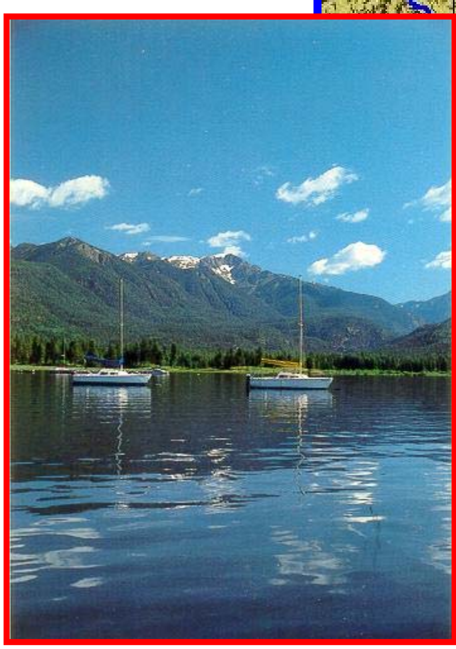
San Juan / Dolores River Basin Water Resources Planning Model User's Manual



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COLORADO'S DECISION SUPPORT SYSTEMS

Table of Contents

Table of Figures

Table of Tables

1. Introduction

1.1 Background

The Colorado Decision Support System (CDSS) consists of a database of hydrologic and administrative information related to water use in Colorado, and a variety of tools and models for reviewing, reporting, and analyzing the data. The CDSS water resources planning models, of which the San Juan / Dolores River Basin Water Resources Planning Model (San Juan Model) is one, are water allocation models which determine availability of water to individual users and projects, based on hydrology, water rights, and operating rules and practices. They are implementations of "StateMod", a code developed by the State of Colorado for application in the CDSS project. The San Juan Model "Baseline" data set, which this document describes, extends from the 1909 through 2013. It simulates current demands, current infrastructure and projects, and the current administrative environment as though they had been in place throughout the modeled period.

The San Juan Model was developed as a tool to test the impacts of proposed diversions, reservoirs, water rights and/or changes in operations and management strategies. The model simulates proposed changes using a highly variable physical water supply constrained by administrative water rights. The Baseline data set can serve as the starting point, demonstrating condition of the stream absent the proposed change but including all current conditions. It is presumed that the user will compare the Baseline simulation results to results from a model to which he has added the proposed features, to determine their performance and effects.

Information used in the model datasets are based on available data collected and developed through the CDSS, including information recorded by the State Engineer's Office. The model datasets and results are intended for basin-wide planning purposes. Individuals seeking to use the model dataset or results in any legal proceeding are responsible for verifying the accuracy of information included in the model.

1.2 Development of the San Juan / Dolores River Basin Water Resources Planning Model

The San Juan Model was developed in a series of phases that spanned 1996 through the present. The earliest effort; designated Phase II following a Phase I scoping task, accomplished development of a calibrated model that simulated an estimated 75 percent of water use in the basin, leaving the remaining 25 percent of the use "in the gage". The original model study period was 1975 through 1991, which also served as the model's calibration period.

The objective of the CDSS endeavor was to represent all potential consumptive use within Colorado, and estimate actual consumptive use under water supply limitations. Therefore in Phase IIIa, the previously unmodeled 25 percent use was added to the model as 27 aggregations of numerous small users. With the introduction of this demand, the calibration was reviewed and refined. The objective of Phase IIIb was to extend the model study period, using automated data filling techniques as well as research in the State's Records office to estimate or obtain historical gage and diversion information. The data set was extended back to 1909 and forward through 1996. The calibration was again reviewed, now using through the period 1975 through 1996.

The State continues to refine the San Juan Model. In 2005, the study period was extended through 2003, the "variable efficiency" method was added for determining irrigation consumptive use and return flows, and a daily version was created. In addition, based on revisions to irrigated acreage, the aggregations of small users were revised and increased to 42.

The model input files were enhanced during the CRWAS project in 2009 to extend the study period through 2006 and the most recent effort extended the model through 2013 and incorporated new basin reservoirs, including Ridges Basin Reservoir (aka Lake Nighthorse) and Long Hollow Reservoir. In addition, the model was updated to represent current irrigation uses based on the recent 2005 and 2010 irrigated acreage assessments. In some areas, notably the San Miguel River basin, additional structures were represented explicitly and associated aggregations were removed. The calibration was again reviewed, now using through the period 1975 through 2013 results.

The key results of the San Juan Model efforts are as follows:

- A water resources planning model has been developed that can make comparative analyses of historical and future water management policies in the San Juan and Dolores River Basins. The model includes 100% of the basin's surface water use.
- The model has been calibrated for a study period extending from calendar years 1975 to 2013.
- The calibration in the Historical scenario is considered very good, based on a comparison of historical to simulated streamflows, reservoir contents, and diversions.
- A Calculated data set has been prepared where historical irrigation demands are replaced by calculated demands, which represent the amount of water crops would have used if given a full supply. These demands are the basis for the Baseline data set. The Calculated monthly simulation results were compared to historical streamflows, reservoir contents, and diversions. The comparison is considered good.
- A Baseline data set has been prepared which, unlike the Historical and Calculated data sets, assumes all existing water resources systems were on-line and operational for calendar years 1909 to 2013. This Baseline set is an appropriate starting point for evaluating various "what if" scenarios over a long hydrologic time period containing dry, average, and wet hydrologic cycles.
- Input data for the San Juan Model using a daily time-step has been developed. As with the monthly model, the daily model may be operated to represent the Historical, Calculated, and Baseline scenarios by using the appropriate response file.   The purpose of the daily Baseline model data set is to capture daily variations in streamflow and call regime. Depending on the "what if" question the user wishes to investigate, a daily time-step may provide more detail regarding water availability.

1.3 Future Enhancements

The San Juan Model was developed to include 100 percent of the basin's consumptive use through a combination of explicit and aggregated structures. The San Juan Model could be enhanced in the future by incorporating additional information gained by consulting with the division engineer, the U.S. Bureau of Reclamation, and other major water users regarding historical and future reservoir operations.

1.4 Acknowledgements

CDSS is a project of the Colorado Water Conservation Board (CWCB), with support from the Colorado Division of Water Resources. The San Juan Model has been developed and enhanced at different stages by Riverside Technology, Inc., Boyle Engineering Corporation, Leonard Rice Engineers, and CWCB staff. The updated model through 2013 was completed by Wilson Water Group.

2. What's in This Document

2.1 Scope of this Manual

This reference manual describes the CDSS San Juan / Dolores River Water Resources Planning Model, an application of the generic water allocation model StateMod and one component of the Colorado Decision Support System. It is intended for the reader who:

- Wants to understand basin operations and issues through review of the model
- Needs to evaluate the model's applicability to a particular planning or management issue
- Intends to use the model to analyze a particular San Juan / Dolores River Basin development or management scenario
- Is interested in estimated conditions in the San Juan / Dolores River Basin under current development over a range of hydrologic conditions, as simulated by this model; and in understanding assumptions embedded in the modeling estimates.

For this manual to be most effective, the reader should have access to a complete set of data files for the San Juan Model, as well as other CDSS documentation as needed (see below).

The manual describes content and assumptions in the model, implementation issues encountered, approaches used to estimate parameters, and results of both calibrating and simulating with the model. Only very general information is provided on the mechanics of assembling data sets, using various CDSS tools.

2.2 Manual Contents

The manual is divided into the following sections:

Section 3 San Juan / Dolores River Basin – describes the physical setting for the model, reviews very generally water resources development and issues in the basin.

Section 4 Modeling Approach – provides an overview of methods and techniques used in the San Juan Model, addressing an array of typical modeling issues such as:

- Aerial extent and spatial detail, including the model network diagram
- Study period
- Aggregation of small structures

- Data filling methods
- Simulation of processes related to irrigation use, such as delivery loss, soil moisture storage, crop consumptive use, and returns of excess diversions
- Development of baseflows
- Calibration methods

Much of Section 4 is common to the other CDSS models, although the section refers specifically to the San Juan Model.

Section 5 Baseline Data Set – refers to the Monthly Baseline data set input files for simulating under current demands, current infrastructure and projects, and the current administrative environment, as though they were in place throughout the modeled period. The data set is generic with respect to future projects, and could be used as the basis against which to compare a simulation that includes a new use or operation. The user should understand how demands and operations are represented. Elements of these are subject to interpretation, and could legitimately be represented differently.

This section is organized by input file. The first is the response file, which lists all other files and therefore serves as a table of contents within the section. The content, source of data, and particular implementation issues are described for each file in specific detail.

Section 6 Baseline Results – presents summarized results of the Monthly Baseline simulation. It shows the state of the basin as the San Juan Model characterizes it under Baseline conditions. Both total flow and flow legally available to new development are presented for key sites.

Section 7 Calibration – describes the calibration process and demonstrates the model's ability to replicate historical conditions under historical demand and operations. Comparisons of streamflow, diversions, and reservoir levels are presented.

Appendices A – presents approach and results for most current irrigation structure aggregations specific to the San Juan Model.

The body of the manual contains references to other CDSS technical memos that are more general in scope, which are available at the CDSS website.

There is some overlap of topics both within this manual and between this and other CDSS documentation. To help the user take advantage of all sources, pointers are included as applicable under the heading "**Where To Find More Information**" throughout the manual.

2.3 What's in other CDSS documentation

The user may find the need to supplement this manual with information from other CDSS documentation. This is particularly true for the reader who wants to:

- Make significant changes to the San Juan Model to implement specific future operations
- Introduce changes that require regenerating the baseflow data file
- Regenerate input files using the Data Management Interface (DMI) tools and HydroBase
- Develop a StateMod model for a different basin

An ample body of documentation exists for CDSS, and is still growing. A user's biggest challenge may be in efficiently finding the information. This list of descriptions is intended to help in selecting the most relevant data source:

Basin Information – the report "San Juan / Dolores River Basin Information" provides information on specific structures, operations, and practices within the basin. While the information was gathered in support of the planning model when it was first undertaken, it is widely useful to anyone doing any kind of water resources investigation or analysis.

Consumptive Use Report – the report "Historical Crop Consumptive Use Analysis: San Juan/Dolores River Basin 2015" provides information on the consumptive use analysis that was used as input to the Baseline Demand scenario.

DMI user documentation – user documentation for the **StateDMI** and **TSTool** is currently available, and covers all aspects of executing these codes against the HydroBase database. The DMIs preprocess some of the StateMod input data. For example, **StateDMI** computes coefficients for distributing baseflow gains throughout the model and can aggregate water rights for numerous small structures. **TSTool** fills missing time series data and computes headgate demands for irrigation structures. Thus the documentation, which explains algorithms for these processes, is helpful in understanding assumptions embedded in the planning models. In addition, the documentation is essential for the user who is modifying and regenerating input files using the DMI's.

StateMod documentation – the StateMod user manual describes the model in generic terms and specific detail. Section 3 Model Description and Section 7 - Technical Notes offer the best descriptions of StateMod functionality, and would enhance the San Juan Model user's understanding of results. If the user is modifying input files, the user should consult Section 4 - Input Description to determine how to format files. To analyze model results in detail, review Section 5 - Output Description, which describes the wide variety of reports available to the user.

Self-documented input files – an important aspect of the StateMod input files is that their genesis is documented in the files themselves. Command files that directed the DMI's creation of the files are echoed in the file header. Generally, the model developers have incorporated comments in the command file that explain use of options, sources of data, etc.

Technical Memoranda – many aspects of the modeling methods adopted in CDSS were explored in feasibility or pilot studies before being implemented. Technical memoranda and reports for these activities are available on the CDSS website:

- Phase IIIb Task Memorandum 10.1 – Data Extension Feasibility
- Task Memorandum 10.2 – Evaluate Extension of Historical Data
- Task Memorandum 11.5 – Characterize Streamflow Data
- Task Memorandum 11.7 – Verify Diversion Estimates
- Task Memorandum 11.10 – Fill Missing Baseflow Data (include Mixed Station Model user instruction)
- Daily Yampa Model Task Memorandum 2 – Pilot Study
- Daily Yampa Model Task Memorandum 3 – Selecting a Daily or Monthly Model
- Variable Efficiency Evaluation Task Memorandum 1.3 – Run StateMod to create baseflows using the Variable Efficiency and Soil Moisture Accounting Approach
- Variable Efficiency Evaluation Task Memorandum 1.5 – Compare StateMod Variable Efficiency and Soil Moisture Accounting Historical Model Results to Previous CDSS Model Results and Historical Measurements
- CDSS Memorandum "Colorado River Basin Representative Irrigation Return Flow Patterns"
- Task Memorandum 2.03.13 – Non-Irrigation (Other Uses) Consumptive Uses and Losses in the Dolores and San Juan River Basin
- SPDSS Task 59.1 Memorandum – Develop Locally Calibrated Blaney-Criddle Crop Coefficients

3. The San Juan / Dolores River Basin

The San Juan and Dolores River basins lie in the southwest corner of Colorado, with the headwaters of both rivers originating in the San Juan Mountains. The San Juan River flows southwest to Navajo Reservoir, leaves the state in Archuleta County, and reaches the Colorado River. The Dolores River basin is located directly north of the San Juan River basin. The Dolores River flows southwest to McPhee Reservoir and then continues northward before exiting the state in Mesa County. The San Juan and Dolores River basins encompass all of San Miguel, Dolores, Montezuma and La Plata counties, and parts of Mesa, Montrose, San Juan, Hinsdale, Mineral, and Archuleta counties in Colorado. **Figure 3.1** is a map of the basin.

3.1 Physical Geography

The San Juan River basin extends into portions of New Mexico on the south and Utah to the west, contributing approximately 23,000 square miles of drainage area to the San Juan River at the gage in Bluff, Utah. About one third of this area, or 7,200 square miles, lies within Colorado. Elevations within the basin range from over 13,000 feet in the headwaters at the continental divide, to about 4,050 feet near the city of Bluff, Utah. The lowest point in the basin within Colorado is in the Four Corners area, with an elevation at about 4,800 feet. The major tributaries to the San Juan River include the Navajo River, Piedra River, Los Pinos River, Animas River, Florida River, La Plata River, Mancos River, and McElmo Creek. Average annual streamflow for years 1971 to 1991 in the San Juan River above Navajo Reservoir is about 427,500 acre-feet. Prior to completion in 1971 of the San Juan-Chama project, which diverts water from the San Juan River basin to the Rio Grande basin in New Mexico, the annual average streamflow above Navajo Reservoir was 457,900 acre-feet. At the Bluff, Utah gage, the annual average streamflow is 1,863,000 acre-feet. This value is not adjusted for flow regulation caused by Navajo Reservoir since 1962.

The Dolores River rises in the San Juan National Forest near Bolam Pass, just north of the San Juan River basin. Some elevations around the headwater areas lie above 13,700 feet. The river flows southwest to McPhee Reservoir where it turns to flow to the northwest until it leaves Colorado and eventually joins the Colorado River near Cisco, Utah. The drainage area upstream of the gage at Cisco is approximately 4,580 square miles. The drainage area upstream of the most downstream Colorado gage on the Dolores River, at Gateway, Colorado is about 4,350 square miles. Major tributaries to the Dolores River include the West Fork of the Dolores, Lost Canyon Creek, Disappointment Creek, West Paradox Creek, and the San Miguel River, which is discussed separately below. The mean annual flow at Cisco, Utah for the 32 years prior to the construction of McPhee Reservoir in 1986 was 612,200 acre-feet. After construction the mean annual flow was 555,386 acre-feet between 1986 and 1993. The San Miguel River is a major tributary to the Dolores River, which it joins near the town of Uravan, Colorado. The San Miguel headwaters begin near the town of Telluride in the Uncompahgre National Forest where peaks are over 13,400 feet. The drainage area of the San Miguel River above the gage at Uravan is approximately 1,499 square miles. Average annual flow at this gage is about 273,100 acre-feet.

Major tributaries to the San Miguel River include South Fork, Fall Creek, Leopard Creek, Beaver Creek, Horsefly Creek, Naturita Creek, and Tabegauche Creek.

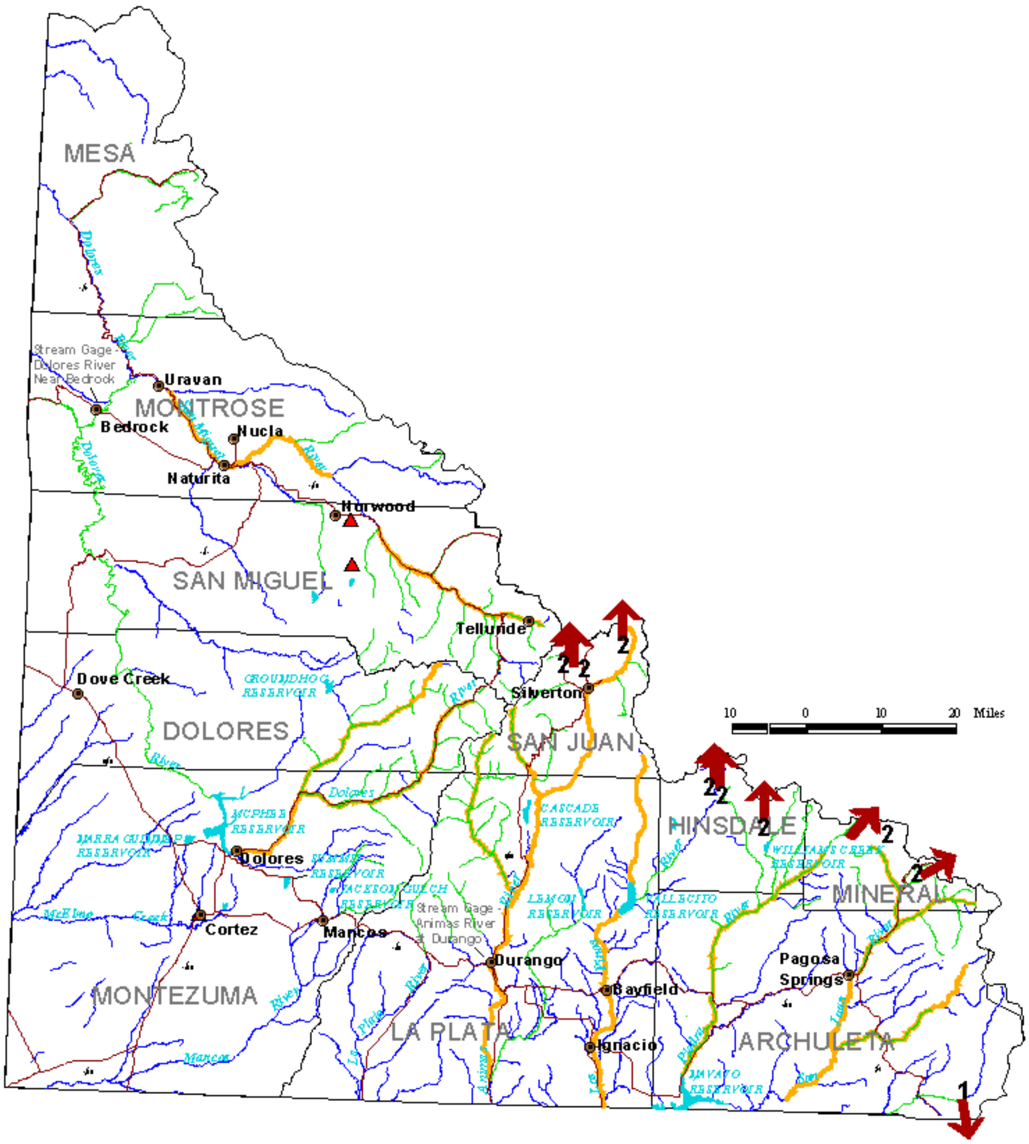
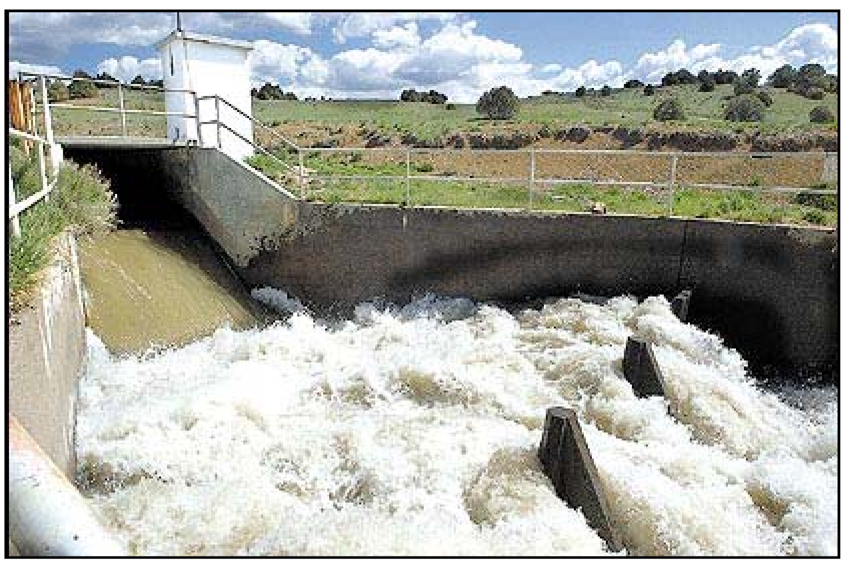


Figure 3.1 – San Juan and Dolores River Basins

3.2 Human and Economic Factors

The area remains relatively sparsely populated, with the 2003 census estimates placing the combined populations of San Miguel, Dolores, Montezuma and La Plata Counties at approximately 79,543. Durango and Cortez are the major population centers in the basin, with approximately 13,900 and 8,000 residents respectively. Dolores, La Plata and Montezuma Counties grew by just around 25 percent from 1990 to 2000, whereas San Miguel County grew by over 45 percent in the same time period. Population growth is concentrated along the San Juan Skyway including Cortez and Durango, as well as in the Telluride Canyon. This growth attests to the importance of recreation-based activities, as the ski area and other outdoor recreation opportunities draws people and increase tourism within the basin. Tourism serves as an important part of the basin's economy.

The principal water use in both the San Juan and Dolores river basins is irrigation. The total irrigated acreage in 2000 was approximately: 200,000 acres in the San Juan basin; 13,000 acres in the Dolores basin; and 23,000 acres in the San Miguel basin. Non-agricultural diversions in the San Juan Model include power generation at Cascade Reservoir (Electra Lake), the Ames-Ilium Hydro Project and the Nucla Power Plant; the municipal water supply for the city of Durango and the towns of Mancos, Animas, Rico, Fairfield, and Cortez; and parts of the Montezuma Valley Irrigation Company diversions.



Several diversions from rivers in the San Juan Model are exported from the basin. These diversions include the San Juan-Chama Project, which diverts from the Rio Blanco, Little Navajo, and Navajo Rivers for use in the Rio Grande basin. Other smaller diversions transport water from the San Juan, Piedra, Los Pinos, and Animas rivers for delivery to basins outside of the San Juan River basin. The San Juan Model includes many diversions that transfer water from one tributary basin to another within the model. Several diversions from the San Juan and Animas rivers that are physically located in New Mexico have been included in the San Juan Model. These provide water for large irrigation projects in New Mexico and two power plants downstream of Navajo Reservoir.

The San Juan Model includes 13 explicitly modeled reservoirs as well as 10 aggregated reservoirs and 7 aggregated stock ponds. The explicitly modeled reservoirs are distributed geographically as follows: four in the San Miguel basin (Gurley, Miramonte, Trout Lake, and Lake Hope), four in the Dolores basin

(Groundhog, McPhee, Summit and Narraguinnep), and five in the San Juan basin (Jackson Gulch, Cascade, Vallecito, Lemon, and Navajo). The smallest two are Lake Hope and Trout Lake with storage volumes of 2,315 and 3,422 acre-feet, respectively. The largest is Navajo Reservoir with storage of over 1.7 million acre-feet. Navajo Reservoir lies mostly outside of the State of Colorado, but was included in the model because of its impact on water distribution within the San Juan and Colorado River basins.

3.3 Water Resources Development

The San Juan and Dolores River basins have had substantial water resources developments in the form of storage projects and pipelines developed by private groups and federal agencies. **Table 3.1** presents a timeline of key developments within the basin.

Table 3.1 - Key Water Resources Developments

Date	Project	Agency
Early 1940's	Pine River Project - Vallecito Reservoir	USBR
Late 1940's	Mancos Project - Jackson Gulch Reservoir	USBR
Late 1950's	Colorado River Storage Project - Navajo Reservoir	USBR
1964	Florida Project - Lemon Reservoir	USBR
1972	San Juan-Chama Project	USBR
1985	Dolores Project - McPhee Reservoir	USBR
2010	Animas-La Plata Project – Ridges Basin	USBR
2015	Long Hollow Reservoir	LPWCD

3.4 Water Rights Administration and Operations

Historical water rights have been administered in the San Juan and Dolores River basins according to the prior appropriation doctrine. Some special cases of water rights administration are as follows:

- The San Juan-Chama Project diverts water from the Rio Blanco, Little Navajo, and Navajo rivers in Colorado for export to the Rio Grande basin in New Mexico. The project does not have absolute decreed water rights in Colorado and is administered as the most junior right on the system within the state. Minimum streamflow bypass requirements on each of the streams are administered as just senior to the diversions for this project.
- Indian water rights exist in the San Juan basin. They are relatively senior and are modeled via the prior appropriation doctrine like any other water rights in the basin.
- Navajo Reservoir and several large diversions from the San Juan River in New Mexico are included in the San Juan Model, although they are not administered by the State of Colorado. They are administered within the model as junior in priority to all Colorado water rights.
- The La Plata Compact governs the distribution of water on the La Plata River between the states of Colorado and New Mexico. The administration is dependent upon the streamflow at two gaging stations: 1) Hesperus Station (USGS No. 09365500) and 2) Interstate Station (USGS No.

9366500). During the year from December 1 to February 14, each state has the right to use all water within its boundaries. For the remainder of the year, February 15 to November 30, allocation for La Plata River water is performed according to the following guidelines:

1. If the flow at Interstate Station is greater than or equal to 100 cubic feet per second (cfs), each state has unrestricted rights to all water within its boundaries.
2. If the flow at Interstate Station is less than 100 cfs, the State of Colorado shall deliver at the Interstate Station a quantity of water equal to one-half of the mean flow at the Hesperus Station for the preceding day, not to exceed 100 cfs.

During periods of extreme low flow, the guidelines above may be superseded by a method of administration that allows the delivery of all available water successively to each state in alternating periods. When flow at the Hesperus Station is less than 30 cfs, the lower reaches of the La Plata will run dry, and Colorado cannot deliver any water in accordance with No. 2 above.

3.5 Section 3 References

1. Colorado River Decision Support System San Juan River Basin Water Resources Planning Model, Boyle Engineering Corporation, November 1999.

2. San Juan / Dolores River Basin Facts, Colorado Water Conservation Board, available at http://cwcb.state.co.us

3. Census and Population Estimate Data, Colorado Demography Office, available at http://dola.colorado.gov/demog/Demog.cfm

4. Azotea Tunnel picture by Richard Pipes, San Juan-Chama Project, as covered by the Albuquerque Journal, available at http://www.abqjournal.com/water/

5. San Juan and Dolores River Basin Information Report, November 2005.

4. Modeling Approach

This section describes the approach taken in modeling the San Juan/Dolores River Basin, from a general perspective. It addresses scope and level of detail of this model in both the space and time domains, and describes how certain hydrologic processes are parameterized.

4.1 Modeling Objectives

The objective of the San Juan Modeling effort was to develop a water allocation and accounting model that water resources professionals can apply to evaluations of planning issues or management alternatives. The resulting “Baseline” input data set is one representation of current water use, demand, and administrative conditions, which can serve as the base in paired runs comparing river conditions with and without proposed future changes. By modifying the Baseline data set to incorporate the proposed features to be analyzed, the user can create the second input data set of the pair.

The model estimates the basin’s current consumptive use by simulating 100 percent of basin demand. This objective was accomplished by representing large or administratively significant structures at model nodes identified with individual structures, and representing many small structures at “aggregated” nodes. Although the model was first developed and calibrated for the period from 1975 forward, the data set was extended backward to 1909, creating a long-term data set reflecting a wide variety of hydrologic conditions.

Another objective of the CDSS modeling effort was to achieve good calibration, demonstrated by agreement between historical and simulated streamflows, reservoir contents, and diversions when the model was executed with historical demands and operating rules. This objective was achieved, as demonstrated in Section 5.

4.2 Model coverage and extent

4.2.1. Network Diagram

The network diagram for the San Juan/Dolores model can be viewed in StateDMI. It includes 490 nodes for both river systems. For the San Juan River, the network begins with the headwaters of the East Fork of the San Juan River and ends at the streamflow gage near Bluff, Utah. The Dolores River network begins at its headwaters near Bolam Pass in the San Juan National Forest. The San Miguel joins the Dolores just downstream of Bedrock, Colorado. The Dolores network ends at the streamflow gage near Gateway, Colorado.

4.2.2. Diversion Structures

4.2.2.1 Key Diversion Structures

Early in the CDSS process it was decided that, while all consumptive use should be represented in the models, it was not practical to model each and every water right or diversion structure individually. Seventy-five percent of use in the basin, however, should be represented at strictly correct river locations relative to other users, with strictly correct priorities relative to other users. With this objective in mind, key structures to be "explicitly" modeled were identified by:

- Identifying net absolute water rights for each structure and accumulating each structure's decreed amounts
- Ranking structures according to net total absolute water rights
- Identifying the decreed amount at 75 percent of the basinwide total decreed amount in the ranked list
- Generating a structures/water rights list consisting of structures at or above the threshold decreed amount
- Field verifying structures/water rights, or confirming their significance with basin water commissioners, and making adjustments

Based on this procedure, 5 cubic feet per second (cfs) was selected as the cutoff value for the San Juan River basin and 6.5 cfs was selected as the cutoff for the Dolores River basin. Key diversion structures are generally those with total absolute water rights equal to or greater than these cutoffs. The San Juan Model includes approximately 316 key diversion structures.

Groups of key structures on the same tributary that operate in a similar fashion to satisfy a common demand are sometimes combined into "diversion systems". Diversion systems are modeled the same as other key structures.

Where to find more information

- Section 3 of the CDSS document "San Juan / Dolores River Basin Information" lists candidate key structures and in some cases indicates why structures were or were not designated as "key". These decisions were often based on Water Commissioner input, which is also documented in the San Juan / Dolores Basin Information Section "Basin Meeting Notes".

4.2.2.2 Aggregation of Irrigation Structures

In general, the use associated with irrigation diversions having total absolute rights less than 5 cfs in the San Juan River basin and 6.5 cfs in the Dolores River basin were included in the model at "aggregated nodes." These nodes represent the combined historical diversions, demand, and water rights of many small structures within a prescribed sub-basin. The aggregation boundaries were based generally on tributary boundaries, gage location, critical administrative reaches, and instream flow reaches. To the extent possible, aggregations were devised so that they represented no more than 2,200 irrigated acres. In the San Juan Model, 26 aggregated nodes were identified, representing around 29,000 acres of irrigated crops. These nodes were placed in the model at the most downstream position within the aggregated area.

Aggregated irrigation nodes were assigned all the water rights associated with their constituent structures. Their historical diversions were developed by summing the historical diversions of the individual structures, and their irrigation water requirement is based on the total acreage associated with the aggregation.

Where to find more information

- Appendix A includes a memorandum describing the task in which irrigation structures were aggregated. It includes a table showing what diversion structures are included in each aggregation, and a description of where they are located in the model network.

4.2.2.3 Municipal and Industrial Uses

Two nodes in the model represent the combined small diversions for municipal, industrial, and livestock use (M&I); one on the San Juan River in Water District 32 and the other on the Dolores River in Water District 63. Total non-irrigation consumptive use in the San Juan / Dolores basin was estimated, as documented in the CDSS task memorandum "Non-Irrigation (Other Uses) Consumptive Uses and Losses in the Dolores and San Juan River Basins." Consumptive use of the key M&I diversions in the model was subtracted from this basinwide M&I consumption, to derive the basinwide consumptive use attributable to small M&I users. This value was distributed to Water Districts 32 and 63 in accordance with a general distribution of M&I use.

The two aggregated M&I nodes in the San Juan Model represent approximately 2,400 af of consumptive use, a small percentage of the basin total use. These diversions have a priority of 1.0 (very senior) in the model, and a decreed amount that greatly exceeds their demands. In other words, these structures' diversions are not limited by their water right. The monthly demands (which are set to the consumptive use rather than diversion amount) were set in accordance with results of the CDSS memorandum cited above.

Several diversions for municipal and industrial use are modeled explicitly in the San Juan Model. These explicitly modeled municipal diversions include the Town of Durango, Town of Mancos, Original Rico Flume, the Town of Cortez, Town of Dolores, and the Town of Fairfield. Three industrial diversions for power generation are explicitly modeled including Power Canal No. 1, Ames Hydro Project, and Nucla Power Diversion. These diversions are non-consumptive.

Where to find more information

- Appendix B includes a memorandum describing the task in which municipal and industrial uses were aggregated.

4.2.3. Reservoirs

4.2.3.1 Key Reservoirs

Reservoirs with decreed capacities equal to or in excess of 4,000 acre-feet are considered key reservoirs, and are explicitly modeled. There are 16 key reservoirs with a combined total capacity of approximately 772,000 af, or 91 percent of the total absolute storage rights of the basin. Five reservoirs with capacity of less than 4,000 acre-feet are included in the 16 key reservoirs and are explicitly modeled because they are served by diversions that exceed the cut-off rate as indicated in the previous section or are administratively important (for example, Long Hollow Reservoir).

4.2.3.2 Aggregation of Reservoirs

In keeping with CDSS's objective of representing all consumptive use in the basin, the evaporation losses associated with small reservoirs were incorporated using nine aggregated reservoir structures. These structures were used to represent all the adjudicated, absolute storage rights in the database that are otherwise unaccounted for. **Table 4.1** below summarizes storage capacity for the nine reservoirs. Surface area for the reservoirs was developed assuming they are straight-sided pits with a depth of 25 feet, based on available dam safety records.

Table 4.1
Aggregated Reservoirs

ID	WD	Name	Capacity (AF)	%
29_ARS002	29	ARS002_SanJuan	2,761	7%
30_ARS005	30	ARS005_Animas	3,359	8%
31_ARS004	31	ARS004_LosPinos	504	1%
32_ARS008	32	ARS008_McElmo	1,005	3%
33_ARS006	33	ARS006_LaPlata	2,465	6%
34_ARS007	34	31_ARS007_Mancos	2,830	7%
63_ARS009	63	ARS009_Dolores	10,392	26%
77_ARS001	77	ARS001_Navajo	874	2%
78_ARS003	78	ARS003_PiedraR	15,611	39%
TOTAL			**39,801**	**100**

The seven remaining reservoirs represented stockpond use, as documented in CDSS Task 2.09.13 Memorandum "Non-Irrigation (Other Uses) Consumptive Uses and Losses in the Dolores and San Juan River Basins". The total storage was divided into seven aggregated stockponds, located to correspond with the major stock-use areas. The stockponds, shown in **Table 4.2**, were modeled as 10-foot deep straight-sided pits.

Neither the aggregated reservoirs nor the stockponds release to the river in the models. They evaporate, however, and fill to replace the evaporated amount. The effects of small reservoirs filling and releasing are left "in the gage" in the model, and are reflected in CDSS baseflow computations. The aggregated reservoirs are assigned storage rights with a priority of 1.0 (very senior) so that the evaporation use is not constrained by water rights.

Table 4.2
Aggregated Stockponds

ID	WD	Name	Capacity (AF)	%
29_ASS001	29	ASS001_SanJuan	4,233	12
30_ASS002	30	ASS002_AnimasR	2,469	7
31_ASS003	31	ASS003_LosPinos	1,411	4
32_ASS004	32	ASS004_McElmo	16,930	48
33_ASS005	33	ASS005_LaPlata	2,116	6
34_ASS006	34	ASS006_Mancos	7,760	22
63_ASS007	63	ASS007_Dolores	352	1
TOTAL			**35,271**	**100**

Where to find more information

- Appendix B includes a memo describing the task in which small reservoir and stockponds use was aggregated.

4.2.4. Instream Flow Structures

The model includes 62 instream flow reaches representing instream flow rights held by CWCB, minimum reservoir release agreements, and filings by the U.S. Department of the Interior. These are only a subset of the total CWCB tabulation of rights because many instream flow decrees are for stream reaches very high in the basin, above the model network.

4.3 Modeling Period

The San Juan Model data set extends from 1909 through 2013 and operates on USGS water year (October 1 through September 30). The calibration period was 1975 through 2013, a period selected because historical diversion data were readily available in electronic format for key structures. In addition, the period reflects most recent operations in the basin, and includes both drought (1977, 1989-1992, 2000s) and wet cycles (1983-1985).

As one goes back in time within the data set, more and more data are estimated. Before extending the data set, a feasibility study was done which included a survey of available data and methods for data extension. The scope of the study included all five western slope planning models.

Where to find more information

- The feasibility study for the data extension is documented in two task memos, which are collected in the CDSS *(Technical Papers)*:

  -Data Extension Feasibility

  -Evaluate Extension of Historical Data

4.4 Data Filling

In order to extend the data set to 1909, a substantial amount of reservoir content, diversion, demand, and baseflow time series data needed to be estimated. In many areas of the San Juan / Dolores basin, HydroBase data begins in 1975, although for some structures there is additional, earlier historical data. Therefore, major structures were selected for additional investigation outside the database, or outside the standard CDSS data tables in the case of reservoir contents. CDSS tools were then developed to automate the estimation process for the remaining structures. This section describes data filling and extension for the San Juan Model.

4.4.1. Historical Data Extension for Major Structures

4.4.1.1 Historical Diversions

Fourteen major diversions in the San Juan / Dolores River basin were identified as warranting additional investigation to find actual diversion records prior to 1975, as shown in **Table 4.3**. Most of the structures had diversion records stored in HydroBase from November, 1975 through the current year. Available records prior to 1975 were digitized from SEO and USBR records to complete historic diversions

Table 4.3
Investigated and Extended Major Structures

WDID	Name	1909-2013 Annual Diversion
310665	Spring Creek Ditch	60,070
714674	Main Canal No. 2 (Great Cut)	79,126
714675	Main Canal No. 1 (Dolores Tunnel)	62,556
600633	Highline Canal + Enl	29,587
301011	Florida Farmers Ditch + Florida Canal	23,705
310519	King Ditch	22,775
310547	Robert Morrison Ditch	18,220
300506	Animas Consolidated Ditch	18,284
300617	Reid Ditch	14,479
320772	MVIC U Lateral	74,058
324675	MVIC Dolores Tunnel	57,432

4.4.1.2 Historical Reservoir Contents

Historical reservoir content data is limited in HydroBase. Therefore, historical information for the major reservoirs was collected from several sources, including the U.S. Bureau of Reclamation and reservoir owners and operators. It was necessary to include data from sources other than HydroBase for most of the explicitly modeled reservoirs.

4.4.2. Automated Time Series Filling

An automated procedure was adopted to fill time series (i.e., historical diversions, demand, historical reservoir contents, reservoir targets, and irrigation water requirement) input to the model. It is a refinement over using an overall monthly average as the estimated value. Each month of the modeling period has been categorized as an Average, Wet, or Dry month based on the gage flow at long-term “indicator” gages in the San Juan / Dolores River basin. A data point missing for a Wet March, for example, is then filled with the average of only the Wet Marches in the partial time series, rather than all Marches.

The process of developing the Average, Wet, and Dry designation for each month is referred to as “streamflow characterization”. There are five streamflow characterizations in the San Juan / Dolores River basin, based on five indicator gages: San Juan River at Pagosa Springs (09342500), Animas River at Durango (09361500), La Plata River at Hesperus (09365500), Dolores River at Dolores (09166500), and San Miguel River near Placerville (09172500). The characterization for the San Juan gage is used when filling in time series for structures in Districts 29, 46, 77 and 78. The Animas gage characterization pertains to Districts 30 and 31. The La Plata gage characterization pertains to Districts 33 and 34. The Dolores gage characterization pertains to Districts 32, 69, and 71. The San Miguel gage characterization pertains to Districts 60, 61, 63, and 73.

Months with gage flows at or below the 25th percentile for that month are characterized as “Dry”, while months at or above the 75th percentile are characterized as “Wet”, and months with flows in the middle are characterized as “Average”.

When historical diversion records are filled, a constraint is added to the estimation procedure. The estimated diversion may not exceed the water rights that were available to the diversion at the time. For example, if a ditch was enlarged and a junior right added to it in the 1950s, then a diversion estimate for 1935 cannot exceed the amount of the original right. The date of first use is derived from the administration number of the water right, which reflects the appropriation date.

Where to find more information

- A proof-of-concept effort with respect to the automated data filling process produced the following task memos, which are collected in the CDSS (*Technical Papers)*:

  -Data Extension Feasibility

  -Evaluate Extension of Historical Data

  -Characterize Streamflow Data

  -Verify Diversion Estimates

  These memos describe rationale for the data-filling approach, explore availability of basic gage data, explain the streamflow characterization procedure, and provide validation of the methods.

- **StateDMI** documentation describes the Streamflow Characterization Tool, a calculator for categorizing months as Average, Wet, or Dry
- **TSTool** documentation describes how to invoke the automated data filling procedure using those DMI's

4.4.3. Baseflow Filling

A typical approach to filling missing hydrologic sequences in the process of basin modeling is to develop regression models between historical stream gages. The best fitting model is then applied to estimate missing data points in the dependent gage's record. Once gage flow time series are complete, observed or estimated diversions, changes in storage, and so forth are added to or subtracted from the gage value to produce an estimated naturalized flow or baseflow.

The typical approach was deemed inadequate for a study period that extended over decades and greatly changed operating environments. Gage relationships derived from late-century gage records probably are not applicable to much earlier conditions, because the later gages reflect water use that may not have been occurring at the earlier time. The CDSS approach is therefore to estimate baseflows at all points where actual gage records are available, and then correlate between naturalized flows, as permitted by availability of data. Ideally, since baseflows do not reflect human activity, the relationship between two sets of baseflows is independent of the resource use and can be applied to any period.

Baseflow filling is carried out more or less automatically using the USGS Mixed Station Model, enhanced for this application under the CDSS project. The name refers to its ability to fill many series, using data from all available stations. Many independent stations can be used to fill one time series, but only one station is used to fill each individual missing value. The Mixed Station Model fits each combination of dependent and independent variable with a linear regression relationship on log-transformed values, using the common period of record. For each point to be filled, the model then selects the regression that yields the least standard error of prediction (SEP) among all eligible correlations. Note that TSTool is being enhanced to include the functionality of the Mixed Station Model for future modeling updates.

The further one goes back in time, the fewer gage records exist to create baseflow series that can serve as independent variables. In 1920, there were five gages in the San Juan / Dolores River basin that have enough continuity in records to be used in the modeling effort. By 1950, the number of gages used in the model with data increased to 29. Approximately 48 percent of the gage site baseflows are filled.

Where to find more information

- The task memorandum documenting application of the Mixed Station Model to CDSS baseflows is entitled "Subtask 11.10 Fill Missing Baseflows" and is in the CDSS (*Technical Papers).* It describes a sensitivity investigation of the use of historical gage data in lieu of baseflow estimates.

4.5 Consumptive Use and Return Flow Amounts

The related values, consumptive use and return flow, are key components of both baseflow estimation and simulation in water resources modeling. StateMod's baseflow estimating equation includes a term for return flows. Imports and reservoir releases aside, water that was in the gage historically is either natural runoff or delayed return flow. To estimate the natural runoff, or more generally, the baseflow, one must estimate return flow. During simulation, return flows affect availability of water in the stream in both the month of the diversion and subsequent months.

