

A.1.11 Memorandum on NPNRD
and SPNRD Canal Excess Flow
Diversion, Recharge Analysis
Comparison, and Canal Loss
Recommendation

Memo

Adaptive Resources, Inc.

To: John Berge, General Manager NPNRD, Rod L. Horn, General Manager SPNRD, and Platte Basin Water Project Coalition

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Re: Robust Review Analysis: NPNRD and SPNRD Canal Excess Flow Diversion, Recharge Analysis Comparison, and Canal Loss Recommendation

INTRODUCTION

On January 23, 2017, the POAC Technical Committee (TC) requested that Adaptive Resources, Inc. (ARI) provide a technical discussion of differences between the Robust Review (RR) and the January 2013 Department of Natural Resources (DNR) Technical Memorandum (TM) titled Upper Platte River Recharge and Flood Mitigation Demonstration Project: Part of the Conjunctive Management Toolbox. Additionally, during an analysis completed for SPNRD, ARI discovered several discrepancies within the TM's datasets, processes, and methodology that the POAC TC should consider. The TM describes a methodology to quantify accretion credits from the excess flow diversions into canal recharge that each NRD can expect. The Canal Recharge Analysis task that is part of RR is designed to refine the accretion credit estimates by utilizing the Western Water Use Management Modeling (WWUMM) and COHYST Modeling and will be completed under that scope of work.

2011 Canal Excess Flow Diversion Review

During the spring and fall of 2011, high river flows occurred due to significant snowpack runoff from the Rocky Mountains. Consequently, emergency action was taken to divert water into canals to alleviate flood flows and recharge water along the North Platte River, South Platte River, and Platte River. Irrigation districts and canal companies that were amenable and able to participate were paid by the NRDs and DNR to divert the water to recharge local aquifers, and in exchange, accretion credit was obtained by each NRD for depletion offset. For the accretion credits to be considered valid, no irrigation could take place during the diversion of the flood flows. Additionally, the NRDs or DNR recorded the amount and total days that diversion occurred in each canal. In the case of the Western Irrigation District (WID), recharge pits were utilized to recharge water in addition to the canal itself.

Outline of Data Obtained and Compiled:

- Headgate diversion records were collected by DNR using recording devices
- DNR or NRD personnel collected surface return flow spill measurements
 - Typically, data was collected manually at varying times (days or weeks apart)
- Recharge pit diversions were collected using staff gages or flowmeters

As discussed in the TM, some diversions and spills were not measured.



Memo

2013 Technical Memorandum Analysis Review

The TM's Analysis used the following equation for calculating canal loss as a percentage of the diverted excess flows:

$$\text{Canal Loss \%} = \left(1 - \frac{\text{rate measured at spill}}{\text{daily diversion rate}} \right) \times 100$$

The calculation of the Canal Loss percentage was completed on days that a canal had both diversion and return flow measurements. The resulting daily calculations were averaged to determine a recharge rate for each canal. Model estimates (WWUMM or COHYST) of canal recharge were utilized for canals that did not have return flow spill measurements.

Once the average recharge rate is determined, it is multiplied by the total amount of excess flow diversion completed by the canal. The total amount of recharge is then lagged back to a river or stream using the PBHEP zone's response functions that represent monthly return flow patterns that were developed using the Jenkins Method analytical equation.

Issues with the Technical Memorandum's Analysis

In 2015, ARI conducted an excess flow recharge and accretion credit analysis for SPNRD. Completing that analysis provided insight to refine the calculation of excess flow recharge estimates and put forth complications with the TM methodology, associated datasets, and processes.

Data obtained for the analysis were provided by SPNRD and DNR and include diversion dates for WID, diversion dates for SPNRD and TPNRD recharge pits along WID, diversion rates, spill rate measurements, and canal loss estimates. The WID excess flow events were recorded in the spring and fall of 2011, fall of 2013, and spring of 2014. SPNRD provided the following WID diversion dates of the excess flows:

- April 10 – June 1, 2011
- September 1 – November 14, 2011
- September 30 – October 27, 2013
- June 11 – July 8, 2014

Additionally, SPNRD, TPNRD, and the TM provided the total amount of pit recharge that occurred along WID per event.

Western Irrigation District Error and Differences in Total Diversion Days

Following a review of initial recharge estimates within the TM, it was discovered that the data provided was identical to that of Kearney Canal. Consequently, new diversion data for WID was requested from DNR on 12/08/2014 and 07/02/2015 and was determined that the data used for WID was the data for Kearney Canal. The excess flow diversion dates maintained by SPNRD and the new diversion data obtained from DNR confirmed the original TM data was in error.

Western Irrigation District Recharge Pit Calculation Error



Memo

The TM's calculation of canal loss for WID used the difference of the canal diversion and return flow spill measurements to determine total canal recharge. However, recharge pits were also employed along WID canal and were not considered in the calculation. This caused the TM methodology to overestimate the recharge. To mitigate this issue, the TM's canal loss calculation method should be altered to account for the water diverted into the recharge pits.

