# RGDSS Memorandum

# Phase 6 - Non-Irrigation Pumping and Return Flows

# Final

**TO:** File
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**SUBJECT:** RGDSS Groundwater Model – Phase 6: Non-Irrigation Pumping and Return Flows
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## 1. Introduction

This memorandum describes enhancements to non-irrigation wells included in Phase 6 of the Rio Grande Decision Support System (RGDSS) Groundwater Model (Model) as defined by Model Version 6P98. The objectives of this task were as follows:

1. *Identify non-irrigation wells and group wells into categories based on their type of water use.*
2. *Estimate non-irrigation pumping and return flows explicitly represented in the Groundwater Model.*
3. *Implement refinements to the list of small flowing wells and associated locations, assignment to groundwater model layers, and discharge rates based on improved well information and enhancements to HydroBase.*

In Phase 6, an effort was made to investigate wells in Division 3 available in HydroBase. A tremendous amount of work was conducted by the DWR modeling group, HydroBase development personnel, and Division 3 staff. As a result of this inventory investigation, a WDID was issued to each active well that is subject to the *Rules Governing the Measurement of Ground Water Diversions Located in Water Division No. 3, the Rio Grande Basin* (Well Measurement Rules), and a WDID was issued to each well that has historical diversion records. This effort enabled the modeling group to evaluate pumping and return flow of non-irrigation wells in Division 3 and update the groundwater modeling input data through 2010.

In this memorandum, for consistency between sections, "pumping" is used to describe groundwater withdrawals whether the withdrawal is by a mechanical pump or if the well flows under artesian pressure. Some of the wells that are discussed herein flow under artesian pressures and do not have a pump installed in the casing even though the section uses the term "pumping" to describe their withdrawal of groundwater.

## 2. Previous Efforts

In previous Phase 4 and Phase 5 efforts, the non-irrigation wells that were included in the modeling were predominantly used for municipal and industrial purposes and therefore the wells were referred to as M&I Wells. The previous efforts regarding pumping data of non-irrigation wells were documented in RGDSS Surface Water, Task 4.8 – M&I Water Use (Hydrosphere 1999) and RGDSS Ground Water, Task 16 – Pumping Data (HRS 2000). In Task 4.8, Ed Armbruster researched and documented the most significant municipal and industrial water users in the Rio Grande Basin. The research results of Task 4.8 show that municipal and industrial water is predominantly supplied from groundwater pumping systems, although several towns also use surface water as part of their water supply. In Phase 4 of the RGDSS groundwater

model development, Excel spreadsheets were developed to estimate municipal and industrial (M&I) pumping and return flows for the period of 1950 through 2002. In Phase 5, the spreadsheets were updated to incorporate well data through 2005.

## 3. Approach

With the progress that has been made to HydroBase and TSTool, in Phase 6 it is possible to use TSTool to improve the efficiency of updating the non-irrigation well pumping and return flow data. WDIDs are generally used for representing wells for both irrigation and non-irrigation wells and provide the unique identification necessary to query specific information for each well from HydroBase.

The approach to estimate pumping and return flow for a specific well depends on the use of the well. The water use for non-irrigation wells can vary tremendously depending on the purpose of water use. The difference can be expressed in terms of 1) time of use, 2) amount of groundwater withdrawn, 3) amount of consumptive use, and 4) amount and location of return flow. This section describes:

- Categorization of Non-Irrigation Wells by Water Use, and
- Pumping and Return Flow Data Availability and Estimates.

### 3.1 Categorization of Non-Irrigation Wells by Water Use

The State of Colorado's Water Resources Relational Database (HydroBase) was searched to identify non-irrigation wells in Division 3. The wells whose rate of diversion and type of use meet the requirements of sections 37-92-602(1) through (5), C.R.S., ("exempt wells") were not evaluated as non-irrigation wells. However, these wells were evaluated for potential inclusion as small flowing wells if they were completed into the confined aquifer. The non-irrigation wells were investigated and grouped into seven categories based on the use of each well:

- Closed Basin Project wells (170 wells)
- Blanca Wetlands wells (42 wells)
- Division of Wildlife wells (10 wells)
- Municipal wells (67 wells) – wells operated for public water supplies for towns or communities
- Industrial, commercial and other wells are divided into four subgroups based on the water consumptive use patterns:
    - Pond wells (13 wells)
    - Potato Washing wells (7 wells)
    - Confined wells on the Meadow Ranch (4)
    - Other wells (94 wells)

### 3.2 Pumping and Return Flow Data Availability and Estimates

#### 3.2.1 Closed Basin Project Wells

*Pumping*

The Closed Basin Project (CBP) well pumping data have been provided by staff of the Alamosa Field Division (AFD), under the U.S. Bureau of Reclamation (USBR), who manage the project. The data provided by AFD are monthly pumping volumes listed using well identification SW1 through SW170 (SW stands for salvage well). In Phase 4 and 5 the SW identifications were matched with permit numbers and permit numbers were used in the model. In Phase 6, SW IDs were matched to WDIDs. The CBP

wells without WDIDs at the time of matching were identified and WDIDs were created by Division 3 staff. A list of CBP well WDIDs is listed below in Table 1.