For non-irrigation uses, consumptive use is the depletive portion of a diversion, the amount that is taken from the stream and removed from the hydrologic system by virtue of the beneficial use. The difference between the diversion and the consumptive use constitutes the return flow to the stream.

For irrigation uses, the relationship between crop consumptive use and return flow is complicated by interactions with the water supply stored in the soil, i.e., the soil moisture reservoir, and losses not attributable to crop use. This is explained in greater detail below.

4.5.1. Variable Efficiency of Irrigation Use

Generally, the efficiency of irrigation structures in the San Juan Model is allowed to vary through time, up to a specified maximum efficiency. Setting aside soil moisture dynamics for the moment, the predetermined crop irrigation water requirement is met out of the simulated headgate diversion, and efficiency (the ratio of consumed water to diverted water) falls where it may – up to the specified maximum efficiency. If the diversion is too small to meet the irrigation requirement at the maximum efficiency, maximum efficiency becomes the controlling parameter. Crop consumption is limited to the diverted amount times maximum efficiency, and the balance of the diversion, less 6 percent of the non-consumed water, returns to the stream.

The 6 percent of non-consumed water represents water lost to the hydrologic system altogether, through, for example, non-crop consumptive use, deep groundwater storage, or evaporation. Note that for the San Juan Model, 6 percent of non-consumed water represents approximately 10 percent of basin-wide crop consumptive use. This value is recommended as an appropriate estimate of incidental use for the San Juan/Dolores basins.

The model is supplied with time series of irrigation water requirements for each structure, based on its crop type and irrigated acreage. This information is generated using the CDSS StateCU model. Maximum system efficiency (combined ditch efficiency and application efficiency) is also input to the model. For the San Juan / Dolores River basin maximum system efficiency is estimated to be 60 percent. Exceptions include Dolores Project recipients that primarily irrigate with sprinklers.

Headgate diversion is determined by the model, and is calculated in each time step as the minimum of 1) the water right, 2) available supply, 3) diversion capacity, and 4) headgate demand. Headgate demand is input as a time series for each structure. During calibration, headgate demand for each structure is simply its historical diversion time series. In the Baseline data set, headgate demand is set to the irrigation water requirement for the specific time step and structure, divided by the historical efficiency for that month of the year. Historical efficiency is defined as the smaller of 1) average historical diversion for the month, divided by average irrigation water requirement, and 2) maximum efficiency. In other words, if water supply is generally plentiful, the headgate demand reflects the water supply that has been typical in the past; and if water supply is generally limiting, it reflects the supply the crop needs in order to satisfy full crop irrigation requirement at the maximum efficiency.

Now StateMod also accounts for water supply available to the crop from the soil. Soil moisture capacity acts as a small reservoir, re-timing physical consumption of the water, and affecting the amount of return flow in any given month. Soil moisture capacity is input to the model for each irrigation structure, based on NRCS mapping. Formally, StateMod accounts for water supply to the crop as follows:

Let **DIV** be defined as the river diversion, $\boldsymbol{\eta_{max}}$ be defined as the maximum system efficiency, and let $\mathbf{CU_i}$ be defined as the crop irrigation water requirement.

Then, $SW = DIV * \eta_{max}$; (Max available water to crop)

when $SW \geq CU_i$: (Available water to crop is sufficient to meet crop demand)

$CU_w = CU_i$ (Water supply-limited CU = Crop irrigation water requirement)

$SS_f = SS_i + \min[(SS_m - SS_i),(SW - CU_w)]$ (Excess available water fills soil reservoir)

$SR = DIV - CU_w - (SS_f - SS_i)$ (Remaining diversion is “non-consumed”)

$TR = 0.97 * SR$ (Non-consumed less incidental loss is total return flow)

when $SW < CU_i$: (Available water to Crop is not sufficient to meet crop demand)

$CU_w = SW + \min[(CU_i - SW), SS_i]$ (Water supply-limited CU = available water to crop + available soil storage)

$SS_f = SS_i - \min[(CU_i - SW), SS_i]$ (Soil storage used to meet unsatisfied crop demand)

$SR = DIV - SW$ (Remaining diversion is "non-consumed")

$TR = 0.97 * SR$ (Non-consumed less incidental loss is total return flow)

where **SW** is maximum water available to meet crop demand

CU_w is water supply limited consumptive use;

SS_m is the maximum soil moisture reservoir storage;

SS_i is the initial soil moisture reservoir storage;

SS_f is the final soil moisture reservoir storage;

SR is the diverted water in excess of crop requirement (non-consumed water);

TR is the total return to the stream attributable to this month's diversion.

For the following example, assume the maximum system efficiency is 60 percent; therefore a maximum of 60 percent of the diverted amount can be delivered and available to the crop. When this amount exceeds the irrigation water requirement, the balance goes to the soil moisture reservoir, up to its capacity. Additional non-consumed water returns to the stream, subject to 5 percent incidental loss. In this case, the crop needs are completely satisfied, and the water supply-limited consumptive use equals the irrigation water requirement.

When 60 percent of the diverted amount (the water delivered and available to meet crop demands) is less than the irrigation water requirement, the crop pulls water out of soil moisture storage, limited by the available soil moisture and the unsatisfied irrigation water requirement. Water supply-limited consumptive use is the sum of diverted water available to the crop and supply taken from soil moisture, and may be less than the crop water requirement. Total return flow is the 40 percent of the diversion deemed unable to reach the field (non-consumed), less 5 percent incidental loss.

With respect to consumptive use and return flow, aggregated irrigation structures are treated as described above, where the irrigation water requirement is based on total acreage for the aggregate.

4.5.2. Constant Efficiency for Other Uses and Special Cases

In specific cases, the San Juan Model applies an assumed, specified annual or monthly efficiency to a diversion in order to determine consumptive use and return flows. Although the efficiency may vary by month, the monthly pattern is the same in each simulation year. This approach is applied to municipal, industrial, transbasin users, and reservoir feeder canals. It can also apply to irrigation diversions for which irrigation water requirement has not been developed.

In the San Juan Model, irrigation water requirements have been developed for all irrigation diversions in Colorado. The one major transbasin diversion (San Juan-Chama Project) and 10 minor transbasin diversions in the San Juan Model have been assigned a diversion efficiency of 1.00 in all months. During both baseflow estimation and simulation, the entire amount of the diversion is assumed to be removed from the hydrologic system. The explicitly modeled municipal systems, including Durango, Cortez, Dolores, Mancos, Rico, and Fairfield have been assigned monthly efficiencies representing municipal consumptive use patterns. The two aggregated municipal demands have been modeled using historical consumptive use, not withdrawls, and efficiencies have been set to 100 percent.

Reservoir feeders and other carriers that do not irrigate lands have been assigned a diversion efficiency of zero in all months, reflecting that 100 percent of the diversions “return” to the reservoirs. These feeders include the following:

- Cascade Canal
- Narraguinnep Reservoir Inlet
- Jackson Gulch Inlet Canal
- Naturita Canal
- Paxton Ditch
- Summit Ditch
- Turkey Creek Ditch

Three non-consumptive diversions for hydropower generation are included in the model and have been assigned an efficiency of zero. They include Power Canal No. 1, Ames Hydro Project, and Nucla Power Diversion.

Key structures diverting off the mainstem San Juan in New Mexico, Arizona and Utah are assigned monthly efficiencies provided by the USBR, with the exception of the Hammond Ditch, the 4-Corners Power Plant, and the Navajo Indian Irrigation Project (NIIP). Depletions for the Hammond Ditch and the 4-Corners Power Plant were provided by the USBR, therefore they are simulated using the variable efficiency approach. The NIIP diversion return flows are increasing over time as the ground water table is building, therefore diversions are modeled as 100 percent consumptive and associated return flows, provided by the USBR, are "imported" back to the river as negative diversions.

Where to find more information

- StateCU documentation describes different methods for estimating irrigation water requirement for structures, for input to the StateMod model.
- Section 7 of the StateMod documentation has subsections that describe "Variable Efficiency Considerations" and "Soil Moisture Accounting"
- Section 5 of this manual describes the input files where the parameters for computing consumptive use and return flow amounts are specified:
    - Irrigation water requirement in the Irrigation Water Requirement file (Section 5.5.3)
    - Headgate demand in the Direct Diversion Demand file (Section 5.4.4)
    - Historical efficiency in the Direct Diversion Station file (Section 5.4.1)
    - Maximum efficiency in the CU Time Series file (Section 5.5.2)
    - Soil moisture capacity in the Structure Parameter file (Section 5.5.1)
    - Loss to the hydrologic system in the Delay Table file (Section 5.4.2)

4.6 Return Flows

4.6.1. Return Flow Timing

Return flow timing is specified to the model by specifying what percentage of the return flow accruing from a diversion reaches the stream in the same month as the diversion, and in each month following the diversion month. Four different return flow patterns are used in the San Juan / Dolores model. One pattern represents instantaneous (or within the same month as the diversion) returns and is applied to municipal and non-consumptive diversions.

The other patterns are generalized irrigation return patterns, applicable to irrigated lands "close" to the stream (center of acreage is approximately 1,000 feet from the stream), and "further" from the stream (center of acreage is approximately 2,000 feet from the stream). They were developed using the Glover analytical solution for parallel drain systems. The State's Analytical Steam Depletion Model (September, 1978), which is widely used in determining return flows for water rights transfers and augmentation plans, permits this option for determining accretion factors. The two irrigation patterns used in Colorado representing "close" and "further" include a 5 percent incidental loss. New Mexico, Arizona, and Utah irrigation structures use a "close" delay pattern that includes a 10 percent incidental loss.

The Glover analysis requires these input parameters:

T = Transmissivity in gallons per day per foot (gpd/ft). Transmissivity is the product of hydraulic conductivity (K) in feet per day, saturated thickness (b) in feet, and the appropriate conversion factor.

S = Specific Yield as a fraction

W = Distance from stream to impervious boundary in feet (ft)

x = Distance from point of recharge to stream in feet (ft)

Q = Recharge Rate in gallons per minute (gpm)

Regionalized values for the aquifer parameters were determined by selecting ten representative sites throughout the west slope, based partly on the ready availability of geologic data, and averaging them. The analysis estimated generalized transmissivity as 48,250 gpd/ft, specific yield as 0.13, and distance from the stream to the alluvial boundary as 3,500 ft. The Glover analysis was then executed for both 1,000 feet from the recharge center to the stream, and 2,000 feet from the recharge center to the stream.

It was assumed that the resulting pattern applies to only half of the return flow, and that the other half returns within the month via the surface (tailwater returns, headgate losses, etc.). Combining surface water returns with groundwater returns resulted in the two irrigation return patterns shown in **Table 4.4** and graphed in **Figure 4.1.** A third return flow pattern was included for the San Juan Model to reflect returns to Long Hollow from irrigation on Red Mesa. As shown in **Table 4.4**, this pattern reflects a longer period of return through the ground water system. Month 1 is the month in which the diversion takes place. Note that **Figure 4.1** reflects 100 percent of unused water returning to the river, both from surface runoff and subsurface flow. For each CDSS basin, the first month's return flow percent will be reduced to recognize incidental loss. As discussed above, incidental losses in the San Juan / Dolores model are estimated to be 6 percent of unused water, as shown in **Table 4.4**.

Where to find more information

- CDSS Memorandum "Colorado River Basin Representative Irrigation Return Flow Patterns", Leonard Rice Engineers, January, 2003. *(Technical Papers)*

4.6.2. Return Flow Locations

Return flow locations were determined during the original data gathering, by examining irrigated lands mapping and USGS topographical maps, and confirming locations with Division 7 and 4 personnel. Some return flow locations were modified during calibration.

Table 4.4
Percent of Return Flow Entering Stream in Month *n* after Diversion (6% loss)

Month *n*	For Lands "Close" to Stream (%)	For lands "Further" from Stream (%)	For Lands Returning to Long Hollow (%)
1	72.6	54.4	1.3
2	11.3	14.5	1.5
3	3.2	7.2	1.6
4	2.2	5.0	3.0
5	1.6	3.7	3.0
6	1.2	2.7	3.0
7	0.8	2.0	3.0
8	0.6	1.5	3.0
9	0.5	1.1	3.0
10	0	0.8	3.0
11	0	0.6	3.0
12	0	0.5	3.0
13 - 14	0	0	2.7
15 - 36	0	0	2.6
Total	94	94	94

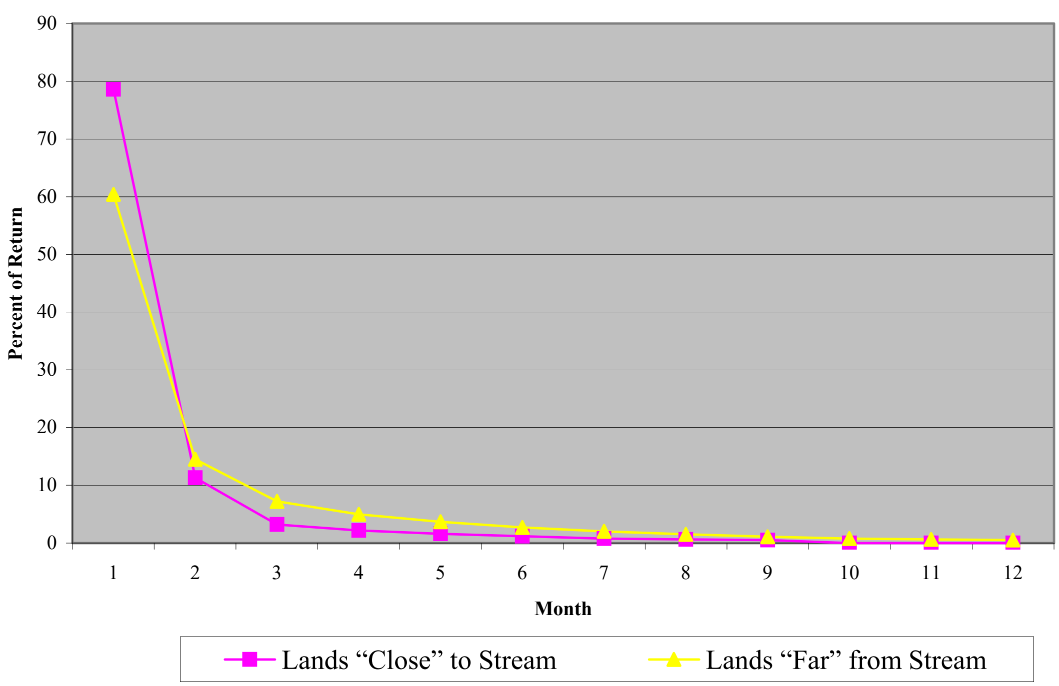


Figure 4.1 Percent of Return in Months after Diversion

4.7 Baseflow Estimation

In order to simulate river basin operations, the model starts with the amount of water that would have been in the stream if none of the operations being modeled had taken place. These undepleted flows are called “baseflows”. The term is used in favor of “virgin flow” or “naturalized flow” because it recognizes that some historical operations can be left “in the gage”, with the assumption that those operations and impacts will not change in the hypothetical situation being simulated.

Given data on historical depletions and reservoir operations, StateMod can estimate baseflow time series at specified discrete inflow nodes. This process was executed prior to executing any simulation, and the resulting baseflow file became part of the input data set for subsequent simulations. Baseflow estimation requires three steps: 1) adjust USGS stream gage flows using historical records of operations to get baseflow time series at gaged points, for the gage period of record; 2) fill the baseflow time series by regression against other baseflow time series; 3) distribute baseflow gains above and between gages to user-specified, ungaged inflow nodes. These three steps are described below.

4.7.1. Baseflow Computations At Gages

Baseflow at a site where historical gage data is available is computed by adding historical values of all upstream depletive effects to the gaged value, and subtracting historical values of all upstream augmenting effects from the gaged value:

$$Q_{baseflow} = Q_{gage} + Diversions - Returns - Imports +/- \Delta Storage + Evap$$

Historical diversions, imports, and reservoir contents are provided directly to StateMod to make this computation. Evaporation is computed by StateMod based on historical evaporation rates and reservoir contents. Return flows are similarly computed based on diversions, crop water requirements, and/or efficiencies as described in Section 4.5, and return flow parameters as described in Section 4.6.

> **Where to find more information**
>
> - When StateMod is executed to estimate baseflows at gages, it creates a Baseflow Information file *(*.xbi*) that shows this computation for each gage and each month of the time step.

4.7.2. Baseflow Filling

Wherever gage records are missing, baseflows are estimated as described in Section 4.4.3 -Baseflow Filling.

4.7.3. Distribution of Baseflow To Ungaged Points

In order for StateMod to have flow on tributary headwaters, baseflow must be estimated at all ungaged headwater nodes. In addition, gains between gages are modeled as entering the system at locations to reflect increased flow due to unmodeled tributaries. Most key reservoirs were represented as baseflow nodes in order for the model to “see” all available water supply at the site. During calibration, other baseflow nodes were added to better simulate a water supply that would support historical operations.

StateMod has an operating mode that distributes a portion of baseflows at gaged locations to ungaged locations based on drainage area and average annual precipitation. The default method is the “gain approach”. In this approach, StateMod pro-rates baseflow gain above or between gages to ungaged locations using the product of drainage area and average annual precipitation.

Figure 4.2 illustrates a hypothetical basin and the areas associated with three gages and three ungaged baseflow nodes.

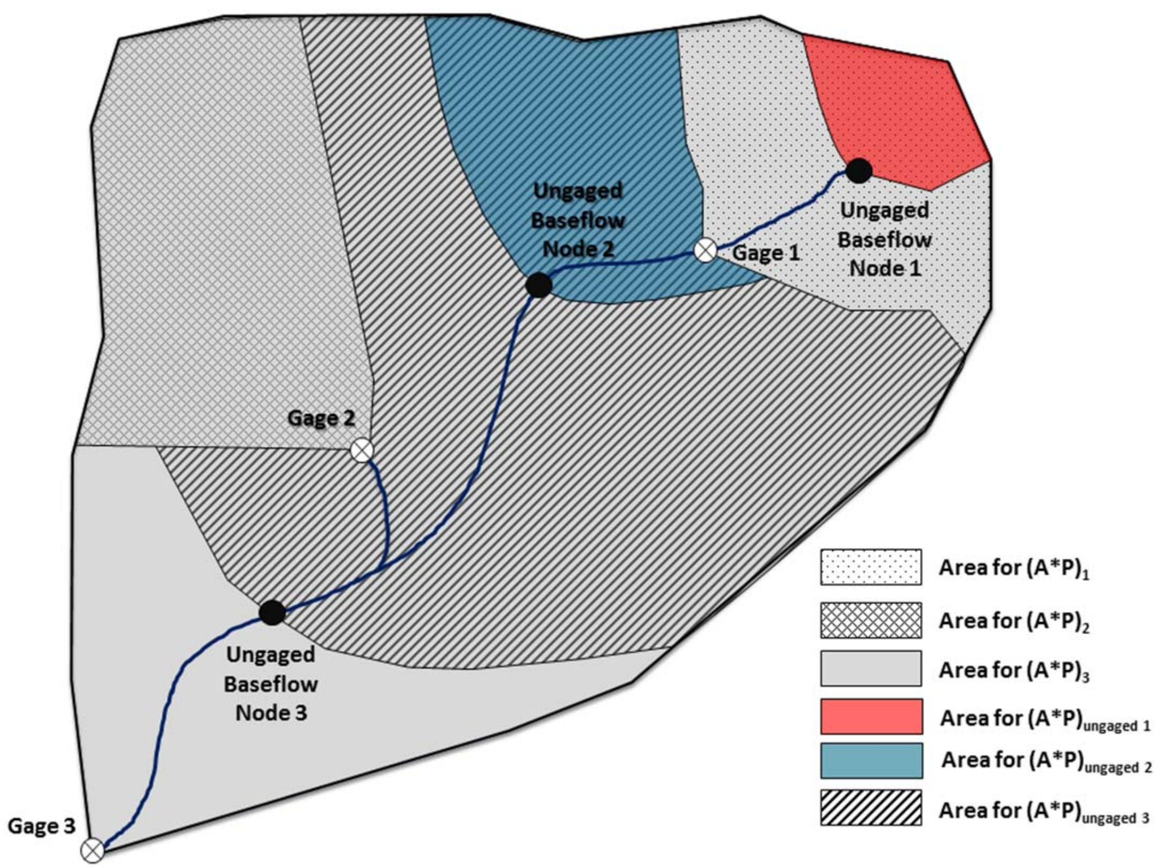


Figure 4.2 Hypothetical Basin Illustration

The area associated with gages is the total upstream area. The area associated with ungaged nodes only includes the incremental area from the ungaged location to the next upstream gage or gages. For example, Gage 3 area includes the entire basin. Ungaged Baseflow Node 3 area (diagonal stripes) includes the upstream area between the Ungaged Baseflow Node 3 and Gage 2 and Gage 1.

In **Figure 4.2**, there are three ungaged baseflow nodes; the StateMod "gain approach" computes the total baseflow at each ungaged node based on the following:

The baseflow gain distributed to Ungaged Baseflow Node 1 is the baseflow gain above Gage 1 pro-rated on the A*P terms.

$$Gain_{ungaged,1} = \left(\frac{(A*P)_{ungaged,1}}{(A*P)_{gage,1}}\right)(BF_{gage,1})$$

Total baseflow at Ungaged Node 1 is equal to the $Gain_{ungaged,1}$ term.

The baseflow gain distributed to Ungaged Baseflow Node 2 is the baseflow gain between Gage 1, 2, and 3 pro-rated on the A*P terms.

$$Gain_{ungaged,2} = \left(\frac{(A*P)_{ungaged,2}}{(A*P)_{gage,3} - (A*P)_{gage,2} - (A*P)_{gage,1}}\right)(BF_{gage,3} - BF_{gage,2} - BF_{gage,1})$$

Total baseflow at Ungaged Node 2 is equal to the $Gain_{ungaged,2}$ term plus the baseflow at Gage 1.

$$BF_{ungaged,2} = Gain_{ungaged,2} + BF_{gage,1}$$

Ungaged Baseflow Node 3 calculations are very similar. The baseflow gain distributed to Ungaged Baseflow Node 3 is the baseflow gain between Gage 1, 2, and 3 pro-rated on the A*P term.

$$Gain_{ungaged,3} = \left(\frac{(A*P)_{ungaged,3}}{(A*P)_{gage,3} - (A*P)_{gage,2} - (A*P)_{gage,1}}\right)(BF_{gage,3} - BF_{gage,2} - BF_{gage,1})$$

Total baseflow at Ungaged Node 3 is equal to the $Gain_{ungaged,3}$ term plus baseflow at Gage 1 and Gage 2.

$$BF_{ungaged,3} = Gain_{ungaged,3} + BF_{gage,1} + BF_{gage,2}$$

A second option for estimating headwater baseflows can be used if the default "gain approach" method created results that do not seem credible. This method, referred to as the "neighboring gage approach", creates a baseflow time series by multiplying the baseflows at a specified gage by the ratio $(A*P)_{headwater}/(A*P)_{gage}$. This approach is effective when the runoff at an ungaged location does not follow the same pattern as the gains along the main stem. For example, a small ungaged tributary that peaks much earlier or later than the main stem should use the neighboring gage approach with a streamgage in a similar watershed. The user is responsible for ensuring that the overall reach water balance is maintained when using the neighboring gage approach.

Where to find more information

- The **StateDMI** documentation in section 5.10 “Stream Estimate Data” for describes computation of baseflow distribution parameters based on A*P, incremental A*P, and the network configuration.

4.8 Calibration Approach

Calibration is the process of simulating the river basin under historical conditions, and judiciously adjusting parameter estimates to achieve agreement between observed and simulated values of streamgages, reservoir levels, and diversions. The San Juan Model was calibrated in a two-step process described below. The issues encountered and results obtained are described in Section 7.

4.8.1. First Step Calibration

In the first calibration run, the model was executed with relatively little freedom with respect to operating rules. Headgate demand was simulated by historical diversions, and historical reservoir contents served as operational targets. The reservoirs would not fill beyond the historical content even if water was legally and physically available. Operating rules caused the reservoir to release to satisfy beneficiaries’ demands, but if simulated reservoir content was higher than historical after all demand was satisfied, the reservoir released water to the river to achieve the historical end-of-month content. In addition, multiple-headgated collection systems would feature the historical diversion as the demand at each diversion point.

The objective of the first calibration run was to refine baseflow hydrology and return flow locations before introducing uncertainties related to rule-based operations. Diversion shortages, that is, the inability of a water right to divert what it diverted historically, indicated possible problems with the way baseflows were represented or with the location assigned to return flows back to the river. Baseflow issues were also evidenced by poor simulation of the historical gages. Generally, the parameters that were adjusted related to the distribution of baseflows (i.e., A*P parameters or the method for distributing baseflows to ungaged locations), and locations of return flows.

4.8.2. Second Step Calibration

In the second calibration run, constraints on reservoir operations were relaxed. As in the first calibration run, reservoirs were simulated only for the period in which they were on-line historically. Reservoir storage was limited only by water right and availability, and generally, reservoir releases were controlled by downstream demands. Exceptions were made for reservoirs known to operate by power or flood control curves, or other unmodeled considerations. In these cases, targets were developed to express the operation. For multi-structures in the San Juan Model, the centralized demand was placed at the final destination nodes, and priorities and legal availability govern diversions from the various headgates.

The objective of the second calibration step was to refine operational parameters. For example, poor calibration at a reservoir might indicate poor representation of administration or operating objectives. Calibration was evaluated by comparing simulated gageflows, reservoir contents, and diversions with historical observations of these parameters.

Where to find more information

- Section 7 of this document describes calibration of the San Juan Model.

4.9 Baseline Data Set

The Baseline data set is intended as a representation of recent conditions on the Dolores and San Juan Rivers, to be used for "what if" analyses. It represents one interpretation of current use, operating, and administrative conditions, as though they prevailed throughout the modeling period. All existing water resources systems are on line and operational in the model from 1909 forward, as are all water rights and modern levels of demand. The data set is a starting point, which the user may choose to add to or adapt for a given application or interpretation of probable demands and near-term conditions.

4.9.1. Calculated Irrigation Demand

In the Baseline data set, irrigation demand is set to a time series determined from crop irrigation water requirement and average irrigation efficiency for the structure. This "Calculated Demand" is an estimate of the amount of water the structure would have diverted absent physical or legal availability constraints. Thus if more water was to become available to the diverter under a proposed new regime, the model would show the irrigator with sufficient water rights diverting more than he did historically.

Calculated demands must account for both crop needs and irrigation practices. Monthly calculated demand for 1975 through 2005 is generated directly, by taking the maximum of crop irrigation water requirement divided by average monthly irrigation efficiency, and historic diversions. The system irrigation efficiency may not exceed the defined maximum efficiency. Thus calculated demand for a perennially shorted diversion can be greater than the historical diversion for at least some months. By estimating demand to be the maximum of calculated demand and historical diversions, such irrigation practices as diverting to fill the soil moisture zone or diverting for stock watering can be mimicked more accurately.

4.9.2. Municipal And Industrial Demand

Municipal and industrial demands were set to recent values or averages of recent records.

4.9.3. Transbasin Demand

Transbasin diversion demands were set to average monthly diversions over the period 1975-1991.

4.9.4. Reservoirs

All reservoirs are represented as being on-line throughout the study period, at their current capacities. Initial reservoir contents were set to full. During simulation, StateMod sizes reservoir releases to satisfy unmet headgate demand, assuming the reservoir is a supplemental supply to direct flow rights. (StateMod has the option of sizing releases to meet irrigation water requirement at maximum efficiency, but that style of operation is not characteristic of the San Juan River basin reservoirs.)

5. Baseline Data Set

This section describes each StateMod input file in the Baseline Data Set. The data set, described in more general terms in Section 4.9, is expected to be a starting point for users who want to apply the San Juan River water resources planning model to a particular management issue. Typically, the investigator wants to understand how the river regime would change under a new use or different operations. The change needs to be quantified relative to how the river would look today absent the new use or different operation, which may be quite different from the historical record. The Baseline data set provides a basis against which to compare future scenarios. Users may opt to modify the Baseline data set for their own interpretation of current or near-future conditions. For instance, they may want to look at the effect of conditional water rights on available flow. The following detailed, file-by-file description is intended to provide enough detail that this can be done with confidence.

This section is divided into several subsections:

- Section 5.1 describes the response file, which lists names of the rest of the data files. The section tells briefly what is contained in each of the named files, so refer to it if you need to know where to find specific information.
- Section 5.2 describes the control file, which sets execution parameters for the run.
- Section 5.3 includes four files that together specify the river system. These files express the model network and baseflow hydrology.
- Section 5.4 includes files that define characteristics of the diversion structures in the model: physical characteristics, irrigation parameters, historical diversions, demand, and water rights.
- Section 5.5 includes files that further define irrigation parameters for diversion structures.
- Section 5.6 includes files that define characteristics of the reservoir structures in the model: physical characteristics, evaporation parameters, historical contents, operational targets, and water rights.
- Section 5.7 includes files that define characteristics of instream flow structures in the model: location, demand, and water rights.
- Section 5.8 describes the operating rights file, which specifies operations other than simple diversions, on-stream reservoir storage, and instream flow reservations. For example, the file specifies rules for reservoir releases to downstream users, diversions by exchange, and movement of water from one reservoir to another.

Where to find more information

- For generic information on every input file listed below, see the StateMod documentation. It describes how input parameters are used as well as format of the files.

5.1 Response File (*.rsp)

The response file is created by hand using a text editor, and lists all the other files in the data set. StateMod reads the response file first, and then "knows" what files to open to get the rest of the input data. The list of input files is slightly different depending on whether StateMod is being run to generate baseflows or to simulate. Since the "Baseline data set" refers to a particular simulation scenario, the response file for the Baseline is presented first; it is followed by a description of the files used for baseflow generation.

5.1.1. For Baseline Simulation

The listing below shows the file names in *sj2015B.rsp*, describes contents of each file, and shows the subsection of this chapter where the file is described in more detail.

File Name	Description	Reference
sj2015.ctl	Control file – specifies execution parameters, such as run title, modeling period, options switches	Section 5.2
sj2015.rin	River network file – lists every model node and specifies connectivity of network	Section 5.3.1
sj20015B.res	Reservoir station file – lists physical reservoir characteristics such as volume, area-capacity table, and some administration parameters	Section 5.6.1
sj2015B.dds	Direct diversion station file – contains parameters for each diversion structure in the model, such as diversion capacity, return flow characteristics, and irrigated acreage served	Section 5.4.1
sj2015.ris	River station file – lists model nodes, both gaged and ungaged, where hydrologic inflow enters the system	Section 5.3.2
sj2015.ifs	Instream flow station file – lists instream flow reaches	Section 5.7.1
sj2015.ifr	Instream flow right file – gives decreed amount and administration number of instream flow rights associated with instream flow reaches	Section 5.7.3

File Name	Description	Reference
sj2015.rer	Reservoir rights file – lists storage rights for all reservoirs	Section 5.6.5
sj2015.ddr	Direct diversion rights file – lists water rights for direct diversion	Section 5.4.5
sj2015B.opr	Operational rights file – specifies many different kinds of operations that are more complex than a direct diversion or an on-stream storage right. Operational rights can specify, for example, a reservoir release for delivery to a downstream diversion point, a reservoir release to allow diversion by exchange at a point which is not downstream, or a direct diversion to fill a reservoir via a feeder	Section 5.8
sj2015.eva	Evaporation file – gives monthly rates for net evaporation from free water surface	Section 5.6.2
sj2015x.xbm	Baseflow data file – time series of undepleted flows at all nodes listed in *sj2015.ris*	Section 5.3.5
sj2015B.ddm	Monthly demand file – monthly time series of headgate demands for each direct diversion structure	Section 5.4.4
sj2015.ifa	Instream flow demand file – gives the decreed monthly instream flow rates	Section 5.7.2
sj2015.dly	Delay Table – contains several return flow patterns that express how much of the return flow accruing from diversions in one month reach the stream in each of the subsequent months, until the return is extinguished	Section 5.4.2
sj2015B.tar	Reservoir target file – monthly time series of maximum and minimum targets for each reservoir. A reservoir may not store above its maximum target, and may not release below the minimum target	Section 5.6.4
sj2015.ipy	CU Irrigation Parameter Yearly file – maximum efficiency and irrigated acreage by year and by structure, for variable efficiency structures	Section 5.5.2
sj2015B.iwr	Irrigation Water Requirement file – monthly time series of crop water requirement by structure, for variable efficiency structures	Section 5.5.3
sj2015.str	StateCU Structure file – soil moisture capacity by structure, for variable efficiency structures	Section 5.5.1
sj2015.eom	Reservoir End of month contents file – Monthly time series of historical reservoir contents	Section 5.6.3
sj2015.rib	Baseflow Parameter file – gives coefficients and related gage ID's for each baseflow node, with which StateMod computes baseflow gain at the node	Section 5.3.3
sj2015.rih	Historical streamflow file – Monthly time series of streamflows	Section 5.3.4

File Name	Description	Reference
	at modeled gages	
sj2015.ddh	Historical Diversions – Monthly time series of historical diversions	Section 5.4.3

5.1.2. For Generating Baseflow

The baseflow file (*.xbm) that is part of the Baseline data set was created by StateMod and the Mixed Station Model in three steps which are described in Sections 4.7.1 through 4.7.3. In the first step, StateMod estimates baseflows at gaged locations, using the files listed in the response file sj2015.rsp. The baseflow response file calls for different reservoir station, operational rights, and reservoir target files from the Baseline response file, in all cases to reflect strictly historical data.

The baseflow time series created in the first run are all partial series, because gage data is missing some of the time for all gages. The Mixed Station Model is used to fill the series, creating a complete series of baseflows at gages in a file named sj2015.xbf. The response file for the third step, in which StateMod distributes baseflow to ungaged points, is named sj2015x.rsp. The only difference between the first-step response file sj2015.rsp and third-step response file sj2015x.rsp is that the sj2015.xbf file replaces the historical gage file sj2015.rih.

5.2 Control File (*.ctl)

The control file is hand-created using a text editor. It contains execution parameters for the model run, including the starting and ending year for the simulation, the number of entries in certain files, conversion factors, and operational switches. Many of the switches relate to either debugging output, or to integrated simulation of groundwater and surface water supply sources. The latter was developed for the Rio Grande basin and is not a feature of the San Juan Model. Control file switches are all specifically described in the StateMod documentation. The simulation period parameters (starting and ending year) are the ones that users most typically adjust.

5.3 River System Files

5.3.1. River Network File (*.rin)

The river network file is created by StateDMI, which reads in a hand-edited file (sj2015.net) that specifies the model network.

The river network file describes the location and connectivity of each node in the model. Specifically, it is a list of each structure ID and name, along with the ID of the next structure downstream. It is an inherent characteristic of the network that, with the exception of the downstream terminal node, each node has exactly one downstream node.

The network diagram for the San Juan/Dolores model can be viewed in StateDMI. Major tributaries to the San Juan River, including the East Fork San Juan, Rio Blanco, Piedra River, Los Pinos River, Animas River, La Plata River, Mancos River, and McElmo Creek. The Dolores River and its major tributaries, including the San Miguel River, are represented through the Dolores River at Gateway gage near the Colorado-Utah state line.

River gage nodes are labeled with United States Geological Survey (USGS) stream gaging station numbers (i.e., 09000000). In general, diversion and reservoir structure identification numbers are composed of Water District number followed by the State Engineer's four-digit structure ID. Instream flow water rights are also identified by the Water District number followed by the assigned State Engineer's four-digit identifier. **Table 5.1** shows how many nodes of each type are in the San Juan Model.

Table 5.1
River Network Elements

Type	**Number**
Diversion	342
Instream Flow	62
Reservoirs	33
Stream Gages	54
Total	**494**

Where to find more information

- StateDMI documentation gives the file layout and format for the *.net* file.

5.3.2. River Station File (*.ris)

The river station file is also created by StateDMI. It lists the model's baseflow nodes, both gaged and ungaged. These are the discrete locations where streamflow is added to the modeled system.

There are 54 gages in the model and 128 ungaged baseflow locations, for a total of 182 hydrologic inflows to the San Juan River model. Ungaged baseflow nodes include all ungaged headwater nodes, 5 key reservoir nodes, 4 aggregated diversion nodes, and other nodes where calibration revealed a need for it. In the last case, a portion of the water that was simulated as entering the system further down (e.g., at the next gage) was moved up the system to the ungaged point.

5.3.3. Baseflow Parameter File (*.rib)

The baseflow parameter file has an entry for each ungaged baseflow node in the model, specifying coefficients, or "proration factors", used to calculate the baseflow gain at that point. StateDMI computes proration factors based on the network structure and Area*Precipitation values supplied for both gages and ungaged baseflow nodes. This information is in the network file which is input to StateDMI. Under the default "gain approach", described in Section 4.7.3, the factors reflect the ratio of the product of incremental area and local average precipitation above the ungaged point to the product of incremental area and local average precipitation for the entire gage-to-gage reach.

At some locations, the hydrograph developed using the gain approach showed an attenuated shape that was not representative of a "natural" hydrograph. This occurred in headwater areas where the hydrograph is dominated by runoff from spring snowmelt. In these situations, baseflow was determined as a function of baseflow at a nearby stream gage, specified by the user. Ideally, this "neighboring gage" was from a drainage basin with similar physiographic characteristics. Baseflow at the ungaged site was assumed to be in the same proportion to baseflow at the nearby gage as the product of area and average precipitation at the two locations. This procedure, referred to as the "neighboring gage approach", was applied to these structures:

Tributary Name	Baseflow WDID	Neighboring Gage
Mill Creek	2900582	09343300
Rito Blanco	2900588	09343300
Mill Creek	2900613	09343300
Coal Creek	2900729	09339900
Four Mile Creek	2902005	09342000
Bear Creek	3000510	09357500
Wildcat Canyon	3001056	09357500
Salt Creek	3001219	09357500
Junction Creek	3001901	09357500
Elbert Creek	3003536	09357500
Rock Creek	3100575	09355000
Los Pinos River	3104637	09352900
Stollsteimer Creek	3200558	09371500
Yellow Jacket Creek	3200590	09371500
Chicken Creek	3400508	09371000
West Fork Mancos River	3400535	09368500
Crystal Creek	3400560	09368500
Beaver Creek	4600503	09355000
Saltado Creek	6000521	09173000

Basin Creek	6000569	09173000
Naturita Creek	6000574	09173000
Horsefly Creek	6000585	09173000
Tabeguache Creek	6000607	09173000
Leopard Creek	6000611	09172500
Naturita Creek	6000670	09173000
Naturita Creek	6000672	09173000
Horsefly Creek	6000733	09173000
Horsefly Creek	6000777	09175500
Big Bear Creek	6001319	09171200
Bilk Creek	6001320	09171200
Deep Creek	6001374	09171200
Fall Creek	6001378	09172500
Fall Creek	6001388	09172500
Lake Fork	6001397	09171200
Lake Fork	6003527	09171200
West Paradox Creek	6100527	09165000
West Creek	6300644	09177000
Bear Creek	7100504	09165000
West Dolores River	7100531	09165000
Groundhog Creek	7103612	09165000
Little Dolores River	73_ADS025	09177000
Weminuche Creek	7800562	09352900
Tiffany Arroyo	7800692	09352900

In addition, a straight proration was used when an appropriate "neighboring gage" could not be identified due to unique characteristics of a structures' drainage basin. For the structures in the following table, a percent of downstream baseflow to be applied at the structure location was directly set in StateDMI.

Tributary Name	**Baseflow WDID**	**Baseflow Percent**	**Downstream Gage**
North Fork Los Pinos River	3104638	20 %	09353500
Cascade Creek	3000523	40 %	09361500

Where to find more information

- StateDMI documentation gives the file layout and format for the *.net* file.
- Section 4.7.3 describes how baseflows are distributed spatially.

5.3.4. Historical Streamflow File (*.rih)

Created by **TSTool**, the historical streamflow file contains historical gage records for 1909 through 2013, for the modeled gages. These are used for baseflow stream generation and to create comparison output that is useful during model calibration . All records are taken directly from USGS tables in the database. Missing values, when the gage was not in operation, are denoted as such, using the value “-999.” **Table 5.2** lists the USGS gages used, their periods of record, and their average annual flows over the period of record. Large periods of missing data are specified, however, most gages listed have days, months, or years missing within the full period.

5.3.5. Baseflow File (*.xbm)

The baseflow file contains estimates of base streamflows throughout the modeling period, at the locations listed in the river station file. Baseflows represent the conditions upon which simulated diversion, reservoir, and minimum streamflow demands are superimposed. StateMod estimates baseflows at stream gages, during the gage’s period of record, from historical streamflows, diversions, end-of-month contents of modeled reservoirs, and estimated consumption and return flow patterns. It then distributes baseflow at gage sites to ungaged locations using proration factors representing the fraction of the reach gain estimated to be tributary to a baseflow point.

Table 5.3 compares historical gage flows with simulated baseflows for the 20 gages that operated continuously during the calibration period (1975-2013). The difference between the two represents estimated historical consumptive use upstream of the gage over this period. As shown, baseflows at gage 09372000 – McElmo Creek near CO-UT State Line are less than historical flows, representing the significant imports to that tributary from the Dolores River.

Where to find more information

- Sections 4.7.1 through 4.7.3 explain how StateMod and the Mixed Station Model are used to create baseflows.
- When StateMod is executed to estimate baseflows at gages, it creates a Baseflow Information file *(*.xbi*) that shows this computation for each gage and each month of the time step.
- When the Mixed Station Model is used to fill baseflows, it creates two reports, *sj2015.sum* and *sj2015.sts*. The first indicates which stations were used to estimate each missing data point, and the second compares statistics of the unfilled time series with statistics of the filled series for each gage.

