593
2024	8,613	98,291	151,262	5,593
2025	8,613	98,291	151,262	5,593
2026	8,613	98,291	151,262	5,593

Table 8. TPNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Arthur	Keith	Lincoln	McPherson
2027	8,613	98,291	151,262	5,593
2028	8,613	98,291	151,262	5,593
2029	8,613	98,291	151,262	5,593
2030	8,613	98,291	151,262	5,593
2031	8,613	98,291	151,262	5,593
2032	8,613	98,291	151,262	5,593
2033	8,613	98,291	151,262	5,593
2034	8,613	98,291	151,262	5,593
2035	8,613	98,291	151,262	5,593
2036	8,613	98,291	151,262	5,593
2037	8,613	98,291	151,262	5,593
2038	8,613	98,291	151,262	5,593
2039	8,613	98,291	151,262	5,593
2040	8,613	98,291	151,262	5,593
2041	8,613	98,291	151,262	5,593
2042	8,613	98,291	151,262	5,593
2043	8,613	98,291	151,262	5,593
2044	8,613	98,291	151,262	5,593
2045	8,613	98,291	151,262	5,593
2046	8,613	98,291	151,262	5,593
2047	8,613	98,291	151,262	5,593
2048	8,613	98,291	151,262	5,593
2049	8,613	98,291	151,262	5,593
2050	8,613	98,291	151,262	5,593
2051	8,613	98,291	151,262	5,593
2052	8,613	98,291	151,262	5,593
2053	8,613	98,291	151,262	5,593

Table 9. TPNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set

Year	Arthur	Keith	Lincoln	McPherson
2027	8,613	98,291	151,262	5,593
2028	8,613	98,291	151,262	5,593
2029	8,613	98,291	151,262	5,593
2030	8,613	98,291	151,262	5,593
2031	8,613	98,291	151,262	5,593
2032	8,613	98,291	151,262	5,593
2033	8,613	98,291	151,262	5,593
2034	8,613	98,291	151,262	5,593
2035	8,613	98,291	151,262	5,593
2036	8,613	98,291	151,262	5,593
2037	8,613	98,291	151,262	5,593
2038	8,613	98,291	151,262	5,593
2039	8,613	98,291	151,262	5,593
2040	8,613	98,291	151,262	5,593
2041	8,613	98,291	151,262	5,593
2042	8,613	98,291	151,262	5,593
2043	8,613	98,291	151,262	5,593
2044	8,613	98,291	151,262	5,593
2045	8,613	98,291	151,262	5,593
2046	8,613	98,291	151,262	5,593
2047	8,613	98,291	151,262	5,593
2048	8,613	98,291	151,262	5,593
2049	8,613	98,291	151,262	5,593
2050	8,613	98,291	151,262	5,593
2051	8,613	98,291	151,262	5,593
2052	8,613	98,291	151,262	5,593
2053	8,613	98,291	151,262	5,593

Table 8. TPNRD county summary of groundwater only irrigated lands robust review baseline land use data set

Year	Arthur	Keith	Lincoln	McPherson
2054	8,613	98,291	151,262	5,593
2055	8,613	98,291	151,262	5,593
2056	8,613	98,291	151,262	5,593
2057	8,613	98,291	151,262	5,593
2058	8,613	98,291	151,262	5,593
2059	8,613	98,291	151,262	5,593
2060	8,613	98,291	151,262	5,593
2061	8,613	98,291	151,262	5,593
2062	8,613	98,291	151,262	5,593
2063	8,613	98,291	151,262	5,593

Table 9. TPNRD county summary of groundwater only irrigated lands robust review unretired scenario land use data set

Year	Arthur	Keith	Lincoln	McPherson
2054	8,613	98,291	151,262	5,593
2055	8,613	98,291	151,262	5,593
2056	8,613	98,291	151,262	5,593
2057	8,613	98,291	151,262	5,593
2058	8,613	98,291	151,262	5,593
2059	8,613	98,291	151,262	5,593
2060	8,613	98,291	151,262	5,593
2061	8,613	98,291	151,262	5,593
2062	8,613	98,291	151,262	5,593
2063	8,613	98,291	151,262	5,593

*Due to the construct of the model, up to 132 groundwater acres in the TPNRD are located in cells classified as Logan County. This is caused by cell boundaries and legal boundaries not being congruent. The cell is the smallest unit of the model. Each cell was assigned a county designation by the location of the cell centroid. Even if a cell is bisected by the county boundary, the entire cell is assigned to one county. The same process was used to assign each cell an NRD designation.

Table 10. TPNRD county summary of groundwater only irrigated lands robust review baseline land use data set within the Platte River drainage basin.

Year	Arthur	Keith	Lincoln	McPherson
1950	-	3,940	2,329	-
1951	-	5,100	2,338	-
1952	-	6,508	2,496	-
1953	-	7,848	3,049	-
1954	-	8,869	4,411	140
1955	259	9,516	6,515	140
1956	235	9,818	8,263	140
1957	280	10,146	9,979	140
1958	237	10,757	11,654	140
1959	259	11,005	13,561	140
1960	280	12,094	13,907	140
1961	358	12,915	13,899	280
1962	365	13,965	14,224	280
1963	336	14,932	14,688	420
1964	330	15,801	14,834	420
1965	420	17,898	17,282	420
1966	399	19,714	19,328	420
1967	549	22,527	21,819	420
1968	790	24,513	23,841	700
1969	1,042	26,573	25,977	840
1970	1,165	28,357	31,009	980
1971	1,581	29,789	35,502	980
1972	1,465	31,546	40,067	980
1973	1,607	33,154	45,177	1,260
1974	1,907	34,313	49,581	1,540
1975	2,517	39,056	56,459	1,540

Table 11. TPNRD county summary of groundwater only irrigated lands robust review Unretired Scenario land use data set within the Platte River drainage basin.

Year	Arthur	Keith	Lincoln	McPherson
1950	-	3,940	2,329	-
1951	-	5,100	2,338	-
1952	-	6,508	2,496	-
1953	-	7,848	3,049	-
1954	-	8,869	4,411	140
1955	259	9,516	6,515	140
1956	235	9,818	8,263	140
1957	280	10,146	9,979	140
1958	237	10,757	11,654	140
1959	259	11,005	13,561	140
1960	280	12,094	13,907	140
1961	358	12,915	13,899	280
1962	365	13,965	14,224	280
1963	336	14,932	14,688	420
1964	330	15,801	14,834	420
1965	420	17,898	17,282	420
1966	399	19,714	19,328	420
1967	549	22,527	21,819	420
1968	790	24,513	23,841	700
1969	1,042	26,573	25,977	840
1970	1,165	28,357	31,009	980
1971	1,581	29,789	35,502	980
1972	1,465	31,546	40,067	980
1973	1,607	33,154	45,177	1,260
1974	1,907	34,313	49,581	1,540
1975	2,517	39,056	56,459	1,540

Table 10. TPNRD county summary of groundwater only irrigated lands robust review baseline land use data set within the Platte River drainage basin.

Year	Arthur	Keith	Lincoln	McPherson
1976	2,648	44,393	61,489	1,540
1977	3,492	50,259	67,666	1,820
1978	4,857	55,248	73,851	2,940
1979	5,193	57,314	75,932	3,560
1980	6,067	59,598	79,123	4,158
1981	6,841	62,163	80,738	4,387
1982	7,188	64,269	82,255	4,746
1983	7,149	63,644	81,798	4,972
1984	7,267	63,585	79,110	5,350
1985	9,901	56,403	90,075	4,987
1986	9,918	56,495	89,710	5,094
1987	10,096	56,326	89,000	5,263
1988	10,118	57,462	89,449	5,323
1989	10,227	59,711	90,637	5,380
1990	10,247	61,259	91,808	5,438
1991	10,268	62,572	92,572	5,494
1992	10,305	63,804	94,330	5,573
1993	10,326	64,581	95,231	5,561
1994	10,464	66,004	95,934	5,550
1995	10,605	67,724	97,373	5,545
1996	10,857	69,868	100,180	5,541
1997	10,899	72,742	101,466	5,541
1998	10,618	73,239	102,532	5,226
1999	10,227	74,435	103,200	4,987
2000	9,934	75,965	104,291	4,826
2001	9,000	77,152	105,988	4,318

Table 11. TPNRD county summary of groundwater only irrigated lands robust review Unretired Scenario land use data set within the Platte River drainage basin.

Year	Arthur	Keith	Lincoln	McPherson
1976	2,648	44,393	61,489	1,540
1977	3,492	50,259	67,666	1,820
1978	4,857	55,248	73,851	2,940
1979	5,193	57,314	75,932	3,560
1980	6,067	59,598	79,123	4,158
1981	6,841	62,163	80,738	4,387
1982	7,188	64,269	82,255	4,746
1983	7,149	63,644	81,798	4,972
1984	7,267	63,585	79,110	5,350
1985	9,901	56,403	90,075	4,987
1986	9,918	56,495	89,710	5,094
1987	10,096	56,326	89,000	5,263
1988	10,118	57,462	89,449	5,323
1989	10,227	59,711	90,637	5,380
1990	10,247	61,259	91,808	5,438
1991	10,268	62,572	92,572	5,494
1992	10,305	63,804	94,330	5,573
1993	10,326	64,581	95,231	5,561
1994	10,464	66,004	95,934	5,550
1995	10,605	67,724	97,373	5,545
1996	10,857	69,868	100,180	5,541
1997	10,899	72,742	101,466	5,541
1998	10,618	73,239	102,532	5,226
1999	10,227	74,435	103,200	4,987
2000	9,934	75,965	104,291	4,826
2001	9,000	77,152	105,988	4,318

Table 10. TPNRD county summary of groundwater only irrigated lands robust review baseline land use data set within the Platte River drainage basin.

Year	Arthur	Keith	Lincoln	McPherson
2002	8,796	79,165	111,189	5,077
2003	9,018	82,477	118,006	5,207
2004	9,232	87,078	124,383	5,339
2005	9,577	87,274	128,022	5,791
2006	9,784	86,962	134,677	5,427
2007	10,646	89,800	139,541	6,310
2008	10,296	89,452	137,752	6,339
2009	9,599	90,077	140,367	6,554
2010	8,722	89,812	137,454	5,583
2011	8,722	89,740	137,524	5,583
2012	8,722	89,756	137,434	5,583
2013	8,155	89,580	138,005	5,593
2014	8,155	89,580	138,005	5,593
2015	8,155	89,580	138,005	5,593
2016	8,155	89,580	138,005	5,593
2017	8,155	90,146	138,032	5,593
2018	8,155	90,146	138,032	5,593
2019	8,155	90,146	138,032	5,593
2020	8,155	90,146	138,032	5,593
2021	8,155	90,146	138,032	5,593
2022	8,155	90,146	138,032	5,593
2023	8,155	90,146	138,073	5,593
2024	8,155	90,146	138,073	5,593
2025	8,155	90,146	138,073	5,593
2026	8,155	90,146	138,073	5,593
2027	8,155	90,146	138,073	5,593

Table 11. TPNRD county summary of groundwater only irrigated lands robust review Unretired Scenario land use data set within the Platte River drainage basin.

Year	Arthur	Keith	Lincoln	McPherson
2002	8,796	79,165	111,189	5,077
2003	9,018	82,477	118,006	5,207
2004	9,232	87,078	124,383	5,339
2005	9,577	87,274	128,022	5,791
2006	9,784	87,557	134,677	5,427
2007	10,646	90,395	139,568	6,310
2008	10,296	90,047	137,779	6,339
2009	9,599	90,672	140,394	6,554
2010	8,722	90,407	137,481	5,583
2011	8,722	90,335	137,551	5,583
2012	8,722	90,322	137,502	5,583
2013	8,155	90,146	138,073	5,593
2014	8,155	90,146	138,073	5,593
2015	8,155	90,146	138,073	5,593
2016	8,155	90,146	138,073	5,593
2017	8,155	90,146	138,073	5,593
2018	8,155	90,146	138,073	5,593
2019	8,155	90,146	138,073	5,593
2020	8,155	90,146	138,073	5,593
2021	8,155	90,146	138,073	5,593
2022	8,155	90,146	138,073	5,593
2023	8,155	90,146	138,073	5,593
2024	8,155	90,146	138,073	5,593
2025	8,155	90,146	138,073	5,593
2026	8,155	90,146	138,073	5,593
2027	8,155	90,146	138,073	5,593

Table 10. TPNRD county summary of groundwater only irrigated lands robust review baseline land use data set within the Platte River drainage basin.

Year	Arthur	Keith	Lincoln	McPherson
2028	8,155	90,146	138,073	5,593
2029	8,155	90,146	138,073	5,593
2030	8,155	90,146	138,073	5,593
2031	8,155	90,146	138,073	5,593
2032	8,155	90,146	138,073	5,593
2033	8,155	90,146	138,073	5,593
2034	8,155	90,146	138,073	5,593
2035	8,155	90,146	138,073	5,593
2036	8,155	90,146	138,073	5,593
2037	8,155	90,146	138,073	5,593
2038	8,155	90,146	138,073	5,593
2039	8,155	90,146	138,073	5,593
2040	8,155	90,146	138,073	5,593
2041	8,155	90,146	138,073	5,593
2042	8,155	90,146	138,073	5,593
2043	8,155	90,146	138,073	5,593
2044	8,155	90,146	138,073	5,593
2045	8,155	90,146	138,073	5,593
2046	8,155	90,146	138,073	5,593
2047	8,155	90,146	138,073	5,593
2048	8,155	90,146	138,073	5,593
2049	8,155	90,146	138,073	5,593
2050	8,155	90,146	138,073	5,593
2051	8,155	90,146	138,073	5,593
2052	8,155	90,146	138,073	5,593
2053	8,155	90,146	138,073	5,593

Table 11. TPNRD county summary of groundwater only irrigated lands robust review Unretired Scenario land use data set within the Platte River drainage basin.

Year	Arthur	Keith	Lincoln	McPherson
2028	8,155	90,146	138,073	5,593
2029	8,155	90,146	138,073	5,593
2030	8,155	90,146	138,073	5,593
2031	8,155	90,146	138,073	5,593
2032	8,155	90,146	138,073	5,593
2033	8,155	90,146	138,073	5,593
2034	8,155	90,146	138,073	5,593
2035	8,155	90,146	138,073	5,593
2036	8,155	90,146	138,073	5,593
2037	8,155	90,146	138,073	5,593
2038	8,155	90,146	138,073	5,593
2039	8,155	90,146	138,073	5,593
2040	8,155	90,146	138,073	5,593
2041	8,155	90,146	138,073	5,593
2042	8,155	90,146	138,073	5,593
2043	8,155	90,146	138,073	5,593
2044	8,155	90,146	138,073	5,593
2045	8,155	90,146	138,073	5,593
2046	8,155	90,146	138,073	5,593
2047	8,155	90,146	138,073	5,593
2048	8,155	90,146	138,073	5,593
2049	8,155	90,146	138,073	5,593
2050	8,155	90,146	138,073	5,593
2051	8,155	90,146	138,073	5,593
2052	8,155	90,146	138,073	5,593
2053	8,155	90,146	138,073	5,593

Table 10. TPNRD county summary of groundwater only irrigated lands robust review baseline land use data set within the Platte River drainage basin.

Year	Arthur	Keith	Lincoln	McPherson
2054	8,155	90,146	138,073	5,593
2055	8,155	90,146	138,073	5,593
2056	8,155	90,146	138,073	5,593
2057	8,155	90,146	138,073	5,593
2058	8,155	90,146	138,073	5,593
2059	8,155	90,146	138,073	5,593
2060	8,155	90,146	138,073	5,593
2061	8,155	90,146	138,073	5,593
2062	8,155	90,146	138,073	5,593
2063	8,155	90,146	138,073	5,593

Table 11. TPNRD county summary of groundwater only irrigated lands robust review Unretired Scenario land use data set within the Platte River drainage basin.

Year	Arthur	Keith	Lincoln	McPherson
2054	8,155	90,146	138,073	5,593
2055	8,155	90,146	138,073	5,593
2056	8,155	90,146	138,073	5,593
2057	8,155	90,146	138,073	5,593
2058	8,155	90,146	138,073	5,593
2059	8,155	90,146	138,073	5,593
2060	8,155	90,146	138,073	5,593
2061	8,155	90,146	138,073	5,593
2062	8,155	90,146	138,073	5,593
2063	8,155	90,146	138,073	5,593

A.1.6 North Dry Creek pumping data excel spreadsheet

NWNE 27-8N-16W NAD 8 Lat: N40 38' 25.91700" Surface Elev: 2156.92'

Augmentation Production Well Long: W99 06' 59.91771"

G-159762 Well ID: 210850 Stickup: 2.25'

Start Date / Time	End Date Time	MP Depth	Stickup	Depth	Elevation	Begin Meter	End Meter	Ac/In Pumped Interval	Ac/In Annual Total	Pumping Rate GPM	Gallons Pumped Interval	Annual Total Gallons	Comments
7/12/2011 15:00	7/12/2011 15:00	M	2.25			0.00	0.31	0.31		1275			Well Contractor Pumped Well
7/13/2011 10:40	7/13/2011 11:00	M	2.25			0.31	1.21	0.90		1250			Started Well @ 10:40--No SWL--Access Blocked
7/13/2011 11:00	7/13/2011 11:20	23.13	2.25	20.88	2136.04	1.21	2.12	0.91		1250			Observed No Irrigation Wells Running In Local Area
7/13/2011 11:20	7/13/2011 11:40	23.25	2.25	21.00	2135.92	2.12	3.03	0.91		1240			Well Contractor Removed Blockage From Access Port
7/13/2011 11:40	7/13/2011 12:00	23.28	2.25	21.03	2135.89	3.03	3.92	0.89		1240			
7/13/2011 12:00	7/13/2011 12:20	23.44	2.25	21.19	2135.73	3.92	4.84	0.92		1240			
7/13/2011 12:20	7/13/2011 12:40	23.51	2.25	21.26	2135.66	4.84	5.70	0.86		1240			
7/13/2011 12:40	7/13/2011 13:00	23.56	2.25	21.31	2135.61	5.70	6.61	0.91		1240			
7/13/2011 13:00	7/13/2011 13:20	23.62	2.25	21.37	2135.55	6.61	7.58	0.97		1240			Discharge Water Temp 52 F / 11 C
7/13/2011 13:20	7/13/2011 13:40	23.69	2.25	21.44	2135.48	7.58	8.40	0.82		1240			
7/13/2011 13:40	7/13/2011 14:00	23.72	2.25	21.47	2135.45	8.40	9.32	0.92		1240			Stopped Well @ 14:00--9.01 A/I Pumped 7/13/2011
7/13/2011 14:00	7/13/2011 14:10	8.56	2.25	6.31	2150.61	9.32	9.32	0.00		0			
7/13/2011 14:10	7/13/2011 14:20	8.39	2.25	6.14	2150.78	9.32	9.32	0.00		0			
7/13/2011 14:20	7/13/2011 14:30	8.24	2.25	5.99	2150.93	9.32	9.32	0.00		0			
7/13/2011 14:30	7/13/2011 14:40	8.12	2.25	5.87	2151.05	9.32	9.32	0.00		0			
7/13/2011 14:40	7/13/2011 15:00	7.92	2.25	5.67	2151.25	9.32	9.32	0.00		0			
7/13/2011 15:00	7/13/2011 15:30	7.67	2.25	5.42	2151.50	9.32	9.32	0.00		0			
7/14/2011 13:20		7.07	2.25	4.82	2152.10	9.32	9.32	0.00		0			1/2 Pivot @ W1/2NW1/4 & Pivot @ SE1/4 Running
7/20/2011 13:20		7.40	2.25	5.15	2151.77	9.32	9.32	0.00		0			
8/5/2011 13:10		8.04	2.25	5.79	2151.13	9.32	9.32	0.00		0			Nitrate Sample=28.4 ppm
10/24/2011 12:00		7.61	2.25	5.36	2151.56	9.32	18.39	9.07	**18.39**	1200		**499,362**	Well Ran During The Month Of October--JT
3/12/2012 11:45		7.67	2.25	5.42	2151.50	18.39	18.39	0.00	0.00	0	0	0	Water Meter Reading @ 11:45--0018.39 A/I
5/11/2012 12:00		7.54	2.25	5.29	2151.63	18.39	18.39	0.00	0.00	0	0	0	Water Meter Reading @ 12:00--0018.39 A/I
6/6/2012 14:25		7.72	2.25	5.47	2151.45	18.39	18.45	0.06	0.06	1200	1,629	1,629	Water Meter Reading @ 14:30--0018.45 A/I--Well In SW1/4 Sec 26 Running
6/7/2012 13:10	6/7/2012 13:15	7.76	2.25	5.51	2151.41	18.45	18.52	0.07	0.13	1200	1,901	3,530	Water Meter Reading @ 13:10--Well In SW1/4 Sec 26 OFF / Well In NW1/4 Sec 26 Running
6/7/2012 13:15	6/7/2012 13:30	21.94	2.25	19.69	2137.23	18.52	19.01	0.49	0.62	1200	13,305	16,835	Started Augmentation Well @ 13:15
6/7/2012 13:30	6/7/2012 13:45	22.15	2.25	19.90	2137.02	19.01	19.66	0.65	1.27	1200	17,650	34,486	
6/7/2012 13:45	6/7/2012 14:00	22.28	2.25	20.03	2136.89	19.66	20.31	0.65	1.92	1200	17,650	52,136	
6/7/2012 14:00	6/7/2012 14:15	22.36	2.25	20.11	2136.81	20.31	20.94	0.63	2.55	1200	17,107	69,243	
6/7/2012 14:15	6/7/2012 14:30	22.47	2.25	20.22	2136.70	20.94	21.59	0.65	3.20	1200	17,650	86,893	Discharge Water Temp 52 F / 11 C--N40 38' 25.80" / W099 06' 58.40" Elev ~2158' RH
6/7/2012 14:30	6/7/2012 14:45	22.55	2.25	20.30	2136.62	21.59	22.26	0.67	3.87	1200	18,193	105,086	
6/7/2012 14:45	6/7/2012 15:00	22.62	2.25	20.37	2136.55	22.26	22.90	0.64	4.51	1200	17,379	122,465	
6/7/2012 15:00	6/7/2012 15:15	22.68	2.25	20.43	2136.49	22.90	23.58	0.68	5.19	1200	18,465	140,929	
6/7/2012 15:15	6/7/2012 15:30	22.72	2.25	20.47	2136.45	23.58	24.19	0.61	5.80	1200	16,564	157,493	
6/7/2012 15:30	6/7/2012 15:45	22.74	2.25	20.49	2136.43	24.19	24.86	0.67	6.47	1200	18,193	175,686	Last Measurement For 6/7/2012--Well Still Running

6/7/2012 15:45	6/8/2012 9:00	23.93	2.25	21.68	2135.24	24.86	68.97	44.11	50.58	1190	1,197,763	1,373,449	Started Nickel Pivot Well @ 10:00
6/8/2012 9:00	6/8/2012 10:15	23.98	2.25	21.73	2135.19	68.97	72.33	3.36	53.94	1190	91,237	1,464,687	Discharge Water Temp 52 F / 11 C
6/8/2012 10:15	6/8/2012 11:00	23.98	2.25	21.73	2135.19	72.33	74.30	1.97	55.91	1190	53,493	1,518,180	
6/8/2012 11:00	6/8/2012 14:15	24.07	2.25	21.82	2135.10	74.30	82.50	8.20	64.11	1190	222,663	1,740,843	Started Nickel Gravity Well @ 13:15
6/8/2012 14:15	6/8/2012 15:45	24.10	2.25	21.85	2135.07	82.50	86.35	3.85	67.96	1190	104,543	1,845,386	Last Measurement For 6/8/2012--Well Still Running
6/8/2012 15:45	6/11/2012 15:50	24.78	2.25	22.53	2134.39	86.35					0	0	Gravity Well OFF / Pivot Well Running / No Meter Reading
6/11/2012 15:50		24.78	2.25	22.53	2134.39	86.35					0	0	Wells In E1/2 Sec 27 Running
6/11/2012 15:50	6/15/2012 11:45	25.24	2.25	22.99	2133.93	86.35	503.68	417.33	485.29	1180	11,332,179	13,177,565	Wells In E1/2 Sec 27 Running--Well In NW1/4 Sec 26 Running--Gravity Well OFF
6/15/2012 11:45	6/18/2012 15:00	25.30	2.25	23.05	2133.87	503.68	695.02	191.34	676.63	1190	5,195,646	18,373,211	Wells in E1/3 Sec 27 Running--Gravity Well Running--Augmentation Well Running
6/18/2012 15:00	6/18/2012 15:10	25.30	2.25	23.05	2133.87	695.02	695.43	0.41	677.04	1190	11,133	18,384,344	Wells in E1/3 Sec 27 Running--Gravity Well Running--Augmentation Well Running
6/18/2012 15:10	6/18/2012 15:15	25.30	2.25	23.05	2133.87	695.43	695.63	0.20	677.24	1190	5,431	18,389,775	Wells in E1/3 Sec 27 Running--Gravity Well Running--Augmentation Well Running
6/18/2012 15:15	6/18/2012 16:00	25.30	2.25	23.05	2133.87	695.63	697.54	1.91	679.15	1190	51,864	18,441,639	Wells in E1/3 Sec 27 Running--Gravity Well Running--Augmentation Well Running
6/18/2012 16:00	6/21/2012 12:30	25.48	2.25	23.23	2133.69	697.54	871.30	173.76	852.91	1180	4,718,279	23,159,918	Gravity, Pivot, Augmentation Wells Running / Wells in NW1/4 Sec 27, SW1/4 Sec 26 Running
6/21/2012 12:30	6/21/2012 13:00	25.48	2.25	23.23	2133.69	871.30	872.56	1.26	854.17	1180	34,214	23,194,132	Gravity, Pivot, Augmentation Wells Running / Wells in NW1/4 Sec 27, SW1/4 Sec 26 Running
6/21/2012 13:00	6/21/2012 13:15	25.48	2.25	23.23	2133.69	872.56	873.21	0.65	854.82	1180	17,650	23,211,782	Gravity, Pivot, Augmentation Wells Running / Wells in NW1/4 Sec 27, SW1/4 Sec 26 Running
6/21/2012 13:15	6/21/2012 13:16	25.48	2.25	23.23	2133.69	873.21	873.24	0.03	854.85	1180	815	23,212,597	Augmentation Well OFF @ 13:16
6/21/2012 13:16	6/21/2012 13:21	12.16	2.25	9.91	2147.01	873.24	873.24	0.00	854.85	0	0	23,212,597	Augmentation Well OFF, Gravity, Pivot, Wells Running / Wells in NW1/4 Sec 27, SW1/4 Sec 26 Running
6/21/2012 13:21	6/21/2012 13:26	12.04	2.25	9.79	2147.13	873.24	873.24	0.00	854.85	0	0	23,212,597	Augmentation Well OFF, Gravity, Pivot, Wells Running / Wells in NW1/4 Sec 27, SW1/4 Sec 26 Running
6/21/2012 13:26	6/21/2012 13:30	11.96	2.25	9.71	2147.21	873.24	873.24	0.00	854.85	0	0	23,212,597	Augmentation Well OFF, Gravity, Pivot, Wells Running / Wells in NW1/4 Sec 27, SW1/4 Sec 26 Running
6/21/2012 13:30	6/21/2012 13:45	11.70	2.25	9.45	2147.47	873.24	873.24	0.00	854.85	0	0	23,212,597	Augmentation Well OFF, Gravity, Pivot, Wells Running / Wells in NW1/4 Sec 27, SW1/4 Sec 26 Running
6/21/2012 13:45	6/21/2012 14:00	11.52	2.25	9.27	2147.65	873.24	873.24	0.00	854.85	0	0	23,212,597	Augmentation Well OFF, Gravity, Pivot, Wells Running / Wells in NW1/4 Sec 27, SW1/4 Sec 26 Running
6/21/2012 14:00	6/21/2012 14:30	11.42	2.25	9.17	2147.75	873.24	873.24	0.00	854.85	0	0	23,212,597	Augmentation, Gravity Wells OFF, Pivot, Well Running / Well in NW1/4 Sec 27 OFF, SW1/4 Sec 26 Running

6/21/2012 14:30	6/21/2012 15:00	11.04	2.25	8.79	2148.13	873.24	873.24	0.00	854.85	0	0	23,212,597	Augmentation, Gravity Wells OFF, Pivot, Well Running / Well in NW1/4 Sec 27 OFF, SW1/4 Sec 26 Running
6/21/2012 15:00	6/21/2012 15:30	10.85	2.25	8.60	2148.32	873.24	873.24	0.00	854.85	0	0	23,212,597	Augmentation, Gravity Wells OFF, Pivot, Well Running / Well in NW1/4 Sec 27 OFF, SW1/4 Sec 26 Running
6/21/2012 15:30	6/21/2012 15:45	10.77	2.25	8.52	2148.40	873.24	873.24	0.00	854.85	0	0	23,212,597	Augmentation, Gravity Wells OFF, Pivot, Well Running / Well in NW1/4 Sec 27 OFF, SW1/4 Sec 26 Running
6/21/2012 15:45	6/22/2012 10:40	9.31	2.25	7.06	2149.86	873.24	873.24	0.00	854.85	0	0	23,212,597	Augmentation, Gravity Wells OFF, Pivot, Well Running / Wells in NW1/4, SW1/4 Sec 26 Running, Well in SE1/4 Sec 27 Running
6/25/2012 13:05		8.67	2.25	6.42	2150.50	873.24	873.24	0.00	854.85	0	0	23,212,597	Gravity OFF, Augmentation Well OFF, Pivot OFF / Wells in SW1/4 Sec 26 Running, SE1/4 Sec 27 Running / Loggers Returned To 12-Hour Readings
8/30/2012		[redacted]			2146.67	873.24	4038.93	3165.69	4020.54	1175	85,961,146	109,173,743	Augmentation Well running, Pivot Running, Gravity Off
9/5/2012					2146.67	4038.93	4405.50	366.57	4387.11	1175	9,953,842	119,127,585	Augmentation Well running, Pivot Off, Gravity Off
9/6/2012					2146.17	4405.50	4464.20	58.70	4445.81	1175	1,593,940	120,721,525	Augmentation Well running, Pivot Off, Gravity Off
9/7/2012					2146.17	4464.20	4511.65	47.45	4493.26	1150	1,288,457	122,009,982	Augmentation Well OFF @ 9:29 AM
9/11/2012		11.56	2.25	9.31	2147.61	4511.65	4511.65	0.00	4493.26	0	0	122,009,982	Augmentation Well OFF, Creek Dry
9/17/2012		11.28	2.25	9.03	2147.89	4511.65	4511.65	0.00	4493.26	0	0	122,009,982	Augmentation Well OFF, Creek Dry
10/22/2012		10.61	2.25	8.36	2148.56	4511.65	4511.65	0.00	**4493.26**	0	0	**122,009,982**	Augmentation Well OFF, Creek Dry, Pivot off, Gravity on livestock, Well in SW1/4 Sec 26 Running
5/10/2013		8.50	2.25	6.25	2150.67	4511.65	4511.65	0.00	0.00		0	0	Augmentation Well OFF - started at 11:00. SE 27 pivot dripping, Other wells off, Nickel wells off
5/20/2013		10.81	2.25	8.56	2148.36	4511.65	5005.05	493.40	493.40	1200	13,397,784	13,397,784	Augmentation Well ON, Gravity Off, Pivot Off (12 Hr cycle)
5/30/2013		9.16	2.25	6.91	2150.01	5005.05	5305.77	300.72	794.12	0	8,165,751	21,563,534	All Wells OFF (12 Hr cycle)
6/6/2013		9.67	2.25	7.42	2149.50	5305.77	5529.03	223.26	1017.38	0	6,062,402	27,625,937	All Wells OFF (12 Hr cycle)
6/13/2013		10.08	2.25	7.83	2149.09	5529.00	5750.02	221.02	1238.40	0	6,001,577	33,627,514	All Wells OFF (12 Hr cycle)
7/5/2013		11.72	2.25	9.47	2147.45	5750.02	6391.70	641.68	1880.08	0	17,424,179	51,051,692	Augmentation Well Off, All Wells Pumping
7/16/2013		11.75	2.25	9.50	2147.42	6391.70	6711.23	319.53	2199.61	0	8,676,518	59,728,210	Augmentation Well Off, Creek Dry, All Wells Pumping
7/25/2013		10.92	2.25	8.67	2148.25	6711.23	6711.23	0.00	2199.61	0	0	59,728,210	Augmentation Well Off, Beginning Flow in Creek, Nickel Pivot Off, All other surrounding wells running
7/31/2013		10.51	2.25	8.26	2148.66	6711.23	6711.23	0.00	2199.61	0	0	59,728,210	Augmentation Well Off, Creek Flowing @ Outlet, Not flowing at River Road, Gravity Off, Pivot Running
8/7/2013		13.17	2.25	10.92	2146.00	6711.23	6929.92	218.69	2418.30	0	5,938,308	65,666,518	Augmentation Well Off, Creek Flowing
8/21/2013		13.00	2.25	10.75	2146.17	6929.92	7498.93	569.01	2987.31	0	15,450,898	81,117,416	Augmentation Well Off, Creek Flowing
8/29/2013		11.72	2.25	9.47	2147.45	7498.93	7762.48	263.55	3250.86	0	7,156,437	88,273,852	Augmentation Well Off, No Flow in Creek
9/6/2013		11.45	2.25	9.20	2147.72	7762.48	7762.48	0.00	3250.86	0	0	88,273,852	Augmentation Well Off, No Flow in Creek

9/17/2013	11.80	2.25	9.55	2147.37	7762.48	7762.48	0.00	3250.86	0	0	88,273,852	Augmentation Well Off, No Flow in Creek
11/7/2013	9.53	2.25	7.28	2149.64	7762.48	7762.48	0.00	**3250.86**	0	0	**88,273,852**	Augmentation Well Off, No Flow in Creek

A.1.7 Memorandums on the Calculations of Excess Flows, Recharge Volumes and Percentages, and Discharge Volumes for Canal Recharge

March 15, 2018
rev. June 12, 2018 and June 7, 2019

To: The Platte Overappropriated Area Committee Technical Committee

From: Margeaux Carter and Kari Burgert, Nebraska Department of Natural Resources

Date: March 15, 2018, revised June 12, 2018, revised June 7, 2019

Re: Data Sourcing and Summary of Diversion of Excess Flows for Canal Recharge

Summary

The accepted various diversions of excess flow for canal recharge have been combined into a single file with daily discharge rates for each canal with excess flow for 2011, 2012, and 2013. The final discharge data file is "POAC_2011_2013_FINAL.xlsx."

This memo will list the data sources for the excess flow data which will be used to assess the effectiveness of artificial recharge and streamflow augmentation projects in the Robust Review. The diversion periods described in the 10/26/2017 memo from Tracy Zayac "Memo to POAC Admins on canal recharge for RR rev10262017.pdf" (Zayac memo) are used for the analysis. The records of the diversion period from the sources described in this memo may vary from those described in the Zayac memo. The periods of diversion chosen in the Zayac memo considered information additional to diversion records, including contracts, irrigation season, and other records from the time of the excess flow diversion. The canal diversion sources used for this analysis may have been updated since the memo causing slight variations in the diversion periods.

Data Sources for Excess Flow Diversions

Listed in Table 1 are the canals for which the NeDNR streamgaging website was used to obtain discharge data during periods of excess flow from 2011 to 2013. The canals are listed by their name in the Zayac memo with their stream gage name and number in the NeDNR stream gaging list and index (https://nednr.nebraska.gov/RealTime/Gage/Index). Note that Farmers canal is referred to as "Tri-State Canal" and Pathfinder as "Interstate Canal" in the NeDNR Gage Index. According to the Zayac memo, Winters Canal excess flow dates apply to the combined discharge between the "Winters Canal from Winters Creek" and "Winters Canal from North Platte River". These values have been combined in the final excess flow datasheet, but it should be noted that the discharge recorded in Winters Canal from North Platte River during the accepted excess flow dates was zero. Lateral E65 discharge is not available in the NeDNR database. Pathfinder discharge data prior to 2012 and Lisco data between 4/13/2011 and 10/1/2011 are not digitized in the NeDNR streamgaging website and can be found in the annual NeDNR Hydrographic reports. The NeDNR Hydrographic report originally obtained for Pathfinder for this study reported on United States Bureau of Reclamation (USBR) measurements that had since been updated by the USBR. The diversions on Pathfinder Canal used in this study were obtained from the USBR Hydromet website on May 2018.

Table 1. Canals with excess flow between 2011 and 2013 obtained from NeDNR streamgaging database and the canal gage name and number

Canal	NeDNR Gage Name	Gage Number
Belmont	Belmont Canal from North Platte River	9000
Castle Rock	Castle Rock-Steamboat Canal from North Platte River	21000
Central	Central Canal from North Platte River	22000
Chimney Rock	Chimney Rock Canal from North Platte River	24000
Cozad	Cozad Canal from Platte River	33000
Dawson County	Dawson County Canal from Platte River	37000
Enterprise	Enterprise Canal from North Platte River	40000
Farmer’s	Tri-State Canal from North Platte	145100
Gothenburg	Gothenburg Canal from Platte River	57000
Kearney	Kearney Canal from Platte River	73000
Keith Lincoln	Keith-Lincoln County Canal from North Platte River	76000
Lisco	Lisco Canal from North Platte River	8200
Minatare	Minatare Canal from North Platte River	99000
Nine Mile	Ninemile Canal from North Platte River	106000
North Platte	North Platte Canal from North Platte River	114000
Orchard-Alfalfa	Orchard-Alfalfa Canal from Platte River	117000
Paxton Hershey	Paxton-Hershey Canal from North Platter	121000
Suburban	Suburban Canal from North Platte River	136000
Thirty Mile	Thirty Mile Canal from Platte River	141000
Western	Western Canal from South Platte River	147000
Winters	Winters Creek Canal from North Platte River	148000
Winters	Winters Creek Canal from Winters Creek	149000

Listed in Table 2 are the data sources for excess flow canal discharge not found in the NeDNR streamgaging database. Daily discharge data for Dawson County and Thirty Mile canals in the fall of 2013 were available in the interactive NeDNR streamgaging database and were corroborated with external data provided in Table 2. Daily discharge data for Lisco canals was available in the Hydrographic reports and also corroborated with externally obtained data provided in Table 2. Digitized discharge data was available for 23 days of Lisco canal’s excess flow period in the fall of 2011. Discharge data for E65 Canal and Phelps Canal were provided entirely by CNPPID.

Table 2. Data sources for canal discharge not found in NeDNR gage database

Canal	Event	Data Source	Obtained
Lisco	Spring 2011	WISKI NeDNR, "2017-12-04Lisco.xlsx"	12/4/17
Pathfinder	Spring 2011	USBR Hydromet	May 2018
Lisco	Fall 2011	WISKI NeDNR, "2017-12-04Lisco.xlsx"	12/4/17
Dawson County	Fall 2013	NPPD, Jeff Shafer to NeDNR, Jessie Strom, "Dawson County Canal Diversion 2013-09-22 to 2013-10-09.xlsx"	3/13/17
E-65	Fall 2013	CNPPID , "Groundwater Recharge Diversions Summary 4-9-2018.xlsx"	4/9/18
Phelps	Fall 2013	CNPPID , "Groundwater Recharge Diversions Summary 4-9-2018.xlsx"	4/9/18
Thirty Mile	Fall 2013	CPNRD, Duane Woodward to NeDNR, Jessie Strom, "ThirtyMileexcess_Diversion_2013fall.xlsx"	2/21/17

To: The Platte Overappropriated Area Committee Technical Committee
From: Kari Burgert, Nebraska Department of Natural Resources
Date: June 14, 2018, updated October 11, 2018
Re: CPNRD, **TBNRD, and TPNRD Monthly Excess Flow Discharge Volumes, Recharge Percentages, Recharge Volumes, and Locations for the COHYST model**

This memo provides the final recharge volumes from excess flow diversions into Elwood Reservoir and excess flow canal diversions from 2011-2013 for Central Platte Natural Resources District (CPNRD), Tri-Basin Natural Resources District (TBNRD), and Twin Platte Natural Resources District (TPNRD) for use in the COHYST-area portion of the 2018 Robust Review. TPNRD and South Platte Natural Resources District excess flow diversions on Western Canal will be assessed with the Western Water Use Model.

Tables 1-3 have summaries of the monthly volumes of excess flow and resulting estimated recharge volumes for CPNRD, TBNRD, and TPNRD-contracted canal excess flows, respectively. Canal diversion volumes in this memorandum are from the POAC Technical Committee memorandum ExcessFlowData_SourceSummary.docx and associated data spreadsheet POAC_2011_2013.xlsx. Recharge percentages for all excess flow canal diversions except the Fall 2013 E65 diversions and CPNRD canals Cozad, Orchard-Alfalfa, and Thirty Mile were obtained from the spreadsheet PlatteRechargeDateComparison_For POAC_daw.xlsx. The methodology for calculating the recharge percentages in that spreadsheet was to assume recharge up to the rate modeled in the COHYST surface water operations model and average the percentage of the assumed recharge rates to the diversion rates over the period of excess flow diversion. This methodology was applied to the Fall 2013 E65 diversions, and 100% recharge was calculated. Recharge rates for Cozad, Orchard-Alfalfa, and Thirty Mile canals for these recharge events were obtained from CPNRD.

TBNRD contracted 50% of the Fall 2011 and Fall 2013 excess flow events on Phelps Canal; PRRIP contracted the remaining 50% of these events. The total recharge volumes for these events will be included in the model files, and benefits to the Platte Basin from TBNRD management will be calculated as 50% of the modeled accretions from these events. Inclusion of additional excess flow recharge events from Phelps and E65 are discussed in the July 17, 2018, NeDNR memo to the POAC Technical Committee Re: Phelps/E65 Canal Recharge Sensitivity (20180718_PhelpsE65_Sensititivy_Memo.docx).

Recharge from excess flow diversions into Elwood Reservoir were assumed to be 100% of the total pumped. For each excess flow event, all of the excess flow water pumped was assumed be recharged at a constant daily rate over 180 days starting with the first diversion date. The daily volumes pumped into Elwood Reservoir were obtained from the spreadsheet obtained from CNPPID, "CNPPID_Groundwater Recharge Diversions Summary 1-8-2016.xlsx." A total of 44,730 acre-feet of excess flow were diverted to and recharged from Elwood Reservoir from 2006 to 2013. Table 4 provides the Elwood Reservoir diversion/recharge volumes per event. Shown in Figure 1 are the monthly diversion and recharge volumes for the Elwood Reservoir excess flow recharge projects for analysis in the 2018 Robust Review.

Figures of the model cell locations of recharge are also provided (Figures 2-4). The model cell locations for each canal were obtained from the COHYST model table StellaCanalToModflowGrid.csv used for assigning canal recharge from the surface water model to the groundwater model during integrated runs. The model cell locations for Elwood recharge were obtained from the COHYST model table StellaReservoirToModflowGrid.csv. Figure 2 shows the model cell locations of the CPNRD excess flow recharge events. Figure 3 presents the model cell locations of the TBNRD excess flow recharge events. The Phelps and E65 canal recharge locations were determined from the CNPPID groundwater recharge diversion summaries spreadsheets and the contracts for the events. The TBNRD Fall 2011 event occurred on Phelps canal to Mile Post 9.7. The TBNRD Fall 2013 event occurred on Phelps canal to Mile Post 13.3 (including the section to Mile Post 9.7) and on the E65 canal to Mile Post 23.7, on laterals to and within Cottonwood WPA, and on E65 to Mile Post 36.2S/Loomis. Figure 4 presents the model cell locations of the TPNRD excess flow recharge events. Spring and Fall 2011 excess flow events for TPNRD occurred on all four canals: Keith Lincoln, North Platte, Paxton Hershey, and Suburban. The TPNRD Fall 2013 events occurred on North Platte and Paxton Hershey.

Table 1. CPNRD-contracted monthly excess flow discharge volumes, recharge percentages, and recharge volumes

		Cozad			Orchard-Alfalfa			Thirty Mile		
Year	Month	Diversion (af)	Recharge Fraction	Recharge (af)	Diversion (af)	Recharge Fraction	Recharge (af)	Diversion (af)	Recharge Fraction	Recharge (af)
2011	4	833	0.85	708	144	0.85	122	1,192	0.60	715
2011	5	930	0.85	791	830	0.85	706	4,322	0.60	2,593
2011	9	877	0.85	745	1,010	0.85	858	4,760	0.60	2,856
2011	10	474	0.85	403	506	0.85	430	379	0.60	227
2012	3				78	0.85	66			
2013	9							3693	0.60	2,216
2013	10							3442	0.60	2,065
	Total	3,114		2,647	2,567		21,825	17,789		10,673

		Dawson County			Gothenburg			Kearney			Total
Year	Month	Diversion (af)	Recharge Fraction	Recharge (af)	Diversion (af)	Recharge Fraction	Recharge (af)	Diversion (af)	Recharge Fraction	Recharge (af)	Recharge (af)
2011	4	899	0.998	897	3,124	0.995	3,108	3074	0.286	879	6,430
2011	5	3,148	0.998	3,141	3,154	0.995	3,138	1216	0.286	348	10,717
2011	9	2,436	0.998	2,431	3,602	0.995	3,584				10,474
2011	10	1,018	0.998	1,015	2,126	0.995	2,116				4,191
2012	3										66
2013	9	932	1.000	932	1,481	0.985	1,458				4,607
2013	10	569	1.000	569	748	0.985	737				3,371
	Total	9,001		8,986	14,234		14,141	4,290		1,227	39,856

Table 2. TBNRD-contracted monthly excess flow canal discharge volumes, canal recharge percentages, and canal recharge volumes

		E65			Phelps				Total
Year	Month	Diversion (af)	Recharge Fraction	Recharge (af)	Diversion (af)	Recharge Fraction	Contracted Fraction	Recharge (af)	Recharge (af)
2011	9				603	1.000	0.50	302	302
2011	10				1,828	1.000	0.50	914	914
2011	11				1,731	1.000	0.50	866	866
2011	12				1,257	1.000	0.50	629	629
2012	1				139	1.000	0.50	70	70
2013	9	1,341	1.000	1,341	1,821	0.981	0.50	893	2,234
2013	10	1,293	1.000	1,293	1,907	0.981	0.50	935	2,228
	Total	2,634		2,634	9,286			4,608	7,242

Table 3. TPNRD-contracted monthly excess flow discharge volumes, recharge percentages, and recharge volumes

Year	Month	Keith Lincoln			North Platte		
		Diversion (af)	Recharge Fraction	Recharge (af)	Diversion (af)	Recharge Fraction	Recharge (af)
2011	4	1,256	0.972	1,221	2,102	0.988	2,077
2011	5	1,012	0.972	983	2,557	0.988	2,526
2011	6	99	0.972	96			
2011	9	724	0.972	704	795	0.988	786
2011	10	1,315	0.972	1,278	3,582	0.988	3,539
2013	9				2,261	0.954	2,157
2013	10				1,248	0.954	1,191
Total		4,406		4,283	12,546		12,276

Year	Month	Paxton Hershey			Suburban			Total
		Diversion (af)	Recharge Fraction	Recharge (af)	Diversion (af)	Recharge Fraction	Recharge (af)	Recharge (af)
2011	4	982	0.969	951	925	1.000	925	5,175
2011	5	849	0.969	823	964	1.000	964	5,296
2011	6							96
2011	9	785	0.969	761	924	1.000	924	3,175
2011	10	1,554	0.969	1,505	839	1.000	839	7,162
2013	9	1,117	0.878	980				3,138
2013	10	667	0.878	585				1,776
Total		5,953		5,606	3,652		3,652	25,818

Table 4. Diversion/recharge volumes per Elwood Reservoir excess flow recharge projects for analysis in the 2018 Robust Review.

Start Date of Elwood Recharge Diversions	End Date of Elwood Recharge Diversions	Diverted and Recharged Volume (acre-feet)
1/24/2006	2/13/2006	6,132
8/8/2006	8/10/2006	627
12/22/2006	12/31/2006	2,793
5/30/2007	6/25/2007	7,262
7/9/2007	7/11/2007	419
7/31/2007	8/8/2007	2,277
5/23/2008	6/11/2008	6,963
7/18/2008	7/21/2008	1,169
8/10/2008	8/19/2008	1,193
6/21/2009	8/21/2009	2,906
9/19/2013	10/31/2013	12,989

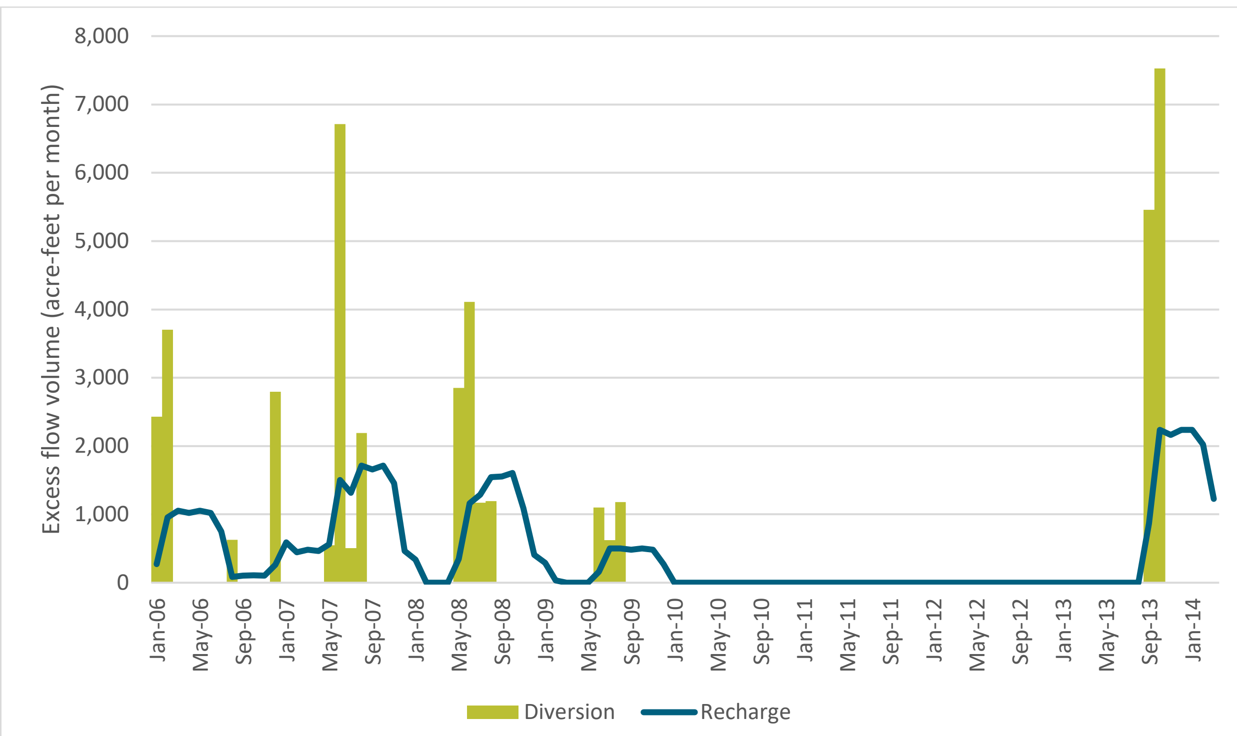


Figure 1. Excess flow monthly volumes pumped into and monthly volumes of excess flow water recharged from Elwood Reservoir.

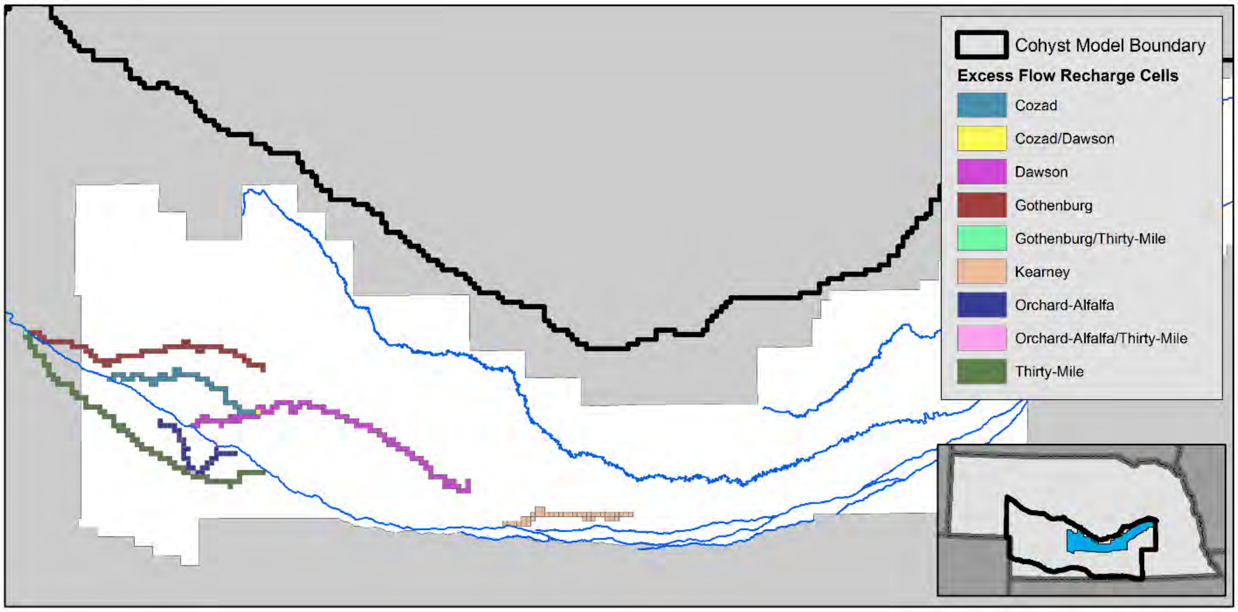


Figure 2. Model cell locations for the CPNRD excess flow recharge events within the COHYST model area.

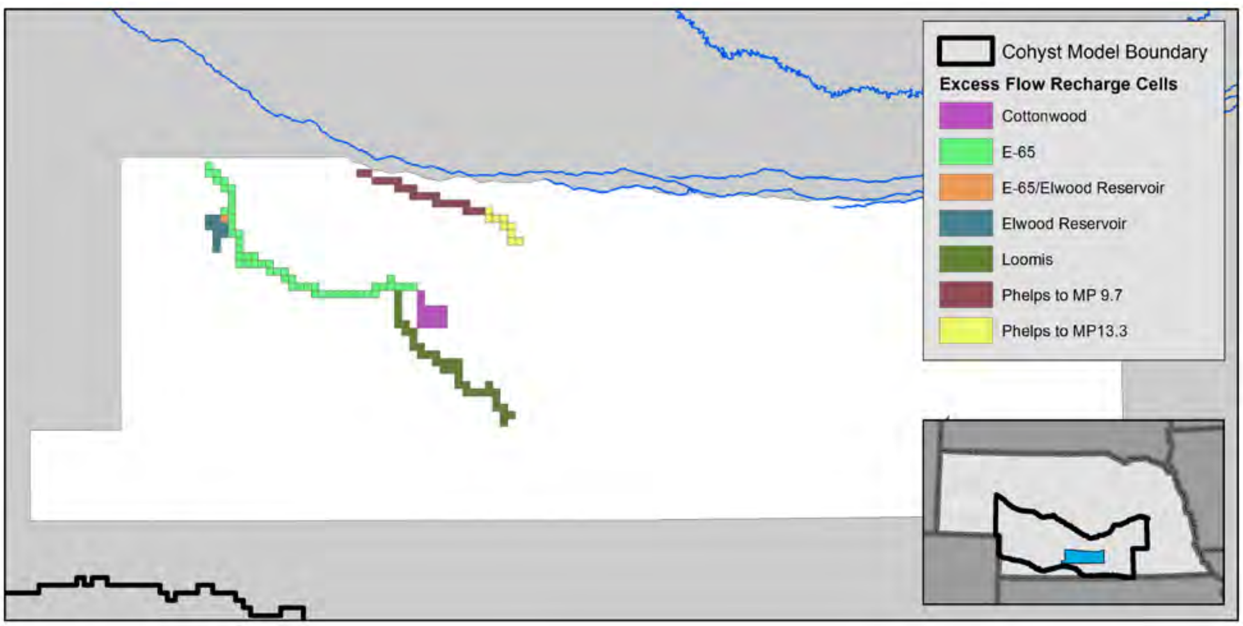


Figure 2. Model cell locations of the TBNRD excess flow recharge events within the COHYST model area.

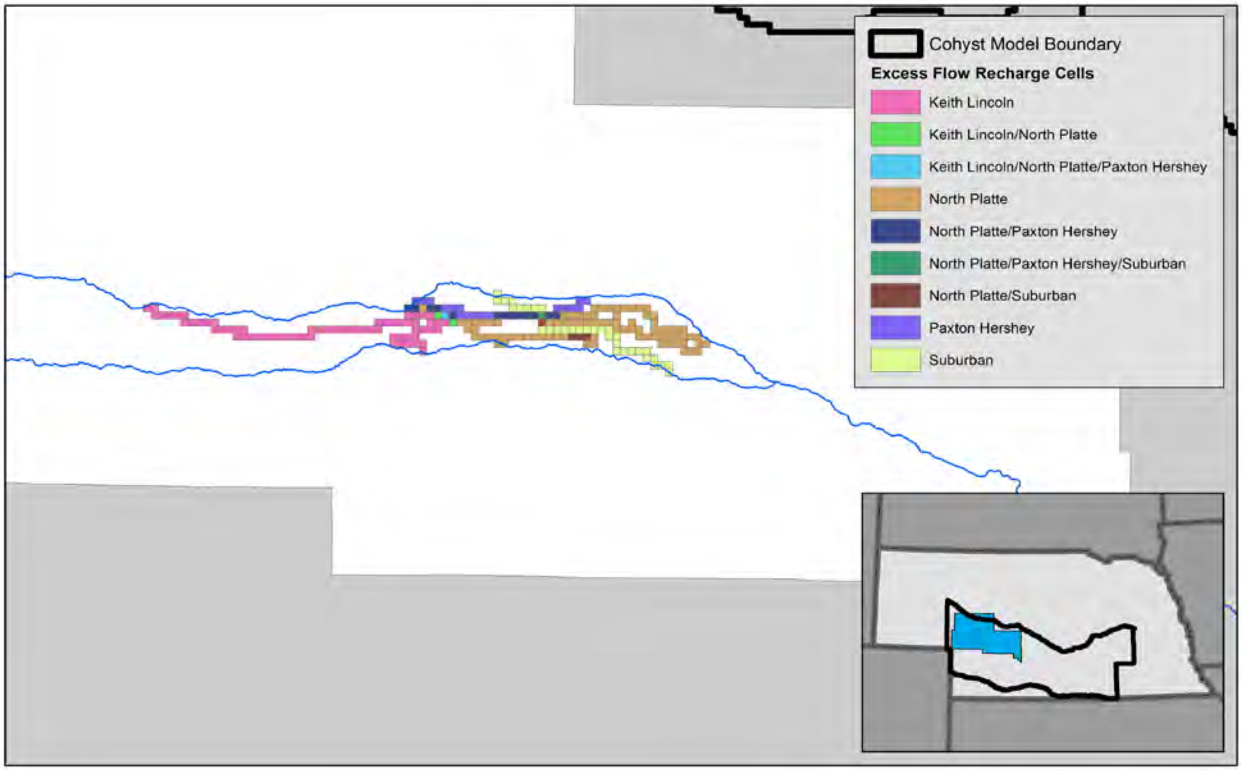


Figure 3. Model cell locations for the TPNRD excess flow recharge events within the COHYST model area.

Date	Belmont	Castle Rock	Central	Chimney Rock	Cozad	Dawson County	Enterprise	E65	Farmer’s	Gothenburg	Kearney	Keith Lincoln	Lisco	Minatare	Nine Mile	North Platte	Orchard-Alfalfa	Pathfinder	Paxton Hershey	Phelps	Suburban	Thirty Mile	Western	Winters Creek
1/1/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/2/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/3/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/4/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/5/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/6/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/7/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/8/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/9/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/10/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/11/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/12/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/13/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/14/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/15/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/16/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/17/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/18/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/19/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/20/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/21/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/22/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/23/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/24/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/25/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/26/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/27/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/28/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/29/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/30/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/31/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/1/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/2/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/3/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/4/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/5/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/6/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/7/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/8/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/9/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/10/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/11/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/12/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/13/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/14/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/15/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/16/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/17/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/18/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/19/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/20/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/21/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/22/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/23/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/24/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/25/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/26/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/27/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/28/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/1/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/2/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/3/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/4/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/5/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/6/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Date	Belmont	Castle Rock	Central	Chimney Rock	Cozad	Dawson County	Enterprise	E65	Farmer's	Gothenburg	Kearney	Keith Lincoln	Lisco	Minatare	Nine Mile	North Platte	Orchard-Alfalfa	Pathfinder	Paxton Hershey	Phelps	Suburban	Thirty Mile	Western	Winters Creek
3/7/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/8/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/9/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/10/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/11/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/12/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/13/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/14/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/15/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/16/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/17/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/18/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/19/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/20/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/21/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/22/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/23/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/24/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/25/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/26/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/27/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/28/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/29/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/30/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/31/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	99	0	0	0	0	0	0
4/1/2011	65	0	0	22	0	0	0	0	0	0	0	0	0	14	3.5	0	0	392	0	0	0	0	0	0
4/2/2011	56	0	0	17	0	0	0	0	0	0	0	0	0	12	8.2	0	0	404	0	0	0	0	0	0
4/3/2011	53	3	0	2.9	0	0	0	0	0	0	0	0	0	21	0.91	2.7	0	402	0	0	0	0	0	0
4/4/2011	43	0	0	7.6	0	0	51	0	0	0	0	0	0	48	0.98	64	0	400	7	0	24	0	0	0
4/5/2011	31	17	0	11	0	0	57	0	0	0	0	0	0	46	0	62	0	402	32	0	35	0	0	0
4/6/2011	22	30	2	13	0	0	49	0	480	0	0	0	0	43	0	40	0	433	32	0	29	0	0	0
4/7/2011	26	26	5.5	10	0	0	45	0	457	0	0	21	0	43	0	50	0	415	32	0	23	0	0	0
4/8/2011	39	28	14	8.7	0	0	45	0	414	0	0	35	0	44	0	55	0	404	32	0	25	0	0	0
4/9/2011	67	37	9.1	7.5	0	0	45	0	378	0	0	27	0	46	0	56	0	404	32	0	22	0	0	0
4/10/2011	39	28	4.3	7.7	0	0	45	0	378	0	0	31	0	44	0	58	0	402	32	0	22	0	80	0
4/11/2011	36	29	0	8.1	0	0	45	0	360	12	0	30	0	42	0	59	0	404	31	0	18	0	81	0
4/12/2011	34	29	0	8.1	0	0	44	0	339	95	0	28	0	43	0	55	0	404	30	0	18	0	80	0
4/13/2011	33	29	0	8.5	0	0	44	0	332	69	0	28	47	43	0	56	0	402	31	0	16	0	80	0
4/14/2011	32	29	0	9	0	0	44	0	332	59	0	28	46	43	2.2	52	0	431	17	0	18	0	84	0
4/15/2011	29	31	0	9.5	0	0	44	0	325	58	53	26	36	42	5.2	30	0	713	0	0	18	0	90	0
4/16/2011	26	22	0	9.7	0	0	44	0	323	58	102	28	33	41	13	0	0	0	0	0	11	0	95	0
4/17/2011	24	22	3.5	31	0	0	44	0	333	58	91	28	35	42	19	0	0	0	0	0	11	0	100	0
4/18/2011	24	23	5.8	20	28	30	44	0	338	68	88	28	39	43	20	0	1.6	0	0	0	11	0	101	0
4/19/2011	22	21	5.5	20	49	62	44	0	316	109	84	28	43	41	13	0	6.6	0	0	0	11	0	104	0
4/20/2011	17	15	6.5	22	49	64	44	0	287	102	106	28	43	39	15	8.3	6.3	0	0	0	7.4	0	100	0
4/21/2011	28	16	6.3	23	41	46	44	0	287	90	116	29	42	40	24	11	6.2	0	0	0	11	0	107	0
4/22/2011	43	17	7.8	20	29	35	45	0	291	91	119	30	37	43	20	18	8.2	0	5.9	0	15	46	102	0
4/23/2011	37	22	6.6	26	28	34	44	0	279	89	121	30	27	43	17	28	6.9	0	11	0	13	68	98	0
4/24/2011	32	24	9.6	29	28	34	44	0	278	89	120	30	25	45	16	27	5	0	14	0	11	68	102	0
4/25/2011	32	25	9.8	29	28	23	44	0	277	89	123	30	30	47	17	32	7.8	0	24	0	11	68	92	0
4/26/2011	31	28	9.7	29	28	23	44	0	279	89	121	30	39	49	16	50	9	0	25	0	14	69	76	0
4/27/2011	27	31	11	25	28	27	41	0	274	90	127	8.4	34	49	17	60	6.5	0	28	0	14	70	73	0
4/28/2011	29	26	11	19	28	26	38	0	274	89	86	18	34	46	24	61	5.4	0	28	0	13	71	88	0
4/29/2011	28	27	14	18	28	25	37	0	276	87	47	34	34	44	29	60	2	0	26	0	20	71	87	0
4/30/2011	25	29	17	17	28	24	37	0	268	84	46	0	33	43	30	65	0.99	0	25	0	25	70	66	0
5/1/2011	21	28	17	18	28	23	36	0	275	82	44	21	35	42	29	68	12	0	25	0	23	71	66	0
5/2/2011	26	27	18	17	28	23	35	0	267	84	41	26	38	41	29	68	20	0	25	0	23	71	67	0
5/3/2011	28	36	17	17	27	23	35	0	281	83	41	0	38	42	29	71	21	0	25	0	24	71	77	0
5/4/2011	34	43	2.9	0	27	23	0	0	289	83	41	0	38	44	29	73	21	0	25	0	24	71	74	0
5/5/2011	32	34	2.1	0	27	23	0	0	292	83	44	0	39	43	30	74	21	0	26	0	25	71	77	0
5/6/2011	35	39	2.1	0	27	23	0	0	284	84	43	0	39	0	31	71	21	0	26	0	25	71	81	0
5/7/2011	38	52	2.2	0	27	24	0	0	257	84	40	0	39	0	36	68	21	0	26	0	24	71	85	0
5/8/2011	36	54	6.1	0	27	47	0	0	267	84	38	0	39	0	35	73	21	0	27	0	30	71	89	0
5/9/2011	37	56	13	0	28	60	0	0	274	84	44	0	39	0	44	69	23	0	27	0	30	74	76	0
5/10/2011	34	59	13	0	27	64	0	0	0	85	46	0	39	0	44	64	23	0	27	0	28	75	76	0

Date	Belmont	Castle Rock	Central	Chimney Rock	Cozad	Dawson County	Enterprise	E65	Farmer’s	Gothenburg	Kearney	Keith Lincoln	Lisco	Minatare	Nine Mile	North Platte	Orchard-Alfalfa	Pathfinder	Paxton Hershey	Phelps	Suburban	Thirty Mile	Western	Winters Creek
5/11/2011	44	0	13	0	27	65	0	0	0	85	43	0	34	0	40	67	18	0	28	0	28	75	42	0
5/12/2011	0	0	14	0	27	71	0	0	0	86	39	0	43	0	39	75	6.5	0	28	0	29	76	29	0
5/13/2011	0	0	13	0	24	77	0	0	0	86	36	0	32	0	41	74	12	0	28	0	28	76	48	0
5/14/2011	0	0	12	0	19	78	0	0	0	84	34	0	41	0	45	73	18	0	28	0	28	75	43	0
5/15/2011	0	0	12	0	17	76	0	0	0	80	39	0	45	0	44	73	17	0	28	0	29	73	48	0
5/16/2011	0	0	13	0	17	71	0	0	0	83	0	0	35	0	43	73	18	0	29	0	29	76	68	0
5/17/2011	0	0	14	0	20	70	0	0	0	83	0	0	35	0	47	76	17	0	0	0	29	75	76	0
5/18/2011	0	0	14	0	22	70	0	0	0	84	0	13	42	0	38	79	17	0	0	0	30	76	53	0
5/19/2011	0	0	14	0	23	66	0	0	0	83	0	32	0	0	39	0	18	0	0	0	0	77	59	0
5/20/2011	0	0	13	0	0	63	0	0	0	0	0	40	0	0	35	0	19	0	0	0	0	77	72	0
5/21/2011	0	0	13	0	0	63	0	0	0	0	0	39	0	0	41	0	19	0	0	0	0	77	76	0
5/22/2011	0	0	13	0	0	75	0	0	0	0	0	25	0	0	41	0	19	0	0	0	0	77	88	0
5/23/2011	0	0	13	0	0	86	0	0	0	0	0	32	0	0	35	0	16	0	0	0	0	79	78	0
5/24/2011	0	0	12	0	0	108	0	0	0	0	0	37	0	0	0	0	0	0	0	0	0	80	74	0
5/25/2011	0	0	9.3	0	0	112	0	0	0	0	0	37	0	0	0	0	0	0	0	0	0	66	48	0
5/26/2011	0	0	12	0	0	103	0	0	0	0	0	38	0	0	0	0	0	0	0	0	0	53	65	0
5/27/2011	0	0	12	0	0	0	0	0	0	0	0	36	0	0	0	0	0	0	0	0	0	70	73	0
5/28/2011	0	0	12	0	0	0	0	0	0	0	0	37	0	0	0	0	0	0	0	0	0	71	64	0
5/29/2011	0	0	13	0	0	0	0	0	0	0	0	35	0	0	0	0	0	0	0	0	0	67	67	0
5/30/2011	0	0	14	0	0	0	0	0	0	0	0	34	0	0	0	0	0	0	0	0	0	66	75	0
5/31/2011	0	0	12	0	0	0	0	0	0	0	0	28	0	0	0	0	0	0	0	0	0	0	75	0
6/1/2011	0	0	12	0	0	0	0	0	0	0	0	27	0	0	0	0	0	0	0	0	0	0	57	0
6/2/2011	0	0	12	0	0	0	0	0	0	0	0	23	0	0	0	0	0	0	0	0	0	0	0	0
6/3/2011	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/4/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/5/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/6/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/7/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/8/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/9/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/10/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/11/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/12/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/13/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/14/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/15/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/16/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/17/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/18/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/19/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/20/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/21/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/22/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/23/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/24/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/25/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/26/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/27/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/28/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/29/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/30/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/1/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/2/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/3/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/4/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/5/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/6/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/7/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/8/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/9/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/10/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/11/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/12/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/13/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/14/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Date	Belmont	Castle Rock	Central	Chimney Rock	Cozad	Dawson County	Enterprise	E65	Farmer’s	Gothenburg	Kearney	Keith Lincoln	Lisco	Minatare	Nine Mile	North Platte	Orchard-Alfalfa	Pathfinder	Paxton Hershey	Phelps	Suburban	Thirty Mile	Western	Winters Creek
7/15/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/16/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/17/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/18/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/19/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/20/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/21/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/22/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/23/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/24/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/25/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/26/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/27/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/28/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/29/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/30/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/31/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/1/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/2/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/3/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/4/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/5/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/6/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/7/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/8/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/9/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/10/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/11/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/12/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/13/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/14/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/15/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/16/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/17/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/18/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/19/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/20/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/21/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/22/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/23/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/24/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/25/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/26/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/27/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/28/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/29/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/30/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/31/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/1/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	96	0	0
9/2/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	77	0	0
9/3/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	78	0	0
9/4/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	77	0	0
9/5/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	77	0	0
9/6/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	77	0	0
9/7/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	77	0	0
9/8/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	77	0	0
9/9/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	77	0	0
9/10/2011	0	0	0	0	0	74	0	0	0	88	0	0	0	0	0	0	0	0	0	0	0	78	0	0
9/11/2011	0	0	0	0	0	73	0	0	0	87	0	0	0	0	0	0	0	0	0	0	0	78	0	0
9/12/2011	0	0	0	0	0	72	0	0	0	87	0	0	0	0	0	0	26	0	0	0	0	78	0	0
9/13/2011	0	0	0	0	0	72	0	0	0	87	0	0	0	0	0	0	26	0	0	0	0	78	0	0
9/14/2011	0	0	0	0	0	70	0	0	0	87	0	0	0	0	0	0	26	0	0	0	0	80	0	0
9/15/2011	0	0	0	0	0	71	0	0	0	87	0	0	0	0	0	0	26	0	0	0	34	81	0	0
9/16/2011	0	0	0	0	29	61	0	0	0	86	0	0	0	0	0	0	26	0	0	0	31	81	0	0
9/17/2011	0	0	0	0	23	61	0	0	0	87	0	0	0	0	0	0	27	0	0	0	30	82	0	0

Date	Belmont	Castle Rock	Central	Chimney Rock	Cozad	Dawson County	Enterprise	E65	Farmer's	Gothenburg	Kearney	Keith Lincoln	Lisco	Minatare	Nine Mile	North Platte	Orchard-Alfalfa	Pathfinder	Paxton Hershey	Phelps	Suburban	Thirty Mile	Western	Winters Creek
9/18/2011	0	0	0	0	20	58	0	0	0	85	0	0	0	0	0	0	26	0	0	0	33	81	0	0
9/19/2011	0	0	0	0	20	56	0	0	0	84	0	0	0	0	0	0	24	0	33	0	30	81	0	0
9/20/2011	0	0	0	0	31	55	0	0	0	83	0	62	19	0	0	0	26	0	33	0	28	81	0	0
9/21/2011	0	0	0	0	37	54	0	0	0	83	0	54	29	0	0	0	28	0	33	0	28	81	92	0
9/22/2011	0	0	0	0	37	53	0	0	0	84	0	36	37	0	0	0	28	0	33	0	28	81	97	0
9/23/2011	0	0	0	0	37	52	0	0	0	87	0	29	49	0	0	17	28	0	33	0	28	81	103	0
9/24/2011	0	0	0	0	37	52	0	0	0	87	0	27	36	0	0	23	28	0	33	0	28	81	110	0
9/25/2011	0	0	0	0	37	52	0	0	0	87	0	27	27	0	0	30	28	0	33	0	28	81	106	0
9/26/2011	0	0	0	0	37	51	0	0	0	88	0	26	22	0	0	68	28	0	33	0	28	81	103	0
9/27/2011	37	0	0	0	29	50	0	0	0	88	0	26	34	0	0	67	28	0	33	0	28	81	110	0
9/28/2011	37	0	0	0	22	49	0	0	0	88	0	26	31	0	0	66	28	0	33	107.0245833	28	81	101	0
9/29/2011	36	0	0	0	23	48	0	0	0	88	0	26	33	0	0	63	27	0	33	130.7943552	28	80	80	0
9/30/2011	37	0	0	0	23	44	0	0	0	88	0	26	34	0	0	67	25	0	33	66.27578399	28	80	82	0
10/1/2011	34	0	14	0	23	44	0	0	0	89	0	26	40	49	0	69	23	0	33	55.71881339	28	79	87	0
10/2/2011	27	0	21	0	23	44	0	0	0	89	0	26	27	46	0	68	24	0	33	22.75661044	27	79	84	0
10/3/2011	30	0	19	0	25	44	0	0	0	89	0	15	32	48	0	67	26	0	33	21.96796914	27	33	86	0
10/4/2011	26	0	22	0	27	44	0	0	0	89	0	17	27	51	0	66	26	0	32	33.35316094	23	0	94	0
10/5/2011	27	39	19	0	27	42	0	0	0	86	0	26	14	52	0	65	25	0	34	31.1066026	18	0	91	0
10/6/2011	26	34	18	0	25	41	0	0	0	83	0	25	6.2	51	0	64	22	0	34	26.21892733	25	0	78	0
10/7/2011	29	29	17	0	23	40	0	0	0	82	0	25	25	52	0	65	19	0	33	27.76251847	25	0	82	8.7
10/8/2011	27	31	22	0	25	40	0	0	0	85	0	27	25	62	0	68	20	0	30	18.70105505	13	0	77	10
10/9/2011	32	29	17	0	25	40	0	0	0	83	0	27	30	60	0	66	22	0	33	16.50571029	17	0	78	11
10/10/2011	29	25	20	0	16	39	0	0	0	82	0	27	21	56	22	65	19	0	33	25.62372614	31	0	84	9.7
10/11/2011	26	22	20	0	0	39	0	0	0	82	0	27	9.9	54	18	68	17	0	32	29.49386531	28	0	86	8.1
10/12/2011	23	21	20	0	0	39	0	0	0	81	0	27	21	55	14	70	12	0	33	26.40047254	28	0	86	7.5
10/13/2011	27	19	20	0	0	17	0	0	0	52	0	27	27	54	10	80	0	0	35	25.9602625	28	0	89	7.7
10/14/2011	31	18	16	34	0	0	0	0	0	0	0	26	26	51	6.7	82	0	0	36	27.32035996	28	0	90	7.9
10/15/2011	29	16	16	32	0	0	0	0	0	0	0	26	25	49	16	82	0	0	36	30.30356712	28	0	90	7.6
10/16/2011	28	15	13	31	0	0	0	0	0	0	0	26	23	45	16	83	0	0	35	31.55053162	28	0	90	7.9
10/17/2011	27	14	10	30	0	0	0	0	0	0	0	25	20	41	16	82	0	0	35	32.14070129	21	0	90	7.7
10/18/2011	25	13	9.6	30	0	0	0	0	0	0	0	27	16	39	13	73	0	0	33	32.45730879	0	0	90	7.5
10/19/2011	22	12	8.6	29	0	0	0	0	0	0	0	27	16	35	12	71	0	0	31	31.60906005	0	0	90	7.5
10/20/2011	20	12	7.3	28	0	0	0	0	0	0	0	26	22	32	11	71	0	0	30	30.55971707	0	0	90	7.7
10/21/2011	19	11	6.3	27	0	0	0	0	0	0	0	27	21	27	10	71	0	0	29	30.10753279	0	0	90	7.5
10/22/2011	18	11	8.1	26	0	0	0	0	0	0	0	27	19	26	8.4	70	0	0	29	30.71397968	0	0	90	7.5
10/23/2011	19	10	9.3	25	0	0	0	0	0	0	0	26	4.9	23	5.6	70	0	0	15	31.29432116	0	0	90	7.1
10/24/2011	18	9.6	8.6	25	0	0	0	0	0	0	0	27	0	20	0.67	70	0	0	6.3	31.39295055	0	0	90	7.1
10/25/2011	17	9.2	7.9	25	0	0	0	0	0	0	0	27	0	18	0	71	0	0	6	31.81079293	0	0	90	6.6
10/26/2011	16	8.8	6.9	25	0	0	0	0	0	0	0	12	0	17	0	29	0	0	6.2	31.32254123	0	0	90	6.4
10/27/2011	16	8.6	6.9	25	0	0	0	0	0	0	0	12	0	17	0	0	0	0	6.2	31.03914659	0	0	90	9
10/28/2011	15	7.8	6.1	24	0	0	0	0	0	0	0	0	0	15	0	0	0	0	6.4	30.99669949	0	0	90	9
10/29/2011	14	7.4	4.2	23	0	0	0	0	0	0	0	0	0	14	0	0	0	0	6.4	31.01082991	0	0	90	9
10/30/2011	13	6.9	0	20	0	0	0	0	0	0	0	0	0	13	0	0	0	0	5.8	31.84057248	0	0	90	9
10/31/2011	13	6.6	0	20	0	0	0	0	0	0	0	0	0	12	0	0	0	0	3	32.69996217	0	0	90	9
11/1/2011	5	6.2	0	20	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	31.26940491	0	0	90	9
11/2/2011	0	6.3	0	24	0	0	0	0	0	0	0	0	0	3.9	0	0	0	0	0	29.26379644	0	0	90	9
11/3/2011	0	6.8	0	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29.61045523	0	0	90	9
11/4/2011	0	7.4	0	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	31.30914677	0	0	90	9
11/5/2011	0	8.1	0	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30.92692318	0	0	72	9
11/6/2011	0	8.8	0	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29.66091242	0	0	68	10
11/7/2011	0	9.5	0	23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29.4802135	0	0	65	10
11/8/2011	0	10	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29.21421057	0	0	63	0
11/9/2011	0	10	0	4.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29.04828308	0	0	62	0
11/10/2011	0	9.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28.77270441	0	0	58	0
11/11/2011	0	7.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28.82751547	0	0	55	0
11/12/2011	0	6.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28.74536424	0	0	40	0
11/13/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28.78684948	0	0	35	0
11/14/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28.69062646	0	0	12	0
11/15/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28.75901254	0	0	0	0
11/16/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28.81379455	0	0	0	0
11/17/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29.3674676	0	0	0	0
11/18/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29.06163742	0	0	0	0
11/19/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29.21435512	0	0	0	0
11/20/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29.14384701	0	0	0	0
11/21/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29.25569608	0	0	0	0

Date	Belmont	Castle Rock	Central	Chimney Rock	Cozad	Dawson County	Enterprise	E65	Farmer's	Gothenburg	Kearney	Keith Lincoln	Lisco	Minatare	Nine Mile	North Platte	Orchard-Alfalfa	Pathfinder	Paxton Hershey	Phelps	Suburban	Thirty Mile	Western	Winters Creek
11/22/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29.26976879	0	0	0	0
11/23/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29.17199244	0	0	0	0
11/24/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29.19977155	0	0	0	0
11/25/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	26.38807493	0	0	0	0
11/26/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25.49514785	0	0	0	0
11/27/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	26.31471992	0	0	0	0
11/28/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	27.1202245	0	0	0	0
11/29/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	32.22353539	0	0	0	0
11/30/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	30.19276729	0	0	0	0
12/1/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29.25784596	0	0	0	0
12/2/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29.00605042	0	0	0	0
12/3/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	26.26838394	0	0	0	0
12/4/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23.59863297	0	0	0	0
12/5/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22.65851702	0	0	0	0
12/6/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22.1829093	0	0	0	0
12/7/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24.44082576	0	0	0	0
12/8/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25.36887359	0	0	0	0
12/9/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23.73413124	0	0	0	0
12/10/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	27.15072983	0	0	0	0
12/11/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	27.41524308	0	0	0	0
12/12/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24.86557985	0	0	0	0
12/13/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24.59032798	0	0	0	0
12/14/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24.2423059	0	0	0	0
12/15/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20.82674941	0	0	0	0
12/16/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13.16926831	0	0	0	0
12/17/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12.98407558	0	0	0	0
12/18/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12.81960907	0	0	0	0
12/19/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12.36881778	0	0	0	0
12/20/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15.62049278	0	0	0	0
12/21/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17.91246182	0	0	0	0
12/22/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17.76136171	0	0	0	0
12/23/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17.8645644	0	0	0	0
12/24/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17.72761418	0	0	0	0
12/25/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17.46246447	0	0	0	0
12/26/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17.26676907	0	0	0	0
12/27/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17.17556774	0	0	0	0
12/28/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17.20950242	0	0	0	0
12/29/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17.27926976	0	0	0	0
12/30/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16.98344119	0	0	0	0
12/31/2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16.57826339	0	0	0	0

Date	Belmont	Castle Rock	Central	Chimney Rock	Cozad	Dawson County	Enterprise	E65	Farmer’s	Gothenburg	Kearney	Keith Lincoln	Lisco	Minatare	Nine Mile	North Platte	Orchard-Alfalfa	Pathfinder	Paxton Hershey	Phelps	Suburban	Thirty Mile	Western	Winters Creek
1/1/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16.46557587	0	0	0	0
1/2/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16.49902963	0	0	0	0
1/3/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16.33391967	0	0	0	0
1/4/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14.11774274	0	0	0	0
1/5/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6.556257488	0	0	0	0
1/6/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/7/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/8/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/9/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/10/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/11/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/12/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/13/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/14/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/15/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/16/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/17/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/18/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/19/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/20/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/21/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/22/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/23/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/24/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/25/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/26/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/27/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/28/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/29/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/30/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/31/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/1/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/2/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/3/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/4/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/5/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/6/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/7/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/8/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/9/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/10/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/11/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/12/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/13/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/14/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/15/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/16/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/17/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/18/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/19/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/20/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/21/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/22/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/23/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/24/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/25/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/26/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/27/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/28/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/29/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/1/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/2/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/3/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/4/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/5/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Date	Belmont	Castle Rock	Central	Chimney Rock	Cozad	Dawson County	Enterprise	E65	Farmer’s	Gothenburg	Kearney	Keith Lincoln	Lisco	Minatare	Nine Mile	North Platte	Orchard-Alfalfa	Pathfinder	Paxton Hershey	Phelps	Suburban	Thirty Mile	Western	Winters Creek
3/6/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/7/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/8/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/9/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/10/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/11/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/12/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/13/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/14/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/15/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/16/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/17/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/18/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7.2	0	0	0	0	0	0	0
3/19/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0
3/20/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7.9	0	0	0	0	0	0	0
3/21/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7.7	0	0	0	0	0	0	0
3/22/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8.5	0	0	0	0	0	0	0
3/23/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/24/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/25/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/26/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/27/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/28/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/29/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/30/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/31/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/1/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/2/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/3/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/4/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/5/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/6/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/7/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/8/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/9/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/10/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/11/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/12/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/13/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/14/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/15/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/16/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/17/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/18/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/19/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/20/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/21/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/22/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/23/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/24/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/25/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/26/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/27/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/28/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/29/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/30/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/1/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/2/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/3/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/4/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/5/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/6/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/7/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/8/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/9/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Date	Belmont	Castle Rock	Central	Chimney Rock	Cozad	Dawson County	Enterprise	E65	Farmer's	Gothenburg	Kearney	Keith Lincoln	Lisco	Minatare	Nine Mile	North Platte	Orchard-Alfalfa	Pathfinder	Paxton Hershey	Phelps	Suburban	Thirty Mile	Western	Winters Creek
5/10/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/11/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/12/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/13/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/14/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/15/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/16/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/17/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/18/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/19/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/20/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/21/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/22/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/23/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/24/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/25/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/26/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/27/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/28/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/29/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/30/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/31/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/1/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/2/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/3/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/4/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/5/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/6/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/7/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/8/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/9/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/10/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/11/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/12/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/13/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/14/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/15/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/16/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/17/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/18/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/19/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/20/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/21/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/22/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/23/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/24/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/25/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/26/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/27/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/28/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/29/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/30/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/1/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/2/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/3/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/4/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/5/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/6/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/7/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/8/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/9/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/10/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/11/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/12/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/13/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Date	Belmont	Castle Rock	Central	Chimney Rock	Cozad	Dawson County	Enterprise	E65	Farmer's	Gothenburg	Kearney	Keith Lincoln	Lisco	Minatare	Nine Mile	North Platte	Orchard-Alfalfa	Pathfinder	Paxton Hershey	Phelps	Suburban	Thirty Mile	Western	Winters Creek
7/14/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/15/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/16/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/17/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/18/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/19/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/20/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/21/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/22/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/23/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/24/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/25/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/26/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/27/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/28/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/29/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/30/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/31/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/1/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/2/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/3/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/4/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/5/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/6/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/7/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/8/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/9/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/10/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/11/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/12/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/13/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/14/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/15/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/16/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/17/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/18/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/19/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/20/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/21/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/22/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/23/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/24/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/25/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/26/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/27/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/28/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/29/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/30/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/31/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/1/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/2/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/3/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/4/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/5/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/6/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/7/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/8/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/9/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/10/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/11/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/12/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/13/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/14/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/15/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/16/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Date	Belmont	Castle Rock	Central	Chimney Rock	Cozad	Dawson County	Enterprise	E65	Farmer’s	Gothenburg	Kearney	Keith Lincoln	Lisco	Minatare	Nine Mile	North Platte	Orchard-Alfalfa	Pathfinder	Paxton Hershey	Phelps	Suburban	Thirty Mile	Western	Winters Creek
9/17/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/18/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/19/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/20/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/21/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/22/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/23/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/24/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/25/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/26/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/27/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/28/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/29/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/30/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/1/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/2/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/3/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/4/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/5/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/6/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/7/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/8/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/9/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/10/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/11/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/12/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/13/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/14/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/15/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/16/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/17/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/18/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/19/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/20/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/21/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/22/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/23/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/24/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/25/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/26/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/27/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/28/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/29/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/30/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/31/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/1/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/2/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/3/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/4/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/5/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/6/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/7/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/8/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/9/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/10/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/11/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/12/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/13/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/14/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/15/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/16/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/17/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/18/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/19/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/20/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Date	Belmont	Castle Rock	Central	Chimney Rock	Cozad	Dawson County	Enterprise	E65	Farmer’s	Gothenburg	Kearney	Keith Lincoln	Lisco	Minatare	Nine Mile	North Platte	Orchard-Alfalfa	Pathfinder	Paxton Hershey	Phelps	Suburban	Thirty Mile	Western	Winters Creek
11/21/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/22/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/23/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/24/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/25/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/26/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/27/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/28/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/29/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/30/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/1/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/2/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/3/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/4/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/5/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/6/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/7/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/8/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/9/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/10/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/11/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/12/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/13/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/14/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/15/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/16/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/17/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/18/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/19/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/20/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/21/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/22/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/23/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/24/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/25/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/26/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/27/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/28/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/29/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/30/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/31/2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

POAC_2011_2013.xlsx

Date	Belmont	Castle Rock	Central	Chimney Rock	Cozad	Dawson County	Enterprise	E65	Farmer's	Gothenburg	Kearney	Keith Lincoln	Lisco	Minatare	Nine Mile	North Platte	Orchard-Alfalfa	Pathfinder	Paxton Hershey	Phelps	Suburban	Thirty Mile	Western	Winters Creek
1/1/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/2/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/3/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/4/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/5/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/6/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/7/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/8/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/9/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/10/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/11/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/12/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/13/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/14/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/15/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/16/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/17/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/18/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/19/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/20/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/21/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/22/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/23/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/24/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/25/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/26/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/27/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/28/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/29/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/30/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1/31/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/1/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/2/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/3/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/4/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/5/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/6/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/7/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/8/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/9/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/10/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/11/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/12/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/13/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/14/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/15/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/16/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/17/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/18/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/19/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/20/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/21/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/22/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/23/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/24/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/25/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/26/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/27/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2/28/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/1/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/2/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/3/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/4/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/5/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Date	Belmont	Castle Rock	Central	Chimney Rock	Cozad	Dawson County	Enterprise	E65	Farmer’s	Gothenburg	Kearney	Keith Lincoln	Lisco	Minatare	Nine Mile	North Platte	Orchard-Alfalfa	Pathfinder	Paxton Hershey	Phelps	Suburban	Thirty Mile	Western	Winters Creek
3/6/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/7/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/8/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/9/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/10/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/11/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/12/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/13/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/14/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/15/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/16/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/17/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/18/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/19/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/20/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/21/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/22/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/23/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/24/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/25/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/26/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/27/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/28/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/29/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/30/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3/31/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/1/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/2/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/3/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/4/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/5/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/6/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/7/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/8/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/9/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/10/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/11/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/12/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/13/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/14/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/15/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/16/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/17/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/18/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/19/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/20/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/21/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/22/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/23/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/24/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/25/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/26/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/27/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/28/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/29/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4/30/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/1/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/2/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/3/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/4/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/5/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/6/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/7/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/8/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Date	Belmont	Castle Rock	Central	Chimney Rock	Cozad	Dawson County	Enterprise	E65	Farmer’s	Gothenburg	Kearney	Keith Lincoln	Lisco	Minatare	Nine Mile	North Platte	Orchard-Alfalfa	Pathfinder	Paxton Hershey	Phelps	Suburban	Thirty Mile	Western	Winters Creek
5/9/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/10/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/11/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/12/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/13/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/14/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/15/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/16/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/17/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/18/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/19/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/20/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/21/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/22/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/23/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/24/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/25/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/26/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/27/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/28/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/29/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/30/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5/31/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/1/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/2/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/3/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/4/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/5/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/6/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/7/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/8/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/9/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/10/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/11/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/12/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/13/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/14/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/15/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/16/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/17/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/18/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/19/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/20/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/21/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/22/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/23/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/24/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/25/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/26/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/27/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/28/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/29/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6/30/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/1/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/2/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/3/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/4/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/5/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/6/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/7/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/8/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/9/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/10/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/11/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Date	Belmont	Castle Rock	Central	Chimney Rock	Cozad	Dawson County	Enterprise	E65	Farmer's	Gothenburg	Kearney	Keith Lincoln	Lisco	Minatare	Nine Mile	North Platte	Orchard-Alfalfa	Pathfinder	Paxton Hershey	Phelps	Suburban	Thirty Mile	Western	Winters Creek
7/12/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/13/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/14/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/15/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/16/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/17/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/18/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/19/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/20/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/21/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/22/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/23/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/24/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/25/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/26/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/27/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/28/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/29/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/30/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7/31/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/1/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/2/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/3/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/4/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/5/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/6/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/7/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/8/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/9/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/10/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/11/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/12/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/13/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/14/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/15/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/16/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/17/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/18/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/19/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/20/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/21/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/22/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/23/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/24/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/25/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/26/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/27/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/28/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/29/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/30/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8/31/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/1/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/2/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/3/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/4/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/5/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/6/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/7/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/8/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/9/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/10/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/11/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/12/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/13/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Date	Belmont	Castle Rock	Central	Chimney Rock	Cozad	Dawson County	Enterprise	E65	Farmer's	Gothenburg	Kearney	Keith Lincoln	Lisco	Minatare	Nine Mile	North Platte	Orchard-Alfalfa	Pathfinder	Paxton Hershey	Phelps	Suburban	Thirty Mile	Western	Winters Creek
9/14/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/15/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9/16/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	64	0	0	43	0	0	0	0	0
9/17/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	64	0	0	42	0	0	0	0	0
9/18/2013	0	0	0	0	0	0	0	0	0	3.8	0	0	0	0	0	64	0	0	40	0	0	0	137	0
9/19/2013	0	0	0	0	0	0	0	0	0	3.7	0	0	0	0	0	67	0	0	43	0	0	0	192	0
9/20/2013	0	0	0	0	0	0	0	51	0	3.7	0	0	0	0	0	81	0	0	43	485	0	0	202	0
9/21/2013	0	0	0	0	0	0	0	68	0	3.3	0	0	0	0	0	88	0	0	34	109	0	0	184	0
9/22/2013	0	0	0	0	0	0	0	92	0	17	0	0	0	0	0	86	0	0	31	36	0	203.305675	143	0
9/23/2013	0	0	0	0	0	70	0	84	0	106	0	0	0	0	0	87	0	0	34	36	0	247.93375	99	0
9/24/2013	0	0	0	0	0	72	0	54	0	104	0	0	0	0	0	89	0	0	39	36	0	225.6197125	62	0
9/25/2013	0	0	0	0	0	69	0	52	0	98	0	0	0	0	0	88	0	0	35	36	0	230.5783875	61	0
9/26/2013	0	0	0	0	0	59	0	52	0	91	0	0	0	0	0	85	0	0	30	36	0	203.305675	45	0
9/27/2013	0	0	0	0	0	56	0	85	0	87	0	0	0	0	0	76	0	0	38	36	0	195.8676625	49	0
9/28/2013	0	0	0	0	0	52	0	33	0	85	0	0	0	0	0	68	0	0	44	36	0	190.9089875	43	0
9/29/2013	0	0	0	0	0	48	0	53	0	72	0	0	0	0	0	67	0	0	34	36	0	180.9916375	18	0
9/30/2013	0	0	0	0	0	44	0	52	0	72	0	0	0	0	0	66	0	0	33	36	0	183.470975	43	0
10/1/2013	0	0	0	0	0	40	0	51	0	79	0	0	0	0	0	70	0	0	38	36	0	205.7850125	49	0
10/2/2013	0	0	0	0	0	44	0	56	0	73	0	0	0	0	0	71	0	0	40	36	0	198.347	48	0
10/3/2013	0	0	0	0	0	63	0	58	0	79	0	0	0	0	0	76	0	0	37	36	0	190.9089875	56	0
10/4/2013	0	0	0	0	0	0	0	57	0	62	0	0	0	0	0	74	0	0	34	36	0	195.8676625	45	0
10/5/2013	0	0	0	0	0	55	0	55	0	43	0	0	0	0	0	72	0	0	31	36	0	183.470975	50	0
10/6/2013	0	0	0	0	0	41	0	50	0	24	0	0	0	0	0	71	0	0	28	36	0	190.9089875	48	0
10/7/2013	0	0	0	0	0	34	0	45	0	11	0	0	0	0	0	64	0	0	28	36	0	171.0742875	43	0
10/8/2013	0	0	0	0	0	10	0	37	0	6	0	0	0	0	0	53	0	0	28	36	0	158.6776	41	0
10/9/2013	0	0	0	0	0	0	0	43	0	0	0	0	0	0	0	44	0	0	27	36	0	133.884225	47	0
10/10/2013	0	0	0	0	0	0	0	43	0	0	0	0	0	0	0	27	0	0	29	36	0	74.380125	62	0
10/11/2013	0	0	0	0	0	0	0	37	0	0	0	0	0	0	0	3.8	0	0	14	36	0	32.2313875	49	0
10/12/2013	0	0	0	0	0	0	0	34	0	0	0	0	0	0	0	3.6	0	0	0	36	0	0	44	0
10/13/2013	0	0	0	0	0	0	0	37	0	0	0	0	0	0	0	0	0	0	0	36	0	0	35	0
10/14/2013	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	36	0	0	39	0
10/15/2013	0	0	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	0	2.2	36	0	0	58	0
10/16/2013	0	0	0	0	0	0	0	14	0	0	0	0	0	0	0	0	0	0	0	36	0	0	55	0
10/17/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	36	0	0	50	0
10/18/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	36	0	0	45	0
10/19/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	36	0	0	49	0
10/20/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	36	0	0	53	0
10/21/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	36	0	0	22	0
10/22/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29	0	0	0	0
10/23/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	34	0	0	39	0
10/24/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28	0	0	61	0
10/25/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	26	0	0	40	0
10/26/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28	0	0	19	0
10/27/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29	0	0	1.6	0
10/28/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	32	0	0	0	0
10/29/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/30/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10/31/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/1/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/2/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/3/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/4/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/5/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/6/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/7/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/8/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/9/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/10/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/11/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/12/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/13/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/14/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/15/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/16/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Date	Belmont	Castle Rock	Central	Chimney Rock	Cozad	Dawson County	Enterprise	E65	Farmer’s	Gothenburg	Kearney	Keith Lincoln	Lisco	Minatare	Nine Mile	North Platte	Orchard-Alfalfa	Pathfinder	Paxton Hershey	Phelps	Suburban	Thirty Mile	Western	Winters Creek
11/17/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/18/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/19/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/20/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/21/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/22/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/23/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/24/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/25/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/26/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/27/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/28/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/29/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11/30/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/1/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/2/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/3/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/4/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/5/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/6/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/7/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/8/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/9/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/10/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/11/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/12/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/13/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/14/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/15/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/16/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/17/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/18/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/19/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/20/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/21/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/22/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/23/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/24/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/25/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/26/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/27/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/28/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/29/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/30/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12/31/2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

A.1.8 Memorandum October 2018 Update: Post 97 Analysis WWUMM

Memorandum

To:	Kari Burgert, DNR
From:	The Flatwater Group, Inc.
Subject:	October 2018 Update: Post 97 Analysis – Western Water Use Model (WWUM) Area
Update:	10/11/2018

A. Introduction

The Flatwater Group, Inc. (TFG) was tasked by the Nebraska Department of Natural Resources (DNR) with developing recharge and pumping files (.RCH and .WEL files, respectively) for several Post 97 Analysis scenarios in the WWUM area. Section B of this memorandum describes the setup of the model TFG used to develop these files. TFG's task originally consisted of developing 7 simulation runs which were divided into two groups based upon assumed future (scenario years 2014-2063) climate conditions:

Group 1: 50-year projection by repeating a 25-year historical period (1989-2013) twice; and
Group 2: 50-year projection by repeating a five-year historical period (2009-2013) ten times.

Section C describes the inputs for the Group 1 model runs and is organized as follows:

C1. Baseline Scenario
C2. No Groundwater Only Pumping Scenario
C3. Post 97 Development Rollback Scenario

Section D describes the inputs for the Group 2 model runs and is organized as follows:

D1. Metered Baseline Scenario
D2. Metered Baseline Scenario: No Groundwater Only Pumping Scenario
D3. Metered Baseline Scenario: Simulated Groundwater Pumping Scenario
D4. Metered Baseline Scenario: Post 97 Development Rollback Scenario

TFG's task was updated in October 2018 to develop files (.RCH and .WEL files) for seven additional runs based on the Group 2 (Section D) model setup. For these runs, revised canal recharge and municipal and industrial (M&I) pumping information was used; and is described in section E.

Section F describes the inputs for each of the seven additional runs and is organized as follows:

F1_a. Metered Baseline Scenario with updated canal recharge and M&I pumping
F1_b. Metered Baseline Scenario without canal recharge or M&I pumping
F2_a. Metered Baseline Scenario: No Groundwater Pumping with updated canal recharge and no M&I Pumping
F2_b. Metered Baseline Scenario: No Groundwater Pumping without canal recharge or M&I pumping
F3_a. Metered Baseline Scenario: Post 97 Rollback Scenario with updated canal recharge and 1997 level of M&I pumping
F3_b. Metered Baseline Scenario: Post 97 Rollback Scenario with updated canal recharge and historic levels of M&I pumping

F3_c. Metered Baseline Scenario: Post 97 Rollback Scenario without canal recharge or M&I pumping

B. Model Setup[1]

The watershed model utilized for DNR's Post 97 analysis was based upon the historically calibrated Western Water Use Model (WWUM). Inputs were incorporated from the results of the Historically Calibrated Model (Run028) and the Conservation Study's Baseline (Base001). Several modifications were necessary to implement the scenarios through the watershed model. All scenario changes were made to region 1 of the WWUM. Regions 2-6 remained consistent with the Historically Calibrated Model and did not vary from scenario to scenario.

B1. Climate

The climate inputs for the watershed model remained consistent with the Historically Calibrated Model's inputs.

B2. Land Use

The Post 97 analysis converted from a parcel and cell-based approach, to strictly a cell-based approach. This methodology was chosen to simplify the manipulation of the data sets used for the scenarios. This required three different land use data sets.

1) Baseline Data Set (LU004)
The baseline data set was acquired directly from the Historically Calibrated Model. No modifications were made.

2) No Groundwater Only Pumping Data Set (LU004_ngwp)
The No Groundwater Only Pumping data set was developed by making alterations to the Baseline Data Set. All groundwater only irrigated lands were converted to dryland cropping maintaining the crop mix.

3) Restrict Post 97 Groundwater Only Irrigated Land Development Data Set (LU004_p97)
The Post 97 data set was developed by making alterations to the Baseline Data Set. For the years 1953 through 1997 the land use remained constant. Between 1998 and 2013 surface water only and comingled lands were developed as seen in the Baseline Data Set, while groundwater only irrigated lands were kept at 1997 levels. The balance of the acres within a cell were handled one of three ways:

   - If the number of irrigated acres[2] in the cell exceeded 40.0 acres, the excess acres remained in the model and the dryland acres were set to 0.0. The annual total of excess acres never exceeded 1,000 acres and was typically less than 125 per year.
   - If the irrigated acres were less than 40.0 acres, but the irrigated acres plus the dry acres were greater than 40.0 acres; acres were removed from the dryland crops until the total number of acres was equal to 40.0[3].

[1] All alterations to the land use occurred strictly in WWUM region 1.
[2] Irrigated acres are defined as the total of the land use file year's surface water only and comingled irrigated acres plus the 1997 groundwater only irrigated acres.
[3] The removal process proceeded in order from crop 1 to crop 12.

- If the irrigated acres plus the dryland acres was less than 40.0 acres, the balance was added as dryland corn.

B3. Irrigation Estimates

Typically, in the WWUM, the irrigation volumes applied within a cell are first determined on a parcel basis then divided among the cells which the parcel overlays. At the same time, an application efficiency for the cell is determined weighted, according to the volume applied by either sprinklers or flood irrigation. The migration from the parcel-based approach to the cell-based approach yields the need to develop a new way to initialize the volume of applied water. This method will be described for each scenario and replaces the 'Parcel_Pump_wSWdel' program in the RSWB.

The irrigation estimates were copied from either the Conservation Study baseline or the Calibrated Historical model. The conservation study represents a scenario where all irrigation volumes are simulated to meet a target NIR. Furthermore, methodology between determining the irrigation split on comingled lands consistently uses the 'mutual ditch' across all canals.

The irrigation volumes in the Calibrated Historical model include diversion records and metered pumping supplemented by simulated volumes based on a target NIR. Additionally, the surface water canals in the area use different methodology to determine the irrigation split on comingled lands; incorporating either a 'mutual ditch' or a 'maximum supply' approach.

Simulated irrigation volumes use one of two sets of NIR values. Set 1 is based on 95% of the CROPSIM predicted NIR. Set 2 is based on 95% of the CROPSIM predicted NIR for all crops except Alfalfa, Small Spring Grains, and Irrigated Pasture which are set at 80% of the CROPSIM predicted NIR.

B4. Virtual Pumping in the '.WEL' file

Another by-product of migrating from the parcel based approach was the removal of the link between the cell on which the pumping was applied and the certificate and well from which it was pumped. Rather, for all runs in this analysis a 'virtual pumping' technique was used in which pumping was extracted from the cell it was applied.

B5. Call Year Routine

A call year routine was initiated in each program of the RSWB to allow for the projection of the model results into a period of time where no input files exist. The call year file was able to control the land use, climate, application efficiency, canal recharge, miscellaneous pumping and recharge, and municipal and industrial pumping which was included in the simulation years results.

B6. Canal Recharge, Miscellaneous Pumping and Recharge, Municipal and Industrial pumping

Canal recharge was obtained from the conservation study's baseline inputs. Two canal recharge data sets were used; the baseline NPNRD data set and the Western Canal and Pumpkin Creek data set. For the model projected simulation years, the canal recharge annual file from the simulated climate year was used. For example, in 2063 climate from 2013 was used; therefore, canal recharge values from 2013 were also used.

Miscellaneous pumping and recharge was obtained from the datasets used to create the Calibrated Historical Model. These datasets included UNW_Run012, WCOHYST_Run025, Western_002, Colorado002, and Wyoming002 for regions 2-6. The miscellaneous pumping and recharge files matched the representative year for the simulated climate. For example, in 2063 the climate is represented by

2013; however, there is no 2013 data for the Region 4, rather it is copied from 2010. Therefore, 2010 data for region 4 will be included in the results for 2063.[4]

There is no municipal and industrial pumping included in any scenarios.

[4] The projected years used the same canal recharge and miscellaneous inputs as the as the climate year used to represent projected year. This information is defined in the WWUM watershed model documentation.

C. Post 97 Scenarios with 25 Year Period Projected Twice

The following description defines the changes made to the model. Each scenario is implemented in Region 1 then combined with the pumping and recharge from UNW_Run012, WCOHYST_Run025, Colorado002, Western002, and Wyoming002; and the canal recharge from Base001 and WPC001 to create the '.WEL' and '.RCH' file for inclusion in the groundwater model.

C1. Baseline Scenario (1953-2063) (Baseline001)

Deliverable: WWUM_p97_Baseline001.zip
Date: 10/24/2017

Simulated Period (1953-2013)

Climate:	1953-2013
Land use:	Baseline Data Set
Surface Water Deliveries:	Copied from the conservation study's baseline scenario
Comingled Pumping:	Copied from the conservation study's baseline scenario
Groundwater Pumping:	Simulated to meet a target NIR
NIR Set:	2
Application Efficiency:	Copied from the conservation study's baseline scenario
Canal Recharge:	Yes
M&I Pumping:	No
Miscellaneous Pumping:	Yes
Miscellaneous Recharge:	Yes

Simulated Period (2014-2063)

Climate:	1989-2013 repeated twice
Land use:	Baseline Data Set: year 2013
Surface Water Deliveries:	Simulated to meet a target NIR
NIR Set:	1
Comingled Pumping:	Simulated to meet a target NIR
NIR Set:	1
Comingled Split:	85%[5] surface water 15% groundwater
Groundwater Pumping:	Simulated to meet a target NIR
NIR Set:	2
Application Efficiency:	Copied from the conservation study's baseline scenario's year 2013
Canal Recharge:	Yes – match simulated climate year
M&I Pumping:	No
Miscellaneous Pumping:	Yes – match simulated climate year
Miscellaneous Recharge:	Yes – match simulated climate year

[5] The conservation study's baseline had an average split of 85%-15% on comingled irrigation 1989-2013.

C2. No Groundwater Only Pumping Scenario (1953-2063) (NGWP_001)
Deliverable: WWUM_p97_NGWP_001_20171026.zip
Date: 10/26/2017

Simulated Period (1953-2013)

Climate:	1953-2013
Land use:	No Groundwater Only Pumping Data Set
Surface Water Deliveries:	Copied from the conservation study's baseline scenario
Comingled Pumping:	Copied from the conservation study's baseline scenario
Groundwater Pumping:	None
Application Efficiency:	Copied from the conservation study's baseline scenario
Canal Recharge:	Yes
M&I Pumping:	No
Miscellaneous Pumping:	Yes
Miscellaneous Recharge:	Yes

Simulated Period (2014-2063)

Climate:	1989-2013 repeated twice
Land use:	No Groundwater Only Pumping Data Set: year 2013
Surface Water Deliveries:	Simulated to meet a target NIR
NIR Set:	1
Comingled Pumping:	Simulated to meet a target NIR
NIR Set:	1
Comingled Split:	85% surface water 15% groundwater
Groundwater Pumping:	None
Application Efficiency:	Copied from the conservation study's baseline scenario's year 2013
Canal Recharge:	Yes – match simulated climate year
M&I Pumping:	No
Miscellaneous Pumping:	Yes – match simulated climate year
Miscellaneous Recharge:	Yes – match simulated climate year

C3. Post 97 Development Rollback Scenario (p97_001)

Deliverable: WWUM_p97_p97_001_20171025.zip
Date: 10/25/2017

Simulated Period (1953-2013)

Climate:	1953-2013
Land use:	Restrict Post 97 Groundwater Only Irrigated Land Development Data Set
Surface Water Deliveries:	Copied from the conservation study's baseline scenario
Comingled Pumping:	Copied from the conservation study's baseline scenario
Groundwater Pumping:	Simulated to meet a target NIR
NIR Set:	2
Application Efficiency:	Copied from the conservation study's baseline scenario
Canal Recharge:	Yes
M&I Pumping:	No
Miscellaneous Pumping:	Yes
Miscellaneous Recharge:	Yes

Simulated Period (2014-2063)

Climate:	1989-2013 repeated twice
Land use:	Restrict Post 97 Groundwater Only Irrigated Land Development Data Set: year 2013
Surface Water Deliveries:	Simulated to meet a target NIR
NIR Set:	1
Comingled Pumping:	Simulated to meet a target NIR
NIR Set:	1
Comingled Split:	85% surface water 15% groundwater
Groundwater Pumping:	Simulated to meet a target NIR
NIR Set:	2
Application Efficiency:	Copied from the conservation study's baseline scenario's year 2013
Canal Recharge:	Yes – match simulated climate year
M&I Pumping:	No
Miscellaneous Pumping:	Yes – match simulated climate year
Miscellaneous Recharge:	Yes – match simulated climate year

D. Post 97 Scenarios with 5 Year Period Projected 10 times

The following description defines the changes made to the model. Each scenario is implemented in Region 1 then combined with the pumping and recharge from UNW_Run012, WCOHYST_Run025, Colorado002, Western002, and Wyoming002; and the canal recharge from Base001 and WPC001 to create the '.WEL' and '.RCH' file for inclusion in the groundwater model.

D1. Metered Baseline Scenario (1953-2063) (HistBase_001)
Deliverable: WWUM_p97_HistBase_001_20171030.zip
Date: 10/30/2017

Simulated Period (1953-2013)

Climate:	1953-2013
Land use:	Baseline Data Set
Surface Water Deliveries:	Copied from the Calibrated Historical Model
Comingled Pumping:	Copied from the Calibrated Historical Model
Groundwater Pumping:	Copied from the Calibrated Historical Model
Application Efficiency:	Copied from the Calibrated Historical Model
Canal Recharge:	Yes
M&I Pumping:	No
Miscellaneous Pumping:	Yes
Miscellaneous Recharge:	Yes

Simulated Period (2014-2063)

Climate:	2009-2013 repeated ten times
Land use:	Baseline Data Set; matches simulated climate year
Surface Water Deliveries:	Copied from the Calibrated Historical Model to match simulated climate year
Comingled Pumping:	Copied from the Calibrated Historical Model to match simulated climate year
Groundwater Pumping:	Copied from the Calibrated Historical Model to match simulated climate year
Application Efficiency:	Copied from the Calibrated Historical Model to match simulated climate year
Canal Recharge:	Yes – match simulated climate year
M&I Pumping:	No
Miscellaneous Pumping:	Yes – match simulated climate year
Miscellaneous Recharge:	Yes – match simulated climate year

D2. Metered Baseline Scenario: No Groundwater Pumping (1953-2063) (Histngwp_001)
Deliverable: WWUM_p97_Histngwp_001_20171030.zip
Date: 10/30/2017

Simulated Period (1953-2013)

Climate:	1953-2013
Land use:	Baseline Data Set
Surface Water Deliveries:	Copied from the Calibrated Historical Model
Comingled Pumping:	Copied from the Calibrated Historical Model
Groundwater Pumping:	None
Application Efficiency:	Copied from the Calibrated Historical Model
Canal Recharge:	Yes
M&I Pumping:	No
Miscellaneous Pumping:	Yes
Miscellaneous Recharge:	Yes

Simulated Period (2014-2063)

Climate:	2009-2013 repeated ten times
Land use:	Baseline Data Set; matches simulated climate year
Surface Water Deliveries:	Copied from the Calibrated Historical Model to match simulated climate year
Comingled Pumping:	Copied from the Calibrated Historical Model to match simulated climate year
Groundwater Pumping:	None
Application Efficiency:	Copied from the Calibrated Historical Model to match simulated climate year
Canal Recharge:	Yes – match simulated climate year
M&I Pumping:	No
Miscellaneous Pumping:	Yes – match simulated climate year
Miscellaneous Recharge:	Yes – match simulated climate year

D3. Metered Baseline Scenario: Simulated Groundwater Pumping (1953-2063) (HistNIR_002)
Deliverable: WWUM_p97_HistNIR_002_20171208.zip
Date: 12/8/2017

Simulation Period (1953-2006)

Climate:	1953-2006
Land use:	Baseline Data Set
Surface Water Deliveries:	Copied from the Calibrated Historical Model
Comingled Pumping:	Copied from the Calibrated Historical Model
Groundwater Pumping:	Copied from the Calibrated Historical Model[6]
Application Efficiency:	Copied from the Calibrated Historical Model
Canal Recharge:	Yes
M&I Pumping:	No
Miscellaneous Pumping:	Yes
Miscellaneous Recharge:	Yes

Simulation Period (2007-2013)

Climate:	2007-2013
Land use:	Baseline Data Set
Surface Water Deliveries:	Copied from the Calibrated Historical Model
Comingled Pumping:	Copied from the Calibrated Historical Model
Groundwater Pumping:	Simulated to meet a target NIR
NIR Set:	2
Application Efficiency:	Copied from the Calibrated Historical Model
Canal Recharge:	Yes
M&I Pumping:	No
Miscellaneous Pumping:	Yes
Miscellaneous Recharge:	Yes

Simulation Period (2014-2063)

Climate:	2009-2013 repeated ten times
Land use:	Baseline Data Set; matches simulated climate year
Surface Water Deliveries:	Copied from the Calibrated Historical Model to match simulated climate year
Comingled Pumping:	Copied from the Calibrated Historical Model to match simulated climate year
Groundwater Pumping:	Simulated to meet a target NIR
NIR Set:	2
Application Efficiency:	Copied from the Calibrated Historical Model to match simulated climate year
Canal Recharge:	Yes – match simulated climate year
M&I Pumping:	No
Miscellaneous Pumping:	Yes – match simulated climate year
Miscellaneous Recharge:	Yes – match simulated climate year

[6] During this period groundwater pumping in the Historically Calibrated Model is simulated

D4. Metered Baseline Scenario: Post 97 Development Rollback Scenario (1953-2063) (Hist_p97_001)

Deliverable: WWUM_p97_Hist_p97_001_20180302.zip
Date: 3/2/2018

Simulation Period (1953-1997)

Climate:	1953-1997
Land Use:	Restrict Post 97 Groundwater Only Irrigated Land Development Data Set (Same as the baseline for this period of time)
Surface Water Deliveries:	Copied from the Calibrated Historical Model
Comingled Pumping:	Copied from the Calibrated Historical Model
Groundwater Pumping:	Copied from the Calibrated Historical Model (During this period groundwater pumping in the Historically Calibrated Model is simulated)
Application Efficiency:	Copied from the Calibrated Historical Model
Canal Recharge:	Yes
M&I Pumping:	No
Miscellaneous Pumping:	Yes
Miscellaneous Recharge:	Yes

Simulation Period (1998-2013)

Climate:	1998-2013
Land Use:	Restrict Post 97 Groundwater Only Irrigated Land Development Data Set
Surface Water Deliveries:	Copied from the Calibrated Historical Model
Comingled Pumping:	Copied from the Calibrated Historical Model
Groundwater Pumping:	Simulated to meet a target NIR
NIR Set:	2
Application Efficiency:	Copied from the Calibrated Historical Model
Canal Recharge:	Yes
M&I Pumping:	No
Miscellaneous Pumping:	Yes
Miscellaneous Recharge:	Yes

Simulation Period (2014-2063)

Climate:	2009-2013 repeated ten times
Land Use:	Restrict Post 97 Groundwater Only Irrigated Land Development Data Set; matches simulated climate year
Surface Water Deliveries:	Copied from the Calibrated Historical Model to match simulated climate year
Comingled Pumping:	Copied from the Calibrated Historical Model to match simulated climate year
Groundwater Pumping:	Simulated to meet a target NIR
NIR Set:	2
Application Efficiency:	Copied from the Calibrated Historical Model to match simulated climate year
Canal Recharge:	Yes – match simulated climate year
M&I Pumping:	No
Miscellaneous Pumping:	Yes – match simulated climate year
Miscellaneous Recharge:	Yes – match simulated climate year

E. Update to the Post 97 Analysis Scenario Input files *Updated October 2018

The Metered Baseline Scenarios were updated to include new canal recharge and municipal and industrial (M&I) pumping data. The new groundwater model inputs were created by appending the new data sets to existing agricultural pumping and recharge datasets.

E1. Updates to the Model Setup: Canal Recharge, M&I Pumping
This section replaces section B6 of the model setup for future runs.

Adaptive Resources, Inc. (ARI) develop an update version of the canal recharge inputs: *WWUM_ConveyanceLoss_28092018.csv*. Data was provided for the period 1953-2013. This information was provided to DNR. DNR then provided the information to TFG on October 1, 2018. This canal recharge data was compiled and formatted into the canal recharge data set *WWUMrr_001* which replaced the data sets *Base001* and *WPC001*. For the model projected simulation years, the canal recharge annual file from the simulated climate year was used. For example, in 2063 climate from 2013 was used; therefore, canal recharge values from 2013 were also used.

ARI also developed a set of Municipal and Industrial pumping data: *rr2018_muni_ind_inpu.csv*. Data was provided for the period May 1953 through 2063[7]; with instruction that the 2014-2063 was repeated from the years 2009-2013. The data was provided in ft^3/day. ARI provided this information to DNR. DNR then provided the information to TFG on October 1, 2018. The M&I data was converted in AF/mon[8] using the actual number of calendar days for each month. Then compiled and formatted into the M&I data set *MIrr_001*.

The following description defines the changes made to the model. Each scenario is implemented in Region 1 then combined with the pumping and recharge from UNW_Run012, WCOHYST_Run025,

[7] It should be noted that prior to 1997 there was no M&I pumping in the provided data
[8] Or AF/stress period

Colorado002, Western002, and Wyoming002 to create the '.WEL' and '.RCH' file for inclusion in the groundwater model.

F. Post 97 Scenarios with 5 Year Period Projected 10 times *Updated October 2018

Section 0 describes the runs which incorporates the changes to the DNR Post 97 Analysis defined in Section E.

F1. Metered Baseline Scenario (1953-2063) (HistBase_001) Updated

These runs use the same agricultural pumping and recharge as *Metered Baseline Scenario (HistBase_001)* from section D1.

F1_a. Metered Baseline Scenario (1953-2063) (HistBase_001) with updated canal recharge and M&I pumping

Deliverable: WWUM_p97_HistBase_001_CnlSeep_MI_20181010.zip
Date: 10/10/2018

Simulated Period (1953-2013)

Climate:	1953-2013
Land use:	Baseline Data Set
Surface Water Deliveries:	Copied from the Calibrated Historical Model
Comingled Pumping:	Copied from the Calibrated Historical Model
Groundwater Pumping:	Copied from the Calibrated Historical Model
Application Efficiency:	Copied from the Calibrated Historical Model
Canal Recharge:	Yes
M&I Pumping:	Yes
Miscellaneous Pumping:	Yes
Miscellaneous Recharge:	Yes

Simulated Period (2014-2063)

Climate:	2009-2013 repeated ten times
Land use:	Baseline Data Set; matches simulated climate year
Surface Water Deliveries:	Copied from the Calibrated Historical Model to match simulated climate year
Comingled Pumping:	Copied from the Calibrated Historical Model to match simulated climate year
Groundwater Pumping:	Copied from the Calibrated Historical Model to match simulated climate year
Application Efficiency:	Copied from the Calibrated Historical Model to match simulated climate year
Canal Recharge:	Yes – match simulated climate year
M&I Pumping:	Yes – as specified by ARI dataset
Miscellaneous Pumping:	Yes – match simulated climate year
Miscellaneous Recharge:	Yes – match simulated climate year

F1_b. Metered Baseline Scenario (1953-2063) (HistBase_001) without canal recharge or M&I pumping

Deliverable: WWUM_p97_HistBase_001_NoCnlSeep_NoMI_20181010.zip
Date: 10/10/2018

Simulated Period (1953-2013)

Climate:	1953-2013
Land use:	Baseline Data Set
Surface Water Deliveries:	Copied from the Calibrated Historical Model
Comingled Pumping:	Copied from the Calibrated Historical Model
Groundwater Pumping:	Copied from the Calibrated Historical Model
Application Efficiency:	Copied from the Calibrated Historical Model
Canal Recharge:	No
M&I Pumping:	No
Miscellaneous Pumping:	Yes
Miscellaneous Recharge:	Yes

Simulated Period (2014-2063)

Climate:	2009-2013 repeated ten times
Land use:	Baseline Data Set; matches simulated climate year
Surface Water Deliveries:	Copied from the Calibrated Historical Model to match simulated climate year
Comingled Pumping:	Copied from the Calibrated Historical Model to match simulated climate year
Groundwater Pumping:	Copied from the Calibrated Historical Model to match simulated climate year
Application Efficiency:	Copied from the Calibrated Historical Model to match simulated climate year
Canal Recharge:	No
M&I Pumping:	No
Miscellaneous Pumping:	Yes – match simulated climate year
Miscellaneous Recharge:	Yes – match simulated climate year

F2. Metered Baseline Scenario: No Groundwater Pumping (1953-2063) (Histngwp_001) *Updated

These runs use the same agricultural pumping and recharge as *Metered Baseline: No Groundwater Pumping (Histngwp_001)* from section D2.

F2_a. Metered Baseline Scenario: No Groundwater Pumping (1953-2063) (Histngwp_001) with updated canal recharge and without M&I pumping

Deliverable: WWUM_p97_HistNgwp_001_CnlSeep_NoMI_20181010.zip
Date: 10/10/2018

Simulated Period (1953-2013)

Climate:	1953-2013
Land use:	Baseline Data Set
Surface Water Deliveries:	Copied from the Calibrated Historical Model
Comingled Pumping:	Copied from the Calibrated Historical Model
Groundwater Pumping:	None
Application Efficiency:	Copied from the Calibrated Historical Model
Canal Recharge:	Yes
M&I Pumping:	No
Miscellaneous Pumping:	Yes
Miscellaneous Recharge:	Yes

Simulated Period (2014-2063)

Climate:	2009-2013 repeated ten times
Land use:	Baseline Data Set; matches simulated climate year
Surface Water Deliveries:	Copied from the Calibrated Historical Model to match simulated climate year
Comingled Pumping:	Copied from the Calibrated Historical Model to match simulated climate year
Groundwater Pumping:	None
Application Efficiency:	Copied from the Calibrated Historical Model to match simulated climate year
Canal Recharge:	Yes – match simulated climate year
M&I Pumping:	No
Miscellaneous Pumping:	Yes – match simulated climate year
Miscellaneous Recharge:	Yes – match simulated climate year

F2_b. Metered Baseline Scenario: No Groundwater Pumping (1953-2063) (Histngwp_001) without canal recharge or M&I pumping

Deliverable: WWUM_p97_HistNgwp_001_NoCnlSeep_NoMI_20181010.zip
Date: 10/10/2018

Simulated Period (1953-2013)

Climate:	1953-2013
Land use:	Baseline Data Set
Surface Water Deliveries:	Copied from the Calibrated Historical Model
Comingled Pumping:	Copied from the Calibrated Historical Model
Groundwater Pumping:	None
Application Efficiency:	Copied from the Calibrated Historical Model
Canal Recharge:	No
M&I Pumping:	No
Miscellaneous Pumping:	Yes
Miscellaneous Recharge:	Yes

Simulated Period (2014-2063)

Climate:	2009-2013 repeated ten times
Land use:	Baseline Data Set; matches simulated climate year
Surface Water Deliveries:	Copied from the Calibrated Historical Model to match simulated climate year
Comingled Pumping:	Copied from the Calibrated Historical Model to match simulated climate year
Groundwater Pumping:	None
Application Efficiency:	Copied from the Calibrated Historical Model to match simulated climate year
Canal Recharge:	No
M&I Pumping:	No
Miscellaneous Pumping:	Yes – match simulated climate year
Miscellaneous Recharge:	Yes – match simulated climate year

F3. Metered Baseline: Post 97 Development Rollback Scenario (Hist_p97_001) *Updated

These runs use the same agricultural pumping and recharge as *Metered Baseline: Post 97 Development Rollback Scenario (Hist_p97_001)* from section D4.

F3_a. Metered Baseline Scenario: Post 97 Development Rollback Scenario (1953-2063) (Hist_p97_001) with updated canal recharge and 1997 level of M&I pumping

Deliverable: WWUM_p97_Hist_p97_001_CnlSeep_97MI_20181011.zip
Date: 10/11/2018

Simulation Period (1953-1997)

Climate:	1953-1997
Land Use:	Restrict Post 97 Groundwater Only Irrigated Land Development Data Set (Same as the baseline for this period of time)
Surface Water Deliveries:	Copied from the Calibrated Historical Model
Comingled Pumping:	Copied from the Calibrated Historical Model
Groundwater Pumping:	Copied from the Calibrated Historical Model (During this period groundwater pumping in the Historically Calibrated Model is simulated)
Application Efficiency:	Copied from the Calibrated Historical Model
Canal Recharge:	Yes
M&I Pumping:	Yes
Miscellaneous Pumping:	Yes
Miscellaneous Recharge:	Yes

Simulation Period (1998-2013)

Climate:	1998-2013
Land Use:	Restrict Post 97 Groundwater Only Irrigated Land Development Data Set
Surface Water Deliveries:	Copied from the Calibrated Historical Model
Comingled Pumping:	Copied from the Calibrated Historical Model
Groundwater Pumping:	Simulated to meet a target NIR
NIR Set:	2
Application Efficiency:	Copied from the Calibrated Historical Model
Canal Recharge:	Yes
M&I Pumping:	Yes – At 1997 levels
Miscellaneous Pumping:	Yes
Miscellaneous Recharge:	Yes

Simulation Period (2014-2063)

Climate:	2009-2013 repeated ten times
Land Use:	Restrict Post 97 Groundwater Only Irrigated Land Development Data Set; matches simulated climate year
Surface Water Deliveries:	Copied from the Calibrated Historical Model to match simulated climate year
Comingled Pumping:	Copied from the Calibrated Historical Model to match simulated climate year
Groundwater Pumping:	Simulated to meet a target NIR
NIR Set:	2
Application Efficiency:	Copied from the Calibrated Historical Model to match simulated climate year
Canal Recharge:	Yes – match simulated climate year
M&I Pumping:	Yes – At 1997 levels
Miscellaneous Pumping:	Yes – match simulated climate year
Miscellaneous Recharge:	Yes – match simulated climate year

F3_b. Metered Baseline Scenario: Post 97 Development Rollback Scenario (1953-2063) (Hist_p97_001) with updated canal recharge and Historic levels of M&I pumping

Deliverable: WWUM_p97_Hist_p97_001_CnlSeep_HistMI_20181011.zip
Date: 10/11/2018

Simulation Period (1953-1997)

Climate:	1953-1997
Land Use:	Restrict Post 97 Groundwater Only Irrigated Land Development Data Set (Same as the baseline for this period of time)
Surface Water Deliveries:	Copied from the Calibrated Historical Model
Comingled Pumping:	Copied from the Calibrated Historical Model
Groundwater Pumping:	Copied from the Calibrated Historical Model (During this period groundwater pumping in the Historically Calibrated Model is simulated)
Application Efficiency:	Copied from the Calibrated Historical Model
Canal Recharge:	Yes
M&I Pumping:	Yes
Miscellaneous Pumping:	Yes
Miscellaneous Recharge:	Yes

Simulation Period (1998-2013)

Climate:	1998-2013
Land Use:	Restrict Post 97 Groundwater Only Irrigated Land Development Data Set
Surface Water Deliveries:	Copied from the Calibrated Historical Model
Comingled Pumping:	Copied from the Calibrated Historical Model
Groundwater Pumping:	Simulated to meet a target NIR
NIR Set:	2
Application Efficiency:	Copied from the Calibrated Historical Model
Canal Recharge:	Yes
M&I Pumping:	Yes
Miscellaneous Pumping:	Yes
Miscellaneous Recharge:	Yes

Simulation Period (2014-2063)

Climate:	2009-2013 repeated ten times
Land Use:	Restrict Post 97 Groundwater Only Irrigated Land Development Data Set; matches simulated climate year
Surface Water Deliveries:	Copied from the Calibrated Historical Model to match simulated climate year
Comingled Pumping:	Copied from the Calibrated Historical Model to match simulated climate year
Groundwater Pumping:	Simulated to meet a target NIR
NIR Set:	2
Application Efficiency:	Copied from the Calibrated Historical Model to match simulated climate year
Canal Recharge:	Yes – match simulated climate year
M&I Pumping:	Yes – as specified by ARI dataset
Miscellaneous Pumping:	Yes – match simulated climate year
Miscellaneous Recharge:	Yes – match simulated climate year

F3_c. Metered Baseline Scenario: Post 97 Development Rollback Scenario (1953-2063) (Hist_p97_001) without canal recharge or M&I pumping

Deliverable: WWUM_p97_Hist_p97_001_NoCnlSeep_NoMI_20181011.zip
Date: 10/11/2018

Simulation Period (1953-1997)

Climate:	1953-1997
Land Use:	Restrict Post 97 Groundwater Only Irrigated Land Development Data Set (Same as the baseline for this period of time)
Surface Water Deliveries:	Copied from the Calibrated Historical Model
Comingled Pumping:	Copied from the Calibrated Historical Model
Groundwater Pumping:	Copied from the Calibrated Historical Model (During this period groundwater pumping in the Historically Calibrated Model is simulated)
Application Efficiency:	Copied from the Calibrated Historical Model
Canal Recharge:	No
M&I Pumping:	No
Miscellaneous Pumping:	Yes
Miscellaneous Recharge:	Yes

Simulation Period (1998-2013)

Climate:	1998-2013
Land Use:	Restrict Post 97 Groundwater Only Irrigated Land Development Data Set
Surface Water Deliveries:	Copied from the Calibrated Historical Model
Comingled Pumping:	Copied from the Calibrated Historical Model
Groundwater Pumping:	Simulated to meet a target NIR
NIR Set:	2
Application Efficiency:	Copied from the Calibrated Historical Model
Canal Recharge:	No
M&I Pumping:	No
Miscellaneous Pumping:	Yes
Miscellaneous Recharge:	Yes

Simulation Period (2014-2063)

Climate:	2009-2013 repeated ten times
Land Use:	Restrict Post 97 Groundwater Only Irrigated Land Development Data Set; matches simulated climate year
Surface Water Deliveries:	Copied from the Calibrated Historical Model to match simulated climate year
Comingled Pumping:	Copied from the Calibrated Historical Model to match simulated climate year
Groundwater Pumping:	Simulated to meet a target NIR
NIR Set:	2
Application Efficiency:	Copied from the Calibrated Historical Model to match simulated climate year
Canal Recharge:	No
M&I Pumping:	No
Miscellaneous Pumping:	Yes – match simulated climate year
Miscellaneous Recharge:	Yes – match simulated climate year

A.1.9 Memorandums on Industrial and Municipal Pumping for WWUMM

Memo

Adaptive Resources, Inc.

To: John Berge, General Manager NPNRD, Rod L. Horn, General Manager SPNRD, and Platte Basin Water Project Coalition

From: Thad Kuntz, P.G. and Joe Reedy, G.I.

CC:

Date: 7/18/2018

Re: Industrial Pumping Analysis, Robust Review Task: Post 1997 Development – Municipal/Industrial Pumping

EXECUTIVE SUMMARY

Adaptive Resources, Inc. (ARI) analyzed available industrial pumping information for both North Platte Natural Resources District and South Platte Natural Resources District as part of the Robust Review Project Analysis for the Western Water Use Management Modeling. The analysis utilized available water meter records for industrial wells in both Districts from 1997 through 2016, augmented with additional historical pumping records drawn from the Department of Natural Resources' (DNR) 2008 industrial survey, to produce a final industrial pumping dataset for the period from 1997 to 2013. The final pumping estimates include actual meter and survey data when available, and use averages estimated from the available data when meter records did not exist for a given well. These data were further limited to the period of active pumping, between well completion and abandonment, when applicable.

ARI also generated an industrial pumping dataset using the pumping capacity information available in the DNR well registration database. This dataset adapted a per capacity pumping estimation method and per capacity pumping categories developed in previous analyses. The dataset used all industrial registered wells in each District, limited to the period of expected active pumping.

Comparison of final pumping estimates revealed significant differences between methods. Pumping estimated with metered data was more variable later in the modeling period, with decreased variability in early pumping. Pumping estimated with capacity data exhibited limited variability, with the potential for significant overestimation of pumping during the modeling period due. There were also significant discrepancies between the wells included in each dataset. This may be due to discrepancies in actual and registered use, the temporary nature of some industrial uses, or meter and reporting requirements that may not capture all wells.

It is the opinion of ARI that industrial pumping estimated from meter records better reflects actual pumping and should be utilized for future analyses of this type. Meter records capture long and short-term variability in the existing pumping record and are likely to benefit from improved accuracy as additional meter data is incorporated. Changes in well metering or well registration reporting may impact the conclusions and data provided in this memo.

Memo

INTRODUCTION

ARI is completing modifications to the baseline model run of the Western Water Use Management Modeling (WWUMM) under Task 1 of the Robust Review Project Analysis (RRPA). This task includes incorporating observed industrial pumping information into the WWUMM. The updated WWUMM will be utilized in Task 6 to compare the observed pumping information with the historical 1997 pumping information for industrial and commercial wells throughout North Platte Natural Resources District (NPNRD) and South Platte Natural Resources District (SPNRD). The analysis of available industrial pumping data utilized two distinct datasets; metered pumping records provided by the Districts, and the Department of Natural Resources (DNR) well registration database. Industrial well data provided by each NRD was parsed using the following assumptions:

- For NPNRD, only wells labeled "commercial" in the NPNRD dataset were used; including wells for Western Sugar and Bridgeport Ethanol Plant, provided separately (41 wells).
    - Wells from 2008 DNR industrial survey also included (1 well).
- For SPNRD, only wells with meters classified as "industrial" were used; including industrial meters on transferred or dual-use wells (40 wells).

Addendum A provides additional notes and information on the evolution of the analysis as additional datasets were considered.

METERED DATA

METHOD

Historical pumping data became available for industrial wells between 2006 and 2014. NPNRD data was provided annually on a certification basis. SPNRD data was provided as totalizing flow meter (TFM) records, including the date the flow meter was read; generally monthly.

NPNRD pumping data was provided as annual volumes. The average annual pumping was calculated using available pumping records from 2008 through 2016. If a record did not exist for a given year, that year was excluded from the average. The calculated annual average was used to fill any year that did not have a pumping record from 1997 through 2013. These annual values represent the actual or estimated pumping per certification in the District.

The certification and well data provided by NPNRD was used to determine all wells joined to a certification. These wells were assigned an active date based upon completion data from the NRD and the Nebraska Department of Natural Resources (NDNR) well permit database. Each well was also assigned an inactive date based upon the abandonment date from the same sources. A monthly array of active-inactive flags was created from the active-inactive dates. This array was used to determine the number of active wells per certification. The final monthly pumping values ($P_{1...12}$) were distributed to each well to create the final pumping schedule for NPNRD industrial pumping. Inactive wells were assigned a pumping value of 0.

The process for calculating and distributing pumping can be described with the following calculations:

Memo

1) Average annual pumping calculated by certification:

$$(Q_1 + Q_2 + \dots Q_n) \div n = Q_{avg}$$

2) Years with no record filled using the annual average, Q_{avg}
3) Annual pumping distributed to monthly pumping, based on active wells:

$$Q_1 \div 12 = P_{1\dots12} \text{ for given year}$$

$$P_1 \div \text{active wells count for month} = \text{final monthly pumping}$$

SPNRD pumping data was provided as monthly TFM readings. The readings were taken at irregular intervals for some wells. Additionally, each flow meter provided readings in one of three units: acre-inches, acre-feet, or gallons. The number of decimal and non-decimal significant figures recorded also varied by flow meter; the maximum value the flow meter could record is termed the “roll over” for this text. Data provided by SPNRD was used to convert all readings to cubic feet. Flow meters were generally read at the beginning or end of each month, with the day being largely consistent with the readings on a given meter, but not between meters. Serial dates were used to apportion monthly pumping volumes between adjacent months based upon the current and adjacent serial dates (forward and backward in time). This apportionment was only applied to the first and last month of each year. As TFM records were inconsistent for some wells, the calculated monthly pumping volumes were aggregated annually. Using annual data also allowed for consistency in the pumping distribution between NRDs. If a gap existed across years in TFM records, the estimated volume of pumping during the gap was distributed proportionally between each year based on the number of days per year captured by the gap. This process was applied even if the gap covered multiple years. It is possible estimates calculated in this way may be artificially low, as the flow meter may have “rolled over” during an extended gap. The method for estimating annual pumping from TFM records is demonstrated below:

1) Conversion of TFM record to pumping volume:

$$TFM_n - TFM_{n-1} = Q_n$$

2) Conversion of monthly volumes:

$$Q \text{ in gal, acre-in, acre-f} \div \text{conversion factor} = Q\ ft^3$$

3) Shifting of monthly volumes across monthly and annual gaps (effectively only changes pumping at the end and beginning months of gapped years, as values are summed annually).

$$((\text{End of Month Serial}_{n-1} - \text{Serial}_{n-1}) / (\text{Serial}_n - \text{Serial}_{n-1})) * Qn = Q_{n-1\ portion}$$

$$((\text{Serial}_n - \text{End of Month Serial}_{n-1}) / (\text{Serial}_n - \text{Serial}_{n-1})) * Qn = Q_{n\ portion}$$

4) Calculation of annual pumping:

$$Q_n + Q_{n+1} + Q_{n+2} + Q_{n+n} = Q_{total} \text{ for given year}$$

SPNRD pumping was calculated per well, with no additional distribution. Months were determined to be active or inactive using the process described for NPNRD.

ASSUMPTIONS

Several assumptions were made in the processing of the NRD meter records. They include:

1) Wells tied to the same industrial use or certification were pumped equally.

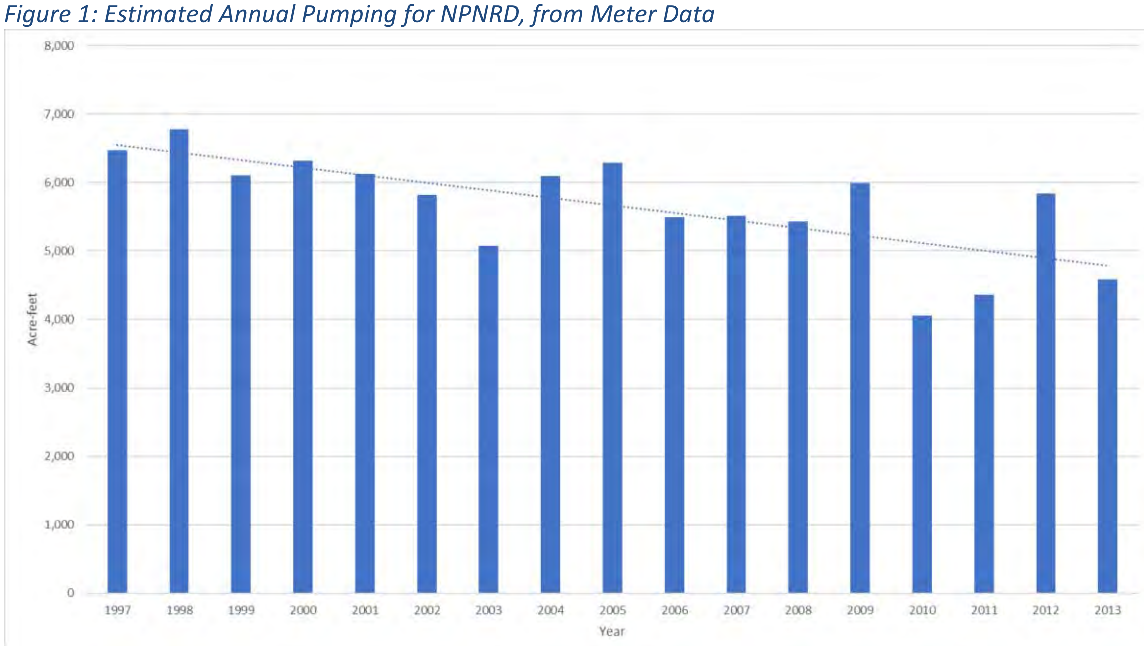
Memo

2) Gaps in TFM readings represent a pumping period if the first new reading differs from the previous reading; pumping is assumed to have occurred at a constant daily rate during the gap.
3) NDNR completion and abandonment dates reasonably approximate first and last use dates for the non-metered period, unless noted in discussion with each NRD or the well owner (in the case of industrial survey wells and those owned by Nebraska Public Power District [NPPD]).

RESULTS

Pumping for NPNRD was generally less than the annual pumping estimated for 1997, with an average annual volume 14% lower (approximately 855 AF). Large users generated most of the variability in annual volumes, with Western Sugar wells driving decreases in 2003, 2010, and 2011.

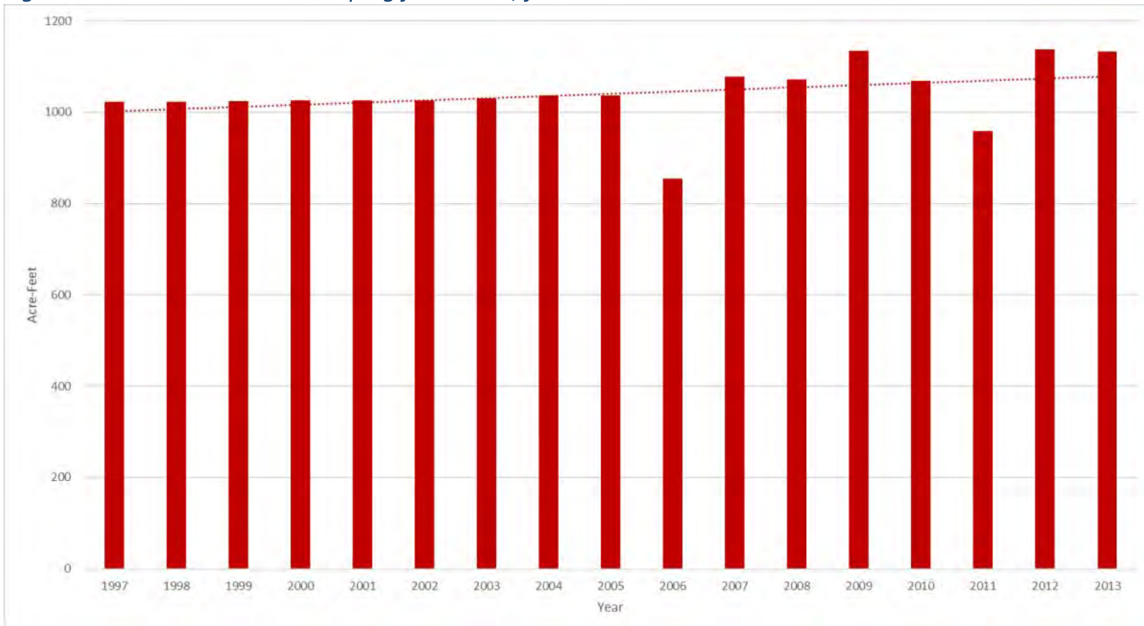
Figure 1: Estimated Annual Pumping for NPNRD, from Meter Data



Pumping for SPNRD was generally greater than the annual pumping estimated for 1997, with an average annual volume 2% greater (approximately 18 AF). Variability in the meter record was largely attributed to pumping by the City of Kimball, including declines in 2003 and 2011.

Memo

Figure 2: Estimated Annual Pumping for SPNRD, from Meter Data



CAPACITY DATA

METHOD

The statewide well registration database was retrieved as a shapefile from the DNR web portal (https://dnr.nebraska.gov/data/groundwater-data). Wells were isolated from the database for both NRDs using the "Commercial" use identification tag and NRD name. Each well was then assigned to an industrial category using the owner's name and description, with each category having an associated consumptive use estimate. This process sought to adapt the methodology described in "Municipal and Industrial Pumping" prepared by The Flatwater Group, Inc, using the per capacity pumping estimates defined in Appendix C. The assignation of industrial classes in North Platte and South Platte NRDs was subjective and cursory, and the results of the estimates calculated with this method may vary if the well classifications were otherwise defined.

- A total of 115 commercial wells were identified in NPNRD.
- A total of 80 commercial wells were identified in SPNRD.

Well capacity information was compiled monthly for each industrial class using well completion and decommission dates to denote active and inactive periods for each well. The same process as detailed for the meter data method was used. Pumping was then estimated using the associated per capacity pumping values. Monthly estimates were converted to annual averages for final analysis. Initially, a large portion of pumping in NPNRD was attributed to 15 wells owned by NPPD. Following communication with Jeff Schafer of NPPD, only one well was determined to be active during the modeling period. He reported that the 14 other wells were believed to be last used in 1986, though they were not abandoned until 2003, and were subsequently removed from the analysis. The remaining well was maintained for domestic and miscellaneous use. However, the original capacity data was maintained in the dataset, as the well's new capacity value is unknown.

Memo

The process for calculating and distributing pumping is described with the following calculations:

1) Total monthly capacity summed by industrial classification:

$$(C_1 + C_2 + \ldots C_n) = C_t$$

2) Monthly capacity per classification converted to annual average:

$$(C_{t1} + C_{t2} + \ldots C_{t12}) \div n = C_{avg}$$

$$C_{avg} * \text{average per capacity pumping estimate} = P \text{ per class}$$

3) Annual pumping per class summed to provide annually estimated pumping per NRD:

$$(P_1 + P_2 + \ldots P_n) = P \text{ for given year}$$

As this method was initially analyzed for comparison purposes, the analysis did not include distribution of annual pumping back to individual wells. If this dataset is chosen, the same method of distribution as was used in the meter data method would be utilized.

ASSUMPTIONS

Several assumptions were made in the processing of the NRD capacity records. They include:

1) Well completion and decommission/abandonment dates are a fair representation of actual pumping periods.
2) Industrial classification for wells is a fair approximation of actual well use.
3) Average per capacity pumping values are a fair estimate of actual pumping.

RESULTS

Pumping for NPNRD was generally greater than the annual pumping estimated for 1997, with an average annual volume 3% higher (approximately 196 AF). Variability in pumping was largely driven by the ethanol and small business classes.

Figure 3: Estimated Annual Pumping for NPNRD, from Capacity Data

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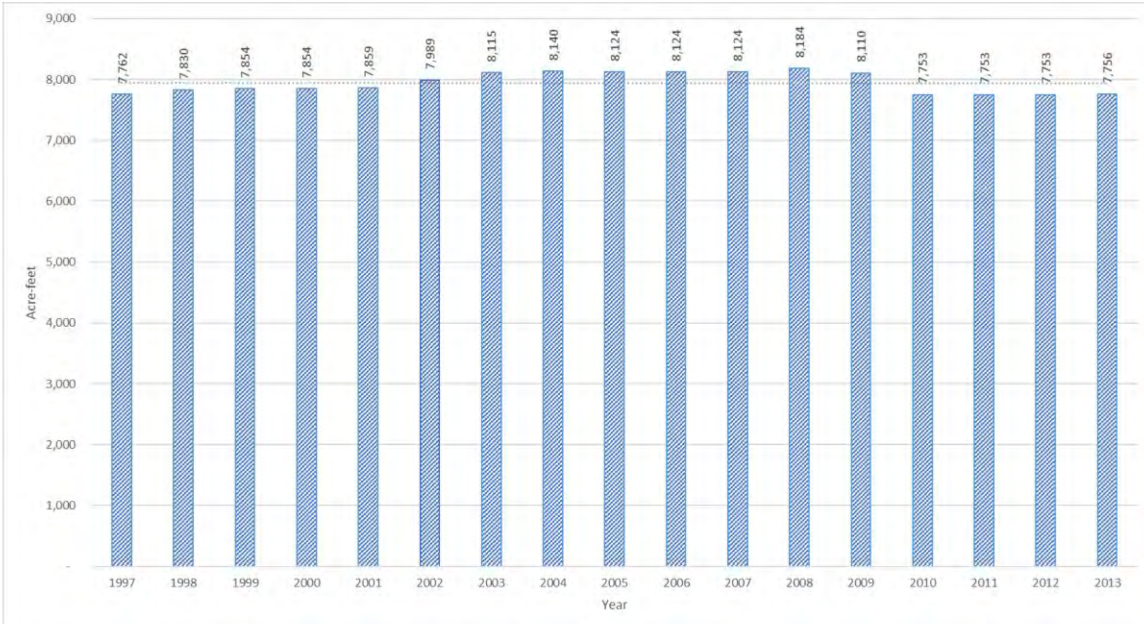
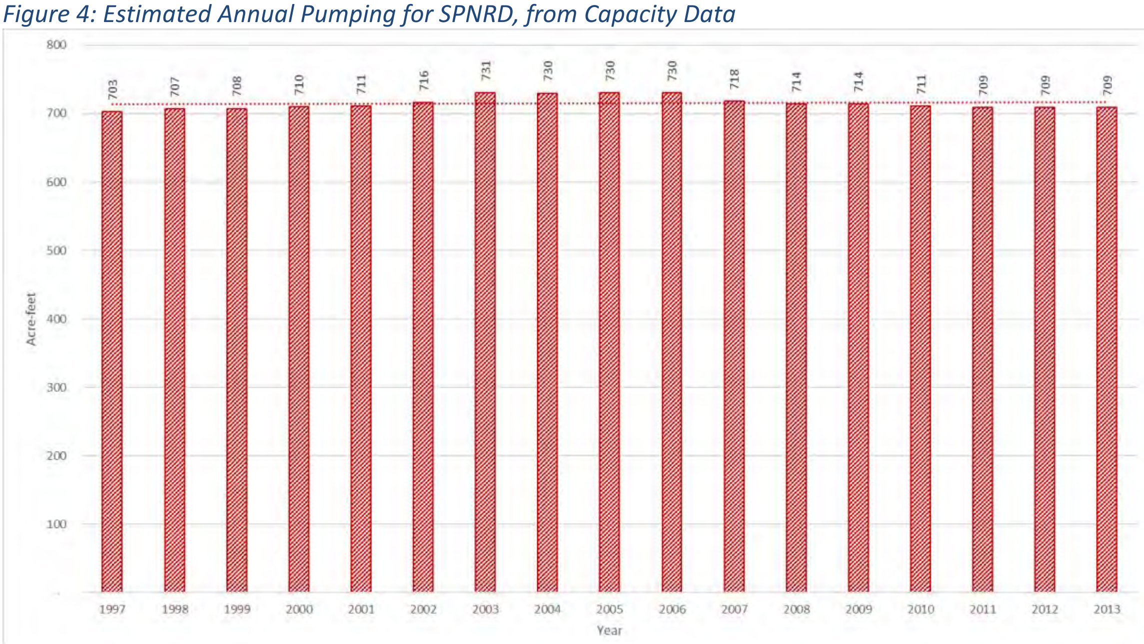


Pumping for SPNRD was generally greater than the annual pumping estimated for 1997, with an average annual volume 1% greater (approximately 13 AF). Variability in the pumping was largely driven by the sand and gravel class.

Figure 4: Estimated Annual Pumping for SPNRD, from Capacity Data



CONCLUSIONS AND RECOMMENDATION

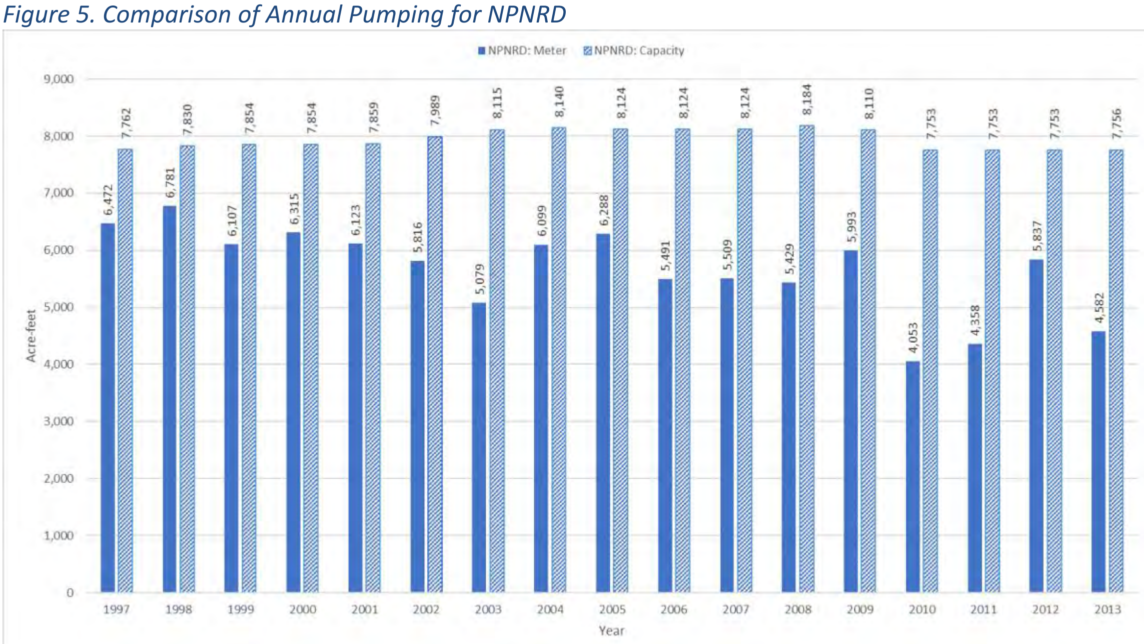
Several issues arose in a direct comparison of the methodologies. A review of well identification numbers and registration numbers between datasets revealed the following:

Memo

- Of the 115 wells identified in the capacity database for NPNRD, only 25 were present in the meter database; additionally, 17 wells identified in the meter database were not identified in the capacity database.
- Of the 80 wells identified in the capacity database for SPNRD, only 15 were present in the meter database; additionally, 25 wells identified in the meter database were not identified in the capacity database.
- Differences in total pumping estimates were significant.
    - NPNRD metered pumping estimates were an average of 71% of capacity estimates.
    - SPNRD metered pumping estimates were an average of 145% of capacity estimates.
- Differences in pumping trends were also noticeable in NPNRD.

NPNRD realized an average 14% decrease in annual pumping in the metered analysis, and an average 3% increase in annual pumping in the capacity analysis.

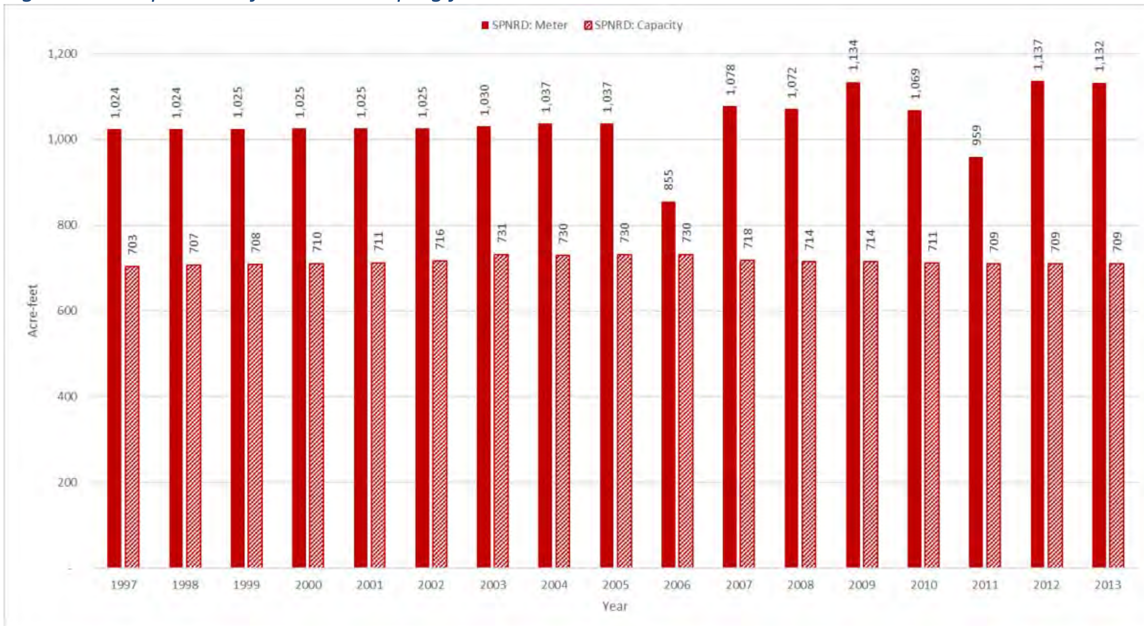
Figure 5. Comparison of Annual Pumping for NPNRD



SPNRD realized an average 2% increase in annual pumping in the metered analysis, and an average 1% increase in annual pumping in the capacity analysis.

Memo

Figure 6. Comparison of Annual Pumping for SPNRD



Each methodology may include unique weaknesses derived from a lack or abundance of data that fails to accurately reflect actual pumping:

- Metered data may over- or underestimate pumping, especially in non-metered years and for certifications/wells with few records.
- Capacity data may over- or underestimate pumping, especially in the case of inaccurate abandonment dates; per capacity pumping estimates were also not determined for the area of interest in this analysis, with the possibility that the existing estimates fail to capture differences in regional industrial use or the presence of other industrial classes.

Differences in wells represented between datasets may be the result of differences in classification between the NRD and DNR database. Wells may be designated dual use, or temporarily transferred, in the NRD database and this change may not be represented in the DNR data. Well use may also vary for climactic, economic, or other reasons, which likely is not represented in the current per capacity pumping estimates. For these reasons, and the addition of future meter data collection by the NRDs, it is ARI's recommendation that a method utilizing the metered data in the Robust Review will most accurately reflect current and future industrial use.

Memo

Adaptive Resources, Inc.

To: POAC Technical Committee

From: Thad Kuntz, P.G. and Joe Reedy, G.I.

CC:

Date: 7/18/2018

Re: Addendum A: Robust Review: Industrial Pumping – Processes and Data Flow

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Adaptive Resources, Inc. (ARI) is providing this document as an addendum to the final Robust Review industrial pumping dataset and associated memo report; Industrial Pumping Analysis, Robust Review Task: Post 1997 Development – Municipal/Industrial Pumping and Excess Flow Recharge, dated July 18, 2018 addressed to John Berge, General Manager NPNRD, Rod L. Horn, General Manager SPNRD, and Platte Basin Water Project Coalition by Thad Kuntz, P.G. and Joe Reedy, G.I. This document seeks to provide insights into the gathering and analysis of industrial and commercial data, specifically addressing changes to the scope of data and processing methods from previous iterations of the analysis and the differences they engender. It represents a short summary of the notes of ARI staff. The full report should be referenced for the final and complete methodology.

The initial Industrial Pumping information relied solely upon two datasets: the North Platte Natural Resources District (NRD) industrial pumping database, and the South Platte NRD industrial pumping database. Both databases include information compiled from industrial flow meters within the Districts. The analysis utilized similar calculations as described in the final report, whereby pumping records were converted to annual volumes, pumping averages were used to fill missing data, and pumping was then distributed monthly. The initial process indicated that South Platte NRD had relatively little industrial pumping and that the volume generally decreased through time. It also indicated that North Platte NRD industrial pumping generally increased through time. Both datasets displayed limited variability in early time data, reflecting the introduction of flow meters in the mid-2000's and the use of averages prior to that.

Following the initial analysis and discussion with the Technical Committee, the datasets were expanded, and slight changes were made to data processing. A review of included data was conducted with staff from both NRDs and both datasets were expanded to include additional wells or pumping records. The South Platte NRD dataset was expanded to include dual-use wells that had a dedicated industrial meter, increasing the number of wells represented in the analysis by a product of four. The North Platte NRD dataset was expanded to include additional pumping for existing wells and to correct for transcription errors in the original dataset that had decreased pumping volume. Additionally, the datasets were expanded to include pumping reported in the 2008 DNR Industrial Survey. The inclusion of Industrial Survey data resulted in additional pumping records for two existing industries, and one additional well in North Platte NRD. Data processing was modified to include the Industrial Survey data, which was reported annually.

As a result of these revisions, modeled pumping in South Platte NRD increased by an order of magnitude and the historical trend reversed, with a slight increase in pumping over time. Modeled pumping in North Platte NRD also increased, with the historical trend reversed (possibly due to the inclusion of additional historical data from the Industrial Survey) and pumping decreasing

Memo

through time. The expanded datasets also displayed increased variability, especially in late time, possibly indicating a more realistic representation of industrial use.

Finally, an ancillary analysis of the state well registration database was conducted. Pumping capacity data for industrial wells in North Platte NRD represents a larger volume of pumping than is seen in the NRD meter database. However, following communication with some high-volume industries identified in the industrial dataset (namely NPPD), multiple wells were identified that had been abandoned prior to the modeling period. These wells were removed from the analysis, significantly decreasing pumping. South Platte NRD capacity data was significantly lower than the pumping represented in the meter database. This may indicate that temporary dual-use permits are not represented in the registration data. The capacity data also exhibits significantly less variability through time. An exhaustive analysis of wells in the registration database was not conducted, so it is unknown how many wells may be overrepresented due to failures in reporting. Additionally, wells that are classified as industrial to the State may be classified differently by each NRD (e.g., CAFO) and may not be represented in their databases.

A.1.10 Memorandums on NPNRD and SPNRD Ground Water Only Retirements

Memo

Adaptive Resources, Inc.

To: John Berge, General Manager NPNRD, Rod L. Horn, General Manager SPNRD, and Platte Basin Water Project Coalition

From: Thad Kuntz, P.G.

CC:

Date: 12/3/2018

Re: Robust Review Project: NPNRD and SPNRD Ground Water Only Retirements

Introduction

Adaptive Resources, Inc. (ARI) has compiled the retirements included in the baseline model run of the Western Water Use Management Modeling (WWUMM) for the Robust Review Project Analysis (RRPA). This memo summarizes information on permanent and temporary retirements incorporated in the land use datasets. The permanent retirements encompass those implemented by either the North Platte Natural Resources District (NPNRD) or South Platte Natural Resources District (SPNRD). The temporary retirements include those implemented through the CREP, CRP, and EQUIP federal programs within NPNRD.

Retired Ground Water Only Lands

The land use dataset created for the WWUMM incorporated ground water only lands that were either temporarily or permanently retired within NPNRD or SPNRD. In the land use dataset, irrigated land use retirements are simulated by removing the irrigated land encompassed by the retirement from the irrigated land use dataset. These lands are added to the dryland land use dataset where they are attributed with information such as crop type using the same process as other non-irrigated lands. For more information on how the WWUMM land use was created, refer to the SPNRD's website of Western Water Use Management Modeling Information (Link), Western Water Use Management Model Irrigated and Dryland Assessment by Leonard Rice Engineers, May 2012 (Link) and the Western Water Use Management Modeling Land Use Dataset Update through 2013, Memorandum to the Western Water Use Management Modeling Joint Board by Thad Kuntz P.G. and Heath Kuntz, April 2016 (Link).

The RRPA utilized the WWUMM ground water model as the initial model to construct the baseline model run which also simulates the irrigated land use retirements. Additionally, the commingled and surface water only retirements are also included in the WWUMM land use dataset, however, these retirements are not being analyzed in this phase of the RRPA.

Table 1 provides the annual and cumulative retired ground water only land information within NPNRD. Table 2 provides the cumulative permanent and temporary retired ground water only land information within NPNRD. Table 3 provides the annual and cumulative retired ground water only land information within SPNRD. In SPNRD, only permanent retirements have been completed. Map 1 and 2 show the locations of the retired ground water only lands within NPNRD and SPNRD, respectively.

