A.1.9 Memorandums on Industrial and Municipal Pumping for WWUMM

Memo

Adaptive Resources, Inc.

To:	John Berge, General Manager NPNRD, Rod L. Horn, General Manager SPNRD, and Platte Basin Water Project Coalition
From:	Thad Kuntz, P.G. and Joe Reedy, G.I.
CC:	
Date:	7/18/2018
Re:	Industrial Pumping Analysis, Robust Review Task: Post 1997 Development – Municipal/Industrial Pumping

EXECUTIVE SUMMARY

Adaptive Resources, Inc. (ARI) analyzed available industrial pumping information for both North Platte Natural Resources District and South Platte Natural Resources District as part of the Robust Review Project Analysis for the Western Water Use Management Modeling. The analysis utilized available water meter records for industrial wells in both Districts from 1997 through 2016, augmented with additional historical pumping records drawn from the Department of Natural Resources' (DNR) 2008 industrial survey, to produce a final industrial pumping dataset for the period from 1997 to 2013. The final pumping estimates include actual meter and survey data when available, and use averages estimated from the available data when meter records did not exist for a given well. These data were further limited to the period of active pumping, between well completion and abandonment, when applicable.

ARI also generated an industrial pumping dataset using the pumping capacity information available in the DNR well registration database. This dataset adapted a per capacity pumping estimation method and per capacity pumping categories developed in previous analyses. The dataset used all industrial registered wells in each District, limited to the period of expected active pumping.

Comparison of final pumping estimates revealed significant differences between methods. Pumping estimated with metered data was more variable later in the modeling period, with decreased variability in early pumping. Pumping estimated with capacity data exhibited limited variability, with the potential for significant overestimation of pumping during the modeling period due. There were also significant discrepancies between the wells included in each dataset. This may be due to discrepancies in actual and registered use, the temporary nature of some industrial uses, or meter and reporting requirements that may not capture all wells.

It is the opinion of ARI that industrial pumping estimated from meter records better reflects actual pumping and should be utilized for future analyses of this type. Meter records capture long and short-term variability in the existing pumping record and are likely to benefit from improved accuracy as additional meter data is incorporated. Changes in well metering or well registration reporting may impact the conclusions and data provided in this memo.

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INTRODUCTION

ARI is completing modifications to the baseline model run of the Western Water Use Management Modeling (WWUMM) under Task 1 of the Robust Review Project Analysis (RRPA). This task includes incorporating observed industrial pumping information into the WWUMM. The updated WWUMM will be utilized in Task 6 to compare the observed pumping information with the historical 1997 pumping information for industrial and commercial wells throughout North Platte Natural Resources District (NPNRD) and South Platte Natural Resources District (SPNRD). The analysis of available industrial pumping data utilized two distinct datasets; metered pumping records provided by the Districts, and the Department of Natural Resources (DNR) well registration database. Industrial well data provided by each NRD was parsed using the following assumptions:

- For NPNRD, only wells labeled "commercial" in the NPNRD dataset were used; including wells for Western Sugar and Bridgeport Ethanol Plant, provided separately (41 wells).
    - Wells from 2008 DNR industrial survey also included (1 well).
- For SPNRD, only wells with meters classified as "industrial" were used; including industrial meters on transferred or dual-use wells (40 wells).

Addendum A provides additional notes and information on the evolution of the analysis as additional datasets were considered.

METERED DATA

METHOD

Historical pumping data became available for industrial wells between 2006 and 2014. NPNRD data was provided annually on a certification basis. SPNRD data was provided as totalizing flow meter (TFM) records, including the date the flow meter was read; generally monthly.

NPNRD pumping data was provided as annual volumes. The average annual pumping was calculated using available pumping records from 2008 through 2016. If a record did not exist for a given year, that year was excluded from the average. The calculated annual average was used to fill any year that did not have a pumping record from 1997 through 2013. These annual values represent the actual or estimated pumping per certification in the District.