| Table 1. Closed Basin Project Well WDIDs | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| WDID | | WDID | | WDID | | WDID | | WDID |
| 2014403 | | 2605985 | | 2706309 | | 3505658 | | 3505693 |
| 2014406 | | 2605986 | | 2706310 | | 3505659 | | 3505694 |
| 2014407 | | 2605987 | | 2706311 | | 3505660 | | 3505695 |
| 2014408 | | 2605988 | | 2706312 | | 3505661 | | 3505696 |
| 2014409 | | 2605989 | | 2706313 | | 3505662 | | 3505697 |
| 2014429 | | 2605990 | | 2706314 | | 3505663 | | 3505698 |
| 2014464 | | 2605991 | | 2706315 | | 3505664 | | 3505699 |
| 2505515 | | 2605992 | | 2706316 | | 3505665 | | 3505700 |
| 2505516 | | 2605993 | | 2706317 | | 3505666 | | 3505701 |
| 2505517 | | 2605994 | | 2706318 | | 3505667 | | 3505702 |
| 2505519 | | 2605995 | | 2706319 | | 3505668 | | 3505703 |
| 2505520 | | 2605996 | | 2706320 | | 3505669 | | 3505704 |
| 2505521 | | 2605997 | | 2706321 | | 3505670 | | 3505705 |
| 2505522 | | 2605998 | | 2706326 | | 3505671 | | 3505706 |
| 2505523 | | 2605999 | | 3503648 | | 3505673 | | 3505707 |
| 2505524 | | 2606000 | | 3505638 | | 3505674 | | 3505708 |
| 2505525 | | 2606001 | | 3505639 | | 3505675 | | 3505709 |
| 2505526 | | 2606002 | | 3505640 | | 3505676 | | 3505710 |
| 2505527 | | 2606003 | | 3505641 | | 3505677 | | 3505712 |
| 2505528 | | 2606004 | | 3505642 | | 3505678 | | 3505713 |
| 2505529 | | 2606005 | | 3505643 | | 3505679 | | 3505714 |
| 2505530 | | 2606006 | | 3505644 | | 3505680 | | 3505715 |
| 2505531 | | 2606007 | | 3505645 | | 3505681 | | 3505716 |
| 2505532 | | 2606008 | | 3505646 | | 3505682 | | 3505717 |
| 2505533 | | 2606009 | | 3505647 | | 3505683 | | 3505718 |
| 2505534 | | 2706299 | | 3505648 | | 3505684 | | 3505719 |
| 2505538 | | 2706300 | | 3505649 | | 3505685 | | 3505720 |
| 2505539 | | 2706301 | | 3505650 | | 3505686 | | 3505721 |
| 2505541 | | 2706302 | | 3505651 | | 3505687 | | 3505722 |
| 2505940 | | 2706303 | | 3505652 | | 3505688 | | 3505723 |
| 2605981 | | 2706304 | | 3505653 | | 3505689 | | 3505724 |
| 2605982 | | 2706305 | | 3505655 | | 3505690 | | 3505730 |
| 2605983 | | 2706306 | | 3505656 | | 3505691 | | 3505731 |
| 2605984 | | 2706307 | | 3505657 | | 3505692 | | 3505732 |

*Return flow*

The water produced from the CBP wells is delivered to the Rio Grande through a lined canal. A portion of the water produced and transported is used for mitigation at the San Luis Lakes, Blanca Wetlands, and the Alamosa National Wildlife Refuge. Due to the operations of the Closed Basin Project primarily

delivering water directly to the stream, these return flows are not explicitly modeled within the groundwater model.

### 3.2.2 Blanca Wetlands Wells

The Blanca Wetlands wells are managed by the United States Bureau of Land Management (BLM). The pumping and return flows associated with these wells are documented in RGDSS Phase 6 Memorandum, Phase 6 - State and Federal Wildlife Operations (June 2016).

### 3.2.3 Colorado Division of Wildlife Wells

Colorado Division of Wildlife (CDOW) wells include three wells at the Native Aquatic Species Restoration Facility (NASRF), five wells at the Monte Vista Hatchery Facility, one well at the Spicer Hatchery Facility, and one well for their Hot Water Pond. The pumping and return flows associated with these wells are documented in RGDSS Phase 6 Memorandum, Phase 6 - State and Federal Wildlife Operations (June 2016).

(During Phase 6, Colorado Division of Wildlife merged with Colorado State Parks to become Colorado Parks and Wildlife (CPW). The new naming convention after the merger has not been incorporated into the modeling datasets, which still reflect the older designation of CDOW.)

### 3.2.4 Municipal Wells

*Pumping*

Municipal well pumping in Division 3 for the study period prior to available diversion records for the Municipalities' wells is estimated based on municipal demand. Municipal demand was estimated based on historical population and water demand rates in gallons per capita per day (GPCPD). The annual municipal demand is then distributed to the municipality's wells equally and disaggregated to monthly values based on a monthly distribution curve. When available, the metered pumping volumes were used for each well and the annual volumes were disaggregated to monthly values based on the monthly distribution curve.