Table 5.2
Historical Average Annual Flows for Modeled San Juan Stream Gages

Gage ID	Gage Name	Period of Record	Historical Flow (acre-feet/year)
09339900	East Fork San Juan River above Sand Creek	1957 – 1996 1999 – 2003	63,180
09341500	West Fork San Juan River near Pagosa Springs	1936 – 1960 1985 – 1987	119,575
09342000	Turkey Creek near Pagosa Springs	1938 – 1949	27,809
09342500	San Juan River at Pagosa Springs	1936 – 2013	266,501
09343000	Rio Blanco near Pagosa Springs	1936 – 1971	61,012
09343300	Rio Blanco below Blanco Diversion Dam near Pagosa Springs	1972 – 2013	30,227
09344000	Navajo River at Banded Peak Ranch near Chromo	1937 – 2013	77,673
09344400	Navajo River below Oso Diversion Dam nr Chromo	1972 – 2013	45,011
09345200	Little Navajo River below Oso Diversion Dam near Chromo	1972 – 1996	6,153
09346000	Navajo River at Edith	1935 – 1996	92,916
09346400	San Juan River near Carracas	1962 – 2013	429,400
09347500	Piedra River at Bridge Ranger Sta. near Pagosa Springs	1937 – 1941 1947 – 1954	78,344
09349500	Piedra River near Piedra	1940 – 1972	220,154
09349800	Piedra River near Arboles	1963 – 2013	283,357
09352900	Vallecito Creek near Bayfield	1963 – 2013	103,542
09353500	Los Pinos River near Bayfield	1928 – 1986	262,049
09354000	Los Pinos River at Bayfield	1932 – 1961	165,805
09354500	Los Pinos River at La Boca	1952 – 2013	166,290
09355000	Spring Creek at La Boca	1952 – 2011	23,028
09357500	Animas River at Howardsville	1936 – 2013	75,223
09359000	Mineral Creek near Silverton	1937 – 1949	77,628
09359500	Animas River at Tall Timber Resort above Tacoma	1946 – 1956 2007 – 2013	356,000
09361000	Hermosa Creek near Hermosa	1921 – 1928 1941 – 1982	96,917
09361200	Falls Creek near Durango	1960 – 1965	1,237
09361400	Junction Creek near Durango	1960 – 1965	12,874
09361500	Animas River at Durango	1912 – 2013	586,511
09362750	Florida River above Lemon Reservoir combined with USBR Data (1964 to 1973)	1964 – 2013	61,062
09363200	Florida River at Bondad	1957 – 1963 1968 – 1983	55,159
09363500	Animas River near Cedar Hill, NM	1934 – 2008	656,010
09365500	La Plata River at Hesperus	1918 – 2013	31,078
LONREDCO	Long Hollow at the Mouth near Red Mesa	1989 – 2013	4,585
09366500	La Plata River at CO-NM State Line	1921 – 2013	24,311
09369500	Middle Mancos River near Mancos	1939 – 1951	5,426
09369000	East Mancos River near Mancos	1938 – 1951	7,717
09368500	West Mancos River near Mancos	1939 – 1953	27,584

Gage ID	Gage Name	Period of Record	Historical Flow (acre-feet/year)
09371000	Mancos River near Towaoc	1922 – 1943 1952 – 2013	35,053
09371400	Hartman Draw at Cortez	1979 – 1986	10,063
09371420	McElmo Creek above Alkali Canyon near Cortez	1973 – 1986	19,881
09371520	McElmo Creek above Trail Canyon near Cortez combined with McElmo Creek near Cortez (09371500)	1927 – 1929 1941 – 1943 1951 – 1954 1982 – 2013	40,396
09372000	McElmo Creek near CO-UT State Line	1952 – 2013	36,424
09165000	Dolores River below Rico	1952 – 1996 1999 – 2013	94,417
09166500	Dolores River at Dolores	1911 – 1912 1922 – 2013	311,142
09166950	Lost Canyon Creek near Dolores	1985 – 2013	13,408
09168100	Disappointment Creek near Dove Creek	1958 – 1986	15,638
09169500	Dolores River at Bedrock	1918 – 1922 1972 – 2013	249,957
09171100	Dolores River near Bedrock	1972 – 2013	242,118
09171200	San Miguel River near Telluride	1960 – 1965	45,841
09172000	Fall Creek near Fall Creek	1942 – 1959	17,824
09172100	Leopard Creek at Noel	1956 – 1963	1,988
09172500	San Miguel River near Placerville	1911 – 1912 1931 – 1934 1943 – 2013	169,355
09173000	Beaver Creek near Norwood	1942 –1967 1976 – 1981	10,852
09175500	San Miguel River at Naturita	1918 – 1929 1941 – 1981	238,227
09177000	San Miguel River at Uravan	1955 – 1962 1974 – 1994 1997 – 2013	253,239
09179500	Dolores River at Gateway	1937 – 1954	679,758

Table 5.3
Baseflow Comparison
1975-2013 Average (acre-feet/yr)

Gage ID	Gage Name	Baseflow	Historical	Difference
09342500	San Juan River at Pagosa Springs	296,537	278,818	17,719
09343300	Rio Blanco below Blanco Diversion Dam near Pagosa Springs	71,651	30,698	40,954
09344000	Navajo River at Banded Peak Ranch near Chromo	81,675	80,776	899
09344400	Navajo River below Oso Diversion Dam nr Chromo	92,195	45,258	46,937
09346400	San Juan River near Carracas	545,215	431,086	114,129
09349800	Piedra River near Arboles	307,305	295,844	11,462
09352900	Vallecito Creek near Bayfield	104,167	104,167	0
09354500	Los Pinos River at La Boca	319,860	176,427	143,433
09357500	Animas River at Howardsville	76,167	76,106	61
09361500	Animas River at Durango	595,072	579,482	15,590
09362750	Florida River above Lemon Reservoir	60,033	60,033	0
09363500	Animas River near Cedar Hill, NM	717,311	660,113	57,197
09365500	La Plata River at Hesperus	32,288	29,537	2,751
09366500	La Plata River at CO-NM State Line	42,364	24,376	17,988
09371000	Mancos River near Towaoc	57,759	35,315	22,444
09372000	McElmo Creek near CO-UT State Line	33,123	38,296	(5,173)
09166500	Dolores River at Dolores	307,989	302,154	5,835
09169500	Dolores River at Bedrock	427,068	228,938	198,129
09171100	Dolores River near Bedrock	439,429	236,746	202,683
09172500	San Miguel River near Placerville	183,037	174,475	8,562

5.4 Diversion Files

5.4.1. Direct Diversion Station File (*.dds)

StateDMI is used in several steps to create the direct diversion station file.

The direct diversion station file describes the physical properties of each diversion simulated in the San Juan Model. **Table 5.4** is a summary of the San Juan Model's diversion station file contents, including each structure's diversion capacity, irrigated acreage served in 2010, and average annual system efficiency. This parameter is summarized from data in the diversion demand file rather than the diversion station file, but it is included here as an important characteristic of each diversion station. In addition to the tabulated parameters, the file also specifies return flow nodes and average monthly efficiencies. The table also includes average annual headgate demand.

Generally, the diversion station ID and name, diversion capacity, and irrigated acreage are gathered from HydroBase by StateDMI. Return flow locations are specified to StateDMI in a hand-edited file sj2015.rtn. The return flow locations and distribution were based on discussions with Division 7 and Division 4 personnel as well as calibration efforts. StateDMI computes monthly system efficiency for irrigation structures from historical diversions and historical crop irrigation requirements, and writes them into the final *.dds file.

For non-irrigation structures, monthly efficiency is specified by the user as input to StateDMI. Baseline irrigation demand is assigned to primary structures of multi-structure systems, therefore primary and secondary structures of multi-structure systems are assigned the average monthly efficiencies calculated for the irrigation system based on irrigation water requirements and water delivered from all sources. If efficiency is constant for each month, it can also be specified in the hand-edited file sj2015.rtn.

Note that unknown capacity is set to 999 by StateDMI. This number is significantly large so as not to limit diversions. Monthly demands for New Mexico, Arizona, and Utah are provided by the USBR, however no acreage was provided for irrigation structures. Unknown acreage is set to -999 by StateDMI.

Table 5.4
Direct Flow Diversion Summary Average
1975-2013

#	Model ID #	Name	Cap (cfs)	2010 Irrig. Acres	Average System Efficiency (percent)	Average Annual Demand (af)
1	2900501	ALLEN CREEK DITCH	6	58	54	258
2	2900519	BEIGHLEY NO 1_DIVSYS	7	27	33	350
3	2900550	C H LOUCKS DITCH	130	21	2	3,688
4	2900555	CARR DITCH	12	227	26	1,685
5	2900560	CHAPSON HOWE_DIVSYS	48	492	32	4,013
6	2900582	DOWELL DITCH	15	91	51	522
7	2900588	ECHO DITCH_DIVSYS	28	1,699	47	6,078
8	2900597	FISH CREEK DITCH	14	110	33	1,039
9	2900601 [1)]	FOUR-MILE_DIVSYS	66	2,673	54	0
10	2900604	FU BAR DITCH	9	95	28	1,025
11	2900613 [1)]	HALLETT DITCH_DIVSYS	18	78	30	0
12	2900618	HARRIS DITCH	6	15	24	313
13	2900621	HIMES DITCH	8	44	54	199
14	2900627	J M ROSS AND STURGILL D	10	168	54	667
15	2900653	LONG HORN_MEE_DIVSYS	20	163	38	1,401
16	2900654	LONG MEADOW DITCH	6	29	38	307
17	2900662	MARTINEZ AND MARTINEZ D	8	25	26	454
18	2900671	MOUNTAIN PARK DITCH	6	35	51	171
19	2900677	OBANNON DITCH	8	13	6	662
20	2900686	PARK DITCH	68	1,031	30	10,417
21	2900691	PHILLIPPS DITCH	5	48	38	423
22	2900716	SISSON-STEPHENS DITCH	10	94	38	802
23	2900718	SNOWBALL DITCH	38	3,220	54	12,317
24	2900729	STURGILL DITCH	6	77	52	421
25	2900900	CARR DITCH (SO UTE)	8	20	2	1,408
26	2902005	DUTTON DITCH	23	399	47	2,008
27	2904667 [4)]	USBR_BLANCO_R_DIVERSION	520	0	100	0
28	2904669 [4)]	TREASURE PASS DIVR DITCH	8	0	100	144
29	29_ADS002	WD 29 AGGREGATE DIVERSION 2	112	1,262	40	7,544
30	29_ADS003	WD 29 AGGREGATE DIVERSION 2	117	1,662	48	8,675
31	29_SUIT [6)]	SUIT RESERVED RIGHTS SAN JUAN	65	1,314	79	0
32	3000504	AMBOLD-WALLACE DITCH	14	113	11	2,744
33	3000506	ANIMAS CONSOLIDATED D	97	920	9	31,720
34	3000509 [2)]	ANIMAS DIVERSION CANAL	300	0	0	0
35	3000510	BEAR CREEK DITCH	13	35	9	1,407
36	3000523 [2)]	CASCADE CANAL	400	0	0	0
37	3000545 [2)]	FALLS CR DIVR DAM & CNL	60	0	0	0
38	3000568	HERMOSA COMPANY DITCH	20	115	6	5,091
39	3000580	JOHN THOMAS DITCH	11	44	4	3,086

#	Model ID #	Name	Cap (cfs)	2010 Irrig. Acres	Average System Efficiency (percent)	Average Annual Demand (af)
40	3000581 [1)]	J P LAMB DITCH	39	0	18	0
41	3000582 [2)]	JUNCTION CR DIVR DAM PL	100	0	0	0
42	3000612 [3)]	POWER CANAL NO 1	250	0	0	23,404
43	3000617	REID DITCH	93	1,136	16	25,208
44	3000634	SITES DITCH	10	56	12	1,433
45	3000641	SULLIVAN-WALLACE DITCH	14	154	12	3,759
46	3001000 [3)]	DURANGO CITY PIPELINE	15	0	36	4,201
47	3001003	HARRIS-PATTERSON DITCH	10	110	38	980
48	3001009	MCCLUER AND MURRAY DITCH	13	97	32	978
49	3001011	FLORIDA_FARMERS_DIVSYS	296	14,869	54	62,944
50	3001019	PIONEER DITCH	36	319	44	1,985
51	3001023	ANIMAS DITCH	64	1,016	14	16,957
52	3001024 [3)]	ANIMAS PMP STA & FOR MN	22	0	36	0
53	3001033	BANKS-TYNER DITCH	8	235	51	1,159
54	3001056 [1)]	BODO PINE RIDGE DITCH	10	121	50	0
55	3001076	CRAIG DITCH	8	50	40	329
56	3001094	EAST MESA DITCH	26	1,216	36	7,020
57	3001219	SITES-KERN_DIVSYS	25	447	42	3,191
58	3001220	SMITH HIGHLINE NO 1 D	11	136	36	923
59	3001228	STEWARD NO 3	7	32	47	201
60	3001243	TYNER EAST SIDE DITCH	10	106	28	1,204
61	3001657 [2)]	RIDGES BASIN PMP PLANT	287	0	0	0
62	3004661 [4)]	MINERAL POINT DITCH	11	0	100	57
63	3004662 [4)]	RED MOUNTAIN DITCH	6	0	100	70
64	3004664 [4)]	RALSTON DITCH	999	0	40	4,937
65	3004665 [4)]	TWIN ROCK DITCH	23	10	40	4,498
66	30_ADS007	WD 30 AGGREGATE DIVERSION 1	39	579	20	7,376
67	30_ADS008	WD 30 AGGREGATE DIVERSION 2	55	1,408	46	7,350
68	30_ADS009	WD 30 AGGREGATE DIVERSION 3	44	817	34	5,164
69	30_ADS010	WD 30 AGGREGATE DIVERSION 4	19	236	24	2,171
70	30_SUIT [6)]	SUIT RESERVED RIGHTS ANIMAS	112	4,295	79	0
71	3100502	CEANABOO DITCH	20	483	40	3,658
72	3100503	COMMISSIONER DITCH	14	579	48	3,099
73	3100505	DR MORRISON_DIVSYS	128	2,158	33	20,241
74	3100507	LA BOCA DITCH	28	322	24	3,311
75	3100508	SEVERO DITCH	23	295	23	3,137
76	3100509	SPRING CREEK DITCH	75	2,277	41	14,711
77	3100510	BEAN DITCH	7	100	27	1,078
78	3100511	THOMPSON-EPPERSON_DIVSYS	47	1,690	48	9,611
79	3100512	LOS PINOS IRRIGATING DIT	26	338	23	4,043
80	3100513	WOMMER IRRIGATION DITCH	18	204	21	2,912
81	3100514	BEAR CREEK AND PINE RIVE	27	474	39	3,813

#	Model ID #	Name	Cap (cfs)	2010 Irrig. Acres	Average System Efficiency (percent)	Average Annual Demand (af)
82	3100516	HIGBEE IRRIGATION DITCH	3	34	39	311
83	3100518	MYERS AND ASHER DITCH	8	96	37	902
84	3100519	DUNCAN_DIVSYS	159	5,049	46	29,146
85	3100523	SCHRODER IRG_DIVSYS	71	2,640	44	16,751
86	3100524	FARRELL DITCH	17	129	39	1,207
87	3100527	ISLAND DITCH	2	7	20	119
88	3100528	BENNETT-MYERS IRR DITCH	12	87	18	1,440
89	3100535	KIRKPATRICK DITCH	17	220	53	1,235
90	3100540	MCLOYD DITCH	8	60	12	1,508
91	3100545	CATLIN DITCH	9	43	49	319
92	3100547	ROBERT MORRISION_DIVSYS	114	5,592	48	28,177
93	3100553	MCBRIDE DITCH	5	30	54	158
94	3100567 [1)]	CAMPBELL DITCH	4	54	52	0
95	3100575	SEMLER DITCH_DIVSYS	10	208	33	1,771
96	3100583	GOOSEBERRY_DIVSYS	51	104	51	737
97	3100665	SPRING CREEK_DIVSYS	299	13,596	48	69,412
98	3100668	SULLIVAN DITCH	11	403	51	2,009
99	3100710	IGNACIO CREEK DITCH	6	195	50	1,035
100	3104637 [4)]	WEMINUCHE PASS DITCH	40	0	100	1,016
101	3104638 [4)]	PINE R WEMINUCHE PASS D	18	0	100	409
102	31_ADS005	WD 31 AGGREGATE DIVERSION 1	37	696	29	7,324
103	31_ADS006	WD 31 AGGREGATE DIVERSION 2	82	1,454	43	7,400
104	31_SUIT [6)]	SUIT RESERVED RIGHTS PINE	404	8,176	57	0
105	3200509	BLACK DIKE DITCH	13	60	11	1,385
106	3200528	COTTONWOOD DITCH NO 1	15	183	18	3,140
107	3200529	COTTONWOOD DITCH NO 2	14	218	18	3,346
108	3200558	EATON DITCH	9	118	23	1,644
109	3200574	HAMBELTON DITCH	16	185	16	4,622
110	3200590	ISMAY DITCH	11	53	18	1,032
111	3200634	MURRAY-ZWICKER-TOZER D	8	78	9	2,139
112	3200652	ROCK CREEK DITCH	42	521	10	11,056
113	3200662	SCHALLES DITCH	6	77	20	1,129
114	3200680 [3)]	TOWN OF CORTEZ	999	0	36	3,145
115	3200690	WILSON DITCH	28	542	44	3,194
116	3200699 [2)]	NARRAGUINNEP RES INLET	999	0	0	0
117	3200772	MVI U LATERAL	999	12,910	22	92,010
118	3200884	TOWAOC CANAL	135	7,489	57	31,282
119	3202001 [3)]	DOLORES WATER DIVR HGT	999	0	36	1,231
120	3202006	DOVE CREEK CANAL	999	26,489	74	70,269
121	3204675	DOLORES TUNNEL	999	15,714	51	70,826
122	32_ADS015	WD 32 AGGREGATE DIVERSION 1	64	1,233	42	7,476
123	32_ADS016	WD 32 AGGREGATE DIVERSION 2	70	1,232	34	7,960

#	Model ID #	Name	Cap (cfs)	2010 Irrig. Acres	Average System Efficiency (percent)	Average Annual Demand (af)
124	32_UMU 6)	UMUT RESERVED RIGHTS MCELMO	1	26	55	0
125	3300501	LA PLATA IRG DITCH	8	106	17	1,816
126	3300504	HAY GULCH DITCH	19	1,138	46	6,758
127	3300508	LA PLATA R & CHERRY CR D	41	2,215	54	8,341
128	3300518	AMMONS DITCH	7	165	50	759
129	3300533	PINE RIDGE DITCH	28	17	10	1,261
130	3300535	SOONER VALLEY DITCH	12	263	35	1,218
131	3300536	H H DITCH	85	2,366	48	10,809
132	3300540	ENTERPRISE ENLARGEMENT D	5	124	39	705
133	3300542	SLADE DITCH	37	1,357	47	6,802
134	3300547	JOSEPH FREED DITCH	31	746	39	3,712
135	3300548	REVIVAL DITCH	11	185	32	755
136	3300549	TREANOR DITCH	67	455	42	3,273
137	3300550	WARREN-VOSBURGH DITCH	13	328	36	1,172
138	3300551	TOWNSITE DITCH	20	203	43	1,196
139	3300554	BIG STICK DITCH	40	1,486	50	6,144
140	3304639 4)	ENTERPRISE ENLARGEMENT D	999	0	40	549
141	3304640 4)	PIONEER DITCH	999	0	40	726
142	33_ADS011	WD 33 AGGREGATE DIVERSION	36	1,089	46	3,498
143	33_SUIT 6)	SUIT RESERVED RIGHTS LAPLATA	32	644	55	0
144	3400505	BEAVER DITCH	14	246	46	1,703
145	3400506	BOSS DITCH	999	22	7	1,124
146	3400508	CARPENTER AND MITCHELL D	11	192	48	1,028
147	3400514	CRYSTAL CREEK DITCH	16	210	46	1,301
148	3400522	EAST MANCOS HIGHLINE DIT	8	202	50	1,024
149	3400527	FRANK DITCH	4	218	49	1,073
150	3400530	GILES DITCH	10	260	47	1,515
151	3400531	GLASGOW & BREWER DITCH	7	388	52	1,841
152	3400534	HENRY BOLEN DITCH	17	470	47	2,855
153	3400535 2)	JACKSON GULCH INLET CNL	526	0	0	0
154	3400542	LEE AND BURKE DITCH	9	275	48	1,520
155	3400543	LEE DITCH	14	141	47	810
156	3400544	LONG PARK DITCH	11	311	48	1,590
157	3400552	NO 6 DITCH	7	310	48	1,557
158	3400554	RATLIFF AND ROOT DITCH	38	1,611	49	7,846
159	3400560	RUSH RESERVOIR_DIVSYS	968	579	47	3,218
160	3400565	SHEEK DITCH	14	586	48	2,903
161	3400567	SMOUSE DITCH	3	75	48	355
162	3400573 3)	TOWN OF MANCOS DITCH	4	0	36	529
163	3400576	WEBBER DITCH	52	1,507	49	7,668
164	3400577	WEBER RESERVOIR INLET D	451	189	32	1,411
165	3400582	WILLIAMS DITCH_DIVSYS	7	170	54	767

#	Model ID #	Name	Cap (cfs)	2010 Irrig. Acres	Average System Efficiency (percent)	Average Annual Demand (af)
166	3400583	WILLIS DITCH	5	258	47	1,374
167	34_ADS012	WD 34 AGGREGATE DIVERSION 1	19	590	52	2,740
168	34_ADS013	WD 34 AGGREGATE DIVERSION 2	7	138	46	963
169	34_ADS014	WD 60 AGGREGATE DIVERSION 3	1,096	983	45	5,045
170	34_AMS001 3)	WD 34 AGGREGATE MUNICIPAL	1	0	100	1,080
171	34_UMU 6)	UMUT RESERVED RIGHTS MANCOS	452	8,585	55	0
172	4600503 1)	BRIGGS DITCH	12	19	52	0
173	6000507	ALEXANDER DITCH	15	104	50	546
174	6000511 3)	AMES ILIUM HYDRO PROJ	100	0	0	10,372
175	6000515	AUSTRIAN TWIN DITCH	2	49	48	310
176	6000520	B C D DITCH	6	32	6	994
177	6000521	BEAVER MESA DITCH	26	938	54	3,492
178	6000535	BRADDOCK DITCH	8	49	12	932
179	6000540 7)	BURCH MORGAN DITCH	5	0	54	153
180	6000549	CARR WADDLE DITCH	8	283	54	1,010
181	6000550	CARRIERE DITCH	18	257	50	1,365
182	6000569	CRAVER DITCH	13	120	40	985
183	6000574	DENISON DITCH	8	86	47	490
184	6000576 7)	DILLON DITCH	3	0	54	187
185	6000578	DOLPHIN DITCH	6	4	4	373
186	6000583	EAGLE DITCH	16	518	54	1,842
187	6000585	EASTON DITCH	13	419	49	1,826
188	6000588	ELK CREEK DITCH	14	152	42	1,003
189	6000594 7)	FAYETTE PLACER	1	0	0	3
190	6000607	GLENCOE DITCH	17	420	50	1,834
191	6000608	GOLDEN DITCH	5	263	54	953
192	6000611	GOLD RUN DITCH	7	231	54	958
193	6000613	GOULDING DITCH	4	61	23	893
194	6000617 7)	GREEN MT DITCH NO 2	2	0	54	136
195	6000618	GROVE DITCH	2	96	54	355
196	6000625	HANKS VALLEY DITCH NO 2	5	62	50	293
197	6000627	HARDSCRABBLE DITCH	4	146	54	564
198	6000628	HASTINGS DITCH	5	87	40	593
199	6000633	HIGHLINE CANAL	145	5,608	36	37,965
200	6000650	J & M HUGHES DITCH	52	1,811	48	6,609
201	6000652 7)	JARRETT DITCH	2	0	54	106
202	6000659	KINLEY DITCH	5	57	35	605
203	6000665	LAST CHANCE DITCH	6	527	54	1,949
204	6000669	LEOPARD CREEK DITCH	17	267	52	1,153
205	6000670 2)	LILYLANDS CANAL	122	0	0	0
206	6000670_I	LILYLANDS CANAL DEMAND	48	2,285	48	8,575
207	6000672 2)	LONE CONE DITCH	188	0	0	0

#	Model ID #	Name	Cap (cfs)	2010 Irrig. Acres	Average System Efficiency (percent)	Average Annual Demand (af)
208	6000672_I	LONE CONE DITCH DEMAND	59	312	29	4,803
209	6000678	LOWER ELK CREEK DITCH	16	12	16	453
210	6000684 7)	MCCOLLOCH SCOTT DITCH	12	0	54	452
211	6000689	MIDDLE ELK CREEK DITCH	20	192	52	940
212	6000707 2)	NATURITA CANAL	1,051	0	0	0
213	6000707_I	NATURITA CANAL DEMAND	232	15,570	48	59,334
214	6000710	NEILSON DITCH	7	120	54	448
215	6000723 3)	NUCLA POWER PLANT DITCH	61	0	0	478
216	6000730	PARKWAY DITCH	10	82	16	1,322
217	6000733 7)	PAXTON DITCH	27	0	54	360
218	6000735	PLATEAU BASIN DITCH	7	218	51	841
219	6000736	PLEASANT VALLEY DITCH	20	634	52	2,557
220	6000745	REED CHATFIELD DITCH	7	31	10	830
221	6000776	TEMPLETON DITCH	8	28	14	657
222	6000777	THEO NETHERLY DITCH NO1	4	45	44	313
223	6000786	TUMBLE CREEK DITCH	4	41	43	271
224	6000831	MAVERICK DRAW DITCH	4	12	13	475
225	6001239 7)	THEO NETHERLY DITCH NO3	9	0	54	77
226	60_ADS020	WD 60 AGGREGATE DIVERSION 1	41	674	46	3,914
227	60_ADS021	WD 60 AGGREGATE DIVERSION 2	17	798	49	3,473
228	60_ADS022	WD 60 AGGREGATE DIVERSION 3	55	2,952	54	10,434
229	6100502	GALLOWAY DITCH	13	550	50	2,231
230	6100512	AMEDED LAURA_DIVSYS	15	164	34	1,101
231	6100517	SOUTH MIDWAY DITCH	53	383	39	2,110
232	6100527	RAY DITCH	25	825	38	3,208
233	6100602 1)	A E L R P & PL	8	0	46	0
234	61_ADS019	WD 61 AGGREGATE DIVERSION	29	962	27	8,335
235	6300501	BARTHOLOMEW AND HATCH D	232	69	12	2,677
236	6300518	CLIFF RANCH DITCH	7	63	14	1,768
237	6300529	HARMS AND HAZEL DITCH	8	57	20	1,042
238	6300547	NOLAN DITCH	8	120	54	673
239	6300553	RED CROSS DITCH	10	28	43	322
240	6300597	IDLEWILD HIGHLINE DITCH	7	11	35	135
241	63_ADS023	WD 63 AGGREGATE DIVERSION 1	79	1,007	45	6,576
242	63_ADS024	WD 63 AGGREGATE DIVERSION 2	143	1,213	35	13,013
243	63_AMS002 3)	WD 63 AGGREGATE MUNICIPAL	2	0	100	1,296
244	6800636	LEOPARD CREEK DITCH	24	593	100	1,188
245	6900502	DAWSON-HAMMOND DITCH	5	32	37	200
246	6900503 7)	DISAPPOINTMENT DITCH	20	0	39	107
247	6900510	HORSESHOE DITCH	18	221	30	1,770
248	6900512	KNIGHT-EMBLING DITCH	8	59	29	695
249	6900520	PINE ARROYA DITCH	11	5	16	684

#	Model ID #	Name	Cap (cfs)	2010 Irrig. Acres	Average System Efficiency (percent)	Average Annual Demand (af)
250	69_ADS018	WD 69 AGGREGATE DIVERSION	67	379	49	1,491
251	7100504	BEAR CREEK DITCH	10	36	36	460
252	7100513	BURCH AND LONGWILL DITCH	8	121	35	943
253	7100531	EAST EDDER_DIVSYS	4	68	44	431
254	7100535	GARBARINO NO 1 DITCH	4	22	43	189
255	7100536	GARBARINO NO 2 DITCH	3	30	50	176
256	7100537	GARBARINO NO 3 DITCH	3	23	46	178
257	7100544	GOEBEL DITCH	7	54	54	231
258	7100545	GOULD & MORIARITY DITCH	7	112	37	934
259	7100549	ILLINOIS DITCH	8	111	21	1,338
260	7100551	ITALIAN DITCH	3	18	34	209
261	7100555	KEYSTONE DITCH	9	71	32	785
262	7100556	KING NO 1 DITCH	5	72	54	262
263	7100559	KOENIG DITCH	4	65	46	443
264	7100563	LINDSTROM DITCH	6	43	36	506
265	7100567	MCEWEN DITCH	10	95	38	1,000
266	7100572	MONUMENT ROCK DITCH	8	89	49	541
267	7100573	MORIARITY DITCH	7	160	44	1,092
268	7100575 3)	ORIGINAL RICO FLUME	0	0	36	31
269	7100582	QUARRY NO 1 DITCH	6	40	26	647
270	7100586	RIEVA DITCH_DIVSYS	5	17	22	340
271	7100609 4)	SUMMIT DITCH	135	0	0	0
272	7100618 4)	TURKEY CREEK DITCH	90	0	0	0
273	7100624	WEST EDER DITCH	7	37	42	334
274	7102002	SUMMIT RES OUTLET	999	3,674	42	17,280
275	7102999 8)	McPHEE RES FISH MSF	70	0	0	0
276	7104674 2)	MAIN CANAL NO 2	999	0	0	0
277	7104675 2)	DOLORES TUNNEL	561	0	0	0
278	71_ADS017	WD 71 AGGREGATE DIVERSION 1	30	412	43	2,609
279	71_ADS019	WD 71 AGGREGATE DIVERSION 2	6	146	21	1,407
280	73_ADS025	WD 73 AGGREGATE DIVERSION	119	1,714	44	11,594
281	7700500	ARCHULETA DITCH	8	88	54	363
282	7700514	CHAMA ROAD DITCH	5	68	54	249
283	7700518	ENTERPRISE DITCH (CORN)	5	73	54	284
284	7700524	EAKLOR DITCH	34	196	31	2,125
285	7700527	EAST FORK DITCH	15	36	26	561
286	7700529	ELMER DITCH NO 1	16	275	50	1,620
287	7700531	ENTERPRISE_DIVSYS	31	171	16	3,285
288	7700536	FITZHUGH DITCH	9	130	48	757
289	7700542	HEADACHE CREEK DITCH	20	118	54	510
290	7700554	LITTLE MUDDY CREEK DITCH	15	69	54	342
291	7700558	MCMULLEN DITCH	9	32	27	498

#	Model ID #	Name	Cap (cfs)	2010 Irrig. Acres	Average System Efficiency (percent)	Average Annual Demand (af)
292	7700559	MIDLAND DITCH	19	128	45	929
293	7700560	MONTOYA DITCH	5	22	29	318
294	7700562	NAVAJO MEADOW DITCH	16	26	28	522
295	7700564	NAVAJO RIVER DITCH	17	18	12	672
296	7700569	NEW BOND HOUSE D (FALL)	5	2	4	206
297	7700570	NEW BOND HOUSE D (ASPEN)	7	13	34	217
298	7700576	SHAHAN IRRIGATION DITCH	8	16	17	339
299	7700577	SHEEP CREEK DITCH	6	42	52	232
300	7700579	SOUTH SIDE DITCH	21	115	19	2,426
301	7700585	UNDERWOOD DITCH	9	49	51	299
302	7700586	UNDERWOOD DITCH NO 2	8	17	24	394
303	7700587	UPPER CAMP DITCH	15	51	20	961
304	7700588	UPPER NAVAJO DITCH	8	100	52	503
305	7700592	WEST RANCH CREEK DITCH	11	29	37	357
306	7700597	NEW BOND HOUSE D (NAVAJO)	35	101	22	1,440
307	7704635 4)	USBR_NAVAJO_DIVERSION	950	0	100	0
308	7704636 4)	USBR_LITTLE_NAVAJO_DIVR	670	0	100	0
309	7799999 4)	SAN JUAN CHAMA SUMMARY	950	0	60	164,502
310	77_ADS001	WD 77 AGGREGATE DIVERSION	55	1,131	54	4,985
311	7800501	ABRAHAM DAVIS DITCH	18	388	51	1,896
312	7800506 1)	BARNES DITCH	11	297	54	0
313	7800507	BARNES-MEUSER_DIVSYS	24	1,673	50	5,979
314	7800513	BUCKSKIN-NAILOR DITCH	22	146	7	3,444
315	7800523 1)	CARL AND WEBB DITCH	10	57	44	0
316	7800524 1)	CIMARRON DITCH	15	201	53	0
317	7800525 1)	CLAYTON-REED DITCH	13	49	33	0
318	7800543	EUGENIO GALLEGOS DITCH	8	53	25	480
319	7800544	F S MOCKLER IRR DITCH	15	446	54	1,634
320	7800545	FARROW AND PETERSON D	20	9	0	2,896
321	7800552	GALLEGOS HOME DITCH	6	69	19	913
322	7800555	GEORGE S MCDONALD DITCH	6	63	35	456
323	7800562	HOPE SPRINGS_DIVSYS	16	269	53	1,289
324	7800565	J C R DITCH	14	6	4	603
325	7800571	BESS GIRL DITCH	11	292	40	1,807
326	7800580	M E AND M DITCH	17	128	25	1,220
327	7800590	NICKLES BROTHERS DITCH	9	429	54	1,553
328	7800594 1)	PAGOSA DITCH	3	67	44	0
329	7800604	PIEDRA FALLS DITCH	26	348	36	3,192
330	7800617 1)	STEVENS AND CLAYTON D	16	270	33	0
331	7800638	TONER AND STEVENS DITCH	13	292	43	1,678
332	7800659 1)	LITTLE PAGOSA CREEK DIVR	26	21	44	0
333	7800671	J C R DITCH ALTERNATE PT	8	297	54	1,047

#	Model ID #	Name	Cap (cfs)	2010 Irrig. Acres	Average System Efficiency (percent)	Average Annual Demand (af)
334	7800692 3)	FAIRFIELD MUN. WATER SYS	999	0	36	805
335	7804670 4)	DON LAFONT DITCH NO 1	5	0	100	39
336	7804671 4)	DON LAFONT DITCH NO 2	6	0	100	172
337	7804672 4)	WILLIAMS CR SQ PASS DIVR	10	0	100	345
338	78_ADS004	WD 78 AGGREGATE DIVERSION	203	1,977	54	7,447
339	78_SUIT 6)	SUIT RESERVED RIGHTS PEIDRA	75	1,525	78	0
340	CO_ALP 5)	FUTURE COLORADO ALP USE	280	0	0	0
341	DUR_ALP 5)	FUTURE DURANGO ALP USE	14	0	0	0
342	NM_ALP 5)	FUTURE NEW MEXICO ALP USE	999	0	50	0

1) Secondary Structure of a Multi-Structure Irrigation System
2) Reservoir Feeder or Carrier Ditch
3) Municipal/Industrial Diversion
4) Basin Export
5) Node for Modeling Future Animas-La Plata Demands
6) Node for Modeling Future Tribal Reserved Right Demands
7) Historical diversions and water rights, but no acreage assigned in 2010
8) Alternate node for future release scenarios

5.4.1.1 Key Structures

Key diversion structures are those that are modeled explicitly, that is, the node associated with a key structure represents that single structure or a diversion system only. In the San Juan Model, diversion structures with water rights totaling 5 cfs or more in the San Juan basin and 6 cfs or more in the Dolores basin were generally designated key structures. They are identified by a six-digit number which is a combination of water district number and structure ID from the State Engineer's structure and water rights tabulations. The San Miguel basin includes most irrigation structures explicitely; regardless of their net water rights.

The majority of the diversion structures in the San Juan basin are for irrigation. Structures diverting for non-irrigation use are noted in Table 5.4 and include structures that carry water to reservoirs or other structure's irrigation demands, municipal and industrial structures, and transbasin export structures.

Average historical monthly efficiencies for each structure appear in the diversion station file; however, StateMod operates in the "variable efficiency" mode for most irrigation structures, in which case, the values are not used during simulation. Efficiency in any give month of the simulation is a function of the amount diverted that month, and the consumptive use, as limited by the water supply.

For municipal, industrial, carriers, and transbasin diverters, StateMod uses the efficiencies in the diversion station file directly during simulation to compute consumptive use and return flows. Diversion efficiency is set to values consistent with the type of use based on engineering judgment, or, if available, user information. Municipal structures are assigned efficiencies that vary by month to reflect indoor and outdoor use patterns. Reservoir feeders and other carriers are assigned an efficiency of 0 percent, meaning their diversions are delivered without loss. Exports from the basin are assigned an efficiency of 100 percent because there are no return flows to the basin.

Diversion capacity is stored in HydroBase for most structures and is generally taken directly from the database. Capacities and irrigated acreage are accumulated by StateDMI for defined diversion systems. In preparing the direct diversion station file, however, StateDMI determines whether historical records of diversion indicate diversions greater than the database capacity. If so, the diversion capacity is modified to reflect the recorded diversion.

Return flow parameters in the diversions station file specify the nodes at which return flows will re-enter the stream, and divide the returns among several locations as appropriate. The locations were determined primarily case-by-case based on topography, locations of irrigated acreage, and conversations with water commissioners and users.

Where to find more information

- When StateMod is executed in the "data check" mode, it generates an *.xtb file which contains summary tables of input. On of these tables gives the return flow locations and percent of return flow to each location, for every diversion structure in the model. Another table provides the information shown in Table 5.4.
- Appendix A identifies structures that are modeled as diversion systems representing a group of structures that irrigated the same acreage.
- Section 4.2.2.1 describes how key structures were selected.
- Section 4.5 describes the variable efficiency approach for irrigation structures, and describes how diversions, consumptive use, and efficiency interact in the model for different types of structures.

5.4.1.2 Aggregate Structures

Small structures within specific sub-basin were combined and represented at aggregated nodes. Aggregated irrigation structures were given the identifiers "WD_ADSxxx", where "WD" is the Water District number, and "ADS" stands for Aggregated Diversions San Juan; the "xxx" ranges from 001 to 025. Similarly, aggregated municipal and industrial structures were named "WD_AMSxxx" for Aggregated Municipal San Juan.

For aggregated M&I diversions, efficiency was set to 100 percent because demands were modeled as depletions.

Where to find more information

- Section 4.2.2.2 describes how small irrigation structures were aggregated into larger structures.
- Appendix A provides details on the aggregate process and structures.

5.4.1.3 Special Structures

5.4.1.3.1 San Juan-Chama Project

The San Juan Chama Project was developed by the U.S. Bureau of Reclamation (USBR) as a participating project of the Colorado River Storage Project (CRSP). The project diverts water from tributaries of the San Juan River in the Colorado River basin for delivery to the Rio Grande basin. The water is used for municipal, domestic and industrial purposes in central New Mexico and also provides a supplemental irrigation supply to approximately 92,500 acres. The San Juan Chama Project was designed to yield an average of about 110,000 acre-feet per year.
There are three principal diversion facilities on tributary streams in Colorado. The Blanco Diversion Dam (2904667) diverts from Rio Blanco and delivers the water into the Blanco Tunnel. The Blanco Tunnel delivers water to the Oso Tunnel, which also diverts water from the Little Navajo River at the Little Oso Diversion Dam (7704636). The Oso Tunnel delivers water to the Azotea Tunnel, which also diverts water from the Navajo River at the Oso Diversion Dam (7704635).

Baseline demand for the San Juan Chama project is assigned to the San Juan Chama Summary Node (7799999). The individual diversion structures on the tributaries are modeled as carriers to the summary node demand.

5.4.1.3.2 MVIC and the Dolores Project

The Montezuma Valley Irrigation Company irrigates lands in the McElmo Creek basin primarily with water imported from the Dolores River. Water was historically delivered from direct diversion rights and from Groundhog Reservoirs via two structures; Main Canal No 1 (7104675) and Main Canal No 2 (7104674). With the construction of the Dolores Project, water from McPhee Reservoir is also delivered for increased irrigation and municipal use. Main Canals No 1 and 2 operate as carriers, with no baseline demand. Main Canal No 1 carries water to MVIC Dolores Tunnel irrigation demand (3204675), Towaoc Canal irrigation demand (3200884), the City of Dolores demand (3202001), and the Town of Cortez (3200680) demand. Main Canal No 2 carries water for storage in MVIC's Narraguinnep Reservoir, to

MVIC U-Lateral irrigation demand (3200772), and to Dove Creek Canal irrigation demand (3202006). MVIC U-Lateral demand can also be satisfied from Narraguinnep Reservoir.

5.4.1.3.3 Summit Irrigation Company

The Summit Reservoir system is a privately-owned system of canals and reservoirs that imports water from the Dolores River basin for irrigation purposes in the upper reaches of the McElmo Creek and Mancos River drainages. Summit Ditch (7100609) and Turkey Creek Ditch (7100608) carry water for storage in the Summit Reservoir System and to the Summit irrigation demand node (3202006). Summit irrigation demand can also be satisfied from the Summit Reservoir System.

5.4.1.3.4 Future Use Diversion Structures

Several diversion structures in the network are "placeholders" for modeling future anticipated demands in the San Juan basin. Strictly speaking, they are not part of the Baseline data set because their demands are set to zero or their rights are either absent or turned off. The diversion structures that fall into this category, and their potential configurations, are:

- CO_ALP, NM_ALP, and DUR_ALP are included in the model so future demands on the Animas-La Plata Project Ridges Basin Reservoir in Colorado and New Mexico can be accounted for.
- Future uses under Tribal Reserved Water Rights are included for both the Sourthern Ute Indian Tribe (SUIT) and the Ute Mountain Ute Indian Tribe (UMU). The Reserved Water Rights have been quantified by water district. These future demands are represented by 29_SUIT, 30_SUIT, 31_SUIT, 33_SUIT, 78_SUIT, 32_UMU, and 34_UMU.

5.4.2. Return Flow Delay Tables (*.dly)

The sj2015.dly file, which is hand-built with a text editor, describes the estimated re-entry of return flows into the river system. The irrigation return patterns are based on Glover analysis for generalized characteristics of the alluvium, and have been applied in all the west slope basin models. The return flow patterns also account for surface water return. Percent return flow in the first month for the Glover-derived patterns was adjusted to reflect 6 percent loss of returns due to non-crop consumption or evaporation, termed "incidental losses". In all cases, these lag times represent the combined impact of surface and subsurface returns.

The 6 percent of non-consumed water, used to represent incidental loss, is based on a recommendation used in the Colorado River Consumptive Uses and Losses Report, developed for the Colorado Water Conservation Board (Consumptive Uses and Losses Report, Comparison between StateCU CU & Losses Report and the USBR CU & Losses Report (1998-1995), October 1999, Leonard Rice Engineers). In the CU and Losses Report, incidental losses are estimated to be 10 percent of basin-wide crop consumptive use. However, StateMod applies a loss factor to unused diverted water, not crop consumptive use. Therefore, an equivalent loss factor was developed for non-consumed diverted water from the results of the StateCU consumptive use analyses performed in support of the San Juan Model as follows:

StateCU Total Basin Crop Consumptive Use (Ave 1975 – 2003) = 350,880 acre-feet

Incidental loss = 10% of Total Crop CU = 35,088 acre-feet

StateCU Unused Water (Ave 1975 – 2003) = 556,993

Incidental Loss as percent of Unused Water = 35,088 / 556,993 = 6%

Five patterns available in this file are used in the San Juan Model, as shown in **Table 5.5**. Pattern 1 represents returns from irrigated lands relatively close to a live stream or drain (<1200 feet). Pattern 2 should be used for irrigation further from a live stream (>1200 feet). Pattern 3 represents ground water returns to Long Hollow from irrigation on Red Mesa. Pattern 4 represents immediate returns, as for municipal and industrial uses. Pattern 5 is applicable to snowmaking diversions (not used in the San Juan Model). Pattern 6 represents no diversion incidental loss for lands irrigated close to a live stream. New Mexico, Arizona, and Utah structures are assigned Pattern 6, as incidental losses for these structures are represented in their demands and depletions.

Table 5.5
Percent of Return Flow Entering Stream in Months Following Diversion

Month n	Pattern 1	Pattern 2	Pattern 3	Pattern 4	Pattern 5	Pattern 6
1	72.6	54.4	1.3	100	0	78.6
2	11.3	14.5	1.5	0	0	11.3
3	3.2	7.2	1.6	0	0	3.2
4	2.2	5.0	3.0	0	0	2.2
5	1.6	3.7	3.0	0	100	1.6
6	1.2	2.7	3.0	0	0	1.2
7	0.8	2.0	3.0	0	0	0.8
8	0.6	1.5	3.0	0	0	0.6
9	0.5	1.1	3.0	0	0	0.5
10	0	0.8	3.0	0	0	0
11	0	0.6	3.0	0	0	0
12	0	0.5	3.0	0	0	0
13 – 14	0	0	2.7	0	0	0
15 - 36	0	0	2.6	0	0	0
Total	94	94	94	100	100	100
Note: Month 1 is the same month as diversion						

Where to find more information

- Section 4.6.1 describes how irrigation return flow delay patterns were developed.