Memo

Table 1: Annual and Cumulative Retired Ground Water Only Lands within NPNRD (Acres)

Year	Annual Retired Acres	Cumulative Retired Acres
2002	42.5	42.5
2003	116.4	158.9
2004	61.6	220.4
2005	155.6	376.1
2006	872.2	1248.2
2007	479.1	1727.3
2008	238.6	1966.0
2009	-163.2	1802.8
2010	439.6	2242.4
2011	458.3	2700.7
2012	192.1	2892.8
2013	249.0	3141.9

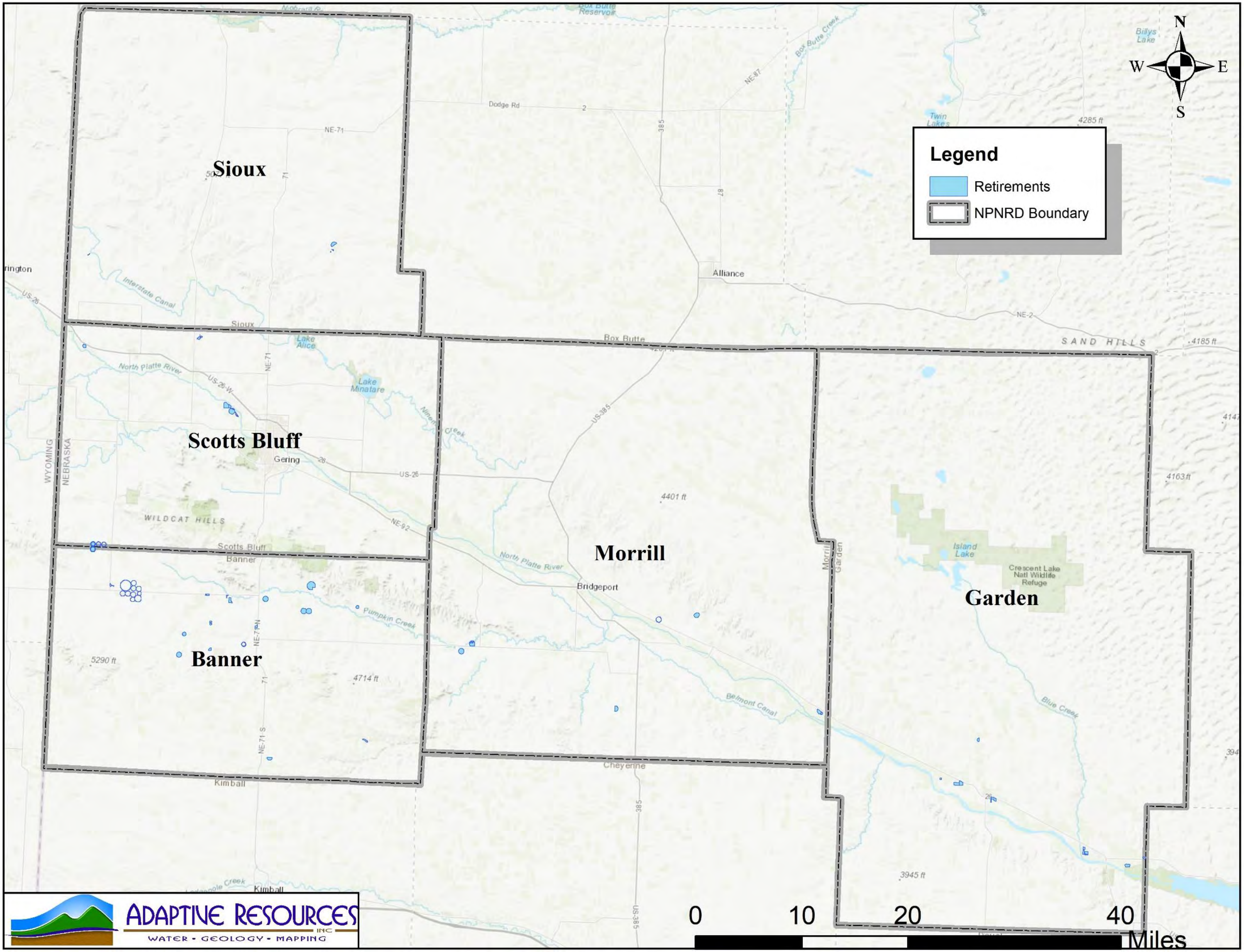
Table 2: Cumulative Permanent and Temporary Retired Ground Water Only Lands within NPNRD (Acres)

Year	Permanent Acres	Temporary Acres	Total Acres
2002	0.0	42.5	42.5
2003	116.4	42.5	158.9
2004	116.4	104.1	220.4
2005	116.4	259.7	376.1
2006	611.5	636.8	1248.2
2007	949.7	777.6	1727.3
2008	1187.8	778.2	1966.0
2009	1216.5	586.2	1802.8
2010	1227.5	1014.9	2242.4
2011	1258.5	1442.2	2700.7
2012	1309.7	1583.2	2892.8
2013	1426.0	1715.8	3141.9

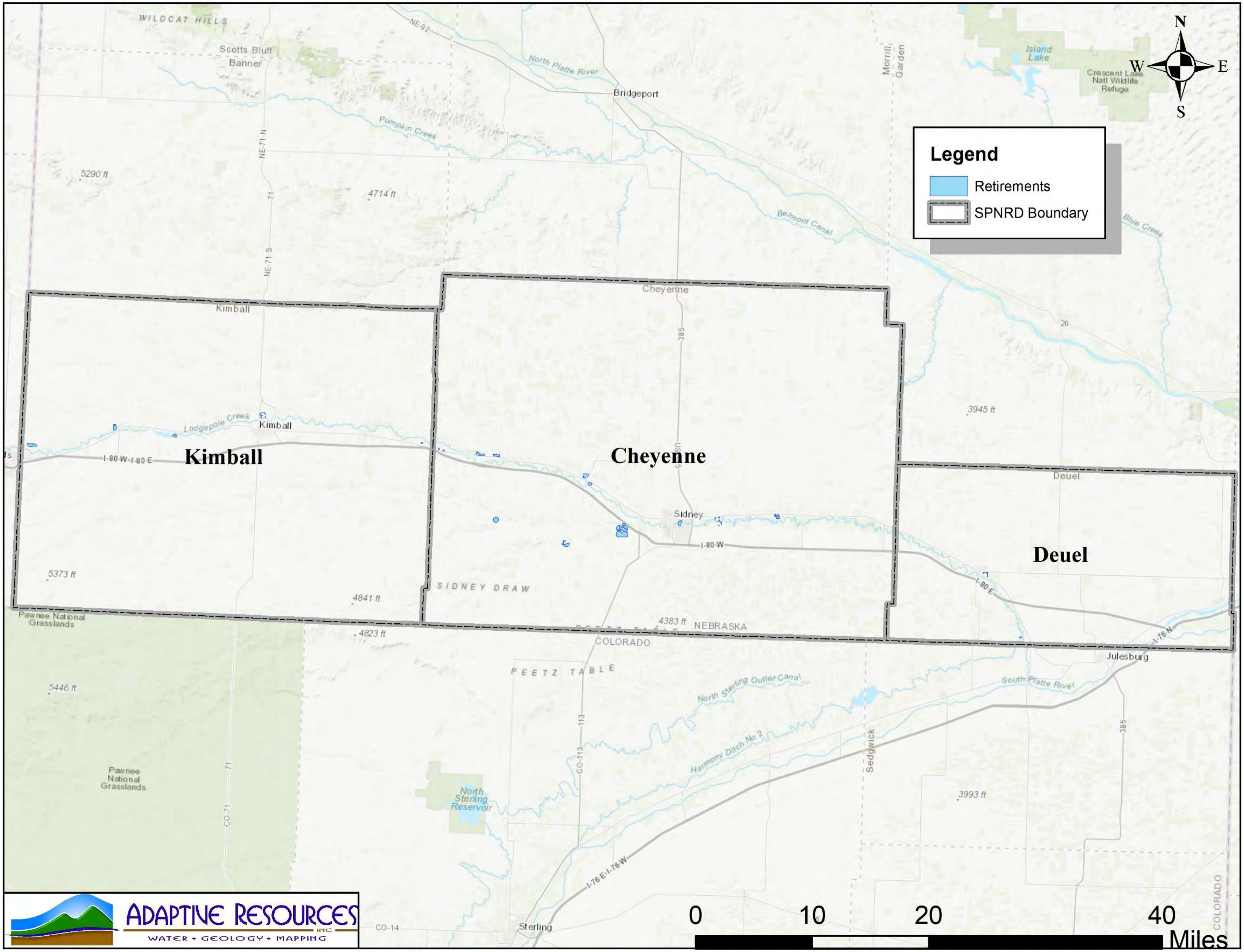
Table 3: Annual and Cumulative Retired Ground Water Only Lands within SPNRD (Acres)

Year	Annual Retired Acres	Cumulative Retired Acres
2007	585.1	585.1
2008	328.8	913.9
2009	138.9	1052.8
2010	176.1	1228.9
2011	59.6	1288.4
2012	99.0	1387.4
2013	0.0	1387.4

Map 1: Retired Ground Water Only Lands within NPNRD



Map 2: Retired Ground Water Only Lands within SPNRD



A.1.11 Memorandum on NPNRD and SPNRD Canal Excess Flow Diversion, Recharge Analysis Comparison, and Canal Loss Recommendation

Memo

Adaptive Resources, Inc.

To: John Berge, General Manager NPNRD, Rod L. Horn, General Manager SPNRD, and Platte Basin Water Project Coalition

From: Thad Kuntz, P.G., Joe Reedy G.I.T., and Jason Yuill

Date: 03/10/2017

Re: Robust Review Analysis: NPNRD and SPNRD Canal Excess Flow Diversion, Recharge Analysis Comparison, and Canal Loss Recommendation

INTRODUCTION

On January 23, 2017, the POAC Technical Committee (TC) requested that Adaptive Resources, Inc. (ARI) provide a technical discussion of differences between the Robust Review (RR) and the January 2013 Department of Natural Resources (DNR) Technical Memorandum (TM) titled Upper Platte River Recharge and Flood Mitigation Demonstration Project: Part of the Conjunctive Management Toolbox. Additionally, during an analysis completed for SPNRD, ARI discovered several discrepancies within the TM's datasets, processes, and methodology that the POAC TC should consider. The TM describes a methodology to quantify accretion credits from the excess flow diversions into canal recharge that each NRD can expect. The Canal Recharge Analysis task that is part of RR is designed to refine the accretion credit estimates by utilizing the Western Water Use Management Modeling (WWUMM) and COHYST Modeling and will be completed under that scope of work.

2011 Canal Excess Flow Diversion Review

During the spring and fall of 2011, high river flows occurred due to significant snowpack runoff from the Rocky Mountains. Consequently, emergency action was taken to divert water into canals to alleviate flood flows and recharge water along the North Platte River, South Platte River, and Platte River. Irrigation districts and canal companies that were amenable and able to participate were paid by the NRDs and DNR to divert the water to recharge local aquifers, and in exchange, accretion credit was obtained by each NRD for depletion offset. For the accretion credits to be considered valid, no irrigation could take place during the diversion of the flood flows. Additionally, the NRDs or DNR recorded the amount and total days that diversion occurred in each canal. In the case of the Western Irrigation District (WID), recharge pits were utilized to recharge water in addition to the canal itself.

Outline of Data Obtained and Compiled:

- Headgate diversion records were collected by DNR using recording devices
- DNR or NRD personnel collected surface return flow spill measurements
    - Typically, data was collected manually at varying times (days or weeks apart)
- Recharge pit diversions were collected using staff gages or flowmeters

As discussed in the TM, some diversions and spills were not measured.

Memo

2013 Technical Memorandum Analysis Review
The TM's Analysis used the following equation for calculating canal loss as a percentage of the diverted excess flows:

$$Canal\ Loss\ \% = \left(1 - \frac{rate\ measured\ at\ spill}{daily\ diversion\ rate}\right) \times 100$$

The calculation of the Canal Loss percentage was completed on days that a canal had both diversion and return flow measurements. The resulting daily calculations were averaged to determine a recharge rate for each canal. Model estimates (WWUMM or COHYST) of canal recharge were utilized for canals that did not have return flow spill measurements.

Once the average recharge rate is determined, it is multiplied by the total amount of excess flow diversion completed by the canal. The total amount of recharge is then lagged back to a river or stream using the PBHEP zone's response functions that represent monthly return flow patterns that were developed using the Jenkins Method analytical equation.

Issues with the Technical Memorandum's Analysis
In 2015, ARI conducted an excess flow recharge and accretion credit analysis for SPNRD. Completing that analysis provided insight to refine the calculation of excess flow recharge estimates and put forth complications with the TM methodology, associated datasets, and processes.

Data obtained for the analysis were provided by SPNRD and DNR and include diversion dates for WID, diversion dates for SPNRD and TPNRD recharge pits along WID, diversion rates, spill rate measurements, and canal loss estimates. The WID excess flow events were recorded in the spring and fall of 2011, fall of 2013, and spring of 2014. SPNRD provided the following WID diversion dates of the excess flows:

- April 10 – June 1, 2011
- September 1 – November 14, 2011
- September 30 – October 27, 2013
- June 11 – July 8, 2014

Additionally, SPNRD, TPNRD, and the TM provided the total amount of pit recharge that occurred along WID per event.

Western Irrigation District Error and Differences in Total Diversion Days
Following a review of initial recharge estimates within the TM, it was discovered that the data provided was identical to that of Kearney Canal. Consequently, new diversion data for WID was requested from DNR on 12/08/2014 and 07/02/2015 and was determined that the data used for WID was the data for Kearney Canal. The excess flow diversion dates maintained by SPNRD and the new diversion data obtained from DNR confirmed the original TM data was in error.

Western Irrigation District Recharge Pit Calculation Error

Memo

The TM's calculation of canal loss for WID used the difference of the canal diversion and return flow spill measurements to determine total canal recharge. However, recharge pits were also employed along WID canal and were not considered in the calculation. This caused the TM methodology to overestimate the recharge. To mitigate this issue, the TM's canal loss calculation method should be altered to account for the water diverted into the recharge pits.

The analysis for SPNRD calculated the canal loss based upon their and TPNRD's information. These NRDs visited and tracked these sites and provided information that water was diverted into the pits through the final day of excess flow diversion. During the spring 2011 event, the WID diversion data and the number of total days each pit received water were used to complete the canal loss calculation to incorporate the recharge pits. The calculation was carried out starting on the last day of excess flow diversion and moved backward in time until the correct number of diversion days for each pit had been achieved.

Using additional SPNRD records, it was assumed that all pits diverted for the entire canal excess flow diversion events of 2013 and 2014 events. The excess flow diversion in 2014 occurred during the irrigation season, so only recharge into the pits was credited.

Possible Additional Refinements

During the completion of the SPNRD analysis, some additional discrepancies were identified in the data, and several additional changes were made to the process.

- Differences in diversion data obtained from DNR at different times were discovered; discrepancies also existed between data in the TM and data requested from DNR after the publication of the TM. Differences in preliminary and final data may account for this issue. Potentially, NRDs may need access to the method utilized by DNR for adjusting preliminary/raw diversion records to ensure a more accurate estimate of the canal recharge that the NRDs can use for planning purposes and before the payment to the irrigation district or canal company is completed.
- Adjustments in diversion data and the removal of pit diversion volumes sometimes resulted in negative canal recharge values. These issues require a more extensive investigation of the data and methods.
- For some excess flow events, canal loss was estimated over a relatively extended period but with few return flow records. In a few cases, only one return flow measurement was obtained. Because of the minimal return flow measurements, the average canal loss estimate may not represent the individual canal's actual average for the entire event.

Robust Review Analysis Review

During the final edits to the RR scope of work, the POAC TC decided that the Canal Recharge Project task utilize the WWUMM and COHYST model's calibrated canal leakage estimates for each canal to determine the total amount of recharge that occurs during excess flow diversion events. Simply, the analysis will remove these diversions and subsequent canal recharge from the modified modeling for each canal to determine the accretive effects. Total recharge for WID will need to account for the recharge pits by removing the total pit diversions from the overall headgate diversions before the calculation of the canal recharge using the models.

Robust Review Analysis Discussion

As provided above, the TM's analysis to determine the amount of canal recharge that occurs differs from the RR design. The RR scope of work did not incorporate the return flow spill measurements for each canal as part of the analysis. The POAC TC will need to determine if this data is appropriate to utilize or if the calibrated modeled estimates of canal leakage are suitable.

Our recommendation is to independently review each canal during each diversion event to determine whether the calculated canal loss TM's methodology, the modeled estimates of irrigation season canal loss, or a combination of the two are appropriate. While this is time intensive and somewhat subjective, a one size fits all recommendation is not possible because either the TM's canal loss calculation or the modeled estimates may not be appropriate. Table 1 is an evaluation of each canal within WWUMM area and provides an updated version of TM calculated canal loss using the finalized DNR diversions, the number of spill measurements, modeled canal loss, our recommendation of the canal loss to use, and an explanation of the criteria we used to determine the recommended canal loss. We completed this for the WWUMM area due to our familiarity with the system. However, for the COHYST area, we recommend that someone with more extensive knowledge of that system complete a similar evaluation.

Memo

Table 1: WWUM Modeling Area 2011 Spring Assessment of Canal Loss Calculations, Recommended Canal Loss, and Explanation

Canal	Updated TM Canal Loss %	Number of Spill Measurements	Modeled Canal Loss %	Recommended Canal Loss % to Use	Recommended Canal Loss %	Explanation of the Criteria for the Recommendation
Pathfinder	40%	1	55%	Modeled	55%	There was only a single spill measurement taken at the Pathfinder Spill. However, there is no data for the other Pathfinder spill locations to determine if there were additional spills.
Farmers	45%	3	49%	Modeled	49%	There were three spill measurements. However, two measurements only recorded spills at Red Willow Creek at the end of the canal, and one measurement measured Winters Creek and Red Willow Creek. We personally know they spilled some water into Nine Mile Creek. The canal has several other spills points, and the dataset does not provide any information on whether spills occurred at these locations.
Enterprise	69%	3	42%	Modeled	42%	There were three spill measurements with decent distribution during the excess flow diversion. However, one measurement recorded spill at Tub Springs Creek and two measurements measured at Winters Creek at the end of the canal. There is no additional information on whether the Tub Springs or Winters Creek spills were active during each other measurement.
Minatare	24%	4	41%	Measured	24%	Minatare Canal had a decent number of spill measurements between 4-5-2011 and 4-26-2011. The canal diverted between 4-1-2011 and 4-30-2011. This is an acceptable resolution to determine the canal loss.
Castle Rock	41%	3	41%	Average of Measured and Modeled	41%	Castle Rock Canal had a decent number of spill measurements between 4-13-2011 and 4-26-2011. However, the canal diverted from 4-3-2011 and 5-3-2011. Because of the narrow date range of the spill measurements the measurements were averaged with the modeled estimate of canal loss.
Chimney Rock	45%	4	42%	Measured	45%	Chimney Rock Canal had a decent number of spill measurements between 4-4-2011 and 4-26-2011. The canal diverted between 4-1-2011 and 5-1-2011. This is an acceptable resolution to determine the canal loss.
Nine Mile	96%	1	41%	Average of Measured and Modeled	68%	There was only a single spill measurement taken at Nine Mile Spill. However, with only one measurement on 4-21-2011, there is not sufficient data to determine if the canal leakage was realistic, so the measured and modeled data were averaged.
Belmont	53%	3	38%	Measured	53%	Belmont Canal had a decent number of spill measurements between 4-4-2011 and 4-20-2011. The canal diverted between 4-1-2011 and 5-1-2011. This is an acceptable resolution to determine the canal loss.
Lisco	24%	1	41%	Average of Measured and Modeled	33%	There was only a single spill measurement taken at Lisco Spill. However, with only one measurement on 4-19-2011, there is not sufficient data to determine if the canal leakage was realistic, so we averaged the measured and modeled data.
Central	25%	0	42%	Modeled	42%	There were no spill measurements taken for Central Canal. The spreadsheet associated with the TM provides an estimated number. However, the estimated number was ignored as well, and 25% was used. We disregarded both these numbers and used the modeled estimate for canal leakage.
Western	31%	11	37%	Corrected Measurements	31%	There were 11 measurements from 4-21-2011 through 5-31-2011 for Western Canal which is a decent resolution. To determine the canal loss, the original TM was corrected by using Western Canal's diversions instead of Kearney Canal's. Note: Contractually, 70% of the canal recharge goes to TPNRD and 30% goes to SPNRD
Western Canal Pits	100%	N/A	N/A	N/A	100%	TM assumed that all the recorded values were recharged at 100%

Memo

Table 2: WWUM Modeling Area 2011 Fall Assessment of Canal Loss Calculations, Recommended Canal Loss, and Explanation

Canal	Updated TM Canal Loss %	Number of Spill Measurements	Modeled Canal Loss %	Recommended Canal Loss % to Use	Recommended Canal Loss %	Explanation of the Criteria for the Recommendation
Minatare	17%	1	41%	Average of Measured and Modeled	29%	There was only a single spill measurement taken at the Minatare Canal spill. Because one measurement is not sufficient, the averaged measured and model data was used.
Castle Rock	45%	2	41%	Average of Measured and Modeled	43%	Castle Rock Canal had two measurements occurring on 10-10-11 and 10-17-11. Due to the limited number of measurements, the averaged measured and model data was used.
Chimney Rock	17%	2	42%	Average of Measured and Modeled	30%	Chimney Rock Canal had two measurements occurring on 10-10-11 and 10-18-11. Due to the limited number of measurements, the averaged measured and model data was used.
Nine Mile	96%	0	41%	Modeled	41%	No measurements were taken in the fall at Nine Mile Spill, so the modeled canal loss was used.
Belmont	63%	2	38%	Average of Measured and Modeled	51%	Belmont Canal had two measurements occurring on 10-12-11 and 10-18-11. Due to the limited number of measurements, the averaged measured and model data was used.
Lisco	56%	2	41%	Average of Measured and Modeled	49%	Lisco had two measurements occurring on 10-12-11 and 10-18-11. Due to the limited number of measurements, the averaged measured and model data was used.
Central	26%	2	42%	Average of Measured and Modeled	34%	Central had two measurements occurring on 10-11-11 and 10-17-11. Due to the limited number of measurements, the averaged measured and model data was used.
Winters	1%	2	41%	Average of Measured and Modeled	21%	Winters had two measurements occurring on 10-11-11 and 10-17-11. The spill measurement on 10-17-11 created a negative canal loss measurement and was ignored. Consequently, 1% loss was used as the measured amount. Due to the limited number of measurements, the averaged measured and model data was used.
Western	38%	3	37%	Measured	38%	Western Canal had 3 measurements in the fall which occurred on 10-17-11, 10-5-11, and 11-9-11. The measurement from 11-9-11 was ignored because it was a negative value. Due to the limited number of measurements, the averaged measured and model data was used. Note: Contractually, 70% of the canal recharge goes to TPNRD and 30% goes to SPNRD
Western Canal Pits	100%	N/A	N/A	N/A	100%	TM assumed that all the recorded values were recharged at 100%

Memo

Table 3: WWUM Modeling Area 2013 Fall Assessment of Canal Loss Calculations, Recommended Canal Loss, and Explanation

Canal	Updated TM Canal Loss %	Number of Spill Measurements	Modeled Canal Loss %	Recommended Canal Loss % to Use	Recommended Canal Loss %	Explanation of the Criteria for the Recommendation
Western	31%	3	37%	Duplicate Measurements	31%	Because there were no measurements for fall 2013 for Western Canal, the same canal loss % for fall 2011 was used. Note: Contractually, 70% of the canal recharge goes to TPNRD and 30% goes to SPNRD
Western Canal Pits	100%	N/A	N/A	N/A	100%	TM assumed that all the recorded values were recharged at 100%

B.1 Evaluation of Livestock Uses

B.1.1 Cattle Analysis- COHYST

8200 Cody Driver
Suite A
Lincoln, Nebraska 68512-9550

Phone: 402.435.5441
Fax: 402.435.7108

MEMORANDUM

To: POAC Technical Committee and Administrators

From: Marc Groff

Date: 8/7/2017

Re: Robust Review Cattle Number Summary – COHYST Modeling Area

Executive Summary

Task 1 of the current Robust Review Scope of Work (SOW) includes developing model runs which would incorporate changes to cattle on feed numbers over the 1997 baseline condition. At the time the SOW was developed, there was concern that cattle numbers across the Robust Review modeling domain may have increased significantly enough between 1997 and 2013 to impact results from the modeling effort. Prior to developing model input files for this scenario, the technical team developed estimates of how consumption would change based on changes in cattle population from 1997. The primary data source for this estimation effort was National Agricultural Statistics Service (NASS). Unfortunately, NASS did not request information related to the number of cattle on feed as part of its 1997 survey; however, NASS has requested total cattle inventory numbers continuously from 1997 through 2013. For this reason, the consumption estimates for the COHYST region are based on changes to total cattle (including calves) population estimates. The consumption related specifically to cattle on feed would be some fraction of the total estimated numbers provided below in Table ES-1.

Table ES-1. Estimated Change in Annual Water Consumption From 1997 Baseline Condition (Acre-Feet)

NRD	Average Difference	High Value (Year)	Low Value (Year)
CPNRD	-297	102 (1999)	-610 (2004)
TBNRD	-22	78 (2007)	-101 (2003 & 2005)
TPNRD	52	176 (2013)	-44 (2003)

For context, the average annual estimated consumption by crops of pumped ground water between 1985 and 2010 within the Twin Platte NRD portion of the COHYST model alone exceeded 245,000 acre-feet per year. The magnitude of the differences summarized in Table ES-1 are not likely to be noticeable in the overall modeling results. **For this reason, it is recommended that modeling files related to identifying impacts resulting from changes to cattle on feed numbers not be developed for further analysis as part of the Robust Review.**

Introduction

Task 1 of the current Robust Review SOW includes developing model runs which would incorporate changes to cattle on feed numbers over the 1997 baseline condition. At the time the SOW was developed, there was concern that cattle numbers across the Robust Review modeling domain may have increased significantly enough between 1997 and 2013 to impact results from the modeling effort. Prior to developing model input files which would be designed to account for impacts related to change in cattle on feed numbers, the technical team developed estimates of the expected changes in consumption related to the changes in cattle populations. This memorandum documents the methods used to develop that estimate over the COHYST modeling area of Robust Review project domain.

Methods

To estimate changes to water consumption related to changes in cattle on feed numbers, the general approach used in this analysis was to estimate consumption as a function of population. In October of 2008, the Nebraska Department of Natural Resources (DNR) used a similar approach in developing a document which examined cattle population changes from 1992 through 2007. That work was based on population estimates from the National Agricultural Statistics Service (NASS) and also identified a daily water use rate for cattle of 7 gallons per head (gph) per day.

To maintain consistency with that past work, information from NASS was again used for this analysis along with the daily water use rate of 7 gph. Unfortunately, NASS did not request information specifically related to the number of cattle on feed as part of its 1997 survey. NASS has, however, continuously from 1997 through 2013 requested information on total cattle (including calves) inventory. This appears to be the information summarized in the 2008 DNR analysis and was selected for use in this analysis. Figure 1 provides a screen shot of the query submitted via the web to NASS which returned the information used for this analysis.

The NASS information is aggregated at a county level basis. To develop summaries of the information by NRD, it was assumed that the cattle population statistics represented within the NASS dataset were uniformly distributed across a county. Information to suggest a different distribution or specific locations within a county where the estimated cattle numbers were located was not available. Using the uniform distribution assumption, it was possible to estimate cattle populations by NRD based on the percentage of a given county located within a given NRD. The county population statistic was distributed based on the percentage of a given county's area within a given NRD. Figure 2 shows the respective boundaries of the COHYST modeling boundary, NRD boundaries, and county boundaries within the focus area of this memo. Standard GIS techniques were used to determine the percentage of a given county within a given NRD.

After estimating the annual total number of cattle (including calves) per NRD, the population change relative to 1997 was calculated and an annual estimated change in water consumption was computed by multiplying the change in the number of head times 7 gph and converting to units of acre-feet to be consistent with the units used in other publications. The specific formula used was:

Eqn 1: *Population Change * 7 gph/day * 3.06889E-06 Acre-Feet/gal * 362.25 days/year*

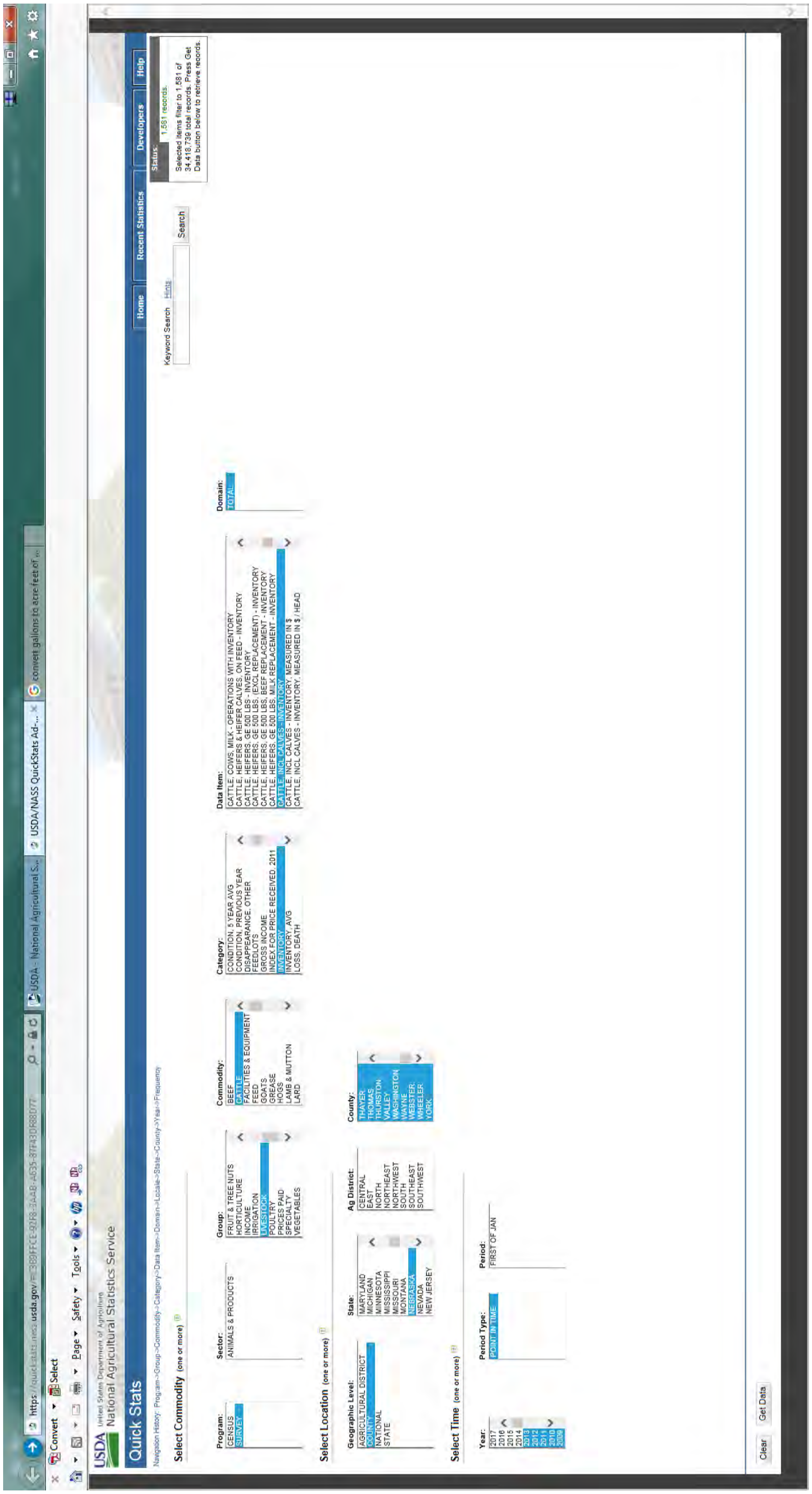


Figure 1: Web Query Screen Shot

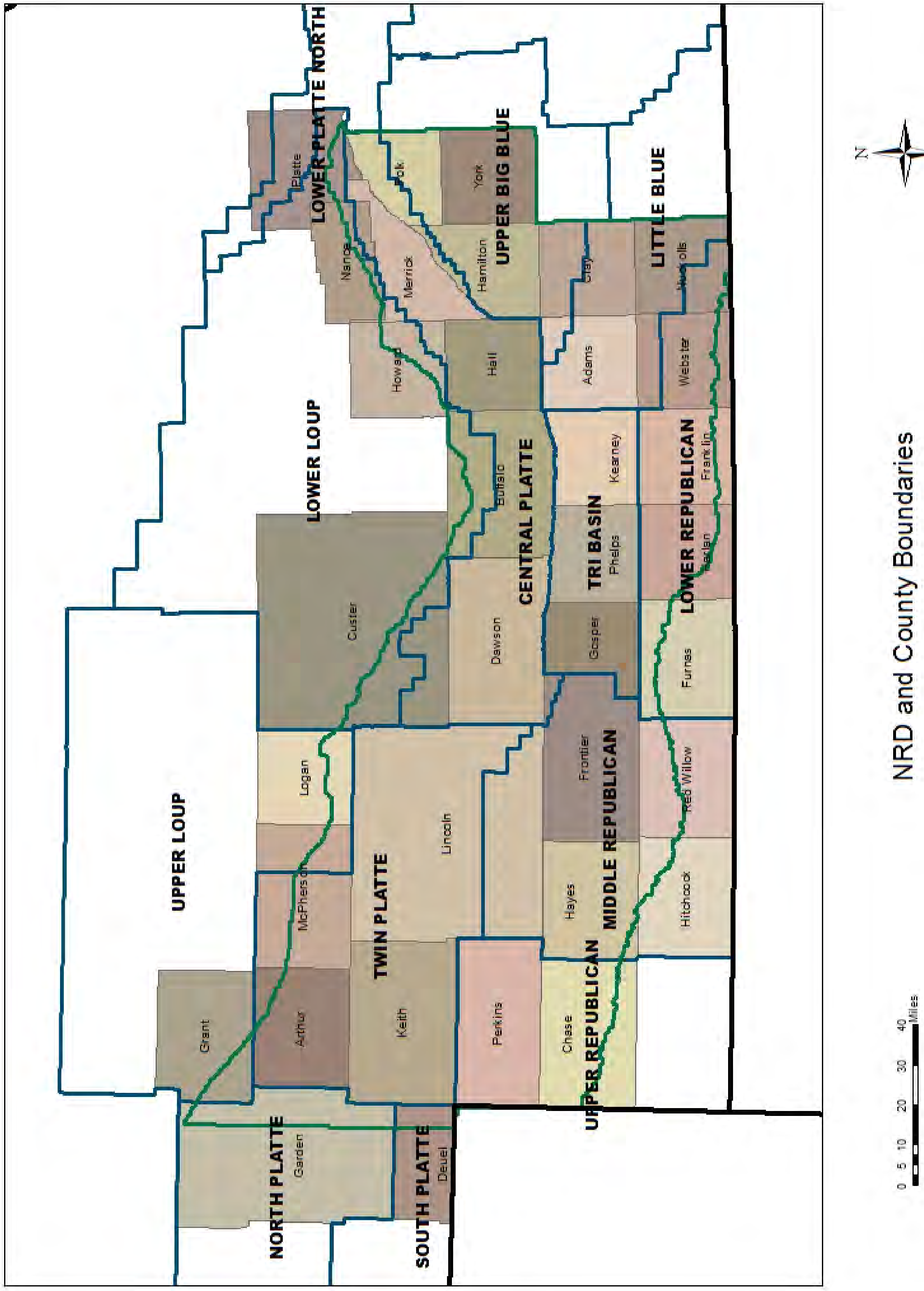


Figure 2: COHYST Model, County and NRD Boundaries

Results

Table 1 below summarizes the results of this analysis.

Table 1. Estimated Change in Annual Water Consumption From 1997 Baseline Condition (Acre-Feet)

NRD	Average Difference	High Value (Year)	Low Value (Year)
CPNRD	-297	102 (1999)	-610 (2004)
TBNRD	-22	78 (2007)	-101 (2003 & 2005)
TPNRD	52	176 (2013)	-44 (2003)

Table 1 was built up using the process described in the Methods section. Following are a series of tables which trace the process through those steps.

The results of the web query shown on Figure 1 for counties within the COHYST area of the Robust Review domain are shown on Table 2.

The estimates of cattle population by NRD developed from that information are shown on Tables 3-5. The percentages used to distribute each county's estimate to the NRD estimate is included on the table.

Table 6 lists the annual change in cattle populations by NRD from the 1997 baseline condition.

Table 7 lists the annual change in water use by NRD resulting from the cattle population changes shown on Table 6 and Eqn 1 discussed in the Methods section. The summaries presented above on Table 1 were taken from Table 7.

Table 2: Summary Of Nebraska Total Cattle Inventory (Including Calves) - Platte Basin COHYST Model Area

Source: Annual National Agricultural Statistics Service Surveys from 1997 through 2013

County	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
ARTHUR	38,000	38,000	37,000	36,000	35,000	33,000	30,000	30,000	33,000	33,000	36,000	31,500	31,000	30,500	31,000	31,000	25,500
BUFFALO	116,000	116,000	118,000	116,000	114,000	106,000	103,000	100,000	100,000	106,000	108,000	100,000	98,000	98,000	98,000	100,000	105,000
CUSTER	285,000	292,000	294,000	292,000	292,000	282,000	285,000	277,000	279,000	290,000	306,000	300,000	295,000	290,000	290,000	300,000	290,000
DAWSON	250,000	253,000	256,000	252,000	251,000	240,000	215,000	213,000	212,000	227,000	237,000	220,000	215,000	215,000	215,000	220,000	240,000
FRONTIER	72,000	79,000	79,000	72,000	66,000	60,000	55,000	57,000	59,000	61,000	64,000	58,000	57,000	57,000	57,000	58,000	57,000
GOSPER	36,000	33,000	33,000	32,000	30,000	28,000	26,000	27,000	27,000	29,000	28,000	25,000	24,500	24,500	24,000	25,000	27,000
HALL	80,000	79,000	81,000	79,000	80,000	77,000	77,000	74,000	72,000	77,000	81,000	85,000	84,000	84,000	83,000	85,000	69,000
HAMILTON	40,000	42,000	39,000	38,000	41,000	44,000	46,000	43,000	43,000	43,000	39,000	32,500	32,000	31,500	31,500	32,000	41,000
HOWARD	73,000	74,000	75,000	78,000	80,000	76,000	72,000	70,000	73,000	79,000	79,000	82,000	80,000	80,000	80,000	81,000	80,000
KEARNEY	85,000	90,000	86,000	83,000	83,000	83,000	82,000	77,000	77,000	78,000	81,000	80,000	78,000	78,000	78,000	80,000	82,000
KEITH	78,000	80,000	75,000	72,000	69,000	64,000	58,000	56,000	54,000	55,000	53,000	54,000	53,000	52,000	52,000	54,000	55,000
LINCOLN	189,000	206,000	202,000	204,000	211,000	210,000	215,000	225,000	228,000	235,000	227,000	245,000	240,000	240,000	240,000	245,000	270,000
MCPHERSON	38,000	41,000	41,000	42,000	43,000	42,000	43,000	43,000	43,000	42,000	45,000	42,000	41,000	41,000	41,000	42,000	36,500
MERRICK	81,000	80,000	79,000	78,000	73,000	66,000	60,000	63,000	66,000	70,000	69,000	58,000	57,000	57,000	57,000	58,000	45,000
NANCE	43,000	41,000	39,000	38,000	37,000	36,000	35,000	37,000	39,000	40,000	37,000	33,500	33,000	32,500	32,500	33,000	28,000
PHELPS	158,000	165,000	164,000	163,000	163,000	162,000	158,000	163,000	162,000	168,000	180,000	175,000	175,000	170,000	170,000	175,000	165,000
PLATTE	85,000	86,000	82,000	80,000	80,000	80,000	80,000	80,000	85,000	89,000	101,000	120,000	120,000	120,000	120,000	120,000	125,000
POLK	65,000	64,000	65,000	67,000	65,000	60,000	56,000	55,000	58,000	62,000	68,000	78,000	77,000	76,000	76,000	78,000	69,000
Total	1,812,000	1,859,000	1,845,000	1,822,000	1,813,000	1,749,000	1,696,000	1,690,000	1,710,000	1,784,000	1,839,000	1,819,500	1,790,500	1,777,000	1,776,000	1,817,000	1,810,000

Table 3
Annual Estimated Head of Cattle within the Central Platte NRD

Year	BUFFALO	CUSTER	DAWSON	FRONTIER	HALL	HAMILTON	HOWARD	NANCE	PHELPS	PLATTE	POLK	Total
1997	74,240	31,350	250,000	71,280	79,200	3,600	6,570	40,420	18,960	3,400	27,300	606,320
1998	74,240	32,120	253,000	78,210	78,210	3,780	6,660	38,540	19,800	3,440	26,880	614,880
1999	75,520	32,340	256,000	78,210	80,190	3,510	6,750	36,660	19,680	3,280	27,300	619,440
2000	74,240	32,120	252,000	71,280	78,210	3,420	7,020	35,720	19,560	3,200	28,140	604,910
2001	72,960	32,120	251,000	65,340	79,200	3,690	7,200	34,780	19,560	3,200	27,300	596,350
2002	67,840	31,020	240,000	59,400	76,230	3,960	6,840	33,840	19,440	3,200	25,200	566,970
2003	65,920	31,350	215,000	54,450	76,230	4,140	6,480	32,900	18,960	3,200	23,520	532,150
2004	64,000	30,470	213,000	56,430	73,260	3,870	6,300	34,780	19,560	3,200	23,100	527,970
2005	64,000	30,690	212,000	58,410	71,280	3,870	6,570	36,660	19,440	3,400	24,360	530,680
2006	67,840	31,900	227,000	60,390	76,230	3,870	7,110	37,600	20,160	3,560	26,040	561,700
2007	69,120	33,660	237,000	63,360	80,190	3,510	7,110	34,780	21,600	4,040	28,560	582,930
2008	64,000	33,000	220,000	57,420	84,150	2,925	7,380	31,490	21,000	4,800	32,760	558,925
2009	62,720	32,450	215,000	56,430	83,160	2,880	7,200	31,020	21,000	4,800	32,340	549,000
2010	62,720	31,900	215,000	56,430	83,160	2,835	7,200	30,550	20,400	4,800	31,920	546,915
2011	62,720	31,900	215,000	56,430	82,170	2,835	7,200	30,550	20,400	4,800	31,920	545,925
2012	64,000	33,000	220,000	57,420	84,150	2,880	7,290	31,020	21,000	4,800	32,760	558,320
2013	67,200	31,900	240,000	56,430	68,310	3,690	7,200	26,320	19,800	5,000	28,980	554,830
% in NRD	64%	11%	100%	4%	99%	9%	9%	94%	12%	4%	42%	

Table 4
Annual Estimated Head of Cattle within the Tri-Basin NRD

Year	GOSPER	KEARNEY	PHELPS	Total
1997	36,000	85,000	158,000	279,000
1998	33,000	90,000	165,000	288,000
1999	33,000	86,000	164,000	283,000
2000	32,000	83,000	163,000	278,000
2001	30,000	83,000	163,000	276,000
2002	28,000	83,000	162,000	273,000
2003	26,000	82,000	158,000	266,000
2004	27,000	77,000	163,000	267,000
2005	27,000	77,000	162,000	266,000
2006	29,000	78,000	168,000	275,000
2007	28,000	81,000	180,000	289,000
2008	25,000	80,000	175,000	280,000
2009	24,500	78,000	175,000	277,500
2010	24,500	78,000	170,000	272,500
2011	24,000	78,000	170,000	272,000
2012	25,000	80,000	175,000	280,000
2013	27,000	82,000	165,000	274,000
% in NRD	100%	100%	100%	

Table 5
Annual Estimated Head of Cattle within the Twin Platte NRD

Year	ARTHUR	KEITH	LINCOLN	MCPHERSON	Total
1997	38,000	78,000	137,970	25,460	279,430
1998	38,000	80,000	150,380	27,470	295,850
1999	37,000	75,000	147,460	27,470	286,930
2000	36,000	72,000	148,920	28,140	285,060
2001	35,000	69,000	154,030	28,810	286,840
2002	33,000	64,000	153,300	28,140	278,440
2003	30,000	58,000	156,950	28,810	273,760
2004	30,000	56,000	164,250	28,810	279,060
2005	33,000	54,000	166,440	28,810	282,250
2006	33,000	55,000	171,550	28,140	287,690
2007	36,000	53,000	165,710	30,150	284,860
2008	31,500	54,000	178,850	28,140	292,490
2009	31,000	53,000	175,200	27,470	286,670
2010	30,500	52,000	175,200	27,470	285,170
2011	31,000	52,000	175,200	27,470	285,670
2012	31,000	54,000	178,850	28,140	291,990
2013	25,500	55,000	197,100	24,455	302,055
% in NRD	100%	100%	73%	67%	

Table 6
Annual Change in Total Head of Cattle From 1997 Basline Conditions

Year	Central Platte NRD	Tri-Basin NRD	Twin Platte NRD	3 NRD Area
1997	0	0	0	0
1998	8,560	9,000	16,420	33,980
1999	13,120	4,000	7,500	24,620
2000	-1,410	-1,000	5,630	3,220
2001	-9,970	-3,000	7,410	-5,560
2002	-39,350	-6,000	-990	-46,340
2003	-74,170	-13,000	-5,670	-92,840
2004	-78,350	-12,000	-370	-90,720
2005	-75,640	-13,000	2,820	-85,820
2006	-44,620	-4,000	8,260	-40,360
2007	-23,390	10,000	5,430	-7,960
2008	-47,395	1,000	13,060	-33,335
2009	-57,320	-1,500	7,240	-51,580
2010	-59,405	-6,500	5,740	-60,165
2011	-60,395	-7,000	6,240	-61,155
2012	-48,000	1,000	12,560	-34,440
2013	-51,490	-5,000	22,625	-33,865

Table 7
Estimated Annual Change in Water Consumption From 1997 Basline Conditions (Acre-Feet)

Year	Central Platte NRD	Tri-Basin NRD	Twin Platte NRD	3 NRD Area
1997	0	0	0	0
1998	67	70	128	264
1999	102	31	58	192
2000	-11	-8	44	25
2001	-78	-23	58	-43
2002	-306	-47	-8	-361
2003	-577	-101	-44	-722
2004	-610	-93	-3	-706
2005	-589	-101	22	-668
2006	-347	-31	64	-314
2007	-182	78	42	-62
2008	-369	8	102	-259
2009	-446	-12	56	-401
2010	-462	-51	45	-468
2011	-470	-54	49	-476
2012	-374	8	98	-268
2013	-401	-39	176	-264
Average	-297	-22	52	-267

B.1.2 Confined Livestock Feeding Facility Pumping- WWUM

Memo

Adaptive Resources, Inc.

To: John Berge, General Manager NPNRD, Rod L. Horn, General Manager SPNRD, and Platte Basin Water Project Coalition

From: Thad Kuntz, P.G., Heath Kuntz, and Joe Reedy, G.I.

CC:

Date: 7/26/2017

Re: Robust Review: Confined Livestock Feeding Facility Pumping

Introduction

Adaptive Resources, Inc. (ARI) is completed modifications to the baseline model run of the Western Water Use Management Modeling (WWUMM) under Task 1 of the Robust Review Project Analysis (RRPA). This task includes analyzing the confined livestock feeding facility or cattle feedlot operations pumping.

Pumping data for the analysis was obtained from the North Platte Natural Resources District (NPNRD) and the South Platte Natural Resources District (SPNRD) who started collecting records for these facilities between 2009 and 2011.

Metered Pumping Records

The NPNRD pumping records include 64 cattle feedlot facilities in the overappropriated North Platte Valley and Pumpkin Creek areas. NPNRD estimated the pumping for years where failed meters, no meter was in place, or no meter reading was completed. The estimates were based on the districtwide average measured head-day pumping multiplied by either the Nebraska Department of Environmental Quality (NDEQ) permitted head, or if the feedlot is too small, an owner reported maximum head. Appendix A, Table A1 provides all NPNRD records where black numbers represent actual meter readings, and red numbers represent NPNRD estimated pumping.

The SPNRD pumping records include 5 cattle feedlot facilities. Appendix A, Table A2 provides all annual SPNRD records.

Cattle Statistics and Estimated Pumping

A method to determine pumping before meter records use the United States Department of Agriculture (USDA) National Agricultural Statistics Survey (NASS) statistics to determine the total number of cattle on feed. However, the only statistics that are available from the USDA NASS is total cattle including calves per county per year. Table 3 provides the total cattle per year for each NRD starting in 1997.

Memo

Table 3: USDA NASS Annual Cattle Statistics Per NRD (Head including Calves)

	NPNRD	SPNRD		NPNRD	SPNRD
1997	429,688	102,000	**2006**	411,469	86,000
1998	449,393	104,000	**2007**	426,662	87,000
1999	453,637	102,000	**2008**	421,087	86,300
2000	453,637	98,000	**2009**	419,087	81,900
2001	448,637	94,000	**2010**	412,587	83,700
2002	432,419	89,000	**2011**	412,587	84,700
2003	415,200	85,000	**2012**	421,805	86,300
2004	411,931	82,000	**2013**	405,906	96,000
2005	412,444	84,000			

Estimated Pumping from Well Capacity Information

For the COHYST portion of the RRPA, The Flatwater Group estimated the number of cattle on feed based on the total pumping capacity of well(s) queried from the Nebraska Department of Natural Resources (DNR) well registration database that serves feeding facilities. In the NPNRD, there are a total 198 feedlot wells (multiple wells per feedlot). However, 68 of the 198 wells are not registered with DNR. Therefore, no pumping capacity data can be obtained from these wells, so consequently, we are not confident about providing an estimate using The Flatwater Group methodology.

Pumping Estimation Methodology

To provide the estimated consumptive use pumping for the confined livestock feeding facilities from 1997 through 2009 for NPNRD or 2010 for SPNRD, we used the reported pumping data to derive an estimated head in feedlots. The estimated head is compared to the NASS statistics to create a ratio to adjust the NASS statistics to represent the number of cattle in feedlots backward through time. The methodology was necessary as the only data available from 1997 through 2010 is the NASS total cattle.

The NPNRD pumping records from 2010 through 2013 was incomplete. To fill the incomplete records, a calculation using the NPNRD reported certification capacity and an estimated total pumping amount per head in gallons per day (GPD) was completed, as seen in the following equation.

$$\begin{gathered} Annual\ Capacity\ per\ Certification \times\ 7\ Gallons\ per\ Day \times\ 365.25\ Days \\ = Total\ Annual\ Pumping\ per\ Certification \end{gathered}$$

The document titled PPRIP COHYST AREA Livestock Population Analysis, provided in an email from Jessie Winter (Strom) of Nebraska Department of Natural Resources on April 7, 2017, listed the 7 GPD per head water use estimate as an assumption. The finalized total pumping per NRD (2010 through 2013) is provided in Table 6.

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Table 6: Revised Annual Total Pumping per NRD (Gallons)

	2010	2011	2012	2013
NPNRD	894,164,617	784,305,372	865,235,670	844,237,764
SPNRD		103,612,952	163,038,542	148,280,636

Note: SPNRD values were not revised, as capacity information was not available for certifications/wells that were missing data.

To estimate the number of cattle in feedlot facilities per year for each NRD, the revised annual total pumping was divided by 7 GPD per head and 365.25 days. This estimate was compared to the NASS statistics of each NRD to develop a ratio of metered pumping cattle numbers to NASS statistics, provided in Tables 7 and 8.

Table 7: Comparison of NPNRD Pumping Estimated and USDA NASS Cattle Numbers (Head)

	2010	2011	2012	2013	Average
NPNRD	349,727	306,759	338,412	330,200	331,274
NASS	412,587	412,587	421,805	405,906	413,221
Ratio	85%	74%	80%	81%	80%

Table 8: Comparison of SPNRD Pumping Estimated and USDA NASS Cattle Numbers (Head)

	2011	2012	2013	Average
SPNRD	40,525	63,768	57,996	54,096
NASS	84,700	86,300	96,000	89,000
Ratio	48%	74%	60%	61%

The historical USDA NASS data were adjusted using the average ratio for each NRD (80% for NPNRD and 61% for SPNRD). Table 9 provides the adjusted and revised pumping estimated cattle numbers.

Table 9: Adjusted Annual Cattle Numbers per NRD (Head)

	NPNRD	SPNRD		NPNRD	SPNRD
1997	344,495	61,931	**2006**	329,888	52,216
1998	360,293	63,145	**2007**	342,069	52,823
1999	363,696	61,931	**2008**	337,599	52,398
2000	363,696	59,502	**2009**	335,995	49,727
2001	359,687	57,073	**2010**	349,727	50,820
2002	346,684	54,037	**2011**	306,759	40,525
2003	332,880	51,609	**2012**	338,412	63,768
2004	330,259	49,787	**2013**	330,200	57,996
2005	330,670	51,002			

Memo

Using the adjusted annual cattle numbers per NRD the annual cattle consumptive use pumping was calculated before being distributed to the final pumping dataset. The calculated consumptive use pumping values are shown in Table 10. The consumptive use was calculated with the following equation:

$$Annual\ Total\ Cattle\ per\ NRD\ \times\ 7\ Gallons\ per\ Day\ \times\ 365.25\ Days$$
$$= Total\ Cattle\ Water\ Consumptive\ Use$$

Table 10: Adjusted Annual Cattle Water Consumptive Use Pumping per NRD (Gallons)

	NPNRD	SPNRD		NPNRD	SPNRD
1997	880,786,468	158,341,064	**2006**	843,441,836	133,503,250
1998	921,179,944	161,445,790	**2007**	874,585,179	135,055,613
1999	929,878,768	158,341,064	**2008**	863,155,713	133,968,959
2000	929,878,768	152,131,610	**2009**	859,056,055	127,138,560
2001	919,629,622	145,922,157	**2010**	894,164,617	129,932,814
2002	886,384,648	138,160,340	**2011**	784,305,372	103,612,952
2003	851,089,844	131,950,886	**2012**	865,235,670	163,038,542
2004	844,389,048	127,293,796	**2013**	844,237,764	148,280,636
2005	845,439,864	130,398,523			

A comparison of 1997 estimated CAFO pumping to each successive year was conducted to understand any variability in estimated pumping through time. This comparison is demonstrated in Table 11. Positive values indicate greater pumping in that year, and negative values indicate less pumping as compared to 1997.

Table 11: Difference Between 1997 and Successive Year's Estimated Pumping for each NRD (Acre-Feet)

	NPNRD	SPNRD		NPNRD	SPNRD
1998	124	10	**2006**	-115	-76
1999	151	0	**2007**	-19	-71
2000	151	-19	**2008**	-54	-75
2001	119	-38	**2009**	-67	-96
2002	17	-62	**2010**	41	-87
2003	-91	-81	**2011**	-296	-168
2004	-112	-95	**2012**	-48	14
2005	-108	-86	**2013**	-112	-31

A review of the difference between estimated annual (1998-2013) pumping and estimated baseline (1997) pumping revealed relatively minor changes in consumptive use historically. As these changes represent a negligible portion of pumping that occurs in the system, there may be limited value to modeling these facilities.

Memo

APPENDIX A

Memo

Table A1: Annual Livestock Metered Pumping per Certification in NPNRD (Gallons)

Certification	2008 Gallons Used	2009 Gallons Used	2010 Gallons Used	2011 Gallons Used	2012 Gallons Used	2013 Gallons Used
1008	No Meter	6,596,700	1,348,700	917,300	589,200	1,269,600
1071	755,480	1,026,560	9,720	No Meter	No Meter	No Meter
1096	9,160,400	9,807,400	5,298,060	No Meter	No Meter	No Meter
1136	No Meter	4,659,000	70,602,390	1,242,310	450	0
1156	No Meter	248,460	0	527,070	231,740	198,180
1225	No Meter	8,542,480	1,279,670	7,223,820	702,660	477,490
1332	No Meter	2,569,580	12,532,470	5,283,600	4,938,270	1,031,170
1388			Failed Meter	32,028,750	19,162,500	24,637,500
1395	Failed Meter	Failed Meter	Failed Meter	Failed Meter	Failed Meter	Failed Meter
1434	No Meter	No Meter	1,260,160	1,019,560	6,832,990	5,552,780
1497	No Meter	3,076,010	2,671,800	2,463,700	2,795,970	2,021,400
1625	No Meter	50,031,245	35,856,857	4,303,909	37,651,736	59,130,000
1793	No Meter	No Meter	92,865,200	74,584,600	166,585,800	178,234,600
1840	No Meter	No Meter	2,373,720	7,421,780	10,800,210	12,294,560
2123	No Meter	1,218,100	19,675,100	14,355,600	18,895,700	20,815,300
2176	No Meter	1,125,900	3,964,600	2,149,900	3,832,500	4,974,300
2274	No Meter	100,284,200	100,993,500	2,330,600	2,299,500	2,541,700
2275	No Meter	1,189,100	7,286,600	7,419,500	10,828,800	12,070,418
2350	No Meter	1,911,700	10,064,100	11,621,600	10,219,800	11,732,900
2412	No Meter	No Meter	60,317,180	21,530,406	20,452,393	35,865,003
2491	No Meter	55,400	25,533,900	16,920,800	19,427,200	36,796,000
2501	No Meter	7,696,285	18,214,740	15,424,368	16,648,660	4,221,469
2516	No Meter	No Meter	185,100	178,100	104,900	345,100
2523	No Meter	No Meter	2,174,500	2,435,600	2,784,200	4,146,200
2634	No Meter	5,166,200	20,047,400	14,062,600	34,618,400	42,740,100
2667	No Meter	No Meter	13,225,200	21,503,000	5,330,000	3,963,400
2771	No Meter	No Meter	812,420	786,270	704,540	697,170
2826	No Meter	2,389,280	12,029,765	46,898,955	No Meter	No Meter
2837	No Meter	91,270	548,100	437,530	459,810	1,166,890
2874	No Meter	132,945,984	Not Read	6,405,750	3,832,500	4,927,500
2894	No Meter	86,590	808,880	8,030,470	8,171,410	7,832,780
2895	No Meter	43,380	67,410	86,140	30,180	13,580
2959	No Meter	12,066,390	17,587,520	49,211,900	Failed Meter	Failed Meter

Memo

Table A1 Continued: Annual Livestock Metered Pumping per Certification in NPNRD (Gallons)

Certification	2008 Gallons Used	2009 Gallons Used	2010 Gallons Used	2011 Gallons Used	2012 Gallons Used	2013 Gallons Used
2960	No Meter	594,700	1,137,900	1,528,800	1,022,000	1,314,000
2981	No Meter	683,330	321,320	229,100	299,230	569,200
3005	No Meter	16,145,660	40,744,251	66,213,291	88,467,732	62,415,000
3008	No Meter	1,784,018	1,673,881	2,877,564	2,059,685	6,570,000
3009	No Meter	152,171	218,318	879,464	457,816	8,212,500
3010	No Meter	2,772,966	1,925,436	5,484,999	11,879,115	3,285,000
3011	No Meter	2,334,375	1,631,847	1,951,504	No Meter	No Meter
3030	No Meter	21,021,106	15,450,735	21,071,504	7,125,406	9,523,595
3041	No Meter	1,299,070	2,203,140	5,614,360	5,290,390	2,428,340
3056	No Meter	No Meter	8,519,900	18,333,300	18,648,500	44,897,200
3073	No Meter	210,070	537,350	358,200	577,860	580,570
3079	No Meter	7,994,708	4,983,628	10,601,519	16,299,053	21,270,380
3095	No Meter	746,600	114,100	174,200	381,400	489,500
3101	No Meter	12,698,492	45,141,027	62,024,222	52,846,680	51,214,214
3171	No Meter	1,438,293	Not Read	19,217,250	19,162,500	14,782,500
3174	No Meter	92,500	4,864,560	5,414,950	3,176,430	3,089,480
3189	No Meter	No Meter	13,500	43,010	134,830	44,150
3190	No Meter	No Meter	8,778,900	8,477,300	8,900,000	7,850,500
3217	No Meter	19,267,700	21,457,700	16,926,000	15,394,700	18,645,800
3231	No Meter	No Meter	No Meter	21,447,274	35,131,415	1,504,740
3243	No Meter	211,950	412,190	271,330	177,540	229,360
3252	No Meter	2,064,600	3,467,600	3,625,700	2,373,900	2,477,900
3300	No Meter	1,093,780	1,998,040	1,341,520	1,611,510	1,459,130
3346	No Meter	3,031,800	5,197,900	6,365,000	8,838,700	7,223,000
3361	No Meter	1,439,162	2,375,975	219,947	42,965,774	12,661,910
3393	No Meter	No Meter	1,122,800	2,405,600	2,760,100	2,694,200
3401	No Meter	No Meter	9,594,600	158,300	5,122,200	5,287,000
3437	No Meter	91,000	2,017,500	1,680,300	806,400	860,800
3629	No Meter	4,195,890	5,059,632	5,957,913	5,529,831	4,069,977
3647	No Meter	No Meter	452,900	11,360,400	12,212,200	9,400,800
3648	No Meter	No Meter	30,162,224	87,748,200	29,957,470	1,162,901
Total Annual Pumping	9,915,880	454,191,157	761,213,617	768,807,509	808,542,388	785,910,739

Memo

Table A2: Annual Livestock Metered Pumping per Meter in SPNRD (Gallons)

Meter	2010 Gallons Used	2011 Gallons Used	2012 Gallons Used	2013 Gallons Used
7080962	13,273,015	70,163,960	93,967,407	85,278,035
6982485	10,393,700	12,720,000	13,644,800	13,644,800
6982484	4,863,100	12,675,700	14,168,800	12,286,200
8110115		7,075,592	37,113,935	33,841,300
8110738		977,700	4,143,600	3,230,300
Total Annual Pumping	28,529,815	103,612,952	163,038,542	148,280,636

B.2 Evaluation of Sandpits and Small Reservoirs

2019

Upper Platte River Basin Consumptive Use Change from New Reservoirs and New or Expanded Sandpit Lakes: 2005 to 2010

Amy Zoller
Kaku Ajaere
Andy Pedley
Water Planning Division
Nebraska Department of Natural Resources
6/7/2019

Table of Contents

Listing of Figures

Listing of Tables

Background

As part of its commitment to the Platte River Recovery Implementation Program (Program), the Nebraska Department of Natural Resources (NeDNR) estimates the cumulative impacts of new surface water-related activities within the State's portion of the Program area (**Figure 1**). NeDNR monitors most new surface water-related activities in Nebraska through the surface water permitting process; however, small waterbodies like sandpits used in gravel and sand mining, and reservoirs smaller than 15 acre-feet (af), do not require surface water permits. Thus, the Department has conducted the following study to estimate the cumulative impacts of new surface water activities attributed to these small waterbodies.

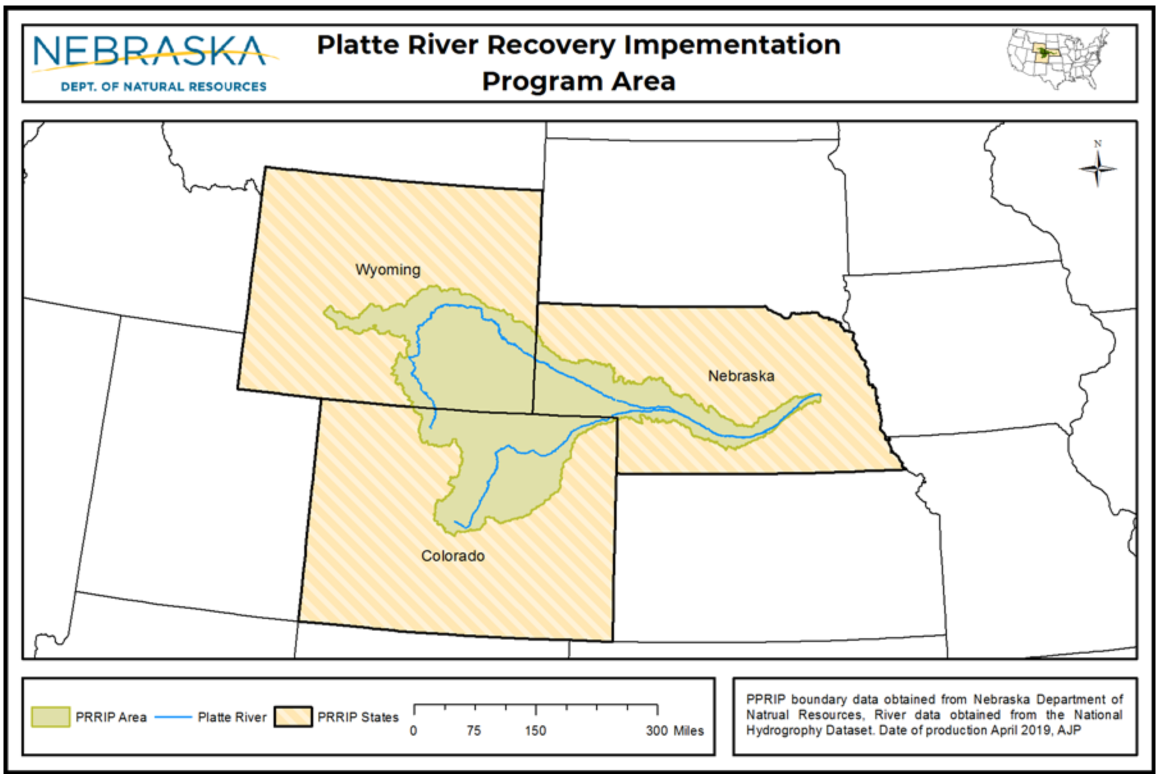

Figure 1. The Platte River Recovery Implementation Program in Nebraska, Wyoming, and Colorado.

History and Description of the Platte River Recovery Implementation Program

On July 1, 1997, the states of Nebraska, Colorado, and Wyoming, and the US Department of the Interior, entered into a cooperative agreement to address the needs of four target species: the endangered whooping crane, interior least tern, and pallid sturgeon, and the threatened piping plover, along the central Platte River Basin. As part of that agreement, a Governance Committee formed of representatives from the three basin states, the US Bureau of Reclamation, the US Fish and Wildlife Service (USFWS), water users, and environmental groups, developed the foundation for the Program. In early 2006, the Governance Committee presented a final program document, which provided direction regarding the management of land and water resources for the benefit of the four target species. The Program officially commenced on January 1, 2007 after the Secretary of the Interior and the governors of Nebraska, Wyoming, and Colorado signed the final Program agreement.

The Program brings together the involved states, federal agencies, water users, and environmental groups to work collaboratively to improve and maintain the associated habitats for the designated, target species, in 13-year increments. The first increment spanned the years 2007 to 2019 and utilized an adaptive management approach supported by data and scientific research. This has allowed the Program to test hypotheses and adjust goals and targets accordingly, throughout the first increment.

The three main elements of the Program are to:

- Increase stream flows in the central Platte River during relevant time periods
- Enhance, restore, and protect habitat lands for the target bird species
- Accommodate certain new water-related activities.

The Program's Adaptive Management Plan, Land Plan, and Water Plan support these elements. The Adaptive Management Plan sets the framework for how Program management uses the best available science and data. The Land Plan details the Program's long-term objective to acquire land interests for habitat restoration. The Water Plan is the road map developed to meet water goals of the Program.

The USFWS has established stream flow targets for the Platte River based on the habitat needs of the Program's target species. As part of the Program's Water Plan, each of the collaborating states and the federal government developed "Depletion Plans" that describe mitigation, offsets, or prevention of any new stream depletions that started after July 1, 1997, and with regard to target flows. Nebraska's New Depletion Plan covers the surface water basin within the state of Nebraska and above Columbus, NE, and will hereinto be referred to as the "study area" (**Figure 2**).

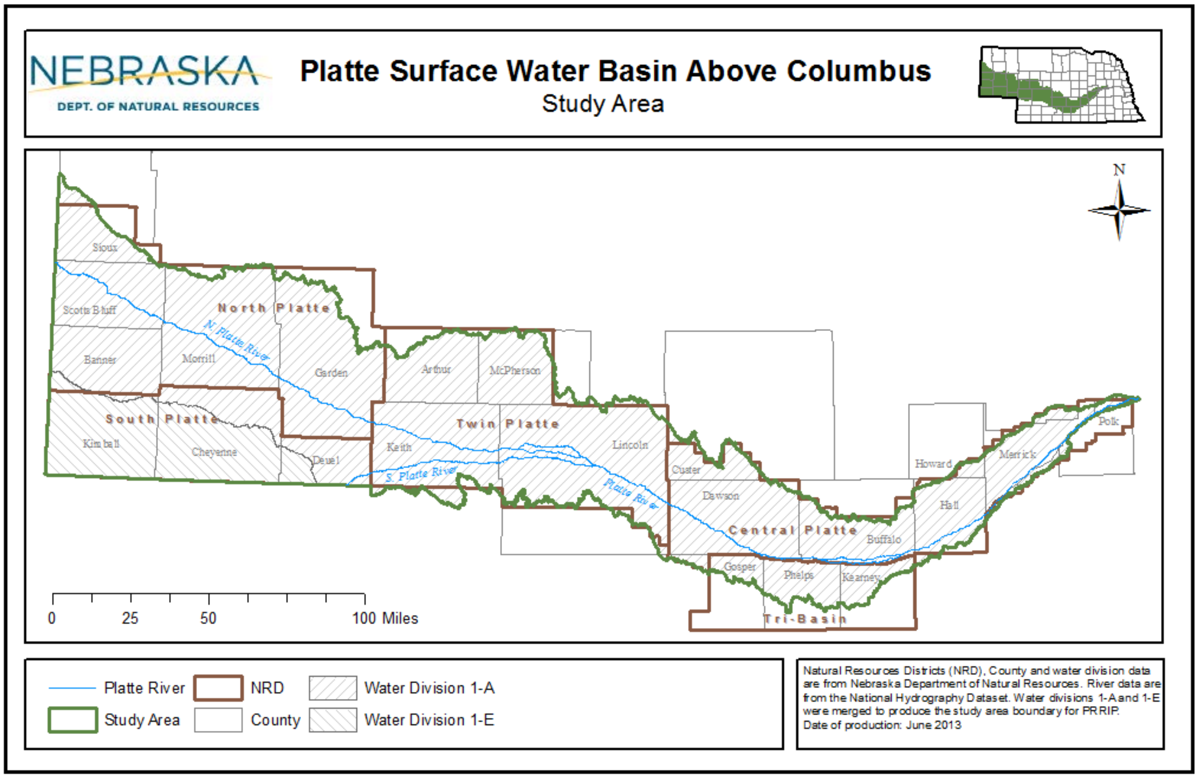

Figure 2. The study area consists of the Nebraska portion of the Program area, which is the Platte River Basin above Columbus, Nebraska.

In compliance with the Nebraska New Depletions Plan, the State must consider potential effects of new or expanded small water bodies on target flows. The purpose of this study is to assess the cumulative impact of new or expanded sandpit lakes and new, small reservoirs on target flows. This study has two overarching objectives:

1. Identify new or expanded sandpits and other small water bodies that do not require permits from NeDNR that occurred between the years 2005 and 2010.
2. Utilize the Natural Resources Conservation Service (NRCS) Evapotranspiration (ET) calculator to determine what water consumption impact, if any, could be attributed to the new or expanded small, unpermitted waterbodies.

2005 and 2010 waterbody inventories and change detection

Introduction

This section describes the work performed to create an inventory of 2005 and 2010 waterbodies. It details the procedures used to compare inventories in order to identify potential new reservoirs and new or expanded sandpit lakes, and then determine whether the new or expanded waterbodies had permits, plans or mitigation already in place. NRD staff provided local expertise to review and further refine the dataset. A geospatial layer of new reservoirs and new or expanded sandpits was finalized for subsequent consumptive use analyses.

Creation of the baseline (2005) waterbody inventory

In 2006, the NeDNR created a 2005 waterbody inventory to establish baseline conditions for this study. This GIS-based inventory was created using manual identification, digitization, and classification of waterbodies through interpretation of 2005 Farm Service Agency (FSA) orthophotography. NeDNR classified the waterbodies as follows:

- **Reservoirs** - Water bodies with a visible dam structure or those in upland drainages that had a linear edge perpendicular to an incised drain
- **Sandpits** - Human-made water bodies located within the flood plain of a river or stream
- **Lakes** - Irregular shaped water bodies in floodplains or upland depressions (not in a natural drain)
- **Miscellaneous** - Visible water bodies that do not fall into the other categories, including treatment plants, animal waste pits, etc.

The 2005 baseline inventory identified roughly 11,500 waterbodies (**Figure 3**). The methodology used in the creation of the 2005 baseline inventory was relatively labor intensive and required approximately 1,200 staff hours to complete.

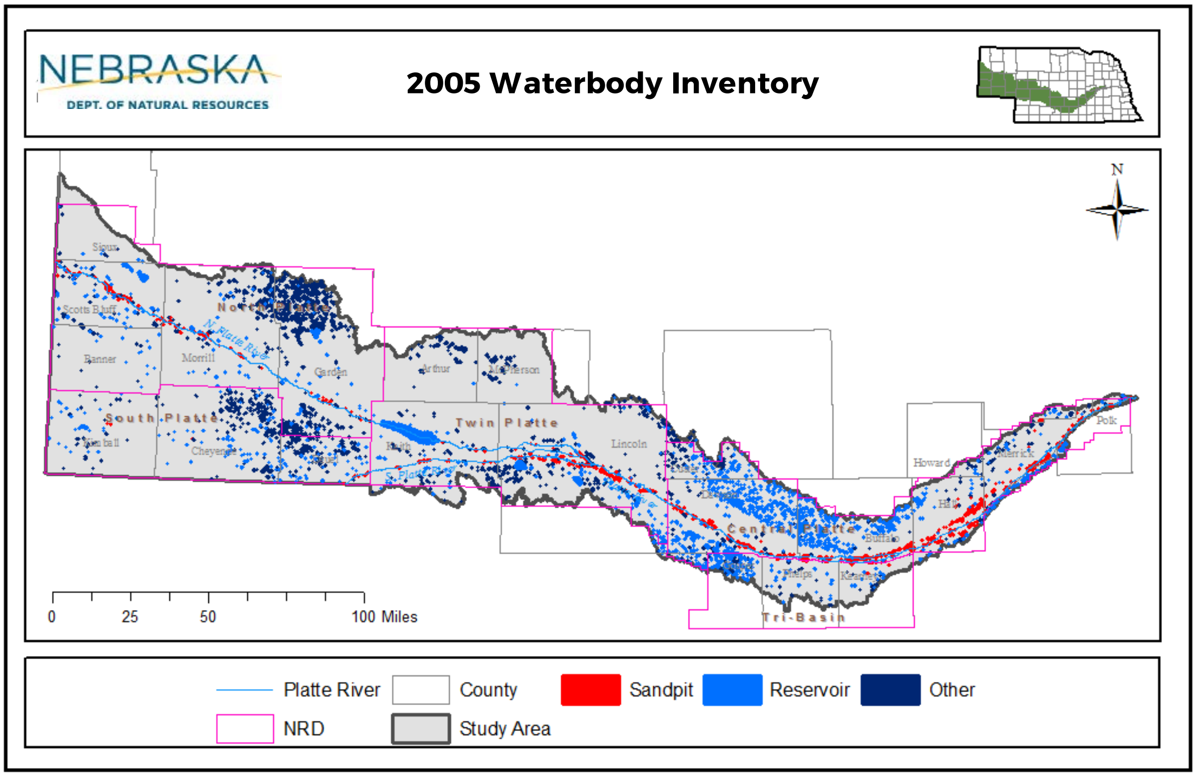

Figure 3. The 2005 waterbody inventory used as a baseline for the change analysis.

Creation of the 2010 waterbody inventory

<u>Preparation</u>

In 2011, and inventory of 2010 waterbodies was created using a semi-automated classification methodology. An initial comparison of 2005 and 2010 aerial imagery showed a considerable increase in waterbodies in 2010 due to it being a much wetter year than 2005. **Figure 4** shows FSA imagery of the same area in 2005 and 2010, and provides a visual example of the significant increase in surface water from 2005 to 2010. It was estimated that the 2010 inventory would take approximately 4,000 hours to complete if the same manual methods employed in 2005 were used. As such, a semi-automated classification was employed as a first-cut to identify waterbodies. This classification utilized 2010 FSA National Agriculture Imagery Program (NAIP) one-meter resolution aerial imagery to discriminate waterbodies based on the unique spectral reflectance characteristics of open water.

Figure 4. Aerial imagery showing differences in surface water between a drier year (2005, left) and a wetter year (2010, right)

County-level FSA images were combined using ERDAS IMAGINE software to create a single image of all counties within the study area. The Nebraska Sandhills region in the northern portion of the study area was removed because waterbodies in this region were assumed to be natural features. Because dataset size was an issue, the 2010 imagery mosaic was resampled to a resolution of 5-meters as visual inspection showed that 5-meter pixels were appropriate for the waterbody discrimination. This step greatly reduced the file size of the dataset.

<u>Classification</u>

To conduct the classification, values from the near infrared (NIR) band of FSA imagery were evaluated visually to determine the difference in NIR reflectance between vegetation and waterbodies. Reflectance values represent the amount of light at specific wavelengths (in this case near infrared) reflected back to the sensor by specific land cover type. Vegetation and waterbodies have uniquely different reflectance in the NIR band, which ranges from 0.7 to 1.2 micrometers in the electromagnetic spectrum. Vegetation has high reflectance in the NIR band, while open water has high absorption in this region. As a result, NIR reflectance values for vegetation are generally high while values for open water tend to be low.

A pixel-based threshold (0-128) was determined through visual inspection and used to isolate potential pixels that represented waterbodies. This threshold represented the left "tail" of the bell-shaped histogram of all land cover types and associated pixel values from 0-255 in the study area (**Figure 5**). Groups of contiguous pixels that would theoretically constitute a waterbody were then isolated and converted to polygons (shapes). Polygons smaller than 1-acre were removed as visual examination revealed that these were generally artifacts or ephemeral water bodies.

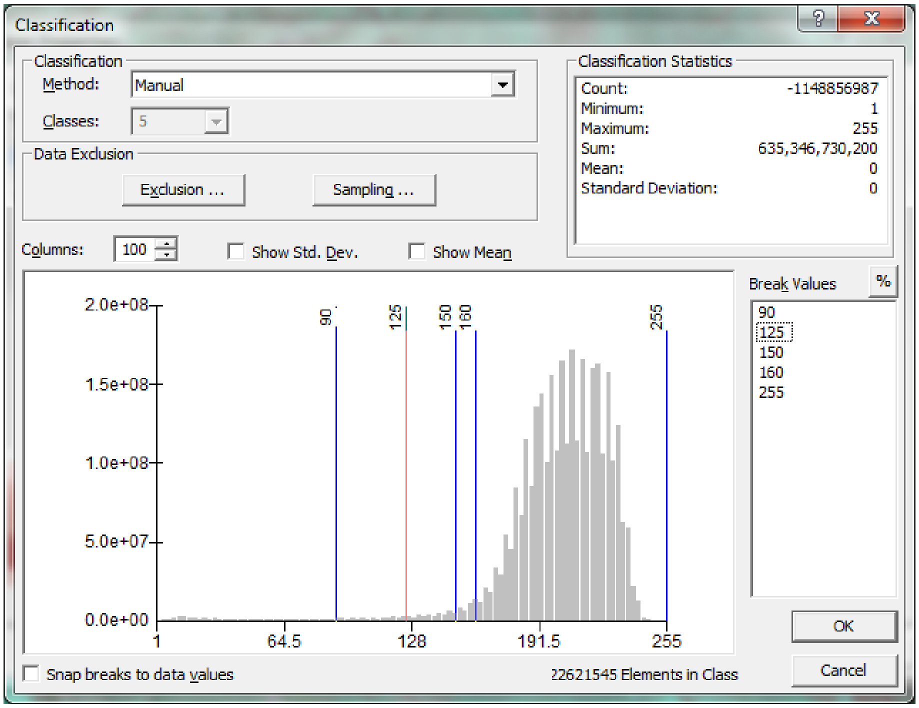

Figure 5. Histogram showing all near-infrared pixel values in the study area. Values of 0 to 128 were selected as a first-cut to isolate waterbodies.

An example of 2010 FSA imagery during the classification process is shown in **Figure 6**. In this image, waterbodies appear as black or very dark grey, indicating high levels of near-infrared absorption. Vegetation, on the other hand, appears light gray or white due to high reflectance in the near-infrared band. Of note, there were some issues with the classification of FSA imagery for this project. For example, high levels of suspended solids in some reservoirs produced confusion in the classification due to higher reflectance of soils and other particles within the waterbodies. Additionally, very wet soils, shadows of clouds, trains, and other features also had high absorption in the near-infrared spectrum and produced unwanted features (i.e. "artifacts").

There were also inconsistencies between aerial imagery tiles across the study area because FSA imagery is captured at different times and from different angles. Satellite-based imagery, which is acquired at the same time and from the same vantage point, generally produces more consistent classification results, but at the expense of resolution. Landsat imagery was considered for this study, but it was determined that the 30-meter resolution was not sufficient to discriminate small waterbodies. As such, the FSA approach was used to retain a fine spatial resolution (5 m after resampling); however, this approach did require substantial manual editing.

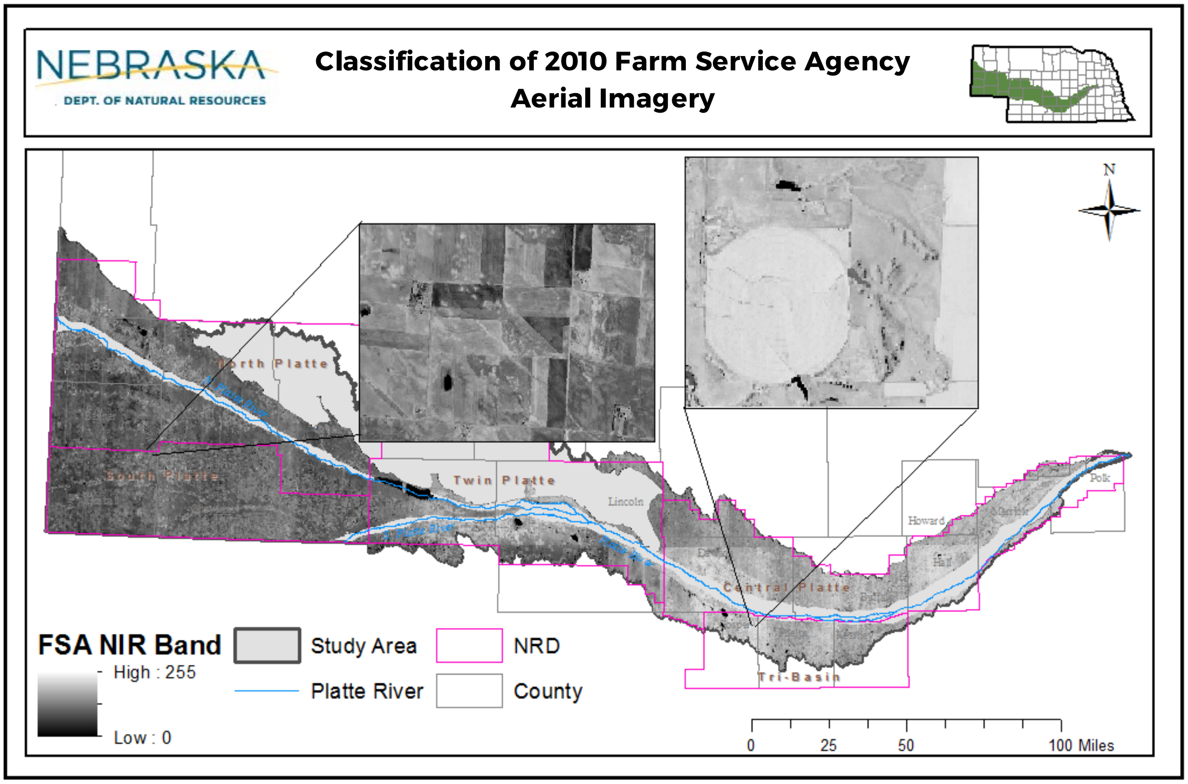

Figure 6. FSA aerial imagery near-infrared (NIR) band classification. Waterbodies appear dark grey or black due to strong absorption in the NIR band.

<u>Manual editing of first-cut waterbody features</u>

The initial image classification for the 2010 small waterbody inventory required substantial manual work. For this process, NeDNR staff members methodically reviewed the entire study area, using 1-meter FSA imagery as a backdrop to inspect and edit roughly 20,000 features. All scanning, editing, and digitizing occurred at a minimum scale of 1:10,000. GIS editing tools were employed to remove artifacts (e.g. shadows, wet soils) produced from the classification process. Likewise, editing tools were used to digitize “missing” waterbodies; e.g., waterbodies that were misclassified typically due to a high sediment content. The automated classification process performed the best for sandpit waterbodies, which are generally clear and have low levels of suspended materials, resulting in high absorption of the NIR wavelengths. Staff also categorized the waterbodies as they reviewed the dataset (discussed further in next section). **Figure 7** shows the results of the 2010 waterbody inventory, which included classification, manual editing, and categorization of the features.

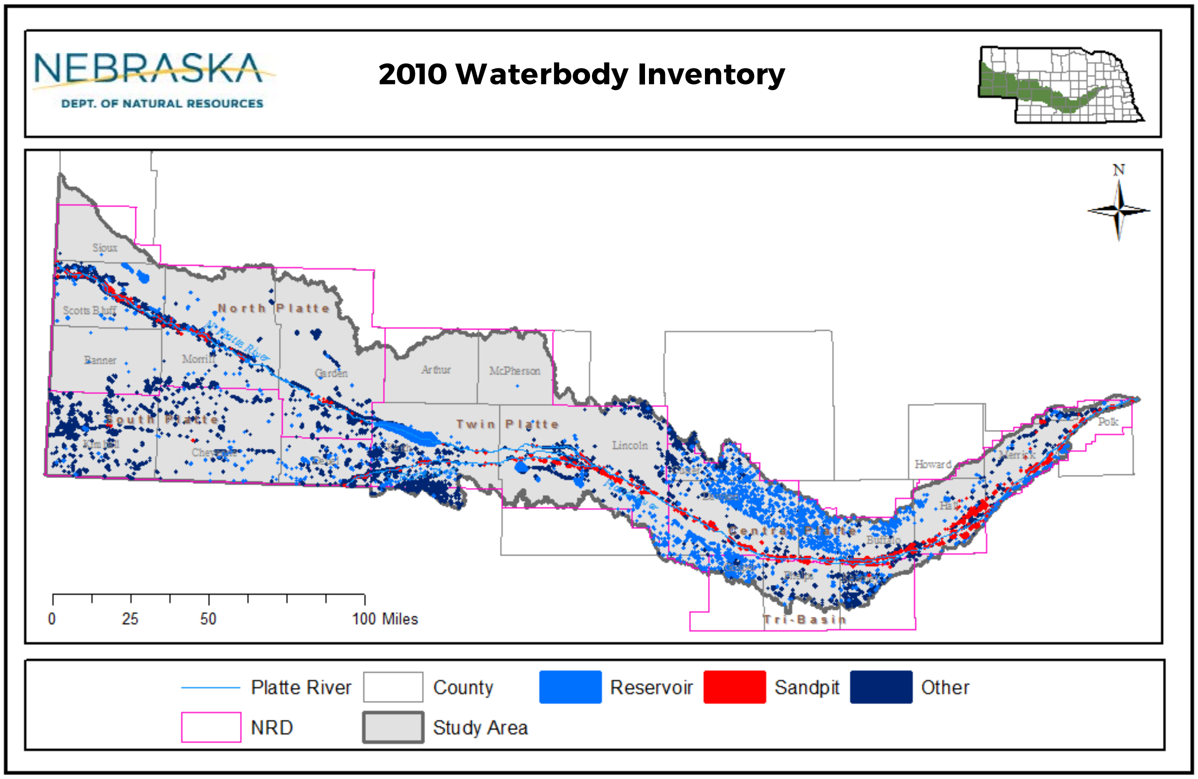

Figure 7. Classification and editing results of 2010 waterbodies.

<u>Categorization of Waterbodies</u>

During the editing process, staff categorized waterbodies based on 18 surface water classification as shown in **Table 1**. The process of categorizing these waterbodies took into consideration the shape, size, and association with other identifiable features, such as proximity to the Platte River, farmlands, or towns and cities. For example, staff categorized waterbodies that intersected streams and/or had visible embankments as "reservoirs"; and features within the Platte River valley that had the characteristic sandpit shape as "sandpits". Other feature classifications used to categorize waterbodies in this step included reuse pits, natural lakes, and water treatment facilities.

It should be noted that features in the 2005 waterbody inventory had been classified using four broad categories (lake, reservoir, sandpit, and miscellaneous), and therefore needed to be recategorized to match the 2010 waterbody categories. To accomplish this, staff kept the 2005 dataset in the GIS mapping project view and compared it with the 2010 inventory throughout manual editing. Waterbodies from both years were reviewed and edited as necessary to ensure features were lining up and that categories were consistent between the years.

After digitizing and initial categorization, staff merged the waterbody categories into six general categories: Active Sandpit, Inactive Sandpit, Reservoir, Feedlot, Industrial/Municipal, and Other (**Table 1**). Features classified as Feedlots, Industrial/Municipal, or Other were removed (but preserved as a supplemental dataset) from the database because the Department has other mechanisms in place to account for depletions due to these uses. Features categorized as Reservoirs or Sandpits (Active and Inactive) were retained for both the 2005 and 2010 datasets.

Table 1. Waterbody categories used in the 2010 inventory.

Waterbody Category	Generalized Category
Feedlot	Feedlot
Industrial	Industrial/Municipal
Municipal	
Golf Course	Reservoir
Reservoir	
Reservoir-off NHD and Large	
Urban Recreation	
Sandpit-active	Sandpit Active
Sandpit-inactive	Sandpit Inactive
Natural Lake	Other
Natural Other	
Natural Reservoir	
Other	
Question	
Re-use pond/Natural Field Depression	
Re-use pond-engineered with banks	
Water Backup from Road	
Watering Hole	

Waterbody Change Analysis: 2005 to 2010

Identification of potential new reservoirs and new or expanded sandpits

The 2010 waterbody inventory revealed 1,578 features classified as reservoirs and 1,005 features classified as sandpits. Staff overlaid the features onto the 2005 inventory layer to identify non-overlapping features, which would indicate potential new reservoirs, or new or expanded sandpits. From this overlay process, it was determined that there were 573 potentially new reservoirs and 185 sandpits with significant area change in 2010. In all, the first-cut change analysis dataset identified 758 potentially new or expanded waterbodies with a cumulative surface area of 3,723 acres (**Figure 8**).

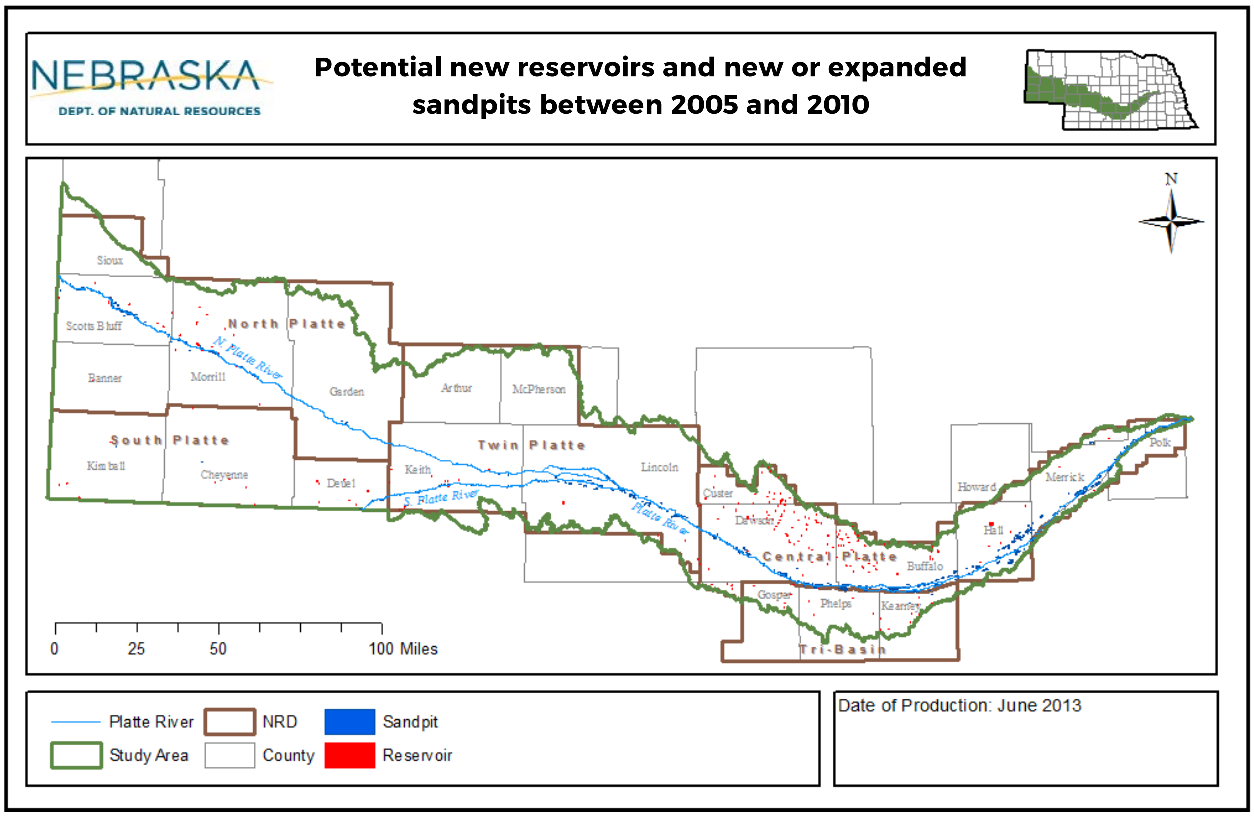

Figure 8. Map of potential new reservoirs or new or expanded sandpits between 2005 and 2010.

Evaluation of potentially changed waterbodies

Next, staff conducted additional research to determine if any of the potentially new or expanded waterbodies were actually new, and if so, if these had existing permits, plans, offsets, and/or mitigation. For reservoirs, staff utilized aerial imagery to evaluate whether potentially new reservoirs had embankments built between 2005 and 2010. Examples of two reservoirs with new embankments are shown in **Figure 9**. If there was a pre-existing embankment, the reservoir was removed from further analyses as it had had the capability to store water in 2005, even if there was no water present in that year. As a result, only 11 out of the 573 reservoirs identified in the first-cut analysis were determined to be "new" by the presence of a new embankment.

Figure 9. Aerial imagery from 2005 (left) and 2010 (right) shows enbankments and surface water from two new reservoirs, detected as a part of this study.

Reservoirs were then evaluated for existing permits to store water or for plans on file with NeDNR's dam safely section. It was determined that two of the reservoirs had either a surface water permit or a dam safety plan on file with NeDNR, and were therefore removed from the dataset. At this point, there were nine new reservoirs retained for further analysis regarding consumptive use.

The 185 sandpit lakes that had been determined to have significant area change from 2005 to 2010 were also reviewed. NeDNR records were reviewed to check if there were any pre-existing offsets in place. The sandpit lakes were visually inspected using aerial imagery to determine whether they had actually changed and what, if any, mitigation measures were already in place. **Figure 10** shows an example of mitigation that occurred for a sandpit lake between 2005 and 2010. Although the sandpit had increased in size due to expanded mining, there had been some filling in of the open water (mitigation) along one end of the sandpit. These areas of expansion and mitigation were separated geospatially and would be evaluated separately in the subsequent consumptive use analyses. Of the 185 sandpits with significant area change, 98 were determined to be sandpits with actual change. Of those, four had some level of mitigation in place.

Figure 10. An example of a sandpit lake from 2005 (top left), 2010 (top right), with both mitigation and expansion change (bottom left).

<u>Review of waterbody features by NRD staff</u>

As a final check, the geospatial dataset of new reservoirs and new or expanded sandpits was separated by NRD and sent to each respective NRD for review. An example of one feature identified as "changed" that had not actually changed, per NRD staff evaluation, is shown in **Figure 11**. In this instance, a sandpit lake had been identified as expanded, but NRD staff with local knowledge indicated that the enlarged shape was due to high stream flows that spilled into the lake. As such, this feature was removed from the "changed waterbody" database.

Figure 11. Example of a sandpit lake with a size increase that was not due to mining expansion, as identified by NRD staff.

<u>Synopsis of Procedure and Final Dataset for Changed Small Waterbodies</u>

A map displaying the final dataset of new reservoirs and new or expanded sandpit lakes for the entirety of the study area is shown in **Figure 12**. In all, 9 new reservoirs and 94 new or expanded sandpit lakes were identified within the PRRIP study area. The vast majority of these lie along the North Platte, South Platte, or Platte Rivers, with a few new reservoirs in or near South Platte NRD. The process of identifying these 103 total features was extensive and involved several steps. A synopsis of this change analysis and the number/area of features identified in each step is shown in **Table 2.**

In summary, the change analysis process started with a classification that yielded roughly 20,000 features for 2010, of which, many were artifacts with a reflectance similar to water. Staff members systematically analyzed these features and identified 2,500 reservoir or sandpit lake features. The analysis was then conducted by first overlaying the 2005 and 2010 waterbody inventories, which identified roughly 750 features as "potentially changed" from 2005. These features were verified through: 1) visual inspection of aerial imagery, 2) comparison to permits, plans and offset documentation on file with NeDNR, and 3) NRD staff review. In total, 103 features were retained for subsequent consumptive use analysis discussed in the next sections.

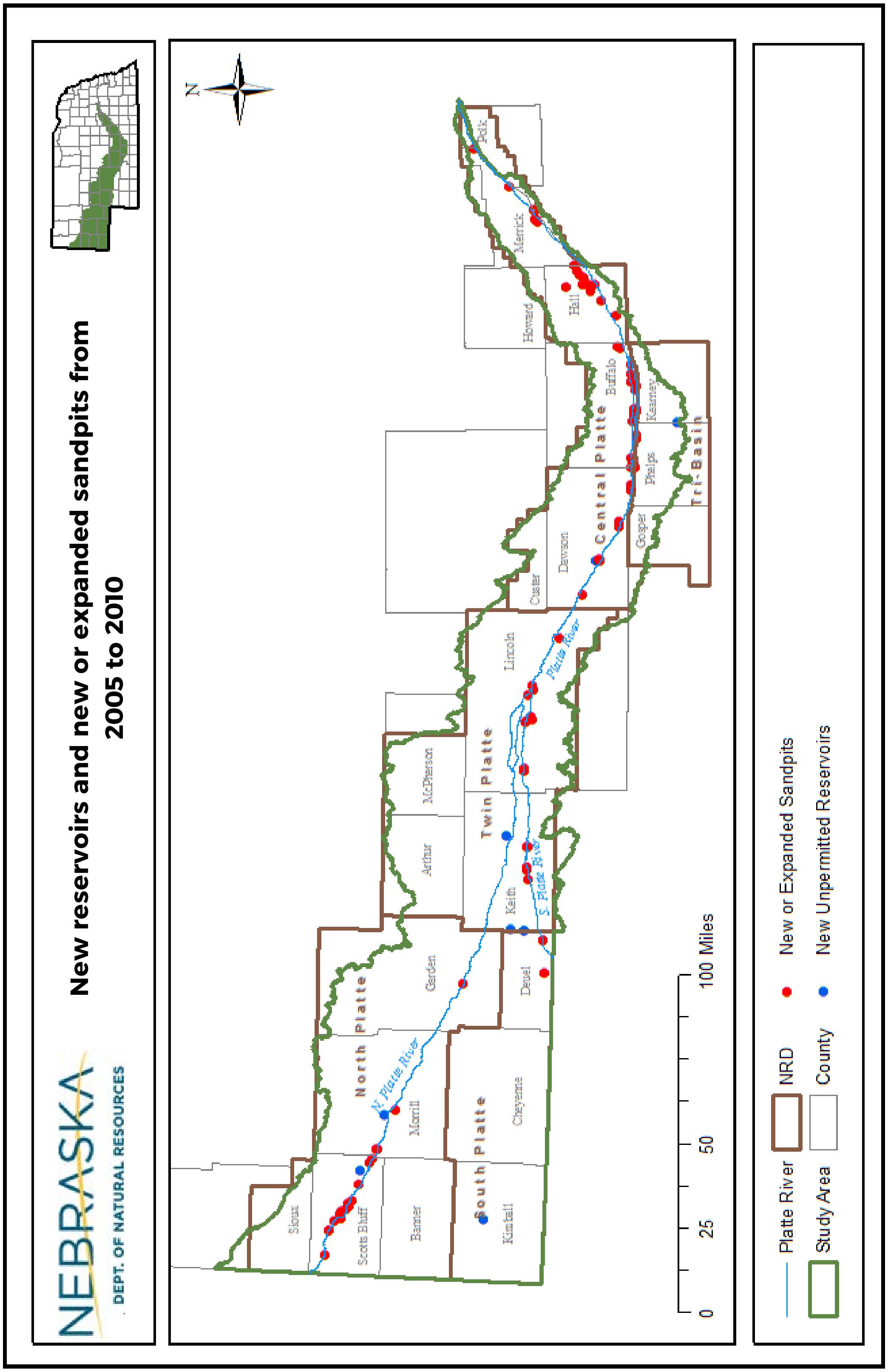

Figure 12. New reservoirs and new or expanded sandpits results between 2005 and 2010.

Table 2. Synopsis of change analyses and features/area in each step.

Change Analysis: Reservoirs		
Procedure	**Features**	**Area (acres)**
Reservoirs classified from 2010 imagery	1,578	45,507
Reservoirs with no overlap with 2005 inventory	573	1,521
Reservoirs with new embankments between 2005 and 2010	11	405
New reservoirs with permits between 2005 and 2010	(2)	386
New unpermitted reservoirs between 2005 and 2010	9	19
Change Analysis: Sandpit Lakes		
Procedure	**Features**	**Area (acres)**
Sandpits classified from 2010 imagery	1,005	8,050
Sandpits with area change from 2005	185	2,202
New/expanded sandpits (no offsets and post-visual inspection)	98	736
New sandpits with mitigation	(4)	8
New/expanded sandpits between 2005 and 2010	94	728

Consumptive Use (ET) Calculations for New or Expanded Waterbodies

The next step in evaluating the effects of changes in small waterbodies was to determine differences in ET due to the change from the prior land cover to open water. This was accomplished using the NRCS Consumptive Use Calculator (Calculator). The Calculator is Excel-based and has been used by the NRCS and USFWS for consumptive use calculations for biological opinions.

The Calculator uses reference crop ET that is translated to land use consumptive use using monthly coefficients that are hard-coded into the calculator. Estimation of consumptive use using this Calculator requires several inputs, including surface area, soil texture, land cover, and location within one of eight pre-defined climate zones.

Creation of Input Layers for the NRCS Consumptive Use Calculator

The following sections describe the process of creating the necessary inputs for the Calculator. Here, GIS data pertaining to soils, land cover, and climate zones were assembled and adapted for Calculator inputs.

<u>Soil texture</u>

The Calculator requires soil texture (relative percentage of sand, silt, and clay in soils) data for the location(s) where consumptive use calculations will be applied. For this study, GIS data to describe soil texture were acquired from the 1:250,000 State Soil Geographic Database (STATSGO). This widely used US dataset for soils has extensive data about soil characteristics, not only on the land surface, but also within the soil profile. For this study, information about soil textures at the surface was extracted for Calculator inputs. The entire study area was processed and then specific areas with new waterbodies were extracted for Calculator use. The STATSGO soil texture classifications were more refined than the Calculator pre-defined classes, so the STATSGO classes were reclassified for use as inputs for the Calculator. **Table 3** shows the reclassification scheme used to adapt STATGSO data for use in the Calculator, and **Figure 4** shows the spatial distribution of the soil texture (post-reclassification) for the entirety of the study area.

Table 3. STATSGO soil textures reclassification to adapt texture classes to the NRCS Consumptive Use Calculator.

STATSGO Soil Texture	NRCS Calculator Soil Texture
Fine Sand	Sand
Fine Sandy Loam	Sandy Loam
Sandy Loam	
Very Fine Sandy Loam	
Loamy Fine Sand	Loamy Sand
Loamy Sand	
Loamy Very Fine Sand	
Loam	Silt Loam
Silt Loam	

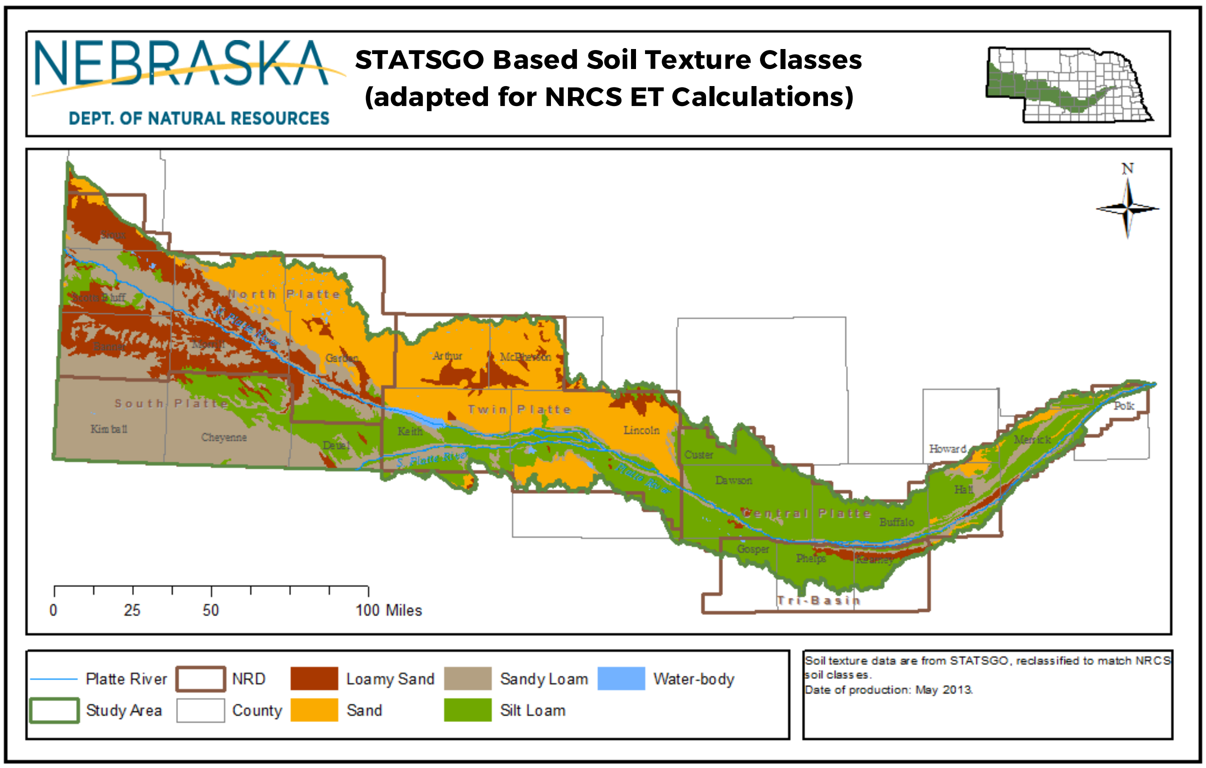

Figure 13. Spatial distribution of soil texture classes used to define soils at specific waterbody locations for consumptive use calculations.

<u>Land cover</u>

The Calculator provides 46 different land cover coefficients, including many vegetation types, bare soil, and open-water surfaces. Two statewide GIS data sources were used to determine land cover classes for use in the Calculator. The first GIS dataset that was used was the Center for Advanced Land Management Information Technologies (CALMIT) 2005 Land Use-Land Cover dataset, which is a 30-meter spatial scale raster dataset with 25 land cover classes that focus on agricultural crop types (**Figure 14**). The land use portion of CALMIT's 2005 dataset is also in vector format and provides information about irrigated vs. dryland agricultural areas. The CALMIT land cover/land use categories were reclassified to adapt to the Calculator categories as shown in **Table 4**.

The Calculator provided more options for grassland categories than did the CALMIT dataset, which was more focused on agricultural categories. As such, data from the 1993 UNL Conservation and Survey Division native vegetation map were utilized for areas where the CALMIT land cover class was either 'Range, Pasture, Grass' or 'Summer Fallow' (**Figure 14**). The native vegetation types were reclassified to correspond with the Calculator grassland options as shown in **Table 5**.

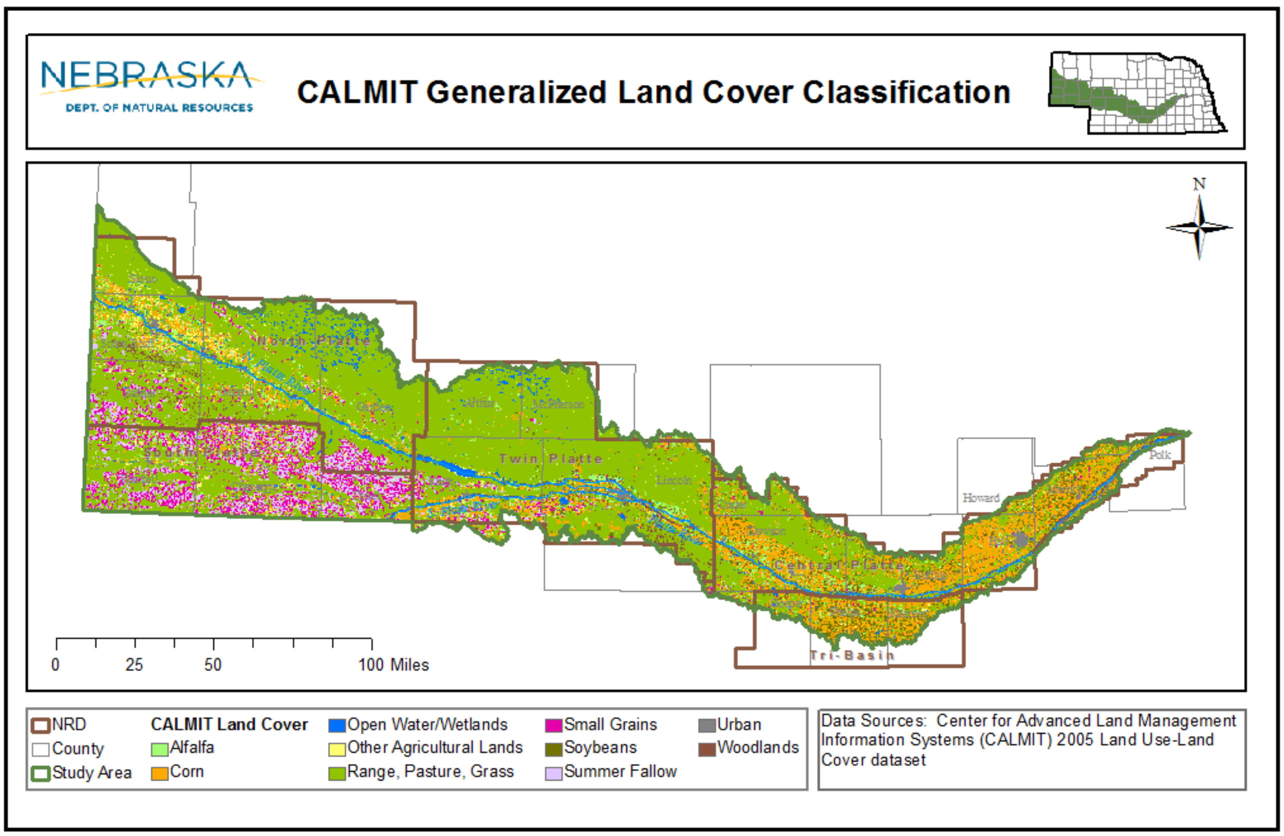

Figure 14. CALMIT land cover/land use dataset with generalized categories.

Table 4. Reclassification scheme for CALMIT land use-land cover adaption to Calculator categories.

CALMIT Land Use/Cover Class	NRCS ET Calculator Land Use/Cover Class
Dryland Alfalfa	Dryland Alfalfa
Irrigated Alfalfa	Irrigated Alfalfa
Barren	Bare Soil
Other Agricultural Land	
Roads	
Urban Land	
Dryland Corn	Dryland Corn
Irrigated Corn	Irrigated Corn
Irrigated Sugar Beets	
Irrigated Potatoes	
Range, Pasture, Grass	Refer to Table 4 for a breakdown of this land cover type
Summer Fallow	
Dryland Small Grains	Dryland Millet
Irrigated Small Grains	Irrigated Millet
Dryland Sorghum (Milo, Sudan)	Dryland Sorghum
Irrigated Sorghum (Milo, Sudan)	Irrigated Sorghum
Dryland Dry Edible Beans	Dryland Soybeans
Dryland Soybeans	
Irrigated Dry Edible Beans	Irrigated Soybeans
Irrigated Soybeans	
Dryland Sunflower	Dryland Sunflower
Irrigated Sunflower	Irrigated Sunflower
Open Water	Water (Deep)
	Water (Shallow)
Wetlands	Wet Tall Grasses
Riparian Forest and Woodlands	Trees (Average of Cottonwood and Willow)

Table 5. Reclassification scheme for UNL-CSD native vegetation adaption to Calculator categories.

UNL CSD Native Vegetation Types	NRCS Land Cover Class
Gravelly Mixed-grass Prairie	Grass Warm Short/ Grass Cool Short
Loess Mixed-grass Prairie	Grass Warm Tall
Lowland Tall grass Prairie	Grass Warm Tall/ Grass Cool Tall
Mosaic of Mixed-grass/Short grass Prairie	Grass Warm Short
Ponderosa Pine Forests and Savannas	Conifers
Riparian Deciduous Forests	Trees (Cottonwood and Willow)
Salt Marsh and Flats	Wetlands
Sand Hills Borders Mixed-grass Prairie	Grass Warm Mid
Sand Hills Mixed-grass Prairie	Grass Warm Mid
Upland Tall grass Prairie	Grass Cool Tall

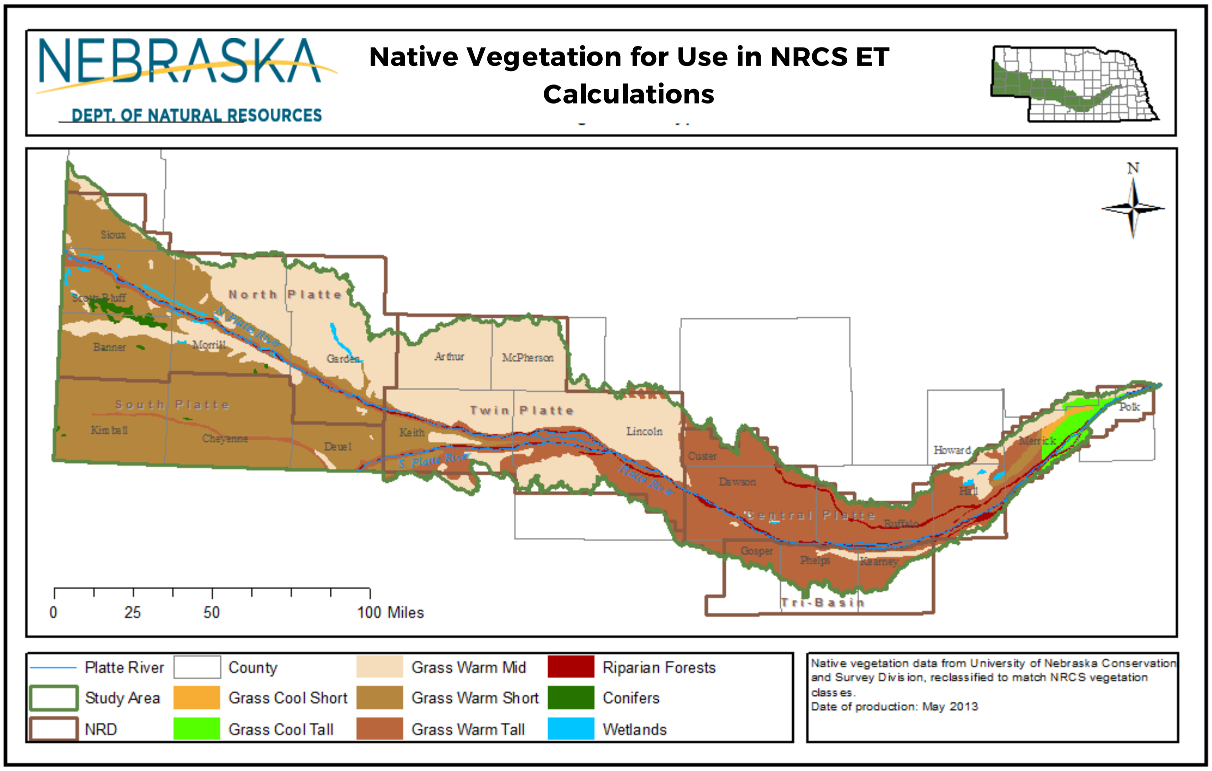

Figure 15. Spatial distribution of native vegetation in the study area; these were used to sub-divide grassland depicted in the 2005 CALMIT land cover dataset.

Climate zones

The NRCS consumptive use calculator documentation designates eight unique climate zones for the Platte River Basin, to be used for ET calculations (**Figure 16**). These areas have unique combinations of vegetation phenology, seasonal evaporation, and other climatic conditions.

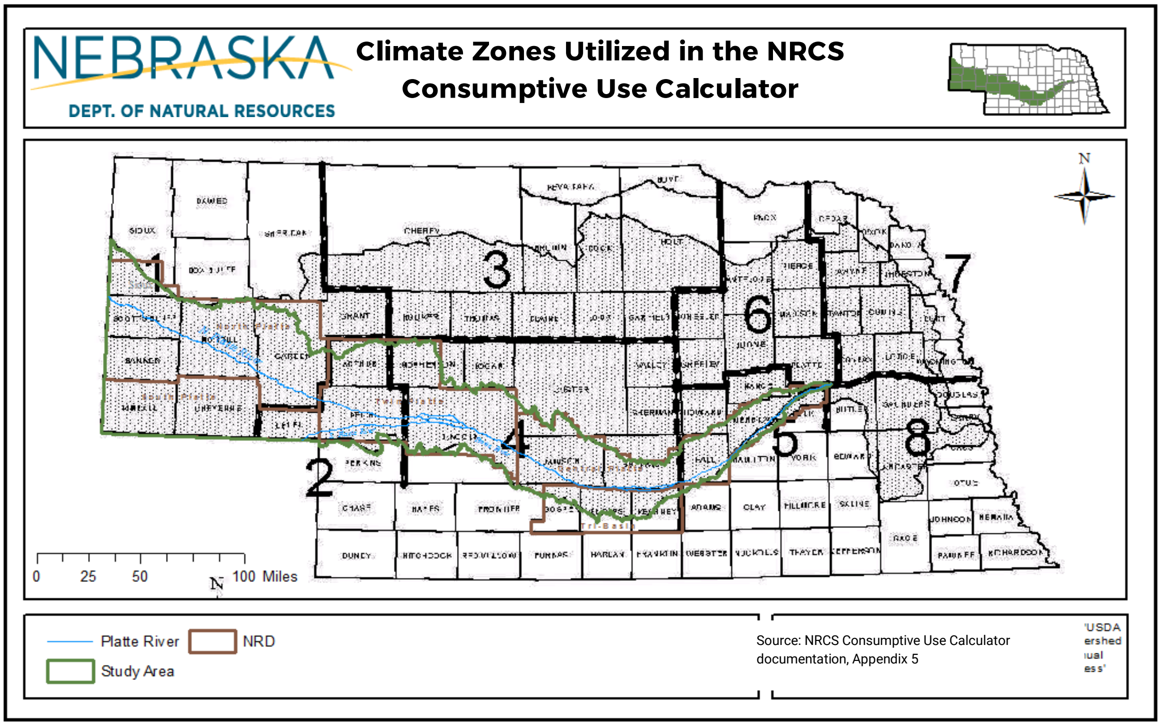

Figure 16. NRCS climate zones used in calculations of consumptive use for the study area.

Implementation of NRCS Calculator

The NRCS calculator was used to estimate ET for the 103 waterbodies identified as new or expanded. A before (2005) and after (2010) calculation was run for each of the waterbodies, and the difference was used to determine change in ET. In using the Calculator to estimate ET, the following assumptions and decisions were made:

- Cottonwoods and willows were used to represent riparian trees.
- Wet tall grasses were used to represent wetlands.
- Daily irrigation was set to run from May to September for irrigated crops.
- Small reservoirs represented shallow water (less than 1 meter averaged over the water area)
- Sandpits represented deep water (over 1 meter when averaged over the water area)
- Mitigated areas of expanded sandpits were modeled as follows: ET for deep water (2005 condition) to ET for sand (2010 condition).

Results

This section presents the results of analyses on the changes to ET due to new or expanded small waterbodies with no surface water permits, dam safety plans, or offsets by the Department between 2005 and 2010. The first set of results discusses the effects on ET from reservoirs, and the second set of results discusses the effects on ET from sandpits.

Consumptive Use Change for New Reservoirs

There were nine "unregulated" reservoirs, accounting for 18 acres in total, constructed within the study area between 2005 and 2010 **(Figure 17)**. The term "unregulated" refers to new reservoirs that had no surface water permits, dam safety plans, or offsets in place upon construction and through 2010.

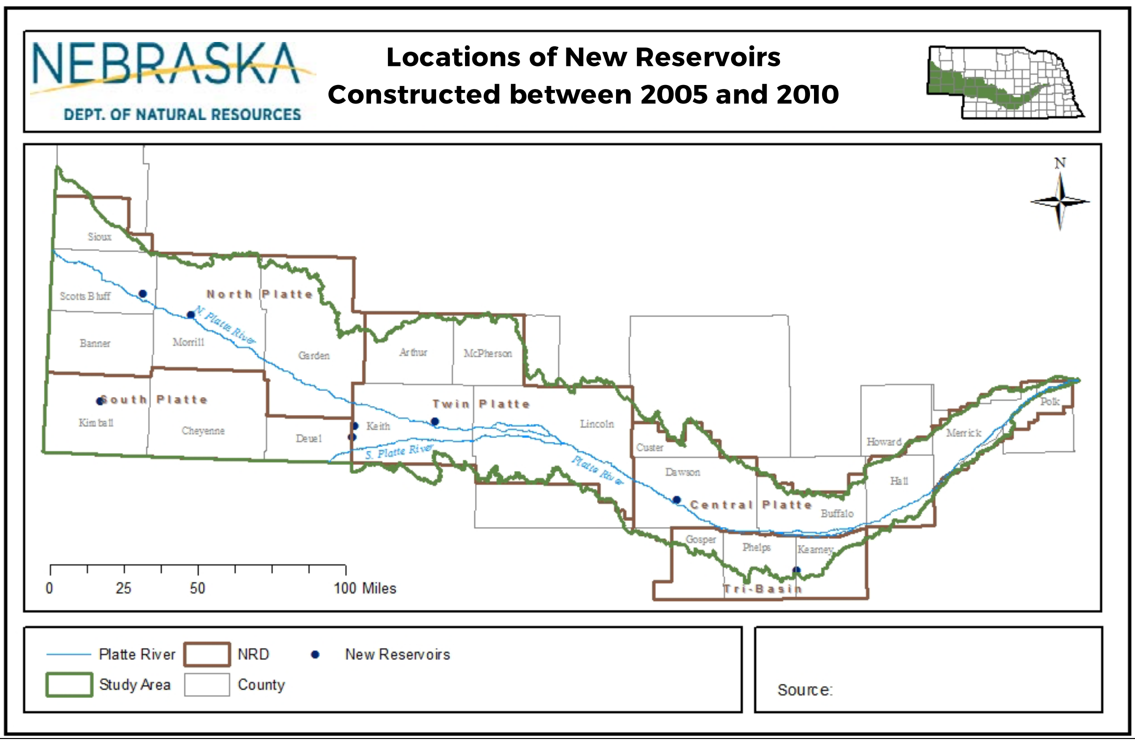

Figure 17. Locations of new reservoirs for consumptive use analysis.

The distribution of land cover/land use types that existed in the locations of the reservoirs prior to conversion to open water is provided in **Table 6**. Combined grassland (modeled as native types) comprised about 63 percent, irrigated crops comprised 26 percent, and dryland crops comprised 11 percent of the area prior to conversion to open water. The associated ET with these land cover/land use types resulted in 7 af for dryland crops; 9 af for grassland; and 16 af for irrigated crops, with 10 af of the total irrigated crops associated with irrigated alfalfa. In all, about 32 af of consumptive use per year was occurring in these areas prior to reservoir development. Nearly half of the consumptive use was associated with irrigated crops, 30 percent associated with grassland, and the remainder (22 percent) associated with dryland crops. Please see Appendix A to access more detailed information about how specific land cover/land use types are modeled in the Calculator with regard to ET.

Table 6. Land cover/land use types and associated ET of new reservoir areas prior to conversion to open water.

Prior Land Cover and Associated Evapotranspiration (ET) for New Reservoir Areas				
Prior land cover (2005)	**Acres**	**ET (af)**	**Acres (%)**	**ET (%)**
Dryland Alfalfa	1	4	6	12
Dryland Millet	1	3	7	10
Grass Warm Mid	1	2	5	7
Grass Warm Short	10	4	50	14
Grass Warm Tall	1	3	6	9
Irrigated Alfalfa	3	10	15	30
Irrigated Corn	1	6	11	18
Total	**18**	**32**	**100**	**100**

The modeled ET for the combined prior land cover/land use against the post-land cover (open, shallow water) is shown in **Figure 18**. Monthly change in consumptive use that occurred from conversion of the initial land cover/land use to a reservoir (modeled as open, shallow water) is presented in **Figure 21**. When summed, there was a total increase of 18.4 af of ET due to the conversion of 19 acres to shallow, open water. A little less than half (9 af) of that ET increase occurred in the non-peak season months of March, April, October, and November (winter months are not included in the Calculator due to minimal ET). The highest monthly differences were in April, May, September, and October, where agricultural vegetation would be in initial growth stages, or senescence and harvest. The lowest differences were at the height of the growing season where more ET would be occurring in agricultural areas, which as modeled, would be close to the amount of evaporation occurring on open, shallow water.

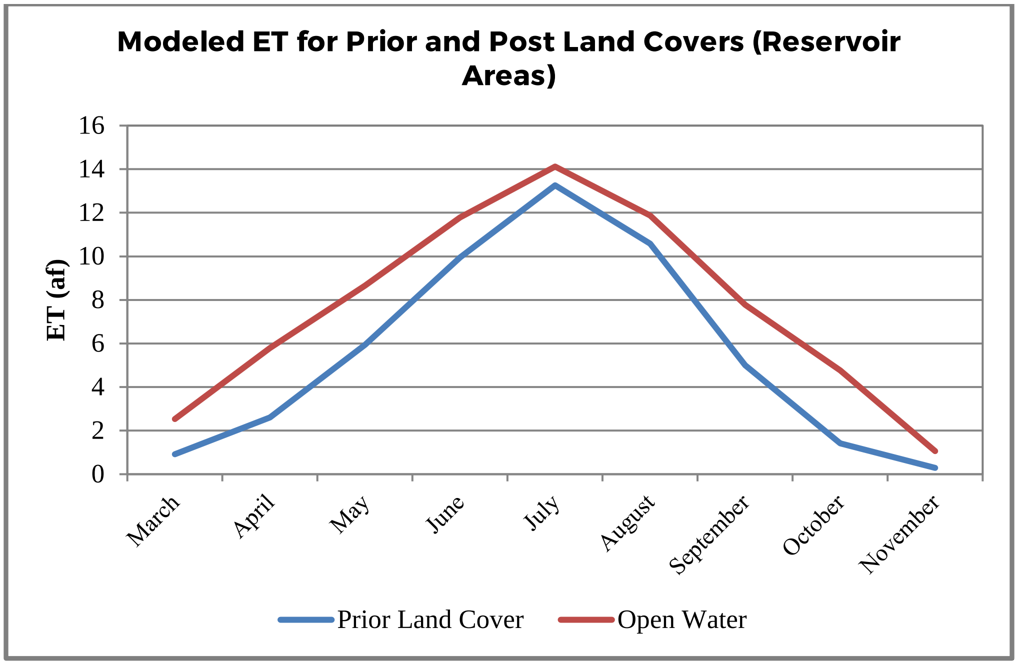

Figure 18. Modeled ET for prior and post land covers in new reservoir areas.

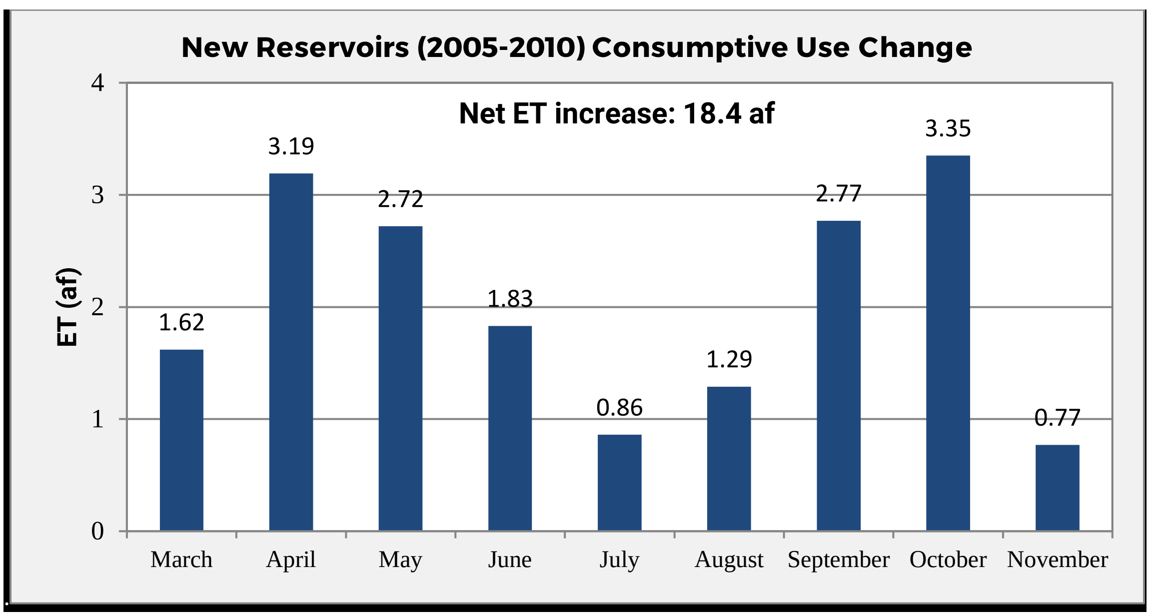

Figure 19. Change in ET due to land coversion to reservoirs, expressed in monthly values from March to November.

Consumptive Use Change for New or Expanded Sandpits

Between 2005 and 2010, 94 sandpits were either built or expanded within study area. The total area of land that the new and expanded sandpits encompassed was 734 acres. The total area of active sandpits that reduced in size between 2005 and 2010 was 145 acres. This resulted in 879 sandpit-related acres that underwent a change in land cover type between 2005 and 2010. The locations of new or expanded sandpits are shown in **Figure 20**.

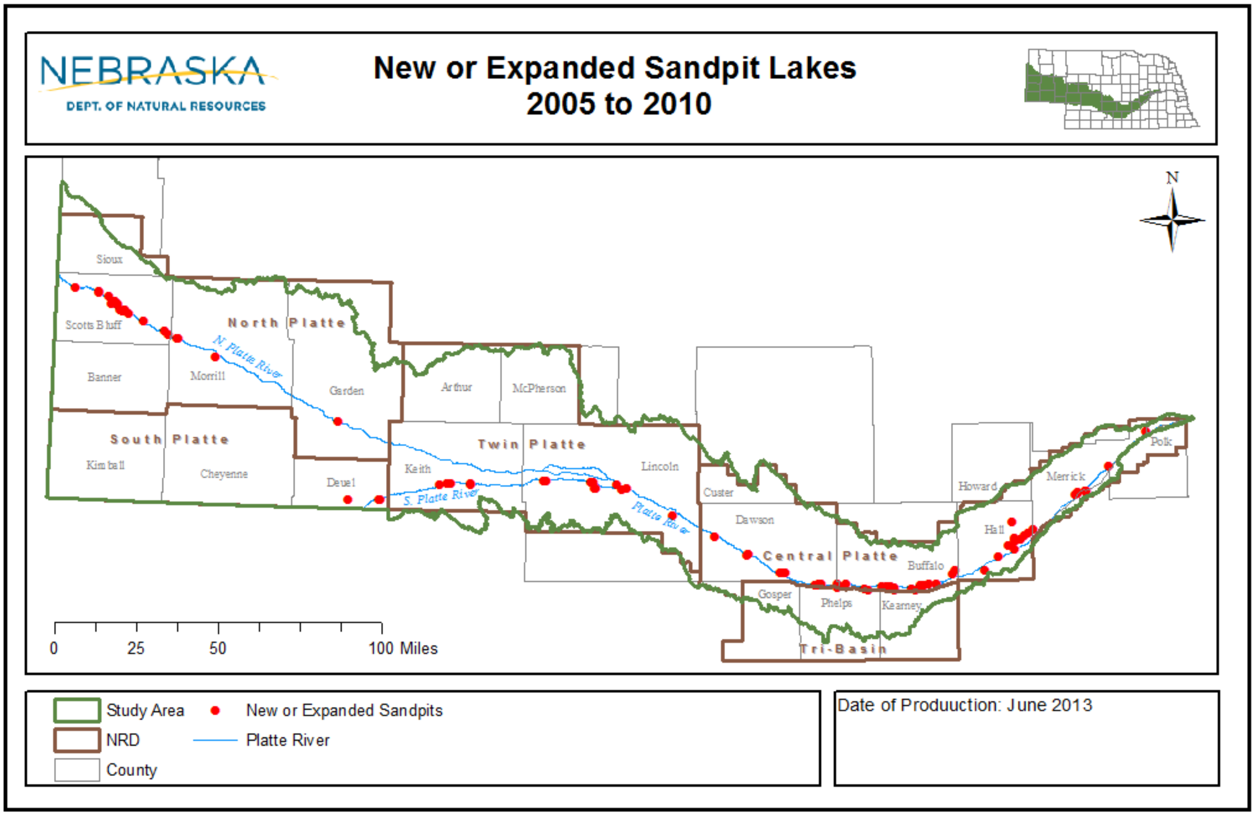

Figure 20. Locations of new or expanded sandpits within the Platte Surface Water Basin above Columbus.

The distribution of land cover/land use type that existed in the locations of new or expanded sandpits prior to conversion to open water is provided in **Table 7**. Most (85 percent) of the pre-sandpit lake area was comprised of riparian forests and woodlands, wetlands, and grasslands, as would be expected in areas close to the Platte River. About 15 percent of the land cover/land use, most of which was irrigated (13 percent), was devoted to agriculture prior to sandpit development. As discussed earlier, some new or expanded sandpits also had mitigation in certain areas, which totaled 145 acres across the study area. These areas were modeled as a land cover change from deep, open water to sand. Please refer to Appendix A for more information about Calculator ET values for specific land cover/land use.

Table 7. Total acres of generalized land cover and the percent contribution of each group to the total number of sandpit acres within the study are. All figures have been rounded to the nearest whole number.

Land Cover Groups to Prior New or Expanded Sandpits in the Platte SW Basin above Columbus		
Prior Land Cover Groups (2005)	**Acres**	**Acres (%)**
New/Expanded Sandpits		
Dryland Crops	18	2
Irrigated Crops	93	13
Grasslands	167	23
Riparian Forest and Woodlands	275	37
Wetlands	181	25
Sub-total (new or expanded)	734	84
Reduced Sandpit Areas		
Open Water to Sand	145	16
Total New/Expanded and Reduced Acres	**879**	**100**

A graphical comparison of the monthly ET associated with active sandpits in 2005 and 2010 (all prior and post-land cover groups were combined) is shown in **Figure 21**. Note that the prior land cover ET is much higher during the peak growing season compared to ET for the sandpit lakes. This is related to higher heat storage capacities for deep water, compared to heat storage capacities for shallow water. Solar energy is stored in the deep water and does not evaporate as readily as in shallow water. The NRCS Consumptive Use calculator modeling parameters reflect this concept, and the vegetation opposed to deep water is modeled as having higher ET for the sandpit lake areas.

Monthly change in consumptive use that occurred from conversion of the initial vegetation to a sandpit lake (or vice versa for mitigated areas) is presented in **Figure 22**. When summed, there was a total decrease of 698 af of ET due to the combined conversion of 784 acres to deep, open water (expanded or new areas), and 145 acres from sand to deep, open water (mitigated areas). The majority of the calculated ET differences occurred in the hottest summer months (June, July, and August), when sandpit lakes had less evaporation than the previous land cover due to the storage of solar energy (opposed to evaporation) in the deep, open water. Conversely, more evaporation occurred with the open, deep water than ET that occurred in the previous land cover (vegetation) for the months of March, April, October, and November.

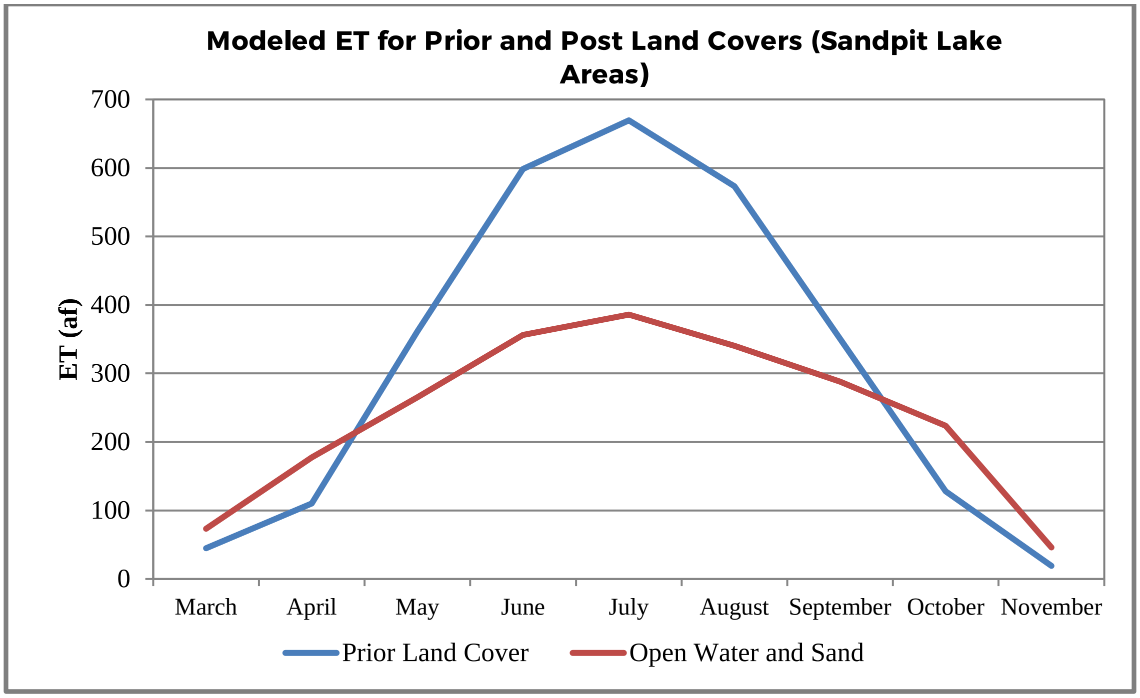

Figure 21. Modeled ET for prior and post land covers in new or expanded, or mitigated sandpit lake areas.

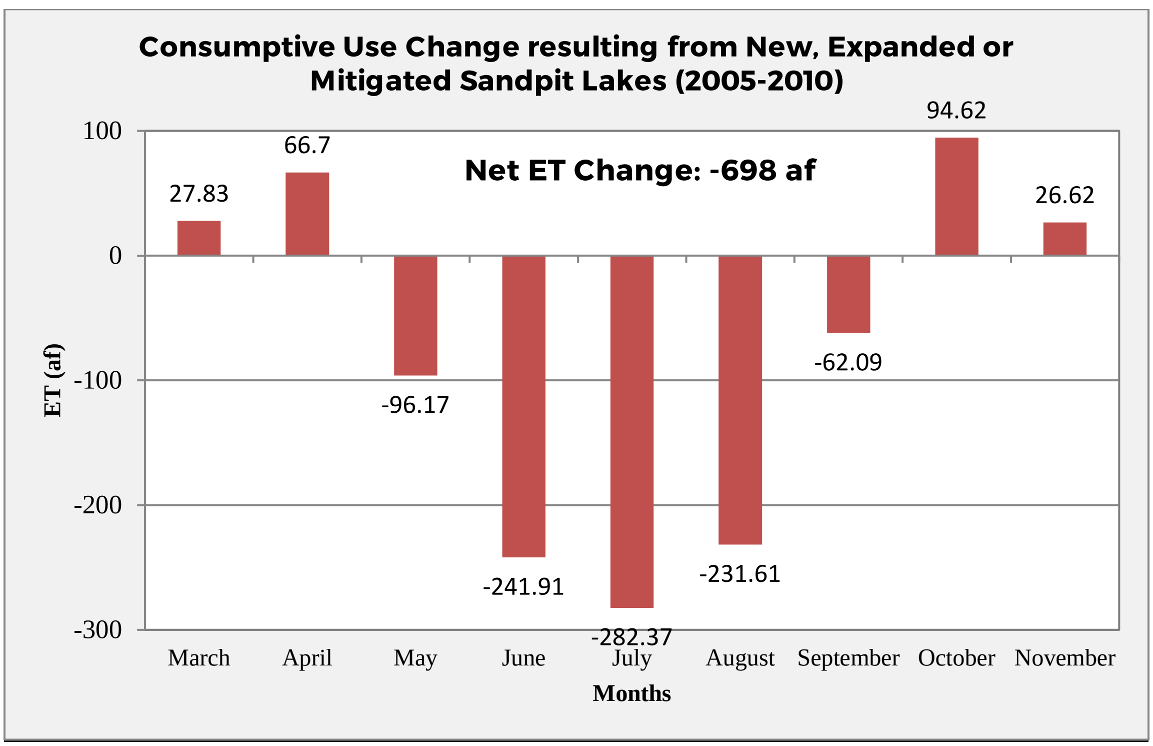

Figure 22. Change in ET due to land coversion associated with sandpit lake construction or mitigation, expressed in monthly values from March to November.

Combined Results

When combining the results of land area change to reservoirs and sandpit lakes together, the overall ET decreased by 678 af. **Figure 23** shows the total ET monthly change from new, expanded, or mitigated sandpit lakes and new reservoirs. The ET change from various sandpit lake construction dwarfs the ET change from new reservoirs in the graph; but more than 700 acres are associated with changes due to sandpit lakes, opposed to only 18 acres associated with new reservoir areas. The total ET change appears to be most affected by the conversion of vegetation to deep open water, as the deep, open water of sandpit lakes stores solar energy in the summer months that would otherwise be evaporated.

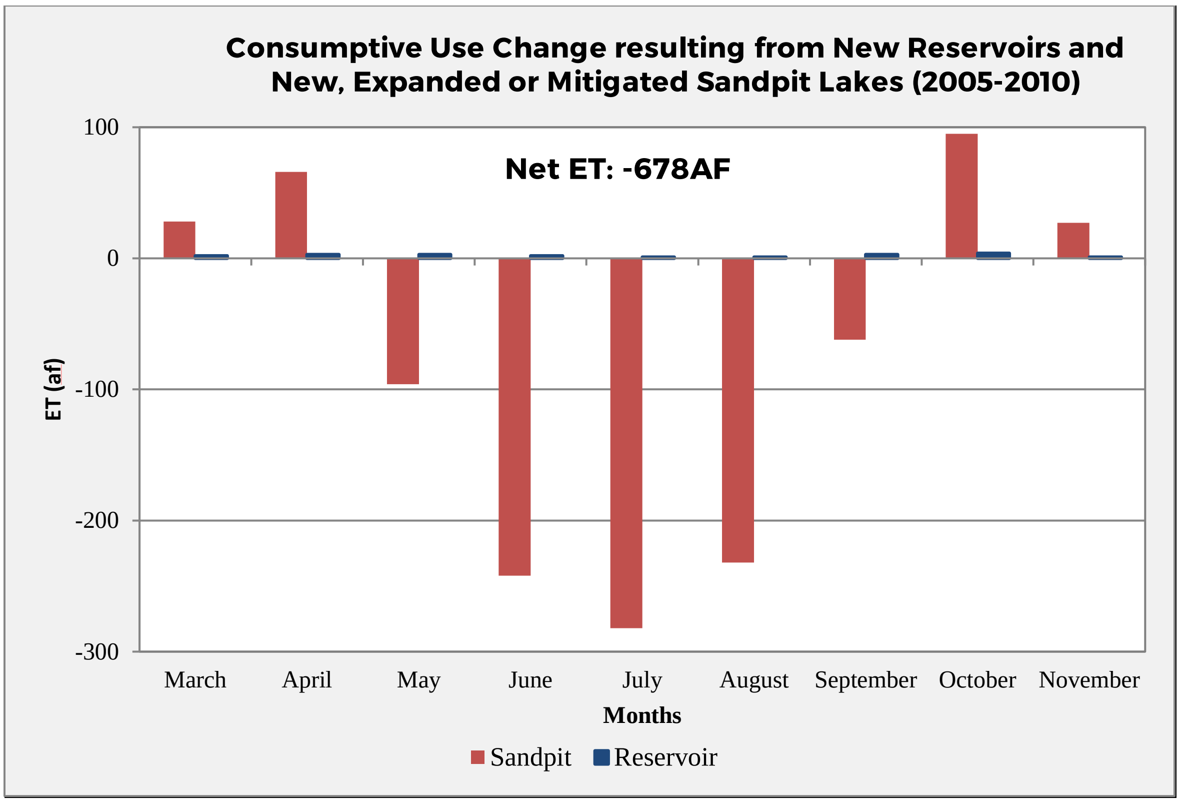

Figure 23. Overall change in ET by month, for conversion of land to new reservoirs and new or expanded sandpit lakes.

Summary

- A large effort was undertaken to create inventories of water bodies in 2005 and 2010 for the Platte River Basin above Columbus, Nebraska. An extensive amount of manual work was involved, and took an estimated 2,500 hours of NeDNR staff time to conduct.
- The extent of water bodies was affected greatly by the different precipitation amounts for each year (2010 was a wet year, so more water features were apparent on the aerial imagery).
- The inventories were compared to determine changes in water bodies that occurred between 2005 and 2010.
- The results of the inventory comparison were distilled by removing water bodies that did not have certain, apparent physical features (e.g. construction of new dams); had permits, plans, or offsets in place; and were determined by local expertise to not have actual change. What began as an analysis of thousands of features was reduced to just over 100 features that would be included in consumptive use change analysis.
- A total of 95 new or expanded sandpits and 9 new reservoirs were used for land cover/land use ET change analysis. The NRCS Consumptive Use Calculator was used to determine ET for the prior land cover/land use and for the post-land cover/land use (shallow or deep open water). Sandpit lakes with mitigation in place were also modeled to account for deep, open water that had been converted to sand.
- In all, the modeled results showed that there was an annual decrease in ET of 678 af due to new reservoirs and new, expanded or mitigated sandpit lakes, over the previous land cover/land use. These results were largely affected by the much higher acreage in sandpit lakes compared to new reservoirs and the modeled deep, open water, which stores solar energy in hot summer months, whereas vegetation in the same location would have a higher ET during these months as modeled.

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APPENDIX A.

NRCS Consumptive Use Calculator ET values for specific land covers

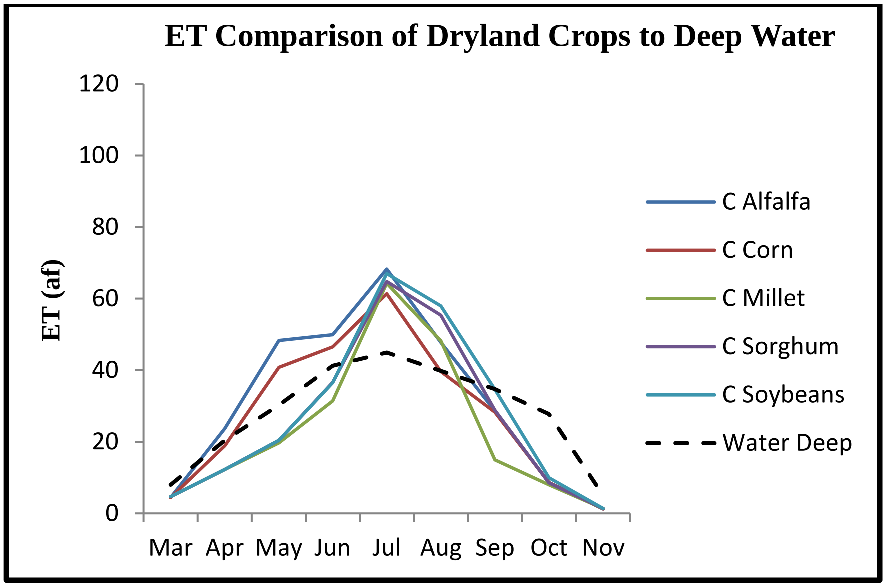


Figure B-1. The ET pattern of dryland crops per 100 acres of each dryland crop type within the study area.

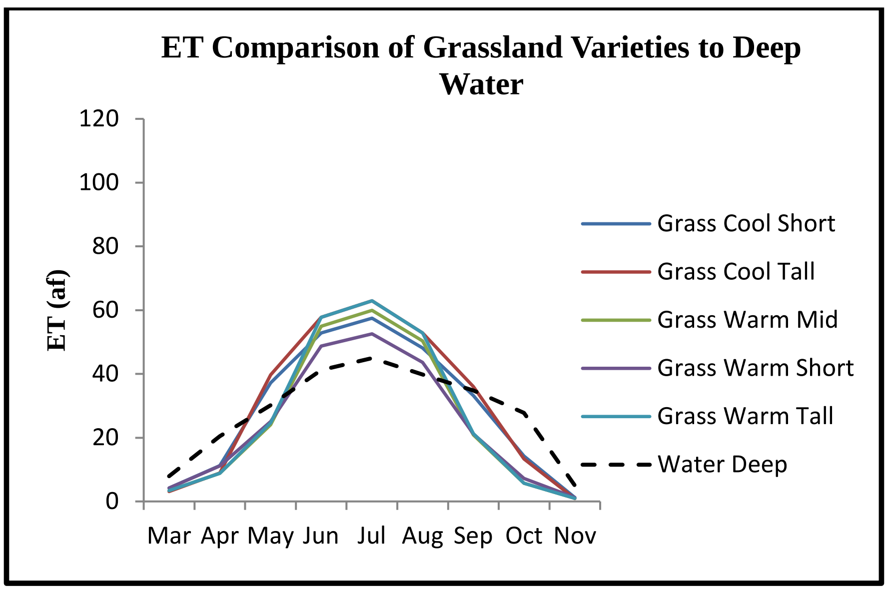


Figure B-2. The ET pattern of grasslands per 100 acres of grassland type in the study area.

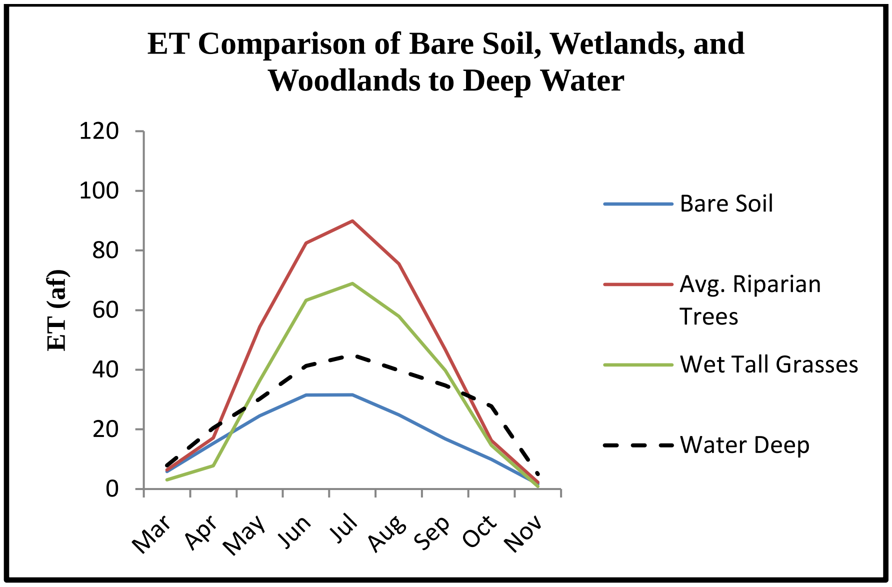


Figure B-3. The ET pattern of bare soil, wetlands, and woodlands per 100 acres of each land cover type in the study area.