Historical population data is available in HydroBase from two sources: U.S. Census Bureau (Census) and Colorado Department of Local Affairs (DOLA). Census population data are collected and published every ten years. DOLA evaluates between the Census Bureau data and estimates population for every year starting in 1991. The TSTool command file used for the SPDSS Task Memo 66.2 (LRE, 2007) was used as a guide for the method of gathering the population data for Division 3. The population data was processed using TSTool to combine Census Bureau data with DOLA data and to fill missing data by linearly interpolating between data points. Table 2 presents population data summarized every 10 years by municipality. The combined Census and DOLA population data are presented on Figure 1.

| Table 2. Municipality Population in the San Luis Valley | | | | | | | |
|---|---|---|---|---|---|---|---|
| Municipality | Year | | | | | | |
| | 1950 | 1960 | 1970 | 1980 | 1990 | 2000 | 2010 |
| Alamosa | 5354 | 6205 | 6985 | 6830 | 7579 | 7960 | 8780 |
| Antonito | 1255 | 1045 | 1113 | 1103 | 875 | 873 | 781 |
| Blanca | 376 | 233 | 212 | 252 | 272 | 391 | 385 |
| Center | 2024 | 1600 | 1470 | 1630 | 1963 | 2392 | 2230 |
| Del Norte | 2048 | 1856 | 1569 | 1709 | 1674 | 1705 | 1686 |
| La Jara | 912 | 724 | 768 | 858 | 725 | 877 | 818 |
| Manassa | 832 | 831 | 814 | 945 | 988 | 1042 | 991 |
| Monte Vista | 3272 | 3385 | 3909 | 3902 | 4324 | 4529 | 4444 |
| Romeo | 404 | 339 | 352 | 308 | 341 | 375 | 404 |
| Saguache | 1024 | 722 | 642 | 656 | 584 | 578 | 485 |
| San Luis | 1239 | 0 | 781 | 842 | 800 | 739 | 629 |
| Sanford | 666 | 679 | 638 | 687 | 750 | 817 | 879 |

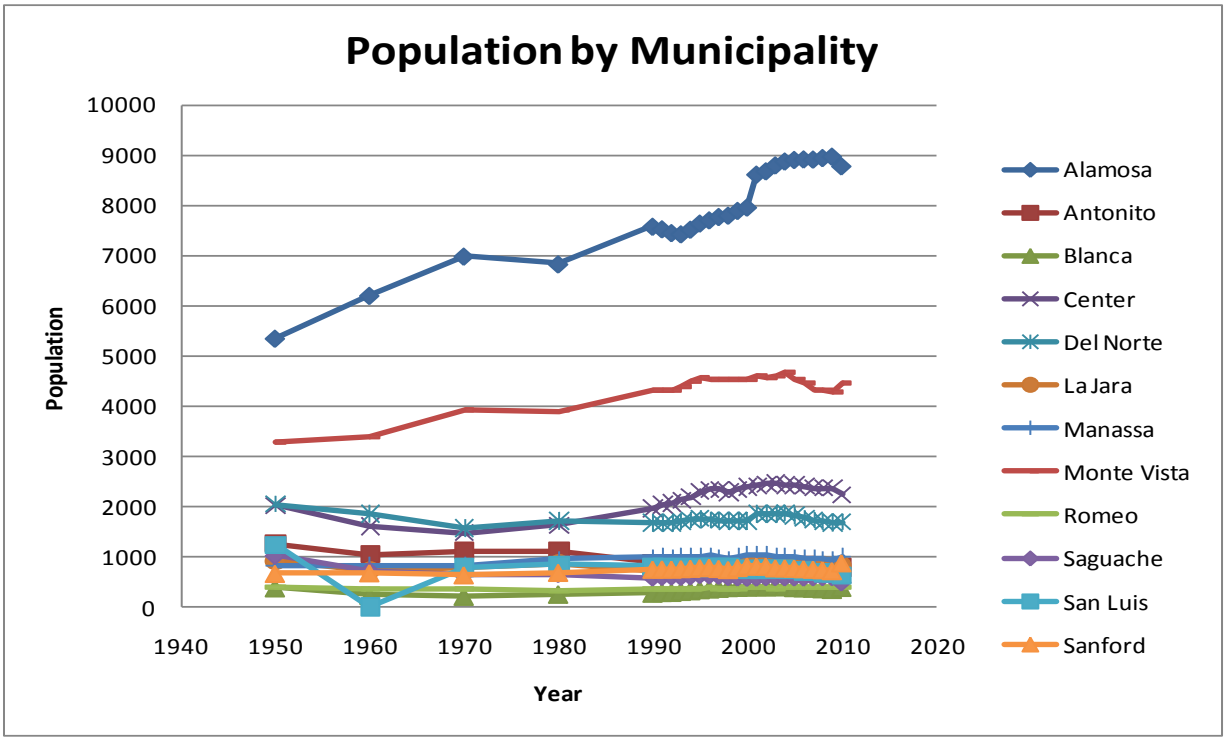


Figure 1. San Luis Valley Populations by Municipality

Population data are available for the majority of municipalities in Division 3, but is not available for the following communities and developments that have a central water supply served by a well: Baca Water and Sanitation (Unites States Fish and Wildlife Service), Capulin, Conejos, Fort Garland, Garcia, KV

Homeowners, La Valley, Melby Ranch, San Acacio, and Sand Dunes. For communities without population data, HydroBase contains diversion data for their well(s) for at least two years, and in some cases more than two years. For the previously listed communities, the well diversion data were used and the missing data were filled using the average of available historical data for the years in which the wells were operational.