The certification and well data provided by NPNRD was used to determine all wells joined to a certification. These wells were assigned an active date based upon completion data from the NRD and the Nebraska Department of Natural Resources (NDNR) well permit database. Each well was also assigned an inactive date based upon the abandonment date from the same sources. A monthly array of active-inactive flags was created from the active-inactive dates. This array was used to determine the number of active wells per certification. The final monthly pumping values ($P_{1...12}$) were distributed to each well to create the final pumping schedule for NPNRD industrial pumping. Inactive wells were assigned a pumping value of 0.

The process for calculating and distributing pumping can be described with the following calculations:

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1) Average annual pumping calculated by certification:

$$(Q_1 + Q_2 + \ldots Q_n) \div n = Q_{avg}$$

2) Years with no record filled using the annual average, Q_{avg}
3) Annual pumping distributed to monthly pumping, based on active wells:

$$Q_1 \div 12 = P_{1\ldots12} \text{ for given year}$$

$$P_1 \div \text{active wells count for month} = \text{final monthly pumping}$$

SPNRD pumping data was provided as monthly TFM readings. The readings were taken at irregular intervals for some wells. Additionally, each flow meter provided readings in one of three units: acre-inches, acre-feet, or gallons. The number of decimal and non-decimal significant figures recorded also varied by flow meter; the maximum value the flow meter could record is termed the "roll over" for this text. Data provided by SPNRD was used to convert all readings to cubic feet. Flow meters were generally read at the beginning or end of each month, with the day being largely consistent with the readings on a given meter, but not between meters. Serial dates were used to apportion monthly pumping volumes between adjacent months based upon the current and adjacent serial dates (forward and backward in time). This apportionment was only applied to the first and last month of each year. As TFM records were inconsistent for some wells, the calculated monthly pumping volumes were aggregated annually. Using annual data also allowed for consistency in the pumping distribution between NRDs. If a gap existed across years in TFM records, the estimated volume of pumping during the gap was distributed proportionally between each year based on the number of days per year captured by the gap. This process was applied even if the gap covered multiple years. It is possible estimates calculated in this way may be artificially low, as the flow meter may have "rolled over" during an extended gap. The method for estimating annual pumping from TFM records is demonstrated below:

1) Conversion of TFM record to pumping volume:

$$TFM_n - TFM_{n-1} = Q_n$$

2) Conversion of monthly volumes:

$$Q \text{ in gal, acre-in, acre-f} \div \text{conversion factor} = Q\ ft^3$$

3) Shifting of monthly volumes across monthly and annual gaps (effectively only changes pumping at the end and beginning months of gapped years, as values are summed annually).

$$((\text{End of Month Serial}_{n-1} - \text{Serial}_{n-1}) / (\text{Serial}_n - \text{Serial}_{n-1})) * Qn = Q_{n-1\ portion}$$

$$((\text{Serial}_n - \text{End of Month Serial}_{n-1}) / (\text{Serial}_n - \text{Serial}_{n-1})) * Qn = Q_{n\ portion}$$

4) Calculation of annual pumping:

$$Q_n + Q_{n+1} + Q_{n+2} + Q_{n+n} = Q_{total} \text{ for given year}$$

SPNRD pumping was calculated per well, with no additional distribution. Months were determined to be active or inactive using the process described for NPNRD.

ASSUMPTIONS

Several assumptions were made in the processing of the NRD meter records. They include:

1) Wells tied to the same industrial use or certification were pumped equally.