2005-2010 Consumptive Use of Small Man-made Water Bodies in the Platte Surface Water Basin above Columbus

PRRIP Water Advisory Committee Meeting-May 6, 2014

Amy Zoller, MS
Integrated Water Management Analyst
Nebraska Department of Natural Resources

Nebraska
Department of Natural Resources

Introduction

Nebraska New Depletion Plan (NNDP) for the Platte River Recovery Implementation Program (PRRIP)

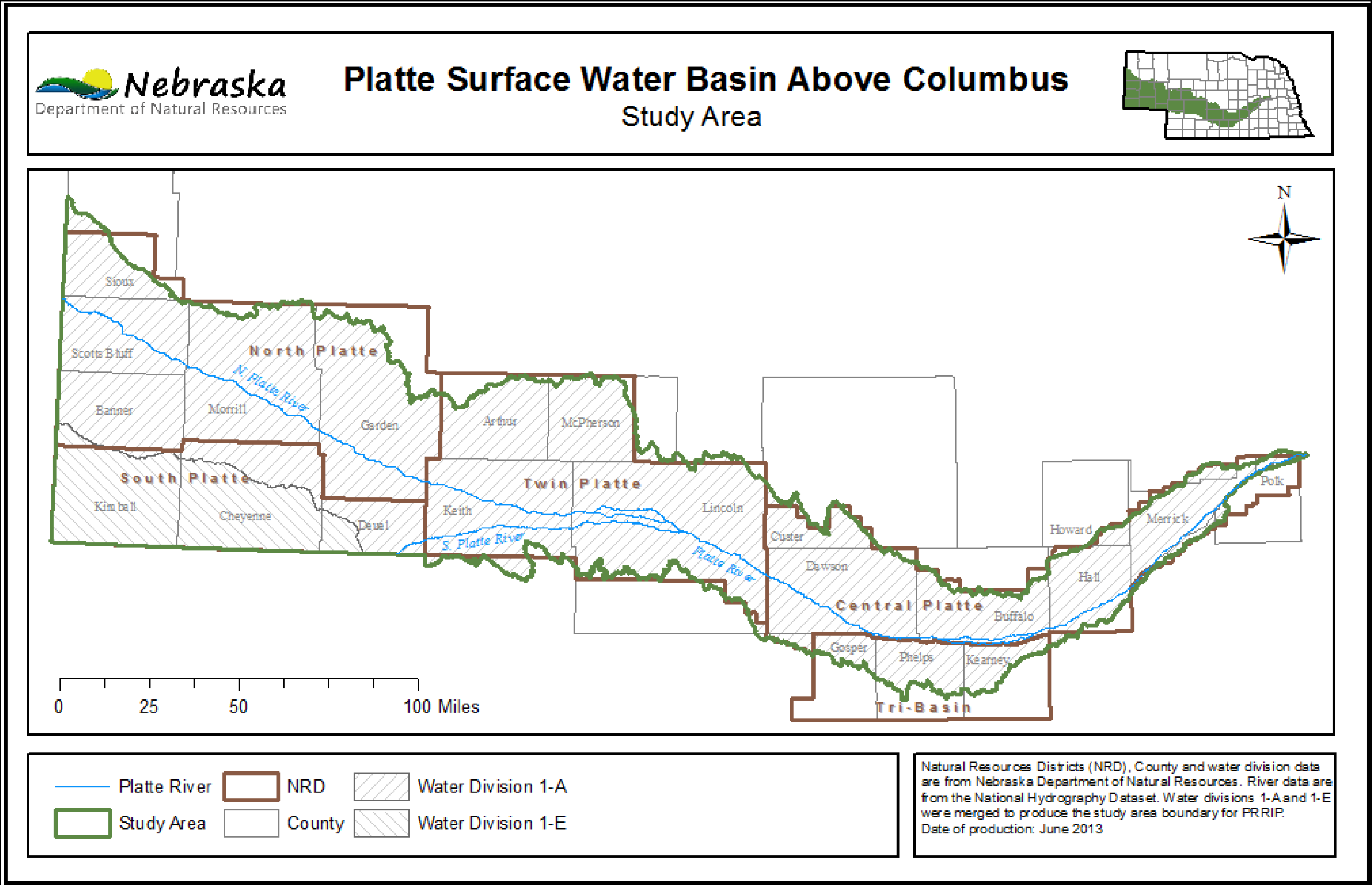
- The NNPD describes the actions Nebraska proposes to take to prevent or mitigate for new depletions to U.S. Fish and Wildlife Service (USFWS) target flows

- The Nebraska Department of Natural Resources (NDNR) has jurisdiction over surface water uses, and requires permits for
  - stream diversions, and
  - on-stream storage reservoirs greater than 15 AF

- For new or expanded sandpits, and new, small reservoirs that do not require permits, NDNR will estimate the cumulative impact on state-protected and target flows
  - Adverse effects will be mitigated by the state

Introduction

- The goal of this work was to estimate cumulative effect of new or expanded sandpits, or new reservoirs on protected flows from 2005-2010



Overview of Methods

- Create a 2005 water body inventory (baseline)
- Create a 2010 water body inventory
- Compare 2010 inventory to baseline
  - New or expanded sandpits
  - New reservoirs

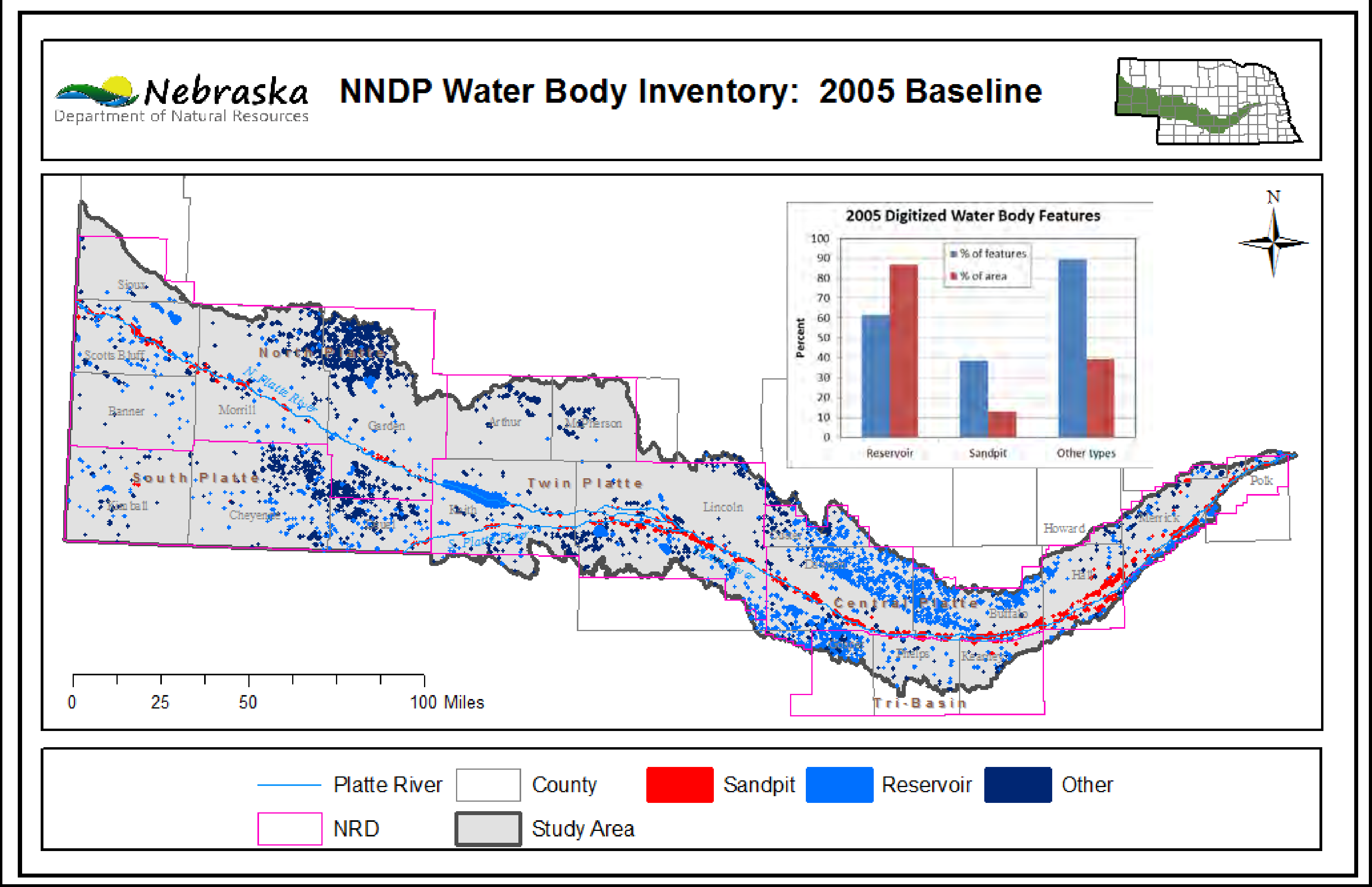
GIS

- Evaluate for permits/mitigation in place
- Use the NRCS calculator to estimate consumptive use change due to new/expanded water bodies with no permits

GIS Methods
Create a baseline water inventory for 2005

- In 2005, aerial imagery was scanned frame by frame and all water bodies were digitized/ categorized
- From this, the water bodies were categorized
  - Sandpits
  - Reservoirs
  - “Other”
- Resulted in roughly 11,500 features
- Whole inventory took 1200 hours to complete

GIS Methods
Create a baseline water inventory for 2005



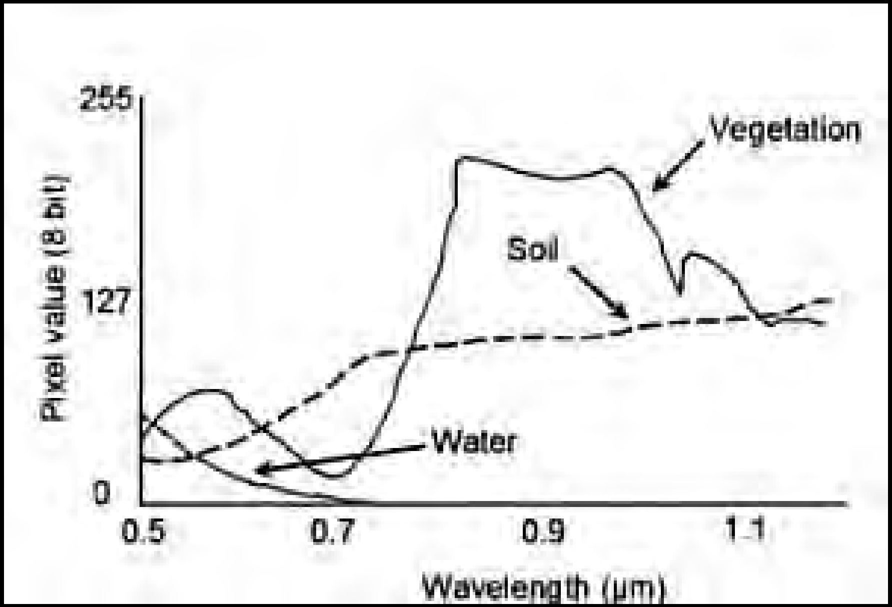
GIS Methods:
Create a 2010 water body inventory

- In 2010, the 2005 baseline methods and final dataset were reviewed, as well as aerial imagery

- 2010 was a much more wet year, resulted in roughly 3-4 times as much water
  - potential for 4000 hours of labor if same methods were employed

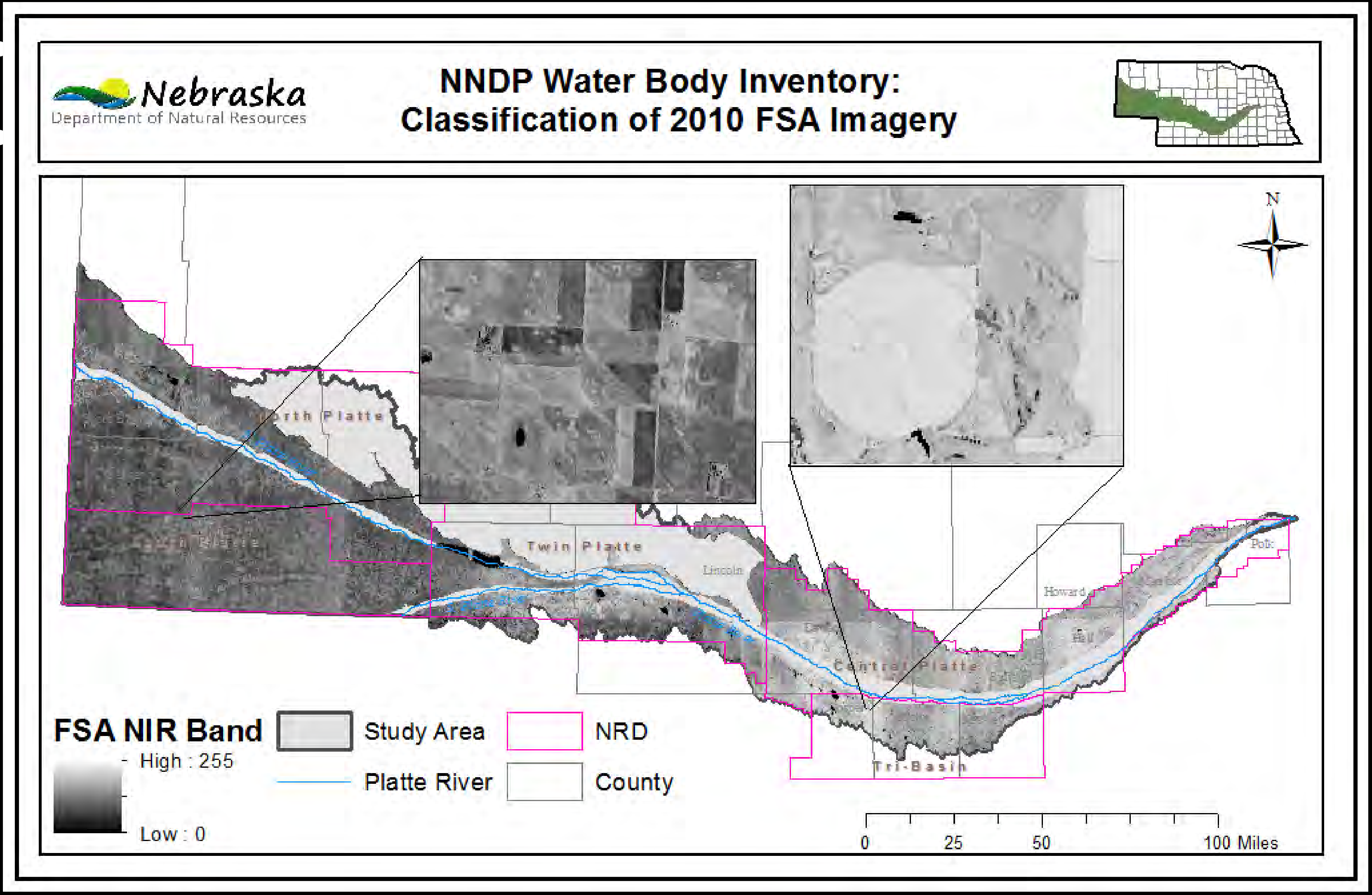
GIS Methods
Create a 2010 water body inventory

- Semi-automatic approach
- Classification of FSA imagery to identify water
  - Utilized Near-Infrared band values

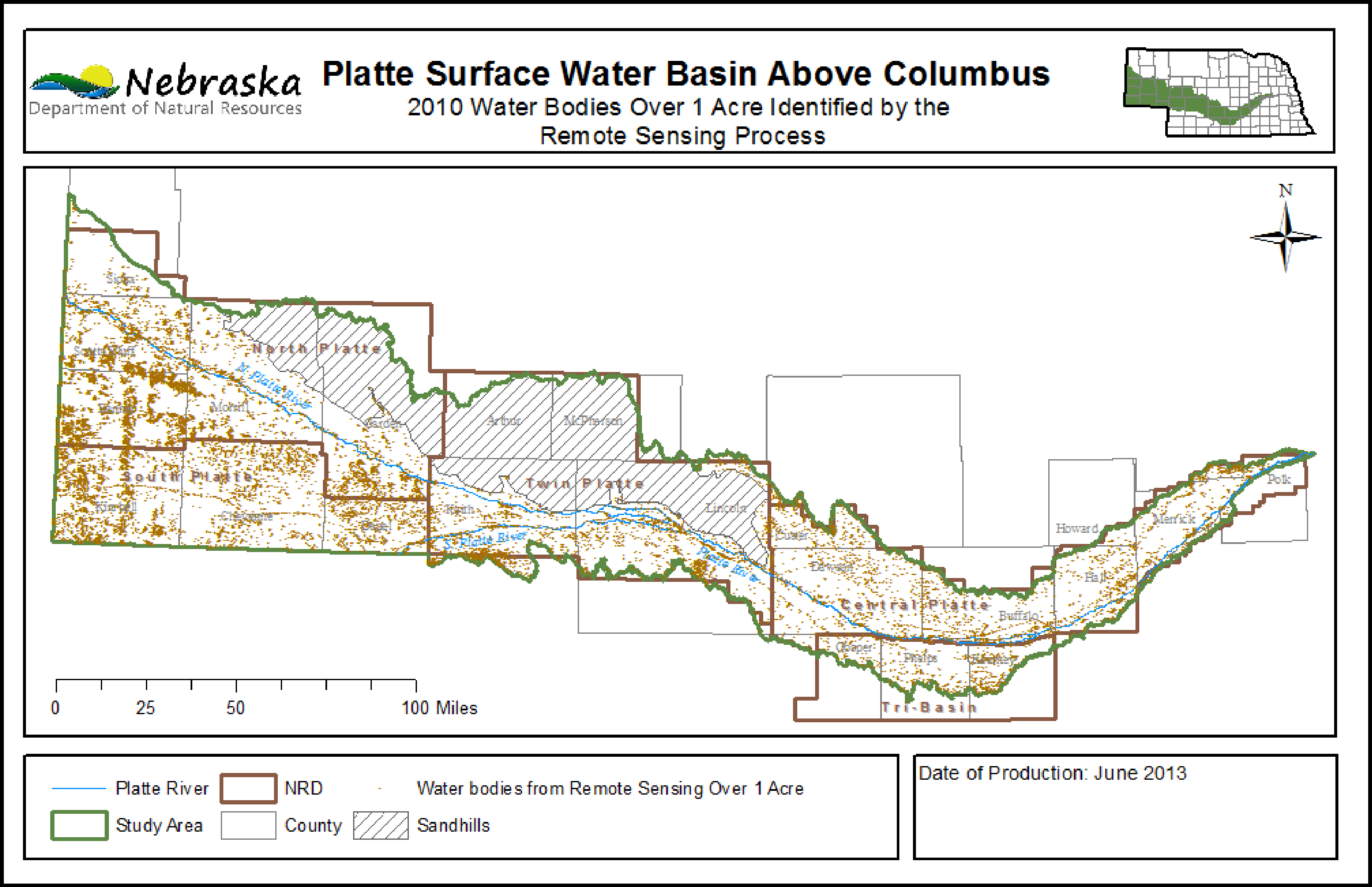


From Mather and Koch, 2011

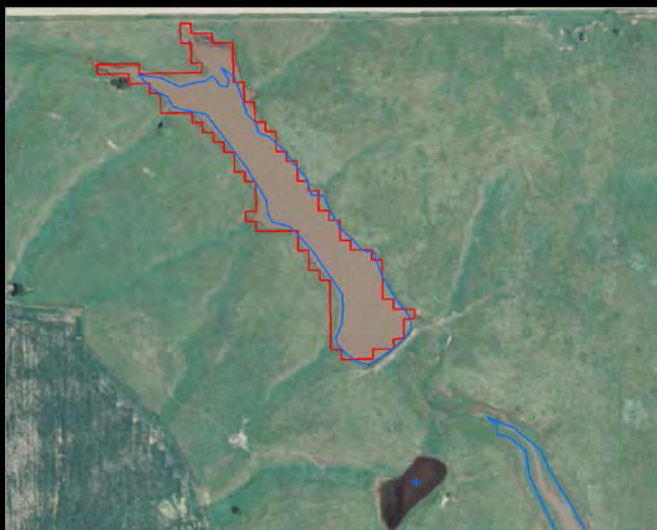
GIS Methods
Create a 2010 water body inventory



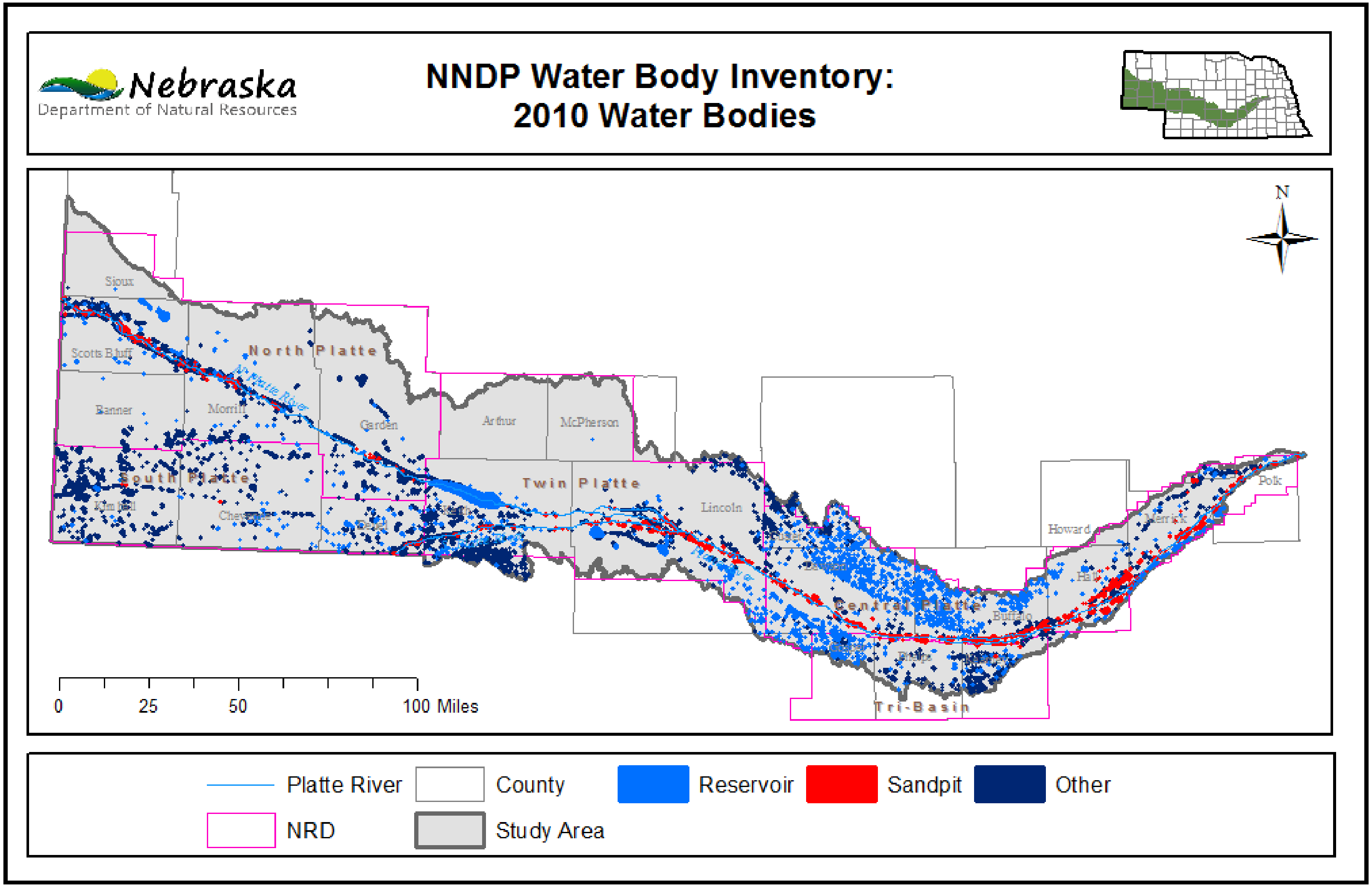
GIS Methods
Create a 2010 water body inventory



GIS Methods
Manual Editing of Classified Features

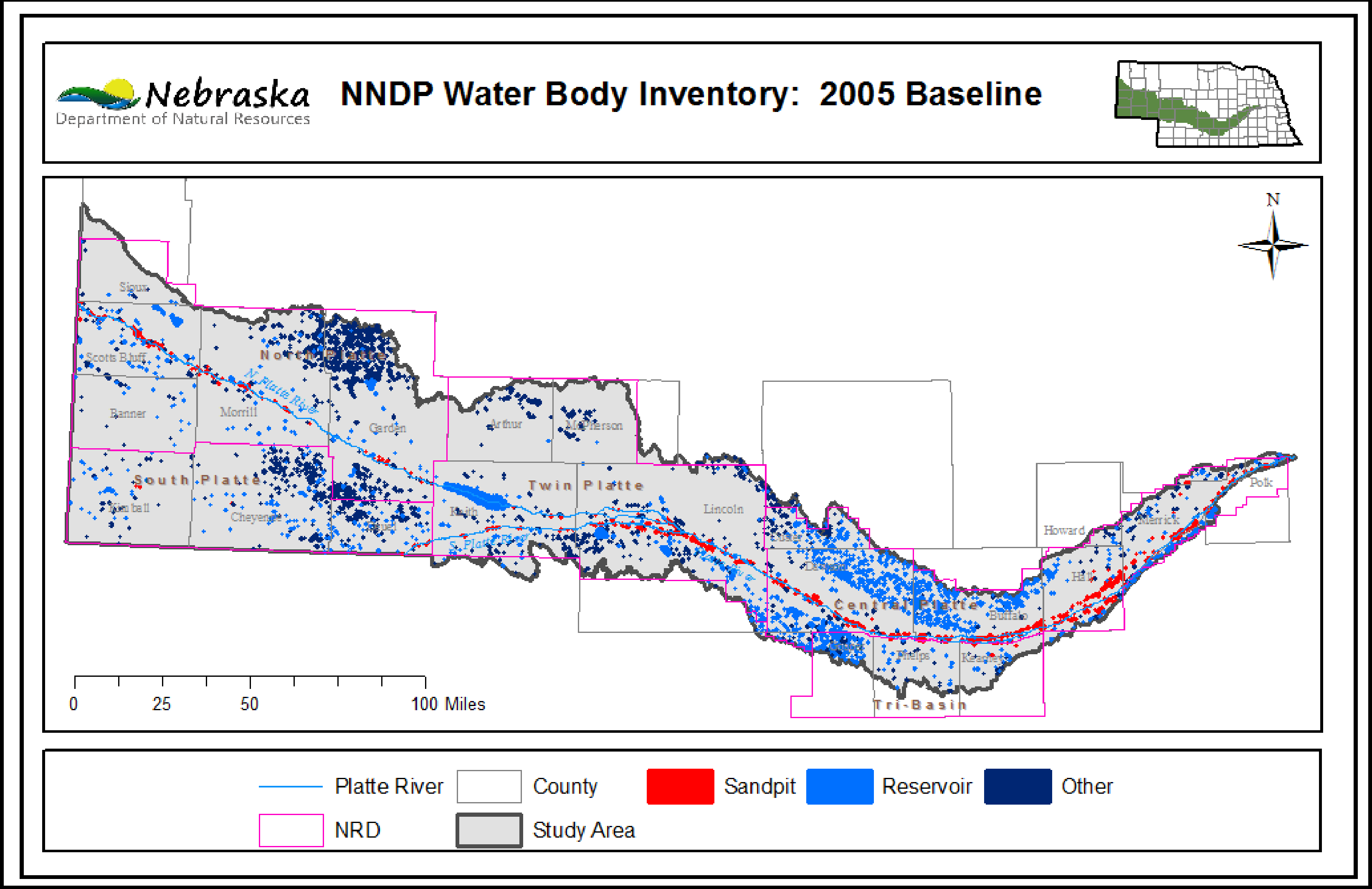


GIS Methods
Classification of 2010 water body inventory

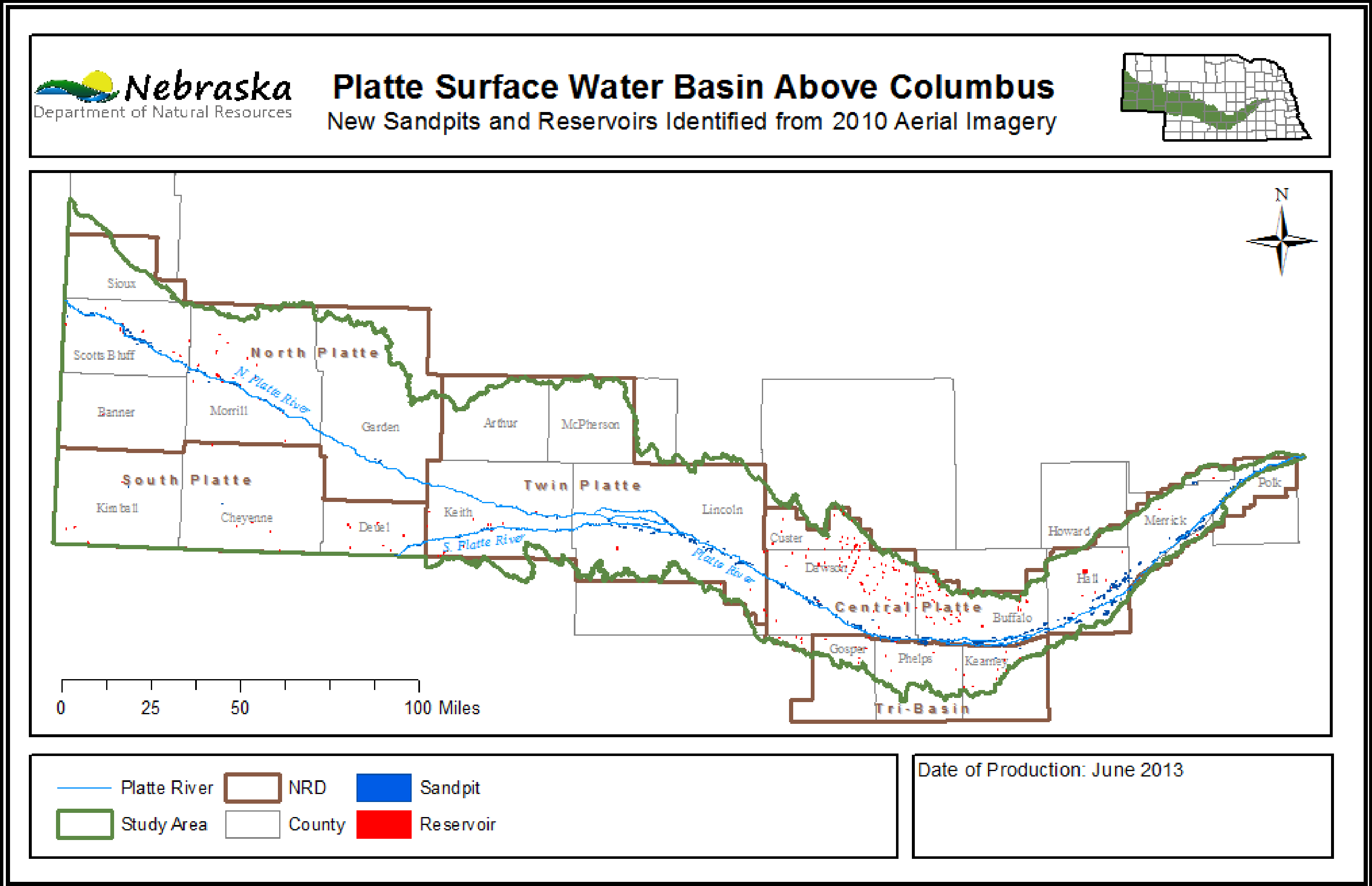


2,583 water bodies classified as sandpits or reservoirs (53,557 acres)

GIS Methods
Overlay with 2005 water body inventory



Potential Sandpits and Reservoirs for Change Analysis



758 sandpits and reservoirs preliminarily designated as changed (3,723 acres)

Criteria for Inclusion in Change Analysis

Reservoirs

- New embankment
- No permits
  - Surface water right or dam safety plan
  - If a right or plan exists, check for depletions and mitigation already in place

Sandpits

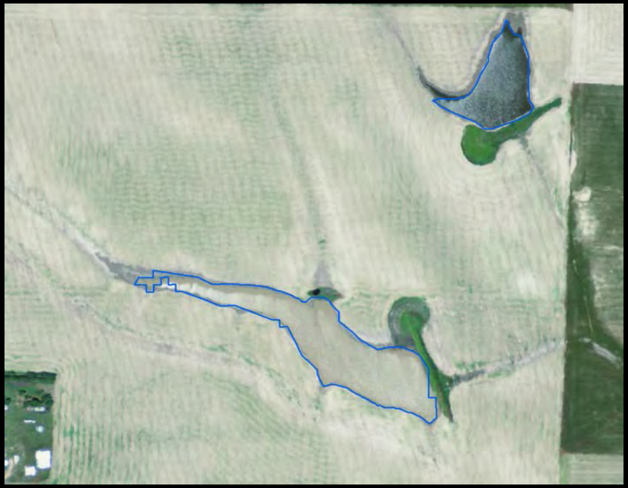
- Active gravel pit
- No estimated depletions or mitigation
- Account for land reclamation

Reservoir Change Analysis Criteria: New Embankment

- New embankment physically present after 2005

2005

2006

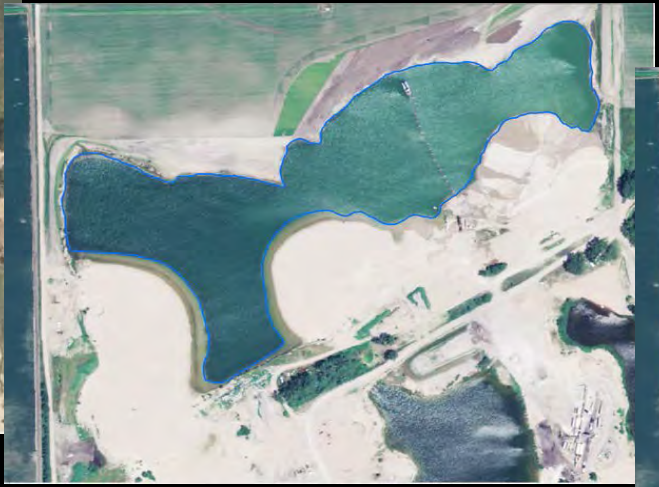


2010

Sandpit Change Analysis Criteria: Activity

- Sandpit criteria
  - Sand around new/expanded sandpits
  - Looked at expanded portions, accounted for reclaimed portions

2005



2010

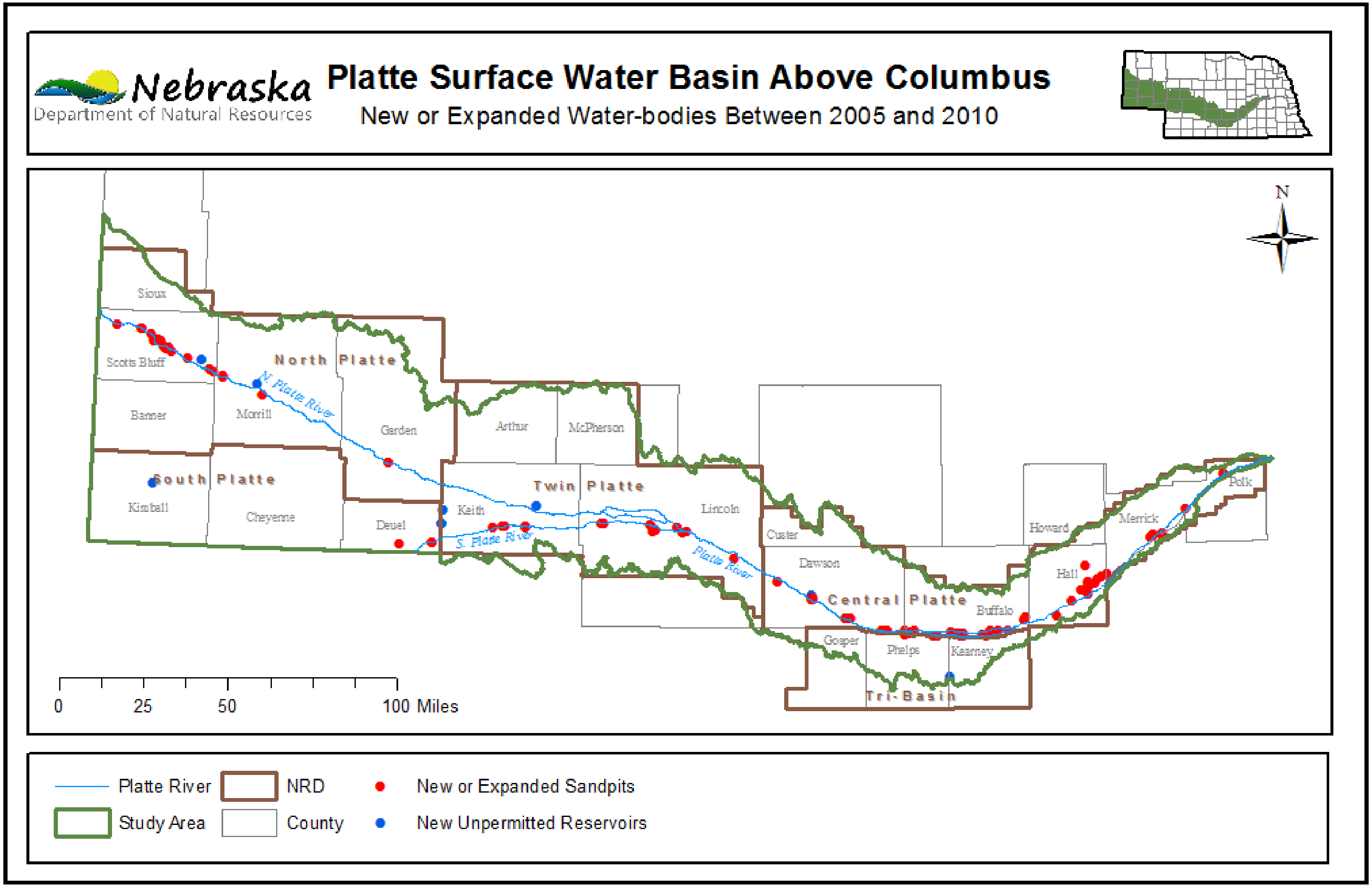
Reduced Areas
Expanded Areas

NRD Review

- Features Identified as new or expanded were sent to NRDs for review

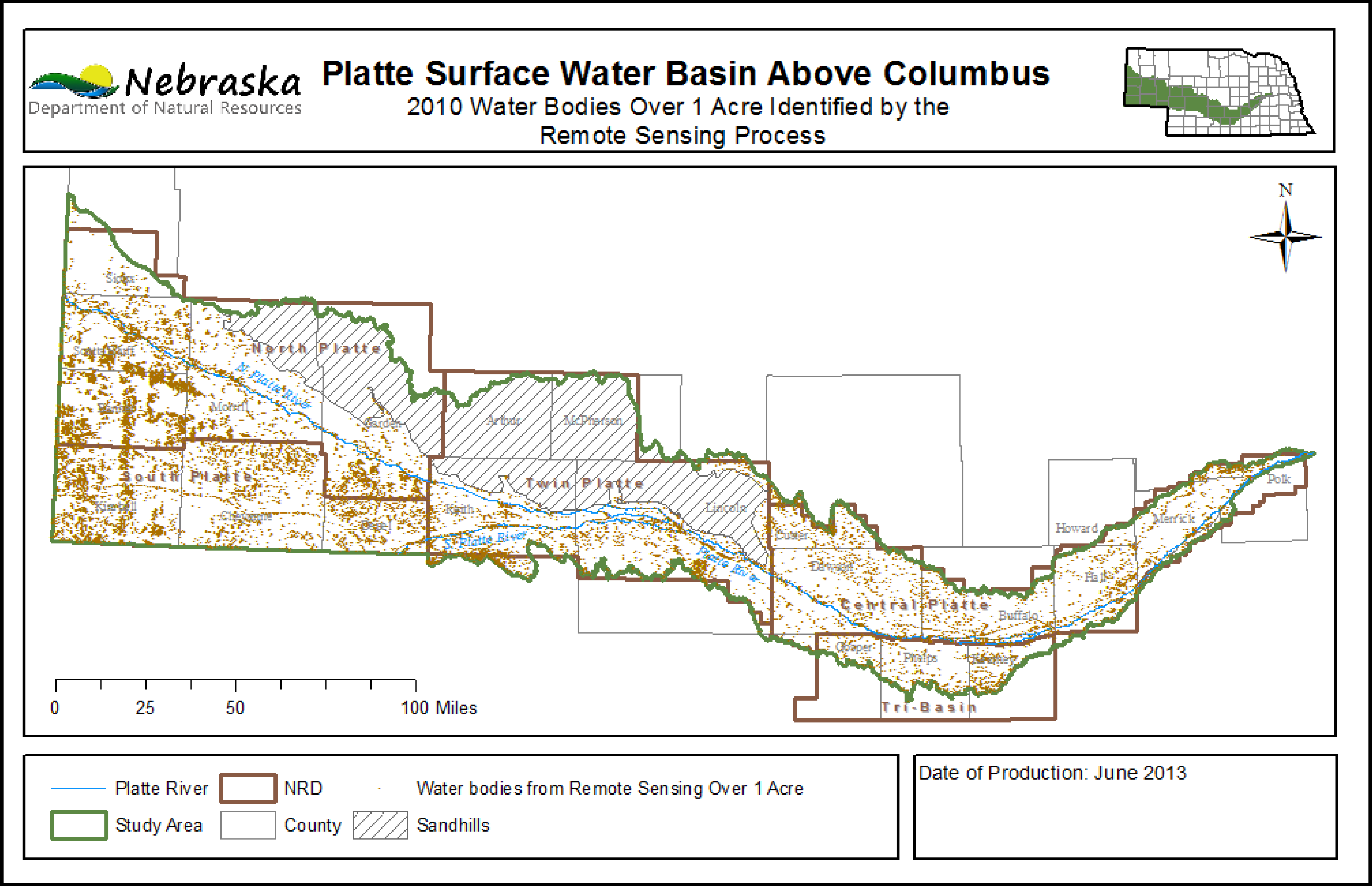
- A few features had not changed due to man's activities,
- A few features had been mitigated
- These were removed from subsequent analyses

Sandpits and Reservoirs for ET Change



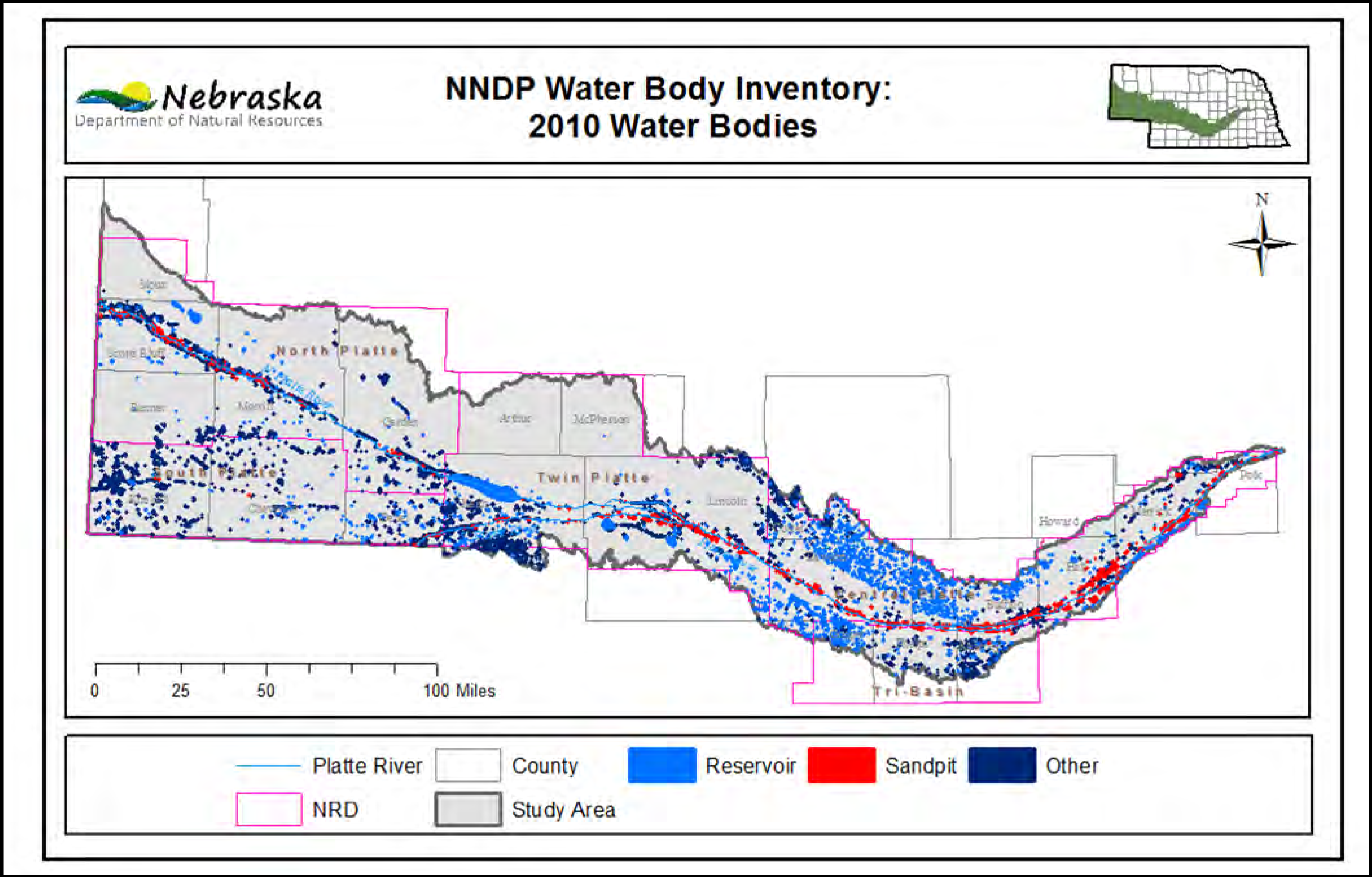
94 sandpits, and 9 reservoirs for change analysis

Synopsis of steps to create water body layer for change analysis



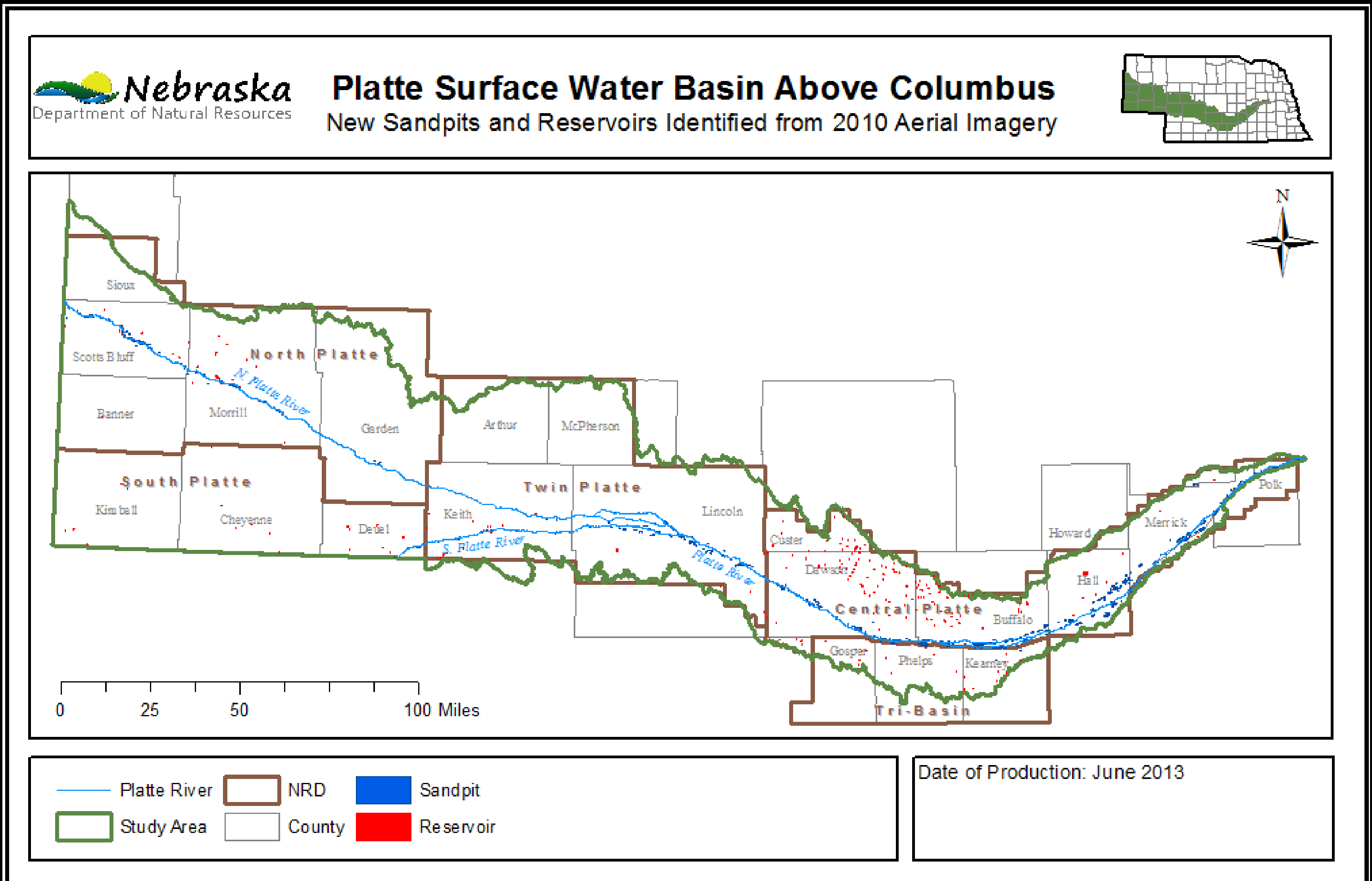
19,043 features (122,431 acres)

Synopsis of steps to create water body layer for change analysis



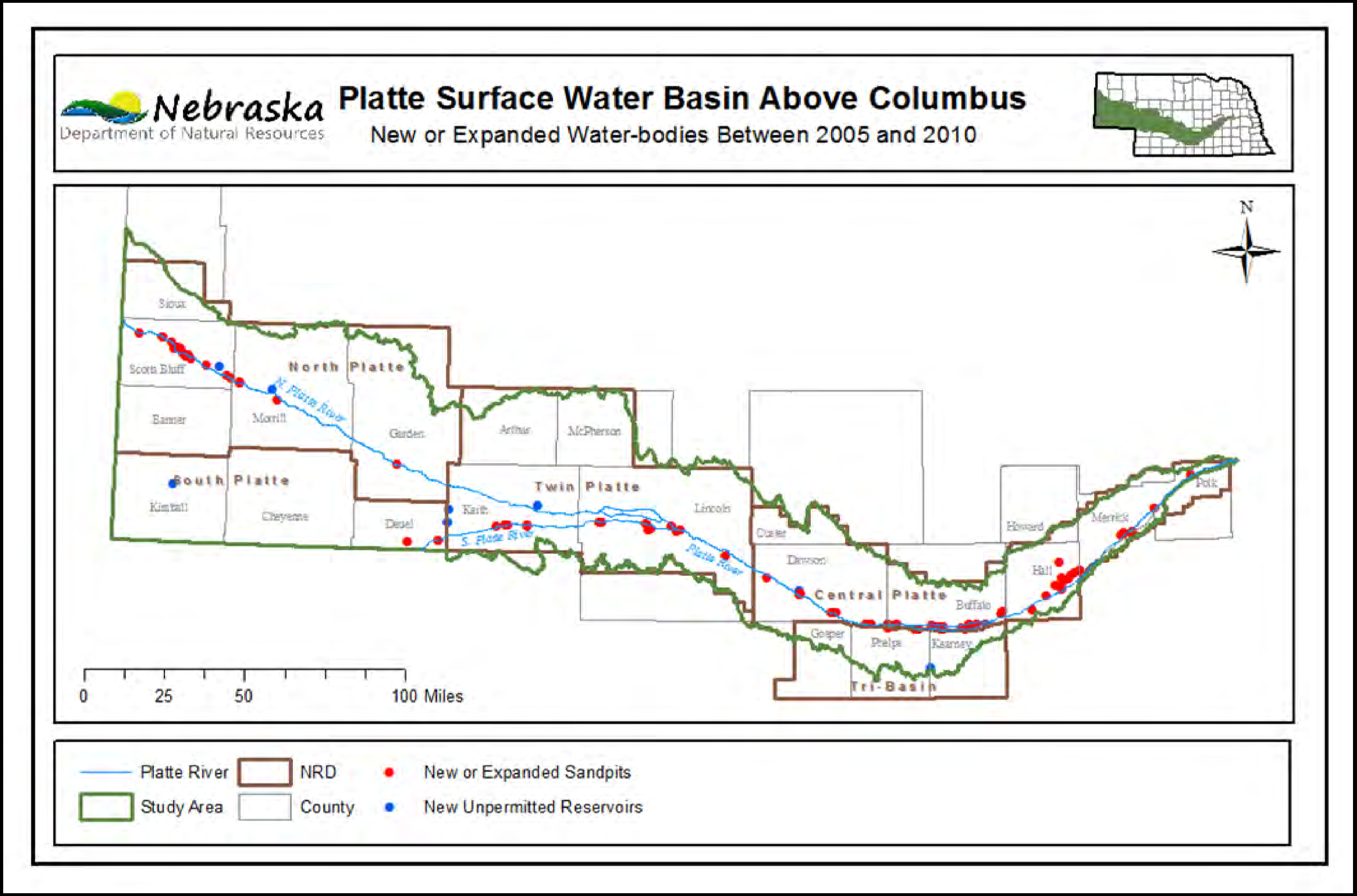
2,583 sandpits and reservoirs (53,557 acres)

Synopsis of steps to create water body layer for change analysis



758 sandpits and reservoirs (3,723 acres)

Synopsis of steps to create water body layer for change analysis



Sandpits: 94 (728 acres); Reservoirs: 9 (19 acres)

Breakdown of evaluated water bodies

Change Analysis Reservoir Identification Process		
Procedure	**Number of Features**	**Area (acres)**
Reservoirs classified from 2010 imagery	1,578	45,507
Reservoirs not included in 2005 inventory	573	1,521
Reservoirs with new embankments between 2005 and 2010	11	405
New reservoirs with permits between 2005 and 2010	(2)	386
New unpermitted reservoirs between 2005 and 2010	9	19

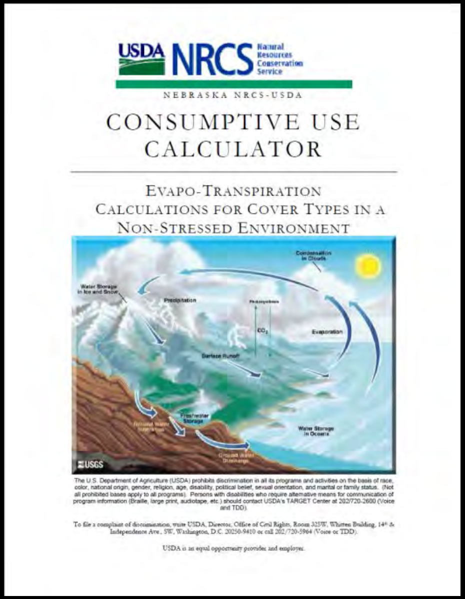
Change Analysis Sandpit Identification Process		
Procedure	**Number of Features**	**Area (acres)**
Sandpits classified from 2010 imagery	1,005	8,050
Sandpits with area change from 2005	185	2,202
New/expanded sandpits identified from visual analysis	98	736
New sandpits with mitigation	(4)	8
New/expanded sandpits between 2005 and 2010	94	728

Methods

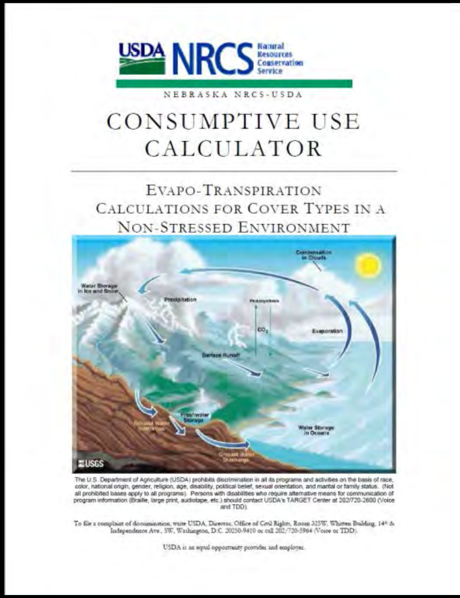
Evapotranspiration (ET) estimation using NRCS ET calculator

NRCS ET Calculator

- Created by Natural Resources Conservation Service (NRCS)
- Consumptive use change assessment in Platte basin
- Average monthly ET of 46 land covers
  - Grasslands
    grass cool mid; grass cool short; grass cool tall; grass warm mid; grass warm short; grass warm tall; grass pasture good; grass pasture bad
  - Wetlands
    wet tall grasses; wet cattail/bulrush moist; wet cattail/bulrush standing water; wet linear; wet short veg moist; wet short veg standing water
  - Water
    water shallow; water deep
- March to November ET

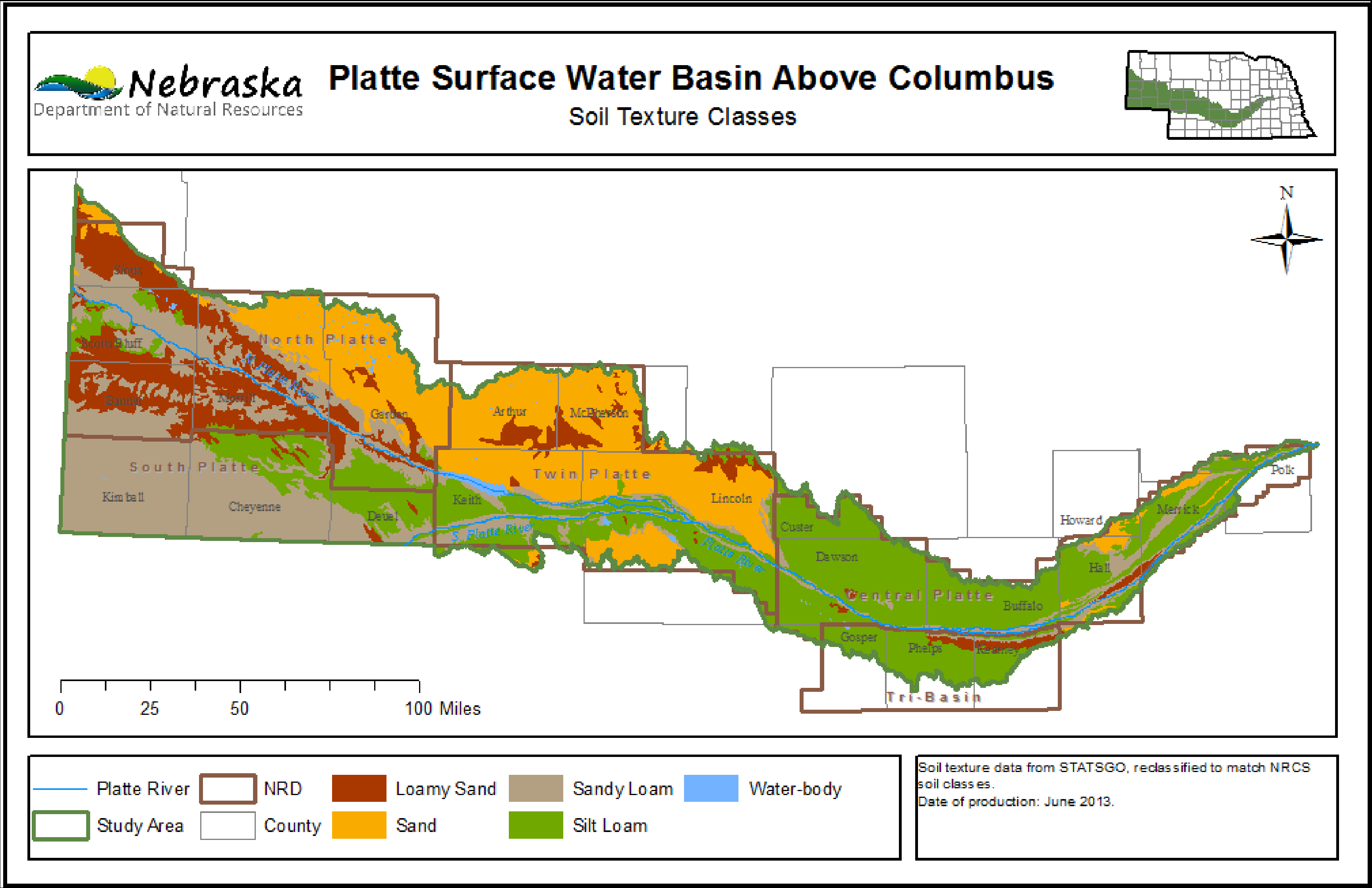


Methods: ET Calculation

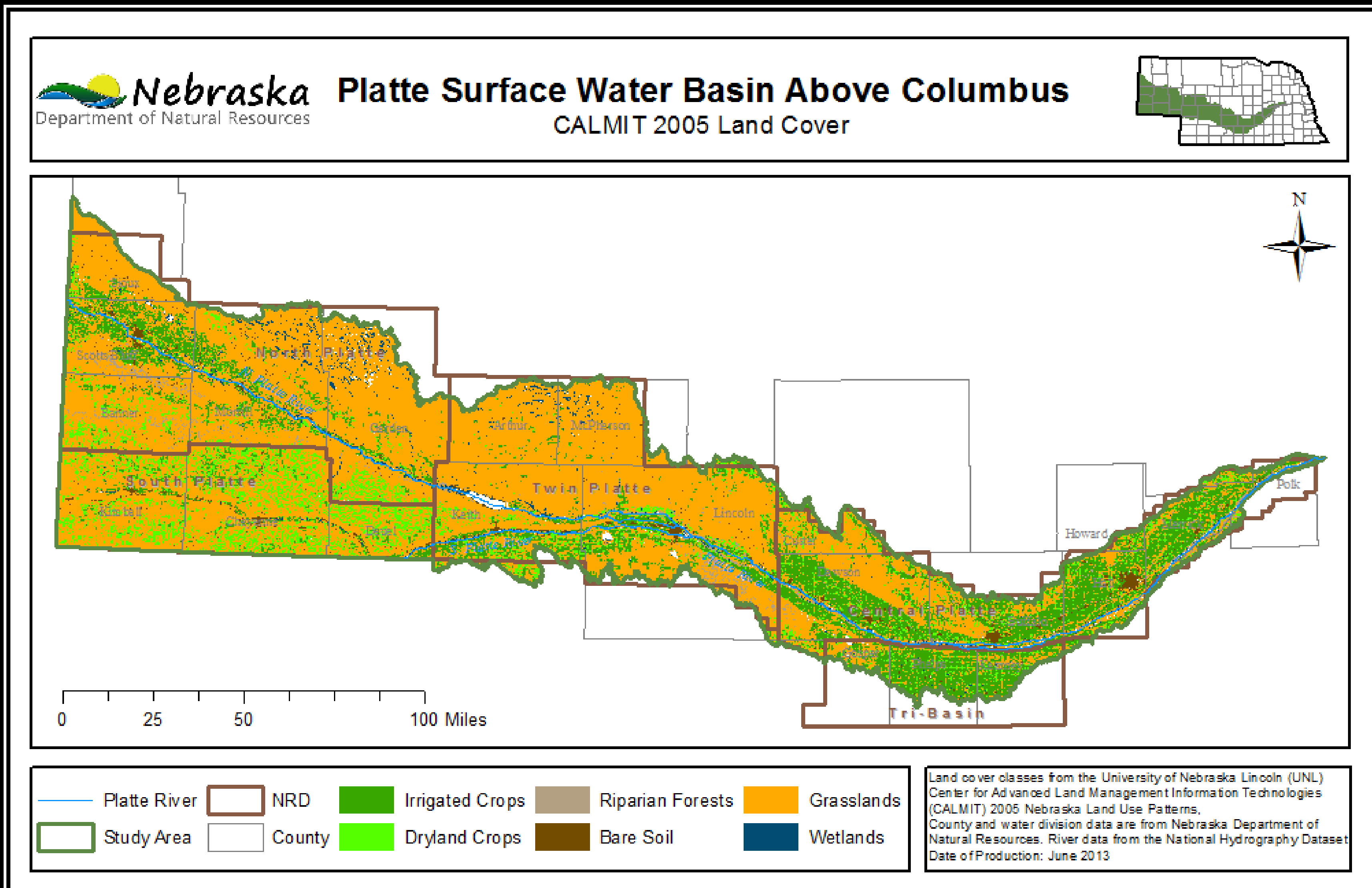


- Data for ET Calculator
  - Location and acres
    - GIS process
  - Soil type
    - STATSGO (horizon 1)
  - Land cover
    - CALMIT 2005 land cover dataset
    - UNL CSD native vegetation
  - Location in ET climate areas
    - NRCS consumptive use calculator guide

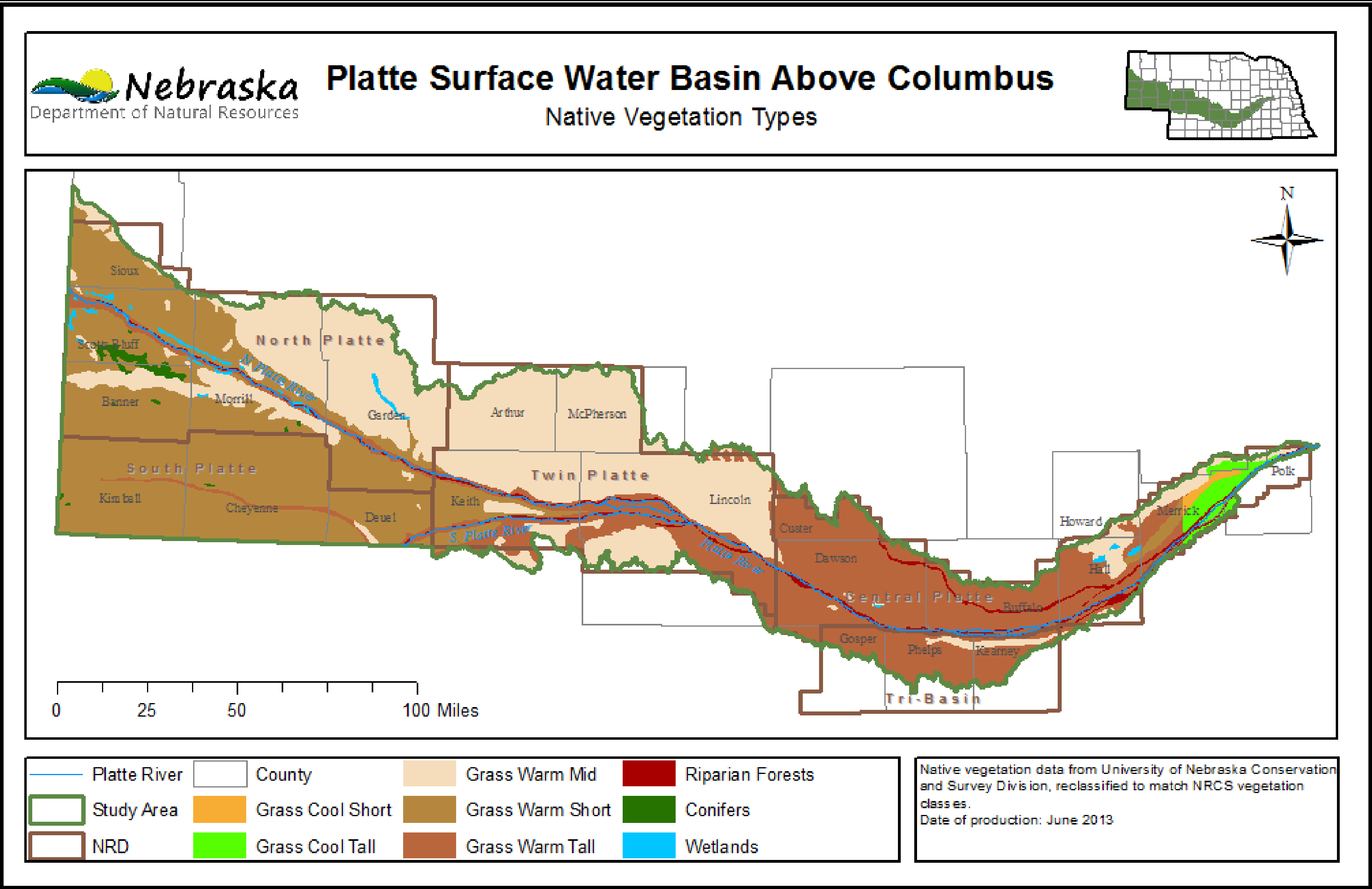
Methods: ET Calculation



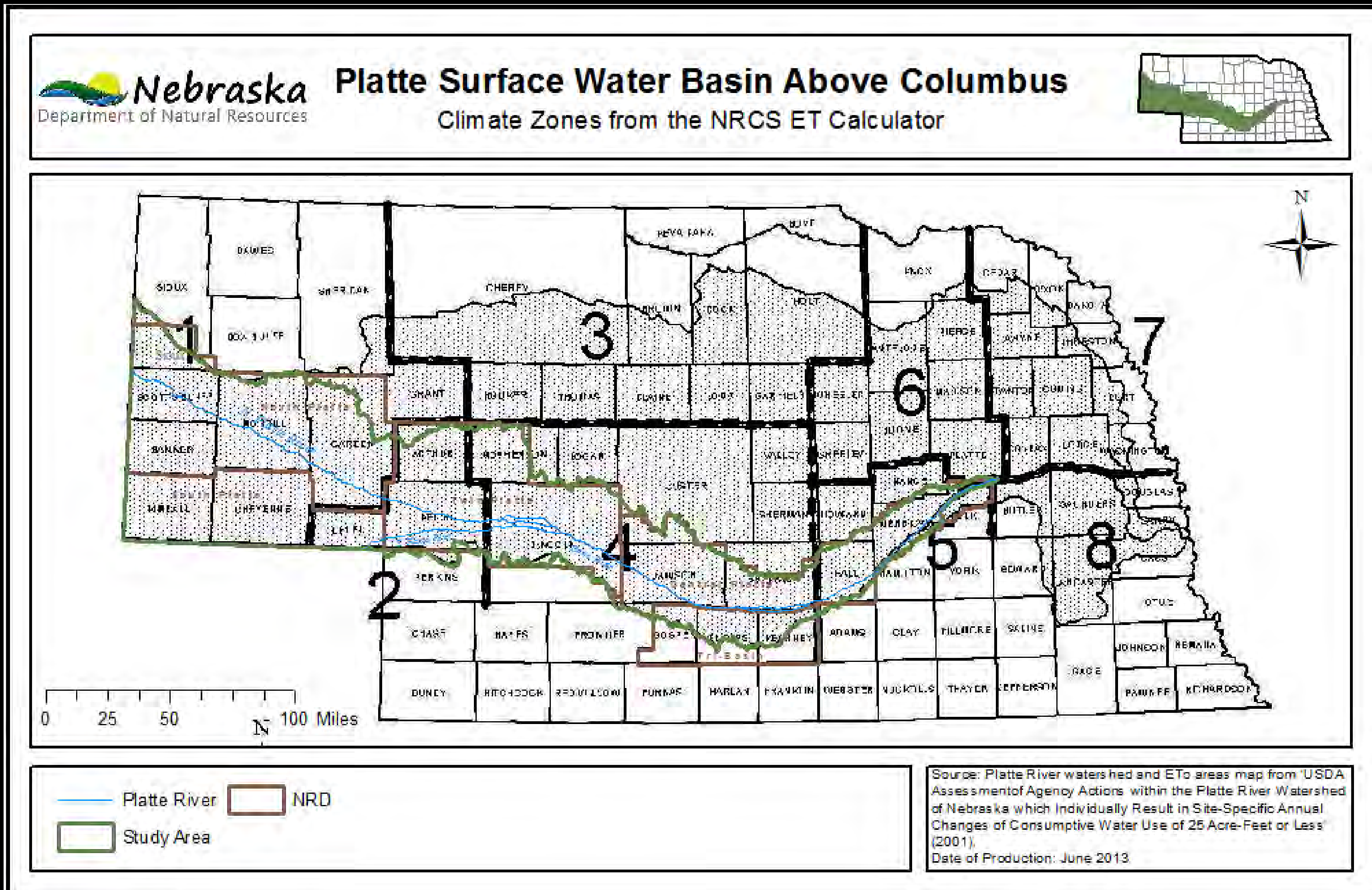
Methods: ET Calculation



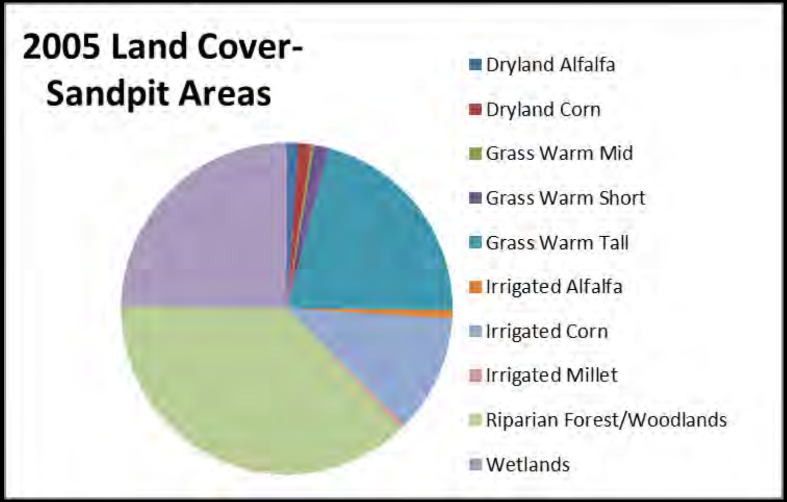
Methods: ET Calculation

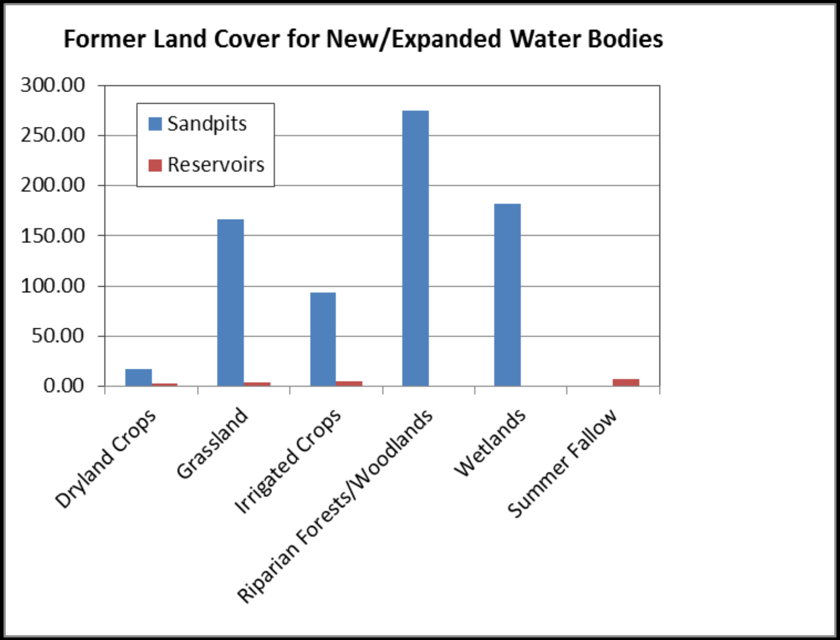


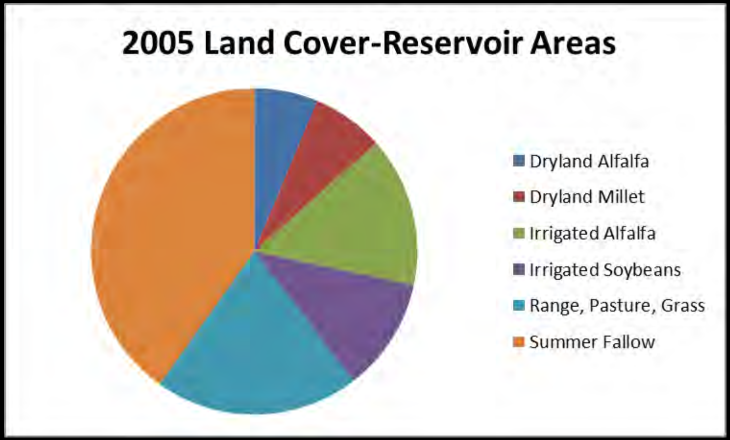
Methods: ET Calculation



Methods: Prior Land Use for ET Calculation



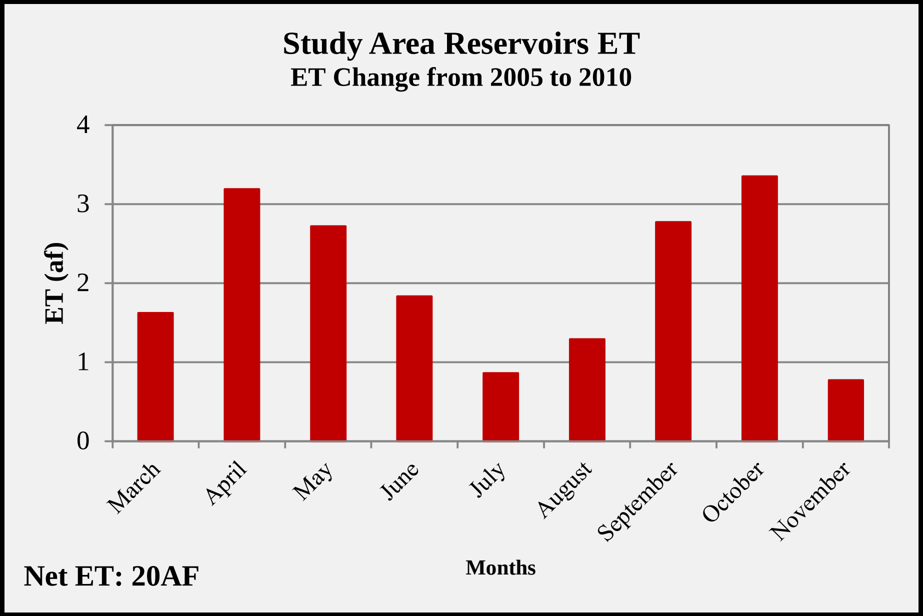


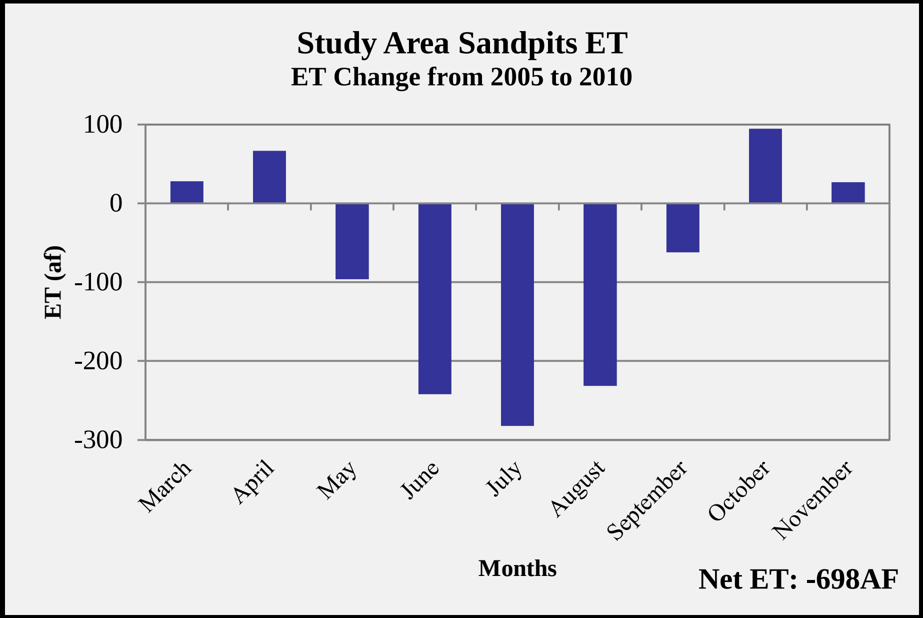


Methods: ET Calculator Assumptions/Decisions

- 2005 land cover
  - CALMIT land cover
    - UNL CSD native grasses
  - Wet tall grasses for wetlands
  - Average ET of cottonwoods and willows for riparian trees
- 2010 land cover
  - Shallow water (<1m) for reservoirs
  - Deep water (>1m) for sandpits
- Reclaimed sandpit land
  - 2010 land cover: Sand
- Irrigation application timeframe: May to September

Results: ET Change 2005 to 2010

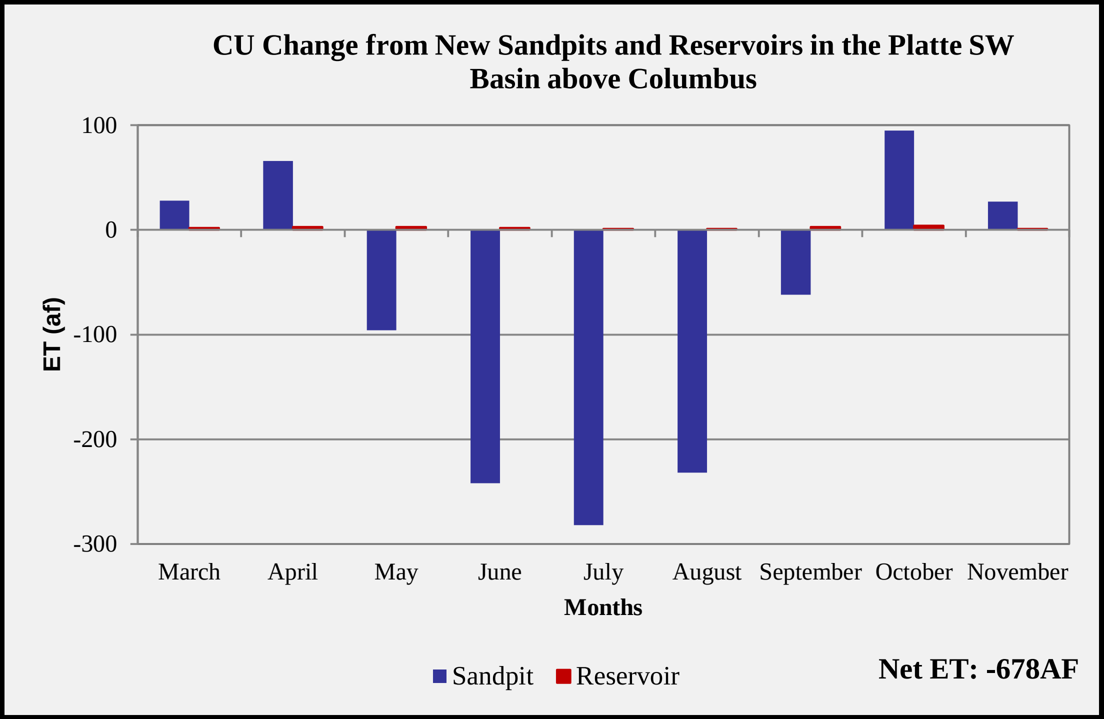




20af ET increase from new unpermitted reservoirs

698af ET decrease from new or expanded sandpits

Results: ET Change 2005 to 2010



Overall ET decrease of 678af per year from sandpits and reservoirs

Summary

- Used geospatial technologies to identify small man-made water bodies
- Used NRCS calculator to estimate ET due to changed land cover.
- 747 acres of new reservoirs and new/expanded sandpits
- Increase in ET during all months for reservoirs
- ET increase in non-irrigation months and decrease in irrigation months for sandpits
- Overall annual decrease of 678af in consumptive use via ET
- 2500 hours to create inventory and run ET calculations

Nebraska
Department of Natural Resources

Amy Zoller, MS, Integrated Water Management Analyst
Nebraska Department of Natural Resources

References

Mather and Koch, 2011. Computer Processing of Remotely-Sensed Images: An Introduction, Fourth Edition. John Wiley & Sons, Ltd, Chichester, UK. p. 142.

NRCS Consumptive Use Calculator, online at http://dnr.nebraska.gov/iwm/prrip-nrcs-consumptive-use-calculator-report

Data Sources

- 2005 Farm Service Agency Digital Aerial Imagery: http://dnr.ne.gov/databank/DigitalImagery.html
- CALMIT 2005 Statewide Land Use Dataset: http://calmit.unl.edu/2005landuse/statewide.php
- UNL CSD Native Vegetation Dataset: http://snr.unl.edu/data/geographygis/NebrGISland.asp
- National Hydrography Dataset: http://dnr.ne.gov/databank/nhd.html
- STATSGO Soil Data: http://www.dnr.ne.gov/databank/statsgo1.html
- NRCS ET Areas: NRCS Consumptive Use Calculator http://dnr.nebraska.gov/iwm/prrip-nrcs-consumptive-use-calculator-report

C

Appendix C

MOST RECENT UPPER PLATTE BASIN-WIDE PLAN ANNUAL REPORTS

The most recent Upper Platte Basin-Wide Plan annual reports can be found on the NeDNR website at the following link:

https://dnr.nebraska.gov/water-planning/upper-platte-basin-wide-meetings-and-annual-reports

D

Appendix D

PRELIMINARY ESTIMATE OF HISTORICAL STREAM FLOW REDUCTIONS IN THE OVERAPPROPRIATED PORTION OF THE PLATTE RIVER IN NEBRASKA

Preliminary Estimate of Historical Stream Flow Reductions in the Overappropriated Portion of the Platte River in Nebraska.

Prepared at the Request of the Basin-Wide Stakeholder Group

by

Jesse Bradley
Nebraska Department of Natural Resources,

Duane Woodward
Central Platte Natural Resources District,

Jeff Shafer
Nebraska Public Power District,

and

Mike Drain
Central Nebraska Public Power and Irrigation District

TABLE OF CONTENTS

TABLE OF TABLES

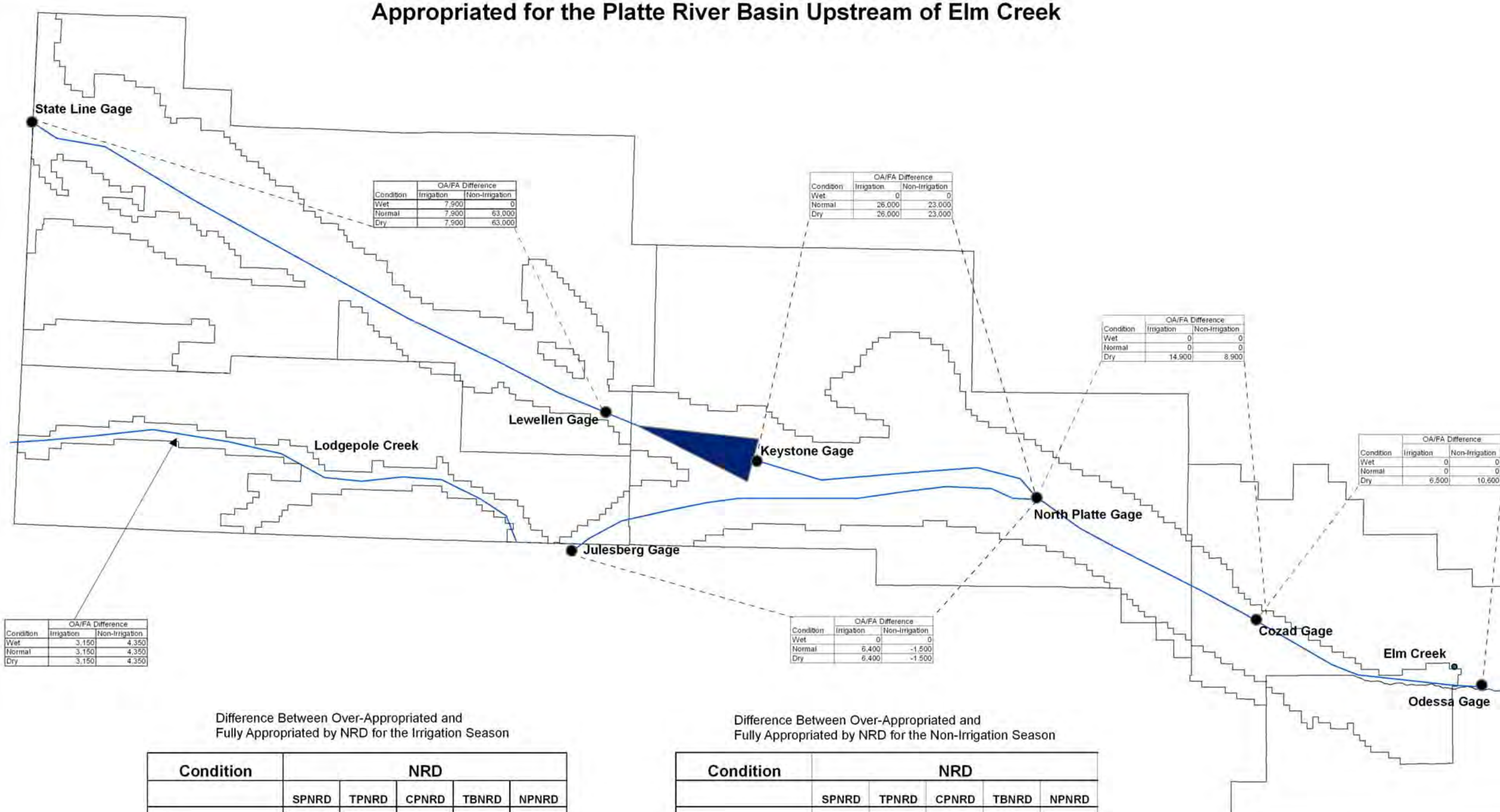
TABLE OF FIGURES

1.0 EXECUTIVE SUMMARY

The objective of this study was to identify the overall difference between overapproriated and fully appropriated for the Platte River Basin upstream of Elm Creek. This study focused on analyzing the impacts to the gains in surface water flows for specific reaches of the Platte River. The gains were used to represent the natural flow conditions that are available to surface water appropriations. The reaches identified for purposes of this study were based on long-term gage locations and the demands of surface water appropriations. The five reaches evaluated in this study include: 1) Cozad to Odessa; 2) North Platte to Cozad; 3) Keystone to North Platte; 4) state line to Lewellen; and 5) Julesburg to North Platte on the South Platte River. In addition to these five reaches, Lodgepole Creek was also evaluated.

The process used to evaluate each reach consists of three steps. Step one was to identify reach gain changes that have occurred within the reach. Reach gain reductions were identified by distinguishing significant changes in historical gains due to factors other than precipitation. Step two was to identify the unmet demands for each reach, which sometimes included unmet demands occurring downstream. Unmet demands were identified for surface water appropriations used for irrigation, hydropower, instream flows, and aquifer storage, as well as for groundwater users reliant on surface water flows for aquifer recharge. Unmet demands were based on specific users' historical need for water under varying hydrologic conditions. Three hydrologic conditions were considered in the evaluation: wet, normal, and dry. These conditions were necessary since stream reach gain reductions and unmet demands can be closely linked to the hydrologic conditions of the basin. Step three was to identify the overall difference between overappropriated and fully appropriated. This difference was determined by comparing the stream reach gain reductions within a reach to the cumulative unmet demands for that reach. The lesser of the two values was used to represent the difference, with certain exceptions that are specifically noted in the report. The lesser value was used because when reach gain reductions are less than unmet demands, it would not be expected that unmet demands be fully met, only that reach gain reductions not further erode the supply available for those demands. Conversely, when reach gain reductions are greater than unmet demands, reach gain reductions would not be expected to be made up in the absence of demands for the supply. Figure 1-1 summarizes the overall difference between overappropriated and fully appropriated for each reach and for Lodgepole Creek.

Overall Difference Between Overappropriated and Fully Appropriated for the Platte River Basin Upstream of Elm Creek



Difference Between Over-Appropriated and Fully Appropriated by NRD for the Irrigation Season

Condition	NRD				
	SPNRD	TPNRD	CPNRD	TBNRD	NPNRD
Wet	3,200	0	0	0	7,850
Normal	3,850	31,750	0	0	7,850
Dry	3,850	40,450	9,200	3,500	7,850

Difference Between Over-Appropriated and Fully Appropriated by NRD for the Non-Irrigation Season

Condition	NRD				
	SPNRD	TPNRD	CPNRD	TBNRD	NPNRD
Wet	4,350	0	0	0	0
Normal	4,625	21,650	0	0	62,575
Dry	4,625	26,850	8,550	5,750	62,575

Figure 1-1

Figure 1-1. Summary of the stream reach gain reductions, unmet demands, and overall difference between overappropriated and fully appropriated.

2.0 PROCESS OVERVIEW

2.1 Selection of Reaches

Within the overappropriated basin, precipitation generally increases and irrigation requirements generally decrease from west to east. Additionally, the further upstream a stream reach gain reduction occurs, the greater the number of downstream uses that can potentially be impacted. To address issues resulting from the spatial variation of precipitation supplies and demands, the overappropriated area was divided into six sub-areas or reaches.

Reaches were selected based upon a combination of key river gage locations and key points of diversion or use. The number and size of the reaches balance the analytical need to differentiate between various locations (generally easier with more numerous and shorter reaches) and the analytical need to discern differences in the data (generally easier with less numerous and lengthier reaches). Stream inflows and outflows for each reach are measured by key gages, diversions, and returns located at or near the ends of the reaches. The following reaches were used in the analyses:

- North Platte River –state line to Lewellen
- Lodgepole Creek – Wyoming state line to Colorado state line
- South Platte River and North Platte River below McConaughy, subdivided as
  - North Platte River – Keystone to North Platte; and
  - South Platte River – Julesburg to North Platte
- Platte River – North Platte to Cozad
- Platte River – Cozad to Odessa

Note that the above listing of reaches excludes the stretch of North Platte River from Lewellen to Keystone, which is basically the stretch of river containing Lake McConaughy and Lake Ogallala. Streamflow reductions through this reach, and their consequent potential impact to uses and contribution to the overappropriated condition were not evaluated due to the ungaged nature of tributaries within the reach. The potential for Lake McConaughy storage to satisfy unmet downstream demands was not evaluated since the analysis focused on nature flows (e.g., reach gains). Additionally, the demand for storage water losses (e.g., evaporation and seepage) was considered but not included as part of the unmet demands, as will be discussed.

2.2 Hydrologic Variability in the Analysis

Consideration was given to the potential for temporal hydrologic variation in the analyses of the overall difference between overappropriated and fully appropriated conditions. Generally, stream reach gain reductions are less likely to have an adverse impact on downstream demands under wetter hydrologic conditions than under drier hydrologic conditions. Moreover, some streamflow demands, such as irrigation diversions, are seasonal in nature. The irrigation requirement for crops can increase and decrease with annual variations in effective precipitation.

In these analyses, the difference between overappropriated and fully appropriated was evaluated for the irrigation season and non-irrigation season, and for a range of hydrologic conditions (wet, normal, and dry). The duration of the irrigation season and non-irrigation season was kept constant for all reaches: the irrigation season encompassed May through September, and the non-irrigation season encompassed October through April. The hydrologic periods representing wet, normal, and dry conditions were determined on a reach-by-reach basis. The reaches downstream of Lake McConaughy all appeared to be subject to the same periods of wet, normal, and dry conditions, whereas the reach from the state line to Lewellen had a different set of periods (table 2-1).

Table 2-1. Representative periods for wet, normal, and dry conditions in the six reaches used in the analysis.

Reach	Wet	Normal	Dry
State line to Lewellen	1971-1973 and 1995-1999	1962-1967	1954-1961 and 2002-2006
Lodgepole Creek	Specific period not identified	Specific period not identified	Specific period not identified
Julesburg to North Platte	1983-1986 and 1995-1999	1974-1979 and 1988-1994	1953-1956 and 2002-2006
Keystone to North Platte	1983-1986 and 1995-1999	1974-1979 and 1988-1994	1953-1956 and 2002-2006
North Platte to Cozad	1983-1986 and 1995-1999	1974-1979 and 1988-1994	1953-1956 and 2002-2006
Cozad to Odessa	1983-1986 and 1995-1999	1974-1979 and 1988-1994	1953-1956 and 2002-2006

For areas downstream of Lake McConaughy, wet conditions were defined as periods when all uses were able to satisfy their full beneficial use and reservoir levels in Lake McConaughy were sustained at a full pool. Dry conditions were defined as periods of near-historic low streamflows and precipitation and an inability to satisfy the beneficial uses of all demands. The periods used to assess normal conditions were difficult to determine, but they were predominantly periods of near-average streamflows and precipitation but inadequate surface water storage supplies to satisfy all beneficial uses of the demands.

For areas upstream of Lake McConaughy, wet conditions were defined as periods when all downstream uses were able to satisfy their full beneficial use and reservoir levels in Lake McConaughy were sustained at a full pool. Dry conditions were defined as periods of historic low streamflows and precipitation and an inability to satisfy the beneficial uses of all demands. The periods used to assess normal conditions were difficult to determine, but they were predominantly periods of near-average streamflows, state line inflows, near-average precipitation, and inadequate surface water storage supplies to satisfy all downstream beneficial uses of the demands.

Although the method of analysis recognized the potential for temporal variation by season and hydrologic condition, it was also recognized that this might not always be the case. In some cases, a temporal distribution in streamflow impact or unmet demand simply might not exist. In other cases, the method of analysis may not have been sufficient to identify a temporal variation that may have been present in the dataset. Where a streamflow impact or unmet demand was identified with no observable temporal distribution, a single value was used for all conditions.

2.3 Stream Reach Gain Reductions

The assessment of stream reach gain reductions focused on the gains in the Platte River between specified gages or on specific tributaries (e.g., Lodgepole Creek) when necessary. This type of analysis was used as a means to assess total impacts to surface water flows within the overappropriated basin. For the purposes of this report, stream reach gain reductions are defined as ***any long-term reduction in the gain within a specific reach or tributary*** (the reaches are described in section 2.1). Long-term reduction would include only those periods of five or more years in which the trend was consistent.

The gain within a reach is measured as the increased streamflow at a downstream gage when compared to an upstream gage, taking into account the activities occurring within that reach. Figure 2-1 illustrates a typical reach of the Platte River and the data used to calculate the reach gain.

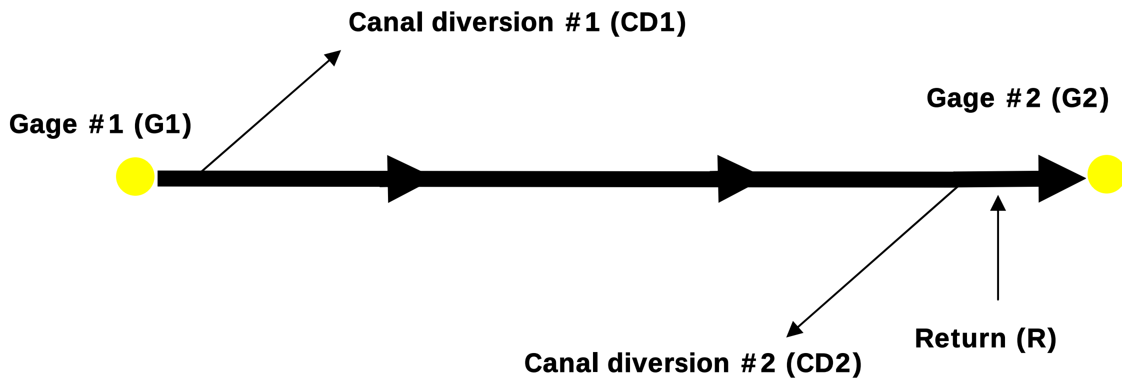


Figure 2-1. Representation of typical reach gain segment.

This type of reach analysis is useful for removing the impacts of anthropogenic activities (e.g., reservoir releases, diversions, etc.) and focusing on changes within the reach. Reach gain is computed by adding all canal diversions to the downstream gage and subtracting the return flows and flows at the upstream gage, as follows (using the abbreviation from figure 2-1).

Reach Gain = G2 + CD1 + CD2 – R –G1

Reach gains were calculated on an irrigation season (May – September) and a non-irrigation season basis (October – April). Any reduction in the reach gains would indicate a reduction in the natural flow available within the reach.

Stream reach gain reductions calculated using this methodology could include impacts from: reduced runoff, reduced surface water return flows (relative to diversions), reduced groundwater inflow, and reduced tributary inflows.

2.3.1 Assessment of Changes in Streamflow

The first step in analyzing the calculated reach gains was an assessment of the long-term trends in streamflow relative to natural variability (e.g., precipitation cycles) and anthropogenic changes (e.g., increased diversions). Double-mass curves were developed for each reach or tributary investigated in this study to understand better the points in time related to and the potential causes of long-term changes in streamflow. A double-mass curve is the plot of the cumulative amount of one variable relative to the cumulative amount of a second variable. These are useful for identifying points in time at which the relationship between these two values changes (termed "break points").

The double-mass curve was used in this study to analyze the temporal variability (if any) in the relationship between reach gains and other factors (e.g., precipitation) that could influence those reach gains. The resulting plot will form a straight line if the variability in reach gain can be attributed only to the corresponding variable (e.g. precipitation) against which gain is plotted. If the reach gains are influenced by other factors (figure 2-2), then break points in the double-mass curve will be apparent. These break points may be due to a single cause or some combination of several of the potential causes discussed below.

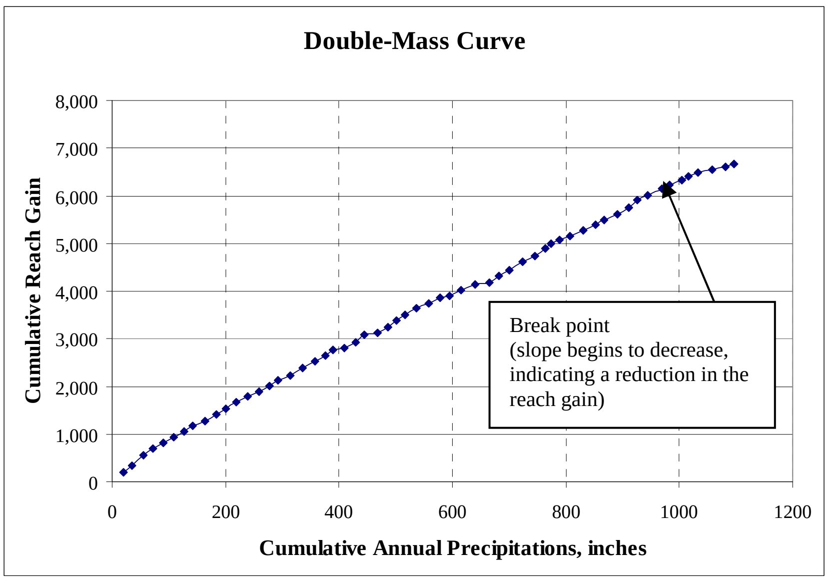


Figure 2-2. Example of a double-mass curve of cumulative reach gain and cumulative precipitation.

2.3.2 Quantification of Stream Reach Gain Reductions

Once stream reach gain reductions had been identified, the next step was to quantify the magnitude of the change. This was done by calculating the precipitation-corrected slopes for the "representative period" prior to a break point in the double-mass curve and the precipitation-corrected slope for the "recent period" following the break point (figure 2-3). Each slope was then multiplied by the average precipitation for both time periods and the result for the recent period was subtracted from the result for the representative period.

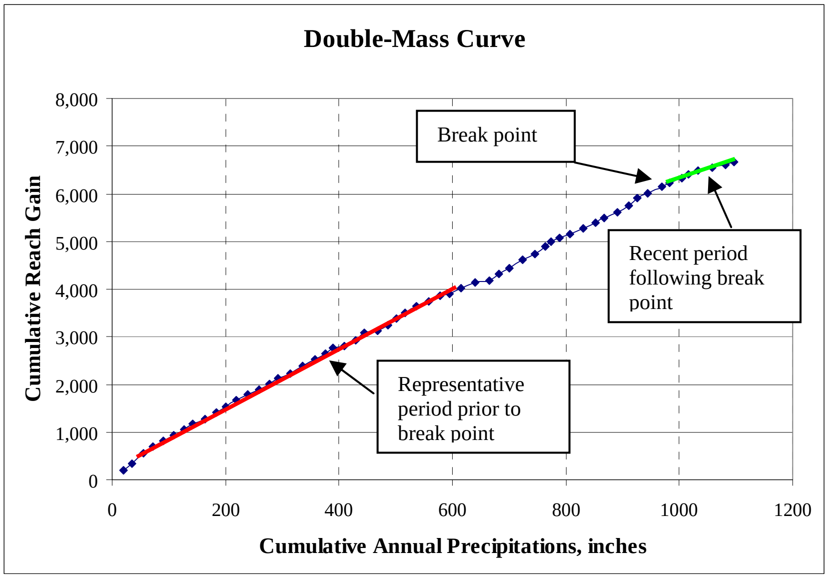


Figure 2-3. Example of using the double-mass curve to determine a representative-period slope and the more recent-period slope.

For example if:

Representative period average reach gain prior to break point 1952-1980

Recent period average reach gain following the break point 1999-2006

Calculating the average reach gains:

Representative period average reach gain = (y_2-y_1/ x_2-x_1) * average precipitation (1952-1980 and 1999-2006)

Recent period average reach gain = (y_4-y_3/x_4-x_3) * average precipitation (1952-1980 and 1999-2006)

where

x_1 = cumulative precipitation at the beginning of the representative period (1952)

x_2 = cumulative precipitation at the end of the representative period (1980)

x_3 = cumulative precipitation at the beginning of the recent period (1999)

x_4 = cumulative precipitation at the end of the recent period (2006)

y_1= cumulative reach gain at the beginning of the representative period (1952)

y_2= cumulative reach gain at the end of the representative period (1980)

y_3= cumulative reach gain at the beginning of the recent period (1999)

y_4= cumulative reach gain at the end of the recent period (2006)

Calculate stream reach gain reduction:

Stream reach gain reduction = (Representative period average reach gain – Recent period average reach gain)

2.3.3 Assessment of Potential Causes

Break points identified in the double-mass curves were further investigated by analyzing the relationship between the reach gain and five potentially related datasets: 1) baseflow (e.g., groundwater inflow to the reach); 2) surface water inflows; 3) surface water diversions; 4) groundwater development; and 5) surface water development. The source of data and potential significance of any relationship between the reach gains and that data type is explained in the following sections. The authors recognize that this list may not be comprehensive and that further assessment of potential causes of reach gain reductions may be warranted.

2.3.3.1 Baseflow Changes

Baseflow is a term often used to describe the groundwater component of flow into a stream. Baseflow can be determined using various hydrograph separation techniques; the goal of each technique is to determine the consistent component of flow within the hydrograph or the baseflow. A digital filtering technique was used in this report to calculate baseflow for each reach. Baseflows were compared to reach gains or tributary flows to determine whether changes in the reach gains were associated with changes in the baseflow component. Reductions in the baseflow component could represent a reduction of groundwater inflow within that reach, thereby identifying the portion of the reach gain reduction due to decreased groundwater inflow.

2.3.3.2 Inflow Changes

Inflows as described here represent flows that occur at the upstream end of a reach that could influence the gains within the reach being evaluated. Inflows were evaluated due to the fact that many reaches receive returns from canal deliveries that have significant influence on the potential gain within the reach.

2.3.3.3 Diversion Changes

Diversions are the surface water deliveries used by the major canals within each reach, and are added to the downstream gaged flows when determining the reach gains. Diversions within a reach can be a significant component in the amount of gain within that reach. Therefore, this study evaluated the consistency of diversions occurring within each reach. If diversions were determined to have decreased in volume within a reach, this could be a potential cause for a portion of any reduced reach gains due to reductions in seepage from those diversions back to the reach. To account for this, a correction was applied to the stream reach gain reductions to account for the seepage change between the representative period and the recent period.

2.3.3.4 Groundwater Development Changes

Groundwater irrigated acres were assessed to determine if any general increase of groundwater irrigated acres is related to any reduction in reach gains. New groundwater irrigated acres were computed in annual quantities based on completion dates within the Nebraska Department of Natural Resources (NDNR) water well registration database. These annual new groundwater irrigated acres were plotted cumulatively to determine trends in development. The cumulated groundwater irrigated acres extracted from the NDNR water well registration database were compared to the estimates of groundwater irrigated acres developed by COHYST for the years 1997 to 2005 to validate recent acre estimates.

2.3.3.5 Surface Water Development Changes

Acres approved to be irrigated under surface water appropriations were assessed to determine if an increase in surface water irrigated acres is related to any reduction in reach gains. Surface water irrigated acres were extracted from the NDNR surface water appropriation database to determine the annual newly appropriated acres. The annual acres associated with new appropriations were accumulated to determine trends in surface water development.

2.4 Unmet Demand

A streamflow reach gain reduction alone does not necessarily result in an adverse impact to an appropriation, to recharge needed for existing wells, or to the State's ability to comply with an interstate agreement. For a streamflow reach gain reduction to result in such an adverse impact, the reach gain reduction would have to be sufficient to reduce the supply that would be available to and needed by one of the abovementioned uses. Therefore, in order to determine when and how often streamflow reach gain reductions might have an adverse impact, it is necessary to determine when and how often shortages to appropriations, to streamflow needed for recharge, or to streamflow needed for compliance with interstate agreements occur. These shortages to uses are referred to in these analyses as "unmet demands."

In assessing unmet demands, it is recognized that some demands, and therefore unmet demands, can or do make use of the same water supply. For example, streamflow in the non-irrigation season may be used for power production and then returned to the river, and it may then flow downstream to become part of the water supply for instream flow appropriations. Other examples include water diverted for irrigation that also is used in power production, water that is used for power production in multiple locations, and water in the river that is used for both instream flow appropriations and recharge for wells. Thus it is important to recognize that unmet demands are not always cumulative, and efforts were made in the analyses where appropriate to avoid double-counting the impacts from streamflow reach gain reductions.

2.4.1 Instream Flow Appropriations Unmet Demands

Both the Central Platte Natural Resources District (CPNRD) and the Nebraska Game and Parks Commission (NGPC) hold natural flow appropriations for instream flows within and below the lower reaches of the study area. For purposes of estimating the unmet demand, the instream flow appropriations as measured at Odessa were compared against the historic daily streamflow record. If the streamflows were greater than the instream flow appropriation, there was no unmet demand. If the streamflows were less than the instream flow appropriation, then the difference between the instream flow appropriation and recorded streamflow was determined to be a daily unmet demand. The daily values were then totaled for the irrigation and non-irrigation seasons to determine the average seasonal unmet demands.

2.4.2 Irrigation Appropriations Unmet Demands

Appropriations for irrigation exist throughout the study area. The unmet demands for these appropriations were considered for the irrigation season only; it is assumed that no unmet irrigation appropriation demand exists during the non-irrigation season. Because not all irrigation appropriations have storage water available as an additional source of supply, two methods were employed to determine the unmet demand. For those appropriations with a storage supply, it was assumed that historic storage use could be used as an estimate of unmet demand, provided that the storage quantity available was not otherwise reduced (allocated) to below-normal amounts. For those appropriations for which storage water is not available to supplement natural flow for irrigation, the historical diversion record was compared against the consistent historical use (i.e., total diversion at times when natural flow availability was not a limiting factor in the amount diverted) as a way to estimate unmet demand.

2.4.3 Power Appropriations Unmet Demands

Appropriations for power production in the study area include water used in hydropower plants and water used as cooling water in thermal generation plants.

Hydropower generation in the study area represents a large non-consumptive demand in both the irrigation season and the non-irrigation season. Because hydropower generation is non-consumptive, the water used to meet a hydropower demand is often the same water used to meet other demands as well, including other hydropower generation, irrigation, and instream flows. The historical diversion record was compared against the consistent peak historical use (i.e., total diversion at times when natural flow availability was not a limiting factor in the amount diverted) to estimate unmet demand. Unmet demand for hydropower that would also coincide with other unmet demands identified elsewhere was not double-counted.

Cooling water uses in the study area were typically designed to take advantage of other already existing uses. For the purposes of these analyses, any unmet cooling water demand was assumed to coexist with some other unmet demand and therefore did not need to be counted separately.

2.4.4 Storage Reservoir Appropriation Unmet Demands

Appropriations exist in the study area for the purpose of storing water in reservoirs, with the intent that the storage water would then be put to some later use. These storage appropriations are primarily located in Lake McConaughy (including Lake McConaughy appropriations allowed to be stored in Elwood Reservoir) and in the Sutherland system (some of which are also allowed to be stored in Lake McConaughy). The demand for storage includes both the water needed to be stored for some future use and the water needed to satisfy evaporation and seepage losses from the reservoir.

Because the uses to which storage water would be applied have their own estimates of unmet demand (e.g. irrigation and hydropower generation), no additional unmet demand was estimated for storage for these purposes. In addition, because the reservoir evaporation and seepage demands are uncontrolled and have historically been met, no unmet demand was assumed to exist for this storage demand. Consequently, total demand for water from storage will likely be underestimated, as storage often occurs at times when all other demands are already met. Nevertheless, these analyses assumed that omitting these additional unmet storage demands does not substantially affect the estimate of the overall difference between overappropriated and fully appropriated.

2.4.5 Groundwater Recharge Demands

Water flowing in a river or stream can provide recharge to the underlying or surrounding aquifer, particularly where the river or stream is a losing (as opposed to gaining) reach. For purposes of these analyses, an unmet demand for recharge was assumed to exist where river or stream reaches that were historically continuously flowing with baseflow are now dry. In many or all cases, the water needed in the river or stream to keep a stream flowing is the same water needed to meet some other use. Consequently, the unmet demand for recharge would coincide with some other unmet demand and did not need to be quantified separately.

2.4.6 Interstate Agreement Unmet Demands

The only interstate agreement operative within the study area is the Platte River Recovery and Implementation Program (PRRIP). Under PRRIP, additional unmet demands could be those post-1997 reach gain reductions that impact United States Fish and Wildlife Service (USFWS) target flows or PRRIP water supply projects. Although instream flows do not always equal or exceed USFWS target flows, the authors assumed that the requirement to get to a fully appropriated condition for these appropriations alone will probably provide benefits equal to or in excess of those required to meet Nebraska's obligations under PRRIP in terms of water quantity. Thus, no separate unmet demand for purposes of compliance with interstate agreements was estimated. These analyses do not estimate the amount of time that will be needed to achieve the fully appropriated condition, however, and PRRIP compliance issues with respect to timing of water obligations have not been addressed in this report.

2.5 Accumulating Unmet Demands

Reach gain reductions within a given reach can have impacts on both the demands within the reach and the demands downstream of that reach. The total unmet demands for each reach were calculated by adding the unmet demands in that reach to the accumulated unmet demands from the reach downstream. The cumulating process is not always strictly additive; water can be used multiple times by non-consumptive users (e.g. instream flow and hydropower uses). Careful consideration was given to those reaches in which non-consumptive uses were a portion of the unmet demand to ensure that unmet demands were not overestimated.

2.6 Overall Difference between Overappropriated and Fully Appropriated

The overall difference between overappropriated and fully appropriated was determined by comparing each reach's accumulated unmet demands with each reach's stream reach gain reductions. When reach gain reductions are less than unmet demands, unmet demands would not be expected to be fully met but reach gain reductions would not further erode the supply available for those demands. When reach gain reductions are greater than unmet demands, reach gain reductions would not be expected to be made up in the absence of demands for the supply. Therefore, the lesser of the two values was used to determine the total difference between overappropriated and fully appropriated for each reach.

For example, if unmet demands in a given reach equal 50,000 acre-feet, but if the stream reach gain reduction is only 100 acre-feet, then 100 acre-feet would be the value used because that value represents the magnitude of the impact to the available supply. If the results indicate that the total reach gain reduction is greater than accumulated unmet demand, then the sponsors will be responsible for negotiating how much stream reach gain reduction must be replaced in the system within each reach.

3.0 CALCULATION OF STREAM REACH GAIN REDUCTIONS, UNMET DEMANDS, ACCUMULATED UNMET DEMANDS, AND THE OVERALL DIFFERENCE BETWEEN OVERAPPROPRIATED AND FULLY APPROPRIATED

3.1 Section Overview

This section details the double-mass curves used to determine irrigation season and non-irrigation season stream reach gain reductions and provides supporting data as to potential causes of the stream reach gain reductions, unmet demands within each reach, and the accumulated unmet demands assigned to each reach. Further refinement of these estimates will likely be completed in the future and those future refinements may more specifically identify causes of the stream reach gain reductions and the timing of unmet demands.

3.2 Platte River – Cozad to Odessa Reach

The Cozad to Odessa reach is the contributing surface water basin between the stream gages located on the Platte River at Cozad and at Odessa. This reach includes inflows from the Johnson Return and small ungaged tributaries and outflows to the Kearney Canal.

3.2.1 Assessment of Reach Gain Reductions

The double-mass curve of cumulative reach gains and cumulative precipitation during the period of 1949-2006 for the irrigation season and non-irrigation season, respectively, are illustrated in figures 3-1 and 3-2. The cumulative precipitation for this reach was developed based on the weighted precipitation from the following gages:

Gage	Weight of Gage (based on Thiessen polygons)
Elwood	0.218
Gothenburg	0.456
Holdrege	0.179
Kearney	0.063
North Platte	0.069
Stockville	0.015

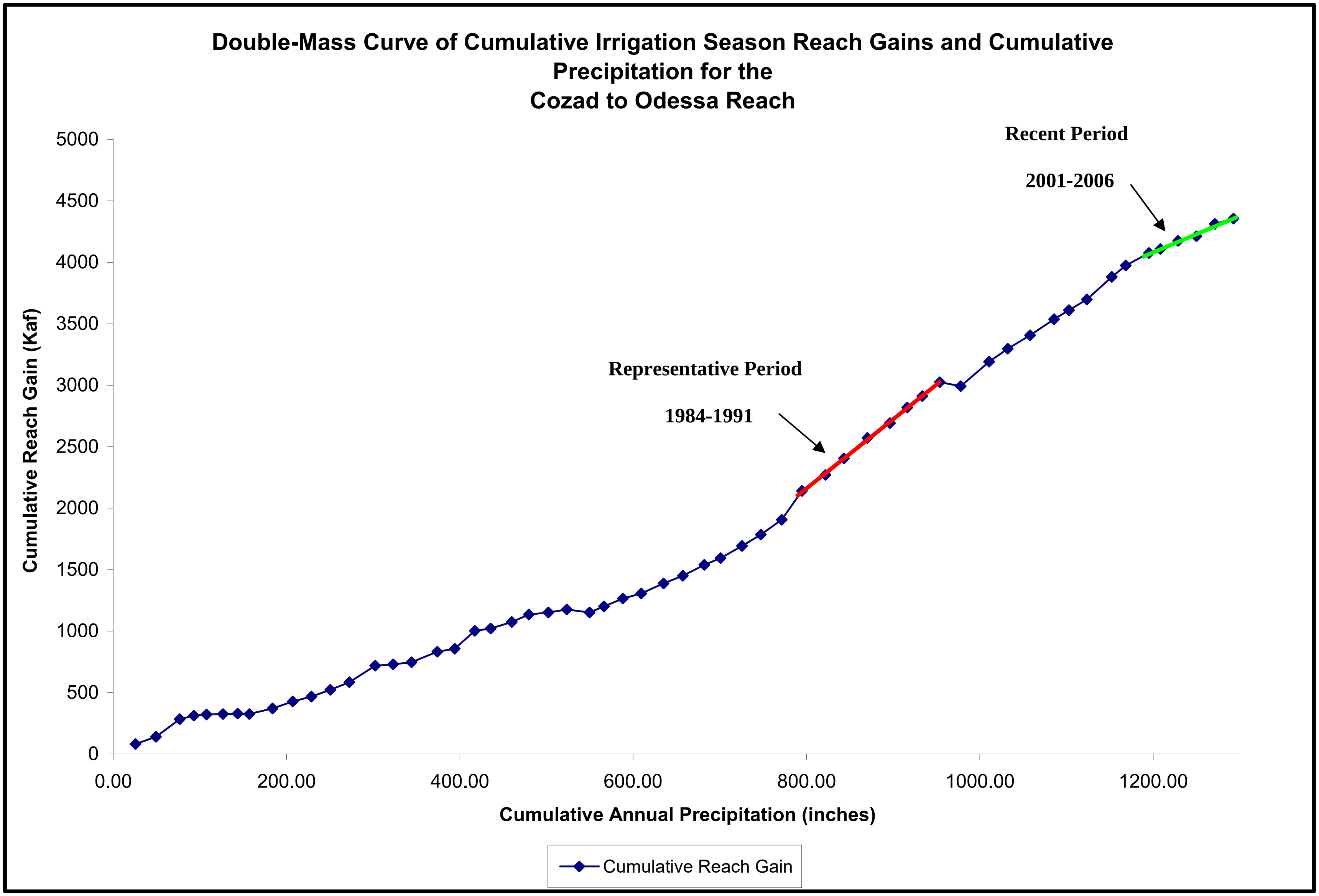


Figure 3-1. Double-mass curve of the cumulative irrigation season reach gain and cumulative annual precipitation.

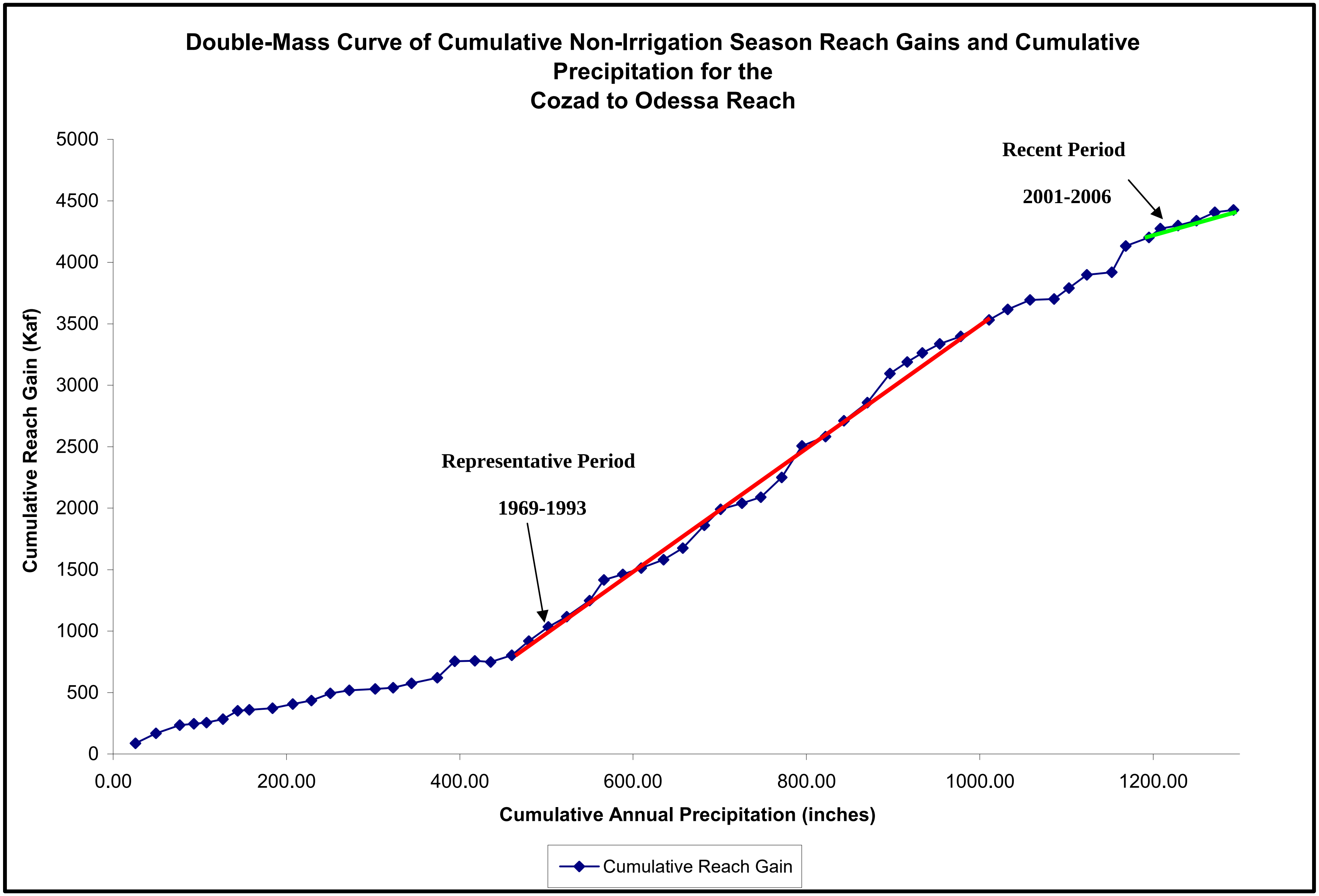


Figure 3-2. Double-mass curve of the cumulative non-irrigation season reach gain and cumulative annual precipitation.

In evaluating potential stream reach gain reductions, the 1969-1993 period was used as the representative period for the non-irrigation season and the 1984-1991 period was used as the representative period for the irrigation season. The period 2001-2006 was used to represent the recent periods for both the irrigation season and the non-irrigation season. The authors acknowledge that the 2001-2006 period represents a dry condition, thus any stream reach gain reductions identified for this reach were thought to represent only dry conditions. An earlier breakpoint in the double mass curve for the irrigation season was indicated, but a corresponding point in the non-irrigation season was not evident, and therefore further work should be completed to determine the cause of this inconsistency between the irrigation season and non-irrigation season double mass curves.

The calculated stream reach gain reductions for this reach are summarized in table 3-1. The stream reach gain reductions within this reach are very sensitive to the representative period used. The representative value used for this reach was selected by the authors because it appeared to represent conditions in which seepage from canals within the reach reached equilibrium. Increased gains within this reach from 1960 to 1990 may be due to a variety of factors, however, and further investigation is necessary.

Table 3-1. Summary of stream reach gain reductions for the Cozad to Odessa reach.

Cozad to Odessa Reach Gain Reduction		
Condition	Irrigation Season (ac-ft)	Non-Irrigation Season (ac-ft)
Wet	0	0
Normal	0	0
Dry	59,300	60,300

3.2.2 Potential Causes for Reach Gain Reductions

The potential causes for stream reach gain reductions within this reach were investigated by evaluating reach gain baseflows, diversions (seepage returns to the reach), groundwater development, and surface water development. Figures 3-3 and 3-4 illustrate how baseflow within the reach has changed over this period. The baseflows appear to have increased through the 1965-1990 period with a rapid decrease in the more recent period. This decrease in baseflow could indicate that a portion of the recent period stream reach gain reduction is due to reduced groundwater inflow in the reach.

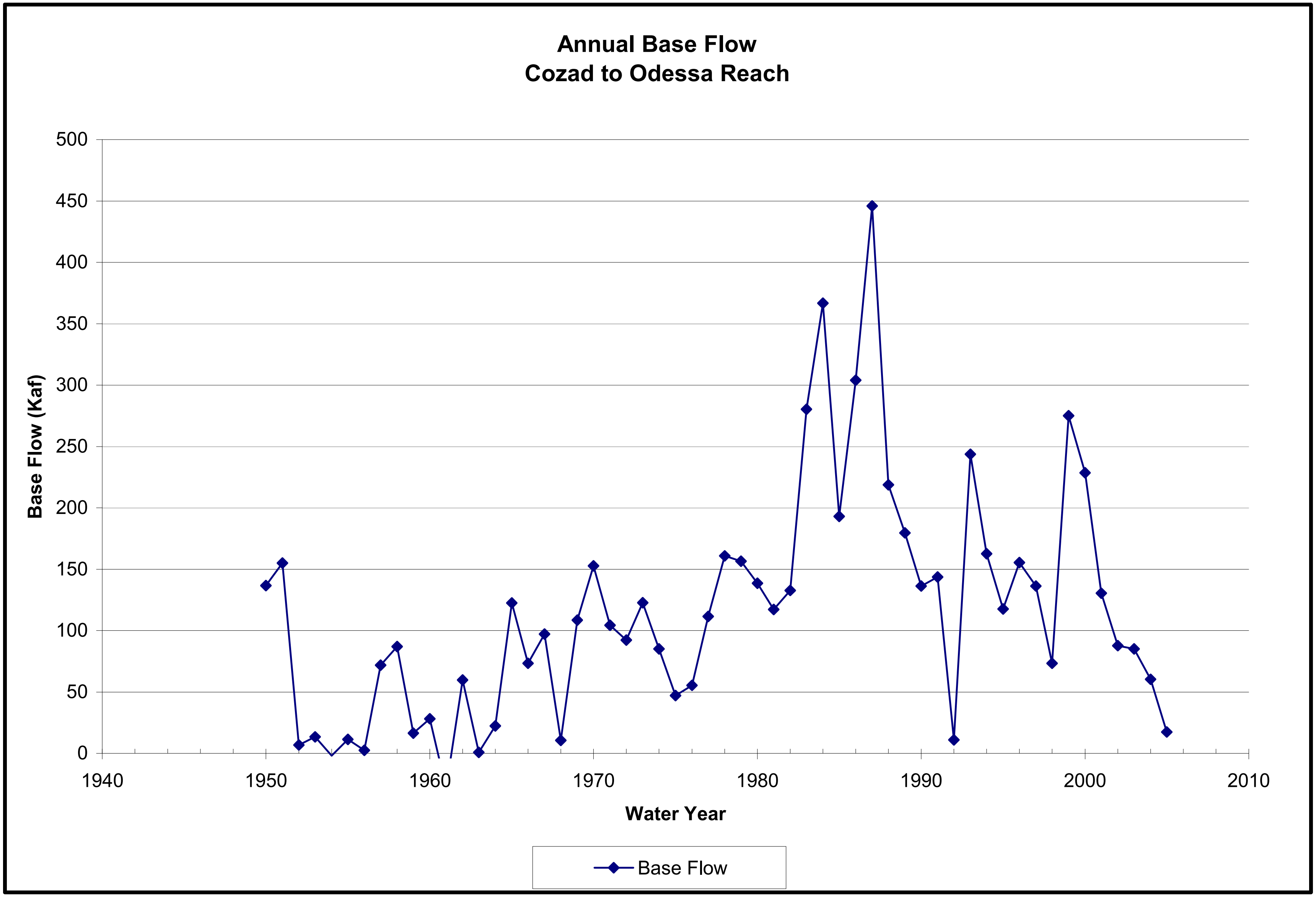


Figure 3-3. Cozad to Odessa reach annual baseflow gain.

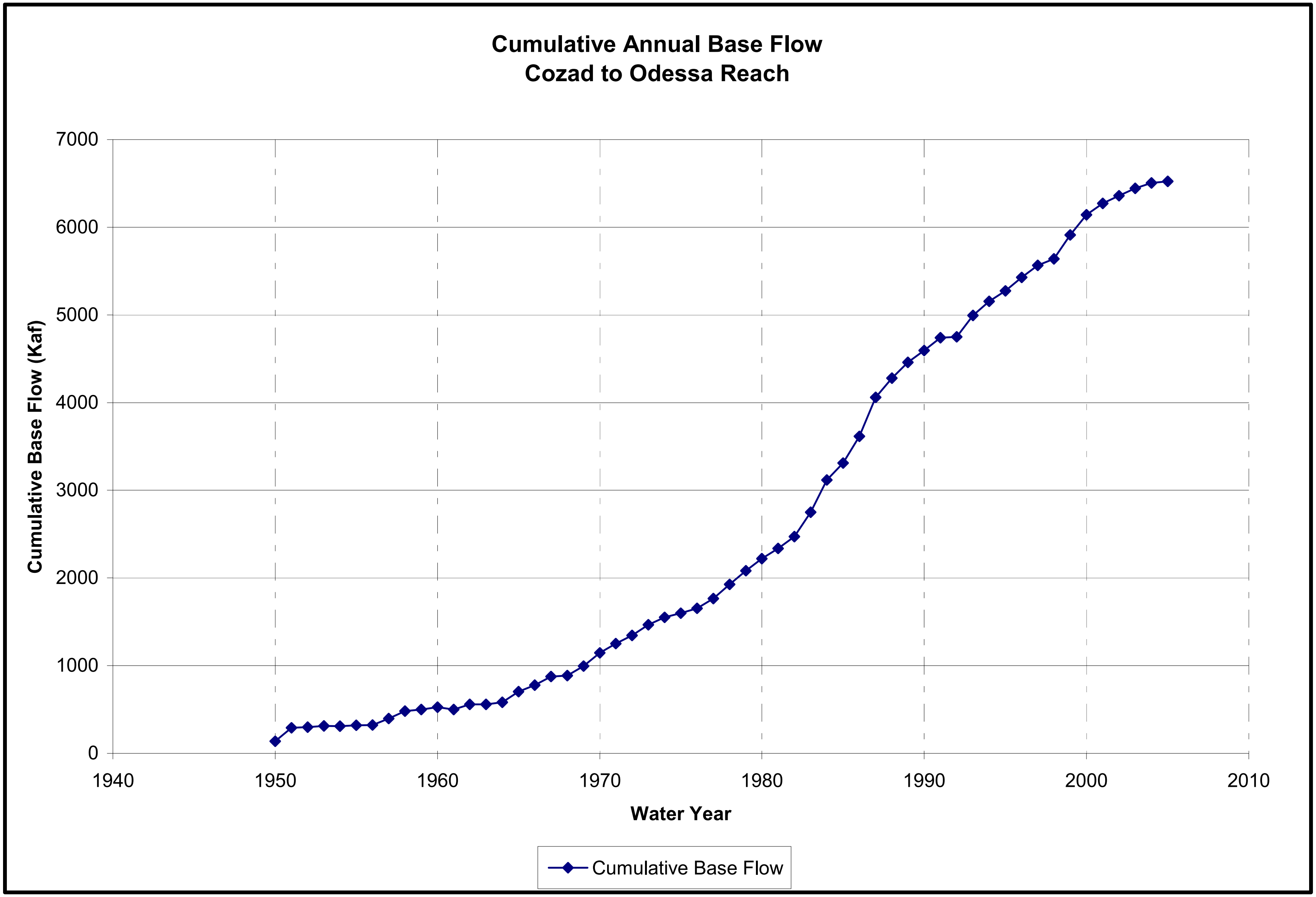


Figure 3-4. Cozad to Odessa cumulative annual baseflow.

Surface water diversions within the reach were evaluated to determine if reduced surface water diversions, and, therefore, reduced returns from those diversions, could be a potential cause of stream reach gain reductions. Figures 3-5 and 3-6 illustrate historical diversions for irrigation and hydropower demands for Kearney Canal and the Tri-County Canal.

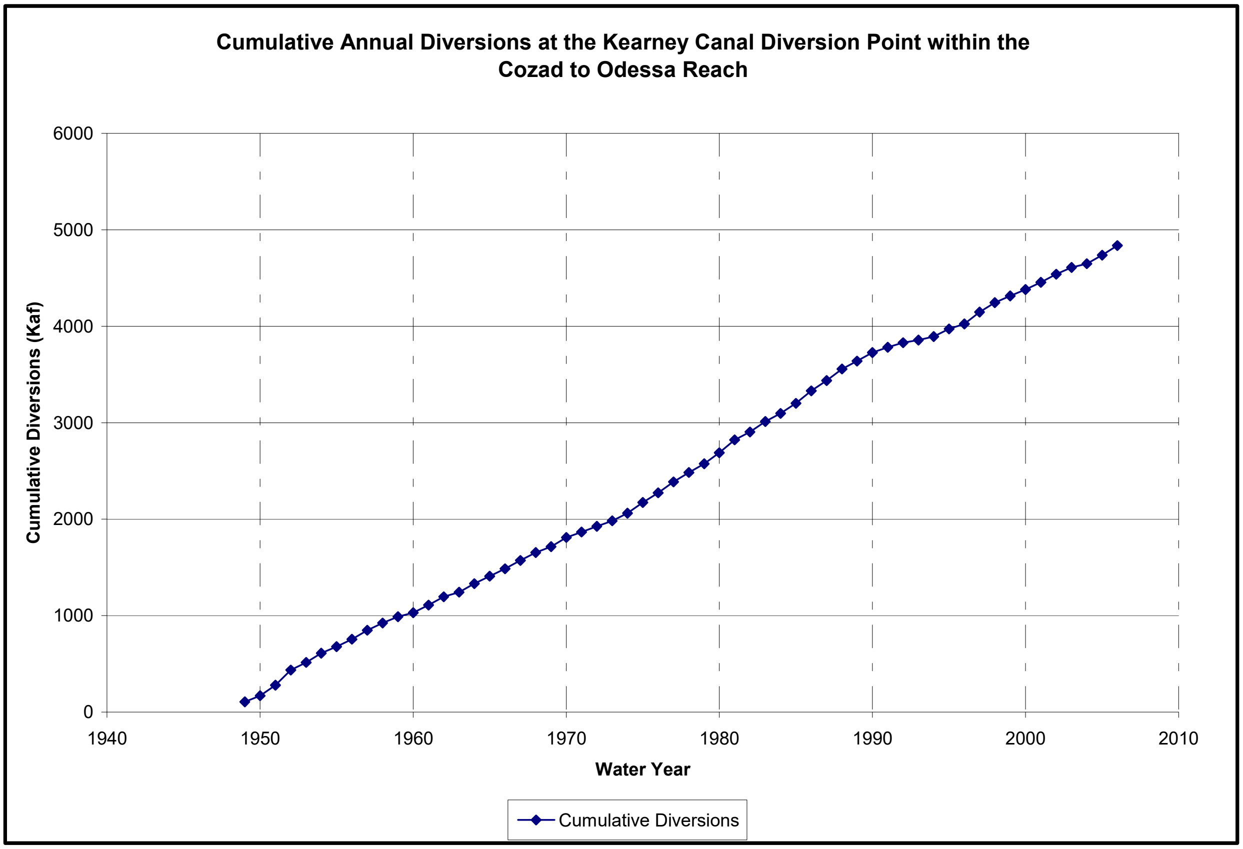


Figure 3-5. Cumulative surface water diversions for Kearney Canal.

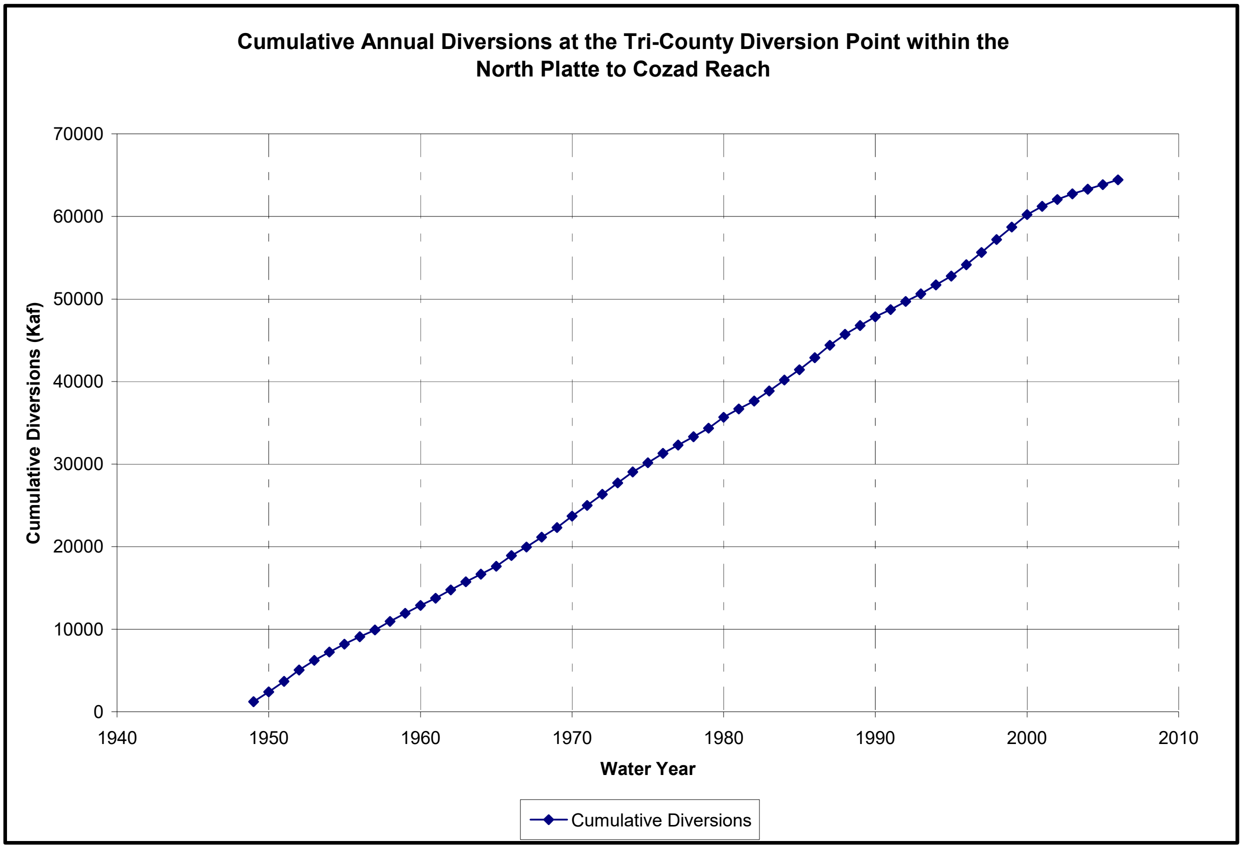


Figure 3-6. Cumulative surface water diversions for the Tri-County Canal.

Evaluation of the diversion records indicated that estimated annual seepage from diversions affecting this reach decreased significantly from the representative period to the recent period (2001-2006). Annual seepage decreased by an estimated 33,200 acre-feet per year (ac-ft/yr) in the irrigation season and 17,800 ac-ft/yr in the non-irrigation season when comparing the representative period to the later recent period. Since any reach gain would include gains from these seepage losses, the seepage changes were subtracted from the calculated reach gain reductions to derive the final reach gain reductions shown in table 3.2.

Table 3-2. Summary of stream reach gain reductions for the Cozad to Odessa reach adjusted for reduced seepage from diversions.

Cozad to Odessa Reach Reach Gain Reduction		
Condition	Irrigation Season (ac-ft)	Non-Irrigation Season (ac-ft)
Wet	0	0
Normal	0	0
Dry	26,100	42,500

The level of groundwater development within the reach was evaluated and is illustrated in figures 3-7 and 3-8. The results indicate that approximately 210,000 additional groundwater irrigated acres were developed through the period analyzed (1949-2006). The increase in groundwater irrigated acres may be potential cause of reductions in the reach gain.

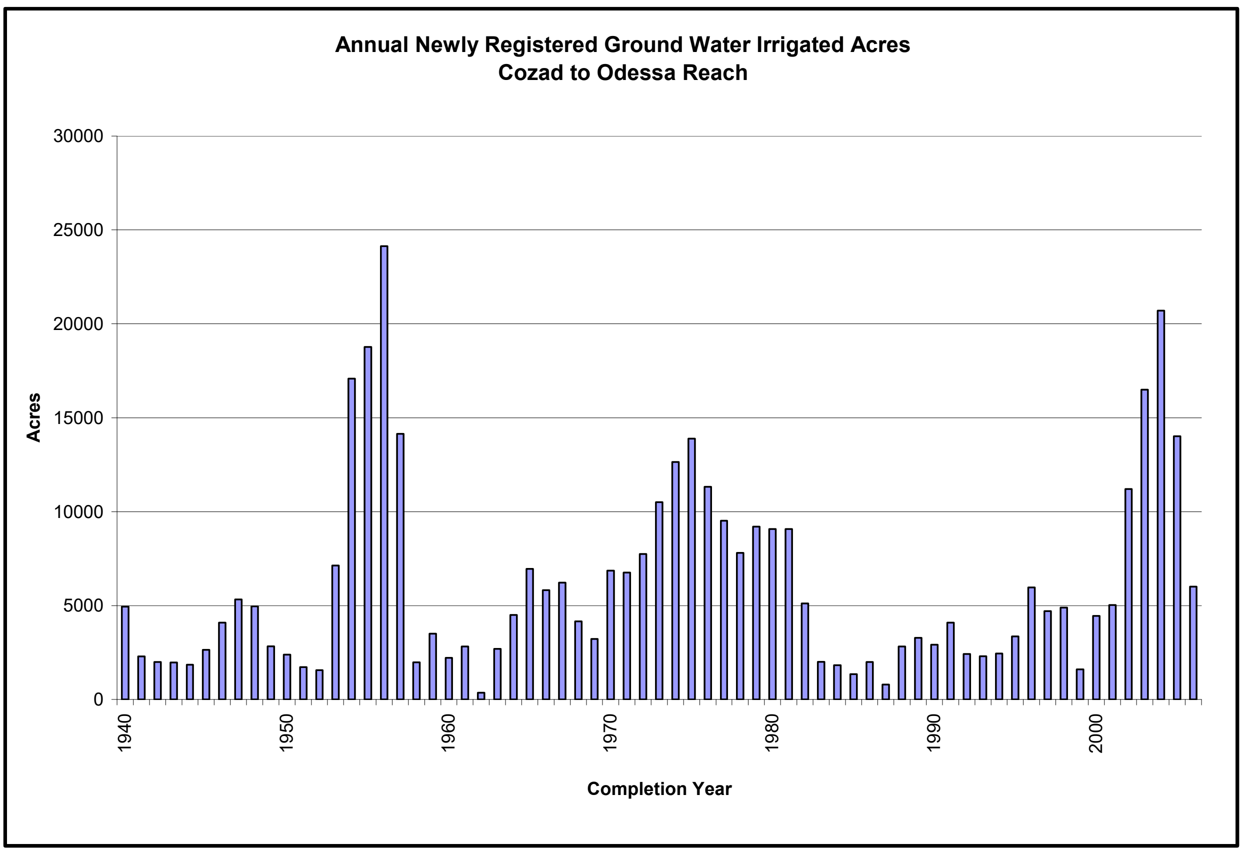


Figure 3-7. Annual newly registered groundwater irrigated acres.

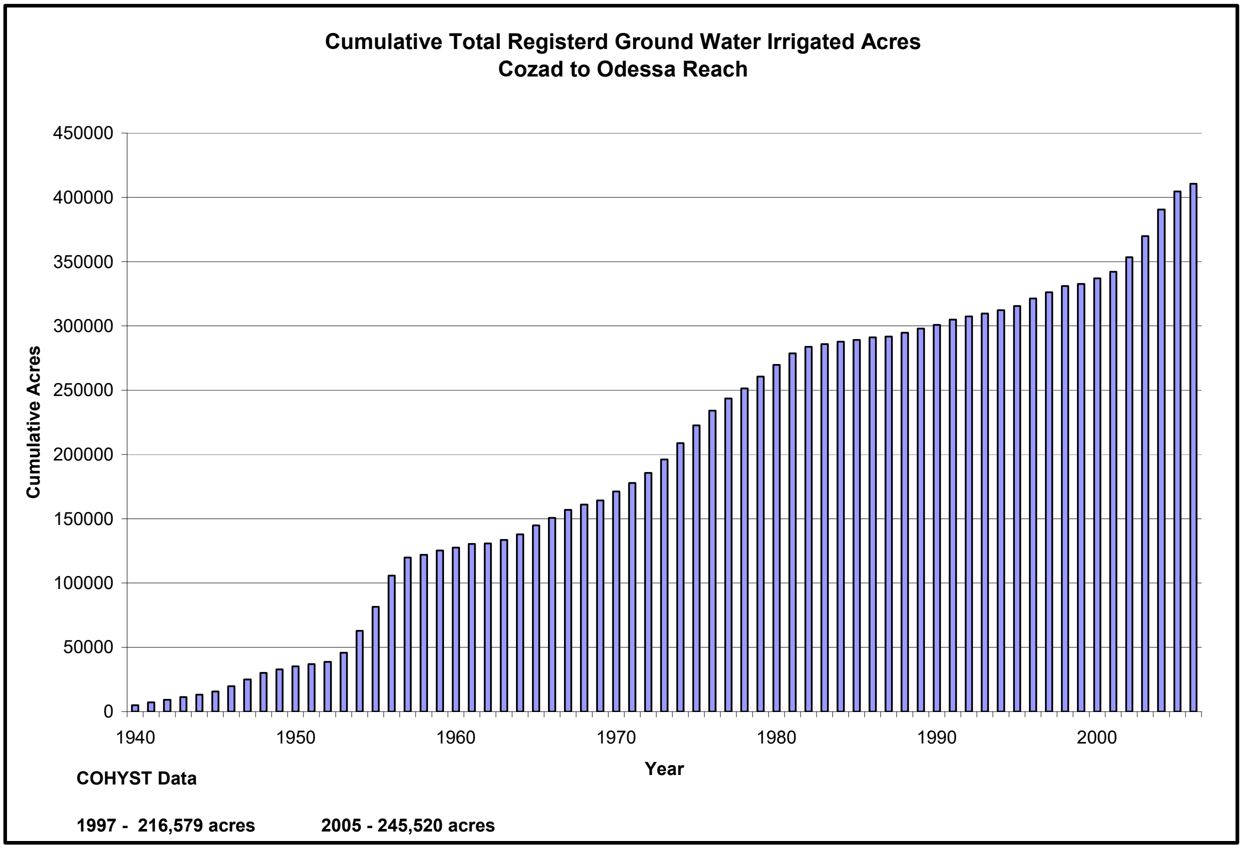


Figure 3-8. Cumulative groundwater irrigated acres.

The level of surface water development within the reach was evaluated and is illustrated in figures 3-9 and 3-10. The results indicate that approximately 7,500 additional acres were approved for surface water irrigation through the period analyzed (1949-2006). These new appropriations may have an impact on reductions in the reach gain. These reductions may be minimal during dry periods, however, when senior appropriations can call for administration on the river.

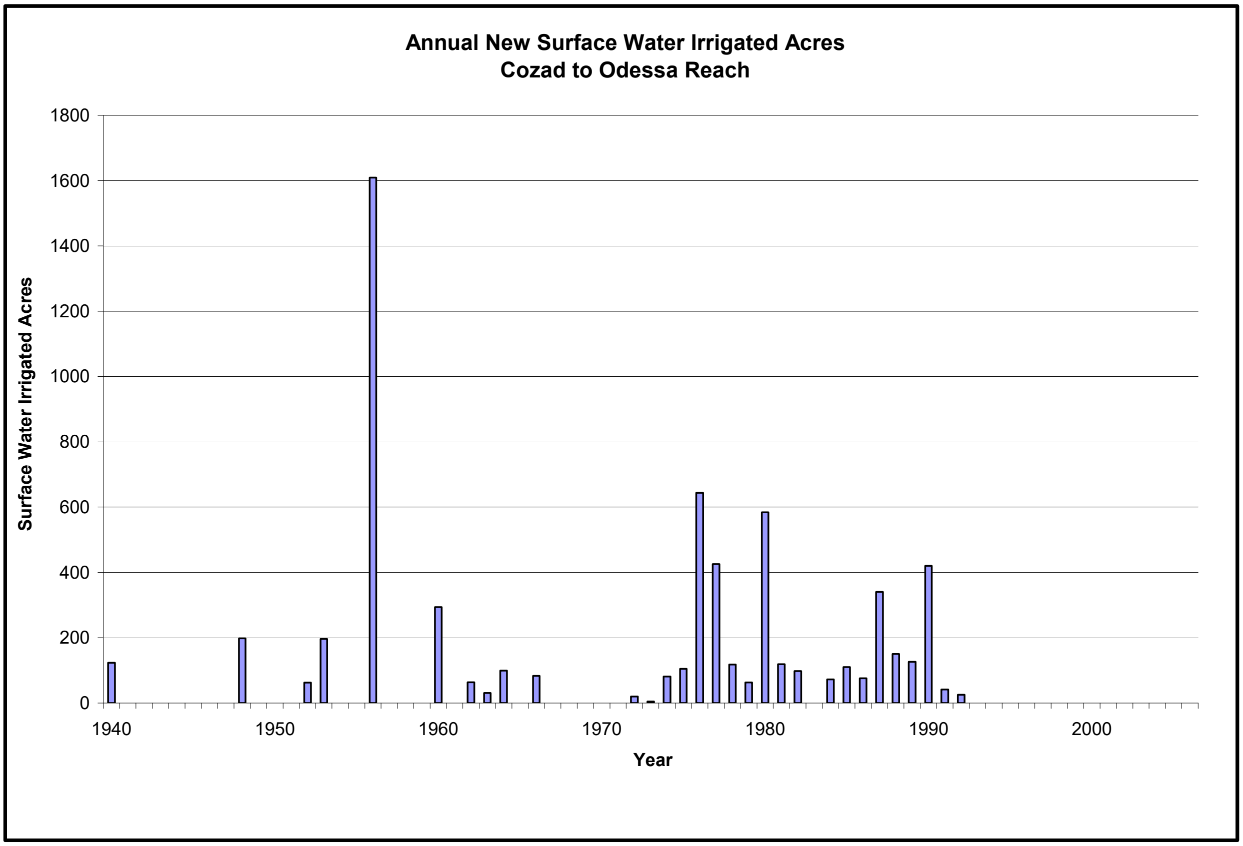


Figure 3-9. Annual new surface water irrigated acres.

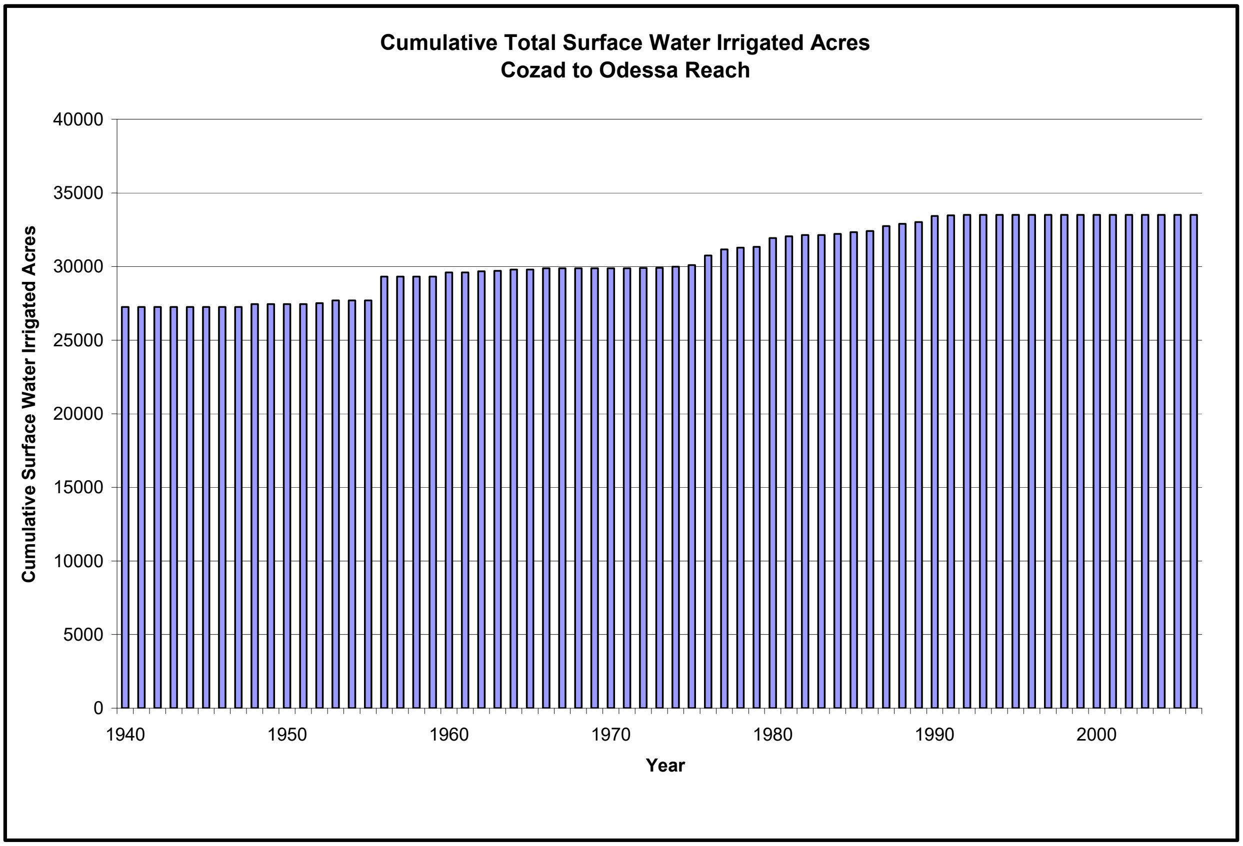


Figure 3-10. Cumulative total surface water irrigated acres.

3.2.3 Unmet Demands

The following demands were considered for the Cozad to Odessa reach:

- Instream flow appropriations
- Platte River recharge for wells
- Kearney Canal irrigation
- Kearney Canal hydropower generation

Both the CPNRD and the NGPC hold instream flow appropriations in the Platte River. The instream flow appropriations of the NGPC are additive to those of the CPNRD. Unmet demand in the normal and dry periods (as defined in table 2-1) was determined by comparing the combined CPNRD and NGPC appropriations against the historic river flow at the Odessa gage. Unmet demand for instream flows in wet periods was assumed to be zero. This was assumed because in the later process of accumulating, the unmet demands for instream flows are overridden by hydropower demands or irrigation operations such that instream flow demands are no longer factored into the calculations for reaches upstream of North Platte.

The need for recharge from the Platte River for the maintenance of existing wells was also considered. Although no actual shortage of water for wells in or below this reach has been demonstrated, some water quality issues with the Grand Island municipal wellfield have been measured when the river goes completely dry. Because the amount of streamflow that would be necessary to keep the river from going completely dry is believed to be substantially less than the flow required for the instream flow appropriations, and because the same water in the stream can serve both purposes, the unmet demand for recharge for wells was assumed to be zero.

The Kearney Canal's primary appropriations for both irrigation and power generation are some of the most senior appropriations on the Platte River, and as such, the demand for water on Kearney Canal is almost always met by natural flow alone. In some instances natural flow in the Platte River has been insufficient to satisfy Kearney Canal's demand (typically during dry periods), however, these instances are infrequent and for the purposes of these analyses, the unmet demand for Kearney Canal for both irrigation and hydropower is assumed to be zero. Thus the only unmet demand that was quantified for this reach was the instream flow demand during normal and dry conditions (table 3-3).

Table 3-3. Cozad to Odessa reach unmet demands.

Condition	**Irrigation Season (ac-ft)**	**Non-Irrigation Season (ac-ft)**
Wet	0	0
Normal	38,000	44,000
Dry	101,000	128,000

3.2.4 Accumulated Unmet Demands

This reach is at the furthest downstream end of the reaches analyzed and therefore nothing accumulates to this reach's unmet demands from downstream. The unmet demands from the reach (instream flows, hydropower, and irrigation) are passed entirely upstream to the North Platte to Cozad reach (table 3-4).

Table 3-4. Unmet Demands passed upstream to the North Platte to Cozad reach.

Condition	Irrigation Season (ac-ft)	Non-Irrigation Season (ac-ft)
Wet	0	0
Normal	38,000	44,000
Dry	101,000	128,000

3.2.5 Overall Difference between Overappropriated and Fully Appropriated

The overall difference between overappropriated and fully appropriated (termed the "OA/FA difference", table 3-7) was reduced from the total reach gain reduction (table 3-5) to account for the junior priority status of the instream flows and the level of development that was established within the basin. The magnitude of this adjustment was determined by assessing the level of groundwater development prior to 1990 (the approximate priority date of the instream flow appropriations) and the 2005 level of groundwater development. The assessment showed that only twenty-five percent of groundwater development occurred subsequent to the priority of the instream flow appropriations; the stream reach gain reduction values were correspondingly reduced by seventy-five percent. This methodology should be scrutinized in future reports to assess its validity.

Table 3-5. Stream reach gain reduction for the Cozad to Odessa reach.

Condition	Stream Reach Gain Reduction	
	Irrigation Season (ac-ft)	Non-Irrigation Season (ac-ft)
Wet	0	0
Normal	0	0
Dry	26,100	42,500

Table 3-6. Unmet demands for the Cozad to Odessa reach.

Condition	Unmet Demands	
	Irrigation Season (ac-ft)	Non-Irrigation Season (ac-ft)
Wet	0	0
Normal	38,000	44,000
Dry	101,000	128,000

Table 3-7. Overall difference between overappropriated and fully appropriated for the Cozad to Odessa reach.

Condition	OA/FA Difference	
	Irrigation Season (ac-ft)	Non-Irrigation Season (ac-ft)
Wet	0	0
Normal	0	0
Dry	6,500	10,600

3.3 Platte River – North Platte to Cozad Reach Gain Reductions

The North Platte to Cozad reach is the contributing surface water basin between the stream gages located on the North Platte River at North Platte and the Platte River at Cozad. This reach includes inflows from the South Platte River, Sutherland Return, Jeffrey Return, Gothenberg Return (1949-1973), and small ungaged tributaries and outflows to the Tri-County Canal, Gothenberg Canal, Thirty-Mile Canal, Orchard-Alfalfa Canal, Six-Mile Canal, Cozad Canal, and Dawson County Canal.

3.3.1 Assessment of Reach Gain Reductions

The double-mass curves of cumulative reach gains and cumulative precipitation during the period of 1949-2006 for the irrigation season and non-irrigation season, respectively, are illustrated in figures 3-11 and 3-12. The cumulative precipitation for this reach was developed based on the weighted precipitation from the following gages:

Gage	Weight of Gage (based on Thiessen polygons)
Arthur	0.005
Gothenburg	0.310
Stapleton	0.309
North Platte	0.376

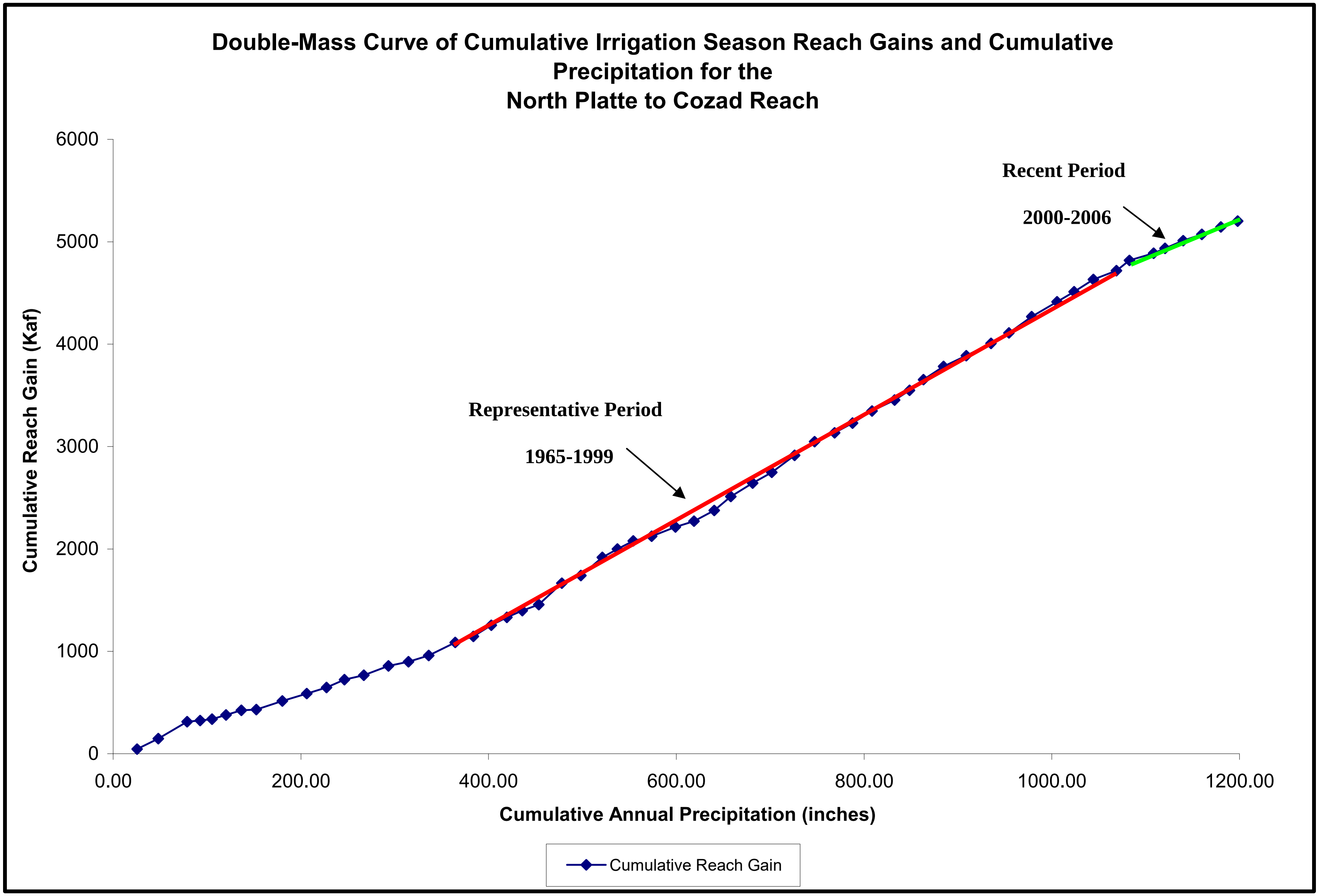


Figure 3-11. Double-mass curve of the cumulative irrigation season reach gain and cumulative annual precipitation.

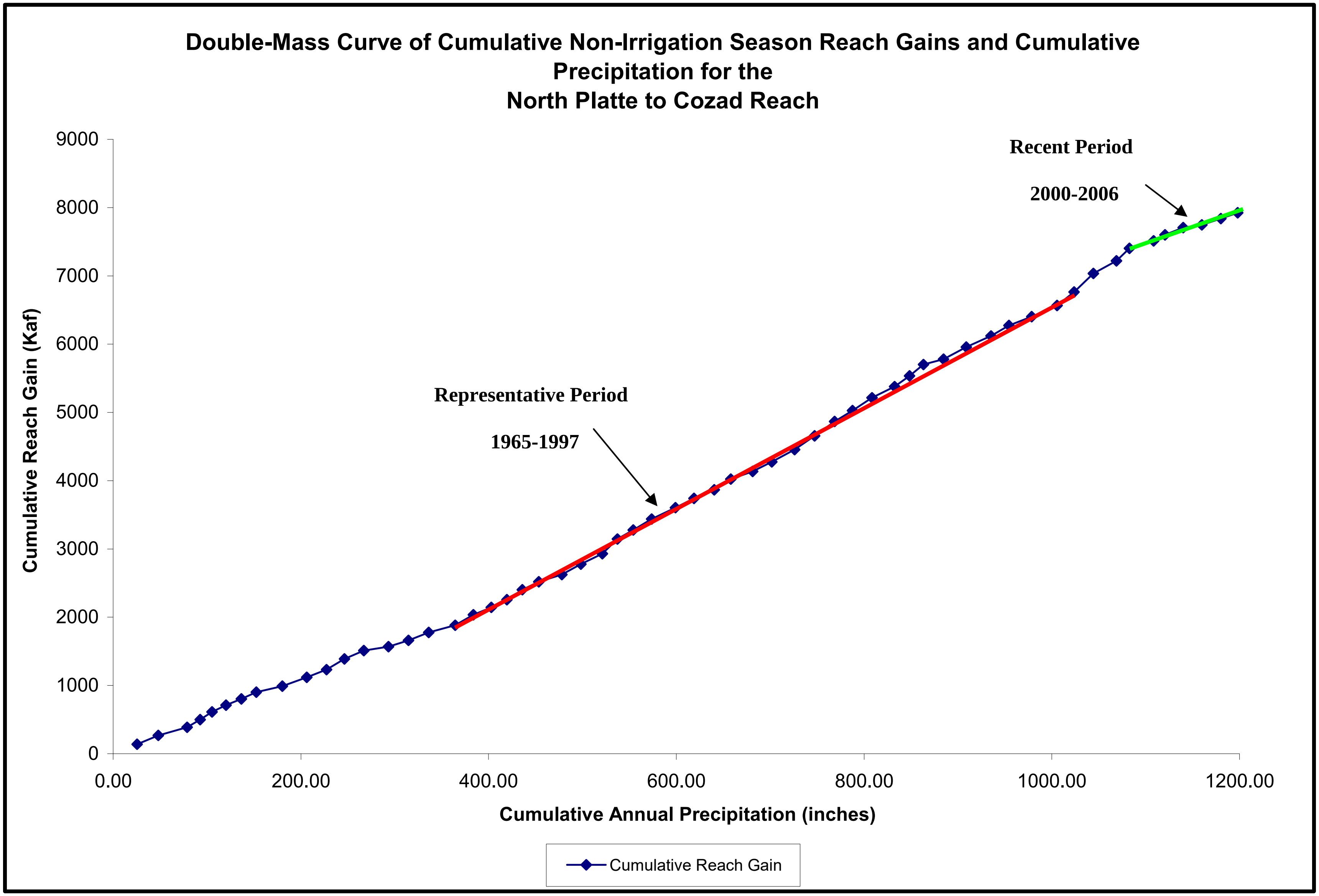


Figure 3-12. Double-mass curve of the cumulative non-irrigation season reach gain and cumulative annual precipitation.

In evaluating potential stream reach gain reductions, the 1965-1999 period was used as the representative period for the irrigation season and the 1965-1997 period was used as the representative period for the non-irrigation season. The period 2000-2006 was used to represent the recent periods for both the irrigation season and the non-irrigation season. The authors acknowledge that the 2000-2006 period represents a dry condition, thus any stream reach gain reductions identified for this reach were only with dry conditions. The calculated stream reach gain reductions for this reach are summarized in table 3-8.

Table 3-8. Summary of stream reach gain reductions for the North Platte to Cozad reach.

North Platte to Cozad Reach Gain Reduction		
Condition	Irrigatation Season (ac-ft)	Non-Irrigation Season (ac-ft)
Wet	0	0
Normal	0	0
Dry	37,300	59,000

3.3.2 Potential Causes for Reach Gain Reductions

The potential causes for stream reach gain reductions within this reach were investigated by evaluating reach gain baseflows, diversions (seepage returns to the reach), groundwater development, and surface water development. Figures 3-13 and 3-14 illustrate how baseflow within the reach has changed over this period. The baseflows appear to have increased through the 1965-1990 period with a rapid decrease in the more recent period. This decrease in baseflow could indicate that a portion of the recent period stream reach gain reduction is due to reduced groundwater inflow in the reach.

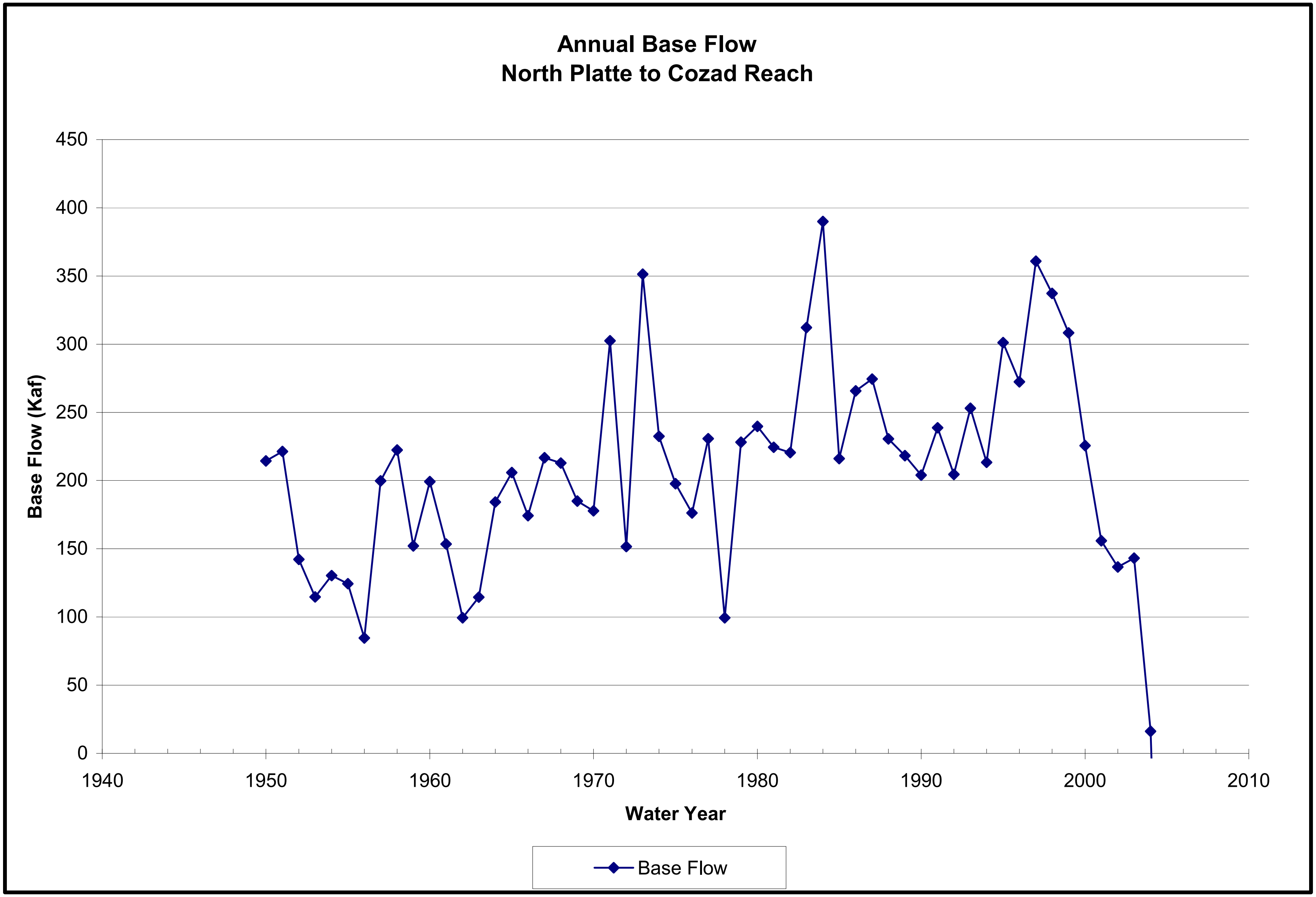


Figure 3-13. North Platte to Cozad reach annual baseflow gain.

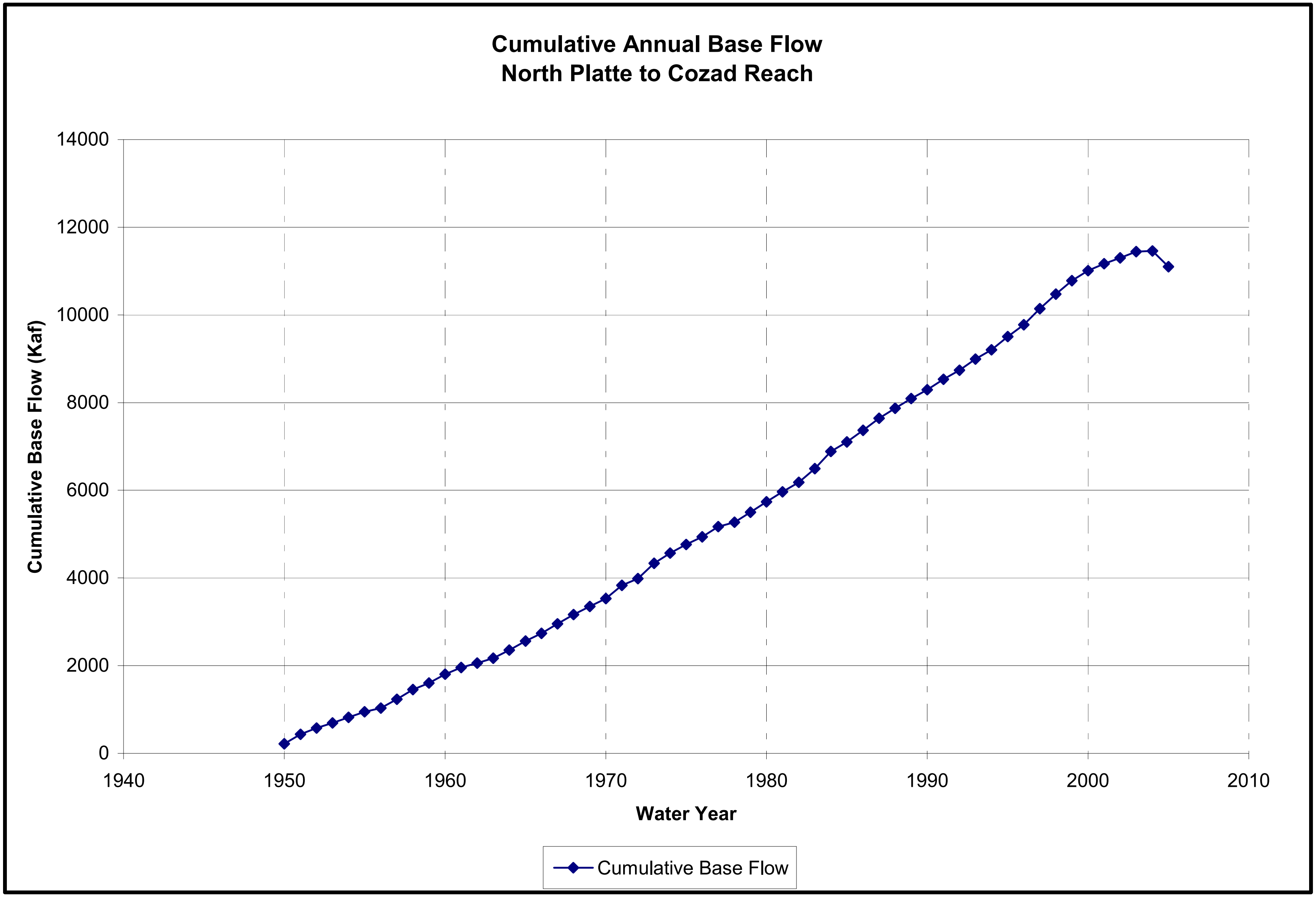


Figure 3-14. North Platte to Cozad cumulative annual baseflow.

Surface water diversions within the reach were evaluated to determine if reduced surface water diversions and therefore reduced returns from those diversions could be a potential cause of stream reach gain reductions. Figures 3-15 and 3-16 illustrate historical diversions for irrigation within this reach and historical diversions for the Tri-County Canal.

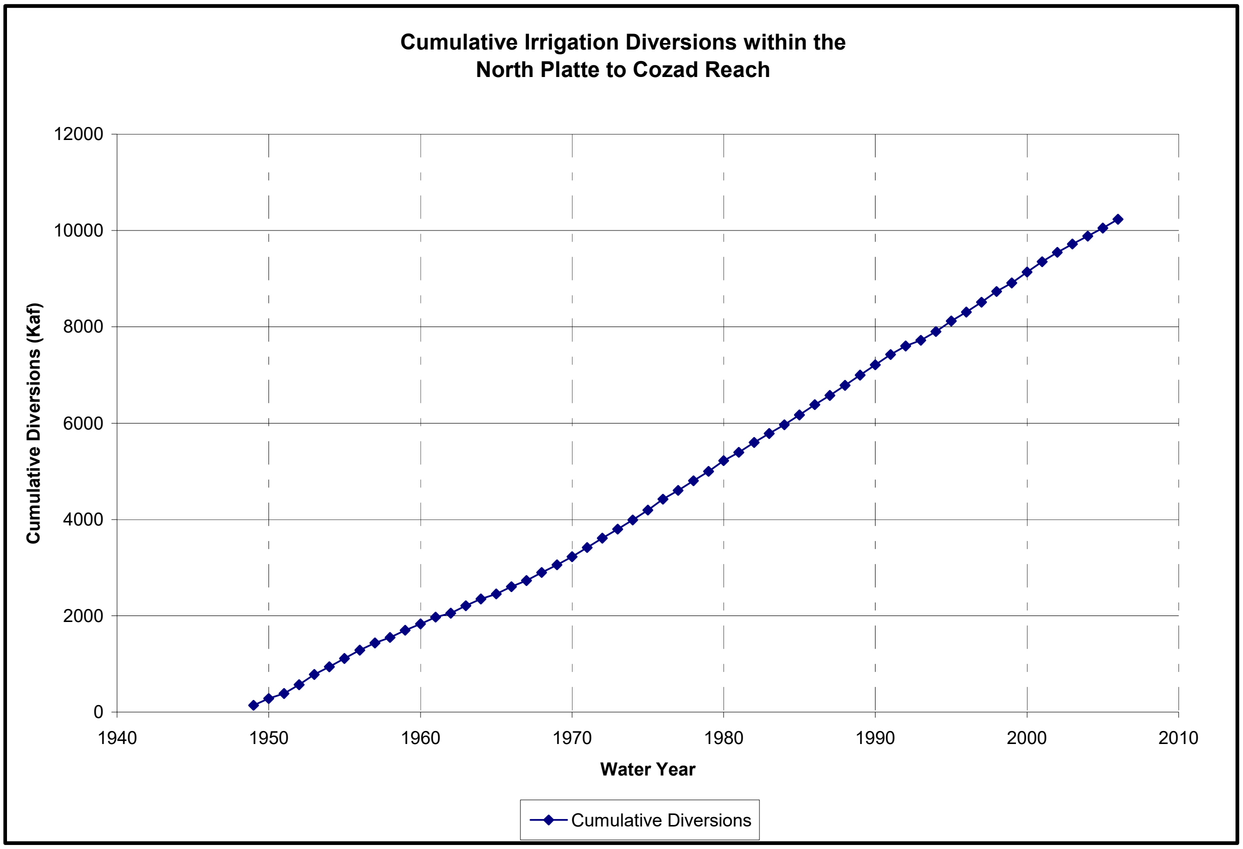


Figure 3-15. Cumulative surface water diversions for irrigation within the North Platte to Cozad reach.

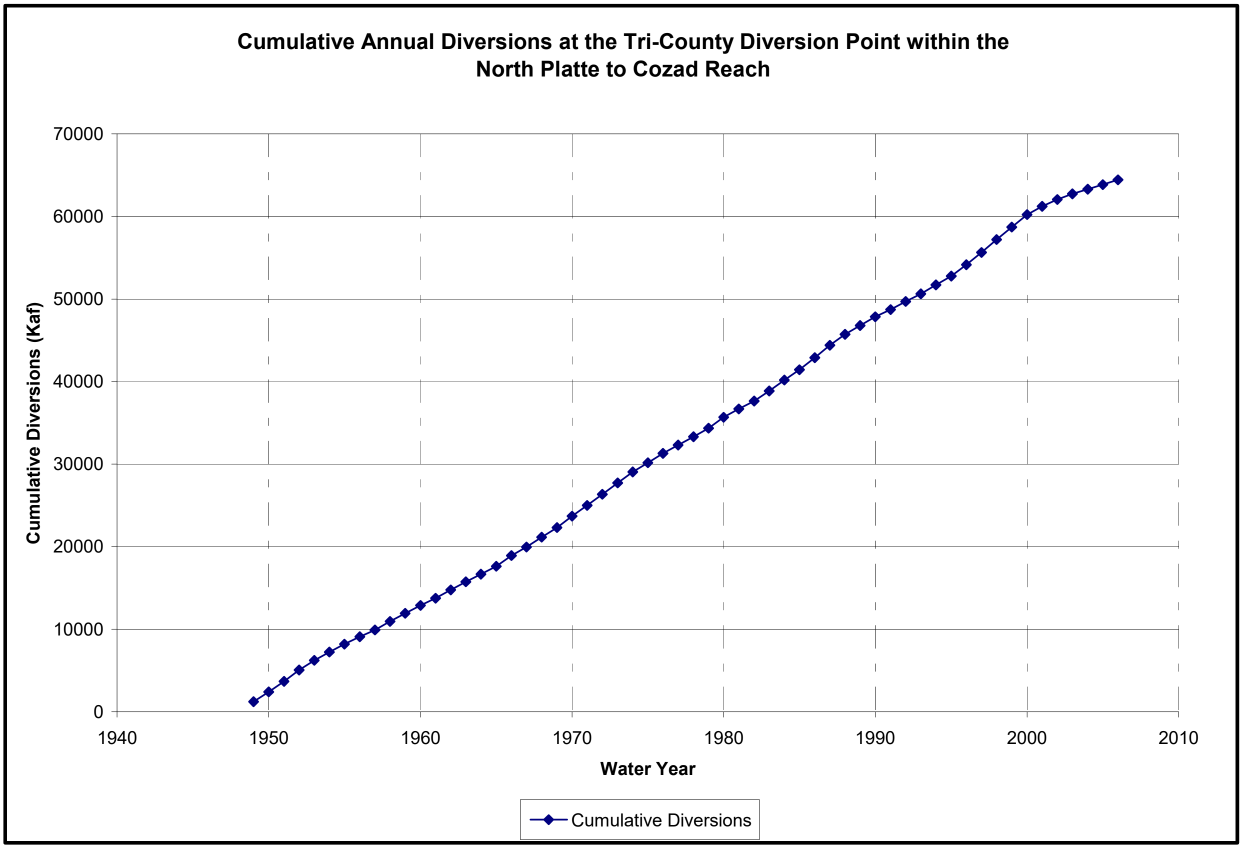


Figure 3-16. Cumulative surface water diversions of the Tri-County Supply Canal.

Evaluation of the diversion records indicated that estimated annual seepage from diversions affecting this reach decreased significantly from the representative period to the recent period (22,400 ac-ft/yr in the irrigation season and 29,500 ac-ft/yr in the non-irrigation season). Since any reach gain would include gains from these seepage losses these seepage changes were subtracted from the reach gain reduction to derive the final reach gain reductions shown in table 3-9.

Table 3-9. Summary of stream reach gain reductions for the North Platte to Cozad reach adjusted for reduced seepage from diversions.

North Platte to Cozad Reach Gain Reduction		
Condition	Irrigatation Season (ac-ft)	Non-Irrigation Season (ac-ft)
Wet	0	0
Normal	0	0
Dry	14,900	29,500

The level of groundwater development within the reach was evaluated and is illustrated in figures 3-17 and 3-18. The results indicate that approximately 135,000 acres of additional groundwater irrigated acres were developed through the period analyzed (1949-2006). The increase in groundwater irrigated acres may be a potential cause of reductions in the reach gain.