The water demand rates in GPCPD for municipalities in Division 3 are based on the report, State of Colorado 2050 Municipal and Industrial Water Use Projection, by Colorado Water Conservation Board (CWCB) published in July 2010. The GPCPD rate of water use demands for municipalities in Table 3 below is based on Table 3.1 Baseline M&I Forecast by County of the report. According to the report, the water demand for municipal wells was estimated by county. The municipalities in the San Luis Valley, as shown in Table 3, are geographically included in one of five counties - Alamosa, Conejos, Costilla, Rio Grande, or Saguache.

**Table 3. Municipal Demand in San Luis Valley**

| City | County | Demand | |
|---|---|---|---|
| | | GPCPD | Acre-Feet/YEAR |
| Alamosa | Alamosa | 258 | 0.28921 |
| Antonito | Conejos | 521 | 0.58403 |
| Blanca | Costilla | 193 | 0.21635 |
| Center | Saguache | 274 | 0.30715 |
| Crestone | Saguache | 274 | 0.30715 |
| Del Norte | Rio Grande | 306 | 0.34302 |
| Fort Garland | Costilla | 193 | 0.21635 |
| Hooper | Alamosa | 258 | 0.28921 |
| La Jara | Conejos | 521 | 0.58403 |
| Manassa | Conejos | 521 | 0.58403 |
| Moffat | Saguache | 332 | 0.37217 |
| Monte Vista | Rio Grande | 306 | 0.34302 |
| Romeo | Conejos | 521 | 0.58403 |
| Saguache | Saguache | 274 | 0.30715 |
| San Luis | Costilla | 193 | 0.21635 |
| Sanford | Conejos | 521 | 0.58403 |

To determine the annual municipal pumping demands, the annual population was multiplied by the municipality's demand rate.

The towns of Hooper and Moffat do not have public water supplies. The residents of these towns use individual house wells for their domestic water supplies. For these towns, no municipal diversions are estimated and therefore no municipal wells are simulated as non-irrigation wells in the groundwater model. The small residential wells were included in the modeling as small flowing wells if completed into the confined aquifer.

Two towns have adjustments made to their estimated pumping – Antonito and Center. For the Town of Antonito, a portion of their water supply comes from surface water sources, according to the RGDSS

Surface Water, Task 4.8 memo (Armbruster 1999). Therefore, the predicted pumping is estimated as the total demand minus the surface water supply. For the Town of Center, approximately 50% of the residents use domestic wells for their water supply, based on information gathered through the RGDSS Peer Review process. Accordingly, the municipal pumping in Center is reduced to 50% of the population based calculated demand.

After the annual pumping estimates for a municipality have been determined, this information is assigned to the municipality's wells and distributed by month. The pumping for public water supply in a municipality can be produced from one or more well and the number of wells a municipality uses can vary from year to year. The yearly total estimated pumping, as calculated using population information for a given town, is evenly distributed over the available wells that are used for public water supply for the given year. The number of wells in use by a municipality is determined based on how many wells were operational for a given year. The operational starting year for each well was estimated based on the data available in the following order: 1) the decreed appropriation date, 2) the beneficial use date, and 3) the permit issue date. The annual pumping was then distributed to 12 months using the ratios given in Table 4, as originally developed in RGDSS Ground Water, Task 16 – Pumping Data (HRS 2000) and relying upon RGDSS Surface Water, Task 4.8 – M&I Water Use (Hydrosphere 1999) and initially implemented in Phase 3 of the groundwater modeling effort.

**Table 4. Monthly Pumping and Consumptive Use in San Luis Valley**

| Month | Estimated Percent of Annual Pumping | Estimated Percent Consumptive Use |
|---|---|---|
| Jan | 5% | 10% |
| Feb | 5% | 10% |
| Mar | 6% | 20% |
| Apr | 8% | 30% |
| May | 9% | 40% |
| June | 10% | 50% |
| July | 15% | 60% |
| Aug | 15% | 60% |
| Sept | 9% | 50% |
| Oct | 7% | 40% |
| Nov | 6% | 20% |
| Dec | 5% | 10% |

When available, annual metered pumping data was used for each individual well. The annual metered volumes were distributed based on the monthly distribution presented in Table 4 above. The list of wells by municipality is listed below in Table 5.