5.4.3. Historical Diversion File (*.ddh)

The historical diversion file contains time series of diversions for each structure. The file is created by StateDMI, which also fills missing records as described in Section 4.4.2. The file is used by StateMod for baseflow estimations at stream gage locations, and for comparison output that is useful during calibration.

The file is also referenced by StateDMI when developing average efficiency values for the diversion station file, and headgate demand time series for the diversion demand file.

5.4.3.1 Key Structures

For most explicitly modeled irrigation and M&I structures, StateDMI accesses HydroBase for historical diversion records. Historical diversions are accumulated by StateDMI for defined diversion systems. For certain structures, the data was assembled from other sources or developed from database data into a time-series file which StateDMI can be directed to read. These include Dolores Project diversions plus other larger diverters as follows:

WDID	Name
3000506	Animas Consolidated Ditch
3000617	Reid Ditch
3001003	Harris-Patterson Ditch
3001009	McClure and Murray Ditch
3001011	Florida Canal
3001019	Pioneer Ditch
3001033	Banks-Tyner Ditch
3001243	Tyner East Side Ditch
3100519	King Ditch
3100547	Robert Morrison Ditch
3100665	Spring Creek Ditch
3200772	MVI U Lateral
3200884	Towaoc Canal
3202006	Dove Creek Canal

3204675	Dolores Tunnel
6000633	Highline Canal Enlargement
6000670_I	Lilylands Canal Demand
6000672_I	Lone Cone Canal Demand
6000707_I	Naturita Canal Demand
6000777	Theo Netherly Ditch No 1
7104674	Main Canal No 2
7104675	Main Canal No 1

The following carrier and summary structures have their historical use represented at other nodes, diversions are set to zero. In addition, all future use structures, which include Animas La Plata structures, have historical diversions set to zero because they did not divert historically.

WDID	Name
3001024	Animas Pump Station
3000523	Cascade Canal
3200699	Narraguinnep Reservoir Feeder
7799999	San Juan Chamo Summary

Historical diversions for the following transbasin diversions were extracted from USGS or DNR streamflow records in HydroBase, as shown, which are more complete than records stored in HydroBase under the WDID.

WDID	Name	USGS or DNR Streamgage
2904669	Treasure Pass Diversion Ditch	09341000
3104637	Weminuche Pass Ditch	09351500
3104638	Pine River Weminuche Pass Ditch	09351000
7804670	Don LaFont Ditch No 1	DLFDT1CO
7804671	Don LaFont Ditch No 2	09347000
7804672	Williams Creek Squaw Pass Ditch	09348000

In addition, historical diversions for New Mexico, Arizona and Utah were provided by the USBR in time-series file which StateDMI is directed to read.

5.4.3.2 Aggregate Structures

Aggregated irrigation structures are assigned the sum of the constituent structures' historical diversion records from the database.

Two nodes in the model represent the combined small diversion for municipal, industrial, and livestock use in two water districts in the basin. These structures are modeled as diverting only the depletive portion of their diversions, and consuming all of it. Thus estimated historic diversions are equivalent to estimated consumptive use. Total non-irrigation consumptive use in the San Juan / Dolores basin was estimated, as documented in the task memorandum "Non-Irrigation (Other Uses) Consumptive Uses and Losses in the Dolores and San Juan River Basins". Consumptive use of the key municipal and industrial diversion in the model was subtracted from this basin wide M&I consumption, to derive the basin wide consumptive use attributable to small M&I users. This value was distributed to Water Districts 34 and 63 in accordance with a general distribution of M&I use. The use is the same each year of the study.

Where to find more information

- The feasibility study for the data extension is documented in two task memos, which are collected in the CDSS *(Technical Papers)*:

  -Data Extension Feasibility

  -Evaluate Extension of Historical Data

5.4.4. Direct Diversion Demand File (*.ddm)

Created by StateDMI, this file contains time series of demand for each structure in the model. Demand is the amount of water the structure "wants" to divert during simulation. Thus demand differs from historical diversions, as it represents what the structure would divert in order to get a full water supply. **Table 5.4** in Section 5.4.1 lists average annual demand for each diversion structure. Note that the Baseline demands do not include demands associated with conditional water rights.

5.4.4.1 Key Structures

Irrigation demand was computed as the maximum of crop irrigation water requirement divided by average monthly efficiency for the structure or historical diversions, as described in Section 4.9.1. Note that the irrigation water requirement is based on actual climate data beginning in 1950. Prior to that, it is filled using the automatic data filling algorithm

described in Section 4.4.2. Monthly efficiency is the average efficiency over the efficiency period (1976 through 2013) but capped at 0.54.
New Mexico, Arizona, and Utah baseline demands were provided by the USBR. Transbasin and municipal and industrial demands were set to recent values or averages of recent records.

5.4.4.2 Aggregate Structures

Aggregated irrigation structure demand is computed as for key irrigation structures. The only difference is that the irrigated acreage, which is the basis of irrigation water requirement, is the sum of irrigated acreage for constituent structures. Similarly, filled diversions are summed across all constituent structures, and average efficiency is based on efficiency of the aggregation as a unit.

5.4.4.3 Special Structures

5.4.4.3.1 San Juan Chama Project

Total demand for the San Juan Chama Project was placed at the San Juan Chama Summary Node (7799999). Demands at the individual diversion structures (2904667, 7704635, and 7704636) were set to zero. Diversions to the summary node are driven by operating rules.

5.4.4.3.2 MVIC and Dolores Project

Demands associated with MVIC and the Dolores Project increased or began when McPhee Reservoir was completed in 1984. Irrigation demand was computed as the maximum of crop irrigation water requirement (based on current acreage) divided by 1984 through 2013 average monthly efficiency for MVIC U-Lateral (3200772), MVIC Dolores Tunnel (3204675), Towaoc Canal (3200884), and Dove Creek Canal (3202006). Demands for the Dolores Project carrier nodes 7104674 (Main Canal #2) and 7104675 (Dolores Tunnel) were set to zero. Diversions to meet Dolores Project demands through the carriers from direct rights and storage are driven by operating rules.

5.4.4.3.3 Summit Irrigation System

Total demand for the Summit Irrigation System was placed at the Summit Reservoir Outlet Node (7102002). Demands at the individual diversion structures (7100609 and 7100618) were set to zero. Diversions to the summary node from direct rights and reservoir storage are driven by operating rules.

5.4.4.3.4 Carrier Structures and Multistructures

Demands for reservoir and demand carrier structures are set to zero. Irrigation demand for multistructures is placed on the primary structure node, and secondary structures are set to zero. Note that diversions through these carrier structures are driven by operating rules.

5.4.4.4 Future Use Diversion Structures

Demands for future depletion nodes are zeroed out, as they are not active in the Baseline data set.

5.4.5. Direct Diversion Right File (*.ddr)

The direct diversion right file contains water rights information for each diversion structure in the model. StateDMI created the diversion right file based on the structure list in the diversion station file. Note that the Baseline direct diversion right file does not include conditional water rights. It is recommended for future updates that the StateDMI commands be run initially without the “set” commands. This allows the modeler to view any changes to water rights (transfers, conditional to absolute, abandonment, etc.) reflected in updated versions of HydroBase and modify the “set” commands as necessary.

The information in this file is used during simulation to allocate water in the right sequence or priority and to limit the allocation by decreed amount. The file is also an input to StateDMI when it is filling historical diversion time series. Based on the appropriation dates expressed in the administration number in the rights file, StateDMI determines the total amount of the water right during the time of the missing data, and constrains the diversion estimate accordingly. For example, suppose a ditch has two decrees, one for 2.5 cfs with an appropriation date of 1886, and the other for 6 cfs with an appropriation data of 1932. When StateDMI estimates historical diversions prior to 1932, it limits them to a maximum rate of 2.5 cfs for the month, regardless of the average from available diversion records. This approach was adopted so the water development of the study period could be simulated.

5.4.5.1 Key Structures

Water rights for explicitly modeled structures were taken from HydroBase and match the State Engineer’s official water rights tabulation. Water rights for each individual structure in a diversion system are included under the defined diversion system identifier. In addition, many structures have been assigned a “free river right”, with an extremely junior administration number of 99999.99999 and a decreed amount of 999.0 cfs. These rights allow structures to divert more than their decreed water rights under free river conditions, provided their demand is unsatisfied and water is legally available.

5.4.5.2 Aggregate Structures

In the San Juan Model, aggregated structures can include more than 70 individual structures. Therefore, aggregated irrigation structures were assigned up to 13 water rights, one for each of 13 water right (administration) classes. The decreed amount for a given water right class was set to the sum of all water rights that 1) were associated with individual structures included in the aggregated irrigation structure, and 2) had an administration number that fell within the water right class. The administration number for each right was calculated to be the weighted average by summing the product of each administration number and decree and dividing by the total decree within the water right class. For example, given 2 water rights; one for 10 cfs at an administration number of 1 and one for 2 cfs at an administration number of 4, the weighted administration number would be (10 x 1 + 4 x 2) / (10 + 2) = 1.5.
Aggregated M&I water rights were assigned an amount equal to their depletions and assigned an administration number of 1.00000.

5.4.5.3 Special Diversion Rights

5.4.5.3.1 San Juan Chama Project

The San Juan Chama diversions do not have decreed water rights in Colorado. The San Juan Chama diversions were given water rights equal to each tunnel's capacity and assigned administration numbers junior to all water rights in Colorado (99999.00000), but senior to the New Mexico diversions.

5.4.5.3.2 MVIC and the Dolores Project

Some of the Dolores River direct diversion rights for MVIC and Dolores Project users are assigned in HydroBase to structure WDIDs in the McElmo Creek basin (MVIC U-Lateral, etc.). These rights were re-assigned to the Dolores River structures (Main Canals No 1 and 2) and used in conjunction with operating rules to meet the MVIC and Dolores Project demands.

5.4.5.3.3 Miscellaneous Structures

Fairfield Municipal water right is not stored in HydroBase. The water right was set to the Fairfield Municipal (7800692) structure as follows: 999 cfs with an administration number of 22962.19157.
The Jackson Gulch Inlet Canal water right is not stored in HydroBase. The water right was set to the Jackson Gulch Inlet Canal (3400535) structure as follows: 3.91 cfs with an administration number of 9997.00000.

A non-decreed existing use water right for the J P Lamb Ditch (3000581) is set to assure the existing use is considered senior to a downstream instream flow right as follows: 999 cfs with and administration number of 49136.99999.

5.4.5.3.4 Future Use Diversion Structures

Animas-La Plata carrier is provided with its conditional water right administration number of 32386.00000 for 600 cfs. No water rights are assigned to the future ALP demand structures. Future Tribal Reserved Water Rights are assigned an administration number of 6636.0000 and the decreed amount based on the sum of reserved rights in each water district.

5.5 Irrigation Files

The irrigation files provide parameters used during simulation to compute on-farm consumptive use, and return flow volumes related to a given month's diversions.

5.5.1. StateCU Structure File (*.str)

This file gives the soil moisture capacity of each irrigation structure for which efficiency varies, in inches per inch of soil depth. It is required for StateMod's soil moisture accounting in both baseflow and simulation modes. Soil moisture capacity values were gathered from Natural Resources Conservation Service (NRCS) mapping. The file was created by StateDMI.

5.5.2. Irrigation Parameter Yearly (*.ipy)

This file contains conveyance efficiency and maximum application efficiency by irrigation type for each irrigation structure for which efficiency varies, and each year of the study period. The file also contains acreage by irrigation type – either flood or sprinkler. In the San Juan basin, all acreage has been assigned flood irrigation type. Maximum system efficiency (includes both conveyance and application efficiencies) is estimated to be 54 percent for Colorado structures with the exception of MVIC/Dolores Project structures. Maximum system efficiency for Towaoc Canal (3200884) is set to 72 percent and Dove Creek Canal (3202006) is set to 63 percent to reflect the percent of acreage irrigated with sprinklers. Because overall system efficiency is considered, conveyance efficiency is set to 1.0 and maximum flood application efficiency is set to the system efficiencies outlined here. This file was created by StateDMI for use with the StateCU analysis on a calendar year basis. Although this is an annual time-series file, StateMod will not simulate the San Juan datasets if the irrigation parameter yearly file header is not changed from CYR to WYR. This change has to be done by hand in a text editor.

5.5.3. Irrigation Water Requirement File (*.iwr)

Data for the irrigation water requirement file was generated by StateCU for the period 1950 through 2013, then extended back to 1909 using TSTool. StateCU was executed using the SCS modified Blaney-Criddle monthly evapotranspiration option with TR-21 crop parameters for lands irrigated below elevation 6500 feet. A standard elevation adjustment was applied to TR-21 crop coefficients. For structures irrigating pasture grass above 6500 feet, StateCU was executed using the original Blaney-Criddle method with high-altitude crop coefficients, as described in the SPDSS 59.2 Task Memorandum *Develop Locally Calibrated Blaney-Criddle Crop Coefficients*, March 2005. Acreage for each structure was set to the acreage defined in 2010 for the entire study period. The irrigation water requirement file contains the time series of monthly irrigation water requirements for structures whose efficiency varied through the simulation.

5.6 Reservoir Files

5.6.1. Reservoir Station File (*.res)

This file describes physical properties and some administrative characteristics of each reservoir simulated in the San Juan basin. It is assembled by StateDMI, using a considerable amount of information provided in the commands file. Sixteen key reservoirs were modeled explicitly. Seventeen aggregated reservoirs and stock ponds account for evaporation from numerous small storage facilities. The modeled reservoirs are listed below with their capacity and their number of accounts or pools.

#	ID #	Name	Capacity (af)	# of Owners
1	29_ARS002	WD 29 AGGREGATED RESERVOIR	2,761	1
2	29_ASS001	WD 29 AGGREGATED STOCKPOND	4,233	1
3	3003536	CASCADE RESERVOIR	23,468	2
4	3003581	LEMON RESERVOIR	40,140	10
5	3003623	RIDGES BASIN RESERVOIR	120,000	2
6	30_ARS005	WD 30 AGGREGATED RESERVOIR	3,359	1
7	30_ASS002	WD 30 AGGREGATED STOCKPOND	2,469	1
8	3103518	VALLECITO RESERVOIR	125,441	21
9	31_ARS004	WD 31 AGGREGATED RESERVOIR	504	1
10	31_ASS003	WD 31 AGGREGATED STOCKPOND	1,411	1
11	32_ARS008	WD 32 AGGREGATED RESERVOIR	1,005	1
12	32_ASS004	WD 32 AGGREGATED STOCKPOND	16,930	1
13	3303530	LONG HOLLOW RESERVOIR	1,200	1
14	33_ARS006	WD 33 AGGREGATED RESERVOIR	2,465	1
15	33_ASS005	WD 33 AGGREGATED STOCKPOND	2,116	1
16	3403589	JACKSON GULCH RESERVOIR	9,980	4
17	34_ARS007	WD 34 AGGREGATED RESERVOIR	2,830	1

18	34_ASS006	WD 34 AGGREGATED STOCKPOND	7,760	1
19	6003507	GURLEY RESERVOIR	10,039	2
20	6003509	LAKE HOPE RESERVOIR	2,315	1
21	6003510	LILYLANDS RESERVOIR	494	1
22	6003511	LONE CONE RESERVOIR	1,840	1
23	6003512	MIRAMONTE RESERVOIR	6,852	1
24	6003527	TROUT LAKE RESERVOIR	3,422	2
25	63_ARS009	WD 63 AGGREGATED RESERVOIR	10,392	1
26	63_ASS007	WD 63 AGGREGATED STOCKPOND	352	1
27	7103602	NARRAGUINNEP RESERVOIR	18,960	1
28	7103612	GROUNDHOG RESERVOIR	22,011	3
29	7103614	MCPHEE RESERVOIR	380,905	9
30	7103619	SUMMIT RESERVOIR	5,508	2
31	71_Call	MCPHEE MVIC CALL RESERVOIR	72,000	1
32	77_ARS001	WD 77 AGGREGATED RESERVOIR	874	1
33	78_ARS003	WD 78 AGGREGATED RESERVOIR	15,611	1

5.6.1.1 Key Reservoirs

Parameters related to the physical attributes of key reservoirs include inactive storage where applicable, total storage, area-capacity data, applicable evaporation/precipitation stations, and initial reservoir contents. For explicitly modeled reservoirs, storage and area-capacity information were obtained from either the Division Engineer or the reservoir owners. Initial contents for all reservoirs are set to average September end-of-month contents over the period 1975 through 1996. After filling dead pools, initial contents are prorated to reservoir accounts based on account size.
Administrative information includes reservoir account ownership, administrative fill date, and evaporation charge specifications. This information was obtained from interview with the Division Engineer, local water commissioners, and in most cases, the owner/operator of the individual reservoirs.

5.6.1.2 Aggregate Reservoirs

The amount of storage for aggregate reservoirs and stockponds is based on storage decrees and the CDSS Task 1.14-23 Memorandum “Non-Irrigation (Other Uses) Consumptive Uses and Losses in the Dolores and San Juan River Basins” (see Appendix B). Surface area for the aggregate reservoirs was developed assuming they are straight-sided pits with a depth of 25 feet for aggregate reservoirs and a depth of 10 feet for aggregate stockponds. Initial contents were set to full.

5.6.1.3 Reservoir Accounts

Except as noted below, San Juan Model reservoirs are modeled with only one active account.

5.6.1.3.1 Lemon Reservoir

Lemon Reservoir (3003581) Lemon Reservoir, constructed by the USBR in the early 1960s as a part of the Colorado River Storage Project (CRSP), stores surplus water available during spring runoff months and releases for late season irrigation demands. The reservoir has a total active capacity of 39,030 acre-feet, and has a decreed storage right of 40,240 acre-feet. There is also a second fill storage right of 7,760 acre-feet. A subsequent refill decree remains conditional. There are seven major irrigation structures on the Florida River cumulatively decreed for over 200 cfs which represent the structures that use the majority of the project water in the reservoir. For this model, these structures have been divided into Groups A and B. Group A accounts for 5.9 percent of the project water, and consists of 5 ditches: Harris Patterson (3001003), Pioneer (3001019), McCluer-Murray (3001009), Banks-Tyner (3001033), and Tyner-East Side (3001243). Group B accounts for 94.1 percent of the project supply and consists of only two diversions that are operated as a single demand, Florida Farmers/Florida Canal (3001011). The U.S. Government has also reserved an account for 2,900 acre-feet.

Each ditch under the Florida Project is limited to their acreage-prorated share of available torage. If the ditch does not use their prorata share by the end of the irrigation season, it cannot be carried over and is re-distributed. The bookover account is used for the operating rule that re-distrubutes water between accounts. The storage in Lemon Reservoir is allocated as follows:

Acct	Owner	Capacity (acre-feet)
1	Harris_Patterson Ditch	183
2	Pioneer Ditch	547
3	McCluer-Murray Ditch	198
4	Banks-Tyner Ditch	410
5	Tyner-East/WestSide Ditch	182
6	Florida_Farmers Ditch	24,220
7	USA	13,290
8	Inactive/Dead Pool	1,110
Lemon Total		**40,140**
9	*Bookover*	*25,740*

5.6.1.3.2 Vallecito Reservoir

Vallecito Reservoir (3103518) is the principal feature of the Pine River Project, constructed by the USBR in the early 1940s. The project is managed by the Pine River Irrigation District (PRID) and supplies water to late season irrigation demands. The reservoir has a decreed storage right of 129,674 acre-feet. One-sixth of the active storage is owned by the Southern Ute Indian Tribe. Each ditch under the PRID is limited to their acreage-prorated share of available PRID storage. If the ditch does not use their prorata share by the end of the irrigation season, it cannot be carried over and is re-distributed. The bookover account is used for the operating rule that re-distrubutes water between accounts. The storage in Vallecito Reservoir is allocated as follows:

Acct	Owner	Capacity (acre-feet)
1	Southern Ute Account	20,900
2	Farrell Ditch	500
3	McBride Ditch	167
4	Bennet-Myers Ditch	376
5	Myers-Asher Ditch	322
6	Wommer Ditch	685
7	Catlin Ditch	82
8	Bear Creek/Pine River D	1,212
9	Sullivan Ditch	980
10	Los Pinos Ditch	1,887
11	Thompson Epperson D	5,608
12	Schroder Ditch	8,777
13	Bean Ditch	363
14	King Ditch	20,060
15	Higbee Ditch	82
16	Island Ditch	47
17	Robert Morrison Ditch	16,288
18	Spring Creek Ditch	42,709
19	Dr. Morrison non-Indian	167
20	Inactive/Dead Pool	4,240
Vallecito Total		**125,441**
21	*Bookover*	*125,067*

5.6.1.3.3 Jackson Gulch Reservoir

Jackson Gulch Reservoir (3403589) is the principal feature of the Mancos Project, constructed by the USBR in the late 1940s. Jackson Gulch has a storage capacity of 9,980 acre-feet, with an active capacity of 9,630 acre-feet. The reservoir is filled by diversions from the Jackson Gulch Inlet Canal (3400535) located on the West

Mancos River approximately 2.5 miles upstream from the reservoir. The U.S. Government has reserved 200 acre-feet of storage plus and 120 acre-feet specified for use by Mesa Verde National Park. Therefore, reservoir is modeled with three active accounts, Mesa Verde, USA, and remaining storage for general irrigation.

5.6.1.3.4 McPhee Reservoir System and Dolores Project

The operations of the Dolores Project and the Groundhog and Narraguinnep reservoirs are the most complicated operations in the San Juan and Dolores basins. The project involves agricultural, municipal, and transbasin diversions, as well as individual tunnels and carrier structures that carry water for multiple users. In addition, MVIC direct-flow rights can be stored in McPhee Reservoir constrained by volumetric limitations. McPhee Reservoir (7103614) is the principal feature of the Dolores Project, located on the main stem of the Dolores, just downstream of the town of Dolores. The storage in McPhee Reservoir, Groundhog Reservoir (7103612) and Narraguinnep Reservoir (7103602) is allocated as follows:

Reservoir	Acct	Owner	Capacity (acre-feet)
McPhee Reservoir	1	MVIC	105,500
McPhee Reservoir	2	Ute Mountain Tribe	23,300
McPhee Reservoir	3	Dove Creek	55,200
McPhee Reservoir	4	Municipal Users	8,700
McPhee Reservoir	5	Fishery	29,300
McPhee Reservoir	6	Unallocated	7,150
McPhee Reservoir	7	Inactive/Dead Pool	151,705
McPhee Total			**380,855**
McPhee Reservoir	*8*	*MVIC_Call Bookover*	*72,000*
McPhee Reservoir	*9*	*Bookover*	*229,200*
Groundhog Reservoir	1	MVIC	19,411
Groundhog Reservoir	2	McPhee Exchange	2,300
Groundhog Reservoir	3	Inactive/Dead Pool	300
Groundhog Total			**22,011**
Narraguinnep Total	1	General Irrigation	18,900

The Montezuma Valley Irrigation Company (MVIC) capacity of 105,500 acre-feet represents the maximum delivery of project water that would be available through MVIC's senior rights. McPhee Reservoir currently has a conditional storage right of 750,000 acre-feet but no absolute water rights. For this model, McPhee Reservoir has been assigned a storage right of 381,200 acre-feet, which represents the actual physical capacity of the reservoir. Because of the complicated operations associated with the Dolores Project, two additional accounts in McPhee Reservoir are used to bookover water to allow MVIC senior direct rights to be stored when they are in excess of irrigation demands. These accounts are used to bookover water between other McPhee Reservoir accounts and with the 71_Call "phantom" reservoir. Operations are described in Section 5.9.3.

Groundhog Reservoir is modeled with two accounts. An exchange pool of 2,300 acre-feet has been set aside by agreement between MVIC and the Dolores Water Conservancy District. Since the construction of McPhee Reservoir, MVIC has reportedly not required water from Groundhog. An exchange agreement with the conservancy district provides for a release of 2,300 acre-feet of storage from Groundhog which protects a continuance of historical diversions of water rights on the upper Dolores River that are junior to the senior rights of the MVIC. For simplicity, this water is released to the system in July and August.

Narraguinnep Reservoir is an off-channel reservoir used to supplement late season irrigation supplies. It is modeled as one account for general irrigation releases. Prior to construction of the McPhee Reservoir, Groundhog and Narraguinnep reservoirs were used extensively to supplement irrigation demands from the river. This supplemental irrigation water is not used as often now that McPhee Reservoir can usually meet late season irrigation demands. Based on discussion with the MVIC, releases are made from McPhee Reservoir first, then Narraguinnep, then Groundhog.

5.6.2. Net Evaporation File (*.eva)

The evaporation file contains monthly average evaporation data (12 values that are applied in every year). The annual net reservoir evaporation was estimated by subtracting the weighted average effective monthly precipitation from the estimated gross monthly free water surface evaporation. Annual estimates of gross free water surface evaporation were taken from the National Oceanic and Atmospheric Administration (NOAA) Technical Report NWS 33. The annual estimates of evaporation were distributed to monthly values based on elevation through the distributions listed in Table 5.6. These monthly distributions are used by the State Engineer's Office.

Table 5.6
Monthly Distribution of Evaporation as a Function of Elevation (percent)

Month	Greater than 6,500 feet	Less than 6,500 feet
Jan	3.0	1.0
Feb	3.5	3.0
Mar	5.5	6.0
Apr	9.0	9.0
May	12.0	12.5
Jun	14.5	15.5
Jul	15.0	16.0
Aug	13.5	13.0
Sep	10.0	11.0
Oct	7.0	7.5
Nov	4.0	4.0
Dec	3.0	1.5

Three evaporation stations were used in the calculation of annual net evaporation in the San Juan Model:

1. Gateway 1 SE, Uravan (10003) was used to calculate evaporation for the following reservoirs: 32_ARS008, 32_ASS004, Gurley, Lake Hope, Miramonte, Trout Lake, 60_ARS010, 63_ARS009, 63_ASS007, Narraguinnep, Groundhog, McPhee, and Summit.
2. Arboles (10004) was used to calculate evaporation for Ridges Basin Reservoir.
3. San Juan (10007) was used to calculate evaporation for the following reservoirs: 29_ARS002, 29_ASS001, Cascade, Lemon, 30_ARS005, 30_ASS002, Vallecito, 31_ARS004, 31_ASS003, Long Hollow, 33_ARS006, 33_ASS005, Jackson Gulch, 34_ARS007, 34_ASS006, 77_ARS001, and 78_ARS003.

The resulting net monthly free water surface evaporation estimates, in feet, used in the San Juan Model are as follows:

Station	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
10003	0.13	0.04	-0.02	-0.03	0.05	0.11	0.22	0.33	0.48	0.43	0.32	0.28	2.34
10004	0.14	0.07	0.05	0.05	0.06	0.12	0.19	0.28	0.34	0.36	0.21	0.23	2.10
10007	0.03	-0.15	-0.16	-0.08	-0.07	-0.01	0.15	0.29	0.41	0.29	0.07	0.08	0.85

5.6.3. End-Of-Month Content File (*.eom)

The end-of-month content file contains historical end-of-month storage contents for all reservoirs in the reservoir station file. The historical EOM reservoir contents in this file are used by StateMod when estimating baseflow to reverse the effects of reservoir storage and evaporation on gaged streamflows, and to produce comparison output useful for calibration. The file is created by **TSTool**, which reads data from HydroBase and can fill it under a variety of user-specified algorithms.

5.6.3.1 Key Reservoirs

Data for the San Juan Model key reservoirs was either provided by Division 7, Division 4, reservoir owners, the USBR, or generated by converting available daily observations stored in HydroBase to month-end data. Missing end-of-month contents were filled with the average of available values for months with the same hydrologic condition. For reservoirs with little or no historical data available, end-of-month contents were set to reservoir capacity. Table 5.7 presents the on-line date for each reservoir and the primary data source for end-of-month contents. Historical contents in the *.eom file are set to zero prior to the on-line date.

Table 5.7
Reservoir On-line Dates and EOM Contents Data Source

WDID	Reservoir Name	On-Line Date	Primary Data Source
3003536	Cascade Reservoir	1906	HydroBase Daily
3003581	Lemon Reservoir	1963	USBR
3003623	Ridges Basin Reservoir	2010	HydroBase Daily
3103518	Vallecito Reservoir	1941	USBR
3303530	Long Hollow Reservoir	2015	N/A
3403589	Jackson Gulch Reservoir	1949	USBR
6003507	Gurley Reservoir	1961	HydroBase Daily
6003509	Lake Hope Reservoir	1903	Capacity Used
6003510	Lilylands Reservoir	1939	HydroBase Daily
6003511	Lone Cone Reservoir	1914	HydroBase Daily
6003512	Miramonte Reservoir	1978	Capacity Used
6003527	Trout Lake Reservoir	1954	HydroBase Daily
7103602	Narraguinnep Reservoir	1908	HydroBase Daily
7103612	Groundhog Reservoir	1905	HydroBase Daily
7103614	McPhee Reservoir	1985	USBR
7103619	Summit Reservoir	1905	HydroBase Daily

5.6.3.2 Aggregate Reservoirs

Aggregated reservoirs were assigned contents equal to their capacity, because there is no actual data. Aggregated reservoirs are modeled as though in operation throughout the study period.

5.6.4. Reservoir Target File (*.tar)

The reservoir target file contains minimum and maximum target storage limits for all reservoirs in the reservoir station file. The reservoir may not store more than the maximum target, or release to the extent that storage falls below the minimum target. In the Baseline data set, the minimum targets were set to zero for all reservoirs, and the maximum targets were set to capacity for all reservoirs that operate primarily for agricultural and municipal diversion storage. Maximum targets were set to operational targets for flood contraol according to rule curves provided by USBR for Lemon and Vallecito Reservoir. Cascade, Trout, and Navajo reservoirs operate for hydropower generation. For these reservoirs, maximum targets were set to historical end-of-month contents. Long Hollow reservoirs maximum storage targets was set to zero, as the reservoir was not on-line during the model period; this effectively disables the structures with regard to having an impact on the river.

5.6.5. Reservoir Right File (*.rer)

The reservoir right file contains the water rights associated with each reservoir in the reservoir station file. Specifically, the parameters for each storage right include the reservoir, administration number, decreed amount, the account(s) to which exercise of the right accrues, and whether the right is used as a first or second fill.

5.6.5.1 Key Reservoirs

In general, water rights for explicitly modeled reservoirs were taken from HydroBase and correspond to the State Engineer's official water rights tabulation. In addition, the key reservoirs were assigned a "free water right", with an extremely junior administration number to allow storage under free river conditions.

5.6.5.2 Aggregate Reservoirs

Aggregated reservoirs and stock ponds were assigned a decreed amount equal to their capacity, and an administration number 1.00000.

5.6.5.3 Special Reservoir Rights

5.6.5.3.1 Ridges Basin Reservoir

The water right for Ridges Basin Reservoir (3003623) includes an absolute alternate point of exchange for 123,541 acre-feet. StateDMI does not pull alternat point water rights; therefore the water right was set with an administration number of 32386.00000.

5.6.5.3.2 Long Hollow Reservoir

Long Hollow Reservoir (3303530) was recently constructed and has two conditional storage rights. These conditional rights were set in the model for 1,200 acre-feet with an administration number of 47481.45077 and for 4,200 acre-feet with an administration number of 52595.45077.

5.7 Instream Flow Files

5.7.1. Instream Station File (*.ifs)

Sixty instream flow reaches or minimum flow bypasses are defined in this file, which is created in StateDMI. The file specifies an instream flow station and downstream terminus node for each reach, through which instream flow rights can exert a demand in priority. Minimum bypasses below reservoirs or carriers are models as a single point. Table 5.8 lists each instream flow station included in the San Juan Model along with their location and maximum daily demand. These rights represent decrees acquired by CWCB, with the exception of instream flow stations listed under the following section.

5.7.1.1 Special Instream Flow Stations

Several modeled instream flow stations were not obtained from HydroBase as follows:

- An instream flow node was added to reflect minimum bypass requirements at Lemon Reservoir (3003581_M).
- An instream flow node was added to reflect minimum bypass requirements at the carrier to Ridges Basin Reservoir (3001657_M).
- An instream flow node was added to reflect minimum reservoir releases at Vallecito Reservoir (3199999) made to avoid cavitation.
- An instream flow node was added to the La Plata River at the Colorado-New Mexico state line to facilitate incorporation of the La Plata River Compact in the StateMod Model (3302999).

- An instream flow node was added downstream of Groundhog Reservoir to simplify the exchange of irrigation water from Groundhog Reservoir to miscellaneous users on the Dolores River (7199999).
- An instream flow node was added on the Little Navajo River downstream of the San Juan Chama diversion to reflect USBR bypass requirements of the project (7702000).
- An instream flow node was added on the Rio Blanco downstream of the San Juan Chama diversion to reflect USBR bypass requirements of the project (29_bypass).
- An instream flow node was added on the Navajo River downstream of the San Juan Chama diversion to USBR reflect bypass requirements of the project (77_bypass).
- An instream flow nodes was used to represent the recreational instream diversion right associated with the Durango Boating Park (301691).
- A CWCB instream flow on the Navajo River was "split" into two instream flows (7702005 and 7702005b) so as not to overlap with the USBR minimum bypass requirement flow.

5.7.2. Instream Demand File (*.ifa)

CWCB instream flow demands were developed from decreed amounts and comments in the State Engineer's water rights tabulation. Minimum bypass instream flow demands were based on agreements. Twelve monthly instream flow demands were used for each year of the simulation. The file contains monthly demands for each instream flow structure included in the San Juan Model.

5.7.3. Instream Right File (*.ifr)

Water rights for each instream flow reach modeled in the San Juan Model are contained in the instream flow right file, and shown in Table 5.8. Note that the decree represents the maximum demand, which may vary throughout the year. These data were obtained from the CWCB instream flow database with the exception of instream flow reaches listed under the following section.

Table 5.8
Instream Flow Summary

#	ID	Name	Decree (cfs)
1	2900768	RIO BLANCO MIN FLOW	29.0
2	2900768b	Rioblanco_isf	29.0
3	2901900	SAN JUAN RIVER MIN FLOW	50.0
4	2901902	WEST FK SAN JUAN R MIN F	25.0
5	2901905	WOLF CREEK MIN FLOW	11.0
6	29_bypass	Rioblanco_bypass	40.0
7	3001657_M	RidgesBasin_Min_Bypass	225.0
8	3001691	Durango Boating Park	1,400.0
9	3001901	LIGHTNER CREEK	10.0

#	ID	Name	Decree (cfs)
10	3001902	JUNCTION CREEK	15.0
11	3001903	FLORIDA RIVER	14.0
12	3001904	FLORIDA RIVER	20.0
13	3001928	HERMOSA CR(LOWER REACH)	37.0
14	3001937	MINERAL CREEK	15.0
15	3003581_M	Lemon_Res_Rel_USA	4.0
16	3101900	LOS PINOS RIVER	32.0
17	3199999	Vallecito_Res_Winter	0.0
18	3301905	LA PLATA RIVER	9.0
19	3302999	LaPlata_Compact_ISF	100.0
20	3401902	EAST MANCOS RIVER	2.0
21	6001319	BIG BEAR CREEK	2.0
22	6001320	BILK CREEK	3.0
23	6001358	HORSEFLY CREEK	13.0
24	6001374	DEEP CREEK	4.0
25	6001378	ELK CREEK	2.5
26	6001381	SAN MIGUEL RIVER	6.5
27	6001382	SAN MIGUEL RIVER	20.0
28	6001383	SOUTH FK SAN MIGUEL R	9.0
29	6001388	FALL CREEK	5.0
30	6001389	LEOPARD CREEK	2.5
31	6001390	NATURITA CREEK	3.0
32	6001397	LAKE FORK SAN MIGUEL RIV	2.5
33	6001788	BEAVER CREEK	5.0
34	6001789	SALTADO CREEK	2.0
35	6001950	SAN MIGUEL RIVER	93.0
36	6002070	TABEGUACHE CREEK	4.75
37	6002071	TABEGUACHE CREEK	4.75
38	6002075	TABEGUACHE CREEK	3.50
39	6002119	SAN MIGUEL RIVER	325.0
40	6300644	WEST CREEK	6.0
41	7100639	DOLORES MINIMUM FLOW	78.0
42	7101907	DOLORES RIVER	20.0
43	7101912	DOLORES RIVER	35.0
44	7101915	DOLORES RIVER	50.0
45	7101920	WEST FORK DOLORES RIVER	10.0
46	7101921	WEST FORK DOLORES RIVER	17.0
47	7101922	FISH CREEK	3.0
48	7199999	GroundHog/McPhee_Ex	0.0
49	7702000	Little_Navajo-Chama_B	27.0
50	7702005	NAVAJO RIVER MIN FLOW	55.0

#	ID	Name	Decree (cfs)
51	7702005b	Navajo_isf	55.0
52	77_bypass	Navajo_bypass	88.0
53	7801900	PIEDRA RIVER MIN FLOW	30.0
54	7801901	PIEDRA RIVER MIN FLOW	44.0
55	7801902	PIEDRA RIVER MIN FLOW	53.0
56	7801903	PIEDRA RIVER MIN FLOW	70.0
57	7801905	MID FK PIEDRA R MIN FLOW	11.0
58	7801906	EAST FK PIEDRA R MIN FL	10.0
59	7801907	WILLIAMS CREEK MIN FLOW	14.0
60	7801908	WEMINUCHE CR MIN FLOW	9.0
61	7801909	WEMINUCHE CR MIN FLOW	18.0
62	7801910	PIEDRA RIVER MIN FLOW	70.0

5.7.3.1 Special Instream Flow rights

Several modeled instream flow water rights were not obtained from HydroBase as follows:

- The instream flow right used to represent the minimum reservoir release requirements at Lemon Reservoir (3003581_M) was set to 4.0 cfs with an administration number of 51499.42185.
- The instream flow right used to represent the minimum bypass requirement at the carrier structure to Ridges Basin Reservoir (3001657_M) was set to 225.0 cfs with an administration number of 32385.99999.
- The instream flow right used to represent the minimum winter releases at Vallecito Reservoir (3199999) was set to 0.0 cfs and turned “off”. The demand is met entirely by an operating rule.
- The instream flow right used to represent the La Plata River Compact (3302999), in conjunction with an operating rule, was set to 100.0 cfs with the senior administration number of 0.00001.
- The instream flow right used to represent the irrigation exchange from Groundhog Reservoir (7199999) was set to 0.0 cfs and turned “off”. The demand is met entirely by an operating rule.
- The instream flow right used to represent the bypass requirement on the Little Navajo River downstream of the San Juan Chama diversion (7702000) was set to 27.0 cfs with an administration number just senior to the diversion of 99998.99999.
- The instream flow right used to represent the bypass requirement on Rio Blanco downstream of the San Juan Chama diversion (29_bypass) was set to 40.0 cfs with an administration number just senior to the diversion of 99998.99999.
- The instream flow right used to represent the bypass requirement on the Navajo River downstream of the San Juan Chama diversion (77_bypass) was set to 88.0 cfs with an administration number just senior to the diversion of 99998.99999.

5.8 Plan Data File (*.pln)

The plan data file can contain information related to operating terms and conditions, well augmentation, water reuse, recharge, and out-of-priority plans. Plan structures are accounting tools used in coordination with operating rights to model complicated systems. Three plan structures are used in the San Juan Model. The type 12 plan limit (MVICPlan) limits the amount of MVIC direct flow rights that can be used for project purposes to 150,400 af. The MVIC_WR type 13 plan (changed water right plan) temporarily "stores" for MVIC's water rights when in priority for subsequent allocation to several demands including MVIC irrigation demands and storage in McPhee Reservoir. The ALP type 13 plan (ALP_Pln) temporarily "stores" water available under the ALP water right when in priority for subsequent allocation to Ridges Basin Reservoir and, for future scenarios, to meet ALP demands directly from the Animas River.

5.9 Operating Rights File (*.opr)

The operating rights file specifies all operations that are more complicated than a direct diversion or storage in an on-stream reservoir. Typically, these are reservoir operations involving two or more structures, such as a release from a reservoir to a diversion structure, a release from on reservoir to a second reservoir, or a diversion to an off-stream reservoir. The file is created by hand, and the user is required to assign each operating right an administration number consistent with the structures' other rights and operations.

In the San Juan Model, fourteen different types of operating rights are used:

- **Type 1** – a release from storage to the stream to satisfy an instream flow demand. In the San Juan Model, this rule is used to satisfy minimum reservoir release requirements at McPhee, Groundhog, Vallecito, and Lemon Reservoirs.
- **Type 2** – a release from storage to the stream, for shepherded delivery to a downstream diversion or carrier. Typically, the reservoir supply is supplemental, and its release is given an administration number junior to direct flow rights at the destination structure. A release is made only if demand at the diversion structure is not satisfied after direct flow rights have diverted.
- **Type 3** – a release from storage directly to a carrier (a ditch or canal as opposed to the river), for delivery to a diversion station. Typically, the reservoir supply is supplemental, and its release is given an administration number junior to direct flow rights at the destination structure. A release is made only if demand at the diversion structure is not satisfied after direct flow rights have diverted.
- **Type 4** – a release from storage in exchange for a direct diversion elsewhere in the system. The release can occur only to the extent that legally available water occurs in the exchange reach. Typically, the storage water is supplemental, and is give an administration number junior to direct flow rights at the diverting structure.
- **Type 6** – a reservoir to reservoir transfer (bookover). It is commonly used to transfer water from one reservoir storage account to another in a particular month. It can be used to transfer

water from one storage account to another based on the amount of water diverted by another operating rule, or it can be used to transfer “unused” water to be redistributed to individual accounts when operations do not allow carry-over storage is. For example, in the San Juan Model, water unused water from indivual user accounts in Lemon Reservoir is booked over to a common account then re-allocated to individual accounts based pro-rate account size.

- **Type 9** – a release from storage to the river to meet a reservoir target. This operation is used in the San Juan Baseline data set for the reservoirs that operate for flood control or power generation (Lemon, Vallecito, Cascade, and Trout.) Targets allow maximum control of reservoir levels by storage rights and releases to meet demands.
- **Type 11** – a direct flow diversion to another diversion or reservoir through an intervening carrier. It uses the administration number and decreed amount of the direct flow right associated with the carrier, regardless of the administration number assigned to the operating right itself. In the San Juan Model, the Type 11 operating right is used both as a direct flow diversion to another diversion and as a direct flow diversion to a reservoir. For example, this rule type is used to deliver water from the Dolores River through Main Canal No 1 to meet MVIC-U Lateral demands. This rule type is also used to deliver water to Summit Reservoir through the Turkey Creek Canal; the demand is Summit Reservoir’s capacity.
- **Type 13** – The type 13 operating rule allows an instream flow to operate based on its location on the river and the flow at a remote location. In the San Juan Model, the Type 13 operating rule is used to represent the requirements of the La Plata Compact. This compact, in general, defines Colorado's commitment to deliver water to New Mexico based on the flow at the upstream La Plata River at Hesperus index gage.
- **Type 22** – The type 22 operating rule directs StateMod to consider soil moisture in the variable efficiency accounting. For structures with crop irrigation water requirements, excess diverted water not required by the crops during the month of diversion will be stored in the soil reservoir zone, up to the soil reservoir’s available capacity. If diversions are not adequate to meet crop irrigation water requirements during the month of diversion, water can be withdrawn from the soil reservoir to meet unsatisfied demands. The depth of the soil zone is defined in the control file (*.ctl). For the San Juan model, the effective soil depth or root zone was set to 3 feet. As discussed in section 5.5.1, the available water content, in inches per inch, is defined for each irrigating structure in the StateCU structure file (*.str).
- **Type 26 -** The type 26 operating rule allows a changed water right to be diverted from the river and temporarily stored in an accounting plan. For example, in the San Juan Model this operating rule MVIC senior water rights when in priority and “temporarily” stores them in the MVIC_WR plan for subsequent use via Type 27 operating rules.
- **Type 27** – provides a method to release water from a reservoir, reuse plan, accounting plan, or out-of-priority plan to a diversion, reservoir, or instream flow either directly via the river to by a carrier. For example, in the San Juan Model this operating rule is used release water the senior MVIC water rights “temporarily” stored in the MVIC_WR plan to meet MVIC irrigation demands and to store in MVIC’s account in McPhee.
- **Type 29 -** The type 29 operating rule provides a method to spill water from a Reservoir or Reuse Plan or Accounting Plan or a Changed Water Right Plan to the system. For example, in the San Juan Model this operating rule is used to “spill” any unused water temporarily stored in the MVIC_WR plan back to the river.