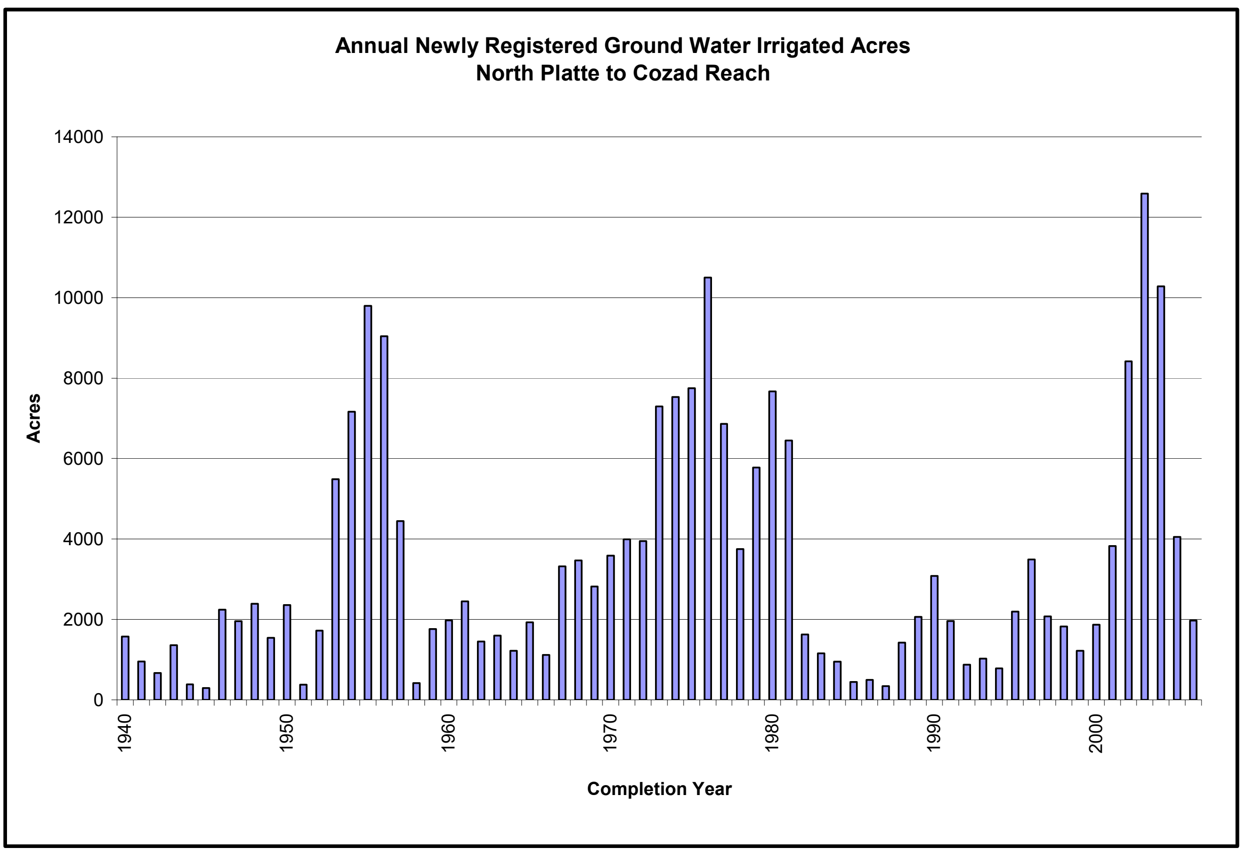


Figure 3-17. Annual newly registered groundwater irrigated acres.

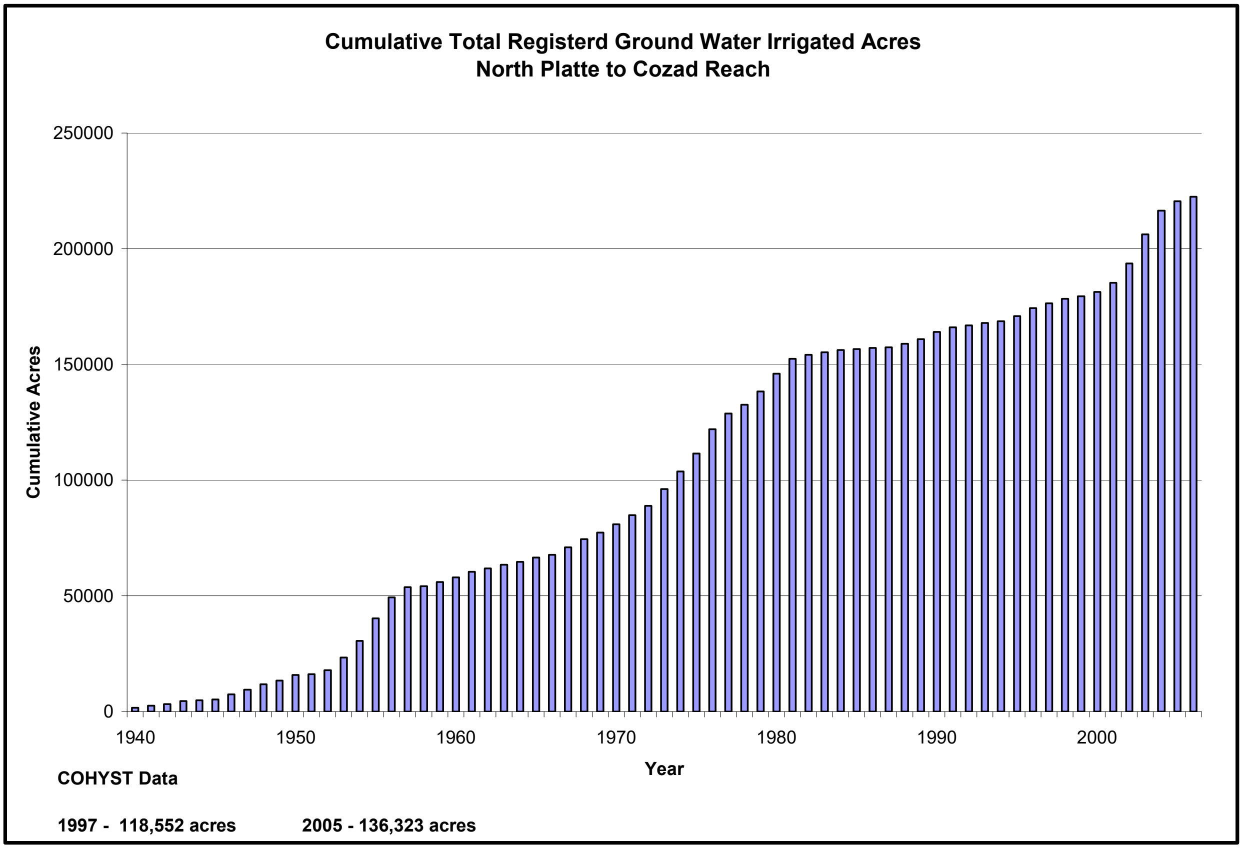


Figure 3-18. Cumulative groundwater irrigated acres.

The level of surface water development within the reach was evaluated and is illustrated in figures 3-19 and 3-20. The results indicate that approximately 45,000 additional acres were approved for irrigation under surface water appropriations through the period analyzed (1949-2006). These new acres may have an impact on reductions in the reach gain; these reductions may be minimal during dry periods, however, when senior appropriations can call for administration on the river.

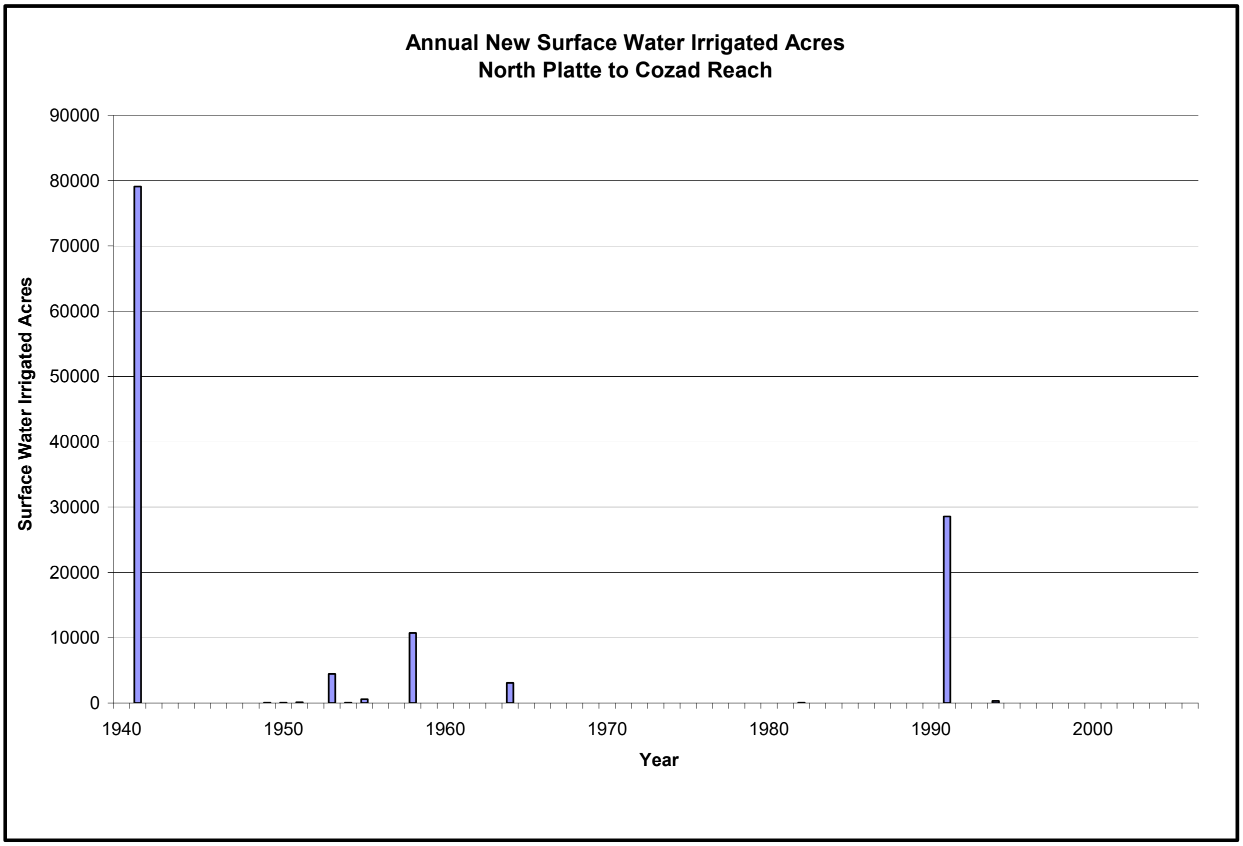


Figure 3-19. Annual new surface water irrigated acres.

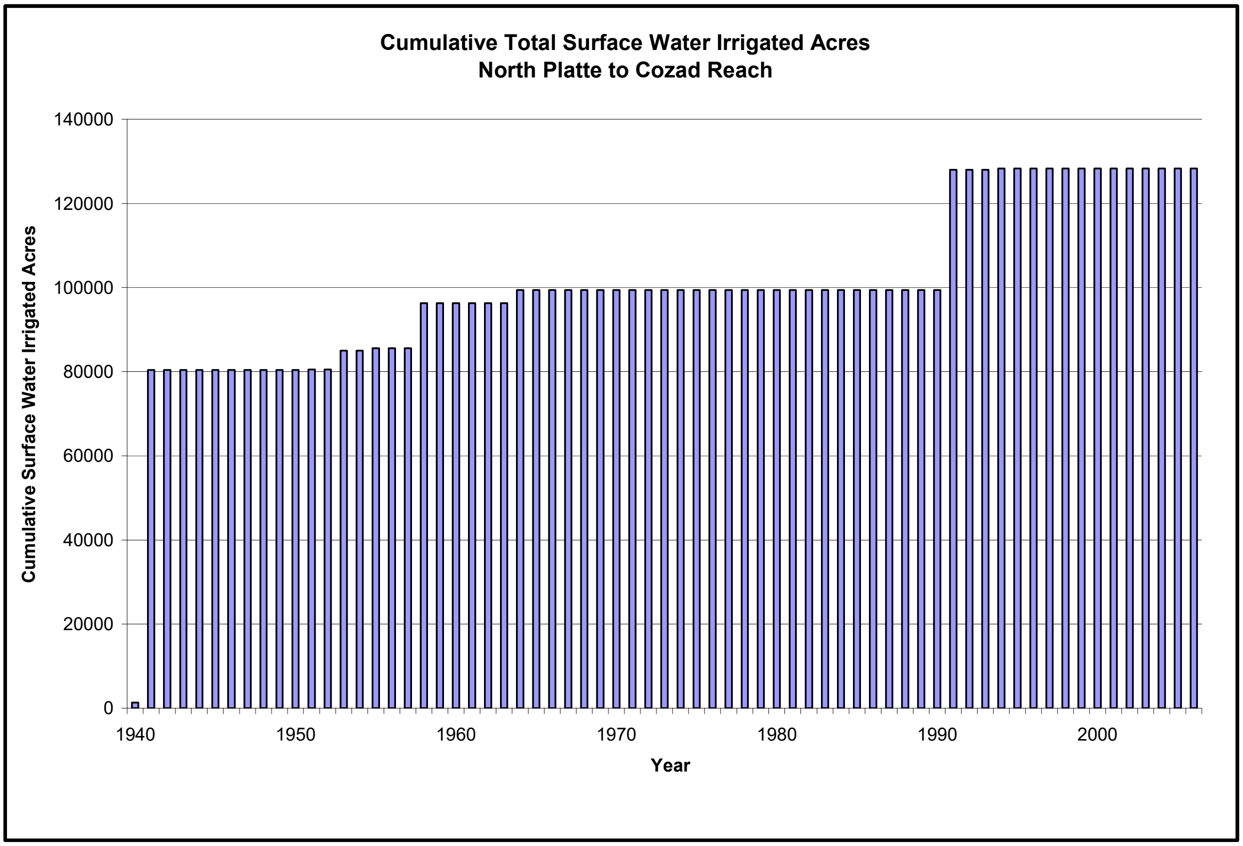


Figure 3-20 Cumulative total surface water irrigated acres.

3.3.3 Unmet Demands

The following demands were considered for the North Platte to Cozad reach:

- Irrigation from six Platte River canals

Surface water irrigation demand in the North Platte to Cozad reach occurs primarily from six irrigation canals: Gothenburg Canal, Thirty Mile Canal, Cozad Canal, Orchard-Alfalfa Canal, Six-Mile Canal, and Dawson County Canal. These canals represent a demand in the irrigation season only. All of these canals have access to storage water from Lake McConaughy and the Sutherland Reservoir as a supplemental source of water when natural flow alone is insufficient to meet irrigation demands. For the purposes of these analyses, storage water diversions by these canals were assumed to represent unmet demand for natural flow for irrigation. Unmet demand for irrigation for this reach was estimated by evaluating the annual cumulative storage diversions for these canals for representative wet, normal, and dry periods (figure 3-21).

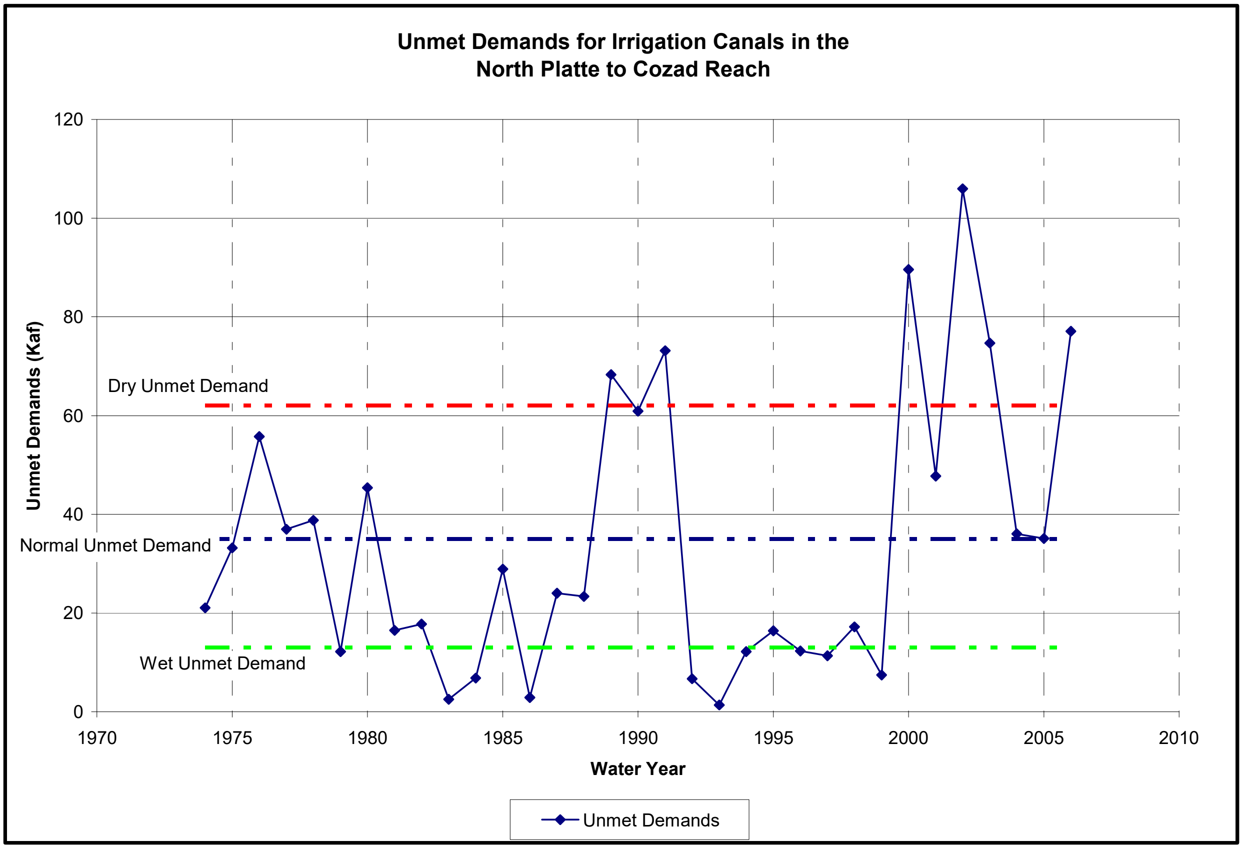


Figure 3-21. Annual storage demands for the six irrigation canals in the North Platte to Cozad reach.

For this reach, demand, and therefore unmet demand, was assumed to be zero in the non-irrigation season. The unmet demand for the North Platte to Cozad reach is summarized in table 3-10.

Table 3-10. North Platte to Cozad reach unmet demands.

Condition	**Irrigation Season (ac-ft)**	**Non-Irrigation Season (ac-ft)**
Wet	13,000	0
Normal	35,000	0
Dry	62,000	0

3.3.4 Accumulated Unmet Demands

The unmet demands from the reach below (Cozad to Odessa) are passed into this reach and added to the unmet demands in this reach to determine the accumulated unmet demands within the reach (tables 3-11 through 3-13)

Table 3-11. Unmet demands passed upstream from the Cozad to Odessa reach.

Condition	Irrigation Season (ac-ft)	Non-Irrigation Season (ac-ft)
Wet	0	0
Normal	38,000	44,000
Dry	101,000	128,000

Table 3-12. Unmet demands in the North Platte to Cozad reach.

Condition	Irrigation Season (ac-ft)	Non-Irrigation Season (ac-ft)
Wet	13,000	0
Normal	35,000	0
Dry	62,000	0

Table 3-13. Cumulative unmet demands in the North Platte to Cozad reach.

Condition	Irrigation Season (ac-ft)	Non-Irrigation Season (ac-ft)
Wet	13,000	0
Normal	73,000	44,000
Dry	163,000	128,000

Not all of the cumulative unmet demands for this reach were passed upstream to the next reach. The upstream reaches include large, non-consumptive, hydropower demands which are larger that those associated with the instream flow. Consequently, only the consumptive portion (i.e., irrigation) of the cumulative unmet demands is passed upstream.

Table 3-14. Unmet demands passed upstream to the South Platte and to the North Platte below McConaughy reaches.

Condition	Irrigation Season (ac-ft)	Non-Irrigation Season (ac-ft)
Wet	13,000	0
Normal	35,000	0
Dry	62,000	0

3.3.5 Overall Difference between Overappropriated and Fully Appropriated

The OA/FA difference (table 3-17) was reduced from the total reach gain reduction (table 3-15) to account for the junior priority status of the instream flows and for the level of development in the basin. The magnitude of this adjustment was determined by assessing the level of groundwater development prior to 1990 (the approximate priority date of the instream flow appropriations) and the 2005 level of groundwater development. The assessment showed that only thirty percent of groundwater development occurred subsequent to the priority of the instream flow appropriations. Thus, the stream reach gain reduction values for the non-irrigation season were correspondingly reduced by seventy percent. However, the irrigation-season reach gain reductions were not reduced, as both instream flow and irrigation appropriation demands occur in the irrigation season, and the unmet irrigation demands exceed the level of stream reach gain reduction. This methodology should be scrutinized in future reports to assess its validity.

Table 3-15. Stream reach gain reduction for the North Platte to Cozad reach.

Condition	Stream Reach Gain Reduction	
	Irrigation Season (ac-ft)	**Non-Irrigation Season (ac-ft)**
Wet	0	0
Normal	0	0
Dry	14,900	29,500

Table 3-16. Unmet demands for the North Platte to Cozad reach.

Condition	Unmet Demands	
	Irrigation Season (ac-ft)	**Non-Irrigation Season (ac-ft)**
Wet	13,000	0
Normal	73,000	44,000
Dry	163,000	128,000

Table 3-17. Overall difference between overappropriated and fully appropriated for the North Platte to Cozad reach.

Condition	OA/FA Difference	
	Irrigation Season (ac-ft)	Non-Irrigation Season (ac-ft)
Wet	0	0
Normal	0	0
Dry	14,900	8,900

3.4 North Platte River – Keystone to North Platte

The Keystone to North Platte reach is the contributing surface water basin between the stream gages located on the North Platte River at Keystone and the North Platte River at North Platte. This reach includes inflows from Birdwood Creek and small ungaged tributaries and outflows to the North Platte Canal, Keith-Lincoln Canal, Suburban Canal, Paxton-Hershey Canal, Cody-Dillon Canal, and historic outflows for Sheridan-Wilson Canal (through 1964).

3.4.1 Assessment of Reach Gain Reductions

The double-mass curves of cumulative reach gains and cumulative precipitation during the period 1949-2006 for the irrigation season and non-irrigation season, respectively, are illustrated in figures 3-22 and 3-23. The cumulative precipitation for this reach was developed based on the weighted precipitation from the following gages:

Gage	Weight of Gage (based on Thiessen polygons)
Arthur	0.566
Ogallala	0.182
Stapleton	0.096
North Platte	0.132
Wallace	0.024

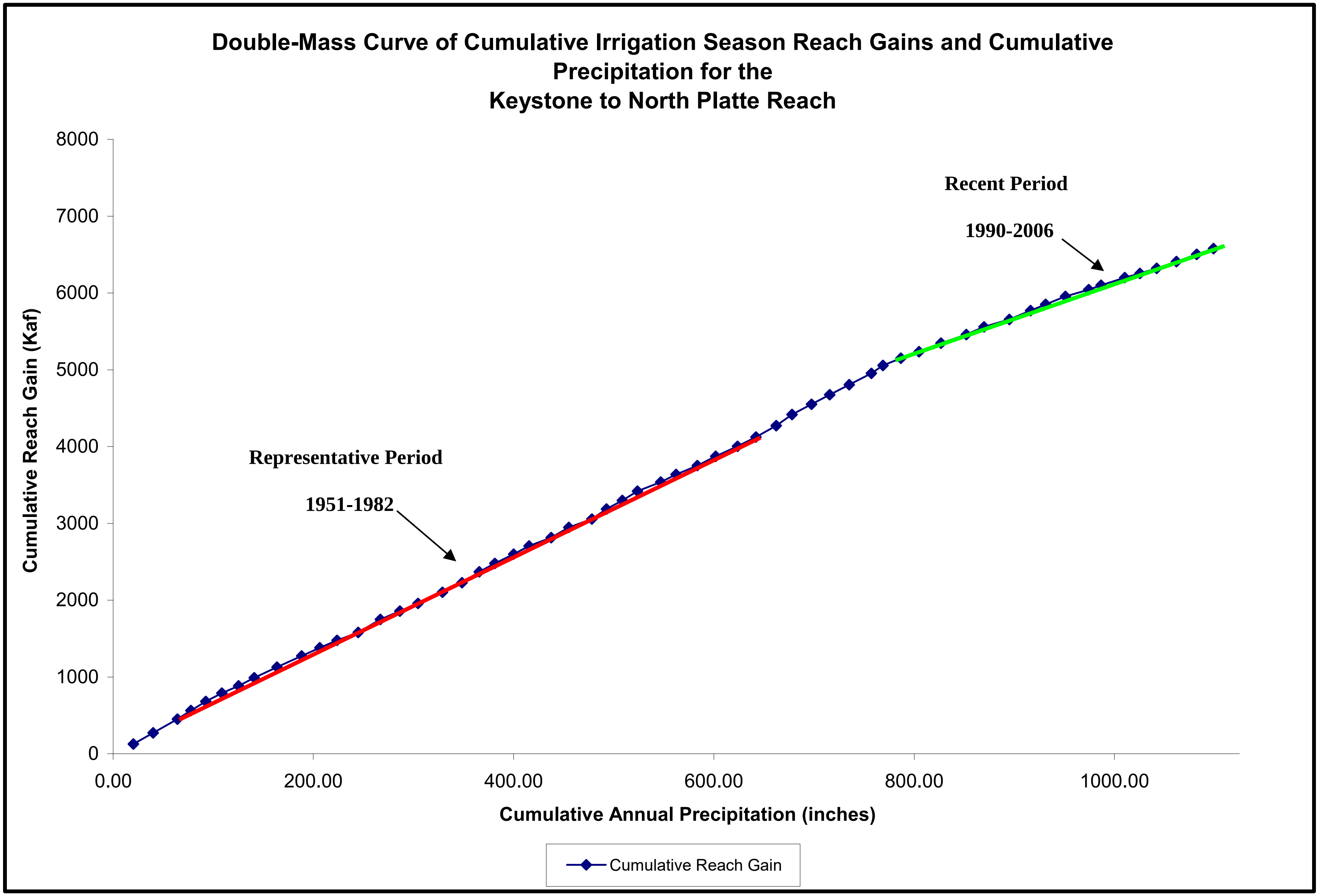


Figure 3-22. Double-mass curve of the cumulative irrigation season reach gain and cumulative annual precipitation.

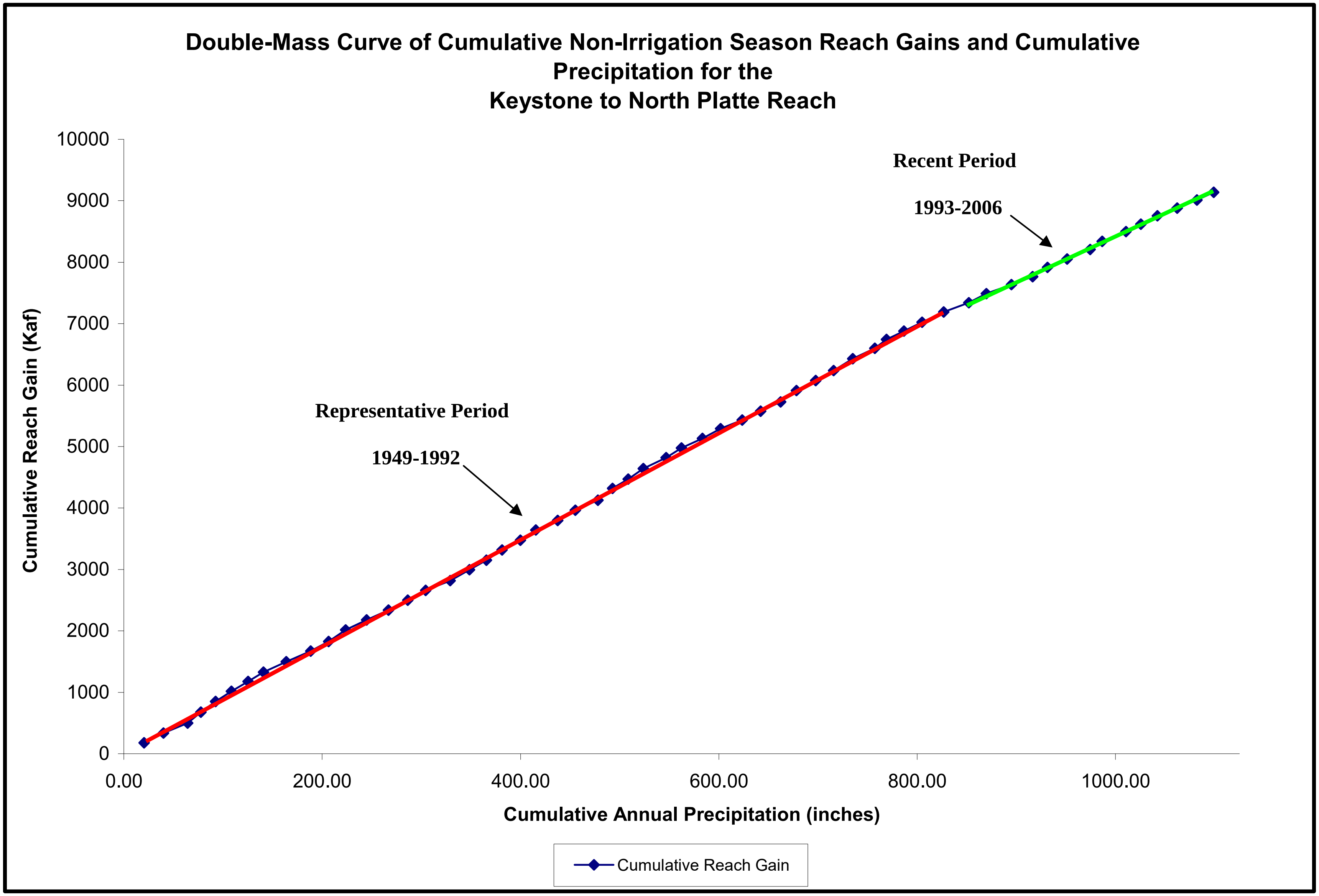


Figure 3-23. Double-mass curve of the cumulative non-irrigation season reach gain and cumulative annual precipitation.

In evaluating to determine potential stream reach gain reductions, the 1951-1982 period was used as the representative period for the irrigation season and the 1949-1992 period was used as the representative period for the non-irrigation season. The intervals used to represent the recent periods were 1990-2006 for the irrigation season and 1993-2006 for the non-irrigation season. Since the break point on the curves falls prior to the dry conditions of 2000-2006 that were identified in the downstream reaches, this break point seems to represent reach gain reductions that have occurred under wet, normal, and dry hydrologic conditions. The calculated stream reach gain reductions for this reach are summarized in table 3-18.

Table 3-18. Summary of stream reach gain reductions for the Keystone to North Platte reach.

Keystone to North Platte Reach Gain Reduction		
Condition	Irrigation Season (ac-ft)	Non-Irrigation Season (ac-ft)
Wet	33,900	26,700
Normal	33,900	26,700
Dry	33,900	26,700

3.4.2 Potential Causes for Reach Gain Reductions

The potential causes for stream reach gain reductions within this reach were investigated by evaluating reach gain baseflows, diversions (seepage return to the reach), groundwater development, and surface water development. Figures 3-24 and 3-25 illustrate how baseflow within the reach has changed over this period. The baseflows appear to have remained fairly constant through the 1949-1992 period with sharp increases during the wet periods. The more recent period (2000-2005) saw a rapid decrease in baseflow. This decrease in baseflow could indicate that a portion of the recent period stream reach gain reduction is due to reduced groundwater inflow in the reach.

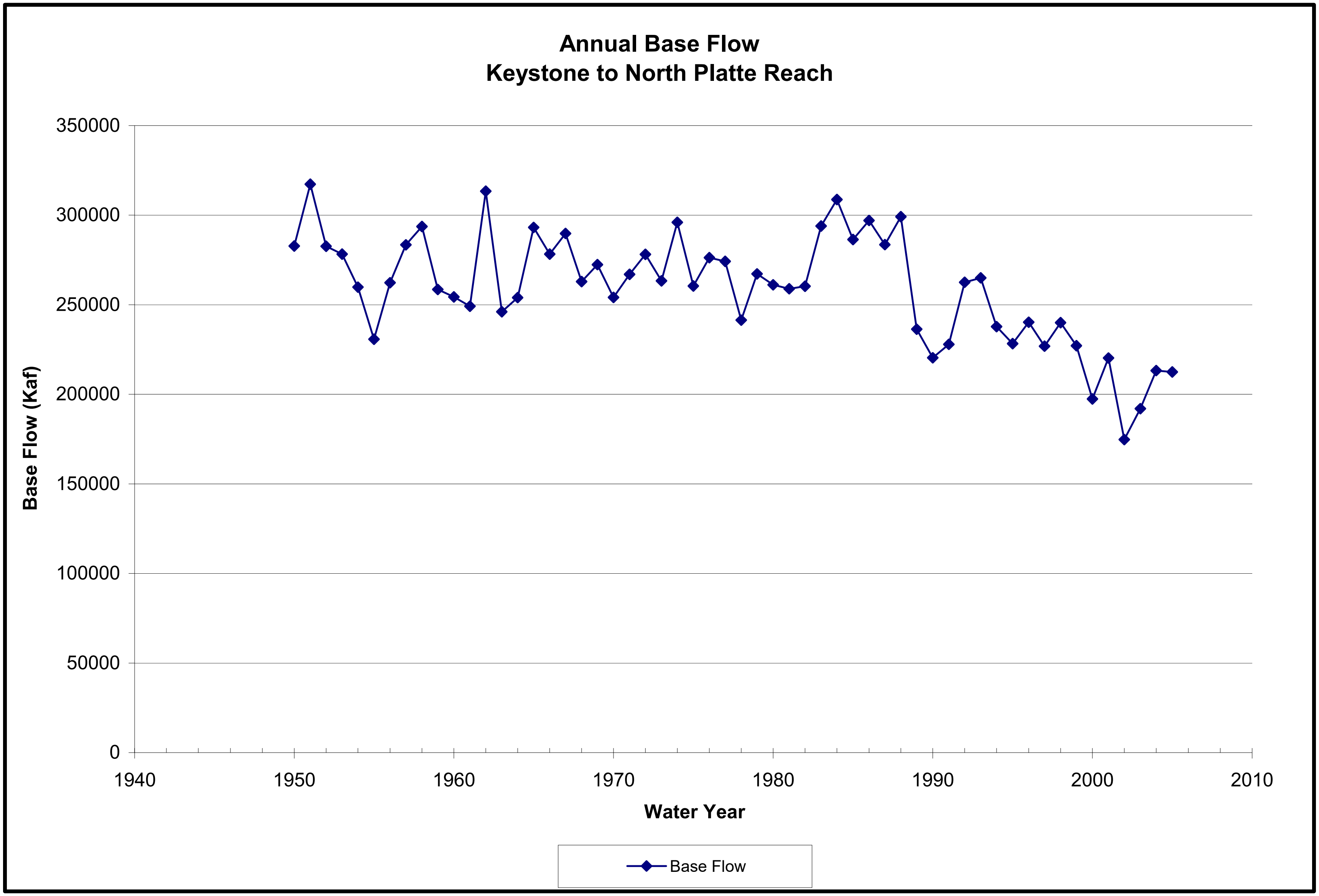


Figure 3-24. Keystone to North Platte reach annual baseflow gain (reach baseflow includes contribution from Birdwood Creek).

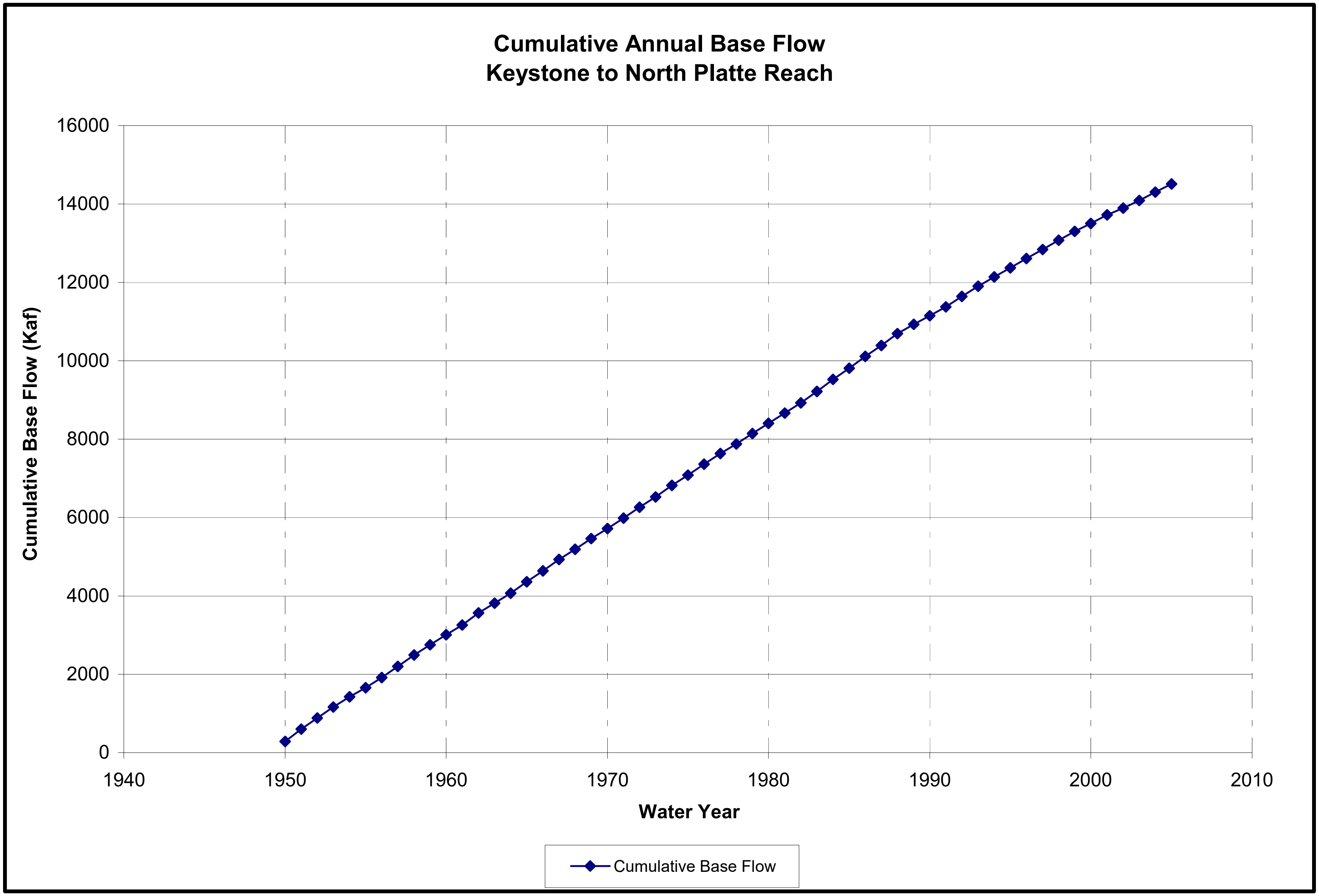


Figure 3-25. Keystone to North Platte cumulative annual baseflow (reach baseflow includes contribution from Birdwood Creek).

Surface water diversions within the reach were evaluated to determine if reduced surface water diversions and therefore reduced returns from those diversions could be a potential cause of stream reach gain reductions. Evaluation of the diversion records indicated that estimated annual seepage from diversions affecting this reach decreased significantly from the representative period to the recent period (7,900 ac-ft/yr in the irrigation season and 3,800 ac-ft/yr in the non-irrigation season). Since any reach gain would include gains from these seepage losses, these changes were subtracted from the reach gain reduction to derive the final reach gain reductions (table 3.19).

Table 3-19. Summary of stream reach gain reductions for the Keystone to North Platte reach adjusted for reduced seepage from diversions.

Keystone to North Platte Reach Gain Reduction		
Condition	Irrigation Season (ac-ft)	Non-Irrigation Season (ac-ft)
Wet	26,000	22,900
Normal	26,000	22,900
Dry	26,000	22,900

The level of groundwater development within the reach was evaluated and is illustrated in figures 3-26 and 3-27. The results indicate that approximately 27,000 additional groundwater irrigated acres were developed through the period analyzed (1949-2006). The increase in groundwater irrigated acres may be a potential cause of reductions in the reach gain.

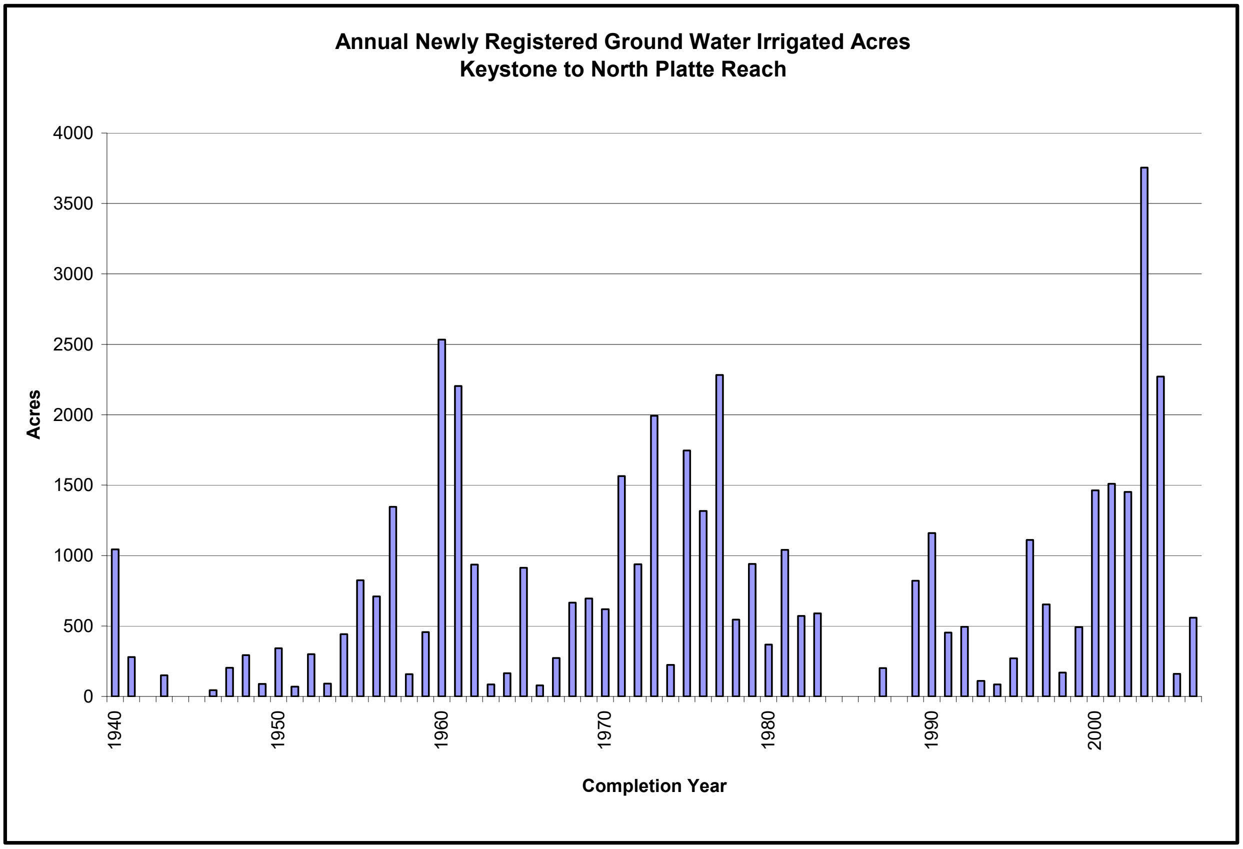


Figure 3-26. Annual newly registered groundwater irrigated acres.

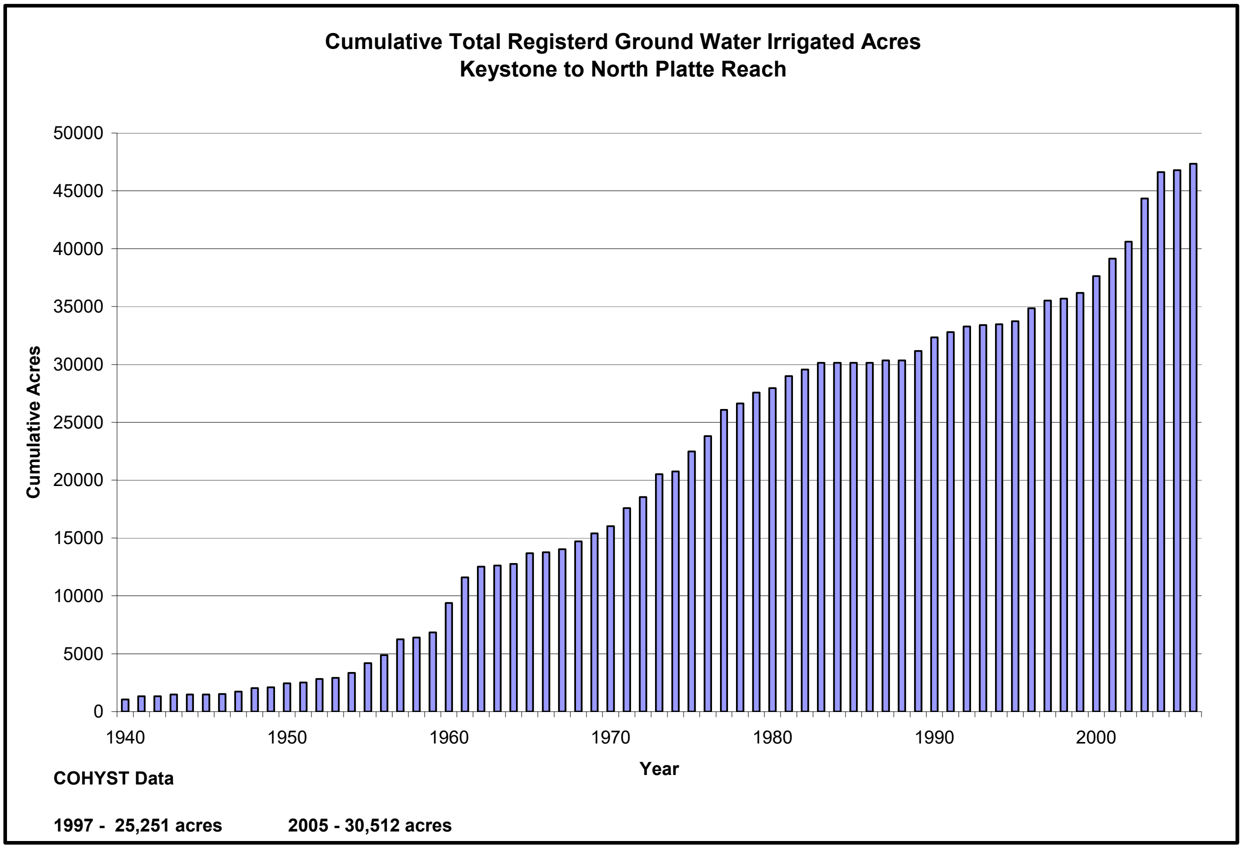


Figure 3-27. Cumulative groundwater irrigated acres.

The level of surface water development within the reach was evaluated and is illustrated in figures 3-28 and 3-29. The results indicate that approximately 30,000 additional acres were approved for irrigation under surface water appropriations through the period analyzed (1949-2006). The majority of these new acres were added early in the representative period (prior to 1955). Thus any impacts from the additional surface water acres on the reach gains would be expected to be minimal.

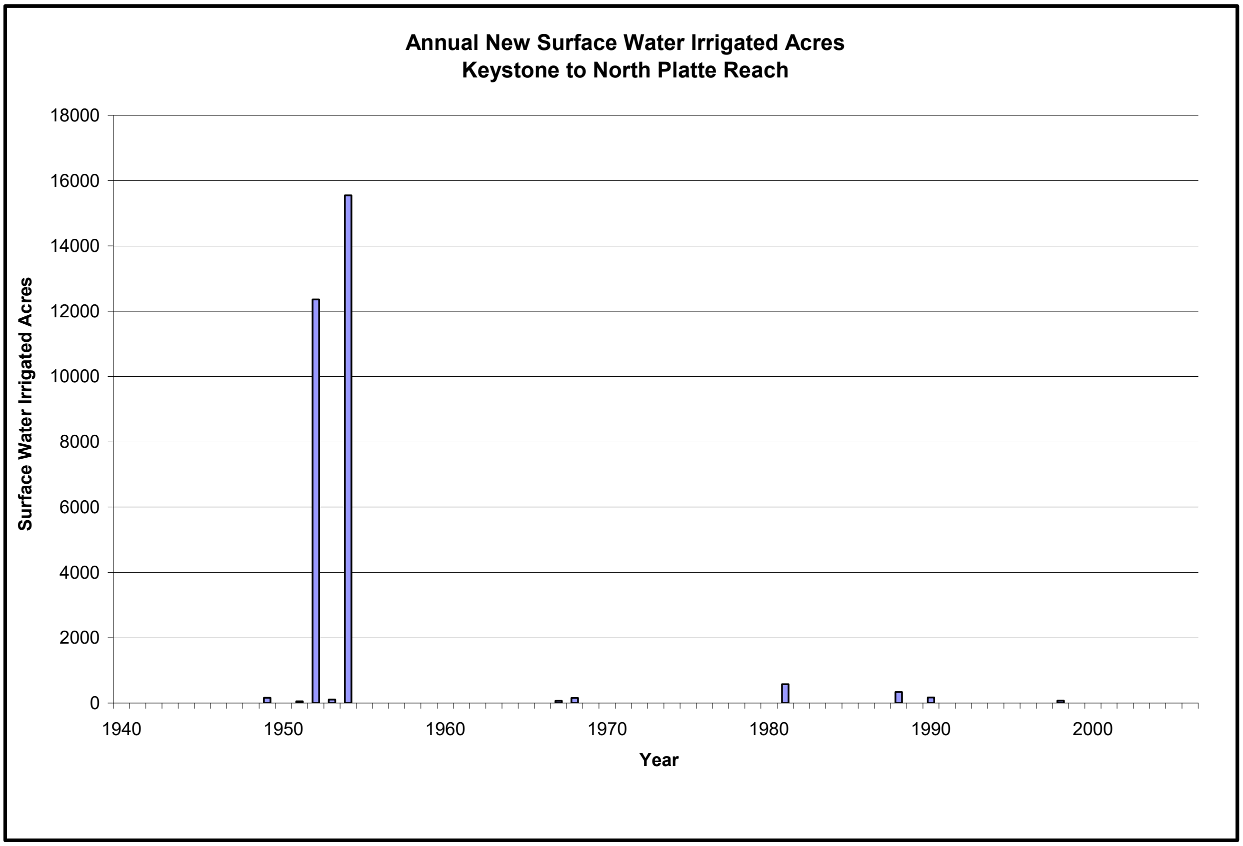


Figure 3-28. Annual new surface water irrigated acres.

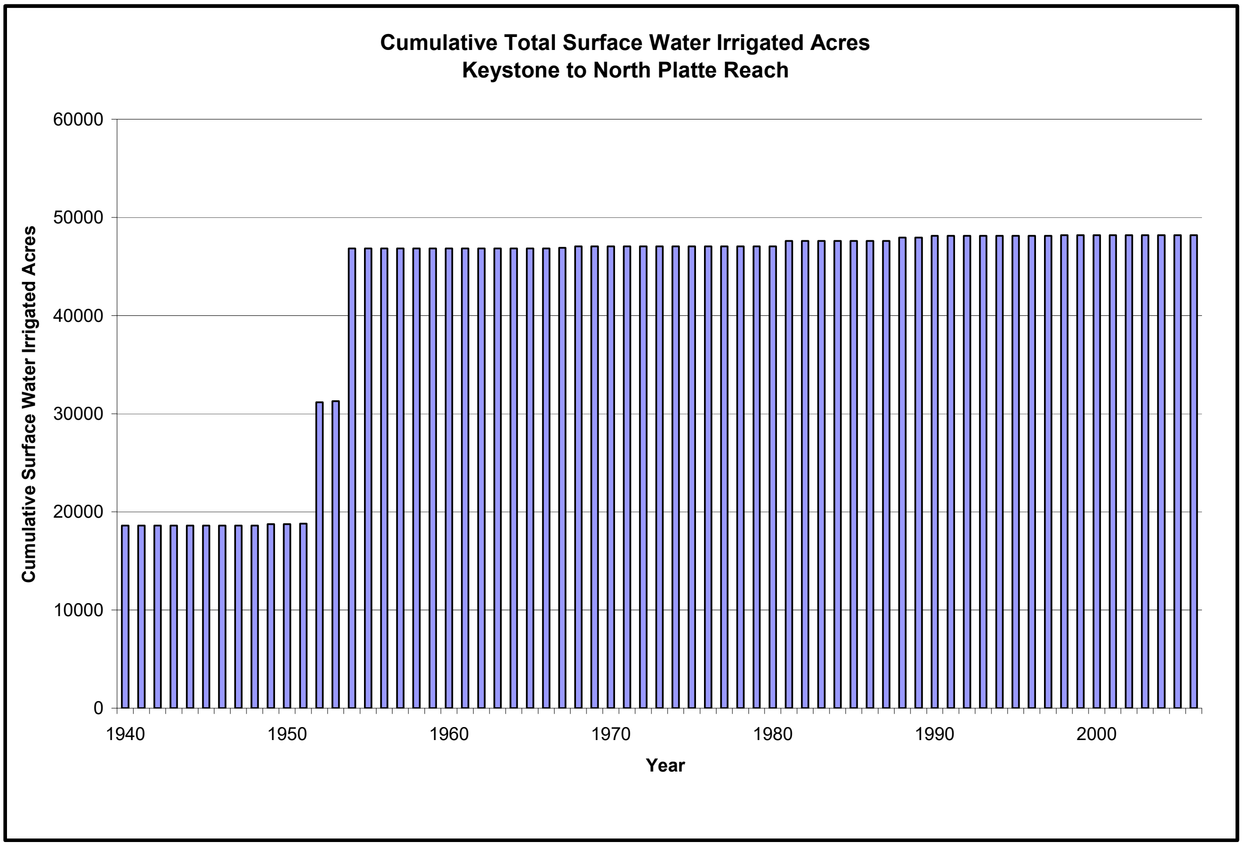


Figure 3-29. Cumulative total surface water irrigated acres.

3.4.3 Unmet Demands

The following demands were considered for the Keystone to North Platte reach:

- CNPPID irrigation
- CNPPID Supply Canal hydropower generation
- Canaday Steam Plant cooling
- Irrigation from five North Platte River canals

The Central Nebraska Public Power and Irrigation District (CNPPID) irrigation, CNPPID Supply Canal hydropower generation, and Canaday Steam Plant cooling demands all receive Platte River water through the Tri-County Canal diversion near North Platte. Because the Tri-County diversion point is located at the confluence of the North Platte River and South Platte River, these uses represent demands (and therefore potentially unmet demands) for both the North Platte River-Keystone to North Platte reach and the South Platte River-Julesburg to North Platte reach.

CNPPID irrigation is assumed to be a demand in the irrigation season only. CNPPID irrigation typically has access to storage water from Lake McConaughy as a supplemental source of water when natural flow alone is insufficient to meet irrigation demand. For the purposes of these analyses, storage water diversions by these canals were assumed to represent unmet demand for natural flow for irrigation, except for those years in which the irrigation use is allocated to a less-than-normal supply because of a limited supply of storage water in Lake McConaughy. Unmet demand for irrigation for this reach was estimated by evaluating the annual cumulative storage diversions for the Tri-County Canal for representative wet, normal, and dry periods. The years 2005 to present were excluded, as irrigation deliveries were limited in duration and quantity to less than a normal supply due to limited storage supplies in Lake McConaughy. Unmet demand for CNPPID irrigation is summarized in table 3-20.

Table 3-20. Unmet demand for CNPPID irrigation.

Condition	**Irrigation Season (ac-ft)**	**Non-Irrigation Season (ac-ft)**
Wet	200,000	0
Normal	235,000	0
Dry	290,000	0

Hydropower generation on the CNPIPD Supply Canal represents a year-round non-consumptive demand for Platte River water. Water diverted for CNPPID hydropower generation that is not also used for CNPPID irrigation is returned to the Platte River at the J-2 Return near Lexington or, to a lesser extent, the Jeffrey Return near Brady. Like irrigation, CNPPID hydropower generation has access to storage water from Lake McConaughy. Unlike for irrigation, however, storage water will not always be released for hydropower generation to cover an unmet demand. Instead, the priority is to preserve the storage water for future unmet demand for irrigation. Thus, storage water use is not a good indicator of unmet demand for hydropower generation. Instead, it is assumed that Tri-County Canal total diversions in the most recent wet period of the late 1990s were assumed to be representative of a fully-met hydropower demand. Unmet demand for CNPPID Supply Canal hydropower generation was thus estimated by comparing historic total diversions for representative periods against the total diversion amount from the late 1990s. Because storage water for irrigation is a part of this total diversion, the unmet irrigation demand will not be double-counted as a part of the unmet hydropower demand; in other words, the unmet demand for hydropower is above and beyond the unmet demand for irrigation. Unmet demand for CNPPID Supply Canal hydropower generation is summarized in table 3-21.

Table 3-21. Unmet demand for CNPPID hydropower generation.

Condition	Irrigation Season (ac-ft)	Non-Irrigation Season (ac-ft)
Wet	0	0
Normal	152,000	240,000
Dry	220,000	440,000

Canaday Steam Plant draws cooling water year-round from the CNPPID Supply Canal just upstream from the J-2 Return. Cooling for Canaday Steam Plant is mostly non-consumptive and was designed to take advantage of water that is already in the CNPPID Canal for other purposes. Demand for Canaday Steam Plant cooling was assumed to be met if other CNPPID hydropower and irrigation demands are met, and the additional unmet demand for Canaday Steam Plant cooling is therefore assumed to be zero.

Surface water irrigation demand in the Keystone to North Platte reach occurs primarily from five irrigation canals: North Platte Canal, Paxton-Hershey Canal, Suburban Canal, Keith-Lincoln Canal, and Cody-Dillon Canal. These canals represent a demand in the irrigation season only. These canals often have contractual access, under certain condtions, to storage water from Lake McConaughy (including some storage water from Glendo Reservoir in Wyoming that is sent to McConaughy) as a supplemental source of water when natural flow alone is insufficient to meet irrigation demand. For the purposes of these analyses, storage water diversions by these canals at the times that their contracts allow them access to such storage water were assumed to represent unmet demand for natural flow for irrigation. Unmet demand for irrigation for this reach was estimated by evaluating the annual cumulative storage diversions for these canals for representative wet, normal, and dry periods (figure 3-30 and table 3-22).

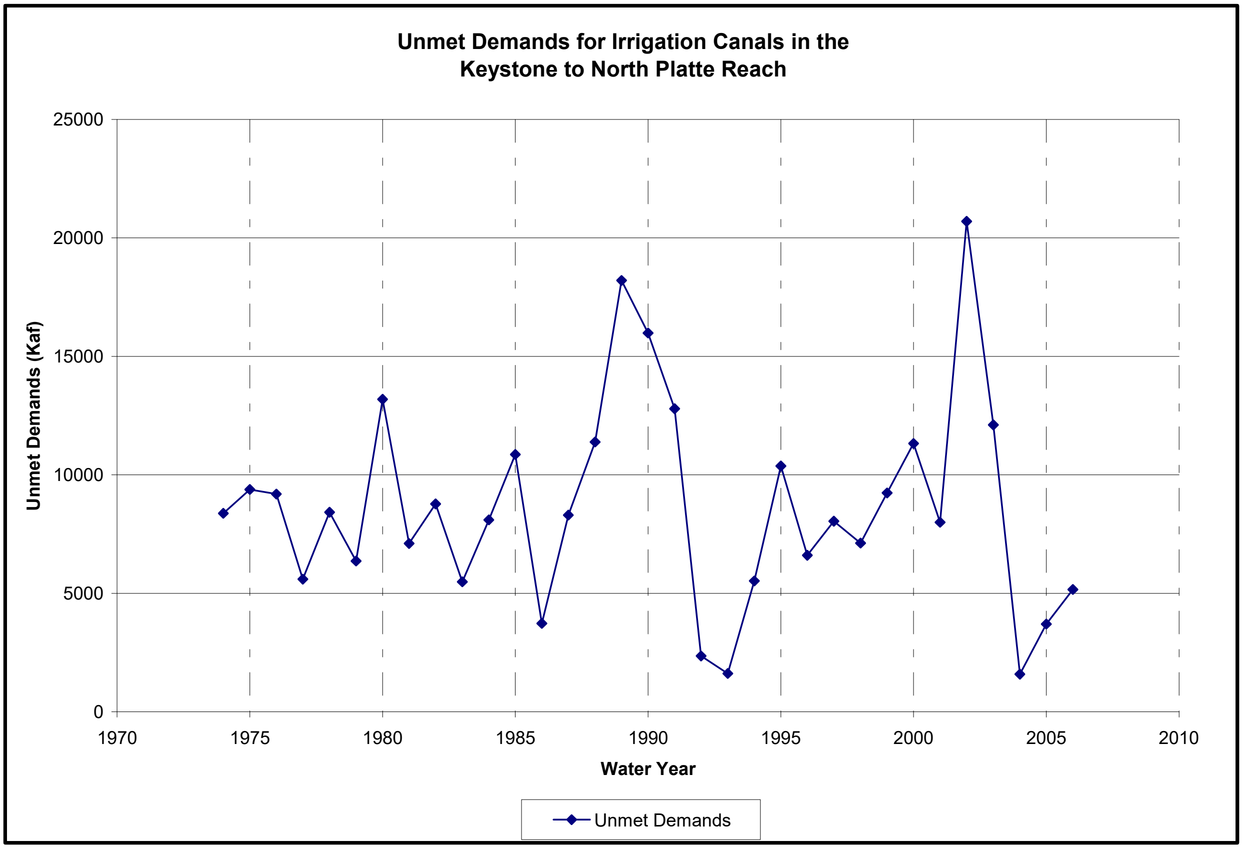


Figure 3-30. Storage demands for the irrigation canals located in the Keystone to North Platte reach.

Table 3-22. Unmet demands for the irrigation canals located in the Keystone to North Platte reach.

Condition	Irrigation Season (ac-ft)	Non-Irrigation Season (ac-ft)
Wet	7,500	0
Normal	7,500	0
Dry	15,000	0

The total unmet demands for the Keystone to North Platte reach were calculated by adding the unmet demands for CNPPID's irrigation and hydropower needs to the unmet demands for the five irrigation canals within the reach (table 3-23).

Table 3-23. Total unmet demands for the Keystone to North Platte reach.

Condition	Irrigation Season (ac-ft)	Non-Irrigation Season (ac-ft)
Wet	207,500	0
Normal	394,500	240,000
Dry	525,000	440,000

3.4.4 Accumulated Unmet Demands

The unmet demands from the downstream reaches are passed into this reach and added to the unmet demands in this reach to determine the cumulative unmet demands within the reach (tables 3-24 through 3-26).

Table 3-24. Unmet demands passed upstream from the Cozad to Odessa and North Platte to Cozad reaches.

Condition	Irrigation Season (ac-ft)	Non-Irrigation Season (ac-ft)
Wet	13,000	0
Normal	35,000	0
Dry	62,000	0

Table 3-25. Unmet demands in the Keystone to North Platte reach.

Condition	Irrigation Season (ac-ft)	Non-Irrigation Season (ac-ft)
Wet	207,500	0
Normal	394,500	240,000
Dry	525,000	440,000

Table 3-26. Cumulative unmet demands in the Keystone to North Platte reach.

Condition	Irrigation Season (ac-ft)	Non-Irrigation Season (ac-ft)
Wet	220,500	0
Normal	429,500	240,000
Dry	587,000	440,000

All of the cumulative unmet demands for this reach were passed upstream to the state line to Lewellen reach (table 3-27). None of the cumulative unmet demands for this reach were passed upstream to the Lodgepole Creek reach. An analysis was completed that showed that if stream reach gain reductions were replaced in Lodgepole Creek reach, almost all of the water would go to users in Colorado and not benefit the unmet demands downstream of the Colorado-Nebraska state line.

Table 3-27. Unmet demands passed upstream to the state line to Lewellen reach.

Condition	Irrigation Season (ac-ft)	Non-Irrigation Season (ac-ft)
Wet	220,500	0
Normal	429,500	240,000
Dry	587,000	440,000

3.4.5 Overall Difference between Overappropriated and Fully Appropriated

The overall difference between overappropriated and fully appropriated was set to zero under wet conditions. This was considered a reasonable adjustment because no unmet demands appear to be present under wet conditions. Future work should evaluate these conclusions.

Table 3-28. Stream reach gain reduction for the Keystone to North Platte reach.

Condition	Stream Reach Gain Reduction	
	Irrigation Season (ac-ft)	Non-Irrigation Season (ac-ft)
Wet	26,000	22,900
Normal	26,000	22,900
Dry	26,000	22,900

Table 3-29. Unmet demands for the Keystone to North Platte reach.

Condition	Unmet Demands	
	Irrigation Season (ac-ft)	Non-Irrigation Season (ac-ft)
Wet	220,500	0
Normal	429,500	240,000
Dry	587,000	440,000

Table 3-30. Overall difference between overappropriated and fully appropriated for the Keystone to North Platte reach.

Condition	OA/FA Difference	
	Irrigation Season (ac-ft)	Non-Irrigation Season (ac-ft)
Wet	0	0
Normal	26,000	22,900
Dry	26,000	22,900

3.5 South Platte River – Julesburg to North Platte

The Julesburg to North Platte reach is the contributing surface water basin between the stream gages located on the South Platte River at Julesburg and the South Platte River at North Platte. This reach includes inflows from some small ungaged tributaries and outflows to Western Canal and Korty Canal.

3.5.1 Assessment of Reach Gain Reductions

The double-mass curve of cumulative reach gains and cumulative precipitation during the period 1949-2006 for the irrigation season and non-irrigation season, respectively, are illustrated in figures 3-31 and 3-32. The cumulative precipitation for this reach was developed based on the weighted precipitation from the following gages:

Gage	Weight of Gage (based on Thiessen polygons)
Big Springs	0.320
Ogallala	0.309
Sidney	0.007
North Platte	0.069
Wallace	0.211
Oshkosh	0.084

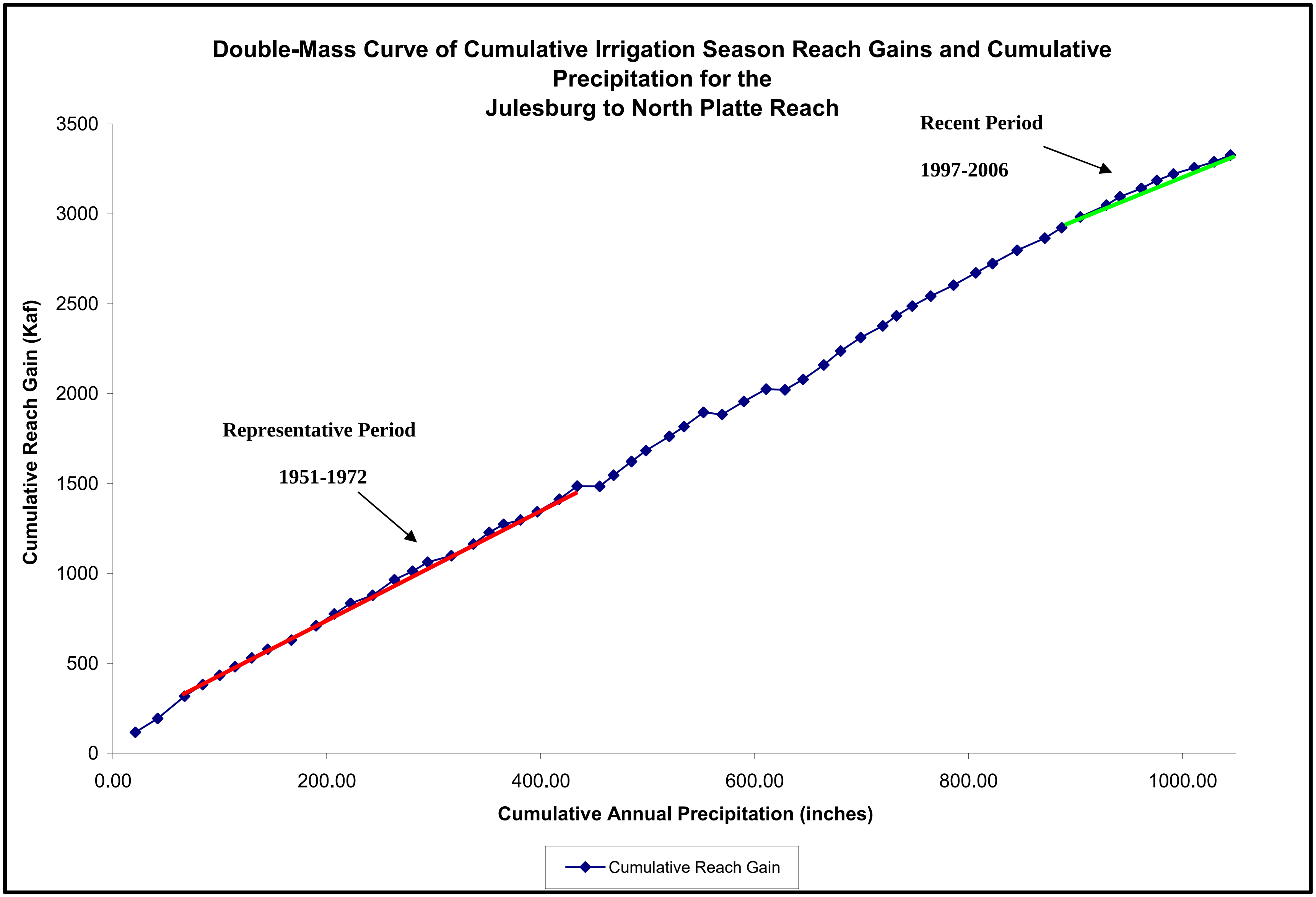


Figure 3-31. Double-mass curve of the cumulative irrigation season reach gain and cumulative annual precipitation.

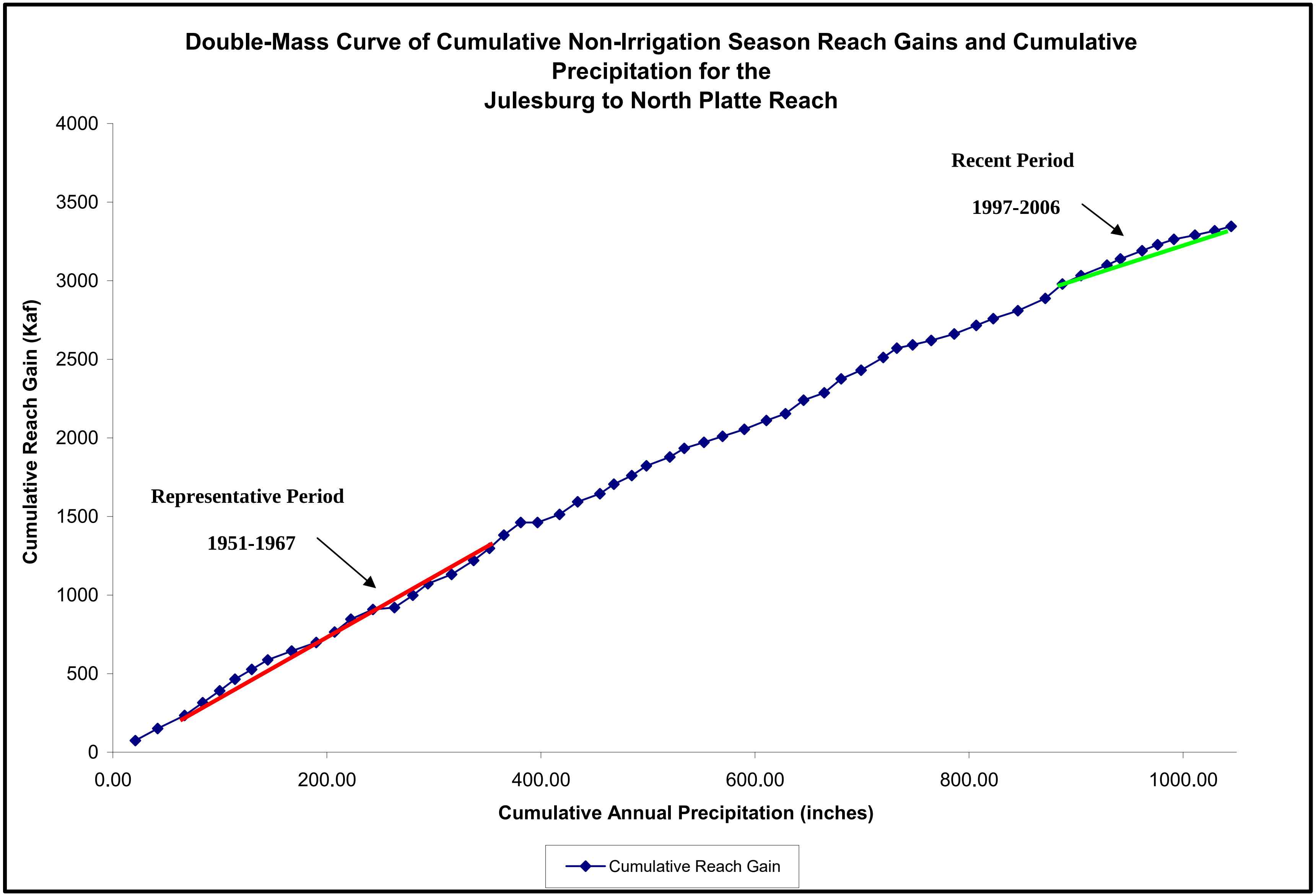


Figure 3-32. Double-mass curve of the cumulative non-irrigation season reach gain and cumulative annual precipitation.

In evaluating potential stream reach gain reductions, the 1951-1972 period was used as the representative period for the irrigation season and the 1951-1967 period was used as the representative period for the non-irrigation season. The period 1997-2006 was used to represent the recent period for both the irrigation season and the non-irrigation season. Since the break point on the curves falls prior to the dry conditions of 2000-2006 that were identified in the downstream reaches, this break point seems to represent reach gain reductions that have occurred under wet, normal, and dry hydrologic conditions. The calculated stream reach gain reductions for this reach are summarized in table 3-31.

Table 3-31. Summary of stream reach gain reductions for the Julesburg to North Platte reach.

Julesburg to North Platte Reach Gain Reduction		
Condition	Irrigation Season (ac-ft)	Non-Irrigation Season (ac-ft)
Wet	25,300	11,000
Normal	25,300	11,000
Dry	25,300	11,000

3.5.2 Potential Causes for Reach Gain Reductions

The potential causes for stream reach gain reductions within this reach were investigated by evaluating reach gain baseflows, diversions (seepage returns to the reach), groundwater development, and surface water development. Figures 3-33 and 3-34 illustrate how baseflow within the reach has changed over this period. The baseflows appear to have remained consistent through the 1949-2000 period with a decrease in the period subsequent to 2000. This decrease in baseflow could indicate that a portion of the recent period stream reach gain reduction is due to reduced groundwater inflow in the reach.

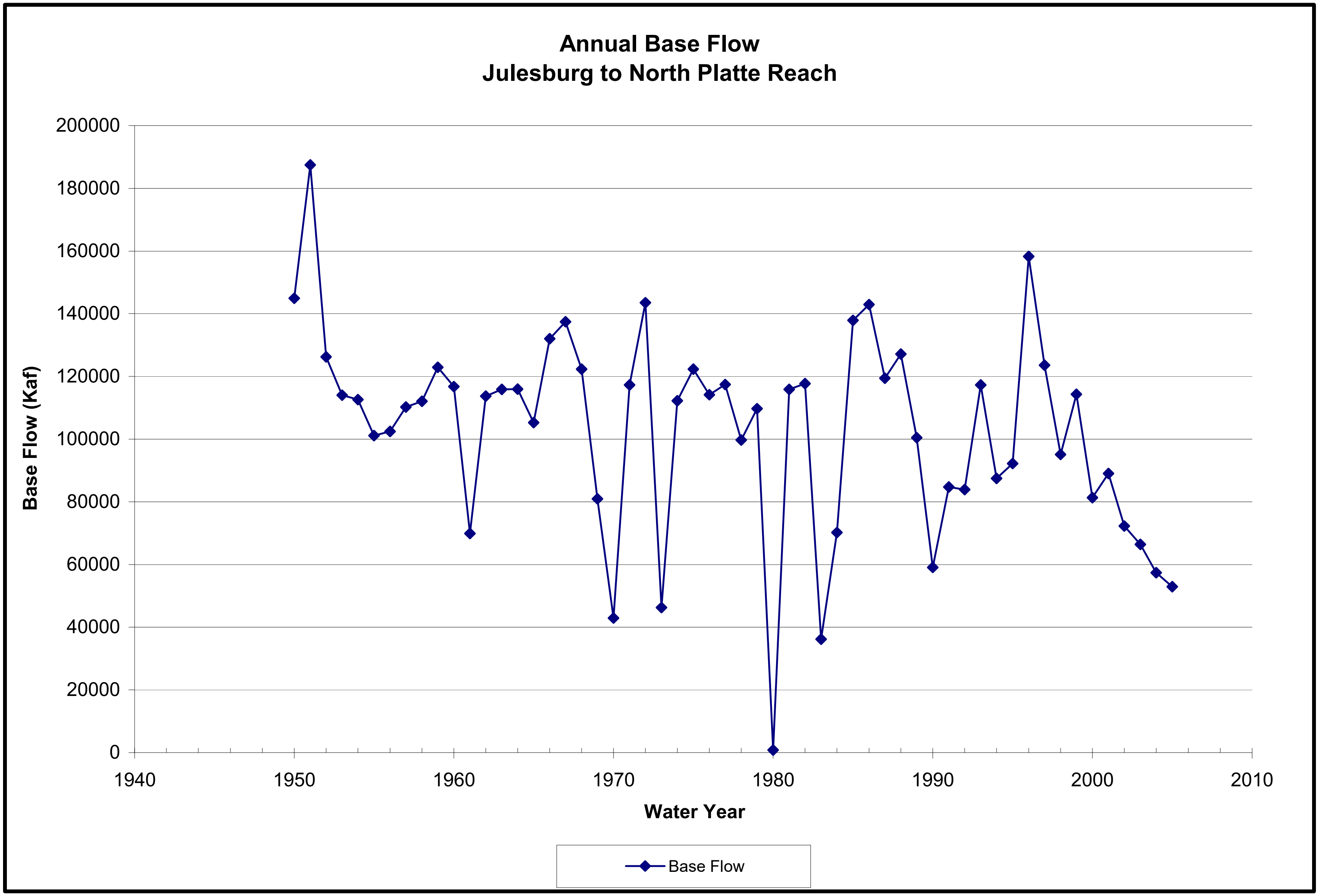


Figure 3-33. Julesburg to North Platte reach annual baseflow gain.

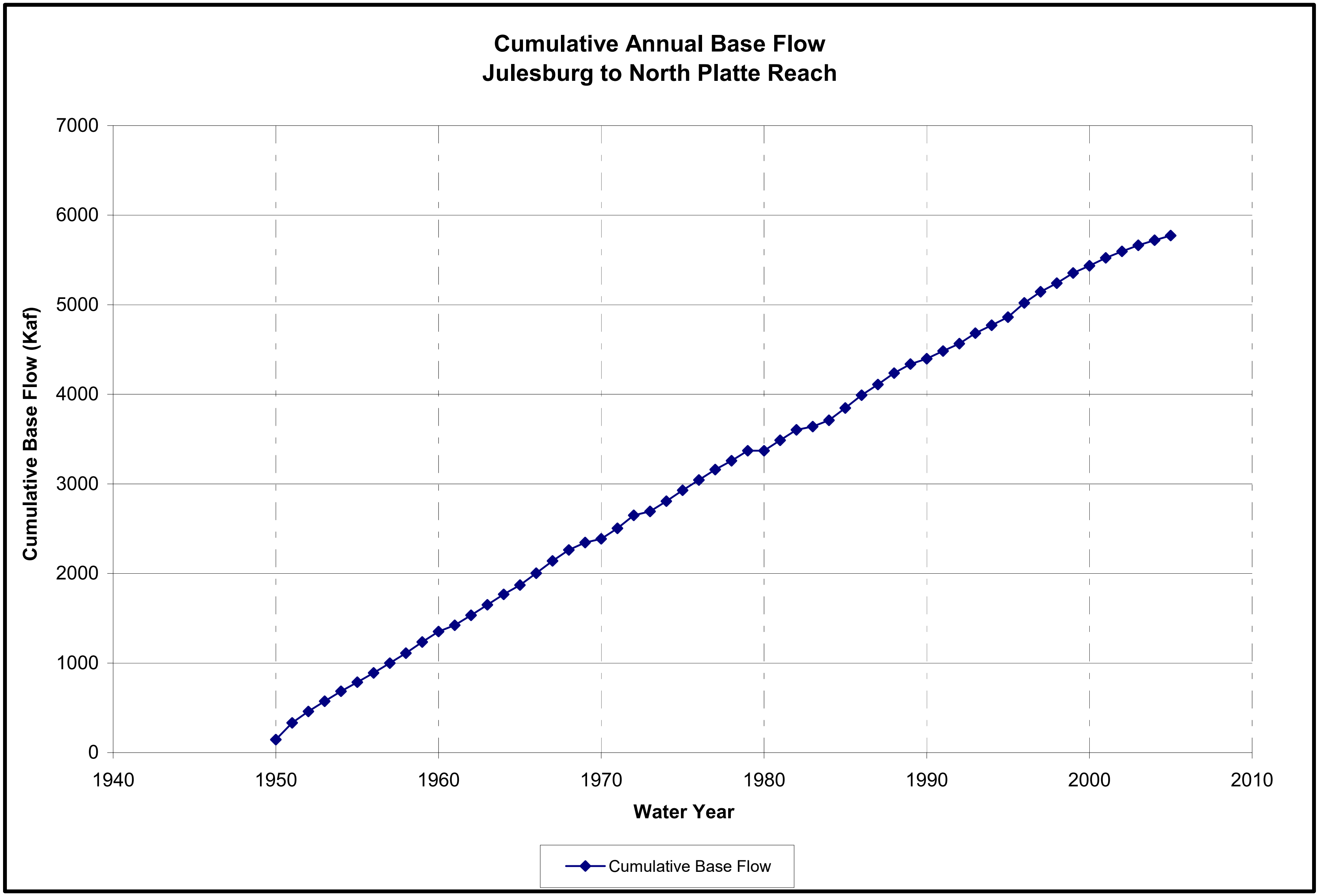


Figure 3-34. Julesburg to North Platte cumulative annual baseflow.

Surface water diversions within the reach were evaluated to determine if reduced surface water diversions and therefore reduced returns from those diversions could be a potential cause of stream reach gain reductions. Figures 3-35 and 3-36 illustrate historical diversions for irrigation within this reach and historical diversions for the Korty Canal.

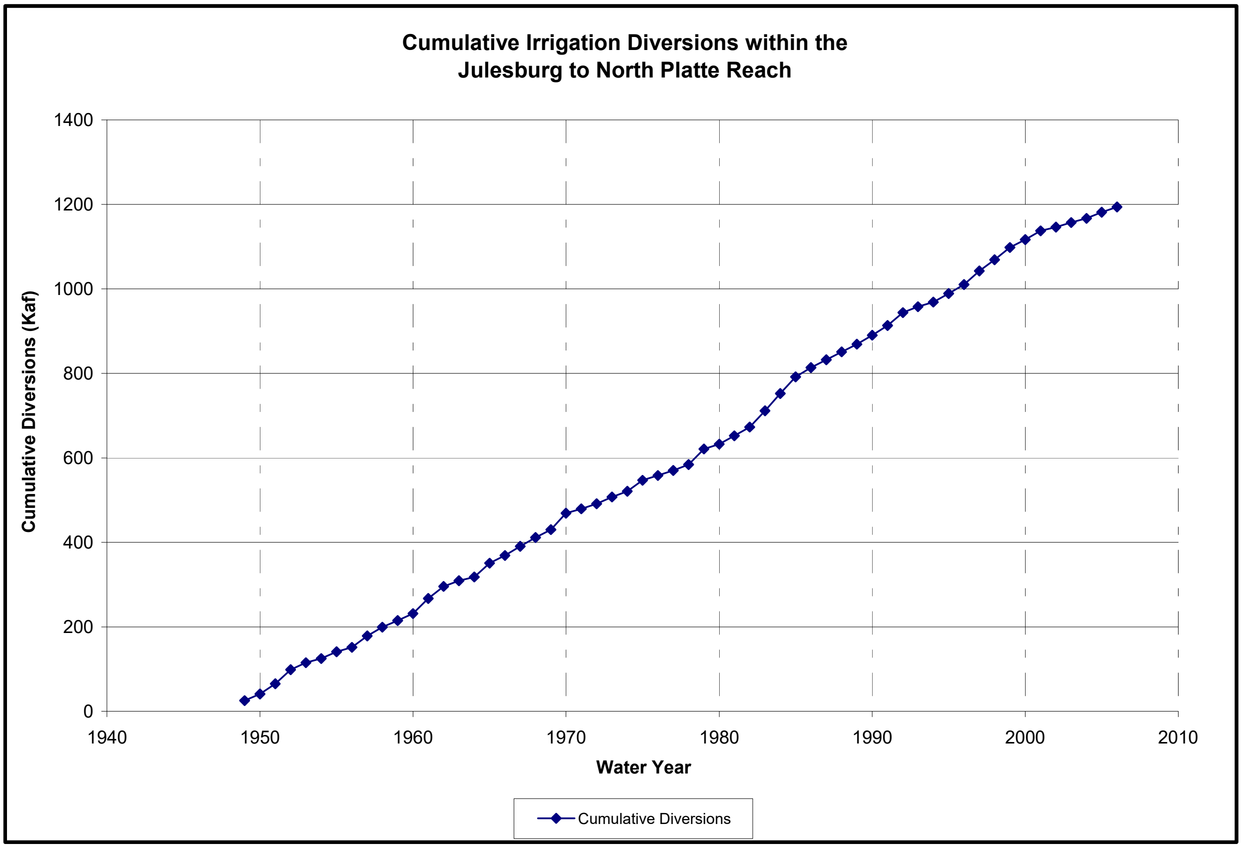


Figure 3-35. Cumulative surface water diversions for irrigation within the Julesburg to North Platte reach.

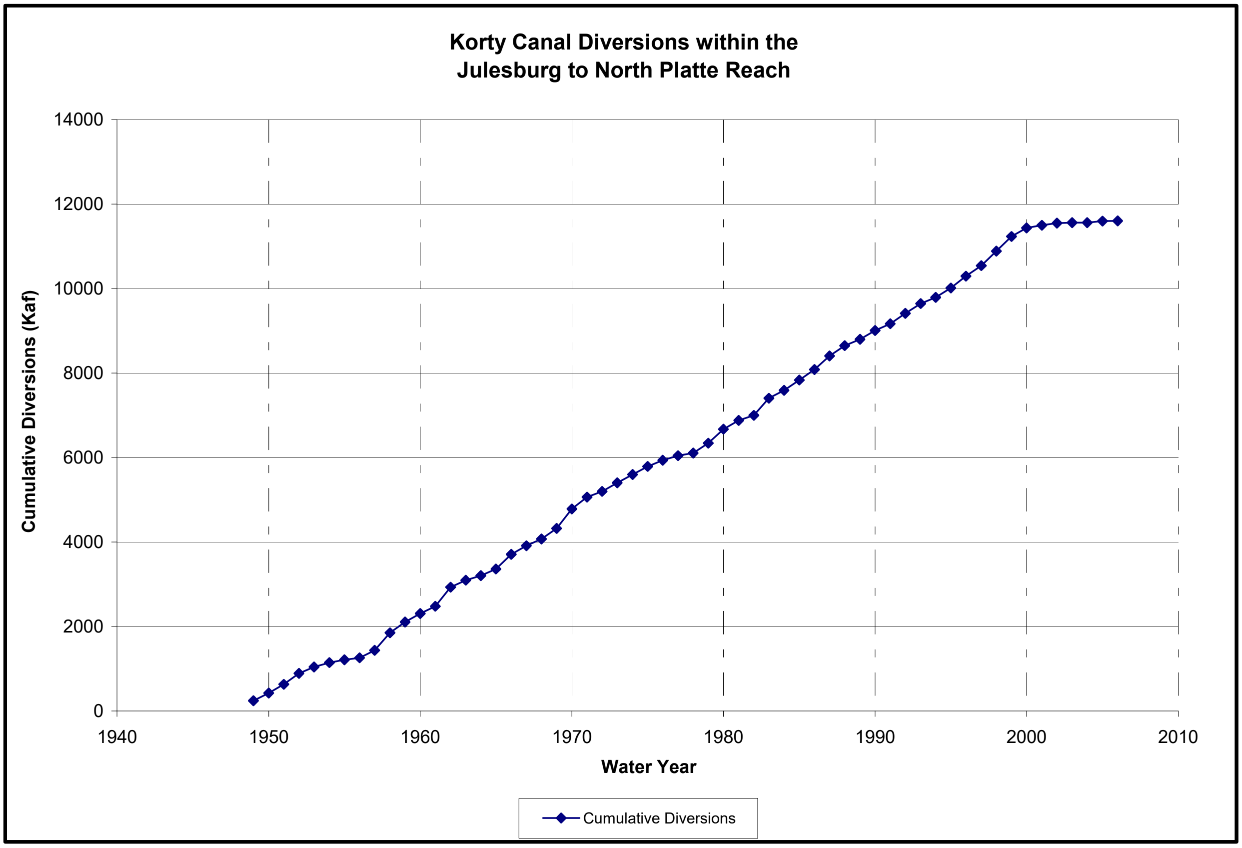


Figure 3-36. Cumulative annual surface water diversions of Korty Canal.

Evaluation of the diversion records indicated that estimated annual seepage from diversions affecting this reach decreased significantly from the representative period to the recent period (4,600 ac-ft/yr in the irrigation season and 26,800 ac-ft/yr in the non-irrigation season). Since any reach gain would include gains from these seepage losses, these seepage changes were subtracted from the reach gain reduction to derive the final reach gain reductions shown in table 3-32.

Table 3-32. Summary of stream reach gain reductions for the Julesburg to North Platte reach adjusted for reduced seepage returns.

Julesburg to North Platte Reach Gain Reduction		
Condition	Irrigation Season (ac-ft)	Non-Irrigation Season (ac-ft)
Wet	6,400	-1,500
Normal	6,400	-1,500
Dry	6,400	-1,500

The level of groundwater development within the reach was evaluated and is illustrated in figures 3-34 and 3-35. The results indicate that approximately 140,000 acres of additional groundwater irrigated acres were developed through the period analyzed (1949-2006). The increase in groundwater irrigated acres may be a potential cause of reductions in the reach gain.

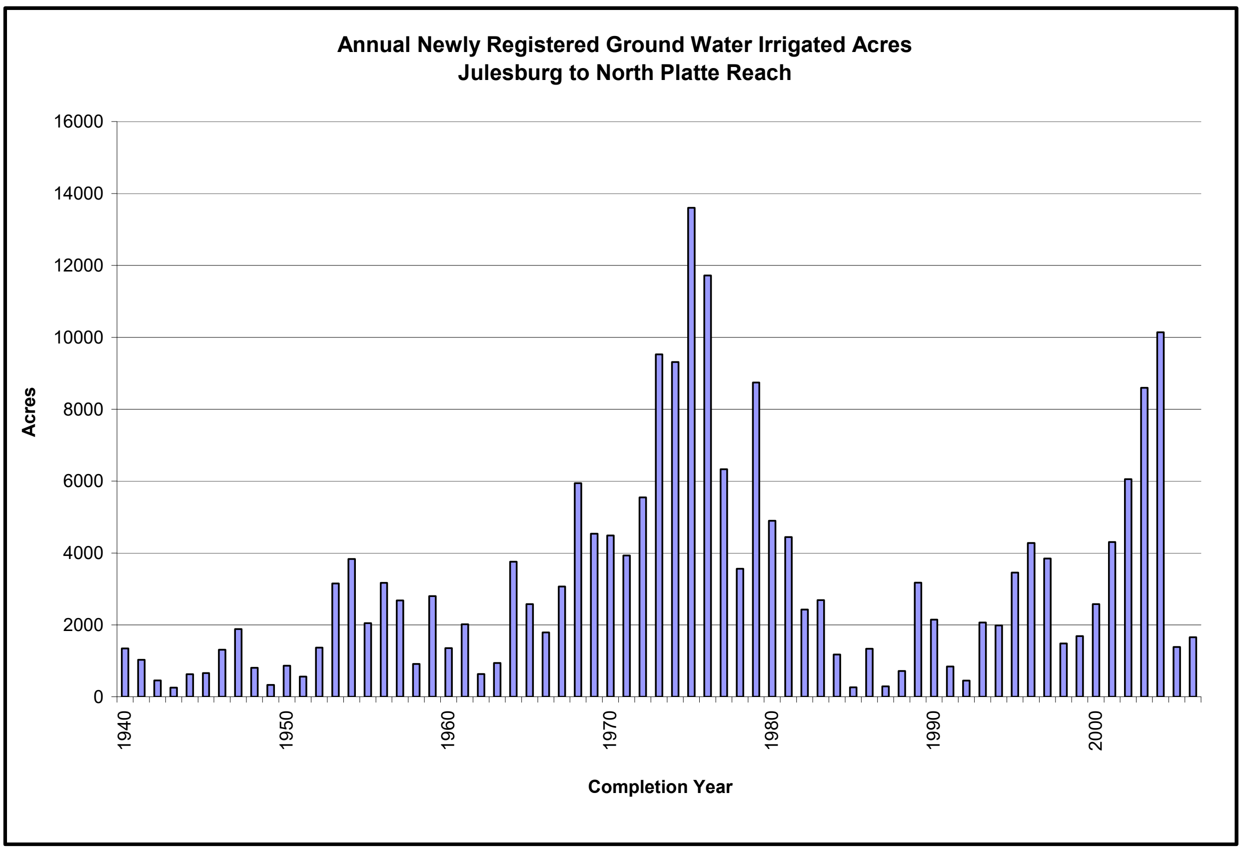


Figure 3-37. Annual newly registered groundwater irrigated acres.

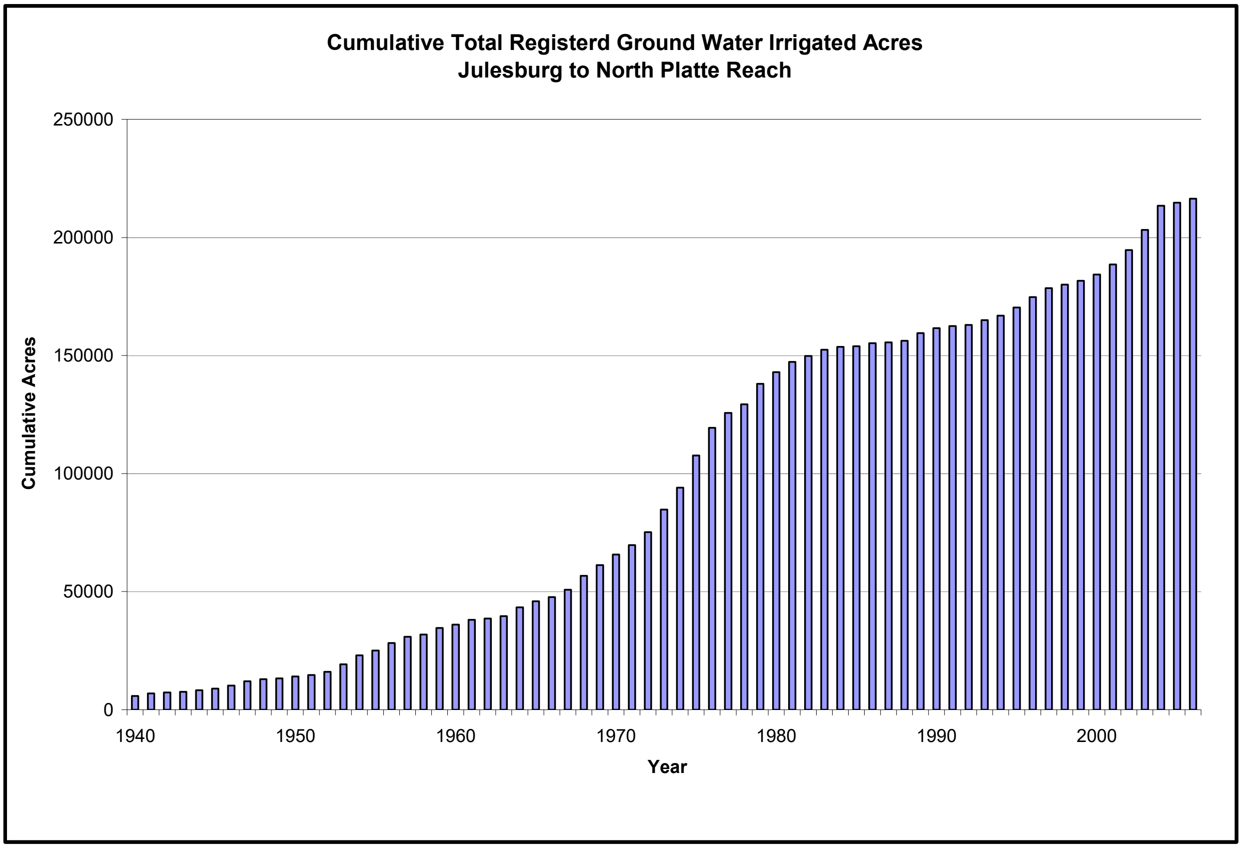


Figure 3-38. Cumulative groundwater irrigated acres.

The level of surface water development within the reach was evaluated and is illustrated in figures 3-39 and 3-40. The results indicate that approximately 1,700 additional acres were approved for irrigation under surface water appropriation through the period analyzed (1949-2006). These new acres may have an impact on reductions in the reach gain; these reductions may be minimal during dry periods, however, when senior appropriations can call for administration on the river.

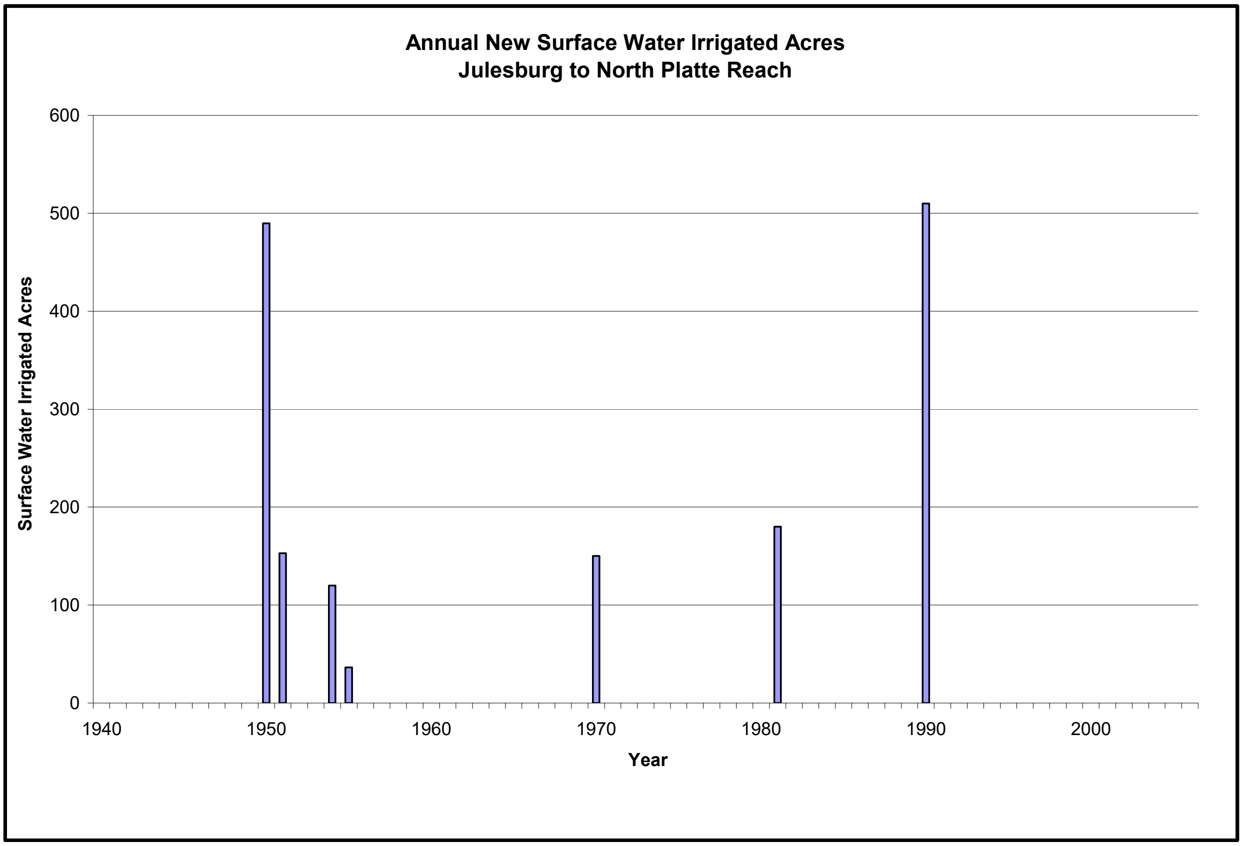


Figure 3-39. Annual new surface water irrigated acres.

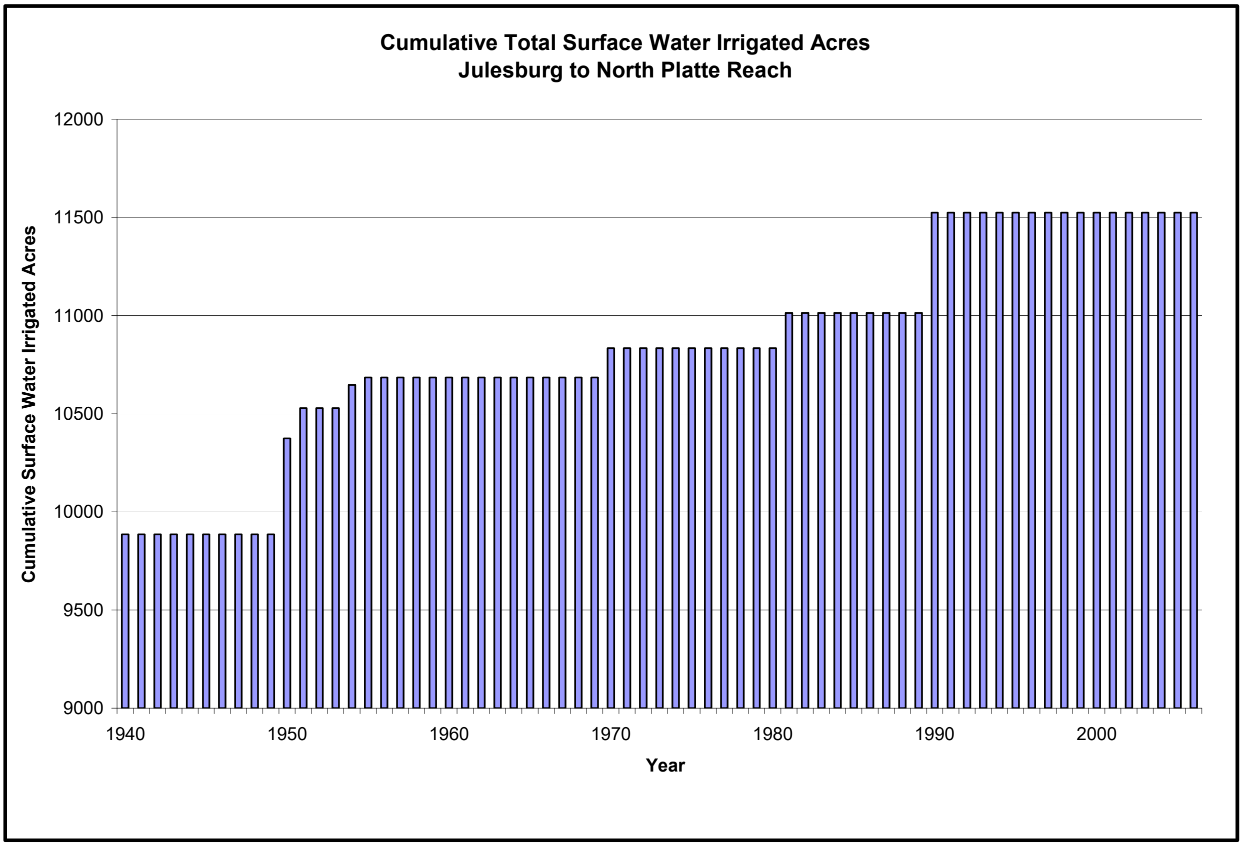


Figure 3-40. Cumulative total surface water irrigated acres.

3.5.3 Unmet Demands

The following demands were considered for the Julesburg to North Platte reach:

- CNPPID irrigation
- CNPPID Supply Canal hydropower generation
- Canaday Steam Plant cooling
- North Platte Hydro (via Korty Canal diversion)
- Gerald Gentleman Station cooling (via Korty Canal diversion)

Because the Tri-County diversion point is located at the confluence of the North Platte River and South Platte River, the unmet demands for CNPPID Irrigation, CNPPID Supply Canal hydropower generation, and Canaday Steam Plant cooling for the South Platte-River Julesburg to North Platte reach are the same as those for the North Platte River-Keystone to North Platte reach.

One source for the North Platte Hydro use is the Korty Canal diversion on the South Platte River in the Julesburg to North Platte reach; the other source is the Keystone Canal diversion on the North Platte River just below Lake McConaughy). Hydropower generation for North Platte Hydro represents a year-round non-consumptive demand for Platte River water. The water passed through the North Platte Hydro is returned to the South Platte River just upstream of the Tri-County diversion. Thus, the demand for North Platte Hydro was assumed to be met if the demands associated with the Tri-County diversion were met. Therefore, to avoid double-counting of unmet demand, additional unmet demand for North Platte Hydro was assumed to be zero.

Like North Platte Hydro, Gerald Gentleman Station cooling represents a year-round demand for the Korty Canal diversion in this reach as well as for the Keystone Canal diversion in another reach. In addition, Gerald Gentleman Station cooling water takes advantage of other water moving through the Sutherland system that is returned to the river just upstream of the Tri-County diversion. Therefore, additional unmet demand for Gerald Gentleman Station cooling was assumed to be zero. Thus, the unmet demand for the Julesburg to North Platte reach is the same as the Keystone to North Platte reach, except for irrigation season demands resulting from the five irrigation canals located in the Keystone to North Platte reach (table 3-33).

Table 3-33. Unmet demands for the Julesburg to North Platte reach.

Condition	Irrigation Season (ac-ft)	Non-Irrigation Season (ac-ft)
Wet	200,000	0
Normal	387,000	240,000
Dry	510,000	440,000

3.5.4 Accumulated Unmet Demands

The unmet demands from the downstream reaches are passed into this reach and added to the unmet demands in this reach to determine the cumulative unmet demands within the reach (tables 3-34 through 3-36).

Table 3-34. Unmet demands passed upstream from the Cozad to Odessa and North Platte to Cozad reaches.

Condition	Irrigation Season (ac-ft)	Non-Irrigation Season (ac-ft)
Wet	13,000	0
Normal	35,000	0
Dry	62,000	0

Table 3-35. Unmet demands in the Julesburg to North Platte reach.

Condition	Irrigation Season (ac-ft)	Non-Irrigation Season (ac-ft)
Wet	200,000	0
Normal	387,000	240,000
Dry	510,000	440,000

Table 3-36. Cumulative unmet demands in the Julesburg to North Platte reach.

Condition	Irrigation Season (ac-ft)	Non-Irrigation Season (ac-ft)
Wet	213,000	0
Normal	422,000	240,000
Dry	572,000	440,000

All of the cumulative unmet demands for this reach were passed upstream to the state line to Lewellen reach (table 3-37). None of the cumulative unmet demands for this reach were passed upstream to the Lodgepole Creek reach. An analysis showed that if stream reach gain reductions were replaced in Lodgepole Creek reach, almost all of the water would go to users in Colorado and not benefit the unmet demands downstream of the Colorado-Nebraska state line.

Table 3-37. Unmet demands passed upstream to the state line to Lewellen Reach (refer to table 3-27 in section 3.4.4).

Condition	Irrigation Season (ac-ft)	Non-Irrigation Season (ac-ft)
Wet	220,500	0
Normal	429,500	240,000
Dry	587,000	440,000

3.5.5 Overall Difference between Overappropriated and Fully Appropriated

The overall difference between overappropriated and fully appropriated was set to zero under wet conditions. This was considered a reasonable adjustment because no unmet demands appear to be present under wet conditions. Future work should evaluate the authors' conclusions more carefully.

Table 3-38. Stream reach gain reduction for the Julesburg to North Platte reach.

Condition	Stream Reach Gain Reduction	
	Irrigation Season (ac-ft)	Non-Irrigation Season (ac-ft)
Wet	6,400	-1,500
Normal	6,400	-1,500
Dry	6,400	-1,500

Table 3-39. Unmet demands for the Julesburg to North Platte reach.

Condition	Unmet Demands	
	Irrigation Season (ac-ft)	Non-Irrigation Season (ac-ft)
Wet	213,000	0
Normal	422,000	240,000
Dry	572,000	440,000

Table 3-40. Overall Difference between overappropriated and fully appropriated for the Julesburg to North Platte reach.

Condition	OA/FA Difference	
	Irrigation	**Non-Irrigation**
Wet	0	0
Normal	6,400	-1,500
Dry	6,400	-1,500

3.6 State Line to Lewellen Reach

The state line to Lewellen reach is the contributing surface water basin between the stream gages located on the Wyoming-Nebraska state line at North Platte and the North Platte River at Lewellen. This reach includes inflows from Wyoming, Horse Creek, Interstate Canal, Mitchell-Gering Canal, Fort Laramie Canal and many tributary drains and outflows for numerous canals including: Tri-State Canal, Winters Creek Canal, Empire Canal, Central Canal, Enterprise Canal, Minatare Canal, Chimney Rock Canal, Beerline Canal, Browns Creek Canal, Lisco Canal, Midland-Overland Canal, Belmont Canal, Castle Rock Canal, Short Line Canal, Nine Mile Canal, along with other canals located on the tributaries.

3.6.1 Assessment of Reach Gain Reductions

The double-mass curves of cumulative reach gains and cumulative precipitation during the period 1949-2006 for the irrigation season and non-irrigation season, respectively, are illustrated in figures 3-41 and 3-42. The cumulative precipitation for this reach was developed based on the weighted precipitation from the following gages:

Gage	Weight of Gage (based on Thiessen polygons)
Big Springs	0.003
Agate	0.042
Alliance	0.097
Bridgeport	0.227
Harrisburg	0.107
Oshkosh	0.223

Scottsbluff	0.192
Sidney	0.061
Kimball	0.048

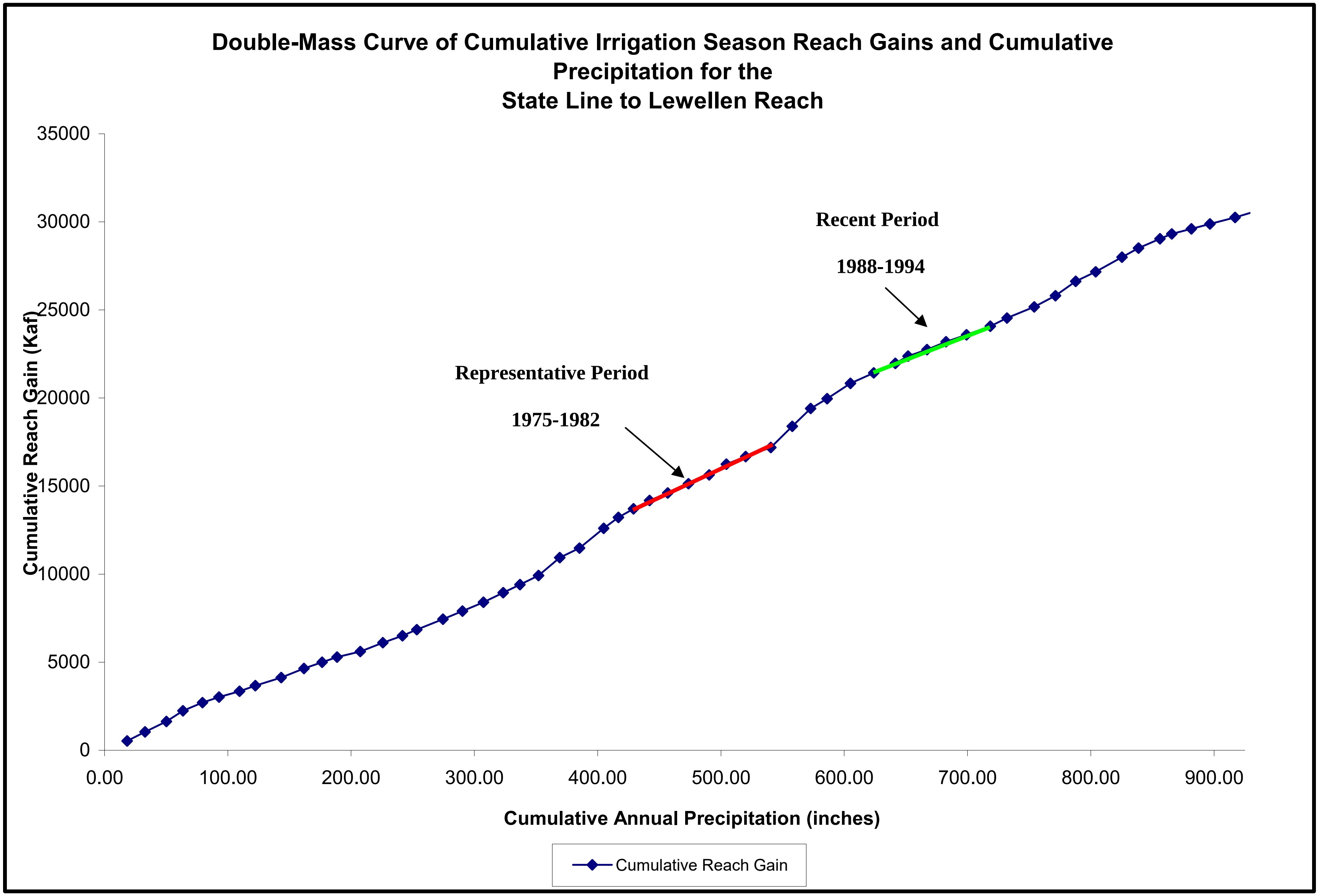


Figure 3-41. Double-mass curve of the cumulative irrigation season reach gain and cumulative annual precipitation.

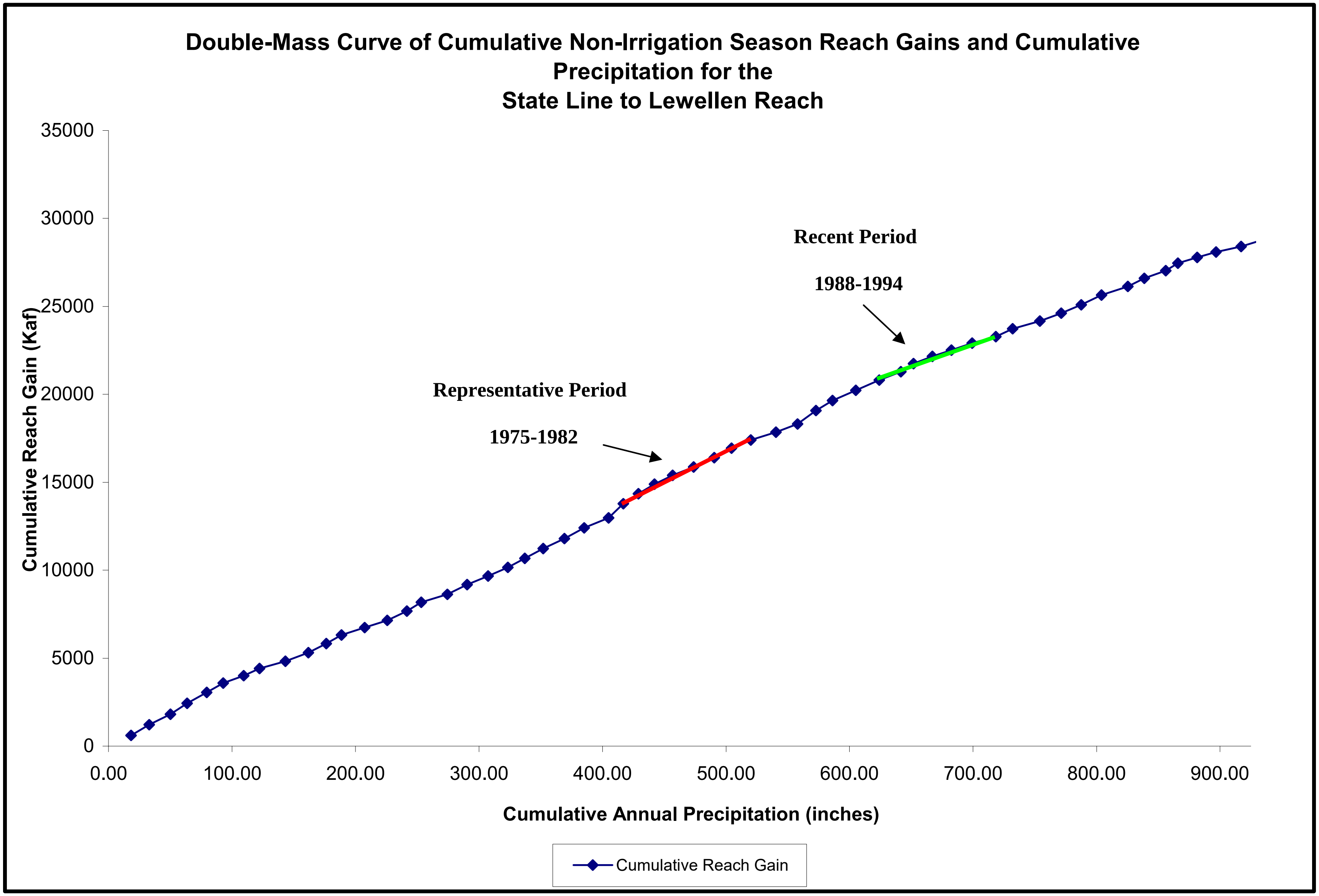


Figure 3-42. Double-mass curve of the cumulative non-irrigation season reach gain and cumulative annual precipitation.

In evaluating potential stream reach gain reductions, the 1975-1982 period was used as the representative period for both the irrigation season and the non-irrigation season. The period 1988-1994 was used to represent the recent period for both the irrigation season and the non-irrigation season. Since the break point on the curves falls prior to the dry conditions identified subsequent to 2000, this break point seems to represent reach gain reductions that have occurred under wet, normal, and dry hydrologic conditions. The calculated stream reach gain reductions for this reach are summarized in table 3-41.

Table 3-41. Summary of stream reach gain reductions for the state line to Lewellen reach.

State Line to Lewellen Reach Gain Reduction		
Condition	Irrigation Season (ac-ft)	Non-Irrigation Season (ac-ft)
Wet	44,900	68,500
Normal	44,900	68,500
Dry	44,900	68,500

3.6.2 Potential Causes for Reach Gain Reductions

The potential causes for stream reach gain reductions within this reach were investigated by evaluating state line canal inflows, diversions (seepage returns to the reach), groundwater development, and surface water development. Figure 3-43 illustrates state line inflows from canals that originate in Wyoming (Interstate Canal, Mitchell-Gering Canal, and Fort Laramie Canal). Surface water diversions within the reach were evaluated to determine if reduced surface water diversions and therefore reduced returns from those diversions could be a potential cause of stream reach gain reductions.

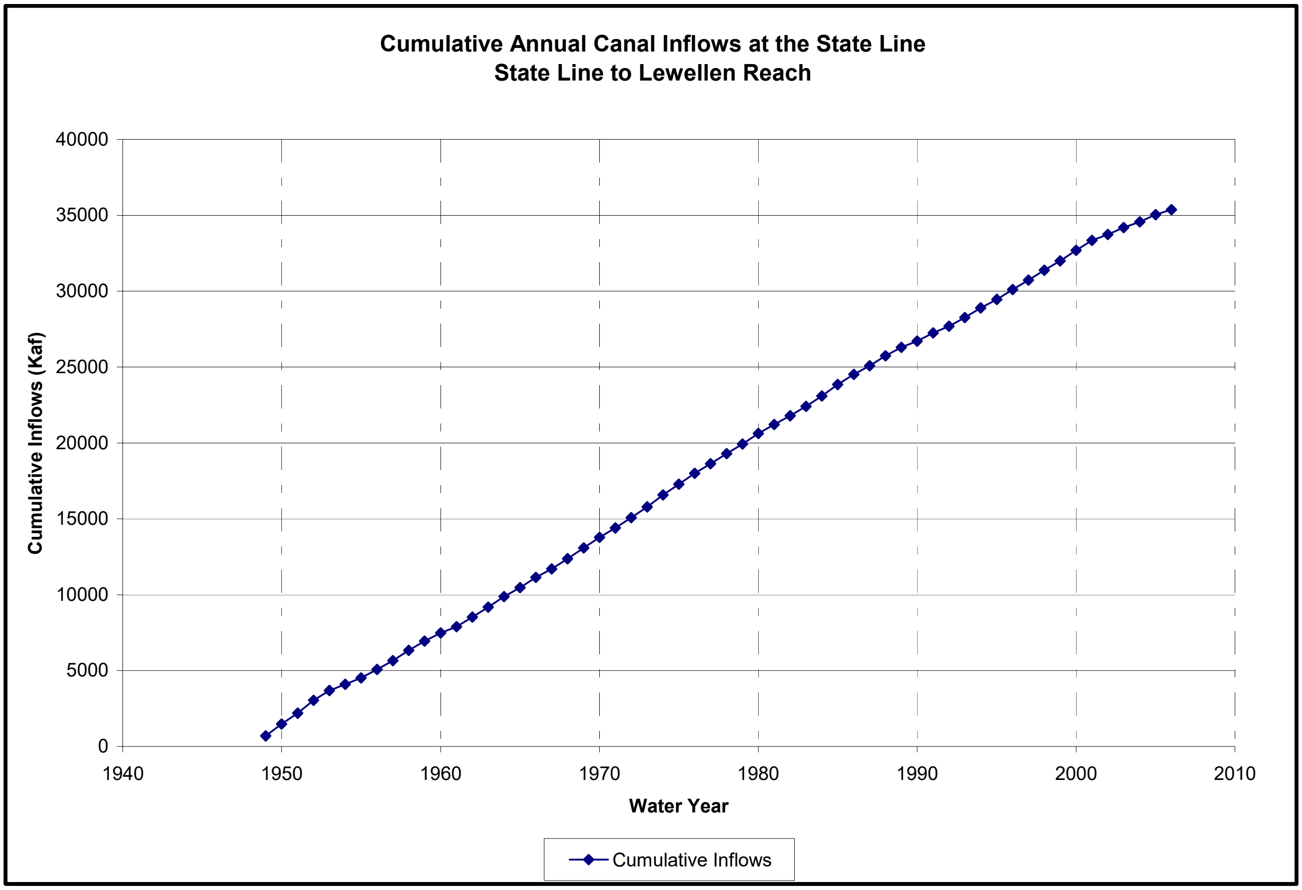


Figure 3-43. Cumulative annual state line canal inflows.

Evaluation of the diversion records indicated that estimated annual seepage from diversions affecting this reach decreased significantly from the representative period to the recent period (37,000 ac-ft/yr in the irrigation season and 5,500 ac-ft/yr in the non-irrigation season). Since any reach gain would include gains from these seepage losses, these seepage changes were subtracted from the reach gain reduction to derive the final reach gain reductions shown in table 3-42.

Table 3-42. Summary of stream reach gain reductions for the state line to Lewellen reach adjusted for reduced seepage from canal diversions.

State Line to Lewellen Reach Gain Reduction		
Condition	Irrigation Season (ac-ft)	Non-Irrigation Season (ac-ft)
Wet	7,900	63,000
Normal	7,900	63,000
Dry	7,900	63,000

The level of groundwater development within the reach was evaluated and is illustrated in figures 3-44 and 3-45. The results indicate that approximately 120,000 additional groundwater irrigated acres were developed through the period analyzed (1949-2006). The increase in groundwater irrigated acres may be a potential cause of reductions in the reach gain.

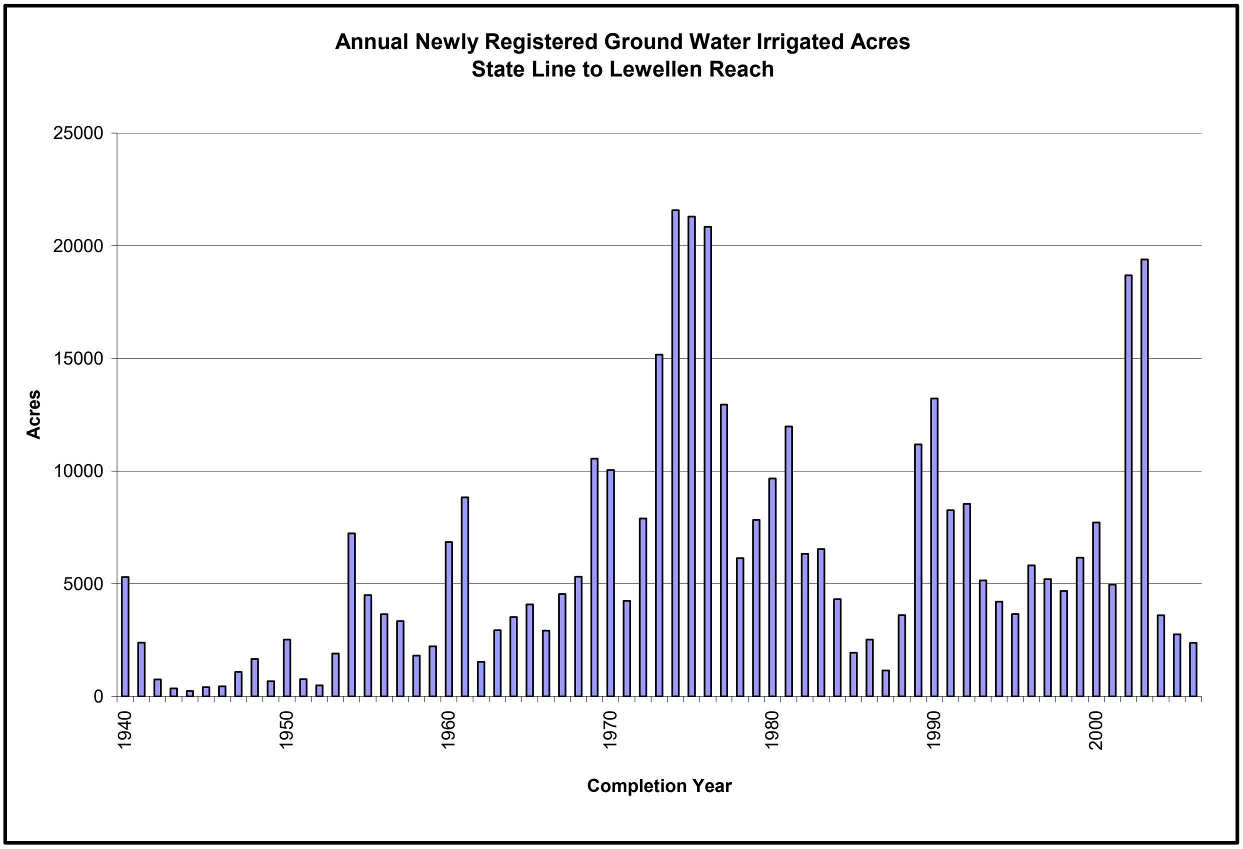


Figure 3-44. Annual newly registered groundwater irrigated acres.

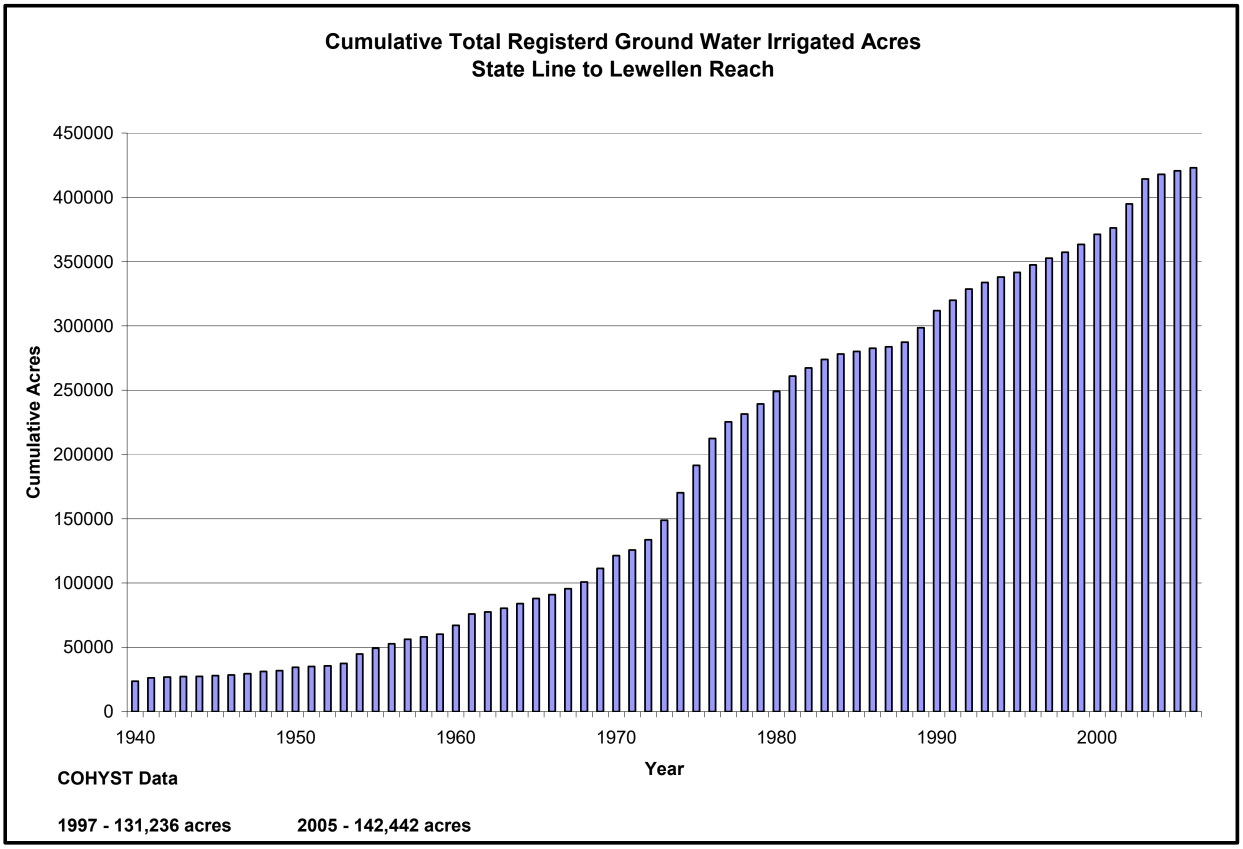


Figure 3-45. Cumulative groundwater irrigated acres.

The level of surface water development within the reach was evaluated and is illustrated in figures 3-46 and 3-47. The results indicate that approximately 45,000 additional acres were approved for irrigation under surface water appropriations through the period analyzed (1949-2006). These new acres may have an impact on reductions in the reach gain; these reductions may be minimal during dry periods, however, when senior appropriations can call for administration on the river.

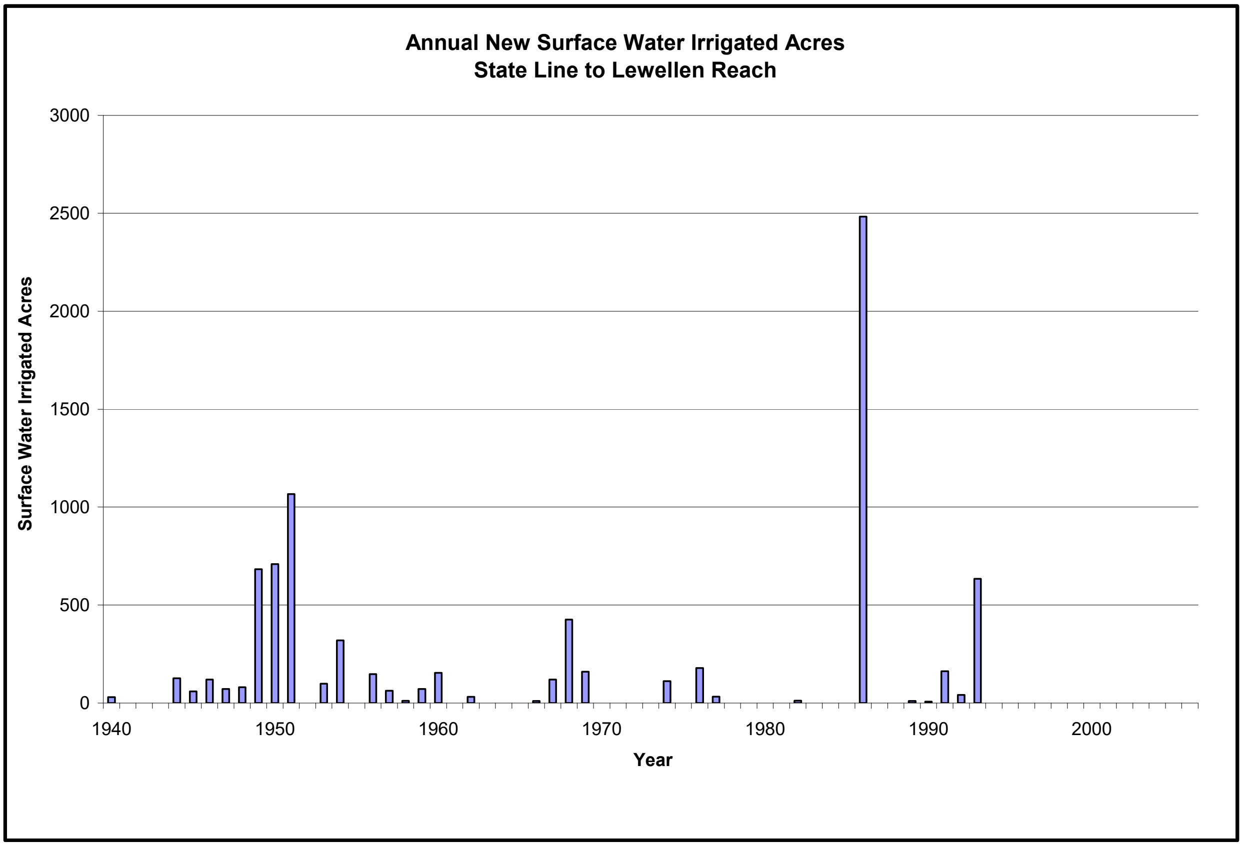


Figure 3-46. Annual new surface water irrigated acres.

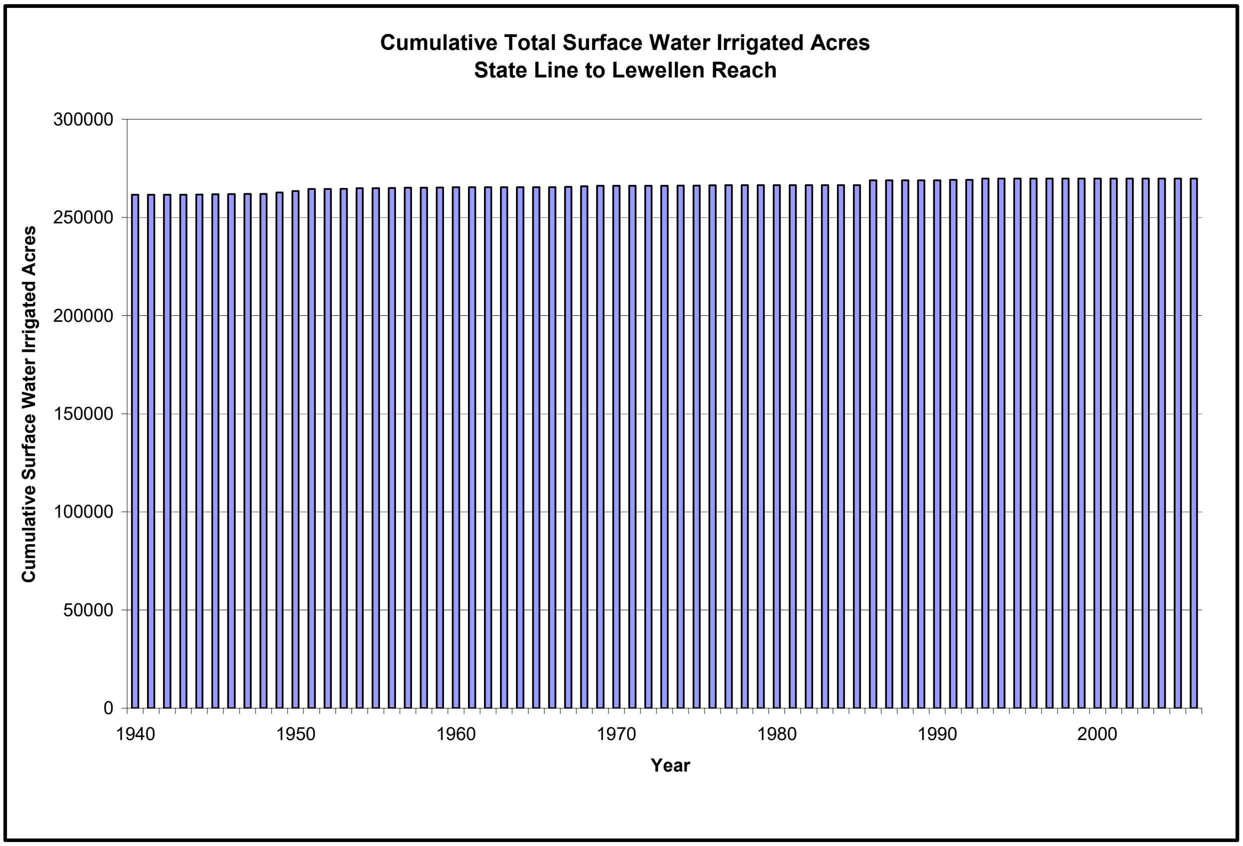


Figure 3-47. Cumulative total surface water irrigated acres.

3.6.3 Unmet Demands

The following demands were considered for the Wyoming state line to Lewellen reach:

- Kingsley Hydropower generation
- Environmental Account
- Lake McConaughy storage
- North Platte Hydro (via Keystone Canal diversion)
- Gerald Gentleman Station cooling (via Keystone Canal diversion)
- Sutherland storage (via Keystone Canal diversion)
- Panhandle Irrigation canals with storage water
- Panhandle Tributary Irrigation canals without storage water

The Kingsley Hydropower Plant is located within Kingsley Dam and serves as the primary outlet works for Lake McConaughy. Kingsley Hydro primarily generates as storage water is released from Lake McConaughy or natural flow is passed through Kingsley Dam for some other purpose. Though exceptions may occur, these analyses assumed that if all other demands that rely on Lake McConaughy for supplemental storage are met, then Kingsley Hydro demand is met as well. Therefore, additional unmet demand associated with Kingsley Hydropower Plant generation was assumed to be zero.

The Environmental Account is a storage-use appropriation that provides storage water from Lake McConaughy for instream use for fish and wildlife. Though the end use is intended for downstream reaches, the amount of water available for use is calculated based upon storable inflows to Lake McConaughy at Lewellen. The “demand” for the Environmental Account is an amount derived through a complex set of calculations. Because it is anticipated that all new uses that post-date the Environmental Account will have to be offset as a result of the PRRIP requirement to offset for post-1997 reach gain reductions (the Environmental Account has a 1998 priority date), the unmet demand for the Environmental Account was assumed to be zero.

The total demand for water to be stored in Lake McConaughy includes the amount needed to supplement downstream demands, as well as the amount needed to maintain evaporation and seepage losses from the reservoir. Because the unmet demands for the downstream uses that rely on Lake McConaughy as a supplemental source have already been calculated, additional unmet demand for storage for those purposes was assumed to be zero. Additionally, because seepage and evaporation losses from the reservoir are uncontrolled and have historically been “met” under all conditions, additional unmet demand for storage for those purposes was also assumed to be zero.

The Keystone Canal diversion point is physically located immediately downstream from Lake McConaughy. As noted above, because Lake McConaughy basically bears all losses between Lewellen and Keystone on the North Platte River, the demands associated with the Keystone Canal diversion are treated as reach demands for the state line to Lewellen reach. As was the case for the Korty Canal diversion on the South Platte River, the additional unmet demands for the Keystone Canal diversion for both the North Platte Hydro and Gerald Gentleman Station were assumed to be zero.

Storage appropriations for Sutherland Reservoir specify the North Platte River, at the Keystone Canal diversion, as the source of supply. As was the case with Lake McConaughy storage, however, because unmet demands have already been calculated for those uses that rely on Sutherland Reservoir storage, and because seepage and evaporation losses have historically been “met,” the additional unmet demand for Sutherland Reservoir storage was assumed to be zero.

Several irrigation canals are located within the reach: Enterprise Canal, Central Canal, Chimney Rock Canal, Bridgeport Canal, Browns Creek Canal, Beerline Canal, and Lisco Canal. These canals all utilize storage to satisfy their demands fully. The unmet demand for these canals was determined based on the estimated storage used by these canals during varying hydrologic conditions.

In addition to determining the demands for the abovementioned canals, the demands for the canals that divert from the tributaries of Pumpkin Creek and Blue Creek were also determined. Figure 3-48 illustrates the demands for the irrigation canals on Pumpkin Creek. The historic demand was estimated at 7,700 acre-feet but current supply allows for 350 acre-feet of diversion. Thus the unmet demand was determined to be 7,350 acre-feet for the canals diverting from Pumpkin Creek.

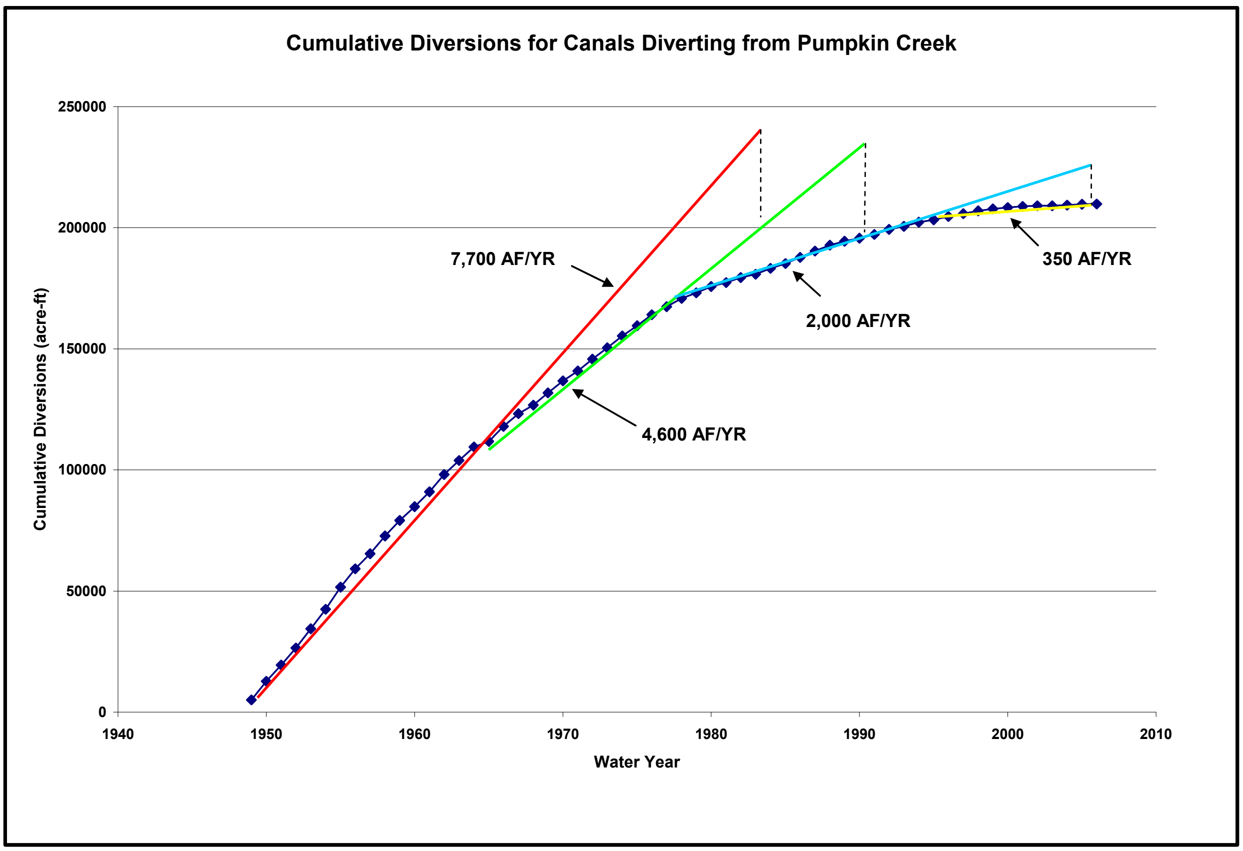


Figure 3-48. Cumulative diversions for canals diverting from Pumpkin Creek.

The canals that divert from Blue Creek were evaluated to determine if historic canal diversions have changed through time. The evaluation indicated no significant changes in current diversions from historic diversions. Therefore, no unmet demand was assumed to exist for those users. Table 3-43 summarizes the unmet demands for the irrigation canals evaluated in this reach.

Table 3-43. Unmet demands for irrigation canals in the state line to Lewellen reach.

Condition	Irrigation Season (ac-ft)	Non-Irrigation Season (ac-ft)
Wet	9,350	0
Normal	10,550	0
Dry	15,350	0

3.6.4 Accumulated Unmet Demands

The unmet demands from the downstream reaches are passed into this reach and added to the unmet demands in this reach to determine the cumulative unmet demands within the reach (tables 3-44 through 3-46).

Table 3-44. Unmet demands passed upstream from the Cozad to Odessa, North Platte to Cozad, South Platte, and North Platte below McConaughy reaches.

Condition	Irrigation Season (ac-ft)	Non-Irrigation Season (ac-ft)
Wet	220,500	0
Normal	429,500	240,000
Dry	587,000	440,000

Table 3-45. Unmet demands in the state line to Lewellen reach.

Condition	Irrigation Season (ac-ft)	Non-Irrigation Season (ac-ft)
Wet	9,350	0
Normal	10,550	0
Dry	15,350	0

Table 3-46. Cumulative unmet demands in the state line to Lewellen reach.

	Irrigation Season Ac-ft	**Non-Irrigation Season Ac-ft**
Wet	229,850	0
Normal	440,050	240,000
Dry	602,350	440,000

3.6.5 Overall Difference between Overappropriated and Fully Appropriated

The overall difference between overappropriated and fully appropriated is the intersection of the stream reach gain reduction (table 3-47) and the unmet demands for the state line to Lewellen reach (table 3-48). Although the difference between overappropriated and fully appropriated (table 3-49) was set to zero under wet conditions for other reaches downstream (i.e., Keystone to North Platte and Julesberg to North Platte), the difference was not set to zero for this reach since unmet demands for irrigation within the reach were identified for canals that do not have access to supplemental storage water. The unmet demands for these canals should be reassessed in the future.

Table 3-47. Stream reach gain reduction for the state line to Lewellen reach.

Condition	**Stream Reach Gain Reduction**	
	Irrigation Season (ac-ft)	**Non-Irrigation Season (ac-ft)**
Wet	7,900	63,000
Normal	7,900	63,000
Dry	7,900	63,000

Table 3-48. Unmet demands for the state line to Lewellen reach.

Condition	**Unmet Demands**	
	Irrigation Season (ac-ft)	**Non-Irrigation Season (ac-ft)**
Wet	229,850	0
Normal	440,050	240,000
Dry	602,350	440,000

Table 3-49. Overall difference between overappropriated and fully appropriated for the state line to Lewellen reach.

Condition	**OA/FA Difference**	
	Irrigation Season (ac-ft)	**Non-Irrigation Season (ac-ft)**
Wet	7,900	0
Normal	7,900	63,000
Dry	7,900	63,000

3.7 Lodgepole Creek

The Lodgepole Creek reach includes its entire contributing surface water basin upstream from the Nebraska–Colorado state line to the Nebraska–Wyoming state line. Available long-term records are very limited in the basin, so only a small portion of the basin (Bushnell to Ralton) was analyzed. Data used in the reach gain calculations included inflows from Lodgepole Creek at Bushnell and outflows to the eleven irrigation canals in the reach, as well as changes in storage to Oliver Reservoir, and Lodgepole Creek at Ralton. Because of the relatively short period of available data for the abovementioned gages (1955-1971), previously described analyses were not used for evaluating the changes in gains for Lodgepole Creek.

3.7.1 Assessment of Reach Gain Reductions

The streamflow reach gain reduction estimation was simplified by using our knowledge of the existing flows in the creek and assuming the present period gains to be zero. This assumption can be justified by comparing the Bushnell and Ralton annual streamflows for the period 2003 to 2006 (table 3-50).

Table 3-50. Recent streamflows at Bushnell and Ralton for Lodgepole Creek.

Year	**Lodgepole Creek at Bushnell Annual Flows, (ac-ft)**	**Lodgepole Creek at Ralton Annual Flows, (ac-ft)**
2003	350	0
2004	190	0
2005	80	No data published
2006	16	0

The historical gains for 1955-1971 were calculated using the gaged data available for the period. The gains range from 700 acre-feet in 1964 to over 14,000 acre-feet in 1959 as shown in table 3-51. The average gain for the analysis period is 7,500 acre-feet and the median gain is 6,900 acre-feet. For this analysis, the annual stream reach gain reduction was estimated at 7,500 acre-feet since this represented the average historical gain; as stated above, recent gains are assumed to be zero.

Table 3-51. Lodgepole Creek historical reach gains for the Bushnell to Ralton reach.

Year	**Stream Gain (ac-ft)**
1955	9,800
1956	4,100
1957	3,200
1958	13,700
1959	14,400
1960	5,700
1961	5,600
1962	7,600
1963	8,600
1964	700
1965	11,300
1966	8,800
1967	5,500
1968	12,300
1969	6,900
1970	4,800
1971	5,000

If the annual gain is assumed to occur at an equal rate through the year, 42% will occur during the irrigation season and 58% will occur during the non-irrigation season. By proportionally dividing the annual figure, 7,500 acre-feet into the respective seasons, the resulting reach gain reduction for the irrigation season is 3,150 acre-feet and the non-irrigation season reduction is 4,350 acre-feet.

3.7.2 Unmet Demands

Detailed records do not exist to allow the unmet demand for surface water irrigation to be calcualted in this reach for surface water irrigation using previously described methods. The 1955-1971 diversion records and gain calculations do show that the reach gain and the diversions are nearly equal in magnitude. Therefore, for this analysis, the reach gain was assumed to be equal to the unmet demand (table 3-52).

Table 3-52. Unmet demands for irrigation canals in the Lodgepole Creek reach.

Condition	Irrigation Season (ac-ft)	Non-Irrigation Season (ac-ft)
Wet	3,150	4,350
Normal	3,150	4,350
Dry	3,150	4,350

3.7.3 Accumulated Unmet Demands

Further analysis is warranted to assess the fate of flows that cross the state line into Colorado. In the absence of such an analysis, no unmet demand was assumed to be passed upstream into the Lodgepole Creek reach. Additionally, this reach is at the upstream end of the analysis, so no demand is passed upstream.

3.7.4 Overall Difference between Overappropriated and Fully Appropriated

Table 3-53. Stream reach gain reduction for Lodgepole Creek.

Condition	Stream Reach Gain Reduction	
	Irrigation Season (ac-ft)	Non-Irrigation Season (ac-ft)
Wet	3,150	4,350
Normal	3,150	4,350
Dry	3,150	4,350

Table 3-54. Unmet demands for Lodgepole Creek.

Condition	**Unmet Demands**	
	Irrigation Season (ac-ft)	**Non-Irrigation Season (ac-ft)**
Wet	3,150	4,350
Normal	3,150	4,350
Dry	3,150	4,350

Table 3-55. Overall difference between overappropriated and fully appropriated for Lodgepole Creek.

Condition	**OA/FA Difference**	
	Irrigation Season (ac-ft)	**Non-Irrigation Season (ac-ft)**
Wet	3,150	4,350
Normal	3,150	4,350
Dry	3,150	4,350

Based on current understanding and methodology, the Lodgepole Creek reach is not thought to have any impacts on downstream reaches. Consequently, the overall difference between overappropriated and fully appropriated may largely depend on the assessment of current unmet demands within the Lodgepole Creek reach.

4.0 ASSIGNMENT OF IMPACTS TO INDIVIDUAL NRDS

4.1 Methodology

The assessment of the difference between overappropriated and fully appropriated was completed on each of the reaches discussed in this report. Since the contributing surface water basins for the reaches used for the analysis do not coincide with the boundaries of the NRDs, through which the reaches pass, the overall OA/FA difference needed to be apportioned to each individual NRD. This apportionment was completed using the 2005 COHYST groundwater irrigated acres in each reach by NRD within the defined overappropriated basin. Table 4-1 illustrates the percentage of impacts that were assigned to each NRD.

Table 4-1. Percentage of reach impacts to be assigned to each NRD based on 2005 COHYST groundwater irrigated acres within the overappropriated basin.

Reach	SPNRD	TPNRD	CPNRD	TBNRD	NPNRD
Stateline - Lewellen	0.7%	0.0%	0%	0%	99.3%
Julesburg - North Platte	10.4%	89.6%	0%	0%	0%
Keystone - North Platte	0%	100%	0%	0.0%	0%
North Platte - Cozad	0%	58.5%	41.5%	0.0%	0%
Cozad - Odessa	0%	0%	45.9%	54.1%	0%
Lodgepole Creek	100%	0%	0%	0%	0%

4.2 North Platte NRD

The North Platte NRD (NPNRD) was assigned reach impacts only in the state line to Lewellen reach. The total difference between overappropriated and fully appropriated for this reach is listed in table 4-2.

Table 4-2. Overall difference between overappropriated and fully appropriated for the state line to Lewellen reach.

State Line to Lewellen Reach		
Condition	**Irrigation Season (ac-ft)**	**Non-Irrigation Season (ac-ft)**
Wet	7,900	0
Normal	7,900	63,000
Dry	7,900	63,000

NPNRD was assigned 99.3 percent of the total impacts, based on acres within the overappropriated basin. Table 4-3 summarizes the results from the analysis of the overall difference between overappropriated and fully appropriated for the NPNRD during the irrigation season, non-irrigation season, and annually.

Table 4-3. Overall difference between overappropriated and fully appropriated for the NPNRD for the irrigation season, the non-irrigation season, and annually.

NPNRD			
Condition	**Irrigation Season (ac-ft)**	**Non-Irrigation Season (ac-ft)**	**Total Annual (ac-ft)**
Wet	7,850	0	7,850
Normal	7,850	62,575	70,425
Dry	7,850	62,575	70,425

4.3 South Platte NRD

For the purposes of this analysis, the South Platte NRD (SPNRD) was assigned reach impacts in the state line to Lewellen reach, Julesburg to North Platte reach, and Lodgepole Creek. The total difference between overappropriated and fully appropriated for these two reaches and Lodgepole Creek is listed in tables 4-4, 4-5, and 4-6.

Table 4-4. Overall difference between overappropriated and fully appropriated for the state line to Lewellen reach.

State Line to Lewellen Reach		
Condition	**Irrigation Season (ac-ft)**	**Non-Irrigation Season (ac-ft)**
Wet	7,900	0
Normal	7,900	63,000
Dry	7,900	63,000

Table 4-5. Overall difference between overappropriated and fully appropriated for the Julesburg to North Platte reach.

Julesburg to North Platte Reach		
Condition	**Irrigation Season (ac-ft)**	**Non-Irrigation Season (ac-ft)**
Wet	0	0
Normal	6,400	-1,500
Dry	6,400	-1,500

Table 4-6. Overall difference between overappropriated and fully appropriated for Lodgepole Creek.

Lodgepole Creek		
Condition	**Irrigation Season (ac-ft)**	**Non-Irrigation Season (ac-ft)**
Wet	3,150	4,350
Normal	3,150	4,350
Dry	3,150	4,350

SPNRD was assigned 0.7 percent of the total impacts in the state line to Lewellen reach based on acres within the overappropriated basin. SPNRD was assigned 10.4 percent of the total impacts in the Julesburg to North Platte reach and 100 percent of the difference between overappropriated and fully appropriated for Lodgepole Creek. Tables 4-7 through 4-9 list the results from the analysis of the overall difference between overappropriated and fully appropriated for the South Platte NRD during the irrigation season, the non-irrigation season, and annually for the three reaches for which impacts were assigned to SPNRD.

Table 4-7. Overall difference between overappropriated and fully appropriated for the SPNRD for the irrigation season, the non-irrigation season, and annually for the state line to Lewellen reach.

SPNRD			
Condition	**Irrigation Season (ac-ft)**	**Non-Irrigation Season (ac-ft)**	**Total Annual (ac-ft)**
Wet	50	0	50
Normal	50	425	475
Dry	50	425	475

Table 4-8. Overall difference between overappropriated and fully appropriated for the SPNRD for the irrigation season, the non-irrigation season, and annually for the Julesburg to North Platte reach.

SPNRD			
Condition	**Irrigation Season (ac-ft)**	**Non-Irrigation Season (ac-ft)**	**Total Annual (ac-ft)**
Wet	0	0	0
Normal	650	-150	500
Dry	650	-150	500

Table 4-9. Overall difference between overappropriated and fully appropriated for the SPNRD for the irrigation season, the non-irrigation season, and annually for Lodgepole Creek.

SPNRD			
Condition	**Irrigation Season (ac-ft)**	**Non-Irrigation Season (ac-ft)**	**Total Annual (ac-ft)**
Wet	3,150	4,350	7,500
Normal	3,150	4,350	7,500
Dry	3,150	4,350	7,500

4.4 Twin Platte NRD

For purposes of this analysis, the Twin Platte NRD (TPNRD) was assigned reach impacts in the Keystone to North Platte reach, the Julesburg to North Platte reach, and the North Platte to

Cozad reach. The total difference between overappropriated and fully appropriated for these three reaches is listed in tables 4-10 through 4-12.

Table 4-10. Overall difference between overappropriated and fully appropriated for the Keystone to North Platte reach.

Keystone to North Platte Reach		
Condition	**Irrigation Season (ac-ft)**	**Non-Irrigation Season (ac-ft)**
Wet	0	0
Normal	26,000	23,000
Dry	26,000	23,000

Table 4-11. Overall difference between overappropriated and fully appropriated for the Julesburg to North Platte reach.

Julesburg to North Platte Reach		
Condition	**Irrigation Season (ac-ft)**	**Non-Irrigation Season (ac-ft)**
Wet	0	0
Normal	6,400	-1,500
Dry	6,400	-1,500

Table 4-12. Overall difference between overappropriated and fully appropriated for the North Platte to Cozad reach.

North Platte to Cozad Reach		
Condition	**Irrigation Season (ac-ft)**	**Non-Irrigation (ac-ft)**
Wet	0	0
Normal	0	0
Dry	14,900	8,900

TPNRD was assigned 100 percent of the total impacts in the Keystone to North Platte reach, 89.6 percent of the total impacts in the Julesburg to North Platte reach, and 58.5 percent of the total impacts in the North Platte to Cozad reach. Tables 4-13 through 4-15 list the results from the analysis of the overall difference between overappropriated and fully appropriated for the Twin Platte NRD during the irrigation season, non-irrigation season, and annually for the three reaches for which impacts were assigned to TPNRD.

Table 4-13. Overall difference between overappropriated and fully appropriated for the TPNRD for the irrigation season, the non-irrigation season, and annually for the Keystone to North Platte reach.

TPNRD			
Condition	**Irrigation Season (ac-ft)**	**Non-Irrigation Season (ac-ft)**	**Total Annual (ac-ft)**
Wet	0	0	0
Normal	26,000	23,000	49,000
Dry	26,000	23,000	49,000

Table 4-14. Overall difference between overappropriated and fully appropriated for the TPNRD for the irrigation season, the non-irrigation season, and annually for the Julesburg to North Platte reach.

TPNRD			
Condition	**Irrigation Season (ac-ft)**	**Non-Irrigation Season (ac-ft)**	**Total Annual (ac-ft)**
Wet	0	0	0
Normal	5,750	-1,350	4,400
Dry	5,750	-1,350	4,400

Table 4-15. Overall difference between overappropriated and fully appropriated for the TPNRD for the irrigation season, the non-irrigation season, and annually for the North Platte to Cozad reach.

TPNRD			
Condition	**Irrigation Season (ac-ft)**	**Non-Irrigation Season (ac-ft)**	**Total Annual (ac-ft)**
Wet	0	0	0
Normal	0	0	0
Dry	8,700	5,200	13,900

4.5 Central Platte NRD

For purposes of this analysis, the Central Platte NRD (CPNRD) was assigned reach impacts in the North Platte to Cozad reach and the Cozad to Odessa reach. The total difference between overappropriated and fully appropriated for these two reaches is listed in tables 4-16 and 4-17.

Table 4-16. Overall difference between overappropriated and fully appropriated for the North Platte to Cozad reach.

North Platte to Cozad Reach		
Condition	**Irrigation Season (ac-ft)**	**Non-Irrigation Season (ac-ft)**
Wet	0	0
Normal	0	0
Dry	14,900	8,900

Table 4-17. Overall difference between overappropriated and fully appropriated for the Cozad to Odessa reach.

Cozad to Odessa Reach		
Condition	**Irrigation Season (ac-ft)**	**Non-Irrigation Season (ac-ft)**
Wet	0	0
Normal	0	0
Dry	6,500	10,600

The CPNRD was assigned 41.5 percent of the total impacts in the North Platte to Cozad reach and 45.9 percent of the total impacts in the Cozad to Odessa reach. Tables 4-18 and 4-19 list the results from the analysis of the overall difference between overappropriated and fully appropriated for the Central Platte NRD during the irrigation season, non-irrigation season, and annually for the two reaches for which impacts were assigned to CPNRD.

Table 4-18. Overall difference between overappropriated and fully appropriated for the CPNRD for the irrigation season, the non-irrigation season, and annually for the North Platte to Cozad reach.

CPNRD			
Condition	**Irrigation Season (ac-ft)**	**Non-Irrigation Season (ac-ft)**	**Total Annual (ac-ft)**
Wet	0	0	0
Normal	0	0	0
Dry	6,200	3,700	9,900

Table 4-19. Overall difference between overappropriated and fully appropriated for the CPNRD for the irrigation season, the non-irrigation season, and annually for the Cozad to Odessa reach.

CPNRD			
Condition	**Irrigation Season (ac-ft)**	**Non-Irrigation Season (ac-ft)**	**Total Annual (ac-ft)**
Wet	0	0	0
Normal	0	0	0
Dry	3,000	4,850	7,850

4.6 Tri-Basin NRD

For purposes of this analysis, the Tri-Basin NRD (TBNRD) was assigned impacts only included in the Cozad to Odessa reach. The total difference between overappropriated and fully appropriated for this reach is listed in table 4-20.

Table 4-20. Overall difference between overappropriated and fully appropriated for the Cozad to Odessa reach.

Cozad to Odessa Reach		
Condition	**Irrigated Season (ac-ft)**	**Non-Irrigated Season (ac-ft)**
Wet	0	0
Normal	0	0
Dry	6,500	10,600

TBNRD was assigned 54.1 percent of the total impacts for the Cozad to Odessa reach. Table 4-21 lists the results from the analysis of the overall difference between overappropriated and fully appropriated for the TBNRD during the irrigation season, the non-irrigation season, and annually.

Table 4-21. Overall difference between overappropriated and fully appropriated for the TBNRD for the irrigation season, the non-irrigation season, and annually.

TBNRD			
Condition	**Irrigation Season (ac-ft)**	**Non-Irrigation Season (ac-ft)**	**Total Annual (ac-ft)**
Wet	0	0	0
Normal	0	0	0
Dry	3,500	5,750	9,250

5.0 LIMITATIONS AND FUTURE WORK

5.1 Limitations and Assumptions

The methodology used is this report focused on identification of overall changes in reach gains for the five reaches and Lodgepole Creek. With the exception of corrections for reduced canal deliveries, this methodology did not seek to specifically identify the causes for the reduction in reach gains. This limitation will need to be addressed when more refined estimates are calculated in the future. The method also attempted to indentify when changes in reach gains would have a potential impact on existing users dependent on those gains to meet their natural flow appropriations or to provide recharge for existing wells. These potential impacts were indentified under three hydrologic conditions (i.e., wet, normal, and dry). A more rigorous analysis should be conducted in the future to further refine hydrologic conditions and the estimates related to potential shortages.

Reach selection was driven in part by the need to be able to discern differences in data within a river reach, which tends to require that reaches be larger in size. Many of these reaches are composed of separate subreaches or tributary streams for which the actual flow changes may vary greatly from one to the other. As a consequence, it is possible that changes in one subreach or tributary are being masked by other changes in another subreach or tributary of the same overall reach. It is also possible that impacts on individual tributaries would be more easily determined if tributaries were analyzed separately. The ability to more easily discern changes in the smaller flows of the tributary are not adequately captured by the river reach analysis because the changes in tributary flow, though real, are simply not discernable within the total mainstem flow. Additional work or alternative methodologies may be needed to discern changes at smaller scales and different locations than those used in this analysis.

Several assumptions were utilized for simplicity when identifying potential shortages to surface water appropriations. Due to the non-consumptive nature of the Tri-County Canal power diversions, the unmet demands associated with the Tri-County Canal were used to represent the potential shortage of the Sutherland System, including the North Platte Hydro (non-consumptive), and Gerald Gentlemen Station, instream flows upstream of the Tri-County County diversion (non-consumptive), and storage water shortages in Lake McConaughy. Additionally, these analyses assumed that if all other demands that rely on Lake McConaughy for supplemental storage are met, then Kingsley Hydro demand is met as well.

Shortages to surface water appropriations for irrigation were assessed through evaluation of historical Platte Water Accounting Program (PWAP) data maintained by NDNR. Shortages were estimated by averaging the storage water usage through the various hydrologic conditions for those districts to which storage water was available. The canals that divert from Blue Creek were evaluated to determine if historic canal diversions have changed through time. The evaluation indicated no significant changes in current diversions from historic diversions. Therefore, no unmet demand was assumed to exist for those users.

The instream flow appropriations were evaluated for shortage through evaluation of daily shortages to the appropriation located at Overton. It is not clear at the time of publication of this report if the instream flow appropriations should be evaluated based on daily shortages (as done for this report) or through evaluation of the frequency at which flows occur. Additionally, instream flows are much more junior than other appropriations evaluated in this report and interpretation of statutes may be required to further assess what, if any, shortages exist for these appropriations. If shortages are not determined to exist for the instream flow appropriations then the assumption that the Kearney Canal appropriation is satisfied may need to be further evaluated.

The Environmental Account is a storage-use appropriation that provides storage water from Lake McConaughy for instream use for fish and wildlife. Though the end use is intended for downstream reaches, the amount of water available for use is calculated based upon storable inflows to Lake McConaughy at Lewellen. The “demand” for the Environmental Account is an amount derived through a complex set of calculations. It is assumed for purposes of this report that no unmet demand exists for the Environmental Account since depletions resulting from development subsequent to 1997 will be offset through the integrated management planning process.

The total demand for water to be stored in Lake McConaughy includes the amount needed to supplement downstream demands, as well as the amount needed to maintain evaporation and seepage losses from the reservoir. Because the unmet demands for the downstream uses that rely on Lake McConaughy as a supplemental source have already been calculated, additional unmet demand for storage for those purposes was assumed to be zero. Additionally, because seepage and evaporation losses from the reservoir are uncontrolled and have historically been “met” under all conditions, additional unmet demand for storage for those purposes was also assumed to be zero.