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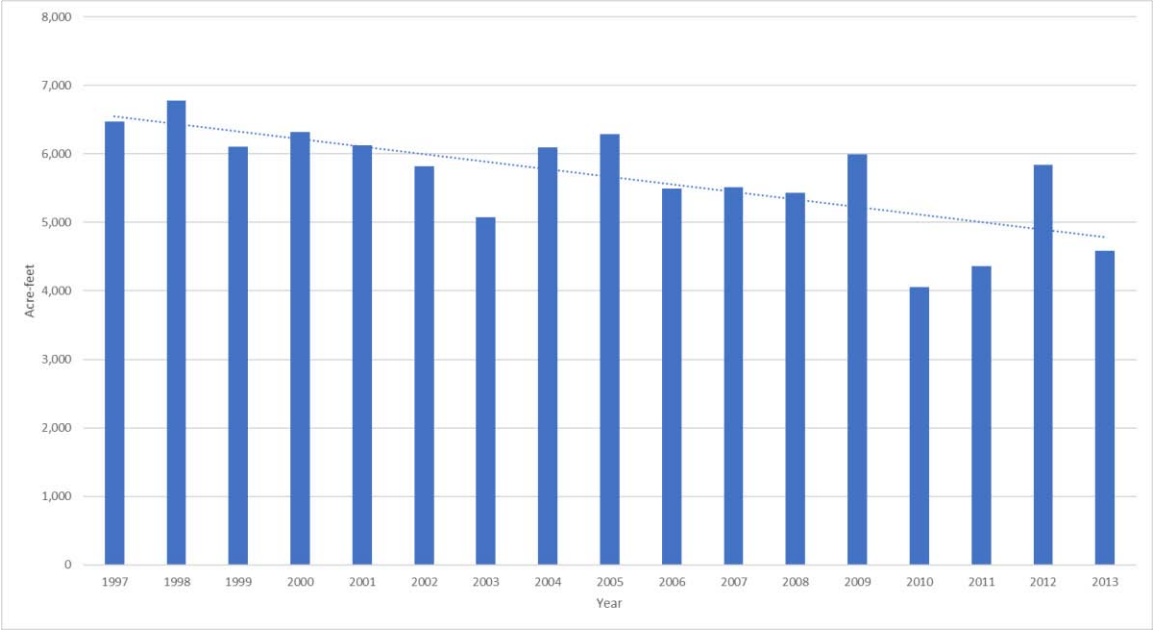
2) Gaps in TFM readings represent a pumping period if the first new reading differs from the previous reading; pumping is assumed to have occurred at a constant daily rate during the gap.
3) NDNR completion and abandonment dates reasonably approximate first and last use dates for the non-metered period, unless noted in discussion with each NRD or the well owner (in the case of industrial survey wells and those owned by Nebraska Public Power District [NPPD]).

RESULTS

Pumping for NPNRD was generally less than the annual pumping estimated for 1997, with an average annual volume 14% lower (approximately 855 AF). Large users generated most of the variability in annual volumes, with Western Sugar wells driving decreases in 2003, 2010, and 2011.

Figure 1: Estimated Annual Pumping for NPNRD, from Meter Data



Pumping for SPNRD was generally greater than the annual pumping estimated for 1997, with an average annual volume 2% greater (approximately 18 AF). Variability in the meter record was largely attributed to pumping by the City of Kimball, including declines in 2003 and 2011.