- **Type 45 -** The type 45 operating rule provides a method to divert water via a carrier with loss to a diversion or reservoir. The source may be a diversion or reservoir water right. For example, in the San Juan Model this operating rule is used to divert water through the Naturita Canal and deliver 80 percent of the water to Gurley Reservoir. The 20 percent loss is lagged back to the river.
- **Type 47 –** The type 47 operating rule provides a method to impose monthly and annual limits for one or more operating rules.

For all type 2, 3, 4, and 11 operating rules where water is released from a reservoir or diverted by a carrier to irrigation, the variable iopsou(4,1) in the operating file has been set to "1". This directs StateMod to release water only when an irrigation water requirement exists. When an irrigation water requirement exists, the operating rule will attempt to release the full amount required to satisfy the headgate demand defined in the *.ddm file. The variable efficiency algorithm will then determine the actual efficiency of the released water.

The presentation of operating rights for the San Juan Model is generally organized according to the projects involved:

Section	Description
5.9.1	San Juan Chama Project
5.9.2	Summit Reservoir System
5.9.3	MVIC /Dolores Project
5.9.4	Vallecito Reservoir
5.9.5	Lemon Reservoir
5.9.6	Jackson Gulch Reservoir
5.9.7	Cascade Reservoir
5.9.8	Gurley Reservoir
5.9.9	Lone Cone Reservoir
5.9.10	Lilylands Reservoir
5.9.11	Trout Lake and Lake Hope
5.9.12	Multiple Structures Irrigating Same Acreage

Where to find more information

- StateMod documentation describes the different types of operating rights that can be specified in this file, and describes the required format for the file.
- The section "San Juan and Dolores River Projects and Special Operations" in the document "San Juan and Dolores River Basin Information" describes each reservoir's typical operations.

5.9.1. San Juan Chama-Project

The San Juan-Chama Project diverts water from tributaries of the San Juan River in the Colorado River basin for export to the Rio Grande River basin. The diversion structures in the project do not have decreed Colorado water rights, and were assigned administration numbers that are junior to all Colorado water rights in the model.

Three operating rights are used to simulate San Juan-Chama operations:

Right #	Destination	Carriers	Admin #	Right Type	Description
1	San Juan Chama Summary	Rio Blanco Diversion Little Navajo Diversion, Navajo Diversion	99999.00000	11	Carrier to diversion
2	San Juan Chama Summary	Little Navajo Diversion, Navajo Diversion	99999.00000	11	Carrier to diversion
3	San Juan Chama Summary	Navajo Diversion	99999.00000	11	Carrier to diversion

Operating rules 1 through 3 carry water from the San Juan-Chama collection points, when water is legally available, to meet the total demand at the San Juan-Chama Summary structure. The San Juan-Chama Summary structure collects water from the Rio Blanco, Little Navajo, and Navajo basins.

5.9.2. Summit Reservoir System

Summit Reservoir System sits at the top of the drainage divide between the Dolores River, McElmo Creek, and the Mancos River. Summit Reservoir (7103619) is filled by two direct flow diversions from District 71: the Turkey Creek Ditch and the Summit Ditch. The Summit Reservoir system also includes several smaller reservoirs and ditches; however because of their relatively small size they are not explicitly modeled. Summit Reservoir is operated with two accounts.

Acct	Owner	Capacity (acre-feet)
1	General Irrigation	4,708
2	Inactive Recreation Pool	400

Eight operating rules are used to simulate Summit Reservoir operations:

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Summit Reservoir Outlet	Turkey Creek D	13346.00000	11	Carrier to diversion
2	Summit Reservoir Outlet	Turkey Creek D	30667.20168	11	Carrier to diversion

3	Summit Reservoir Outlet	Summit Ditch	30667.23175	11	Carrier to diversion
4	Summit Reservoir Outlet	Summit Reservoir	30667.23177	2	Release to direct diversion
5	Summit Reservoir	Turkey Creek D	13346.00000	11	Carrier to reservoir
6	Summit Reservoir	Turkey Creek D	30667.20168	11	Carrier to reservoir
7	Summit Reservoir	Summit Ditch	30667.23175	11	Carrier to reservoir
8	Summit to Target	All	99999.99999	9	Release to river by target

Operating rules 1 through 3 carry water from the supply ditches to irrigation under Summit Reservoir Outlet. The Turkey Creek Ditch has two direct water rights, while Summit Reservoir has one.

Operating rule 4 releases reservoir water to meet the irrigation demand. The administration number is junior to the three direct use rights.

Operating rules 5 through 7 carry water from the supply ditches to fill Summit Reservoir. The operation to store the carrier rights are set junior to meeting irrigation diversions.

Operating rule 8 releases water from all accounts, proportionally, to meet the historical end-of-month target values at Summit Reservoir. For the Baseline data set, end-of-month targets for Summit Reservoir are set to capacity, so releases to target are never made.

5.9.3. MVIC / Dolores Project

The operations of the MVIC and the Dolores Project, including McPhee (7103614), Groundhog (7103612) and Narraguinnep (7103602) reservoirs, are the most complicated operation in the San Juan and Dolores basins. The project involves many agricultural, municipal, and transbasin diversions, as well as individual tunnels and carrier structures that carry water for multiple users. McPhee Reservoir is the principal feature of the Dolores Project, located on the main stem of the Dolores, just downstream of the town of Dolores. McPhee Reservoir is modeled with five active accounts, the Montezuma Valley Irrigation Company (MVIC) 105,500 acre-feet account represents the maximum amount of project water that MVIC is entitled to. MVIC can also store direct rights in McPhee.

Groundhog Reservoir is modeled with two accounts. An exchange pool of 2,300 acre-feet has been set aside by agreement between MVIC and the Dolores Water Conservancy District. An exchange agreement with the conservancy district provides for a release of 2,300 acre-feet of storage from Groundhog which protects a continuance of historical diversions of water rights on the upper Dolores River that are junior to the senior rights of the MVIC. For simplicity, this agreement is modeled as an instream flow demand during July and August.

Narraguinnep Reservoir is an off-channel reservoir used to supplement late season irrigation supplies. It is modeled as one account for general irrigation releases. Prior to construction of the McPhee Reservoir, Groundhog and Narraguinnep reservoirs were used extensively to supplement irrigation demands from the river. This supplemental irrigation water is not used as often now that McPhee Reservoir can usually meet late season irrigation demands. Based on discussion with the MVIC, releases are made from McPhee Reservoir first, then Narraguinnep, then Groundhog.

Reservoir	Acct	Owner	Capacity (acre-feet)
McPhee	1	MVIC	105,500
McPhee	2	Ute Tribe	23,300
McPhee	3	Dove Creek	55,200
McPhee	4	Municipal	8,700
McPhee	5	Fishery	29,300
McPhee	6	Unallocated	7,150
McPhee	7	Inactive	151,705
MVIC “Phantom”	1	MVIC	72,000
Groundhog	1	MVIC	19,411
Groundhog	2	McPhee Exchange	2,300
Groundhog	3	Dead Pool	300
Narraguinnep	1	MVIC	18,900

MVIC is limited to deliveries of 150,400 acre-feet per year from their direct rights and project reservoir storage. They are limited to the use of 48,000 acre-feet per year of their senior direct flow rights. If their full direct flow rights are not needed to meet demands in April, May, and June, they can be stored in McPhee Reservoir; limited to excess capacity that cannot be filled by the Dolores Project storage right. The 150,400 acre-feet per year volumetric limits is defined with type 47 Plan Limit operating rules and the MVICLim plan. Subsequent operating rules that deliver water to MVIC irrigation use and storage in Narraguinep Reservoir check the MVCLim limits.

Thirty-five operating rules are used to simulate MVIC and Dolores Project operations. They are split below into the seventeen direct right operations, the eight McPhee Reservoir operations, and the five Groundhog/Narraguinnep operations.

Direct Rights to Plan Operations

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	MVIC_WR Plan	MVIC Water Right No 5	13113.00000	26	Water right to plan
2	MVIC_WR Plan	MVIC Water Right No 6	30667.13113	26	Water right to plan

Operating rules 1 and 2 place Dolores River water in the MVIC water right accounting plan for subsequent use when the two MVIC irrigation rights are in priority, limited to 48,000 acre-feet per year. Note that MVIC_WR plan is an accounting plan to track water available under the water rights with plan limitations and, as such, cannot "hold" water to a subsequent time step.

Note that Historical model, MVIC's junior 307 cfs water right is also placed in the MVIC_WR plan to allow full use of their water rights prior to the Dolores Project construction and subsequent restrictions. In addition, MVIC is not limited to the 150,400 acre-feet per year volumetric limits associated with the Dolores Project.

Plan to Demand Operations

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	MVIC Dolores Tunnel Irrigation	MVIC_WR Plan 7104675	30667.13114	27	Plan to diversion
2	MVIC U Lateral Irrigation	MVIC _WR Plan 7104674	30667.13114	27	Plan to diversion
3	Narraguinnep Reservoir	MVIC_WR Plan 7104674 3200699	30667.13114	27	Plan to reservoir
4	Montezuma Water Company	MVIC_WR Plan 7104675	30667.13114	27	Plan to diversion
5	MVIC "Phantom" Reservoir	MVIC_WR Plan	30667.13115	27	Plan to reservoir
6	Dolores River	MVIC_WR Plan	30667.13116	29	Plan spill

Operating rule 1 provides available water in the MVIC water right plan to MVIC Dolores Tunnel irrigation demand (3204675) via the Dolores Tunnel diversion on the Dolores River (7104675).

Operating rule 2 provides available water in the MVIC water right plan to MVIC U Lateral irrigation demand (3200772) via the U Lateral diversion on the Dolores River (7104674).

Operating Rule 3 provides available water in the MVIC water right plan to storage in Narraguinep Reservoir (7103602) via U Lateral diversin on the Dolores River (7104674) and the Narraguinnep Inlet Canal (3200699).

Operating rule 4 provides available water in the MVIC plan to the Montezuma Water Company (3202001) via the Dolores Tunnel diversion (7104675).

Operating rule 5 provides any remaining water in the MVIC plan to the MVIC "Phantom" reservoir (71_Call). This operating only occurs in April, May, and June. If there is storage capacity remaining in McPhee Reservoir after project water is stored, this water can then be moved to McPhee Reservoir, as described below.

Operating rule 6 "spills" any remaining water in the MVIC plan after rules 1 through 5 have operated.

Direct Right Operations

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Town of Cortez	Dolores Tunnel	10743.00000	11	Carrier to diversion
2	Town of Cortez	Dolores Tunnel	11063.00000	11	Carrier to diversion
3	Town of Cortez	Dolores Tunnel	11839.00000	11	Carrier to diversion
4	Town of Cortez	Dolores Tunnel	12204.00000	11	Carrier to diversion

Operating rules 1 through 4 provide Dolores River via the Dolores Tunnel (7104675) to the Town of Cortez (3200680) through the town's four water rights.

MVIC "Phantom" Reservoir Operations

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	MVIC "Phantom Reservoir"	1	1.00000	6	Reservoir Bookover
2	MVIC Dolores Tunnel Irrigation	Dolores Tunnel	30667.13115	27	Release to carrier
3	MVIC U Lateral Irrigation	U Lateral	30667.13115	27	Release to carrier
4	McPhee Reservoir	MVIC Bookover	999999.00000	6	Reservoir Bookover
5	Dolores River	MVIC Phantom Res	999999.00001	29	Reservoir Release

Operating rule 1 moves water from the MVIC Bookover account in McPhee Reservoir to the MVIC Phantom Reservoir (71_Call). This is water that was stored under the MVIC direct storage rights in previous time steps. This operation occurs every month prior to other Dolores Project operations.

Operating rules 2 and 3 provide water from the MVIC Phantom Reservoir (71_Call) to MVIC Dolores Tunnel irrigation demand (3204675) and MVIC U Lateral irrigation demand (3200772) via the Dolores Tunnel diversion on the Dolores River (7104675) and the U Lateral diversion on the Dolores River (7104674). These operations occur after deliveries of direct rights to MVIC irrigation demands from the MVIC_WR plan.
Operating rule 4 books water from the MVIC Phantom Reservoir (71_Call) back to the MVIC Bookover account in McPhee Reservoir. This operating rule triggers at the end of each time step and can limit the amount of MVIC direct flow rights stored in the reservoir based on storage under the Dolores Project storage right.

Operating rule 5 releases water temporarily stored in the MVIC Phantom Reservoir back to the Dolores River if there is not enough capacity in McPhee to book it back into the MVIC Bookover account because the storage space was filled with the Dolores Project storage rights.

McPhee Reservoir Operations

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	MVIC Dolores Tunnel Irrigation	1	30667.13116	27	Release to carrier
2	MVIC U Lateral Irrigation	1	30667.13116	27	Release to carrier
3	Towaoc Canal	2	1.00000	3	Release to carrier
4	Town of Cortez	4	30667.13116	3	Release to carrier
5	Montezuma Water Company	4	30667.13116	3	Release to carrier
6	Dove Creek Canal	3	1.00000	3	Release to carrier
7	McPhee Fish and Wildlife	5	45776.00001	2	Release diversion
8	McPhee to Target	All	99999.99999	9	Release to river by target
9-14	McPhee Bookover Acct	9	99999.99999	6	Reservoir bookover
15	McPhee Active Accounts	1-6	100000.00000	6	Reservoir bookover

Operating rules 1 and 2 deliver water from the MVIC project account in McPhee Reservoir to MVIC Dolores Tunnel irrigation demand (3204675) and MVIC U Lateral irrigation demand (3200772) via the Dolores Tunnel diversion on the Dolores River (7104675) and the U Lateral diversion on the Dolores River (7104674). These operations occur after deliveries of direct rights from the MVIC_WR plan and delivery of MVIC direct rights stored in McPhee.

Operating rule 3 delivers water from McPhee Reservoir to Towaoc Canal irrigation demand (3200884) through the Dolores Tunnel. Towaoc Canal has no decreed water rights and obtains all its water from McPhee Reservoir, therefore it has been given the senior water right.

Operating rules 4 and 5 deliver water from McPhee Reservoir to Cortez (3200680) and Montezuma Water Company (3202001) demands through the Dolores Tunnel. The administration numbers have been set just junior to direct water right deliveries.

Operating Rule 6 delivers water from McPhee Reservoir to Dove Creek Canal irrigation demand (3202006). Dove Creek Canal has no decreed water rights and obtains all its water from McPhee Reservoir therefore it has been given the senior water right.

Operating rule 7 delivers water from McPhee Reservoir to the Fish and Wildlife demand (7102999) on the Dolores River downstream of the reservoir.

Operating rule 8 releases water from all accounts, proportionally, to meet the historical end-of-month target values at McPhee Reservoir. For the Baseline data set, end-of-month targets for McPhee Reservoir are set to capacity, so releases to target are never made.

Individual accounts cannot carry-over water from year to year. After filling, stored water is pro-rated to each account. Operating rules 9 through 14 move water remaining in the individual ditch accounts to a common “bookover” account at the end of April when the reservoir has generally filled from runoff.

Operating rule 15 re-distributes the available storage to each individual ditch account based on their pro-rata share. This operation also occurs at the end of April.

Groundhog/Narraguinnep Reservoir Operations

Operatin

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	MVIC Dolores Tunnel	Groundhog - 1	30667.13117	27	Release to river to carrier
2	MVIC U Lateral	Groundhog - 1	30667.13117	27	Release to river to carrier
3	Groundhog Misc Users	Groundhog - 2	1.00000	1	Release to instream flow
4	Groundhog Target	Groundhog - 4	99999.99999	9	Release to river by target
5	MVIC U Lateral	Narraguinnep	30667.13118	3	Release to carrier

Operating rule 1 releases water from Groundhog Reservoir to the Dolores Tunnel (7104675o meet MVIC Dolores Tunnel irrigation demands (3204675). The administration numbers have been set just junior to the release from McPhee.

Operating rule 2 releases water from Groundhog Reservoir to MVIC U Lateral to meet MVIC U Lateral irrigation demands. The administration numbers have been set just junior to the release from McPhee.

Operating rule 3 is a simplified approach to operating the 2,300 acre-feet exchange between Groundhog Reservoir and miscellaneous water users on the Dolores River, whose demands is represented by an instream flow demand in July and August. It has been give the senior administration number.

Operating rule 4 releases water from all accounts, proportionally, to meet the historical end-of-month target values at Groundhog Reservoir. For the Baseline data set, end-of-month targets for Groundhog Reservoir are set to capacity, so releases to target are never made.

Operating rule 5 delivers water from Narraguinnep Reservoir to MVIC U Lateral irrigation demands. The administration number has been set just junior to Groundhog Reservoirs junior storage right.

5.9.4. Vallecito Reservoir

Vallecito Reservoir (3103518) is the principal feature of the Pine River Project, constructed by the USBR in the early 1940s. The project is managed by the Pine River Irrigation District and supplies water to late season irrigation demands. The reservoir capacity is 125,441 acre-feet.

The reservoir has a decreed storage right of 108,062 acre-feet and is modeled with a second "free" right to allow a second fill. One-sixth of the active storage is owned by the Southern Ute Indian Tribe. In addition, non-Indian ditches can only receive their acreage-prorated portion of available storage each year. For this reason, the reservoir is modeled with 19 active accounts.

Acct	Owner	Capacity (acre-feet)
1	Southern Ute Account	20,900
2	Farrell Ditch	500
3	McBride Ditch	167
4	Bennet-Myers Ditch	376
5	Myers-Asher Ditch	322
6	Wommer Ditch	685
7	Catlin Ditch	82
8	Bear Creek/Pine River D	1,212
9	Sullivan Ditch	980
10	Los Pinos Ditch	1,887
11	Thompson Epperson D	5,608
12	Schroder Ditch	8,777
13	Bean Ditch	363
14	King Ditch	20,060
15	Higbee Ditch	82
16	Island Ditch	47
17	Robert Morrison Ditch	16,288
18	Spring Creek Ditch	42,709
19	Dr. Morrison non-Indian	167

Note that some of the 18 non-Indian ditches are modeled together as diversion systems that irrigate common lands and have similar irrigation practices. Forty-four operating rules are used to simulate Vallecito Reservoir operations.

Right #	Destination	Account	Admin #	Right Type	Description
1	Farrel Ditch	2	51499.33238	2	Release to diversion
2	McBride Ditch	3	51499.33238	2	Release to diversion
3	Bennett-Myers Irr Ditch	4	51499.33238	2	Release to diversion
4	Myers and Asher Ditch	5	51499.33238	2	Release to diversion
5	Wommer Irrigation Ditch	6	51499.33238	2	Release to diversion

6	Catlin Ditch	7	51499.33238	2	Release to diversion
7	Bear Creek and Pine R Ditch	8	51499.33238	2	Release to diversion
8	Sullivan Ditch	9	51499.33238	2	Release to diversion
9	Los Pinos Irr Ditch	10	51499.33238	2	Release to diversion
10	Thompson-Epperson Ditch	11	51499.33238	2	Release to diversion
11	Schroder Irr Ditch	12	51499.33238	2	Release to diversion
12	Bean Ditch	13	51499.33238	2	Release to diversion
13	King Ditch	14	51499.33238	2	Release to diversion
14	Higbee Irrigation Ditch	15	51499.33238	2	Release to diversion
15	Island Ditch	16	51499.33238	2	Release to diversion
16	Robert Morrison Ditch	17	51499.33238	2	Release to diversion
17	Spring Creek Ditch	18	51499.33238	2	Release to diversion
18	Dr Morrison Ditch non-Indian	19	51499.33238	2	Release to diversion
19	Dr Morrison Indian	1	18536.00001	2	Release to diversion
20	Ceanaboo Ditch	1	6781.00001	2	Release to diversion
21	Spring Creek Ditch	1	6781.00001	2	Release to diversion
22	La Boca Ditch	1	6781.00001	2	Release to diversion
23	Severo Ditch	1	58215.00001	2	Release to diversion
24	Vallecito Target	All	99999.99999	9	Release to river by target
25 - 43	Bookover Account	21	99999.99999	6	Account Bookover
44	Active Accounts	1-19	100000.00000	6	Account Bookover

Operating rules 1 through 18 deliver project water to non-Indian owned ditches on the Pine River. These structures have all been assigned the same administration number just junior to the most junior direct flow right in the group. The King Ditch (310519) has a direct flow administration number of 51499.33237.

Operating rules 19 through 23 deliver project water to the Indian-owned ditches on the Pine River. These ditches hold the number one priority on the Los Pinos River, although they are modeled using their administration number according to the prior appropriation doctrine like any other water right in the model.

Operating rule 24 releases water to meet operational flood-control targets per USBR operations. The junior administration number insures this is the last operating rule to fire.

Individual accounts cannot carry-over water from year to year. Operating rules 25 through 43 move water remaining in the individual ditch accounts to a common “bookover” account at the end of April when the reservoir has generally filled from runoff.

Operating rule 44 re-distributes the available storage to each individual ditch account based on their pro-rata share. This operation also occurs at the end of April.

5.9.5. Lemon Reservoir

Lemon Reservoir (3003581), constructed by the USBR in the early 1960s as a part of the Colorado River Storage Project (CRSP), stores surplus water available during spring runoff months and releases for late season irrigation demands. The majority of the irrigated area is located on the Florida Mesa, adjacent to the Florida River. The reservoir has a total active capacity of 39,030 acre-feet, and decreed storage rights of 40,240 acre-feet and 7,760 acre-feet. Florida Project ditches can only receive their acreage-prorated portion of available storage each year. For this reason, the reservoir is modeled with 7 active accounts.

Acct	Owner	Capacity (acre-feet)
1	Harris_Patterson Ditch	183
2	Pioneer Ditch	547
3	McCluer-Murray Ditch	198
4	Banks-Tyner Ditch	410
5	Tyner-East/WestSide Ditch	182
6	Florida_Farmers Ditch	24,220
7	USA	13,290

The reservoir is maintained at a fairly constant level during the fall, with releases made in January, February, and March when necessary to provide flood control capacity. Releases from the reservoir are maintained below 1,000 cfs to protect the Florida River downstream. The U.S. Government has agreed to maintain a minimum streamflow of 4 cfs in the river below the dam downstream of the Florida Farmers Ditch.

Note that some of the project ditches are modeled together as diversion systems that irrigate common lands and have similar irrigation practices. Eighteen operating rules are used to simulate Vallecito Reservoir operations.

These operations are represented by eight operating rules.

Right #	Destination	Account	Admin #	Right Type	Description
1	Harris-Patterson Ditch	1	26974.22967	2	Release to diversion
2	Pioneer Ditch	2	26974.22967	2	Release to diversion
3	McCluer and Murray Ditch	3	26974.22967	2	Release to diversion
4	Banks-Tyner Ditch	4	26974.22967	2	Release to diversion

5	Tyner East Side Ditch	5	26974.22967	2	Release to diversion
6	Tyner West Side Ditch	5	26974.22967	2	Release to diversion
7	Florida Farmers/Florida Canal	6	35219.00001	2	Release to diversion
8	Lemon Minimum Release	7	51499.42186	1	Release to instream flow
9	Lemon Target	All	99999.99999	9	Release to river by target
10-15	Bookover Account	9	99999.99999	6	Account Bookover
16	Irrigation Accounts	1-6	100000.00000	6	Account Bookover

Operating rules 1 through 6 deliver water to project ditches on the Florida River. These structures have all been assigned the same administration number just junior to the most junior direct flow right in the group. The Tyner East Side Ditch (301243) has a direct flow administration number of 26974.22966.

Operating rule 7 releases water to Group B (Florida Farmers/Florida Canal) irrigation demand. The administration number for this group is just junior to the most junior direct flow right for both ditches. This administration number allows these ditches to receive water from direct flow rights before taking water from storage.

Operating rule 8 releases storage water from the USA account reservoir to meet the minimum streamflow.

Operating rule 9 releases water to meet operational targets per USBR operations. The junior administration number insures this is the last operating rule to fire.

Individual accounts cannot carry-over water from year to year. Operating rules 10 through 15 move water remaining in the individual ditch accounts to a common “bookover” account at the end of April when the reservoir has generally filled from runoff.

Operating rule 16 re-distributes the available storage to each individual ditch account based on their pro-rata share. This operation also occurs at the end of April.

5.9.6. Jackson Gulch Reservoir

Jackson Gulch Reservoir (3403589) is the principal feature of the Mancos Project, constructed by the USBR in the late 1940s. Jackson Gulch has a storage capacity of 9,977 acre-feet. The reservoir is filled by diversions from the Jackson Gulch Inlet Canal (3400535) located on the West Mancos River approximately 2.5 miles upstream from the reservoir. Some of the rights for the inlet canal were either transferred to the inlet canal from other irrigation ditches, or have decreed the canal as an alternate point of diversion.

Acct	Owner	Capacity (acre-feet)
1	Project	9,486
2	USA	200
3	Mesa_Verde	120
4	Inactive	167

Thirty-one operating rules are used to simulate Mancos Project operations:

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Jackson Gulch Reservoir	Jackson Inlet	31715.00000	11	Carrier to storage
2	Jackson Gulch Reservoir	Jackson Inlet	51499.44559	11	Carrier to storage
3	Jackson Gulch Reservoir	Jackson Inlet	14015.00000	11	Carrier to storage
4	Jackson Gulch Reservoir	Jackson Inlet	11093.00000	11	Carrier to storage
5	Jackson Gulch Reservoir	Jackson Inlet	11823.00000	11	Carrier to storage
6	Jackson Gulch Reservoir	Jackson Inlet	11489.00000	11	Carrier to storage
7	Jackson Gulch Reservoir	Jackson Inlet	9997.00000	11	Carrier to storage
8	Lee and Burke Ditch	1	36712.00001	2	Release to diversion
9	Webber Ditch	1	36712.00001	2	Release to diversion
10	Ratliff and Root Ditch	1	36712.00001	2	Release to diversion
11	Lee Ditch	1	36712.00001	2	Release to diversion
12	Frank Ditch	1	36712.00001	2	Release to diversion
13	Willis Ditch	1	36712.00001	2	Release to diversion
14	Boss Ditch	1	36712.00001	2	Release to diversion
15	No. 6 Ditch	1	36712.00001	2	Release to diversion
16	Sheek Ditch	1	36712.00001	2	Release to diversion
17	Beaver Ditch	1	36712.00001	2	Release to diversion
18	Henry Bolen Ditch	1	36712.00001	2	Release to diversion
19	Crystal Creek Ditch	1	36712.00001	4	Exchange to diversion
20	Long Park Ditch	1	36712.00001	4	Exchange to diversion
21	Smouse Ditch	1	36712.00001	4	Exchange to diversion
22	Williams Ditch	1	36712.00001	4	Exchange to diversion
23	East Mancos Highline D.	1	36712.00001	4	Exchange to diversion
24	Rush Reservoir Ditch	1	36712.00001	4	Exchange to diversion
25	Weber Reservoir Inlet D	1	36712.00001	4	Exchange to diversion
26	Town of Mancos Ditch	1	36712.00001	2	Release to diversion

27	Carpenter and Mitchell	1	36712.00001	3	Release to carrier
28	34_ADS012	1	36712.00001	2	Release to diversion
29	34_ADS013	1	36712.00001	2	Release to diversion
30	34_ADS014	1	36712.00001	2	Release to diversion
31	Jackson Gulch Target	All	99999.99999	9	Release to river by target

Operating rules 1 through 7 fill the reservoir through direct flow rights from the West Mancos River at structure 3400535.

Operating rules 8 through 18, rule 26, and rules 28 through 30 release water for downstream irrigation demands. Rules 19 through 25 provide reservoir water by exchange. All reservoir releases were assigned a single administration number just junior to the most junior direct flow rights in the group. The Ratliff and Root Ditch has a direct flow administration number of 36712.00000.

Operating rule 27 supplies water to the Carpenter and Mitchell Ditch on Chicken Creek through a carrier ditch. The Carpenter and Mitchell Ditch (3400508) is located on Chicken Creek, a tributary to the Mancos River. It actually receives Jackson Gulch water via a relatively small reservoir and carrier ditch not explicitly modeled. For simplicity, this structure is modeled to receive project water directly from Jackson Gulch Reservoir.

Operating rule 31 releases water from all accounts, proportionally, to meet the historical end-of-month target values at Jackson Gulch Reservoir. For the Baseline data set, end-of-month targets for Jackson Gulch Reservoir are set to capacity, so releases to target are never made.

5.9.7. Cascade Reservoir

Cascade Reservoir (3000523) is the principal feature of the Tacoma Project and is owned and operated by Public Service Company of Colorado. The reservoir is located on Elbert Creek, a tributary to the Animas River. The principal source of supply for the reservoir is transbasin water diverted from Big Cascade Creek via the Cascade Canal (3000523). Non-consumptive releases for power are made through Power Canal No. 1 (3000612). Cascade Reservoir is modeled with one active account.

Acct	Owner	Capacity (acre-feet)
1	Project	22,364
2	Inactive	1,100

Four operating rules are used to simulate Cascade Reservoir operations:

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Cascade Reservoir	Cascade Canal	26974.19267	11	Carrier to reservoir
2	Power Canal No 1	Cascade Canal	26974.19266	11	Carrier to diversion
3	Power Canal No 1	Cascade Reservoir	26974.19268	2	Release to diversion
4	Cascade to Target	All	99999.99999	9	Release to river by target

Operating rule 1 diverts water through the Cascade Canal to the reservoir for storage.

Operating rule 2 diverts water through the Cascade Canal directly to meet the Power Canal demands. This rule ties the inflow to the reservoir directly to the outlet works of the reservoir.

Operating rule 3 releases water in Cascade Reservoir to meet the Power Canal demands. The administration number for this rule is just junior to the direct flow delivered in operating rule 2. This assures that demands are met from direct diversions prior to releasing water from storage.

Operating rule 4 releases water from all accounts, proportionally, to meet the historical end-of-month target values at Cascade Reservoir. For the Baseline data set, end-of-month targets for Cascade Reservoir are set to capacity, so releases to target are never made.

5.9.8. Naturita Canal and Gurley Reservoir

Gurley Reservoir (6003507) is located on a tributary to the San Miguel River and is used to provide supplemental irrigation to over 15,000 acres in the area near Norwood, Colorado. The reservoir has an active capacity of about 9,540 acre-feet. It has a small tributary drainage area and receives most of its supply via the Naturita Canal (6000707). Because Naturita Canal diverts water both directly to irrigation and for storage in Gurley, the irrigation demand is represented separately under structure 6000707_I and Naturita Canal is modeled as a carrier. Gurley Reservoir has one active irrigation account.

Acct	Owner	Capacity (acre-feet)
1	Irrigation	9,539
2	Dead Pool	500

Twenty operating rules are used to simulate Naturita Canal and Gurley Reservoir operations:

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Naturita Irrigation	Naturita Canal	12570.00000	45	Carrier to irrigation w/ loss
2	Naturita Irrigation	Naturita Canal	20889.00000	45	Carrier to irrigation w/ loss

3	Naturita Irrigation	Naturita Canal	23681.20889	45	Carrier to irrigation w/ loss
4	Naturita Irrigation	Naturita Canal	23681.23212	45	Carrier to irrigation w/ loss
5	Naturita Irrigation	Naturita Canal	23681.23215	45	Carrier to irrigation w/ loss
6	Naturita Irrigation	Naturita Canal	28911.28052	45	Carrier to irrigation w/ loss
7	Naturita Irrigation	Naturita Canal	30604.30604	45	Carrier to irrigation w/ loss
8	Naturita Irrigation	Naturita Canal	32811.31726	45	Carrier to irrigation w/ loss
9	Naturita Irrigation	Naturita Canal	52595.12570	45	Carrier to irrigation w/ loss
10	Gurley Reservoir	Naturita Canal	12570.00000	45	Carrier to storage w/ loss
11	Gurley Reservoir	Naturita Canal	20889.00000	45	Carrier to storage w/ loss
12	Gurley Reservoir	Naturita Canal	23681.20889	45	Carrier to storage w/ loss
13	Gurley Reservoir	Naturita Canal	23681.23212	45	Carrier to storage w/ loss
14	Gurley Reservoir	Naturita Canal	23681.23215	45	Carrier to storage w/ loss
15	Gurley Reservoir	Naturita Canal	28911.28052	45	Carrier to storage w/ loss
16	Gurley Reservoir	Naturita Canal	30604.30604	45	Carrier to storage w/ loss
17	Gurley Reservoir	Naturita Canal	32811.31726	45	Carrier to storage w/ loss
18	Gurley Reservoir	Naturita Canal	52595.12570	45	Carrier to storage w/ loss
19	Naturita Irrigation	Gurley Reservoir	52595.12571	2	Release to diversion
20	Gurley to Target	All	99999.99999	9	Release to river by target

Operating rules 1 through 9 carry water from Naturita Canal to meet Naturita Irrigation demands using the nine water rights of the Naturita Canal. A conveyance loss of 20 percent is assigned to the operating rules. The canal loss returns back to the river based on the return flow location and timing set for the Naturita Canal in the direct diversion (*.dds) file.

Operating rules 10 through 8 carry water from Naturita Canal to fill Gurley Reservoir using the nine water rights of the Naturita Canal if there is water available in priority after meeting irrigation demands. A conveyance loss of 20 percent is assigned to the operating rules. The canal loss returns back to the river based on the return flow location and timing set for the Naturita Canal in the direct diversion (*.dds) file.

Operating rule 19 releases water from Gurley Reservoir to meet Naturita Canal irrigation demands. The administration number for this rule is just junior to Naturita Canal's most junior right. This assures that demands are met from direct diversions prior to releasing water from storage.

Operating rule 20 releases water from all accounts, proportionally, to meet the historical end-of-month target values at Gurley Reservoir. For the Baseline data set, end-of-month targets for Gurley Reservoir are set to capacity, so releases to target are never made.

5.9.9. Lilylands Canal and Reservoir

Lilylands Reservoir (6003510) is located on a tributary to the San Miguel River and is used to provide supplemental irrigation to approximately 2,300. The reservoir has an active capacity of about 1,840 acre-feet. It has a small tributary drainage area and receives most of its supply via Lilylands Canal (6000670). Because Lilyands Canal diverts water both directly to irrigation and for storage in Lilylands Reservoir, the irrigation demand is represented separately under structure 6000670_I and Lilylands Canal is modeled as a carrier. Lilylands Reservoir has one active irrigation account.

Acct	Owner	Capacity (acre-feet)
1	Irrigation	494

Eighteen operating rules are used to simulate Lilylands Canal and Lilylands Reservoir operations:

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Lilylands Irrigation	Lilylands Canal	13060.00000	45	Carrier to irrigation w/ loss
2	Lilylands Irrigation	Lilylands Canal	13453.00000	45	Carrier to irrigation w/ loss
3	Lilylands Irrigation	Lilylands Canal	13704.00000	45	Carrier to irrigation w/ loss
4	Lilylands Irrigation	Lilylands Canal	14156.00000	45	Carrier to irrigation w/ loss
5	Lilylands Irrigation	Lilylands Canal	18478.00000	45	Carrier to irrigation w/ loss
6	Lilylands Irrigation	Lilylands Canal	24379.23212	45	Carrier to irrigation w/ loss
7	Lilylands Irrigation	Lilylands Canal	30604.28053	45	Carrier to irrigation w/ loss
8	Lilylands Irrigation	Lilylands Canal	30604.29766	45	Carrier to irrigation w/ loss
9	Lilylands Reservoir	Lilylands Canal	13060.00000	45	Carrier to storage w/ loss
10	Lilylands Reservoir	Lilylands Canal	13453.00000	45	Carrier to storage w/ loss
11	Lilylands Reservoir	Lilylands Canal	13704.00000	45	Carrier to storage w/ loss
12	Lilylands Reservoir	Lilylands Canal	14156.00000	45	Carrier to storage w/ loss
13	Lilylands Reservoir	Lilylands Canal	18478.00000	45	Carrier to storage w/ loss
14	Lilylands Reservoir	Lilylands Canal	24379.23212	45	Carrier to storage w/ loss
15	Lilylands Reservoir	Lilylands Canal	30604.28053	45	Carrier to storage w/ loss
16	Lilylands Reservoir	Lilylands Canal	30604.29766	45	Carrier to storage w/ loss
17	Lilylands Irrigation	Lilylands Reservoir	30604.29767	2	Release to Diversion
18	Lilylands to Target	All	99999.99999	9	Carrier to storage w/ loss

Operating rules 1 through 8 carry water from Lilylands Canal to meet Lilylands Canal Irrigation demands using the eight water rights of the Lilylands Canal. A conveyance loss of 20 percent is assigned to the operating rules. The canal loss returns back to the river based on the return flow location and timing set for the Lilylands Canal in the direct diversion (*.dds) file.

Operating rules 9 through 16 carry water from Lilylands Canal to storage in Lilylands Reservoir using the nine water rights of the Lilylands Canal if there is water available in priority after meeting irrigation demands. A conveyance loss of 20 percent is assigned to the operating rules. The canal loss returns back to the river based on the return flow location and timing set for the Lilylands Canal in the direct diversion (*.dds) file.

Operating rule 17 releases water from Lilylands Reservoir to meet Lilylands Canal irrigation demands. The administration number for this rule is just junior to Lilylands Canal's most junior right. This assures that demands are met from direct diversions prior to releasing water from storage.

Operating rule 18 releases water from all accounts, proportionally, to meet the historical end-of-month target values at Lilylands Reservoir. For the Baseline data set, end-of-month targets for Lilylands Reservoir are set to capacity, so releases to target are never made.

5.9.10. Lone Cone Canal and Reservoir

Lone Cone Reservoir (6003511) is located on a tributary to the San Miguel River and is used to provide supplemental irrigation to approximately 350 acres. The reservoir has an active capacity of about 1,840 acre-feet. It has a small tributary drainage area and receives most of its supply via Lone Cone Ditch (6000672). Because the Lone Cone Ditch diverts water both directly to irrigation and for storage in Lone Cone Reservoir, the irrigation demand is represented separately under structure 6000672_I and Lone Cone Ditch is modeled as a carrier. Lone Cone Reservoir has one active irrigation account.

Acct	Owner	Capacity (acre-feet)
1	Irrigation	1,840

Twenty-two operating rules are used to simulate Lone Cone Ditch and Lone Cone Reservoir operations:

Right #	Destination	Account or Carrier	Admin #	Right Type	Description
1	Lone Cone Irrigation	Lone Cone Ditch	14549.00000	45	Carrier to irrigation w/ loss
2	Lone Cone Irrigation	Lone Cone Ditch	14914.00000	45	Carrier to irrigation w/ loss
3	Lone Cone Irrigation	Lone Cone Ditch	15279.00000	45	Carrier to irrigation w/ loss
4	Lone Cone Irrigation	Lone Cone Ditch	15645.00000	45	Carrier to irrigation w/ loss

5	Lone Cone Irrigation	Lone Cone Ditch	16375.00000	45	Carrier to irrigation w/ loss
6	Lone Cone Irrigation	Lone Cone Ditch	19073.00000	45	Carrier to irrigation w/ loss
7	Lone Cone Irrigation	Lone Cone Ditch	22621.00000	45	Carrier to irrigation w/ loss
8	Lone Cone Irrigation	Lone Cone Ditch	23681.14092	45	Carrier to irrigation w/ loss
9	Lone Cone Irrigation	Lone Cone Ditch	30604.28053	45	Carrier to irrigation w/ loss
10	Lone Cone Irrigation	Lone Cone Ditch	43829.41532	45	Carrier to irrigation w/ loss
11	Lone Cone Reservoir	Lone Cone Ditch	14549.00000	45	Carrier to storage w/ loss
12	Lone Cone Reservoir	Lone Cone Ditch	14914.00000	45	Carrier to storage w/ loss
13	Lone Cone Reservoir	Lone Cone Ditch	15279.00000	45	Carrier to storage w/ loss
14	Lone Cone Reservoir	Lone Cone Ditch	15645.00000	45	Carrier to storage w/ loss
15	Lone Cone Reservoir	Lone Cone Ditch	16375.00000	45	Carrier to storage w/ loss
16	Lone Cone Reservoir	Lone Cone Ditch	19073.00000	45	Carrier to storage w/ loss
17	Lone Cone Reservoir	Lone Cone Ditch	22621.00000	45	Carrier to storage w/ loss
18	Lone Cone Reservoir	Lone Cone Ditch	23681.14092	45	Carrier to storage w/ loss
19	Lone Cone Reservoir	Lone Cone Ditch	30604.28053	45	Carrier to storage w/ loss
20	Lone Cone Reservoir	Lone Cone Ditch	43829.41532	45	Carrier to storage w/ loss
21	Lone Cone Irrigation	Lone Cone Reservoir	43829.41533	2	Release to diversion
22	Lone Cone to Target	All	99999.99999	9	Release to target

Operating rules 1 through 10 carry water from Lone Cone Ditch to meet Lone Cone Irrigation demands using the ten water rights of the Lone Cone Ditch. A conveyance loss of 20 percent is assigned to the operating rules. The canal loss returns back to the river based on the return flow location and timing set for the Lone Cone Ditch in the direct diversion (*.dds) file.

Operating rules 11 through 20 carry water from Lone Cone Ditch to storage in Lone Cone Reservoir using the nine water rights of the Lone Cone Ditch if there is water available in priority after meeting irrigation demands. A conveyance loss of 20 percent is assigned to the operating rules. The canal loss returns back to the river based on the return flow location and timing set for the Lone Cone Ditch in the direct diversion (*.dds) file.

Operating rule 21 releases water from Lone Cone Reservoir to meet Lone Cone Ditch irrigation demands. The administration number for this rule is just junior to Lone Cone Ditch's most junior right. This assures that demands are met from direct diversions prior to releasing water from storage.

Operating rule 22 releases water from all accounts, proportionally, to meet the historical end-of-month target values at Lone Cone Reservoir. For the Baseline data set, end-of-month targets for Lone Cone Reservoir are set to capacity, so releases to target are never made.

5.9.11. Trout Lake and Lake Hope

Trout Lake (6003527) and Lake Hope (6003509) reservoirs are used together by the Public Service Company of Colorado for power generation at the Ames and Nucla power plants (6000511 and 60o0723). Trout Lake delivers storage water to both plants. The Ames plant also receives storage water from Lake Hope in late summer and fall. Trout Lake is modeled with an active and dead pool, and Lake Hope has an active pool only.

Reservoir	Acct	Owner	Capacity (acre-feet)
Trout Lake	1	Active	2,504
Trout Lake	2	Dead Pool	918
Lake Hope	1	Active	1,037

Five operating rules are used to simulate Trout Lake and Lake Hope power operations:

Right #	Destination	Reservoir	Admin #	Right Type	Description
1	Ames Power	Trout	30604.15158	2	Release to diversion
2	Ames Power	Hope	30604.15159	2	Release to diversion
3	Nucla Power	Trout	38468.00001	2	Release to diversion
4	Lake Hope to Target	Hope	99999.99999	9	Release to river by target
5	Trout Lake to Target	Trout	99999.99999	9	Release to river by target

Operating rule 1 releases water from Trout Lake to satisfy demands at Ames power plant. The administration number assigned is just senior to releases to Ames from Lake Hope.