Gerald Gentleman Station cooling water takes advantage of other water moving through the Sutherland system that is returned to the river just upstream of the Tri-County diversion. Therefore, additional unmet demand for Gerald Gentleman Station cooling was assumed to be zero.

Canaday Steam Plant draws cooling water year-round from the CNPPID Supply Canal just upstream from the J-2 Return. Cooling for Canaday Steam Plant is mostly non-consumptive and was designed to take advantage of water that is already in the CNPPID Canal for other purposes. Demand for Canaday Steam Plant cooling was assumed to be met if other CNPPID hydropower and irrigation demands are met, and the additional unmet demand for Canaday Steam Plant cooling is therefore assumed to be zero.

The need for recharge from the Platte River for the maintenance of existing wells was also considered. Although no actual shortage of water for wells has been demonstrated, some water quality issues with the Grand Island municipal wellfield have been measured when the river goes completely dry. Because the amount of streamflow that would be necessary to keep the river from going completely dry is believed to be substantially less than the flow required for the instream flow appropriations, and because the same water in the stream can serve both purposes, the unmet demand for recharge for wells was assumed to be zero.

5.2 Future Work

As discussed in section 5.1 (above), future work will need to focus on identification of causes for reduction in reach gains. This future work should include: 1) evaluation of historical groundwater well depletions; 2) evaluation of the impact of conservation practices; 3) evaluation of changes in historical diversions and the potential reduction in return flows; 4) evaluation of the impacts of riparian vegetation; and 5) improvements to or replacements of the methodologies used to estimate changes in flow, unmet demands, or the intersection of changes with unmet demands, including refinements in reaches and locations for analysis, greater consideration of consequences of variable hydrologic conditions, and use of other analytical tools or numerical models as appropriate.

In addition to the technical limitations and future work described above, there are certain policy/statute-related issues that need to be considered. These issues include: 1) when shortages are identified, how these shortages should be distributed (i.e., only within the natural resources district where the appropriation is located, all natural resources districts upstream of the appropriation, etc.); 2) how should instream flow appropriations be evaluated; 3) what is the acceptable level of depletion to streamflow from groundwater uses permitted prior to July 1, 1997; 4) evaluation of the socioeconomic implications of shortages to existing permit or appropriation holders; and 5) what is the role of PRRIP projects or retirements.

E

Appendix E

CONSERVATION MEASURES STUDY PHASE I

8200 Cody Drive
Suite A
Lincoln, Nebraska 68512-9550

Phone: 402.435.5441
Fax: 402.435.7108

MEMORANDUM

To: **Platte Basin Coalition**

From: **The Flatwater Group, Inc.**

Date: **23 December 2013**

Re: **Final Technical Memorandum on Conservation Study**

The purpose of this technical memorandum is to describe the results of the review and inventory completed for this effort, including a matrix describing the availability of data and its usefulness in achieving the project purpose, a description of three potential methods for implementing an approach to assess the effects of conservation measures that can be utilized to develop a Scope of Work for Phase II, and a cost estimate for each method.

I. Proposed Definition of Conservation Measures

The proposed definition for "conservation measures" is included below. This definition was developed with input and feedback from a number of sources, including Coalition members, but relied primarily on research done on existing State Statute related to the term or similar terms. As has been discussed elsewhere, the terms "conservation measures", "conservation practices" and "conservation activities" are all used within the text of the Groundwater Management and Protection Act – arguably interchangeably. Since the primary statute language of interest for this project uses the term "conservation measures", it is that term which has been adopted, for the most part, in this effort. In some cases, the term "conservation practices" may have been used, in which case the term should be considered synonymous with "conservation measures":

Conservation measures*, for the purposes of Neb. Rev. Stat. §46-715(5)(c), shall mean practices designed to control or prevent soil erosion, enhance the beneficial use of precipitation and irrigation water, or reduce non-beneficial water consumption.*

II. Other Definitions

Several other terms have been used in this effort which will be defined here to help establish a consistent "language" and hopefully avoid confusion over terminology.

A. Techniques – for each of the identified conservation measures, the matrix includes at least one "technique" to develop estimates of recharge, runoff, and/or ET. These techniques may include simple equations or algorithms found in textbooks or research papers, complex computer models, physical site sampling procedures, or other processes used to develop these estimates.

B. Methods – the Coalition itself used the term “methods” within its Scope of Work RFP for Phase I tasks. Three methods are identified in this effort as potential ways to derive estimates, for all conservation measures throughout the entire study area, of changes to recharge, runoff, and ET. Methods are made up of a suite of “techniques” to address the entire list of identified conservation measures.
C. Matrix – the “Matrix on Quantification of Conservation Impacts to Streamflow”, developed by the project team to fulfill the requirement in the Scope of Work directing the team to “include a matrix describing the availability of data and its usefulness in achieving the project purpose”. The Matrix includes a list of all conservation measures considered, and preliminary estimates as to the availability of data on the respective measures and the potential magnitude of impact to streamflow created by each measure.
D. Base Conditions – the Matrix includes estimates of the impact to recharge, runoff, and ET, using the qualitative terms of “increase”, “decrease”, “no change”, or “not applicable”. In order to make these estimates, “base conditions” had to be established for each conservation measure listed. For instance, in making an estimate of changes to runoff resulting from conversion to surge irrigation, the base conditions used to estimate these changes were established as furrow irrigation with gated pipe.
E. Evapotranspiration (ET) – the conversion of liquid water into vapor which leaves the watershed through evaporation from the soil, plants, or free-water surfaces, or through transpiration through plants.
F. Recharge – the movement of water from the surface to ground water, through the vadose zone.
G. Overland Runoff – the movement of water over the surface as a result of excess precipitation, irrigation, meltwater, or other surface water sources. This may include return flow.
H. Return Flow – the portion of diverted surface water returning to the stream, which is a component of overland runoff.

III. Magnitude of Impact and Frames of Reference

In order to make estimates of the assumed basin-wide[1] magnitude of impact associated with the various conservation measures, it is important to define and explain the time frames that are important for this particular study.

The language that governs the study of the impacts of conservation measures is contained within State Statute, in Neb. Rev. Stat. §46-715(5)(c):

> *Any integrated management plan developed under this subsection shall identify the overall difference between the current and fully appropriated levels of development. Such determination shall take into account cyclical supply, including drought, identify the portion of the overall difference between the current and fully appropriated levels of development that is due to conservation measures…*

[1] Basin-wide impact in the context of this review includes consideration of the total number of conservation measures installed across the entire basin, meaning the cumulative effect for each conservation measure, rather than a comparison of conservation measures on a per acre basis.

In addition, the definition in Neb. Rev. Stat. §46-706(27) provides additional guidance in terms of how conservation measures factor into the difference between the two levels of development:

> *Overall difference between the current and fully appropriated levels of development means the extent to which existing uses of hydrologically connected surface water and ground water and conservation activities result in the water supply available for purposes identified in subsection (3) of section 46-713 to be less than the water supply available if the river basin, subbasin, or reach had been determined to be fully appropriated in accordance with section 46-714;*

Using this language as a basis, Figure 1 shows a simplified representation of a hypothetical comparison of water supplies against the combined impacts from water uses and conservation measures. As shown, this graphic assumes that the supply remains constant between the period when the basin become fully appropriated and the current overappropriated time period. In this example, both the water uses and the impacts from conservation measures – which are assumed to have negative impacts to streamflow in this example – grow between fully appropriated to overappropriated conditions. The statutory language appears to call for the determination of the difference in the impacts from conservation measures between these two points in time, as indicated by the green double-arrow in Figure 1.

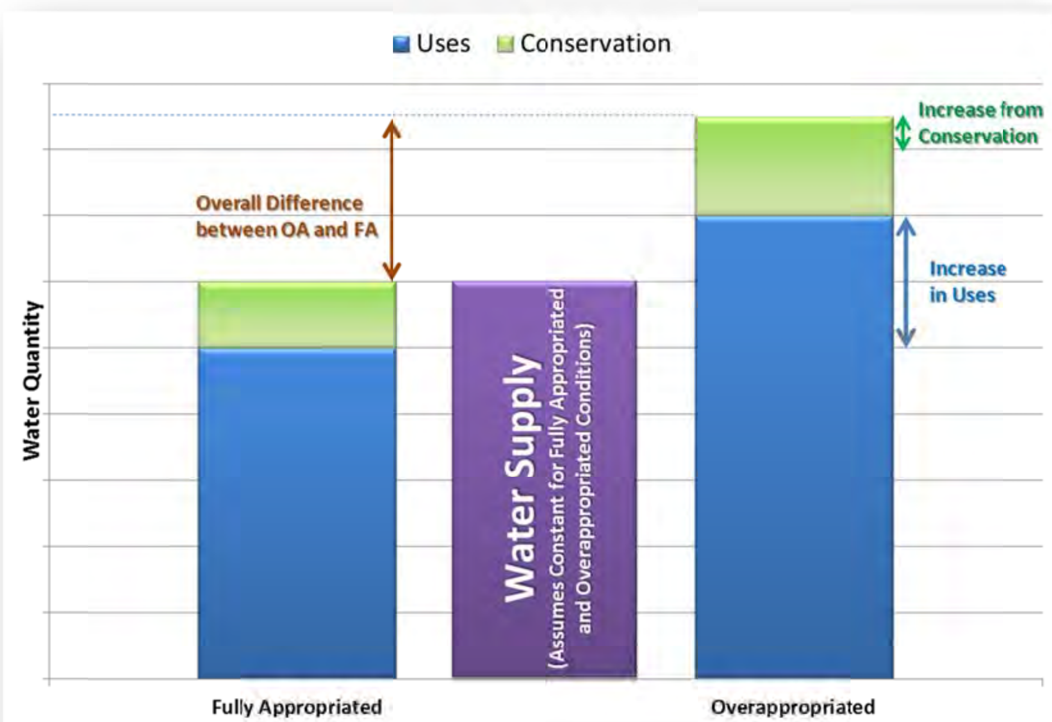


Figure 1: Water Uses, Supplies, and Conservation Impacts

To illustrate this relationship, we can consider a simplified example of conservation measures in the basin. Assume that only one single conservation measure is in place in the basin: Measure A. We can also assume for this simple example that water uses increased by 20 acre-feet per year between the time at which the basin became fully appropriated and the current date. If we assume that Measure A was put into place before the point in time when the basin became fully appropriated, we can estimate the impact that the measure had on streamflow by considering the difference in streamflow between base conditions and conditions with Measure A in place. For example, we might estimate that under base conditions, without Measure A, we might have seen a streamflow of 100 acre-feet per year, whereas with Measure A in place, we actually saw only 90 acre-feet per year as of the point in time when the basin became fully appropriated. As a result, we would estimate that Measure A had a negative impact to streamflow of approximately 10 acre-feet per year at the time the basin became fully appropriated.

As the next step, we could estimate the impact to streamflow from Measure A as of the present time, using the same overall methodology. If estimated streamflow for the current time period would have been 80 acre-feet per year without Measure A, and only 65 acre-feet per year with Measure A, we would estimate a current level of negative impact from Measure A of 15 acre-feet per year.

Finally, we could estimate the change in conservation impacts between the fully appropriated and current overappropriated periods, which would simply be the difference between the 10 acre-feet per year and 15 acre-feet per year, which is 5 acre-feet per year of additional negative impacts to streamflow. It's this 5 acre-feet per year of additional impacts to streamflow that could be used to quantify the portion of the difference between the current and fully appropriated levels of development associated with conservation measures, as shown in Figure 1 with the double-arrow labeled "Increase from Conservation". Water managers may also be interested in the overall impact to streamflow of conservation measures as of the current time, which would in this example be the entire 15 acre-feet per year quantity.

It's important to note that while the example described above would indicate a negative impact to streamflow, some conservation measures could show a positive impact. For example, deficit irrigation is a conservation measure that could result in increases to streamflow as a result of lower levels of ET. It's also possible that these positive impacts to streamflow could grow over time – including between the time that the basin became fully appropriated and the present – which could result in a decrease in negative impacts from those particular conservation measures (note that the impacts shown in the figure represent negative impacts to streamflow).

In all cases, it will be important to determine the date at which the various conservation measures were initiated, both for the time period prior to the point of fully appropriated conditions[2] and up to the current time. This is similar to the way in

[2] The year 1984 was assumed to be the date when the basin became Fully Appropriated for purposes of completing this review.

which depletions to streamflow are assessed for groundwater wells – the addition of new wells must be tracked over time, and the level of depletion caused by each well must also be tracked over the lifetime of pumping and beyond due to the continuing lag effects.

IV. Literature Review Summary

The project team examined a variety of sources for its literature review, including publications from the University of Nebraska's School of Natural Resources, handbooks from state and federal resources agencies, relevant textbooks, phone conversations with representatives of irrigation manufacturing companies, other texts recommended by the University faculty on our team, and general internet searches. An attempt was made to find materials that were relevant to conditions throughout the study area, with an understanding that the geographic extent of the study area prevents using a "one size fits all" approach in terms of assessing the impacts of conservation measures. In some cases, literature was found that was specific to a particular portion of Nebraska. However, in many cases, the literature pertained to areas entirely outside of Nebraska. Because of these facts, it will be crucial for future efforts that any techniques for estimating impacts from conservation measures identified in this literature review be adjusted, or replaced altogether, to ensure accurate representation of the unique conditions in different portions of the study area.

The remainder of this section will involve briefly highlighting some of the primary sources identified in the literature review for the major categories of conservation measures. A more complete listing of the literature review sources can be found as a separate tab of the "matrix" spreadsheet. The citations listed in this section apply to the abbreviated codes used in that listing.

<u>Structural Conservation Measures</u>

1. Conservation terraces – journal articles on conservation terrace system hydrology were reviewed. Impacts to runoff, recharge and ET were evaluated on a field scale (L3, L32), small watershed (L20), and basin scale (L21, L32). Impact estimates from these studies could be applicable to the Platte River watershed for basins with similar characteristics. Hydrologic models have been found effective in modeling terrace systems including the Water Erosion Prediction Project (WEPP) (L2, L20), Root Zone Water Quality Model (RZWQM) (L2), the Hydrologic Modeling System (HEC-HMS) (L4), and Analytical Surface Water and Groundwater Modeling (L21). General area and spatial location of terraced land can be obtained as available from the U.S. Bureau of Reclamation and USDA-NRCS; however, field locations and characteristics of terraces across the basin will require surveys and perhaps digitization of terraced fields.
2. Non-jurisdictional/non-permitted small dams – this conservation measure category includes structures that are not included in Nebraska DNR's dam database, and therefore the National Hydrography Dataset from USGS (L24) would be used as a GIS resource to catalog small impoundments in the basin. Based on areas of small impoundments, location in the watershed, and other spatial data (soils, precipitation, etc.), the calculations from L2, L25, and L83 could be applied to quantify impact on streamflow from small dams. Location

and surface area of typical reservoirs could be determined from digitization of aerial photographs.

3. Jurisdictional/permitted dams – for this constructed conservation measure, a publication (L25) from the Journal of Soil and Water Conservation was reviewed that quantified groundwater recharge from seepage from flood reservoirs. The study goal was to determine the potential for increasing groundwater recharge. Average seepage rates for two reservoirs were measured to be 0.50 and 0.59 inch/day at the Clay and York County sites respectively. These calculations could be applied on a larger basin scale by considering the specific conditions at the sites and by utilizing GIS inventories of dams in the basin.
4. Canal rehabilitation – for this practice, research was conducted with the use of electrical resistivity to quantify seepage losses in unlined irrigation canals for a test reach of 100 feet (L11). This technique could be applied on a larger scale to quantify the impact on streamflow after canal rehabilitation. Nebraska DNR conducted a demonstration project (L13) with Nebraska irrigation districts to estimate canal seepage in the Platte Basin. The results of that study could be applied in this study. Canal seepage estimates can be calculated based on the findings of the demonstration project. The USDOI-USBR and irrigation districts often maintain records of the amount of water diverted from streams or reservoirs, and the average amount of water delivered to farms. These data provide an overall water conveyance efficiency. The USDOI-USBR also administers a WaterSMART program (L12) on a national level that includes reporting on canal seepage and conversion to buried pipeline.
5. Conversion from open laterals and canals to pipelines – for this measure, CNPPID has studied (L14) and analyzed the conversion to buried pipeline as an improved measure of efficiency for water conveyance. These improvements have an effect on streamflow in regard to impacts to canal return flows and changes in seepage. CNPPID estimates a reduction in transportation loses (due to seepage and evaporation) by 45-50% based on their research and study of irrigation canals in the Central Platte Region.
6. Irrigation runoff recovery systems or return-flow facilities – this conservation measure was described in Nebraska as part of a study in the Republican River basin by the Lower Republican NRD (L48) that successfully used soil moisture sensors for water conservation of irrigation water. The program provided soil moisture sensors to farmers to monitor soil moisture in fields with a goal of reducing irrigation volumes and improving timing and efficiency of irrigation application.

<u>Non-Structural Conservation Measures</u>

1. Changes in tillage practices – journal articles focusing on tillage practices were reviewed (L37, L53) along with University of Nebraska-Lincoln CropWatch publications (L52, L54) and USDA FSA data and statistics (L45, L46). Steady ponded infiltration rates from L53 and soil permeability and runoff potential rates from L54 for different tillage systems could be used to estimate effects at the field level water balance. Farm Service Agency (FSA) data on the approximate locations of different practices would require FOIA procedures. The Conservation Technology Information Center (http://www.ctic.purdue.edu/) maintains a database of conservation practices and related conservation

resources including web sites, documents, and research results. These data usually include county-level estimates of the adoption of various conservation treatments over time. These data will provide a resource to assess tillage changes.

2. Changes in irrigation management – for irrigation scheduling, while information on the general process is fairly easy to find, information relevant to its impact on recharge, runoff, and ET is not. A 2005 NebGuide (L75) was reviewed which looks at the use of atmometers to schedule irrigation for crops, including corn and soybeans. This document, and others like it (L77, L78), present how scheduling can be accomplished to optimize the fulfillment of ET requirements for the crop. For deficit irrigation, several sources were found that discuss impacts to yield and ET for crops in west-central Nebraska, including corn and soybeans (L76, L79, L80). These studies were focused in the North Platte and Curtis areas, but provided information on ET responses that could be used elsewhere as well. The Water Optimizer program was developed to evaluate irrigation management options for deficit irrigation and provide estimates of the net return expected from deficit irrigation. Irrigation practices considered for these studies included center pivot irrigation and subsurface drip. Additional information on irrigation management was found concerning reductions in irrigation supplies, which could be used to help determine impacts from conversion of irrigated lands to dryland crops or rangeland (L84).
3. Improvements in irrigation efficiency – for these practices, the University of Nebraska has several publications, including NebGuides and Extension Circulars, which are useful in providing estimates of application efficiencies for a given practice (L16, L17). These water application efficiencies are generally given in terms of percentage values, and are defined as "the fraction of the total volume of water delivered to the farm or field to that which is stored in the root zone to meet the crop evapotranspiration needs". While these application efficiencies do not translate directly to estimates of runoff or recharge, they provide an estimate for an important component of the water balance at the field level. For surge irrigation, one study of note was conducted from 1990 to 1993 by researchers at Colorado State (L62), which included estimates of reductions in deep percolation associated with surge technology. For variable rate irrigation with center pivots, most of the major irrigation manufacturing companies were contacted directly by phone to inquire as to estimated impacts, but only limited information was obtained as a result (L63, L64, L65) – probably due in part to the relative infancy of this particular technology. The Farm Irrigation Rating Index (http://www.wcc.nrcs.usda.gov/ftpref/wntsc/Irrigation/FIRI/FiriMan.pdf) is a program developed by the USDA-NRCS to evaluate the impacts of irrigation management changes on the irrigation efficiency. This program can provide a framework for integration of expected outcomes.
4. Changes in crop rotation pattern/mixes – for conservation measures involving the conversion of irrigated continuous corn to alternative irrigated crops in rotation with corn, there is literature that considers the change in ET resulting from the altered crop rotations (L66 for example). For dryland crops, there is also documentation on impacts on ET resulting from various crop rotations (L81). For the four conversion practices involving CRP or CREP lands, journal articles dealing with Conservation Reserve Program (CRP) lands were reviewed (L59,

L60, L61). L60 has runoff, recharge, and ET variable mean annual measurements for lands under crop production and lands under CRP by region. Farm Service Agency (FSA) data could potentially be used to spatially locate CRP lands and how they change over time (L45, L36).

5. Changes in crop production intensity – several sources were located that describe the processes and impacts from changing crop production intensities (L85, L86, L87, L88, L89). These include looking at higher plant populations, narrower row spacing, and skip-row planting. The findings in these references and studies often included descriptions of the impact to ET resulting from these changes in intensity.
6. Implementation of soil moisture sensors – for soil moisture sensors, a significant amount of literature is available describing the basic operation and management techniques concerning the practice (L47, L92). Sensors have been adopted in some portions of Nebraska, and certain NRDs have provided cost-share opportunities for producers to help pay for their installation (L48). Specific information on the level of impacts to recharge, runoff, and ET, however, is more difficult to locate.
7. Changes in rangeland management – journal articles focusing on rangeland management impacts were reviewed (L55, L56, L57). These articles list infiltration rates for different grazing intensities. These infiltration rates can be used at the field level in water balance calculations. The National Resources Inventory website (L58) has GIS data on topics ranging from rangeland health to rangeland locations to soils and plant species. The GIS data may be helpful in determining rangeland locations relative to streams and may be used in translating field level impacts to streams.
8. Application of buffers – Journal articles on conservation buffer hydrology were reviewed. Research has been conducted on the ability to model hydrology and trapping efficiency of overland runoff with the Vegetative Filter Strips Modelling System (VFSMOD) (L29, L30). Trapping efficiencies have been estimated on a field (L29, L31) and small watershed (L5) scale. Impacts to ET from conversion of cropland in riparian zones to grass and forest buffer have been estimated for climate regions across Nebraska (L30, L82). Area and spatial location of conservation buffers can be obtained as available from the USDA-NRCS.
9. Management of phreatophytes/invasive vegetation – a journal article on case studies in Kansas in the Arkansas and Cimarron River basins was reviewed. In the article (L90), the White method (White 1932) utilized specific yield of an alluvial aquifer and the difference in net change of water level in monitoring wells in areas without vegetation control and areas with vegetation control on a daily time step to quantify impact of phreatophyte on groundwater ET. An additional study in the Platte and Republican River basins provided the observed impacts on invasive species removal on ET (L91). Specifically, a portion of the study calculated potential water savings from invasive species removal along riparian corridors using direct observations and an ecosystem/land surface model.

V. Geographic Uniqueness

No two parts of the State, or two areas within the study area, are the same, and each location has its own unique attributes with respect to climate, soil types, tillage practices, cropping techniques, terrain, groundwater and surface water availability and use, institutional frameworks, and other features. It will be crucial during any future phase of this effort that this recognition of "geographic uniqueness" be incorporated into all techniques used to derive estimates of impacts due to conservation measures. While an attempt was made within the Matrix to acknowledge this fact, and to include elements that reflect more than one area within the study area, it is not possible within a simple summary table of this sort to include all the potential combinations and permutations necessary to represent the full range of possibilities. However, future estimates will require various techniques that are tailored for the different regions instead of using a "one size fits all" approach.

These issues of geographic uniqueness will be important not only in making estimates of the changes to runoff, recharge, and ET on a field-level basis, but also in terms of how these field-level impacts are translated to impacts to streamflow. As will be discussed later in this memorandum, this process of translation must consider the geographic location of where the conservation measures are in place, as well as the region between those locations and the stream or tributary. The use of GIS coverages that include geographically indexed parameters would likely greatly facilitate this process, as would local knowledge and understanding of the particular region of interest.

As mentioned above, groundwater and surface water resources, in terms of availability and use, vary across the study area. The source of irrigation supplies is important in determining the timing and magnitude of any changes due to conservation measures. These effects are complex, but still require careful consideration in developing estimates of the impacts from conservation measures. One example is within the western portion of the study area, where extensive conversion has taken place from furrow irrigation using surface water to center pivots using either surface or groundwater. The timing of impacts to streamflow, the changes to surface water return flows that used to serve as a supply for downstream irrigators, and potential increases in overall ET resulting from better distribution of irrigation supplies to the crop, all could have significant impacts to the overall water balance. As a result, these aspects would also need to be considered in any future estimates of impacts to streamflow from conservation measures.

VI. Translations of Impacts to the Stream

As has been mentioned elsewhere, the focus of Phase I efforts involved identifying techniques capable of estimating changes to runoff, recharge, and ET. For the most part, the calculations, models, and other techniques found to derive estimates for these factors often only included impact estimates at the field level, and not in terms of depletions or accretions to a stream. As a result, it will be necessary to develop a protocol, or set of potential protocols, to translate the field-level impacts into impacts at the stream. For example, review of a certain conservation measure might suggest that by implementing the practice at a particular location, 50 acre-feet of additional recharge would occur at the field-level. Unless the location is directly adjacent to a stream, it's unlikely that the additional recharge will immediately result in a 50 acre-feet increase in stream flow.

A. Recharge – to translate impacts to recharge from the field level to the stream, some type of protocol is required to simulate the movement of groundwater between the location of the conservation measure and the stream location of interest. One potential option would be to use a mathematical model such as MODFLOW, which is regularly used throughout much of the State. More basic analytical models, such as the Jenkins Method, could also be used to translate the recharge impacts to the stream. Another simpler approach could involve using stream depletion factor (SDF) maps already developed for other purposes to make rough estimates of impacts to streamflow from recharge changes.
B. Runoff – to translate impacts to runoff from the field level to the stream, a surface water-based approach would be required to estimate stream impacts. One possible protocol would be the Soil and Water Assessment Tool (SWAT) model, which is specifically designed to estimate impacts from changes in land use and land management practices. Transmission losses are estimated based on channel geometry and hydraulic conductivity using the method described in Chapter 19 of the SCS Hydrology Handbook. The Agricultural Policy/Environmental eXtender (APEX) model is another technique which could be used to translate local runoff changes to stream impacts. Simpler approaches could involve applying a range of percentage values, based on professional judgment and known geographic factors, to estimate what percent of the runoff change might eventually translate to streamflow changes.
C. Geospatial Accuracy – any protocol for translating impacts from the field-level to the stream will require some consideration of the location of the conservation measure. For some conservation measures, there is readily available and highly accurate geospatial information, such as the location of center pivot systems. For other conservation measures, little or no geospatial information may exist. Depending on the level of accuracy required, different approaches could be taken to estimate the location for the different measures. GPS measurements could be precisely established through site visits and surveys, although the logistics of this level of effort could be considerable, and it would still require some knowledge of approximately where the conservation measures are in place. In some cases, it may be sufficient to assume a fairly even geospatial distribution across irrigated lands, and simplified GIS maps of irrigated acres are available, for certain historical periods, throughout the study area. Additional geospatial information for conservation measures may be available from the local NRDs, through DNR, or through University or other sources.
D. Infrastructure Impediments – certain structures such as road embankments, ditch alignments, railroads, and hydraulic structures, have an impact on the transmission of surface overland runoff from the location of the local impact to the respective stream. While these structures have not been defined through this effort as conservation measures, they could affect the way in which changes to runoff and recharge are translated from the field-level to the stream. Adjustment of hydrologic routing parameters such as time of concentration and infiltration area could be used to evaluate these impediments. Where possible, these structures could be included in the particular protocol adopted for this translation work, and used to predict stream impacts.

VII. Description of the Three Methods

Three methods have been identified which include a suite of potential techniques to estimate impacts to streamflow resulting from all of the listed conservation measures. These methods (low intensity, medium intensity, and high intensity) are based on the level of expert opinion and literature review, models, and field measurement used to develop estimates of streamflow impacts for each conservation measure. A separate table (Tab 3 – Expertise and Methods) has been developed, which will be included with this technical memorandum, indicating the technical expertise required to conduct the evaluation of impacts, the models that could be used for that purpose, and potential field measurements that could be conducted. A separate table (Tab 4 – Budget and Methods) also includes a range of cost estimates for each conservation measure based on the level of intensity of each method. Economies of scale could also come into play into these cost estimates, and some suggestions are made as to how to reflect those cost savings by applying estimated "cost adjustment factors".

In terms of time frames to implement any of the three methods, project durations will depend on the input of human resources, and any estimates at this stage will be only general estimates. As a starting point, activities under the "low intensity" could be on a 6-12 month time frame, medium intensity efforts could be 2-3 years, and high intensity activities could require 4-6 years.

VIII. Conclusions

The information produced through this Phase I document, the Matrix, and the corresponding supporting documents, should provide a foundation to make future decisions on which conservation measures to include and potential methods for developing estimates of impacts to streamflow for any Phase II efforts. The three methods presented serve as an initial attempt to categorize the resources and techniques needed to produce these estimates of streamflow impacts for each of the conservation measures. The Matrix includes an indication of the estimated overall magnitude of impacts from each of the conservation measures, the required resources and budget to conduct investigations to gage these impacts, and the availability of data associated with each conservation measure.

Conservation Study

Conservation Measure and Matrix Category Descriptions

Conservation Measure Descriptions

Structural

1. **Conservation Terraces** – Earthen embankments and channels constructed across a slope at suitable spacings and with acceptable grades for one or more of the following purposes: to reduce soil erosion, provide for maximum retention of moisture for crop use, or improve water quality (L72).
2. **Non-jurisdictional/Non-permitted Small Dams** – Stream impoundment that is < 15 AF in storage volume and < 25 feet in height built for soil and water conservation purposes. Permits from DNR are not required for these structures.
3. **Jurisdictional/Permitted Dams** – Stream impoundment that is > 15 AF in storage volume and/or > 25 feet in height built for soil and water conservation purposes. Permits from DNR are required for these structures.
4. **Canal Rehabilitation** – Conveyance improvements made to canals that include lining with impervious materials or chemical treatments and repairs and/or improvements to the infrastructure of the canal system (automating gates and checks, etc).
5. **Conversion from open laterals and canals to pipelines** – This practice involves converting open irrigation laterals and canals to buried pipeline to improve conveyance efficiency.
6. **Irrigation runoff recovery systems or return-flow facilities** – A system of ditches, pipelines, pumps and reservoirs to collect and convey surface (tailwater) or subsurface runoff from an irrigated field for reuse. Sometimes called tailwater reuse facilities or pumpback facilities (L73), these impoundments are constructed to capture field runoff as a water source for irrigation on nearby fields.

Non-Structural

1. **Changes in Tillage Practices** – The adoption of conservation tillage and/or no-till practices. This practice includes the reduction of non-growing season tillage and residue management. Conservation tillage is a tillage practice that leaves plant residues on the soil surface for erosion control and moisture conservation. This is sometimes defined as tillage that leaves at least 30% residue cover on the surface after the planting operation (L72). No-till is a tillage system in which the soil is not tilled except during planting when a small slit is made in the soil for seed and agrochemical placement (L73).
   a. **Dryland** – changes in tillage practices under dryland conditions.
   b. **Irrigated** – changes in tillage practices under irrigated conditions.
2. **Changes in Irrigation Management** – The adoption of irrigation management strategies to conserve water:

    a. **Irrigation Scheduling** - Irrigation scheduling is the process of determining when to irrigate and how much water to apply, based upon measurement or estimates of soil moisture or water used by the plant (L73).
    b. **Deficit Irrigation under Allocations** - strategies that allow plant stress, resulting in lower ET and lower yields, usually as a result of allocation requirements. Irrigation water flow meters are often used as a tool to employ this practice.
    c. **Conversion of irrigated land to dryland cropland** – as suggested, conversion of irrigated cropland to dryland conditions.
    d. **Conversion of irrigated land to rangeland** – as suggested, conversion of irrigated cropland to rangeland. Rangeland conditions could include the use of grazing.
3. **Improvements in Irrigation Efficiency** – Irrigation efficiency is the ratio of the average depth of irrigation water that is beneficially used to the average depth of irrigation water applied, expressed as a percent (L73). Technological advances used to improve irrigation efficiency include but are not limited to the following:
    a. **Surge irrigation with furrow irrigation** – surge irrigation is an irrigation technique wherein flow is applied via gated pipe to furrows intermittently, using a programmed surge valve to alternate flows to either side of the valve during a single irrigation set (L73), resulting in more uniform water applications from the top to the bottom of the field. Matrix entries for this conservation measure are relative to base conditions for conventional gated pipe with furrow irrigation.
    b. **Variable Rate Irrigation with center pivots** – center pivot conversion that enables variable irrigation application rates to different portions of the field through variable pivot travel speed and/or through enabling individual sprinklers or groups of sprinklers to vary application rates during a circle. This is usually done in conjunction with GIS technology to monitor the pivot's position in the field. Matrix entries for this conservation measure are relative to base conditions for conventional center pivot systems.
    c. **Conventional gated pipe with furrow irrigation –** the use of conventional gated pipe to deliver water to the field through furrow irrigation. Matrix entries for this conservation measure are relative to base conditions for open ditch irrigation using siphon tubes or check structures.
    d. **Conventional center pivots –** standard center pivot systems consisting of a tower, or set of towers, rotating around a central station via tracked propulsion, delivering water through sprinklers set along the tower axes. Matrix entries for this conservation measure are relative to base conditions for conventional gated pipe with furrow irrigation.
    e. **Subsurface Drip Irrigation –** the use of buried pipes, tubes, or tape to provide irrigation supplies through below-surface application, directly to the root zone. Matrix entries for this conservation measure are relative to base conditions for conventional gated pipe with furrow irrigation.
4. **Changes in Crop Rotation Pattern/Mixes** – The adoption of crop rotation practices for nutrient management purposes, soil conservation and reduced water consumption.

a. **Irrigated Crops: lower consumption crops in rotation with corn**. Rotation crops might include soybeans, winter wheat, sugar beets, dry beans, or other crops, depending on the region.
b. **Dryland Crops**:
    i. **Conversion of wheat-fallow rotation to eco-fallow system** with corn (or grain sorghum or millet)-wheat-fallow.
    ii. Conversion of cropland to rangeland – as indicated, conversion from cropland to rangeland that can include grazing.
c. **CRP/CREP Conversion**:
    i. **Dryland Cropland to CRP/CREP** – The conversion of dryland cropland to CRP (Conservation Reserve Program) or CREP (Conservation Reserve Enhancement Program) is a soil management technique used to remove highly erodible lands and fragile soils from crop production.
    ii. **Irrigated Cropland to CRP/CREP** – Same as above, except for irrigated lands.

5. **Changes in crop production intensity** – the adoption of management practices that increase crop production on less land with better crop hybrids (e.g. higher plant populations, narrower row spacing, skip row, etc.).
    a. Higher plant populations – planting more seeds per unit area.
    b. Narrower row spacing – reducing the space between rows.
    c. Skip row planting – a practice in which certain rows are not planted to improve yields in times of water scarcity. Examples include planting one row and skipping the next, planting two rows and skipping two rows, and planting two rows and skipping one row.
6. **Implementation of soil moisture monitoring program** – The adoption of sensors for irrigation scheduling decisions by monitoring the soil moisture status.
7. **Changes in rangeland management** – changes that affect range condition and, as a result, ET from rangeland, including the adoption of management techniques that more efficiently utilize available animal forage and reduce overgrazing (e.g cross-fencing, pasture rotation, cedar burns, etc.).
8. **Application of Buffers** – Buffers can include riparian buffers, filter strips, and grassed waterways. Riparian buffers are streamside plantings of trees, shrubs, and grasses that can intercept contaminants from both surface water and ground water before they reach a stream and that help restore damaged streams (L74). Filter strips are strips of grass used to intercept or trap field sediment, organics, pesticides, and other potential pollutants before they reach a body of water (L74). Grassed waterways are strips of grass seeded in areas of cropland where water concentrates or flows off a field. They are primarily used to prevent gully erosion (L74).
9. **Management of Phreatophytes/Invasive Vegetation** – This practice involves the management and removal of phreatophytes and invasive vegetation to reduce evapotranspiration.

Matrix Category Descriptions

Assumed Magnitude of Impact – This category is a preliminary estimate of the overall magnitude of impacts to streamflow based on expert opinion and literature on a basin-wide scale. Basin-wide impact in the context of this review includes consideration of the total number of conservation measures installed across the entire basin, meaning the cumulative effect for each conservation measure, rather than a comparison of conservation measures on a per acre basis. The impact magnitude will be assigned as high, medium or low. This impact estimate is based on the difference in streamflow between fully appropriated conditions (assumed to have occurred in 1984 for these purposes) and current overappropriated conditions. As a result, the high, medium and low entries provide a very rough indication of how great this change in streamflow caused by a particular conservation measure compares to the change in streamflow resulting from the other conservation measures in the basin. In laypersons terms, the impact estimates are graded on a curve.

Availability of Information

For these three sub-categories, high quality information is readily available (RA), has limited availability (LA), or not available (NA):

- **ET, Overland Runoff, Recharge** – Information availability concerning the quantity of flow via the three categories of hydrologic processes considered in this evaluation: evapotranspiration (ET), overland runoff, and recharge and irrigation return flow. For example, surge valves for surface irrigation have been extensively studied with respect to their impacts on recharge and return flow and overland runoff and therefore we assigned a Readily Available "RA" value for information availability.
- **Spatial** – Information availability for the location of the respective conservation practices. For canal rehabilitation, it is likely that irrigation districts will have detailed spatial information about location of these practices, and as a result that practice was assigned a Readily Available "RA" level of spatial information availability in the matrix.
- **Implementation Timing** – Availability of temporal information on when practices were historically put in place. For conversion of open laterals or canals to pipe, irrigation districts will likely have good information about the timing of these improvements, and as a result we assigned that practice an "RA" value in the matrix.

Is Local Impact Quantified on Annual Basis – This column defines whether local impact to ET, recharge, and runoff is available on an annual time step. If annual time step is not available then additional work is needed to determine annual impacts to streamflow. "Y" indicates the annual quantification is available, and "N" indicates it is not. For example, for surge irrigation, information is available on an annual time step ("Y"), since the impact only occurs during the irrigation season, which is the same time that quantified impact information is available.

Conservation Measure/Practice Impact on – For these three categories, information is provided on whether the conservation measure increases, decreases, or does not change (NC) one of the three components of the water balance, on an annual basis:

- **Overland Runoff**
- **Recharge**
- **Net Effect on ET**

MATRIX ON QUANTIFICATION OF CONSERVATION IMPACTS TO STREAMFLOW

Final

23 December 2013 Version

	Assumed Magnitude of Impact	AVAILABILITY OF INFORMATION			Is Local Impact Quantified on Annual Basis	Conservation Measure/Practice Impact on		
		ET, Overland Runoff, & Recharge	Spatial	Implementation Timing		Overland Runoff	Recharge	NET Effect on ET
Structural	(LOW, MED, HIGH)	Not Available (NA), Limited Availability (LA), Readily Available (RA)			Y or N	INCREASE, DECREASE, NO CHANGE (NC), NOT APPLICABLE (NA)		
1. Conservation terraces	LOW +	RA	LA	LA	Y	DECREASE	INCREASE	INCREASE
2. Non-jurisdictional/Non-permitted Small Dams	LOW +	RA	LA	LA	Y	DECREASE	INCREASE	INCREASE
3. Jurisdictional/Permitted Dams	LOW +	RA	RA	RA	Y	DECREASE	INCREASE	INCREASE
4. Canal rehabilitation	LOW -	LA	LA	LA	Y	NA	DECREASE	DECREASE
5. Conversion from open laterals and canals to pipelines	LOW -	LA	LA	LA	Y	NA	DECREASE	DECREASE
6. Irrigation runoff recovery systems or return-flow facilities	LOW	RA	LA	LA	Y	DECREASE	INCREASE	NC
7. Others								
Non-Structural								
1. Changes in tillage practices								
1.a. Dryland	MED to HIGH -	RA	LA	RA	Y	DECREASE	INCREASE	INCREASE
1.b. Irrigated	LOW +	RA	LA	RA	Y	DECREASE	INCREASE	DECREASE
2. Changes in irrigation management								
2.a. Irrigation scheduling	LOW	LA	LA	LA	Y	DECREASE	DECREASE	DECREASE
2.b. Deficit irrigation	LOW *see Tab 2	LA	LA	LA	Y	NC	DECREASE	DECREASE
2.c. Conversion of irrigated land to dryland cropland	LOW	NA	NA	NA	Y	DECREASE	DECREASE	DECREASE
2.d. Conversion of irrigated land to rangeland	LOW	NA	NA	NA	Y	DECREASE	DECREASE	DECREASE
3. Improvements in irrigation efficiency								
3.a. Surge irrigation with furrow irrigation	LOW	LA	LA	LA	Y	DECREASE TO NC	DECREASE	NC
3.b. Variable Rate Irrigation with center pivots	LOW	LA	LA	LA	Y	DECREASE	DECREASE	NC TO DECREASE
3.c. Conventional gated pipe with furrow irrigation	LOW	LA	LA	LA	Y	NC	DECREASE	NC
3.d. Conventional center pivots	LOW - *see Tab 2	RA	RA	RA	Y	DECREASE	DECREASE	NC TO DECREASE
3.e. Sub-surface drip irrigation	LOW	LA	LA	LA	Y	DECREASE	DECREASE	DECREASE
4. Changes in crop rotation pattern/mixes								
4.a. Irrigated Crops: lower consumption crops in rotation with corn	MED +	RA	RA	RA	Y	NC	NC	DECREASE
4.b. Dryland crops								
4.b.i. Conversion of wheat-fallow rotation to eco-fallow syst	LOW TO MED -	LA	LA	LA	Y	DECREASE	DECREASE	INCREASE
4.b.ii. Conversion of cropland to rangeland	LOW -	LA	LA	LA	Y	DECREASE	DECREASE	INCREASE
4.c. CRP/CREP conversion								
4.c.i. Dryland Cropland to CRP/CREP	MED -	RA	RA-subject to FOIA	RA-subject to FOIA	Y	DECREASE	DECREASE	INCREASE
4.c.ii. Irrigated Cropland to CRP/CREP	LOW TO MED +	RA	RA-subject to FOIA	RA-subject to FOIA	Y	DECREASE	DECREASE	DECREASE
5. Changes in crop production intensity								
5.a. Higher plant populations	LOW -	LA	LA	LA	Y	NC	NC	NC
5.b. Narrower row spacing	LOW -	LA	LA	LA	Y	NC	NC	NC
5.c. Skip row planting	LOW +	LA	LA	LA	Y	NC	NC	NC
6. Implementation of soil moisture sensors	LOW	LA	LA	LA	Y	DECREASE	DECREASE	DECREASE
7. Changes in rangeland management	LOW	LA	LA	LA	Y	HEAVY TO LIGHT = DECREASE	HEAVY TO LIGHT = DECREASE	HEAVY TO LIGHT = INCREASE
8. Application of Buffers	LOW	LA	LA	LA	Y	DECREASE	VARIES	VARIES
9. Management of Phreatophytes/Invasive vegetation	LOW +	LA	RA	RA	Y	NC	INCREASE	DECREASE
10. Others								

Structural	Assumed Basin-Wide Magnitude Of Impact (Low, Med, High)	Characteristics of Sub-basins with Significant Impacts	Rationale (Assumes FA conditions reached in 1984. Impact magnitudes are basin-wide and relative to those from other conservation measures in the basin.)
1. Conservation terraces	Low +		The base condition for this practice is unterraced dryland fields. Most terraces were in place before the basin became Fully Appropriated. Surface effects of ET increase and direct runoff reduction occur over a short period, so the effect of this practice on direct overland runoff is included in historical values. Seepage from the terrace channels requires long periods to reach the water table if the vadose zone is thick. About 15% of the land In the Republican River Basin (actually about 10% when considering land above the lower terrace) has been treated with conservation terraces. We expect that the percentage in the Overappropriated study area is less than the Republican Basin. Thus, some small increases in streamflow could result relative to the impacts to the stream from the terraces at the time the basin became Fully Appropriated.
2. Non-jurisdictional/Non-permitted Small Dams	Low +		The base condition for this practice would be land without dams. Most permitted dams were in place before the basin became Fully Appropriated. Surface effects of increased ET and storage occur over a short period so the effect is included in the recorded stream flow data. Seepage from dams requires extended periods to reach the water table due to transport through the vadose zone; however, dams are located in stream valleys that would be closer to groundwater than upland areas such as terrace lands. Thus, some small increases in streamflow could have resulted since the basin became Fully Appropriated.
3. Jurisdictional/Permitted Dams	Low +		The base condition for this practice would be land without dams. Most permitted dams were in place before the basin became Fully Appropriated. Surface effects of increased ET and storage occur over a short period so the effect is included in the recorded stream flow data. Seepage from dams requires extended periods to reach the water table due to transport through the vadose zone; however, dams are located in stream valleys that would be closer groundwater than upland areas such as terrace lands. Thus, some small increases in streamflow could have resulted since the basin became Fully Appropriated.
4. Canal rehabilitation	Low -		The base condition for this practice is unlined canals. The impact is considered low because of the low amount of change since the basin became Fully Appropriated. The primary impact is reduced seepage and spills with a small reduction of evaporation from the canal. The ultimate outcome for of lining and piping is probably delivery of more water to irrigated lands than before, which could result in a higher consumptive use proportion . The impact is negative because the "water savings" is thought to be utilized by crop ET.
5. Conversion from open laterals and canals to pipelines	Low -		The base condition for this practice is surface water delivery though an earthen canal. The primary impact is reduced seepage and spills with a small reduction of evaporation from the canal. Evapotranspiration from waterlogged areas due to seepage/spills is consumptive. Seepage from the canal that percolates beyond root zones of nontarget plants will recharge the groundwater. The ultimate outcome for of lining and piping is probably delivery of more water to irrigated lands than before, which could result in a higher consumptive use proportion . Therefore, we believe that the impact has negatively affected streamflow to a slight degree since the basin became Fully Appropriated.
6. Irrigation runoff recovery systems or return-flow facilities	Low		The base condition for this practice is surface irrigation, mainly furrow using gated pipe, without runoff recovery. The impact of runoff recovery is to reduce the amount of irrigation runoff that leaves the field. The impact on stream flow is low because few systems have been put in place since the basin became Fully Appropriated.
7. Others			
Non-Structural			
1. Changes in tillage practices			
1.a. Dryland	MED To HIGH -		The base condition for this practice is a disked tillage system in the east and a stubble mulch system in the west. Conversion to conservation tillage generally produces more infiltration and less evaporation from the soil surface if adequate residue is present. Infiltrated water often results in increased crop yield and therefore more evapotranspiration (ET) for dryland areas. The reduction of runoff from the field and increased ET from dryland areas could noticeably reduce streamflow. Conversion to reduced tillage has occurred since the late 1970s and we continue to see conversions, so a large portion of the impact likely would have occurred after the basin became Fully Appropriated. There is also a strong east-west impact as reductions in ET depend on the frequency of rainfall for dryland fields. When the interval between wetting events is long the initial ET rate is suppressed, but if the period is long enough, about the same amount of water may evaporate from the soil. Dryland cropping is widespread across the basin so we believe that the practice will have had a noticeable negative impact on streamflow.
1.b. Irrigated	Low +		Our base condition for irrigated cropland is a disked tillage system. Conservation tillage does not increase crop ET for irrigated land unless the field is deficit irrigated. The primary impact on irrigated fields would be to reduce evaporation and thus reduce ET. The impact on irrigated lands is different than for dryland because the wetting frequency is higher than for dryland crops, there is more crop residue for some irrigated crops than for dryland, and transpiration rates are not influenced by the additional residue. Therefore, we expect less of an impact than for dryland but a positive increase in streamflow due to reduced evaporation and thus reduced ET.
2. Changes in irrigation management			
2.a. Scientific Irrigation scheduling	Low		The base condition for this practice non-scientific irrigation scheduling. The impact is considered low because we believe that the increase in this practice has been minimal since the basin became Fully Appropriated. The practice should have a positive impact on streamflow because of fewer irrigation water applications thus less wetting of the plant leaves and soil. Evaporation should be reduced. But with an unknown change in adoption since the fully appropriated condition, we rated this as low.
2.b. Deficit irrigation	Low+	The impact can be medium to high + in sub-basins that have implemented water allocations that restrict water withdrawals to levels that would result in either deficit irrigation or a change in crop selection.	The base condition would be the fully irrigated condition, that is, irrigation application to the level that there is no plant water stress. When plant water stress occurs, transpiration is reduced. On a basin scale the impact is considered low because the level of adoption since the basin became Fully Appropriated will be relatively small but where adopted the impact would be medium to high +.

2.c. Conversion of irrigated land to dryland cropland	**Low**		The base condition is irrigated cropland. This practice would reduce ET significantly but the impact is considered low since the conversion to dryland has been minimal since the basin became fully appropriated.
2.d. Conversion of irrigated land to rangeland	**Low**		The base condition is irrigated cropland. This practice would reduce ET significantly but the impact is considered low since the conversion of irrigated cropland to rangeland would be minimal if any occurred at all since the basin became fully appropriated.
3. Improvements in irrigation efficiency			There is widespread misunderstanding about the impact of irrigation efficiency on water balances. The deciding factor is to determine the pathway for the water affected by conversion to more efficient irrigation methods.
3.a. Surge irrigation with furrow irrigation	**Low -**		Our base condition here is the conversion from traditional furrow irrigation using gated pipe. Utilization of surge flow usually provides more rapid advance of water across the field for water applied. This usually reduces deep percolation at the upper end of the field and reduces crop water stress if water did not usually reach the lower end of the field in a timely manner. The reduction of deep percolation is probably more significant than increased crop water use in most applications. We feel that the impact is low because there is little land area that utilizes surge flow irrigation. In addition, if the primary effect is changing deep percolation, then the water that percolates is not consumptive and eventually affects recharge.
3.b. Variable Rate Irrigation with center pivots	**Low**		The base case for Variable Rate Irrigation (VRI) is a traditional center pivot irrigation system. VRI allows for the application of varying depths across the field in a targeted manner. There could be various goals in using VRI. One approach could be to reduce pumping on areas of the field that hold more water than lighter textured soils. Application depths could also be curtailed on nonproductive areas of the field. When combined with areas that are deficitly irrigated under water allocation programs the amount of ET could be increased if water that was not needed in part of the field resulted in deep percolation at that location and is instead is applied on areas that usually receive less water and experience more stress. In the latter case, VRI could increase ET. VRI is new so any impacts are the result of recent developments and certainly occurred after the basin became Fully Appropriated. VRI will most certainly reduce leaching of agricultural chemicals, which will positively impact groundwater quality.
3.c. Conventional gated pipe with furrow irrigation	**Low**		The base case for this practice is furrow-irrigated land using siphon tubes. Conversion to gated pipe has generally occurred some time ago so the changes since the basin became Fully Appropriated are primarily small. The primary impact of using gated pipe rather than siphon tubes would be the difference in seepage from on-farm ditches and perhaps some spills. The difference in seepage depends on the type of ditch used for supply siphon tubes. Concrete-lined ditches would have little seepage. Earth lined ditches would have more seepage. However, leaky gates for gated pipe can also contribute to seepage at the head of the field. In some case, leaks from gates can be as bad as seepage from an earthen ditch. Evaporation from the open water surface of an open ditch is generally small. Finally, with groundwater supplies the percolation from the ditch or gated pipe is primarily seepage, which returns eventually to the aquifer.
3.d. Conventional center pivots	**Low -**	There could be subbasin exceptions where irrigation water distribution before conversion was so nonuniform that it caused lower ET and subsequent yield reductions. In these cases, the impacts to streamflow could be greater than the overall basin estimate.	The base case for this practice is fields furrow irrigated with gated pipe. There has been a continual conversion from gated pipe to center pivots all across the basin. Key issues for this practice are the amount of land irrigated with the pivot compared to the furrow irrigated field, and changes in the adequacy of irrigation on the areas of the field that may have been under irrigated with furrow irrigation. Runoff from center pivots should be less than for furrow irrigation. The key is how the runoff is managed. If the water is recycled to the field through reuse systems then the main loss of water is seepage in the reuse system and increased evaporation/evapotranspiration from open water surface and weeds along conveyance channels. With center pivots some of the water evaporates in the air and evaporation from the canopy is generally more than the transpiration would have been. Combined evaporation losses from evaporation in the air, drift losses and canopy evaporation increases is generally less than ten percent. In our view there is a small negative impact on streamflow on a basin-wide level since the basin became Fully Appropriated.
3.e. Sub-surface drip irrigation	**Low**		The base case for this practice is furrow-irrigated land using gated pipe. The conversion to SDI has certainly occurred since the basin became Fully Appropriated. Issues with SDI are similar to that for conventional center pivots. The amount of land irrigated is probably about the same as for furrowed irrigated land. Evapotranspiration from SDI can be somewhat less than for furrow irrigation, as the soil surface remains dry. Losses from SDI are primarily due to deep percolation if the field is not properly scheduled. Those losses would recharge groundwater aquifers eventually. Evapotranspiration could increase if the furrow system did not provide adequate supplies. SDI would dramatically reduce runoff of irrigation water and perhaps rainfall as well. If crop yields increase due to improved irrigation distribution, then ET likely increased. The areal extent of SDI is still quite small so we have rated its impact as low.
4. Changes in crop rotation pattern/mixes			
4.a. Irrigated Crops: lower consumption crops in rotation with corn	**Med +**	The impact can be medium to high + in sub-basins that have implemented water allocations that restrict water withdrawals to levels that would result in either deficit irrigation or a change in crop selection.	The base condition would be irrigated corn with full-season hybrid selection that matches the geographic area. The impact of changes in crops with lower ET is often the result of the shorter growing season for alternative crops. Thus, shorter season corn hybrids could also be considered in this option. Changes from corn to soybean in much of the basin could have been significant since the Fully Appropriated condition.
4.b. Dryland crops			
4.b.i. Conversion of wheat-fallow rotation to eco-fallow	**Low To Med -**		The base condition for this practice would be wheat-fallow rotation with mulch tillage. The negative impact of this change is due to increased crop ET which is a result of producing two crops in a three year period versus one crop in two years. Overall magnitude depends on level of change since the Fully Appropriated Condition.

4.b.ii. Conversion of cropland to rangeland	**Low -**		The base condition for this practice would be dryland cropland, either wheat-fallow or eco-fallow, with mulch tillage. The negative impact of this change is due to increased rangeland ET associated with the longer growing periods of rangeland and possibly due to the deeper root zone that is expected for the perennial vegetation. The deeper root zone results in a larger soil moisture reservoir for storing water for subsequent ET. Overall magnitude depends on level of change since the Fully Appropriated Condition but we assume that it is minimal if at all.
4.c. CRP/CREP conversion			
4.c.i. Dryland Cropland to CRP/CREP	**Med -**		The base condition for this practice would be dryland cropland, either wheat-fallow or eco-fallow, with mulch tillage. The negative impact of this change is due to increased ET on the CRP/CREP land associated with the longer growing periods of CRP/CREP land and possibly due to the deeper root zone that is expected for the perennial vegetation. The deeper root zone results in a larger soil moisture reservoir for storing water for subsequent ET. Overall magnitude depends on level of change since the Fully Appropriated Condition and we assume that the adoption has been significant.
4.c.ii. Irrigated Cropland to CRP/CREP	**Low To Med +**		The base condition for this practice would be irrigated cropland, mainly corn. The positive impact of this change is due to reduced ET during periods of moisture stress on the CRP/CREP land. Overall magnitude depends on level of change since the Fully Appropriated Condition and we assume that the adoption has been significant.
5. Changes in crop production intensity			
5.a. Higher plant populations	**Low -**		The base condition for this practice is a normal planting density of about 30,000 corn plants per acre for irrigated land. The primary effect of increasing the density is that the canopy closes earlier in the season. For most irrigated crops the leaf area index for previous populations were well above the amount of leaf area that would produce full ET. Higher populations allow for more ET somewhat earlier in the season and the canopy may senesce more slowly but not materially. We expect that this impact will be a small increase in ET but not materially. Impacts on dryland will be minimal as precipitation generally dictates ET.
5.b. Narrower row spacing	**Low -**		This practice compares to a traditional row width of about 30 inches. The impact on planting narrower crop rows allows the canopy to close more quickly and perhaps last a little longer at the end of the growing season. Narrower rows do not increase the leaf area index materially. The net effect will be a small increase of ET early and late in the season, which would deplete streamflow slightly. Impacts on dryland will be minimal as precipitation generally dictates ET.
5.c. Skip row planting	**Low +**		The base condition for this practice is planting rows at equal spacing for all rows. Skip-row involves not planting one row out of a set; *i.e.* skipping a row. One scheme skips one row and plants one row (every-other row skipped), a second scheme involves planting two rows and skipping one row with a three row basic unit. Skipping a row allows for storage of precipitation over the wider width which requires more time for the roots of the crop to reach during the season. The additional storage provides water to allow crops to complete crop development and increase grain development. In the most arid areas, the impacts will probably be small as precipitation is the limiting factor and this practice is only altering the time during the season when the water is used for ET. In wetter years, and in the more humid areas, there is a chance that some of the stored water in the skipped row will not be needed for the season. If the skipped row was planted ET would have been higher. The effect is that ET would be decreased in wetter years when the row is skipped. This practice has only been adopted since the basin became Fully Appropriated and is not widely implemented - thus we believe this impact will be small.
6. Implementation of soil moisture sensors	**Low**		The base condition for this practice would be irrigated cropland without soil moisture sensors. Assuming that the sensors are used for scientific irrigation scheduling we're assuming that the impact is low because we believe that the increase in this practice has been minimal since the basin became Fully Appropriated. The practice should have a positive impact on streamflow because of fewer irrigation water applications thus less wetting of the plant leaves and soil. Evaporation should be reduced.
7. Changes in rangeland management	**Low**		The primary management practice change for rangeland is the management of grazing duration and intensity. Higher levels of range management generally provide periods on intense grazing and then regrowth periods. The base practice would be where animals are free to graze the whole pasture. Enhanced management can have two effects: (1) taller grass in some portions of the field after intense grazing and (2) maintenance of different grass mixtures, as periodic grazing does not allow time for the animals to graze out the desirable grasses with regrowth of less desirable species. Enhanced management has gained popularity since the time at which the basin became Fully Appropriated and has become significantly widespread. We believe that enhanced management would lead to slight increases in ET due to more regrowth but that the impact would be small. If ranchers planted a different grass species, the impact could be different.
8. Application of Buffers	**Low**		The base condition for this practice would be cropland, either irrigated or dryland. The impact of this change would be due to a change in ET. If changing from irrigated land to buffers, the impact would be positive since ET would likely go down. The opposite would occur with dryland cropland. Since the Fully Appropriated Condition, we assume that the adoption has been low and thus the impact is low.
9. Management of Phreatophytes/Invasive vegetation	**Low +**		The base condition for this practice would be a riparian zone with native species that existed up to thirty years ago. Invasive species include salt cedar phragmites, Russian olive and red cedar trees. Research has shown that removing the invasive species next to a stream results in the majority of the impact ocurring in the first few years after clearing. Once invasive species are removed, a mixture of understory species quickly fill the area where the invasive species were located. The species that we have observed are the native climax vegetation and thus the potential reduction of ET from clearing invasive species is smaller than some reports. In addition, the fraction of the watershed that is affect by riparian species removal is small for the whole watershed. Thus, we expect the impact to be a small positive impact when considered over a long period.
10. Others			

MATRIX ON QUANTIFICATION OF CONSERVATION IMPACTS TO STREAMFLOW

Final

23 December 2013 Version

	--- Expertise Needed for Project ---										---Type of Models Needed ---								---- Measurement Methods ---										
Structural	Agronomist/Soil Scientist	Rangeland ecologist	Riparian ecologist	Microclimatologist	Eco-hydrologist	Agricultural hydrologist	Irrigation engineer	Hydraulic engineer	Vadose zone hydrologist/soil physiscist	Groundwater geologist/engineer	Spatial analysis (GIS, etc.)	Irrigation hydraulics (SRFR, Sirmod,CPNozzle)	Surface hydrology (SWAT, WEPP, HEC-HMS, MIKE-SHE)	Root zone hydrology (Cropsim)	Evapotranspiration (Models that use Penman Monteith)	Vadose zone hydrology (HYDRUS, RZWQM)	Groundwater hydrology (MODFLOW)	Integrated hydrologic model (MIKE-SHE, Farm Process/MODFLOW)	Groundwater levels	Matric potential and water content in intermediate vadose zone	Matric potential and water content in root zone	Tracers in vadose zone	Stream flow (Gauging stations)	Field runoff (flumes, weirs)	Evapotranspiration (BREB, Eddy Co-variance, Remote Sensing)	Infiltration	Seepage	Plant Growth and Management Practices	**Literature Review Reference** *See other worksheet*
1. Conservation terrace						X		X	X	X	X		X	X	X	X	X	X		X	X	X	X	X	X	X		X	L2, L3, L4, L5, L10, L18, L19, L20, L21, L22, L23, L32
2. Non-jurisdictional/Non-permitted Small Dams						X		X	X	X	X		X			X	X		X	X			X	X	X		X	X	L25
3. Jurisdictional/Permitted Dams						X		X	X	X	X		X			X	X		X	X			X	X	X		X	X	
4. Canal rehabilitation						X	X	X	X	X	X					X	X		X	X			X	X			X		L14
5. Conversion from open laterals and canals to pipelines						X	X	X	X	X	X	X				X	X		X	X			X	X			X	X	L15, L14
6. Irrigation runoff recovery systems or return-flow facilities							X				X	X				X	X							X			X	X	L16, L27
7. Others																													
Non-Structural																													
1. Changes in tillage practices (I --> irrigated, R --> Rainfed)																													
1.a. Dryland	X					X			X	X	X		X	X	X	X	X	X		X	X	X		X	X				L37, L45, L46, L52, L53, L54
1.b. Irrigated	X					X	X		X	X	X		X	X	X	X	X	X		X	X	X		X	X				L37, L45, L46, L52, L53, L54
2. Changes in irrigation management																													
2.a. Scientific irrigation scheduling							X		X	X	X	X		X	X	X	X	X		X	X	X		X	X			X	L33, L35, L41, L75, L77, L78
2.b. Deficit irrigation	X						X		X	X	X			X	X	X	X	X		X	X	X			X			X	L76, L79, L80
2.c. Conversion of irrigated land to dryland cropland	X					X	X		X	X	X			X	X	X	X	X		X	X	X			X			X	
2.D. Conversion of irrigated land to rangeland		X				X	X		X	X	X			X	X	X	X	X		X	X	X		X	X			X	
3. Improvements in irrigation efficiency																													
3.a. Surge irrigation with furrow irrigation							X		X	X	X	X						X						X		X			L17, L41, L42, L43, L62
3.b. Precision irrigation with variable rate center pivot technology							X		X	X	X	X						X		X	X					X			L63, L64, L65
3.c. Conversion to gated pipe with furrow irrigation							X		X	X	X	X				X	X	X		X	X			X		X			L16, L27
3.d. Conversion to conventional center pivot systems							X		X		X	X		X		X	X	X		X	X	X	X			X			L16, L27
3.e. Conversion to sub-surface drip irrigation							X		X	X	X	X		X		X	X	X		X	X	X							L16, L27
4. Changes in crop rotation pattern/mixes																													L66
4.a. Irrigated crops: more lower water consumption crops in rotation with corn	X			X		X	X		X	X	X			X	X	X	X	X		X	X	X			X			X	
4.b. Dryland crops																													
4.b.i. Conversion of wheat-fallow rotation to eco-fallow system	X					X			X	X	X		X	X	X	X	X	X		X	X	X		X	X			X	
4.b.ii. Conversion of cropland to rangeland	X					X			X	X	X		X	X	X	X	X	X		X	X	X		X	X			X	
4.c. CRP conversion																													
4.c.i. Dryland Cropland to CRP	X					X			X	X	X		X	X	X	X	X	X		X	X	X		X	X			X	L45, L46, L59, L60, L61
4.c.ii. Irrigated Cropland to CRP	X					X			X	X	X		X	X	X	X	X	X		X	X	X		X	X			X	L45, L46, L59, L60, L61
5. Changes in crop production intensity																													
5.a. Higher plant populations	X					X			X	X	X		X	X	X	X	X	X		X	X	X			X			X	
5.b. Narrower row spacing	X					X			X	X	X			X	X	X	X	X		X	X	X			X			X	
5.c. Skip row planting	X					X			X	X	X			X	X	X	X	X		X	X	X			X			X	
6. Implementation of soil moisture sensors							X		X	X	X		X	X	X	X	X	X		X	X	X			X			X	
7. Changes in rangeland management		X				X			X	X	X		X	X	X	X	X	X		X	X	X		X	X			X	L38, L55, L56, L57, L58
8. Application of Buffers			X			X			X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X			X	L5, L28, L29, L30, L31
9. Management of Phreatophytes/Invasive vegetation			X			X			X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X			X	
10. Others																													

MATRIX ON QUANTIFICATION OF CONSERVATION IMPACTS TO STREAMFLOW

Final

23 December 2013 Version

			Quality			
			Low Intensity	**Medium Intensity**	**High Intensity**	
		Multiplier for	**Expert dominant**	**Expert + model**	**Expert + Model + Field**	
	Multiplier for	**Medium and**	60%	30%	15%	Uncertainty
Structural	**Low Intensity***	**High Intensity***	$50,000	$300,000	$600,000	Baseline Values**
1. Conservation terrace	3	4	$150,000	$1,200,000	$2,400,000	
2. Non-jurisdictional/Non-permitted Small Dams	2.5	3.5	$125,000	$1,050,000	$2,100,000	
3. Jurisdictional/Permitted Dams	2	3	$100,000	$900,000	$1,800,000	
4. Canal rehabilitation	2	4	$100,000	$1,200,000	$2,400,000	
5. Conversion from open laterals and canals to pipelines	2	4	$100,000	$1,200,000	$2,400,000	
6. Irrigation runoff recovery systems or return-flow facilities	2	2	$100,000	$600,000	$1,200,000	
7. Others						
Non-Structural						
1. Changes in tillage practices (I --> irrigated, R --> Rainfed)						
1.a. Dryland	3.5	4.5	$175,000	$1,350,000	$2,700,000	
1.b. Irrigated	3.5	4.5	$175,000	$1,350,000	$2,700,000	
2. Changes in irrigation management						
2.a. Scientific irrigation scheduling	2	3	$100,000	$900,000	$1,800,000	
2.b. Deficit irrigation	3	4	$150,000	$1,200,000	$2,400,000	
2.c. Conversion of irrigated land to dryland cropland	5	6	$250,000	$1,800,000	$3,600,000	
2.D. Conversion of irrigated land to rangeland	5	6	$250,000	$1,800,000	$3,600,000	
3. Improvements in irrigation efficiency						
3.a. Surge irrigation with furrow irrigation	1	2	$50,000	$600,000	$1,200,000	
3.b. Precision irrigation with variable rate center pivot technology	3	4	$150,000	$1,200,000	$2,400,000	
3.c. Conversion to gated pipe with furrow irrigation	1	2	$50,000	$600,000	$1,200,000	
3.d. Conversion to conventional center pivot systems	2	3	$100,000	$900,000	$1,800,000	
3.e. Conversion to sub-surface drip irrigation	2	4	$100,000	$1,200,000	$2,400,000	
4. Changes in crop rotation pattern/mixes						
4.a. Irrigated crops: more lower water consumption crops in rotation with corn	4	5	$200,000	$1,500,000	$3,000,000	
4.b. Dryland crops						
4.b.i. Conversion of wheat-fallow rotation to eco-fallow system	4	5	$200,000	$1,500,000	$3,000,000	
4.b.ii. Conversion of cropland to rangeland	4	5	$200,000	$1,500,000	$3,000,000	
4.c. CRP conversion						
4.c.i. Dryland Cropland to CRP	4	5	$200,000	$1,500,000	$3,000,000	
4.c.ii. Irrigated Cropland to CRP	4	5	$200,000	$1,500,000	$3,000,000	
5. Changes in crop production intensity						
5.a. Higher plant populations	2	3	$100,000	$900,000	$1,800,000	
5.b. Narrower row spacing	2	3	$100,000	$900,000	$1,800,000	
5.c. Skip row planting	2	3	$100,000	$900,000	$1,800,000	
6. Implementation of soil moisture sensors	2	3	$100,000	$900,000	$1,800,000	
7. Changes in rangeland management	4	5	$200,000	$1,500,000	$3,000,000	
8. Application of Buffers	4	5	$200,000	$1,500,000	$3,000,000	
9. Management of Phreatophytes/Invasive vegetation	5	6	$250,000	$1,800,000	$3,600,000	
10. Others						

Activities associated with low intensity are dominated by the use of expert opinion and the published literature with the assistance of some modeling and little if any field measurement
Activities associated with medium intensity are dominated by the use of expert opinion, the literature, and a strong emphasis on modeling and a small amount of field measurement if needed
Activities associated with high intensity are dominated by the blend of expert opinion, the literature, extensive use of models and a significant amount of field measurement
* The multiplier accounts for system complexity and what is already known
**Baseline values are relative values and are used in conjunction with the multipliers to determine the estimated budget

Evaluation of Multiple Practices - As a starting estimate, multiply the sum of costs of all individual practices by the following cost adjustment factors

No of Practices	Cost Adjustment Factor
1	1.00
2	0.66
3	0.52
4	0.44
5	0.38
6	0.34
7	0.31
8	0.29
9	0.27
10	0.25
>10	0.25

Here is an example of how to apply the cost adjustment factor:

Consider a project with medium intensity analysis of conservation terraces, canal rehabilitation, and augmentation. The associated single practice costs are $1.2 M, $1.2 M, and $1.8 M. If the projects were completed individually, the cost total would be $4.2 M. But if all three projects were pooled into one project, the total cost would be $4.2 M X 0.52 = $2.2 M. The cost adjustment factor in this case in 0.52, the factor for three practices.

	MODEL	AUTHOR/AGENCY	DATE	Link (if applicable)	SUMMARY	GEOGRAPHIC SCALE	TEMPORAL SCALE	CONSERVATION PRACTICES	REFERENCES	ADDITIONAL INFORMATION
M1	POTYLD POTential YieLD Model Revised.	Koelliker, J.K. Kansas State University	1994	http://www.kgs.ku.edu/Publications/Bulletins/239/Koelliker/index.html	POTYLD assesses the effects of land use and conservation practices on large wathershed. POTYLD functions on a daily time step to calculate water budget fro different land uses and estimates the water yield on a monthly or annual basis for a drainage area. Hydrologic processes considered include evapotranspiration, transpiration, interception, runoff, snow, soil water evaporation, infiltration and redistribution. Spatial calculations performed for hydrogic response units.	Watershed	Daily	Ponds and terraces. Buffers, conservation reserve programs, tillage practices, irrigation methods and management, crop rotation, and grazing management conservation practices can be evaluated through infiltration parameters.	Koelliker, J. K., 1994a, User's manual for POTential YieLD Model Revised: Kansas State University, Manhattan, Civil Engineering Department Arabi, M., R.S. Govindaraju, M. Sophocleous, and J.K. Koelliker. 2006. Use of distributed models for watershed management: Case Studies. In Watershed Models. V.P. Singh, and D. Frevert, eds. CRC Press, Taylor and Francis Group, New York, pp 503-526.	POTYLD utilizes values of runoff curve numbers (RCN) to predict the split between runoff and infiltration for land uses from daily amounts of rainfall and snowmelt (See chapter I for more information on RCN values). Individual land uses and conservation-practice conditions can be described by a RCN, and the RCN technique is used widely to predict runoff from design storms. It follows that the RCN method can predict runoff over a period of time provided the antecedent moisture condition (AMC), how wet the soil was at the time of each storm, can be determined. This technique to assess runoff through a computer-simulation model is now used widely in watershedsimulation models. Recently, POTYLD has been modified to include additional refinements and to include irrigation; consequently, the name was changed to Potential Yield Revised (POTYLDR) (Koelliker, 1994a, 1994b).
M2	SWAT Soil and Water Assessment Tool	S.L. Neitsch, J.G. Arnold, J.R. Kiniry, J.R. Williams Grassland, Soil and Water Research Laboratory - Agricultural Research Service Blackland Research Center - Texas AgriLife Research	2009	http://swat.tamu.edu/documentation/	SWAT is used to predict the impact of land management practices on water, sediment and agricultural chemical yields. SWAT functions on a continuous daily time step to simulate the hydrologic water balance. Model inputs include climate, hydrologic response units (GIS based spatially unique areas of land cover, soil type and management practices), ponds, groundwater, and channel data. Water balance equations calcuate the change in daily soil water content from precipitation, surface runoff, evapotranspiration, seepage into the vadose zone, and ground water returnflow and recharge. Additional hydrologic considerations include canopy storage, infiltration, redistribution, lateral subsurface flow, surface runoff, pond storage, and tributary channel routing and transmission losses. Model is available in a GIS format (ArcSWAT).	Watershed	Daily	Ponds, terraces, buffers, conservation reserve programs, tillage practices, irrigation methods and management, crop rotation, and grazing management.	S.L. Neitsch, J.G. Arnold, J.R. Kiniry, J.R. Williams. 2011. Soil and Water Assessment Tool Theoretical Documentation Version 2009. Texas Water Resources Institute Technical Report No. 406. Arnold, J. G., D. N. Moriasi, P. W. Gassman, K. C. Abbaspour, M. J. White, R. Srinivasan, C. Santhi, R. D. Harmel, A. van Griensven, M. W. Van Liew, N. Kannan, M. K. Jha. 2012. SWAT: Model Use, Calibration, and Validation. Transactions of the ASABE. Vol. 55(4): 1491-1508. Gassman, P. W., J. R. Williams, X. Wang, A. Saleh, E. Osei, L. M. Hauck, R. C. Izaurralde, J. D. Flowers. 2010. The Agricultural Policy Environmental EXtender (APEX) Model: An Emerging Tool for Landscape and Watershed Environmental Analyses. Transactions of the ASABE. 53(3): 711-740. Srinivasan, R., X. Zhang, J. Arnold. 2010. SWAT Ungauged: Hydrological Budget and Crop Yield Predictions in the Upper Mississippi River Basin. Transactions of the ASABE. Vol. 53(5): 1533-1546	The Soil and Water Assessment Tool (SWAT) is a public domain model jointly developed by USDA Agricultural Research Service (USDA-ARS) and Texas A&M AgriLife Research, part of The Texas A&M University System. SWAT is a small watershed to river basin-scale model to simulate the quality and quantity of surface and ground water and predict the environmental impact of land use, land management practices, and climate change. SWAT is widely used in assessing soil erosion prevention and control, non-point source pollution control and regional management in watersheds.
M3	RZWQM2 Root Zone Water Quality Model	L.R. Ahuja, K.W. Rojas, J.D. Hanson, M.J.Shaffer, L. Ma USDA-ARS	2000	http://www.wrpllc.com/books/rzwqm.html	RZWQM2 is used to predict the hydrologic response of alternative crop-management systems. RZWQM2 functions on a daily timestep and one-dimensional soil profile. The model simulates crop development and the movement of water, nutrients, and pesticides over and through the root zone on a field level. Model inputs include daily weather data, soil properties, and managment practices. Hydrologic processes include infiltration; flow through soil matrix, micropores, and macropores; fluctuating water table; tile drain, bare, and residue-covered soil evaporation; crop transpiration; soil water redistribution between rainfall and irrigation events; and snow accumulation and melt. Model is available in a GIS format (RZWQM2-GIS).	Field	Annual	Terraces, buffers, conservation reserve programs, tillage practices, irrigation methods and managment, crop rotation, and grazing management.	Ahuja, L. R., K. W. Rojas, J., D. Hanson, M. J. Shaffer, and L. Ma (eds). 2000. The Root Zone Water Quality Model. Water Resources Publications LLC. Highlands Ranch, CO.	The Root Zone Water Quality Model (RZWQM) was developed in the 1990's by a team of USDA Agricultural Research Service (ARS) scientists. A majority of the team members are part of the present Agricultural Systems Research Unit, Fort Collins, CO. Parts of the model have been revised and enhanced with cooperation of the ARS Northwest Watershed Research Laboratory, Boise, ID, and the ARS Nematode Research Laboratory, Tifton, GA. The next generation, RZWQM2 has been revised and enhanced to include the DSSAT 4.0 Cropping System Models with the cooperation of the University of Georgia and DSSAT modeling group. Additional crops and model enhancements for applications are done in cooperation with users nationally and internationally with the USDA ARS Agricultural System Research Unit RZWQM2 team.
M4	WEPP Water Erosion Prediction Project	D.C. Flanagan and M.A. Nearing (ed.) USDA-ARS National Soil Erosion Research Laboratory	1995	http://www.ars.usda.gov/Research/docs.htm?docid=18073	WEPP is a continuous simulation model used in hillslope and watershed applications. WEPP functions on a daily timestep Model inputs include climate, slope, soil and cropping management data files. Hydrologic processes include infiltration, runoff, soil evaporation, plant transpiratioin, soil water percolation, plant and residue interception of rainfall, depressional storage, and soil profile drainage by subsurface tiles. Translation is modeled with the kinematic wave equation.	Watershed or Field	Event, Monthly, or Annual	Ponds, terraces, buffers, conservation reserve programs, tillage practices, irrigation methods and management, crop rotation, and grazing management.	D.C. Flanagan and M.A. Nearing (ed.). 1995. USDA - Water Erosion Prediction Project (WEPP) Hillslope Profile and Watershed Model Documentation. NSERL Report No. 10. USDA-ARS National Soil Erosion Research Laboratory. Lane, L. J., D. L. Schertz, E. E. Alberts, J. M. Laflen, and V. L. Lopes. 1988. The US National Project to Develop Improved Erosion Prediction Technology to Replace the USLE. Proc. IAHS Intrl. Symposium on Sediment Budgets, Porto Alegre, Brazil, 11- 15 Dec. 1988, IAHS Publ. No. 174, pp. 473-481. Lane, L.J., J.E. Gilley, M. Nearing, and A.D. Nicks. 1988. The USDA Water Erosion Prediction Project. National Conf. on Hydraulic Engineering, Colorado Springs, CO. August, 1988.	The Water Erosion Prediction Project (WEPP) model is a process-based, distributed parameter, continuous simulation, erosion prediction model for use on personal computers. Processes considered in hillslope profile model applications include rill and interrill erosion, sediment transport and deposition, infiltration, soil consolidation, residue and canopy effects on soil detachment and infiltration, surface sealing, rill hydraulics, surface runoff, plant growth, residue decomposition, percolation, evaporation, transpiration, snow melt, frozen soil effects on infiltration and erodibility, climate, tillage effects on soil properties, effects of soil random roughness, and contour effects including potential overtopping of contour ridges. The model accommodates the spatial and temporal variability in topography, surface roughness, soil properties, crops, and land use conditions on hillslopes. In watershed applications, the model allows linkage of hillslope profiles to channels and impoundments. Water and sediment from one or more hillslopes can be routed through a small field-scale watershed. Almost all of the parameter updating for hillslopes is duplicated for channels. The model simulates channel detachment, sediment transport and deposition. Impoundments such as farm ponds, terraces, culverts, filter fences and check dams can be simulated to remove sediment from the flow.
M5	HEC-HMS Hydrologic Modeling System	US Army Corps of Engineers Hydrologic Engineering Center	2000	http://www.hec.usace.army.mil/software/hec-hms/documentation.aspx	HEC-HMS is an event based rainfall - runoff response model. Model inputs include meterologic, infiltration, transformation, and reservoir routing data. Model results include overland runoff volume and flow rate. Model is available in a GIS format (HEC-geoHMS).	Watershed	Event	Ponds and terraces. Buffers, conservation reserve programs, tillage practices, irrigation methods and managment, crop rotation, and grazing management conservation practices can be evaluated through infiltration parameters.	Hydrologic Engineering Center. 2000. Hydrologic Modeling System (HEC-HMS): Technical Reference Manual. U.S. Army Corps of Engineers. Davis, CA	The Hydrologic Modeling System (HEC-HMS) is designed to simulate the precipitation-runoff processes of dendritic watershed systems. It is designed to be applicable in a wide range of geographic areas for solving the widest possible range of problems. This includes large river basin water supply and flood hydrology, and small urban or natural watershed runoff. Hydrographs produced by the program are used directly or in conjunction with other software for studies of water availability, urban drainage, flow forecasting, future urbanization impact, reservoir spillway design, flood damage reduction, floodplain regulation, and systems operation. The program is a generalized modeling system capable of representing many different watersheds. A model of the watershed is constructed by separating the hydrologic cycle into manageable pieces and constructing boundaries around the watershed of interest. Any mass or energy flux in the cycle can then be represented with a mathematical model. In most cases, several model choices are available for representing each flux. Each mathematical model included in the program is suitable in different environments and under different conditions. Making the correct choice requires knowledge of the watershed, the goals of the hydrologic study, and engineering judgment. The program features a completely integrated work environment including a database, data entry utilities, computation engine, and results reporting tools. A graphical user interface allows the seamless movement between the different parts of the program. Program functionality and appearance are the same across all supported platforms.
M6	HYDRUS 2D	J. Simunek and M. Sejna PC-Progress, Prague, Czech Republic	2007	http://www.pc-progress.com/en/Default.aspx?hydrus-2d	Hydrus-2D is a finite element model used to simulate the movement of water and root uptake in the vadose zone comprised of uniform or nonuniform soils. Simulation time increments are user dependent ranging from seconds to days. Flow and transport can occur in the vertical plane, the horizontal plane, a three-dimensional region exhibiting radial symmetry about a vertical axis, or in a three-dimensional region. The water flow part of the model can deal with (constant or time-varying) prescribed head and flux boundaries, as well as boundaries controlled by atmospheric conditions. Soil surface boundary conditions may change during the simulation from prescribed flux to prescribed head type conditions (and vice versa). The code can also handle a seepage face boundary, through which water leaves the saturated part of the flow domain, and free drainage boundary conditions. Nodal drains are represented by a simple relationship derived from analog experiments.	Field	Seconds to Days	Canal rehabilitation, conversion of canal open laterals to buried pipes, and conversion to drip irrigation.	Šimůnek, J. and M. Šejna. 2007. HYDRUS 2D/3D Software Package for Simulating Two- and Three-Dimensional Movement of Water, Heat, and Multiple Solutes in Variably-Saturated Media User Manual Version 1.02. PC-Progress, Prague, Czech Republic. Šimůnek, J., D. Jacques, G. Langergraber, S. A. Bradford, M. Šejna, and M. Th. van Genuchten. 2013. Numerical modeling of contaminant transport with HYDRUS and its specialized modules, Invited paper for the Special Issue "Water Management in Changing Environment", Editor M. S. Mohan Kumar, Journal of the Indian Institute of Science, 93(2) 265-284, ISSN: 0970-4140 Coden-JIISAD.	HYDRUS is a Microsoft Windows based modeling environment for the analysis of water flow and solute transport in variably saturated porous media. The software package includes computational finite element models for simulating the two- and three-dimensional movement of water, heat, and multiple solutes in variably saturated media. The model includes a parameter optimization algorithm for inverse estimation of a variety of soil hydraulic and/or solute transport parameters. The model is supported by an interactive graphics-based interface for data-preprocessing, generation of structured and unstructured finite element mesh, and graphic presentation of the results. The program can handle flow domains delineated by irregular boundaries.
M7	VFSMOD-W Vegetative Filter Strips Modelling System	Rafael Munoz-Carpena, John E. Parsons University of Florida	2011	http://abe.ufl.edu/carpena/vfsmod/	VFSMOD is a numerical model used to study hydrology and sediment transport through vegetative filter strips. VFSMOD functions on a field scale and event basis to calcualte outflow and infiltration of overland runoff. Model inputs include rainfall hyetographs or inflow hydrographs, soil infiltration parameters and soil water content, and surface storage.	Field	Event	Buffers and conservation reserve programs.	Rafael Munoz-Carpena, John E. Parsons. 2011. VFSMOD-W Vegetative Filter Strips Modelling System Model Documentation and User's Manual Version 6.x. University of Florida.	
M8	CROPSIM	Derrel Martin University of Nebraska			CROPSIM is a numerical model used to calculate soil water balance. CROP-SIM functions on a daily time-step at the field or watershed. Model inputs include climatic, soil, phenology, land cover, and management data. Water balance equations estimate ET, deep percolation, and runoff.	Watershed or Field	Daily, Monthly, or Annual	Buffers, conservation reserve programs, tillage practices, irrigation methods and management, crop rotation, and grazing management conservation practices.		
M9	Water Optimizer	Chris Thompson, Ray Supalla, and Derrel Martin University of Nebraska	2010	http://agecon.unl.edu/wateroptimizer/download.html	Water Optimizer is a spreadsheet based model used to predict the profit maximizing cropping strategy and corresponding amount of applied irrigation water. Model inputs include crop type, soil type, irrigation system, well and pump characteristics, well or canal delivery, and power source.	Field	Season	Irrigation management and improvements in irrigation efficiency.	Water Optimizer Decision Support Tool for Deficit Irrigation Multi-field Water Optimizer Model	Water Optimizer is a suite of optimization programs to predict the profit maximizing cropping strategy and corresponding amount of applied irrigation water when water supplies are limited. The Water Optimizer Suite consists of four separate, but similar models; the basic Water Optimizer, a multi-field Water Optimizer, a multi-year Water Optimizer and an independent budget calculator. The single-field single-year model seeks to maximize the average annual net return subject to water supply constraints and user specified cropping limitations. The single-field single-year model is the platform for which the multi-year and multi-field tools are built upon.
M10	RHEM A Rangeland Hydrology and Erosion Model	M.A. Nearing, H. Wei, J.J. Stone, F.B. Pierson, K.E. Spaeth, M.A. Weltz, D.C. Flanagan, M.Herandez	2011	https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0CCBQFjAA&url=http%3A%2F%2Fwww.nrcs.usda.gov%2FInternet%2FFSE_DOCUMENTS%2Fstelprdb1045656.pdf&ei=VUszUuXGKuOT2QW5-oDICQ&usg=AFQjCNH-9JxKQbCUEgImWpa8vU-8Lsx4YA&sig2=LrTavJ6t44L8ttL857h6Gg&bvm=bv.52164340,d.b2I	The Rangeland Hydrology and Erosion Model (RHEM) is a web based tool designed to model and predict runoff and erosion rates on rangelands. This model can also assist in assessing rangeland conservation practice effects. RHEM is a process-based erosion prediction tool specific for rangeland application, based on fundamentals of infiltration, hydrology, plant science, hydraulics and erosion mechanics. It is designed to use data that are routinely collected by rangeland managers and in national monitoring programs such as the Natural Resources Conservation Service (NRCS) National Resource Inventory (NRI). Using RHEM allows land managers to be proactive in preventing accelerated soil loss on rangelands by targeting areas for conservation management that are most vulnerable to soil erosion.	Watershed or Field	Event, Monthly, or Annual	Rangeland Management.	Nearing M, Wei H, Stone J, Pierson F, Spaeth K, Weltz M, Flanagan D, and Hernandez M. 2011. A Rangeland Hydrology and Erosion Model. In Transactions of the Asabe. 54 (3): 901-908. Wei H, Nearing M, Stone J, and Breshears D. 2008. A Dual Monte Carlo approach to estimate uncertainty and its applications to the Rangeland Hydrology and Erosion Model. In Transactions of the Asabe. 51(2): 515-520. Wei h, Nearing M, and Stone J. 2007. A comprehensive sensitivity analysis framework for model evaluation and improvement using a case study of the Rangeland Hydrology and Erosion Model. In Transactions of the Asabe. 50(3): 945-953	
M11	MODFLOW Modular Ground-Water Model	Arlen W. Harbaugh U.S. Geologic Survey	2005	http://pubs.usgs.gov/tm/2005/tm6A16/PDF.htm	MODFLOW is a three dimensional finite-difference model used to calculate groundwater budget. MODFLOW functions on a user defined time increment (seconds to years) over a model grid. Model inputs include pressure head, soil medium type and layer thickness, aquifer hydraulic conductivity and transmissivity, and riverbed conductance.	Model Grid	Seconds to Years	The groundwater translation portion of all conservation practices	MODFLOW-2005, The U.S. Geologic Survey Modular Ground-Water Model - The Ground-Water Flow Process	
M12	MIKE-SHE	DHI Water and Environment	2012	http://www.mikebydhi.com/Products/WaterResources/MIKESHE.aspx	MIKE SHE is a physically based hydrological and water quality modeling system that simulates surface and groundwater movment. MIKE SHE functions on a minute or day time step at a watershed scale. Hydrologic processes include evapotranspiration, overland flow, channel flow, soil water and ground water movement. Model inputs include topography, precipitation, land use, reference ET, rivers and lakes, overland flow, unsaturated zone, groundwater table, and saturated zone characteristics. MIKE SHE is GIS compatible.	Watershed	Minutes or Days	Ponds, terraces, buffers, conservation reserve programs, tillage practices, irrigation methods and management, and crop rotation, and grazing management.	DHI Software. 2007. MIKE SHE USER MANUAL VOLUME 2: REFERENCE GUIDE. Jason Yan, Joyce Zhang. Evaluation of the MIKE SHE Modeling System. http://s1004.okstate.edu/S1004/Regional-Bulletins/Modeling-Bulletin/MIKESHEfinal.html	
M13	SPUR Simulation of Production and Utilization of Rangelands	Wight (ed.), J.R.	1983		SPUR (Simulating Production and Utilization of Range Land) is a simulation and process model. Its purpose is to determine and analyze management scenarios as they affect rangeland sustainability and to forecast the effects of climate change on rangelands. ELM, BLUE GRAMA and ROOTS were studied extensively during the construction of this plant growth model.			Rangeland Management.	Wight (ed.), J.R. 1983.SPUR--simulation of production and utilization of rangelands : a rangeland model for management and research. Washington, D.C. : U.S. Dept. of Agriculture, Agricultural Research Service , no. 1431. Carlson, D.H. and T.L. Thurow. 1996. Comprehensive evaluation of the improved SPUR model (SPUR-91). Ecological Modelling. 85(2–3):229-240.	
M14	SPAW	Saxton, K. E. and P. H. Willey	2006		The SPAW (Soil-Plant-Air-Water) computer model simulates the daily hydrology of agricultural fields and ponds including wetlands, lagoons and reservoirs. Field hydrology is represented by daily climatic descriptions of rainfall, temperature and evaporation; a layered soil profile with automated water characteristics; annual crop growth; and management with crop rotation and irrigation. Pond, lagoon, and wetland simulations which have agricultural watershed fields or producer operations as their water source provide daily inundation levels as controlled by multiple input and depletion processes. Data input and file selection are by graphical screens. Simulation results are both tabular and graphical. Typical applications include analyses of crop water status, deep seepage, wetland inundation duration and frequency, lagoon designs, and water supply reservoir reliability.			Ponds	Saxton, K.E. 1989. Models for predicting water and energy relationships in soils under limited rainfall conditions. Proc. Inter. Symp. on Managing Sandy Soils, Jodhpur, India, Feb. 6-10, 1989. Saxton, K.E. and G.C. Bluhm. 1982. Regional prediction of crop water stress by soil water budgets and climatic demand. Trans. of Am. Soc. Agric. Engr. 25(1):105-110. Saxton, K.E. and P.H. Willey. 1999. Agricultural Wetland and Pond Hydrologic Calculations Using the SPAW-II. Model. Paper No. 992030, Proc., Amer. Soc. Agric. Eng. Meeting, Toronto, ON, July 18-21, 1999. Saxton, K.E. and P.H. Willey. 2004. Agricultural Wetland and Pond Hydrologic Analyses Using the SPAW model. Proc. Self-Sustaining Solutions for Streams, watersheds and Wetlands Conf., Amer. Soc. Agric. Engr., Sept. 12-15, 2004, St. Paul, MN. Saxton, K. E. and P. H. Willey. 2006. The SPAW Model for Agricultural Field and Pond Hydrologic Simulation. Chapter 17 in: Mathematical Modeling of Watershed Hydrology, V. P. Singh and D. Frevert, Editors; CRC Press, pp 401-435.	

M15	WinSRFR	Bautista, E., A.J. Clemmens, T.S. Strelkoff, J. Schlegel.	2009		WinSRFR integrates and supercedes the legacy SRFR, BORDER, and BASIN programs developed by the former U.S. Water Conservation Lab. The application provides a Windows interface to those programs and will also serve as the foundation for future development. WinSRFR is a tool to help evaluate and design border, basin, and furrow irrigation systems. The tool will assist the user in determining the optimum efficiencies and water utilization. Based on user input the model will calculate advance times, recession times, infiltration depths, runoff, deep percolation, and will provide graphical display of the efficiency and options evaluated. The model is targeted for use by the field office technicians and engineers. For USDA-NRCS, the package that is posted on the ITS Team Services website is the only certified version of this software authorized for installation on ITS workstations. Contact local ITS personnel for installation. Non NRCS users may obtain a copy of the software from the ARS Arid Land Agricultural Research center products and service page			Irrigation Methods and Management	Bautista, E., A.J. Clemmens, T.S. Strelkoff, J. Schlegel. 2009. Modern analysis of surface irrigation systems with WinSRFR. Agricultural Water Management 96 (2009) 1146–1154. Strelkoff, T.S., Clemmens, A.J., Schmidt, B.V., 1998. SRFR, Version 3.31—A model for simulating surface irrigation in borders, basins and furrows. US Department of Agriculture Agricultural Research Service, U.S. Water Conservation Laboratory, Phoenix, AZ.	
M16	FIRI 1.2 Farm Irrrigation Rating Index	John Dalton USDA-NRCS	2005	http://www.wcc.nrcs.usda.gov/ftpref/wntsc/Irrigation/FIRI/FiriMan.pdf	FIRI 1.2 is a procedure to approximate or quantify approximate water conservation through changes made to irrigation systems or through management. The program provides a standardized means of documenting change for various cost share programs and planning efforts. The model has potential application as a tool for field and watershed scale quantification of irrigation changes and the impact to water quality.			Irrigation Methods and Management		
M17	DPEVAP	Thompson, A. L., D. L. Martin, J. M. Norman, J. A. Tolk, T. A. Howell, J. R. Gilley, and A. D. Schneider.	1997		DPEVAP is an evaporation model to water losses during sprinkler irrigation of a plant canopy under field conditions. The model combines equations governing water droplet evaporation and droplet ballistics with a plant-environment energy model. The plant-environment model includes droplet heat and water exchange above the canopy and the energy associated with cool water impinging on warm leaves and soil. The combined model is intended for use in evaluating various sprinkler irrigation systems with respect to water efficiencies during irrigation of a crop.			Irrigation Methods and Management	Thompson, A. L., D. L. Martin, J. M. Norman, J. A. Tolk, T. A. Howell, J. R. Gilley, and A. D. Schneider. 1997. Testing of a water loss distribution model for moving sprinkler systems. Trans. ASAE 40(1): 81-88. Martin, D. L., W. L. Kranz, A. L. Thompson, and H. Liang. 2012. Selecting sprinkler packages for center pivots. Transactions of the ASABE. 55(2): 513-523.	
M18	AquaCrop	Raes, D., Steduto, P., Hsiao, T.C., Fereres, E. and Heng L. Food and Agriculture Organization of the United Nations	2009		Estimating attainable yield under water-limiting conditions remains central in arid, semi-arid and drought-prone environments. To address this need, FAO has been developing a yield-response to water model, AquaCrop, which simulates attainable yields of the major herbaceous crops. As compared to other crop models, AquaCrop has a significantly smaller number of parameters and a better balance between simplicity, accuracy and robustness. Root zone water content is simulated by keeping track of incoming and outgoing water fluxes at its boundaries, considering the soil as a water storage reservoir with different layers. Instead of leaf area index, AquaCrop uses canopy ground cover. Canopy development, stomatal conductance, canopy senescence and harvest index are the key physiological crop responses to water stress. Evapotranspiration is simulated as crop transpiration and soil evaporation and the daily transpiration is used to derive the daily biomass gain via the normalized biomass water productivity of the crop. The normalization is for reference evapotranspiration and CO2 concentration to make the model applicable to diverse locations and seasons, including future climate scenarios. AquaCrop accommodates different water management systems, including rainfed agriculture and supplemental, deficit, and full irrigation. Simulations can be carried out both on calendar and thermal time, and the developing versions will incorporate effects of nutrient regimes, particularly nitrogen, and of soil salinity. AquaCrop is mainly addressed to extension services practitioners, consulting engineers, governmental agencies, NGOs and farmers associations.			Buffers, conservation reserve programs, tillage practices, irrigation methods and management, crop rotation, and grazing management conservation practices.	Raes, D., Steduto, P., Hsiao, T.C., Fereres, E. and Heng L. 2008. AquaCrop Calculation Procedure, Prototype Version 2.3a. FAO, Rome, Italy, 64 p. AquaCrop. 2009. The FAO Crop Model to Simulate Yield Response to Water: I. Concepts and Underlying Principles. Agron J. 101: 426–437. D. Raes, P. Steduto, T.C. Hsiao, and E. Fereres. 2009. AquaCrop—The FAO Crop Model to Simulate Yield Response to Water: II. Main Algorithms and Software Description. Agron J. 101: 438–447 T.C. Hsiao, L.K. Heng, P. Steduto, B. Rojas-Lara, D. Raes, and E. Fereres. 2009. AquaCrop—The FAO Crop Model to Simulate Yield Response to Water: III.Parameterization and Testing for Maize. Agron J. 101: 448–459.	
M19	DSSAT Decision Support System for Agrotechnology Transfer	Jones, J.W.,G. Hoogenboom, C.H. Porter, K.J. Boote, W.D. Batchelor, L.A. Hunt, P.W. Wilkens, U. Singh, A.J. Gijsman and J.T. Ritchie	2003		Decision Support System for Agrotechnology Transfer (DSSAT) is a software application program that comprises crop simulation models for over 28 crops (as of v4.5). DSSAT is supported by data base management programs for soil, weather, and crop management and experimental data, and by utilities and application programs. The crop simulation models in DSSAT simulate growth, development and yield as a function of the soil-plant-atmosphere dynamics, and they have been used for many applications ranging from on-farm and precision management to regional assessments of the impact of climate variability and climate change. It has been in use for more than 20 years by researchers, educators, consultants, extension agents, growers, and policy and decision makers in over 100 countries worldwide.			Irrigation Methods and Management	Jones, J.W.,G. Hoogenboom, C.H. Porter, K.J. Boote, W.D. Batchelor, L.A. Hunt, P.W. Wilkens, U. Singh, A.J. Gijsman and J.T. Ritchie. 2003. The DSSAT cropping system model. Europ. J. Agronomy 18:235-265.	

CODE	SUBJECT	ARTICLE TITLE	AUTHOR/AGENCY	DATE	Article Link (if applicable)	SUMMARY	GEOGRAPHIC SCALE	TEMPORAL SCALE	NOTES
L1	General Conservation	CEAP Benchmark Watersheds: Synthesis of Preliminary Findings	C. Richardson, D. Bucks, & E. Sadler	2008	http://www.jswconline.org/content/63/6/590.short	The initial CEAP findings demonstrate progress toward the overall goals of quantifying conservation practice effects and providing tools to transfer the knowledge to points where they are applied under future conservation policy.	Nation-wide and site specific	Years	Mostly talks about using SWAT but if we could get the runoff data then would be very helpful. Does talk about individual sites (2 in Iowa are closest). The Iowa sites have buffers but since a lot is tile drained, the buffers don't work on drained water. (Also if tile drained then probably don't want to reduce runoff to streams)
L2	Terraces and Small Dams	Impacts of Non-Federal Reservoirs and Land Terracing on Basin Water Supplies	Republican River Compact Settlement Conservation Committee for The Republican River Compact Administration	2013		The study applied water balance and GIS models to summarize the impacts from basins with Non-Federal reservoirs and land terraces within the Republican River watershed. The Potential Yield Revised (POTYLDR) model was used to analyze inflow. The Water Erosion Prediction Project (WEPP) model was used to analyze terrace infiltration, and the Root Zone Water Quality Model (RZWQM) was used to analyze field hydrology. Transmission losses were analyzed using percent per mile estimates. A net seepage model was developed for reservoirs in watershed.	Regional	Years	Impacts to groundwater recharge, surface runoff, and ET were estimated and plotted for HUC-12 subbasins by terraces, reservoirs, and both terraces and reservoirs. These estimates could be applied to similar subbains in the Platte River watershed.
L3	Terraces	Field Scale Hydrology of Conservation Terraces in the Republican River Basin	B. Twombly	2009	CYT Theses LD3656 2008 .T866	Developed a field scale water balance model to evaluate conservation bench and level broadbase terraces in the Republican River basin. Field measurements were used to calibrate a RZWQM hydrologic model.	Fields in Republican Basin	Years	Conservation bench terraces in Colby, KS yielded 79.4% to deep percolation and 19.0% to ET. Broadbase terraces in Norton, KS yielded 45.5% to deep percolation and 42.4% to ET.
L4	Terraces	Modeling and Monitoring the Hydrology of Conservation Terrace Systems	T. Yonts		CYT Theses LD3656 2006 .Y668	Developed a field scale HEC-HMS model to evaluate conservation bench terraces, and steep backslope terraces with underground and grassed waterway outlets. The model was able to represent the detention effects of the terrace systems, but did not account for infiltration.	N/A	Event Basis	Shows potential for using HEC-HMS model for future work.
L5	Buffers & Terraces	Watershed Scale Impacts of Buffers and Upland Conservation Practices on Agrochemical Delivery to Streams	T. Franti, D. Eisenhauer, M. McCullough, L. Stahr, M. Dosskey, D. Snow, R. Spalding, & A. Boldt	Sep-04	http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1024&context=usdafsfacpub	Researchers compared two adjacent watersheds (340 and 400 acres) to evaluate the impact of conservation buffers on surface runoff. These watersheds feed Clear Creek, which is a tributary to the Platte River in Central Nebraska. Monitoring occured in 2002 and 2003, with similar monthly rainfall for April-June. The buffer watershed produced only 27mm of runoff compared to 47mm in the other.	Watershed	April-June for 2 years	Study provides measure of overland runoff reduction on a small watershed basis by conservation buffers.
L6	Invasive Riparian Vegetation	Do Invasive Riparian Woody Plants Affect Hydrology and Ecosystem Processes	J. Huddle, T. Awada, D. Martin, X. Zhou, S. Pegg, & S. Josiah	Apr-11	http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1300&context=natrespapers	This paper summarizes other papers. Table 2 on page 59 (12 in pdf) is very helpful. It says that in a region with 600 mm of annual precip, if you remove the trees along a river in a watershed, then you should gain around 200 mm of water yield. (I'm sure Dr. Martin can give us a better summary)	Watershed and by tree	Monthly/ Annual	Table 2 on page 59 (12 in pdf) is very helpful. It says that in a region with 600 mm of annual precip, if you remove the trees along a river in a watershed, then you should gain around 200 mm of water yield. Dr. Martin is an author on study.
L7	Narrow Grass Hedges	Narrow Grass Hedge Effects on Runoff and Soil Loss	J. Gilley, B. Eghball, L. Kramer, & T. Moorman	Jan-00	http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1128&context=biosysengfacpub	Switchgrass hedges (6 yrs old) substantially reduced runoff and soil loss. Under no-till, plots with corn residue and grass hedges averaged 52% less runoff than similar plots without hedges. Under tilled conditions, plots with corn residue and hedges averaged 22% less runoff than those without hedges. Plots without corn residue but with hedges had 41% less runoff than those with hedges.	3.7 m x 10.7 m plots in fields.	Study applied simulated rainfall to plots for 2 hours.	Narrow Grass Hedges are an effective conservation measure, especially when used in conjunction with no-till or reduced-till farming systems. This study quantifies those effects at field plot level.
L8	Terraces & Small Dams	Modeling and Field Experimentation to Determine the Effects of Terracing and Small Reservoirs on Water Supplies in the Republican River Basin above Hardy, Nebraska	Scott Guenthner	2009	http://www.usbr.gov/research/projects/detail.cfm?id=9517	Website says to contact the Principal Investigator for info about the results. There is also this website: http://www.calmit.unl.edu/people/airmak2/Projects/RepublicanRiverBasin.htm	Republican River Basin	2006-2009	Research question posed: "How are land terracing and small reservoir development affecting surface and ground water supplies?" Author/USBR may have data results from study.
L9	Terraces & Small Dams	Republican River Basin Hydroligic Simulation to Address Water Quality and Quantity (USDA And Kansas State)	KSU	Jun-10	http://www.reeis.usda.gov/web/crisprojectpages/0203306-republican-river-basin-hydrologic-simulation-to-address-water-quality-and-quantity.html	The impacts section says that an estimate of effects on land terracing on streamflow for the Prairie Dog Creek above Keith Sebelius Lake average about 3,200 AF/yr of reduction in streamflow and about 200 AF/yr increase in groundwater recharge.	Republican River Basin	2005-2010	Estimation of the effects of land terracing approach and overall estimate.
L10	Ponds and Terraces	Effect of watershed structures on water supply availability.	Koelliker, J.K., S.R. Ramireddygari, M.A. Sophocleous	1999	ASAE Paper No. 99-2123. St. Joseph, MI.: ASAE.				
L11	Canal Seepage	Determining Irrigation Canal Seepage with Electrical Resistivity	R.H. Hotchkiss, C.B. Wingert and W.E. Kelly		http://ascelibrary.org/doi/abs/10.1061/%28ASCE%290733-9437%282001%29127%3A1%2820%29	Procedures to quantify seepage losses in unlined irrigation canals for test reach of 100ft	100 ft section of canal		
L12	Canal Seepage & Conversion to buried pipeline	WaterSMART: A Three-Year Progress Report	USDOI - USBR	Oct-12	http://www.usbr.gov/WaterSMART/docs/WaterSMART-thee-year-progress-report.pdf	Progress report on USBR WaterSMART. Includes case-studies about water reuse, conservation and effiiciency	Nationwide		
L13	Canal Seepage	Canal Seepage Groundwater Recharge 2011 Demonstration Projects	DNR/Pat Goltl	2011	http://dnr.ne.gov/IWM/Presentations/CanalSeepageProjects6212012.pdf	Demonstration project with group of Nebraska irrigation districts to estimate canal seepage in Platte Basin as part of PRRIP	Platte Basin	2011-2012	Canal seepage estimates in Platte Basin can be quantified.
L14	Conversion to buried pipeline	CNPPID - Irrigation Division	CNPPID		http://www.cnppid.com/Irrigation_Division.htm	Article by CNPPID about their progress on improving canal delivery efficiency	Central Platte Basin	1975-present	Reduced transportation losses (seepage and evap) by 45 to 50%)
L15	Canal Loss and Recharge Volume	Upper Platte River Recharge and Flood Mitigation Demonstration Project: Part of Conjunctive Management Toolbox	Nebraska DNR	Jan-13	http://dnr.ne.gov/IWM/Reports/2011RechargeTM2013.pdf	Technical memo prepared that provides brief summary of canal losses and related recharge volumes	Platte Basin	Sept-Dec 2011	Spreadsheet developed through study could be tool for calculating recharge by canals using canal loss data.
L16	Irrigation Efficiency	Irrigation Efficiency and Uniformity, and Crop Water Use Effiiciency	S. Irmak, L.O. Odhiambo, W.L. Kranz, and D. Eisenhauer	2011	http://ianrpubs.unl.edu/live/ec732/build/ec732.pdf	Nebraska Extension circular describes various irrigation efficiency, crop water use efficiency, and irrigatino uniformity evaluation terms that are relevant to irrigation systems and management practices currently used in Nebraska, in other states, and around the world.	Statewide		Includes formulas to calculate water conveyance efficiency, water application effiiciency, and other delivery efficiency calculations.
L17	Surge Irrigation Management	Surge Irrigation Management	C.D. Yonts	Jul-08	http://www.ianrpubs.unl.edu/live/g1868/build/g1868.pdf	Water delivery efficiceny improvement due to surge irrigation			
L18	Terraces	Terrace dimension changes and the movement of terrace ridges resulting from different farming practices	Schoenleber, L. H		Washington, D.C. : U.S. Dept. of Agriculture, Soil Conservation Service, [1941] CYT S591 .A15 no.40-41 1941	Article by CNPPID about their progress on improving canal delivery efficiency			Canal efficiency information

L19	Terraces	The Nebraska Terrace Program : technical documentation : a technical report / prepared by Ron J. Gaddis and Curtis Winters	Gaddis, Ron J. (Ronald Jay), 1934-; Winters, Curtis N. (Curtis Neal)		UNL Libraries - [S.l. : s.n., 197-?] CYT S627.T4 N43 1970zx hdbk or http://www.worldcat.org/title/nebraska-terrace-program-technical-documentation-a-technical-report/oclc/016655790				
L20	Terraces	Modeling Runoff and Sediment Yield from a Terraced Watershed Using WEPP	Mary Carla McCullough, University of Nebraska - Lincoln Dean E. Eisenhauer, University of Nebraska - Lincoln Mike Dosskey, USDA National Agroforestry Center	2008	http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1020&context=usdafsfacpub	The Watershed Erosion Prediction Project (WEPP) was used to estimate 50-year runoff and sediment yields for a 291 ha watershed in eastern Nebraska that is 90% terraced and which has no historical gage data. Modeled results were comparable to published data.	Eastern Nebraska		Demonstrates ability to model terraces with a process-based continous simulation model.
L21	Terraces	Analytical Modeling of Irrigation and Land Use Effects on Streamflow in Semi-Arid Conditions: Frenchman Creek, Nebraska	J. Traylor	2012	http://digitalcommons.unl.edu/geoscidiss/32/	Streamflow reductions in Frenchman Creek in Republican River basin caused by irrigation, conservation terrace construction and other practices were analyzed by author using analytical model.	Republican River Basin		
L22	Terraces	USDA - Water Erosion Prediction Project (WEPP) Hillslope Profile and Watershed Model Documentation	D.C. Flanagan and M.A. Nearing (ed.)		http://www.ars.usda.gov/Research/docs.htm?docid=18073	Model Documentation for WEPP erosion model. Hydrologic component is based on the Green-Ampt infiltration and kinematic wave equations.	N/A	N/A	N/A
L23	Terraces	Conservation Practive Physical Effects Worksheet	Nebraska NRCS		http://www.ne.nrcs.usda.gov/technical/NEConservationPracStandards.html	Separate worksheet for each conservation practice. Evaluates physical effects on water quality.			
L24	Ponds	National Hydrography Dataset	USGS		http://nhd.usgs.gov/data.html	GIS vector dataset containing features including lakes, ponds, streams, rivers, canals, dams and stream gages. Age of data varies by location.	Nationwide Coverage - Shapefile	N/A	
L25	Ponds	Potential for groundwater recharge with seepage from flood-retarding reservoirs in south central Nebraska.	Eisenhauer, D. E., D. M. Manbeck, and T. H. Storck.	1982	Journal of Soil and Water Conservation. 37(1): 57-60	Groundwater recharge potential with seepage from flood reservoirs			
L26	Terraces	Effectiveness of terraces/grassed waterway systems for soil and wtaer conservation: a field evaluation.	Chow, T.L.	1999	Journal of Soil and Water Conservation. (Third Quarter): 577-593.	Soil and water conservation as result of grassed waterways and terraces			
L27	Surface Irrigation Systems	Guidelines for designing and evaluating surface irrigation systems	Walker, W.R.	1989	http://www.fao.org/docrep/t0231e/t0231e00.htm#Contents	Many equations and techniques for evaluating surface irrigation systems			
L28	Buffers	Two-Dimensional Overland Flow and Sediment Transport in Vegetative Filter	Helmers, M.J.	2003	Unpublished PhD Dissertation	?			
L29	Buffers	A design aid for sizing filter strips using buffer area ratio	M.G. Dosskey, M.J. Helmers and D.E. Eisenhauer	2011	http://nac.unl.edu/research/publications.htm	Used VFSMOD to estimate water % trapping efficiency by filter strips. Provides results for various soils, C factors based on Buffer to Watershed Area Ratios	Field and Watershed	Event	Provides nomographs for determining water trapping efficiceny based on buffer to watershed area ratio.
L30	Buffers	Evapotranspication of Cropland and Grass or Forest Buffers in Riparian Zones in Nebraska	Doroty I. Pedersen	2008		Thesis assessed the potential change in evapotranpiration resulting from the conversion of riparian zones from crop to native grass or forest buffers. Three climate regions (East, Central, West) were evaluated based on annual precipitation ranges. The FAO 56 Penman-Montieth dual crop coefficient method was used to model ET.	Regional	Annual	Provides charts of annual ET estimates for the East, Central and West regions for forest, grass, and cropland in riparian zones and estimates of potential change in ET for conversion of cropland to buffer.
L31	Buffers	Filter Strip Performance and Processes for Different Vegetation, Widths and Contaminants	T.J. Schmit, M.G. Dosskey, and K.D. Hoagland	1999	https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0CDAQFjAA&url=http%3A%2F%2Fwww.nrem.iastate.edu%2Fclass%2Fassets%2FFor460-560%2FManaging%2520AFS_hydrological%2520functions%2FSchmitt%2520et%2520al._1999.pdf&ei=s6ryUZ_RFtPOyAH-54CoCw&usg=AFQjCNGdfJAqG7LSfVzzwU5PLA5qTY5esA&sig2=NkN7Majj-npj3PO9ncRq9w&bvm=bv.49784469,d.aWc	Buffer test plots near Mead, NE were used to determine water trapping efficiency of runoff for grass, grass-shrub-tree, and contour sorghum vegetation.	Regional	Event Based	Provides water trapping efficiencies for test plots that could be scaled and applied on a field or watershed basis.
L32	Terraces	Estimating groundwater recharge from conservation bench terraces	Neibling, W.H. and J.K. Koelliker	1977	http://krex.k-state.edu/dspace/handle/2097/11410	Research was conducted in Garden City, Kansas on bench terraces with 2:1 and 4:1 watershed:bench area ratios. Computed annual groundwater recharge for each scenario for the time period of 1945-1974.	Republican River Basin	Annual	Provides estimates of impacts to groundwater recharge, surface runoff, ET, and change in soil moisture for watersheds with and without conservation bench terraces under a wheat-fallow rotation (Table 7). For instance, a bench terrace with 4:1 and 2:1 watershed:bench area ratio increases groundwater recharge by 4.78cm/yr and 2.26cm/yr, respectively.
L33	Irrigation Management	Irrigation Management Practices in Nebraska	R. Supalla, W. Miller, & B. Juliano	Sep-96	http://digitalcommons.unl.edu/ageconfacpub/67/	This article surveyed 898 irrigators (SW and GW) and says that as of 1996, only 15% reported using Surve Valves while 89% of gravity irrigators vaired flow rates between irrigations, 75% varied flow rates between hard and soft rows, 80% used every other row irrigation, and 51% used less than 12 hr sets.	Nebraska-wide	-----------------	This article helps to determine a rough estimate of how many irrigators statewide were using management practices in 1996.
L34	Cropland Conservation	Environmental Benefits of Conservation on Cropland: The Status of Our Knowledge	M. Schnepf & C. Cox	2006	http://www.swcs.org/en/publications/environmental_benefits_of_conservation_on_cropland/	This book contains D. Eisenhauer's Chapter 3 (See NS3)	International		
L35	Irrigation Scheduling, Crop Residue, Water App. Methods	Chapter 3: Water Management Practices, Irrigated Cropland	D. Eisenhauer	2006	http://www.swcs.org/en/publications/environmental_benefits_of_conservation_on_cropland/	Irrigation Scheduling can reduce water applications by 12% (Ferguson et al. 1990). Duke et al. 1978 showed a 5 to 20% reduction. Crop residue can reduce net depletion of groundwater by 50 to 75mm a year (Boldt et al. 1999). Types of irrigation application also affect efficiency.	---------------------	------------------	Irrigation Scheduling can reduce water applications by up to 20%. Crop residue can reduce net depletion of groundwater. Types of irrigation application also affect efficiency.
L36	Soil cover, Tillage	Agronomy Society Monograph No. 23 "Dryland Agriculture"	G. Peterson, P. Unger, & W. Payne			This is a 900 page book. This summary is for Chapter 3 pages 39-79. This chapter talks about soil cover, tillage, and other things that might not pertain to runoff. Cover slows runoff and increases water storage in soil. Tillage methods that retain crop residue on surface are benifitial for increasing water capture.	---------------------	------------------	Soil Cover and tillage methods that leave surface residue slow runoff and thus increase water storage in the soil. (There could be other things to gain in this monograph, I just looked at Chapter 3 for now.)
L37	Tillage	Hydraulic Conductivity, Infiltration, and Runoff from No-till and Tilled Cropland	J. Deck (D. Eisenhauer was advisor)		http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1013&context=biosysengdiss	More runoff on tilled fields than no-till. (pg 39) In center pivot fields, one had 14.9% irrigation runoff for tilled and 1.7 for no-till. Another had 52% for tilled and 38% no-till. No-till showed greater residue, depressional storage, and higher aggregate stability which pointed to higher amounts of water infiltration.	Fields in NE	2008-2010	Significantly more runoff on tilled fields than no-till sometimes.

L38	Mapping ET	Mapping Evapotranspiration	Jozsef Szilagyi/UNL	2010	http://watercenter.unl.edu/archives/2010MappingET.asp	Mean annual ET was mapped across Nebraska using a calibration-free ET mapping technique (CREMAP)	Statewide	2000-2009	
L39	Estimation of Recharge	Regional Estimation of Total Recharge to Ground Water in Nebraska	J. Szilagyi, F.E. Harvey and J.F. Ayers	2005	http://info.ngwa.org/gwol/pdf/pdf/050381131.pdf	Use of GIS land cover, elevation of land and groundwater levels, base recharge, and recharge potential. Possible verlay with conservation practices.	Statewide		Includes statewide map of recharge potential and recharge rates
L40	ET Mapping for CPNRD	Evapotranspiration Mapping for the Central Platte NRD, Nebraska	A. Kilic and I. Ratcliffe	2012	http://watercenter.unl.edu/Symposium2012/PresentationsOne/Kilic.pdf	Presentation that addresses need for better water depletion information to improve GW management, water balance and models and conjunctive management of SW and GW	Central Platte Basin	1997-2011	Applies METRIC energy balance model with Landsat imagery to develop monthly ET maps at field scale
L41	Irrigation Management Practices	Irrigation Management Practices in Nebraska	UNL		http://water.unl.edu/web/cropswater/management	Discusses irrigation management factors that indicates that irrigators should be scheduling their irrigation applications to make maximum use of precipitation and reduce excess use of irrigation water.	Nebraska-wide		
L42	Effective water use	Effective Use of Irrigation Water	M. Jensen	Jun-98	http://www.cast-science.org/publications/?effective_use_of_water_in_irrigated_agriculture&show=product&productID=2846	Report provides a comprehensive description of irrigation in the U.S. and basic principles of irrigation management.	nationwide		
L43		Natural Resource Commission	M. Quinn						Original document not located
L44	Water Use Efficiency	CALFED Water Use Efficiency Program			http://www.calwater.ca.gov/calfed/library/Archive_WUE.html				
L45	USDA FSA CRP Summary of Practices by Acre	USDA FSA CRP Summary of Practices Acreages for Prior Year Contracts Beginning in Program Year 1986	USDA	2006	https://arcticocean.sc.egov.usda.gov/CRPReport/yearly_report.do?method=displayReport&report=1997-r1meplra-31	Table that lists conservation practices and acreages by type and by county in Nebraska	Statewide	1986-present	Quantifies acreages of conservation practices by county
L46	USDA FSA Conservation Program Statistics	CRP Contract Summary and Statistics	USDA	2012	http://www.fsa.usda.gov/FSA/webapp?area=home&subject=copr&topic=rns-css	Conservation program statistics by state	State level		Lists acreages of conservation practices at state level
L47	Corn Irrigation Water Management Using ET and Soil Moisture Sensors	Corn Irrigation Water Management Using ET and Soil Moisture Sensors	Texas A&M	2011	http://itc.tamu.edu/documents/demonstrations/Colorado%20County%20Corn%20Report%202011.pdf	Results from two on-farm demonstrations			
L48	Soil Moisture Sensor Project in LRNRD	Soil Moisture Sensor Project in LRNRD	Kearney Hub (placeholder)	2011	http://www.kearneyhub.com/news/local/article_16d00b54-d084-11e0-b323-001cc4c03286.html	Article serves as placeholder in literature review for study results	Republican River Basin	2011	Successful use of soil moisture sensors for water conservation
L49	Crop Rotation	USDA-NASS CropScape - Cropland Data Layer 1997 - Current.	USDA - National Agricultural Statistics Service (NASS).	1997-current	http://nassgeodata.gmu.edu/CropScape/	Cropscape data provides raster coverage by crop type including dual crop systems on an annual basis from 1997-current.	Nationwide Coverage - Raster. Pixels are 30 or 56 meters.	1997-current	Raster coverage by crop type
L50	Crop Intensity	USDA-NASS Census of Agriculture. Years 2007, 2002, 1997, 1992...	USDA - National Agricultural Statistics Service (NASS).		http://www.agcensus.usda.gov/index.php	Census data by crop and county. Harvested Acres, Irrigated Acres, Harvested Yield, Irrigated Yield	County	Every 5yrs including 2007, 2002, 1997, 1992	
L51	Crop Intensity	Dryland Cropping Intensification: a fundamental solution to efficient use of preciptitation	Farahani, H.J., G.A. Peterson, and D.G. Westfall	1998	Adv. Agron. 64: 197-223.	Article discusses a fundamental solution to efficient use of precipitation			
L52	Tillage Reduction	Agricultural Irrigation Management: Reduce the Need for Irrigation: Maintain Crop Residue, Reduce Tillage	UNL Water: Agricultural Irrigation	1986-87	://water.unl.edu/web/cropswater/reduce	Research at Garden City, KS showed that up to 30% of ET can be evaporation during irrigation season for corn and soybean on silt loam soils. Study suggests that 2.5-3.0 inch water savings is possible when wheat straw or no-till corn stover is present from early June to end of growing season.	Kansas and Nebraska	Numerous years over course of the study	One component of study estimates 5-12 inches of water are available over the entire season for continuous no-till compared to tilled, depending on rainfall events and frequency. More rainfall or the more a crop is irrigated then the more greater the water savings.
L53	Tillage	Soil infiltration and hydraulic conductivity under long-term no-tillage and conventional tillage systems	Azooz, R.H. and Arshad, M.A.	1995	http://pubs.aic.ca/doi/pdf/10.4141/cjss96-021	Long-term no-till practices kept soil pore structure and continuity undisturbed, which contributed to significantly greater hydraulic conductivity and infiltration rates in no-till than in conventional till.	fields in Canada	2 growing seasons	Long term no-till had more infiltration (less runoff) than conventional till fields
L54	Tillage	Nebraska crop production & pest management information	Jasa, P.	2006	http://cropwatch.unl.edu/web/cropwatch/archive?articleid=1545591	Long-term no-till practices resulted in higher soil permeability and a greater rainfall rate needed to create runoff.	Nebraska		Long term no-till had more infiltration (less runoff) than conventional till fields
L55	Rangeland Management	Infiltration Rates: Three soils with three grazing levels in Northeastern Colorado	Rauzi, F. & Smith, F.	1973	https://journals.uair.arizona.edu/index.php/jrm/article/viewFile/6165/5775	Infiltration rates on light and moderately grazed lands were higher than for heavily grazed pastures (less plant material).	Northeast Colorado		
L56	Rangeland Management	Hydrologic Impact of Grazing on Infiltration: A critical Review	Gifford, G.F. & Hawkins, R.H.	1978	http://www.mojavedata.gov/deserttortoise_gov/documents/copyright_questions/STDY_Hydrologic_Impact_Of_Grazing_On_Inflitration_A_Critical_Review_GiffordG_0478.pdf	Some infiltration data exists for various range conditions and soil groups and is included in this summary paper.			
L57	Rangeland Management	Soil Bulk Density and Water infiltration as affected by grazing systems	Abdel-Magid, A.H., Schuman, G.E. & Hart, R.H.	1987	Journal of Range Management 40(4), July 1987	Infiltration was significantly lower under the heavy stocking rate than under the moderate at the end of the grazing season.	Cheyenne, WY		
L58	Rangeland Management	National Resources Inventory (with GIS)		2010	http://www.ncgc.nrcs.usda.gov/wps/portal/nrcs/detail/national/technical/nra/nri/?cid=stelprdb1041620	The National Resources Inventory website has GIS data about Rangeland health, locations, plant species, soil, etc.	Nationwide		Could use this data to locate rangeland and rangeland health with could be correlated to infiltration rates.
L59	CRP	A web-based GIS Decision Support System for managing and planning USDA's Conservation Reserve Program (CRP)	Rao. M et al.	2006	http://www.hidro.ufcg.edu.br/twiki/pub/Disciplinas/GeotecnologiaAplicada/Heber.pdf	This "program/model" could be useful in determining the CRP based conservation measures impacts. In this paper, the CRP-DSS is a prototype.			
L60	CRP	Many papers in this reference but one is "Conservation Reserve Program: Effects on Soil, Water and Environmental Quality"	Many papers in this reference but for "Conservation Reserve Program: Effects on Soil, Water and Environmental Quality", Blackburn, W.H.; Newman, J.B.; & Wood, J.C.		http://www.nativefishlab.net/library/textpdf/19864.pdf#page=31	Specifically in the "Conservation Reserve Program: Effects on Soil, Water and Environmental Quality" paper, they showed that Annual runoff and deep perc decreased and ET increased for most study sites when going from crop to CRP.	Many Western States		
L61	CRP	A Soil Quality Framework for Evaluating the Impact of CRP	Karlen, D.L.; Gardner, J.C.; & Rosek, M.J.	1998	http://wsudowntownseattle.wsu.edu/econ_development/articles/ASoilQualityFrameworkforEvaluatingtheImpactofCRP_Karlen.pdf	CRP generally increased long-term infiltration. Also, using no-till practices to return CRP land to crop production preserved soil quality benefits while tillage destroyed them almost immediately.	Southern Iowa		
L62	Surge Irrigation	Report to the United States Department of the Interior, Bureau of Reclamation Cooperative Agreement, for Surge Irrigation Research and Development Program, Grand Valley Unit	CSU Cooperative Extension?	1993?	http://www.prsurge.com/works/reclam.html	Field studies of surge use on different fields in Front Range of Colorado. Estimates of deep percolation reductions in %	Grand Valley of CO	Primarily 1993, but some 1990-1993.	Could be used to develop simplified estimates of reductions in recharge, based on the percentages developed in the studies. Limited years available, and only conducted in Front Range area.
L63	Variable Rate Irrigation (VRI)	Key Performance Indicators for Variable Rate Irrigation Implementation on Variable Soils	ASABE Meeting Presentation, Carolyn Hedley, Ian Yule, Mike Tuohy, Iris Vogeler	2009	http://elibrary.asabe.org/abstract.asp?aid=27439&t=2&redir=&redirType=	Soil water balance used on three sites to determine performance indicators for variable rate irrigation, including drainage water loss.	New Zealand	Primarily 2007-2008, but some 2004-2009.	"Drainage water" appears to include all water above soil capacity, and would include both recharge (deep perc) and overland runoff.
L64	Variable Rate Irrigation (VRI)	Agricultural Management Options for Climate Variability and Change: Variable-Rate Irrigation	Calvin Perry, Clyde Fraisse, and Daniel Dourte (University of Florida)	2012	http://edis.ifas.ufl.edu/pdffiles/AE/AE49000.pdf	General info on the practice, including a few references.	Global	No specific time period	No quantifiable techniques mentioned - just a reference document.

L65	Variable Rate Irrigation (VRI)	Variable Rate Irrigation: Concept to Commercialization	Calvin D. Perry and Andrea W. Milton (University of Georgia)	2007	http://www.ag.auburn.edu/auxiliary/nsdl/scasc/Proceedings/2007/orals/Perry.pdf	General description of practice, focused on Southeast US	Southeast U.S.	No specific time period	No quantifiable techniques mentioned - just a reference document.
L66	Crop Rotations	Crop Rotations with Full and Limited Irrigation and Dryland Management	J.p. Schneekloth, N.L. Klocke, G.W. Hergert, D.L. Martin, R.T. Clark	1991	http://panhandle.unl.edu/c/document_library/get_file?folderId=490416&name=DLFE-8307.pdf	Changes in ET - Yield relationships through different crop rotations, including moving from continuous corn to wheat-corn-soybean rotation.	West-Central Nebraska	Mainly 1986-1989	
L67	Road Effects on Hydrology	Effects of Roads on Hydrology, Geomorphology, and Disturbance Patches in Stream Networks	J.A. Jones, F.J. Swanson, B.C. Wemple and K. U. Snyder	Sep-99	http://myweb.facstaff.wwu.edu/wallin/envr435/pdf_files/jones_etal_2000.pdf	Article outlines view of how road networks interact with stream networks at landscape scale and effects on biological and ecological processes in streams and riparian systems	Oregon forests		
L68	Ecological Effects of Roads	Roads and Their Major Ecological Effects	R.T.T. Forman and L.E. Alexander	1998	http://pracownia.org.pl/pliki/roads_and_their_major_ecological_effects.pdf				
L69	Streamflow Alteration from Roads	Alteration of Streamflow Characteristics Following Road Construction in North Central Idaho	J.G. King and L.C. Tennyson	Jul-10	http://onlinelibrary.wiley.com/doi/10.1029/WR020i008p01159/abstract?deniedAccessCustomisedMessage=&userIsAuthenticated=false	Road construction effect on percent of exceedance flows in watershed			
L70	TIGER/Line Shapefiles and TIGER/Line Files.	Shape files for roads	U.S. Census Bureau	2006-current, 2000, 1992	http://www.census.gov/geo/maps-data/data/tiger-line.html	Shapefiles of roads	Statewide	2006-current, 2000, 1992	
L71	Historic Road Maps	Current and Histroi	Nebraska Counties and Nebraska Department of Roads		Obtain by County or from NDOR	Roads maps available statewide at state and/or county level	state or county		
L72	Terraces	Design, layout, construction and management of terrace systems	American Society of Agricultural and Biolgical Engineers	Jan-12	http://elibrary.asabe.org/abstract.asp?aid=41193&t=2&redir=&redirType=	ASABE Standard S268.5			
L73	Soil and Water	Soil and water terminology	American Society of Agricultural and Biolgical Engineers	Sep-07	http://elibrary.asabe.org/abstract.asp?aid=24145&t=2&redir=&redirType=	ASABE Standard S526.3			
L74	Buffers	Buffers, common-sense conservation	U.S. Department of Agriculture	1997		Program Aid 1615			
L75	Irrigation Scheduling	Using Modified Atmometers for Irrigation Management	Suat Irmak, Jose O. Payero, and Derrel L. Martin	Oct-05	http://www.ianrpubs.unl.edu/epublic/live/g1579/build/g1579.pdf	UNL NebGuide G1579			
L76	Deficit Irrigation	Effect of timing of a deficit-irrigation allocation on corn evapotranspiration, yield, water use efficiency and dry mass	J.O. Payero, D.D. Tarkalson, S. Irmak, D. Davison, J.L. Petersen	2009	http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1051&context=biosysengfacpub	Agricultural Water Management 96 (2009) 1387 - 1397	Study done in North Platte, NE	Measurements taken 2005-2006	
L77	Irrigation Scheduling	Irrigation Scheduling: Checkbook Method	Steven R. Melvin, C.Dean Yonts	2009	http://ianrpubs.unl.edu/live/ec709/build/ec709.pdf	UNL Extension Circular			
L78	Irrigation Scheduling	Irrigation Scheduling Using Crop Water Use Data	C. Dean Yonts, Norman L. Klocke	Jun-85	http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=2195&context=extensionhist	UNL NebGuide G85-753			
L79	Deficit Irrigation	Yield Response of Corn to Deficit Irrigation in a Semiarid Climate	Jose O. Payero, Steven R. Melvin, Suat Irmak, David Tarkalson	2006	http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1050&context=biosysengfacpub	Agricultural Water Management 84:1-2 (july 16, 2006), pp. 101-112			
L80	Deficit Irrigation	Response of Soybean to Deficit Irrigation in the Semi-Arid Environment of West-Central Nebraska	J. O. Payero, S. R. Melvin, S. Irmak	2005	http://bse.unl.edu/c/document_library/get_file?uuid=135188a2-de0c-4687-8a53-9e89b55060c0&groupId=4614475&.pdf	Transactions of the ASAE, Vol. 48(6): 2189-2203			
L81	Crop Rotations	Evaluating decision rules for dryland rotation crop selection	David C. Nielsen	2011	http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1872&context=usdaarsfacpub	Field Crops Research 120(2011) 254-261			
L82	Buffers	Consumptive Use Calculator. Evapo-Transpiration Calculations for Cover Types in a Non-Stressed Enviorment	USDA-NRCS	2009	http://www.dnr.ne.gov/PRRIP/docs/PRRIP_NE_DepletionPlan.html	Documentation for a spreadsheet analysis of monthly ET estimates for crop and riparian vegetative covers. Allows for computation comparison across 8 regions along the Platte River Watershed on various soil types.	Regional	Monthly/ Annual	Calcuates monthly ET estimates for buffer and cropland covers.
L83	Small Dams	Modeling Small Reservoirs in the Great Plains to Estimate Overflow and Ground-Water Rehcarge	Ravikumar B. Choodegowda	2009		Developed models to estimate reservoir overflow, gross seepage, and groundwater recharge to evaluate the aggregate effect of small dams in the Republican River Basin. The models utilize POTYLDR for inflow and reservoir water balance inputs.	Republican River Basin	Monthly/ Annual	Researchers found that these reserveroirs reduce streamflow by 74 to 97%. 90 to 95% of retained streamflow contributed ground-water recharge. Model and or estimates could be applied to Platte River Basin.
L84	Irrigation Management	Field Scale Limited Irrigation Scenarios for Water Policy Strategies	N. L. Klocke, J. P. Schneekloth, S. R. Melvin, R. T. Clark, J. O. Payero	2004	http://panhandle.unl.edu/c/document_library/get_file?folderId=490416&name=DLFE-8309.pdf	Applied Engineering in Agriculture 20(5): 623-631			
L85	Crop Production Intensity	Recommended Seeding Rates and Hybrid Selection for Rainfed (Dryland) Corn in Nebraska	Robert N. Klein, Drew J. Lyon	Jun-11	http://www.ianrpubs.unl.edu/live/g2068/build/g2068.pdf	UNL NebGuide G2068			
L86	Crop Production Intensity	Skip-Row Planting Patterns Stabilize Corn Grain Yields in the Central Great Plains	Drew J. Lyon, et al	Feb-09	http://www.plantmanagementnetwork.org/pub/cm/research/2009/skip/	Plant Management Network publication			
L87	Crop Production Intensity	Skip-Row Planting and Irrigation of Graded Furrows	J. T. Musick, D. A. Dusek	1982	http://naldc.nal.usda.gov/download/512/PDF	Transactions of the ASAE Vol. 25, No. 1, pp. 82-87 & 92			
L88	Crop Production Intensity	Grain sorghum water use with skip-row configuration in the Central Great Plains of the USA	Akwasi A. Abunyewa, Richard B. Ferguson, Charles S. Wortmann, Drew J. Lyon, Stephen C. Mason, Suat Irmak, and Robert N. Klein	Oct-11	http://agronomy.unl.edu/c/document_library/get_file?p_l_id=4128278&folderId=5159199&name=DLFE-68503.pdf	African Journal of Agricultural Research Vol. 6(23), pp. 5328-5338, 19 October 2011			
L89	Crop Production Intensity	The effect of row spacing and seeding rate on biomass production and plant stand characteristics of non-irrigated photoperiod-sensitive sorghum	John L. Snider, Randy L. Raper, and Eric B. Schwab	Jan-12	http://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1881&context=usdaarsfacpub	Publications from USDA-ARS/UNL Faculty. Paper 876, 2012			
L90	Phreatophytes/Invasive Vegetation	A Field Assessment of a Method for Estimation of Ground-Water Consumption By Phreatophytes	J.J. Butler, G.J. Kluitenberg, D.O. Whittemore	2008	http://water.usgs.gov/wrri/07grants/progress/2003KS33B.pdf	KGS and KSU Study researched magnitude of phreatophyte impact to stream-aquifer systems in Kansas. Equation to calculate ET consumption of GW prior and post vegetation treatment.	Arkansas and Cimarron River basins in Kansas	Data collected 2003-2008	
L91	Phreatophytes/Invasive Vegetation	Riparian Vegetation Impacts on Water Quantity, Quality, and Stream Ecology	D. Scott, E. Istanbulluoglu, J. Lenters, and Kyle Herman	2012	http://www.eas.unl.edu/~pmykleby/riparian/Documents/NETFinalReport.pdf	Goal of study was to develop quantitative understanding of the role of riparian vegetation dynamics, including invasive species, within Republican and Platte River basins.	Platte and Republican River basins	Reporting Period 2008-2012	
L92	Soil Moisture Sensors	Watermark Granular Matrix Sensor Soil Matric Potential for Irrigation Management	Suat Irmak, Jose O. Payero, Dean Eisenhauer, William Kranz, Derrel Martin, Gary Zoubek, Jennifer Ress, Brandy VanDeWalle, Andrew Christeiansen, Dan Leininger	2006	http://ianrpubs.unl.edu/live/ec783/build/ec783.pdf	UNL Extension Circular EC 783			

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Appendix F

CONSERVATION MEASURES STUDY PHASE II

PHASE II CONSERVATION MEASURES STUDY: IRRIGATION EFFICIENCIES AND TILLAGE PRACTICES

2017

Phase II Conservation Measures Study

Table of Contents

To:	Marc Groff, The Flatwater Group
	Thad Kuntz, Adaptive Resources, Inc.
From:	Kara Sobieski
Date:	June 30, 2016
Re:	**POAC Impact of Soil and Conservation Measure Study**
	Surface Water Model Approach and Results

This technical documentation summarizes the general approach and results for the surface water components of the Platte Overappropriated Area Committee (POAC) Impact of Soil and Conservation Measures Study. This documentation is intended to provide sufficient information to understand how the surface water model datasets were developed and/or revised for the POAC effort and the specific results from these components as they are integrated into the Western Water Use Management (WWUM) Model. This documentation, and surface water model dataset results, will be integrated into a larger document with the results from the WWUM consumptive use and ground water modeling efforts for this study.

Background

The purpose of the Conservation Measures Study is to evaluate impacts that select conservation measures may have on streamflow, in terms of amount, timing, and location, by modifying and analyzing the existing COHYST and WWUM models. The conservation measures that were ultimately selected for evaluation include changes in tillage practices and on-farm irrigation efficiencies. The impact of these conservation measures was evaluated by comparing the results of a model scenario that reflects the conservation measure to the results of a Baseline Scenario. In order to isolate the impact of a specific conservation measure using the WWUM surface water model, it is necessary to develop this Baseline Scenario in which each parameter that will be adjusted in subsequent comparative analyses is explicitly represented and can be individually adjusted while holding all other model parameters constant. The impact of the conservation measure can be analyzed in terms of change in streamflow, consumptive use, diversions, and pumping.

Baseline Scenario

The Conservation Measures Baseline Scenario is based on the existing WWUM surface water model, which reflects the historical climate conditions, hydrology, land-use conditions, and irrigation demands over the 1953 to 2013 period. A considerable amount of information and operations from the existing WWUM model was carried forward into this Baseline Scenario, however some changes were necessary in order to explicitly represent each conservation measure analyzed in this study. This section discusses revisions made to the WWUM model that resulted in the Baseline Scenario; if not specifically discussed below the Baseline Scenario used the information or operations from the existing WWUM model. Information on data and model development of the existing WWUM model is discussed in detail in the *Western Water Use Management Model Water Resources Model User's Manual* and not reproduced herein. Note that although the WWUM model includes irrigated lands in Wyoming, conservation measures were not implemented for these lands.

A comparison of the Baseline Scenario to the historical streamflow at the Lewellen gage is provided at the end of this section; additional comparisons of the Baseline Scenario results to Alternative Scenarios are provided in the Results section below. Note that the following summaries include the water supply, consumptive use, and shortages for surface water only and co-mingled irrigated lands in both Wyoming and Nebraska; Wyoming lands were included because their water use impacts the water availability at downstream diversions and streamflow in Nebraska. The summaries exclude results from ground water only irrigated lands because only a portion of the ground water irrigated acreage is included in the WWUM model.

Additional North Platte Project Supply

Many of the irrigation districts and ditches in the North Platte River Valley have three water supplies available; direct diversion of natural surface water, storage releases from the North Platte Project reservoirs; and supplemental ground water supplies. For the original WWUM modeling effort, the historical surface water diversions included both the natural flow portion and the storage releases from the Project reservoirs; estimated or metered ground water supplies supplemented the surface water diversions.

For the POAC effort, the model is used to estimate the surface and ground water supplies to meet demands that vary from historical due to changes in efficiencies or tillage practices. If these changes create a situation where an irrigation district or ditch can no longer divert natural flow under its direct rights (e.g. they are being called out by senior water rights or the river is dry), many irrigation districts or ditches have the option to meet the remaining irrigation demand by either calling for additional upstream reservoir releases or supplementing with more ground water supplies. For this effort, it is assumed that ditches would call for additional upstream reservoir releases, if available, before incurring pumping costs for additional ground water supplies. Therefore, the POAC modeling effort simulates the opportunity for irrigation districts and ditches currently under contract to receive Project reservoir water to call for additional reservoir releases during the late irrigation season (e.g. July and August).

The historical reservoir releases are already a component of the upstream streamflow that is an input into the model, these additional reservoir releases would be above and beyond the natural flow and reservoir releases already reflected in the streamflow input. Depending on reservoir storage and runoff conditions, the reservoir releases reflected in the streamflow may already be the maximum releases available from the Project reservoir allocation/quota; there may not be additional water available in the reservoirs to call for and release. In order to understand when additional reservoir releases may have been available to irrigators in the North Platte River Valley, an assessment of the reservoir contents of Pathfinder Reservoir was performed to determine years when there would have been sufficient carryover in the reservoir that would accommodate additional storage releases. Additional reservoir releases were estimated to be available in years with significant storage in the reservoir as long as those years were not followed by a dry period. The assessment indicated that 25,000 acre-feet per month of additional releases could feasibly have been made in July and August in the following years during the study period:

Table 1: "Surplus" Years for Additional North Platte Project Reservoir Releases

1973	**1983**	**1988**	**1999**
1974	1984	1996	2000
1975	1985	1997	2010
1976	1986	1998	2011
1980	1987		

For years without additional storage and for irrigation districts or ditches that are not entitled to contract reservoir releases, irrigation demand shortages were generally met from additional supplement ground water supplies, if available.

Mutual Ditch Approach

Metered co-mingled pumping is available for the most recent five years of the WWUM model study period; however it was necessary to develop co-mingled pumping estimates back in time. During the initial model development, it was assumed that the irrigation districts and ditches in the North Platte River Valley operated as mutual ditches, whereby available surface water supplies are evenly applied first to meet crop demands and remaining shortages are met by ground water supplies on lands that receive this supplemental supply. Comparisons of metered co-mingled pumping to estimated co-mingled pumping revealed that some districts and ditches did not operate as such, and the estimated pumping more closely matched those that operated under a "maximum supply" approach. The maximum supply approach occurs when ground water is used first on lands with the highest irrigation efficiency (i.e. sprinkler irrigation), and surface water is used first on lands with lower irrigation efficiency (i.e. flood irrigation) with any shortages being met from ground water supplies. In some “maximum supply” instances, the surface water supply is sufficient to meet the full crop irrigation requirement, however users still pumped ground water. Districts and ditches were assigned as either mutual ditch or maximum supply based on the pumping comparison, and that approach was used, along with the availability of surface water supplies and the crop irrigation requirement, to estimate co-mingled pumping back in time for the WWUM model.

As on-farm irrigation efficiency is a conservation measure analyzed in this study, the Baseline Scenario needed to reflect a single approach. As a majority of the co-mingled lands in the basin operate as a mutual ditch, this approach was selected for implementation in the Baseline Scenario.

Model Demand

The model allocates water to an irrigation district or ditch “demand” when there is water physically and legally available under their water rights. Using the mutual ditch approach, the model demand will first be met by physically and legally available surface water including additional reservoir releases, and then remaining un-met demand can be supplemented from ground water pumping for lands with co-mingled supplies. The WWUM model was simulated based on historical conditions; therefore the demand for each irrigation district or ditch was equal to recorded historical diversions. In order to simulate diversions under varying streamflow conditions, and account for the change in efficiencies and tillage practices, the demand was revised under each POAC scenario.

For the Baseline Scenario, the model demand was calculated by dividing the net irrigation requirement (NIR) by the average monthly system efficiency in order to “back up” the irrigation demand to the headgate. Developing the demand using this approach allows the model to allocate the amount of water needed to meet the irrigation requirement after accounting for conveyance and irrigation application losses. The Baseline Scenario demand is based on the NIR data developed for the WWUM effort, and the average monthly system efficiency is a result of the WWUM consumptive use analysis reflecting the ratio of historical diversions to NIR. The average monthly system efficiency values capture the range of efficiencies throughout the year; low system efficiency in the early summer runoff and high system efficiency later in the season when streamflow supplies are reduced. These average efficiencies capture the seasonal irrigation practices, including diversions to wet canals and fields in the early spring.

As on-farm irrigation efficiency is a conservation measure analyzed in this study, the variable system efficiency values used in the Baseline Scenario were not used to develop the demand of individual alternative scenarios. The general approach to developing demand discussed above was used in the alternative scenarios; additional details regarding the development of the demand for each POAC scenario are provided in the scenario discussions below.

Ground Water Allocations

Recent ground water allocations determined by the NRDs, which can limit the amount of ground water that irrigators pump and apply to irrigated land, were not implemented in the Baseline or Alternative Scenarios. Due the variability under which irrigators can use their allocations, it is difficult to anticipate how this water management practice may be incorporated and appropriately modeled in each alternative.

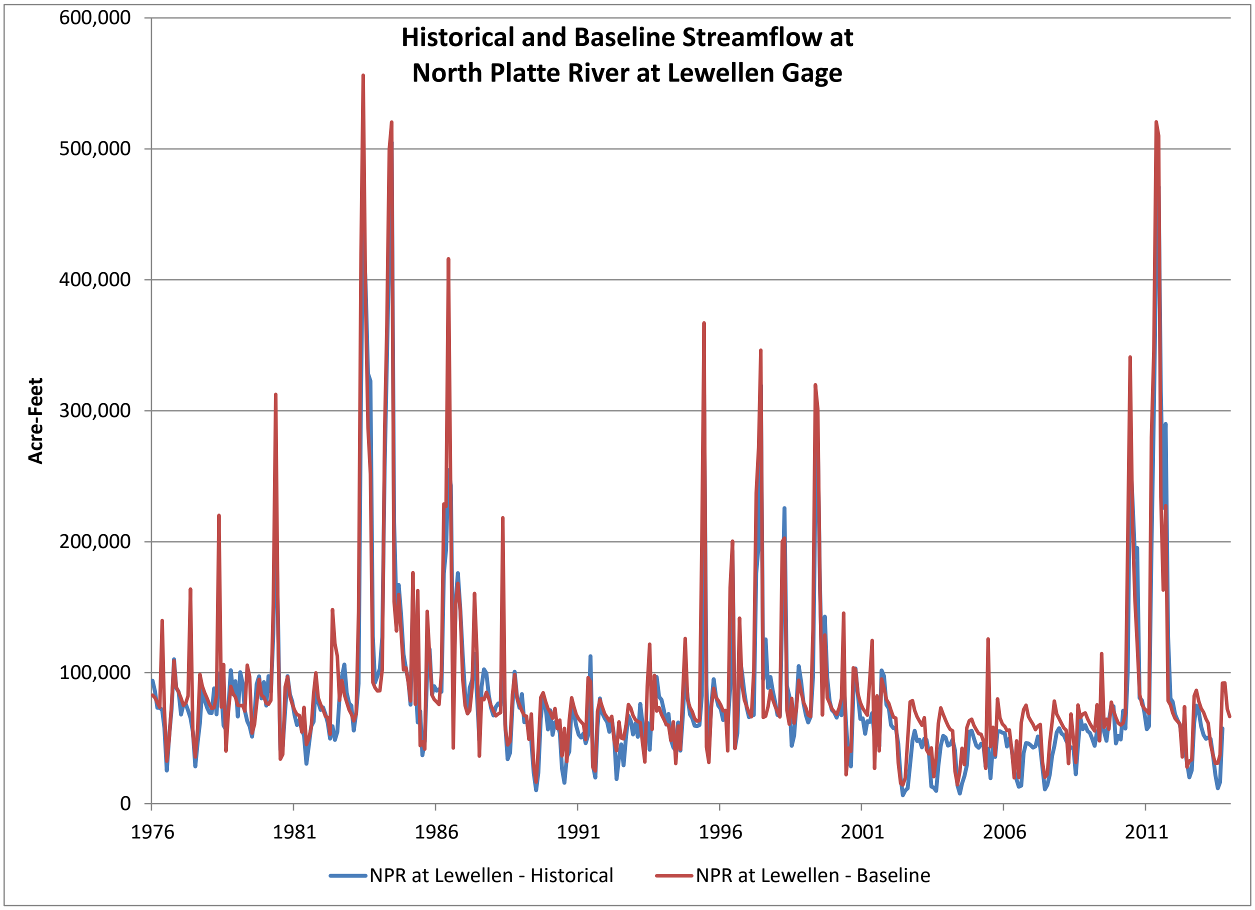
In the Baseline and Alternative Scenarios, ground water pumping is a simulated value based on the availability of surface water supplies to meet irrigation requirement and the ability of existing wells to pump to meet any remaining irrigation requirement. Therefore, pumping is only limited by the capacity of the wells and irrigation requirement, not by historical metered pumping amounts or allocations for the POAC modeling effort.

Impact to Streamflow

The revisions discussed above were applied to the WWUM model in order to create the POAC Baseline model and the model was simulated. Simulated diversions, pumping, and streamflow from the Baseline Scenario were reviewed and compared to historical records to confirm the revisions were implemented appropriately and to understand the impact of the revisions to streamflow. The cumulative effect of the differences between historical and simulated streamflow can be seen at the Lewellen gage, and as shown in **Figure 1** below, they are generally small in magnitude relative to the streamflow amount with a larger impact during dry periods.

The Lewellen gage is the integration point between the upper and lower basin POAC modeling efforts. Based on the differences shown below, it is not recommended that the lower basin POAC modeling efforts be revised to reflect the Baseline Scenario inflow; however coordination is recommended to carry the impact of Alternative Scenarios into the lower basin system.

Figure 1: Historical vs. Baseline Scenario Streamflow Comparison



First-Tier Scenario

The First-Tier Alternative Scenarios represent the "low bookend" to the potential conservation measures. Two alternatives were developed and simulated in this tier:

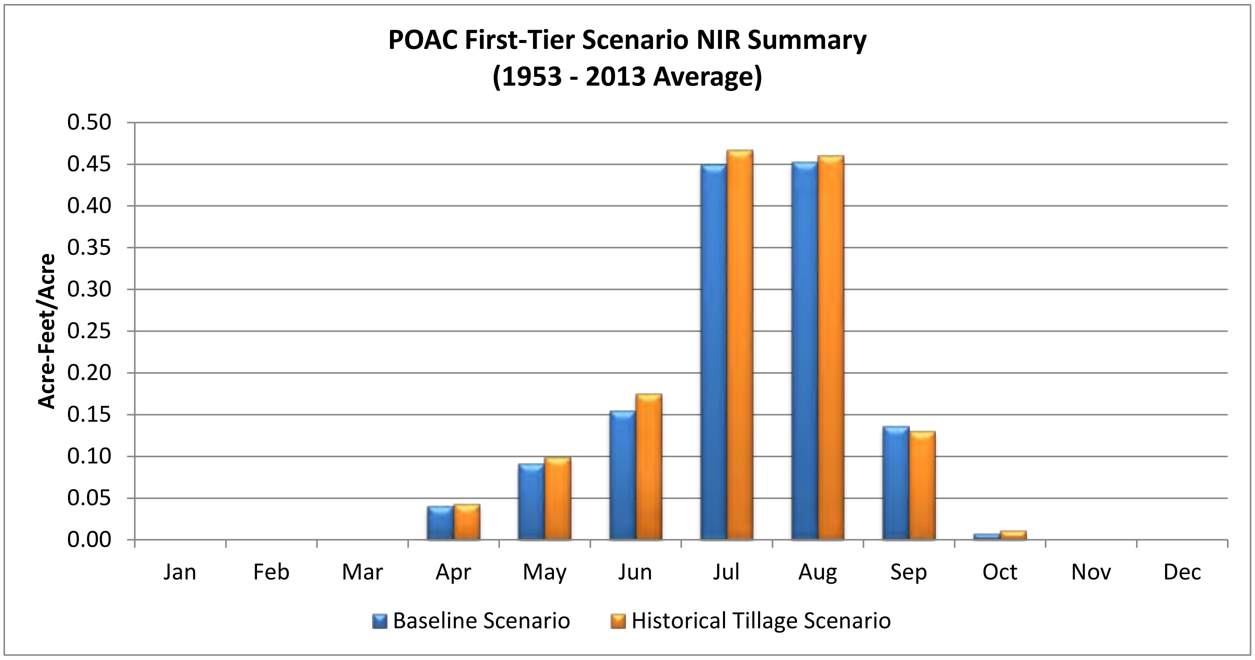
- Historical (circa-1950's) tillage practices, implemented in the model via revised NIR values.
- Low irrigation efficiencies; 50 percent on-farm efficiency for flood application and 60 percent for sprinkler application

Historical Tillage Scenario

This scenario isolates the impact of applying historical circa-1950's tillage practices throughout the full study period. The consumptive use and water allocation tools used by WWG to analyze the alternatives are not able to specifically adjust tillage practices; therefore the impact of this alternative was captured in revised NIR values as provided by The Flatwater Group (TFG) from the CropSim model. Refer to the TFG documentation for more information on how the revised tillage practices were modeled in CropSim. Accounting for historical cropping patterns in the

North Platte River Valley, the model-wide Historical Tillage NIR is greater than the Baseline NIR by approximately 4 percent, raising the unit NIR from 1.33 acre-feet/acre to 1.38 acre-feet/acre annually. As shown in **Figure 2**, the Historical Tillage Scenario has a similar monthly distribution as the Baseline Scenario NIR with the largest differential of NIR in June and July.

Figure 2: First-Tier NIR Summary

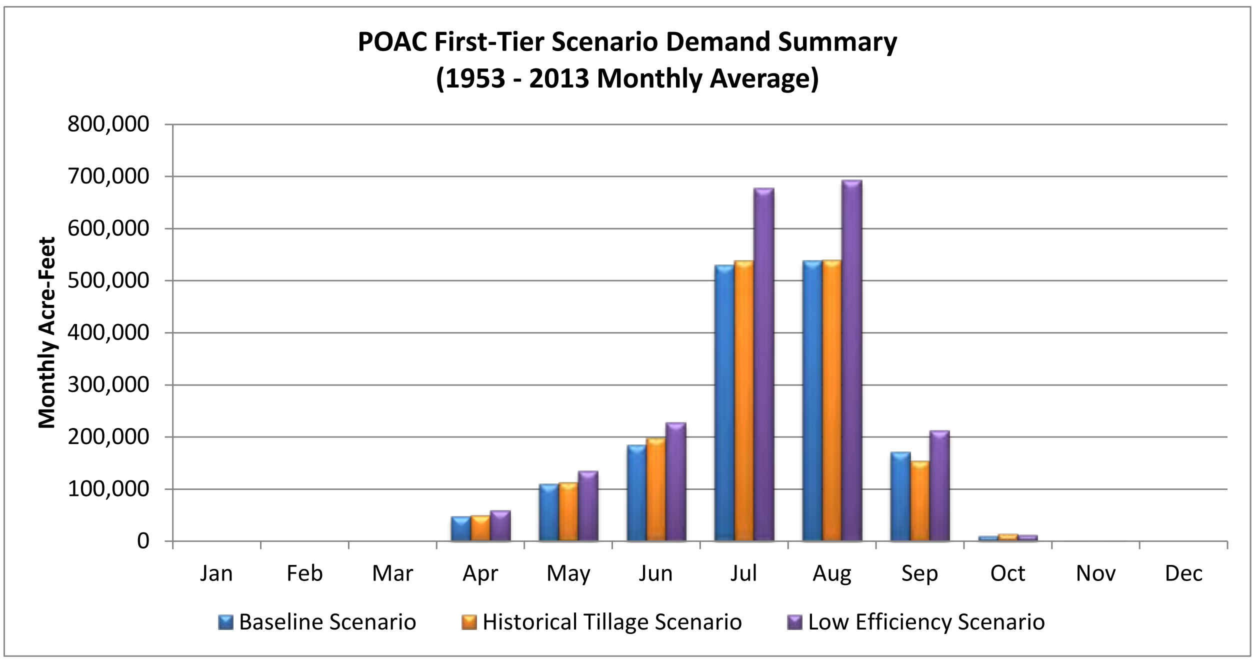


The model demand for this scenario is developed by dividing the Historical Tillage Scenario NIR by the average monthly historical system efficiency for each structure in the model to "back up" the revised demand to the headgate. Due to the minimal increase to NIR, the resulting demand for the Historical Tillage Scenario is only 1 percent greater on average annually than the Baseline Scenario demand. The increase in demand is not equal to the increase in NIR because the revised tillage practices affect crops differently under variable hydrological conditions (e.g. precipitation, soil moisture conditions). See **Figure 3** at the end of this section for a comparison of the average monthly demand from First-Tier Scenarios to the Baseline Scenario.

Low Efficiency Scenario

This scenario isolates the impact of a reduction in the Baseline Scenario on-farm application efficiencies from 65 to 50 percent for flood application, and from between 70 to 85 percent to 60 percent for sprinkler application. The model demand for this scenario was developed by dividing the Baseline Scenario NIR by the revised system efficiency for each structure in the model to "back up" the revised demand to the headgate. The revised system efficiency was calculated by first determining the composite on-farm efficiency accounting for the amount of flood and sprinkler acreage annually served by each structure, then multiplying this composite value by the canal efficiency. For example, if a structure served 100 acres total, with 75 acres served by sprinkler and 25 acres flood irrigation, the composite on-farm efficiency would be 57.5 percent. In this example, if the conveyance efficiency for the structure was 70 percent, then the system efficiency would be approximately 40 percent. Note that one composite system efficiency value was developed for each year in order to capture the change in acreage and the improvement from flood to sprinkler irrigation practices over time. The resulting demand for the Low Efficiency scenario is approximately 25 percent greater on average annually than the Baseline Scenario demand. **Figure 3** reflects the average monthly demand from First-Tier Scenarios compared to the Baseline Scenario.

Figure 3: First-Tier Demand Summary



Second-Tier Scenario

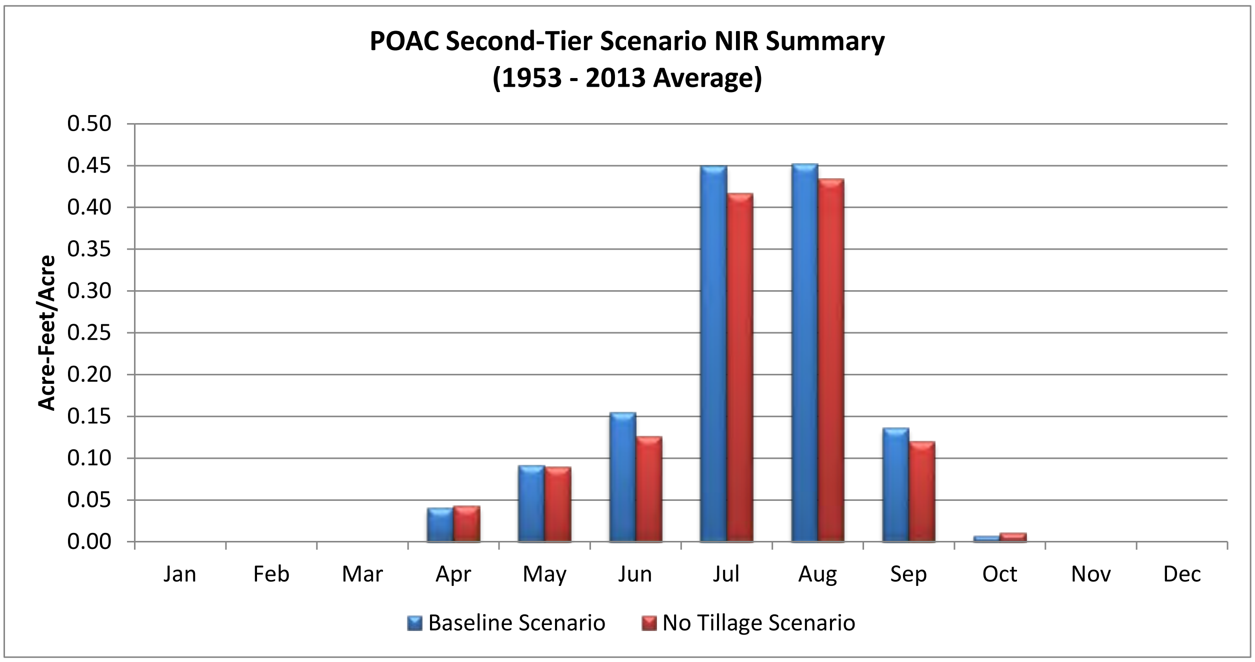
The Second-Tier Alternative Scenarios represent the “high bookend” to the potential conservation measures. Two alternatives were developed and simulated in this tier:

- No tillage practices, implemented in the model via revised NIR values.
- High irrigation efficiencies; 90 percent on-farm efficiency for flood and sprinkler application

No Tillage Scenario

This scenario isolates the impact of applying no tillage practices throughout the full study period. As discussed in the Historical Tillage scenario section above, refer to the TFG documentation for more information on how the no tillage practices were modeled in CropSim. Accounting for historical cropping patterns in the North Platte River Valley, the model-wide No Tillage NIR is less than the Baseline NIR by approximately 7 percent, reducing the unit NIR from 1.38 acre-feet/acre to 1.24 acre-feet/acre annually. As shown in **Figure 4**, the No Tillage Scenario has a similar monthly distribution as the Baseline Scenario NIR with the largest differential of NIR in June and July.

Figure 4: Second-Tier NIR Summary

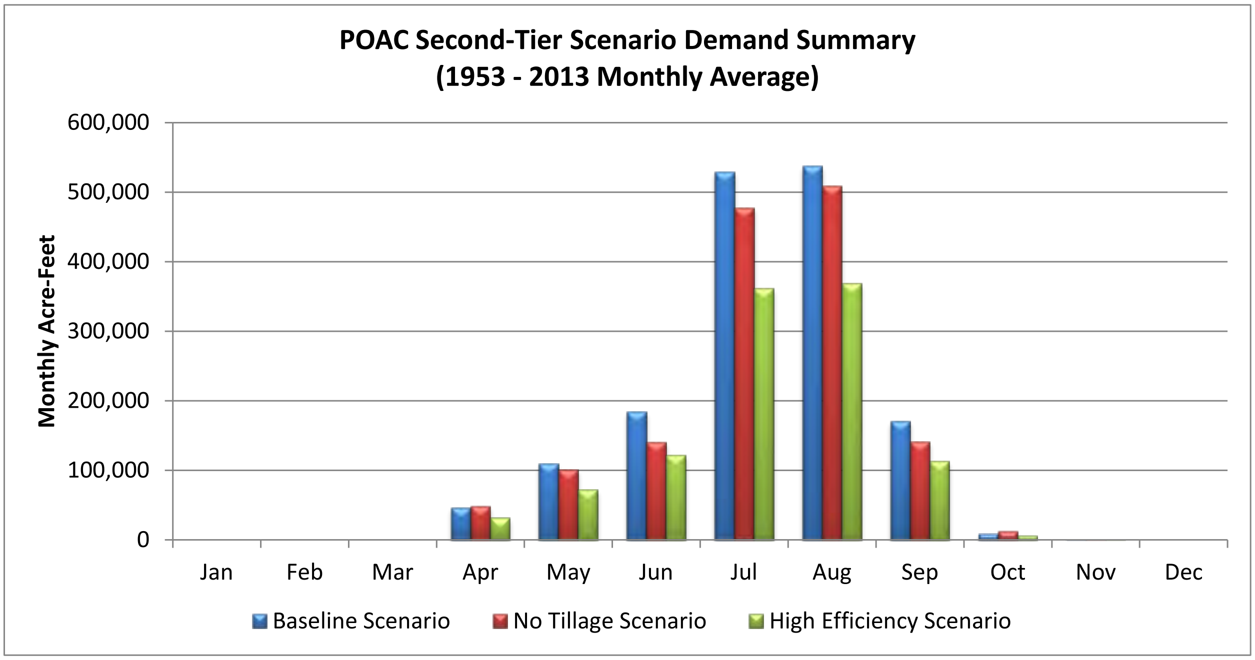


The model demand for this scenario is developed by dividing the No Tillage Scenario NIR by the average monthly historical system efficiency for each structure in the model to "back up" the revised demand to the headgate. The resulting demand for the No Tillage Scenario is 10 percent less on average annually than the Baseline Scenario demand. As discussed above, the decrease in demand is not equal to the decrease in NIR because the revised tillage practices affect crops differently under variable hydrological conditions. See **Figure 5** for a comparison of the average monthly demand from Second-Tier Scenarios to the Baseline Scenario.

High Efficiency Scenario

This scenario isolates the impact of an increase to the Baseline Scenario on-farm application efficiencies to 95 percent for both flood application and sprinkler application. The model demand for this scenario was developed by dividing the NIR by the revised system efficiency for each structure in the model to "back up" the revised demand to the headgate. As the increased efficiency is the same for both flood and sprinkler application, it is not necessary to develop the acreage-weighted composite on-farm efficiency as outlined for the Low Efficiency Scenario. Rather, the revised system efficiency was calculated by multiplying the increased on-farm efficiency by the canal efficiency. The resulting demand for the High Efficiency scenario is approximately 30 percent less on average annually than the Baseline Scenario demand. **Figure 5** reflects the average monthly demand from Second-Tier Scenarios compared to the Baseline Scenario.

Figure 5: Second-Tier Demand Summary



Model Integration Deliverables

The Baseline and four scenarios were simulated over the 1953 to 2013 period and the results were delivered to the POAC technical consultants for integration into the consumptive use and ground water models. The following data types were provided in the deliverable:

- Conveyance Loss: Monthly time series of conveyance loss associated with the simulated diversions in each scenario; integrated into the ground water model as canal and lateral recharge.
- Simulated On-Farm Diversions: Simulated diversions less conveyance loss; integrated into the consumptive use model as surface water supply.

- Simulated Co-Mingled Pumping: Simulated pumping on co-mingled lands: integrated into the consumptive use as supplemental ground water supply and ground water model as pumping demands.

Refer to the documentation associated with the POAC Scenario consumptive use and ground water models for more information on the integration of these components.

Scenario Results

The First and Second Tier scenarios were intended to "bookend" low and high levels of conservation on the North Platte River Valley in order to provide a cursory understanding of how water supply and streamflow may react under these conditions. As a comparative modeling approach was used, this section provides tabular and graphical results from each scenario as they compare to the Baseline Scenario results. Note that graphical results focus on the efficiency scenarios as the tillage scenarios did not impact water availability or streamflow as significantly as the efficiency scenarios.

The following notes and observations can be drawn from the results:

- As discussed in the Baseline Scenario section, conservation measures were not implemented for irrigated lands in Wyoming, which constitute approximately one quarter, or 92,000 acres, of the surface water and co-mingled acreage in the North Platte Valley. The following summaries include their diversions, use of additional upstream storage, co-mingled pumping, consumptive use, and shortages because their water use impacts the water availability at downstream diversions and streamflow in Nebraska.

- Only a portion of the ground water only acreage in the North Platte River Valley is included in the surface water model, therefore the following summaries exclude the water use on these lands. Full reporting of the POAC conservation measures on ground water only lands is provided in the POAC documentation of the ground water model scenarios. Ground water related information presented herein is limited to supplemental/co-mingled ground water supplies only.

- The Low Efficiency Scenario resulted in an increase of river diversions and additional upstream storage releases as shown in **Figures 6 and 7**, however many structures are still limited by the amount of surface water available for diversion. The bulk of these shortages are met from co-mingled pumping, which increases two-fold in this scenario compared to the Baseline Scenario. Under 2002 drought conditions, annual co-mingled pumping exceeded 250,000 acre-feet in this scenario (**Figure 8**).

- As discussed above, the Historical Tillage Scenario and No Tillage Scenario results are relatively similar to the Baseline Scenario. Results from the Historical Tillage Scenario, as shown in **Table 2**, indicate that the increase in NIR is generally met from additional upstream storage release and co-mingled pumping, as the historical diversions are similar in magnitude to the Baseline Scenario. This correlates with the monthly distribution of the Historical Tillage NIR; it is greater than the Baseline Scenario in July and August when streamflow is lowest and additional diversions are not available.