| Table 5. Municipal Wells | | | | | | | |
|---|---|---|---|---|---|---|---|
| **WDID** | **Municipality** | | **WDID** | **Municipality** | | **WDID** | **Municipality** |
| 2005066 | Alamosa | | 2206453 | Conejos County | | 2405021 | San Luis |
| 2005067 | Alamosa | | 2505004 | Crestone | | 2405023 | San Luis |
| 2005143 | Alamosa | | 2505005 | Crestone | | 2405029 | San Luis |
| 2005389 | Alamosa | | 2505444 | Crestone | | 2405020 | San Luis |
| 2005390 | Alamosa | | 2505508 | Crestone | | 2405024 | San Luis |
| 2006317 | Alamosa | | 2005157 | Del Norte | | 3505052 | Sand Dunes |
| 2006408 | Alamosa | | 2006456 | Del Norte | | 3505053 | Sand Dunes |
| 2006316 | Alamosa | | 3505041 | Fort Garland | | 2206378 | Sanford |
| 2010478 | Alamosa | | 3505614 | Fort Garland | | 2206419 | Sanford |
| 2205041 | Antonito | | 2105083 | La Jara | | 2206421 | Sanford |
| 2205043 | Antonito | | 2105084 | La Jara | | 2505403 | Baca |
| 2205016 | Antonito | | 2205012 | Manassa | | 2505420 | USFWS |
| 3505197 | Blanca | | 2205013 | Manassa | | 2505421 | USFWS |
| 2105902 | Capulin | | 2006258 | Monte Vista | | 2405026 | Town of Garcia |
| 2105903 | Capulin | | 2006259 | Monte Vista | | 2405027 | Town of La Valley |
| 2005942 | Center | | 2006260 | Monte Vista | | 2405045 | Melby Ranch |
| 2005943 | Center | | 2006261 | Monte Vista | | 2505163 | KV homeowners |
| 2010884 | Center | | 2006639 | Monte Vista | | 2605285 | KV homeowners |
| 2010885 | Center | | 2006257 | Monte Vista | | 2605286 | KV homeowners |
| 2010886 | Center | | 2014254 | Monte Vista | | | |
| 2010887 | Center | | 2205015 | Romeo | | | |
| 2010888 | Center | | 2605121 | Saguache | | | |
| 2010889 | Center | | 2605968 | Saguache | | | |
| 2010890 | Center | | 2240502 | San Acacio | | | |

*Return flow*

Municipal return flows are determined by subtracting the consumptive use component from the total pumping of the municipality's water use. The consumptive use was determined by the monthly ratios presented in Table 4 above. The monthly consumptive use ratios vary over the course of the year based on how much water is being used indoors and outdoors. These consumptive use ratios were developed in RGDSS Ground Water, Task 16 – Pumping Data (HRS 2000), relying upon RGDSS Surface Water, Task 4.8 – M&I Water Use (Hydrosphere 1999), and initially implemented in Phase 3 of the groundwater modeling effort.

Return flows, in most cases, are returned to the alluvial aquifer, or Layer 1 of the groundwater model, at the location of the well. For the municipalities that have treated effluent discharges to live streams, the return flows are aggregated by municipality and output to a second file, which are then appropriately utilized by the groundwater model.

The Town of Blanca utilizes an evaporative waste water treatment system, therefore the return flows associated with the Town's wells are set to zero.

### 3.2.5 Pond Wells

*Pumping*

Wells that are classified as pond wells are primarily used for fish hatchery purposes. However, some of the wells classified as pond wells have subsequent irrigation use or alternative uses. In general, operational pumping rates for pond wells are estimated to be their decreed or permitted rates. The annual pumping from pond wells are estimated based on data available from the following sources:

- Decreed or permitted pumping rate,
- Decreed or permitted artesian flow rate,
- Decreed or permitted maximum annual volume,
- Water right comments, and
- Diversion records if available.

Metered pumping data and gathered historical operation information were utilized to confirm the annual pumping estimates or provide an alternative method for estimating the annual operations of these wells, see Appendix A for further discussion on some of these wells. The annual pumping was distributed monthly based on the ratios presented in Table 6 below if diversions only occur in the irrigation season. The distribution ratios are calculated based on monthly pan evaporation records at the Alamosa San Luis Valley RGNL NOAA station. The ratio used for each month is the mean value of the month between 1960 and 1995 (period of available data).

**Table 6. Monthly Pan Evaporation Factor in San Luis Valley**

| Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.00 | 0.00 | 0.00 | 0.13 | 0.17 | 0.19 | 0.17 | 0.14 | 0.12 | 0.08 | 0.00 | 0.00 |

For those pond wells that either flow constantly or are pumped continuously, the annual pumping was distributed evenly to every month. Well specific information related to the pumping amount and distribution is presented in Table 6 below.

Note: Two wells used to bottle water (WDIDs 2012183 and 2006551 (a.k.a. 2014386)) are included in the pond well category for convenience of data processing with TSTool command files. WDID 2014386 is a duplicate of 2006551 but currently (March 2013) diversion records are available under WDID 2014386.

*Return flow*

The return flow was determined by subtracting the consumptive use component of the pumping from the total pumping. For most of the pond wells, the return flows are returned to the alluvial aquifer, or Layer 1 of the groundwater model, at the location of the well. For two wells, WDIDs 2105444 and 2105445, their return flows occur to a live stream, which are then appropriately utilized by the groundwater model.

The annual consumptive use of a pond well is calculated based on the surface area of the associated pond(s) and evaporation rate from the free water surface. The evaporation rate of 4 feet per year is based

on an average evaporation from shallow open water bodies in the San Luis Valley (Sanderson, 5/5/2011). As described above, some pond wells are used for irrigation in addition to filling the ponds or for alternative purposes. The 2005 irrigated lands coverage was used to estimate irrigated acreage for the years 1965 through 2010 for the pond wells. For the wells that are used for filling the fishery ponds and for irrigating lands, the consumptive use is calculated as:

$$Consumptive\ Use = Pond\ Surface\ Area\ \times 4\ feet + Irrigated\ Area\ \times 2.5\ feet$$

The annual consumptive use was distributed monthly based on the pan evaporation factors presented above in Table 6. Based on the factors in Table 6, no consumptive use occurs in winter months.