Operating rule 2 releases water from Lake Hope to satisfy demands at Ames power plant. The administration number for this rule is just junior to the Ames power plant direct diversion right.

Operating rules 3 releases water from Trout Lake to satisfy demands at Nucla Power Plant. The administration number for this rule is junior to Nucla’s direct diversion rights.

Operating rules 4 and 5 releases water from all accounts, proportionally, to meet the historical end-of-month target values at Lake Hope and Trout Lake, respectively. For the Baseline data set, end-of-month targets for Lake Hope are set to capacity, so releases to target are never made.

5.9.12. Multistructures Irrigating the Same Acreage

Several parcels of irrigated land in the San Juan and Dolores River basins receive irrigation water from multiple diversion structures often on different tributaries. The historical diversions at these multiple structures are modeled at their respective historical headgate locations for baseflow generation and the Historical calibration (see Section 7). In the Baseline data set, total demand for these lands are assigned to a primary structure, and diversions from the individual headgates are driven by operating rules. The sources for each operating rule are the direct flow rights at each structure. Forty operating rules are used to simulate multistructure operations. Multistructures in the San Juan Model are presented in Appendix A.

Where to find more information

- Appendix A-1 lists the diversion systems and mult-structures represented in the San Juan Model.
- Appendix A-2 describes the process for identifying and modeling diversion systems and multi-structures.

6. Baseline Results

The "Baseline" data set simulates current demands, current infrastructure and projects, and the current administrative environment, as though they had been in place throughout the modeled period. This section summarizes the state of the river as the San Juan Model characterizes it, under these assumptions.

6.1 Baseline Streamflows

Table 6.1 shows the average annual flow from the Baseline simulation for each gage, based on the entire simulation period (1909 through 2013). In general, this value is lower than the historical average, because demand has risen and the development of storage has re-timed the supply so that more of the demand can be met. The second value in the table is the average annual available flow, as identified by the model. Available flow at a point is water that is not needed to satisfy instream flows or downstream diversion demand; it represents the water that could be diverted by a new water right. The available flow is always less or the same as the total simulated flow.

The Baseline data set, and corresponding results, does not include any consideration for Colorado River Compact obligations, nor are conditional water rights represented in the Baseline data set. The La Plata Compact obligations, however, are represented in the simulation. Variations of the Baseline data set could include conditional rights within the San Juan and Dolores basins, and would likely result in less available flow than presented here.

Temporal variability of the historical and Baseline simulated flows is illustrated in Figures 6.1 through 6.10 for selected gages. Each figure shows two graphs: overlain hydrographs of historical gage flow, simulated gage flow, and simulated available flow for 1975 through 2013; and an average annual hydrograph based on the same period. The annual hydrograph is a plot of monthly average flow values, for the three parameters. The gages selected for these figures have a fairly complete record between 1975 and 2013.

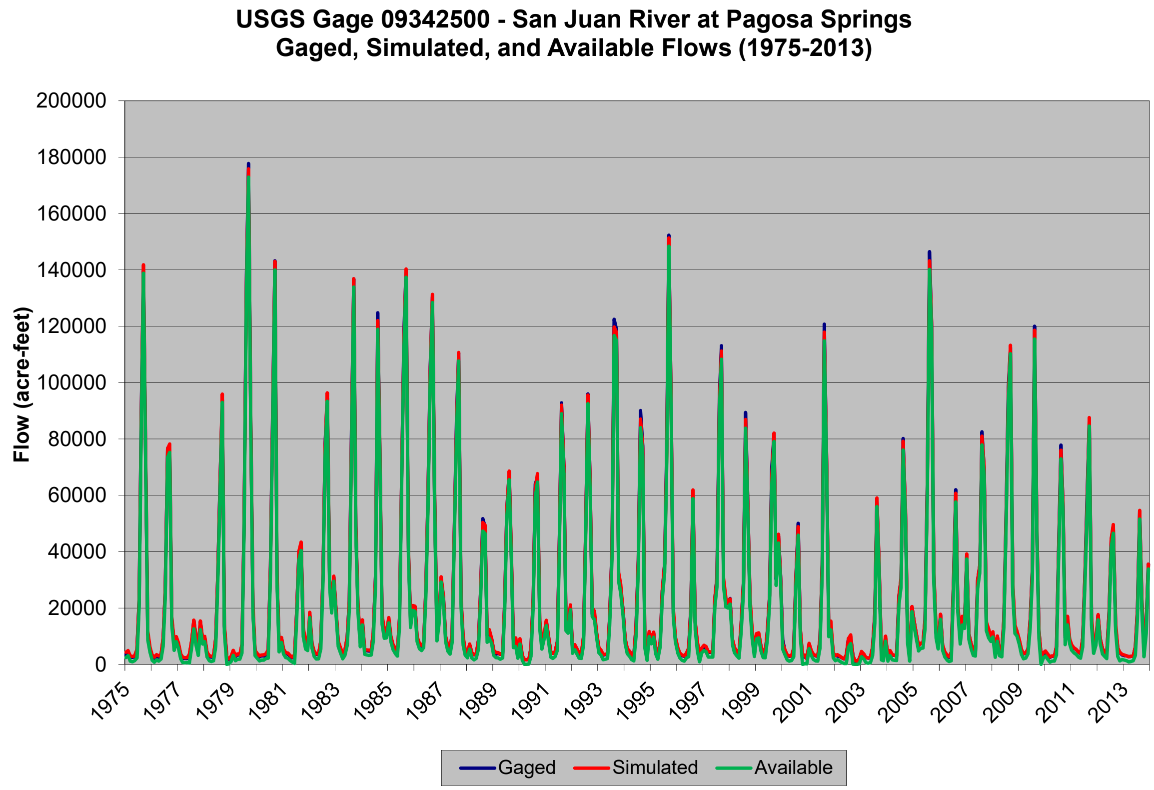
Baseline flows are generally lower than historical flows during the irrigation season largely due to increased diversions required to meet the higher Baseline demands.

On the Los Pinos River, average monthly simulated flows exceed historical gaged flows during the irrigation season. This flow represents return flows as a result of increased use of Vallecito storage water to meet Baseline demands. Similarly, average monthly simulated and available flows on McElmo Creek exceed historical gaged flows during the irrigation season. This flow represents return flows from increased use associated with the Dolores Project. These increased return flows are available for downstream use.

Table 6.1
Simulated and Available Baseline Average Annual Flows for San Juan Model Gages (1909-2013)

Gage ID	Gage Name	Simulated Flow (af)	Simulated Available Flow (af)
09339900	East Fork San Juan River above Sand Creek	66,024	63,619
09341500	West Fork San Juan River near Pagosa Springs	116,978	101,363
09342000	Turkey Creek near Pagosa Springs	28,158	27,934
09342500	San Juan River at Pagosa Springs	282,672	252,529
09343000	Rio Blanco near Pagosa Springs	66,055	1,678
09343300	Rio Blanco bl Blanco Diversion Dam nr Pagosa Sprgs	20,955	2,320
09344000	Navajo River at Banded Peak Ranch near Chromo	80,634	13,556
09344400	Navajo River below Oso Diversion Dam nr Chromo	86,198	47,075
09345200	Little Navajo River bl Oso Diversion Dam nr Chromo	5,139	2,792
09346000	Navajo River at Edith	96,495	60,481
09346400	San Juan River near Carracas	459,696	459,696
09347500	Piedra River at Bridge Ranger Sta. near Pagosa Sprgs	80,106	60,893
09349500	Piedra River near Piedra	242,854	163,997
09349800	Piedra River near Arboles	285,954	246,349
09352900	Vallecito Creek near Bayfield	107,616	42,599
09353500	Los Pinos River near Bayfield	271,443	93,308
09354000	Los Pinos River at Bayfield	139,944	138,213
09354500	Los Pinos River at La Boca	183,083	183,083
09355000	Spring Creek at La Boca	23,477	23,477
09357500	Animas River at Howardsville	77,967	70,030
09359000	Mineral Creek near Silverton	72,115	64,172
09359500	Animas River at Tall Timber Resort above Tacoma	409,363	268,842
09361000	Hermosa Creek near Hermosa	95,675	69,619
09361200	Falls Creek near Durango	1,231	1,156
09361400	Junction Creek near Durango	15,120	8,926
09361500	Animas River at Durango	596,621	287,364
09362750	Florida River above Lemon Reservoir	62,488	1,974
09363200	Florida River at Bondad	51,148	39,141
09363500	Animas River near Cedar Hill, NM	681,598	675,497
09365500	La Plata River at Hesperus	28,826	6,151

Gage ID	Gage Name	Simulated Flow (af)	Simulated Available Flow (af)
LONREDCO	Long Hollow at the Mouth near Red Mesa	5,694	3,637
09366500	La Plata River at CO-NM State Line	22,561	22,561
09369500	Middle Mancos River near Mancos	4,761	4,001
09369000	East Mancos River near Mancos	7,387	4,583
09368500	West Mancos River near Mancos	27,358	8,520
09371000	Mancos River near Towaoc	31,581	30,525
09371400	Hartman Draw at Cortez	7,385	6,960
09371420	McElmo Creek above Alkali Canyon near Cortez	20,397	19,009
09371520	McElmo Creek above Trail Canyon near Cortez	43,057	27,829
09372000	McElmo Creek near CO-UT State Line	41,587	41,587
09165000	Dolores River below Rico	102,529	36,292
09166500	Dolores River at Dolores	321,149	79,067
09166950	Lost Canyon Creek near Dolores	10,988	5,258
09168100	Disappointment Creek near Dove Creek	15,447	11,027
09169500	Dolores River at Bedrock	189,094	137,725
09171100	Dolores River near Bedrock	192,609	146,838
09171200	San Miguel River near Telluride	51,091	34,581
09172000	Fall Creek near Fall Creek	14,704	10,070
09172100	Leopard Creek at Noel	1,330	579
09172500	San Miguel River near Placerville	171,556	88,467
09173000	Beaver Creek near Norwood	3,480	2,291
09175500	San Miguel River at Naturita	210,503	127,203
09177000	San Miguel River at Uravan	237,503	144,861
09179500	Dolores River at Gateway	486,189	486,189



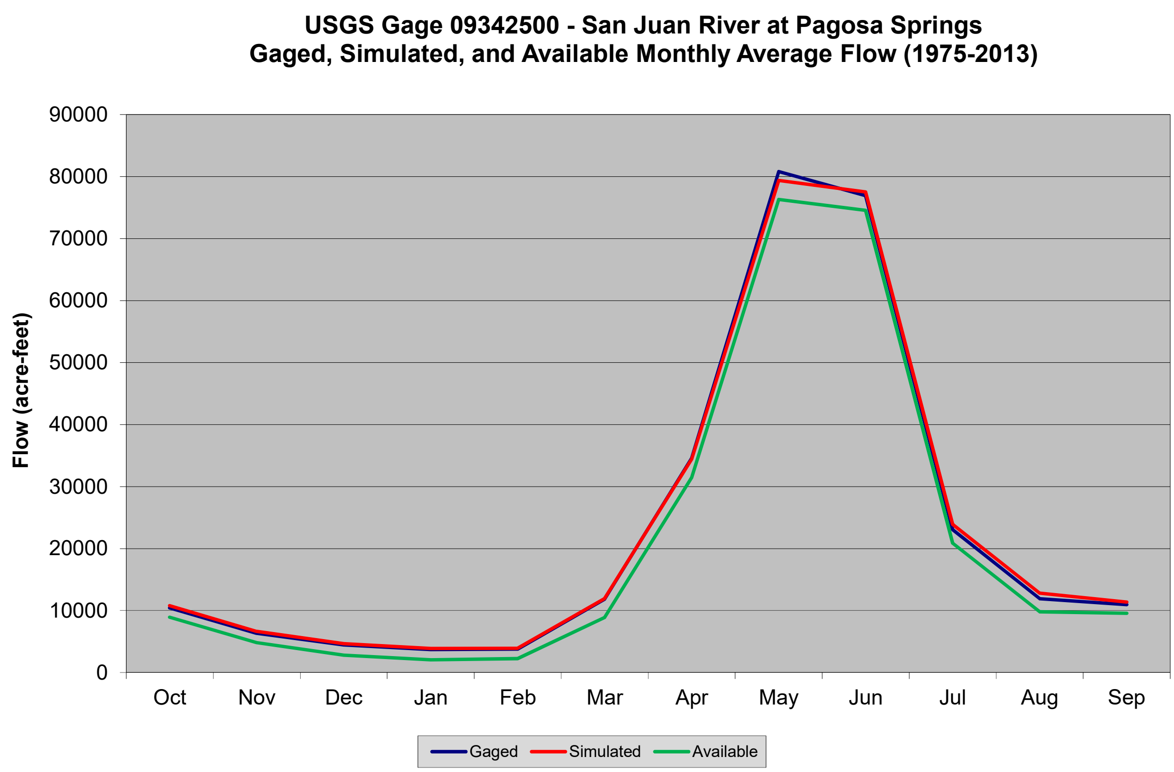
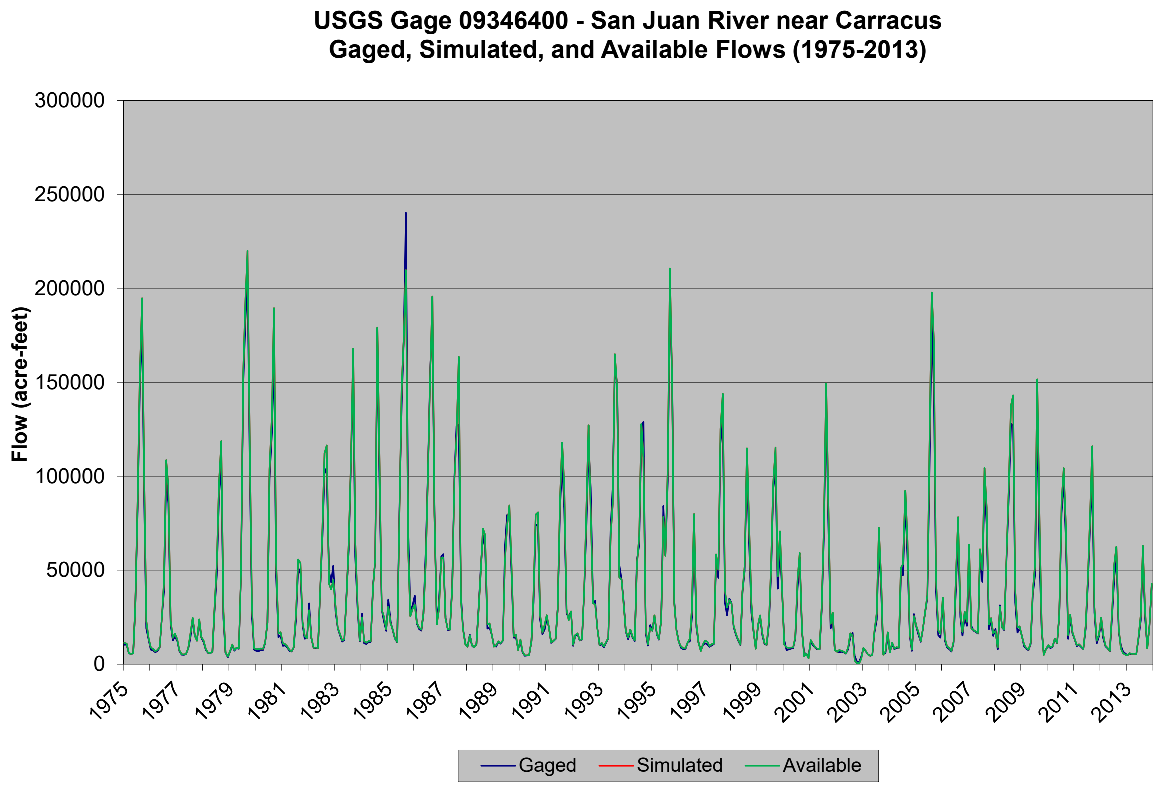


Figure 6.1 Baseline Results – San Juan River at Pagosa Springs



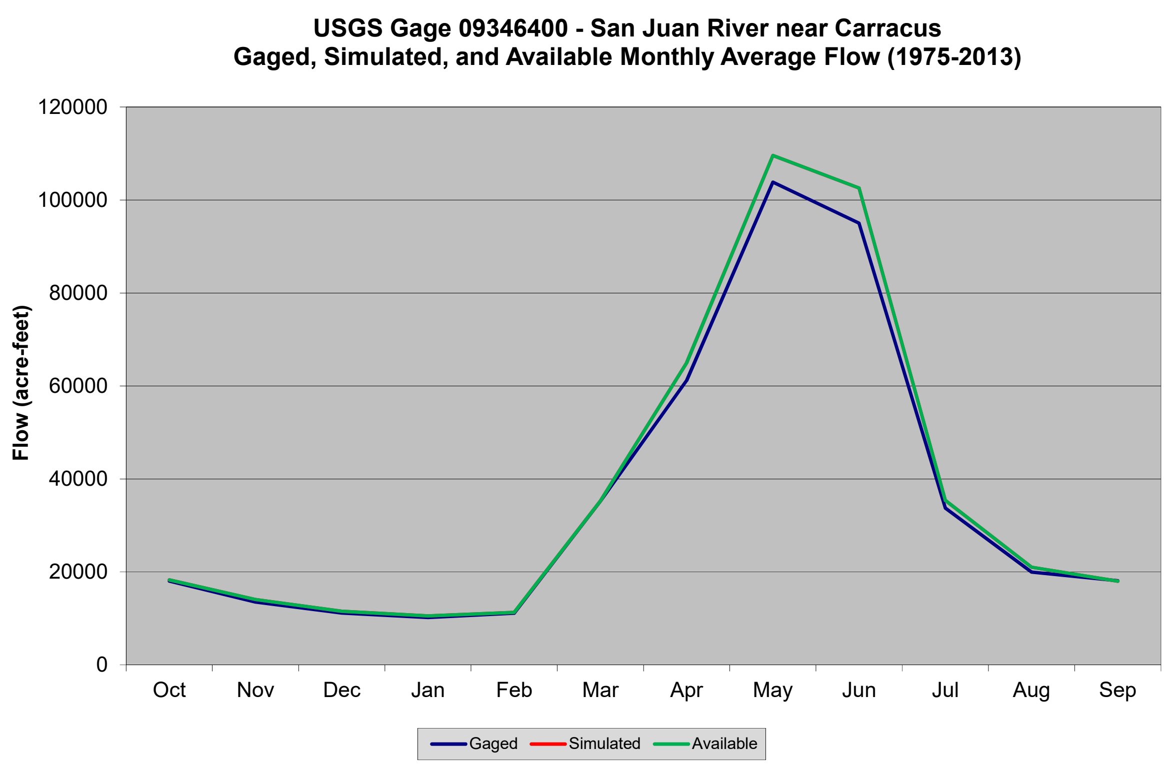
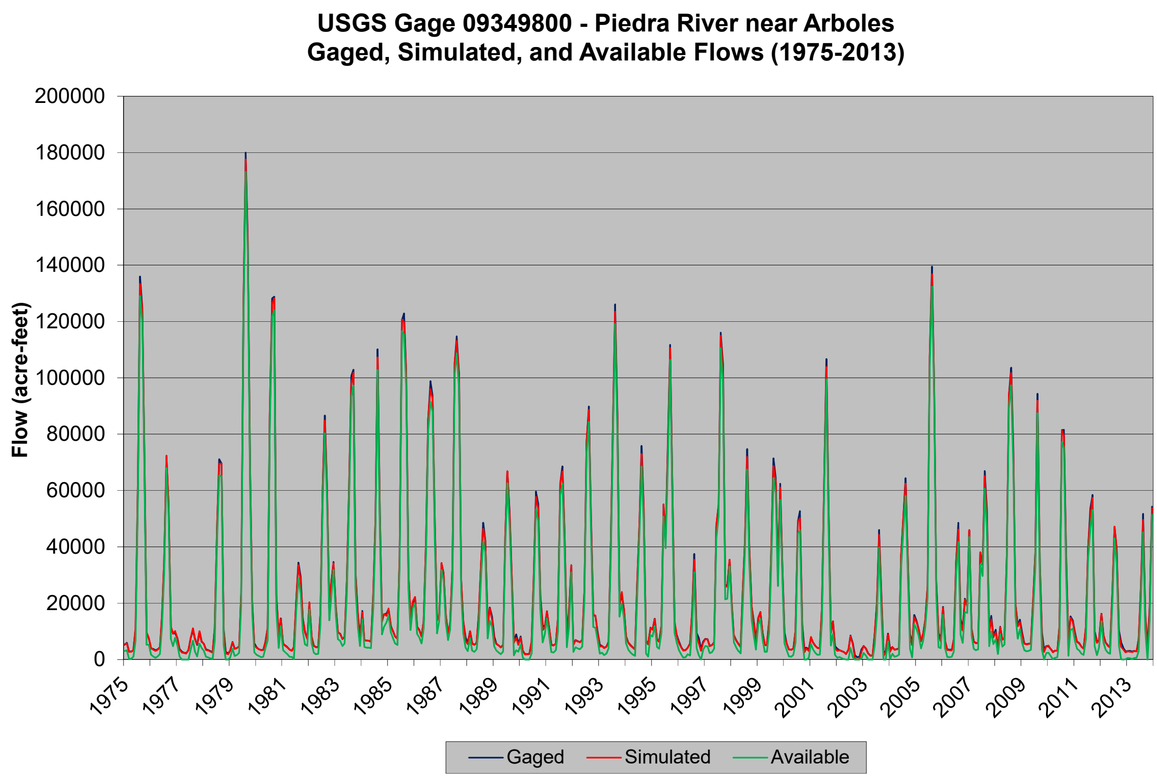


Figure 6.2 Baseline Results – San Juan River near Carracus



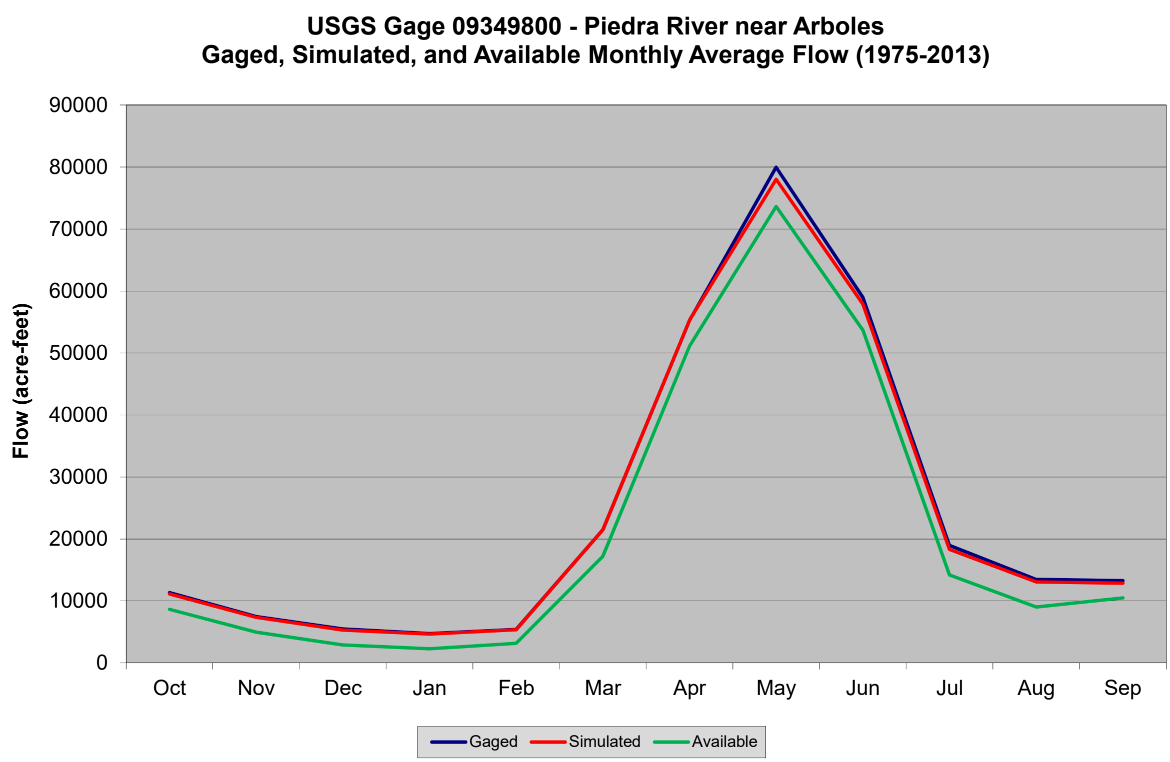
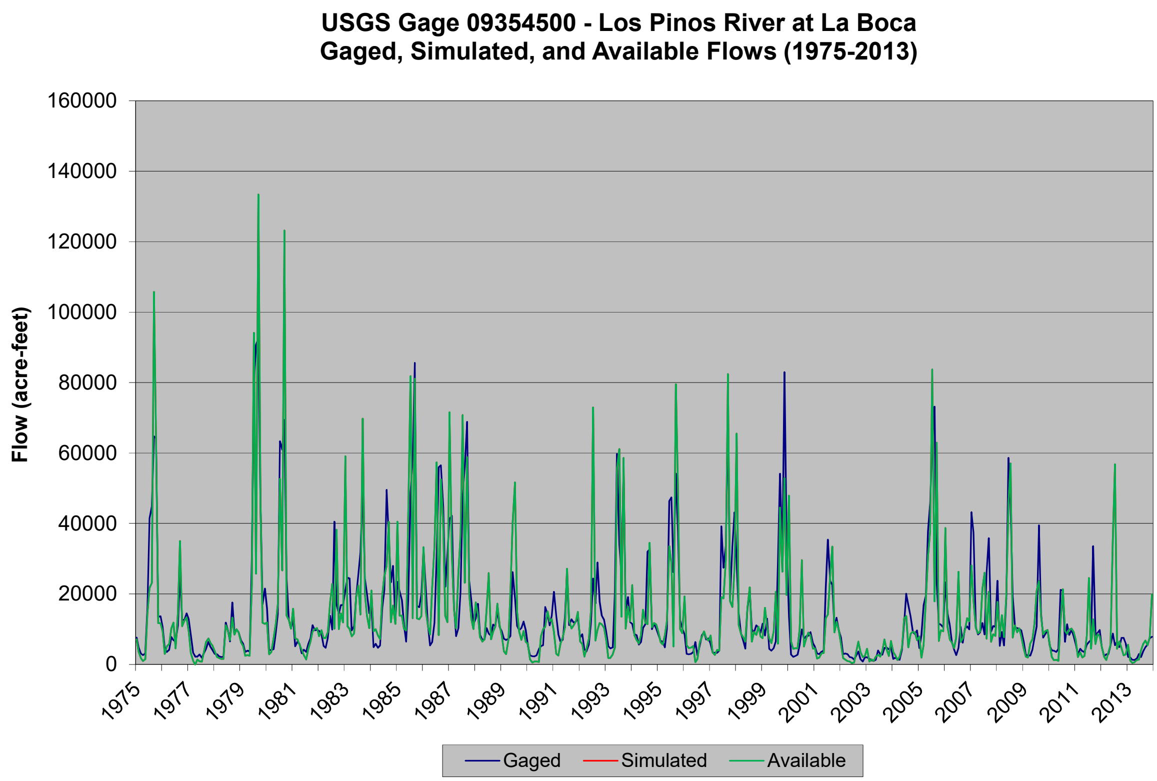


Figure 6.3 Baseline Results – Piedra River near Arboles



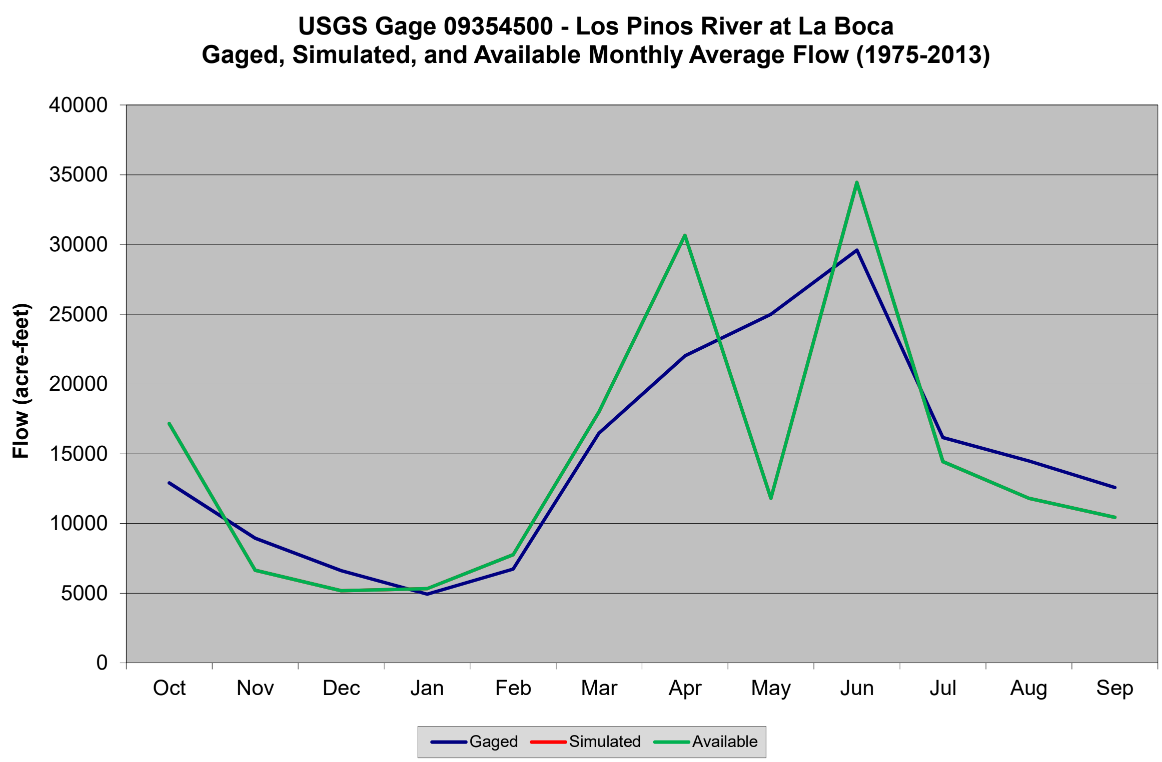
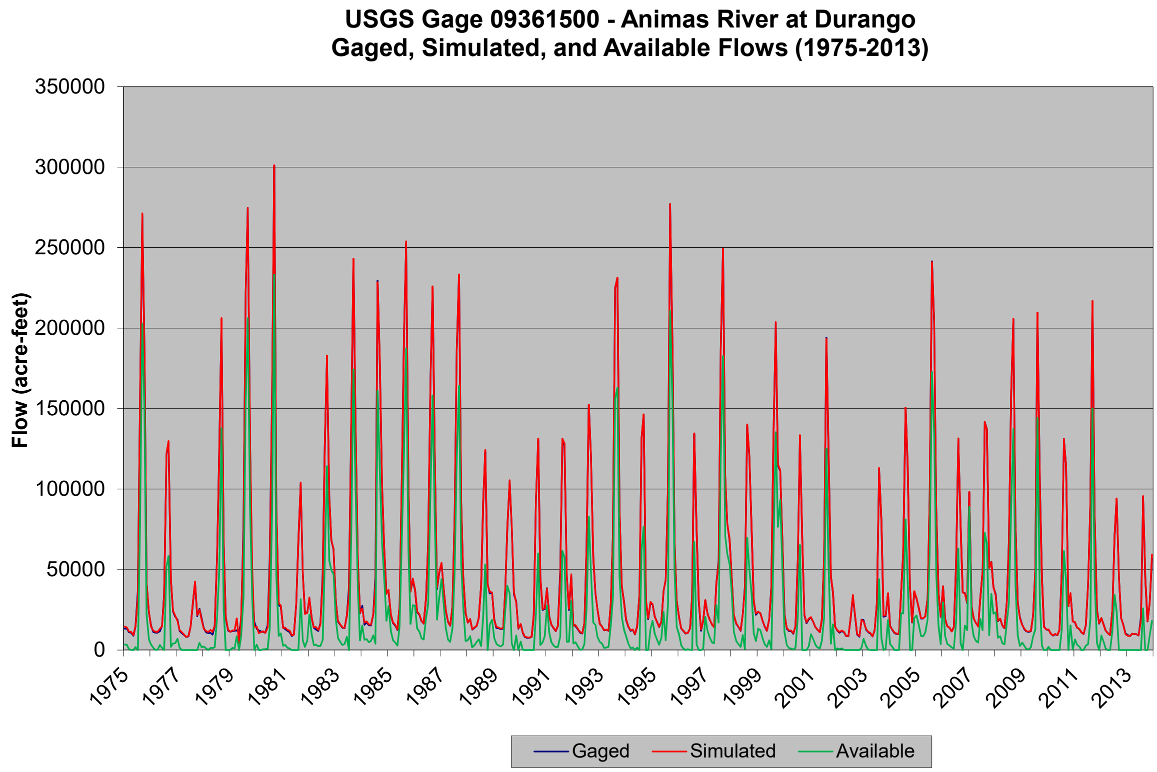


Figure 6.4 Baseline Results – Los Pinos River at La Boca



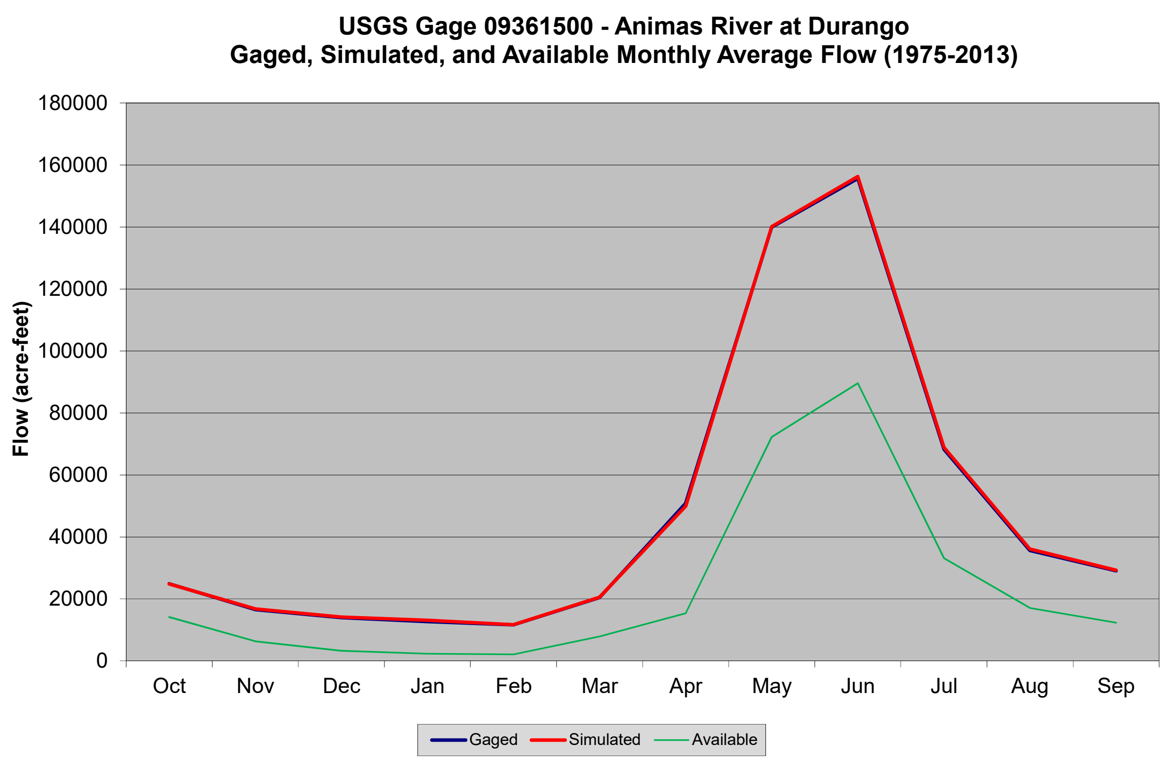
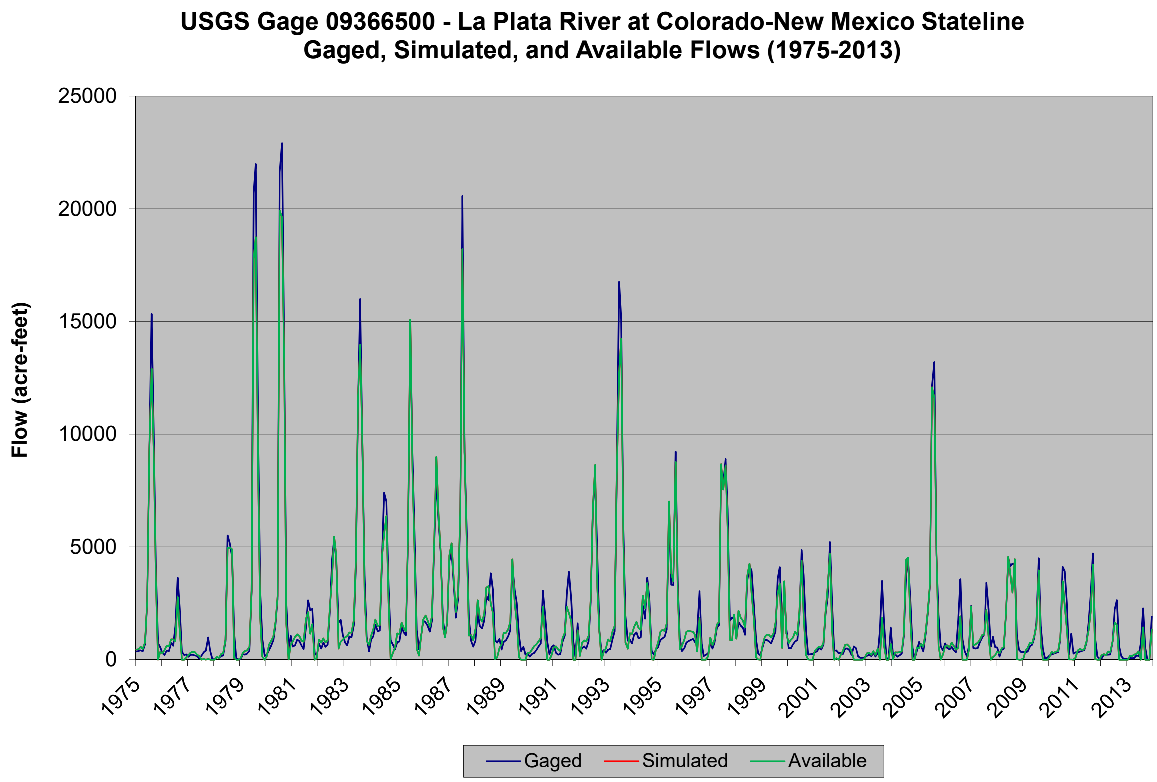


Figure 6.5 Baseline Results – Animas River at Durango



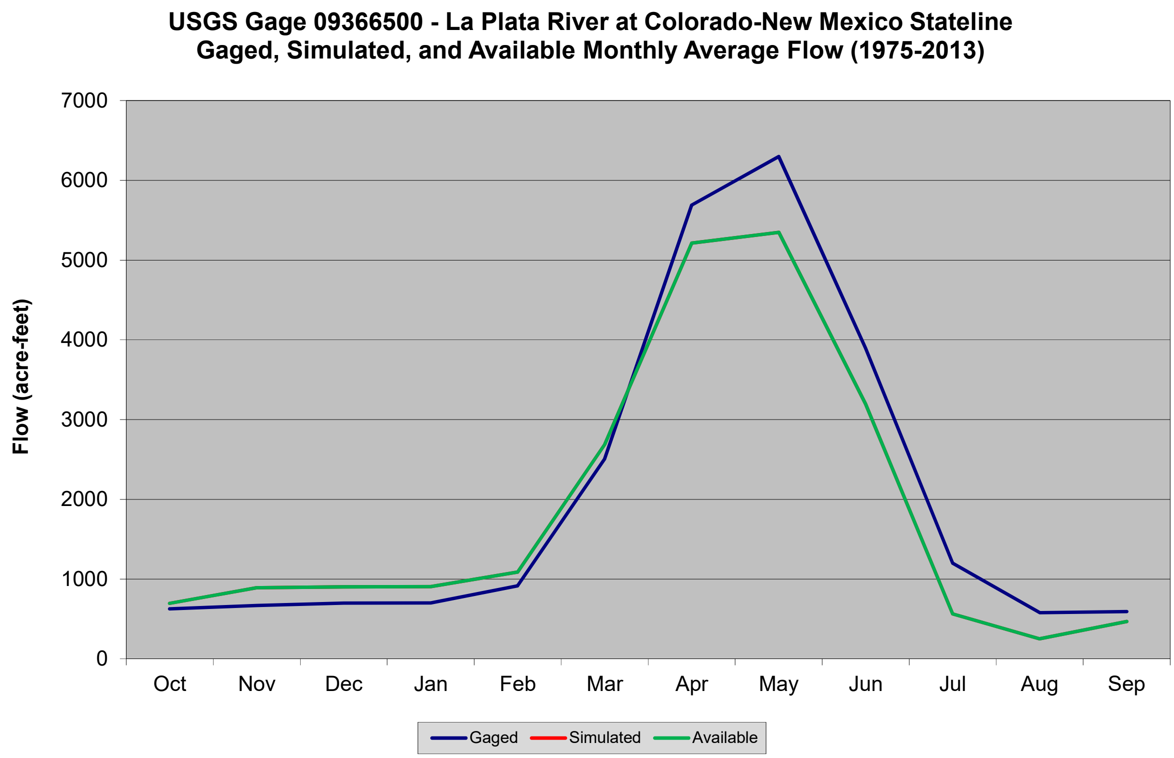
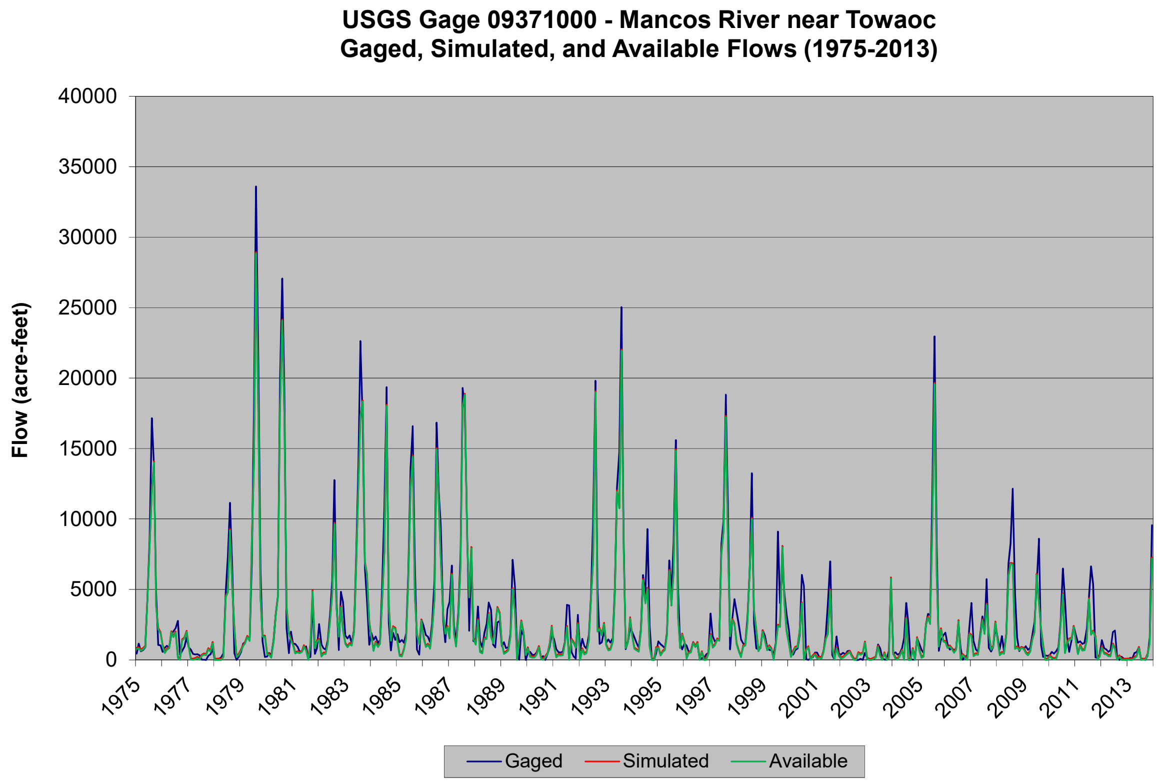