- The No Tillage Scenario results reflect reduced river diversions, upstream storage releases, and co-mingled pumping that corresponds in magnitude to the reduction in NIR for the scenario. This reduction in overall supply, however, results in a less than 2 percent impact on the streamflow at the Lewellen gage.

- The High Efficiency Scenario results reflect a significant increase in consumptive use, with almost 60,000 acre-feet of additional consumptive use each year compared to the Baseline Scenario results. As expected in water short systems and reflected in **Figure 9**, consumptive use increases when efficiency increases. The consumptive use is generally met by more efficient use of the river diversions, resulting in a significant reduction in upstream releases and co-mingled pumping. Co-mingled pumping is reduced to 11,000 acre-feet on average annually in this scenario, and dropping to less than 1,000 acre-feet during wet years as reflected in **Figure 8**.

- As reflected in **Figures 12** through **14** below, the conservation measures cause the greatest impact on the streamflow at the Lewellen gage during dry years. The Low Efficiency scenario results in higher streamflow volumes annually by reducing the amount of water available to crop consumptive use and increasing the return flows during the non-irrigation season when they are generally not re-diverted or consumed. Conversely, the High Efficiency scenario has greater consumptive use of diverted water with reduced return flows during the non-irrigation season. This impact equates to over 58,000 acre-feet less streamflow at the Lewellen gage on average annually over the 1953 to 2013 period.

Table 2: POAC Scenario Results Summary

Percent Change of the Baseline Scenario
Average Annual (1953 – 2013)

Water Use Parameter	Baseline	First-Tier Scenarios Low Efficiency	 Historical Tillage	Second Tier Scenarios No Tillage	 High Efficiency
Total River Diversions [1]	1,353,000	**+ 7%**	No Change	**- 6%**	**- 19%**
Additional Upstream Storage Releases [2]	22,000	**+ 23%**	**+ 5%**	**- 23%**	**- 86%**
Co-mingled Pumping	41,000	**+ 110%**	**+ 7%**	**- 15%**	**- 73%**
NIR	544,000	No Change	**+ 4%**	**-7 %**	No Change
Consumptive Use	450,000	**- 12%**	**+ 3%**	**- 5%**	**+ 13%**
NIR Shortages	94,000	**+ 59%**	**+ 11%**	**- 17%**	**- 63%**
Return Flows	927,000	**+ 20%**	**- 1%**	**- 7%**	**- 37%**
North Platte River at Lewellen Streamflow	1,092,000	**+ 5%**	**- 1%**	**+ 2%**	**- 5%**

[1] Includes direct diversions, diversion of Additional Upstream Storage Releases, and diversions to storage at Inland Lakes.

[2] Average based on years when additional upstream storage was made available, see "Surplus" Years table.

Figure 6: Diversion Summary

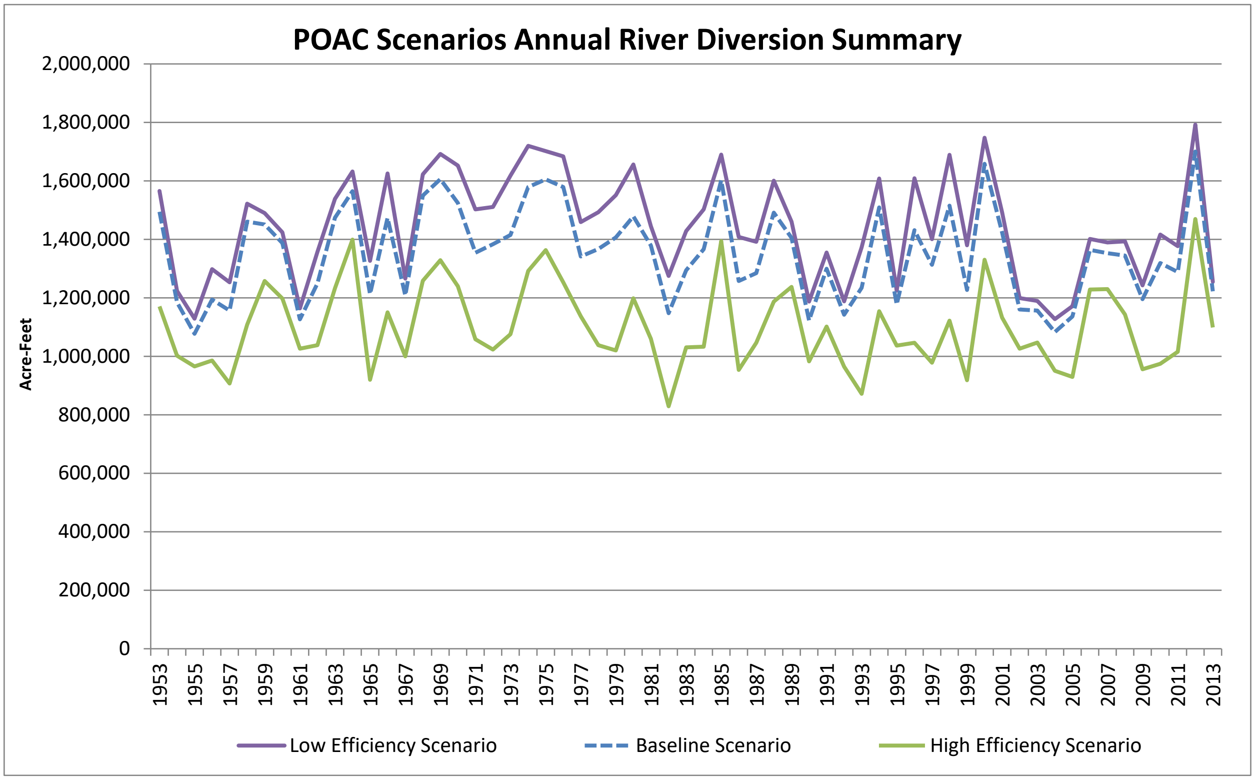


Figure 7: Additional Upstream Storage Release Summary

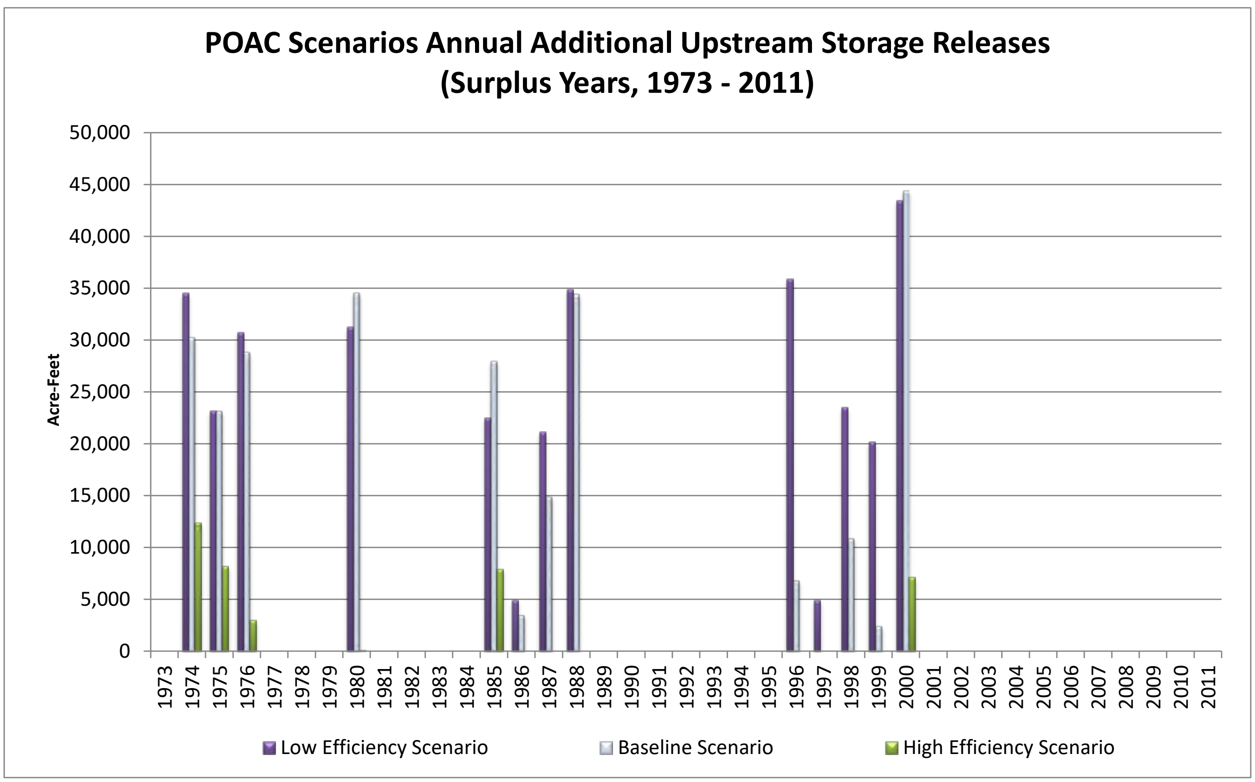


Figure 8: Co-mingled Pumping Summary

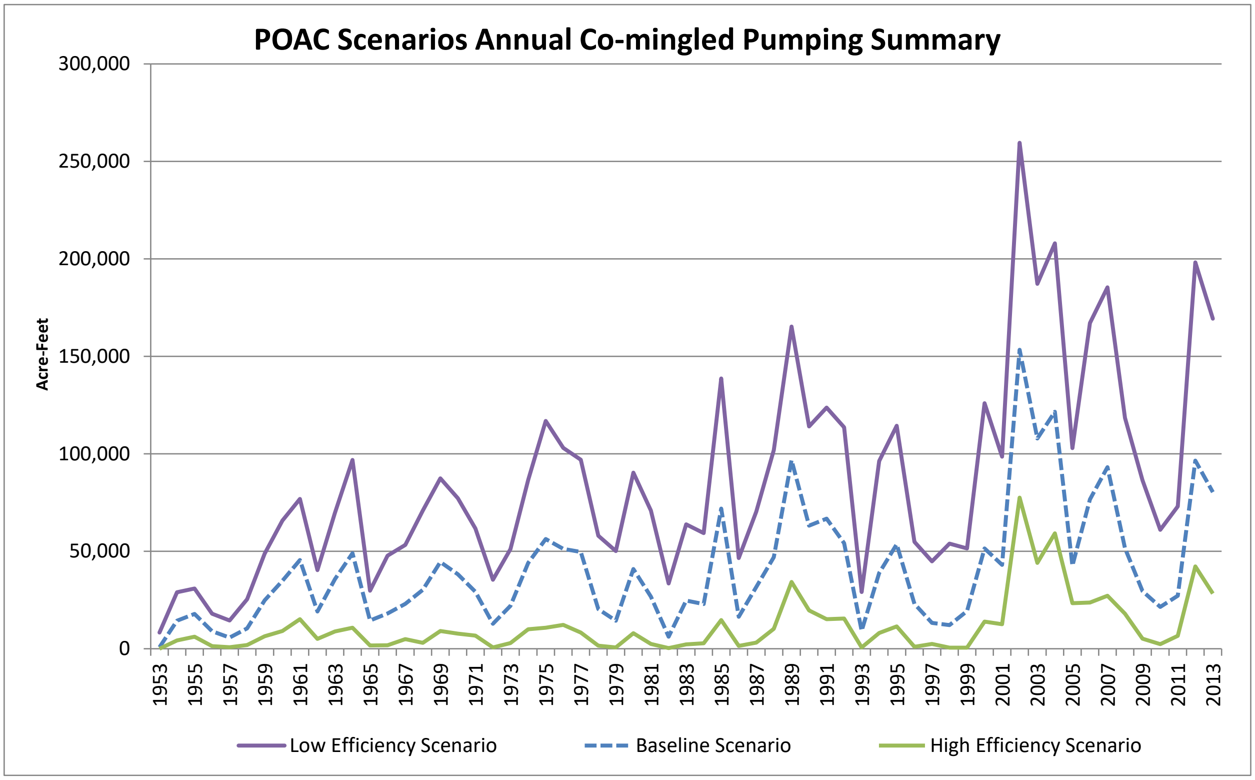


Figure 9: Consumptive Use Summary

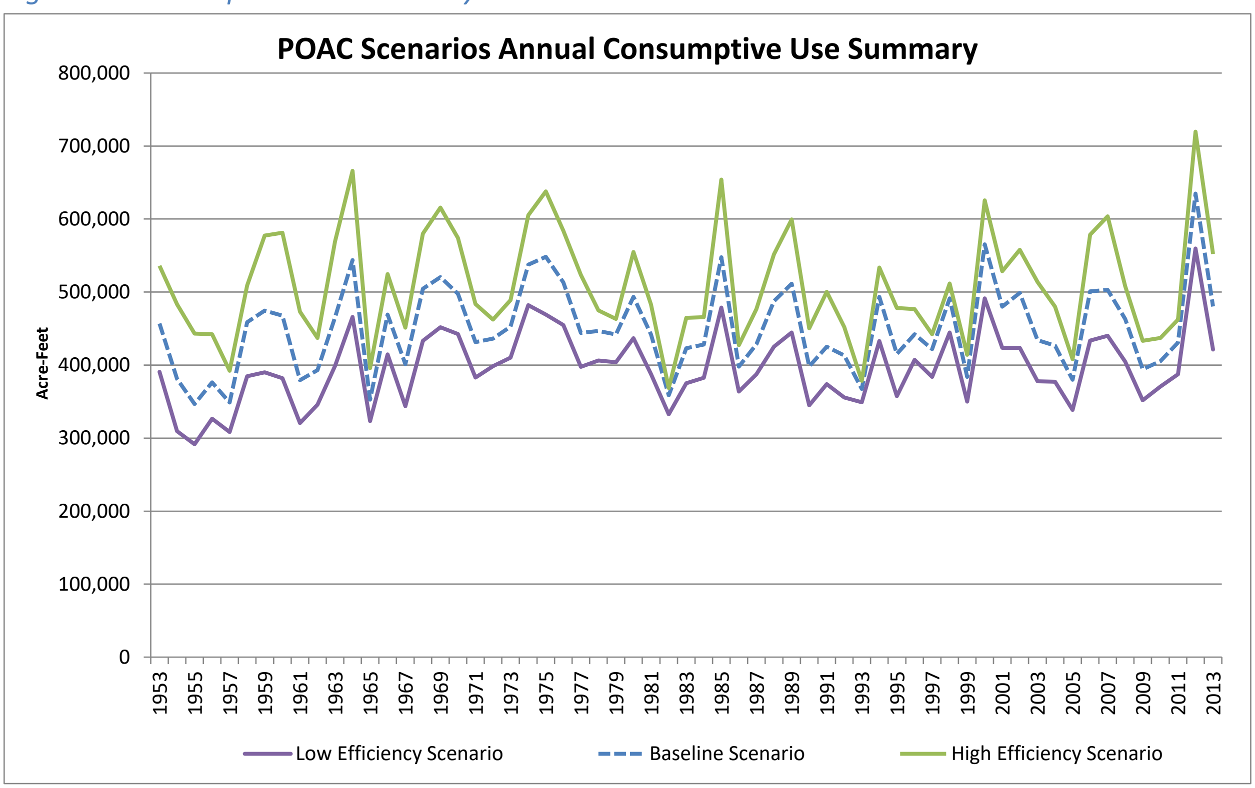


Figure 10: NIR Shortage Summary

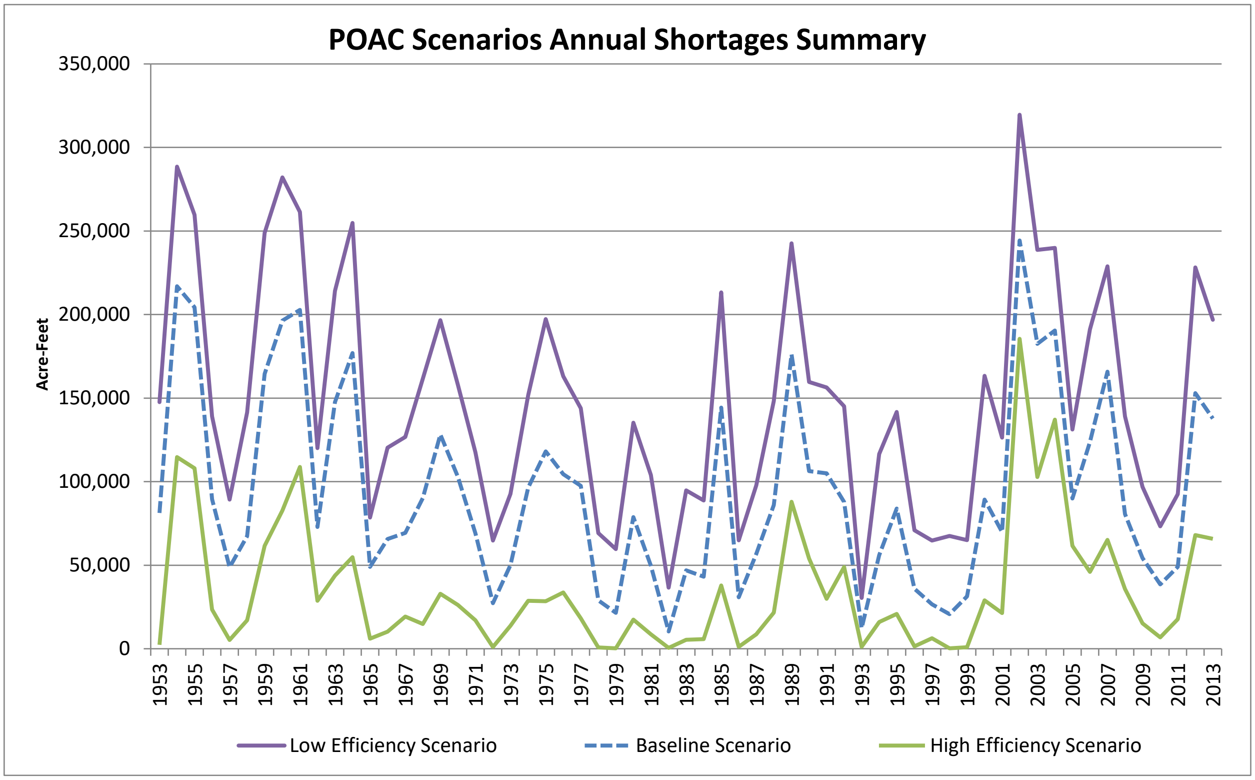


Figure 11: Return Flow Summary

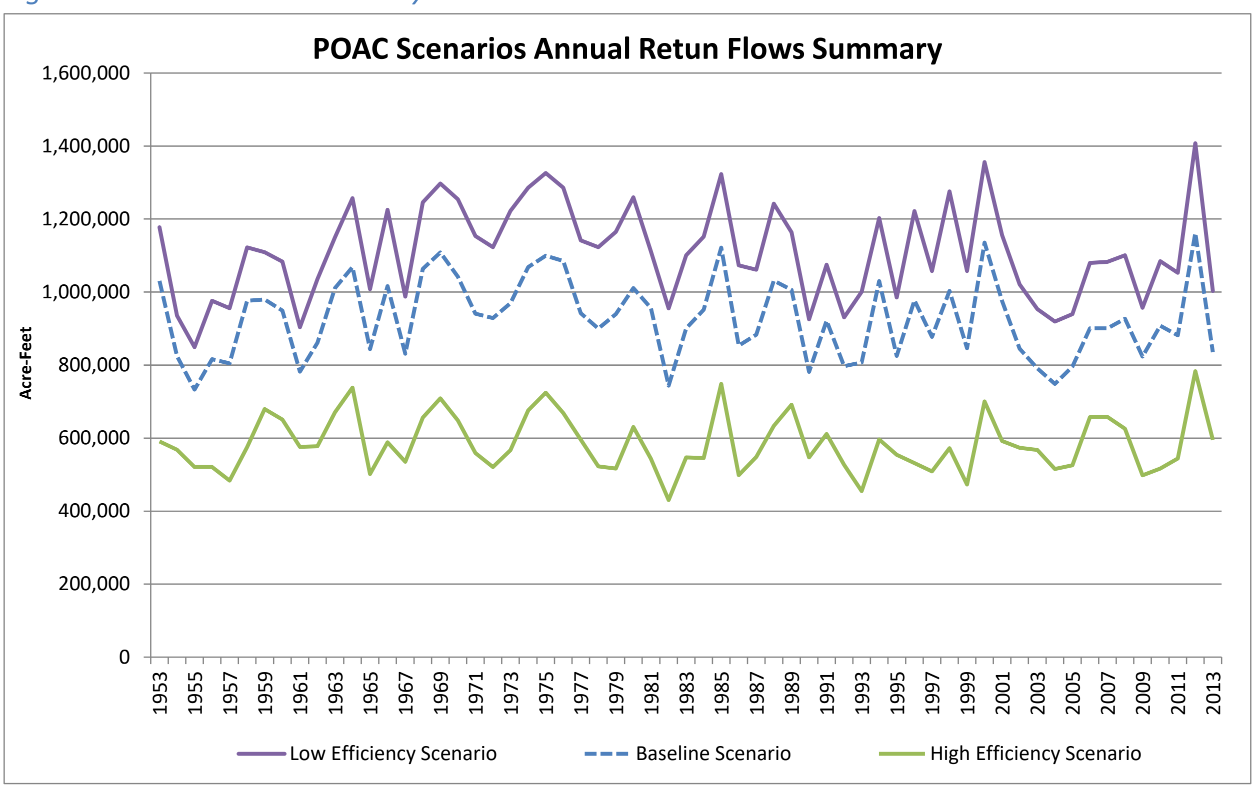


Figure 12: Annual Streamflow Summary

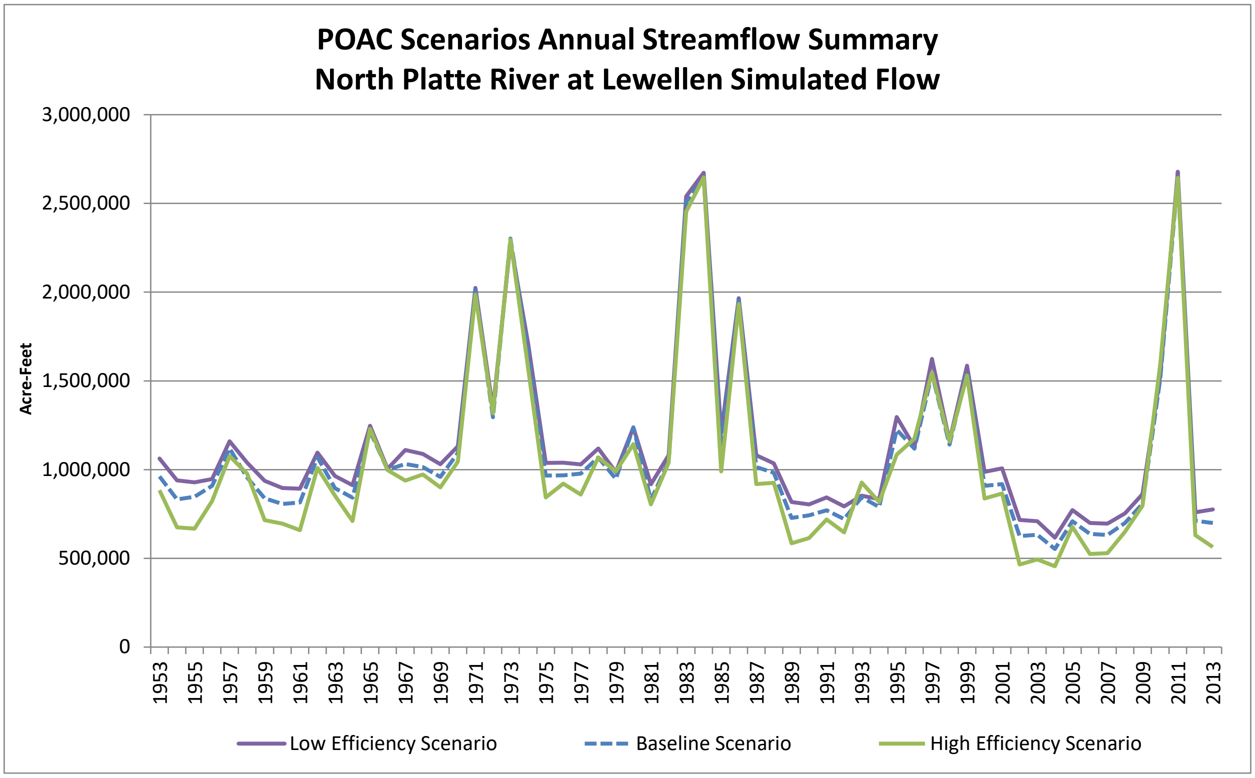


Figure 13: Average Monthly Streamflow Summary

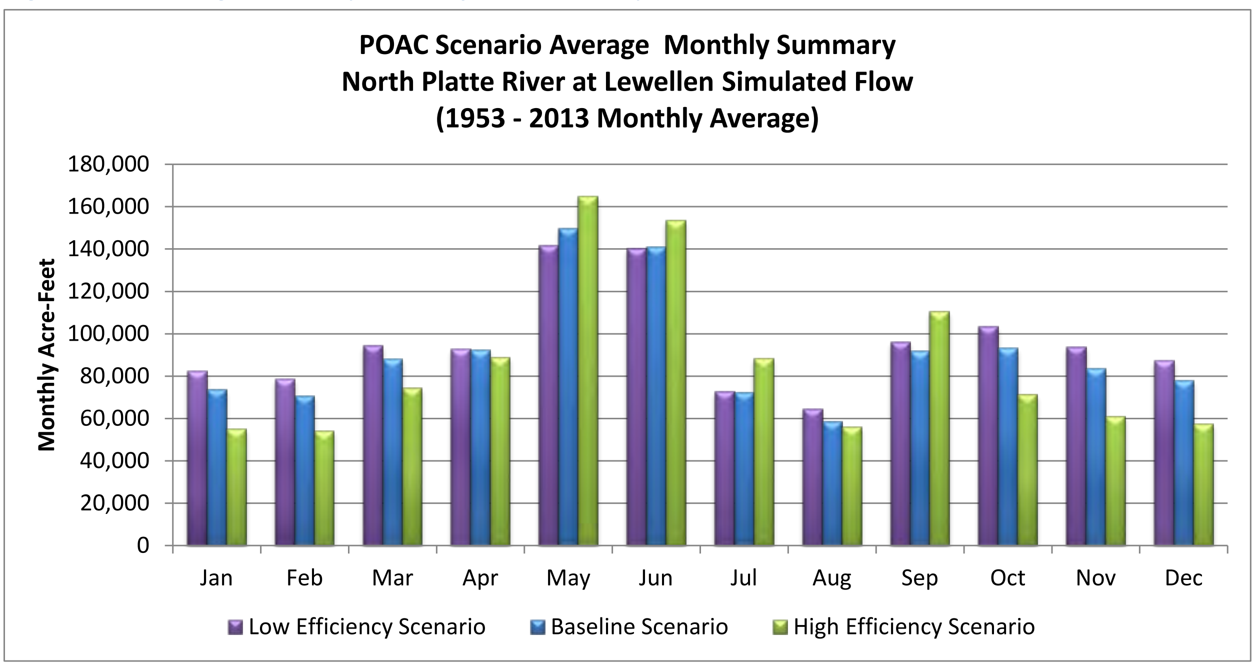
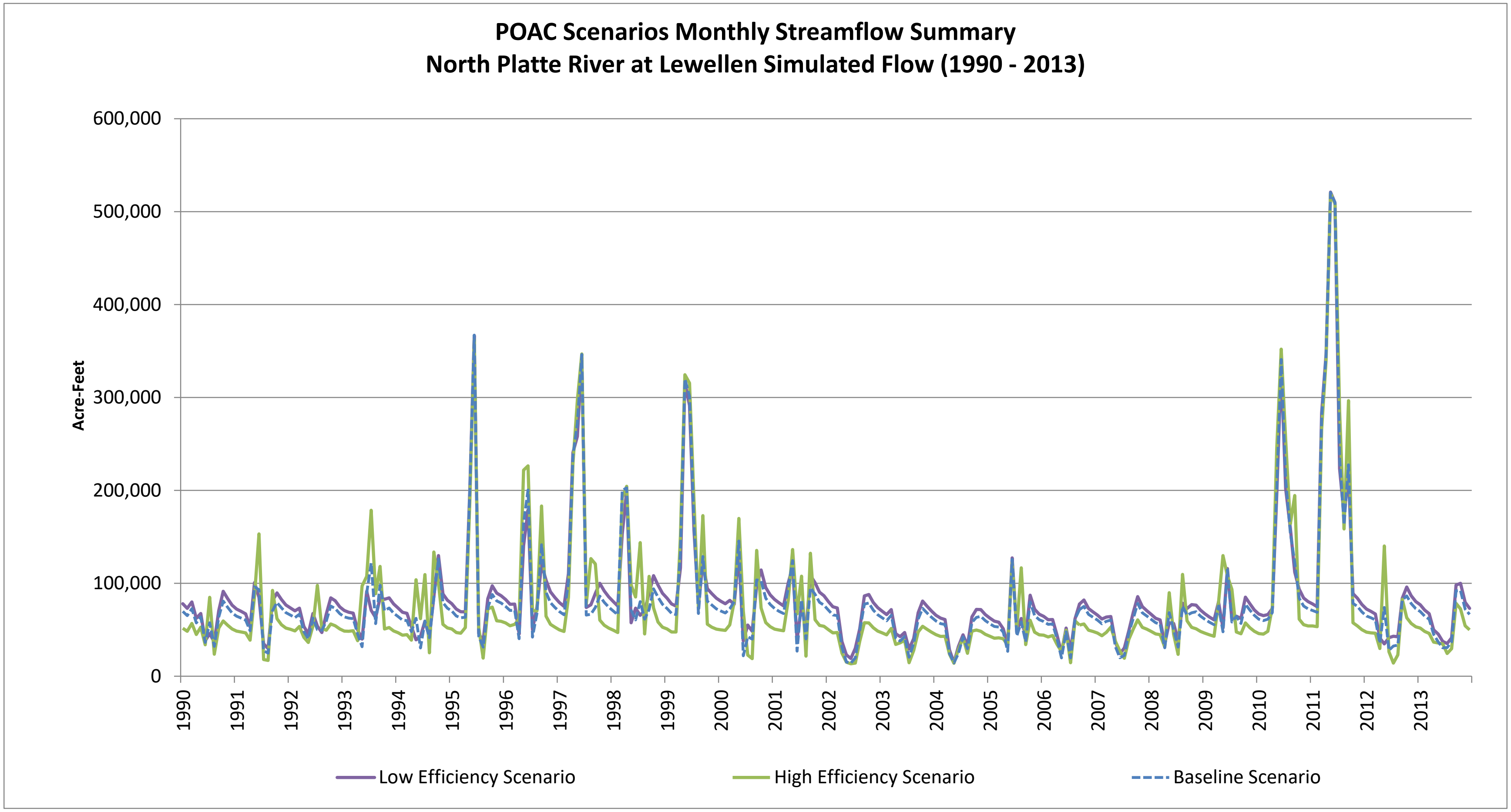


Figure 14: Monthly Streamflow Summary



Adaptive Resources, Inc.

To: File
From: Thad Kuntz, P.G., Heath Kuntz, Joe Reedy, G.I., and Jason Yuill
CC:
Date: 9/1/2017
Re: Conservation Measures Study - Ground Water Modeling Analysis and Results

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INTRODUCTION AND EXECUTIVE SUMMARY

The Conservation Measures Study (Study) uses the Western Water Use Management Modeling (WWUMM) suite of models to estimate the effects of different irrigation efficiency and tillage practices on the ground and surface water resources in the North Platte and South Platte Natural Resources Districts (Districts). The Study is comprised of four analyses, comparing four modified simulations to a historical baseline simulation using the surface water operation model, ground water model, and regionalized soil water balance model. The study period used the existing model's time frame of May 1953 through April 2013.

The first two analyses modeled changes in irrigation practices as compared to the baseline simulation. The irrigation practices considered were low and high irrigation application efficiencies required to meet crop irrigation demands. The baseline simulates historical irrigation efficiencies while the low irrigation efficiency simulation utilizes irrigation applied through either flood irrigation or inefficient early center pivot sprinklers. The high irrigation efficiency simulation applies irrigation using highly efficient sprinkler irrigation technology.

Like the irrigation practice analyses, the tillage practice analyses used a baseline simulation that employs the historical tillage practices on irrigated lands. The baseline simulation was compared to two simulations using either circa-1950's tillage practices or a minimum tillage, or no-till simulation. Each simulation maintained these practices over all irrigated lands and years.

The results of the Study indicate that the effects of each practice vary between the Districts. North Platte Natural Resources District (NPNRD) realizes increased stream baseflow as a result of low efficiency irrigation methods and minimum tillage practices. The increase in stream baseflow from low-efficiency irrigation methods is likely an effect of the additional recharge that occurs from increased surface water diversions in response to the higher irrigation demand, as the North Platte River is a surface water dominated system with an abundance of canals. To a smaller degree, a minimum till approach also has the potential to increase stream baseflow by increasing the amount of recharge into the aquifer through higher infiltration rates and reduced soil evaporation. South Platte Natural Resources District (SPNRD) sees increased stream baseflow as a result of high efficiency irrigation methods and minimum tillage practices. The South Platte River and Lodgepole Creek systems are ground water dominated and may realize greater stream baseflow (or decreased stream baseflow depletion in losing reaches) from decreases in ground water withdrawals, which reduces ground water capture prior to entering the Lodgepole Creek or South Platte River. A minimum till approach has a similar impact in SPNRD as NPNRD. Graphs representing pumping, recharge, and stream baseflow are provided in the text of this report.

CONCEPTUAL DESIGN OF THE ANALYSES

The simulations conducted for this study were completed by modifying the historic irrigation efficiencies and tillage practices of the WWUMM. These modifications are applied throughout the modeling time frame of 1953 through 2013. The following is a list and description of each model simulation and the accompanying modifications:

- Baseline Model – No modifications, irrigation efficiencies and tillage practices reflect historic values and practices.
- High Irrigation Efficiency - All irrigated lands irrigation efficiencies were set at center pivot sprinkler efficiency of 95%.
- Low Irrigation Efficiency – All irrigated lands irrigation efficiencies were set at flood/gravity or low-efficiency center pivot sprinkler irrigation of 50% or 60% respectively.
- Minimum or No Tillage Practices – All irrigated lands tillage practices were set to minimum tillage or no till practices depending on the crop type.
- Circa-1950's Tillage Practices – All irrigated lands tillage practices were set to conventional tillage practices prevalent in the 1950's.

The results from each modified model are compared to the baseline model result. The comparison provides the estimated change in stream baseflow (ground water portion of total streamflow) as a consequence of the different pumping and tillage scenarios.

MODELING ANALYSES

The WWUMM suite is comprised of a regionalized soil water balance (RSWB) model, surface water operations (SWO) model, and ground water (GW) model. The model area includes the Southern Panhandle of Nebraska as well as portions of Colorado and Wyoming. For this Study, simulations were carried out by The Flatwater Group (TFG, operating the RSWB model), Wilson Water Group (WWG, operating the SWO model), and Adaptive Resources, Inc. (ARI, operating the GW model). Using the existing WWUMM, the following changes were made to generate a baseline model for these analyses.

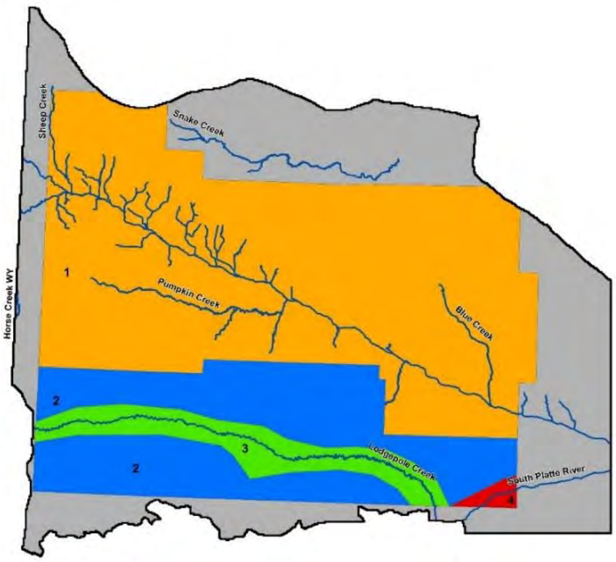
1. The original WWUMM SWO model was modified to create a new baseline model, in which all surface water lands are considered to be mutual ditch, and all users within a canal system share the surface water equally. This change may affect the surface water diversion demands and commingled pumping. In the original modeling, two methods were employed, determined by the amount of diversion and the pumping characteristics of each irrigation district or canal company.
2. If additional storage water was available in the Wyoming reservoirs, the SWO model could utilize that excess water.
3. Only modeled pumping estimates were used to complete a comparison with each conservation practice. Without using metered pumping, the models can determine the change in surface water deliveries, pumping, recharge, and stream baseflow without confusing the comparison with allocation pumping restrictions.

To complete each modified modeling analysis, TFG modified the irrigation efficiencies and tillage practices of the baseline RSWB model to generate net irrigation requirement, recharge, and ground water only pumping datasets. Using information from the RSWB model, the SWO model simulated the surface water system and generated canal recharge and commingled pumping. These datasets were provided to ARI in the form of recharge and pumping which was incorporated with the steady-state municipal, industrial, feedlot, and domestic wells. The final well and recharge files were used in the GW model analyses.

The hydrostratigraphic unit process is a zonal analysis tool that tracks changes in ground water flow and volume at specific model cells. For this Study, the active model area was partitioned based on NRD boundaries, as well as roughly estimated basin boundaries (determined from pumping distribution) in

SPNRD. The map of zones used in the hydrostratigraphic unit process is demonstrated in Figure 1. Zone one encompasses NPNRD, zones two through four encompass SPNRD, with zone three isolating Lodgepole Creek and zone 4 isolating the South Platte River in SPNRD. Figure 1 demonstrates the hydrostratigraphic unit zones used in all analyses.

Figure 1 – Partitioned Ground Water Model Area



MODEL RESULTS

The following ground water model components were summarized by month to complete a total water budget and change analysis:

- Stream baseflow
- General head boundaries (representing lakes)
- Evapotranspiration (ET)
- Well pumping
- Ground water storage

The simplified calculation below is used to determine impacts to the surface water system for the analysis:

$$Modified\ Model - Baseline\ Model\ = Ground\ Water\ Impacts$$

The monthly change in stream baseflow in the North Platte River (including tributaries), Lodgepole Creek, and the South Platte River for the different scenarios was converted to annual volumes for evaluation of the simulation results. The recharge and pumping rates were similarly converted to annual volumes for comparison to stream baseflow. The recharge and pumping volumes include all recharge or pumping simulated flows that occurred in each District, or in each basin (Figure 1). Figure 2 provides the annual change in stream baseflow for the North Platte River (and tributaries) in the NPNRD.

Figure 2 - Annual Change in Stream Baseflow NPNRD: Irrigation Efficiency

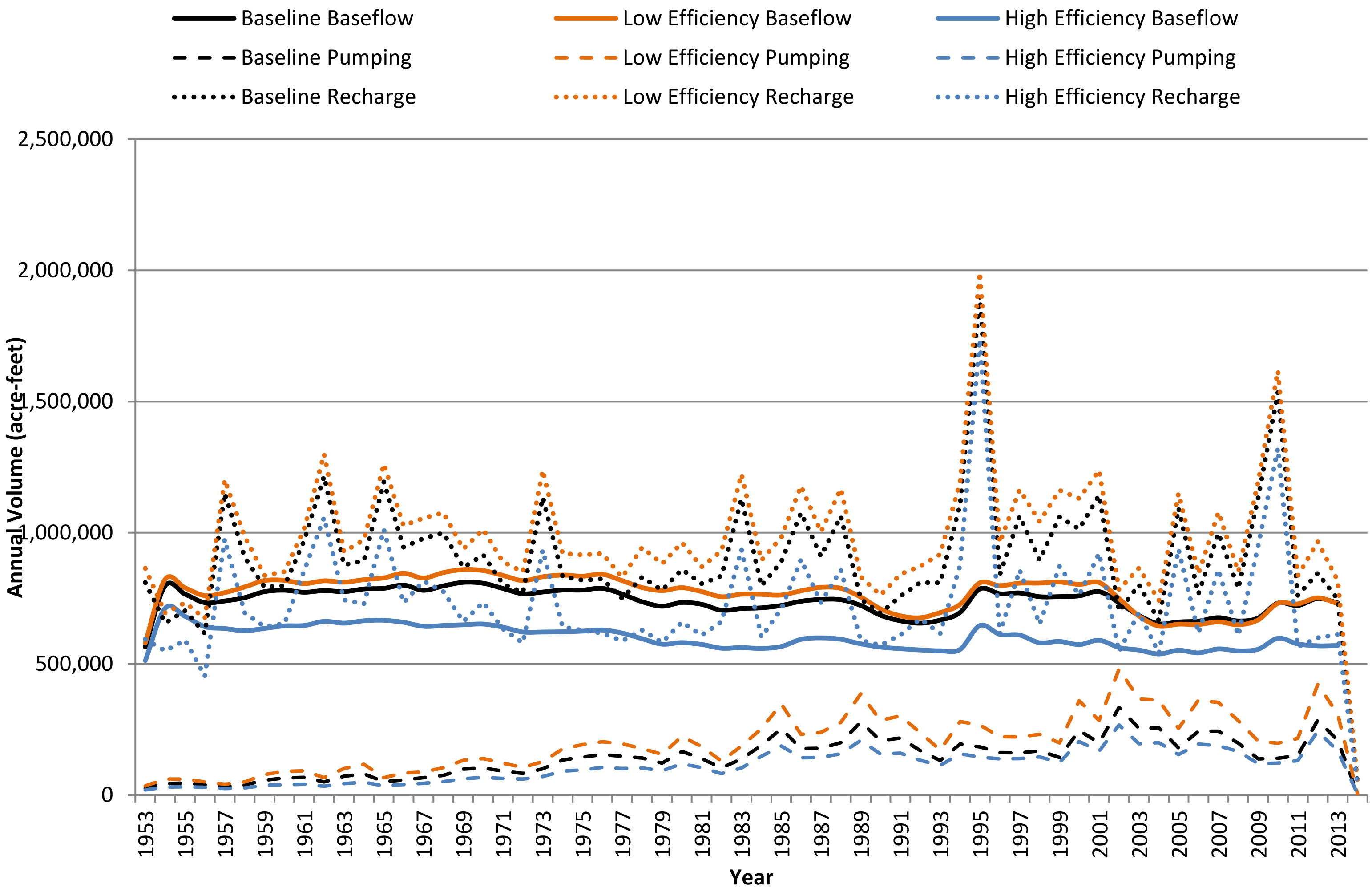


Figure 3 provides the annual change in stream baseflow for Lodgepole Creek and the South Platte River in SPNRD.

Figure 3 - Annual Change in Stream Baseflow SPNRD: Irrigation Efficiency

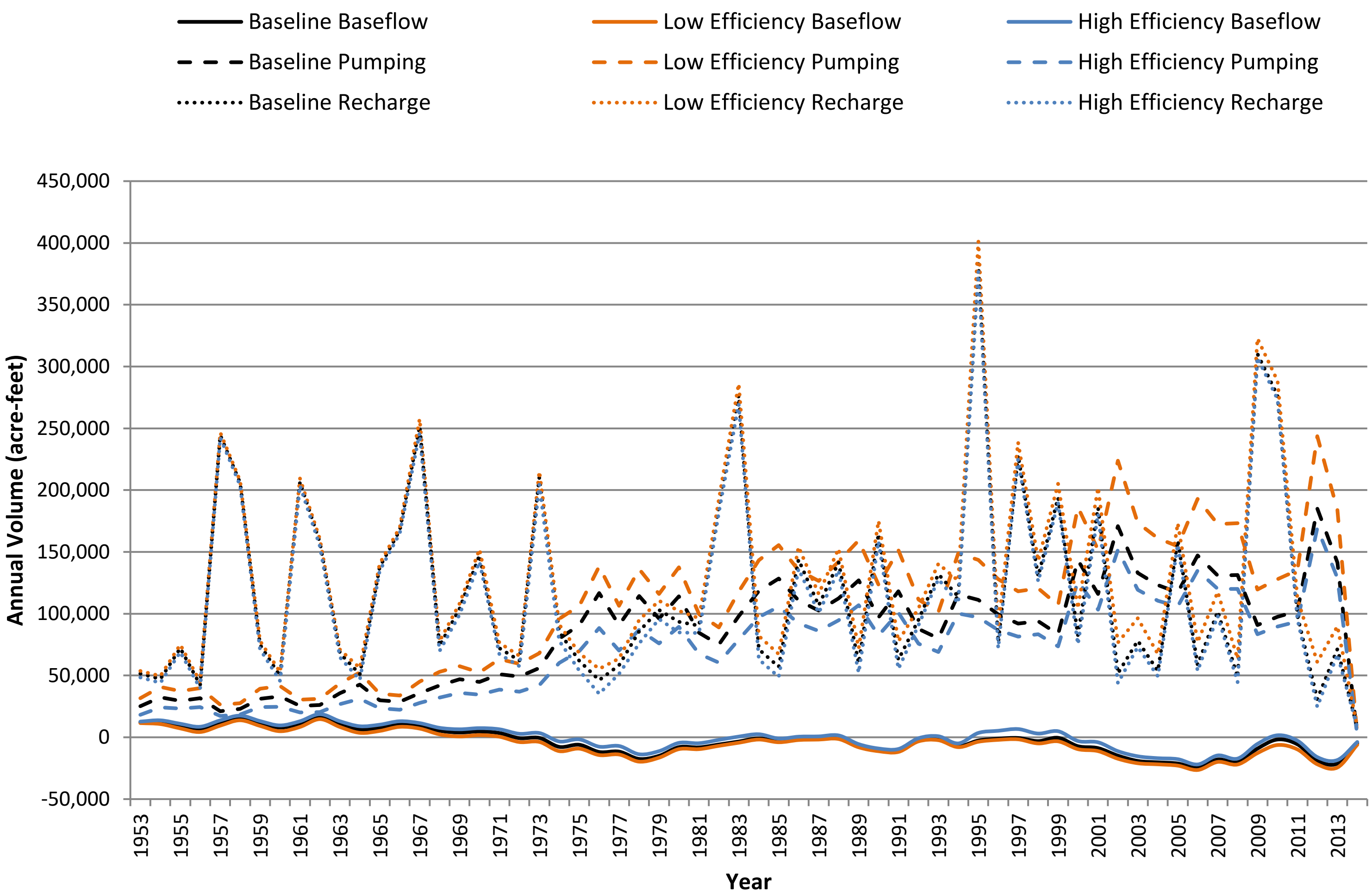


Figure 4 provides the annual change in stream baseflow for the South Platte River in the SPNRD.

Figure 4 - Annual Change in Stream Baseflow in Lodgepole Creek Only: Irrigation Efficiency

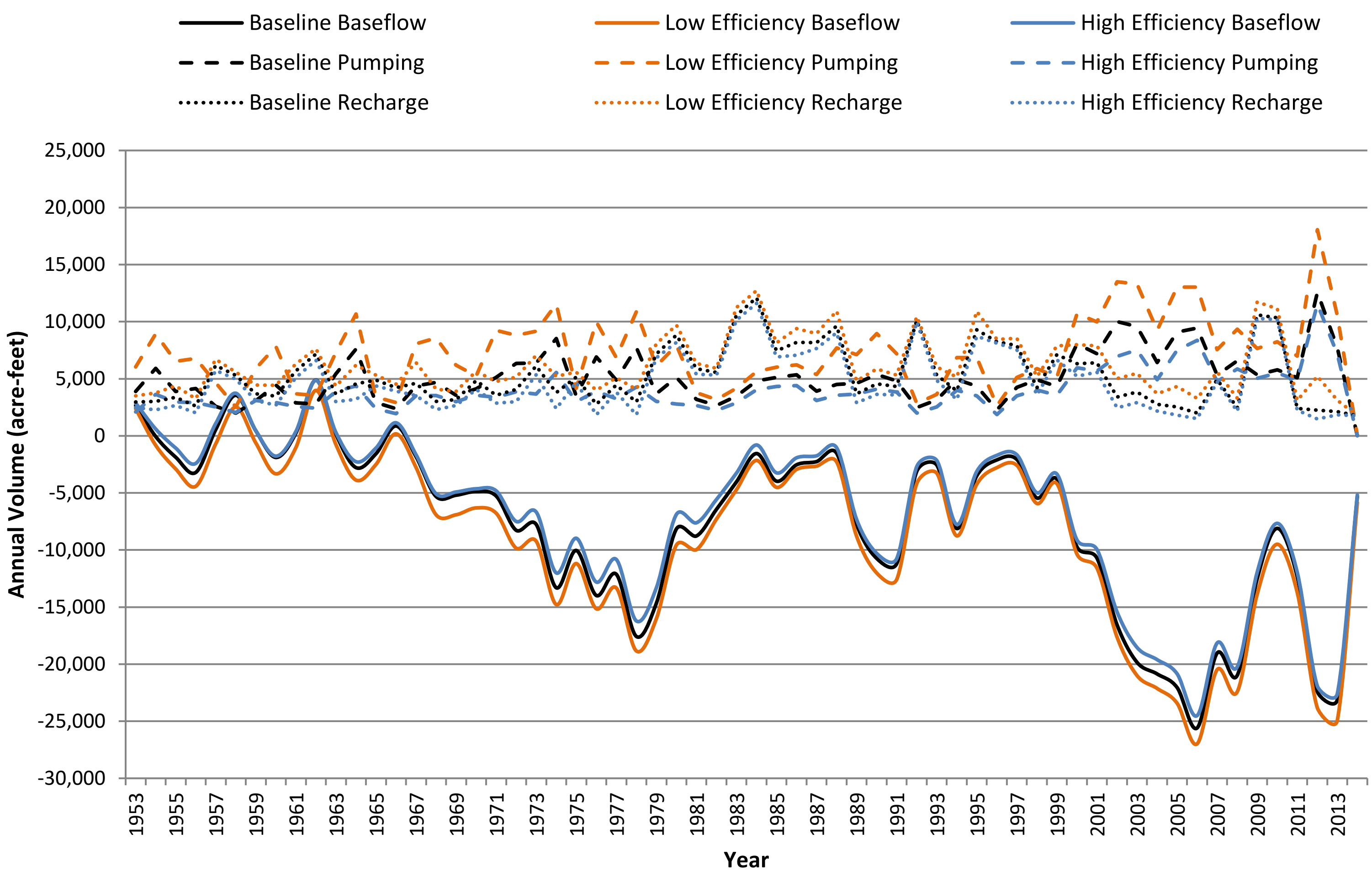


Figure 5 provides the annual change in stream baseflow for Lodgepole Creek in the SPNRD.

Figure 5 - Annual Change in Stream Baseflow in the South Platte River Only: Irrigation Efficiency

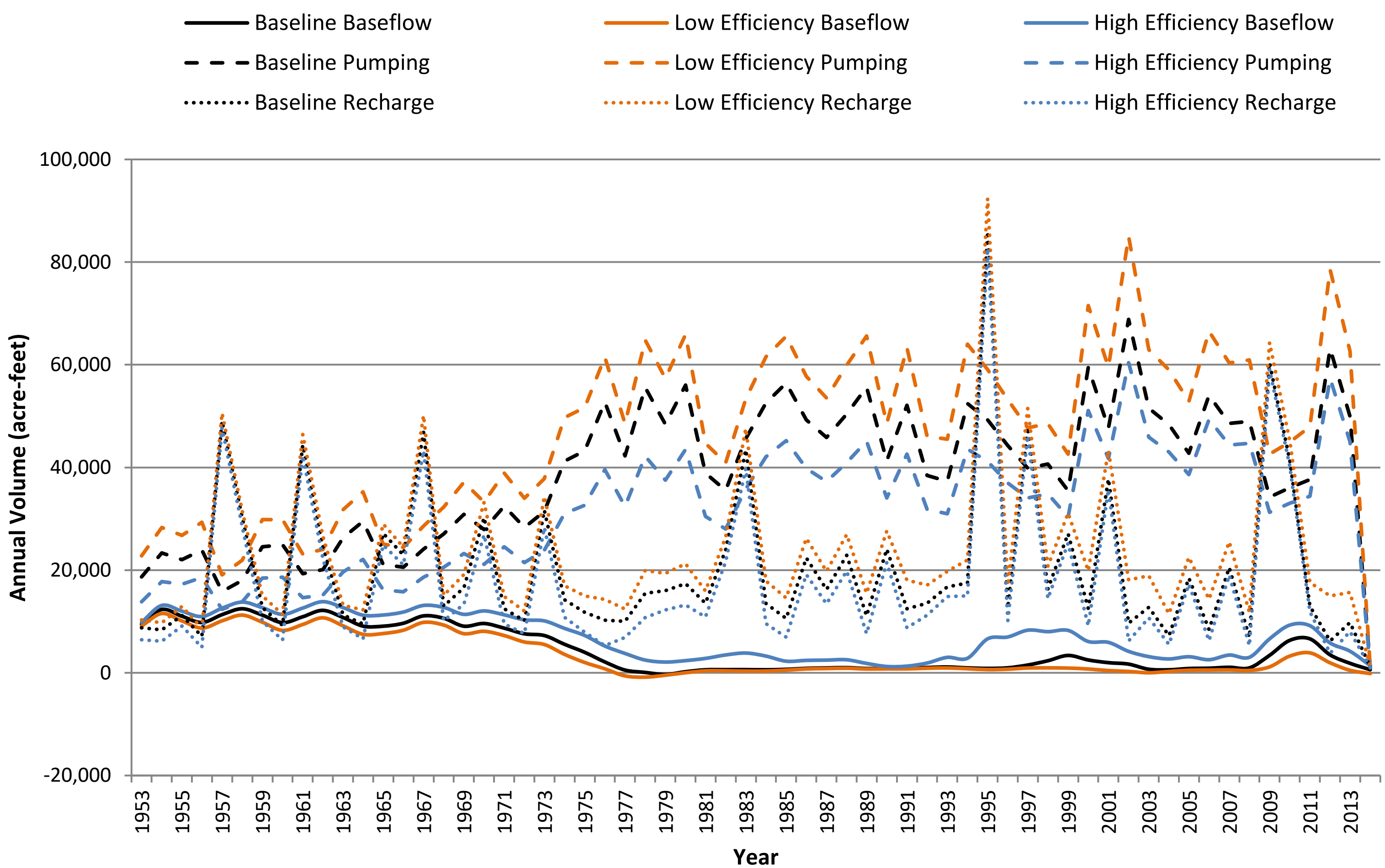


Figure 6 provides the annual change in stream baseflow for the North Platte River (and tributaries) in the NPNRD.

Figure 6 - Annual Change in Stream Baseflow in the South Platte River Only: Tillage Practices

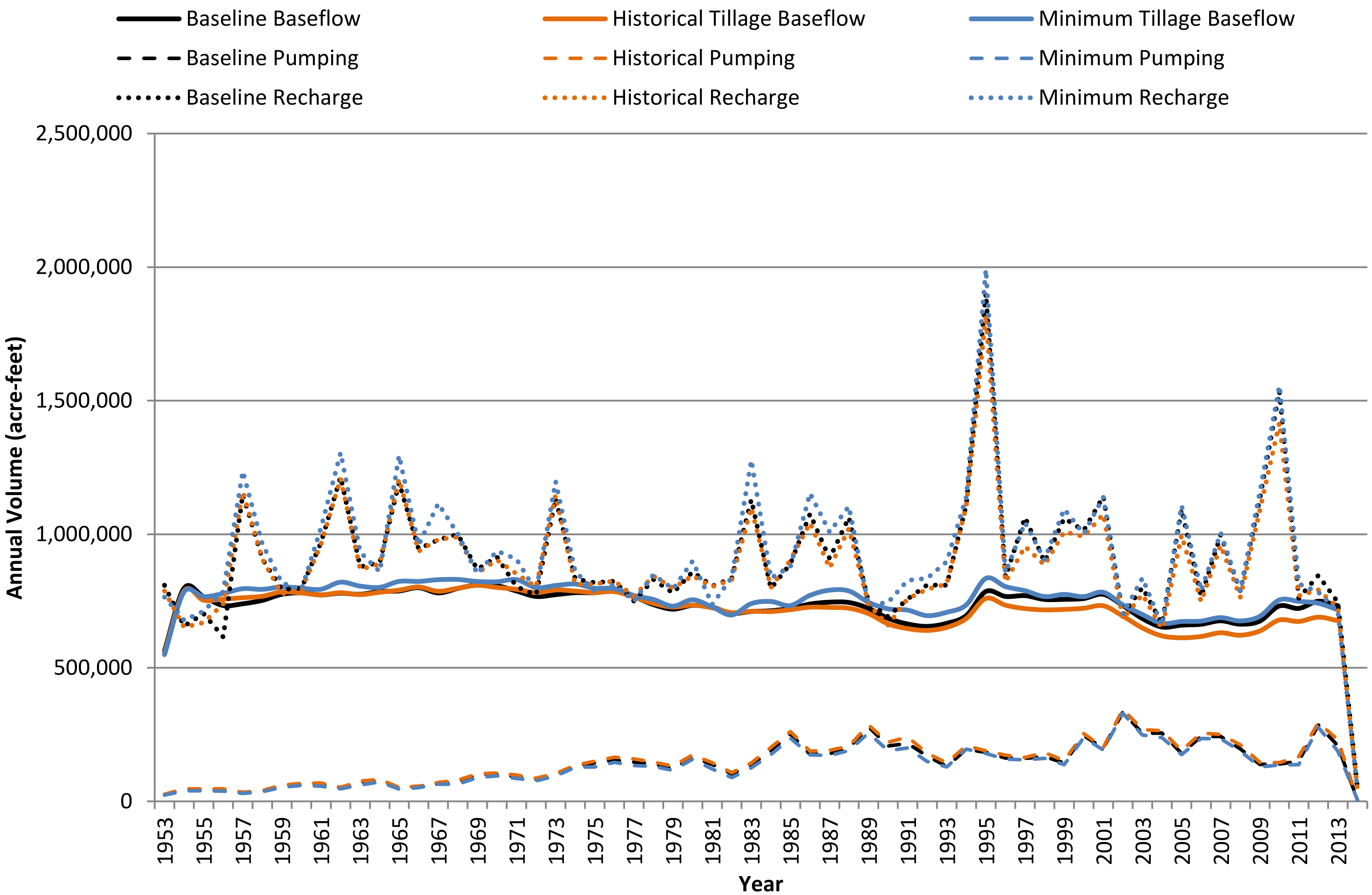


Figure 7 provides the annual change in stream baseflow for Lodgepole Creek and the South Platte River in SPNRD.

Figure 7 - Annual Change in Stream Baseflow SPNRD: Tillage Practices

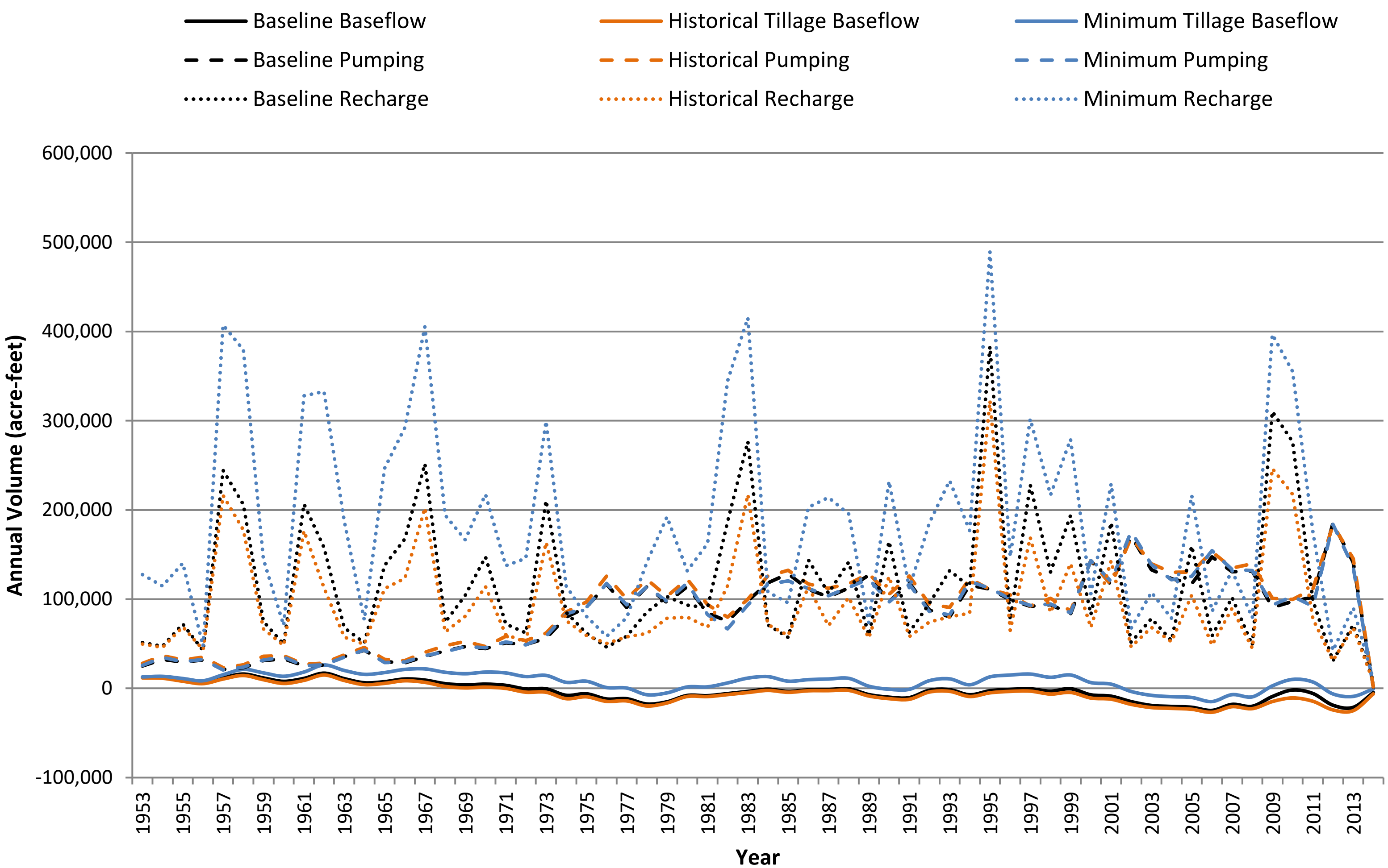


Figure 8 provides the annual change in stream baseflow for the South Platte River in the SPNRD.

Figure 8 - Annual Change in Stream Baseflow in Lodgepole Creek Only: Tillage Practices

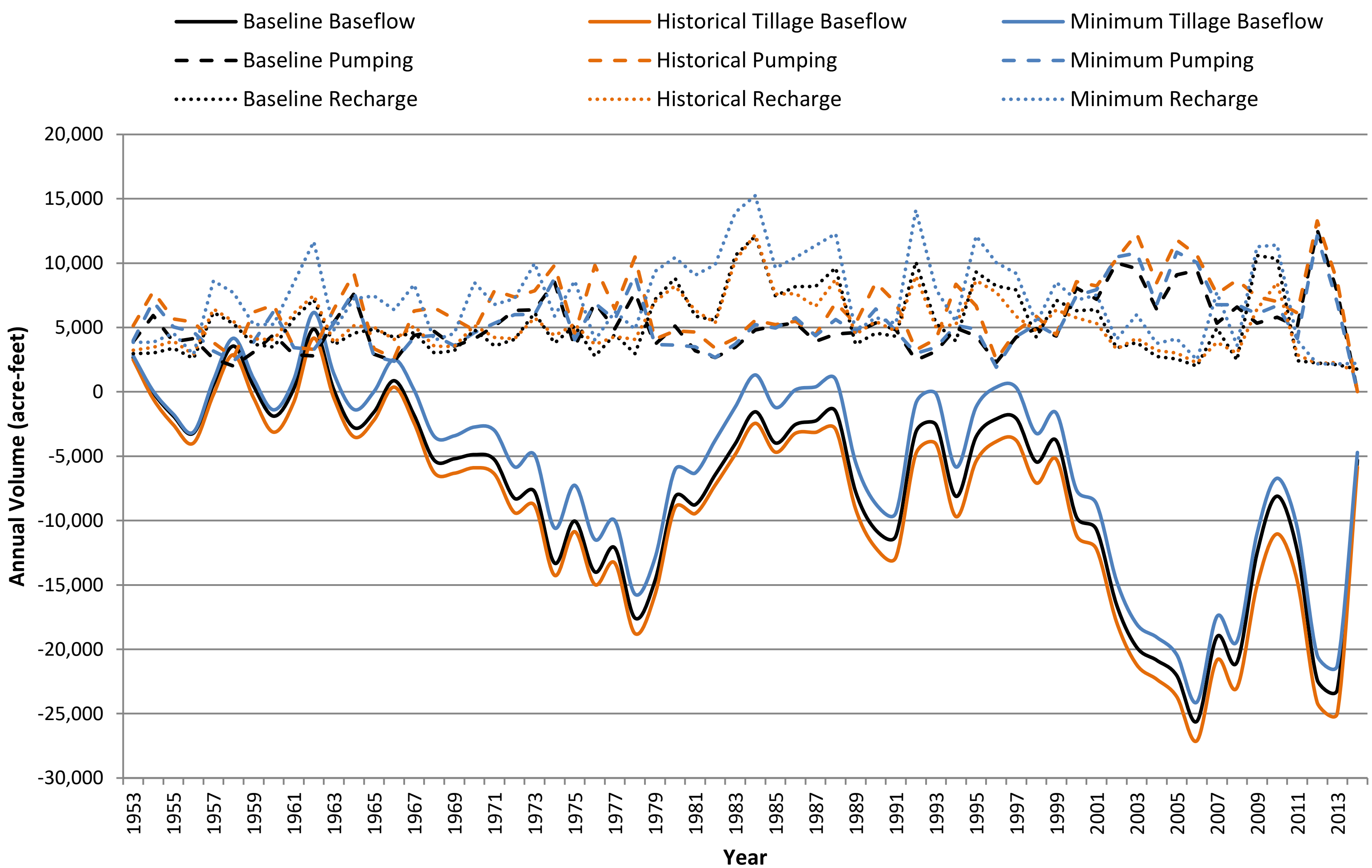
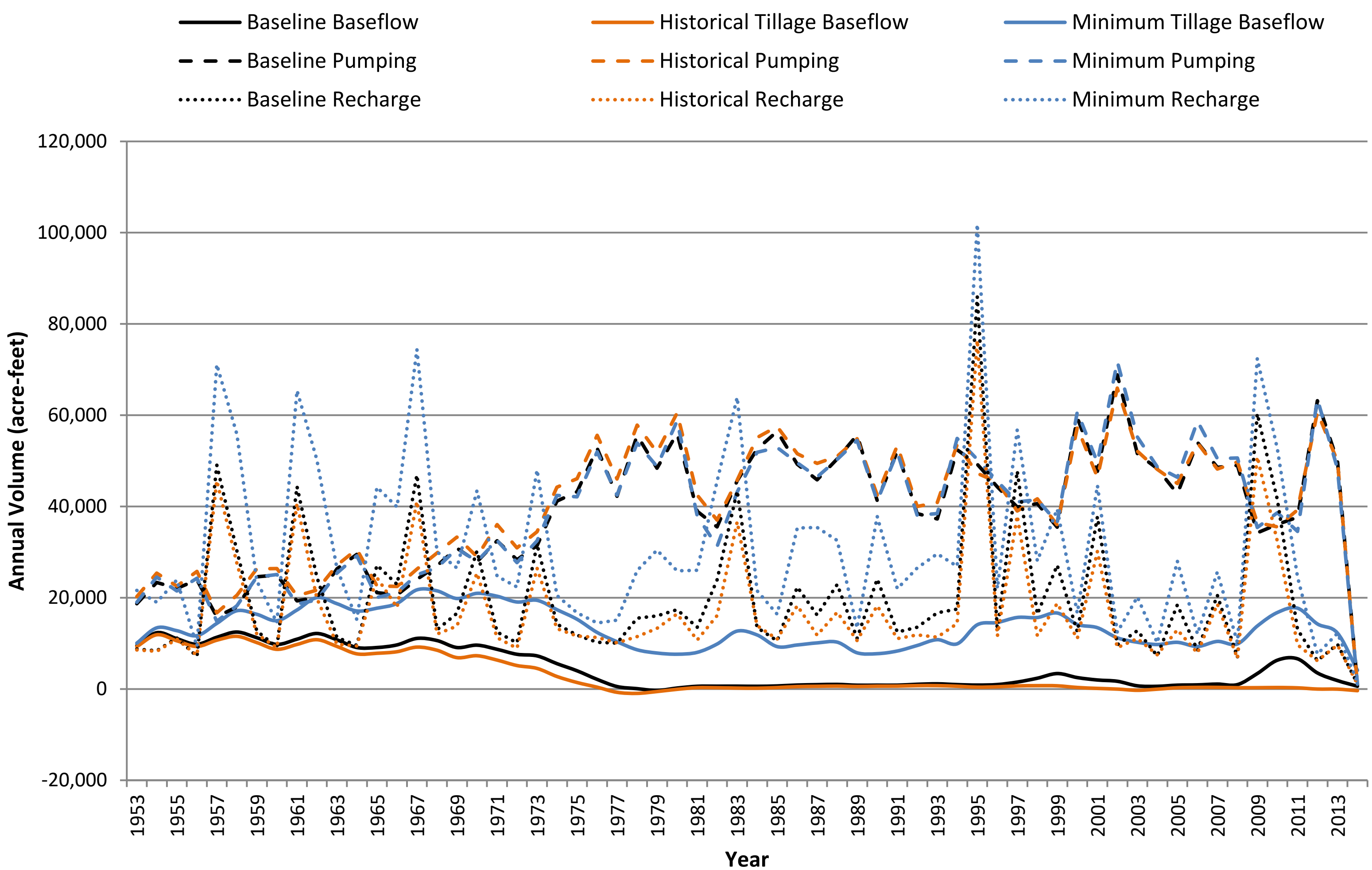


Figure 9 provides the annual change in stream baseflow for Lodgepole Creek in the SPNRD.

Figure 9 - Annual Change in Stream Baseflow in Lodgepole Creek Only: Tillage Practices



Conservation Study: Western Water Use Model
Efficiency Scenarios
December 19, 2017

Scenario Purpose:
The Conservation Study was initiated to evaluate and quantify within each NRD the impact that selected conservation practices have on stream flow. The Efficiency Scenarios explore how the system would respond to alternative means of applying irrigation water to the field throughout the simulation period. Two scenarios were investigated; a High Efficiency Scenario and a Low Efficiency Scenario.

Baseline Description:
The Baseline Scenario represents the standard from which to compare subsequent scenarios. For the Conservation Study, a modified version of the Historically Calibrated Model (Run028) was employed over the period: May 1953 through April 2014. The Baseline Scenario used the historical land use development, and on farm production practices and irrigation management techniques modeled over the simulation period with historic climate conditions. The following changes were made to the Historically Calibrated Model to create the Conservation Study baseline:

Watershed Model
- All groundwater irrigated land is simulated to meet a target NIR. No metered pumping is used

Surface Water Operations Model[1]
- All canals were converted to use a 'mutual ditch' approach for comingled irrigation volumes
- Additional upstream storage water could be made available if needed

Groundwater Model
-

High Efficiency Scenario Description:
The High Efficiency Scenario investigated the impact of converting all irrigated acres within the WWUM Region 1[2] to high efficiency application methods and its effect on diversions, pumping, recharge, aquifer levels, baseflow, and stream flow. The following changers were made to the baseline model to implement this scenario:

Watershed Model
- The irrigation application efficiency in Region 1 was changed to 95% for both sprinkler and flood irrigated parcels.

Surface Water Operations Model
*See attached report

No changes were made to the baseline Groundwater Model. Rather, scenario results reflect changes to inputs resulting from changes to the watershed model and surface water operations model.

[1] This represents a summary of the major changes to the surface water operations model; further detail is available in the attached report.
[2] Region 1 consists of the NPNRD, SPNRD, and dryland pasture areas in Wyoming and Colorado.

Low Efficiency Scenario Description:

The Low Efficiency Scenario investigated the impact of converting all irrigated acres within the WWUM Region 1 to low efficiency application methods and its effect on diversions, pumping, recharge, aquifer levels, baseflow, and stream flow. The following changes were made to the baseline model to implement this scenario:

Watershed Model

- The irrigation application efficiency for sprinkler irrigated lands was changed to 60%
- The irrigation application efficiency for flood irrigated lands was changed to 50%

Surface Water Operations Model

*See attached report

No changes were made to the baseline Groundwater Model. Rather, the scenario results reflect changes to inputs resulting from changes to the watershed model and surface operations model.

Surface Water Model Results:

*See attached report

Watershed Model Results:

Table 1. Groundwater pumping by Natural Resources District – 1953-2013 (AF)

	Baseline	Low Efficiency		High Efficiency	
NRD	Volume	Volume	Change	Volume	Change
North Platte	8,961,000	13,282,000	4,321,000	6,599,000	(2,362,000)
South Platte	5,963,000	8,040,000	2,077,000	4,728,000	(1,235,000)

Table 2. Surface water deliveries by Natural Resources District – 1953-2013 (AF)

	Baseline	Low Efficiency		High Efficiency	
NRD	Volume	Volume	Change	Volume	Change
North Platte	32,001,000	34,613,000	2,612,000	24,761,000	(7,240,000)
South Platte	364,000	364,000	-	364,000	-

Table 3. Recharge by Natural Resources District – 1953-2013 (AF)

	Baseline	Low Efficiency		High Efficiency	
NRD	Volume	Volume	Change	Volume	Change
North Platte	26,903,000	29,959,000	3,056,000	22,974,000	(3,929,000)
South Platte	7,323,000	7,922,000	599,000	6,994,000	(329,000)

Groundwater Model Results:

**See attached report

Conservation Study: Western Water Use Model
Tillage Scenarios
December 19, 2017

Scenario Purpose:
The Conservation Study was initiated to evaluate and quantify within each NRD the impact that selected conservation practices have on stream flow. The Tillage Scenarios explore how the system would respond to alternative tillage practices being used exclusively throughout the simulation period. Two scenarios were investigated; a minimum Tillage Scenario and a Circa 1950's Tillage Scenario.

Baseline Description:
The Baseline Scenario represents the standard from which to compare subsequent scenarios. For the Conservation Study, a modified version of the Historically Calibrated Model (Run028) was employed over the period: May 1953 through April 2014. The Baseline Scenario used the historical land use development, and on farm production practices and irrigation management techniques modeled over the simulation period with historic climate conditions. The following changes were made to the Historically Calibrated Model to create the Conservation Study baseline:

Watershed Model
- All groundwater irrigated land is simulated to meet a target NIR. No metered pumping is used

Surface Water Operations Model[1]
- All canals were converted to use a 'mutual ditch' approach for comingled irrigation volumes
- Additional upstream storage water could be made available if needed

Groundwater Model
-

Minimum Tillage Scenario Description:
The Minimum Tillage Scenario investigated the impact of minimizing the number of tillage practices throughout the year. Minimum tillage was defined as limiting the operation to:

1. Only a planting operation for tilled crops
2. A planting operation preceded by a field cultivator operation 3 days prior (sugar beets, potatoes, and dry edible beans)
3. No changes on perennial forage crops

Limiting the tillage developed a new system response on agricultural fields. This response was applied to the historical land use and climate to investigate the effects on diversions, pumping, recharge, aquifer levels, base flow, and stream flow. The following changes were made to the baseline model to implement this scenario:

[1] This represents a summary of the major changes to the surface water operations model; further detail is available in the attached report.

Watershed Model

- Modifications were made to the soil water balance model CROPSIM
    + A new set of '*simfiles*' were created with minimum tillage practices (Tables 4-11)
    + CROPSIM was used to generate irrigated and dryland results for each crop on each soil at every WWUM weather station over the simulation period
- The CROPSIM results were spatially distributed to create a new set of Water Balance Parameters for the Regionalized Soil Water Balance model
    + This includes new parcel NIR values provided to the surface water operations model

No changes were made to the baseline Surface Water Operations Model or the Groundwater Model. Rather, the scenario results reflect changes to inputs resulting from changes to the watershed model.

Circa 1950's Tillage Scenario Description:

The Circa 1950s Tillage Scenario investigated the impact of implementing tillage practices common in the middle of the 20th century throughout the simulation period. Tillage practices during this time frequently turned the topsoil and destroyed much of the residue on the soil surface. The Circa 1950's Tillage developed a new system response on agricultural fields. This response was applied to the historic land use and climate to investigate the effect on diversions, pumping recharge, aquifer levels, base flow, and stream flow. The following changes were made to the baseline model to implement this scenario:

Watershed Model

- The results of the CROPSIM run using the '*49*' '*simfile*' data set (Tables 4-11) were expanded through 2014
- Temporal distribution of the CROPSIM results was omitted, rather the '*49*' results were spatially distributed to create a new set of Water Balance Parameters for the Regionalized Soil Water Balance model
    + This includes new parcel NIR values provided to the surface water operations model

Surface Water Model Results:

**See attached Report*

Watershed Model Results:

Table 1. Groundwater pumping by Natural Resources District – 1953-2013 (AF)

	Baseline	Circa 1950's Tillage Scenario		Minimum Tillage Scenario	
NRD	Volume	Volume	Change	Volume	Change
North Platte	8,961,000	9,610,000	649,000	8,269,000	(692,000)
South Platte	5,963,000	6,584,000	621,000	5,659,000	(304,000)

Table 2. Surface water deliveries by Natural Resources District – 1953-2013 (AF)

	Baseline	Circa 1950's Tillage Scenario		Minimum Tillage Scenario	
NRD	Volume	Volume	Change	Volume	Change
North Platte	32,001,000	32,179,000	178,000	28,967,000	(3,034,000)
South Platte	364,000	364,000	-	364,000	-

Table 3. Recharge by Natural Resources District – 1953-2013 (AF)

	Baseline	Circa 1950's Tillage Scenario		Minimum Tillage Scenario	
NRD	Volume	Volume	Change	Volume	Change
North Platte	26,903,000	26,000,000	(903,000)	31,345,000	4,442,000
South Platte	7,323,000	5,901,000	(1,422,000)	11,582,000	4,259,000

<u>Groundwater Model Results:</u>

**See attached Report*

Summary of Tillage Practices:

Table 4. Tillage practices for Corn

Circa 1949	
Tandem/Offset Disk - Secondary Tillage	-67
Tandem/Offset Disk - Secondary Tillage	-58
Moldboard Plow	-43
Harrow - Packer Roller	-36
Harrow - Spike Tooth	-22
Finishing - Disks, Shanks, Leveling	-6
Rowcrop Planter - Smooth Coulters	1
Rotary Hoe	18
Row Cultivator - Multiple Sweeps	34
Row Cultivator - Multiple Sweeps	55

Circa 1973	
Knife Applicator	-43
Moldboard Plow	-27
Harrow - Roller	-20
Rowcrop Planter - Ripple/Bubble Coulters	1
Row Cultivator - Multiple Sweeps	18
Row Cultivator - Multiple Sweeps	49

Circa 1998	
Stalk Chopper	-35
Knife Applicator	-30
Tandem/Offset Disk - Secondary Tillage	-21
Tandem Disk - Light	-7
Rowcrop Planter - Double-disk Openers	1
Row Cultivator - Rolling Disc	30
Row Cultivator - Single Sweep	50

Minimum Till	
Rowcrop Planter - Double-disk Openers	1

Table 5. Tillage practices for Dry Edible Beans

Circa 1949	
Tandem/Offset Disk - Secondary Tillage	-101
Tandem/Offset Disk - Secondary Tillage	-94
Moldboard Plow	-61
Harrow - Packer Roller	-56
Harrow - Spike Tooth	-26
Finishing - Disks, Shanks, Leveling	-9
Rowcrop Planter - Smooth Coulters	1
Row Cultivator - Multiple Sweeps	14
Row Cultivator - Multiple Sweeps	21
Rodweeder - Plain	(1)

Circa 1973	
Tandem/Offset Disk - Secondary Tillage	-92
Tandem/Offset Disk - Secondary Tillage	-85
Moldboard Plow	-61
Harrow - Roller	-47
Field Cultivator - Secondary Duckfoot Points	-17
Harrow - Roller	-12
Rowcrop Planter - Ripple/Bubble Coulters	1
Row Cultivator - Multiple Sweeps	19
Row Cultivator - Multiple Sweeps	29
Rodweeder - Plain	(1)

Circa 1998	
Tandem/Offset Disk - Primary Tillage	-30
Tandem Disk - Light	-10
Rowcrop Planter - Double-disk Openers	1
Row Cultivator - Rolling Disc	20
Field Cultivator - Secondary 12-20inch Sweep	40
Undercutter Plow: V-Blade 20-30inch	(3)

Minimum Till	
Field Cultivator - Primary Duckfoot Points	-3
Rowcrop Planter - Double-disk Openers	1

Table 6. Tillage practices for Dry Sugar Beets

Circa 1949	
Tandem/Offset Disk - Primary Tillage	-20
Moldboard Plow	-14
Tandem Disk - Light	-3
Harrow - Roller	-2
Rowcrop Planter - Double-disk Openers	1
Row Cultivator - Rolling Disc	35
Knife Applicator	50
Field Cultivator - Secondary 12-20inch Sweep	65
Rotary Tiller - 6inch deep - Similar to Lifter	(3)
Tandem/Offset Disk - Secondary Tillage	(7)

Circa 1973	
Tandem/Offset Disk - Primary Tillage	-20
Moldboard Plow	-14
Tandem Disk - Light	-3
Harrow - Roller	-2
Rowcrop Planter - Double-disk Openers	1
Row Cultivator - Rolling Disc	35
Knife Applicator	50
Field Cultivator - Secondary 12-20inch Sweep	65
Rotary Tiller - 6inch deep - Similar to Lifter	(3)
Tandem/Offset Disk - Secondary Tillage	(7)

Circa 1998	
Tandem/Offset Disk - Primary Tillage	- 20
Moldboard Plow	- 14
Tandem Disk - Light	-3
Harrow - Roller	-2
Rowcrop Planter - Double-disk Openers	1
Row Cultivator - Rolling Disc	35
Knife Applicator	50
Field Cultivator - Secondary 12-20inch Sweep	65
Rotary Tiller - 6inch deep - Similar to Lifter	(3)
Tandem/Offset Disk - Secondary Tillage	(7)

Minimum Till	
Field Cultivator - Primary Duckfoot Points	-3
Rowcrop Planter - Double-disk Openers	1

Table 7. Tillage practices for Irrigated Sugar Beets

Circa 1949	
Moldboard Plow	-31
Harrow - Packer Roller	-25
Harrow - Spike Tooth	-17
Finishing - Disks, Shanks, Leveling	-7
Rowcrop Planter - Smooth Coulters	1
Rotary Hoe	19
Row Cultivator - Multiple Sweeps	34
Row Cultivator - Multiple Sweeps	61
Row Cultivator - Multiple Sweeps	85
Rotary Tiller - Primary Tillage - 6" deep	(1)

Circa 1973	
Tandem Disk - Light	-31
Moldboard Plow	-27
Harrow - Packer Roller	-22
Harrow - Spike Tooth	-7
Harrow - Roller	-4
Rowcrop Planter - Smooth Coulters	1
Rotary Hoe	19
Row Cultivator - Multiple Sweeps	34
Row Cultivator - Multiple Sweeps	61
Rotary Tiller - Primary Tillage - 6" deep	(1)

Circa 1998	
Tandem/Offset Disk - Primary Tillage	-20
Moldboard Plow	-14
Tandem Disk - Light	-3
Harrow - Roller	-2
Rowcrop Planter - Double-disk Openers	1
Row Cultivator - Rolling Disc	35
Knife Applicator	50
Field Cultivator - Secondary 12-20inch Sweep	65
Rotary Tiller - 6inch deep - Similar to Lifter	(3)
Tandem/Offset Disk - Secondary Tillage	(7)

Minimum Till	
Field Cultivator - Primary Duckfoot Points	-3
Rowcrop Planter - Double-disk Openers	1

Table 8. Tillage practices for Potatoes

Circa 1949	
Tandem/Offset Disk - Primary Tillage	-20
Moldboard Plow	-14
Tandem Disk - Light	-3
Harrow - Roller	-2
Rowcrop Planter - Double-disk Openers	1
Row Cultivator - Rolling Disc	25
Knife Applicator	35
Field Cultivator - Secondary 12-20inch Sweep	50
Rotary Tiller - 6inch deep - Similar to Lifter	(2)
Tandem/Offset Disk - Secondary Tillage	(7)

Circa 1973	
Tandem/Offset Disk - Primary Tillage	-20
Moldboard Plow	-14
Tandem Disk - Light	-3
Harrow - Roller	-2
Rowcrop Planter - Double-disk Openers	1
Row Cultivator - Rolling Disc	25
Knife Applicator	35
Field Cultivator - Secondary 12-20inch Sweep	50
Rotary Tiller - 6inch deep - Similar to Lifter	(2)
Tandem/Offset Disk - Secondary Tillage	(7)

Circa 1998	
Tandem/Offset Disk - Primary Tillage	-20
Moldboard Plow	-14
Tandem Disk - Light	-2
Harrow - Roller	-2
Rowcrop Planter - Double-disk Openers	1
Row Cultivator - Rolling Disc	25
Knife Applicator	35
Field Cultivator - Secondary 12-20inch Sweep	50
Rotary Tiller - 6inch deep - Similar	(1)
Tandem/Offset Disk - Secondary Tillage	(7)

Minimum Till	
Field Cultivator - Primary Duckfoot Points	-3
Rowcrop Planter - Double-disk Openers	1

Table 9. Tillage practices for Small Spring Grains

Circa 1949	
Tandem/Offset Disk - Primary Tillage	-20
Knife Applicator	-15
Tandem/Offset Disk - Secondary Tillage	-5
Drill: Single Disk Opener	1
Undercutter Plow: V-Blade >30inch	(21)

Circa 1973	
Tandem/Offset Disk - Primary Tillage	-20
Knife Applicator	-15
Tandem/Offset Disk - Secondary Tillage	-5
Drill: Single Disk Opener	1
Undercutter Plow: V-Blade >30inch	(21)

Circa 1998	
Tandem/Offset Disk - Primary Tillage	-20
Knife Applicator	-15
Tandem/Offset Disk - Secondary Tillage	-5
Drill: Single Disk Opener	1
Undercutter Plow: V-Blade >30inch	(21)

Minimum Till	
Drill: Single Disk Opener	1

Table 10. Tillage practices for Sorghum

Circa 1949	
Knife Applicator	-30
Tandem/Offset Disk - Secondary Tillage	-21
Tandem Disk - Light	-7
Rowcrop Planter - Double-disk Openers	1
Row Cultivator - Rolling Disc	30
Row Cultivator - Single Sweep	50

Circa 1973	
Knife Applicator	-30
Tandem/Offset Disk - Secondary Tillage	-21
Tandem Disk - Light	-7
Rowcrop Planter - Double-disk Openers	1
Row Cultivator - Rolling Disc	30
Row Cultivator - Single Sweep	50

Circa 1998	
Knife Applicator	-30
Tandem/Offset Disk - Secondary Tillage	-21
Tandem Disk - Light	-7
Rowcrop Planter - Double-disk Openers	1
Row Cultivator - Rolling Disc	30
Row Cultivator - Single Sweep	50

Minimum Till	
Rowcrop Planter - Double-disk Openers	1

Table 11. Tillage practices for Sunflower

Circa 1949	
Knife Applicator	-30
Tandem/Offset Disk - Secondary Tillage	-21
Tandem Disk - Light	-7
Rowcrop Planter - Double-disk Openers	1
Row Cultivator - Rolling Disc	30
Row Cultivator - Single Sweep	50

Circa 1973	
Knife Applicator	-30
Tandem/Offset Disk - Secondary Tillage	-21
Tandem Disk - Light	-7
Rowcrop Planter - Double-disk Openers	1
Row Cultivator - Rolling Disc	30
Row Cultivator - Single Sweep	50

Circa 1998	
Knife Applicator	-30
Tandem/Offset Disk - Secondary Tillage	-21
Tandem Disk - Light	-7
Rowcrop Planter - Double-disk Openers	1
Row Cultivator - Rolling Disc	30
Row Cultivator - Single Sweep	50

Minimum Till	
Rowcrop Planter - Double-disk Openers	1

Conservation Study
Tillage Scenarios
December 19, 2017

Scenario Purpose:

The Conservation Study was initiated to evaluate and quantify within each NRD the impact that selected conservation practices have on stream flow. The Tillage Scenarios explored how the system would respond to alternative tillage practices being used exclusively throughout the simulation period. Two scenarios were investigated; a Minimum Tillage Scenario, and a Circa 1950s Tillage Scenario.

Baseline Description:

The Baseline Scenario represents the standard from which to compare subsequent scenarios. For the Conservation Study, the historical model (COHYST 2010_28_15_28) was extended backward to 1950 and forward to 2013. The Baseline Scenario used the historic land use development, production practices, and irrigation management techniques modeled over the simulation period with historic climate conditions. The following changes were made to the COHYST 2010 model to create the Conservation Study baseline:

Watershed Model

- Land use for the 1950-1984 period was obtained from the 2013 FAB analysis
- Land use for the 2011-2013 period was copied from 2010
    + 6 Mile Canal was shut off. Surface water only and comingled irrigated lands were converted to groundwater only irrigated lands.
- The climate dataset was updated to include the entirety of the 1950-2013 period

Surface Water Operation Model

- Historical gage data at Julesburg, CO and Lewellen, NE were used
- Three temporal diversion patterns were implemented
    + 1950-1990 used average 1985-1990 diversion patterns
    + 1991-2000 used average 1991-2000 diversion patterns
    + 2001-2013 used average 2001-2005 diversion patterns

Groundwater Model

- Initial heads were updated to January 1950 levels
- 1950-1984 High Water Evapotranspiration was set at 1985 levels
- 2011-2013 High Water Evapotranspiration was set at 2010 levels
- Lake McConaughy general head boundaries were set to surface water modeled end of month elevations for January 1950 to December 2013
- Harry Strunk Lake and Hugh Butler Lake general head boundaries were updated with elevations from the United States Bureau of Reclamation

Minimum Tillage Scenario Description:

The Minimum Tillage Scenario investigated the impact of minimizing the number of tillage practices throughout the year. Minimum tillage was defined as limiting operation to a planting operation for tilled crops; perennial forage crops were not changed. Limiting the tillage developed a new system response on agricultural fields. This response was applied to the historical land use and climate to investigate the effect on diversions, pumping, recharge, aquifer levels, base flow, and stream flow. The following changes were made to the baseline model to implement this scenario:

Watershed Model

- Modifications were made to the soil water balance model CROPSIM
    + A new set of '*simfiles´* were created with minimum tillage practices (Tables 8-11)
    + CROPSIM was used to generate irrigated and dryland results for each crop on each soil at every COHYST weather station over the simulation period
- The CROPSIM results were spatially distributed to create a new set of Water Balance Parameters for the Regionalized Soil Water Balance model

No changes were made to the baseline Surface Water Operations Model or the Groundwater Model. Rather, the scenario results reflect changes to inputs resulting from changes to the watershed model during the integrated modeling sequence.

<u>Circa 1950s Tillage Scenario Description:</u>
The Circa 1950s Tillage Scenario investigated the impact of implementing tillage practices common in the middle of the 20th century throughout the simulation period. Tillage practices during this time frequently turned the topsoil and destroyed much of the residue on the soil surface. The circa 1950s tillage developed a new system response on agricultural fields. This response was applied to the historic land use and climate to investigate the effect on diversions, pumping, recharge, aquifer levels, base flow, and stream flow. The following changes were made to the baseline model to implement this scenario:

Watershed Model

- The results of the CROPSIM using the '*49*' '*simfile*' data set (Tables 8-11) were expanded though 2013
- Temporal distribution of the CROPSIM results was omitted, rather the '*49*' results were spatially distributed to create a new set of Water Balance Parameters for the Regionalized Soil Water Balance model

No changes were made to the baseline Surface Water Operations Model or the Groundwater Model. Rather, the scenario results reflect changes to inputs resulting from changes to the watershed model during the integrated modeling sequence.

<u>Surface Water Model Results</u>

Table 1. Platte River Gage Flow – 1950-2013 (AF)

	Baseline	Circa 1950s Tillage		Minimum Tillage	
Platte River Gages	Volume	Volume	Change	Volume	Change
Brady	23,543,000	23,823,000	280,000	22,712,000	(831,000)
Cozad	24,153,000	23,860,000	(293,000)	25,131,000	978,000
Overton	57,855,000	57,074,000	(781,000)	62,447,000	4,592,000
Odessa	59,653,000	59,493,000	(160,000)	63,996,000	4,343,000
Grand Island	62,635,000	62,402,000	(233,000)	69,852,000	7,217,000

Table 2. Platte River diversions and returns – 1950-2013 (AF)

Platte River Diversions and Returns	Baseline	Circa 1950s Tillage Scenario		Minimum Tillage Scenario	
	Volume	Volume	Change	Volume	Change
Keystone	45,265,000	45,007,000	(258,000)	46,751,000	1,486,000
North Platte Canals (Total)	6,912,000	7,055,000	143,000	6,449,000	(463,000)
Western	948,000	955,000	7,000	938,000	(10,000)
Korty	9,397,000	9,467,000	70,000	9,490,000	93,000
Sutherland Return	44,251,000	44,064,000	(187,000)	45,798,000	1,547,000
Tri-County	62,935,000	62,842,000	(93,000)	64,814,000	1,879,000
Jeffrey Return	3,520,000	3,452,000	(68,000)	3,720,000	200,000
Gothenburg	3,547,000	3,654,000	107,000	3,243,000	(304,000)
Thirty Mile	2,287,000	2,359,000	72,000	2,092,000	(195,000)
Cozad	2,006,000	2,083,000	77,000	1,753,000	(253,000)
Orchard Alfalfa	565,000	581,000	16,000	508,000	(57,000)
Dawson	4,299,000	4,420,000	121,000	3,907,000	(392,000)
J-2 Return	28,232,000	27,864,000	(368,000)	31,111,000	2,879,000
Kearney	4,989,000	4,969,000	(20,000)	5,033,000	44,000

Table 3. Platte River main canal recharge – 1950-2013 (AF)

Platte River Diversions and Returns	Baseline	Circa 1950s Tillage Scenario		Minimum Tillage Scenario	
	Volume	Volume	Change	Volume	Change
Keystone	1,013,000	1,013,000	-	1,013,000	-
North Platte Canals (Total)	2,778,000	2,778,000	-	2,778,000	-
Western	729,000	731,000	2,000	732,000	3,000
Korty	508,000	509,000	1,000	520,000	12,000
Sutherland Return	585,000	585,000	-	585,000	-
Tri-County	3,394,000	3,384,000	(10,000)	3,462,000	68,000
Jeffrey Return	4,000,000	4,001,000	1,000	4,015,000	15,000
Gothenburg	1,605,000	1,605,000	-	1,605,000	-
Thirty Mile	915,000	917,000	2,000	924,000	9,000
Cozad	476,000	476,000	-	476,000	-
Orchard Alfalfa	250,000	250,000	-	250,000	-
Dawson	963,000	963,000	-	963,000	-
J-2 Return	(834,000)	(834,000)	-	(834,000)	-
Kearney	8,000	8,000	-	8,000	-

Watershed Model

Table 4. Groundwater pumping by Natural Resources District – 1950-2013 (AF)

NRD	Baseline	Circa 1950s Tillage Scenario		Minimum Tillage Scenario	
	Volume	Volume	Change	Volume	Change
Twin Platte	13,474,000	14,167,000	693,000	11,984,000	(1,490,000)
Central Platte	35,094,000	36,767,000	1,673,000	28,771,000	(6,323,000)
Tri-Basin	16,185,000	17,248,000	1,063,000	12,659,000	(3,526,000)

Table 5. Surface water deliveries by Natural Resources District – 1950-2013 (AF)

NRD	Baseline	Circa 1950s Tillage Scenario		Minimum Tillage Scenario	
	Volume	Volume	Change	Volume	Change
Twin Platte	3,268,000	3,405,000	137,000	2,830,000	(438,000)
Central Platte	4,805,000	5,059,000	254,000	3,823,000	(982,000)
Tri-Basin	4,886,000	5,202,000	316,000	3,474,000	(1,412,000)

Table 6. Recharge by Natural Resources District – 1950-2013 (AF)

NRD	Baseline	Circa 1950s Tillage Scenario		Minimum Tillage Scenario	
	Volume	Volume	Change	Volume	Change
Twin Platte	25,943,000	25,418,000	(525,000)	27,622,000	1,679,000
Central Platte	37,785,000	36,022,000	(1,763,000)	46,274,000	8,489,000
Tri-Basin	15,765,000	15,061,000	(704,000)	20,611,000	4,846,000

Groundwater Model

Table 7. Baseflow by reach – 1950-2013 (AF)

Reach	Baseline	Circa 1950s Tillage Scenario		Minimum Tillage Scenario	
	Volume	Volume	Change	Volume	Change
PR - Brady to Cozad	8,285,000	7,943,000	(342,000)	8,887,000	602,000
PR - Cozad to Overton	3,032,000	2,657,000	(375,000)	4,008,000	976,000
PR - Overton to Odessa	(1,288,000)	(1,464,000)	(176,000)	(470,000)	818,000
PR - Odessa to GI	(6,047,000)	(6,513,000)	(466,000)	(3,063,000)	2,984,000

Summary of tillage practices

Table 8. Tillage practices for corn

Circa 1950	
Tandem/Offset Disk - Secondary Tillage	-67
Tandem/Offset Disk - Secondary Tillage	-58
Moldboard Plow	-43
Harrow - Packer Roller	-36
Harrow - Spike Tooth	-22
Finishing - Disks, Shanks, Leveling	-6
Rowcrop Planter - Smooth Coulters	1
Rotary Hoe	18
Row Cultivator - Multiple Sweeps	34
Row Cultivator - Multiple Sweeps	55

Circa 1975	
Knife Applicator	-43
Moldboard Plow	-27
Harrow	-20
Rowcrop Planter - Ripple/Bubble Coulters	1
Row Cultivator - Multiple Sweeps	18
Row Cultivator - Multiple Sweeps	49

Circa 2000	
Stalk Chopper	-35
Knife Applicator	-30
Tandem/Offset Disk - Secondary Tillage	-21
Tandem Disk - Light	-7
Rowcrop Planter - Double Disk Openers	1
Row Cultivator - Rolling Disc	30
Row Cultivator - Single Sweep	50

Minimum Till	
Rowcrop Planter - Double Disk Openers	1

Table 9. Tillage practices for soybeans

Circa 1950	
Tandem/Offset Disk - Secondary Tillage	-30
Tandem/Offset Disk - Secondary Tillage	-5
Rowcrop Planter - Double-disk Openers	1
Row Cultivator - Rolling Disc	30
Row Cultivator - Multiple Sweeps per Furrow	40

Circa 1975	
Tandem/Offset Disk - Secondary Tillage	-30
Tandem/Offset Disk - Secondary Tillage	-5
Rowcrop Planter - Double-disk Openers	1
Row Cultivator - Rolling Disc	30
Row Cultivator - Multiple Sweeps per Furrow	40

Circa 2000	
Tandem/Offset Disk - Secondary Tillage	-30
Tandem/Offset Disk - Secondary Tillage	-5
Rowcrop Planter - Double-disk Openers	1
Row Cultivator - Rolling Disc	30
Row Cultivator - Multiple Sweeps per Furrow	40

Minimum Till	
Rowcrop Planter - Double Disk Openers	1

Table 10. Tillage practices for sorghum

Circa 1950	
Knife Applicator	-30
Tandem/Offset Disk - Secondary Tillage	-21
Tandem Disk - Light	-7
Rowcrop Planter - Double-disk Openers	1
Row Cultivator - Rolling Disc	30
Row Cultivator - Single Sweep per Furrow	50

Circa 1975	
Knife Applicator	-30
Tandem/Offset Disk - Secondary Tillage	-21
Tandem Disk - Light	-7
Rowcrop Planter - Double-disk Openers	1
Row Cultivator - Rolling Disc	30
Row Cultivator - Single Sweep per Furrow	50

Circa 2000	
Knife Applicator	-30
Tandem/Offset Disk - Secondary Tillage	-21
Tandem Disk - Light	-7
Rowcrop Planter - Double-disk Openers	1
Row Cultivator - Rolling Disc	30
Row Cultivator - Single Sweep per Furrow	50

Minimum Till	
Rowcrop Planter - Double Disk Openers	1

Table 11. Tillage practices for winter wheat

Circa 1950	
Moldboard Plow	-116
Tandem Disk - Light	-90
Field Cultivator - Secondary 6 - 12" Sweep	-60
Rodweeder - Plain	-30
Rodweeder - Plain	-17
Rodweeder - Plain	-5
Drill: Double Disk Opener	1

Circa 1975	
One-way Disc - 12-16" Blades	-123
Chilsel Plow with Spike Points	-109
Field Cultivator - Secondary 12-20" Sweep	-78
Rodweeder - Plain	-31
Rodweeder - Plain	-5
Drill: Hoe Opener	1

Circa 2000	
Tandem/Offset Disk - Primary Tillage	-130
Tandem/Offset Disk - Secondary Tillage	-100
Rodweeder - with Semi-chisels/Shovels	-50
Knife Applicator	-30
Rodweeder - with Semi-chisels/Shovels	-10
Drill: Single Disk Opener	1
Undercutter Plow-V Blade >30inch with Treader	(50)

Minimum Till	
Drill: Single Disk Opener	1

The values in Tables 8-11 represent the number of day relative to planting or maturity:

- Positive numbers represent tillage operations which occur after planting
- Negative number represent tillage operation which occur prior to planting
- Parenthetical numbers represent tillage operations which occur after the growing season is complete

Conservation Study
Efficiency Scenarios
December 19, 2017

Scenario Purpose:
The Conservation Study was initiated to evaluate and quantify within each NRD the impact that selected conservation practices have on stream flow. The Efficiency Scenarios explore how the system would respond to alternative means of applying irrigation water to the field throughout the simulation period. Two scenarios were investigated; a High Efficiency Scenario and a Low Efficiency Scenario.

Baseline Description:
The Baseline Scenario represents the standard from which to compare subsequent scenarios. For the Conservation Study, the historical model (COHYST 2010_28_15_28) was extended backward to 1950 and forward to 2013. The Baseline Scenario used the historic land use development, production practices, and irrigation management techniques modeled over the simulation period with historic climate conditions. The following changes were made to the COHYST 2010 model to create the Conservation Study baseline:

Watershed Model
- Land use for the 1950-1984 period was obtained from the 2013 FAB analysis
- Land use for the 2011-2013 period was copied from 2010
    + 6 Mile Canal was shut off. Surface water only and comingled irrigated lands were converted to groundwater only irrigated lands.
- The climate dataset was updated to include the entirety of the 1950-2013 period

Surface Water Operation Model
- Historical gage data at Julesburg, CO and Lewellen, NE were used
- Three temporal diversion patterns were implemented
    + 1950-1990 used average 1985-1990 diversion patterns
    + 1991-2000 used average 1991-2000 diversion patterns
    + 2001-2013 used average 2001-2005 diversion patterns

Groundwater Model
- Initial heads were updated to January 1950 levels
- 1950-1984 High Water Evapotranspiration was set at 1985 levels
- 2011-2013 High Water Evapotranspiration was set at 2010 levels
- Lake McConaughy general head boundaries were set to surface water modeled end of month elevations for January 1950 to December 2013
- Harry Strunk Lake and Hugh Butler Lake general head boundaries were updated with elevations from the United States Bureau of Reclamation

High Efficiency Scenario Description:
The High Efficiency Scenario investigated the impact of converting all irrigated acres within the model domain to high efficiency application methods and its effect on diversions, pumping, recharge, aquifer levels, baseflow, and stream flow. The following changes were made to the baseline model to implement this scenario:

Watershed Model

- The irrigation application efficiency in all coefficient zones was changed to 95% for both groundwater and surface water irrigated lands

No changes were made to the baseline Surface Water Operations Model or the Groundwater Model. Rather, the scenario results reflect changes to inputs resulting from changes to the watershed model during the integrated modeling sequence.

Low Efficiency Scenario Description:

The Low Efficiency Scenario investigated the impact of converting all irrigated acres within the model domain to low efficiency application methods and its effect on diversions, pumping, recharge, aquifer levels, baseflow, and stream flow. The following changes were made to the baseline model to implement this scenario:

Watershed Model

- The irrigation application efficiency for groundwater irrigated lands was changed to 60%
- The irrigation application efficiency for surface water irrigated lands was changed to 50%

No changes were made to the baseline Surface Water Operations Model or the Groundwater Model. Rather, the scenario results reflect changes to inputs resulting from changes to the watershed model during the integrated modeling sequence.

Surface Water Model Results

Table 1. Platte River Gage Flow – 1950-2013 (AF)

	Baseline	Low Efficiency		High Efficiency	
Platte River Gages	Volume	Volume	Change	Volume	Change
Brady	23,543,000	26,211,000	2,668,000	21,678,000	(1,865,000)
Cozad	24,153,000	24,533,000	380,000	24,597,000	444,000
Overton	57,855,000	55,594,000	(2,261,000)	60,931,000	3,076,000
Odessa	59,653,000	59,285,000	(368,000)	61,283,000	1,630,000
Grand Island	62,635,000	62,249,000	(386,000)	64,497,000	1,862,000

Table 2. Platte River diversions and returns – 1950-2013 (AF)

Platte River Diversions and Returns	Baseline	Low Efficiency		High Efficiency	
	Volume	Volume	Change	Volume	Change
Keystone	45,265,000	42,832,000	(2,433,000)	47,458,000	2,193,000
North Platte Canals (Total)	6,912,000	7,964,000	1,052,000	5,817,000	(1,095,000)
Western	948,000	989,000	41,000	908,000	(40,000)
Korty	9,397,000	9,417,000	20,000	9,194,000	(203,000)
Sutherland Return	44,251,000	41,871,000	(2,380,000)	46,210,000	1,959,000
Tri-County	62,935,000	60,768,000	(2,167,000)	64,765,000	1,830,000
Jeffrey Return	3,520,000	3,028,000	(492,000)	3,951,000	431,000
Gothenburg	3,547,000	4,031,000	484,000	3,026,000	(521,000)
Thirty Mile	2,287,000	2,616,000	329,000	1,952,000	(335,000)
Cozad	2,006,000	2,401,000	395,000	1,586,000	(420,000)
Orchard Alfalfa	565,000	654,000	89,000	471,000	(94,000)
Dawson	4,299,000	5,022,000	723,000	3,568,000	(731,000)
J-2 Return	28,232,000	25,253,000	(2,979,000)	31,148,000	2,916,000
Kearney	4,989,000	4,957,000	(32,000)	4,967,000	(22,000)

Table 3. Platte River main canal recharge – 1950-2013 (AF)

Platte River Diversions and Returns	Baseline	Low Efficiency		High Efficiency	
	Volume	Volume	Change	Volume	Change
Keystone	1,013,000	1,013,000	-	1,012,000	(1,000)
North Platte Canals (Total)	2,778,000	2,785,000	7,000	2,782,000	4,000
Western	729,000	739,000	10,000	722,000	(7,000)
Korty	508,000	506,000	(2,000)	512,000	4,000
Sutherland Return	585,000	585,000	-	585,000	-
Tri-County	3,394,000	3,324,000	(70,000)	3,471,000	77,000
Jeffrey Return	4,000,000	3,992,000	(8,000)	4,012,000	12,000
Gothenburg	1,605,000	1,605,000	-	1,605,000	-
Thirty Mile	915,000	914,000	(1,000)	921,000	6,000
Cozad	476,000	476,000	-	476,000	-
Orchard Alfalfa	250,000	250,000	-	250,000	-
Dawson	963,000	963,000	-	963,000	-
J-2 Return	(834,000)	(834,000)	-	(834,000)	-
Kearney	8,000	8,000	-	8,000	-

Watershed Model

Table 4. Groundwater pumping by Natural Resources District – 1950-2013 (AF)

	Baseline	Low Efficiency		High Efficiency	
NRD	Volume	Volume	Change	Volume	Change
Twin Platte	13,474,000	16,841,000	3,367,000	10,639,000	(2,835,000)
Central Platte	35,094,000	44,479,000	9,385,000	28,138,000	(6,956,000)
Tri-Basin	16,185,000	21,131,000	4,946,000	13,367,000	(2,818,000)

Table 5. Surface water deliveries by Natural Resources District – 1950-2013 (AF)

	Baseline	Low Efficiency		High Efficiency	
NRD	Volume	Volume	Change	Volume	Change
Twin Platte	3,268,000	4,254,000	986,000	2,223,000	(1,045,000)
Central Platte	4,805,000	6,208,000	1,403,000	3,209,000	(1,596,000)
Tri-Basin	4,886,000	6,314,000	1,428,000	3,239,000	(1,647,000)

Table 6. Recharge by Natural Resources District – 1950-2013 (AF)

	Baseline	Low Efficiency		High Efficiency	
NRD	Volume	Volume	Change	Volume	Change
Twin Platte	25,943,000	27,656,000	1,713,000	24,593,000	(1,350,000)
Central Platte	37,785,000	41,738,000	3,953,000	35,165,000	(2,620,000)
Tri-Basin	15,765,000	18,067,000	2,302,000	14,551,000	(1,214,000)

Groundwater Model

Table 7. Baseflow by reach – 1950-2013 (AF)

	Baseline	Low Efficiency		High Efficiency	
Reach	Volume	Volume	Change	Volume	Change
PR - Brady to Cozad	8,285,000	7,961,000	(324,000)	8,413,000	128,000
PR - Cozad to Overton	3,032,000	2,714,000	(318,000)	3,250,000	218,000
PR - Overton to Odessa	(1,288,000)	(1,530,000)	(242,000)	(1,061,000)	227,000
PR - Odessa to GI	(6,047,000)	(6,847,000)	(800,000)	(4,963,000)	1,084,000

G

Appendix G

SECOND INCREMENT PLANNING PUBLIC PARTICIPATION

PUBLIC PARTICIPATION PLAN

FOR THE SECOND INCREMENT - UPPER PLATTE BASIN-WIDE PLAN DEVELOPMENT (2016 – 2019)

March 2016

Public Participation Plan Development Committee Participating Organizations

Irrigation Districts

Central Nebraska Public Power and Irrigation District
Nebraska Public Power and Irrigation District
Pathfinder Irrigation District

Natural Resources Districts

Central Platte
South Platte
Twin Platte
North Platte
Tri-Basin

State of Nebraska

Department of Natural Resources

Public Participation Plan Development Committee

Brian Barels
Nebraska Public Power District

John Berge
North Platte Natural Resources District

Barb Cross
North Platte Natural Resources District

Ann Dimmitt
Twin Platte Natural Resources District

Mike Drain
Central Nebraska Public Power and Irrigation District

Travis Glanz
South Platte Natural Resources District

Rod Horn
South Platte Natural Resources District

Don Kraus
Central Nebraska Public Power and Irrigation District

Kent Miller
Twin Platte Natural Resources District

Melissa Mosier
Nebraska Department of Natural Resources

Ryan Reisdorff
South Platte Natural Resources District

Jennifer Schellpeper
Nebraska Department of Natural Resources

Jeff Shafer
Nebraska Public Power District

Landon Shaw
Twin Platte Natural Resources District

Dennis Strauch
Pathfinder Irrigation District

John Thorburn
Tri-Basin Natural Resources District

Lyndon Vogt
Central Platte Natural Resources District

Jessie Winter
Nebraska Department of Natural Resources

Tracy Zayac
North Platte Natural Resources District

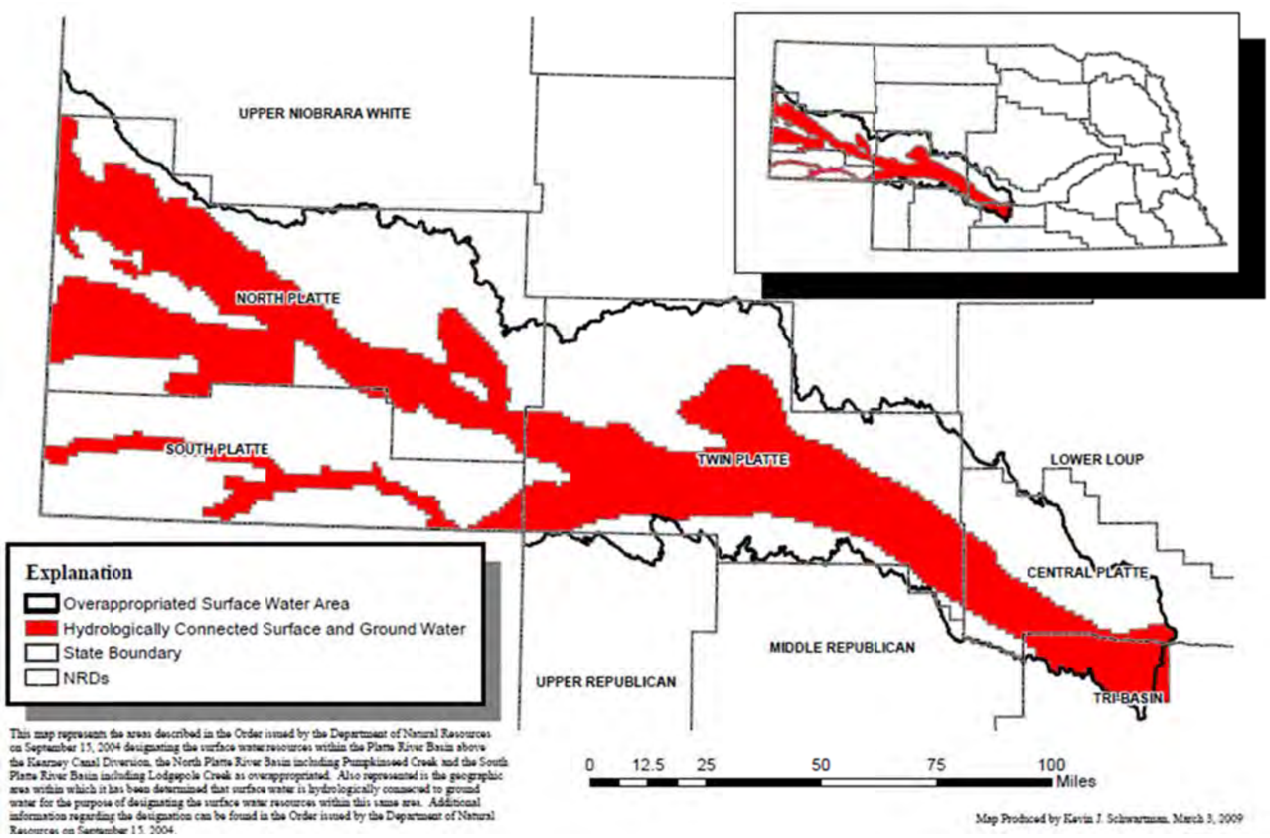
Nancy Shank, PhD, MBA, Acting Director of the University of Nebraska Public Policy Center facilitated the committee meetings and compiled this plan.

Introduction

The Upper Platte Basin Public Participation Plan Development Committee, representing surface and groundwater interests, created this *Public Participation Plan* to guide the process for developing the second increment basin-wide plan that must be completed by September 2019. The *Public Participation Plan* is intended to provide an overall vision for how the basin-wide planning process will be approached. The *Public Participation Plan* is meant to provide guidance that may be modified, as needed.

Nebraska's Ground Water Management and Protection Act requires basin-wide planning when an area has been found to be overappropriated (*Nebraska Revised Statutes* § 46-715; see Appendix A for § 46-715 through 46-719). The Upper Platte Basin was determined to be overappropriated by the Nebraska Department of Natural Resources and a basin-wide plan was adopted in 2009. The heavy black outline in Figure 1 denotes the overappropriated surface water area. The red shaded area denotes the hydrologically connected groundwater area subject to the overapppropriated designation.

Figure 1. Upper Platte Basin planning area



During the ten years following adoption of the basin-wide plan, the Department of Natural Resources and natural resources districts are required to conduct a technical analysis to determine the progress toward meeting the goals and objectives of the plan and examine "(A) available supplies and changes in long-term availability, (B) the effects of conservation practices and natural causes, including, but not limited to, drought, and (C) the effects of the plan on reducing the overall difference between current and fully appropriated levels of development" (*Neb. Rev. Stat.* § 46-715(5)(d)(iii)). The results of this analysis will determine if a subsequent increment of the plan is needed.

It is expected that a second increment will be necessary in order to meet the goals and objectives of the Upper Platte basin-wide plan and to reduce the difference between current and fully appropriated levels of development. Each of the Upper Platte Basin natural resources districts has individual integrated management plans that were adopted in 2009, and that must be consistent with the Upper Platte basin-wide plan. In order to allow sufficient time for the individual integrated management plans to be revised accordingly, the target goal for the completion of the second increment basin-wide plan April 2019, although the deadline is September 2019.

Basin-wide plans, according to the statute, are to be jointly developed by the Department of Natural Resources and each natural resources district

> …after consultation and collaboration with irrigation districts, reclamation districts, public power and irrigation districts, mutual irrigation companies, canal companies, and municipalities that rely on water from within the affected area and that, after being notified of the commencement of the plan development process, indicate in writing their desire to participate in such process. In addition, the department or the affected natural resources districts may include designated representatives of other stakeholders. (*Neb. Rev. Stat.* §46-715(5)(b))

Development of the Public Participation Plan

To guide the upcoming second increment planning process, a Public Participation Plan Development Committee met from August 2015 through January 2016. The committee's goal was to create a robust, understandable, transparent approach for the second increment planning. In the course of developing the Public Participation Plan, the committee did not hold discussions related to the goals, objectives, or other substantive aspects of the Basin-Wide Plan. This *Public Participation Plan* is the result of that effort.

The *Public Participation Plan* may be used by:

- Participants in the planning process as a reference guide
- Facilitators and basin-wide planning consultants as a roadmap
- General public to understand the project and their role in it
- Other interested parties

The remainder of the *Public Participation Plan* describes the parties involved in planning, the decision making structure, the planning process and timeline, governance guidelines, and communications strategies.

Participants in Developing the Basin-Wide Plan

Statutory Requirements

In Nebraska, parties are assigned specific roles and responsibilities in the basin-wide planning process. Nebraska statute describes four categories of types of parties and alludes to general public participation (Table 1). Parties required or invited to participate in the planning process become part of the group asked to reach agreement on the basin-wide plan. Depending on whether agreement is reached, there are two different routes:

- If all parties **come to agreement**, the Department of Natural Resources and the natural resources districts are directed to adopt the basin-wide plan.

- If all parties **cannot reach agreement**, the Department of Natural Resources and the natural resources districts work together to develop and adopt the basin-wide plan. If this is the case in the Upper Platte planning process, to the extent possible, the Department of Natural Resources and the natural resources districts will leave areas of consensus intact and focus their efforts on resolving only the disputed issues.

Table 1. Basin-wide planning roles and responsibilities

Parties	Requirement for Participation	Responsibilities in Basin-Wide Planning	Role in Reaching Agreement
Department of Natural Resources	Required	Jointly responsible with natural resources districts for developing the basin-wide plan Must adopt the plan for it to be valid[1]	Party to agreement decision
Natural resources districts	Required	Jointly responsible with the Department of Natural Resources for developing the basin-wide plan Must adopt the plan for it to be valid[2]	Party to agreement decision

[1] If the Department of Natural Resources and the natural resources districts are unable to adopt a mutually-agreed upon plan, the statute provides for involvement by the Interrelated Water Review Board.
[2] Ibid.

Parties	Requirement for Participation	Responsibilities in Basin-Wide Planning	Role in Reaching Agreement
Irrigation districts, reclamation districts, public power and irrigation districts, mutual irrigation companies, canal companies, and municipalities that rely on water from within the affected area	Required to be invited, but not required to participate	Notified at commencement of the planning process and required to indicate, in writing, desire to participate in the process	Party to agreement decision, if they have indicated, in writing, desire to participate in the process
Designated representatives of other stakeholders	May be invited	May be included in the planning process by the Department of Natural Resources or participating natural resources districts	Party to agreement decision
General public	Public hearings are required at the end of the planning process	None	Not a party asked to reach agreement

Participants in the Upper Platte Basin-Wide Planning Process

The Upper Platte Basin-Wide Planning process will comply with statutory requirements using the following approach to designate representatives and parties:

1. Department of Natural Resources will assign one representative and an alternate to serve as organizational representatives.
2. Each natural resources district will assign one representative and an alternate to serve as organizational representatives.
3. The Department of Natural Resources will invite other named parties (irrigation districts, reclamation districts, public power and irrigation districts, mutual irrigation companies, canal companies, and municipalities that rely on water from within the affected area) to express their interest, in writing, to participate in the process and ask those interested to designate a representative and alternate. The letter should be clear about the process, the role of statutory stakeholders, and the meeting schedule and expectations.
4. The Department of Natural Resources may designate other interests, which may also include asking for a particular person to represent the group. There is particular interest in inviting the Nebraska Game and Parks Commission given their statutory role in the Nebraska Nongame and Endangered Species Conservation Act and their holding of surface water rights.

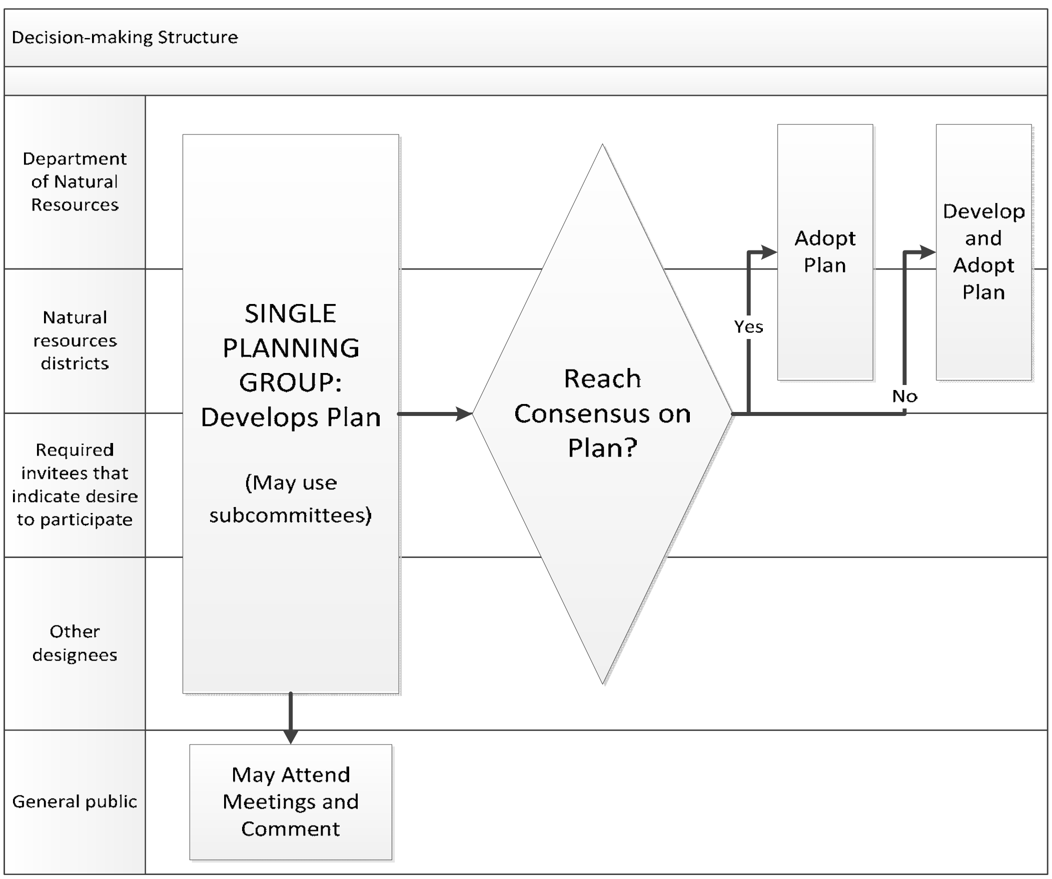
5. Each natural resources district may designate additional representatives of interest groups that may otherwise be underrepresented. Natural resources districts may delay making this decision until interest is expressed by the statutory stakeholders. Possible under-represented groups included groundwater users and industry.

It is not known how many parties will be invited and will choose to engage in the planning process.

Decision-making Structure: Single Planning Group

The *decision-making structure* describes how parties will organize to develop the plan. The Upper Platte basin-wide planning process will include representatives of all parties in a single planning group to develop the basin-wide plan (Figure 2). The group may occasionally employ subcommittees, as deemed appropriate by the single planning group. Subcommittees will not exercise decision making authority, but will offer recommendations to the single planning group.

Figure 2. Planning structure



The single planning group will be the group asked to reach agreement on the plan. If the single planning group cannot reach agreement, the Department of Natural Resources and the natural resources districts will work together to develop the plan. It is the expectation of the single planning group that, to the extent possible, the Department of Natural Resources and the natural resources districts will focus their work to resolve only the disputed issues and leave undisputed areas intact.

The basin-wide plan must be adopted by the Department of Natural Resources and the natural resources districts.

Planning Process and Timeline

The planning process will extend from June 2016 through to a goal for adoption in April 2019 (but that could be adopted as late as September 2019). The four phases of the adoption process and expected time allocations are:

Orient and Prepare

It is anticipated that the single planning group members will be identified by June 2016. Approximately four months (*June through September 2016*) will be devoted to orientation, process planning, and review of technical information. The orientation will include at least one meeting of the single planning group. The orientation and all subsequent meetings will be organized by a facilitator.

Plan

Over the next 17 months (*October 2016 through February 2018*) the single planning group will sequentially address goals, then objectives for each goal, and possible components or actions for each objective. At the end of each sequence, members of the single planning group will be asked to reach agreement on work completed for that sequence. Agreement will be determined through a vote of the single planning group. If the majority of those voting support the work completed for that sequence, the single planning group will move to the next sequence. If the majority of members of the single planning group do not support the work completed for that sequence, Department of Natural Resources and the natural resources districts will work together to resolve the disputed issues for that part of the planning sequence so that the planning process may resume.

Approve

Six months (*March through August 2018*) are scheduled for the single planning group to finalize the plan and come to decision about whether consensus has been achieved. The single planning group will be asked to **determine overall consensus by June 2018**. If the single planning group is unable to come to consensus by June 2018, Department of Natural Resources and the natural resources districts will work together to resolve the disputed issues and create a **final plan by August 2018**. Members of the single planning group will be invited to document their suggestions for the plan within a limited, but yet to be determined amount of time to the Department of Natural Resources and the natural resources districts.

Adopt

To be valid, the plan must be adopted by the Department of Natural Resources and natural resources districts. Eight months (*September 2018 through April 2019*) are allowed for informational public meetings and required public hearings to complete the adoption.

Public Meeting

The single planning group will convene an informational public meeting to inform interested persons and organizations about the plan, its development, and its intent. The meeting will offer all parties an informal opportunity to exchange information and ideas.

Public Hearings

Adopting entities (Department of Natural Resources and natural resources districts) will conduct public hearings in accordance with *Nebraska Revised Statutes* § 46-715 to 46-719. If the outcome of any of the hearings or other events necessitates significant change to the plan, then plan revisions will follow the same process by which the plan was developed:

- If the consensus-based process was the basis of plan development, then potential revisions to the plan will first be considered by the single planning group. If the single planning group is unable to reach consensus on revisions to the plan, the revisions will be developed by Department of Natural Resources and natural resources districts. To the extent possible, revisions developed by the Department of Natural Resources and natural resources districts will focus on those areas of revision which the single planning group was unable to reach consensus.

- If Department of Natural Resources and natural resources district developed the plan (because the single planning group was unable to reach consensus), the Department of Natural Resources and natural resources districts will develop potential revisions to the plan.

If significant revisions to the plan are made, additional public hearings and/or public notice may be necessary.

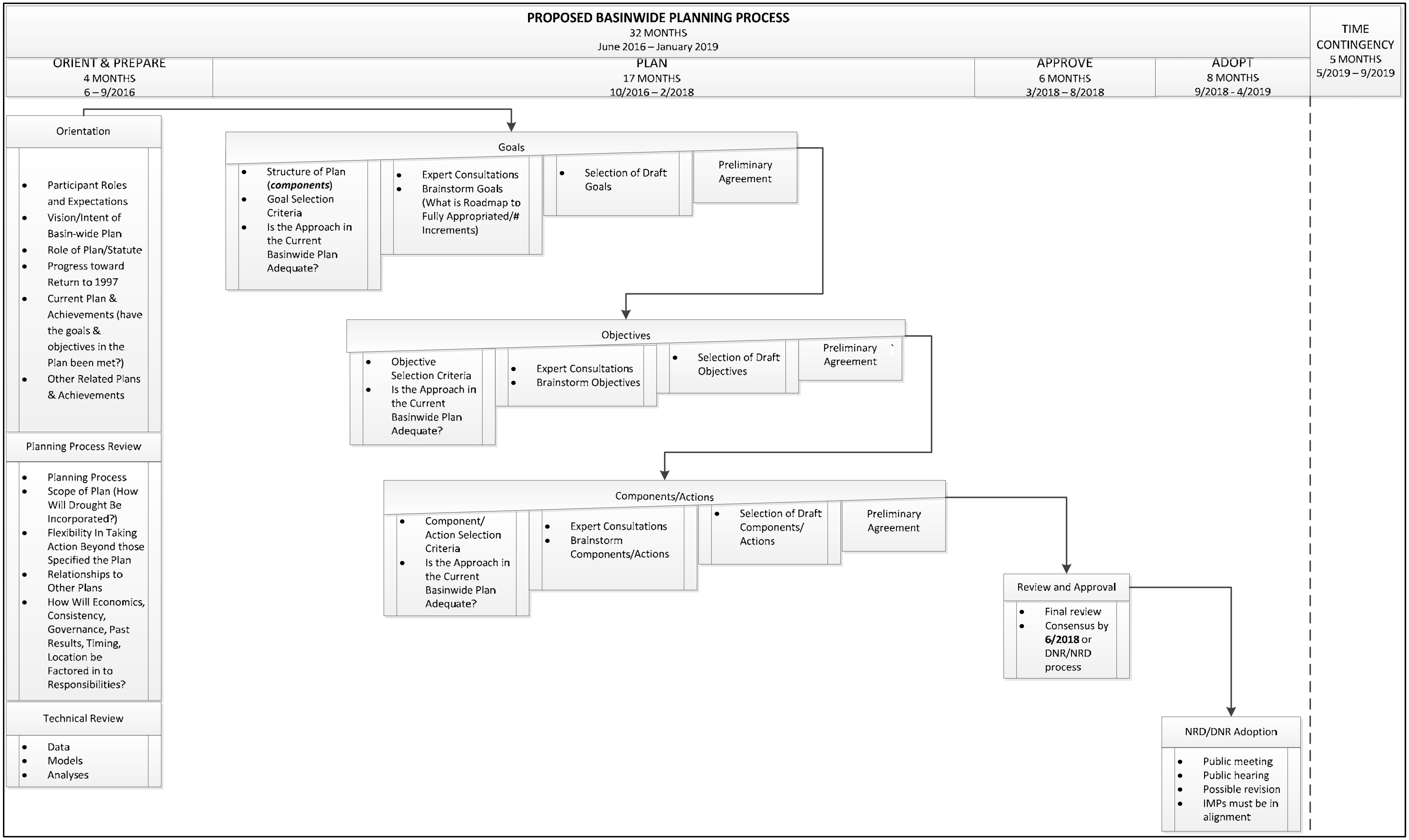
It should also be noted that statute mandates a second increment of each natural resources district's integrated management plan be developed by 2019 and that these second generation plans be consistent with the second increment basin-wide plan. Thus, as the next generation of district plans are developed, the parties will ensure that amendments or changes are consistent with the second increment basin-wide plan.

Time Contingency

In addition to the four planning phases, the timeline includes a time contingency of five months. The planning process must be completed by September 2019.

A visual representation of the planning process and timelines is provided in Figure 3.

Figure 3. Planning process



Governance Guidelines

For the single planning group to operate effectively, governance guidelines address the following issues: meeting times and locations, communications, meeting notice and preparations.

Proposed Meeting Times and Locations

The single planning group will meet at pre-scheduled times and locations. Initially, it is recommended that the meetings follow the proposed schedule (Table 2).

All single planning group meetings will be convened at centrally located venues within the Upper Platte Basin.

Table 2. Proposed meeting times and locations

Date	**Time**	**Location**
June 16, 2016 (first *Orient and Prepare* meeting)	1:00 p.m. – 3:30 p.m. *(Meeting follows the annual basin-wide meeting scheduled for the morning)*	Gothenburg – Monsanto Learning Center 76268 NE-47, Gothenburg, NE 69138
July 20, 2016 (may be a continuation of *Orient and Prepare*) *Subsequent meetings are the* ***3rd Wednesday of every other month***	10:30 a.m. – 3:30 p.m. *(Lunch will be "on your own")*	North Platte – TBD by Department of Natural Resources
September 21, 2016 November 16, 2016 January 18, 2017 March 15, 2017 May 17, 2017 July 19, 2017 September 20, 2017 November 15, 2017 January 17, 2018 March 21, 2018 May 16, 2018 July 18, 2018	10:30 a.m. – 3:30 p.m. *(Lunch will be "on your own")*	North Platte – TBD by Department of Natural Resources

Communications

Communications directed to the public will be approved by the representatives. No individual is authorized to speak on behalf of the group.

Meeting Notice and Preparation

Single planning group members and the general public will have advance notice of single planning group meetings: A basin-wide planning website will be created and all single planning group meetings will be published to that website and will be advertised in local newspapers. To the extent possible, all meeting materials (including the agenda and minutes from the previous meeting) will be sent to representatives and posted on the basin-wide site at least seven days prior to the meeting.

Meeting Operations

Meeting operations focus on how members will participate, the role of the facilitator, and opportunities for participation by the general public.

Single Planning Group Members

For the meetings to be most productive, single planning group members should plan to attend the meetings, read materials in advance, be on time, and fully participate. Members are expected to attend the meetings in person. No provisions will be made for telephone or internet based conferencing.

Members will be asked to signify their agreement at various points along the plan development process. In a consensus-based process, representatives will focus on areas of common ground. One recommendation to achieve this is that when representatives are unable to find agreement, solutions to overcome barriers are offered.

For those members who have named alternates that may attend on their behalf, the regular member should fully brief the alternate prior to any meeting. If a member is unable to regularly attend meetings, the member should notify the designating organization and the designating organization should name a new member in advance of attendance at a meeting.

Single Planning Group Support: Facilitator

A facilitator will be engaged, in part, to ensure progress is being made and that meetings are productive (Appendix B – Facilitator Scope of Work), including responsibilities to:

- Develop meeting agendas and materials
- Create and guide processes to ensure time is productively spent
- Ensure representatives are engaging productively and attentively
- Start and end meetings on time
- Follow the agenda to the extent possible
- Take minutes
- Be responsive to member suggestions and concerns about the process
- Create successive draft plans

Opportunities for Participation by the General Public

The general public is invited to participate in the basin-wide plan development throughout the process by staying informed and providing input (Table 3).

Information will be available through an Upper Platte basin-wide planning **website**. The website will have information about the planning process and meeting materials. **Meetings notices** will be placed in area newspapers. There may be occasional **media releases** about the project. Finally, individuals interested in receiving updates about the process will be invited to sign up to receive **mailings** (likely electronic).

All **single planning group meetings will be open to the public** and each single planning group agenda will include the opportunity for **public comment**. Pursuant to statute (*Neb. Rev. Stat.* §46-715 to 46-719, public hearings about the basin-wide plan will also be conducted by the Department of Natural Resources and the natural resources districts.

Table 3. General public participation

Information	Input
The general public will have access to information to assist their understanding of the problems, alternatives, opportunities and/or solutions • Website • Media releases • Public notice • Mailing lists	*The general public will have opportunities to provide feedback on goals, objectives, and actions* • Open meetings • Hearings will expressly be convened to hear public comment

Contact information

For general information:

Lyndon Vogt
Central Platte Natural Resources District
Phone: 308-385-6282
Email: vogt@cpnrd.org

Jennifer Schellpeper
Nebraska Department of Natural Resources
Phone: 402-471-2363
Email: jennifer.schellpeper@nebraska.gov

John Berge
North Platte Natural Resources District
Phone: 308-632-2749
Email: jberge@npnrd.org

Rod Horn
South Platte Natural Resources District
Phone: 308-254-2377
Email: rlhorn@spnrd.org

John Thorburn
Tri-Basin Natural Resources District
Phone: 308-995-6688
Email: jthorburn@tribasinnrd.org

Kent Miller
Twin Platte Natural Resources District
Phone: 308-535-8080
Email: komiller@tpnrd.org

Appendix A - Nebraska Revised Statute §46-715 through 46-719 of the Nebraska Groundwater Management and Protection Act

46-715. River basin, subbasin, or reach; integrated management plan; considerations; contents; amendment; technical analysis; forecast of water available from streamflow.

(1)(a) Whenever the Department of Natural Resources has designated a river basin, subbasin, or reach as overappropriated or has made a final determination that a river basin, subbasin, or reach is fully appropriated, the natural resources districts encompassing such river basin, subbasin, or reach and the department shall jointly develop an integrated management plan for such river basin, subbasin, or reach. The plan shall be completed, adopted, and take effect within three years after such designation or final determination unless the department and the natural resources districts jointly agree to an extension of not more than two additional years.

(b) A natural resources district encompassing a river basin, subbasin, or reach that has not been designated as overappropriated or has not been finally determined to be fully appropriated may, jointly with the department, develop an integrated management plan for such river basin, subbasin, or reach located within the district. The district shall notify the department of its intention to develop an integrated management plan which shall be developed and adopted according to sections 46-715 to 46-717 and subsections (1) and (2) of section 46-718. The objective of an integrated management plan under this subdivision is to manage such river basin, subbasin, or reach to achieve and sustain a balance between water uses and water supplies for the long term. If a district develops an integrated management plan under this subdivision and the department subsequently determines the affected river basin, subbasin, or reach to be fully appropriated, the department and the affected natural resources district may amend the integrated management plan.

(2) In developing an integrated management plan, the effects of existing and potential new water uses on existing surface water appropriators and ground water users shall be considered. An integrated management plan shall include the following: (a) Clear goals and objectives with a purpose of sustaining a balance between water uses and water supplies so that the economic viability, social and environmental health, safety, and welfare of the river basin, subbasin, or reach can be achieved and maintained for both the near term and the long term; (b) a map clearly delineating the geographic area subject to the integrated management plan; (c) one or more of the ground water controls authorized for adoption by natural resources districts pursuant to section 46-739; (d) one or more of the surface water controls authorized for adoption by the department pursuant to section 46-716; and (e) a plan to gather and evaluate data, information, and methodologies that could be used to implement sections 46-715 to 46-717, increase understanding of the surface water and hydrologically connected ground water system, and test the validity of the conclusions and information upon which the integrated management plan is based. The plan may also provide for utilization of any applicable incentive programs authorized by law. Nothing in the integrated management plan for a fully appropriated river basin, subbasin, or reach shall require a natural resources district to regulate ground water uses in place at the time of the department's preliminary determination that the river basin, subbasin, or reach is fully appropriated, unless such regulation is necessary to carry out the goals and objectives of a basin-wide plan pursuant to section 46-755, but a natural resources district may voluntarily adopt such regulations. The applicable natural resources district may decide to include all water users within the district boundary in an integrated management plan.

(3) In order to provide a process for economic development opportunities and economic sustainability within a river basin, subbasin, or reach, the integrated management plan shall include clear and transparent procedures to track depletions and gains to streamflows resulting from new, retired, or other changes to uses within the river basin, subbasin, or reach. The procedures shall:

(a) Utilize generally accepted methodologies based on the best available information, data, and science;

(b) Include a generally accepted methodology to be utilized to estimate depletions and gains to streamflows, which methodology includes location, amount, and time regarding gains to streamflows as offsets to new uses;

(c) Identify means to be utilized so that new uses will not have more than a de minimis effect upon existing surface water users or ground water users;

(d) Identify procedures the natural resources district and the department will use to report, consult, and otherwise share information on new uses, changes in uses, or other activities affecting water use in the river basin, subbasin, or reach;

(e) Identify, to the extent feasible, potential water available to mitigate new uses, including, but not limited to, water rights leases, interference agreements, augmentation projects, conjunctive use management, and use retirement;

(f) Develop, to the extent feasible, an outline of plans after consultation with and an opportunity to provide input from irrigation districts, public power and irrigation districts, reclamation districts, municipalities, other political subdivisions, and other water users to make water available for offset to enhance and encourage economic development opportunities and economic sustainability in the river basin, subbasin, or reach; and

(g) Clearly identify procedures that applicants for new uses shall take to apply for approval of a new water use and corresponding offset.

Nothing in this subsection shall require revision or amendment of an integrated management plan approved on or before August 30, 2009.

(4) The ground water and surface water controls proposed for adoption in the integrated management plan pursuant to subsection (1) of this section shall, when considered together and with any applicable incentive programs, (a) be consistent with the goals and objectives of the plan, (b) be sufficient to ensure that the state will remain in compliance with applicable state and federal laws and with any applicable interstate water compact or decree or other formal state contract or agreement pertaining to surface water or ground water use or supplies, and (c) protect the ground water users whose water wells are dependent on recharge from the river or stream involved and the surface water appropriators on such river or stream from streamflow depletion caused by surface water uses and ground water uses begun, in the case of a river basin, subbasin, or reach designated as overappropriated or preliminarily determined to be fully appropriated in accordance with section 46-713, after the date of such designation or preliminary determination.

(5)(a) In any river basin, subbasin, or reach that is designated as overappropriated, when the designated area lies within two or more natural resources districts, the department and the affected natural resources districts shall jointly develop a basin-wide plan for the area designated as overappropriated. Such plan shall be developed using the consultation and collaboration process described in subdivision (b) of this subsection, shall be developed concurrently with the development of the integrated management plan required pursuant to subsections (1) through (4) of this section, and shall be designed to achieve, in the incremental manner described in subdivision (d) of this subsection, the goals and objectives described in subsection (2) of this section. The basin-wide plan shall be adopted after hearings by the department and the affected natural resources districts.

(b) In any river basin, subbasin, or reach designated as overappropriated and subject to this subsection, the department and each natural resources district encompassing such river basin, subbasin, or reach shall jointly develop an integrated management plan for such river basin, subbasin, or reach pursuant to subsections (1) through (4) of this section. Each integrated management plan for a river basin, subbasin, or reach subject to this subsection shall be consistent with any basin-wide plan developed pursuant to subdivision (a) of this subsection. Such integrated management plan shall be developed after consultation and collaboration with irrigation districts, reclamation districts, public power and irrigation districts, mutual irrigation companies, canal companies, and municipalities that rely on water from within the affected area and that, after being notified of the commencement of the plan development process, indicate in writing their desire to participate in such process. In addition, the department or the affected natural resources districts may include designated representatives of other stakeholders. If agreement is reached by all parties involved in such consultation and collaboration process, the department and each natural resources district shall adopt the agreed-upon integrated management plan. If agreement cannot be reached by all parties involved, the integrated management plan shall be developed and adopted by the department and the affected natural resources district pursuant to sections 46-715 to 46-718 or by the Interrelated Water Review Board pursuant to section 46-719.

(c) Any integrated management plan developed under this subsection shall identify the overall difference between the current and fully appropriated levels of development. Such determination shall take into account cyclical supply, including drought, identify the portion of the overall difference between the current and fully appropriated levels of development that is due to conservation measures, and identify the portions of the overall difference between the current and fully appropriated levels of development that are due to water use initiated prior to July 1, 1997, and to water use initiated on or after such date.

(d) Any integrated management plan developed under this subsection shall adopt an incremental approach to achieve the goals and objectives identified under subdivision (2)(a) of this section using the following steps:

(i) The first incremental goals shall be to address the impact of streamflow depletions to (A) surface water appropriations and (B) water wells constructed in aquifers dependent upon recharge from streamflow, to the extent those depletions are due to water use initiated after July 1, 1997, and, unless an interstate cooperative agreement for such river basin, subbasin, or reach is no longer in effect, to prevent streamflow depletions that would cause noncompliance by Nebraska with such interstate cooperative agreement. During the first increment, the department and the affected natural resources districts shall also pursue voluntary efforts, subject to the availability of funds, to offset any increase in streamflow depletive effects that occur after July 1, 1997, but are caused by ground water uses initiated prior to such date. The department and the affected natural resources districts may also use other appropriate and authorized measures for such purpose;

(ii) The department and the affected natural resources districts may amend an integrated management plan subject to this subsection (5) as necessary based on an annual review of the progress being made toward achieving the goals for that increment;

(iii) During the ten years following adoption of an integrated management plan developed under this subsection (5) or during the ten years after the adoption of any subsequent increment of the integrated management plan pursuant to subdivision (d)(iv) of this subsection, the department and the affected natural resources district shall conduct a technical analysis of the actions taken in such increment to determine the progress towards meeting the goals and objectives adopted pursuant to subsection (2) of this section. The analysis shall include an examination of (A) available supplies and changes in long-term availability, (B) the effects of conservation practices and natural causes, including, but not limited to, drought, and (C) the effects of the plan on reducing the overall difference between the current and fully appropriated levels of development identified in subdivision (5)(c) of this section. The analysis shall determine whether a subsequent increment is necessary in the integrated management plan to meet the goals and objectives adopted pursuant to subsection (2) of this section and reduce the overall difference between the current and fully appropriated levels of development identified in subdivision (5)(c) of this section;

(iv) Based on the determination made in subdivision (d)(iii) of this subsection, the department and the affected natural resources districts, utilizing the consultative and collaborative process described in subdivision (b) of this subsection, shall if necessary identify goals for a subsequent increment of the integrated management plan. Subsequent increments shall be completed, adopted, and take effect not more than ten years after adoption of the previous increment; and

(v) If necessary, the steps described in subdivisions (d)(ii) through (iv) of this subsection shall be repeated until the department and the affected natural resources districts agree that the goals and objectives identified pursuant to subsection (2) of this section have been met and the overall difference between the current and fully appropriated levels of development identified in subdivision (5)(c) of this section has been addressed so that the river basin, subbasin, or reach has returned to a fully appropriated condition.

(6) In any river basin, subbasin, or reach that is designated as fully appropriated or overappropriated and whenever necessary to ensure that the state is in compliance with an interstate compact or decree or a formal state contract or agreement, the department, in consultation with the affected districts, shall forecast on an annual basis the maximum amount of water that may be available from streamflow for beneficial use in the short term and long term in order to comply with the requirement of subdivision (4)(b) of this section. This forecast shall be made by January 1, 2008, and each January 1 thereafter.

Source: Laws 2004, LB 962, § 55; Laws 2006, LB 1226, § 25; Laws 2007, LB701, § 23; Laws 2009, LB54, § 3; Laws 2010, LB764, § 1; Laws 2014, LB1098, § 14.

46-716. Integrated management plan; surface water controls.

(1) The surface water controls that may be included in an integrated management plan and may be adopted by the Department of Natural Resources are: (a) Increased monitoring and enforcement of surface water diversion rates and amounts diverted annually; (b) the prohibition or limitation of additional surface water appropriations; (c) requirements for surface water appropriators to apply or utilize reasonable conservation measures consistent with good husbandry and other requirements of section 46-231 and consistent with reasonable reliance by other surface water or ground water users on return flows or on seepage to the aquifer; and (d) other reasonable restrictions on surface water use which are consistent with the intent of section 46-715 and the requirements of section 46-231.

(2) If during the development of the integrated management plan the department determines that surface water appropriators should be required to apply or utilize conservation measures or that other reasonable restrictions on surface water use need to be imposed, the department's portion of the integrated management plan shall allow the affected surface water appropriators and surface water project sponsors a reasonable amount of time, not to exceed one hundred eighty days unless extended by the department, to identify the conservation measures to be applied or utilized, to develop a schedule for such application and utilization, and to comment on any other proposed restrictions.

Source: Laws 2004, LB 962, § 56.

46-717. Integrated management plan; scientific data and other information; department; natural resources district; duties.

(1) In developing an integrated management plan, the Department of Natural Resources and the affected natural resources districts shall utilize the best scientific data and other information available and shall review and consider any rules and regulations in effect in any existing ground water management area that encompasses all or part of the geographic area to be encompassed by the plan. Consideration shall be given to the applicable scientific data and other information relied upon by the department in preparing the annual report required by section 46-713 and to other types of data and information that may be deemed appropriate by the department. The department, after seeking input from the affected natural resources districts, shall specify by rule and regulation the types of scientific data and other information that will be considered in developing an integrated management plan. The natural resources districts shall adopt similar rules and regulations specifying the types of scientific data and other information necessary for purposes of this section. Existing research, data, studies, or any other relevant information which has been compiled by or is in possession of other state or federal agencies, other natural resources districts, and other political subdivisions within the State of Nebraska shall be utilized. State agencies and political subdivisions shall furnish information or data upon request of the department or any affected natural resources district. Neither the department nor the natural resources districts shall be required to conduct new research or to develop new computer models to prepare an integrated management plan, but such new research may be conducted or new computer models developed within the limits of available funding if the additional information is desired by the department or the affected natural resources districts.

(2) During preparation of an integrated management plan for a fully appropriated river basin, subbasin, or reach or of an integrated management plan under subdivision (1)(b) of section 46-715, the department and the affected natural resources districts shall consult with any irrigation district, reclamation district, public power and irrigation district, mutual irrigation company, canal company, or municipality that relies on water from the affected river basin, subbasin, or reach and with other water users and stakeholders as deemed appropriate by the department or by the affected natural resources districts. They shall also actively solicit public comments and opinions through public meetings and other means.

Source: Laws 2004, LB 962, § 57; Laws 2010, LB764, § 2.

46-718. Integrated management plan; hearings; implementation order; dispute; procedure.

(1) If the Department of Natural Resources and the affected natural resources districts preparing an integrated management plan reach agreement on (a) the proposed goals and objectives of the plan for the affected river basin, subbasin, or reach, (b) the proposed geographic area to be subject to controls, and (c) the surface water and ground water controls and any incentive programs that are proposed for adoption and implementation in the river basin, subbasin, or reach, they shall schedule one or more public hearings to take testimony on the proposed integrated management plan and the proposed controls. Such hearings shall be held within forty-five days after reaching agreement and within or in reasonable proximity to the area to be affected by implementation of the integrated management plan. Notice of such hearings shall be published as provided in section 46-743. The costs of publishing the notice shall be shared between the department and the affected natural resources districts. All interested persons may appear at the hearings and present testimony or provide other evidence relevant to the issues being considered.

(2) Within sixty days after the final hearing under this section, the department and the affected natural resources districts shall jointly decide whether to implement the plan proposed, with or without modifications, and whether to adopt and implement the surface water and ground water controls and incentive programs proposed in the plan. If the department and the natural resources districts agree to implement the plan and to adopt and implement the proposed controls, the natural resources districts shall by order designate a ground water management area for integrated management or, if the geographic area subject to the integrated management plan is already in a ground water management area, the order shall designate an integrated management subarea for that area. The order shall include a geographic and stratigraphic definition of the ground water management area or integrated management subarea and shall adopt the controls in the integrated management plan that are authorized for adoption by the natural resources district pursuant to section 46-739. The department shall by order adopt the controls in the integrated management plan that are authorized for adoption by the department pursuant to section 46-716. Neither the controls adopted by the district nor those adopted by the department shall include controls substantially different from those set forth in the notice of hearing. The area designated as a ground water management area or an integrated management subarea by the natural resources district shall not include any area that was not identified in the notice of the hearing as within the area proposed to be subject to the controls in the plan. The department and the natural resources district shall each cause a copy of its order to be published in the manner provided in section 46-744.

(3) If at any time during the development of a basin-wide plan or an integrated management plan either the department or the affected natural resources districts conclude that the parties will be unable to reach a timely agreement on the basin-wide plan or on (a) the goals and objectives of the integrated management plan for the affected river basin, subbasin, or reach, (b) the geographic area to be subject to controls, or (c) the surface water or ground water controls or any incentive programs to be proposed for adoption and implementation in the affected river basin, subbasin, or reach, the Governor shall be notified and the dispute shall be submitted to the Interrelated Water Review Board as provided in subsection (2) of section 46-719.

Source: Laws 2004, LB 962, § 58.

46-719. Interrelated Water Review Board; created; members; powers and duties.

(1)(a) The Interrelated Water Review Board is created for the purposes stated in subsections (2) through (5) of this section. The board shall consist of five members. The board, when appointed and convened, shall continue in existence only until it has resolved a dispute referred to it pursuant to such subsections. The Governor shall appoint and convene the board within forty-five days of being notified of the need to resolve a dispute. The board shall be chaired by the Governor or his or her designee, which designee shall be knowledgeable concerning surface water and ground water issues. The Governor shall appoint one additional member of his or her choosing and shall appoint the other three members of the board from a list of no fewer than six nominees provided by the Nebraska Natural Resources Commission within twenty days after request by the Governor for a list of nominees.

(b) Not more than two members of the board shall reside in the geographic area involved in the dispute. A person is not eligible for membership on the board if the decisions to be made by the board would or could cause financial benefit or detriment to the person, a member of his or her immediate family, or a business with which the person is associated, unless such benefit or detriment is indistinguishable from the effects of such action on the public generally or a broad segment of the public. The board shall be subject to the Open Meetings Act.

(c) For purposes of subsections (2) and (3) of this section, action may be taken by a vote of three of the board's five members. For purposes of subsections (4) and (5) of this section, action may be taken only by a vote of at least four of the board's five members.

(2)(a) If the Department of Natural Resources and the affected natural resources districts cannot resolve disputes over the content of a basin-wide plan or an integrated management plan by utilizing the process described in sections 46-715 to 46-718, the Governor shall be notified and the dispute submitted to the Interrelated Water Review Board. When the board has been appointed and convened to resolve disputes over a basin-wide plan, the department and each affected district shall present their proposed basin-wide plans to the board. When the board has been convened to resolve disputes over an integrated management plan, the department and each affected natural resources district shall present their (i) proposed goals and objectives for the integrated management plan, (ii) proposed geographic area to be subject to controls, and (iii) proposed surface water and ground water controls and any proposed incentive program for adoption and implementation in the river basin, subbasin, or reach involved. The department and each affected natural resources district shall also be given adequate opportunity to comment on the proposals made by the other parties to the dispute.

(b) When the Interrelated Water Review Board concludes that the issues in dispute have been fully presented and commented upon by the parties to the dispute, which conclusion shall be made not more than forty-five days after the board is convened, the board shall select the proposals or portions of proposals that the board will consider for adoption and shall schedule one or more public hearings to take testimony on the selected proposals. The hearings shall be held within forty-five days after the board's selection of proposals to consider for adoption and shall be within or in reasonable proximity to the area that would be affected by implementation of any of the proposals to be considered at the hearings. Notice of the hearings shall be published as provided in section 46-743. The cost of publishing the notice shall be shared by the department and the affected natural resources districts. All interested persons may appear at the hearings and present testimony or provide other evidence relevant to the issues being considered.

(c) Within forty-five days after the final hearing pursuant to subdivision (b) of this subsection, the Interrelated Water Review Board shall by order, as applicable, adopt a basin-wide plan or an integrated management plan for the affected river basin, subbasin, or reach and, in the case of an integrated management plan, shall designate a ground water management area for integrated management or an integrated management subarea for such river basin, subbasin, or reach. An integrated management plan shall be consistent with subsection (2) of section 46-715, and the surface water and ground water controls and any applicable incentive programs adopted as part of that plan shall be consistent with subsection (4) of section 46-715. The controls adopted by the board shall not be substantially different from those described in the notice of hearing. The area designated as a ground water management area or an integrated management subarea shall not include any area that was not identified in the notice of the hearing as within the area proposed to be subject to the controls in the plan.

(d) The order adopted under this subsection shall be published in the manner prescribed in section 46-744.

(e) Surface water controls adopted by the Interrelated Water Review Board shall be implemented and enforced by the department. Ground water controls adopted by the Interrelated Water Review Board shall be implemented and enforced by the affected natural resources districts.

(3) Whether an integrated management plan is adopted pursuant to section 46-718 or by the Interrelated Water Review Board pursuant to subsection (2) of this section, the department or a natural resources district responsible in part for

implementation and enforcement of an integrated management plan may propose modification of the goals or objectives of that plan, of the area subject to the plan, or of the surface water controls, ground water controls, or incentive programs adopted to implement the plan. The department and the affected natural resources districts shall utilize the procedures in sections 46-715 to 46-718 in an attempt to reach agreement on and to adopt and implement proposed modifications. If agreement on such modifications cannot be achieved utilizing those procedures, either the department or an affected natural resources district may notify the Governor of the dispute. The Interrelated Water Review Board shall be appointed and convened in accordance with subsection (1) of this section to resolve the dispute and, if applicable, to adopt any modifications utilizing the procedures in subsection (2) of this section.

(4) The department and the affected natural resources districts may also raise objections concerning the implementation or enforcement of previously adopted surface water or ground water controls. The department and the affected natural resources districts shall utilize the procedures in sections 46-715 to 46-718 in an attempt to reach agreement on such implementation or enforcement issues. If agreement on such issues cannot be achieved utilizing such procedures, either the department or an affected natural resources district may notify the Governor of the dispute. The Interrelated Water Review Board shall be appointed and convened in accordance with subsection (1) of this section. After permitting each party to fully express its reasons for its position on the disputed issues, the board may either take no action or conclude (a) that one or more parties needs to modify its approach to implementation or enforcement and direct that such modifications take place or (b) that one or more parties either has not made a good faith effort to implement or enforce the portion of the plan or controls for which it is responsible or is unable to fully implement and enforce such portion and that such party's jurisdiction with respect to implementation and enforcement of the plan and controls shall be terminated and reassigned to one or more of the other parties responsible for implementation and enforcement. A decision by the Interrelated Water Review Board to terminate and reassign jurisdiction of any portion of the plan or controls shall take effect immediately upon that decision. Notice of such reassignment shall be published at least once in one or more newspapers as necessary to provide general circulation in the area affected by such reassignment.

(5) The board may be reconvened in accordance with subsection (1) of this section at a later date upon request to the Governor by the party for which jurisdiction for implementation and enforcement was terminated if such party desires to have its jurisdiction reinstated, but no such request shall be honored until at least one year after the termination and not more than once per year thereafter. The board may reinstate jurisdiction to that party only upon a clear showing by

such party that it is willing and able to fully implement and enforce the plan and any applicable controls. Notice that a party's jurisdiction has been reinstated shall be provided in the same manner that notice of the earlier termination was given.

Source: Laws 2004, LB 962, § 59; Laws 2006, LB 1226, § 26; Laws 2009, LB54, § 4.

Cross References

Open Meetings Act, see section 84-1407.

Appendix B - Facilitator Scope of Work

Facilitation and Coordination Support for Platte River Basin Water Planning Process
Request for Qualifications
October 30, 2015

Introduction

The Department of Natural Resources, North Platte Natural Resources District, South Platte Natural Resources District, Twin Platte Natural Resources District, Central Platte Natural Resources District, and Tri-Basin Natural Resources District (the Sponsors), all cooperating under an interlocal agreement, are soliciting a Statement of Qualifications (SOQ's) for professional services to provide facilitation services, coordination support in development of the second increment of the Basin-Wide Plan (Plan) in the Upper Platte River Basin within Nebraska, and drafting of the Plan. The Basin-Wide Planning process generally includes the development of goals, objectives, and certain actions aimed at meeting the requirements outlined in Neb Rev. Stat. §46-715. The process of developing the Plan will include participation of the Sponsors in conjunction with various stakeholder interests within the Platte River Basin.

Scope of Services

Services are being sought to ensure effective communication and collaboration throughout the planning process. Likely services that will need to be provided include: project management services to ensure effective project communication and dissemination of information to appropriate parties, meeting coordination and facilitation services to ensure Sponsors objectives are being achieved, development and distribution of educational materials, and drafting, distribution, and completion of the Plan. A more detailed scope of services in outlined in Attachment A.

SOQ Submittal Process

Firms interested in being considered must submit six (6) copies of the Statement of Qualifications (SOQ). The SOQ should be addressed to Jennifer J. Schellpeper and received at the Nebraska Department of Natural Resources no later than 5:00 p.m. December 14, 2015 at 301 Centennial Mall South, Lincoln, NE 68509-4676.

Questions. For questions regarding the project and the SOQ submittal process contact Jennifer J. Schellpeper of the Nebraska Department of Natural Resources by e-mail at jennifer.schellpeper@nebraska.gov with your question. Please include name, name of firm, address, phone, fax, and e-mail.

Pre-Submittal Meeting. No pre-submittal meeting for SOQ's will be conducted.

Submittal Format. Interested firms shall include the following in their submittal:

1. Include pertinent company information, including company name, entity type, home office address, local address (if applicable), telephone, facsimile, contact name and email address. Include a signature of an authorized agent of your firm. Limit to one page.
2. In five pages or less, outline the expertise and knowledge of the team that will be assigned to this project, in the following areas:
    a) Project Management and Facilitation services: experience with large groups of stakeholders with diverse backgrounds and with high conflict,

meeting coordination and meeting organization, effective communication strategies and development of educational materials,

b) Water Planning (with emphasis on integrated water management concepts and the Nebraska Groundwater Management and Protection Act),

c) Knowledge of surface water and groundwater hydrology and hydrogeology, including the Upper Platte River Basin.

3. Include a short description of no more than five (5) relevant projects, describing each project in one page or less. Include a contact for each project.
4. Identify a team who will be available for this scope of work beginning in February 2016 and continuing through January 2019; limit to one page for overview and one page for organization chart. Also state availability. Include a short resume for each team member, no more than one page for each person.

Consultant Selection Process

The selection process will include the following steps:

1. Evaluate and rank the SOQ's. The ranking criteria are included in the Selection Criteria section below. Each respondent will be ranked as a) not acceptable (0 pts.), b) acceptable (2 pts.), or c) excellent (4 pts.) in each criterion. Then based on the weight, each respondent will be given an overall ranking. Respondents will only be ranked on experiences and qualifications included in their SOQ's.
2. After Evaluation and Ranking Interviews may be conducted. If interviews are conducted selected consultants will be notified by January 4th and interviews will be scheduled the week of January 11, 2016.
3. Respondents will be notified of their ranking by 5:00 p.m. January 18, 2016.
4. The firm with the highest ranking will be asked to provide a full cost estimate for the scope of services identified in Attachment A. If the Sponsors and firm are able to reach agreement on contract terms a contract will be executed with that firm. If the Sponsors and firm are unable to reach agreement on contract terms then the next highest ranked firm will be sought until a contract is successfully executed.

Selection Criteria

The selection criteria below, in order of importance and weight, will be used to evaluate the Statement of Qualifications.

1. Previous experience and expertise in providing facilitation services (50%).
2. Previous experience and expertise in water planning (20%).
3. Knowledge of integrated water management planning principles (20%).
4. Knowledge of hydrology and hydrogeologic concepts (10%).

Contact Information

Jennifer J. Schellpeper
Nebraska Department of Natural Resources
301 Centennial Mall South
Lincoln, NE 68509-4676
Email: jennifer.schellpeper@nebraska.gov
Phone: (402) 471-2899

ATTACHMENT A
Anticipated Scope of Services

1. **TASK 1 – Project Management**
   a. **Task Objective**
      Develop effective project communication; confirm that Project elements are being completed. Discover and disseminate project information to improve quality and efficiency.
   b. **Activities**
      The selected consultant/contractor will conduct general project management tasks, which include:
      i. Development and use of a project guide, monthly invoicing, and monthly progress report
      ii. Project scheduling
      iii. Subconsultant/subcontractor management
      iv. Project close-out activities,
      v. Development and use as necessary, with input from the Sponsors and stakeholder participants, a website for document exchange and document management
      vi. Other project administrative activities in support of the project team
   c. **Task Deliverables:**
      i. Monthly invoices and progress reports.
      ii. Project administrative support.
      iii. Secure website (or ftp site).
   d. **Key Understandings:**
      i. The duration of the project is approximately thirty (30) months with a target date for completion of on or before January 1, 2019.

2. **TASK 2 –MEETING COORDINATION AND FACILITATION**
   a. **Task Objective**
      Provide coordination and facilitation support to the Sponsors to assist in the development of a Basin-Wide Management Plan. Facilitate communication of stakeholder participants with the Sponsors.
   b. **Activities:**
      i. **Task 2.1 Sponsor Coordination Meetings**. The selected consultant/contractor will coordinate up to fifteen (15) in-person meetings to discuss the ongoing activities of the planning process and determine future processes for stakeholder participation. The expected number of meetings is an estimated quantity. Meeting coordination will include scheduling meetings, distributing agendas to the Sponsors at least ten (10) days before each meeting, recording notes, distributing meeting summaries to Sponsors for review and comment within fifteen (15) days of each meeting, and incorporating Sponsors comments into meeting summaries.
      ii. **Task 2.2 Stakeholder Meetings.** The selected consultant/contractor will coordinate and facilitate up to fifteen (15) in-person meetings with stakeholders such that the stakeholders are provided opportunity to consult and collaborate on the formulation, evaluation, and recommendation of plans and management actions aimed at the identification of specific basin-wide planning goals and objectives. The expected number of meetings is an estimated quantity. Meeting coordination will include scheduling meetings, distributing agendas to the Sponsors at least ten (10) days before

each meeting, recording stakeholder feedback, distributing meeting summaries to Sponsors for review and comment within fifteen (15) days of each meeting, and incorporating Sponsors comments into meeting summaries. Consultant/contractor will develop effective meeting processes with guidance from the Sponsors.

iii. **Task 2.3 Project Website.** The selected consultant/contractor will design and populate a project website. Website content will be developed by the consultant/contractor with guidance from the Sponsors and stakeholders. The website will be hosted by NDNR. The selected consultant/contractor will keep the website updated throughout the project duration.

c. **Task Deliverables:**

i. Schedule of Sponsor coordination meetings and facilitated Stakeholder meetings.

ii. Fifteen (15) Sponsor coordination meetings with meeting agendas and meeting summaries. The number of meetings is an estimated quantity. This includes 1 hour pre- and post- meetings for preparation and debriefing.

iii. Fifteen (15) Stakeholder meeting agendas and meeting summaries. The number of meetings is an estimated quantity. This includes 1 hour pre- and post- meetings for preparation and debriefing.

iv. Project website and information for populating it.

d. **Key Understandings:**

i. Meetings are anticipated to be held in North Platte, Nebraska but locations may be modified by the Sponsors.Each meeting will last up to four (4) hours.

ii. The project website will be hosted by NDNR.

iii. The selected consultant/contractor will be responsible for printing all handouts and meeting materials.

iv. Facilities for all meetings will be coordinated by the consultant/contractor with advice from the Sponsors.

3. **TASK SERIES 3 – BASIN-WIDE WATER MANAGEMENT PLAN**

a. **Task Objective**

Develop the components of a basin-wide water management plan for the Upper Platte River Basin.

b. **Activities**

i. **Task 3.1 Goals and Objectives.** The selected consultant/contractor will work with the Sponsors and stakeholder participants to modify and/or develop goals and objectives of the basin-wide plan and other requirements set forth in the Ground Water Management and Protection Act (the Act).

ii. **Task 3.2 Summary of Existing Integrated Management Plan Surface and Groundwater Controls.** The selected consultant/contractor will compile and summarize existing ground and surface water control measures currently employed in basin IMPs.

iii. **Task 3.3 Stakeholder Agreement.** The selected consultant/contractor will work to reach agreement between Sponsors and all stakeholder participants on the goals, objectives, and actions of the Plan and actions formulated, evaluated, and recommended as part of the planning process.

iv. **Task 3.4 Data Summaries.** Summarize existing available data from relevant water studies, including information developed by the Sponsors through current implementation efforts. The selected consultant/contractor will not be expected to generate new data as part of this contract, but rather to summarize existing information

4

into handouts and presentations aimed at facilitating plan development.

c. **Task Deliverables:**

- **i.** Summary of goals and objectives.
- **ii.** Summary of existing surface water and groundwater controls
- **iii.** Draft plans and management actions aimed at implementing the goals and objectives of the Plan
- **iv.** Presentations and handouts materials to support meeting facilitation

d. **Key Understandings:**

- **i.** The selected consultant/contractor will be responsible for printing all handouts and meeting materials.