### 3.2.6 Potato Washing Wells

*Pumping*

Wells used for fluming and washing potatoes have a distinct time of use within the year that differs from other wells – the use of water occurs between September 15 and May 15. Table 7 lists the potato operations wells.

**Table 7. Wells Used for Potato Operations**

| WDID | Uses | Season of Use |
|---|---|---|
| 2008176 | Fluming | Sept. 15 – May 15 |
| 2008877 | Fluming and washing | Sept. 15 – May 15 |
| 2014012 | Cooling, humidification, fluming, and washing | Sept. 15 – May 15 |
| 2005914 | Facility and washing | Year Round |
| 2008897 | Facility, cooling, humidification, fluming, washing, and lawn | Year Round |
| 2009270 | Cooling, humidification, and washing | Sept. 15 – May 15 |
| 2013787 | Humidification | Sept. 15 – May 15 |

*Return flow*

The return flow was determined by subtracting the consumptive use component of the pumping from the total pumping. The consumption associated with the water used from these wells can include one or more of the following: evaporation loss from a small recharge pond near the potato washing facility, water evaporated from the surface of individual potatoes, water required for cooling and humidification inside the facility, and water use inside and/or outside of the facility. The estimated consumptive use is based on a review of the wells' permits and decrees, discussion with Division 3 staff, and discussions with the RGDSS Technical Advisory Committee (also known as the Peer Review Team or PRT). Therefore, the return flow is equal to the total pumping from a particular well minus the consumptive use of the operations that the well is providing water for. The return flows are returned to the alluvial aquifer, or Layer 1 of the groundwater model, at the location of the well.

### 3.2.7 Confined Wells on the Meadow Ranch

*Pumping*

Table 8 provides a listing of the four confined aquifer flowing wells on the Meadow Ranch. Pumping was estimated based on these wells flowing at a full yield from April through October and then valved back to 50 gallons per minute November through March. Full yield was estimated for each year from 1970 to

2008 based on a correlation of water level elevation data from nearby wells. Details on this correlation are provided in the EXCEL file *Meadow Ranch Historic Pumping Est.xlsx* provided in the Phase 6 model dataset.

| Table 8. Meadows Ranch Wells | | |
|---|---|---|
| WDID | **Name** | **Permit Number** |
| 2705286 | W1843 Well No HDQTRS 14 | 20548F |
| 2705298 | W0903 Well No HDQTRS 07 | 11666R |
| 2705742 | W0903 Well No HDQTRS 05 | 11664R |
| 2705305 | W0903 Well No HDQTRS 12 | 3911F |

*Return flow*

The historical use of these wells was for irrigation. However, the conveyance loss along the ditch to the irrigated field was so significant that most of the confined aquifer water from these wells was recharging the unconfined aquifer in the area. Only approximately 12% of the water pumped was actually consumed. Thereby, 88% of the pumping was returned to the unconfined aquifer in the months of April through October and 100% of the pumping was returned in the months of November through March.

### 3.2.8 Other Wells

*Pumping*

Other wells include wells that are used for schools, hospitals, jails, museums, visitor centers, shops, businesses, warehouses, potato storage facilities, humidification, greenhouse operations, small scale landscape and cemeteries, domestic use, and unidentified uses. A majority of these wells are believed to be operated in a way that is similar to municipal well operations regarding time of use, consumptive use, and return flows. Annual pumping volumes are estimated using water rights or permitted flow rates from HydroBase, multiplied by a calibration factor. To determine the calibration factor, the well water rights or permitted flow rates were compared to the metered pumping in 2009 and 2010 for this group of wells.

The result of calibration indicates that the metered amount for other wells is about 5% of the decreed amount. Therefore, 5% of decreed amount was used to estimate pumping for the other wells.

The monthly pumping distribution ratios used for municipal wells shown in Table 4, above, were used in estimating the monthly pumping for the other wells. Further, the starting pumping year for the other wells was based on the appropriation date of the well's water right, if available, otherwise the well's permit file information was used to determine the start date for the well.

*Return flow*

The other wells return flows were estimated as the total pumping less the consumptive use. The consumptive use ratios shown in Table 4 above, were used to estimate the monthly consumptive use. The return flows are then the total pumping minus the consumptive use and are returned to the alluvial aquifer, or Layer 1 of the groundwater model, at the location of the well.

### 3.3 Refinements to Small Flowing Wells

Pumping and return flow from small flowing wells are simulated in the drain package of the groundwater model. Therefore this task set out to refine the wells identified as small flowing wells and evaluate their flow rates.

A stepwise process was completed to evaluate the list of wells that are included in the small flowing well dataset for the groundwater model:

1. Review the wells available in HydroBase with a yield of less than 50 gallons per minute (gpm),
2. Exclude wells that have already been included in another well group (irrigation or non-irrigation wells),
3. Determine the wells that are within the active groundwater model domain,
4. Determine the wells that are screened in confined aquifers, and
5. Prorate the yield between layers.