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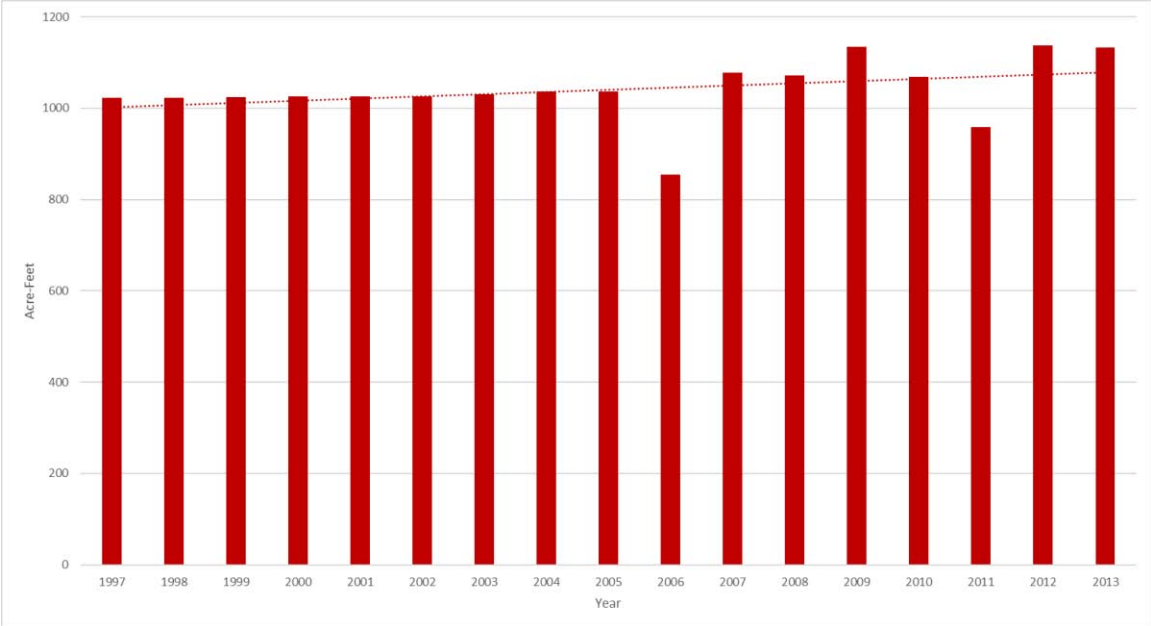
Figure 2: Estimated Annual Pumping for SPNRD, from Meter Data



CAPACITY DATA

METHOD

The statewide well registration database was retrieved as a shapefile from the DNR web portal (https://dnr.nebraska.gov/data/groundwater-data). Wells were isolated from the database for both NRDs using the "Commercial" use identification tag and NRD name. Each well was then assigned to an industrial category using the owner's name and description, with each category having an associated consumptive use estimate. This process sought to adapt the methodology described in "Municipal and Industrial Pumping" prepared by The Flatwater Group, Inc, using the per capacity pumping estimates defined in Appendix C. The assignation of industrial classes in North Platte and South Platte NRDs was subjective and cursory, and the results of the estimates calculated with this method may vary if the well classifications were otherwise defined.

- A total of 115 commercial wells were identified in NPNRD.
- A total of 80 commercial wells were identified in SPNRD.

Well capacity information was compiled monthly for each industrial class using well completion and decommission dates to denote active and inactive periods for each well. The same process as detailed for the meter data method was used. Pumping was then estimated using the associated per capacity pumping values. Monthly estimates were converted to annual averages for final analysis. Initially, a large portion of pumping in NPNRD was attributed to 15 wells owned by NPPD. Following communication with Jeff Schafer of NPPD, only one well was determined to be active during the modeling period. He reported that the 14 other wells were believed to be last used in 1986, though they were not abandoned until 2003, and were subsequently removed from the analysis. The remaining well was maintained for domestic and miscellaneous use. However, the original capacity data was maintained in the dataset, as the well's new capacity value is unknown.

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The process for calculating and distributing pumping is described with the following calculations:

1) Total monthly capacity summed by industrial classification:

$$(C_1 + C_2 + \ldots C_n) = C_t$$

2) Monthly capacity per classification converted to annual average:

$$(C_{t1} + C_{t2} + \ldots C_{t12}) \div n = C_{avg}$$

$$C_{avg} * \text{average per capacity pumping estimate} = P \text{ per class}$$

3) Annual pumping per class summed to provide annually estimated pumping per NRD:

$$(P_1 + P_2 + \ldots P_n) = P \text{ for given year}$$

As this method was initially analyzed for comparison purposes, the analysis did not include distribution of annual pumping back to individual wells. If this dataset is chosen, the same method of distribution as was used in the meter data method would be utilized.

ASSUMPTIONS

Several assumptions were made in the processing of the NRD capacity records. They include:

1) Well completion and decommission/abandonment dates are a fair representation of actual pumping periods.
2) Industrial classification for wells is a fair approximation of actual well use.
3) Average per capacity pumping values are a fair estimate of actual pumping.

RESULTS

Pumping for NPNRD was generally greater than the annual pumping estimated for 1997, with an average annual volume 3% higher (approximately 196 AF). Variability in pumping was largely driven by the ethanol and small business classes.