4. **TASK SERIES 4 – BASIN-WIDE WATER MANAGEMENT PLAN DOCUMENT**

a. **Task Objective**

Prepare draft and final Basin-wide Water Management Plan documents.

b. **Activities**

- **i.** **<u>Task 4.1 Draft Basin-wide Water Management Plan Document</u>**. The selected consultant/contractor will prepare a Draft Basin-wide Water Management Plan for review and comment by the Sponsors and stakeholders. Anticipated major elements include:
  - **a)** Purpose and Scope
  - **b)** Background/Basin Description
  - **c)** Goals and Objectives
  - **d)** Components of the Plan and Action Items
  - **e)** Plan Review and Monitoring
  - **f)** Other elements as required by the Act
- **ii.** **<u>Task 4.2 Facilitate Agreement of Plan and Finalize Plan.</u>** The selected consultant/contractor will work to facilitate agreement of all participants. If participants are unable to reach an agreement within the contract period, the Sponsors will determine whether additional efforts are likely to produce a Plan that is acceptable to all parties, or whether to finalize a draft Plan.

c. **Task Deliverables**

- **i.** Draft Basin-wide Water Management Plan.
- **ii.** Final Basin-wide Water Management Plan.
- **iii.** Comment tracking/resolution.

d. **Key Understandings**

- **i.** Draft plans will be distributed in electronic PDF and Microsoft Word formats for review and comment.
- **ii.** After incorporation of comments, additional draft plans will be distributed in electronic PDF and Microsoft Word formats for review and comment.

Final plan will be distributed in electronic PDF and Microsoft Word formats.

Agenda

Project:	Upper Platte River Basin Water Management Plan– Single Planning Group
Subject:	Orient and Prepare Meeting
Date:	Thursday, June 16, 2016
Location:	Monsanto Learning Center – Gothenburg, NE

Invited:	Vernon Nelson	Thomas Downey	Keith Koupal	Larry Reynolds
	Tyrell Anderson	Russell Edeal	Ervin Kramer	Jay Richeson
	Brian Barels	Judy Eggleston	Don Kraus	Rodney Schaneman
	Jim Bendfeldt	Bernard Fehringer	Galen Larson	Dennis Schilz
	Bob Busch	Dave Fisher	Tim Luchsinger	Jeff Shafer
	Bob Dahlgren	Richard Gatch	Roric Paulman	Carson Sisk
	Kevin Derry	Pat Heath	Joe Pepplitsch	Dennis Strauch
				Kendra Strommen

Agenda:

A. Introductions
B. Why Are We Here?
- o Statutory Authority
- o Current Basin-wide Plan
  - Development
  - Content
- o Basin-wide Plan IMP Relationship
  - How it relates to individual NDRs

C. Process Plan
- o Public Participation Plan
- o Roles & Expectations
- o Administration
- o Decision-Making

D. Next Steps
E. Public Comment

Meeting Minutes

Project:	Upper Platte River Basin Water Management Plan– Single Planning Group
Subject:	Orient and Prepare Meeting
Date:	Thursday, June 16, 2016
Location:	Monsanto Learning Center – Gothenburg, NE
Attendees:	See Sign-in Sheet

A. Introductions – Led by Stephanie White, HDR

B. Why Are We Here? – Presentation by Jennifer Schellpeper, IWM Division Head, NeDNR

- Statutory Authority
- Current Basin-wide Plan
- Basin-wide Plan IMP Relationship

C. Process Plan – Led by Stephanie White, HDR

- Public Participation Plan –
  - Questions arose about whether this process would build upon previous efforts or would start the process over completely. Jennifer reassured the group that there is currently a plan in place and this effort will build upon its success and looked for lessons learned.
  - Several members would like to identify the difference between current and fully appropriated as it would help to inform targets for the second increment.
  - NRDs have made progress, and members would like to see how this progress compares to the first increment goals.
  - Clarification was made that this group would set new goals for the second increment.
- Roles & Expectations – Future meeting dates were shared with the group. The expectation is that all Single Planning Group members (or an alternate) will be present at all meetings. Several members have conflicts with the July meeting and no alternate will be available. Stephanie will have a separate orientation for those who cannot attend in July prior to the September meeting.
- Administration – Suggestions included:
  - Larger font
  - Black and white exhibits
  - Improve on sound/acoustics
  - Share info at least 7 days in advance (digital format) plus provide hard copies at meeting
  - Send link to website

- Decision-Making

D. Next Steps – Led by John Engel, HDR

- Each NRD summarize the goals/objectives/action items from Basinwide Plan. What goals/objectives were achieved? What were the failures? Include perspectives from FWS, for instance. “True up” information – what info was available then vs. today

E. Public Comment – No comments.

1

June 16, 2016 – Upper Platte Basin Water Management Plan – Single Planning Group
1:00 – 3:30 p.m.
Monsanto Learning Center
Gothenburg, NE

Name	Stakeholder Affiliation	Email Address	Attended ?
Vernon Nelson	Tri-Basin NRD		
Tyrell Anderson			
Brian Barels	NPPD		
Jim Bendfeldt	Central Platte NRD Board		
Bob Busch			
Bob Dahlgren	Village of Bertrand		
Kevin Derry			
Thomas Downey			
Russell Edeal			
Judy Eggleston			
Bernard Fehringer			
Dave Fisher			
Richard Gatch			
Pat Heath	City of Gering		
Keith Koupal	NE Game & Parks		
Ervin Kramer	City of North Platte		
Don Kraus	CNPPID		
Galen Larson	Platte Valley Companies		
Tim Luchsinger	City of Grand Island		
Roric Paulman			
Joe Pepplitsch	City of Lexington		
Larry Reynolds	Tri-Basin NRD Board		
Jay Richeson	Gothenburg Irrigation & Well Service		
Rodney Schaneman			
Dennis Schilz	Western Irrigation District		
Jeff Shafer	NPPD		
Carson Sisk	City of Kimball		
Dennis Strauch	Pathfinder Irrigation		
Kendra Strommen	Law Offices of Matzke & Mattoon		

Name	Affiliation	Email Address	Attended?
Melissa Mosier	NDNR	melissa.mosier@nebraska.gov	X
John Berge	North Platte NRD		
Ann Dimmitt	Twin Platte NRD		
Jennifer Schellpeper	NDNR		
Jessie Winter	NDNR	jessie.winter@nebraska.gov	X
Kathy Benson	NDNR	Kathy.Benson@nebraska.	X
Beth Eckles	NDNR	beth.eckles@nebraska.gov	
Colby Osborn	NDNR	Colby.Osborn@nebraska.gov	X
Amy Zoller	NDNR		
Zablon Adane	NDNR		
Lyndon Vogt	Central Platte NRD		
Jesse Mintken	Central Platte NRD		
Duane Woodward	Central Platte NRD		
Tracy Zayac	North Platte NRD	TZayac@npnrd.org	X
Barb Cross	North Platte NRD	bcross@npnrd.org	X
Kyle Ann Hopkins	North Platte NRD		
Rod Horn	South Platte NRD		
Travis Glanz	South Platte NRD		
Ryan Reisdorff	South Platte NRD		
John Thorburn	Tri-Basin NRD		
Tammy Fahrenbruch	Tri-Basin NRD		
Kent Miller	Twin Platte NRD		
Landon Shaw	Twin Platte NRD		
Stephanie White	HDR		
John Engel	HDR		
Ann Williams	HDR		
Frank Albrecht	NGPC	Frank.albrecht@nebraska.gov	X
Gene Zuerlein	NGPC		
John Thorburn	TriBasin NRD	Gene.Zuerlein@nebraska.gov	X
DEAN EDSON	NARD	dedson@nrdnet.org	X
Dustin Wilcox	NARD	dwilcox@nrdnet.org	
Rich Walters	TNC	RWALTERS@TNC	
Lyndon Vogt	CPNRD	vogt@cpnrd.org	x
Joe Wahlgren	TPNRD		

(2)

June 16, 2016 – Upper Platte Basin Water Management Plan – Single Planning Group
1:00 – 3:30 p.m.
Monsanto Learning Center
Gothenburg, NE

Name	Stakeholder Affiliation	Email Address	Attended ?
Vernon Nelson	Tri-Basin NRD		
Tyrell Anderson			
Brian Barels	NPPD		
Jim Bendfeldt	Central Platte NRD Board		
Bob Busch			
Bob Dahlgren	Village of Bertrand		
Kevin Derry			
Thomas Downey			
Russell Edeal			
Judy Eggleston			
Bernard Fehringer			
Dave Fisher			
Richard Gatch			
Pat Heath	City of Gering		
Keith Koupal	NE Game & Parks		
Ervin Kramer	City of North Platte		
Don Kraus	CNPPID		
Galen Larson	Platte Valley Companies		
Tim Luchsinger	City of Grand Island		
Roric Paulman			
Joe Pepplitsch	City of Lexington		
Larry Reynolds	Tri-Basin NRD Board		
Jay Richeson	Gothenburg Irrigation & Well Service		
Rodney Schaneman			
Dennis Schilz	Western Irrigation District		
Jeff Shafer	NPPD		
Carson Sisk	City of Kimball		
Dennis Strauch	Pathfinder Irrigation		
Kendra Strommen	Law Offices of Matzke & Mattoon		
Joe Wahlgren	TPNRD		

Name	Affiliation	Email Address	Attended?
Melissa Mosier	NDNR		
John Berge	North Platte NRD	jberge@npnrd.org	✓
Ann Dimmitt	Twin Platte NRD	afisher@tpnrd.org	X
Jennifer Schellpeper	NDNR		
Jessie Winter	NDNR		
Kathy Benson	NDNR		
Beth Eckles	NDNR		
Colby Osborn	NDNR		
Amy Zoller	NDNR	Amy.Zoller@nebraska.gov	✓
Zablon Adane	NDNR		
Lyndon Vogt	Central Platte NRD		
Jesse Mintken	Central Platte NRD	mintken@cpnrd.org	✓
Duane Woodward	Central Platte NRD	woodward@cpnrd.org	✓
Tracy Zayac	North Platte NRD		
Barb Cross	North Platte NRD		
Kyle Ann Hopkins	North Platte NRD		
Rod Horn	South Platte NRD	rlhorn@spnrd.org	✓
Travis Glanz	South Platte NRD	tglanz@spnrd.org	✓
Ryan Reisdorff	South Platte NRD		
John Thorburn	Tri-Basin NRD		
Tammy Fahrenbruch	Tri-Basin NRD		
Kent Miller	Twin Platte NRD	kmiller@tpnrd.org	✓
Landon Shaw	Twin Platte NRD		
Stephanie White	HDR		
John Engel	HDR		
Ann Williams	HDR		
Jerry Kenny	PRRIP	[illegible]	✓
Leo Hoehn	NPNRD	Leo.Hoehn@Gmail	✓
Jack Revelle	NPNRD	jrevelle@vistabeam.com	✓
Jared Derry	SPNRD	jared.derry32@gmail.com	✓
Kathy Narjes	SPNRD	Rodekohr@hotmail.com	✓
Joe Larson	TBNRD	joelarson21@gmail.com	

③

June 16, 2016 – Upper Platte Basin Water Management Plan – Single Planning Group
1:00 – 3:30 p.m.
Monsanto Learning Center
Gothenburg, NE

	Name	Stakeholder Affiliation	Email Address	Attended ?
	Vernon Nelson	Tri-Basin NRD		
✓	Tyrell Anderson			
✓	Brian Barels	NPPD		
✓	Jim Bendfeldt	Central Platte NRD Board		
✓	Bob Busch			
	Bob Dahlgren	Village of Bertrand		
✓	Kevin Derry			
	Thomas Downey			
✓	Russell Edeal			
✓	Judy Eggleston			
✓	Bernard Fehringer			
✓	Dave Fisher			
	Richard Gatch			
✓	Pat Heath	City of Gering		
✓	Keith Koupal	NE Game & Parks		
	Ervin Kramer	City of North Platte		
✓	Don Kraus	CNPPID		
✓	Galen Larson	Platte Valley Companies		
	Tim Luchsinger	City of Grand Island		
	Roric Paulman			
	Joe Pepplitsch	City of Lexington		
✓	Larry Reynolds	Tri-Basin NRD Board		
	Jay Richeson	Gothenburg Irrigation & Well Service		
	Rodney Schaneman			
shliz. ✓	Dennis Schilz	Western Irrigation District		
	Jeff Shafer	NPPD		
✓	Carson Sisk	City of Kimball		
✓	Dennis Strauch	Pathfinder Irrigation		
✓	Kendra Strommen	Law Offices of Matzke & Mattoon		

✓ Bill Halligan
✓ Chuck Henkel.
?, Kent miller.

Name	Affiliation	Email Address	Attended?
Melissa Mosier	NDNR		
John Berge	North Platte NRD		
Ann Dimmitt	Twin Platte NRD		
Jennifer Schellpeper	NDNR		
Jessie Winter	NDNR		
Kathy Benson	NDNR		
Beth Eckles	NDNR		
Colby Osborn	NDNR		
Amy Zoller	NDNR		
Zablon Adane	NDNR		
Lyndon Vogt	Central Platte NRD		
Jesse Mintken	Central Platte NRD		
Duane Woodward	Central Platte NRD		
Tracy Zayac	North Platte NRD		
Barb Cross	North Platte NRD		
Kyle Ann Hopkins	North Platte NRD		
Rod Horn	South Platte NRD		
Travis Glanz	South Platte NRD		
Ryan Reisdorff	South Platte NRD		
John Thorburn	Tri-Basin NRD		
Tammy Fahrenbruch	Tri-Basin NRD		
Kent Miller	Twin Platte NRD		
Landon Shaw	Twin Platte NRD		
Stephanie White	HDR		
John Engel	HDR		
Ann Williams	HDR		

Agenda

Project:	Upper Platte River Basin Water Management Plan– Single Planning Group
Subject:	Orient and Prepare Meeting - II
Date:	Wednesday, July 20, 2016
Location:	Holiday Inn Express & Suites – North Platte, NE

Invited SPG Members:				
	Vernon Nelson	Thomas Downey	Keith Koupal	Larry Reynolds
	Tyrell Anderson	Russell Edeal	Ervin Kramer	Jay Richeson
	Brian Barels	Judy Eggleston	Don Kraus	Rodney Schaneman
	Jim Bendfeldt	Bernard Fehringer	Galen Larson	Dennis Schilz
	Bob Busch	Dave Fisher	Tim Luchsinger	Carson Sisk
	Bob Dahlgren	Richard Gatch	Roric Paulman	Dennis Strauch
	Kevin Derry	Pat Heath	Joe Pepplitsch	Kendra Strommen

Agenda:

I. Introductions
II. Logistics/Process
  a. Agenda Review
  b. Administrative Items
  c. Single Planning Group Membership
III. Review of First Increment Basin-wide Plan goals and objectives
IV. Working Lunch - to be provided
V. Implementation During the First Increment
  a. North Platte NRD
  b. South Platte NRD
  c. Twin Platte NRD
  d. Tri-Basin NRD
  e. Central Platte NRD
  f. Nebraska DNR
VI. Summary of Implementation with respect to First Increment Basin-wide Plan goals and objectives
VII. New information available
VIII. Additional information requests
IX. Next Steps
X. Public Comment

Meeting Minutes

Project:	Upper Platte River Basin Water Management Plan– Single Planning Group
Subject:	Orient and Prepare Meeting - II
Date:	Wednesday, July 20, 2016
Location:	Holiday Inn Express & Suites – North Platte, NE
Attendees:	See Sign-in Sheet

These minutes correspond to detailed slides that were presented at the meeting and can be found online at www.dnr.nebraska.gov/iwm/upbwp

I. Introductions

II. Logistics/Process

a. Reviewed Open Meetings Act compliance, discussed safety-related items, reviewed facilitation process and logistics, and discussed stakeholder membership and responsibilities.

III. Review of First Increment Basin-wide Plan goals and objectives – Led by John Engel, HDR.

a. Goals and objectives from the first increment Basin-wide Plan were reviewed. Questions arose regarding basis and significance of the year 1997 and its multiple references in the first increment goals and objectives. J. Schellpeper stated that 1997 was the year the Platte River Cooperative Agreement was signed. 1997 was included in the LB 962 language and is explicitly referenced in the governing state statutes.

IV. Implementation During the First Increment – Presentations were given by each NRD and the NeDNR and can be found in the meeting PowerPoint presentation. Below is a summary of the questions and discussion pertaining to each presentation.

a. North Platte NRD – Barb Cross and Tracy Zayac, NPNRD

i. How successful have actions been? The robust review currently being conducted will provide that information

ii. How are COHYST/WWUM model differences resolved? The western unit of the original COHYST model served as the basis from which the WWUM was developed. The WWUM model is used to inform water management decisions in the NPNRD.

iii. How does the NPNRD handle groundwater transfers? NPNRD generally discourages transfers, because NPNRD is mindful of possible interference with surface water appropriators when evaluating potential transfers. Transfers that are permitted are required to offset any increases in depletions resulting from the transfer.

iv. Is there a 'buy-down' for allocation? Yes, $20 per acre-inch

v. What is the impact of lower valuations on retired acres? NPNRD irrigated acre valuations are typically $2700 - $3000 per acre. Pasture or dry land valuations are $500 - $700 per acre. NPNRD is cognizant of potential impacts on entities that rely on property tax revenues.
vi. Costs of temporary and permanent acreage retirements? Temporary (5-yrs typically) are $150-$175 per acre-foot; Permanent are up to $250 per acre-foot
vii. How did the allocation time periods (1-yr, then 3-yr, now 5-yr) develop? Through producer and board member feedback – extended duration provides producers more flexibility.

b. South Platte NRD – Rod Horn, SPNRD
   i. What are the SPNRD offset targets for the South Platte River? The SPNRD's offset target is 700 AF total – 400 AF to the South Platte River, 150 AF to Lodgepole Creek, 150 AF to the North Platte River.
   ii. What are differences between COHYST and WWUM? The western unit of the original COHYST model served as the basis from which the WWUM was developed. Additions incorporated into the WWUM include a surface water operations component and incorporation of additional land use and metering data.
   iii. What recharge efforts have SPNRD been involved in? Thirty percent of Western Irrigation District is in SPNRD. Two recharge pits and the main canal within district boundaries have been used.
   iv. Are there new results from the WWUM and COHYST models that update old information? Yes, the new models are being used in the robust review and that information will be made available.
   v. How does municipality water usage fit in? A baseline for municipal water use has been established and the NRD is responsible for addressing water use over that baseline until 2026, according to statute. If a municipality city limits grow into previously irrigated acres, the consumptive use of those acres can accrue to the NRD and be used to address additional depletions. The SPNRD groundwater management plan prohibits transfers within specified miles of any city limit and within the city limit.

c. Twin Platte NRD – Ann Dimmitt, TPNRD
   i. What is J-2 reference on TPNRD "balance sheet"? J-2 refers to one of the PRRIP proposed water action plan projects involving a new regulating reservoir on CNPPID Tri-County canal system.
   ii. On the "balance sheet" why the drop off in CRP credits? Those are temporary contracts with a sunset date.
   iii. What is the purchase price for offset credits from CPNRD? $35 per AF, with a 7% annual raise.
   iv. What is the significance of 7,700 AF on the "balance sheet"? That is the post-1997 depletions estimate for uses within TPNRD that needs to be offset.

d. Tri-Basin NRD – John Thorburn, TBNRD
   i. Are there wells within TBNRD where drawdown is an issue? Seasonally maybe, but generally not an issue in TBNRD. Seepage from CNPPID surface water canal system operations has created a ground water 'mound' in some areas of TBNRD.

ii. Why were E-65 and Phelps canals used for recharge in 2013-2015? Elwood reservoir and E-65 are the preferred recharge facilities – quantity of available excess flows can dictate what facilities are used.

e. Central Platte NRD – Lyndon Vogt, CPNRD
    i. As we go through this planning process should other changes/restrictions, such as drought provisions, be included? Not sure if specific changes or means to address droughts are necessary in the plan. Conjunctive management projects and activities undertaken in the first increment have helped to prepare and manage during droughts.
    ii. General changes in plan necessary? Overall, the existing plan has been pretty good. Need to incorporate the longer term objective of reaching fully appropriated into the plan, as well as the results and new data from additional studies and updated modeling tools.
    iii. When did COHYST and WWUM start, how is the overlying area between the two models addressed, and what improvements have been made to the models? COHYST initial efforts began in 1998 and consisted of an eastern, central, and western model unit – extending from Duncan to Wyoming. In 2009, the COHYST group started implementing enhancements to the original eastern and central model units, while the WWUM model group started a similar process for the area of the western model unit, using the original COHYST model as a basis. The surface water system in the overlapping area between the two models has a fairly clear division at Lake McConaughy. The link between the two models is the ground water fluxes at the boundaries and the surface water inflows to Lake McConaughy. Enhancements to the models have included incorporation of surface water operations, additional data for calibration, and coding enhancements to improve model performance.

f. Nebraska DNR – Jennifer Schellpeper, NeDNR
    i. No questions were asked.

Following completion of the NRD and NeDNR summaries, K. Koupal of NG&PC provided some thoughts from his group's perspective:

- It was a positive sign that the request was made by the group at the June stakeholder meeting for a conservation group's perspective.
- The process and stakeholders are reliant upon the models for determining impacts to streamflows.
- One success story was the coordination with TBNRD on the North Dry Creek augmentation project and the effects on the fish community have been noticeable.
- Invasive species such as phragmites, silver carp, zebra mussels, quahog snails – are a concern, especially for trans-basin diversions.
- They have seen enough progress and are confident enough in the basin stakeholders and managers that they have allocated financial resources to recreational projects in the area.

K. Koupal was asked if his agency had input on PRRIP target flows. K. Koupal indicated that they participate on various PRRIP committees, but not directly on the PRRIP governance committee.

V. Summary of Implementation with respect to First Increment Basin-wide Plan goals and objectives – J. Engel presented a summary of activities in relation to the current plan goals and objectives. A question arose whether any specific conflicts between surface water and ground water uses had been identified at the annual Basin-wide meetings. CNPPID has submitted several letters to NeDNR for their consideration, requesting the depletive effects of groundwater uses in the Upper North Platte River basin be further investigated. The response to CNPPID has been that the statutory requirements were being met and nothing additional was required at this time.

VI. New information available – J. Engel summarized the additional data, studies, and tools that had been completed or updated during the first increment. A request was made to add the goals and a summary of results for each of the studies identified.

VII. Additional information requests

a. A report card of first increment activities and their effectiveness in meeting plan goals and objectives.
b. A summary of study goals and results
c. A summary of first increment activities that worked the best
d. A glossary/acronym table of commonly used terms
e. A summary of model updates and updated estimates of post-1997 depletions

General requests included:

f. Handouts using 2 slides per page
g. Possible to boost Wifi signal?

VIII. Next Steps – Next single planning group meeting scheduled for September 21, 2016. This will be the first of the Goals meetings.

IX. Public Comment - None

Meeting Date: 7-20-16

NOTE: **Photographs/video may be captured during the meeting. These assets may be used by the NDNR, Districts, or HDR for the sole purpose of marketing, communication about the project and/or advertising. This may include, but is not limited to, printed and published materials on the NDNR, Districts, or HDR website.**

Attended?	Name	Email Address	Affiliation	Primary or Alternate
not on signature sheet?		**SPG Primary Members**		
X	Anderson, Tyrell	tyrell.anderson@retranches.com	North Platte NRD	Primary
X	Barels, Brian	blbarel@nppd.com	Public Power & Irrigation District	Primary
	Bendfeldt, Jim	jcb@nctc.net	Central Platte NRD	Primary
	Busch, Bob	rnbusch@actcom.net	Surface Water User	Primary
	Dahlgren, Bob	No email – 317 Medina Ave Bertrand, NE 68927 *Direct Mail only	Municipality – Village of Bertrand	Primary
X	Derry, Kevin	derrykb@embarqmail.com	Agriculture	Primary
X	Downey, Thomas	tdowney@downeydrilling.com	Ground Water User	Primary
X *no email*	Edeal, Russell	redeal@atcjet.net	Agriculture	Primary
X *no name or email*	Eggleston, Judy	JudyEggleston@aol.com	Irrigation District	Primary
X	Fehringer, Bernard	bfehringer@icloud.com bernie.fehringer@wheatbelt.com	Public Power	Primary
X	Fisher, Dave	dpfisher@scottsbluff.net	Surface Water User	Primary
	Gatch, Richard	Rgatch1@unl.edu	Surface Water User	Primary
X	Halligan, Bill	Bill.halligan@pwcbank.com	South Platte NRD Board	Primary
X	Heath, Pat	pheath@gering.org	Municipality – City of Gering	Primary
X	Henkel, Chuck	henkelchuck@yahoo.com	North Platte NRD Board	Primary
	Hoehn, Leo	Leo.hoehn@gmail.com	Groundwater Irrigator	Primary
X	Koupal, Keith	keith.koupal@nebraska.gov	Environment/Wildlife	Primary
X	Kramer, Erwin	backflow79@hotmail.com	Municipality – City of North Platte	Primary
X	Kraus, Don	Dkraus@cnppid.com	Irrigation District	Primary
X	Larson, Galen	glarson@pvbank.com	Financial	Primary
X	Luchsinger, Tim	tluchsinger@grand-island.com	Municipality – City of Grand Island	Primary
	Nelson, Vernon	vernonjamesnelson@yahoo.com	Agriculture/Groundwater User	Primary
	Paulman, Roric	rpaulman@gpcom.net	Agriculture	Primary
	Pepplitsch, Joe	jpepp@cityoflex.com	Municipality – City of Lexington	Primary
X	Revelle, Jack	jrevelle@vistabeam.com	Ground Irrigator	Primary
X	Reynolds, Larry	larryreynolds68@gmail.com	Tri-basin NRD Board	Primary
X	Richeson, Jay	jay@gothenburgirrigation.com	Municipality – Gothenburg	Primary
X	Schaneman, Rodney	raschman@charter.net	Surface Water User	Primary
	Schilz, Dennis	dennisschilz@gmail.com	Irrigation District	Primary
X	Sisk, Carson	Kimballwater@kimballne.org	Municipality – City of Kimball	Primary

Meeting Date:______________

X	Strauch, Dennis	dennis@pathfinderirrigation.com	Irrigation District – Pathfinder Irrigation	Primary
X	Strommen, Kendra	strommen@mmmlawoffice.com	Financial	Primary
X	Wahlgren, Joe	wahlgrenfarms@gmail.com	Twin Platte NRD Board	Primary
		SPG Alternate Members		
X	Albrecht, Frank	frank.albrecht@nebraska.gov	Environment/Wildlife	Alternate
	Andreas, Kent	kandreas@embarqmail.com	North Platte NRD Board	Alternate
	Burnside, Dennis	dburnside@cityoflex.com	Municipality – City of Lexington	Alternate
	Clymer, Bruce	bclymer@cityofgothenburg.org	Municipality – Gothenburg	Alternate
X	Derry, Jared	Jared.derry@gmail.com	Agriculture	Alternate
	Downey, Brent	bdowney@downeydrilling.com	Ground Water User	Alternate
X # no email	Drain, Mike	mdrain@cnppid.com	Irrigation District	Alternate
	Henry, Chris	cnhenry144@hotmail.com	Central Platte NRD Board	Alternate
X	Hock, Andrew	andrew.extremeag@gmail.com	Agriculture	Alternate
	Jameson, Rhodel		Agriculture/Groundwater User	Alternate
	Larson, Joe	joelarson21@gmail.com	Tri-basin NRD Board	Alternate
	Meismer, Jim	tpnrd1jimm@gmail.com	Twin Platte NRD Board	Alternate
	Meyer, Doug	dgmeyer@NPanhandle.net	Municipality – City of North Platte	Alternate
	Narjes, Kathy	rodekohr@hotmail.com	South Platte NRD Board	Alternate
	Ortiz, Daniel	DOrtiz@kimballne.org	Municipality – City of Kimball	Alternate
X	Shafer, Jeff	jtshafe@nppd.com	Public Power & Irrigation	Alternate
	Smith, Ann	annck@cozadtel.net	Irrigation District	Alternate
	Snarr, Paul	psnarr@gering.org	Municipality – City of Gering	Alternate
	Zach, Randy		Public Power & Irrigation District	Alternate
		POAC Members		
	Adane, Zaibon		NDNR	
X	Benson, Kathy	Kathy.Benson@nebraska.gov	NDNR	
	Berge, John	jberge@npnrd.org	North Platte NRD	
X	Cross, Barb	bcross@npnrd.org	North Platte NRD	
	Crowe, Kayla	kayla.crowe@nebraska.gov	NDNR	
	Czaplewski, Mark	Mark@cpnred.org	Central Platte NRD	
X	Dimmitt, Ann	afisher@tpnrd.org	Twin Platte NRD	
	Eckles, Beth		NDNR	
	Fahrenbuch, Tammy	tfahrenbruch@tribasinnrd.org	Tri-Basin NRD	
X	Glanz, Travis	tglanz@spnrd.org	South Platte NRD	
	Hopkins, Kyle Ann		North Platte NRD	
X	Horn, Rod	rlhorn@spnrd.org	South Platte NRD	
X	Miller, Kent	komiller@tpnrd.org	Twin Platte NRD	
	Mintken, Jesse	mintken@cpnrd.org	Central Platte NRD	

Meeting Date:______________

	Mosier, Melissa	melissa.mosier@nebraska.gov	NDNR
	Osborn, Colby		NDNR
X	Reisdorff, Ryan	rreisdorff@spnrd.org	South Platte NRD
	Schellpeper, Jennifer	jennifer.schellpeper@nebraska.gov	NDNR
X	Shaw, Landon	lshaw@tpnrd.org	Twin Platte NRD
X	Thorburn, John	jthorburn@tribasinnrd.org	Tri-Basin NRD
X	Vogt, Lyndon	vogt@cpnrd.org	Central Platte NRD
X	Winter, Jessie	jessie.winter@nebraska.gov	NDNR
	Woodward, Duane	woodward@cpnrd.org	Central Platte NRD
X	Zayac, Tracy	Tzayac@npnrd.org	North Platte NRD
	Zoller, Amy		NDNR
		Members of the Public	
X	Jeff Fassett	Jeff.Fassett@nebraska.com	DNR
X	Jerry Kenny	Kennyj@headwaterscorp.com	PRRIP
X	DUSTIN WILCOX	dwilcox@nrdnet.org	NARD

Meeting Date: 7/20/16

NORTH PLATTE Natural Resources District

SOUTH PLATTE Natural Resources District

Tri Basin Natural Resources District

TWIN PLATTE Natural Resources District

Nebraska Department of Natural Resources

MEMBERS OF THE PUBLIC

Name	eMail	Affiliation
Jeff Fassett	Jeff.Fassett@nebraska.com	DNR
Jerry Kenny	kennyj@headwaterscorp.com	PRRIP
Jay Richeson	JAY@GOTHENBURGIRRIGATION.COM.	GOTHENBURG
Dustin Wilcox	dwilcox@nrdnet.org	NARD
Erin ? Kuhn	City of North Platte	Water
Ann Dimmitt	afisher@tpnrd.org	TPNRD
Kent O Miller	komiller@tpnrd.org	TPNRD
Landon Shaw	lshaw@tpnrd.org	TPNRD
Frank Albrecht	Frank.albrecht@nebraska.gov	NGPC
~~Rodney R. Schumann~~		

Agenda

Project:	Upper Platte River Basin Water Management Plan– Single Planning Group
Subject:	Meeting #3
Date:	Wednesday, September 21, 2016 from 10:30 a.m. to 3:00 p.m.
Location:	Holiday Inn Express & Suites, North Platte, NE

Agenda:

I. Administration
   a. Meeting Purpose
   b. Today's meeting will offer a working lunch
   c. Follow-up items
II. Platte River Hydrogeology
   a. Hydrogeology 101
   b. Platte River Hydrogeology
   c. COHYST background
   d. Current modeling efforts
III. Review & Refinement of First Increment Plan Goals
   a. Goal 2: Prevent reductions in the flow of a river or stream that would cause noncompliance with an interstate compact or decree or other formal state contract or agreement.
   b. Goal 3: Keep the plan current
IV. Next Steps
V. Public Comment

Meeting Minutes

Project:	Upper Platte River Basin Water Management Plan– Single Planning Group
Subject:	Meeting #3
Date:	Wednesday, September 21, 2016 from 10:30 a.m. to 3:00 p.m.
Location:	Holiday Inn Express & Suites, North Platte, NE

I. Administration – Led by Stephanie White, HDR
   a. Meeting Purpose – This meeting is a turning point from the orientation sessions into discussion and refinement of goals; open meeting act was discussed; Stephanie reminded everyone to sign in
   b. Today's meeting will offer a working lunch – must sign in to eat
   c. Follow-up items – At previous meeting, there was a request for summary of studies and detail of purpose and results; information was summarized into handout and given to meeting attendees; "Glossary of Terms" is in process and will be uploaded to website.
   d. Generic copy of survey responses was requested and will be provided for this and future meetings when surveys are used to gather input in advance of a meeting.

II. Platte River Hydrogeology – Background information and powerpoint presentation led by John Engel, HDR focused on:
   a. Hydrogeology 101
   b. Platte River Hydrogeology
   c. Original COHYST modeling background
   d. Current modeling efforts (WWUM and COHYST)

   Additional Information Requested:
   - How has new data collected been used and what have we learned from it?
   - What is predicted value and reliability of models?
   - How are precipitation patterns/topography/soil type/land use reflected in models?
   - Robust review results will update initial estimates (post 1997 uses) and look at activities that occurred in first increment and what are the benefits
   - Graphic of post-1997 wells (new wells only – not replacements)
   - Graphic that shows calibration targets; map that shows monitoring wells and coverage used to build the models
   - Describe the sensitivity analysis used in developing the models.

At future Single Planning Group meeting, more detailed information on the COHYST and WWUM will be presented.

III. Review & Refinement of First Increment Plan
   - Discussion of PRRIP and Nebraska New Depletion Plan: Led by Jennifer Schellpeper, DNR. This included discussion of PRRIP background, target flows, and water action plan projects to offset depletions
   - NRDs, DNR, and majority of stakeholders have indicated, in general, that the plan is good and it's working; would like to initially work within the plan and refine it, rather than start from scratch
   - Approach for today's discussion is to revisit the current plan "as-is" and determine where it needs to be fine-tuned, focusing on Goals #2 and #3.

a. Goal 2: Prevent reductions in the flow of a river or stream that would cause noncompliance with an interstate compact or decree or other formal state contract or agreement. – Led by Stephanie White, HDR

<u>Goal 2 Goal and Objectives Discussion:</u>

- Poll sent out prior to meeting. 12 responses - 80% said Goal 2 and the objectives are fine "as-is".
- Should it include drought conditions?
- Is "other formal state contract or agreement" a moving target?
- What about when it is not possible to reach goal?
- "Prevent" may not be the right word and sentence is double negative.
- Does interstate compact provide flexibility to be in noncompliance during drought conditions?
- If new interstate compact is added, then would need to keep plan current.
- Is action to ensure compliance or prevent non-compliance?

- Goal 2 Possible Enhancements:
  - "Prevent or mitigate human-induced reductions in the flow of a river or stream that would cause noncompliance with an interstate compact or decree or other formal state contract or agreement"
- Goal 2 Objective 1 – possible enhancement: Change objective to also include "human-induced"
- Goal 2 Objective 1 Action Item A – Discussion
  - DNR and NRDs are responsible for implementation and overseeing of individual IMPs. Who ultimately ensures compliance?
  - Does wording address changes from original IMP?
  - Split action item A into 2 portions? **Discussion consensus is to keep Action Item A as is.**
- Goal 2 Objective 1 Action Item B – Concerns
  - **Unanimous decision to keep Action Item B as is.**
- Goal 2 – Potential Additional Objectives/Concerns:
  - If and when Nebraska New Depletions Plan (NDP) goals are met, what will status be or what will become of the PRRIP? Not explicitly tied together, basin wide plan and PRRIP have their own goals and objectives. The IMP process is integrated with PRRIP in that similar first increment goal is to offset impacts of new uses from 1997-2005 as part of NDP.
  - Flexibility built into BWP to enable opportunity to remove portions, segments, or subbasins from Program
- Requests for future discussion:
  - Develop summary list of formal state contracts or agreements. Do these include reference to drought conditions?
  - Drought conditions need to be addressed in somewhere in plan.
  - Revisit order of goals in plan
  - Graphic showing roles/responsibilities for development and implementation

b. Goal 3: Keep the plan current
- Goal 3 Objective 1 Discussion:
  - Needs to address reporting on implementation and compliance with plan, and results of implementing it.
  - Process for modifications/resolving disputes resolution need to be described.
  - Needs to address transparency of process/tracking of archives/clarity (Stakeholder & public input)
  - This goal may be better as last goal in list (goal 4)

    - Should notice period be amended to require 45 day notice prior to meeting to stakeholders?
    - Should objective #2 be a separate goal?
    - Switch the order of objectives #1 and #2?
    - “At least annually” – is that enough? **Unanimous to keep reference to “at least annually” as is**.

Further discussion on Goal 3 was postponed until the Single Planning Group has completed a thorough review of the current Plan’s Goals and Objectives

IV. Next Steps

- RSVP to next meeting – November 16, 2016
- Read the current Basinwide Plan to fully understand the Goals and Objectives contained therein.
- Respond to pre-meeting survey

V. Public Comment

- Jerry Kenny, Executive Director of the PRRIP provided comment on J. Schellpeper’s presentation – noting that it was precise and accurate. As projects and solutions move forward, the PRRIP and State are working diligently to become good partners in accomplishing the goals.

Meeting Date: 9.21.2016

CPNRD Central Platte · North Platte Natural Resources District · South Platte Natural Resources District · Tri-Basin Natural Resources District · Twin Platte Natural Resources District · Nebraska

NOTE: Photographs/video may be captured during the meeting. These assets may be used by the NDNR, Districts, or HDR for the sole purpose of marketing, communication about the project and/or advertising. This may include, but is not limited to, printed and published materials on the NDNR, Districts, or HDR website.

Attended?	Name	Email Address	Affiliation	Primary or Alternate
		SPG Primary Members		
Yes	Anderson, Tyrell	tyrell.anderson@retranches.com	North Platte NRD	Primary
Yes	Barels, Brian	blbarel@nppd.com	Public Power & Irrigation District	Primary
yes	Bendfeldt, Jim	~~jcb@nctc.net~~ Jcb1@fastmail.com	Central Platte NRD	Primary
yes	Busch, Bob	rnbusch@actcom.net	Surface Water User	Primary
Yes	Dahlgren, Bob	No email – rdahlgren@fsb loomis.com 317 Medina Ave Bertrand, NE 68927 *Direct Mail only	Municipality – Village of Bertrand	Primary
	Derry, Kevin	derrykb@embarqmail.com	Agriculture	Primary
	Downey, Thomas	tdowney@downeydrilling.com	Ground Water User	Primary
yes	Edeal, Russell	redeal@atcjet.net	Agriculture	Primary
Yes	Eggleston, Judy	JudyEggleston@aol.com	Irrigation District	Primary
yes	Fehringer, Bernard	bfehringer@icloud.com bernie.fehringer@wheatbelt.com	Public Power	Primary
Yes	Fisher, Dave	dpfisher@scottsbluff.net	Surface Water User	Primary
	Gatch, Richard	Rgatch1@unl.edu	Surface Water User	Primary
Yes	Halligan, Bill	Bill.halligan@pwcbank.com	South Platte NRD Board	Primary
Yes	Heath, Pat	pheath@gering.org	Municipality – City of Gering	Primary
	Henkel, Chuck	henkelchuck@yahoo.com	North Platte NRD Board	Primary
Yes	Hoehn, Leo	Leo.hoehn@gmail.com	Groundwater Irrigator	Primary
Yes	Koupal, Keith	keith.koupal@nebraska.gov	Environment/Wildlife	Primary
Yes	Kramer, Erwin	backflow79@hotmail.com	Municipality – City of North Platte	Primary
Yes	Kraus, Don	Dkraus@cnppid.com	Irrigation District	Primary
yes	Larson, Galen	glarson@pvbank.com	Financial	Primary
Yes	Luchsinger, Tim	tluchsinger@grand-island.com	Municipality – City of Grand Island	Primary
	Nelson, Vernon	vernonjamesnelson@yahoo.com	Agriculture/Groundwater User	Primary
yes	Paulman, Roric	rpaulman@gpcom.net	Agriculture	Primary
	Pepplitsch, Joe	jpepp@cityoflex.com	Municipality – City of Lexington	Primary
Yes	Revelle, Jack	jrevelle@vistabeam.com	Ground Irrigator	Primary
Yes	Reynolds, Larry	larryreynolds68@gmail.com	Tri-basin NRD Board	Primary
	Richeson, Jay	jay@gothenburgirrigation.com	Municipality – Gothenburg	Primary
Yes	Schaneman, Rodney	raschman@charter.net	Surface Water User	Primary
Yes	Schilz, Dennis	dennisschilz@gmail.com	Irrigation District	Primary
Yes	Sisk, Carson	Kimballwater@kimballne.org	Municipality – City of Kimball	Primary

Meeting Date: 9.21.2016

yes	Strauch, Dennis	dennis@pathfinderirrigation.com	Irrigation District – Pathfinder Irrigation	Primary
	Strommen, Kendra	strommen@mmmlawoffice.com	Financial	Primary
yes	Wahlgren, Joe	wahlgrenfarms@gmail.com	Twin Platte NRD Board	Primary
		SPG Alternate Members		
Yes	Albrecht, Frank	frank.albrecht@nebraska.gov	Environment/Wildlife	Alternate
	Andreas, Kent	kandreas@embarqmail.com	North Platte NRD Board	Alternate
yes	Burnside, Dennis	dburnside@cityoflex.com	Municipality – City of Lexington	Alternate
Yes	Clymer, Bruce	bclymer@cityofgothenburg.org	Municipality – Gothenburg	Alternate
	Derry, Jared	Jared.derry@gmail.com	Agriculture	Alternate
	Downey, Brent	bdowney@downeydrilling.com	Ground Water User	Alternate
yes	Drain, Mike	mdrain@cnppid.com	Irrigation District	Alternate
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	Jameson, Rhodel		Agriculture/Groundwater User	Alternate
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yes	Meismer, Jim	tpnrd1jimm@gmail.com	Twin Platte NRD Board	Alternate
	Meyer, Doug	dgmeyer@NPanhandle.net	Municipality – City of North Platte	Alternate
	Narjes, Kathy	rodekohr@hotmail.com	South Platte NRD Board	Alternate
	Ortiz, Daniel	DOrtiz@kimballne.org	Municipality – City of Kimball	Alternate
yes	Shafer, Jeff	jtshafe@nppd.com	Public Power & Irrigation	Alternate
	Smith, Ann	annck@cozadtel.net	Irrigation District	Alternate
	Snarr, Paul	psnarr@gering.org	Municipality – City of Gering	Alternate
	Zach, Randy		Public Power & Irrigation District	Alternate
		POAC Members		
	Adane, Zaibon		NDNR	
yes	Benson, Kathy	Kathy.Benson@nebraska.gov	NDNR	
yes	Berge, John	jberge@npnrd.org	North Platte NRD	
	Cross, Barb	bcross@npnrd.org	North Platte NRD	
	Crowe, Kayla	kayla.crowe@nebraska.gov	NDNR	
	Czaplewski, Mark	Mark@cpnred.org	Central Platte NRD	
yes	Dimmitt, Ann	afisher@tpnrd.org	Twin Platte NRD	
	Eckles, Beth		NDNR	
	Fahrenbuch, Tammy	tfahrenbruch@tribasinnrd.org	Tri-Basin NRD	
yes	Glanz, Travis	tglanz@spnrd.org	South Platte NRD	
Yes	Horn, Rod	rlhorn@spnrd.org	South Platte NRD	
YES	Miller, Kent	komiller@tpnrd.org	Twin Platte NRD	
	Mintken, Jesse	mintken@cpnrd.org	Central Platte NRD	
YES	Mosier, Melissa	melissa.mosier@nebraska.gov	NDNR	

Meeting Date: 9.21.2016

	Osborn, Colby		NDNR
Yes	Reisdorff, Ryan	rreisdorff@spnrd.org	South Platte NRD
YES	Schellpeper, Jennifer	jennifer.schellpeper@nebraska.gov	NDNR
Yes	Shaw, Landon	lshaw@tpnrd.org	Twin Platte NRD
Yes	Thorburn, John	jthorburn@tribasinnrd.org	Tri-Basin NRD
yes	Vogt, Lyndon	vogt@cpnrd.org	Central Platte NRD
Yes	Winter, Jessie	jessie.winter@nebraska.gov	NDNR
	Woodward, Duane	woodward@cpnrd.org	Central Platte NRD
yes	Zayac, Tracy	Tzayac@npnrd.org	North Platte NRD
yes	Zoller, Amy	amy.zoller@nebraska.gov	NDNR
		Members of the Public	
x	Engel, John		HDR
x	Kenny, Jerry	Kennyj@headwaterscorp.com	PRRIP - EDO
x	Miller, Elizabeth	emiller@npnrd.org	NPNRD
x	Jessie Bradley	[redacted]; jbradley@flatwatergroup.com	/ Flatwater Group
x	Ann Williams	ann.williams@hdrinc.com	HDR
x	Andrew Pierson	apierson@audubon.org	Audubon Nebraska/Rowe Sanctuary
	~~John Tipp~~		

Agenda

Project:	Upper Platte River Basin Water Management Plan– Single Planning Group
Subject:	Meeting #4
Date:	Wednesday, November 16, 2016 from 10:30 a.m. to 3:00 p.m.
Location:	Holiday Inn Express & Suites, North Platte, NE

Agenda:

I. Administration
   a. Today's meeting will offer a working lunch
   b. September Meeting Recap
      i. Meeting Minutes
      ii. Key Discussion / Decisions
      iii. Follow-up items
   c. Review of Roles and Responsibilities
II. Upper Platte Basin-Wide Plan – First Increment Review
   a. Q&A
   b. Bridging the First and Second Increment (Roadmap Handout)
   c. Introduction of January Survey
III. Modeling Overviews
IV. Review & Refinement of First Increment Goals
   a. Goal 1: Incrementally achieve and sustain a fully appropriated condition.
   b. Goal 4: Work cooperatively to identify and investigate disputes between ground water users and surface water appropriators and, if determined appropriate, implement management solutions to address such issues.
V. Next Steps
VI. Public Comment

Next Meeting: January 18, 2017

Meeting Minutes

Project:	Upper Platte River Basin Water Management Plan – Single Planning Group
Subject:	Meeting #4
Date:	Wednesday, November 16, 2016 from 10:30 a.m. to 3:00 p.m.
Location:	Holiday Inn Express & Suites – North Platte, NE
Attendees:	See Sign-in Sheet

I. Administration

a. Announcements and Introductions, including Open meeting act notices

b. September Meeting Recap - minutes from last meeting not linked to DNR website – to be corrected

c. Roles and Responsibilities

- Roles and responsibilities from Public Participation Plan reviewed to provide clarity for the development of second increment; implementation is responsibility of NRDs; manager's will be included in discussion roundtable

II. Upper Platte Basin-Wide Plan – First Increment Review

a. Q&A - none

b. Bridging the First and Second Increment (Roadmap Handout)

- 46-715: interpretation of 46-715 defines additional consideration to be weighted by the SPG to determine additional progress goals towards a fully appropriated condition during the second increment.
- Sustain balance between water uses and supplies so that economic viability, social and environmental health, safety, and welfare of the river basin can be achieved and maintained
- Still need to comply with plan components that were addressed in first increment
- How was overappropriated status determined? Original definition of OA area was not based on technical evaluation 46-713(4); based on areas where SW and GW moratoriums and a multi-state cooperative agreement were in place on July 16, 2004.
- Question about the economic viability component – viability for whom? For some, taxes going up but allocation going down. Highlights the need for input from SPG in defining economic viability
- Question about how do we know where we stand today? Need to monitor progress – currently being done and reported at annual basin meetings.
- Stakeholder Comment - during first increment, we were in 10 year drought. Lesson is that we didn't have enough storage capacity during drought; looking to food/water for future generations, goals may change. Dams will be silted in. We need to start planning now.

c. January survey will address 46-715 additional considerations

III. Review & Refinement of First Increment Goals

A pre-survey was completed in advance of this meeting by 12 individuals. Results of that survey were discussed throughout this section of the meeting; full survey results are included at the end of these minutes.

a. Goal 1: Incrementally achieve and sustain a fully appropriated condition.
    - 10 of 12 survey respondents said this goal is fine as-is
    - Pre-survey stakeholder comment to strike "incrementally achieve and"—REVISIT striking these words if basin is Fully Appropriated
    - Pre-survey stakeholder comment to estimate # of increments
    - **Vote for "No Modifications"** – 2 yellow cards;

Objective 1

- Pre-survey stakeholder comment to delete – this objective is supposed to be met at end of 1st increment, so not necessarily needed now. Where does each NRD think they are in achieving FA condition?
    - CPNRD - believe they have met requirement
    - NPNRD – believe they have met requirement
    - SPNRD – believe they have met requirement
    - TBNRD – believe they have met requirement; potential complication with J2 (now off the table, so need to look for alternatives)
    - TPNRD – believe they have met requirement
    - This will be validated/verified through the Robust Review
- Future decisions made based on best available science at the time (which has improved and is continuing to improve)
- Pre-survey stakeholder comment to end at "streamflow", strike remainder
- Pre-survey stakeholder comment that offset needs to be in stream providing actual flow
- **Vote to move forward with objective as-is** – 1 yellow; **revisit with full set of data about FA condition**

Objective 2

- 9 of 12 survey responses fine as-is
- Pre-survey stakeholder comment to add WWUM.
- Pre-survey stakeholder comment that this is more than one objective. Clarified in action items.
- **Vote to strike reference to COHYST – rest to remain as-is.**

Objective 3

- 6 of 12 survey responses fine as-is
- Pre-survey stakeholder comment to delete. If FA, then does this apply?
- Pre-survey stakeholder comment to delete "continue" or "continue to develop the methodology to". By statute, needs to be done in 1st increment.
- Pre-survey stakeholder comment about develop vs. enhance; difference vs. co-relationship

- Pre-survey stakeholder comment to add application of methodology
- Pre-survey stakeholder comment to add "in collaboration with the stakeholders within 1 year"
- Pre-survey stakeholder comment that objective is vague
- **Vote to move forward with no modifications**

Objective 4

- 8 of 12 survey respondents fine as-is
- Pre-survey stakeholder comment to strike "progress toward" – If FA, then does this apply?
- Pre-survey stakeholder comment to include some measure of how far we are going in this increment (i.e. reduce remaining difference by 50% instead of just making progress).
- Pre-survey stakeholder comment to analyze vs. analysis, i.e. ongoing
- Address timeline - # of increments: if we aren't there, how long should it take to get there?
- **Vote to move forward with no modifications – address the timeline with action items**

Objective 5

- 8 of 12 survey respondents fine as-is
- Pre-survey stakeholder comment to reduce remaining difference by 50%; way it is written appears that funding is the limitation; discussion and comment from NRDs is that funding is not a restriction and other options are not precluded by wording.
- Pre-survey stakeholder comment to include regulation? Funding?
- Pre-survey stakeholder comment to strike first 4 words
- **Vote to move forward with no modifications**

Objective 6

- 9 of 12 survey respondents fine as-is
- Pre-survey stakeholder comment to strike "adopt and implement" and change to "Update"
- Pre-survey stakeholder comment to add "in accordance with the Plan"
- **Vote to move forward with modification – "Update and continue to implement IMPs in each Platte River Basin NRD."**

b. Goal 4: Discuss at January meeting

IV. Modeling Overviews

a. COHYST – Presentation and Q&A by Duane Woodward, CPNRD
b. WWUM – Presentation and Q&A by Thad Kuntz and Heath Kuntz, Adaptive Resources, Inc.

V. Next Steps

- Vote to determine if group should meet if there is no data concerning difference between current and fully appropriated status: Majority voted to meet as scheduled; 6 voted to not meet if data is not available. **January meeting will be held on schedule, regardless of if data is available for difference between current and fully appropriated status.**

- Goal 4: Discuss at January meeting

VI. Topics to Address in 2nd Increment (flip chart topics)

- Drought Conditions
- Revisit order of goals
- Economic & Social Impacts
- Oversight
- Conjunctive Mgmt (ground AND surface)
- Food & Clean water for future generations
- Monitor Progress (score sheet)
- Storage Capacity & Maintenance
- Have we jumped from over to fully?
- Timeline; number of increments

VII. Public Comment

- None

Adjourn at 3:20 pm

Meeting Date: 11/16/16

NOTE: Photographs/video may be captured during the meeting. These assets may be used by the NDNR, Districts, or HDR for the sole purpose of marketing, communication about the project and/or advertising. This may include, but is not limited to, printed and published materials on the NDNR, Districts, or HDR website.

Attended?	Name	Email Address	Affiliation	Primary or Alternate
		SPG Primary Members		
TA	Anderson, Tyrell	tyrell.anderson@retranches.com	North Platte NRD	Primary
	Barels, Brian	blbarel@nppd.com	Public Power & Irrigation District	Primary
✓	Bendfeldt, Jim	jcb1@fastmail.com	Central Platte NRD	Primary
✓	Busch, Bob	rnbusch@actcom.net	Surface Water User	Primary
RBD	Dahlgren, Bob	Rdahlgren@fsbloomis.com	Municipality – Village of Bertrand	Primary
KD	Derry, Kevin	derrykb@embarqmail.com	Agriculture	Primary
	Downey, Thomas	tdowney@downeydrilling.com	Ground Water User	Primary
RE	Edeal, Russell	redeal@atcjet.net	Agriculture	Primary
	Eggleston, Judy	JudyEggleston@aol.com	Irrigation District	Primary
BF	Fehringer, Bernard	bfehringer@icloud.com bernie.fehringer@wheatbelt.com	Public Power	Primary
DF	Fisher, Dave	dpfisher@scottsbluff.net	Surface Water User	Primary
RG	Gatch, Richard	Rgatch1@unl.edu	Surface Water User	Primary
BH	Halligan, Bill	Bill.halligan@pwcbank.com	South Platte NRD Board	Primary
PH	Heath, Pat	pheath@gering.org	Municipality – City of Gering	Primary
CH	Henkel, Chuck	henkelchuck@yahoo.com	North Platte NRD Board	Primary
LH	Hoehn, Leo	Leo.hoehn@gmail.com	Groundwater Irrigator	Primary
KK	Koupal, Keith	keith.koupal@nebraska.gov	Environment/Wildlife	Primary
✓	Kramer, Erwin	backflow79@hotmail.com	Municipality – City of North Platte	Primary
	Kraus, Don	Dkraus@cnppid.com	Irrigation District	Primary
GL	Larson, Galen	glarson@pvbank.com	Financial	Primary
	Luchsinger, Tim	tluchsinger@grand-island.com	Municipality – City of Grand Island	Primary
VJN	Nelson, Vernon	vernonjamesnelson@yahoo.com	Agriculture/Groundwater User	Primary
RP	Paulman, Roric	rpaulman@gpcom.net	Agriculture	Primary
JP	Pepplitsch, Joe	jpepp@cityoflex.com	Municipality – City of Lexington	Primary
JR	Revelle, Jack	jrevelle@vistabeam.com	Ground Irrigator	Primary
LR	Reynolds, Larry	larryreynolds68@gmail.com	Tri-basin NRD Board	Primary
✓	Richeson, Jay	jay@gothenburgirrigation.com	Municipality – Gothenburg	Primary
Rodney Schaneman	Schaneman, Rodney	raschman@charter.net	Surface Water User	Primary
DS	Schilz, Dennis	dennisschilz@gmail.com	Irrigation District	Primary
CS	Sisk, Carson	Kimballwater@kimballne.org	Municipality – City of Kimball	Primary
yes	Strauch, Dennis	dennis@pathfinderirrigation.com	Irrigation District – Pathfinder Irrigation	Primary

Meeting Date:______________

KS	Strommen, Kendra	strommen@mmmlawoffice.com	Financial	Primary
No	Wahlgren, Joe	wahlgrenfarms@gmail.com	Twin Platte NRD Board	Primary
		SPG Alternate Members		
	Albrecht, Frank	frank.albrecht@nebraska.gov	Environment/Wildlife	Alternate
	Andreas, Kent	kandreas@embarqmail.com	North Platte NRD Board	Alternate
	Burnside, Dennis	dburnside@cityoflex.com	Municipality – City of Lexington	Alternate
	Clymer, Bruce	bclymer@cityofgothenburg.org	Municipality – Gothenburg	Alternate
	Derry, Jared	Jared.derry@gmail.com	Agriculture	Alternate
	Downey, Brent	bdowney@downeydrilling.com	Ground Water User	Alternate
no.J.	Drain, Mike	mdrain@cnppid.com	Irrigation District	Alternate
	Henry, Chris	cnhenry144@hotmail.com	Central Platte NRD Board	Alternate
	Hock, Andrew	andrew.extremeag@gmail.com	Agriculture	Alternate
	Jameson, Rhodel		Agriculture/Groundwater User	Alternate
	Larson, Joe	joelarson21@gmail.com	Tri-basin NRD Board	Alternate
J.M.M.	Meismer, Jim	tpnrd1jimm@gmail.com	Twin Platte NRD Board	Alternate
	Meyer, Doug	dgmeyer@NPanhandle.net	Municipality – City of North Platte	Alternate
	Narjes, Kathy	rodekohr@hotmail.com	South Platte NRD Board	Alternate
	Ortiz, Daniel	DOrtiz@kimballne.org	Municipality – City of Kimball	Alternate
	Shafer, Jeff	jtshafe@nppd.com	Public Power & Irrigation	Alternate
	Smith, Ann	annck@cozadtel.net	Irrigation District	Alternate
	Snarr, Paul	psnarr@gering.org	Municipality – City of Gering	Alternate
RZ	Zach, Randy		Public Power & Irrigation District	Alternate
		POAC Members		
	Adane, Zaibon		NDNR	
	Benson, Kathy	Kathy.Benson@nebraska.gov	NDNR	
No	Berge, John	jberge@npnrd.org	North Platte NRD	
Yes	Cross, Barb	bcross@npnrd.org	North Platte NRD	
	Crowe, Kayla	kayla.crowe@nebraska.gov	NDNR	
	Czaplewski, Mark	Mark@cpnred.org	Central Platte NRD	
AMD	Dimmitt, Ann	afisher@tpnrd.org	Twin Platte NRD	
	Eckles, Beth		NDNR	
	~~Fahrenbuch, Tammy~~	~~tfahrenbruch@tribasinnrd.org~~	~~Tri-Basin NRD~~ won't attend	
	Glanz, Travis	tglanz@spnrd.org	South Platte NRD	
Yes	Horn, Rod	rlhorn@spnrd.org	South Platte NRD	
Yes	Miller, Kent	komiller@tpnrd.org	Twin Platte NRD	
	Mintken, Jesse	mintken@cpnrd.org	Central Platte NRD	
	Mosier, Melissa	melissa.mosier@nebraska.gov	NDNR	
	Osborn, Colby		NDNR	
No	Reisdorff, Ryan	rreisdorff@spnrd.org	South Platte NRD	

Meeting Date:______________

JSS	Schellpeper, Jennifer	jennifer.schellpeper@nebraska.gov	NDNR
	Shaw, Landon	lshaw@tpnrd.org	Twin Platte NRD
JT	Thorburn, John	jthorburn@tribasinnrd.org	Tri-Basin NRD
	Vogt, Lyndon	vogt@cpnrd.org	Central Platte NRD
[illegible]	Winter, Jessie	jessie.winter@nebraska.gov	NDNR
DW	Woodward, Duane	woodward@cpnrd.org	Central Platte NRD
[illegible]	Zayac, Tracy	Tzayac@npnrd.org	North Platte NRD
	Zoller, Amy	amy.zoller@nebraska.gov	NDNR
	Members of the Public		
	Fassett, Jeff	Jeff.Fassett@nebraska.gov	DNR
JE	Engel, John	john.engel@hdrinc.com	HDR
[illegible]	Jesse Bradley		The Flatwater Group
AW	Ann Williams	ann.williams@hdrinc.com	HDR
	Dustin Wilcox	dwilcox@NRDNET.ORG	NARD
JFK	Jerry Kenny	Kennyj@headwaterscorp.com	PRRIP-EDO

Agenda

Project:	Upper Platte River Basin Water Management Plan – Single Planning Group
Subject:	Meeting #5
Date:	Wednesday, March 15, 2017 from 10:30 a.m. to 3:00 p.m.
Location:	Holiday Inn Express & Suites, North Platte, NE

Agenda:

I. Administration
   a. Today's meeting will offer a working lunch
   b. This is an Open Meeting
   c. November Meeting Recap
      i. Meeting minutes
      ii. Key discussion / decisions
      iii. Follow-up items
   d. Review of Decision-Making Process
II. Second Increment Discussion
   a. Present survey responses
   b. Desired outcomes for the 2nd Increment
III. Background
   a. INSIGHT Analysis of Basin Supply and Demand
   b. Growth in Depletions
IV. Next Steps
V. Public Comment

Next Meeting: May 17, 2017

SPG Meeting #5 - Meeting Minutes

Date: March 15, 2017
Location: Holiday Inn Express & Suites – North Platte, NE

All meeting materials and a sign-in sheet can be found online at http://upbwp.nednr.nebraska.gov/

Agenda

I. Administration
   a. Today's meeting will offer a working lunch
   b. This is an Open Meeting
   c. November Meeting Recap
      i. Meeting minutes
      ii. Key discussion / decisions
      iii. Follow-up items
   d. Review of Decision-Making Process
II. Second Increment Discussion
   a. Present survey responses
   b. Desired outcomes for the 2nd Increment
III. Background
   a. INSIGHT Analysis of Basin Supply and Demand
   b. Growth in Depletions
IV. Next Steps
V. Public Comment

I. Administration – Stephanie White

November Meeting Recap

Review of on-going parking lot of topics to include in the 2nd Increment Plan; items from the survey results have been added to the list which has been categorized into four groups:

1. Administrative
2. General Management
3. Economic, Social, Environmental
4. New / Additional Sections

The following table shows the four categories of items; text in Green text indicates new topics from the survey.

Issues to be Addressed in the 2nd Increment

Administrative	**General Management**
• Revisit order of goals • Define FA (unknown numbers) • # of increments • Meter the whole state?	• Oversight • Monitor progress (score sheet) • Improved model for lower reaches • Accounting for surface water appropriators • Offsets based on timing and locations
Economic, Social, Environmental	**New Sections / Additional**
• Clean food and water for future generations • Water quality • Fish, Wildlife, park lands • Check valves on wells • Economic analysis (scenarios) • Management of the Resource	• Drought conditions • Storage • Conjunctive Management • Hydropower

Review of SPG Decision Making Process

- The first goal is consensus.
- A majority vote is the determining factor for all sections of the plan.
- If the group cannot reach a majority, the NeDNR and the NRDs will work together to resolve the disputed issues.
- If the SPG is unable to come to consensus by June 2018, the NeDNR and the NRDs will work together to resolve the disputed issues and create a final plan by August 2018.

II. Second Increment Discussion – Stephanie White

Survey results (included in the meeting materials posted online) were reviewed and discussed; discussion focused on questions 1-3, with question 4-6 discussion taking place at the next meeting. The notes in this section reflect an open discussion among the SPG members. Statements are not necessarily attributed to any one individual nor should they be construed as conclusions as the whole group.

Q1 DISCUSSION:

Question 1 focused on the overall intent for the 2nd increment plan. The majority of responses indicated the plan should maintain what has been done to date and make more progress towards fully appropriated conditions. SPG members understand the statute intends for the plan to be reviewed every 10 years to document progress and adjust goals as necessary. Further development of the basin can occur only by maintaining a water supply that meets social and economic goals. Some SPG members feel there are unknowns that inhibit progress (such as definition of fully appropriated, and lack of real numbers and reach targets) and that too many models are being run without definitive results. An option was brought forward for discussion that involved adding storage in order to meet demands during times of shortage. Specific comments included:

- Statute intended that the plan should be reviewed in ten years to document progress and adjust where needed to meet that goal
- There is a lot of space and variability in the term to "make more progress"
- The only way to allow further development in the basin is by meeting the goals - socially and economically
    - Perception that "model after model" is run
    - Can we maintain an inefficient conjunctive management system – we aren't getting there from the unknowns. The unknowns are:
        - Phantom numbers to meet surface water expectations
        - Reach targets for ground water baseflows
- Supply and demands: When you combine (Surface water CU demands) + (hydro power demands), it is not possible to meet all the demands even with no depletions from groundwater use. Need additional storage to maintain balance.
- May be a need for a fourth option for question response – we are done except we need to add storage to the system.

Q2: DISCUSSION

Question 2 requested SPG members provide their input on a specific target for depletion offsets to include in the plan. The majority responded that no further progress was necessary. From those that did respond with a target, the values ranged from 10,000 – 150,000 AF. The discussion focused on uncertainty in the definition of fully-appropriated with SPG members suggesting definitions ranging from consideration of balancing water supplies and demands only, to maintaining the economic viability of the basin, to a system that can hydrologically reset itself periodically – presumably during wet periods. In addition, the need for a target range rather than a specific value was discussed. Specific discussion items included:

- We do not have a definition for fully appropriated
    - Numbers are not set in stone; need a real number
    - Until there is a definition of fully appropriated Q1 and Q2 aren't relevant
- The notion that we need to fulfill every need on the river is not what a prior appropriation state is about
- A range of values is more appropriate given variability in hydrology – also is consistent with how the NRDs and NeDNR will implement the plan.
- We need to find a range that basin members are willing to work within
    - Need to find ways to get the consumption within that range
    - Need to adjust to the economics accordingly – we have no choice

Q3: DISCUSSION

Question 3 focused on the current plan's adequacy in addressing the call to maintain the economic viability of the basin. The majority of respondents indicated that they believe the current plan does maintain the basin's economic viability. Economic viability is very important to the group and considerations such as agricultural production, fish and game, hydropower, municipal and industrial development, property tax and land values, political subdivisions, production costs, commodity prices, etc. were all identified as key factors. Some of these factors are related to water supply and some are farther removed. The group expressed concern that taking more land out of production is not viable long term – for producers as well as others that generate income and tax revenue based on agricultural production. Alternative management of conjunctive management or hydropower projects was also discussed as a means to better meet the water demands of the basin. Specific items of discussion included:

- How would you develop economic viability?
  - A lot is considered in this, ag production use, fish and game, hydro power, pumping, land values, different political subdivisions (school districts, fire districts - need to understand the political subdivisions and impacts) – seeing this affect in southern Lincoln county from NCORPE. If you don't have income producing land and projects, you don't have a tax base to support these elements
- Hydropower users understand they have a junior right. Their concern is shortages, not by being a junior appropriator, but by further shortages caused by further development.
- Concern about land values; water demands make Nebraska land less valuable than adjacent states.
- Economic viability is not the objective based on statute – "Achieve and sustain a balance" as stated in statute
  - Water should not become the obstacle to economic viability; need the balance
- We have spent millions of tax dollars purchasing water and taking it out of production to meet first increment goals; this is counter intuitive and impacts the basin and the tax base
- Establish the viability of independent systems – there are established uses and established rights that should be supported
- Conjunctive Management – managing the ground water and surface water as one resource. Can we do it a little differently so we can meet goals?
- Funding sources – where are funds going to come from and is that source sustainable?
- Can what has been done to date be economically sustainable going forward? What part does the water supply specifically play?
  - Need to be careful that what we are doing isn't hindering people from economic viability in the basin
  - There is a minimum amount of water to deliver a crop - that is a base or floor of required water supply for viable ag production.
  - Taking land out of production can't be sustained for future generations
- So many factors (production costs, commodity prices, etc) involved in the economic viability for producers that water is far removed from true economic viability
- Some stakeholders want to be allowed to keep doing what they are doing – they don't want to curb their usage any further
- Return On Investment – Cost Benefit – should a cost-benefit analysis of different uses of available supply be completed to inform 'best' use?
- It is not viable to continue to retire land from ag production.
- It is important that economic viability be geographically/spatially balanced across the entire basin.

III. Background

INSIGHT Analysis of Basin Supply and Demand – Jessie Winter

This section of these minutes includes actual speakers notes used at the meeting. The PowerPoint presentation is posted with the meeting materials.

DRAFT ANALYSIS FOR THE UPPER PLATTE RIVER ABOVE ODESSA

The following is a brief summary of the information presented at the Platte Basin Single Planning Group meeting on March 15, 2017. The water supply and water demand information presented at the meeting represents the culmination of years of work by the Nebraska Department of Natural Resources and five Upper Platte River Basin Natural Resources Districts. This effort was one of many actions called for in the basin-wide plan and integrated management plans adopted in 2009, following an initial designation by the Legislature in 2004 that the Platte River Basin upstream of the Kearney Canal (approximately Odessa, Nebraska) is overappropriated.

This water supply and water demand information will assist stakeholders and decision makers in developing management targets for the second increment of planning (2019-2029) to support implementation of various activities aimed at ensuring the sustainability of water supplies and water uses so that the economic viability, social, and environmental health, welfare, and safety of the Upper Platte River Basin can be maintained for the long-term.

METHODS USED FOR THE EVALUATION

The methods used for this evaluation were developed over the course of several years and included participation from: state and natural resources district management and staff, stakeholder input through several basin and statewide meetings, and hired consulting services.

- The concept is generally quite simple, we consider how much water comes in to the basin as streamflow supply, how much goes out through consumptive uses and how much needs to remain in the stream for areas downstream or for other non-consumptive uses such as hydropower and instream flows for supporting various species in the central Platte River.
- For this analysis, we looked at the period of 1988 – 2012 to represent naturally occurring wet and dry cycles.
- The annual data are parsed out into two seasons: June-August, which represents the peak season, when irrigation demands are highest, and September-May, which represents the non-peak season, when demands are lower.
- The goal of the method is to evaluate the balance in water supplies and water demands through the wet and dry cycles and the two seasons to identify times of shortage and times of surplus.

WATER SUPPLIES

The water supplies in this evaluation consist of estimating the amount of streamflow supply that would be available prior to uses occurring. Essentially this is how much water would be in the river before we take any out. This is accomplished by adding together the following information:

- Streamflow is the first component of the basin water supply. This is the gaged or measured streamflow at the Platte River at Odessa gage.

- The surface water consumption for irrigation generally estimated from crop irrigation demands and the acreage served by surface water within each irrigation district. These estimates come from the extensive modeling efforts (WWUM and COHYST) that have been developed for the Platte Basin.
- Evaporation from major reservoirs was determined using weather station and pan evaporation data. The reservoirs for which evaporation was considered were Lake McConaughy, Lake Maloney, Elwood Reservoir, Jeffery Reservoir, and Johnson Reservoir.
- Groundwater depletions are the final component. Depletions represent the estimate of water removed from streamflow due to groundwater pumping in the hydrologically connected area. Groundwater depletions were estimated using the COHYST and WWUM.
- The estimated total basin water supply ranges from about 1 million acre-feet during drier periods to over 2.5 million acre-feet during wet periods.
- The supply does vary through time, there are wetter times and dryer times. This is primarily driven by the streamflow component so it is naturally occurring.

WATER DEMANDS

The water demands considered in the evaluation consists of consumptive uses of surface water and groundwater, water used by large canals to deliver water to the fields in those irrigation districts, hydropower, instream flows, and water for downstream areas. The following further describes these demands.

- Surface water demands include those for irrigation and evaporation.
- Groundwater depletions include demands for irrigation and municipal needs and represent the estimate of water removed from streamflow due to groundwater pumping in the hydrologically connected area.
- The demands for net surface water loss represent the seepage loss to the aquifer during transport of surface water through canal systems and losses at the field for surface water irrigated lands. Another way to say that is, that it represents the amount of water needed to get the consumptive use portion to the field.
- Non-consumptive demands represent uses that require water to remain in the stream. The three types that exist in the Upper Platte above Odessa are hydropower, instream flows for fish and wildlife, and downstream demands for the Platte basin below Odessa.
- The total consumptive demands to meet municipal demands and all irrigation demands, including water to conveying supplies through irrigation canals averages approximately 1.5 million acre-feet.
- An additional approximately 1 million acre-feet is necessary to meet all non-consumptive demands.

BALANCES

The results of the evaluation indicate that the current volume of water permitted for use is larger than the volume of water supply that is available on an average annual basis within the Upper Platte River Basin.

- The average annual supply is generally sufficient to balance the irrigation and municipal demands, however shortages do occur and are typical during the irrigation season.
- The average annual supply is typically insufficient to meet all demands once the non-consumptive demands such as hydropower, instream flows, and downstream need are included. The average deficit is approximately 1 million acre-feet per year.

QUESTIONS AND DISCUSSION ON DRAFT ANALYSIS

The notes in this section reflect an open discussion among the SPG members on the INSIGHT analyses. Statements are not necessarily attributed to any one individual nor should they be construed as conclusions as the whole group.

- Are you overstating the non-consumptive demands in terms of hydro?
- If hydro was reduced by management, how would that affect the graph
  - Different management of hydropower would have a direct affect
  - Where would we be if we had wind power and only used the water for hydropower when we needed it?
- Net surface water loss – is this hydrologically connected and accounted for?
  - Assume that the canal loss is to seepage and baseflow gains to the river due to this seepage are reflected in surface flows at the downstream river gages.
- Surface water supplies – how was storage accounted for?
  - Change in storage during non-irrigation period was quantified and added to the supply available to meet demands during peak season.
- The surface water canal system plays an important role because seepage revitalizes the aquifers; need to keep the canal system healthy.
- How is atmospheric moisture accounted for?
- Keep in mind the goal of this is to make the resource last forever. Surface water supply varies considerably from year to year. This year all water demands are satisfied, but what if it is dry next year?
- INSIGHT analysis doesn't reflect the prior appropriation system used to manage surface water, but instead shows all existing demands on the system
- Dependency of system on return flows – smaller surface water reductions
- The INSIGHT analysis is based on historic flow conditions and existing demands, not predictive in nature.

Growth in Depletions - John Engel

This discussion centered on an 11x17 handout called 'Growth in Depletions Infographic' which can be found online: http://upbwp.nednr.nebraska.gov/Media/GrowthInDepletions_05.pdf

- Numbers are based on best available data – will be updated based on the robust review currently underway.
- Supply and Demand Balance - Shows the values taken from the Basin-Wide Supply and Demand Analysis. Moves from being in the positive to the negative incrementally as demands are added to reach total demand on the system. (annual average values illustrated)
- Growth and Depletions - This is what the modeling shows – this is developed by running a simulation with no groundwater pumping occurring and then you run the same model again with groundwater pumping occurring.
- 16,880 AF is the starting point for the second increment (Post – 1997 use depletions required by statute to be addressed in first increment)

- For a desired outcome – the chart is useful in showing what mitigation targets correspond to the desired outcome.
- The growth in depletions are not based on new uses - we have uses in place that have affects that haven't hit the stream yet
- The Statute refers to the overappropriated areas; this is the only basin in the State of Nebraska that is overappropriated
- Question - Concern about the blue line – if we maintain the aquifers and the elevation of the river is higher than the surrounding ground, do we have growth in depletions?
- When you look at the table – it compares what it would be like without pumping
- Can we tighten up 43,600 AF to 126,170 AF of estimated first increment activity benefits?

IV. Next Steps

Next Meeting: May 17, 2017

Topics will include:

- A working definition of economic viability based on the conversation today
- Continued discussion of survey questions 4-6
- Review of annotated 1st Increment Plan that shows updating progress to-date.

Action items

- Request to add assumptions on Jessie's slides
- Move resources materials up on website page
- Include a link to the resource materials in meeting invitations to SPG members
- Shift room so the front wall is open for white wall work

V. Public Comment

- Request for a summary of the data presented – Jerry Kenny

May 2017 **SUMMARY**

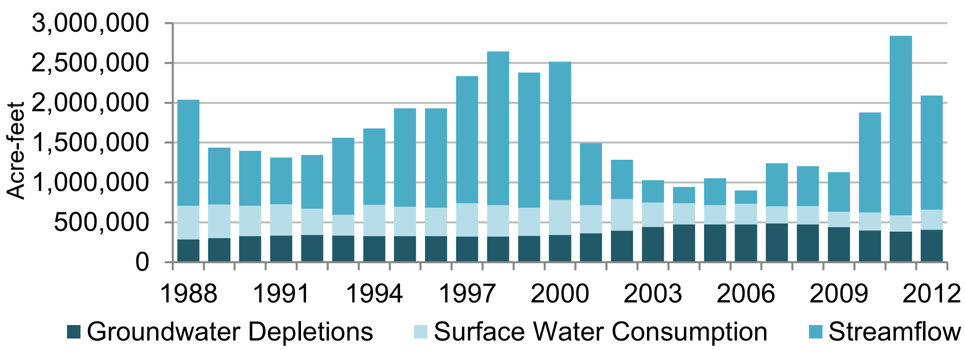
UPPER PLATTE BASIN-WIDE PLANNING PROCESS

INSIGHT WATER SUPPLY AND WATER DEMAND - DRAFT

SUMMARY FOR THE **UPPER PLATTE RIVER BASIN ABOVE ODESSA**[1]

Overall findings: The draft results of the evaluation indicate that the current volume of water permitted for use is larger than the volume of water supply that is available on an average annual basis within the Upper Platte River Basin.

Basin Water Supply: Annual



THE WATER SUPPLIES IN THIS EVALUATION CONSIST OF ESTIMATING THE AMOUNT OF WATER THAT WOULD BE IN THE RIVER BEFORE ANY IS TAKEN OUT.

The total water supply is determined by adding together the following components:

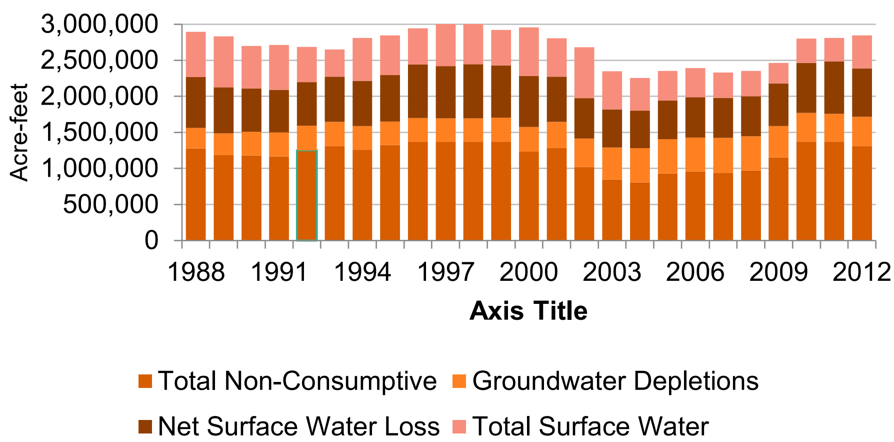
- Groundwater depletions represent the estimate of water removed from streamflow due to groundwater pumping in the hydrologically connected area.
- **S**urface water consumptive use for irrigation was estimated from crop irrigation demands and the acreage served by surface water within each irrigation district.
    - o Evaporation from major reservoirs was determined using weather station and pan evaporation data. Reservoirs considered were Lake McConaughy, Lake Maloney, and Elwood, Jeffery, and Johnson Reservoirs.

[1] This is a brief summary of the DRAFT information presented at the Platte Basin Single Planning Group meeting on March 15, 2017. This information and the results of the evaluation are draft at this time and subject to change following further review.

- o Streamflow is the gaged or measured streamflow at the Platte River at Odessa gage. The supply varies through time - naturally occurring wet and dry periods are reflected in the streamflow component.

Results: The estimated total basin water supply ranges from about 1 million acre-feet during drier periods to over 2.5 million acre-feet during wet periods.

Total Demand: Annual (Near-Term)



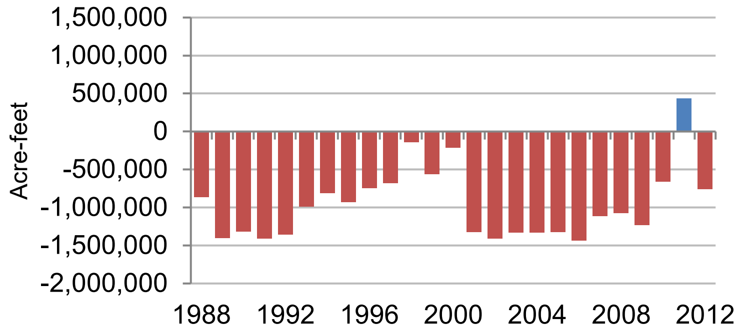
THE WATER DEMANDS IN THE EVALUATION CONSIST OF ALL CONSUMPTIVE AND NON-CONSUMPTIVE WATER USES WITHIN THE BASIN.

The total water demand is determined by adding together the following components:

- Non-consumptive demands represent uses that require water to remain in the stream. The three types that exist in the Upper Platte above Odessa are hydropower, instream flows for fish and wildlife, and downstream demands for the Platte Basin below Odessa.
- Groundwater depletions include demands for irrigation and municipal needs and represent the estimate of water removed from streamflow due to groundwater pumping in the hydrologically connected area.
- The demands for net surface water loss represent seepage loss to the aquifer during transport of surface water through canal systems and losses at the field for surface water irrigated lands.
- Surface water demands include those for irrigation and evaporation.

Results: The total consumptive demands to meet all municipal demands and irrigation demands averages approximately 1.5 million acre-feet. An additional approximately 1 million acre-feet is necessary to meet all non-consumptive demands.

Balance: Annual



THE AVERAGE ANNUAL SUPPLY IS TYPICALLY INSUFFICIENT TO MEET ALL DEMANDS. THE AVERAGE DEFICIT IS APPROXIMATELY 1 MILLION ACRE-FEET PER YEAR.

INSIGHT WATER SUPPLY AND WATER DEMAND - DRAFT

KEY ASSUMPTIONS AND METHODS FOR THE UPPER PLATTE RIVER BASIN ABOVE ODESSA

Water Supplies

For purposes of the evaluation methodology, the water supplies consist of the summation of streamflows, surface water consumptive uses, and groundwater depletions. Water supplies were tabulated for the period of 1988 – 2012 to represent naturally occurring wet and dry cycles. Required inflows are also included in the water supplies when evaluating individual sub-basins, but not when evaluating the entire overappropriated basin. Further description of each element of the water supply is provided below.

Streamflows– streamflows are the measured streamflow of the basin with the exception that mean daily flows in excess of the five-percent exceedance probability are capped at the five-percent exceedance value (see Figure 1)[2]. The streamflows for a sub-basin are calculated by subtracting the upstream gage from the downstream gage to establish the gain/loss in streamflow for each sub-basin. The exceptions are as follows:

- Lewellen Streamflow = Uncapped Lewellen gage
- South Platte Streamflow = Capped South Platte River at North Platte gage + Historic Korty Diversion
- North Platte Streamflow Gain = Capped North Platte gage + 40 cfs – Capped Keystone gage. (This was done to prevent Lake MAC operations from influencing the analysis.)
- Odessa Streamflow Gain = Capped Odessa gage – Capped “Streamflow at Confluence” of North Platte & South Platte Rivers + Kearney Diversion where the “Streamflow at Confluence” = North Platte River at North Platte + South Platte River at North Platte + Sutherland Return

[2] Note: This is not done at Lewellen because Lake MAC does have the capacity to capture extreme events.

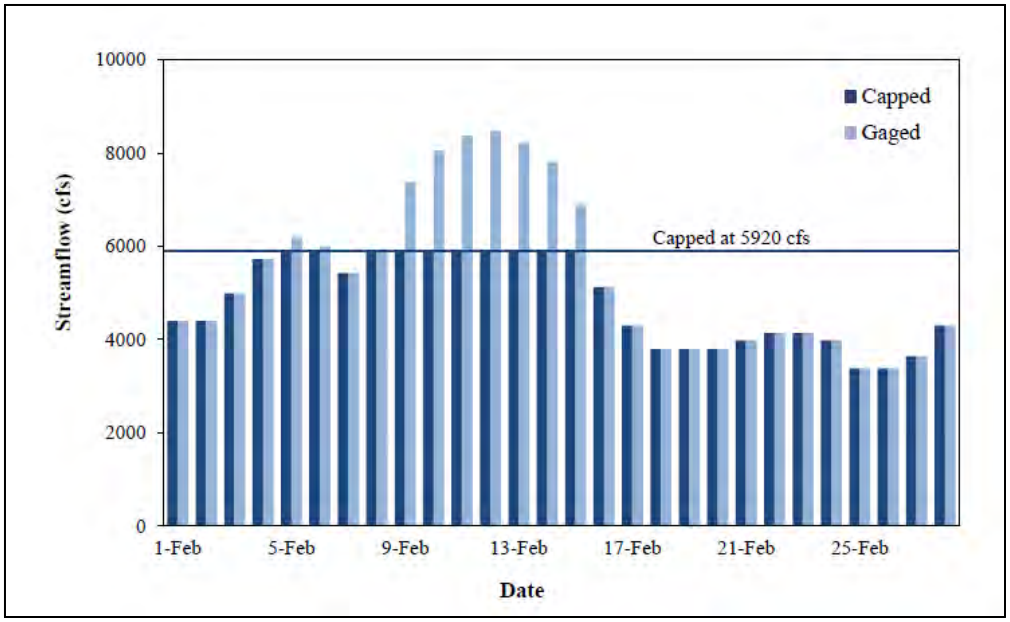


FIGURE 1: EXAMPLE OF AN EXCEEDANCE PLOT AND THE RESULT FROM CAPPING STREAMFLOWS AT THE FIVE-PERCENT EXCEEDANCE FLOW PROBABILITY (SOURCE: "INSIGHT METHODS" 2015)

Groundwater Depletions – Groundwater depletions within the overappropriated portion of the Platte River Basin were calculated using the COHYST and WWUM to estimate the total impact groundwater pumping has had on streamflows through the period of record evaluated in the analysis (1988-2012).

Historical groundwater pumping and surface water deliveries within the COHYST model area which determined based on crop demands. Groundwater was used to meet the portion of crop demand that could not be met by surface water deliveries.

Surface Water Consumptive Use[3] – The surface water consumptive use aims to identify the level of consumption that occurred as a result of surface water diversions for irrigation and evaporation from major reservoirs (Lake McConaughy, Lake Maloney, Elwood Reservoir, Jeffery Reservoir, and Johnson Reservoir). The surface water consumption that was calculated for each canal included in the analysis was generally estimated from crop irrigation demands and the acreage that is served by surface water within each irrigation district. Surface water consumption was calculated for all major canals in the overappropriated portion of the Platte River Basin with the exception of Pathfinder Irrigation District, Gering-Fort Laramie, Mitchell-Gering, and Tri-State canals that divert from the North Platte River in the proximity of the Nebraska-Wyoming state line. The surface water consumptive use from these canals was not included in the water supply calculations and was also excluded from the consumptive surface

[3] . Note: There are still three years (1993, 1995 and 1999) that the SW CU exceeds the demand in the WWUM. ARI would need more time to refine the splits for GW Pumping to CU on comingled acres versus the SW diversions to CU on comingled acres.

water demand calculations. The models used to estimate surface water consumptive use represent historic irrigation practices.

Required Inflows – Required inflows are included as part of the water supply for each sub-basin with the exception of the two sub-basins (North Platte River Stateline to Lewellen and South Platte River Stateline to North Platte) that initiate from the state line. Required inflows represent the portion of water supply that flows from upstream locations to assist in meeting a portion of demands in downstream locations. The process for determining the portion of demands that is met by required inflows is based on determining each upstream subbasins proportional contribution to the overall water supply available in the downstream subbasin.

Water Demands

For purposes of the evaluation methodology, the water demands consist of the summation of consumptive use demands for irrigation, municipal, and industrial uses that are served by groundwater or surface water, net surface water loss, hydropower, instream flows, and downstream demands. Further description of each element of the water demands is provided below.

Consumptive Surface Water Demands[4] – The demands for surface water include those for irrigation and evaporation as no significant municipal or industrial uses occur in the area. The models used to estimate surface water demands assume commingled lands are irrigated with groundwater. The demands are calculated by multiplying the surface water irrigated acres by the consumptive use estimates (irrigation requirements). Additionally, the temporal distribution of surface water demands differs from surface water consumptive use in that surface water demands that have access to water stored in reservoirs are redistributed from the peak season (June – August) to the non-peak season (September – May). SWD has been defined as the greater of either SWCU or the product of surface water irrigated acreage and the NIR for corn. The COHYST utilized the BL001 run data which assumed that comingled acres were fully met by groundwater. Also, BL001 repeats year 2005 land use post 2005.

Consumptive Demands for Hydrologically Connected Groundwater **(Long-Term Groundwater Demands)**[5] – The demands for hydrologically connected groundwater are based on consumptive use estimates (irrigation requirements) multiplied by groundwater irrigated acres and commingled acres within the hydrologically connected area (10/50 area). The COHYST utilized the BL001 run data which assumed that comingled acres were fully met by groundwater. BL001 varies land use, acreage, and climate from year-to-year through 2005. Post 2005, BL001 repeats year 2005 land use and acreage but varies climate. For the WWUM area groundwater demands were set equal to groundwater depletions since groundwater depletions

[4] In the COHYST area, SW demands for canals that may span more than one subbasin can be assigned to the point of diversion.
[5] ARI has indicated that M&I pumping has been included in the provided data. TFG has provided M&I as a separate dataset. The TFG M&I data only goes through 2005; therefore, 2005 was repeated through 2012.

were often in excess of the groundwater demands[6]. The seasonal distribution of groundwater demands assigns 70% of the demands to the non-peak season (September – May) and 30% to the peak season (June – August). The split is current condition, and may shift in the future to more peak season depletions (60/40, 50/50, etc.) in coming years as aquifers are depleted.

Lake McConaughy Change-in-Storage- Non-peak season change-in-storage is used to reduce peak season uses that hold storage water rights in Lake MAC. These demands are not reassigned to the non-peak season (break from INSIGHT methodology)

Demands for Net Surface Water Loss – The demands for net surface water loss represent the seepage loss to the aquifer during transport of surface water through canal systems and losses at the field for surface water irrigated lands. This loss was estimated based on the difference between modeled head-gate diversions and surface water demands (the consumptive portion of diversions)[7].

Demands for Hydropower – Hydropower demands are represented for the Sutherland hydropower facility, CNPPID hydropower facilities (Jeffery, J-1, and J-2, with the Kingsley Hydropower excluded)[8], and Kearney hydropower facility. The demands for hydropower are represented by summing the streamflow and groundwater depletions (undepleted streamflow) available at the point of diversion and comparing that value to the lesser of the canal capacity or water right. Once the lesser of the undepleted stream, canal capacity, or water right has been established, the final step in calculating the hydropower demand is to integrate the surface water irrigation demands with the hydropower demands to ensure that the combination of demands does not exceed the canal capacity. If the combined demands exceed the canal capacity then the hydropower demands are further reduced to the canal capacity.

Two Sutherland demands scenarios were considered in order to "bookend" the demands that could be placed on either the North Platte or South Platte subbasin. The Keystone demand scenario is shown below. The Korty Demand Scenario reverses this process.

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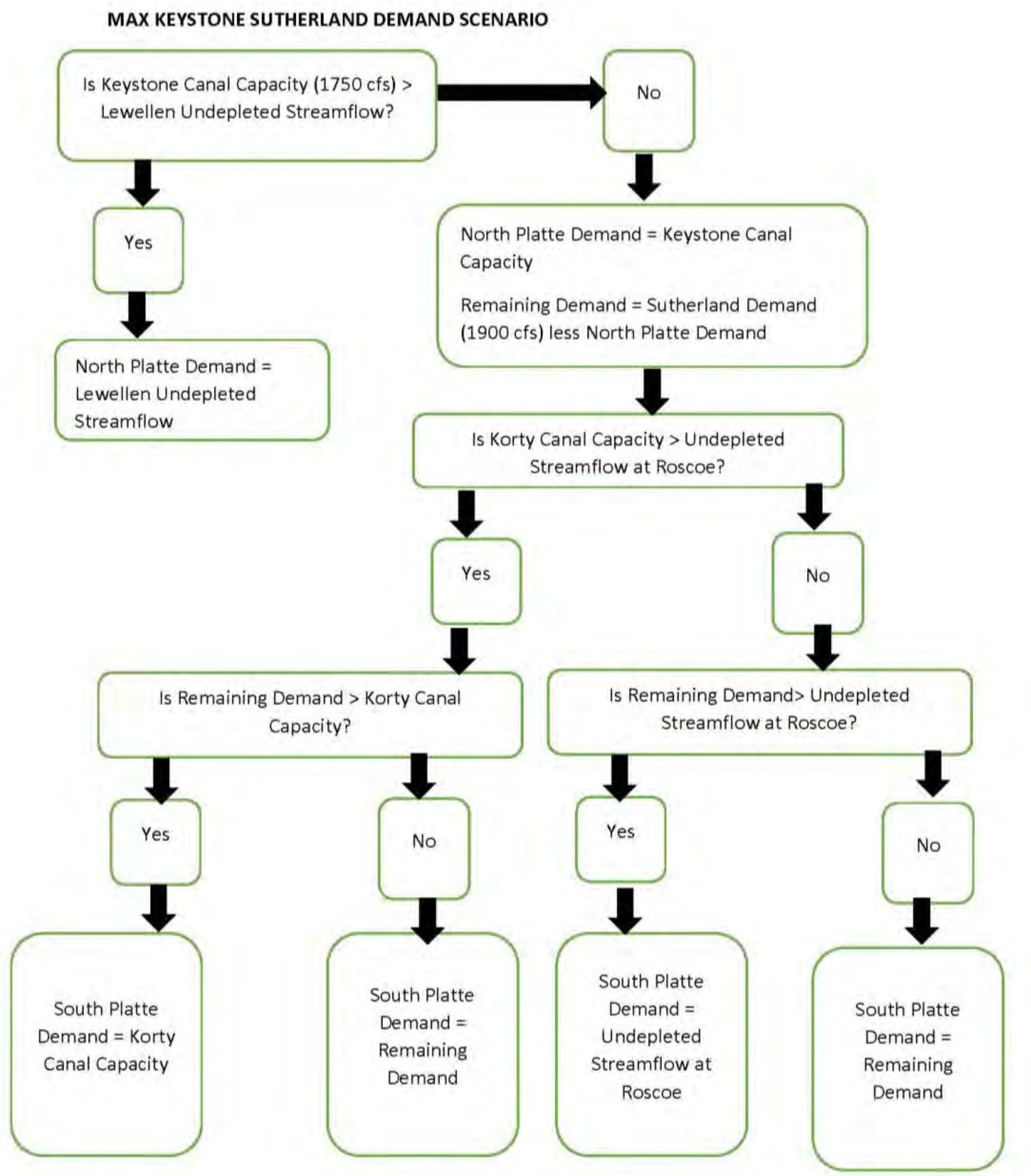
[6] This was done because in some cases the GWDP > GWCU which was counterintuitive. This occurs more frequently in the WWUM area than the COHYST area. This issue could be investigated further in future analysis.
[7] Reservoir seepage was not considered as it is assumed this seepage is not a "demand" that must be satisfied in order to convey water in this System. Additionally, this seepage water returns to the System as baseflow/groundwater.
[8] Lake McConaughy is assumed to operate to satisfy the CNPPID demand; therefore, the CNPPID downstream demand was applied to the North Platte Subbasin instead of applying the full Lake McConaughy hydropower demand.



Undepleted streamflow at Lewellen = Uncapped streamflow at Lewellen gage + GWDP above Lewellen gage.

Undepleted streamflow at Roscoe = [South Platte River at Paxton] + [Reach Gain Loss from Roscoe to North Platte] + [South Platte River GWDP].

Demands for Instream Flows – Instream flow demands are represented in a similar manner to that of hydropower demands. Similar to hydropower demands the daily undepleted streamflow is calculated at the instream flow location and capped at the daily instream flow appropriation value. If the daily undepleted streamflow does not meet the instream flow appropriation, then the daily instream flow demand is capped to the undepleted streamflow. The final adjustment is to subtract the volume of consumption associated with upstream groundwater development in place at the time the appropriation was granted (i.e., 1993) to create a final volume of instream flow demand.

Demands for Downstream Uses – Downstream demands for the overappropriated basin consist of a portion (based on the proportion of overappropriated basin water supplies relative to the water supplies at downstream locations) of downstream mainstem surface water and net surface water loss demands within the central and lower Platte River Basin plus a portion of the greater of instream flow or induced recharge appropriations located in the central and lower Platte River Basin. Downstream demands within the overappropriated basin vary based on location and the demands located downstream of that subbasin.

Tri-County Non-consumptive & Surface Water Demand Split: The Tri-County Canal serves both surface water and non-consumptive use demands. In some cases, the surface water demands are located upstream the non-consumptive use demands; therefore, it was necessary to consider the surface water and non-consumptive use demands separately for this canal. These demands were broken out as follow:

- **Full Tri-County Demand** = Minimum of [Canal losses above Brady + Max (surface water demands or CNPPID hydropower demand) OR Undepleted streamflow at Confluence of North Platte & South Platte Rivers]
- **Tri-County Non-consumptive Use Demand** = Full Tri-County Demand – Tri-County SW Demand – Tri-County Canal seepage

The Balance of Water Supplies and Water Demands

The evaluation methodology seeks to compare the water supplies and water demands for two periods throughout the year. The peak season (June – August) and non-peak season (September – May) are used to assess the balance in water supplies and water uses. These comparisons evaluate the average balance in water supplies and water demands over the most recent twenty-five year period of data (1988-2012) to assess how wet and dry cycles impact the balance in water supplies and water demands.

Meeting Date: 3/15/17

CPNRD Central Platte | North Platte Natural Resources District | South Platte Natural Resources District | Tri Basin Natural Resources District | Twin Platte Natural Resources District | Nebraska Department of Natural Resources

NOTE: Photographs/video may be captured during the meeting. These assets may be used by the NDNR, Districts, or HDR for the sole purpose of marketing, communication about the project and/or advertising. This may include, but is not limited to, printed and published materials on the NDNR, Districts, or HDR website.

Attended?	Name	Email Address	Affiliation	Primary or Alternate
		SPG Primary Members		
[signature]	Anderson, Tyrell	tyrell.anderson@retranches.com	North Platte NRD	Primary
	Barels, Brian	blbarel@nppd.com	Public Power & Irrigation District	Primary
[signature]	Bendfeldt, Jim	jcb1@fastmail.com	Central Platte NRD	Primary
Bob Busch	Busch, Bob	rnbusch@actcom.net	Surface Water User	Primary
[signature]	Dahlgren, Bob	Rdahlgren@fsbloomis.com	Municipality – Village of Bertrand	Primary
Kevin Derry	Derry, Kevin	derrykb@embarqmail.com	Agriculture	Primary
	Downey, Thomas	tdowney@downeydrilling.com	Ground Water User	Primary
Russ Edeal	Edeal, Russell	redeal@atcjet.net	Agriculture	Primary
	Eggleston, Judy	JudyEggleston@aol.com	Irrigation District	Primary
[signature]	Fehringer, Bernard	bfehringer@icloud.com bernie.fehringer@wheatbelt.com	Public Power	Primary
[signature]	Fisher, Dave	dpfisher@scottsbluff.net	Surface Water User	Primary
	Gatch, Richard	Rgatch1@unl.edu	Surface Water User	Primary
[signature]	Halligan, Bill	Bill.halligan@pwcbank.com	South Platte NRD Board	Primary
[signature]	Heath, Pat	pheath@gering.org	Municipality – City of Gering	Primary
[signature]	Henkel, Chuck	henkelchuck@yahoo.com	North Platte NRD Board	Primary
	Hoehn, Leo	Leo.hoehn@gmail.com	Groundwater Irrigator	Primary
[signature]	Koupal, Keith	keith.koupal@nebraska.gov	Environment/Wildlife	Primary
[signature]	Kramer, Erwin	backflow79@hotmail.com	Municipality – City of North Platte	Primary
	Kraus, Don	Dkraus@cnppid.com	Irrigation District	Primary
Galen Larson	Larson, Galen	glarson@pvbank.com	Financial	Primary
	Luchsinger, Tim	tluchsinger@grand-island.com	Municipality – City of Grand Island	Primary
[signature]	Nelson, Vernon	vernonjamesnelson@yahoo.com	Agriculture/Groundwater User	Primary
[signature]	Paulman, Roric	rpaulman@gpcom.net	Agriculture	Primary
Dennis Burnside	Pepplitsch, Joe	jpepp@cityoflex.com	Municipality – City of Lexington	Primary
Jack Revelle	Revelle, Jack	jrevelle@vistabeam.com	Ground Irrigator	Primary
Larry Reynolds	Reynolds, Larry	larryreynolds68@gmail.com	Tri-basin NRD Board	Primary
Jay Richeson	Richeson, Jay	jay@gothenburgirrigation.com	Municipality – Gothenburg	Primary
[signature]	Schaneman, Rodney	raschman@charter.net	Surface Water User	Primary
	Schilz, Dennis	dennisschilz@gmail.com	Irrigation District	Primary
	Sisk, Carson	Kimballwater@kimballne.org	Municipality – City of Kimball	Primary
Dennis Strauch	Strauch, Dennis	dennis@pathfinderirrigation.com	Irrigation District – Pathfinder Irrigation	Primary

Meeting Date:______________

[signature]	Strommen, Kendra	strommen@mmmlawoffice.com	Financial	Primary
[signature]	Wahlgren, Joe	wahlgrenfarms@gmail.com	Twin Platte NRD Board	Primary
		SPG Alternate Members		
	Albrecht, Frank	frank.albrecht@nebraska.gov	Environment/Wildlife	Alternate
	Andreas, Kent	kandreas@embarqmail.com	North Platte NRD Board	Alternate
	Burnside, Dennis	dburnside@cityoflex.com	Municipality – City of Lexington	Alternate
	Clymer, Bruce	bclymer@cityofgothenburg.org	Municipality – Gothenburg	Alternate
	Derry, Jared	Jared.derry@gmail.com	Agriculture	Alternate
	Downey, Brent	bdowney@downeydrilling.com	Ground Water User	Alternate
[signature]	Drain, Mike	mdrain@cnppid.com	Irrigation District	Alternate
	Henry, Chris	cnhenry144@hotmail.com	Central Platte NRD Board	Alternate
	Hock, Andrew	andrew.extremeag@gmail.com	Agriculture	Alternate
	Jameson, Rhodel		Agriculture/Groundwater User	Alternate
	Larson, Joe	joelarson21@gmail.com	Tri-basin NRD Board	Alternate
	Meismer, Jim	tpnrd1jimm@gmail.com	Twin Platte NRD Board	Alternate
	Meyer, Doug	dgmeyer@NPanhandle.net	Municipality – City of North Platte	Alternate
	Narjes, Kathy	rodekohr@hotmail.com	South Platte NRD Board	Alternate
	Ortiz, Daniel	DOrtiz@kimballne.org	Municipality – City of Kimball	Alternate
[signature]	Shafer, Jeff	jtshafe@nppd.com	Public Power & Irrigation	Alternate
	Smith, Ann	annck@cozadtel.net	Irrigation District	Alternate
	Snarr, Paul	psnarr@gering.org	Municipality – City of Gering	Alternate
	Zach, Randy		Public Power & Irrigation District	Alternate
		POAC Members		
	Adane, Zaibon		NDNR	
	Benson, Kathy	Kathy.Benson@nebraska.gov	NDNR	
[signature]	Berge, John	jberge@npnrd.org	North Platte NRD	
Barb Cross	Cross, Barb	bcross@npnrd.org	North Platte NRD	
	Crowe, Kayla	kayla.crowe@nebraska.gov	NDNR	
	Czaplewski, Mark	Mark@cpnred.org	Central Platte NRD	
Ann Dimmitt	Dimmitt, Ann	afisher@tpnrd.org	Twin Platte NRD	
	Eckles, Beth		NDNR	
Travis Glanz	Glanz, Travis	tglanz@spnrd.org	South Platte NRD	
[signature]	Horn, Rod	rlhorn@spnrd.org	South Platte NRD	
[signature]	Miller, Kent	komiller@tpnrd.org	Twin Platte NRD	
[signature]	Mintken, Jesse	mintken@cpnrd.org	Central Platte NRD	
[signature]	Mosier, Melissa	melissa.mosier@nebraska.gov	NDNR	
	Osborn, Colby		NDNR	
[signature]	Reisdorff, Ryan	rreisdorff@spnrd.org	South Platte NRD	
[signature]	Schellpeper, Jennifer	jennifer.schellpeper@nebraska.gov	NDNR	

Meeting Date:______________

CPNRD Central Platte Natural Resources District · North Platte Natural Resources District · South Platte Natural Resources District · Tri-Basin Natural Resources District · Twin Platte Natural Resources District · Nebraska Department of Natural Resources

	Shaw, Landon	lshaw@tpnrd.org	Twin Platte NRD
[illegible]	Thorburn, John	jthorburn@tribasinnrd.org	Tri-Basin NRD
[illegible]	Vogt, Lyndon	vogt@cpnrd.org	Central Platte NRD
[illegible]	Winter, Jessie	jessie.winter@nebraska.gov	NDNR
	Woodward, Duane	woodward@cpnrd.org	Central Platte NRD
[illegible]	Zayac, Tracy	Tzayac@npnrd.org	North Platte NRD
	Zoller, Amy	amy.zoller@nebraska.gov	NDNR
Members of the Public			
Jerry F. Kenny	Kenny, Jerry	kennyj@headwaterscorp.com	PRRIP
Marc Groff	~~[illegible]~~ Groff, Marc	MGROFF@FLATWATERGROUP.COM	TFG
	Wilcox, Dustin	dwilcox@NRDNET.ORG	NARD
	Jim Meisner	TPNRD	
	Elizabeth Miller	emiller@npnrd.org	
	Frank Albrecht	NARC	
	JACOB FRITTON	JFRITTON@TNC.ORG	The Nature Conservancy
	Thad Kuntz	thad@ari-water.com	Adaptive Resources Inc

Agenda

Project:	Upper Platte River Basin Water Management Plan – Single Planning Group
Subject:	Meeting #6
Date:	Wednesday, May 17, 2017
Location:	Holiday Inn Express & Suites, North Platte, NE

Agenda:

I. Administration
   a. Today's meeting will offer a working lunch
   b. This is an Open Meeting
   c. March Meeting Recap
      i. Meeting minutes
      ii. Key discussion / decisions
      iii. Follow-up items
   d. Review of Decision-Making Process
II. Economics of Water Users
   a. Review Input from March
   b. Water Use Vulnerability Discussion
   c. Refinement of Economic Viability (Goals and Objectives)
III. Continued Work on Definitions for Additional Elements
   a. Social and Environmental Health
   b. Safety
   c. Welfare
IV. Next Steps
V. Public Comment

Next Meeting: July 19, 2017

Upper Platte River Basin-Wide Plan – Second Increment

SPG Meeting #6 - Meeting Minutes

Date: Wednesday, May 17, 2017 from 10:30 a.m. to 3:00 p.m.
Location: Holiday Inn Express & Suites, North Platte, NE

Agenda:

I. Administration
   a. Today's meeting will offer a working lunch
   b. This is an Open Meeting
   c. March Meeting Recap
      i. Meeting minutes
      ii. Key discussion / decisions
      iii. Follow-up items
   d. Review of Decision-Making Process
II. Economics of Water Users
   a. Review Input from March
   b. Water Use Vulnerability Discussion
   c. Refinement of Economic Viability (Goals and Objectives)
III. Continued Work on Definitions for Additional Elements
   a. Social and Environmental Health
   b. Safety
   c. Welfare
IV. Next Steps
V. Public Comment

Attendance:

A copy of the attendance sheet is attached at the end of this document.

Minutes

These minutes follow a PowerPoint presentation that can be found online: http://upbwp.nebraska.gov/

I. Administration – Stephanie White

a. Today's meeting will offer a working lunch
b. This is an Open Meeting
c. March Meeting Recap
    i. Meeting minutes
    ii. Key discussion / decisions
    iii. Follow-up items
d. Review of Decision-Making Process – The goal is always consensus
e. J. Engel reviewed the handout of supply and demand and groundwater use depletion estimates. Clarified that the Supply and Demand Balance is simply a comparison of total supplies and total demands in the basin. Shortages when comparing total supply vs. demand are only partially attributable to groundwater use depletions, as the deficit between basin supply and demand is greater than total estimated groundwater use depletions.

II. Economics of Water Users – Stephanie White

a. Review Input from March – see summary on slides
b. Water Use Vulnerability Discussion
    i. Under what water supply condition has water been a limiting factor to your economic productivity?
        1. Galen Larson (North Platte NRD; Platte Valley Bank of Scottsbluff)
            a. $130 million in agriculture loans/debt (Scottsbluff)
            b. There are no other true makers of new money outside of agriculture (hospital is only other main employment center)
            c. Scottsbluff county has had discussion to bring in new employers, but they all need water
            d. Suggestions: good winter storage and timely rain; timely hail storm (before crops are planted or after crops are mature)
        2. Dave Fisher (North Platte NRD; surface water user)
            a. Representing next generation
            b. Treat water as a reusable resource
            c. Recognize we are fully appropriated
            d. Need storage to maintain river flows; deregulate and let the land be the storage
            e. People can irrigate when and where they want (and no cost for storage)
            f. Work with Wyoming and Colorado to save water if we don't need it so it doesn't flow out of the state
            g. Lake McConaughy is limited for storage.
            h. Provided handout to SPG regarding need for storage.
        3. Bill Halligan (South Platte NRD)

  a. The allocation system has worked well (our economic effect was when we lost the water table and were sucking air from wells)
  b. Only 8% of irrigated acres are on river, and they have not experienced a draw down in water tables, but we're under allocations just because of government regulations
  c. Suggestion: Only allocate during dry years; geographic equity of regulations; recharge must last 40 years
  d. No major recharge event in the bulk of our wells
  e. The crop rotation is changing for allocation (dry beans and alfalfa when there is no water)
4. Jack Revelle (Groundwater user from Pumpkin Creek)
   a. Allocations have brought changes to farming practices (currently on a 12 inch allocation):
      i. No till, drip irrigation system to conserve water, less consumptive use crops (peas, dry beans, wheat in spring); retired some irrigated acres with buyout; to compensate and stay viable, found way to cut out or reduce water usage
      ii. Suggestions: NRDs should use flow meters to see where water usage is and how much. Also, put in measurement devices in the field to know how much water is in the field so it doesn't get watered if it doesn't need it; technology with crop moisture sensors/metering allow better water management.
      iii. Hwy 71 is seeing high flow and farm has seen a good source of corn stalks by using cattle – cattle has helped with the economics (diversity of revenue)
      iv. Success on Pumpkin Creek – some flow has returned. Dam on Pumpkin Creek is full for the first time in a long time.
      v. Western Sugar Cooperative a major user
5. Jay Richeson (Gothenburg Irrigation & Well Service)
   a. Fortunate to have plenty of water
   b. Economic development is suffering – the City can't have a large company (large water user) come in because of water supply limitations.
   c. The City does not allocate water and farmers are good about not overusing it
   d. Suggestion: the City can't recruit any industry unless it has water - fully appropriated designation would provide more flexibility to find water.
6. Bob Dahlgren (Village of Bertrand, Bank of Bertrand)

   a. Should water be for who is in the city now or for new businesses?
   b. His farm has 36 inches of water because of McConaughy
   c. Suggestion: They get what we need, but they need storage and it needs to be in the west part of the state so the western stakeholders can have water since they can't get it from McConaughy.
7. Mike Drain (Central Nebraska Public Power and Irrigation District)
   a. CNPPID's primary purpose is to provide water to its irrigators
   b. For financial reasons, hydro power is a necessity; we maintain a significant system, a large dam, a large canal, and a lot of regulatory requirements
   c. Prior to 20 years ago, you would have seen 75% of revenue from hydro power sales
   d. Annual budget covering operations and maintenance is $10-12 million – in a wet year like the last year, we delivered irrigation water and produced electricity with the water that runs down the river; that allows us to have the money in the years we don't have that water
   e. Hydro power revenue over last 20 years averages $9 million – but varies greatly: some years like '97-'99 revenues are around $12M, but also years like 2003/4/5/6, producing only $3 million a year. Carryover from wet year revenues is essential.
   f. If system operated for irrigation deliveries only, hydro power generation would be around $7M (similar to 2001 operations). Discretionary hydro power generation is critical to close revenue gap.
   g. Irrigation revenues are fixed – annual per acre cost regardless of water needed or delivered. Charge per acre is around $36 an acre (covers water and O&M). Approximately 80% of acres served are co-mingled (access to surface and ground water)
   h. 12 inches is what we try to give irrigators; but some dry years we had to reduce the allocation. Reduced delivery means less hydro power generation and less revenue.
   i. Suggestions: More storage will help; we have to generate our own revenue (no taxing authority)
   j. We'll prioritize to save the water in McConaughy for the farmers to irrigate over hydro generation in drought years,
   k. Sell much of our electricity generated to Kansas because they have a renewable portfolio standard and pay a higher

price for hydro power as part of that portfolio. Currently in a 10 year contract;

l. Trying to be more efficient; land and irrigation practices, as well as hydro facilities and system management.

8. Dennis Strauch (Surface water irrigator, Pathfinder)
    a. Live and die by snow pack from Colorado and Wyoming
    b. Annual need is about 15-18 inches and majority of water comes from federal reservoirs from Wyoming
    c. 7 of the last 15 years have been water short years and therefore delivered only 8-12 inches.
    d. 1/3 of the land is co-mingled and are restricted to an allocation; our producers in those water short years changed crop mix, went idle
    e. No economic impact on the district as long as the producers remain viable
    f. Operations have changed since 2002 – farmers are consuming more of diversion to less returns; impacts downstream
    g. Since there is only so much storage, farmers have become more efficient; reduces spills and losses that can be stored so then we can increase the supply overall
    h. Approximately 70% of land has pivots - operating at 85% of what we used to in terms of diversion
    i. Suggestion: Basin support in getting Congressional approval/BOR red tape to allow facilities to be used for intentional recharge.
9. Brian Barels (NPPD)
    a. Looks at the snow pack west of Ogallala; also monitor the snow pack and reservoir storage in Wyoming; 8-9 months of non-irrigation season key for supply as well as hydro power generation
    b. Irrigation – 80,000 acres; own operate 3 irrigation canals; provide storage to 3 additional canals. Allocated storage amount every year to supply water to the canals; that is not a total supply – 80% of water from canals is natural; 20% from our storage capabilities
        i. In early 2000s, ran out of storage for the six canals; negative economic impact to customers (80,000 acres)
    c. Hydro Power – Major facility is in North Platte and smaller facility in Kearney – can take water from the South and North Platte Rivers to feed hydro system
    d. Cooling of power plant at Gentleman Station – Use McConaughy and Sutherland Reservoir

i. Use stored water to cool it before going to Sutherland Reservoir for water
ii. If there is a shortage, there are agreements with irrigators near Sutherland to pay irrigators to not use water so the power plant can be cooled via water pumped from adjacent wells
iii. Power from hydro is about 50% of energy generation (includes Kingsley hydro generation)

10. Tyrell Anderson (Lewellen Ranch, Turner Corporation)
    a. 84K acres, produce hay/alfalfa for 4000 head of bison, 5 year allocation since 2009 and so far it's been okay
    b. If allocation was restricted farther it would be detrimental
    c. Suggestion: Be more inclusive and less in a silo; focus on conservation – be good stewards of the resources
11. Keith Koupal (Nebraska Game and Parks)
    a. People need to want to live here and be able to afford to live here.
    b. Recreational and ecological: Recreation largely reservoir based - if water is low in McConaughy, there aren't as many visitors and they don't spend money in the state; if fishing and hunting is hot then we'll see more revenue; people want to live by water so that might drive growth in population and loans, building, buying, etc. ; ecological balance has a reliance on water
    c. Natural hydrograph is important to fish and wildlife
12. Bernie Fehringer (Power District in western Nebraska and groundwater irrigator)
    a. Allocation is 13 inches; on rainy years, the water could be rolled over
    b. For a 125 acre pivot, 600 gpm and 51 days of pumping and they can't use all of 13-in allocation
    c. The allocation has not affected the farm and hasn't reduced irrigation sales much; largely because farmers have changed cropping patterns due to limited amount of water
    d. Success: planted hundreds of trees to bring in hunters to supplement revenue from dry crop years
    e. Allocation started in 2009 (currently third allocation period); if they have a dry year, there won't be much impact due to adaptation of producers.
13. Kevin Derry (South Platte NRD)
    a. 13 inch allocation has required short season cropping - went from 108 to 103 day corn because of water restrictions, so yield has gone down

   b. Cost of hail insurance limits the amount and types of crops
   c. Rotation is expensive if you have a crop that can't withstand the hail and can't be insured
14. Chris Holly (North Platte Water Department)
   a. Plenty of water and a license to pump 4 billion gallons a year; on a dry year, up to 3 billion is used, but normally around 2.5 billion
   b. In the business of selling water – only pump what is sold
   c. No quality issues
   d. Dispersed wells – not a concentrated well field. The problem is finding land to place a new well; there is no variability in water quality during droughts
   e. Some wells are about 100 feet, but most are 300+ feet
   f. Question: If there is a license to pump 4 billion gallons but now only pumping 2 billion, will the license amount change? And then what happens to that additional 2 billion gallons of water?
15. Dennis Burnside (City of Lexington)
   a. Attractive to new industries; new and existing industries rely on water; if that's reduced then it would effect a lot of other areas of life quality
   b. Aren't experiencing limitations since it is a municipality
16. Bob Busch (surface water user)
   a. In 2002, the snow melt all went into the ground and there was no runoff water; and there was a tight limit in terms of allocation. Regarding the weather forecasts: when you see it you believe it
   b. New storage is challenging – Deer Creek failed; people looking at Glendo storage but likely won't happen.
   c. Endangered Species Act requires water – balance of human and environmental needs, feel we have done our share
17. Jim Benfeldt (Central Platte NRD; retired farmer and cattle feeder)
   a. Plentiful supply of water in the 45 years of production
   b. Never been short of water or have had to experience what the upstream farmers had to deal with
   c. Technology has been key: flood irrigation to center pivots, drip, water management, automated water management
   d. There will be a conservation/sustainability impact
   e. Son uses technology for water management because of college education – pivots is a labor saving and advent of better pump systems and water consumption measurement technology – right thing to do, but economics also play a role.

18. Rod Horn (South Platte NRD)
    a. SPNRD Irrigates 1.5% of acres in state
    b. 96% of water consumption in district is ag
    c. In early 2000s, first district to look at moratorium at Lodgepole Creek
    d. Referenced 2010 UNL study (Compton) on economic impact of allocations in their district; found modest impacts
19. Barb Cross (North Platte NRD)
    a. From 2008-2016, District spent $5.6 million (doesn't include cost share portion) on groundwater management activities and worked 87,000 hours at a labor cost of $2.4 million
    b. Initial focus was to retire irrigated acres – it costs a lot (LB962) to meet obligations; shift now to efficiency improvements
    c. Suggestion: Educate on water efficiencies; if there is no money to spend on new technology, only option is to reduce allocation; but a 6-inch allocation will get rid of a ton of crops and it effects every piece of the economy; concentrate on efficiency to reduce consumptive use;
20. Leo Hoehn (North Platte NRD, Pumpkin Creek GW user)
    a. Most years, short of water but son is a big supporter of technology
    b. In 1989, the ranch had 1,700 acres of water rights from Pumpkin Creek – today creek is dry
    c. Surrendered 1,000 acres of irrigated land
    d. Revenue stream is different now from 20 years ago
    e. NRD programs are valuable and try to take advantage of them
    f. Education programs are important
    g. Purchased in 1989, creek was dry by 1994. Last two years flows again in creek.
21. Rodney Schaneman (Surface water user)
    a. In 2002, irrigation was shut off at the farm
    b. Water is very important and you can't pump wherever you want; why are some over appropriated when the rest of the state downstream can pump however they want
    c. Geographic equity – be fair across the entire basin
22. Carson Sisk (City of Kimball)
    a. Haven't experienced shortage of water; no restrictions but can if need to
    b. Produce and distribute water to about 2,500 users, down from peak population of 7,000

   c. If groundwater levels got low enough and wells start sucking air then there can be some economic issues
   d. Current inventory: Three wells a mile apart and all come into town on same pipeline
   e. One big economic concern: decrease in population (7,000 to 2,500); it's the same amount for O&M, but fewer people paying bills so it's harder to maintain – and what about if there needs to be infrastructure improvements (no reserves for upgrades)

23. Joe Wahlgren (Twin Platte NRD and producer)
   a. Never been short of water – 50 ground wells and they are mixed with a series of supply canals that provide recharge and static water levels
   b. Have had to make changes to become more efficient – 50% of producers in area have left because they never invested in items that were attractive to the next generation
   c. Don't do things the same old way; give parameters and they'll change to what can be managed
   d. Suggestion: Farmers need to change (technology, efficiency, management, rules, legislation) for betterment of the next generation

24. Kent Miller (Twin Platte NRD)
   a. LB962 passed and moratorium set in – the main direction of District was based on economics – protect what we have today
   b. Stakeholders have said to maintain what they have and recognize that legislation enforcement is expensive for the agency and expensive to the irrigator
   c. Board's focus has been to find offset water to maintain the acres today – it is not cheap for NRD, but isn't as expensive for irrigators
   d. To get offset water, the NRD increase property tax (highest in state) and occupation tax (only NRD to have one in state – chosen over regulation) but it's working
   e. No requirement on meters, but most of the Twin Platte NRD sits on sandy soil; run off goes back into the land – irrigators rarely pump more than they need and if so it isn't a big deal because of connection with aquifer

25. Pat Heath (City of Gering)
   a. Economic development – we'll take whatever we can get
   b. No supply issues and have never been short
   c. Have a transfer permit to protect surface water users
   d. $9.5 million spent for arsenic and uranium regulations; $4.5 million for waste water treatment plant

   e. Reuse wastewater – cost for some areas were not too good; took a beating from public on use of waste water
   f. $1.5 million for O&M of water system; proactive on water conservation – always promote wise water use (someone else can benefit from water that we aren't wasting/using because we are conserving) – never had mandatory no-water ordinances, but encouraged it on a voluntary basis

26. Russell Edeal (Loomis)
    a. Irrigator, dad in SCS, Grandpa SCS board
    b. Win-win mentality observed is a shift for planning group from 1st increment
27. Larry Reynolds – nothing to add
28. John Thorburn (Tri Basin NRD)
    a. Minimize regulations but take an approach that enables the current irrigation economy to thrive
    b. Diversion of high flows to offset impacts to surface water, needed to recharge groundwater aquifer
    c. Suggestion: work with and educate farmers on efficiencies and making progress towards that, but it's long term (multi-generational)
29. Lyndon Vogt
    a. Regulatory expense and cost of ongoing regulation versus a more voluntary management program
    b. Producers and NRDs have changed due to shortages
    c. Make a change – put water back to the river without negatively impacting producers – no one below McConaughy is having water issues (only west) – so what management system can change to solve that?
30. Vernon Nelson (Tri Basin NRD, Ground and Surface Water User)
    a. No water problem since the farmers left gravity irrigation; water supply never a problem in his area largely due to technology advances
    b. Suggestions: A lot of feed lots and nitrates in water – grow corn using nitrogen (soil probes, timing, nutrients at the top of soil, limit pivots) – technology has been great – pivot on every farm and a swing arm (laying pipe in corner lots is a waste) – son and three grandkids working for him – it's about the next generation!
31. Jennifer Schellpeper (State of Nebraska Natural Resources Department)
    a. Goal is to help water users feel less vulnerable about water use
    b. NeDNR has to follow the law and has to make sure everyone else is, too

c. Themes from today: water supply variation across basin
d. NeDNR cost share with NRDs (50/50 or 60/40 split usually), balance to follow law and see where dollars are being spent

32. Roric Paulman (Producer)
    a. Technology and collaboration is key – what technologies and processes exist to be more efficient, use less water, store for dry years
    b. In 1986, it cost $80K for property and occupancy tax and now $700K
    c. We've established the value of water – we are all in this pretty deep;
    d. Suggestion: TAPS (testing agriculture performance systems) through UNL – how can they take concepts and (taps.unl.edu) implement them; a simulated farm making all of the decisions and it's about ROI and about nutrient and water management (not about yield)

c. Refinement of Economic Viability (Goals and Objectives) (will discuss at next meeting)

III. Continued Work on Definitions for Additional Elements (will discuss at future meetings)
   a. Social and Environmental Health
   b. Safety
   c. Welfare

IV. Next Steps
   a. Next meeting: July 19, 2017

V. Public Comment
   a. No public comments

Meeting Date: 5/17/17

NOTE: Photographs/video may be captured during the meeting. These assets may be used by the NDNR, Districts, or HDR for the sole purpose of marketing, communication about the project and/or advertising. This may include, but is not limited to, printed and published materials on the NDNR, Districts, or HDR website.				
Attended?	**Name**	**Email Address**	**Affiliation**	**Primary or Alternate**
		SPG Primary Members		
TA	Anderson, Tyrell	tyrell.anderson@retranches.com	North Platte NRD	Primary
BLB	Barels, Brian	blbarel@nppd.com	Public Power & Irrigation District	Primary
JWB	Bendfeldt, Jim	jcb1@fastmail.com	Central Platte NRD	Primary
Bob	Busch, Bob	rnbusch@actcom.net	Surface Water User	Primary
R Dahlgren	Dahlgren, Bob	Rdahlgren@fsbloomis.com	Municipality – Village of Bertrand	Primary
	Derry, Kevin	derrykb@embarqmail.com	Agriculture	Primary
	Downey, Thomas	tdowney@downeydrilling.com	Ground Water User	Primary
RDE	Edeal, Russell	redeal@atcjet.net	Agriculture	Primary
	Eggleston, Judy	JudyEggleston@aol.com	Irrigation District	Primary
BJF	Fehringer, Bernard	bfehringer@icloud.com bernie.fehringer@wheatbelt.com	Public Power	Primary
DF	Fisher, Dave	dpfisher@scottsbluff.net	Surface Water User	Primary
	Gatch, Richard	Rgatch1@unl.edu	Surface Water User	Primary
BJH	Halligan, Bill	Bill.halligan@pwcbank.com	South Platte NRD Board	Primary
PH	Heath, Pat	pheath@gering.org	Municipality – City of Gering	Primary
JH	Henkel, Chuck	henkelchuck@yahoo.com	North Platte NRD Board	Primary
	Hoehn, Leo	Leo.hoehn@gmail.com	Groundwater Irrigator	Primary
KDK	Koupal, Keith	keith.koupal@nebraska.gov	Environment/Wildlife	Primary
CWA	Kramer, Erwin	backflow79@hotmail.com	Municipality – City of North Platte	Primary
	Kraus, Don	Dkraus@cnppid.com	Irrigation District	Primary
GL	Larson, Galen	glarson@pvbank.com	Financial	Primary
	Luchsinger, Tim	tluchsinger@grand-island.com	Municipality – City of Grand Island	Primary
VJN	Nelson, Vernon	vernonjamesnelson@yahoo.com	Agriculture/Groundwater User	Primary
RP	Paulman, Roric	rpaulman@gpcom.net	Agriculture	Primary
DB	Pepplitsch, Joe	jpepp@cityoflex.com (Dennis Burnside)	Municipality – City of Lexington	Primary
JDR	Revelle, Jack	jrevelle@vistabeam.com	Ground Irrigator	Primary
LR	Reynolds, Larry	larryreynolds68@gmail.com	Tri-basin NRD Board	Primary
J Richeson	Richeson, Jay	jay@gothenburgirrigation.com	Municipality – Gothenburg	Primary
Rodney A. Schaneman	Schaneman, Rodney	raschman@charter.net	Surface Water User	Primary
	Schilz, Dennis	dennisschilz@gmail.com	Irrigation District	Primary
C Sisk	Sisk, Carson	Kimballwater@kimballne.org	Municipality – City of Kimball	Primary
X	Strauch, Dennis	dennis@pathfinderirrigation.com	Irrigation District – Pathfinder Irrigation	Primary

Meeting Date: 5/17/17

	Strommen, Kendra	strommen@mmmlawoffice.com	Financial	Primary
	Wahlgren, Joe	wahlgrenfarms@gmail.com	Twin Platte NRD Board	Primary
	SPG Alternate Members			
	Albrecht, Frank	frank.albrecht@nebraska.gov	Environment/Wildlife	Alternate
	Andreas, Kent	kandreas@embarqmail.com	North Platte NRD Board	Alternate
	Burnside, Dennis	dburnside@cityoflex.com	Municipality – City of Lexington	Alternate
	Clymer, Bruce	bclymer@cityofgothenburg.org	Municipality – Gothenburg	Alternate
	Derry, Jared	Jared.derry@gmail.com	Agriculture	Alternate
	Downey, Brent	bdowney@downeydrilling.com	Ground Water User	Alternate
	Drain, Mike	mdrain@cnppid.com	Irrigation District	Alternate
	Henry, Chris	cnhenry144@hotmail.com	Central Platte NRD Board	Alternate
	Hock, Andrew	andrew.extremeag@gmail.com	Agriculture	Alternate
	Holley, Chris		Municipality – North Platte	Alternate
	Jameson, Rhodel		Agriculture/Groundwater User	Alternate
	Larson, Joe	joelarson21@gmail.com	Tri-basin NRD Board	Alternate
	Meismer, Jim	tpnrd1jimm@gmail.com	Twin Platte NRD Board	Alternate
	Meyer, Doug	dgmeyer@NPanhandle.net	Municipality – City of North Platte	Alternate
	Narjes, Kathy	rodekohr@hotmail.com	South Platte NRD Board	Alternate
	Ortiz, Daniel	DOrtiz@kimballne.org	Municipality – City of Kimball	Alternate
JS	Shafer, Jeff	jtshafe@nppd.com	Public Power & Irrigation	Alternate
	Smith, Ann	annck@cozadtel.net	Irrigation District	Alternate
	Snarr, Paul	psnarr@gering.org	Municipality – City of Gering	Alternate
	Zach, Randy		Public Power & Irrigation District	Alternate
	POAC Members			
	Adane, Zaibon		NDNR	
	Benson, Kathy	Kathy.Benson@nebraska.gov	NDNR	
	Berge, John	jberge@npnrd.org	North Platte NRD	
BC	Cross, Barb	bcross@npnrd.org	North Platte NRD	
	Crowe, Kayla	kayla.crowe@nebraska.gov	NDNR	
	Czaplewski, Mark	Mark@cpnred.org	Central Platte NRD	
AD	Dimmitt, Ann	afisher@tpnrd.org	Twin Platte NRD	
	Eckles, Beth		NDNR	
	Glanz, Travis	tglanz@spnrd.org	South Platte NRD	
	Hopkins, Kyle Ann		North Platte NRD	
	Horn, Rod	rlhorn@spnrd.org	South Platte NRD	
	Miller, Kent	komiller@tpnrd.org	Twin Platte NRD	
	Mintken, Jesse	mintken@cpnrd.org	Central Platte NRD	
	Mosier, Melissa	melissa.mosier@nebraska.gov	NDNR	

Meeting Date: 5/17/17

CPNRD · NORTH PLATTE Natural Resources District · SOUTH PLATTE Natural Resources District · Tri-Basin Natural Resources District · TWIN PLATTE Natural Resources District · NEBRASKA DEPT. OF NATURAL RESOURCES

	Osborn, Colby		NDNR
RR	Reisdorff, Ryan	rreisdorff@spnrd.org	South Platte NRD
JS	Schellpeper, Jennifer	jennifer.schellpeper@nebraska.gov	NDNR
JT	Thorburn, John	jthorburn@tribasinnrd.org	Tri-Basin NRD
LV	Vogt, Lyndon	vogt@cpnrd.org	Central Platte NRD
JW	Winter, Jessie	jessie.winter@nebraska.gov	NDNR
	Woodward, Duane	woodward@cpnrd.org	Central Platte NRD
TZ	Zayac, Tracy	Tzayac@npnrd.org	North Platte NRD
	Zoller, Amy	amy.zoller@nebraska.gov	NDNR
Members of the Public			
JE	Engel, John		HDR
JFK	Kenny, Jerry	Kennyj@headwaterscorp.com	PRRIP
ML	Matt Lynch	MLYNCH@DowneDrilling.Com	
	Jim Meismen		Twin Platte NRD
AW	Ann Williams	HDR	"
CW	CARRIE WIESE	carrie.wiese@nebraska.gov	NeDNR

Agenda

Project:	Upper Platte River Basin Water Management Plan – Single Planning Group
Subject:	Meeting #7
Date:	Wednesday, July 19, 2017 from 10:30 a.m. to 2:00 p.m.
Location:	Holiday Inn Express & Suites, North Platte, NE

Agenda:

I. Administration
   1. Today's meeting will offer a working lunch
   2. This is an Open Meeting
   3. Review of Decision-Making Process
   4. May Meeting Recap
      i. Meeting minutes
      ii. Key discussion / decisions
      iii. Follow-up items

II. Review NRD/DNR responsibilities for Municipal and Industrial Users

III. Basin Values (from May Discussion)

IV. Potential New Goals Discussion

V. Potential New Objectives for Goal 3 Discussion

VI. Continued Work on Definitions for Additional Elements
   1. Social and Environmental Health
   2. Safety
   3. Welfare

VII. Next Steps

VIII. Public Comment

Next Meeting: September 20, 2017

Meeting Minutes

Project:	Upper Platte River Basin Water Management Plan – Single Planning Group
Subject:	Meeting #7
Date:	Wednesday, July 19, 2017 from 10:30 a.m. to 2:00 p.m.
Location:	Holiday Inn Express & Suites, North Platte, NE

Agenda:

I. Administration (Stephanie White)
  1. Today's meeting will offer a working lunch
  2. This is an Open Meeting
  3. Review of Decision-Making Process
     - The goal is always consensus
  4. May Meeting Recap
     - Covered thoroughly in Basin Value discussion (III)

II. Review NRD/NeDNR responsibilities for Municipal and Industrial Users (Jennifer Schellpeper)
  1. Nebraska Revised Statute 46-740 – Describes options and authorities related to municipal & commercial/industrial water uses
     - Through December 31, 2025, municipalities and industries are exempted from water allocation limitations
       - In order to qualify for the exemption through 2025, a conservation plan could be required by an NRD's IMP
       - Right now the only NRD that has that in effect is the SPNRD
     - Exemption does not apply to increases in industrial consumptive uses that are greater than 25 million gallons/year
       - Offsets for these uses may be the responsibility of the industry
     - Statute based on reductions in consumptive use associated with municipal growth
       - Any consumptive use reduction associated with municipal growth shall accrue to the net benefit to the NRD
       - Any reduction in consumptive use of water associated with new non-municipal industrial or commercial uses of <25 million gallons accrues to the benefit of the NRD
       - IMP controls protect existing users (not injured by any new uses)
       - IMP controls shall ensure compliance with state & federal laws

        - PRRIP – mitigation for new or expanded uses after July 1, 1997
  - In 2026 – when exemption ends for allocation, then allocations can be re-set for municipalities
  - Stakeholder question: "Have you (NRD) tracked any new uses, referring to the newer expanded uses since '97"
    - NRDs monitors new uses (municipal, industrial, agricultural) through meters or other methods and reports that information as required in the annual IMP/basin reports.
  - Noted that M&I usage in the basin is a small part of the number for overall use.
  - Moratoriums on new uses were implemented at different times in basin NRDs (some moratoriums related to aquifer declines and well interference unrelated to surface water depletive effects) so there are additional agricultural uses post-1997 that occurred prior to moratoriums and regulation. Each NRD is responsible for mitigating the post-1997 uses within its boundaries

III. Basin Values (from May Discussion)

- Several common themes kept coming up
  - Generational stewardship
  - Maintaining the good life
  - There is a space for all; willingness and interest in working together, a shared burden
  - Looking beyond our own fences
  - Municipality contributions – others can make good use of water we save
  - Long culture of adapting & changing with the times
  - "Putting water back to the river without causing economic harm"
  - "We are making a difference! Restored flow to Pumpkin Creek"
- Have we missed any big themes or guiding principles that we should use to help us stay true to our goal?
  - Stakeholder comment – storage is critical piece.
  - Noted that storage is included in that matrix of issues to be addressed in 2nd increment – but may not be appropriate in the bigger picture mission statement.

IV. Potential New Goals Discussion

- To reflect the themes from the May meeting, some possible new goals have been drafted to review
- Revised goals and objectives

1. Potential new goal #1 – *Partner with municipalities and industries to maximize conservation and water use efficiency*

    - *Establish community education programs; track effectiveness annually*
    - *Establish standardized economic development policies regarding new water-intensive business*
- Feedback on first potential new goal
    - Typical municipal rate structure noted – potential disincentive for conservation.
    - Industrial component noted.
    - Suggestion to eliminate two bullets and keep the outline of 46-470 from state statutes
    - Differences in approaches taken to conservation and efficiency noted and suggestion that not all water is treated equally or used equally throughout the basin. Locally determined by NRDs and users within its boundaries
    - Ties into the value of stewardship

Consensus on potential new goal – group agreed to move the goal forward in further consideration of plan and bring elements of 46-470 forward as objectives

2. Potential new goal #2 – *Work to maintain the economic viability of users within the basin*
    - *Increase sustainability under cyclical supply conditions*
        - *Identify storage opportunities*
        - *Conjunctive management*
        - *Continue to encourage diversity in revenue streams (hunting, cattle, alternative crops, hydro, etc.)*
    - *Pursue regulatory modifications (local, state, Federal)*
    - *Identify strategies to establish geographic equity for water users above and below Lake McConaughy*
    - *Continued support of advancing technological practices; efficiency of use*
- Feedback on second potential new goal
    - Platte River System has seen many changes, these list items (objectives) should reflect that.
    - Efficiency has direct effects on return flows that need to be understood.
    - Discussion on efficiencies and return flows:
        - Need to understand the roles of return flows as water supplies, effects of efficiency on returns, and develop plans as appropriate. Suggestion to add as its own objective under this goal
        - System above McConaughy is at risk as it depends on return flows – impacts everything downstream.
        - Focus on using water as a reusable resource (returns to be used as downstream supplies, for example), rather than shipping away. Use it in multiple ways"
    - Broaden reference to revenue stream diversity to include hunting, fishing, etc as they are industries getting a more diversified revenue across the state

- NRDs are in different places as far as planning and management and the geographic differences across basins make mandating equality difficult.
- Some differences are solely based on geographical (and hydrological) circumstances.
- Recommendation to eliminate reference to geographical differences (eliminate reference to "above and below Lake McConaughy")
- Stakeholder comment that if western NRDs are under allocation and send water downstream (negatively impacting the economy) and similar management actions are not taken downstream it doesn't seem fair.
- Discussion and concerns that if storage is overemphasized increase sustainability under cyclical conditions, we need to recognize limitations:
  - Prospect of building new large surface water storage is unlikely due to prior appropriations and environmental issues.
  - Comment that drought and flood conditions need to be considered in a comprehensive manner. Storage could be dry half the time – may not be politically acceptable, but need the extra storage to capture excess flows
  - Storage will require excess flows and it is hard to depend on the availability of excess flows. We need to take advantage of opportunities to use/direct excess flow when it is available. Excess flow is not available every year, but we should be putting it into storage when it is available so that we have access to it in dry years.
  - The impact of surface water irrigation efficiencies on return flows needs to be considered in our discussions about storage. Efficiencies in surface water systems limit supplies that downstream users have come to rely upon. How might we mitigate the impact of efficiencies on return flows?
  - Existing storage could be improved by restoring lost storage to siltation in addition to new surface water storage.
- Stakeholder Comment that the word *geographic* in the objective is in the wrong place – relates to creating water efficiency under differing geographic conditions. The nature of water cannot be changed
- Recommendation to delete 'geographic equity'
- Recommendation to incorporate tracking equity, so amend the objective but don't remove entirely
  - Discussion of timing of moratoriums placed within the basin and that those that allowed development should have to offset more. It was noted that is consistent with practice – each NRD is responsible for mitigating post-1997 uses that occurred within its boundaries.
- Recommendation to changing 'establish' to improve'

- SPG request to add "Develop strategies for drought" to the second increment plan

- SPG agreed to replace ‘pursue’ with ‘identify’*,* so that it reads *identify regulatory modifications*
- The Plan should identify opportunities and provide direction on what conditions are necessary in order to take advantage of excess flows for groundwater recharge.

- Noted that Representative Smith has requested irrigation infrastructure funding added to President’s plan – could include working with other states as well.
- Comment that drought and flood conditions need to be considered is a comprehensive manner. Storage could be dry half the time – may not be politically acceptable, but need the extra storage to capture excess flows
- S. White asked how they’d feel if we replaced ‘equity’ with ‘fairness’
    - Comment that fairness & geographic equity are two different things.
    - Stakeholder comment that Equity and/or fairness can never be 100% possible but important to acknowledge and mitigate it
- Based on possible edits to Goals & Objectives – used the red/yellow/green card activity to gauge acceptance of additions/revisions to goals and objectives
    - Based on the edits (Stephanie’s in-meeting edits to Goals & Objectives)
    - Majority held up yellow – not quite happy with suggested solutions
    - *Majority were stuck on the second to last bullet (Identify strategies to establish geographic equity for water users above and below Lake McConaughy)*
- Discussion on *Pursue regulatory modifications:*
    - Delete the parenthetical reference in *Pursue regulatory modifications (local, state, Federal)*
    - Intentional recharge project purpose is restricted on BOR canals as an example.
    - Limits on leasing surface water exist – benefits to all in being able to extend those leases as another example.
    - Stakeholder comment regarding deregulation/suspension of regulation during wet years could be beneficial.
    - Noted that having this as an objective strengthens the argument in discussions with public policy makers.

SPG consensus on potential new goal & respective objectives – group agreed that it could move forward once:

- **Third objective regarding geographic equity was removed**
- **“Pursue” in second objective changed to “identify”**

V. Potential New Objectives for Goal 3 Discussion

- *Increased, standardized and regular reporting / education on business health*
    - *Impact of community conservation education programs*
    - *Establish standard indices if economic health for distinct user groups (including cost of regulations to irrigators)*
- *Broader public inclusion in process and information dissemination*

- Comment in support of intent, but concern that establishment of standard indices linking water availability to economic health may be impossible.
- Many factors beyond water impact farm economy.
- Noted that if economic viability is one of the plan goals or related to the second increment offset targets, plan will need to include some metric to answer the question “How are we doing?” when monitoring and reporting during implementation.

SPG consensus - agreed not to add the two new objectives to Goal 3 as currently proposed.

VI. Discussion of SPG role in providing input on goals/objectives/action items – is there a limit on level of detail?

- Noted that currently the SPG has discussed and provided input on all 3.
- This group’s discussions and identification of possible projects/management actions is helpful to NRDs and the input is useful in identifying activities, to include in the basin-wide plan, as well as for each individual NRDs to consider when updating their individual plans and implementation.
- S. White asked the NRD managers/staff if current level of detail from SPG was enough for purposes of the basin-wide plan?
    - Consensus was yes, that it was.

VII. Continued Work on Definitions for Additional Elements

- Handouts were passed out to SPG to assess the following three foundations in regards to the Upper Platte River Basin, the maintenance of each in the basin, and how they’re vulnerable to water shortage
    1. Social and Environmental Health
    2. Safety
    3. Welfare

VIII. Next Steps

- NeDNR will post 46-715 Statute to the UPBWB website
- HDR will post a summary of the survey responses and discuss more at meeting in September
- HDR will bring a poster and stickers of value statements

Next Meeting: September 20, 2017

IX. Public Comment - *None*

Meeting Date: 7/19/17

CPNRD Central Platte Natural Resources District | North Platte Natural Resources District | South Platte Natural Resources District | Tri-Basin Natural Resources District | Twin Platte Natural Resources District | Nebraska Dept. of Natural Resources

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Attended?	**Name**	**Email Address**	**Affiliation**	**Primary or Alternate**
		SPG Primary Members		
	Anderson, Tyrell	tyrell.anderson@retranches.com	North Platte NRD	Primary
	Barels, Brian	blbarel@nppd.com	Public Power & Irrigation District	Primary
[signature]	Bendfeldt, Jim	jcb1@fastmail.com	Central Platte NRD	Primary
	Busch, Bob	rnbusch@actcom.net	Surface Water User	Primary
[signature]	Dahlgren, Bob	Rdahlgren@fsbloomis.com	Municipality – Village of Bertrand	Primary
X	Derry, Kevin	derrykb@embarqmail.com	Agriculture	Primary
	Downey, Thomas	tdowney@downeydrilling.com	Ground Water User	Primary
	Edeal, Russell	redeal@atcjet.net	Agriculture	Primary
[signature]	Eggleston, Judy	JudyEggleston@aol.com	Irrigation District	Primary
X	Fehringer, Bernard	bfehringer@icloud.com bernie.fehringer@wheatbelt.com	Public Power	Primary
[signature]	Fisher, Dave	dpfisher@scottsbluff.net	Surface Water User	Primary
	Gatch, Richard	Rgatch1@unl.edu	Surface Water User	Primary
[signature]	Halligan, Bill	Bill.halligan@pwcbank.com	South Platte NRD Board	Primary
X	Heath, Pat	pheath@gering.org	Municipality – City of Gering	Primary
	Henkel, Chuck	henkelchuck@yahoo.com	North Platte NRD Board	Primary
	Hoehn, Leo	Leo.hoehn@gmail.com	Groundwater Irrigator	Primary
	Koupal, Keith	keith.koupal@nebraska.gov	Environment/Wildlife	Primary
	Kramer, Erwin	backflow79@hotmail.com	Municipality – City of North Platte	Primary
[signature]	Kraus, Don	Dkraus@cnppid.com	Irrigation District	Primary
	Larson, Galen	glarson@pvbank.com	Financial	Primary
	Luchsinger, Tim	tluchsinger@grand-island.com	Municipality – City of Grand Island	Primary
[signature]	Nelson, Vernon	vernonjamesnelson@yahoo.com	Agriculture/Groundwater User	Primary
	Paulman, Roric	rpaulman@gpcom.net	Agriculture	Primary
	Pepplitsch, Joe	jpepp@cityoflex.com	Municipality – City of Lexington	Primary
[signature]	Revelle, Jack	jrevelle@vistabeam.com	Ground Irrigator	Primary
[signature]	Reynolds, Larry	larryreynolds68@gmail.com	Tri-basin NRD Board	Primary
	Richeson, Jay	jay@gothenburgirrigation.com	Municipality – Gothenburg	Primary
[signature]	Schaneman, Rodney	raschman@charter.net	Surface Water User	Primary
[signature]	Schilz, Dennis	dennisschilz@gmail.com	Irrigation District	Primary
[signature]	Sisk, Carson	Kimballwater@kimballne.org	Municipality – City of Kimball	Primary
✓	Strauch, Dennis	dennis@pathfinderirrigation.com	Irrigation District – Pathfinder Irrigation	Primary

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	Strommen, Kendra	strommen@mmmlawoffice.com	Financial	Primary
	Wahlgren, Joe	wahlgrenfarms@gmail.com	Twin Platte NRD Board	Primary
		SPG Alternate Members		
	Albrecht, Frank	frank.albrecht@nebraska.gov	Environment/Wildlife	Alternate
	Andreas, Kent	kandreas@embarqmail.com	North Platte NRD Board	Alternate
	Burnside, Dennis	dburnside@cityoflex.com	Municipality – City of Lexington	Alternate
	Clymer, Bruce	bclymer@cityofgothenburg.org	Municipality – Gothenburg	Alternate
✓	Derry, Jared	Jared.derry@gmail.com	Agriculture	Alternate
	Downey, Brent	bdowney@downeydrilling.com	Ground Water User	Alternate
	Drain, Mike	mdrain@cnppid.com	Irrigation District	Alternate
	Henry, Chris	cnhenry144@hotmail.com	Central Platte NRD Board	Alternate
	Hock, Andrew	andrew.extremeag@gmail.com	Agriculture	Alternate
	Holley, Chris		Municipality – North Platte	Alternate
	Jameson, Rhodel		Agriculture/Groundwater User	Alternate
	Larson, Joe	joelarson21@gmail.com	Tri-basin NRD Board	Alternate
	Meismer, Jim	tpnrd1jimm@gmail.com	Twin Platte NRD Board	Alternate
	Meyer, Doug	dgmeyer@NPanhandle.net	Municipality – City of North Platte	Alternate
	Narjes, Kathy	rodekohr@hotmail.com	South Platte NRD Board	Alternate
	Ortiz, Daniel	DOrtiz@kimballne.org	Municipality – City of Kimball	Alternate
X	Shafer, Jeff	jtshafe@nppd.com	Public Power & Irrigation	Alternate
	Smith, Ann	annck@cozadtel.net	Irrigation District	Alternate
	Snarr, Paul	psnarr@gering.org	Municipality – City of Gering	Alternate
	Zach, Randy		Public Power & Irrigation District	Alternate
		POAC Members		
✓	Adane, Zaibon		NDNR	
	Benson, Kathy	Kathy.Benson@nebraska.gov	NDNR	
✓	Berge, John	jberge@npnrd.org	North Platte NRD	
LJB ✓	Bodner, Lacey	Lacey.bodner@nebraska.gov	NDNR	
	Cross, Barb	bcross@npnrd.org	North Platte NRD	
	Crowe, Kayla	kayla.crowe@nebraska.gov	NDNR	
	Czaplewski, Mark	Mark@cpnred.org	Central Platte NRD	
	Dimmitt, Ann	afisher@tpnrd.org	Twin Platte NRD	
✓	Eckles, Beth		NDNR	
✓	Glanz, Travis	tglanz@spnrd.org	South Platte NRD	
✓	Hopkins, Kyle Ann		North Platte NRD	
✓	Horn, Rod	rlhorn@spnrd.org	South Platte NRD	
✓	Miller, Kent	komiller@tpnrd.org	Twin Platte NRD	
✓	Mintken, Jesse	mintken@cpnrd.org	Central Platte NRD	
	Flyr, Brandi	flyr@cpnrd.org	Central Platte NRD	

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CPNRD Central Platte · North Platte Natural Resources District · South Platte Natural Resources District · Tri-Basin Natural Resources District · Twin Platte Natural Resources District · Nebraska Dept. of Natural Resources

✓	Mosier, Melissa	melissa.mosier@nebraska.gov	NDNR
	Osborn, Colby		NDNR
✓	Reisdorff, Ryan	rreisdorff@spnrd.org	South Platte NRD
✓	Schellpeper, Jennifer	jennifer.schellpeper@nebraska.gov	NDNR
	Thorburn, John	jthorburn@tribasinnrd.org	Tri-Basin NRD
✓	Vogt, Lyndon	vogt@cpnrd.org	Central Platte NRD
JS ✓	Strom, Jessie	jessie.strom@nebraska.gov	NDNR
✓	Woodward, Duane	woodward@cpnrd.org	Central Platte NRD
✓	Zayac, Tracy	Tzayac@npnrd.org	North Platte NRD
	Zoller, Amy	amy.zoller@nebraska.gov	NDNR
Members of the Public			
	Elizabeth Miller		NPNRD
	Ann Williams		HDR
	Jerry Kenny	Kennyj@headwaterscorp.com	PRRIP-EDO
	Kevin Derry		

Agenda

Project: Upper Platte River Basin Water Management Plan – Single Planning Group

Subject: Meeting #8

Date: Wednesday, September 20, 2017 from 10:30 a.m. to 3:00 p.m.

Location: Holiday Inn Express & Suites, North Platte, NE

Agenda:

I. Administration
   1. Today's meeting will offer a working lunch
   2. This is an Open Meeting
   3. Review of Decision-Making Process
   4. July Meeting Recap
      i. Meeting minutes
      ii. Key discussion / decisions
      iii. Follow-up items

II. Path Forward Discussion
   1. Roadmap for Today and next 3 meetings
   2. Statute 46-715 interpretation, discussion, and how it relates to our planning process

III. Continued Work on Definitions for Additional Elements
   1. Social and Environmental Health
   2. Safety
   3. Welfare

IV. Next Steps

V. Public Comment

Next Meeting: November 15, 2017

Updated: September 1, 2017

Minutes

Project: Upper Platte River Basin Water Management Plan – Single Planning Group

Subject: Meeting #8

Date: Wednesday, September 20, 2017 from 10:30 a.m. to 3:00 p.m.

Location: Holiday Inn Express & Suites, North Platte, NE

NOTE: A complete set of slides and handouts can be found online at: upbwp.nebraska.gov

I. Administration (Stephanie White)

1. Today's meeting will offer a working lunch
2. This is an Open Meeting
3. Review of Decision-Making Process
    - This group is here to give guidance and thoughtful stewardship to the plan
4. July Meeting Recap
    - Explore existing economic indicators (Jennifer Schellpeper)
        - At the this point, economists and the department haven't found an already existing economic package
            - There have been past studies and reports – NeDNR will start to compile that data together and continue research to determine good economic indicators related to water supplies and water uses
        - Once NeDNR has determined potential economic indicators, they will bring back to SPG
    - July Discussion Summary (John Engel)

II. Path Forward Discussion (Stephanie White)

1. Roadmap for Today and next 3 meetings
    - Today's focus will be on defining social and environmental health, safety and welfare of the river basin
    - November
        - Redefining possible new Goals & Objectives based on today's discussion
        - Identify 2nd Increment Intent – discuss target
    - January
        - Review & discuss Annotated 1st Increment and identify additional missing elements
        - Set the roadmap for March, May, & July of 2018
2. Statute 46-715 interpretation, discussion, and how it relates to our planning process:

Nebraska Revised Statute 46-715 (2) In developing an integrated management plan, the effects of existing and potential new water uses on existing surface water appropriators and ground water users shall be considered. An integrated management plan shall include the following:

a) *Clear goals and objectives with a purpose of sustaining a balance between water uses and water supplies so that the economic viability, social and environmental health, safety, and welfare of the river basin, subbasin, or reach can be achieved and maintained for both the near term and the long term*

- Interpretation (Jennifer Schellpeper & Jesse Bradley)
  - Since LB 962 was passed in 2004, there have been many different interpretations
  - How NeDNR interprets:
    - *Supply* and *Use* will always be in balance (cannot use more water than is available)
    - The economic viability, social and environmental health, safety, and welfare of the basin will help determine how we want to achieve that balance; from using all of the supply to using none of the supply
    - NeDNR doesn't have that answer – seeking input from the stakeholders
    - This conversation also helps link the Goals & Objectives in the plan to the surface water & ground water controls in the individual NRD IMPs
    - Statute states that controls are chosen based on consistency with the Goals & Objectives in the plan
    - Spectrum between using none of the water in the system and using all was presented – economic implications exist on either end
    - The SPG has already discussed economic viability – today we will look at the rest of the statute which includes social and environmental health, safety, and welfare
  - Interpretation of FA (fully appropriated) / OA (overappropriated) distinctions:
    - For both OA and FA basins, IMPs require some similar standards – protecting existing users; a process for new development; and requirements for at least one ground water control and one surface water control
    - With an FA basin, you can be done at that point, although we (NRDs and NeDNR) have typically taken it further
    - But in an OA basin, we will need to address post-1997 use depletions; identify where we are in relation to FA / OA; develop Goals & Objectives that NeDNR & individual NRDs

incorporate into IMPs; and continue plans in subsequent increments until reaching FA status.

        - As we move forward to the Second Increment can address these Goals & Objectives through:
            - Projects / Incentives
            - Regulation
              (Important to understand that next increment doesn't exclusively mean regulation will apply to ground water users. First increment primarily focused on GW because very few post-1997 new SW uses.)
        - Costs are likely to continue increasing – ongoing operational & maintenance costs, willing seller / willing buyer platforms, competition for water, etc.
    - Big picture – Process will include stakeholder's input in a finalized Goals & Objectives which will go to individual NRDs to include in IMPs
- Related to our planning process (Stephanie White)
    - Results of March 2017 SPG survey on Second Increment Plan
        - Overall Intent – majority (18/27) agreed that the overall intent of the second increment is to maintain what has already been done and make more progress toward fully appropriated conditions
        - Reasonable target for additional progress during the second increment – 14/25 said that no additional progress needs to be made, while 11/25 said the target should be anywhere from 10,000 – 150,000
    - The big question for the November 2017 meeting is: what is our target goal?
- Discussion
    - Stakeholders discussed the need for a definition of the amount of supply
        - Determining a definition for how much we want to use is part of this process
    - Stakeholders discussed the need of a definition between Overappropriated and Fully
    - SPG conversed about the 1997 depletions and the projected increasing total depletion in the future
        - IMPs have established projects through 2019 to minimize depletion growth and offset post-1997 use depletions
        - Group reviewed 'Growth in Depletions' handout
        - Although water supplies might be abundant at times, because of continued use, the basin is still facing depletions
            - Darcy's Law & Law of Conservation of Mass

        - Stream flow might be increasing but is not increasing as much as it would have had there been no pumping at all
      - There is a difference between depletion and an observed reduction in stream flow (can have ground water depletions but see no difference in the gage, in fact you can have increasing flows and ground water elevations and still have depletions because the flow/GW elevations would have been greater had ground water not been pumped.)
      - The robust review that is being completed as part of the first increment will show the benefits of first increment activities.
      - Although an obligation to resetting pre-'97 depletions is not specifically called out in the statute, the group discussed this possibility and determined that a later conversation in regards to resetting the pre-'97 depletions may be necessary.
      - Models incorporate baseline conditions – changes in consumptive use are reflected in the model
      - The models have a variability of land uses represented in order to accurately capture the fluctuations in use for varying types of land / grasses / etc.
      - Changes in climate are captured, assuming that crop is intended to be fully irrigated, more pumping during dryer periods to provide full supply to crop.
      - Concerns and comments over views of consumptive use vs. reusable use
        - Based on geographic perspective and hydrogeologic conditions in each area
      - Where is this balance? What is enough and what is sustainable?
  - Stakeholders recognize that the level of success achieved in the first increment might be much more expensive to achieve in the second
      - What do we want to spend and what kind of regulations might we want to put into place?
      - Stakeholders pointed out that they would like to see first increment activities in terms of costs and benefits
        - ACTION ITEM: Team will work to compile this data and bring back to stakeholder group
  - Stakeholders discussed the need to be mindful of economic impacts on communities and producers
      - Changes in land valuations and tax increases may result with impacts to producers and also surrounding communities.
      - Challenge in consideration of incentive programs of the economic burden it places on producers and land owners

when valuations (and taxes) are increased, but production does not or is reduced.
        - Regulations may help to make a difference without placing as heavy of a tax burden on land owners – however production may be impacted.
        - 90% of NRD funding in first increment came from district occupation and property taxes
        - Producers don't have the resources to overspend
            - Some agreement from group that residents in the cities should be taxed in order to spread out costs and ease the burden on producers
    - Stakeholders focused on drought
        - Reminded the group of harm experienced by irrigators between 2000 – 2007
        - Warning that the SPG needs to recognize this and remember throughout this planning process
        - Storage may be a solution that could work for everyone
    - Stakeholder comment that the western NRDs keeps very good records of their water use and that it would be helpful for the rest of the state to follow suit
    - Stakeholders recognized credit for some drought mitigation steps that have been taken already
    - Stakeholder comment that maybe next increment will not focus on average offset of depletions, but on making system more resilient during drought periods.
    - Spectrum of projects we invest in that can be directed at droughts – focused incrementally, there is a range of things that can be done that can make a difference
    - Stakeholder comment that future SPG meetings should focus on conjunctive management as a solution to many of these challenges – changes in current system operations may address many of the basin issues and shortages.

III. Continued Work on Definitions for Additional Elements

1. Social and Environmental Health
    - *When is the social & environmental health of the basin vulnerable?*
        - *There is not enough flow necessary to:*
            - *Maintain water quality for human consumption and ecosystem health*
            - *Serve agricultural, municipal, and industrial needs*
            - *Provide recreational opportunities*
            - *Maintain water quality*
    - SPG feedback:

    - Agreed that nothing was missing from this definition
    - Combine the two bullet points that say: "*Serve agricultural, municipal, and industrial needs"* & *"Provide recreational opportunities"*
    - Can remove the last bullet reiterating water quality
2. Safety
    - *When is the safety of the basin vulnerable?*
        - *When there is not enough flow necessary:*
            - *For fire suppression*
            - *To maintain water quality that supports public health*
    - Stakeholder feedback:
        - Add flood control
        - Broaden safety to include environmental, economic, etc. in addition to physical
            - As it relates to personal and property, economic and environmental safety captured in those definitions
        - Safety, as it relates to power, is important to include - *defined* by "protecting critical infrastructure / using infrastructure to mitigate for floods"
            - Example using canals to relieve during times of flooding
            - Dam safety from a shortage standpoint
        - Incorporate a component of food security
3. Welfare
    - *When is the welfare of the basin vulnerable?*
        - *When water shortage causes a decline in Ag production such that the basin cannot maintain its population*
    - Stakeholder feedback:
        - Importance of maintaining agricultural base in this state's economy
        - Identify that there is more than one sector of economic viability, shouldn't be exclusive to agriculture
            - Agricultural trends of large farms has actually decreased population in many ways, it is important to keep this in mind – maintaining population may not be good signal of welfare of basin.
        - This definition is directly tied to the economic viability of the basin
        - Possibly remove 'ag production' altogether
        - Possibly replace "its population" with "quality of life"
            - However, a metric is necessary for measuring this – the reason for population
            - Quality of Life cannot be measured

        - Decrease in population does not necessarily come from water shortages
    - Much of the welfare items are captured from previous discussion of economic viability.

IV. Next Steps

- SPG identified priorities to discuss at future meetings:
    - Drought
    - Conjunctive Management
    - Storage
    - Economic data and scenario planning/costs
        - Dollars spent by district
        - Dollars required to continue by district
        - Cost of regulation in terms of cost of production and benefits
        - Do nothing alternative
        - Economic return per are foot
        - ACTION ITEM: Team to compile this data and bring back to stakeholder group
- Team will look into cost-benefit research done by Thompson at UNL.
    - ACTION ITEM: Team to compile this data and bring back to stakeholder group

V. Public Comment

- Member of the public stated that it was an excellent conversation, and asked that one aspect to be explicitly incorporated is the river in regards to who gets shorted. He said that in response to 'maintain water quality for human consumption and ecosystem health,' it would be good to consider adding that quantity is also important to include with quality. He also asked that environmental and ecosystem needs are explicitly addressed in the goal: 'serve agricultural, municipal, and industrial needs.'

Next Meeting: November 15, 2017

*Note that the January meeting will be held in the Best Western.

Meeting Date:______________

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		SPG Primary Members		
	Anderson, Tyrell	tyrell.anderson@retranches.com	North Platte NRD	Primary
yes	Barels, Brian	blbarel@nppd.com	Public Power & Irrigation District	Primary
	Bendfeldt, Jim	jcb1@fastmail.com	Central Platte NRD	Primary
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	Downey, Thomas	tdowney@downeydrilling.com	Ground Water User	Primary
	Edeal, Russell	redeal@atcjet.net	Agriculture	Primary
	Eggleston, Judy	JudyEggleston@aol.com	Irrigation District	Primary
yes	Fehringer, Bernard	bfehringer@icloud.com bernie.fehringer@wheatbelt.com	Public Power	Primary
	Fisher, Dave	dpfisher@scottsbluff.net	Surface Water User	Primary
	Gatch, Richard	Rgatch1@unl.edu	Surface Water User	Primary
yes	Halligan, Bill	Bill.halligan@pwcbank.com	South Platte NRD Board	Primary
	Heath, Pat	pheath@gering.org	Municipality – City of Gering	Primary
	Henkel, Chuck	henkelchuck@yahoo.com	North Platte NRD Board	Primary
	Hoehn, Leo	Leo.hoehn@gmail.com	Groundwater Irrigator	Primary
✓	Koupal, Keith	keith.koupal@nebraska.gov	Environment/Wildlife	Primary
	Kramer, Erwin	backflow79@hotmail.com	Municipality – City of North Platte	Primary
✓	Kraus, Don	Dkraus@cnppid.com	Irrigation District	Primary
	Larson, Galen	glarson@pvbank.com	Financial	Primary
	Luchsinger, Tim	tluchsinger@grand-island.com	Municipality – City of Grand Island	Primary
	Nelson, Vernon	vernonjamesnelson@yahoo.com	Agriculture/Groundwater User	Primary
	Paulman, Roric	rpaulman@gpcom.net	Agriculture	Primary
	Pepplitsch, Joe	jpepp@cityoflex.com	Municipality – City of Lexington	Primary
	Revelle, Jack	jrevelle@vistabeam.com	Ground Irrigator	Primary
	Reynolds, Larry	larryreynolds68@gmail.com	Tri-basin NRD Board	Primary
	Richeson, Jay	jay@gothenburgirrigation.com	Municipality – Gothenburg	Primary
	Schaneman, Rodney	raschman@charter.net	Surface Water User	Primary
	Schilz, Dennis	dennisschilz@gmail.com	Irrigation District	Primary
[signature]	Sisk, Carson	Kimballwater@kimballne.org	Municipality – City of Kimball	Primary
	Strauch, Dennis	dennis@pathfinderirrigation.com	Irrigation District – Pathfinder Irrigation	Primary

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	Strommen, Kendra	strommen@mmmlawoffice.com	Financial	Primary
	Wahlgren, Joe	wahlgrenfarms@gmail.com	Twin Platte NRD Board	Primary
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	Andreas, Kent	kandreas@embarqmail.com	North Platte NRD Board	Alternate
	Burnside, Dennis	dburnside@cityoflex.com	Municipality – City of Lexington	Alternate
	Clymer, Bruce	bclymer@cityofgothenburg.org	Municipality – Gothenburg	Alternate
	Derry, Jared	Jared.derry@gmail.com	Agriculture	Alternate
	Downey, Brent	bdowney@downeydrilling.com	Ground Water User	Alternate
	Drain, Mike	mdrain@cnppid.com	Irrigation District	Alternate
	Henry, Chris	cnhenry144@hotmail.com	Central Platte NRD Board	Alternate
	Hock, Andrew	andrew.extremeag@gmail.com	Agriculture	Alternate
	Holley, Chris		Municipality – North Platte	Alternate
	Jameson, Rhodel		Agriculture/Groundwater User	Alternate
	Larson, Joe	joelarson21@gmail.com	Tri-basin NRD Board	Alternate
	Meismer, Jim	tpnrd1jimm@gmail.com	Twin Platte NRD Board	Alternate
	Meyer, Doug	dgmeyer@NPanhandle.net	Municipality – City of North Platte	Alternate
	Narjes, Kathy	rodekohr@hotmail.com	South Platte NRD Board	Alternate
	Ortiz, Daniel	DOrtiz@kimballne.org	Municipality – City of Kimball	Alternate
	Shafer, Jeff	jtshafe@nppd.com	Public Power & Irrigation	Alternate
	Smith, Ann	annck@cozadtel.net	Irrigation District	Alternate
	Snarr, Paul	psnarr@gering.org	Municipality – City of Gering	Alternate
	Zach, Randy		Public Power & Irrigation District	Alternate
		POAC Members		
	Adane, Zaibon		NDNR	
	Benson, Kathy	Kathy.Benson@nebraska.gov	NDNR	
	Berge, John	jberge@npnrd.org	North Platte NRD	
	Bodner, Lacey	Lacey.bodner@nebraska.gov	NDNR	
	Cross, Barb	bcross@npnrd.org	North Platte NRD	
	Crowe, Kayla	kayla.crowe@nebraska.gov	NDNR	
	Czaplewski, Mark	Mark@cpnred.org	Central Platte NRD	
	Dimmitt, Ann	afisher@tpnrd.org	Twin Platte NRD	
	Eckles, Beth		NDNR	
	Glanz, Travis	tglanz@spnrd.org	South Platte NRD	
	Hopkins, Kyle Ann		North Platte NRD	
	Horn, Rod	rlhorn@spnrd.org	South Platte NRD	
	Miller, Kent	komiller@tpnrd.org	Twin Platte NRD	
	Mintken, Jesse	mintken@cpnrd.org	Central Platte NRD	

Meeting Date:_______________

CPNRD | NORTH PLATTE Natural Resources District | SOUTH PLATTE Natural Resources District | Tri Basin Natural Resources District | TWIN PLATTE Natural Resources District | NEBRASKA DEPT. OF NATURAL RESOURCES

X	Mosier, Melissa	melissa.mosier@nebraska.gov	NDNR
	Osborn, Colby		NDNR
	Reisdorff, Ryan	rreisdorff@spnrd.org	South Platte NRD
	Schellpeper, Jennifer	jennifer.schellpeper@nebraska.gov	NDNR
	Thorburn, John	jthorburn@tribasinnrd.org	Tri-Basin NRD
	Vogt, Lyndon	vogt@cpnrd.org	Central Platte NRD
	Strom, Jessie	jessie.strom@nebraska.gov	NDNR
	Woodward, Duane	woodward@cpnrd.org	Central Platte NRD
	Zayac, Tracy	Tzayac@npnrd.org	North Platte NRD
	Zoller, Amy	amy.zoller@nebraska.gov	NDNR
		Members of the Public	

Agenda

Project:	Upper Platte River Basin Water Management Plan – Single Planning Group
Subject:	Meeting #9
Date:	Wednesday, January 17, 2018 from 10:30 a.m. to 3:00 p.m.
Location:	Best Western Plus, 3201 S. Jeffers St., North Platte, NE

Agenda:

I. Administration
  1. Today's meeting will offer a working lunch
  2. This is an Open Meeting
  3. Review of Decision-Making Process
  4. September Meeting Recap
     i. Meeting minutes
     ii. Key discussion / decisions
     iii. Follow-up items
     iv. Glossary of Terms
     v. Annotated First Increment

II. First Increment Activities Cost & Benefits
  1. Costs Incurred for 1st Increment Activities
  2. Cost of Regulation in terms of Production
  3. Do-Nothing Alternative
  4. Economic Return Per Acre Foot

III. Second Increment Intent

IV. Next Steps

V. Public Comment

Next Meeting: March 21, 2017 at the Holiday Inn Express

Minutes

Project:	Upper Platte River Basin Water Management Plan – Single Planning Group
Subject:	Meeting #9
Date:	Wednesday, January 17, 2018 from 10:30 a.m. to 3:00 p.m.
Location:	Best Western Plus, 3201 S. Jeffers St., North Platte, NE

I. **Administration**
   1. **Today's meeting will offer a working lunch**
   2. **This is an Open Meeting**
      - Dave Fisher (Scotts Bluff) presented to group about an IMP proposal to end "offsets", deregulate, and add storage
      - If any SPG members had further questions, Dave encouraged them to contact him
      - Stephanie pointed out that conjunctive management will be a topic of conversation in the next meeting
   3. **Review of Decision-Making Process – role of primary vs. delegate**
   4. **September Meeting Recap**
      i. Meeting minutes
      ii. Key discussion / decisions
      iii. Follow-up items
      iv. Glossary of Terms
      v. Annotated First Increment
      - Progress made towards a full document through the assistance of the SPG can be seen in track changes of the document
   5. **Roadmap through spring 2018**
   6. **Lodgepole Creek (Rod Horn – South Platte NRD)**
      - Proposal: treat Lodgepole Creek subbasin differently from the rest of the Platte River Basin Overappropriated area
      - SPNRD and NeDNR have begun conversations to assess this possibility and would like stakeholder input
      - Lodgepole Creek is a tributary of the South Platte River – flows east from Laramie into SPNRD – then meets South Platte River east of Ovid, NE
        - Has historically always been an intermediate creek
        - Gains through groundwater
      - Accounts for about 3 – 4% of overappropriated area in the basin and about 72% of overappropriated area in the South Platte NRD
      - 2002 – SPNRD moved towards a moratorium of Lodgepole Creek
      - Complex area

    - Lodgepole Creek flows southeast through NRD and meets South Platte River
    - Hydrologic connectivity (surface water and groundwater) is not significant to the flows that would impact the wildlife target flows or the instream flows downstream
- Don't think the connection is significant enough that it's contributing to Platte River flows in Nebraska – flows are unprotected in Colorado and the state of Colorado likely picks up any significant amount of flows contributed by Lodgepole Creek.
- Feedback on this proposal:
    - Stakeholders discussed whether snowmelt contributes to the NE system on Lodgepole Creek – doesn't generally cross state lines
    - Stakeholders asked for clarification on how this proposal will work and what changes SPNRD will want to see
        - NeDNR explained that the first step is recognition of the hydrologic disconnection, that it is not having a downstream impact to NE users, and getting input from stakeholders
    - Stakeholders discussed diversions in Colorado – that they have irrigation season diversions in addition to efforts to capture during non-irrigation seasons
    - Rod reiterated for the group that SPNRD has met their Post '97 obligations on Lodgepole Creek substantially (using monitoring, flow meter system, retirements, etc.)
    - Stakeholders agreed that Lodgepole Creek is unique because of its interaction with Colorado, and the possibility of different treatment is reasonable
        - Generally they support different treatment but do not know enough about the proposal for a different treatment.
        - Some concern about setting a precedent of carving special sections from the plan area.
    - Western Canal and Lodgepole Creek are both dealt with in South Platte Compact – incorporated in Colorado's administrative system
    - Stakeholders not asked to agree on the exact treatment at this meeting, but NeDNR and SPNRD wanted their initial thoughts and will bring back more specifics for conversation in March meeting
        - NeDNR/SPNRD ACTION item

II. Draft Post '97 Analysis (slides 15 - 61 in Power Point presented)

- Looking at some preliminary results of our robust review – assessing First Increment targets that were laid out in Basin-wide plan and IMPs
- NeDNR has been speaking with NRD managers and each individual board about the numbers that will be presented
- This data is determined with the COHYST model and WWUMM
    - Many limitations present in the COHYST model in First Increment have been addressed
- Numbers do not reflect the management actions that have taken place in First Increment (with the exception of groundwater-irrigated acreage retirements).