HydroBase was queried for wells within Water Division 3 that are permitted or decreed for a rate less than 50 gpm. The resulting list of wells was then compared against the explicitly modeled irrigation and non-irrigation well lists. From this review, wells already included in the irrigation and non-irrigation well lists were removed from the small flowing well list. Next, the wells were evaluated spatially to determine if they fall within the active model grid of the groundwater model. HydroBase contains UTM X and UTM Y coordinates for each well. These coordinates were imported into ArcGIS to create a well point coverage. The GIS well coverage was then intersected with the model grid. The next step evaluated the model layer from which the wells produce. An evaluation was conducted using the screen perforation or total depth information stored in HydroBase and the depths of the modeled layers from the GIS model grid layer. Wells that were screened below layer 1 and wells that were completed into layers below layer 1 (if no screen interval information was available) were included in the final small flowing well list.

The final process was to estimate the distribution of well yield assigned to each of the modeled layers. If a well does not have screened intervals stored in HydroBase, the yield of the well was associated with the layer that the well is completed into. If a well has screened intervals that are associated with only one layer, the yield is assigned entirely to that layer. When screened intervals are inclusive of more than one layer, the yield is split between the layers on a pro rata basis based on the linear footage of screen within each layer. The final product from the small flowing well review is the rg2012.sfw file.

## 4. Comments and Concerns

### Recommended Enhancement of HydroBase Data

In order to implement a more data centered approach, it is recommend that available monthly well diversion data from the Closed Basin Project and any other wells be entered into HydroBase. Currently, monthly data from the CBP are available and collected by the Alamosa Field Division of the U.S. Bureau of Reclamation. It would be more efficient to extend the model data if monthly data of CBP pumping were available in HydroBase.

## 5. References

Hydrosphere, Ed Armbruster, RGDSS Memorandum, RGDSS Surface Water, Task 4.8 – M&I Water Use, July 8, 1999.

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Leonard Rice Engineers, Inc., Rick Parsons, Kara Sobieski, and Erin Wilson, SPDSS Memorandum, Task 66.2 – Collect and Develop Municipal and Industrial Consumptive Use Estimates, Final, November 14, 2007.

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## Appendix A

**HOOPER WELLS**

This facility currently uses two wells for irrigation, a swimming pool and a greenhouse. Historically these wells were also used for fish production. The two non-exempt wells on the property are:

| | Hooper Cold Well | Hooper Hot Well |
|---|---|---|
| Aquifer | Unconfined | Confined |
| WDID | 2013341 | 2008576 |
| Permit No. | 017197R | 20782R |
| Decree | W-3395 & W-1702 | W-156 (Well No. 1) |
| Beneficial Use | 1935 for 600 gpm<br>1975 for 1900 gpm | 1922 for 500 gpm<br>1975 for 2000 gpm |

The following operations information was obtained from the owner and the facilities manager:

- From the time the current owner purchased the facility in 1994, the Cold Well has been used only for irrigation and the Hot Well has been used only for the swimming and greenhouse facilities. The monthly pumping estimates were not available; however, the owner stated that the hot well is turned up more in the winter. As an approximation it was assumed that monthly use in Dec-Feb was four times more than that used during the rest of the year.
- Since purchase of the property in 1994, all discharge is on site to the ditches and ponds on the property. Historically, when the hatchery was operating the discharge went to the Gibson Drain.

Based on discussions with the owner/operator, and review of the decrees and permit information the following operation schedule was developed:

| Year | Activity |
|---|---|
| 1932 | Pool Starts |
| 1948 | Fish Hatchery Starts |
| 1965 | Fish Hatchery Closes |
| 1966-1974 | Pool Only |
| 1975 | Fish Hatchery Reopens |
| 1984 | Fish Hatchery Closes |
| 1984-1994 | Pool Closed - hot well shut in |
| 1995 | Pool open |

To estimate the monthly pumping and recharge the following assumptions were made to the fish hatchery, greenhouse and pool operations:

- The Hot Well was used as the sole source for the pool and greenhouse from 1995 to 2010.
- For pool use it was assumed that monthly use in Dec-Feb was 4 times more than that used during the rest of the year. When the hatchery operated the discharge from the pool went to the hatchery.
- Both the Hot and Cold wells were used for the fish hatchery. Fish hatchery use was assumed to be constant throughout the year. Because no actual monthly data was available this assumption was considered reasonable based on conversations with the hatchery manager at the Colorado

Parks & Wildlife (CPW), Native Aquatic Restoration Facility. Because there are no historical data and the previous owner could not be located, the annual volume of water pumped from each wells was assumed to be:

  - For 1975-1984: Both wells had pumps installed in 1975; therefore, they had increased pumping capacities of 2000 gpm. It seemed unrealistic to set the continuous pumping rate at the pump capacity, therefore, the pumping rate was set at 1130 gpm which is equal to the average yearly pumping from the CPW Monte Vista Hatchery well. The CPW hatchery has similar water rights as the Hooper facility.
  - For 1950-1965 the wells operated at a lower flowing capacity of 600 gpm for the Cold Well and 500 gpm for the Hot Well. These values were obtained from permit information.