Figure 3: Estimated Annual Pumping for NPNRD, from Capacity Data

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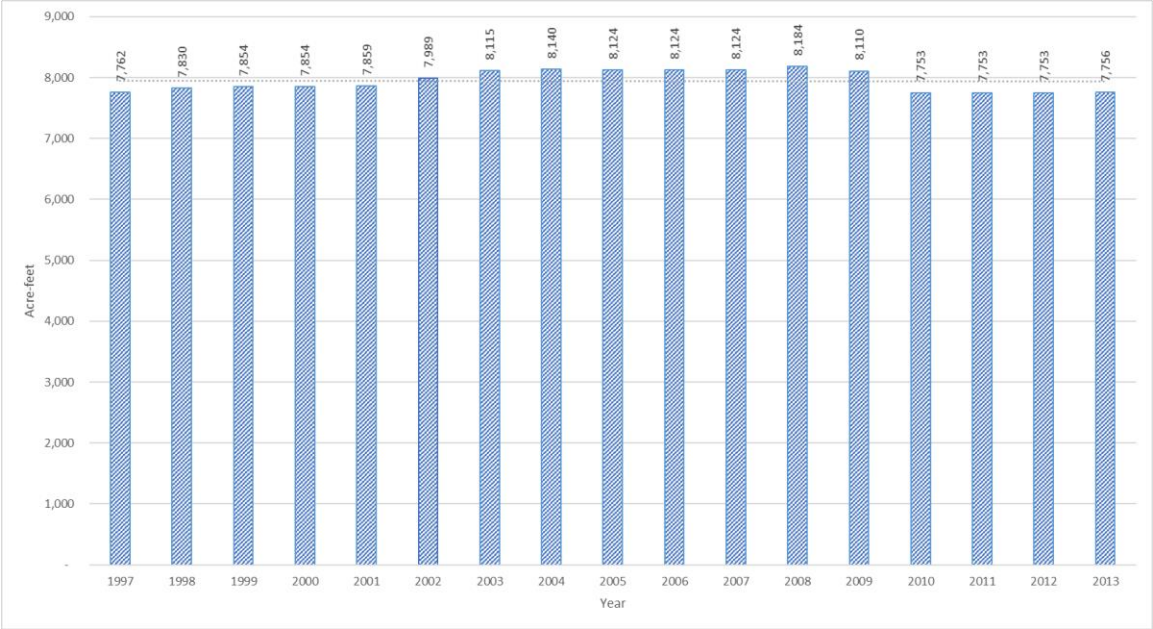
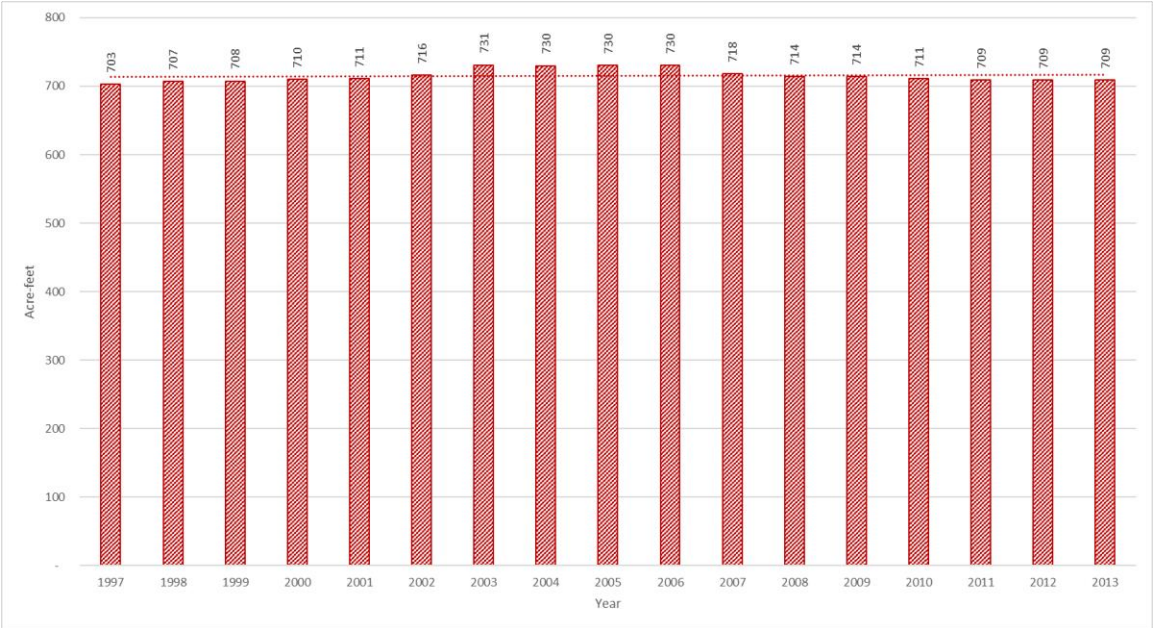