Figure 6.6 Baseline Results – La Plata River at Colorado-New Mexico Stateline



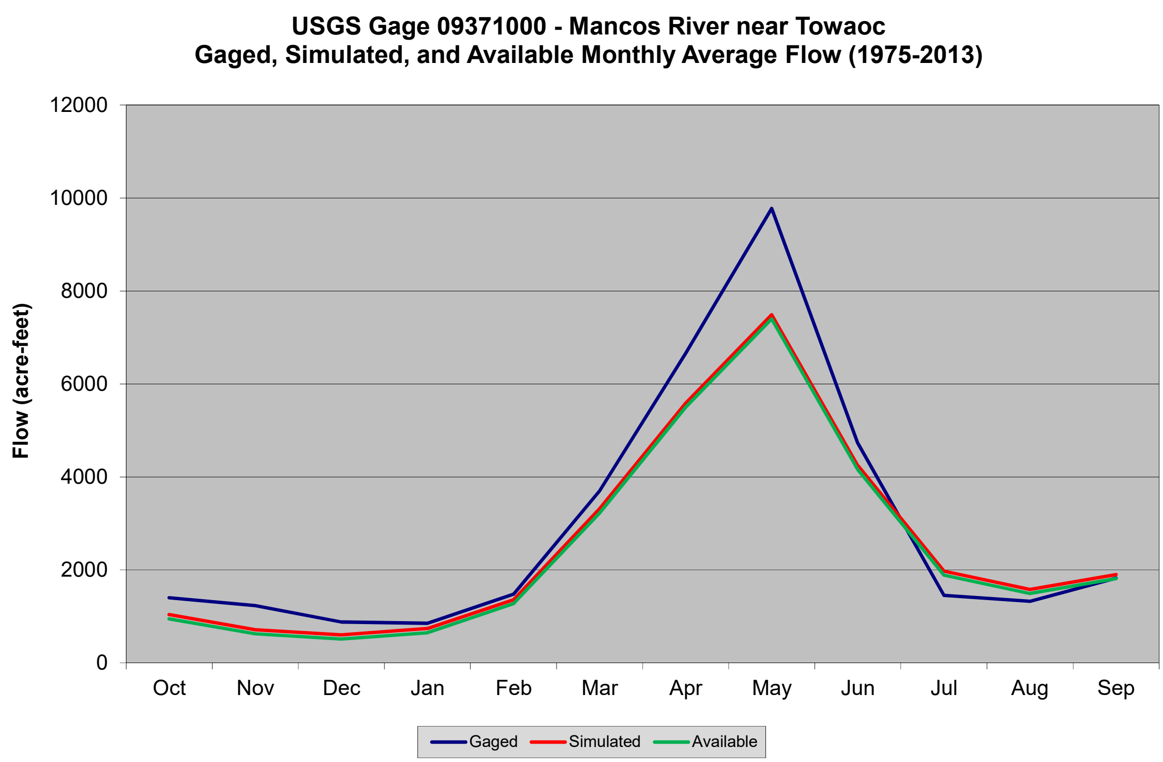
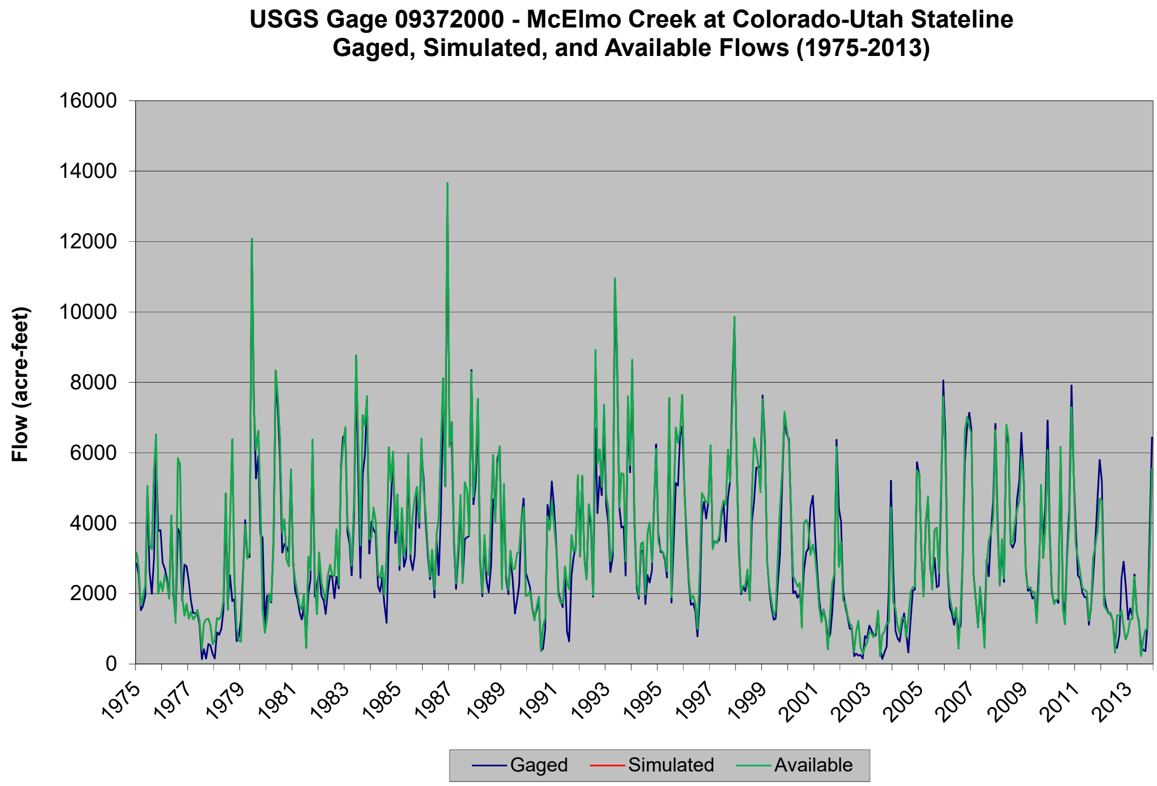


Figure 6.7 Baseline Results – Mancos River near Towaoc



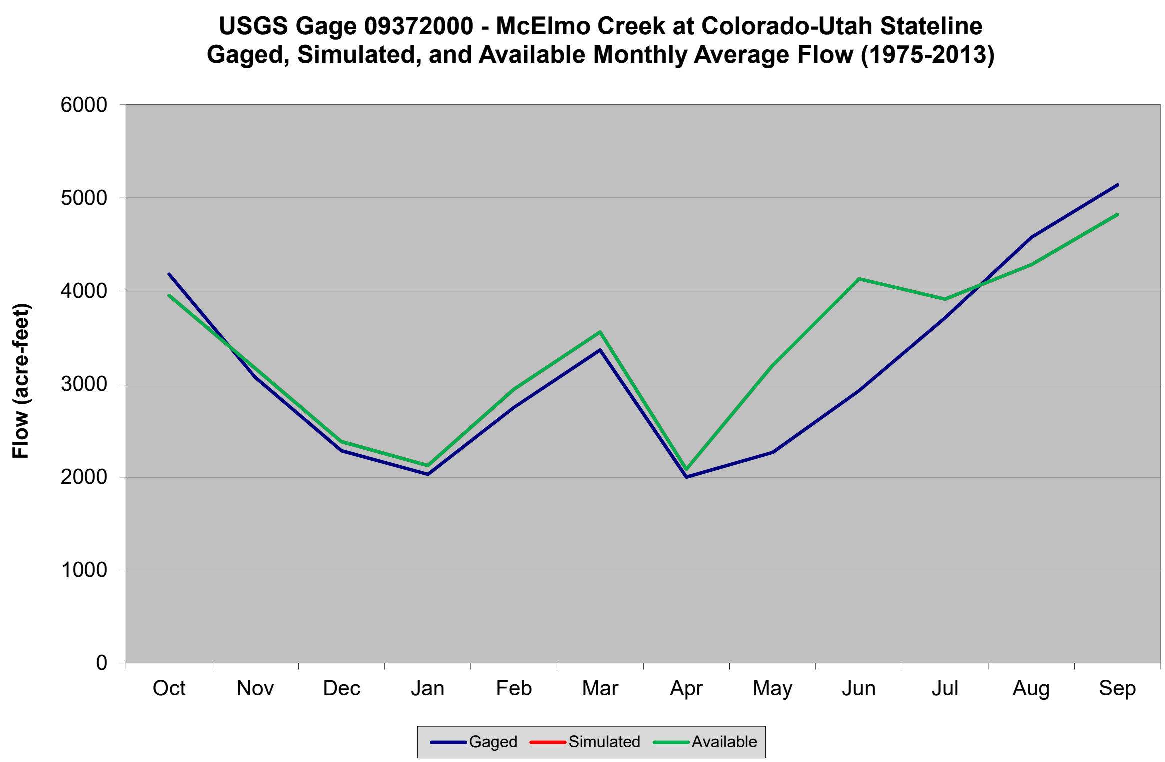
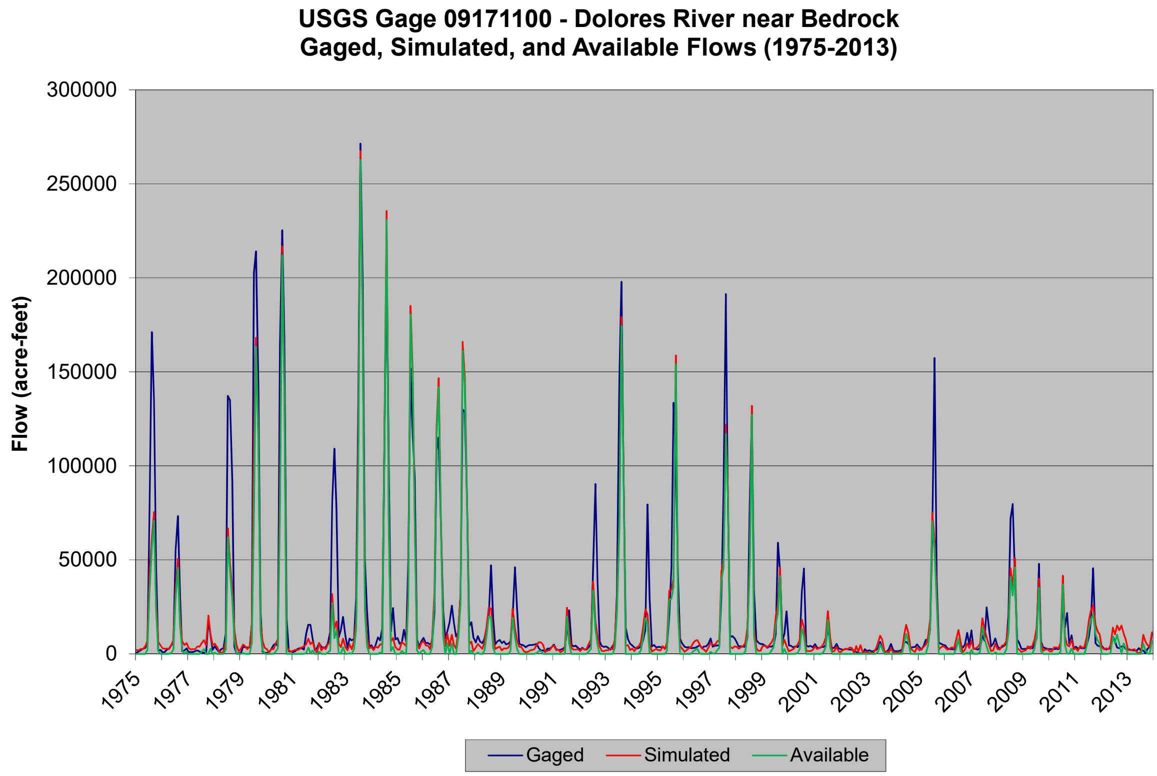


Figure 6.8 Baseline Results – McElmo Creek at Colorado-Utah Stateline



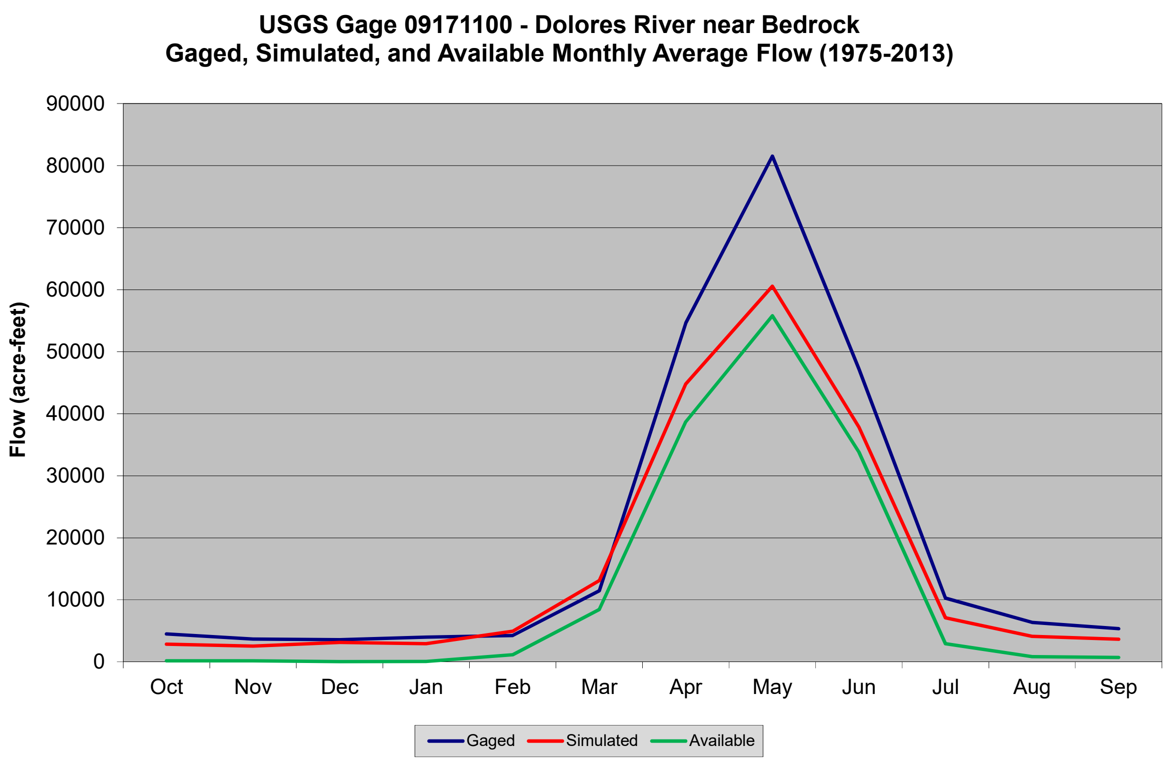
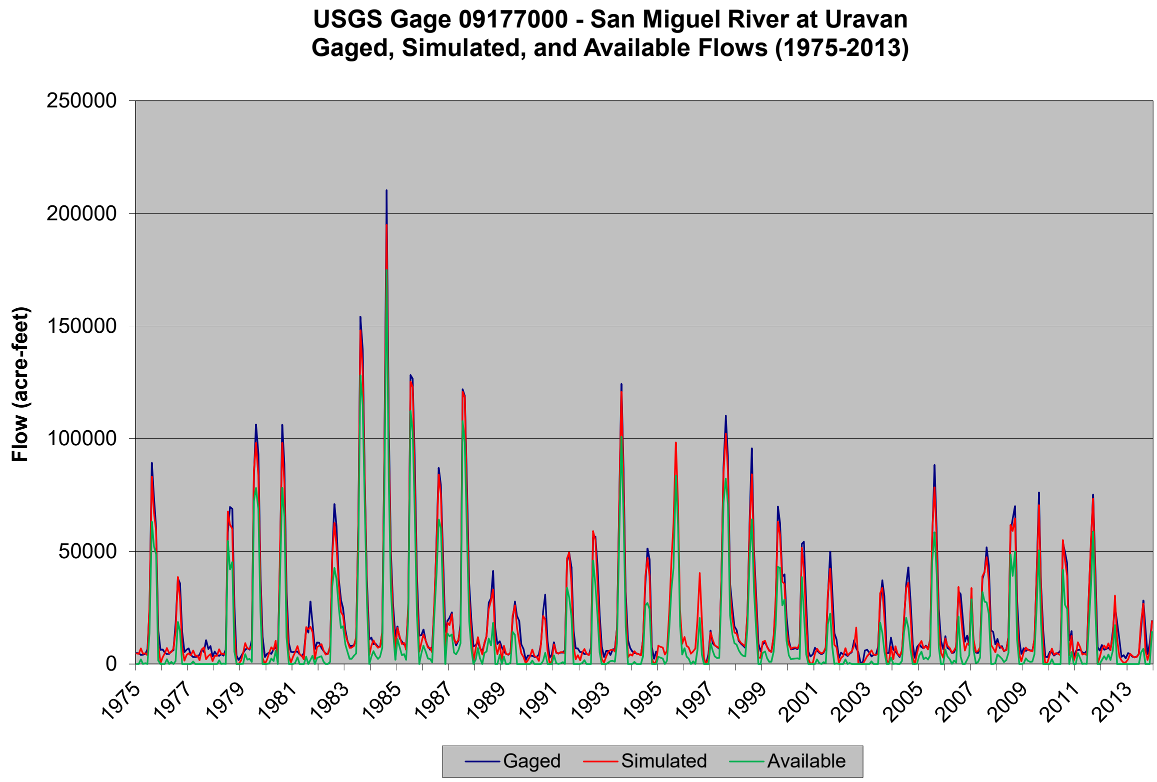


Figure 6.9 Baseline Results – Dolores River near Bedrock



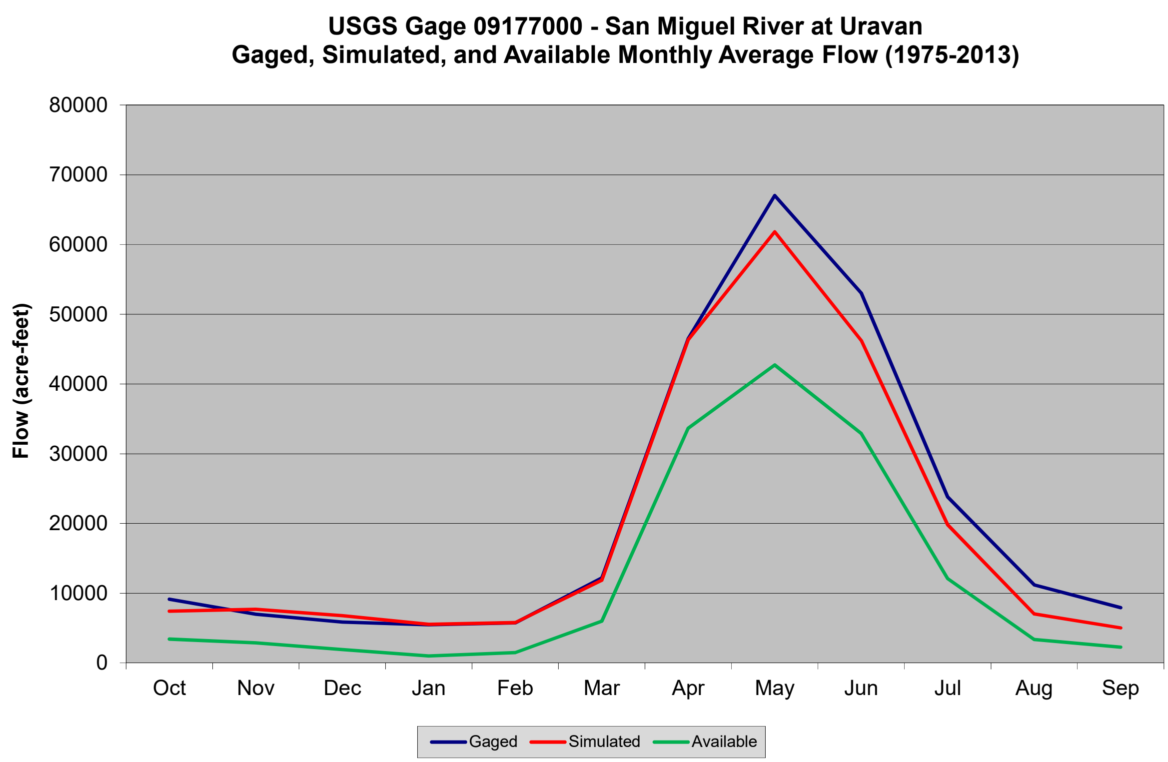


Figure 6.10 Baseline Results – San Miguel River at Uravan

7. Calibration

Calibration is the process of executing the model under historical conditions, and modifying estimated parameters to improve agreement between the model results and the historical record. This section describes the general approach taken in calibrating the San Juan Model. It describes specific areas of the basin that were worked on, and it presents summaries comparing modeled results for 1975 through 2013 with historical values for the period. Diversion, depletion, and reservoir use data for the portion of the model that extends into New Mexico were provided by New Mexico and used directly without review. Therefore, the model calibration focuses on the portion of the model in Colorado.

7.1 Calibration Process

The San Juan Model was calibrated in a two-step process, based on the period 1975 through 2013. In the first step, demands were set to historical diversions, and reservoir levels were constrained to their historical levels. Reservoir storage was limited to the historical monthly content for each month. Reservoirs released water upon demand, but if the demand-driven operations left more water in a reservoir than it had historically, the model released enough water to the stream to achieve its historical end-of-month contents. In this step, the basic hydrology was assessed, and in general, baseflow distribution parameters and return flow characteristics were modified.

Reviewing the model run consisted of comparing simulated gage flows with historical flows, and determining where and why diversion shortages occurred. For example, a shortage might occur because a user’s water right is limiting. But it might also occur because water is physically unavailable or the water right is called out. In this typical calibration problem, there may be too little baseflow in a tributary reach to support historical levels of diversion in the model. Gains may not occur in the system until the next downstream gage, bypassing the shorted structures. Because the historical diversion and consumption do not occur in the model, the model then overestimates flow at the downstream gage. Baseflow distribution parameters must be adjusted such that more water enters the system within the tributary, and typically, incremental inflow below the tributary is reduced. The first step of calibration might also expose errors such as incorrect placement of a gage, or incorrect treatment of imports.

In the second step, reservoirs responded to demands and were permitted to seek the level required to meet the demands. Model results were again reviewed, this time focusing on the operations. For example, operating criteria in the form of monthly targets might be added for reservoirs that operate for unmodeled reasons such as flood control, hydropower generation, or winter maintenance. As another example, where reservoir history revealed that annual administration was not strictly observed, the annual administration feature was removed.

The model at the conclusion of the second step is considered the calibrated model.

7.2 Historical Data Set

Calibration is based on supplying input that represents historical conditions, so that resulting gage and diversion values can be compared with the historical record. This data set is referred to as the "Historical data set", and it is helpful to understand how it differs from the Baseline data set described in Section 5.

7.2.1. Direct Diversion Station and Demand File

A primary difference in data sets is the representation of demands (*.ddm file). For calibration, both irrigation and non-irrigation demands were set to historical diversions; to the extent they were known. Gaps in the diversion records were filled using the automatic data filling algorithm described in Section 4.4.2. This demand reflects both limitations in the water supply and irrigation practices that cannot be predicted – headgate maintenance, dry-up periods, and so on.

Demands for irrigation multistructures were placed at the point of diversion. In the Baseline data set, these demands were placed at the destination node, and operating rules drove the diversion from the individual headgates. This includes San Juan-Chama project demands, which are placed on the individual tunnels, not at the San Juan-Chama summary node.

7.2.2. Irrigation Water Requirement File

Irrigation water requirement file for the Historical data set is based on historical irrigated acreage, whereas the Baseline irrigation water requirement is based on current levels of irrigated acreage. This affects structures that came on-line during the study period, or significantly increased acreage during the study period. The largest differences in irrigation water requirement are for structures receiving water from the Dolores Project, including MVIC structures, Dove Creek Canal, and Towaoc Canal.

7.2.3. Reservoir Station File and Reservoir Target File

In the Historical data set, reservoirs are inactive prior to onset of their historical operations. Initial contents in the reservoir file (*.res) are set their historical end-of-month content in September, 1908, and storage targets (*.tar file) are set to zero until the reservoir actually began to fill. In the first calibration step, storage targets assume the value of the historical end-of-month contents, but in the second calibration step, irrigation reservoirs' storage targets are set to capacity for all reservoirs that operate primarily for agricultural and municipal diversion storage, as soon as those reservoirs came on-line. Maximum targets were set to operational targets according to rule curves provided by USBR for Lemon and Vallecito reservoirs when those reservoirs came on-line. Cascade and Trout reservoirs operate for hydropower generation. For these reservoirs, maximum targets were set to historical end-of-month contents. If capacity of a reservoir changed midway through the study period, the Historical model takes the enlargement into account.

7.2.4. Operational Rights File

The reservoir storage target file (*.tar) and the operating rules file (*.opr) work together to constrain reservoir operations in the first calibration step. The operational rights include rules to release water that remains in the reservoir above historical levels (specified in the target file) after all demand-driven releases are made. In the second calibration step, release-to-target rules in the *.opr file remain on, but do not fire for most reservoirs, as targets are set to capacity. The exceptions are noted above in Section 7.2.3. In the initial calibration run, when water is released to a downstream diversion, enough water is released to meet the diverter's historical diverted amount, regardless of the efficiency of that operation or whether crop irrigation water requirements have been satisfied. In the second step calibration, enough water is released to meet the historical diverted amount only if there is deficit crop irrigation water requirement. Section 5.8 describes each operating rule used in the Baseline and Historical calibration simulations.

Differences between the Baseline data set and the Historical data set are summarized in Table 7.1.

Table 7.1
Comparison of Baseline and Historical (Calibration) Files

Input File	Baseline Data Set	Historical Data Set
Demand (*.ddm)	▪ Irrigation structures – "Calculated" demand for full crop supply, based on historical efficiency ▪ Non-irrigation structures – estimated current demand ▪ Demands placed on primary structures of multistructure systems and demands placed at destination structures; carrier structure demands are set to zero	▪ Historical diversions ▪ Historical diversions for multistructures and San Juan-Chama structures are set at individual diversion headgates
Reservoir target (*.tar)	▪ Current maximum capacity except reservoirs that release for flood control or power generation	▪ First step – historical eom contents, 0 prior to construction ▪ Second step – 0 prior to construction, historical maximum capacity except reservoirs that release for flood control or power generation
Operational right (*.opr)	▪ Operating rules drive diversions to demand destination through multi-structure and carrier structures ▪ Reservoir releases are made to irrigation structures to satisfy headgate demands only if crop irrigation water requirements have not been met by other sources.	▪ Release-to-target operations allow reservoirs to release to target contents ▪ Step 1 calibration, reservoir releases are made to irrigation structures to satisfy headgate demands regardless if crop irrigation water requirements have been met.

7.3 Calibration Issues

This section describes areas of the model that have been investigated in the various calibration efforts for the San Juan Model. Note that in general, simulating using the variable efficiency approach improved basin-wide calibration from previous efforts.

7.3.1. Aggregated Structures and Diversion Systems

Several revisions have taken place to aggregated structures throughout the modeling process, generally in attempt to reduce shortages. Initially, the 1993 Irrigated Acreage Coverage was used as the basis for aggregation of smaller structures. The most recent 2005 and 2010 Irrigated Acreage Coverages are now used as the basis for the aggregation. As a result of the more recent acreage snap-shots, some structures were removed as key and added to aggregates. The update also included the development of "no diversion" aggregates—groups of structures that have been assigned acreage but do not have current diversion records. "No diversion" aggregates are included in StateCU in order to capture 100 percent of irrigated acreage. However, they were not included in the StateMod modeling effort. Because the individual structures included in these aggregates do not have current diversion records, their effect on the stream cannot be accounted for in the development of natural flows. Therefore, it is appropriate that their diversions also not be included in simulation. The individual structures in the "no diversion" aggregates generally irrigate minimal acreage, often with spring water as a source. There is an assumption that the use will not change in future "what-if" modeling scenarios.

In addition, several structures were combined into diversion systems to represent lands served by more than one ditch on the same tributary. These efforts helped to reduce shortages to aggregate structures and to structures with overlapping acreage. Finally, most structures on the San Miguel and tributaries were removed from aggregates and represented explicitly.

7.3.2. Baseflows

Previous modeling efforts have focused on increasing baseflows at headwater tributaries and distributing enough water to mainstem baseflow nodes that shortages in historical diversions are minimized. This approach can result in StateMod oversimulating the gains between observed streamflow gages. StateMod compensates for excess water in the river by calculating a negative gain term. It is understood that the San Juan River is a naturally gaining river and baseflow should increase from upstream to downstream. To address losing reaches, significant effort was spent on baseflows during calibration.

Reaches where the combined upstream baseflow is larger than the downstream flow were identified and efforts made to improve the baseflow calibration. This included examining filled end-of-month reservoir contents and diversion records, and adjusting return flow locations. In previous modeling efforts, the approach was to include all available USGS streamgages were included in the model regardless of their measurement period. This was shown to cause problems in the baseflow filling algorithm when the streamgage had a short period of record that did not represent dry, average, and wet conditions. For the current effort, streamgages with limited period of records were removed when the filling techniques introduced either a positive or negative flow bias to the model.

Most baseflow gains realized at stream gages are distributed to ungaged locations using the "gain approach" where the gain between gages is distributed upstream based on an area/precipitation proration. This approach does not work well for ungaged tributaries that have relatively small flow compared to the downstream gaged data. Many of these smaller drainages are included in the San Juan Model, especially in the San Miguel and Dolores basins. The "neighboring gage" approach distributes actual baseflow (not gain) from a gaged location to upstream ungaged tributaries. Twenty additional baseflow nodes were assigned the "neighboring gage" approach during the recent model update. This reduced negative baseflows and resulted in better calibration of simulated versus historical diversions on the smaller ungaged tributaries.

7.3.3. McElmo Creek

McElmo Creek calibration has significantly improved through the modeling process. In the first modeling phases, both Narraguinnep and Summit Reservoirs were modeled as tributary to McElmo Creek, and treated as baseflow nodes. The estimated changes in historical reservoir storage were significant components in the baseflow calculations. Discussion with water users indicated that the reservoirs do not fill from or spill to McElmo Creek. Only return flows from reservoir releases to irrigation contribute to McElmo Creek flows. Both of these reservoirs are essentially "off-channel" and are filled with exported water from the Dolores Basin. Historical diversions into the reservoirs are available; however, reservoir release records and end-of-month content records are limited. During the recent modeling phase, these reservoirs were modeled off-channel; therefore changes in storage did not affect McElmo Creek flows.

The other McElmo Creek complication is the significant amount of transbasin water from MVIC Dolores River diversions that are used for irrigation and result in significant return flows to McElmo Creek. Historical diversions through Main Canal No 1 and Main Canal No 2 were recorded under several WDIDs and had several data gaps. During the recent modeling efforts, significant effort was spent to understand the historical diversions and uses in an attempt to better represent natural flows in McElmo Creek.

Simulated streamflow at the McElmo Creek near the Colorado-Utah Stateline improved significantly. Previous modeling phases resulted in simulated average annual streamflows 13 percent higher than historical, whereas the current model simulation results are within 1 percent of historical.

7.3.4. San Miguel River

Most of the modeled diversions in the San Miguel River basin are on ungaged tributaries or tributaries with limited gaged data. Some diversions on smaller tributaries are significantly shorted. In each modeling phase, effort was expended to better represent irrigation use. Efforts for the current model centered around baseflows and diversion disaggregation, as discussed in Sections 7.3.1. and 7.3.2 above. Previous modeling phases resulted in average annual shortages in the San Miguel River basin of 12 percent, whereas the current model simulated shortages average 2 percent.

7.3.5. Dolores River

Similar to the San Miguel River Basin, many of the modeled diversions in the Dolores River basin are on ungaged tributaries or tributaries with limited gaged data. Some diversions on smaller tributaries are significantly shorted. In each modeling phase, effort was expended to better represent irrigation use. Efforts for the current model centered around baseflows, as discussed in Section 7.3.2 above. Previous modeling phases resulted in average annual shortages in the Dolores River basin of 15 percent, whereas the current model simulated shortages average 3 percent.

7.4 Calibration Results

Calibration of the San Juan Model is considered very good, with most streamflow gages deviating less than one percent from historical values on an average annual basis. More than half the diversion structures' shortages are at or below 1 percent on an annual basis, and the basinwide shortage is around 2 percent per year, on average. Simulated reservoir contents are representative of historical values.

7.4.1. Water Balance

Table 7.2 summarizes the water balance for the San Juan Model, for the calibration period (1975 through 2013). Following are observations based on the summary table:

- Stream water inflow to the basin averages 2.85 million acre-feet per year, and stream water outflow averages 2.33 million acre-feet per year.
- Annual diversions amount to approximately 1.04 million acre-feet on average, indicating that there is extensive re-diversion of return flows in the basin.
- Approximately 476,000 acre-feet per year are consumed.
- The column labeled "Inflow – Outflow" represents the net result of gain (inflow, return flows, and negative change in reservoir and soil moisture contents) less outflow terms (diversions, outflow, evaporation, and positive changes in storage), and indicates that the model correctly conserves mass.

Table 7.2
Average Annual Water Balance for Calibrated San Juan Model 1975-2013 (af/yr)

Month	Stream Inflow	Return	From Soil Moisture	Total Inflow	Diversions	Resvr Evap	Stream Outflow	Resvr Change	To Soil Moisture	Soil Moisture Change	Total Outflow	Inflow - Outflow	CU
OCT	109,612	45,061	1,949	156,622	54,269	1,237	111,026	-11,859	2,351	-403	156,623	0	17,145
NOV	61,529	24,393	21	85,943	16,482	-209	65,912	3,738	2,113	-2,092	85,943	0	867
DEC	48,159	18,972	0	67,131	12,339	-619	53,280	2,132	903	-903	67,131	0	326
JAN	46,900	16,243	0	63,143	11,354	-378	52,923	-756	727	-727	63,143	0	318
FEB	56,045	13,788	0	69,833	10,184	153	59,981	-485	555	-554	69,833	0	695
MAR	162,489	14,729	157	177,375	16,328	831	153,343	6,715	1,145	-988	177,375	0	3,340
APR	406,250	23,440	2,904	432,594	53,440	3,037	337,592	35,622	4,463	-1,559	432,594	0	27,864
MAY	752,253	69,736	7,981	829,971	187,790	5,172	555,388	73,638	6,457	1,524	829,970	0	100,951
JUN	650,181	94,126	9,466	753,772	236,140	7,593	498,223	2,349	2,503	6,962	753,771	1	132,337
JUL	270,350	90,885	5,151	366,387	191,440	6,016	206,361	-42,580	1,534	3,617	366,387	0	96,541
AUG	156,098	81,580	2,350	240,028	147,224	3,122	127,143	-39,812	5,948	-3,598	240,028	0	58,004
SEP	126,331	66,787	2,083	195,201	103,171	2,839	107,346	-20,238	3,611	-1,528	195,202	0	37,706
TOT	2,846,197	559,740	32,062	3,438,000	1,040,161	28,794	2,328,517	8,465	32,311	-249	3,437,999	1	476,093

Note: Consumptive Use (CU) = Diversion (Divert) * Efficiency + Reservoir Evaporation (Evap)

7.4.2. Streamflow Calibration Results

Table 7.3 summarizes the annual average streamflow for water years 1975 through 2013, as estimated in the calibration run. It also shows average annual values of actual gage records for comparison. Both numbers are based only on years for which gage data are complete. Figures 7.1 through 7.10 (at the end of this section) graphically present monthly streamflow estimated by the model compared to historical observations at key streamgages in both time-series format and as scatter graphs. When only one line appears on the time-series graph, it indicates that the simulated and historical results are the same at the scale presented. The goodness of fit is indicated on the scatter plot by the equation for the "best fit" regression line relating simulated to gage values. A perfect fit would be indicated by an equation y = 1.000x.

Calibration based on streamflow simulation for gages in is generally very good in terms of both annual volume and monthly pattern. Exceptions include the smaller tributaries of Lost Canyon and Beaver Creek. These exceptions do not affect mainstem or major tributary calibration.

Simulation of streamflow on the Los Pinos River below Vallecito Reservoir accurately models annual volume, but the monthly patterns vary from gaged. Vallecito Reservoir is modeled using a forecasting curve provided by the USBR that is intended to mimic operational storage targets. It appears that the rule curve is used only as a guideline by the USBR, and decisions based on other factors drive actual operations. Step 1 calibration results, when Vallecito Reservoir was "releasing to targets" of historical end-of-month contents, are also shown on Figure 7.4, Los Pinos River below Vallecito Reservoir, further reinforcing the conclusion regarding the effect of Vallecito forecasting on streamgages below the reservoir.

Table 7.3
Historical and Simulated Average Annual Streamflow Volumes (1975-2013)
Calibration Run (acre-feet/year)

			Historical -Simulated		
Gage ID	**Historical**	**Simulated**	**Volume**	**Percent**	**Gage Name**
09339900	64,131	64,131	0	0%	East Fork San Juan River above Sand Creek
09341500	171,819	171,818	0	0%	West Fork San Juan River nr Pagosa Springs
09342000	*No gage during calibration period*				Turkey Creek near Pagosa Springs
09342500	276,681	276,870	-189	0%	San Juan River at Pagosa Springs
09343000	*No gage during calibration period*				Rio Blanco near Pagosa Springs
09343300	30,730	30,786	-55	0%	Rio Blanco bl Blanco Div Dam nr Pagosa Sprgs
09344000	80,209	80,211	-1	0%	Navajo River at Banded Peak Ranch nr Chromo
09344400	45,391	45,579	-188	0%	Navajo River bl Oso Diversion Dam nr Chromo
09345200	6,517	6,713	-195	-3%	Little Navajo River bl Oso Div Dam nr Chromo
09346000	65,865	66,797	-932	-1%	Navajo River at Edith
09346400	426,759	427,044	-285	0%	San Juan River near Carracas
09347500	*No gage during calibration period*				Piedra River at Bridge Ranger Sta. nr Pagosa Sprgs
09349500	*No gage during calibration period*				Piedra River near Piedra
09349800	292,019	291,525	494	0%	Piedra River near Arboles

Gage ID	Historical	Simulated	Historical -Simulated		Gage Name
			Volume	Percent	
09352900	103,454	103,454	0	0%	Vallecito Creek near Bayfield
09353500	297,869	296,280	1,588	1%	Los Pinos River near Bayfield
09354000	*No gage during calibration period*				Los Pinos River at Bayfield
09354500	173,711	175,436	-1,724	-1%	Los Pinos River at La Boca
09355000	23,762	23,755	6	0%	Spring Creek at La Boca
09357500	75,784	75,785	0	0%	Animas River at Howardsville
09359000	*No gage during calibration period*				Mineral Creek near Silverton
09359500	294,063	288,800	5,262	2%	Animas River above Tacoma
09361000	90,600	90,600	0	0%	Hermosa Creek near Hermosa
09361200	*No gage during calibration period*				Falls Creek near Durango
09361400	*No gage during calibration period*				Junction Creek near Durango
09361500	574,261	574,247	14	0%	Animas River at Durango
09362750	59,363	59,363	0	0%	Florida River ab Lemon Reservoir
09363200	56,515	60,078	-3,564	-6%	Florida River at Bondad
09363500	653,586	655,226	-1,641	0%	Animas River near Cedar Hill, NM
9365500	29,098	29,117	-19	0%	La Plata at Hesperus
LONREDCO	4,585	4,660	-75	-2%	Long Hollow at the Mouth near Red Mesa
09366500	23,837	23,862	-25	0%	La Plata River at CO-NM State Line
09368500	*No gage during calibration period*				West Mancos River near Mancos
09369500	*No gage during calibration period*				Middle Mancos River near Mancos
09369000	*No gage during calibration period*				East Mancos River near Mancos
09371000	34,810	34,339	471	1%	Mancos River near Towaoc
09371400	10,063	10,063	0	0%	Hartman Draw at Cortez
09371420	19,397	19,688	-291	-2%	McElmo Creek above Alkali Canyon nr Cortez
09372000	38,343	38,563	-219	-1%	McElmo Creek near CO-UT State Line
09165000	93,481	93,489	-8	0%	Dolores River below Rico
09166500	299,440	301,562	-2,123	-1%	Dolores River at Dolores
09166950	13,408	11,861	1,547	12%	Lost Canyon Creek near Dolores
09168100	21,255	21,272	-18	0%	Disappointment Creek near Dove Creek
09169500	223,605	221,979	1,625	1%	Dolores River at Bedrock
09171100	231,166	229,506	1,660	1%	Dolores River near Bedrock
09171200	*No gage during calibration period*				San Miguel River near Telluride
09172000	*No gage during calibration period*				Fall Creek near Fall Creek
09172100	*No gage during calibration period*				Leopard Creek at Noel
09172500	173,447	173,821	-374	0%	San Miguel River near Placerville
09173000	7,212	5,361	1,850	26%	Beaver Creek near Norwood
09175500	186,173	186,414	-241	0%	San Miguel River at Naturita
09177000	254,128	254,399	-272	0%	San Miguel River at Uravan
09179500	*No gage during calibration period*				Dolores River at Gateway

7.4.3. Diversion Calibration Results

Table 7.4 summarizes the average annual shortage for water years 1975 through 2013, by Water District. Table 7.6 (at the end of this section) shows the average annual shortages for water years 1975 through 2013 by structure. On a basin-wide basis, average annual diversions differ from historical diversions by around 2 percent in the calibration run.