The analysis for SPNRD calculated the canal loss based upon their and TPNRD's information. These NRDs visited and tracked these sites and provided information that water was diverted into the pits through the final day of excess flow diversion. During the spring 2011 event, the WID diversion data and the number of total days each pit received water were used to complete the canal loss calculation to incorporate the recharge pits. The calculation was carried out starting on the last day of excess flow diversion and moved backward in time until the correct number of diversion days for each pit had been achieved.

Using additional SPNRD records, it was assumed that all pits diverted for the entire canal excess flow diversion events of 2013 and 2014 events. The excess flow diversion in 2014 occurred during the irrigation season, so only recharge into the pits was credited.

Possible Additional Refinements

During the completion of the SPNRD analysis, some additional discrepancies were identified in the data, and several additional changes were made to the process.

- Differences in diversion data obtained from DNR at different times were discovered; discrepancies also existed between data in the TM and data requested from DNR after the publication of the TM. Differences in preliminary and final data may account for this issue. Potentially, NRDs may need access to the method utilized by DNR for adjusting preliminary/raw diversion records to ensure a more accurate estimate of the canal recharge that the NRDs can use for planning purposes and before the payment to the irrigation district or canal company is completed.
- Adjustments in diversion data and the removal of pit diversion volumes sometimes resulted in negative canal recharge values. These issues require a more extensive investigation of the data and methods.
- For some excess flow events, canal loss was estimated over a relatively extended period but with few return flow records. In a few cases, only one return flow measurement was obtained. Because of the minimal return flow measurements, the average canal loss estimate may not represent the individual canal's actual average for the entire event.

Robust Review Analysis Review

During the final edits to the RR scope of work, the POAC TC decided that the Canal Recharge Project task utilize the WWUMM and COHYST model's calibrated canal leakage estimates for each canal to determine the total amount of recharge that occurs during excess flow diversion events. Simply, the analysis will remove these diversions and subsequent canal recharge from the modified modeling for each canal to determine the accretive effects. Total recharge for WID



Memo

will need to account for the recharge pits by removing the total pit diversions from the overall headgate diversions before the calculation of the canal recharge using the models.

Robust Review Analysis Discussion

As provided above, the TM's analysis to determine the amount of canal recharge that occurs differs from the RR design. The RR scope of work did not incorporate the return flow spill measurements for each canal as part of the analysis. The POAC TC will need to determine if this data is appropriate to utilize or if the calibrated modeled estimates of canal leakage are suitable.

Our recommendation is to independently review each canal during each diversion event to determine whether the calculated canal loss TM's methodology, the modeled estimates of irrigation season canal loss, or a combination of the two are appropriate. While this is time intensive and somewhat subjective, a one size fits all recommendation is not possible because either the TM's canal loss calculation or the modeled estimates may not be appropriate. Table 1 is an evaluation of each canal within WWUMM area and provides an updated version of TM calculated canal loss using the finalized DNR diversions, the number of spill measurements, modeled canal loss, our recommendation of the canal loss to use, and an explanation of the criteria we used to determine the recommended canal loss. We completed this for the WWUMM area due to our familiarity with the system. However, for the COHYST area, we recommend that someone with more extensive knowledge of that system complete a similar evaluation.



Memo

Table 1: WWUM Modeling Area 2011 Spring Assessment of Canal Loss Calculations, Recommended Canal Loss, and Explanation