Pumping for SPNRD was generally greater than the annual pumping estimated for 1997, with an average annual volume 1% greater (approximately 13 AF). Variability in the pumping was largely driven by the sand and gravel class.

Figure 4: Estimated Annual Pumping for SPNRD, from Capacity Data



CONCLUSIONS AND RECOMMENDATION

Several issues arose in a direct comparison of the methodologies. A review of well identification numbers and registration numbers between datasets revealed the following:

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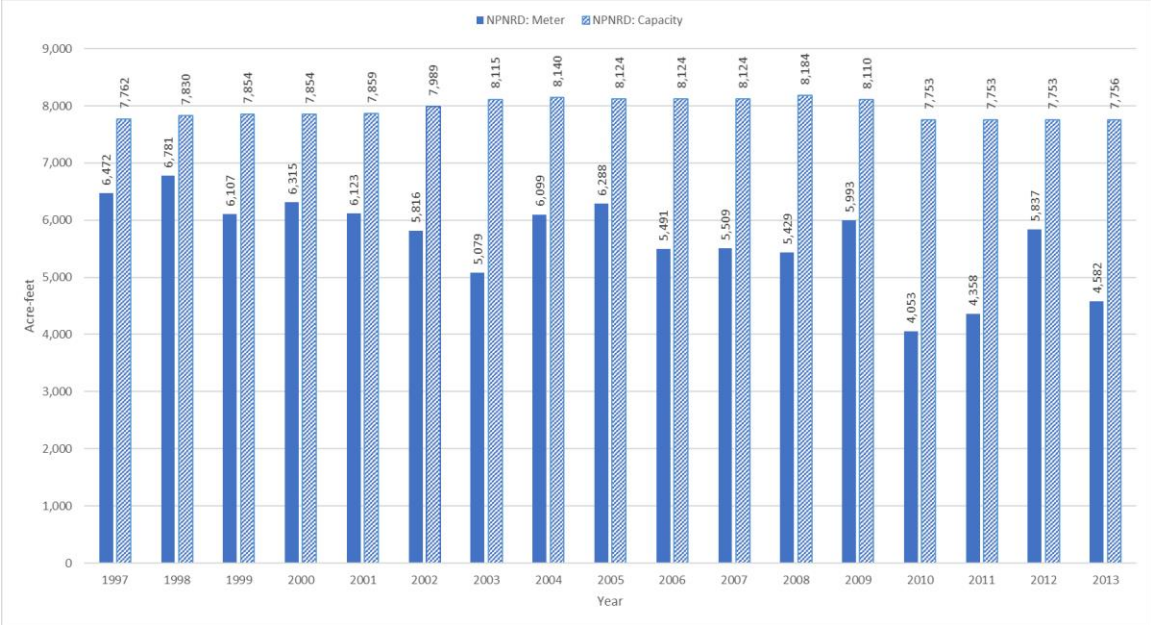
- Of the 115 wells identified in the capacity database for NPNRD, only 25 were present in the meter database; additionally, 17 wells identified in the meter database were not identified in the capacity database.
- Of the 80 wells identified in the capacity database for SPNRD, only 15 were present in the meter database; additionally, 25 wells identified in the meter database were not identified in the capacity database.
- Differences in total pumping estimates were significant.
    - NPNRD metered pumping estimates were an average of 71% of capacity estimates.
    - SPNRD metered pumping estimates were an average of 145% of capacity estimates.
- Differences in pumping trends were also noticeable in NPNRD.