- In NPNRD and SPNRD, data reflect the impact of allocations.
- Many changes have been largely driven by land use change
    - The focus of this data is groundwater irrigated acre land use change
- Models / Set-up used
    - Western Water Use Management Model (WWUMM) has been updated annually for the last several years
        - Land use data sets updated
        - Model starts in 1953 and projects through 2063 (*based on 2013 land use)
        - Climate used for model scenario is a repeat of 1989 – 2013 (representative of wet and dry cycles)
        - Surface water and commingled acres were the same in the baseline and change runs, which canceled out any effects that changes in surface water or commingled acres would have had on streamflow since 1997
        - 1950 – 2063
        - Uses same climate period as WWUMM
        - Isolate changes in groundwater only irrigated acres
        - Based on 2010 land use data
- Model areas
    - Map can be found on slide 19
    - Data will be district-wide changes (acres, pumping changes, etc.) for each NRD in addition to changes in just overappropriated area
- Results for each district – change in acreage and crop typing change, net in acres translates to pumping change, and the overall effect on the river

1. **North Platte NRD**
    - Data can be found slides 23 – 30
    - Total depletions NPNRD – slide 54
        - Address efficiency to a degree in models
        - Producers are adapting – irrigating less acres/different crops and NRD working with producers on incentives and to buy back more acres
        - Acre reductions captured in land use changes
    - Benefits estimated from the allocation analysis are based on the assumption that producers will pump full allocation. Metered data is showing a further reduction in pumping than predicted by the allocation analysis.
2. **South Platte NRD**
    - Data can be found slides 31 – 36
    - Total depletions SPNRD – slide 55
    - Looking at 3 areas – Lodgepole Creek, North Platte River, and South Platte River.
    - Allocations are set at different amounts in different SPNRD subareas.
3. **Twin Platte NRD**
    - Data can be found slides 37 – 41
    - Total depletions TPNRD – slide 56
    - District-wide increase in depletions
4. **Central Platte NRD**

- Slides 42 – 46
- Total depletions CPNRD – slide 57
- District wide increase in depletions
- Stream depletions – impacts to OA basin (upstream of Elm Creek) and the program reach (stream between Elm Creek and Chapman)
  - Program reach – increased in stream flow
  - Redistribution of land use accounts for transfers and other water management activities NRD has done in that area
- The data are based on a projected baseline based on a lot of work COHYST did to calibrate the models (cannot be representative of each individual producer, but reflective as a whole)

5. Tri-Basin NRD

- Slides 47 – 51
- Total depletions TBNRD – slide 58
- Summary – slide 52
- Total Depletions Basin-Wide upstream of Elm Creek – slide 59

- Summary
  - NPNRD and SPNRD are meeting and exceeding their allocations – assuming activities in 2013 remain in effect moving forward
  - Changes in results
    - Modeling analysis did more robust job
    - WWUM eliminated land use changes that did not occur
    - COHYST acreage didn't change much but new version has done a better job of representing precipitation impacts, and full exchange of recharge and pumping
    - Primary changes to results was driven by a net extraction model change
  - NeDNR will post these slides to the website and if stakeholders are interested, can send a summary of how these estimates compare with the depletion estimates in the 1st increment IMPs
    - NeDNR ACTION item
- Stakeholder discussion
  - Raised concern for the growing population and the increase in food demand (and subsequent more water use) – these numbers do not include food demands
  - Some suggest that if streamflow increases are meeting obligations, then the requirement for mitigation beyond Post-'97 is less pertinent
  - Depletions are measured by looking at the streamflow as though there were no pumping – can have increase in streamflow, but it may not be as much as would have occurred without pumping. Models are required to determine depletions.
- General Stakeholder sentiments:

- We have done a lot and may have even accomplished more in the 1st Increment than we thought – this should help in the development of the 2nd Increment
- By law, we have to meet Post-'97 obligations, but we need to determine targets/offsets beyond just our legal obligations we'd like to reach
  - FA is somewhere at or above that line
- In Gothenburg, economic development currently constrained because of water issues
- We need to continue collecting data to increase the accuracy of our information, with more accurate data we can continue to reach more conclusive decisions
- We are in a much better position today because of the steps taken 10 years ago – this shows the benefits of metering and technology and the importance of continuing these efforts
- The modeling is limited - it does not/ cannot include everything that has been done
- Concern over the cost it will take to continue and build upon 1st Increment targets – how will we do this?
- The NRDs/boards/managers that have exceeded their allocations deserve recognition for all they've done
- Have to be nimble to meet the goal once the goal is identified
- Have a new reality to move forward on

III. First Increment Activities Cost & Benefits

1. Costs Incurred for 1st Increment Activities

- Includes projects, retirements (both permanent and temporary), studies (including model development), and administrative costs (includes NRD costs for regulation)
- Department costs include NET funds, Water Resources Cash Fund, Program 19, general funds (CREP not included)
- Slides 62-63

2. Cost of Regulation in terms of Production

- Committed dollars (from NeDNR and the NRDs) are also included in the cost calculations, some have not been spent so in theory could be used towards second increment – NeDNR to clarify in the table that these are not all expended dollars
  - NeDNR ACTION item
- Slide 64

3. Benefits of First Increment Activities

- Berge said there has been overvaluation of property taking place in each district, and since property taxes have been such a significant source, when they re-center themselves, could be very damaging
- Each NRD has its own funding sources
- Much less certainty of funding sources – we have to anticipate this from a strategic planning standpoint
  - Stakeholders asked if this is something that warrants legislative action

- Current farming economy and local economies in towns/communities provide a lot of uncertainty as far as budget is concerned
- Many NRDs experiencing budget cuts in the coming years
  - NET Grant may discontinue – Water Sustainability Fund may also be cut
- Slide 65

IV. Second Increment Intent

- 43.6k AF is estimate (high end at 126k AF) of yield of 1st increment activities at the end of the second increment.
- Minimum - 33,800 AF requirement by statute (post-1997 use depletions at end of second increment)
- Slides 69 – 71
- Jesse Bradley pointed out that it doesn't necessarily have to be a hydrologic solution/answer
  - There are other options for creating improved water certainty in the basin (including addressing vulnerability to drought, etc.) rather than just focusing on hydrologic numbers
  - The hydrologic minimums will always be part of the plan, but we are not limited to the numbers
- Stakeholder discussion on Second Increment Intent
  - We're working with the ideal environment for water storage and recharging – something we should take advantage of
  - Need to gauge the appetite for the taxpayer to spend enough on funding again
  - Drought planning and mitigation is very important to this group and something we know we need to be working towards – build resiliency/drought mitigation practices into the plan
    - Agreement that drought planning is important for the Second Increment Intent
  - Possibility of understanding from groups that are harmed from many of these activities what it would take to offset this harm – should we consider compensating them
  - Second Increment may be about improving efficiency and investments
  - Conjunctive Management needs to be one facet
  - Partnerships among surface and groundwater will be essential
  - Build resiliency into the IMPs
  - Would like to see the robust review results – however, we need to produce the plan before the robust review is complete
  - NCORPE has tools that might be beneficial for drought mitigation
  - Timing and location is critical
  - Spend wisely but keep spending to improve the system
  - Need to contemplate what we have available to each district to help meet whatever goal is identified
  - Call for education on efforts that have been done and continuing

V. Next Steps

- NeDNR will look into a presentation from the Drought Mitigation Center at the March meeting
  - NeDNR ACTION item
- Stakeholders interested in understanding the significance of crop-type changes on water usage in the system, and the sensitivity of the system to crop types throughout the river basin
  - Updated crop type and land use data will be included in the upcoming robust review analysis, for which work is already underway.
- NeDNR (ACTION item) will send the following questions for consideration prior to March meeting
  - From a drought perspective, where are you at risk?
  - What would it take to be more resilient?
- Consider the balance of numerical goals and other components of Second Increment Plan (i.e. drought management) and the possibility of determining such lofty goals that do not require regulatory backstops (like the post-1997 use offset required by statute that has regulatory backstop).
- Continue relationships between water users - give thoughts on how to create and maintain these relationships

VI. Public Comment

- Member of the public reemphasized that the secret is addressing drought mitigation

Next Meeting: March 21, 2017 at the Holiday Inn Express

Meeting Date: January 17, 18

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Attended?	**Name**	**Email Address**	**Affiliation**	**Primary or Alternate**
		SPG Primary Members		
	Anderson, Tyrell	tyrell.anderson@retranches.com	North Platte NRD	Primary
[signature]	Barels, Brian	blbarel@nppd.com	Public Power & Irrigation District	Primary
[signature]	Bendfeldt, Jim	jcb1@fastmail.com	Central Platte NRD	Primary
	Busch, Bob	rnbusch@actcom.net	Surface Water User	Primary
[signature]	Dahlgren, Bob	Rdahlgren@fsbloomis.com	Municipality – Village of Bertrand	Primary
Yes	Derry, Kevin	derrykb@embarqmail.com	Agriculture	Primary
	Downey, Thomas	tdowney@downeydrilling.com	Ground Water User	Primary
[signature]	Edeal, Russell	redeal@atcjet.net	Agriculture	Primary
	Eggleston, Judy	JudyEggleston@aol.com	Irrigation District	Primary
	Fehringer, Bernard	bfehringer@icloud.com bernie.fehringer@wheatbelt.com	Public Power	Primary
[signature]	Fisher, Dave	dpfisher@scottsbluff.net	Surface Water User	Primary
	Gatch, Richard	Rgatch1@unl.edu	Surface Water User	Primary
[signature]	Halligan, Bill	Bill.halligan@pwcbank.com	South Platte NRD Board	Primary
[signature]	Heath, Pat	pheath@gering.org	Municipality – City of Gering	Primary
CH	Henkel, Chuck	henkelchuck@yahoo.com	North Platte NRD Board	Primary
[signature]	Hoehn, Leo	Leo.hoehn@gmail.com	Groundwater Irrigator	Primary
KDK	Koupal, Keith	keith.koupal@nebraska.gov	Environment/Wildlife	Primary
[signature]	Kramer, Erwin	backflow79@hotmail.com	Municipality – City of North Platte	Primary
	Kraus, Don	Dkraus@cnppid.com	Irrigation District	Primary
[signature]	Larson, Galen	glarson@pvbank.com	Financial	Primary
	Luchsinger, Tim	tluchsinger@grand-island.com	Municipality – City of Grand Island	Primary
Yes	Nelson, Vernon	vernonjamesnelson@yahoo.com	Agriculture/Groundwater User	Primary
Yes	Paulman, Roric	rpaulman@gpcom.net	Agriculture	Primary
	Pepplitsch, Joe	jpepp@cityoflex.com	Municipality – City of Lexington	Primary
	Revelle, Jack	jrevelle@vistabeam.com	Ground Irrigator	Primary
Yes	Reynolds, Larry	larryreynolds68@gmail.com	Tri-basin NRD Board	Primary
yes	Richeson, Jay	jay@gothenburgirrigation.com	Municipality – Gothenburg	Primary
[signature]	Schaneman, Rodney	raschman@charter.net	Surface Water User	Primary
Yes	Schilz, Dennis	dennisschilz@gmail.com	Irrigation District	Primary
	Sisk, Carson	Kimballwater@kimballne.org	Municipality – City of Kimball	Primary
yes	Strauch, Dennis	dennis@pathfinderirrigation.com	Irrigation District – Pathfinder Irrigation	Primary

2

Meeting Date: January 17, 18

CPNRD Central Platte · North Platte Natural Resources District · South Platte Natural Resources District · Tri-Basin Natural Resources District · Twin Platte Natural Resources District · Nebraska Dept. of Natural Resources

	Strommen, Kendra	strommen@mmmlawoffice.com	Financial	Primary
[signature]	Wahlgren, Joe	wahlgrenfarms@gmail.com	Twin Platte NRD Board	Primary
		SPG Alternate Members		
	Albrecht, Frank	frank.albrecht@nebraska.gov	Environment/Wildlife	Alternate
	Andreas, Kent	kandreas@embarqmail.com	North Platte NRD Board	Alternate
	Burnside, Dennis	dburnside@cityoflex.com	Municipality – City of Lexington	Alternate
	Clymer, Bruce	bclymer@cityofgothenburg.org	Municipality – Gothenburg	Alternate
Yes	Derry, Jared	~~Jared.derry@gmail.com~~ jared.derry32@gmail.com	Agriculture	Alternate
	Downey, Brent	bdowney@downeydrilling.com	Ground Water User	Alternate
[signature]	Drain, Mike	mdrain@cnppid.com	Irrigation District	Alternate
	Henry, Chris	cnhenry144@hotmail.com	Central Platte NRD Board	Alternate
	Hock, Andrew	andrew.extremeag@gmail.com	Agriculture	Alternate
	Holley, Chris		Municipality – North Platte	Alternate
	Jameson, Rhodel		Agriculture/Groundwater User	Alternate
Joe Larson	Larson, Joe	joelarson21@gmail.com	Tri-basin NRD Board	Alternate
Jim Meismer	Meismer, Jim	tpnrd1jimm@gmail.com	Twin Platte NRD Board	Alternate
	Meyer, Doug	dgmeyer@NPanhandle.net	Municipality – City of North Platte	Alternate
	Narjes, Kathy	rodekohr@hotmail.com	South Platte NRD Board	Alternate
	Ortiz, Daniel	DOrtiz@kimballne.org	Municipality – City of Kimball	Alternate
[signature]	Shafer, Jeff	jtshafe@nppd.com	Public Power & Irrigation	Alternate
	Smith, Ann	annck@cozadtel.net	Irrigation District	Alternate
	Snarr, Paul	psnarr@gering.org	Municipality – City of Gering	Alternate
	Zach, Randy		Public Power & Irrigation District	Alternate
		POAC Members		
	Adane, Zaibon		NDNR	
	Benson, Kathy	Kathy.Benson@nebraska.gov	NDNR	
[signature]	Berge, John	jberge@npnrd.org	North Platte NRD	
	Bodner, Lacey	Lacey.bodner@nebraska.gov	NDNR	
[signature]	Cross, Barb	bcross@npnrd.org	North Platte NRD	
	Crowe, Kayla	kayla.crowe@nebraska.gov	NDNR	
	Czaplewski, Mark	Mark@cpnred.org	Central Platte NRD	
AMD	Dimmitt, Ann	afisher@tpnrd.org	Twin Platte NRD	
	Eckles, Beth		NDNR	
Yes	Glanz, Travis	tglanz@spnrd.org	South Platte NRD	
	Hopkins, Kyle Ann		North Platte NRD	
[signature]	Horn, Rod	rlhorn@spnrd.org	South Platte NRD	
	Miller, Kent	komiller@tpnrd.org	Twin Platte NRD	
	Mintken, Jesse	mintken@cpnrd.org	Central Platte NRD	

3

Meeting Date: January 17, 18

CPNRD Central Platte | North Platte Natural Resources District | South Platte Natural Resources District | Tri-Basin Natural Resources District | Twin Platte Natural Resources District | NEBRASKA Dept. of Natural Resources

	Flyr, Brandi	flyr@cpnrd.org	CPNRD
YES	Mosier, Melissa	melissa.mosier@nebraska.gov	NDNR
	Osborn, Colby		NDNR
RR yes	Reisdorff, Ryan	rreisdorff@spnrd.org	South Platte NRD
Yes	Schellpeper, Jennifer	jennifer.schellpeper@nebraska.gov	NDNR
yes	Thorburn, John	jthorburn@tribasinnrd.org	Tri-Basin NRD
	Vogt, Lyndon	vogt@cpnrd.org	Central Platte NRD
	Strom, Jessie	jessie.strom@nebraska.gov	NDNR
	Woodward, Duane	woodward@cpnrd.org	Central Platte NRD
yes	Zayac, Tracy	Tzayac@npnrd.org	North Platte NRD
	Zoller, Amy	amy.zoller@nebraska.gov	NDNR
Members of the Public			
yes	Steve Windrum		Gothenburg
Yes	John Engel	john.engel@hdrinc.com	HDR
Yes	Jesse Bradley	jesse.bradley@nebraska.gov	NEDNR
Yes			
yes	Cristina Beermann	cristina.beermann@hdrinc.com	HDR

Agenda

Project:	Upper Platte River Basin Water Management Plan – Single Planning Group
Subject:	Meeting #10
Date:	Wednesday, March 21, 2018 from 10:30 a.m. to 3:00 p.m.
Location:	Holiday Inn Express & Suites, North Platte, NE

Agenda:

I. Administration
   1. Today's meeting will offer a working lunch
   2. This is an Open Meeting
   3. Review of Decision-Making Process
   4. January Meeting Recap
      i. Meeting minutes
      ii. Key discussion / decisions
      iii. Follow-up items

II. Special Presentations
   1. Conservation Study
   2. Drought Mitigation
   3. Conjunctive Management

III. Next Steps

IV. Public Comment

Next Meeting: May 16, 2018

Minutes

Project: Upper Platte River Basin Water Management Plan – Single Planning Group

Subject: Meeting #10

Date: Wednesday, March 21, 2018 from 10:30 a.m. to 3:00 p.m.

Location: Holiday Inn Express & Suites, North Platte, NE

I. Administration

1. **Today's meeting will offer a working lunch**
2. **This is an Open Meeting**
3. **Review of Decision-Making Process**
    - Consistent reminder of what we're all working towards
4. **January Meeting Recap**
    - Draft robust review results – First Increment not reflected
    - Updated depletion numbers
    - Estimated depletion growth through the next increment
        - i. **Meeting minutes** – to be published online before the end of the week
        - ii. **Key discussion / decisions**
        - iii. **Follow-up items**
    - This meeting's special presentations are follow up items from January's meeting – purely educational but will inform refined Goals and Objectives
    - In May we'll discuss the elements of the draft Second Increment Plan and the identification of the Second Increment Intent
    - July will include more finalization of the Second Increment plan

II. Special Presentations

1. **Agricultural Hydrology** - Dr. Dean E. Eisenhauer, P.E.
    - Slides 7 – 58 in Power Point
    - Introduction to some of the basics of what influences the models used by NeDNR
    - Reviewed the different zones of soil hydration
        - Geologic setting can influence the thickness of these layers
    - Evapotranspiration: combination of evaporation of water from solid surface and transpiration of plant leaves
    - Relationship between crop yield, evapotranspiration, and irrigation
        - Important takeaway: there is a linear relationship between transpiration/evapotranspiration and yield

    - 0 transpiration = 0 yield
- Harvest index: the proportion of biomass that goes to grain (for example, the harvest index of corn is about 50%)
- The average precipitation in the state of Nebraska is about 22 inches/year – this controls a lot of the water balance in the state
- Irrigation efficiency: beneficially used water divided by amount of water applied
- Water gets into streams by runoff and groundwater discharge (aka baseflow)
    - Often influenced by geological setting
    - Groundwater is usually the primary contributor to stream flow – so when there is a significant depletion to groundwater it has a large impact on streams
    - Pumping decreases the connection between groundwater and surface water, disconnecting the water from the stream
    - Deep percolation of the root zone becomes a part of the recharge system for groundwater, so when pumped excessively it causes a problem
- Different types of irrigation have different impacts on efficiency
    - Return flow systems – increased efficiency
        - Requires less pumping, can divert less water
    - Sub-surface drip irrigation – increased efficiency
        - Less evaporation so groundwater and streamflow increase
    - Sprinklers
        - Less evaporation – as long as evapotranspiration is decreased, practice can put more water into system
    - Key takeaway: reducing evapotranspiration can be great for increasing water back into streamflow
        - Mulching with crop residues decreases evapotranspiration
        - Deficit irrigation decreases ET and involves purposefully stressing the plant
- Stakeholder conversations on the inconclusive correlation between evapotranspiration and rainfall
    - Research showing that water from lakes travels far
    - Irrigation can increase evapotranspiration – irrigation has stabilized the atmosphere above that irrigated crop, so thunderstorms decreased over these areas
- Stakeholder conversation on what it means to double crops in terms of water usage
    - Again, no conclusive data but increasing transpiration has helped increase yield and hybrids have developed a greater drought tolerance

2. **Conservation Study** – Marc Groff, P.E.
   - Slides 59 – 68 in Power Point
   - Using existing models
     - Cooperative Hydrology Study Model (COHYST)
     - Western Water Use Model (WWUM)
   - Within each tool set are 3 separate models: Ground Water model; Surface Water Operations model; Land Use, Watershed model (climate, land use, soils, farming practices, etc.)
   - Out of Phase 1, two conservation practices selected for evaluation:
     - Changes in Irrigation Application Efficiency (IAE)
     - Changes in Tillage Practices (Till)
   - Baseline condition (today) → to extreme condition of a possible future
     - Both scenarios are set up to be possible change analyses
     - IAE – goal is not to adjust the yields, but to reflect a change in evaporation but not transpiration
     - Tillage run scenario set up similarly – baseline conditions and actual climate, then adjusts for changes in single planting operation to represent minimum till (changes in pumping, evaporation, and return flows)
   - Evaluated by looking at *net recharge*: change in pumping or diversion, compared to change in recharge
     - If number is positive, aquifer is gaining water
     - If number is negative, aquifer is losing water
     - Numbers between two models are different because Till model looks at all land, while IAE is exclusive to irrigated land
   - IAE scenario – on average, irrigation efficiency is about 0.5 inch (positive)
   - Tillage efficiency – on average 2.25 inch (positive)
     - Study shows that Tillage efficiencies show a higher potential that IAE scenario
   - But other two tools will show the whole picture, based on location and timing impacts of changes
   - More to do outside of modeling mold (assumption, definitions, data, etc.)
   - Next steps / schedule is a current topic of discussion for NeDNR and eventually SPG
   - Stakeholder discussions
     - Farmers within NRDs started changing efficiencies and we are seeing a trend towards special farming techniques
       - This trend is being accounted for in the models
     - Data on the trends between dry land and irrigation largely falls on NRDs
     - Stakeholders interested in seeing what conservation practices were done over time, specifically their impact to transpiration and return flows

        - Particularly for surface water users (limited supply – depending on return flows from other users)
        - Has total consumptive use been influenced by conservation efforts that have been taken? – have looked into the increase in efficiencies but next steps for developing the scarce measurement data on a basin-wide level are still to be determined
        - NeDNR explained that this is a first step in terms of understanding the effect, and moving forward will determine the next steps (looking at data historically vs. looking forward)
        - Conservation vs. efficiency – term interchangeable?
        - Next steps might be worth including in Second Increment Plan
        - Cost is a huge factor, in addition to gathering a significant amount of more data

3. Drought Planning

- Kelly Helm Smith (Drought Mitigation Center)
    - Slides 69 – 95 in Power Point
    - US Drought Monitor Map
        - 450 experts use numeric data and refine with on the ground observations
    - Cannot predict when drought will happen, only sure that it will happen again
        - Challenge is to channel this concern into constructive action
    - Planning process at all scales - scale matters
        - Agricultural and urban drought threats are very different
    - State drought planning
        - Nebraska has an outdated mitigation plan
        - Mitigation plan – actions ahead of time to prevent drought
        - Response plan – actions taken once drought occurs
    - Nebraska's NRDs are an important asset in the state as far as drought planning is concerned (many states divide power so excessively that it is unproductive)
    - Drought planning occurs on a federal level (drought.gov)
        - No federal water policy, primarily legislated at a state level
        - Many more water management decisions made at a local level
    - Emergency management planning (hazard planning)
        - Look at scenarios such as if the 2012 Nebraska drought had lasted years longer
    - 3 pillars involved in drought planning – 10 step process
        - What you want to protect (identify key vulnerabilities)
        - How you'll know you're in a drought
        - What to do when in a drought

    - Mitigating drought includes irrigation, the use of new technologies, and more
    - Recommend localities establish an operational definition of drought
    - There are many different types of drought, including:
        - Meteorological (not enough rain)
        - Agricultural (not enough water in soil for crops to grow)
        - Hydrological (water in reservoirs/rivers take a while to flow)
        - Socioeconomic (caused by or contributed by society's actions related to drought)
        - Ecological (not enough to sustain ecosystems)
    - Recommend establishing triggers and indicators in order to monitor drought
        - Specific actions connected to specific numeric thresholds
        - Standardized precipitation index recommended as most basic way to track status
    - Mitigation actions include adopting agricultural practices that enhance soil health, enhance infrastructure for storing, etc.
    - Often requires obtaining authority, political will, and stakeholder/public buy-in
        - Sub-committees based on area of impact is a very effective way to keep people involved and informing the plan
    - Some drought planning has occurred in the Lower Elkhorn NRD and North Platte NRD (Tracy Zayac's presentation)
    - The Montana Beaverhead Watershed Drought Resiliency Plan (2016) is a good example

- Tracy Zayac, North Platte NRD
    - Slides 96 – 103 in Power Point
    - North Platte NRD drought planning (2016 - 2017)
        - Mitigation and response plan
    - Built on 3 C's
        - Competition – tournament style, broke stakeholder group up into mixed sector groups
        - Collaboration
        - Community
    - Goal was to bring in as many different perspectives from the district as possible, these segments included:
        - Ag
        - Education
        - Public health
        - Local government
        - Emergency management
        - Etc.
    - Hosted a tournament with mixed stakeholder groups

        - Using data from National Drought Mitigation Center, built scenario and provided all contextual information
        - Groups came together to determine what to do, how to do it, and how to fund activities
        - These plans were scored and prizes were given
        - Each group elected a representative to help write the plan
        - Many ideas were used for conversation in the planning process – prioritized and discussed main vulnerabilities
    - Also used an advisory group made up of major agencies – provided information about programs and capabilities they might be able to leverage
    - Education emerged as the biggest component of the plan
        - Drought, the effects, the basics, etc.
        - Decided to add more of a drought component to existing school program / WET program
        - Work with planning / zoning commissions to include more drought mitigation efforts into landscaping
        - Annual water symposium
    - Focus on water quantity; water quality; public health; education; and more
        - Including solutions for the impacts involving mitigation activities
    - Cooperative funding and continued conversation across communities
    - Intended to be a living document – annual review process and 5 year time-table
        - Schedule of metrics for determining how the plan is working
        - Qualitative and quantitative metrics
        - Self-assessments (monitoring team)
    - Data and partnerships called out in plan
    - Clear definition of roles and responsibilities
    - Intention to increase community resiliency and sustainability
    - Scalability from North Platte NRD to Upper Platte River Basin-wide
        - Includes regional partnerships – differences on the ground
    - Helpful to have a local plan to deal with more local issues
        - Downstream vs. upstream differences
        - Local level plans are great from a response perspective, while basin-wide is a good place to start with mitigation actions
    - Didn't identify triggers in particular, but set up process for studying what triggers would be and the associated conditions

4. **Conjunctive Management** – Jesse Bradley (NeDNR)
    - Slides 104 – 124 In PowerPoint

- Conjunctive management was a tool identified at the beginning of this planning process as an implementation mechanism and to inform policies
    - Managing resources together
- Focus on water quantity and water quality
- Accomplishing conjunctive management can include:
    - Storing water when plentiful
    - Relying more on groundwater resources
    - Changing timing and location of water for more efficient use
- Conjunctive management to bring together groundwater and surface water for a more optimal outcome for both
    - Re-time and re-balance within finite water supplies
- Can work to protect existing users and maintain viability
- There is an opportunity with new water rights and in looking at the un-appropriated
- First Increment has included some examples of conjunctive management, including:
    - 2011 pilot project – saw strong diversion rates into the canals and meaningful recharge
    - 2013 flood flows – largely from a flood protection standpoint
- Different conjunctive management approaches in the First Increment have seen benefits and present opportunities
    - Created partners in infrastructure
    - More comfortable permitting and monitoring processes
    - Creating greater resiliency of system
    - Are there places we can be storing water for shared use?
- Funding
    - Investment from surface water and irrigation districts, NRDs, and NeDNR
- Opportunities for conjunctive management will continue to be looked into
- NeDNR is working to develop a decision support system, which will be a tool to assist better use of excess flows throughout the system in order to meet our Goals & Objectives
    - In addition to other conjunctive management activities
- Increasing efficiency in recharge – many different ideas being discussed
- Stakeholders expressed interest in discussing drought and conjunctive management related to one another

5. Stakeholder feedback on guest presentations

- General agreement that Dr. Eisenhauer's presentation was useful and understanding the role of evapotranspiration is important in this process
- Provided a sense of validation in the actions being taken and ideas being discussed – stakeholders feeling on the right track
    - Reductions and allocations have pushed farmers to be better

- Reiterated the importance of conjunctive management in times of flood and in times of drought
    - Want to avoid interests that are at war with each other
    - Also expressed interest in understanding how conjunctive management opportunities could work related to storage and recharging the aquifer
- Some would like to see the incorporation of climate change language in the Second Increment
- Some feel that parts of Nebraska have been facing a kind of drought for years – would like to look at drought recovery options
- Expressed appreciation for the frequent use of the term "we" throughout this meeting – acting as a common body
- Suggested approaching the next increment by looking at system comprehensively as opposed to a problem by problem basis

III. Next Steps

- Consider the possibility that we are already fully appropriated – can continue to discuss this but would like everyone to think about this concept for the next couple of months
- Stakeholders feel free to send thoughts along prior to May meeting

IV. Public Comment

- Jim Eismer with TPNRD board appreciated hearing about the conservation tillage and shared that he once was able to hear in greater detail some estimates on the savings of the evaporation side of the formula and was very surprised by the positive impacts made by using different techniques and different types of mulch
    - Irrigated acres makes a significant difference so would like to see credit given for conservation tillage taking place in NRDs
- Dr. Eisenhauer expressed that it is great to see former students working on water planning for the state
- Conjunctive management as it relates to excess flows and the fish and wildlife target flows program – changes to target flows could change the type of projects considered as part of a program extension that is identifying top priorities as a prevention service
    - Pointed out that in big flow years this likely won't make a difference, but asked that governing bodies keep this in mind moving forward

Next Meeting: May 16, 2018

Meeting Date: March 21, 18

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Attended?	Name	Email Address	Affiliation	Primary or Alternate
		SPG Primary Members		
TA	Anderson, Tyrell	tyrell.anderson@retranches.com	North Platte NRD	Primary
BB	Barels, Brian	blbarel@nppd.com	Public Power & Irrigation District	Primary
	Bendfeldt, Jim	jcb1@fastmail.com	Central Platte NRD	Primary
yes	Busch, Bob	rnbusch@actcom.net	Surface Water User	Primary
yes	Dahlgren, Bob Bob Dahlgren	Rdahlgren@fsbloomis.com	Municipality – Village of Bertrand	Primary
	Derry, Kevin	derrykb@embarqmail.com	Agriculture	Primary
Don Masten	Downey, Thomas	tdowney@downeydrilling.com	Ground Water User	Primary
R D Edeal	Edeal, Russell	redeal@atcjet.net	Agriculture	Primary
	Eggleston, Judy	JudyEggleston@aol.com	Irrigation District	Primary
BJF	Fehringer, Bernard	bfehringer@icloud.com bernie.fehringer@wheatbelt.com	Public Power	Primary
DF	Fisher, Dave	dpfisher@scottsbluff.net	Surface Water User	Primary
	Gatch, Richard	Rgatch1@unl.edu	Surface Water User	Primary
BH	Halligan, Bill	Bill.halligan@pwcbank.com	South Platte NRD Board	Primary
	Heath, Pat	pheath@gering.org	Municipality – City of Gering	Primary
	Henkel, Chuck	henkelchuck@yahoo.com	North Platte NRD Board	Primary
LH	Hoehn, Leo	Leo.hoehn@gmail.com	Groundwater Irrigator	Primary
KDK	Koupal, Keith	keith.koupal@nebraska.gov	Environment/Wildlife	Primary
CE Holley	Kramer, Erwin	backflow79@hotmail.com	Municipality – City of North Platte	Primary
	Kraus, Don	Dkraus@cnppid.com	Irrigation District	Primary
GL	Larson, Galen	glarson@pvbank.com	Financial	Primary
	Luchsinger, Tim	tluchsinger@grand-island.com	Municipality – City of Grand Island	Primary
VJN	Nelson, Vernon	vernonjamesnelson@yahoo.com	Agriculture/Groundwater User	Primary
	Paulman, Roric	rpaulman@gpcom.net	Agriculture	Primary
	Pepplitsch, Joe	jpepp@cityoflex.com	Municipality – City of Lexington	Primary
JR	Revelle, Jack	jrevelle@vistabeam.com	Ground Irrigator	Primary
	Reynolds, Larry	larryreynolds68@gmail.com	Tri-basin NRD Board	Primary
JR	Richeson, Jay	jay@gothenburgirrigation.com	Municipality – Gothenburg	Primary
Rodney Schaneman	Schaneman, Rodney	raschman@charter.net	Surface Water User	Primary
D. S.	Schilz, Dennis	dennisschilz@gmail.com	Irrigation District	Primary
CS	Sisk, Carson	Kimballwater@kimballne.org	Municipality – City of Kimball	Primary
DS	Strauch, Dennis	dennis@pathfinderirrigation.com	Irrigation District – Pathfinder Irrigation	Primary

Meeting Date:______________

	Strommen, Kendra	strommen@mmmlawoffice.com	Financial	Primary
JSW	Wahlgren, Joe	wahlgrenfarms@gmail.com	Twin Platte NRD Board	Primary
SPG Alternate Members				
	Albrecht, Frank	frank.albrecht@nebraska.gov	Environment/Wildlife	Alternate
	Andreas, Kent	kandreas@embarqmail.com	North Platte NRD Board	Alternate
DB	Burnside, Dennis	dburnside@cityoflex.com	Municipality – City of Lexington	Alternate
	Clymer, Bruce	bclymer@cityofgothenburg.org	Municipality – Gothenburg	Alternate
	Derry, Jared	Jared.derry@gmail.com	Agriculture	Alternate
	Downey, Brent	bdowney@downeydrilling.com	Ground Water User	Alternate
[illegible]	Drain, Mike	mdrain@cnppid.com	Irrigation District	Alternate
	Henry, Chris	cnhenry144@hotmail.com	Central Platte NRD Board	Alternate
	Hock, Andrew	andrew.extremeag@gmail.com	Agriculture	Alternate
	Holley, Chris		Municipality – North Platte	Alternate
	Jameson, Rhodel		Agriculture/Groundwater User	Alternate
	Larson, Joe	joelarson21@gmail.com	Tri-basin NRD Board	Alternate
	Meismer, Jim	tpnrd1jimm@gmail.com	Twin Platte NRD Board	Alternate
	Meyer, Doug	dgmeyer@NPanhandle.net	Municipality – City of North Platte	Alternate
	Narjes, Kathy	rodekohr@hotmail.com	South Platte NRD Board	Alternate
	Ortiz, Daniel	DOrtiz@kimballne.org	Municipality – City of Kimball	Alternate
JS	Shafer, Jeff	jtshafe@nppd.com	Public Power & Irrigation	Alternate
	Smith, Ann	annck@cozadtel.net	Irrigation District	Alternate
	Snarr, Paul	psnarr@gering.org	Municipality – City of Gering	Alternate
	Zach, Randy		Public Power & Irrigation District	Alternate
POAC Members				
	Adane, Zaibon		NDNR	
	Benson, Kathy	Kathy.Benson@nebraska.gov	NDNR	
	Berge, John	jberge@npnrd.org	North Platte NRD	
	Bodner, Lacey	Lacey.bodner@nebraska.gov	NDNR	
BC	Cross, Barb	bcross@npnrd.org	North Platte NRD	
	Crowe, Kayla	kayla.crowe@nebraska.gov	NDNR	
	Czaplewski, Mark	Mark@cpnred.org	Central Platte NRD	
	Dimmitt, Ann	afisher@tpnrd.org	Twin Platte NRD	
	Eckles, Beth		NDNR	
TG	Glanz, Travis	tglanz@spnrd.org	South Platte NRD	
	Hopkins, Kyle Ann		North Platte NRD	
RLH	Horn, Rod	rlhorn@spnrd.org	South Platte NRD	
KOM	Miller, Kent	komiller@tpnrd.org	Twin Platte NRD	
JBM	Mintken, Jesse	mintken@cpnrd.org	Central Platte NRD	

Meeting Date:______________

	Mosier, Melissa	melissa.mosier@nebraska.gov	NDNR
	Osborn, Colby		NDNR
RR	Reisdorff, Ryan	rreisdorff@spnrd.org	South Platte NRD
JJS	Schellpeper, Jennifer	jennifer.schellpeper@nebraska.gov	NDNR
JT	Thorburn, John	jthorburn@tribasinnrd.org	Tri-Basin NRD
	Vogt, Lyndon	vogt@cpnrd.org	Central Platte NRD
	Strom, Jessie	jessie.strom@nebraska.gov	NDNR
	Woodward, Duane	woodward@cpnrd.org	Central Platte NRD
TZ	Zayac, Tracy	Tzayac@npnrd.org	North Platte NRD
	Zoller, Amy	amy.zoller@nebraska.gov	NDNR
Members of the Public			
DM	Don Mosten	dmosten@downeydrilling.com	Downey Drilling
JB	Jesse Bradley		NeDNR
JE	John Engel		HDR

Agenda

Project:	Upper Platte River Basin Water Management Plan – Single Planning Group
Subject:	Meeting #11
Date:	Wednesday, May 16, 2018 from 10:30 a.m. to 3:00 p.m.
Location:	Holiday Inn Express & Suites, North Platte, NE

Agenda:

I. Administration
   1. Today's meeting will offer a working lunch
   2. This is an Open Meeting
   3. Review of Decision-Making Process
   4. March Meeting Recap
      i. Meeting minutes
      ii. Key discussion / decisions
      iii. Follow-up items

II. Elements of Draft Second Increment Plan

III. Identification of Second Increment Intent

IV. Next Steps

V. Public Comment

Next Meeting: September 19, 2018

Meeting Minutes

Project:	Upper Platte River Basin Water Management Plan – Single Planning Group
Subject:	Meeting #11
Date:	Wednesday, May 16, 2018 from 10:30 a.m. to 3:00 p.m.
Location:	Holiday Inn Express & Suites, North Platte, NE

I. Administration

1. Today's meeting will offer a working lunch
2. This is an Open Meeting
3. Review of Decision-Making Process
4. March Meeting Recap
    - i. Meeting minutes
    - ii. Key discussion / decisions
    - iii. Follow-up items
        - Since the last SPG meeting, NeDNR held several meetings with stakeholders who requested more detail into specific action items

II. Elements of Draft Second Increment Plan

Note: Edits were made in the Second Increment Outline which will be published separately from these minutes

III.

Discussion included:

- Goal 6. Issues/concerns include:
    - Recommendation to reword Goal to include reference to "while implementing this plan"
    - Objective 1:
        - Concern with 3-year timeframe; this will open up planning process and will have to re-engage stakeholders.
        - Change wording to remove the timeframe and reference to amending plan
        - Concern about limiting to only hydropower uses
        - Concern that addressing one problem will create another somewhere else
        - Mitigation option is to buy out hydro. Are we willing to tax producers to offset power production? The mitigation option may be the opposite of economic viability

   - Recognition that water that is used for hydro (except during winter) also has other purposes; there is maintenance, cooling water for power plant, irrigation supply, other deliveries
   - A lot of other things in basin impact economic viability besides water.
   - Recognition that NRDs are mitigating and putting water back in river for all downstream users, this is not new, and not just hydro; follow priority list of water users
   - Concern that objective must also tie back into achieving goal 1. (fully appropriated)
- Objectives 1 & 2:
   - Combine
   - Add "Explore mitigation options that impact the greatest number of users"
- Objective 2:
   - Concern about limiting to surface water use, reword to include groundwater uses
   - Recognize that cyclical supply drives GW response and associated depletions; need to take out specificity of SW users
- Suggestion to include reference to ecological system
- Objective 3:
   - Consider relaxing surface water regulations in times of excess flows and allow for the use of excess flows within the basin;
   - Concern that "within the basin" limits NRDs from transferring water out of basin;
   - "Excess flows" is not technically correct terminology, use "non-appropriated flows" or change to "explore use of flows"
   - Strike completely as that is just the definition of conjunctive management
- Objective 4:
   - Clarify if basin-wide drought plan needed; or if each NRD completes own drought plan. Drought plan should reference IMP. Modify Goal language to encompass "E" and guide the goal statement
   - Concern that financial offset alludes to producers thinking they can be given financial offsets if they are not given the full allotment. Request to delete or be more specific
   - Objective 4A: Request to not limit survey to just water users, replace with "stakeholders". Discussion on difference between stakeholder group (will not exist after completion of plan) and stakeholders. Find inclusive term and tie to Goal 3
- Objective 5:
   - Request to add reference to "collaboration with stakeholders" to monitor economic viability indicators and determine mitigation options.
   - Discussion that it was not envisioned that stakeholders would be brought back into the process to amend the plan. Since group will meet annually to review, add review of economic viability to Goal 3

        - Concern that this is too general. Suggestion to define sustainability and define what economic viability indicators are
        - Recommendation to strike objective
        - Question that economic viability is or is not a concern in times that are outside of drought? Replace objective 5 with “Assess economic impacts of regulations and other management actions”
- Goal 1:
    - Suggestion to include word changes to updating modeling to capture technological advances and climatic changes
    - Concern that water used in crop production is not as consumptive as it is being modeled and depletions are being overstated
    - Suggestion to add language about incorporating dynamic data that adjusts to what reality is for precipitation (note: COHYST and WWUM are being brought to current)
    - Fully Appropriated/Overappropriated: Suggestion that basin is FA and should be defined based on whether uses are being met. NeDNR provided short presentation on what it means to be FA and interrelated moving parts. Suggestion that basin needs drought plan. Offsets will still need to be made for municipal growth and new uses
    - Recommendation to strike objective 6 about funding/policies/rules. It was stated that objective would need to be completed in an open and transparent and involve the stakeholders. However, there is no binding agreement for stakeholder group beyond this plan
- Goal 5:
    - Concern that goal is not understood
    - Consideration that it should fit under another goal instead of being stand-alone goal
    - Suggestion to put conservation and water use efficiency in Goal 6.
    - Suggestion to clarify objective by stating that individual IMPs will specify how law change is handled in 2026. (After 2026, NRD will oversee how municipalities and users offset depletions). Goal 3 or Goal 5?
- Goal 3:
    - Reporting success in the future (frequency). HDR/NeDNR will add language regarding more transparency
- Goal 4:
    - Objective 3 (Water Quality)
        - Intent was for environmental vitality of the basin. Recommendation to strike from plan
- Request to meter the entire basin. Consideration that this language belongs in individual IMPs, not Basin-wide Plan
- Concern that sustainability is missing from Plan. Need to determine what is sustainable in this process. Suggest to define metric for knowing when we’ve

reached our goals. NeDNR presented graphic showing interaction between aquifer, stream flow, and economic viability in defining sustainability

- Concern about accounting for groundwater pumping
- Concern about pre-development depletions compared to now

Parking Lot Issues

- Accounting for Surface Water Appropriators: no current concerns, strike from parking lot
- Fish, wildlife, parklands: Concern that plan does not recognize water quality and ecological integrity. Nebraska Game and Parks will make recommendation of what is missing from plan and what to add, if necessary
- Management of the resource: no current concerns, has been addressed in plan. Strike from parking lot

IV. Identification of Second Increment Intent

- Suggestion that for a second increment, drought is really where the problem is

V. Next Steps

VI. Public Comment - None

Next Meeting: September 19, 2018 – Consideration to lengthen meeting

Meeting Date: May 16, 2018

CPNRD Central Platte Natural Resources District | North Platte Natural Resources District | South Platte Natural Resources District | Tri-Basin Natural Resources District | Twin Platte Natural Resources District | Nebraska Department of Natural Resources

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		SPG Primary Members		
TA	Anderson, Tyrell	tyrell.anderson@retranches.com	North Platte NRD	Primary
BLB	Barels, Brian	blbarel@nppd.com	Public Power & Irrigation District	Primary
JWB	Bendfeldt, Jim	jcb1@fastmail.com	Central Platte NRD	Primary
	Busch, Bob	rnbusch@actcom.net	Surface Water User	Primary
Bob Dahlgren	Dahlgren, Bob	Rdahlgren@fsbloomis.com	Municipality – Village of Bertrand	Primary
	Derry, Kevin	derrykb@embarqmail.com	Agriculture	Primary
	Downey, Thomas	tdowney@downeydrilling.com	Ground Water User	Primary
RDE	Edeal, Russell	redeal@atcjet.net	Agriculture	Primary
JE	Eggleston, Judy	JudyEggleston@aol.com	Irrigation District	Primary
BJF	Fehringer, Bernard	bfehringer@icloud.com bernie.fehringer@wheatbelt.com	Public Power	Primary
DF	Fisher, Dave	dpfisher@scottsbluff.net	Surface Water User	Primary
	Gatch, Richard	Rgatch1@unl.edu	Surface Water User	Primary
BH	Halligan, Bill	Bill.halligan@pwcbank.com	South Platte NRD Board	Primary
PH	Heath, Pat	pheath@gering.org	Municipality – City of Gering	Primary
	Henkel, Chuck	henkelchuck@yahoo.com	North Platte NRD Board	Primary
	Hoehn, Leo	Leo.hoehn@gmail.com	Groundwater Irrigator	Primary
KK	Koupal, Keith	keith.koupal@nebraska.gov	Environment/Wildlife	Primary
C Holley	Kramer, Erwin	backflow79@hotmail.com	Municipality – City of North Platte	Primary
DDK	Kraus, Don	Dkraus@cnppid.com	Irrigation District	Primary
HK	Larson, Galen	glarson@pvbank.com	Financial	Primary
	Luchsinger, Tim	tluchsinger@grand-island.com	Municipality – City of Grand Island	Primary
VJN	Nelson, Vernon	vernonjamesnelson@yahoo.com	Agriculture/Groundwater User	Primary
	Paulman, Roric	rpaulman@gpcom.net	Agriculture	Primary
	Pepplitsch, Joe	jpepp@cityoflex.com	Municipality – City of Lexington	Primary
JDR	Revelle, Jack	jrevelle@vistabeam.com	Ground Irrigator	Primary
LR	Reynolds, Larry	larryreynolds68@gmail.com	Tri-basin NRD Board	Primary
JR	Richeson, Jay	jay@gothenburgirrigation.com	Municipality – Gothenburg	Primary
Rodney A. Schaneman	Schaneman, Rodney	raschman@charter.net	Surface Water User	Primary
	Schilz, Dennis	dennisschilz@gmail.com	Irrigation District	Primary
CS	Sisk, Carson	Kimballwater@kimballne.org	Municipality – City of Kimball	Primary
DS	Strauch, Dennis	dennis@pathfinderirrigation.com	Irrigation District – Pathfinder Irrigation	Primary

Meeting Date: 5-16-18

	Strommen, Kendra	strommen@mmmlawoffice.com	Financial	Primary
	Wahlgren, Joe	wahlgrenfarms@gmail.com	Twin Platte NRD Board	Primary
	SPG Alternate Members			
	Albrecht, Frank	frank.albrecht@nebraska.gov	Environment/Wildlife	Alternate
	Andreas, Kent	kandreas@embarqmail.com	North Platte NRD Board	Alternate
dB	Burnside, Dennis	dburnside@cityoflex.com	Municipality – City of Lexington	Alternate
	Clymer, Bruce	bclymer@cityofgothenburg.org	Municipality – Gothenburg	Alternate
	Derry, Jared	Jared.derry@gmail.com	Agriculture	Alternate
	Downey, Brent	bdowney@downeydrilling.com	Ground Water User	Alternate
[illegible]	Drain, Mike	mdrain@cnppid.com	Irrigation District	Alternate
	Henry, Chris	cnhenry144@hotmail.com	Central Platte NRD Board	Alternate
	Hock, Andrew	andrew.extremeag@gmail.com	Agriculture	Alternate
	Holley, Chris		Municipality – North Platte	Alternate
	Jameson, Rhodel		Agriculture/Groundwater User	Alternate
	Larson, Joe	joelarson21@gmail.com	Tri-basin NRD Board	Alternate
	Meismer, Jim	tpnrd1jimm@gmail.com	Twin Platte NRD Board	Alternate
	Meyer, Doug	dgmeyer@NPanhandle.net	Municipality – City of North Platte	Alternate
	Narjes, Kathy	rodekohr@hotmail.com	South Platte NRD Board	Alternate
	Ortiz, Daniel	DOrtiz@kimballne.org	Municipality – City of Kimball	Alternate
JS	Shafer, Jeff	jtshafe@nppd.com	Public Power & Irrigation	Alternate
	Smith, Ann	annck@cozadtel.net	Irrigation District	Alternate
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	Zach, Randy		Public Power & Irrigation District	Alternate
	POAC Members			
	Adane, Zaibon		NDNR	
	Benson, Kathy	Kathy.Benson@nebraska.gov	NDNR	
[illegible]	Berge, John	jberge@npnrd.org	North Platte NRD	
	Cross, Barb	bcross@npnrd.org	North Platte NRD	
	Crowe, Kayla	kayla.crowe@nebraska.gov	NDNR	
	Czaplewski, Mark	Mark@cpnred.org	Central Platte NRD	
AMD	Dimmitt, Ann	afisher@tpnrd.org	Twin Platte NRD	
	Eckles, Beth		NDNR	
TG	Glanz, Travis	tglanz@spnrd.org	South Platte NRD	
	Hopkins, Kyle Ann		North Platte NRD	
RLH	Horn, Rod	rlhorn@spnrd.org	South Platte NRD	
KOM	Miller, Kent	komiller@tpnrd.org	Twin Platte NRD	
	Mintken, Jesse	mintken@cpnrd.org	Central Platte NRD	
MMM	Mosier, Melissa	melissa.mosier@nebraska.gov	NDNR	

Meeting Date: 5-16-18

	Osborn, Colby		NDNR
Ryan Reisdorff	Reisdorff, Ryan	rreisdorff@spnrd.org	South Platte NRD
✓ JS	Schellpeper, Jennifer	jennifer.schellpeper@nebraska.gov	NDNR
	Shaw, Landon	lshaw@tpnrd.org	Twin Platte NRD
JT	Thorburn, John	jthorburn@tribasinnrd.org	Tri-Basin NRD
[illegible]	Vogt, Lyndon	vogt@cpnrd.org	Central Platte NRD
JRS(W)	Winter, Jessie	jessie.winter@nebraska.gov	NDNR
	Woodward, Duane	woodward@cpnrd.org	Central Platte NRD
	Zayac, Tracy	Tzayac@npnrd.org	North Platte NRD
	Zoller, Amy	amy.zoller@nebraska.gov	NDNR
Members of the Public			
✓	Williams, Ann		HDR
WP	Jesse Bradley	jesse.bradley@nebraska.gov	NeDNR
	Jason Farnsworth	farnsworthj@headwaterscorp.com	PRRIP
	Dani Bischoff	danielle.bischoff@nebraska.gov	NeDNR
	Beth Eckles	beth.eckles@nebraska.gov	NeDNR
	Dustin Wilcox	dwilcox@nrdnet.org	NARD
~~[illegible]~~	~~Mike Drain~~		~~CNPPID~~

Agenda

Project:	Upper Platte River Basin Water Management Plan – Single Planning Group
Subject:	Meeting #12
Date:	Wednesday, September 19, 2018 from 10:30 a.m. to 3:00 p.m.
Location:	Holiday Inn Express & Suites, North Platte, NE

Agenda:

I. Administration
   1. Today's meeting will offer a working lunch
   2. This is an Open Meeting
   3. Review of Decision-Making Process
   4. May Meeting Recap

II. 2nd Increment Review & Consensus

III. Next Steps

IV. Public Comment

Upper Platte River Basin Water Management Plan – Single Planning Group Meeting #12 Minutes

Project:	Upper Platte River Basin Water Management Plan – Single Planning Group
Subject:	Meeting #12
Date:	Wednesday, September 19, 2018 from 10:30 a.m. to 3:00 p.m.
Location:	Holiday Inn Express & Suites, North Platte, NE

I. **Administration:** Stephanie White, HDR, opened the meeting at 10:37 a.m. CT. She reminded the group that all districts in the basin have begun the IMP process. Stephanie referenced the handouts, which include the agenda, a copy of the slides, a draft copy of goals and objectives thus far, and a table of contents. She reminded the group of the water management planning values.
   1. **Today's meeting will offer a working lunch**
   2. **This is an Open Meeting:** Stephanie stated the meeting is open and notices were published in five newspapers. She pointed out the copy of the open meetings act in the room.
   3. **Review of Decision-Making Process:** She reminded the group of the decision-making process in which the goal is consensus, if not, a majority. She stated if a majority is not reached, NeDNR and the NRDs will work together to solve disputes and to create a final plan.
   4. **May Meeting Recap:** Stephanie reviewed what was completed in May and noted that the group will be able to see a reflection of the discussion at the last meeting in updates to the plan, and specifically in Goal #1.

II. **2nd Increment Review & Consensus:** Stephanie stated that this process was initiated in 2015 and that today is the 12th stakeholder meeting, and discussed the collaboration effort that included stakeholders, alternates, regular participants, NeDNR, and NRDs. By April of 2019, the NRDs and NeDNR will begin the process of adopting a basin-wide plan, which will require a public hearing. The first annual meeting for the 2nd increment basin-wide plan will happen in the summer of 2020. In 2026, planning for the 3rd increment of the Upper Platte basin-wide plan will be initiated. She noted that all the individual IMPs currently in progress must be consistent with the basin-wide plan.

   Jennifer Schellpeper (NeDNR) stated that in addition, there have been many small group meetings between NeDNR, NRDs, and some stakeholders over the course of the last few months regarding the draft plan.

   Stephanie took roll and noted the number of voters in the room (24 primary voters in attendance today). If there is a goal that the group is willing to take as is, the group will not spend time talking about it today. Each voting member used previously provided red, yellow, and green cards to represent their votes for each goal.

   Goal #5: Keep the Upper Platte Basin-Wide Plan current and keep stakeholders informed.
   - Vote on Goal #5:

- Green: 23, Yellow: 0, Red: 1
- Will revisit discuss Goal #5 if there is time at the end of the meeting

Goal #4: Work cooperatively to identify and investigate disputes between groundwater users and surface water appropriators and, if determined appropriate, implement management solutions to address such issues.

- Vote on Goal #4:
  - **Green: 24**, **Yellow: 0**, **Red: 0**

Goal #3: Partner with municipalities and industries to maximize conservation and water use efficiency.

- Vote on Goal #3:
  - **Green: 20**, **Yellow: 4**, **Red: 0**
  - Will revisit Goal #3

Goal #2: Prevent or mitigate human-induced reductions in the flow of a river or stream that would cause non-compliance with an interstate compact or decree or other formal state contract or agreement.

- Vote on Goal #2:
  - **Green: 21**, **Yellow: 2**, **Red: 1**

Goal #1: Incrementally achieve and sustain a fully appropriated condition while maintaining economic viability, social and environmental health, safety, and welfare of the basin

- Vote on Goal #1:
  - **Green: 12**, **Yellow: 9**, **Red: 3**

- Stephanie noted Goal #1 includes the most new content (objectives and action items) to be discussed, and stated some stakeholders have submitted content for this goal**.** Stephanie counted a vote on just the goal itself (not including objectives and action items) as a formality, since it hasn't changed since the last meeting.
  - **Green: 22**, **Yellow: 2**, **Red: 0**

- Stakeholder comment:
  - Questioning whether or not the basin is already fully appropriated (FA) and suggestion that a simpler definition of FA be decided upon. We should recognize that water is reusable and should also include 'water 101' in this plan.

- Stakeholder asked for a vote on his proposal that the basin-wide plan indicate that the Upper Platte Basin is already FA:
  - Green: 2, Yellow: 10, Red: 11

- Summary of discussion on proposed **Goal 1** and stakeholder's FA suggestion:
  - Discussion on whether the concepts that the stakeholders are currently asking for are satisfactorily addressed in the basin-wide plan. A stakeholder stated that they agree that mitigation should be a focus. A stakeholder pointed out the conflict between the eastern and western portions of the basin, and that recognizing the basin as FA could be a way to resolve this. The plan does not specifically include "water 101" but there is a lot of information about the hydrology of the basin and the variability of supplies. A stakeholder stated that they would like the plan to recognize that crop production can be a reusable source of water, and that the plan needs to focus on the future instead of water use for the current generation. The stakeholder is not suggesting any particular change to the plan, but a goal of simplicity, flexibility, and taxpayer friendliness. Another stakeholder asked if there had been a decision between overappropriated (OA) and FA, and noted that the wording says "current", not

OA. NeDNR pointed out that the language comes from statute, and that the plan is trying to balance statute language with the information needed to represent the current situation. When asked if the wording of OA would ever change, NeDNR responded that the words can't change, but the action in the plan can change; therefore, there needs to be a focus on action, and not wording. The action is focused on drought mitigation and developing a drought plan.

- Summary of discussion on **Table 1.1.1: First Increment Robust Review Results Summary**
  - NeDNR is still working on the final numbers, but there has not been significant change from the preliminary data presented in January. The table is blank because the data has not been finalized yet. The data will continue to be updated throughout the next increment. A stakeholder expressed concern that the information takes so long to update. Another stakeholder stated that they felt uncomfortable voting without adequate information and would like the stakeholders to be better informed. Another stakeholder expressed concern with wasting time on the tables without numbers. NeDNR asked whether or not presentation of final numbers would change stakeholder agreement on goals or objectives; a stakeholder responded that it will cause stakeholders to vote 'no' due to lack of information. Another stakeholder later reiterated this point. NeDNR stated that the numbers will be in the table before the public meetings and hearing, and that there will be many opportunities to provide input later in the process. The initial numbers from the robust review will be in the table by the time each NRD has to adopt the plan.

  - A stakeholder asked if there is flexibility in the basin-wide plan to remove regulations if the updated numbers show that the set goals have been exceeded. Another stakeholder stated that it would be up to the NRD's board of directors.

  - A stakeholder suggested that the basin-wide plan should state what happens when the basin becomes FA, and NeDNR clarified that the plan says once the basin becomes FA, it must maintain that condition.

  - A stakeholder pointed out that the regulations are all on the western part of the state, and asked where the "saved" water goes. It was noted that the regulations in the western NRDs are not articulated in this plan; they are part of the individual IMPs. Statute says we are to protect existing users, but each NRD has the ability to choose management actions in order to reach that goal. A stakeholder reminded the group that statute is where a lot of the wording and requirements are coming from, and that they are trying to provide as much flexibility as possible.

  - A stakeholder asked why the NRDs are at different points; some have met their goals while others have not. NeDNR responded that first increment goals were met by every NRD, and that this group is planning for the second increment.

  - A stakeholder expressed confusion between positive and negative numbers because negative numbers indicate a positive result. Stephanie suggested that could relate to Goal #5 on how to keep stakeholders better informed and how NeDNR and the NRDs can help the public better understand.

  - A stakeholder asked if there is something in the figures to recognize lost value of using and reusing water. NeDNR referenced the section of the plan that talks about use of best available science. Stephanie said that the plan does not state what the best available science is, simply that it is being used.

- A stakeholder pointed out that the group is not adopting the plan, but approving the format, and proper information will be provided once finalized. The group should focus on providing NRDs and NeDNR the information that they need to implement management within the basin.

- Another stakeholder asked for a vote on whether the basin is FA or not. Stephanie called for the vote on whether or not the *basin* is FA (Green: FA, Red: Not FA):
  Red: 14, majority

Goal #2: Prevent or mitigate human-induced reductions in the flow of a river or stream that would cause non-compliance with an interstate compact or decree or other formal state contract or agreement.

- Summary of discussion on **Goal #2**:
  - A stakeholder questioned the definition of environmental health and expressed interest in seeing water quality reporting becoming part of an action item in the plan. A stakeholder said environmental health includes water quality, so it is indirectly included in the plan. Including statistics or requiring annual reporting about water quality in the plan would be confusing because NeDNR has no jurisdiction of water quality issues. The group came to the conclusion that these water quality metrics are already available through other state and federal agencies.

  - Vote to include 10-year report of water quality metrics in the basin-wide plan in Goal #2:
    - Green: 2, Yellow: 0, Red: 21, Abstained: 1
  - Vote on the approval of Goal #2:
    - **Green: 23**, **Yellow: 0**, **Red: 1**

Goal #3: Partner with municipalities and industries to maximize conservation and water use efficiency.

- Summary of discussion on **Goal #3**:
  - NeDNR discussed updates to Objective 3.3 and associated action items. Changes were made following stakeholder conversations and individual IMP stakeholder meeting discussions on municipal/industrial uses and setting baselines (allocations). According to statute, NRDs are responsible for offsetting new uses over an established baseline prior to 2026, but after 2026, an NRD can require the municipality or industry to offset any uses above the baseline. A stakeholder asked if NRDs can establish new baselines that are higher than what they were before and how the baselines are calculated. NeDNR responded that for municipalities in 2026, the amount is either what they had in a permit or their greatest annual use up to 2026. Lyndon Vogt, CPNRD Manager, said the NRDs are responsible for offsetting anything above 1997 use. The NRDs will determine if/how they will offset for municipal and industrial uses in their IMPs.

  - Vote to approve Goal #3:
    - **Green: 23**, **Yellow: 0**, **Red: 1**

Goal #1: Incrementally achieve and sustain a fully appropriated condition while maintaining economic viability, social and environmental health, safety, and welfare of the basin

- Summary of discussion on Goal #1 (**Action Item 1.3.4**)
  - Drought contingency plan – a new component in the basin-wide plan
  - Stephanie called for an early vote to see if stakeholders would approve Action Item 1.3.4 as is, or if there needs to be a discussion

        - Green: 18, Yellow: 0, Red: 6
    - Suggestions from stakeholders for the drought plan action item (1.3.4)
        - A stakeholder suggested adding a time period in the action item to develop the drought plan in 3 or 5 years.
        - Add a new action item (1.3.4.5) that would say "to implement the basin drought contingency plan during times of drought."
        - A stakeholder said annual review in the middle of the drought is not good enough and asked how to make sure it is going to happen. NeDNR responded that once a drought plan is developed, it will be in the basin-wide plan, which is reviewed annually. A stakeholder said 1.3.4.4 reflects that.
        - A stakeholder suggested adding a more concrete requirement of something that is done, other than education, etc. They would like to see more water available to impacted users, more stakeholder involvement in identifying solutions, and specific solutions developed with stakeholders. Noted that when this group ends, there isn't a "stakeholder group", but "affected water users" who will be included in these drought planning conversations. This language is included, rather than "stakeholders" to avoid confusion. Example: Action items under Objective 1.3 references "impacted water users."
        - A stakeholder asked if managing storage water is the only mitigation action that the group wants to mention in 1.3.4.2? A stakeholder asked if someone didn't use their full allocation this year, would there be a reward during drought for those who are preparing before times of drought? NeDNR suggested a drought planning workshop could address this and a drought plan would recognize this. Another stakeholder suggested deleting the example of "management of storage water" in Action Item 1.3.4.2 to strengthen language and add clarity

    - Votes on 1.3.4, with changes agreed on today
        - **Green: 23**, **Yellow: 0**, **Red: 1**

- Summary of discussion on Goal #1 (**Action item 1.3.3**):
    - A stakeholder asked how the water market works and expressed concern about differences in selling water at different ends of the state. A stakeholder suggested new action item or working that emphasizes implementation.

    - Vote to accept Action Item 1.3.3:
        - **Green: 23**, **Yellow: 0**, **Red: 1**

- Summary of discussion on Goal #1 (**Objective 1.4**):
    - A stakeholder asked for clarification on getting back to FA if the basin is declared OA now. NeDNR responded that under the law, in terms of changing the title from OA to FA, there is an interpretation that it can't be done. However, that is not the same thing as saying we can't take the actions we agree would be beneficial for the basin because the plan anticipates that we gate back to FA and maintain it. This objective is focused on the technical analysis used to evaluate getting back to the FA condition. The wording is based on statute.

    - Vote to accept Action Item 1.4:
        - **Green: 24**, **Yellow: 0**, **Red: 0**

- Summary of discussion on Goal #1 (**Objective 1.5):**

- A stakeholder expressed concern with the cost of this plan from a tax point of view and would like to reevaluate cost and simplicity of the plan; is there any way to consider the taxpayer in this plan? A stakeholder suggested using a term like "cost-effective". Stephanie suggested "use available funds and actively pursue new funding opportunities to cost effectively offset depletions…"

- Vote to accept Objective 1.5, with the wording discussed above?
  - **Green: 24**, **Yellow: 0**, **Red: 0**

- Summary of discussion on Goal #1 (**Objective 1.3**)
  - John Engel, HDR**:** Discussed broad context of Objective 1.3 that would help stakeholders understand the intent of the goal overall. Noted how these Action Items can help to answer some questions that came up in earlier discussion.

  - Vote on Action Item 1.3.1:
    - **Green: 24**, **Yellow: 0**, **Red: 0**

  - Votes to accept Action Item 1.3.2:
    - **Green: 24**, **Yellow: 0**, **Red: 0**

- Summary of discussion on Goal #1 (**Objective 1.6**)
  - Discussed that transfers of certified acres across NRD boundaries would be at the NRDs' discretion.

  - Vote to accept Objective 1.6:
    - **Green: 24**, **Yellow: 0**, **Red: 0**

- Summary of discussion on Goal #1 (**Objective 1.1**):
  - A stakeholder said that the plan should mention that flexibility is necessary if this is about maintaining achievements. NeDNR noted in the text under the Action Item that there is wording that references flexibility and that progress from the first increment needs to be maintained. A stakeholder asked if there should be a date on which the basin has to reach 1997 levels. A stakeholder pointed out that the next Action Item says "levels will be met within this increment." A stakeholder said that Action Item 1.1.1 says there is likely going to be funding changes, and asked if it is possible to maintain the levels met in the first increment if that happens. Stephanie suggested adding wording such as "insofar as possible" or "as fiscally possible." A stakeholder asked, in the case of an NRD that exceeded their requirements for the first increment, if that makes up for progress needed in the second increment. NeDNR responded that it is part of getting back to a fully appropriated condition. A stakeholder voiced concerns regarding cost of having to maintain the condition. A stakeholder suggested the wording of "maintaining what has been achieved" be revised to "system viability must be maintained, but flexibility is essential." Stephanie pointed out that changes the intent. A stakeholder had issue with the word "efforts" and asked it to be changed to "progress." NeDNR pointed out that "insofar as possible" could be an excuse not to do anything. A stakeholder further voiced concerns about being able to maintain what has been achieved with limited budgets. NeDNR asked if introducing "cost effective" or "cost benefit" to 1.1.1 would help.

  - Vote to accept Objective 1.1, with modifications to include 'cost benefit analysis,' 'flexibility,' and 'progress.'
    - **Green: 24**, **Yellow: 0**, **Red: 0**

- Summary of discussion on Goal #1 (**Objective 1.2**):

    - A stakeholder pointed out that the plan doesn't recognize the airborne side of the water 101 equation and that water is reusable, and asked if it needs to be considered. NeDNR said their models consider evapotranspiration and precipitation. A stakeholder asked if the loss of value due to using and reusing water needs to be considered. NeDNR discussed how the models measure everything and take the value of using and reusing water into account.

    - Vote to accept Objective 1.2:
        - **Green: 24**, **Yellow: 0**, **Red: 0**

- **Goal #5:**
    - Vote to accept Goal #5:
        - **Green: 24**, **Yellow: 0**, **Red: 0**

- Stephanie asked the group if they felt comfortable with Goal #1 overall, since objectives were discussed out of order.
    - **Stakeholder:** Referencing Action Item 1.3.3.3, on markets. "How can, during drought, some people be marketing in one place, while someone's allocating in another?" Does not feel comfortable with it, but stated that there is no answer. "It will happen again and again."
    - **Stakeholder:** Discussed that there will still be individual NRD control on marketing – local control.
    - **Stephanie:** The requirement in this section is only for a study.
- Stephanie offered stakeholders time to think and called for public comment.

III. Next Steps

IV. Public Comment:

- Jason Farnsworth, PRRIP: Thanked the group for inviting and allowing the public to listen and learn from the meeting. Referenced the conversation on "bang for your buck" and wanted to remind the group that this conversation is going on in other places too. PRRIP has brought a lot of federal money into Nebraska and it has been shown that there are incentives to participating in PRRIP projects. Farnsworth invited questions from stakeholders regarding how the program is helping these efforts financially.

- Stephanie called for a vote for the whole plan
    - (**Stakeholder**: Stated they wanted to change their vote from 'Red' to 'Green' on Action Items 1.3.3 and 1.3.4.)
- **Vote on whole plan:**
    - **Green: 22**, **Yellow: 1**, **Red: 1**

The meeting was adjourned at 3:05 p.m. CT.

Meeting Date: September 19, 2018

CPNRD Central Platte Natural Resources District | North Platte Natural Resources District | South Platte Natural Resources District | Tri Basin Natural Resources District | Twin Platte Natural Resources District | Nebraska Department of Natural Resources

NOTE: Photographs/video may be captured during the meeting. These assets may be used by the NDNR, Districts, or HDR for the sole purpose of marketing, communication about the project and/or advertising. This may include, but is not limited to, printed and published materials on the NDNR, Districts, or HDR website.

Attended?	Name	Email Address	Affiliation	Primary or Alternate
		SPG Primary Members		
✓	Anderson, Tyrell	tyrell.anderson@retranches.com	North Platte NRD	Primary
NO	Barels, Brian	blbarel@nppd.com	Public Power & Irrigation District	Primary
✓	Bendfeldt, Jim	jcb1@fastmail.com	Central Platte NRD	Primary
NO	Busch, Bob	rnbusch@actcom.net	Surface Water User	Primary
✓	Dahlgren, Bob	Rdahlgren@fsbloomis.com	Municipality – Village of Bertrand	Primary
✓	Derry, Kevin	derrykb@embarqmail.com	Agriculture	Primary
NO	Downey, Thomas	tdowney@downeydrilling.com	Ground Water User	Primary
NO	Edeal, Russell	redeal@atcjet.net	Agriculture	Primary
✓	Eggleston, Judy	JudyEggleston@aol.com	Irrigation District	Primary
NO	Fehringer, Bernard	bfehringer@icloud.com bernie.fehringer@wheatbelt.com	Public Power	Primary
✓	Fisher, Dave	dpfisher@scottsbluff.net	Surface Water User	Primary
NO	Gatch, Richard	Rgatch1@unl.edu	Surface Water User	Primary
✓	Halligan, Bill	Bill.halligan@pwcbank.com	South Platte NRD Board	Primary
✓	Heath, Pat	pheath@gering.org	Municipality – City of Gering	Primary
✓	Henkel, Chuck	henkelchuck@yahoo.com	North Platte NRD Board	Primary
✓	Hoehn, Leo	Leo.hoehn@gmail.com	Groundwater Irrigator	Primary
✓	Koupal, Keith	keith.koupal@nebraska.gov	Environment/Wildlife	Primary
NO	Kramer, Erwin	backflow79@hotmail.com	Municipality – City of North Platte	Primary
✓	Kraus, Don	Dkraus@cnppid.com	Irrigation District	Primary
NO	Larson, Galen	glarson@pvbank.com	Financial	Primary
NO	Luchsinger, Tim	tluchsinger@grand-island.com	Municipality – City of Grand Island	Primary
✓	Nelson, Vernon	vernonjamesnelson@yahoo.com	Agriculture/Groundwater User	Primary
NO	Paulman, Roric	rpaulman@gpcom.net	Agriculture	Primary
NO	Pepplitsch, Joe	jpepp@cityoflex.com	Municipality – City of Lexington	Primary
✓	Revelle, Jack	jrevelle@vistabeam.com	Ground Irrigator	Primary
✓	Reynolds, Larry	larryreynolds68@gmail.com	Tri-basin NRD Board	Primary
✓	Richeson, Jay	jay@gothenburgirrigation.com	Municipality – Gothenburg	Primary
✓	Schaneman, Rodney	raschman@charter.net	Surface Water User	Primary
✓	Schilz, Dennis	dennisschilz@gmail.com	Irrigation District	Primary
✓	Sisk, Carson	Kimballwater@kimballne.org	Municipality – City of Kimball	Primary
✓	Strauch, Dennis	dennis@pathfinderirrigation.com	Irrigation District – Pathfinder Irrigation	Primary

Meeting Date:______________

NO	Strommen, Kendra	strommen@mmmlawoffice.com	Financial	Primary
✓	Wahlgren, Joe	wahlgrenfarms@gmail.com	Twin Platte NRD Board	Primary
SPG Alternate Members				
	Albrecht, Frank	frank.albrecht@nebraska.gov	Environment/Wildlife	Alternate
	Andreas, Kent	kandreas@embarqmail.com	North Platte NRD Board	Alternate
✓	Burnside, Dennis	dburnside@cityoflex.com	Municipality – City of Lexington	Alternate
	Clymer, Bruce	bclymer@cityofgothenburg.org	Municipality – Gothenburg	Alternate
	Derry, Jared	Jared.derry@gmail.com	Agriculture	Alternate
	Downey, Brent	bdowney@downeydrilling.com	Ground Water User	Alternate
✓	Drain, Mike	mdrain@cnppid.com	Irrigation District	Alternate
	Henry, Chris	cnhenry144@hotmail.com	Central Platte NRD Board	Alternate
	Hock, Andrew	andrew.extremeag@gmail.com	Agriculture	Alternate
✓	Holley, Chris		Municipality – North Platte	Alternate
	Jameson, Rhodel		Agriculture/Groundwater User	Alternate
	Larson, Joe	joelarson21@gmail.com	Tri-basin NRD Board	Alternate
	Meismer, Jim	tpnrd1jimm@gmail.com	Twin Platte NRD Board	Alternate
	Meyer, Doug	dgmeyer@NPanhandle.net	Municipality – City of North Platte	Alternate
	Narjes, Kathy	rodekohr@hotmail.com	South Platte NRD Board	Alternate
	Ortiz, Daniel	DOrtiz@kimballne.org	Municipality – City of Kimball	Alternate
✓	Shafer, Jeff	jtshafe@nppd.com	Public Power & Irrigation	Alternate
	Smith, Ann	annck@cozadtel.net	Irrigation District	Alternate
	Snarr, Paul	psnarr@gering.org	Municipality – City of Gering	Alternate
	Zach, Randy		Public Power & Irrigation District	Alternate
POAC Members				
	Adane, Zaibon		NDNR	
	Benson, Kathy	Kathy.Benson@nebraska.gov	NDNR	
	Berge, John	jberge@npnrd.org	North Platte NRD	
	Cross, Barb	bcross@npnrd.org	North Platte NRD	
	Crowe, Kayla	kayla.crowe@nebraska.gov	NDNR	
	Czaplewski, Mark	Mark@cpnred.org	Central Platte NRD	
✓	Dimmitt, Ann	afisher@tpnrd.org	Twin Platte NRD	
	Eckles, Beth		NDNR	
✓	Glanz, Travis	tglanz@spnrd.org	South Platte NRD	
	Hopkins, Kyle Ann		North Platte NRD	
	Horn, Rod	rlhorn@spnrd.org	South Platte NRD	
	Miller, Kent	komiller@tpnrd.org	Twin Platte NRD	
	Mintken, Jesse	mintken@cpnrd.org	Central Platte NRD	
✓	Mosier, Melissa	melissa.mosier@nebraska.gov	NDNR	

Meeting Date:______________

	Osborn, Colby		NDNR
	Reisdorff, Ryan	rreisdorff@spnrd.org	South Platte NRD
✓	Schellpeper, Jennifer	jennifer.schellpeper@nebraska.gov	NDNR
	Shaw, Landon	lshaw@tpnrd.org	Twin Platte NRD
	Thorburn, John	jthorburn@tribasinnrd.org	Tri-Basin NRD
✓	Vogt, Lyndon	vogt@cpnrd.org	Central Platte NRD
✓	Winter, Jessie	jessie.winter@nebraska.gov	NDNR
	Woodward, Duane	woodward@cpnrd.org	Central Platte NRD
	Zayac, Tracy	Tzayac@npnrd.org	North Platte NRD
	Zoller, Amy	amy.zoller@nebraska.gov	NDNR
Members of the Public			
	Pierson, Andrew ↳ for Bill Taddicken	apierson@audubon.org	Audubon Nebraska
	Harmon, Brian	brian.harmon@nebraska.gov	NeDNR
	Carter, Margeaux	margeaux.carter@nebraska.gov	NeDNR
	Farnsworth, Jason	farnsworthj@headwaterscorp.com	PRRIP
	Jim Meisner		TPNRD
	Thad Kuntz	thad@ari-water.com	NPNRD + SPNRD

H

Appendix H

FIRST INCREMENT EXPENDITURE SUMMARY

FIRST INCREMENT EXPENDITURES - PROJECTS	CPNRD	NPNRD	SPNRD	TBNRD	TPNRD	Total NRD	DNR (NET Transfer)	NRD/NET total	NET %	DNR General Fund	Total by Project
PBC - YEARS 1-3											
Phase II North Dry Creek	$ -	$ -	$ -	$ 17,068.91	$ -	$ 17,068.91	$ 25,603.36	$ 42,672.27	60.0%	$ -	$ 42,672.27
Industrial Baseline Offset SPNRD	$ -	$ -	$ 4,296.00	$ -	$ -	$ 4,296.00	$ -	$ 4,296.00		$ 6,444.00	$ 10,740.00
Re-Use Pits Recharge Project Spring 2014	$ -	$ -	$ 600.00	$ -	$ 3,600.00	$ 4,200.00	$ -	$ 4,200.00		$ 6,300.00	$ 10,500.00
Thirty-Mile & Orchard Transfer from CPNRD easement package	$ 118,682.40	$ -	$ -	$ -	$ -	$ 118,682.40	$ 178,023.60	$ 296,706.00	60.0%	$ -	$ 296,706.00
Fall 2013 GW recharge	$ 6,000.00	$ -	$ 2,970.00	$ 112,199.34	$ 10,930.00	$ 132,099.34	$ -	$ 132,099.34		$ 198,149.00	$ 330,248.34
Cozad & Thirty-Mile (PBHEP Overruns)	$ 200,000.00	$ -	$ -	$ -	$ -	$ 200,000.00	$ 300,000.00	$ 500,000.00	60.0%	$ -	$ 500,000.00
Subtotal	$ 324,682.40	$ -	$ 7,866.00	$ 129,268.25	$ 14,530.00	$ 476,346.65	$ 503,626.96	$ 979,973.61		$ 210,893.00	$ 1,190,866.61
PBC - YEARS 4-6											
North Platte NRD Lease/Recharge - Cow Camp total	$ -	$ 262,148.25	$ -	$ -	$ -	$ 262,148.25	$ 307,739.25	$ 569,887.50	54.0%	$ -	$ 569,887.50
Oliver Reservoir Streamflow Enhancement Project	$ -	$ -	$ 184,800.00	$ -	$ -	$ 184,800.00	$ 277,200.00	$ 462,000.00	60.0%	$ -	$ 462,000.00
Remaining Commitments	$ -	$ 598,926.37	$ -	$ -	$ -	$ 598,926.37	$ 1,936,774.67	$ 2,407,734.85		$ -	$ 2,347,584.85
Subtotal	$ -	$ 861,074.62	$ 184,800.00	$ -	$ -	$ 1,045,874.62	$ 2,521,713.92	$ 3,439,622.35		$ -	$ 3,379,472.35
PBC - PROJECTS THAT SPANNED YEARS 1-6											
J-2 Reregulating Reservoir											
J-2 Reregulating Reservoir (Years 1-3)	$ 1,168,500.00	$ -	$ -	$ 1,168,500.00	$ 934,800.00	$ 3,271,800.00	$ 4,907,700.00	$ 8,179,500.00	60.0%	$ 6,426,750.00	$ 14,606,250.00
J-2 Reregulating Reservoir (Years 4-6)	$ 403,161.12	$ -	$ -	$ 403,161.12	$ 322,528.90	$ 1,128,851.14	$ 1,693,276.70	$ 2,822,127.84	60.0%	$ 2,217,386.16	$ 5,039,514.00
N-CORPE											
N-CORPE (Years 1-3)	$ -	$ -	$ -	$ -	$ 615,000.00	$ 615,000.00	$ 922,500.00	$ 1,537,500.00	60.0%	$ -	$ 1,537,500.00
N-CORPE (Years 4-6)	$ -	$ -	$ -	$ -	$ 1,730,071.10	$ 1,730,071.10	$ 2,595,106.65	$ 4,325,177.75	60.0%	$ -	$ 4,325,177.75
Orchard-Alfalfa Canal Rehabilitation											
Orchard-Alfalfa Canal Rehabilitation (Years 1-3)	$ 1,665,578.40	$ -	$ -	$ -	$ -	$ 1,665,578.40	$ 2,498,367.60	$ 4,163,946.00	60.0%	$ -	$ 4,163,946.00
Orchard-Alfalfa Canal Rehabilitation (Years 4-6)	$ 501,038.88	$ -	$ -	$ -	$ -	$ 501,038.88	$ 488,106.29	$ 989,145.17	49.3%	$ -	$ 989,145.17
E65 Canal and Elwood Reservoir Recharge Project								$ -			
Spring 2014 E65 Canal and Elwood Reservoir Recharge Project (10,000 acre ft) (Years 1-3	$ -	$ -	$ -	$ 258,121.50	$ -	$ 258,121.50	$ -	$ 258,121.50		$ 258,121.50	$ 516,243.00
Amendment increase acre feet to 15,000 (Years 1-3)				$ 34,378.65		$ 34,378.65		$ 34,378.65		$ 34,378.65	$ 68,757.30
Fall/Winter 2014-2015 E65 Canal and Elwood Reservoir Recharge Project (Years 1-3)	$ -	$ -	$ -	$ 204,922.74	$ -	$ 204,922.74	$ -	$ 204,922.74		$ 204,922.74	$ 409,845.48
Fall/Winter 2014-2015 E65 Canal/Elwood (transfer from North Dry Creek) (Years 1-3)	$ -	$ -	$ -	$ 6,931.09	$ -	$ 6,931.09	$ 10,396.56	$ 17,327.65	60.0%	$ -	$ 17,327.65
Fall/Winter 2014-2015 E65 Canal and Elwood Reservoir (17,000 acre ft) (Years 4-6)	$ -	$ -	$ -	$ 353,850.74	$ -	$ 353,850.74	$ 353,850.74	$ 707,701.48	50.0%	$ -	$ 707,701.48
2015-2016 - E65 Canal and Elwood Reservoir (5,000 acre ft) (Years 4-6)	$ -	$ -	$ -	$ 104,229.00	$ -	$ 104,229.00	$ 104,229.00	$ 208,458.00	50.0%	$ -	$ 208,458.00
2016-2017 - E65 Canal and Elwood Reservoir (Years 4-6)	$ -	$ -	$ -	$ 164,800.00	$ -	$ 164,800.00	$ 247,200.00	$ 412,000.00	60.0%	$ -	$ 412,000.00
Phelps Canal Diversion Project (DNR/PRRIP) (2014-2015)											
Phelps Canal Diversion Project (DNR/PRRIP) (2014-2015) (Years 1-3)	$ -	$ -	$ -	$ -	$ -	$ -	$ -			$ 56,160.00	$ 56,160.00
2016 - Phelps Canal (Years 4-6)	$ -	$ -	$ -	$ -	$ -	$ -		$ -	N/A	$ 131,301.00	$ 131,301.00
2017 - Phelps Canal (10,666 acre ft) --> (NeDNR 2,666 acre ft) (Years 4-6)	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	N/A	$ 20,050.00	$ 80,200.00
Subtotal	$ 3,738,278.40	$ -	$ -	$ 2,698,894.84	$ 3,602,400.00	$ 10,039,573.24	$ 13,820,733.54	$ 23,860,306.78		$ 9,349,070.05	$ 33,269,526.83
PBC - YEAR 6 ADDITIONAL											
NPNRD: Blue Creek Recharge Project		$ 250,000.00				$ 250,000.00	$ -		60.00%	$ 375,000.00	$ 625,000.00
TPNRD and SPNRD: Technology & Recharge Pits			$ 12,000.00		$ 28,000.00	$ 40,000.00	$ -		60.00%	$ 60,000.00	$ 100,000.00
TPNRD: N-CORPE					$ 1,036,666.67	$ 1,036,666.67	$ -		60.00%	$ 1,555,000.01	$ 2,591,666.68
TBNRD/CNPPID - Rainwater Basin Joint Venture				$ 213,550.86		$ 213,550.86	$ -		60.00%	$ 320,326.29	$ 533,877.15
TBNRD: Excess Flow				$ 459,782.47		$ 459,782.47	$ -		60.00%	$ 689,673.71	$ 1,149,456.18
CPNRD:Recharge Pits / Detention Ponds	$ 456,666.67					$ 456,666.67	$ -		60.00%	$ 685,000.01	$ 1,141,666.68
Remaining Commitments	$ (0.00)	$ 823,333.33	$ 81,333.33	$ 0.00	$ (28,000.00)	$ 1,336,449.13	$ -			$ 2,004,673.70	$ 3,341,122.83
Subtotal	$ 456,666.67	$ 1,073,333.33	$ 93,333.33	$ 673,333.33	$ 1,036,666.67	$ 3,793,115.80	$ -	$ -		$ 5,689,673.71	$ 9,482,789.51
PBC - YEAR 6 ADDITIONAL - NPNRD PROJECTS											
Future Projects - 2019		$ 382,000.00				$ 382,000.00	$ -		60.00%	$ 157,500.00	$ 539,500.00
NPNRD-Technology+Allocation Reduction		$ 200,000.00				$ 200,000.00	$ -		60.00%	$ 300,000.00	$ 500,000.00
Remaining Commitments		$ 569,870.60				$ 2,230,944.23				$ 3,346,416.35	$ 5,577,360.98
Subtotal	$ -	$ 1,151,870.60	$ -	$ -	$ -	$ 2,812,944.23	$ -	$ -		$ 3,803,916.35	$ 6,616,860.98
PBC - PROJECT TOTALS	**$ 4,519,627.47**	**$ 3,086,278.56**	**$ 285,999.33**	**$ 3,501,496.42**	**$ 4,653,596.66**	**$ 18,167,854.55**	**$ 16,846,074.42**	**$ 28,279,902.74**		**$ 19,053,553.11**	**$ 53,939,516.28**

FIRST INCREMENT EXPENDITURES - PROJECTS	CPNRD	NPNRD	SPNRD	TBNRD	TPNRD	Total NRD	DNR (NET Transfer)	NRD/NET total	NET %	DNR General Fund	Total by Project
PBHEP PROJECTS											
TBNRD North Dry Creek Project (Apr-June 2011)						$ 13,876.59	$ 6,938.29			$ 13,876.59	$ 34,691.47
TBNRD North Dry Creek Project (July-Sept 2011)						$ 1,368.63	$ 684.32			$ 1,368.63	$ 3,421.58
TBNRD North Dry Creek Project - O&M (Oct 2012)						$ 931.24	$ 465.62			$ 931.24	$ 2,328.10
TBNRD North Dry Creek Project (water lease transfer)						$ 2,000.00	$ 1,000.00			$ 2,000.00	$ 5,000.00
TPNRD/SPNRD Re-Use Pits Project (spring 2011)						$ 2,600.00	$ 1,300.00			$ 2,600.00	$ 6,500.00
TPNRD/SPNRD Re-Use Pits Project (fall 2011)						$ 2,000.00	$ 1,000.00			$ 2,000.00	$ 5,000.00
SPNRD Re-Use Pits Project-flow meters						$ 1,602.08	$ 801.04			$ 1,602.08	$ 4,005.20
DNR GW Recharge Demo Project (spring 2011)						$ 103,067.00	$ 51,533.00			$ 103,067.00	$ 257,667.00
DNR GW Recharge Demo Project (fall 2011)						$ 95,434.80	$ 47,717.40			$ 95,434.80	$ 238,587.00
CPNRD Thirty-Mile Canal Rehab						$ 1,110,741.20	$ 555,370.60			$ 1,110,741.20	$ 2,776,853.00
CPNRD Cozad Canal Rehab						$ 3,095,920.00	$ 1,547,960.00			$ 3,095,920.00	$ 7,739,800.00
DNR GW Recharge Demo Project (spring 2012)						$ 400.00	$ 200.00			$ 400.00	$ 1,000.00
DNR Fall 2013 GW Recharge Project****						$ 151,000.00	$ 75,500.00			$ 151,000.00	$ 377,500.00
TPNRD N-CORPE Project***						$ 120,680.05	$ 60,340.03			$ 120,680.05	$ 301,700.13
PBHEP PROJECT TOTALS						**$ 4,701,621.59**	**$ 2,350,810.30**			**$ 4,701,621.59**	**$ 11,754,053.48**
TPNRD - NCORPE - North Pipeline TPNRD additional Costs					865,182	$ 865,181.58	From K.Miller 11/2017 email - $8,397,026 total - DNR portion-TPNRD Match				
TPNRD - NCORPE - Land Purchase					9,277,500	$ 9,277,500.00	From K.Miller 11/2017 email - $42,500,000 total ($1,7M/year for 25 yrs) = (6-yrs in first increment -				
TPNRD - NCORPE - Operations					453,834	$ 453,834.00	From K.Miller 11/2017 email				- DNR portion ($922,500)
TPNRD - Excess Flows					425,408	$ 425,407.61	From K.Miller 11/2017 email				
TPNRD - Leases					34,000	$ 34,000.00	From K.Miller 11/2017 email				
TPNRD - Purchases/improvements					101,505	$ 101,505.30	From K.Miller 11/2017 email				
NPNRD - Irrigation Management Practices		$ 584,790.55				$ 584,790.55				$ 750,042.82	$ 1,334,833.37
NPNRD - Allocation Buy Down		$ 220,391.86				$ 220,391.86				$ 120,000.00	$ 340,391.86
PROJECT TOTALS						**$ 34,832,087.03**	**$ 19,196,884.72**			**$ 24,625,217.52**	**$ 78,526,223.48**

FIRST INCREMENT EXPENDITURES - RETIREMENTS	CPNRD	NPNRD	SPNRD	TBNRD	TPNRD	Total NRD	DNR (NET Transfer)	NRD/NET total	NET %	DNR General Fund	Total by Project
PBC - YEARS 1-3											
NPNRD Retirement Agreement - Hardt and Tighe	$ -	$ 209,775.87	$ -	$ -	$ -	$ 209,775.87	$ 42,659.40	$ 252,435.27	17%	$ 174,158.73	$ 426,594.00
Grandview Permanent Retirement	$ -	$ 6,288.00	$ -	$ -	$ -	$ 6,288.00	$ -	$ 6,288.00		$ 9,432.00	$ 15,720.00
CPNRD conservation easement package*	$ 623,681.20	$ -	$ -	$ -	$ -	$ 623,681.20	$ 935,521.80	$ 1,559,203.00	60%	$ -	$ 1,559,203.00
Subtotal	$ 623,681.20	$ 216,063.87	$ -	$ -	$ -	$ 839,745.07	$ 978,181.20	$ 1,817,926.27		$ 183,590.73	$ 2,001,517.00
PBC - YEARS 4-6											
NPNRD Retirement Agreement - Hardt and Tighe	$ -	$ 209,775.87	$ -	$ -	$ -	$ 209,775.87	$ 42,659.40	$ 252,435.27	16.90%	$ 174,158.73	$ 426,594.00
Subtotal	$ -	$ 209,775.87	$ -	$ -	$ -	$ 209,775.87	$ 42,659.40	$ 252,435.27		$ 174,158.73	$ 426,594.00
PBC - YEAR 6 ADDITIONAL - NPNRD RETIREMENTS											
NPNRD-Retirement Projects		$ 695,781.00				$ 695,781.00	$ -	$ 695,781.00	40.00%	$ 1,043,671.50	$ 1,739,452.50
NPNRD Retirement Agreement - Hardt and Tighe		$ 629,327.61				$ 629,327.61	$ 127,978.20	$ 757,305.81		$ 522,476.19	$ 1,279,782.00
Cheney Retirement		$ 146,474.30				$ 146,474.30	$ -	$ 146,474.30			$ 146,474.30
Subtotal	$ -	$ 1,471,582.91	$ -	$ -	$ -	$ 1,471,582.91	$ 127,978.20	$ 1,599,561.11		$ 1,566,147.69	$ 3,165,708.80
PBC - RETIREMENT TOTALS	**$ 623,681.20**	**$ 1,897,422.65**	**$ -**	**$ -**	**$ -**	**$ 2,521,103.85**	**$ 1,148,818.80**	**$ 3,669,922.65**		**$ 1,923,897.15**	**$ 5,593,819.80**
PBHEP RETIREMENTS											
CPNRD Conserv Easement Package 1						$ 304,452.00	$ 152,226.00			$ 304,452.00	$ 761,130.00
CPNRD Conserv Easement Package 2**						$ 245,254.09	$ 122,597.05			$ 245,254.09	$ 613,105.23
SPNRD Conserv Easement - Adamson						$ 15,327.24	$ 7,663.61			$ 15,327.24	$ 38,318.09
CPNRD Conserv Easement Package 3						$ 179,060.00	$ 89,530.00			$ 179,060.00	$ 447,650.00
SPNRD Conserv Easement - Lockwood						$ 13,068.00	$ 6,534.00			$ 13,068.00	$ 32,670.00
SPNRD Conserv Easement - Kuehn						$ 25,847.28	$ 12,923.64			$ 25,847.28	$ 64,618.20
CPNRD Conserv Easement Package 4						$ 179,520.00	$ 89,760.00			$ 179,520.00	$ 448,800.00
NPNRD Conserv Easement - Gueck						$ 80,400.00	$ 40,200.00			$ 80,400.00	$ 201,000.00
SPNRD Conserv Easement - Terman & Frerichs						$ 40,720.00	$ 20,360.00			$ 40,720.00	$ 101,800.00
CPNRD Conserv Easement Package 6						$ 152,006.00	$ 76,003.00			$ 152,006.00	$ 380,015.00
NPNRD Conserv Easement - Labovitz						$ 62,736.00	$ 31,368.00			$ 62,736.00	$ 156,840.00
PBHEP RETIREMENTS TOTALS						**$ 1,298,390.61**	**$ 649,165.30**			**$ 1,298,390.61**	**$ 3,245,946.52**
Central Platte NRD											
CPNRD Retirements - non-reimbursed	$ 1,935,803.00					$ 1,935,803.00	$ -			$ -	$ 1,935,803.00
South Platte NRD											
SPNRD Additional Retired/Accured Acres Valued from 2009 through 2017			$ 318,288.00			$ 318,288.00	$ -			$ -	$ 318,288.00
North Platte NRD											
GW16-01		$ 309,337.50				$ 309,337.50	$ -			$ -	$ 309,337.50
GW17-01		$ 572,625.00				$ 572,625.00					$ 572,625.00
GW17-02		$ 1,477,875.00				$ 1,477,875.00					$ 1,477,875.00
						$ 2,359,837.50					**$ 2,359,837.50**
Twin Platte NRD											
Miscellaneous					$ 20,389.18	$ 20,389.18	$ -			$ -	$ 20,389.18
Nebraska Department of Natural Resources											
Conservation Reserve Enhancement Program (CREP)										$ 434,000.00	$ 434,000.00
Environmental Quality Incentives Program (EQIP)										$ 190,955.50	$ 190,955.50
											$ 624,955.50
RETIREMENT TOTALS						**$ 8,453,812.14**	**$ 1,797,984.10**	**$ 3,669,922.65**	**$ -**	**$ 3,847,243.26**	**$ 14,099,039.50**

FIRST INCREMENT REGULATORY ACTIVITIES	CPNRD	NPNRD	SPNRD	TBNRD	TPNRD
Tri-Basin NRD					
Moratorium on development of additional irrigated acres				Since 2004	
Moratorium on new high capacity wells (greater than 50 GPM)				Since 2004	
Increased well spacing requirement				Since 2004	
Certification of existing irrigated acres				2004-2006	
Permitting of groundwater transfers				since 2004	
Permitting of certified irrigated acre transfers				since 2004	
South Platte NRD					
Regulatory activities that broadly include the following (period from 2009 through 2017):			See Admin.		
-Reading and accounting of irrigation flow meter data;			for costs		
-Addressing non-compliance matters;					
-Administration of the District's allocation system/program;					
-Addressing ground water transfers, pooling arrangements, replacement wells, retirement of irrigated acres, and offsets provided for depletions;					
-Addressing variance requests;					
-Municpal and Industrial Accounting;					
-Recharge projects, water banking, and modeling/analyses;					
-Tracking, reporting and evaluation processes as described in the IMP.					

Notes:

1) Most of the costs associated with the certification of irrigated acres and process to have flow meters installed was before 2009.

2) Costs of regulatory actions accounted for under the Administration component

North Platte NRD	CPNRD	NPNRD	SPNRD	TBNRD	TPNRD
Moratorium on drilling of new wells in Pumpkin Creek and establishment of Basin sub-area		2001			
Moratorium on drilling of new wells in the rest of the NRD		2002			
Certification of all groundwater uses in Pumpkin Creek		2002			
Pumpkin Creek Sub-Area Allocation		2003			
Moratorium on Expansion of Irrigated Acres		2004			
Certification of all other groundwater uses in the rest of the District		2006			
Installed flowmeters in the rest of the District - Over Appropriated Sub-Area (River Valley)		2006			
Established Rules for Transfers in the OA		2007			
Installed flowmeters in the rest of the District		2016			

FIRST INCREMENT EXPENDITURES - ADMINISTRATIVE ACTIVITIES	CPNRD	NPNRD	SPNRD	TBNRD	TPNRD	Total NRD	DNR (NET Transfer)	NRD/NET total	NET %	DNR General Fund	Total by Activity
Central Platte NRD											
CPNRD Studies, Certified Acres & Transfer Enforcement/Administration-Per year	$ 158,777.72					$ 158,777.72					$ 158,777.72
Canal Partnership Administration - per year	$ 89,518.32					$ 89,518.32					$ 89,518.32
Tri-Basin NRD											
Administrative costs (2009-2017) - average per year				$ 80,000.00		$ 80,000.00					$ 80,000.00
South Platte NRD											
Salaries and Benefits regarding Water Resources Management - Districtwide Ground Water Management Area Rules and Regulations, IMP, Projects and Programs, and Non-Regulatory Activities (Period from 2009 through 2017) - average per year (total estimated 2009-2017 = $3,617,736)			$ 401,970.67			$ 401,970.67					$ 401,970.67
North Platte NRD											
FY 08-FY 2017 Salary (2,415,846), Mileage (285,581),		$ 270,000.00				$ 270,000.00					$ 270,000.00
Twin Platte NRD											
TPNRD Administrative Costs					$ 249,800.00	$ 249,800.00					$ 249,800.00
(personnel costs)											$ -
Nebraska Department of Natural Resources											
NeDNR Administrative Costs										$ 900,000.00	$ 900,000.00
Average annual administration costs	$ 248,296.04	$ 270,000.00	$ 401,970.67	$ 80,000.00	$ 249,800.00	$ 1,250,066.71				$ 900,000.00	$ 2,150,066.71
					Total for first 8 years of 10-year First Increment	**$ 10,000,533.65**				**$ 7,200,000.00**	

FIRST INCREMENT STUDIES	CPNRD	NPNRD	SPNRD	TBNRD	TPNRD	Total NRD	IWMPPF	DNR General Fund	Total by Study
Conservation Study Phase I Total Budget	$ -	$ -	$ -	$ -	$ -	$ -		$ 70,160.00	$ 70,160.00
Conservation Study Phase II Total Budget	$ 23,706.00	$ 23,706.00	$ 23,706.00	$ 23,706.00	$ 23,706.00	$ 118,530.00		$ 118,530.00	$ 237,060.00
Post-1997 Study								$ 45,000.00	$ 45,000.00
OA/FA Study	$ 9,610.59	$ 9,610.59	$ 9,610.59	$ 9,610.59	$ 9,610.59	$ 48,052.95	$ 180,000.00	$ 3,790.10	$ 231,843.05
OA/FA Refinements # 927	$ 5,200.00	$ 5,200.00	$ 5,200.00	$ 5,200.00	$ 5,200.00	$ 26,000.00		$ 26,000.00	$ 52,000.00
Robust Review Work - #947									
TFG WWUM		$ 24,203.62	$ 24,203.62			$ 48,407.24		$ 48,407.26	$ 96,814.50
FWG Cohyst	$ 25,923.41			$ 25,923.41	$ 25,923.41	$ 77,770.23		$ 77,770.24	$ 155,540.47
ARI WWUM		$ 27,500.00	$ 27,500.00			$ 55,000.00		$ 55,000.00	$ 110,000.00
Facilitation for 2nd Increment - #900	$ 43,440.90	$ 43,440.90	$ 43,440.90	$ 43,440.90	$ 43,440.90	$ 217,204.50		$ 217,204.50	$ 434,409.00
Central Platte NRD									
CPNRD - USGS Platte River tribs study and gages	$ 280,659.00					$ 280,659.00			$ 280,659.00
CPNRD Evapotranspiration Stidues	$ 981,856.00					$ 981,856.00			$ 981,856.00
Conjunctive Water Management	$ 49,080.00					$ 49,080.00			$ 49,080.00
Unsaturated Zone Recharge	$ 202,994.00					$ 202,994.00			$ 202,994.00
Aqua Geo Frame Work Hydro Geologic Study	$ 95,355.00					$ 95,355.00			$ 95,355.00
Tri-Basin NRD									
TBNRD Augmentation Well Impact Study				$ 21,000.00		$ 21,000.00		$ 21,000.00	$ 42,000.00
South Platte NRD									
The Economic Impact of the SPNRD's IMP and Districtwide Ground Water Management Area Rules and Regulations - Dr. Eric Thompson, UNL (2010)			$ 25,000.00			$ 25,000.00			$ 25,000.00
Modeling and Analyses - conservative amount (2009 - 2017)			$ 777,182.00			$ 777,182.00			$ 777,182.00
Lodgepole Creek Flow Evaluation I - Task 1 & 2 (IWMPP) (TFG) - SPNRD Cost			$ 18,010.00			$ 18,010.00			$ 18,010.00
Expanding the Hydrogeological Framework for Selected Areas of the SPNRD (NET) - SPNRD cost			$ 243,137.00			$ 243,137.00			$ 243,137.00
Hydrogeology of Western Nebraska (NET) - SPNRD's Costs			$ 74,000.00			$ 74,000.00			$ 74,000.00
North Platte NRD									
From "Professional Services" under Total Expenditures		$ 388,132.82				$ 388,132.82			$ 388,132.82
Twin Platte NRD									
AEM Data					$ 128,034.00	$ 128,034.00			$ 128,034.00
Computer Modeling					$ 221,000.00	$ 221,000.00			$ 221,000.00
STUDY TOTALS	**$ 1,717,824.90**	**$ 521,793.93**	**$ 1,270,990.11**	**$ 128,880.90**	**$ 456,914.90**	**$ 4,096,404.74**	**$ 180,000.00**	**$ 682,862.10**	**$ 4,959,266.84**

COSTS OF FIRST INCREMENT ACTIVITIES CONTINUING INTO SECOND INCREMENT	CPNRD	NPNRD	SPNRD	TBNRD	TPNRD	Total NRD	DNR (NET Transfer)	NRD/NET total	NET %	DNR General Fund	Total by Activity
Central Platte NRD											
CPNRD Studies, Certified Acres & Transfer Enforcement/Administration-Per year	$ 158,777.72					$ 158,777.72					$ 158,777.72
Canal Partnership Administration - per year	$ 89,518.32					$ 89,518.32					$ 89,518.32
Tri-Basin NRD											
Administrative costs (2009-2017) - average per year				$ 80,000.00		$ 80,000.00					$ 80,000.00
Augmentation Well O&M				$ 20,000.00		$ 20,000.00					$ 20,000.00
South Platte NRD											
Salaries and Benefits regarding Water Resources Management - Districtwide Ground Water Management Area Rules and Regulations, IMP, Projects and Programs, and Non-Regulatory Activities (Period from 2009 through 2017) - average per year (total estimated 2009-2017 = $3,617,736)			$ 401,970.67			$ 401,970.67					$ 401,970.67
North Platte NRD											
Based on FY 08-FY 2017 Salary (2,415,846), Mileage (285,581),		$ 270,000.00				$ 270,000.00					$ 270,000.00
Retirements/SW Lease Payments (Average 2019-2029)		$ 650,000.00				$ 650,000.00					$ 650,000.00
Twin Platte NRD											
TPNRD Administrative Costs					$ 249,800.00	$ 249,800.00					$ 249,800.00
NCORPE O&M (Land + Wellfield)					$ 453,834.00	$ 453,834.00					$ 453,834.00
NCORPE Land Payments					$ 1,700,000.00	$ 1,700,000.00					$ 1,700,000.00
Nebraska Department of Natural Resources											
NeDNR Administrative Costs										$ 900,000.00	$ 900,000.00
Average annual costs	$ 248,296.04	$ 920,000.00	$ 401,970.67	$ 100,000.00	$ 2,403,634.00	$ 4,073,900.71				$ 900,000.00	$ 4,973,900.71

Retirements

Projects

Administrative Costs

Appendix I

EVALUATION OF THE DIFFERENCE IN STREAMFLOW IMPACTS IN THE UPPER PLATTE RIVER BASIN DUE TO WATER USES INITIATED PRIOR TO AND AFTER JULY 1, 1997

2019

Evaluation of the difference in streamflow impacts in the Upper Platte River Basin due to water uses initiated prior to and after July 1, 1997

Table of Contents

INTRODUCTION

Nebraska Department of Natural Resources (NeDNR) and the Upper Platte River Basin Natural Resources Districts (NRDs) adopted the Basin-Wide Plan for Joint Integrated Water Resources Management of Overappropriated Portions of the Platte River Basin (BWP) and NRD-specific integrated management plans (IMPs) in 2009. Those plans contain a number of goals and objectives, including those related to supporting returning the basin to a fully appropriated condition. A key aspect of these goals and objectives is to identify the difference between the current and fully appropriated levels of development. As outlined in the Ground Water Management and Protection Act (Act), the IMPs shall identify the overall difference between the current and fully appropriated levels of development. This evaluation must consider four components: (1) cyclical supply, including drought; (2) the portion of the difference that is due to conservation measures; (3) the portion of the overall difference due to water uses initiated prior to July 1, 1997; and (4) the portion of the overall difference due to water uses initiated or expanded on or after July 1, 1997. Several publications have been developed to support evaluation of these components (see conservation measures study, Robust Review, INSIGHT analysis). This report specifically supports the evaluation of the portion of the overall difference due to water uses initiated prior to July 1, 1997. This is only one component of the identification of the overall difference between the current and fully appropriated levels of development and should not be construed as representative of the overall difference (See Appendix 1).

This evaluation provides summarized estimates of the streamflow impacts resulting from groundwater-only irrigated lands and municipal and industrial (M&I) uses developed through 2013. In the COHYST model, the estimates of streamflow impacts include temporary groundwater irrigation retirements expiring through 2023 within Central Platte NRD (CPNRD), Tri-Basin NRD (TBNRD), and Twin Platte NRD (TPNRD). In the WWUM model, land use and groundwater irrigation pumping data from 2009-2013 was repeated, and therefore, temporary groundwater irrigation retirements did not expire in North Platte NRD (NPNRD) and South Platte (SPNRD). An evaluation of the streamflow impacts resulting from gained and lost irrigated land, controls (allocations and transfers), M&I expansion and contraction, managed recharge, stream augmentation, and permitted uses initiated or expanded on or after July 1, 1997, within each NRD are provided in the Robust Review Report. The projections of future stream baseflow effects contained in this report will be reviewed and updated through the course of the second increment of planning, with future evaluations guiding any necessary refinements and modifications to the planning goals and objectives.

This evaluation represents the best data and information that are currently available for evaluating the portion of the overall difference due to water uses initiated prior to July 1, 1997, but is not inclusive of all water uses. Various modeling and data updates are expected to be completed in the second increment that may modify the results presented in this report. Many of the limitations associated with this analysis are presented in Robust Review Report Appendix 1. Examples of limitations associated with the analyses include:

1) Historical M&I pumping volumes were estimated and not quantified for NPNRD and SPNRD for this analysis prior to 1997;
2) In the COHYST model, future projections are based on 2013 groundwater irrigated acres data, with the exception of temporary retirements, which were reincorporated into subsequent years

until the retirements terminated. In the WWUM model, future projections are based on repeated 2009-2013 groundwater irrigated acres and metered pumping data;

3) Crop type data in the COHYST model area are held constant after 2010 based on the distribution available in 2010. The crop type data are repeated in the WWUM model area based on 2009-2013 land use data;
4) Conservation measures, primarily tillage practices, may not fully reflect present-day practices and associated water supply benefits;
5) Management actions implemented after 2013 are excluded, including N-CORPE operations and conjunctive management operations in CPNRD;
6) Water budget changes associated with modeled changes in on-field runoff have not been incorporated into the new depletions estimates;
7) Groundwater pumping in certain portions of the groundwater models is estimated and may be refined with the collection of measurement data;
8) Certain model areas exhibit dry cells that may limit the incorporation of pumping and recharge changes;
9) The regional nature of the models may not appropriately express the degree of connection between aquifers and streams for capturing smaller scale management actions;
10) Streamflow routing of runoff and diversions were not included and may warrant further evaluation of the impacts on results; and
11) Future projections are based on a single, repeating historical climate scenario and may not be representative of future climate conditions.

NeDNR and the Upper Platte River Basin NRDs will continue to work to address these limitations through the second increment and update this review as these limitations are evaluated.

EVALUATION PROCEDURES AND DATA

This report provides the total depletions from 1950 or 1953, depending on model area, to 2063 due to groundwater-only and M&I pumping within the five Upper Platte River Basin NRDs. The depletions information is separated into depletions resulting from levels of groundwater-only development prior to 1997 and depletions from all groundwater-only development. To calculate the total baseflow depletions within each NRD, the baseflow of a groundwater model run with no groundwater-only irrigation or M&I pumping in each NRD (referred to as the **No GWO Run**) is compared to baseflow from a historical groundwater model run that includes all groundwater-only irrigation pumping and M&I pumping (referred to as the **Historical Run**). The documented Cooperative Hydrology Study (COHYST) 2010 integrated model and Western Water Use Management (WWUM) model were used as the basis for this analysis (See Appendix 2). Updates to the documented Watershed model portions of these models for the baseline in this analysis are documented in Appendix 2. Further documentation of the methods used to conduct the model simulations and summarize model results are contained in Appendix 2.

RESULTS

The results of this evaluation are limited to the effects on streams in the Platte River system, including the North Platte River, South Platte River, Lodgepole Creek, Platte River, and their perennial tributaries within the Overappropriated Basin (Figure 1). The Overappropriated Basin (upstream of Kearney Canal Diversion) is an administrative area established by NeDNR and has significance within the context of Nebraska state law. The analyses of groundwater-only irrigation activities are limited to the five Upper Platte River Basin NRDs in the Overappropriated Basin. The impacts were determined based on pumping occurring within the entirety of each of the five NRDs that were evaluated.

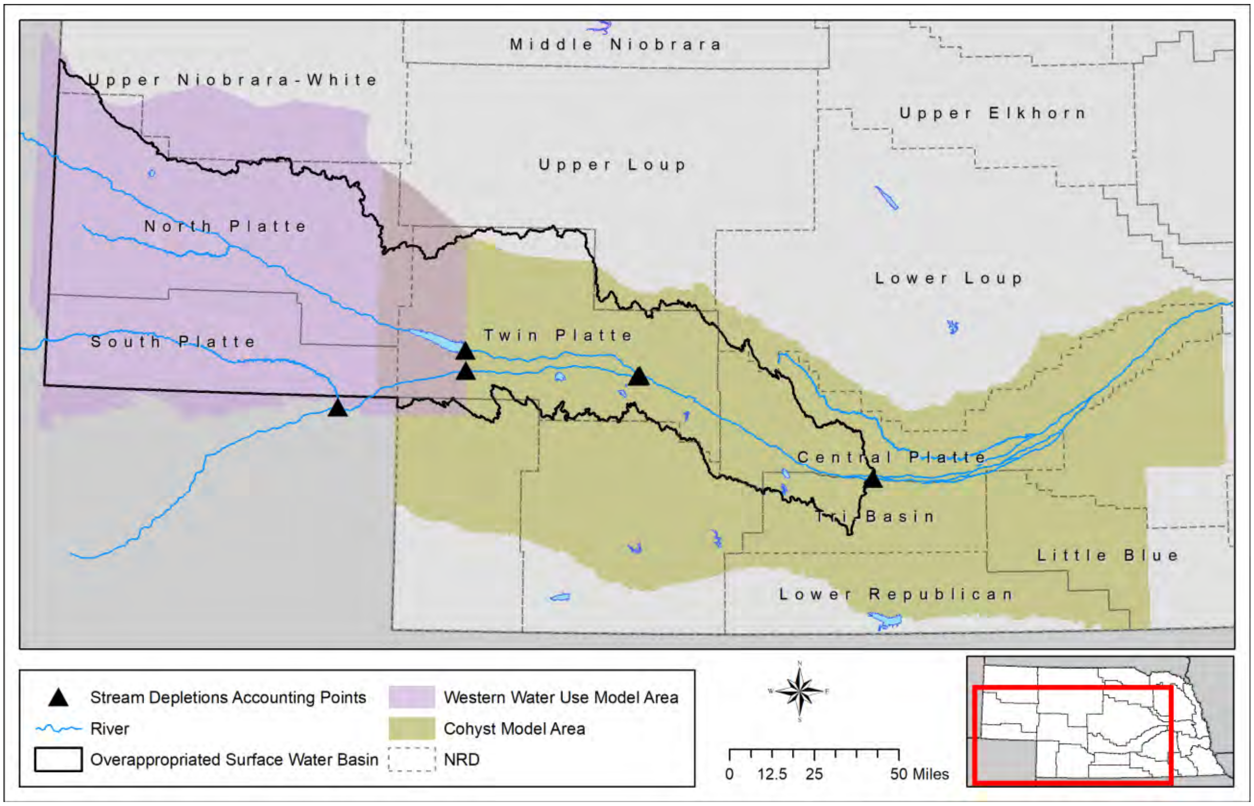

Figure 1. Upper Platte River Basin NRDs, Overappropriated Basin, accounting points, and model domains.

Table 2 illustrates the total number of groundwater-only irrigated acres within each NRD for the years 1997, 2005, 2013, and 2023. Acres values in the COHYST model area were maintained at constant levels after 2013, with the exception of temporary retirements that were reincorporated into subsequent years when the retirements terminated. All temporary retirements were reincorporated into the COHYST dataset until the retirement terminated. In the WWUM model area, acres values from 2009 to 2013 were repeated.

The streamflow impacts for the period 2014-2063 are modeled based on assumptions of a representative climate without additional management actions or changes in land use incorporated after 2013. Tables 4-8 display water budget data for the period 2014-2063, including average values for recharge, groundwater irrigation pumping, M&I groundwater pumping, and net recharge within each NRD. The average annual change in net recharge and change of M&I pumping by NRD for the period 2014 – 2063 accounts for all development of groundwater-only irrigation pumping and related changes in recharge and M&I pumping. The average change in 2014 – 2063 net recharge is based on 2013 land use conditions (with temporary retirements lapsing until 2023 in the COHYST model) with variable, but repeating, future climate conditions based on historical climate data. Negative values indicate net recharge has decreased due to the development of groundwater-only irrigation lands, and positive values indicate a net recharge increase due to the development of groundwater-only irrigation.

The results of the groundwater modeling evaluation of impacts on streamflow due to all groundwater-only and M&I pumping from 1950-2063 are summarized in Figures 2-10. The results of this groundwater modeling evaluation have been combined with the results from evaluations of post-1997 activities (2019 Upper Platte River Basin Robust Review) to determine the specific impacts resulting from activities established prior to 1997, and those established after 1997. In the figures, positive results represent accretions to streamflow and negative results represent depletions to streamflow. The results summarize the impacts (increase or decrease in streamflow relative to no groundwater-only nor M&I development) based on changes within each of the Upper Platte River Basin NRDs. Figure 11 shows the combined impact to streamflow due to changes in all five Upper Platte River Basin NRDs, relative to no groundwater-only nor M&I development. The four stream reaches within the Overappropriated Basin used in the analysis include: 1) Lodgepole Creek; 2) North Platte River; 3) South Platte River; and 4) Platte River between the North Platte and South Platte confluence and Elm Creek.

A variety of outcomes can be observed within this evaluation, in conjunction with the results of the Robust Review Report and other analyses. First, the results for NPNRD, SPNRD, and TBNRD show that depletions from the 1997 level of development are greater than current levels of depletions, indicating that streamflow impacts resulting from post-1997 depletions were fully mitigated as of 2013. Second, the total depletions due groundwater only-irrigation and M&I pumping for the entire Overappropriated Basin are estimated to be approximately 500,000 acre-feet by 2063. This estimate does not reflect additional management actions that have been implemented after 2013 or may be implemented in the second increment or other future increments. Third, the distribution of total depletions to streamflow indicates that approximately 25 percent of impacts are to the North Platte River, 24 percent of impacts are to the South Platte River, 7 percent of impacts are to Lodgepole Creek, and 44 percent of impacts are to the Platte River within the Overappropriated Basin.

SUMMARY

NeDNR and the Upper Platte River Basin NRDs have worked through the course of the first increment to implement action items outlined in each respective IMP. Those action items have included a variety of regulatory and non-regulatory management actions aimed at addressing depletions associated with post-1997 activities. This report provides a summary of the impacts associated with groundwater-only irrigation pumping and M&I pumping for current levels of development and for uses that existed prior to 1997. These results are only one of a number of components that will be used by NeDNR and NRDs in evaluating the overall difference between current and fully appropriated levels of development. Additionally, NeDNR and the Upper Platte River Basin NRDs will continue to update and review data sets and models that support updating this evaluation in the future.

STREAMFLOW DEPLETIONS FIGURES

North Platte NRD (NPNRD)

In Figure 2, the modeled streamflow impacts to the North Platte River from all groundwater-only irrigation and municipal and industrial development within NPNRD with offsetting management actions, including allocations, groundwater irrigated acres, retirements, and recharge projects on the North Platte River, are shown in orange. Also shown are the modeled streamflow impacts from all groundwater-only irrigation and municipal and industrial development prior to 1997 in blue.

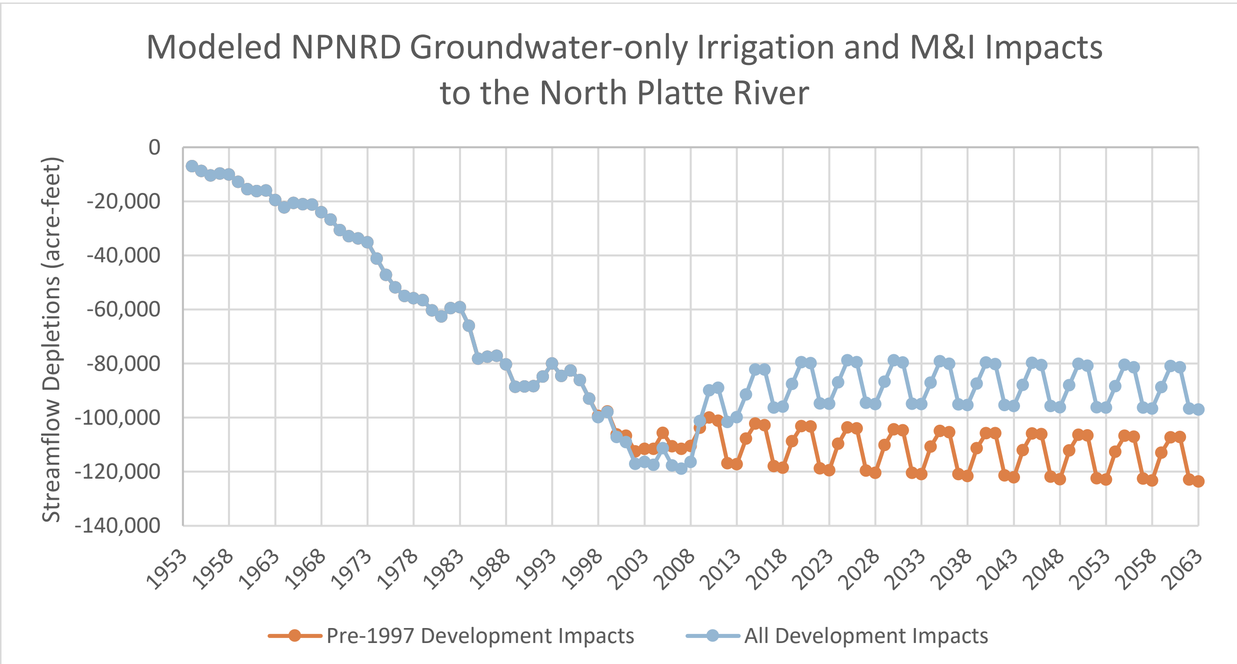

Figure 2. Modeled NPNRD streamflow impacts to the North Platte River from all groundwater-only irrigation and M&I development with offsetting management actions and the streamflow impacts from development pre-1997.

South Platte NRD (SPNRD)

In Figures 3, 4, and 5, the modeled streamflow impacts to the North Platte River, South Platte River, and Lodgepole Creek, respectively, from all groundwater-only irrigation and municipal and industrial development within SPNRD with offsetting management actions, including allocations, groundwater irrigated acres retirements, and recharge projects on the South Platte River, are shown in orange. Also shown are the modeled streamflow impacts from all groundwater-only irrigation and municipal and industrial development prior to 1997 in blue.

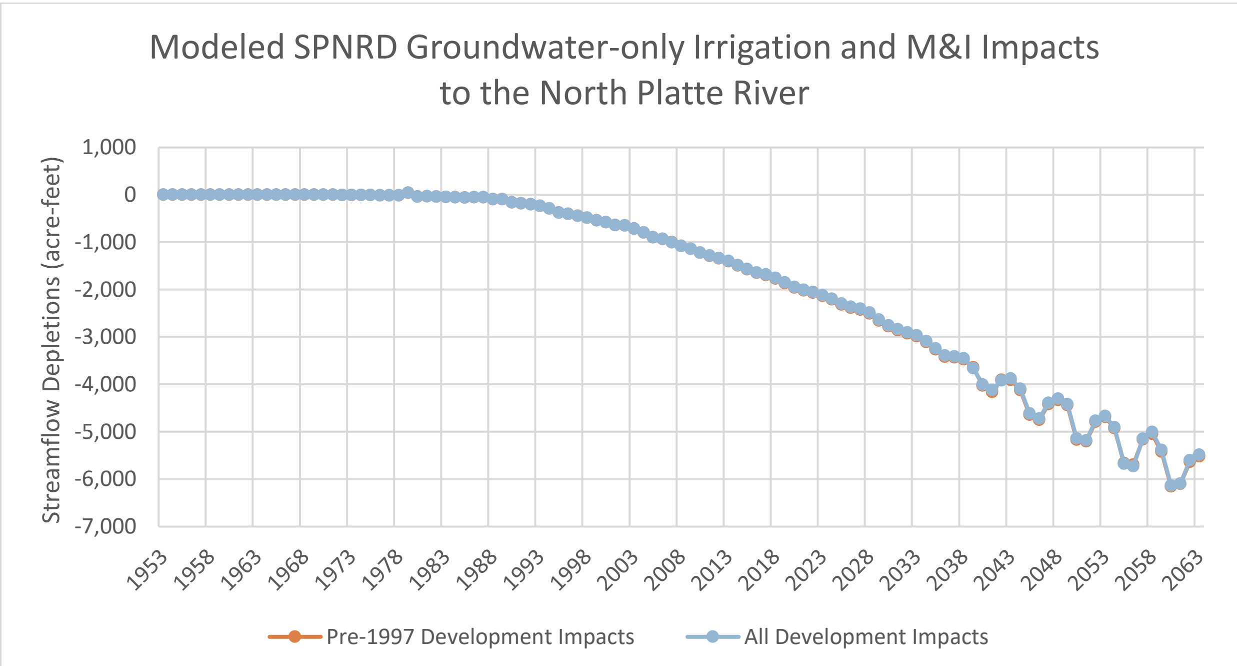

Figure 3. Modeled SPNRD streamflow impacts to the North Platte River from all groundwater-only irrigation and M&I development with offsetting management actions and the streamflow impacts from development pre-1997.

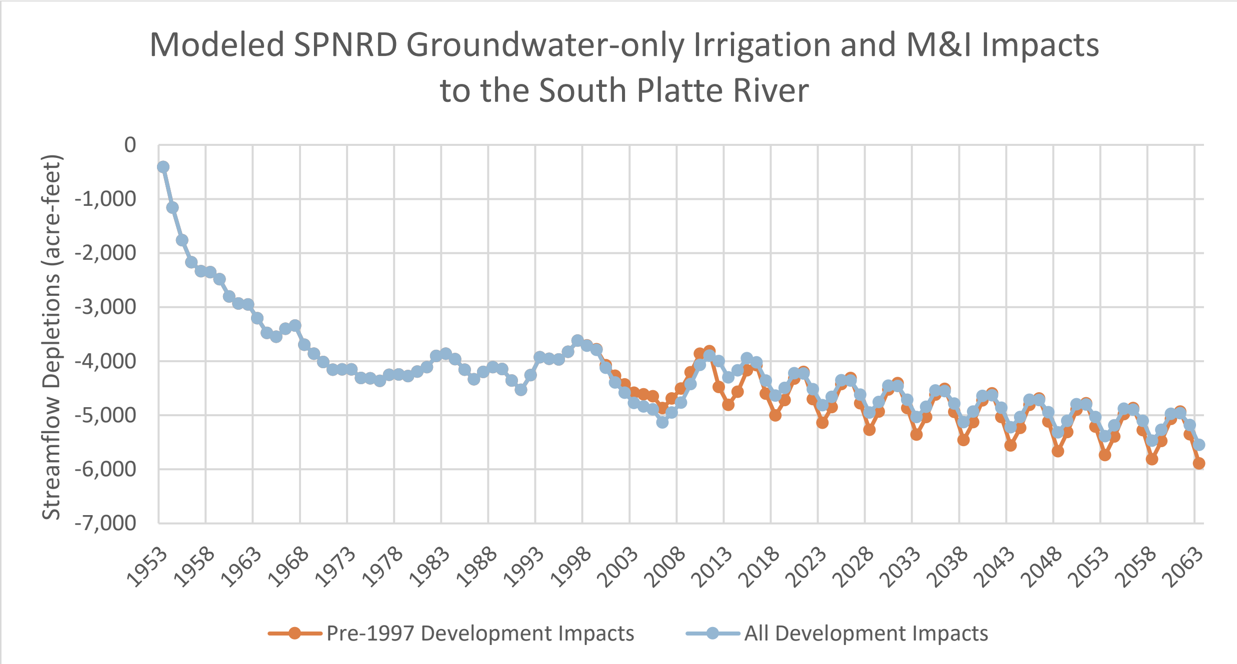

Figure 4. Modeled SPNRD streamflow impacts to the South Platte River from all groundwater-only irrigation and M&I development with offsetting management actions and the streamflow impacts from development pre-1997.

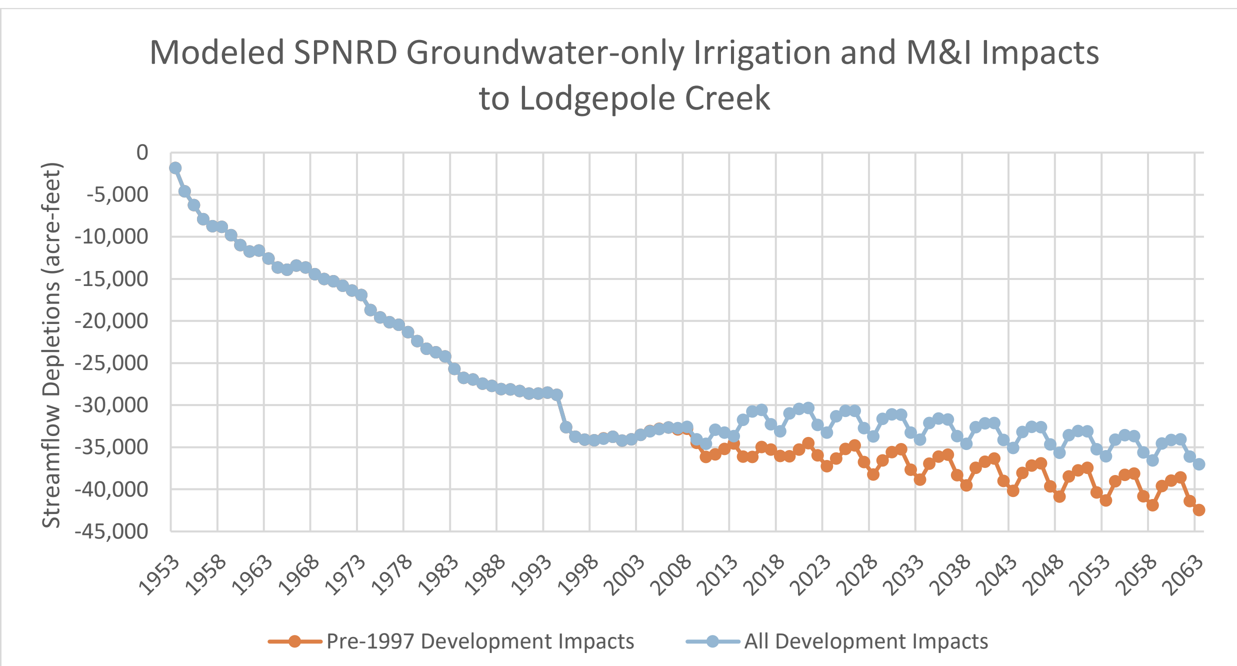

Figure 5. Modeled SPNRD streamflow impacts to Lodgepole Creek from all groundwater-only irrigation and M&I development with offsetting management actions and the streamflow impacts from development pre-1997.

Twin Platte NRD (TPNRD)

In Figure 6, 7, and 8, the modeled streamflow impacts to the South Platte River, North Platte River, and Platte River upstream of Elm Creek, respectively, from all groundwater-only irrigation and municipal and industrial development within TPNRD with offsetting management actions, including groundwater irrigated acres retirements and recharge projects on the South Platte River and Platte River upstream of Elm Creek, are shown in orange. Also shown are the modeled streamflow impacts from all groundwater-only irrigation and municipal and industrial development prior to 1997 in blue.

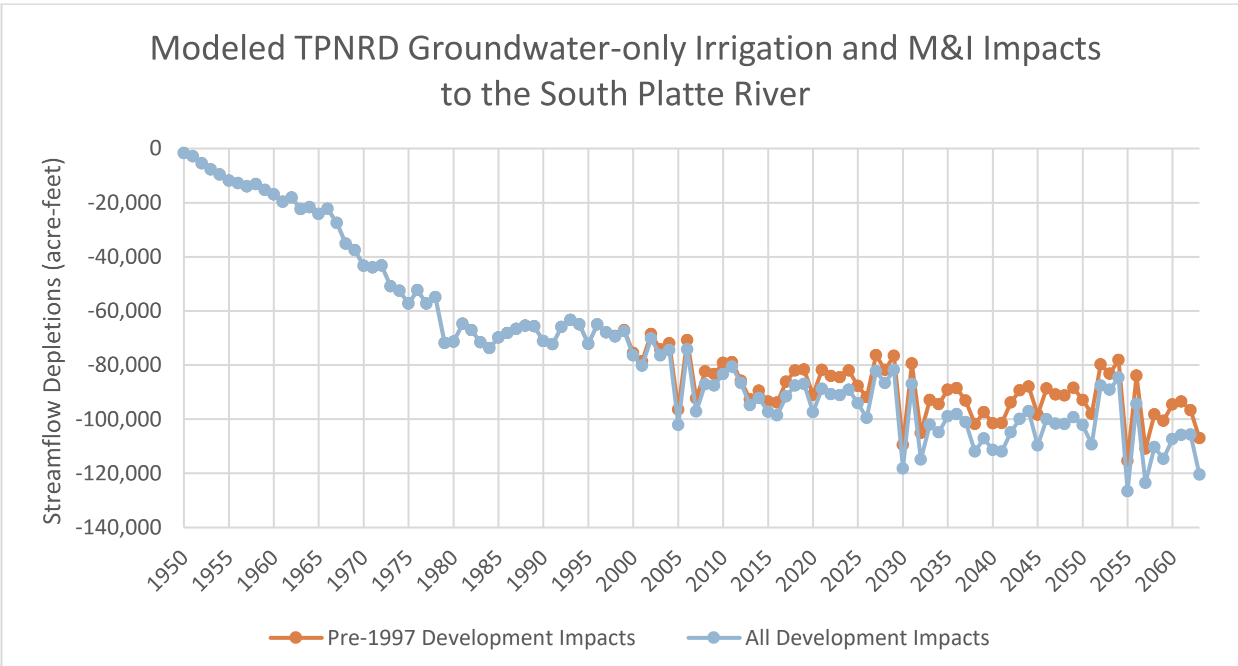

Figure 6: Modeled TPNRD streamflow impacts to the South Platte River from all groundwater-only irrigation and M&I development with offsetting management actions and the streamflow impacts from development pre-1997.

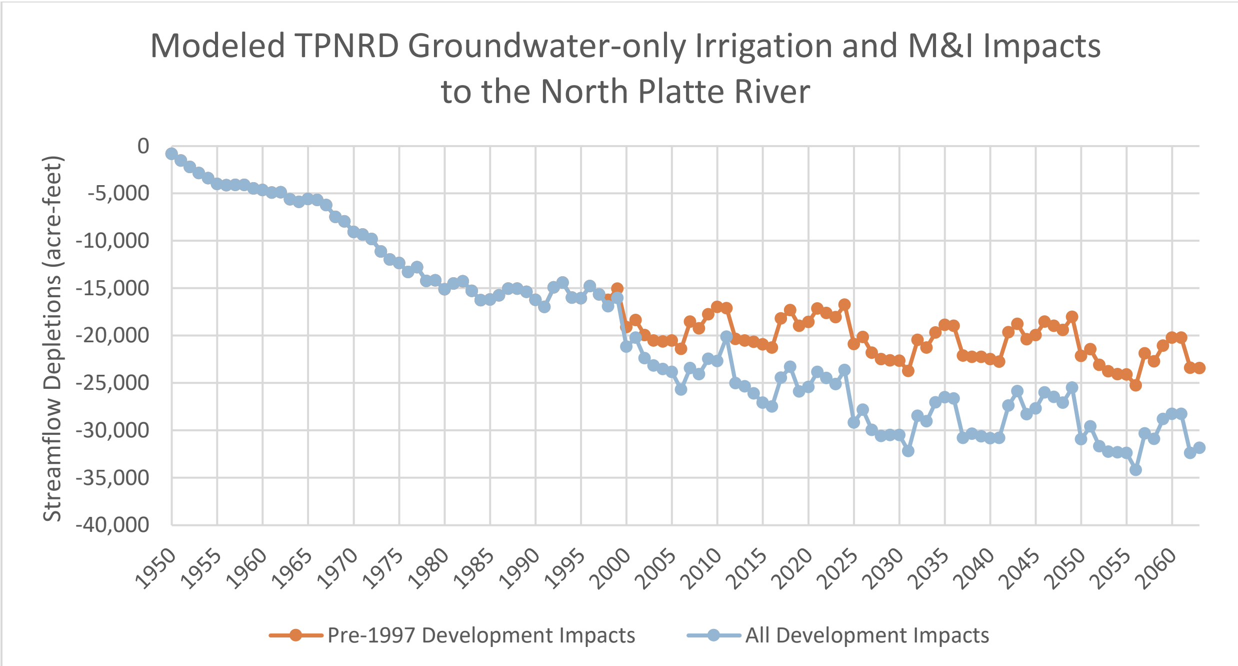

Figure 7: Modeled TPNRD streamflow impacts to the North Platte River from all groundwater-only irrigation and M&I development with offsetting management actions and the streamflow impacts from development pre-1997.

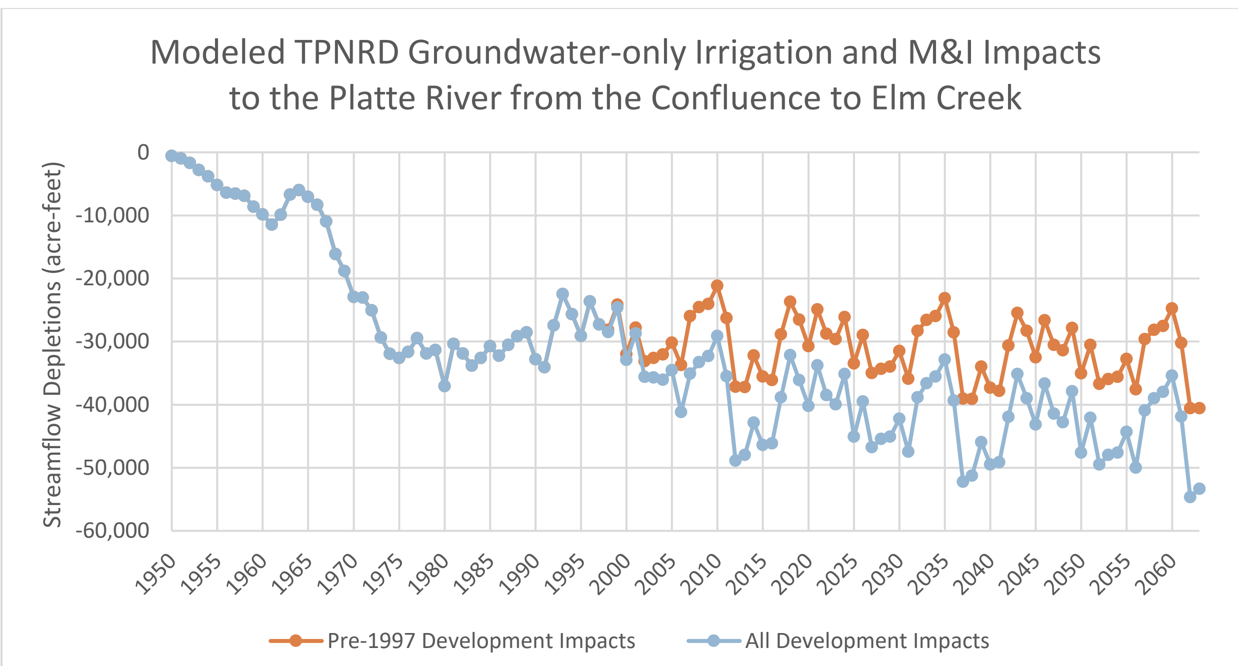

Figure 8: Modeled TPNRD streamflow impacts to the Platte River from the Confluence to Elm Creek from all groundwater-only irrigation and M&I development with offsetting management actions and the streamflow impacts from development pre-1997.

Central Platte NRD (CPNRD)

In Figure 9, the modeled streamflow impacts to the Platte River upstream of Elm Creek from all groundwater-only irrigation and municipal and industrial development within CPNRD with offsetting management actions, including groundwater irrigated acres retirements and recharge projects on the Platte River contracted by CPNRD, are shown in orange. Also shown are the modeled streamflow impacts from all groundwater-only irrigation and municipal and industrial development prior to 1997 in blue.

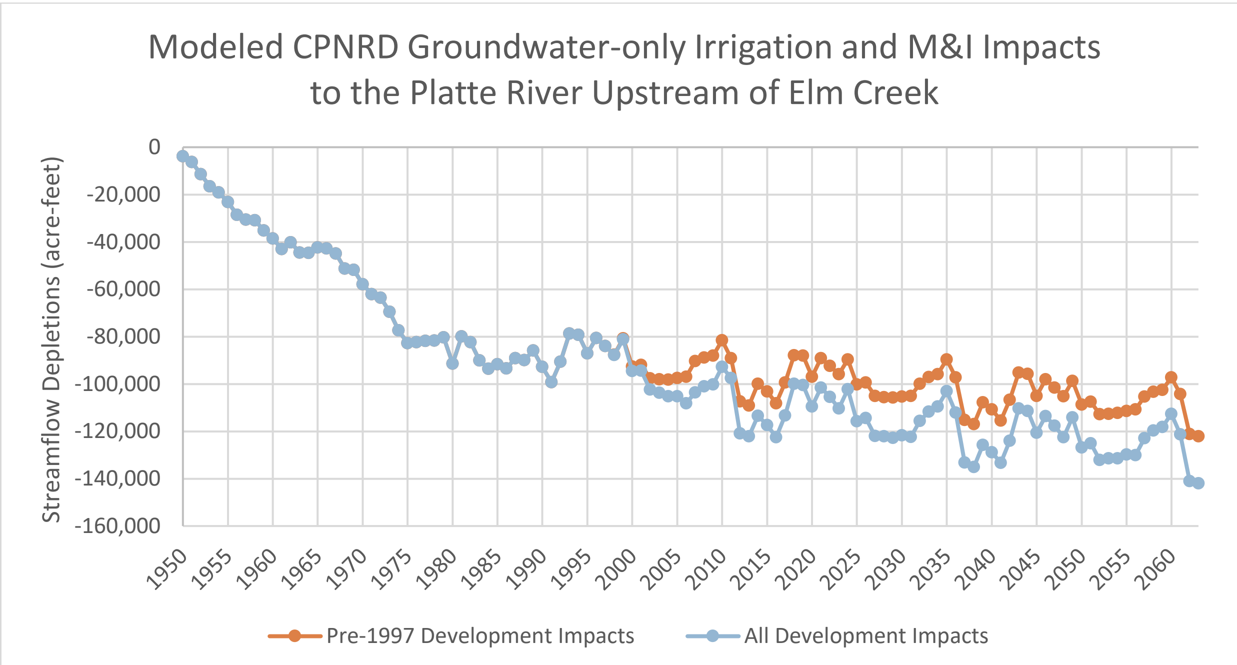

Figure 9: Modeled CPNRD streamflow impacts to the Platte River upstream of Elm Creek from all groundwater-only irrigation and M&I development with offsetting management actions and the streamflow impacts from development pre-1997.

Tri-Basin NRD (TBNRD)

In Figure 10, the modeled streamflow impacts to the Platte River upstream of Elm Creek from all groundwater-only irrigation and municipal and industrial development within TBNRD with offsetting management actions, including groundwater irrigated acres retirements, recharge projects on the Platte River contracted by TBNRD, and streamflow augmentation, are shown in orange. Also shown are the modeled streamflow impacts from all groundwater-only irrigation and municipal and industrial development prior to 1997 in blue.

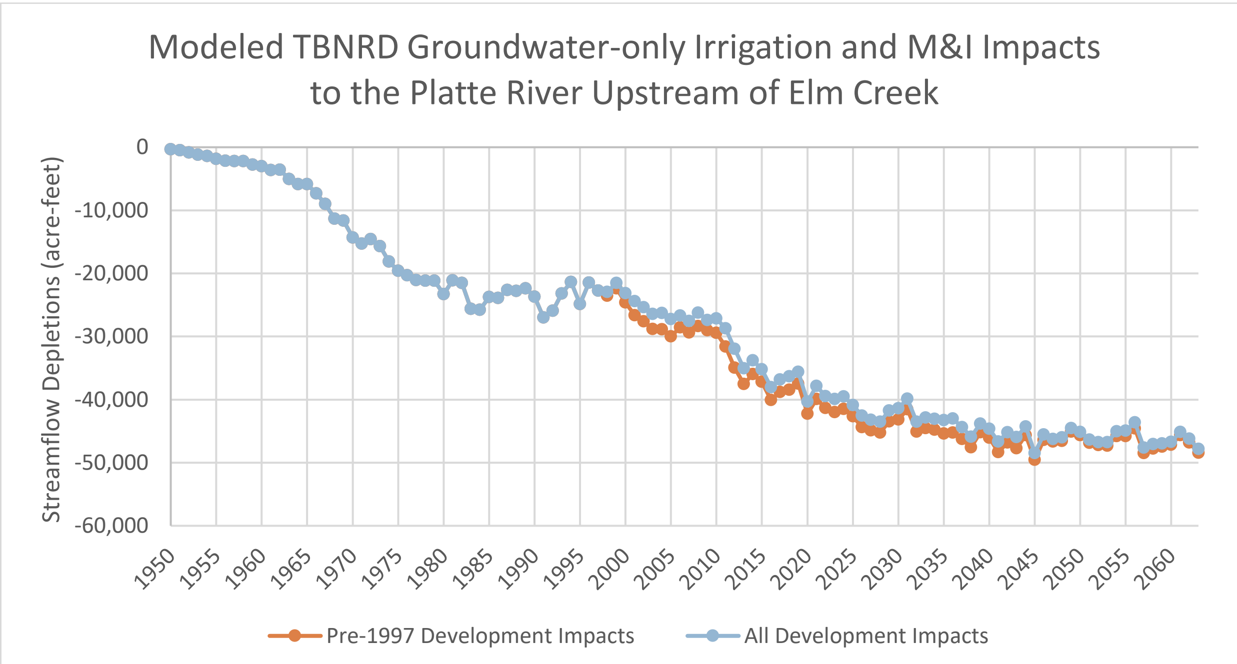

Figure 10: Modeled TBNRD streamflow impacts to the Platte River upstream of Elm Creek from all groundwater-only irrigation and M&I development with offsetting management actions and the streamflow impacts from development pre-1997.

Five Upper Platte River Basin NRDs

Figure 11 shows the modeled impacts to the Platte River upstream of Elm Creek from the five Upper Platte River Basin NRDs (including groundwater-only irrigation, municipal and industrial development, groundwater irrigated acres retirements, recharge projects, and streamflow augmentation).

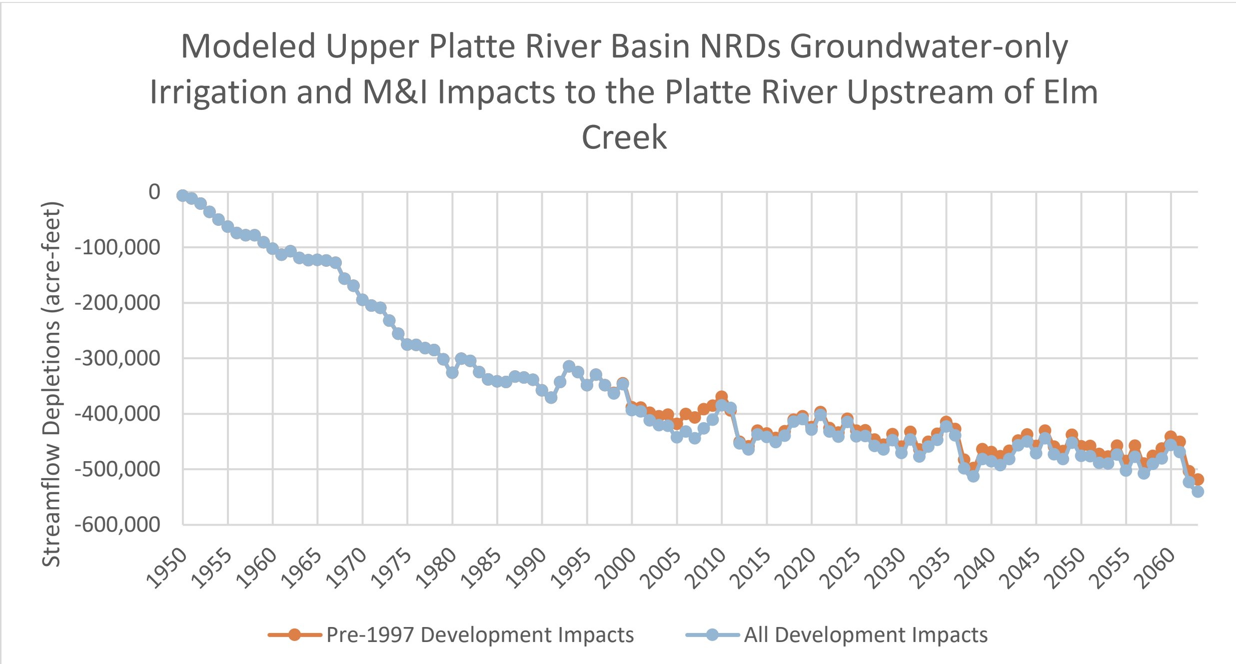

Figure 11: The five Upper Platte River Basin NRDs modeled streamflow impacts to the Platte River upstream of Elm Creek from all groundwater-only irrigation and M&I development with offsetting management actions and the streamflow impacts from development pre-1997.

STREAMFLOW DEPLETIONS TABLES

Table 1: Total groundwater-only irrigated acres for each of the Upper Platte River Basin NRDs used in this analysis, rounded to the nearest hundred acres.

YEAR	NPNRD (acres)	SPNRD (acres)	TPNRD (acres)	CPNRD (acres)	TBNRD (acres)
1997	134,400	103,800	205,700	817,300	406,600
2005	140,300	120,300	250,500	887,400	422,400
2013	131,100	119,000	263,100	902,200	461,300
2023	131,100	119,000	263,800	902,900	461,600

Table 2: Average annual net recharge, irrigation groundwater pumping, municipal and industrial pumping, and net recharge (difference between recharge and groundwater pumping) within the entirety of NPNRD over 2014 to 2063 in acre-feet rounded to the nearest hundred.

NPNRD	HISTORICAL RUN (af)	NO GROUNDWATER-ONLY PUMPING RUN (af)	CHANGE DUE TO DEVELOPMENT (af)
AVERAGE RECHARGE	1,029,700	994,100	35,600
AVERAGE IRRIGATION GROUNDWATER PUMPING	198,800	53,800	145,000
MUNICIPAL AND INDUSTRIAL PUMPING	11,500	0	11,500
AVERAGE NET RECHARGE (Recharge - Groundwater Pumping)	819,400	940,300	-120,900

Table 3: Average annual net recharge, irrigation groundwater pumping, municipal and industrial pumping, and net recharge (difference between recharge and groundwater pumping) within the entirety of SPNRD over 2014 to 2063 in acre-feet rounded to the nearest hundred.

SPNRD	HISTORICAL RUN (af)	NO GROUNDWATER-ONLY PUMPING RUN (af)	CHANGE DUE TO DEVELOPMENT (af)
AVERAGE RECHARGE	160,200	136,100	24,100
AVERAGE IRRIGATION GROUNDWATER PUMPING	114,500	1,600	112,900
MUNICIPAL AND INDUSTRIAL PUMPING	3,600	0	3,600
AVERAGE NET RECHARGE (Recharge - Groundwater Pumping)	42,100	134,500	-92,400

Table 4: Average annual net recharge, irrigation groundwater pumping, municipal and industrial pumping, and net recharge (difference between recharge and groundwater pumping) within the entirety of TPNRD over 2014 to 2063 in acre-feet rounded to the nearest hundred.

TPNRD	**HISTORICAL RUN** (af)	**NO GROUNDWATER-ONLY PUMPING RUN** (af)	**CHANGE DUE TO DEVELOPMENT** (af)
AVERAGE RECHARGE	473,100	437,000	36,000
AVERAGE IRRIGATION GROUNDWATER PUMPING	358,600	37,800	320,800
MUNICIPAL AND INDUSTRIAL PUMPING	8,100	0	8,100
AVERAGE NET RECHARGE (Recharge - Groundwater Pumping)	106,400	399,200	-292,900

Table 5: Average annual net recharge, irrigation groundwater pumping, municipal and industrial pumping, and net recharge (difference between recharge and groundwater pumping) within the entirety of CPNRD over 2014 to 2063 in acre-feet rounded to the nearest hundred.

CPNRD	**HISTORICAL RUN** (af)	**NO GROUNDWATER-ONLY PUMPING RUN** (af)	**CHANGE DUE TO DEVELOPMENT** (af)
AVERAGE RECHARGE	646,200	559,000	87,200
AVERAGE IRRIGATION GROUNDWATER PUMPING	716,000	32,300	683,700
MUNICIPAL AND INDUSTRIAL PUMPING	22,300	0	22,300
AVERAGE NET RECHARGE (Recharge - Groundwater Pumping)	-92,100	526,700	-618,900

Table 6: Average annual net recharge, irrigation groundwater pumping, municipal and industrial pumping, and net recharge (difference between recharge and groundwater pumping) within the entirety of TBNRD over 2014 to 2063 in acre-feet rounded to the nearest hundred.

TBNRD	**HISTORICAL RUN** (af)	**NO GROUNDWATER-ONLY PUMPING RUN** (af)	**CHANGE DUE TO DEVELOPMENT** (af)
AVERAGE RECHARGE	287,300	248,100	39,200
AVERAGE IRRIGATION GROUNDWATER PUMPING	386,900	44,300	342,600
MUNICIPAL AND INDUSTRIAL PUMPING	3,200	0	3,200
AVERAGE NET RECHARGE (Recharge - Groundwater Pumping)	-102,800	203,900	-306,600

APPENDIX 1

Background on the Overall Difference between Current and Fully Appropriated Levels of Development

The Act (*Neb. Rev. Stat.* § 46-713 (3)), specifies that a basin, subbasin, or reach is fully appropriated if the current uses cause or will in the reasonably foreseeable future cause: 1) the surface water supply to be insufficient to sustain over the long term the beneficial or useful purposes for which existing natural-flow or storage appropriations were granted and the beneficial or useful purposes for which, at the time of approval, any existing instream appropriation was granted; 2) the streamflow to be insufficient to sustain over the long term the beneficial uses from wells constructed in aquifers dependent on recharge from the river or stream involved or 3) reduction in the flow of a river or stream sufficient to cause noncompliance by Nebraska with an interstate compact or decree, other formal state contract or agreement, or applicable state or federal laws.

The Act further defines that the overall difference between the current and fully appropriated levels of development to mean the extent to which existing uses of hydrologically connected surface water and ground water and conservation activities result in the water supply available for purposes identified in subsection (3) of section *Neb. Rev. Stat.* § 46-713 to be less than the water supply available if the river basin, subbasin, or reach had been determined to be fully appropriated in accordance with section *Neb. Rev. Stat.* § 46-714. This, in essence, suggests the overall difference between current and fully appropriated levels of development is determined through the rules and methods used by NeDNR to designate basins as fully appropriated.

The rules and methods used by NeDNR to designate a basin as fully appropriated in accordance with *Neb. Rev. Stat.* § 46-714 primarily rely on the evaluation of junior natural-flow surface water irrigation appropriations (see N.A.C. Title 457, Chapter 24 and Annual Evaluation of Availability of Hydrologically Connected Water Supplies, December 30, 2016). The rules further establish that in the event other natural-flow and storage appropriations need to be considered, NeDNR has the ability to utilize a standard of interference appropriate for the use in conducting its evaluation. Through the course of attempting to apply the rules and methods to the complexities of the Upper Platte River Basin, NeDNR and NRDs have agreed that further standards are necessary and have applied different methods (see INSIGHT, Preliminary Estimate of Historical Stream Flow Reductions in the Overappropriated Portion of the Platte River in Nebraska, 2009) were applied to support the assessments. These alternative methods remain flexible to NeDNR and the NRDs and may be refined in subsequent evaluations.

The technical evaluations described in this report, in conjunction with other supporting data, are ultimately used to establish appropriate IMP goals and objectives. The IMPs must contain clear goals and objectives with a purpose of sustaining a balance between ***water uses*** and ***water supplies*** so that the economic viability, social and environmental health, safety, and welfare of the river basin, subbasin, or reach can be achieved and maintained for both the near term and the long term (*Neb. Rev. Stat.* § 46-715 (2)). Understanding that water uses cannot exceed water supplies (natural-flow and storage supplies), a balance will likely exist each year in the overappropriated basin. However, ***water demand*** can exceed water use when supplies are limited. Even if all water users have access to and are able to use water supplies, their total demand may not be met. It is important to review the distribution of the balance of water supply and water use among various water users to see which users might not be meeting their full demand. The distribution of water use among the different user groups in the basin and the degree to which the use meets the demand is what influences the economic viability, social and environmental health, safety, and welfare of the river basin. Therefore, establishing appropriate goals and objectives in the IMP requires careful consideration of this distribution, as well as the total water use and supply, in order to ensure that the balance recognizes the overall welfare of the basin.

APPENDIX 2

Model Documentation: COHYST and WWUM

I. Objective

The purpose of this modeling evaluation is to simulate depletions to streamflow from development of groundwater-only irrigated lands in each of the five Upper Platte River Basin NRDs.

For each NRD analysis, two model runs are necessary: a baseline simulation and an impact/scenario simulation. The baseline simulation is the representation of the historical condition. The scenario simulation is the representation of no groundwater only irrigated acres nor municipal and industrial (M&I) pumping. The difference between these two runs provides an estimate of the streamflow impacts from groundwater development.

The WWUM models were used for the NPNRD and SPNRD analyses. The simulation period for the WWUM analyses is 1953 to 2063. The COHYST models were used for the TPNRD, CPNRD, and TBNRD analyses. The simulation period for the COHYST analyses is 1950 to 2063.

II. Baseline Model Setup – Historical

The baseline WWUM and COHYST models used for this analysis were developed for the 2019 Upper Platte River Basin Robust Review. No additional changes were made to the baselines. The set-ups of the baselines are available in the Robust Review documentations for WWUM and COHYST separately (2019 Upper Platte River Basin Robust Review).

III. Scenario Setup – No groundwater-only pumping

The scenario for each of the five Upper Platte NRDs of NPNRD, SPNRD, TPNRD, CPNRD, and TBNRD is to represent no groundwater-only irrigation development and no M&I development (hereafter referred to as No GWO) as compared to the baseline that has historical groundwater-only irrigation and M&I conditions. This requires the scenario to be modified from the baseline during the scenario watershed model setup (land use and M&I pumping). Only the recharge files and well files change between the baseline and scenario all other MODFLOW package files maintain the same set up as the baseline.

1. Scenario Watershed Model Setup

There was one run of each of the watershed models (WWUM and COHYST) executed for the scenario simulation. The baseline inputs were modified by converting groundwater-only irrigated acres to dryland and not including M&I pumping. The TFG Memorandum Re: Robust Review COHYST area Model Runs, dated November 26, 2018, documents the COHYST Watershed model setup. The TFG Memorandum Re: October 2018 Update: Post 97 Analysis – Western Water Use Model (WWUM) Area, dated October 11, 2018, documents the WWUM Watershed model setup. The land use change and M&I pumping change was made for all areas of the model in a single watershed model run for each model, and the resulting pumping and recharge impacts were isolated by NRD management area in the scenario groundwater model setup. The watershed results for the No GWO scenario were provided from TFG to DNR and include land use and water balance summaries and recharge (.rch) and pumping (.wel) MODFLOW groundwater model files.

2. Scenario Groundwater Model Setup

All scenario groundwater model data remained the same as in the baseline except watershed modeled recharge and pumping. Therefore, North Dry Creek pumping and excess flow recharge volumes were added to the scenarios pumping and recharge files, respectively, from the scenario watershed model output of each model, as applicable, which is described in the baseline models documentations (2019 Upper Platte River Basin Robust Review).

For each of the five NRD management area scenarios, the corresponding scenario recharge and pumping values were replaced in the baseline model for that management area with the baseline watershed model recharge and pumping values remaining the same for the other NRDs and remainder of the model area. The following table summarizes the five groundwater model run scenarios.

Table 1. Scenarios representing no groundwater irrigation and M&I pumping conditions for comparison to the baseline scenario representing historical development and management actions.

Scenario Management Area	Model Area	Scenario Description	Change to baseline pumping	Change to baseline watershed modeled recharge
NPNRD	WWUM	Historical without NPNRD GWO and M&I development	No GWO scenario pumping in NPNRD	No GWO scenario recharge in NPNRD
SPNRD	WWUM	Historical without SPNRD GWO and M&I development	No GWO scenario pumping in SPNRD	No GWO scenario recharge in SPNRD
TPNRD	COHYST	Historical without TPNRD GWO and M&I development	No GWO scenario pumping in TPNRD	No GWO scenario recharge in TPNRD
CPNRD	COHYST	Historical without CPNRD GWO and M&I development	No GWO scenario pumping in CPNRD	No GWO scenario recharge in CPNRD
TBNRD	COHYST	Historical without TBNRD GWO and M&I development	No GWO scenario pumping in TBNRD	No GWO scenario recharge in TBNRD

IV. Model Output and Post-processing

1. Watershed Model Outputs

The Watershed land use and water balance summaries were used to generate the summaries of acres by irrigation type and crop type. The accounting points and NRD area zone files described later in the groundwater model output post processing were used to create these reports. The following differences in the annual number of acres by irrigation source or crop type were used:

Groundwater-only developed acres = Historical/Baseline groundwater-only acres

The land use and water balance summaries were also used to QA/QC the pumping and recharge differences that were calculated in groundwater model post-processing.

2. **Groundwater Model Outputs**

   a. **Process model results by NRD zone**

   The cell-by-cell outputs of the groundwater model runs were processed through Zonebudget with a zone file representing the management areas, detailed in the following Zone files section of the Robust Review documentations (2019 Upper Platte River Basin Robust Review). The difference between the pumping and recharge between the scenario and the baseline were summarized annually and compared to the watershed model outputs for quality control.

   b. **Process model results by accounting zone**

   The cell-by-cell output of the groundwater model was run through ZoneBudget with a zone file representing the delineations of the stream accounting points. For the purpose of the report, the zones were combined to account for the North Platte River, South Platte River, and Platte River Upstream of Elm Creek, as further detailed in the Zone files section of the Robust Review documentations (2019 Upper Platte River Basin Robust Review). The stream leakage terms from the ZoneBudget outputs are summarized on an annual basis. Net stream leakage is calculated as the difference between the volumes of water that went from the aquifer to the stream and from the stream to the aquifer. The difference between the scenario and baseline net stream leakage are the scenario impacts. As calculated, negative impacts are depletions and positive impacts are accretions.

   c. **Pre and post 1997 development and management impacts**

   The results of this analysis provide an estimate of the streamflow impacts from all historical groundwater only irrigation and M&I pumping. To quantify the total impacts of the historical groundwater only irrigation and M&I pumping with the offsetting management actions, the results of this analysis were combined with the impacts of the augmentation and excess flow recharge management actions as calculated in the Robust Review. For further details on the Robust Review and calculation of the augmentation pumping and excess flow recharge impacts see the Robust Review documentation (2019 Upper Platte River Basin Robust Review). The post-1997 impacts quantified in the Robust Review, as described in the Robust Review documentation (2019 Upper Platte River Basin Robust Review), were subtracted from the No GWO results to obtain the pre-1997 development impacts.

V. Results

The acres changes, pumping and recharge differences, and resulting differences in stream leakage are summarized in five spreadsheets – one for each NRD/area. They are titled:

COHYST_RobRevResults_CPNRD.xlsx, COHYST_RobRevResults_TPNRD.xlsx, COHYST_RobRevResults_TBNRD.xlsx, WWUM_RobRevResults_NPNRD.xlsx and WWUM_RobRevResults_SPNRD.xlsx .

These files are available at: https://upjointplanning.nebraska.gov or by contacting NeDNR.

VI. Additional/Further Investigations

The results of this analysis are subject to the limitations of the modeling processes outlined in this and other model documentation. Further investigations may be necessary to test the assumptions of this analysis and to assess the impacts of other management actions. Below is a short list of further investigations that we recommend:

- The sensitivity of annual depletions resulting from different climate representations
- The sensitivity of depletions to different crop type conversions on groundwater-only irrigated acres historically and when converting between groundwater only to dryland
- The sensitivity of annual and accounting point depletions to including runoff and diversions and returns
- Updating conservation practices/more accurate representation of current farming practices
- Hydraulic conductivity and initial head sensitivity in the vicinity of Plum Creek