Canal	Updated TM Canal Loss %	Number of Spill Measurements	Modeled Canal Loss %	Recommended Canal Loss % to Use	Recommended Canal Loss %	Explanation of the Criteria for the Recommendation
Pathfinder	40%	1	55%	Modeled	55%	There was only a single spill measurement taken at the Pathfinder Spill. However, there is no data for the other Pathfinder spill locations to determine if there were additional spills.
Farmers	45%	3	49%	Modeled	49%	There were three spill measurements. However, two measurements only recorded spills at Red Willow Creek at the end of the canal, and one measurement measured Winters Creek and Red Willow Creek. We personally know they spilled some water into Nine Mile Creek. The canal has several other spills points, and the dataset does not provide any information on whether spills occurred at these locations.
Enterprise	69%	3	42%	Modeled	42%	There were three spill measurements with decent distribution during the excess flow diversion. However, one measurement recorded spill at Tub Springs Creek and two measurements measured at Winters Creek at the end of the canal. There is no additional information on whether the Tub Springs or Winters Creek spills were active during each other measurement.
Minatare	24%	4	41%	Measured	24%	Minatare Canal had a decent number of spill measurements between 4-5-2011 and 4-26-2011. The canal diverted between 4-1-2011 and 4-30-2011. This is an acceptable resolution to determine the canal loss.
Castle Rock	41%	3	41%	Average of Measured and Modeled	41%	Castle Rock Canal had a decent number of spill measurements between 4-13-2011 and 4-26-2011. However, the canal diverted from 4-3-2011 and 5-3-2011. Because of the narrow date range of the spill measurements the measurements were averaged with the modeled estimate of canal loss.
Chimney Rock	45%	4	42%	Measured	45%	Chimney Rock Canal had a decent number of spill measurements between 4-4-2011 and 4-26-2011. The canal diverted between 4-1-2011 and 5-1-2011. This is an acceptable resolution to determine the canal loss.
Nine Mile	96%	1	41%	Average of Measured and Modeled	68%	There was only a single spill measurement taken at Nine Mile Spill. However, with only one measurement on 4-21-2011, there is not sufficient data to determine if the canal leakage was realistic, so the measured and modeled data were averaged.
Belmont	53%	3	38%	Measured	53%	Belmont Canal had a decent number of spill measurements between 4-4-2011 and 4-20-2011. The canal diverted between 4-1-2011 and 5-1-2011. This is an acceptable resolution to determine the canal loss.
Lisco	24%	1	41%	Average of Measured and Modeled	33%	There was only a single spill measurement taken at Lisco Spill. However, with only one measurement on 4-19-2011, there is not sufficient data to determine if the canal leakage was realistic, so we averaged the measured and modeled data.
Central	25%	0	42%	Modeled	42%	There were no spill measurements taken for Central Canal. The spreadsheet associated with the TM provides an estimated number. However, the estimated number was ignored as well, and 25% was used. We disregarded both these numbers and used the modeled estimate for canal leakage.
Western	31%	11	37%	Corrected Measurements	31%	There were 11 measurements from 4-21-2011 through 5-31-2011 for Western Canal which is a decent resolution. To determine the canal loss, the original TM was corrected by using Western Canal's diversions instead of Kearney Canal's. Note: Contractually, 70% of the canal recharge goes to TPNRD and 30% goes to SPNRD
Western Canal Pits	100%	N/A	N/A	N/A	100%	TM assumed that all the recorded values were recharged at 100%

Memo

Table 2: WWUM Modeling Area 2011 Fall Assessment of Canal Loss Calculations, Recommended Canal Loss, and Explanation

Canal	Updated TM Canal Loss %	Number of Spill Measurements	Modeled Canal Loss %	Recommended Canal Loss % to Use	Recommended Canal Loss %	Explanation of the Criteria for the Recommendation
Minatare	17%	1	41%	Average of Measured and Modeled	29%	There was only a single spill measurement taken at the Minatare Canal spill. Because one measurement is not sufficient, the averaged measured and model data was used.
Castle Rock	45%	2	41%	Average of Measured and Modeled	43%	Castle Rock Canal had two measurements occurring on 10-10-11 and 10-17-11. Due to the limited number of measurements, the averaged measured and model data was used.
Chimney Rock	17%	2	42%	Average of Measured and Modeled	30%	Chimney Rock Canal had two measurements occurring on 10-10-11 and 10-18-11. Due to the limited number of measurements, the averaged measured and model data was used.
Nine Mile	96%	0	41%	Modeled	41%	No measurements were taken in the fall at Nine Mile Spill, so the modeled canal loss was used.
Belmont	63%	2	38%	Average of Measured and Modeled	51%	Belmont Canal had two measurements occurring on 10-12-11 and 10-18-11. Due to the limited number of measurements, the averaged measured and model data was used.
Lisco	56%	2	41%	Average of Measured and Modeled	49%	Lisco had two measurements occurring on 10-12-11 and 10-18-11. Due to the limited number of measurements, the averaged measured and model data was used.
Central	26%	2	42%	Average of Measured and Modeled	34%	Central had two measurements occurring on 10-11-11 and 10-17-11. Due to the limited number of measurements, the averaged measured and model data was used.
Winters	1%	2	41%	Average of Measured and Modeled	21%	Winters had two measurements occurring on 10-11-11 and 10-17-11. The spill measurement on 10-17-11 created a negative canal loss measurement and was ignored. Consequently, 1% loss was used as the measured amount. Due to the limited number of measurements, the averaged measured and model data was used.
Western	38%	3	37%	Measured	38%	Western Canal had 3 measurements in the fall which occurred on 10-17-11, 10-5-11, and 11-9-11. The measurement from 11-9-11 was ignored because it was a negative value. Due to the limited number of measurements, the averaged measured and model data was used. Note: Contractually, 70% of the canal recharge goes to TPNRD and 30% goes to SPNRD
Western Canal Pits	100%	N/A	N/A	N/A	100%	TM assumed that all the recorded values were recharged at 100%

Memo

Table 3: WWUM Modeling Area 2013 Fall Assessment of Canal Loss Calculations, Recommended Canal Loss, and Explanation

Canal	Updated TM Canal Loss %	Number of Spill Measurements	Modeled Canal Loss %	Recommended Canal Loss % to Use	Recommended Canal Loss %	Explanation of the Criteria for the Recommendation
Western	31%	3	37%	Duplicate Measurements	31%	Because there were no measurements for fall 2013 for Western Canal, the same canal loss % for fall 2011 was used. Note: Contractually, 70% of the canal recharge goes to TPNRD and 30% goes to SPNRD
Western Canal Pits	100%	N/A	N/A	N/A	100%	TM assumed that all the recorded values were recharged at 100%