NPNRD realized an average 14% decrease in annual pumping in the metered analysis, and an average 3% increase in annual pumping in the capacity analysis.

Figure 5. Comparison of Annual Pumping for NPNRD



SPNRD realized an average 2% increase in annual pumping in the metered analysis, and an average 1% increase in annual pumping in the capacity analysis.

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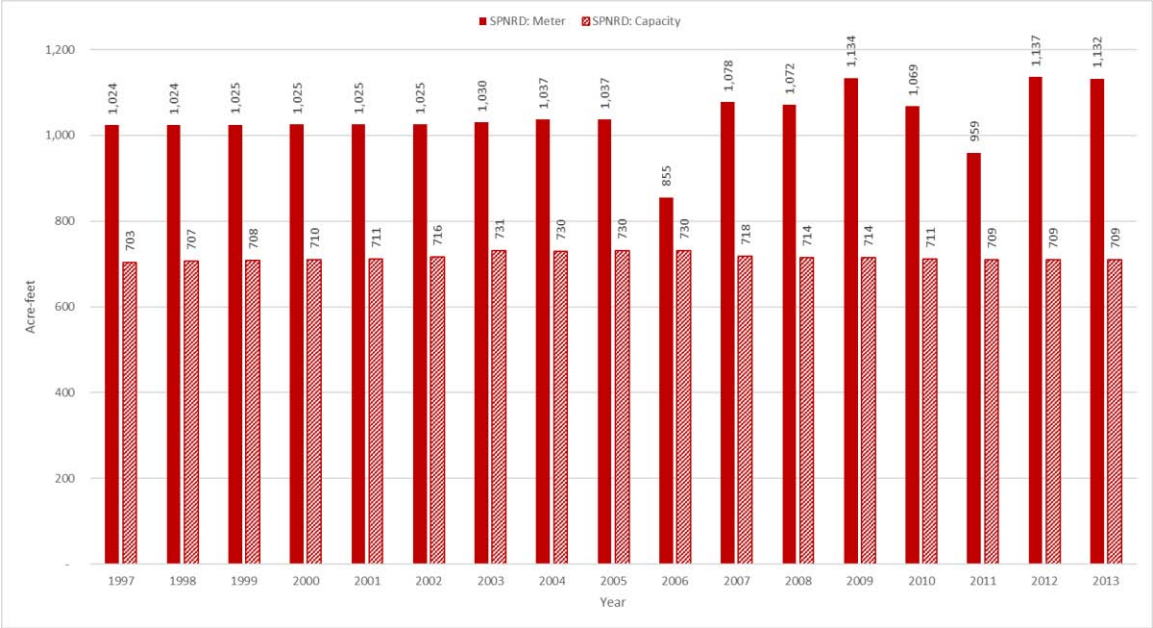
Figure 6. Comparison of Annual Pumping for SPNRD



Each methodology may include unique weaknesses derived from a lack or abundance of data that fails to accurately reflect actual pumping:

- Metered data may over- or underestimate pumping, especially in non-metered years and for certifications/wells with few records.
- Capacity data may over- or underestimate pumping, especially in the case of inaccurate abandonment dates; per capacity pumping estimates were also not determined for the area of interest in this analysis, with the possibility that the existing estimates fail to capture differences in regional industrial use or the presence of other industrial classes.

