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.

[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
2006	595.6
2007	27.4
2008	-
2009	-
2010	-
2011	-
2012	40.8
2013	-
2014	-
2015	-
2016	-
2017	-
2018	-
2019	-
2020	-
2021	-
2022	-
2023	-
Total	663.8

Year	Reinstated Retirements
2006	-
2007	-
2008	-
2009	-
2010	-
2011	-
2012	28.8
2013	-
2014	-
2015	-
2016	-
2017	594.2
2018	-
2019	-
2020	-
2021	-
2022	-
2023	40.8
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

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 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.

[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 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

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.

[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.

	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 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.

	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 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.

	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 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.

[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