- Recharge was calculated as the total volume pumped less volume to irrigation less open water evaporation from open surfaces less consumptive use from greenhouse. Prior to 1984 recharge was directed to the Gibson Drain. Starting in 1995 recharge was on site. Note that the hot well was shut in and the pool/hatchery were closed from 1985 to 1994
- To start with, monthly open-water evaporation was estimated using the CDWR SWSP guidelines with a total annual evaporation of 3 ft/year. Then winter time (December - February) consumptive use for the pool was then increased to equal the evaporation in July to account for the large amount of steam coming off of the pool. This resulted in a total of 4.275 ft/year of open water evaporation.
- The evaporation area for the hatchery and/or the pool was calculated as 5 acres. If the hatchery was closed and discharge was to the Gibson drain the evaporated area is reduced to just the pool (0.1 acres)
- When the greenhouse was operating (1998-2012) the irrigation water requirement (IWR) was calculated based on greenhouse tomato requirements as described in the "Greenhouse Tomato Handbook" (Mississippi State University Extension Service). The area of the greenhouse was 10,000 $ft^2$ for 1998 but was reduced to $^1/_3$ the original size starting in 1999 until the present.

To estimate the monthly pumping and recharge the following irrigation assumptions were made:

- The cold well was used as the sole source of irrigation water from 1995 to 2010
- Annual meter values were used to estimate the total pumping for 2009 through 2012
- Annual values for 2009 and 2010 were distributed on a monthly basis using the monthly IWR percent for the crop type.
- Monthly values for irrigation prior to 2009 was based on IWR calculated using the Center Climate Station.
- Sprinklers were assumed to be 80% efficient. Flood irrigation was assumed to be 60% efficient. Irrigation was by sprinkler from 1996 to the present.
- The irrigated acreage time series was determined by inspection of digital data and is:

| Year | Irrigated Acres | Crop | Method |
|---|---|---|---|
| 2010 | 124.2 | Alfalfa | Sprinkler |
| 2002 | 124.2 | Alfalfa | Sprinkler |
| 1998 | 124.6 | Small Grains | Sprinkler |
| 1996 | 124.6 | Not determined | Sprinkler |
| 1995 | 124.6 | Not determined | flood |
| 1936 | 482.2 | Grass Pasture | flood |

- 1974 to 2010 only the Cold Well was used for irrigation. This is because the yield of the Cold Well was sufficient to meet the IWR adjusted for efficiency. The Cold Well was limited to 600 gpm prior to 1975. Therefore, the Hot Well was needed to meet the IWR from 1950 to 1974. According to well permit information, prior to 1975 the Hot Well capacity was 500 gpm. Thus the combined operation of the hot and cold well could not meet the IWR from 1950 to 1974.
- Recharge was calculated as the amount pumped for irrigation less IWR. For example, if the crop was sprinkler irrigated the efficiency was set at 80% and the recharge would then be calculated as 20% (1 – efficiency) of the irrigation pumping. Recharge was distributed to each well based on the percentage that well pumped to irrigation.

**KERR WELL**

The confined well (WDID 2705494, Permit # 23355-F, Decree W-1505, and Decree 92CW52) at the Kerr site has been used to irrigate crops beginning in 1956 until the present. Starting in 1994 and continuing until the present the well has also been used to raise fish. The information presented herein is based on discussions with the owner and the operator, in addition to review of the decrees and permit information.

To estimate the monthly pumping and recharge the following assumptions were made to the fish hatchery:

- Annual meter readings were available for 2009-2011. The average metered value for 2009-2011 was used for all other years when the hatchery was operating.
- The annual flow was distributed by month as follows:
    - During the irrigation season enough water was pumped to meet the IWR adjusted for efficiency. It was assumed that the water first went to the hatchery then to the irrigation with minimal consumptive use by the hatchery.
    - The amount of water left over was divided equally for the remaining months.
- All water is discharged on site per the decree. Recharge was calculated as the amount pumped less the IWR less the open-water evaporation from the fish facility. The open water area for the hatchery was calculated as 14.24 acres. Monthly open water evaporation was estimated using the CDWR SWSP guidelines with a total annual evaporation of 3 ft/year per the decree.

To estimate the monthly pumping and recharge the following irrigation assumptions were made:

- The well started pumping to agriculture in 1956 per the decree.
- 400 acres were irrigated from 1956-1980 per the decree 92CW52 under flood irrigation
- In 1981 a sprinkler was added according to decree for nearby center pivot wells.
- Irrigation consumptive used was set as 1.75 acre-feet per year per acre based on the decree (92CW52). The annual rate was distributed monthly using the IWR based on the Center Climate Station.
- Sprinklers were assumed to be 80% efficient. Flood irrigation was assumed to be 60% efficient.
- Irrigated acreage was determined by inspection of digital data and is:

| Year | Irrigated Acres | Crop |
|---|---|---|
| 2010 | 125.05 | Small Grains |
| 2009 | 125.05 | Small Grains |
| 2005 | 125.05 | Potatoes |
| 2002 | 130.84 | Small Grains |
| 1998 | 130.84 | Small Grains |