Differences in wells represented between datasets may be the result of differences in classification between the NRD and DNR database. Wells may be designated dual use, or temporarily transferred, in the NRD database and this change may not be represented in the DNR data. Well use may also vary for climactic, economic, or other reasons, which likely is not represented in the current per capacity pumping estimates. For these reasons, and the addition of future meter data collection by the NRDs, it is ARI's recommendation that a method utilizing the metered data in the Robust Review will most accurately reflect current and future industrial use.

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Adaptive Resources, Inc.

To: POAC Technical Committee

From: Thad Kuntz, P.G. and Joe Reedy, G.I.

CC:

Date: 7/18/2018

Re: Addendum A: Robust Review: Industrial Pumping – Processes and Data Flow

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Adaptive Resources, Inc. (ARI) is providing this document as an addendum to the final Robust Review industrial pumping dataset and associated memo report; Industrial Pumping Analysis, Robust Review Task: Post 1997 Development – Municipal/Industrial Pumping and Excess Flow Recharge, dated July 18, 2018 addressed to John Berge, General Manager NPNRD, Rod L. Horn, General Manager SPNRD, and Platte Basin Water Project Coalition by Thad Kuntz, P.G. and Joe Reedy, G.I. This document seeks to provide insights into the gathering and analysis of industrial and commercial data, specifically addressing changes to the scope of data and processing methods from previous iterations of the analysis and the differences they engender. It represents a short summary of the notes of ARI staff. The full report should be referenced for the final and complete methodology.

The initial Industrial Pumping information relied solely upon two datasets: the North Platte Natural Resources District (NRD) industrial pumping database, and the South Platte NRD industrial pumping database. Both databases include information compiled from industrial flow meters within the Districts. The analysis utilized similar calculations as described in the final report, whereby pumping records were converted to annual volumes, pumping averages were used to fill missing data, and pumping was then distributed monthly. The initial process indicated that South Platte NRD had relatively little industrial pumping and that the volume generally decreased through time. It also indicated that North Platte NRD industrial pumping generally increased through time. Both datasets displayed limited variability in early time data, reflecting the introduction of flow meters in the mid-2000's and the use of averages prior to that.

Following the initial analysis and discussion with the Technical Committee, the datasets were expanded, and slight changes were made to data processing. A review of included data was conducted with staff from both NRDs and both datasets were expanded to include additional wells or pumping records. The South Platte NRD dataset was expanded to include dual-use wells that had a dedicated industrial meter, increasing the number of wells represented in the analysis by a product of four. The North Platte NRD dataset was expanded to include additional pumping for existing wells and to correct for transcription errors in the original dataset that had decreased pumping volume. Additionally, the datasets were expanded to include pumping reported in the 2008 DNR Industrial Survey. The inclusion of Industrial Survey data resulted in additional pumping records for two existing industries, and one additional well in North Platte NRD. Data processing was modified to include the Industrial Survey data, which was reported annually.

As a result of these revisions, modeled pumping in South Platte NRD increased by an order of magnitude and the historical trend reversed, with a slight increase in pumping over time. Modeled pumping in North Platte NRD also increased, with the historical trend reversed (possibly due to the inclusion of additional historical data from the Industrial Survey) and pumping decreasing

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through time. The expanded datasets also displayed increased variability, especially in late time, possibly indicating a more realistic representation of industrial use.

Finally, an ancillary analysis of the state well registration database was conducted. Pumping capacity data for industrial wells in North Platte NRD represents a larger volume of pumping than is seen in the NRD meter database. However, following communication with some high-volume industries identified in the industrial dataset (namely NPPD), multiple wells were identified that had been abandoned prior to the modeling period. These wells were removed from the analysis, significantly decreasing pumping. South Platte NRD capacity data was significantly lower than the pumping represented in the meter database. This may indicate that temporary dual-use permits are not represented in the registration data. The capacity data also exhibits significantly less variability through time. An exhaustive analysis of wells in the registration database was not conducted, so it is unknown how many wells may be overrepresented due to failures in reporting. Additionally, wells that are classified as industrial to the State may be classified differently by each NRD (e.g., CAFO) and may not be represented in their databases.