Table 7.4
Historical and Simulated Average Annual Diversions by Sub-basin (1975-2013)
Calibration Run (acre-feet/year)

Water District - Tributary	Historical	Simulated	Historical minus Simulated	
			Volume	Percent
Water District 29 – San Juan/Blanco Rivers	91,630	91,123	507	0.6%
Water District 30 – Animas and Florida	230,308	219,697	10,611	4.6%
Water District 31 &46 – Los Pinos River	212,967	210,954	2,013	0.9%
Water District 32 – McElmo Creek	218,762	214,368	4,394	2.0%
Water District 33 – La Plata River	30,468	29,950	518	1.7%
Water District 34 – Mancos River Use)	43,400	43,364	36	0.1%
Water District 60 – San Miguel River	120,590	118,745	1,845	1.5%
Water Districts 61,63,69,71,73 Dolores River and Tributaries	227,180	219,495	7,685	3.4%
Water District 77 – Navajo River	66,161	65,609	552	0.8%
Water District 78 – Piedra River	28,035	27,353	682	2.4%
Basin Total	**1,790,154**	**1,757,338**	**32,816**	**2.4%**

7.4.4. Reservoir Calibration Results

Figures 7.11 through 7.15 (located at the end of this chapter) present reservoir EOM contents estimated by the model compared to historical observations at selected reservoirs. The following can be observed:

- Vallecito Reservoir operational targets, provided by the USBR, appear to better represent actual operations in recent years, as demonstrated by simulation results. Operations likely evolved during the calibration period.

- Lemon Reservoir operational targets, provided by the USBR, do not appear to mimic historical operations, as demonstrated by simulation results.

7.4.5. Consumptive Use Calibration Results

Crop consumptive use is estimated by StateMod and reported in the consumptive use summary file (*.xcu) for each diversion structure in the scenario. This file includes consumptive use for municipal and industrial diversions in addition to agricultural consumptive use. The crop consumptive use estimated by StateCU is reported in the water supply-limited summary file (*.wsl) for each agricultural diversion structure in the basin. Therefore, to provide a one-to-one comparison, only structures in the StateCU analysis are included.

Table 7.5 shows the comparison of StateCU estimated crop consumptive use compared to StateMod estimate of crop consumptive use for explicit structures, aggregate structures, and total in Colorado. As shown, both explicit and aggregate structure consumptive use match StateCU results very well. Historical diversions are used by StateCU to estimate supply-limited (actual) consumptive use. The approximate 1 percent difference can be explained by the overall basin diversion shortages simulated by the model.

Table 7.5
Average Annual Crop Consumptive Use Comparison (1975-2013)

Comparison	StateCU Results (af/yr)	Calibration Run Results (af/yr)	% Difference
Explicit Structures	299,804	299,168	0.2%
Aggregate Structures	43,880	43,195	1.6%
Basin Total	343,684	342,363	0.4%

Table 7.6
Historical and Simulated Average Annual Diversions (1975-2013)
Calibration Run (acre-feet/year)

			Historical – Simulated		
WDID	Historical	Simulated	Volume	Percent	Name
4600503	2,070	2,063	7	0	BRIGGS DITCH
2900718	5,245	5,104	141	3	SNOWBALL DITCH
2904669	207	207	0	0	TREASURE PASS DIVR DITCH
2900621	111	111	0	0	HIMES DITCH
2900560	3,120	3,120	0	0	CHAPSON HOWE_DIVSYS
2900691	298	298	0	0	PHILLIPPS DITCH
2900501	88	88	1	1	ALLEN CREEK DITCH
2900677	452	452	0	0	OBANNON DITCH
2900729	293	293	0	0	STURGILL DITCH
2900627	388	388	0	0	J M ROSS AND STURGILL D
2900686	8,698	8,698	0	0	PARK DITCH
2902005	1,120	1,063	56	5	DUTTON DITCH
2900601	4,980	4,931	49	1	FOUR-MILE_DIVSYS
2900671	91	91	0	0	MOUNTAIN PARK DITCH
29_ADS002	6,302	6,222	80	1	WD29 AGGREGATE
2900550	2,675	2,675	0	0	C H LOUCKS DITCH
2900582	355	355	0	0	DOWELL DITCH

WDID	Historical	Simulated	Historical – Simulated Volume	Percent	Name
2900613	1,514	1,444	70	5	HALLETT DITCH_DIVSYS
2900654	198	198	0	0	LONG MEADOW DITCH
2900653	1,062	1,062	0	0	LONG HORN_MEE_DIVSYS
2900604	784	784	0	0	FU BAR DITCH
2900597	790	790	0	0	FISH CREEK DITCH
2900716	566	566	0	0	SISSON-STEPHENS DITCH
2900519	261	261	0	0	BEIGHLEY NO 1_DIVSYS
2904667	39,701	39,644	58	0	USBR_BLANCO_R_DIVERSION
2900588	2,142	2,107	35	2	ECHO DITCH_DIVSYS
2900662	302	302	0	0	MARTINEZ AND MARTINEZ D
2900618	189	189	0	0	HARRIS DITCH
7700597	1,041	1,021	20	2	NEW BOND HOUSE D(NAVAJO)
7700587	649	649	0	0	UPPER CAMP DITCH
7700569	120	120	0	0	NEW BOND HOUSE D(FALL)
7700527	385	385	0	0	EAST FORK DITCH
7700570	127	127	0	0	NEW BOND HOUSE D(ASPEN)
7700564	451	451	0	0	NAVAJO RIVER DITCH
7700592	243	243	0	0	WEST RANCH CREEK DITCH
7700562	350	350	0	0	NAVAJO MEADOW DITCH
7700542	261	261	0	0	HEADACHE CREEK DITCH
7700554	173	173	0	0	LITTLE MUDDY CREEK DITCH
7700577	137	137	0	0	SHEEP CREEK DITCH
7700524	1,646	1,646	0	0	EAKLOR DITCH
7700588	344	344	0	0	UPPER NAVAJO DITCH
7700514	32	32	0	0	CHAMA ROAD DITCH
7704635	44,400	44,219	182	0	USBR_NAVAJO_DIVERSION
7799999	0	0	0	0	SanJ_Chama_Summary_Node
7700579	1,888	1,888	0	0	SOUTH SIDE DITCH
7700558	368	366	2	1	MCMULLEN DITCH
7700531	2,468	2,468	0	0	ENTERPRISE_DIVSYS
7700518	122	122	0	0	ENTERPRISE DITCH (CORN)
7700536	545	545	0	0	FITZHUGH DITCH
7700585	181	181	0	0	UNDERWOOD DITCH
7704636	3,652	3,445	208	6	USBR_LITTLE_NAVAJO_DIVR
7700529	1,258	1,160	98	8	ELMER DITCH NO 1
7700559	700	656	44	6	MIDLAND DITCH
7700576	226	226	0	0	SHAHAN IRRIGATION DITCH
7700586	276	276	0	0	UNDERWOOD DITCH NO 2
7700560	213	213	0	0	MONTOYA DITCH
7700500	138	138	0	0	ARCHULETA DITCH
77_ADS001	3,767	3,767	0	0	WD 77 AGGREGATE
2900555	1,336	1,336	0	0	CARR DITCH
2900900	1,137	1,119	18	2	CARR DITCH (SO UTE)
29_SUIT	0	0	0	0	SUIT RESERVED SAN JUAN

WDID	Historical	Simulated	Historical – Simulated Volume	Historical – Simulated Percent	Name
29_ADS003	7,225	7,225	0	0	WD29 AGGREGATE
7800692	742	742	0	0	FAIRFIELD MUN
7804670	43	42	2	4	DON LAFONT DITCH NO 1
7804671	133	131	2	1	DON LAFONT DITCH NO 2
7800501	1,253	1,242	10	1	ABRAHAM DAVIS DITCH
7800604	2,378	2,376	2	0	PIEDRA FALLS DITCH
7800525	1,194	1,004	190	16	CLAYTON-REED DITCH
7800523	325	319	6	2	CARL AND WEBB DITCH
7800617	1,615	1,592	23	1	STEVENS AND CLAYTON D
7800659	316	310	6	2	LITTLE PAGOSA CREEK DIVR
7800594	210	208	2	1	PAGOSA DITCH
7800638	1,383	1,383	0	0	TONER AND STEVENS DITCH
7800571	1,462	1,461	1	0	BESS GIRL DITCH
7800590	469	467	2	0	NICKLES BROTHERS DITCH
7804672	277	274	2	1	WILLIAMS CR SQ PASS DIVR
7800544	283	280	3	1	F S MOCKLER IRR DITCH
7800524	210	204	5	3	CIMARRON DITCH
7800562	919	894	25	3	HOPE SPRINGS_DIVSYS
7800565	395	264	131	33	J C R DITCH
7800507	944	740	204	22	BARNES-MEUSER_DIVSYS
7800671	235	229	6	3	J C R DITCH ALTERNATE PT
7800506	629	578	51	8	BARNES DITCH
7800545	2,702	2,697	5	0	FARROW AND PETERSON D
7800513	2,878	2,878	0	0	BUCKSKIN-NAILOR DITCH
7800580	963	963	0	0	M E AND M DITCH
7800552	726	724	3	0	GALLEGOS HOME DITCH
7800543	337	337	0	0	EUGENIO GALLEGOS DITCH
78_ADS004	4,695	4,695	0	0	Diversion Aggregate
78_SUIT	0	0	0	0	SUIT RESERVED PIEDRA
7800555	319	319	0	0	GEORGE S MCDONALD DITCH
3104638	429	367	62	14	PINE R WEMINUCHE PASS D
3104637	1,029	908	122	12	WEMINUCHE PASS DITCH
3100583	463	271	192	41	GOOSEBERRY_DIVSYS
3100535	833	748	85	10	KIRKPATRICK DITCH
3100540	1,149	1,142	8	1	MCLOYD DITCH
3100553	69	69	0	0	MCBRIDE DITCH
3100524	967	963	4	0	FARRELL DITCH
3100518	706	705	0	0	MYERS AND ASHER DITCH
3100528	1,205	1,201	3	0	BENNETT-MYERS IRR DITCH
3100513	2,508	2,464	44	2	WOMMER IRRIGATION DITCH
3100545	196	119	77	39	CATLIN DITCH
3100514	3,259	3,247	12	0	BEAR CREEK AND PINE RIVE
3100668	1,611	1,541	70	4	SULLIVAN DITCH
3100512	3,651	3,651	0	0	LOS PINOS IRRIGATING DIT

WDID	Historical	Simulated	Historical – Simulated Volume	Historical – Simulated Percent	Name
3100511	8,506	8,506	0	0	THOMPSON-EPPERSON_DIVSYS
3100523	15,166	15,119	47	0	SCHRODER IRG_DIVSYS
3100519	25,986	25,986	0	0	DUNCAN_DIVSYS
3100516	238	225	14	6	HIGBEE IRRIGATION DITCH
3100527	91	91	0	0	ISLAND DITCH
3100510	945	945	0	0	BEAN DITCH
3100547	23,674	23,435	239	1	ROBERT MORRISION_DIVSYS
3100505	18,304	18,304	0	0	DR MORRISON_DIVSYS
31_ADS005	6,466	6,357	108	2	WD31 AGGREGATE
3100502	3,200	3,195	5	0	CEANABOO DITCH
3100665	60,267	59,744	523	1	SPRING CREEK_DIVSYS
3100509	12,851	12,851	0	0	SPRING CREEK DITCH
3100503	2,757	2,397	360	13	COMMISSIONER DITCH
3100575	1,490	1,466	24	2	SEMLER DITCH_DIVSYS
3100710	742	742	0	0	IGNACIO CREEK DITCH
3100508	2,728	2,722	6	0	SEVERO DITCH
3100507	2,842	2,842	0	0	LA BOCA DITCH
31_ADS006	6,253	6,252	1	0	WD31 AGGREGATE
31_SUIT	0	0	0	0	SUIT RESERVED PINE
3100567	316	316	0	0	CAMPBELL DITCH
3000545	0	0	0	0	FALLS CR DIVR DAM & CNL
3004661	61	61	0	1	MINERAL POINT DITCH
3004662	66	66	0	0	RED MOUNTAIN DITCH
3000523	28,008	23,665	4,343	16	CASCADE CANAL
3000509	0	0	0	0	ANIMAS DIVERSION CANAL
3000612	23,404	23,213	191	1	POWER CANAL NO 1
3000510	1,123	1,123	0	0	BEAR CREEK DITCH
3000504	2,264	2,254	10	0	AMBOLD-WALLACE DITCH
3000617	21,840	21,659	181	1	REID DITCH
3000641	3,244	3,218	26	1	SULLIVAN-WALLACE DITCH
3000506	27,673	27,632	41	0	ANIMAS CONSOLIDATED D
3000581	3,161	3,065	95	3	J P LAMB DITCH
3000568	4,392	4,358	34	1	HERMOSA COMPANY DITCH
3000580	2,610	2,535	74	3	JOHN THOMAS DITCH
3001024	0	0	0	0	ANIMAS PMP STA & FOR MN
3000582	0	0	0	0	JUNCTION CR DIVR DAM PL
3000634	1,167	1,155	11	1	SITES DITCH
30_ADS007	6,490	6,490	0	0	WD 30 AGGREGATE
3001228	131	127	3	3	STEWARD NO 3
3001056	110	110	0	0	BODO PINE RIDGE DITCH
DUR_ALP	0	0	0	0	FUTURE DURANGO ALP DEMAND
3001657	3,328	3,352	(24)	-1	RIDGES BASIN PMP PLANT
CO_ALP	0	0	0	0	FUTURE COLORADO ALP DEMAND
3001094	6,224	6,224	0	0	EAST MESA DITCH

			Historical – Simulated		
WDID	Historical	Simulated	Volume	Percent	Name
3001023	14,683	14,683	0	0	ANIMAS DITCH
3001000	4,289	4,273	17	0	DURANGO CITY PIPELINE
3001011	45,917	41,312	4,605	10	FLORIDA_FARMERS_DIVSYS
3001003	783	774	9	1	HARRIS-PATTERSON DITCH
3001019	1,653	1,428	225	14	PIONEER DITCH
3001009	805	750	54	7	MCCLUER AND MURRAY DITCH
3001033	875	814	61	7	BANKS-TYNER DITCH
3001243	979	756	223	23	TYNER EAST SIDE DITCH
30_ADS008	5,863	5,612	251	4	WD 30 AGGREGATE
3001219	2,502	2,371	131	5	SITES-KERN_DIVSYS
3001220	732	687	45	6	SMITH HIGHLINE NO 1 D
30_ADS009	4,457	4,457	0	0	WD 30 AGGREGATE
3001076	230	230	0	0	CRAIG DITCH
30_SUIT	0	0	0	0	SUIT RESERVED ANIMAS
30_ADS010	1,811	1,811	0	0	WD 30 AGGREGATE
3004665	4,496	4,495	1	0	TWIN ROCK DITCH
3004664	4,937	4,937	0	0	RALSTON DITCH
NM_ALP	0	0	0	0	NM_ALP_Animas_Demand
3300508	2,364	2,350	13	1	LA PLATA R & CHERRY CR D
3300533	896	888	8	1	PINE RIDGE DITCH
3300501	1,517	1,484	33	2	LA PLATA IRG DITCH
3300504	5,473	5,373	99	2	HAY GULCH DITCH
3300554	1,873	1,849	24	1	BIG STICK DITCH
3300518	357	357	0	0	AMMONS DITCH
3300536	4,501	4,434	67	1	H H DITCH
3300549	1,820	1,799	21	1	TREANOR DITCH
3300542	3,239	3,106	133	4	SLADE DITCH
3300551	542	527	15	3	TOWNSITE DITCH
3300547	2,492	2,406	87	3	JOSEPH FREED DITCH
3300548	465	461	4	1	REVIVAL DITCH
3300550	708	707	2	0	WARREN-VOSBURGH DITCH
3300535	671	665	6	1	SOONER VALLEY DITCH
3300540	469	464	5	1	ENTERPRISE ENLARGEMENT D
33_SUIT	0	0	0	0	SUIT RESERVED LA PLATA
3304640	726	726	0	0	PIONEER DITCH
3304639	549	548	1	0	ENTERPRISE ENLARGEMENT D
33_ADS011	1,806	1,806	0	0	WD 33 AGGREGATE
3400577	1,094	972	122	11	WEBER RESERVOIR INLET D
3400544	707	691	16	2	LONG PARK DITCH
3400567	128	123	5	4	SMOUSE DITCH
3400582	196	194	2	1	WILLIAMS DITCH_DIVSYS
3400522	581	562	19	3	EAST MANCOS HIGHLINE DIT
3400530	1,127	1,074	53	5	GILES DITCH
3400560	1,786	1,768	19	1	RUSH RESERVOIR_DIVSYS

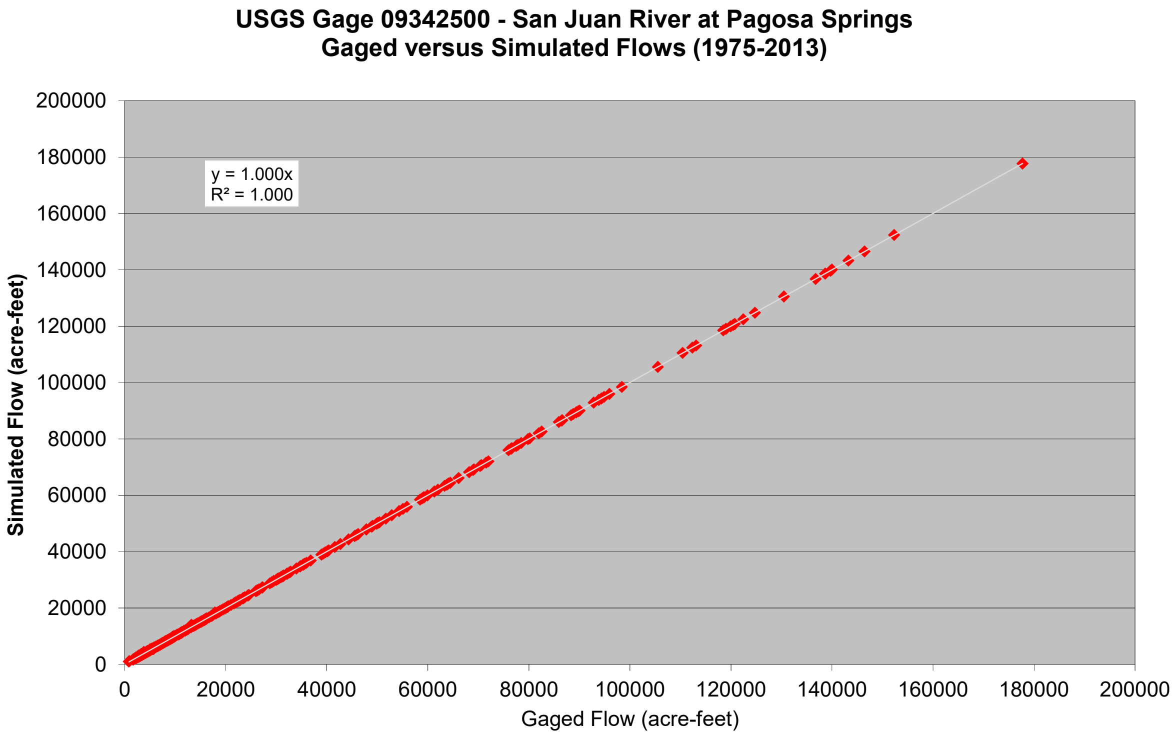
WDID	Historical	Simulated	Historical – Simulated Volume	Historical – Simulated Percent	Name
3400514	658	650	8	1	CRYSTAL CREEK DITCH
3400535	7,797	8,171	(375)	-5	JACKSON GULCH INLET CNL
3400542	958	956	2	0	LEE AND BURKE DITCH
3400573	624	624	0	0	TOWN OF MANCOS DITCH
34_ADS012	1,367	1,366	1	0	WD 34 AGGREGATE
3400576	5,300	5,292	8	0	WEBBER DITCH
3400554	4,401	4,401	0	0	RATLIFF AND ROOT DITCH
3400543	527	526	1	0	LEE DITCH
3400527	494	493	1	0	FRANK DITCH
3400583	800	797	3	0	WILLIS DITCH
3400506	954	947	7	1	BOSS DITCH
3400552	877	876	0	0	NO 6 DITCH
3400565	1,499	1,497	2	0	SHEEK DITCH
3400505	1,360	1,356	5	0	BEAVER DITCH
3400508	697	773	(76)	-11	CARPENTER AND MITCHELL D
34_ADS013	803	800	3	0	WD 34 AGGREGATE
3400534	2,350	2,346	3	0	HENRY BOLEN DITCH
3400531	1,020	854	166	16	GLASGOW & BREWER DITCH
34_UMU	0	0	0	0	UMU RESERVED MANCOS
34_ADS014	4,215	4,199	16	0	WD 34 AGGREGATE
34_AMS001	1,080	1,056	24	2	WD 34 M&I AGGREGATE
3202001	835	835	0	0	DOLORES WATER DIVR HGT
3200680	2,996	2,857	139	5%	TOWN OF CORTEZ
3204675	60,084	60,005	79	0%	DOLORES TUNNEL
3200884	10,081	9,148	933	9%	TOWAOC CANAL
3200690	2,667	2,627	40	2	WILSON DITCH
32_ADS015	6,261	6,080	182	3	WD 32 AGGREGATE
3200558	1,364	1,282	82	6	EATON DITCH
3200662	893	843	50	6	SCHALLES DITCH
3200509	1,039	1,039	0	0	BLACK DIKE DITCH
3200652	9,444	9,427	17	0	ROCK CREEK DITCH
3200574	4,014	3,889	124	3	HAMBELTON DITCH
3200634	1,831	1,700	131	7	MURRAY-ZWICKER-TOZER D
3200528	2,583	2,573	10	0	COTTONWOOD DITCH NO 1
3200529	2,749	2,624	125	5	COTTONWOOD DITCH NO 2
32_ADS016	6,726	6,701	25	0	WD 32 AGGREGATE
32_UMU	0	0	0	0	UMU Reserved MCELMO
3200590	795	795	0	0	ISMAY DITCH
7102002	6,295	5,836	459	7	SUMMIT RES OUTLET
3202006	26,473	24,121	2,352	9%	DOVE CREEK CANAL
3200699	0	0	0	0	NARRAGUINNEP RES INLET
3200772	77,927	77,822	105	0	MVI U LATERAL
73_ADS025	8,031	7,969	62	1	WD 73 AGGREGATE
7100575	44	23	20	47	ORIGINAL RICO FLUME

WDID	Historical	Simulated	Historical – Simulated		Name
			Volume	Percent	
7100556	31	16	15	48	KING NO 1 DITCH
7100504	285	155	131	46	BEAR CREEK DITCH
7100582	464	259	205	44	QUARRY NO 1 DITCH
7100563	345	153	192	56	LINDSTROM DITCH
7100572	381	321	60	16	MONUMENT ROCK DITCH
7100545	723	695	29	4	GOULD & MORIARITY DITCH
7100573	789	536	253	32	MORIARITY DITCH
7100531	300	166	134	45	EAST EDDER_DIVSYS
7100567	640	246	394	62	MCEWEN DITCH
7100624	214	88	127	59	WEST EDER DITCH
7100544	72	23	49	68	GOEBEL DITCH
7100559	292	130	162	55	KOENIG DITCH
7100586	250	125	125	50	RIEVA DITCH_DIVSYS
7100537	106	34	72	68	GARBARINO NO 3 DITCH
7100535	116	44	72	62	GARBARINO NO 1 DITCH
7100536	105	42	63	60	GARBARINO NO 2 DITCH
7100513	750	709	41	5	BURCH AND LONGWILL DITCH
7100551	142	140	2	1	ITALIAN DITCH
7100549	1,127	988	138	12	ILLINOIS DITCH
7100555	577	403	174	30	KEYSTONE DITCH
7100618	1,327	3,178	(1,851)	-139	TURKEY CREEK DITCH
7100609	3,731	3,079	651	17	SUMMIT DITCH
71_ADS017	2,234	2,200	34	2	WD 71 AGGREGATE
7104675	73,903	72,377	1,526	2%	Dolores_Tunnel
7104674	82,927	82,275	652	1%	MAIN CANAL NO 2
7102999	0	0	0	0	McPHEE RES FISH MSF
71_ADS019	1,097	830	267	24	WD 71 AGGREGATE
6900512	505	473	32	6	KNIGHT-EMBLING DITCH
69_ADS018	802	791	11	1	WD 69 AGGREGATE
6900503	107	107	0	0	DISAPPOINTMENT DITCH
6900502	104	104	0	0	DAWSON-HAMMOND DITCH
6900510	1,240	1,186	55	4	HORSESHOE DITCH
6900520	484	463	22	4	PINE ARROYA DITCH
6100602	136	122	14	10	A E L R P & PL
6100527	2,136	1,908	228	11	RAY DITCH
6100517	1,332	1,251	81	6	SOUTH MIDWAY DITCH
6100512	820	777	43	5	AMEDED LAURA_DIVSYS
6100502	1,183	1,150	33	3	GALLOWAY DITCH
61_ADS019	7,400	7,168	232	3	WD 61 AGGREGATE
6000511	10,372	10,317	55	1	AMES ILIUM HYDRO PROJ
6000507	331	317	14	4	ALEXANDER DITCH
6000659	435	413	22	5	KINLEY DITCH
6000627	305	292	13	4	HARDSCRABBLE DITCH
6000549	135	135	0	0	CARR WADDLE DITCH

WDID	Historical	Simulated	Historical – Simulated Volume	Percent	Name
6000550	881	818	62	7	CARRIERE DITCH
6000736	1,600	1,570	30	2	PLEASANT VALLEY DITCH
6000576	187	177	10	5	DILLON DITCH
6000650	1,872	1,766	106	6	J & M HUGHES DITCH
6000588	706	686	19	3	ELK CREEK DITCH
6000689	625	602	23	4	MIDDLE ELK CREEK DITCH
6000678	320	308	12	4	LOWER ELK CREEK DITCH
6000652	106	102	4	4	JARRETT DITCH
6800636	1,188	1,151	37	3	LEOPARD CREEK DITCH
6000583	492	441	51	10	EAGLE DITCH
6000608	167	123	44	26	GOLDEN DITCH
6000669	530	293	237	45	LEOPARD CREEK DITCH
6000611	602	588	14	2	GOLD RUN DITCH
6000628	458	441	17	4	HASTINGS DITCH
6000710	121	119	2	2	NEILSON DITCH
6000617	136	109	26	19	GREEN MT DITCH NO 2
6000594	3	3	0	0	FAYETTE PLACER
60_ADS020	3,057	3,052	4	0	WD 50 AGGREGATE
6000521	962	823	139	14	BEAVER MESA DITCH
6000578	265	197	68	26	DOLPHIN DITCH
6000684	452	391	62	14	MCCOLLOCH SCOTT DITCH
6000707	17,255	17,132	123	1	NATURITA CANAL
6000777	211	211	0	0	THEO NETHERLY DITCH NO1
6000625	131	129	2	2	HANKS VALLEY DITCH NO 2
6000733	360	342	17	5	PAXTON DITCH
6001239	77	75	2	3	THEO NETHERLY DITCH NO3
6000585	308	307	1	0	EASTON DITCH
6000786	148	145	2	1	TUMBLE CREEK DITCH
6000535	754	740	14	2	BRADDOCK DITCH
6000633	33,879	33,438	440	1	HIGHLINE CANAL
6000730	1,072	279	793	74	PARKWAY DITCH
6000723	478	478	0	0	NUCLA POWER PLANT DITCH
6000613	714	710	4	1	GOULDING DITCH
6000745	653	648	5	1	REED CHATFIELD DITCH
6000520	820	818	2	0	B C D DITCH
6000707_I	16,628	16,597	31	0	NATURITA IRRIGATION
6000672_I	3,283	3,237	46	1	LONE CONE IRRIGATION
6000574	352	341	11	3	DENISON DITCH
6000665	570	562	8	1	LAST CHANCE DITCH
6000672	3,437	3,850	(413)	-12	LONE CONE DITCH
6000618	99	90	9	9	GROVE DITCH
6000670_I	3,237	3,158	79	2	LILYLANDS IRRIGATION
6000670	3,453	3,913	(460)	-13	LILYLANDS CANAL
6000515	212	190	22	10	AUSTRIAN TWIN DITCH

WDID	Historical	Simulated	Historical – Simulated Volume	Percent	Name
6000831	367	366	1	0	MAVERICK DRAW DITCH
60_ADS021	802	801	1	0	WD 50 AGGREGATE
60_ADS022	4,377	4,365	12	0	WD 50 AGGREGATE
6000569	657	652	6	1	CRAVER DITCH
6000735	194	160	34	17	PLATEAU BASIN DITCH
6000540	153	151	2	1	BURCH MORGAN DITCH
6000607	304	299	5	2	GLENCOE DITCH
6000776	485	478	7	1	TEMPLETON DITCH
6300553	217	209	8	4	RED CROSS DITCH
6300547	334	253	82	24	NOLAN DITCH
6300597	100	92	8	8	IDLEWILD HIGHLINE DITCH
6300529	883	592	291	33	HARMS AND HAZEL DITCH
6300518	1,425	991	434	30	CLIFF RANCH DITCH
6300501	2,376	1,437	938	40	BARTHOLOMEW AND HATCH D
63_ADS024	11,173	10,316	856	8	WD 53 AGGREGATE
63_ADS023	4,641	4,641	0	0	WD 53 AGGREGATE
63_AMS002	1,296	1,273	23	2	WD 63 M&I AGGREGATE
Basin Total	**1,269,501**	**1,240,658**	**28,843**	**2.4**	

1) Carrier Structures – demand and use accounted for at user structure



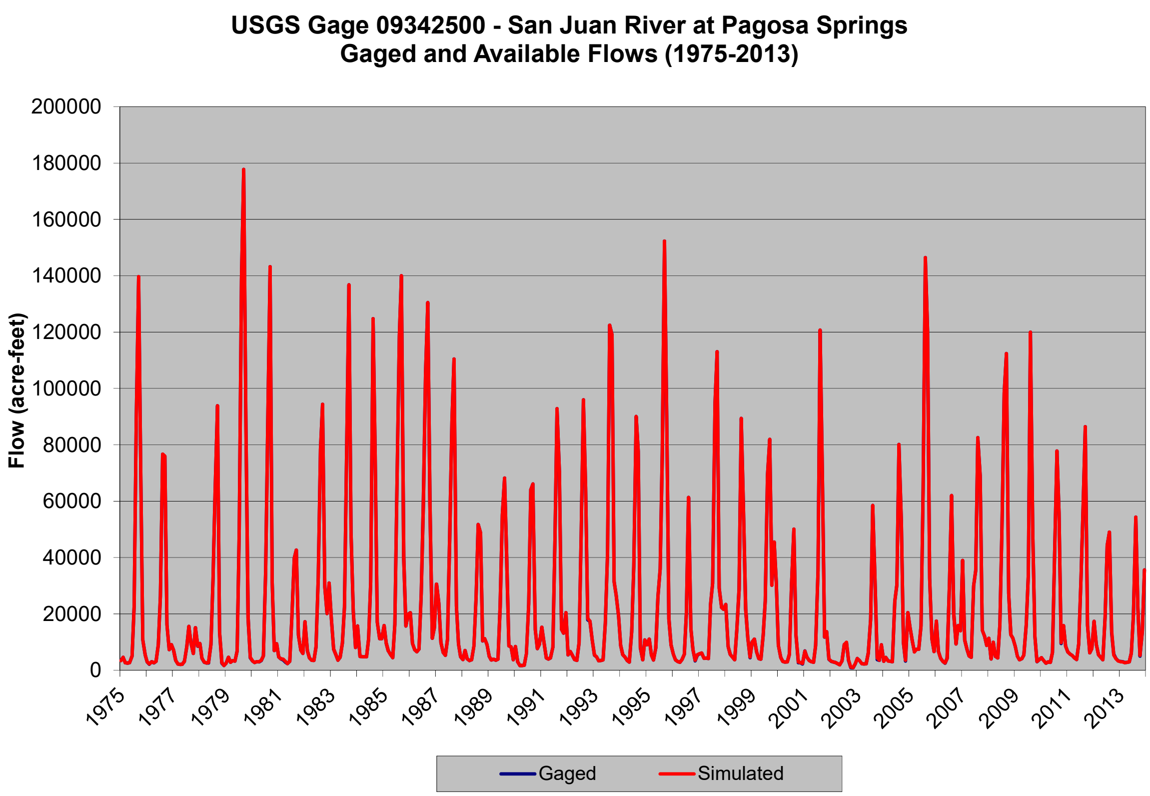
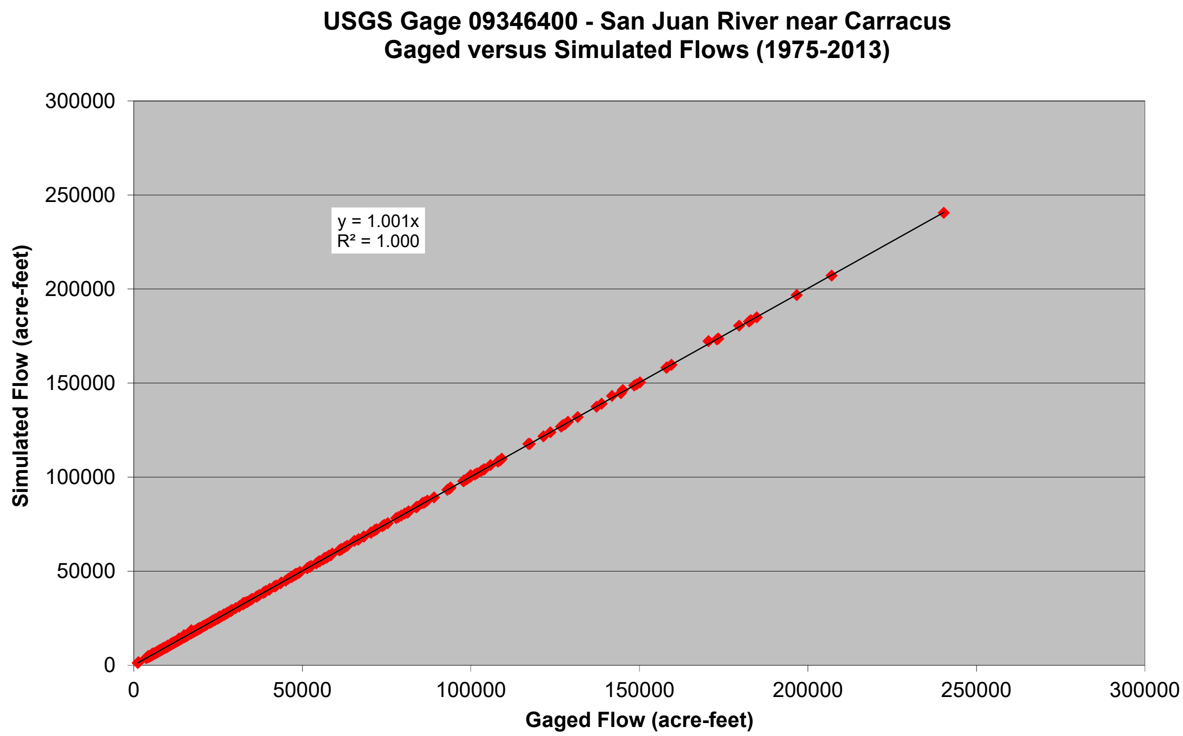


Figure 7.1 Streamflow Calibration – San Juan River at Pagosa Springs



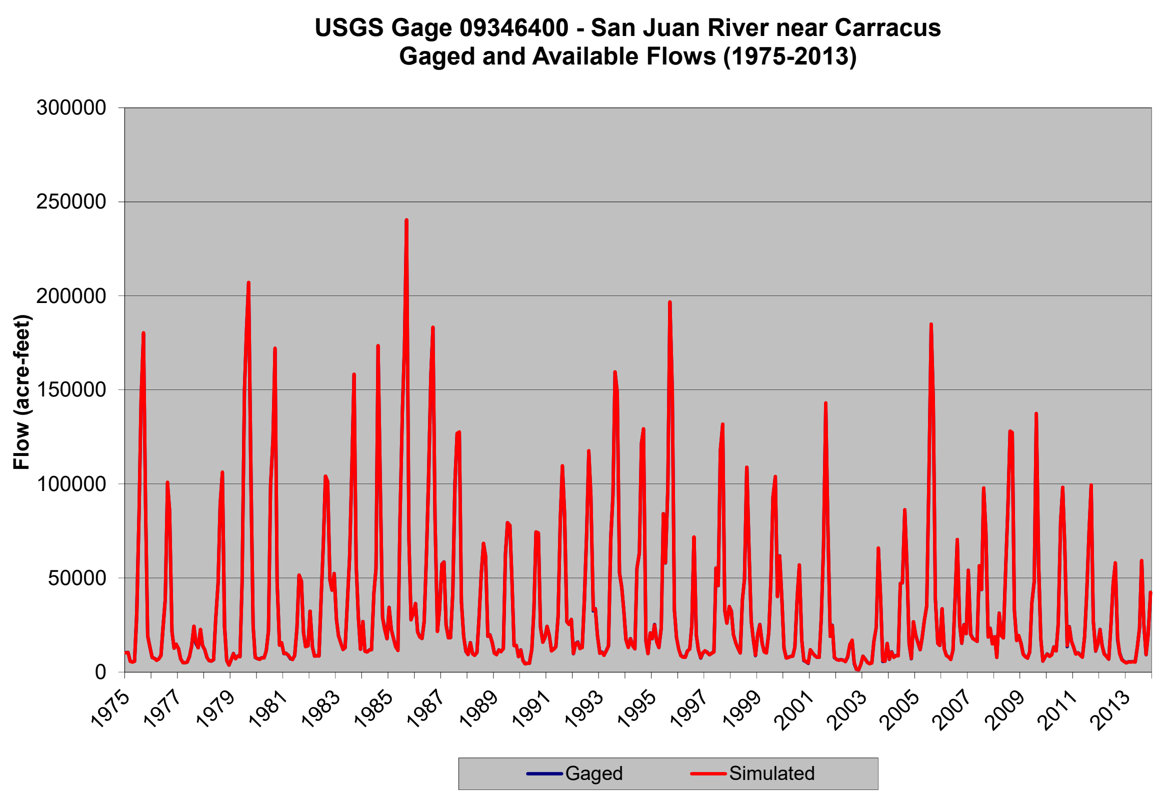
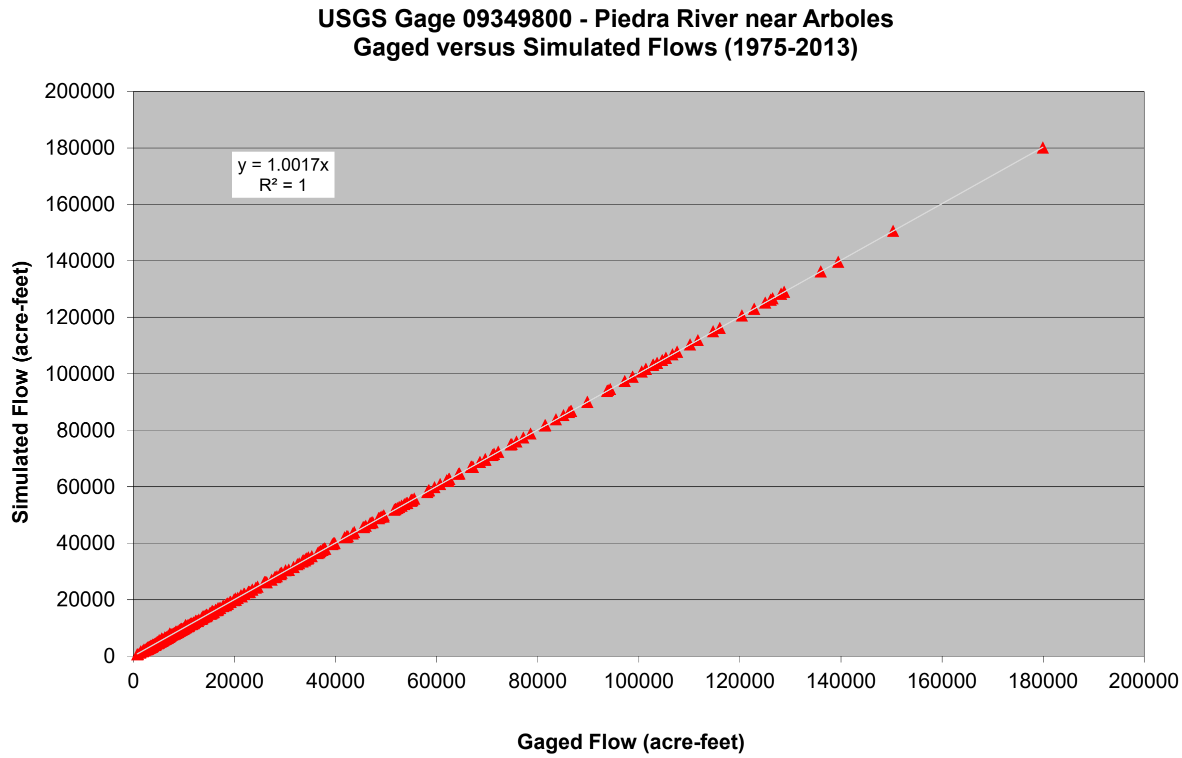


Figure 7.2 Streamflow Calibration – San Juan River near Carracus



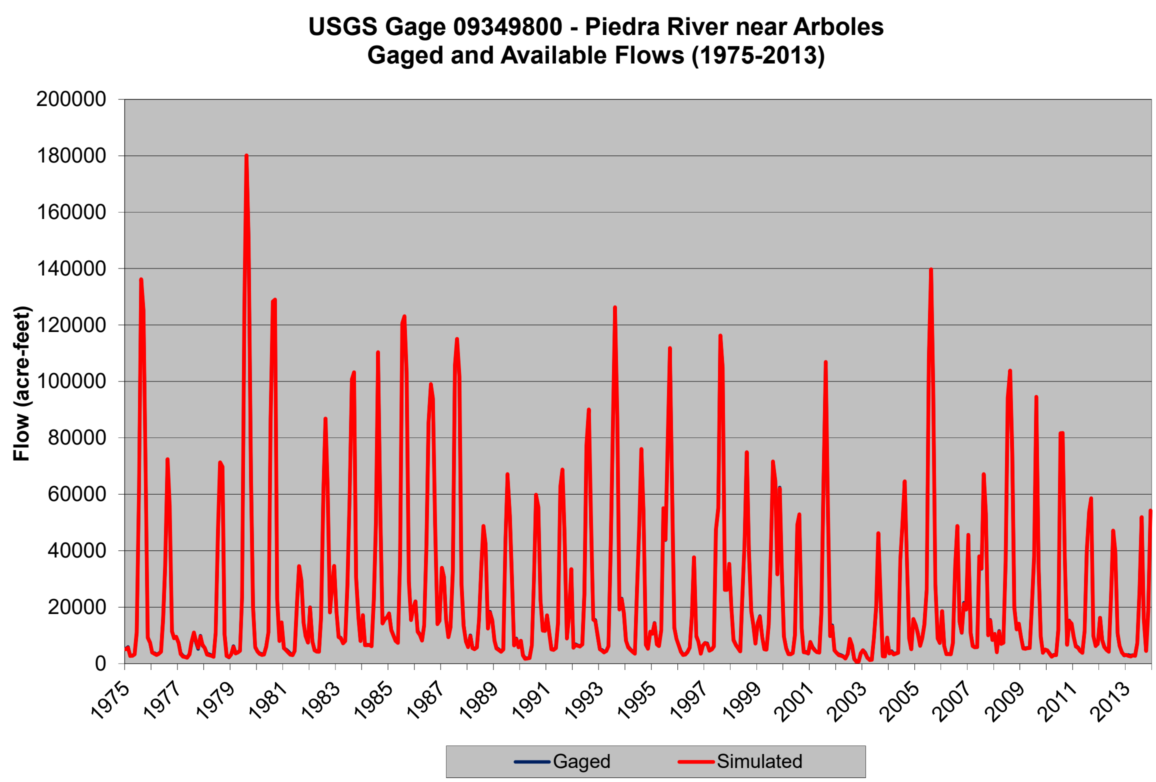
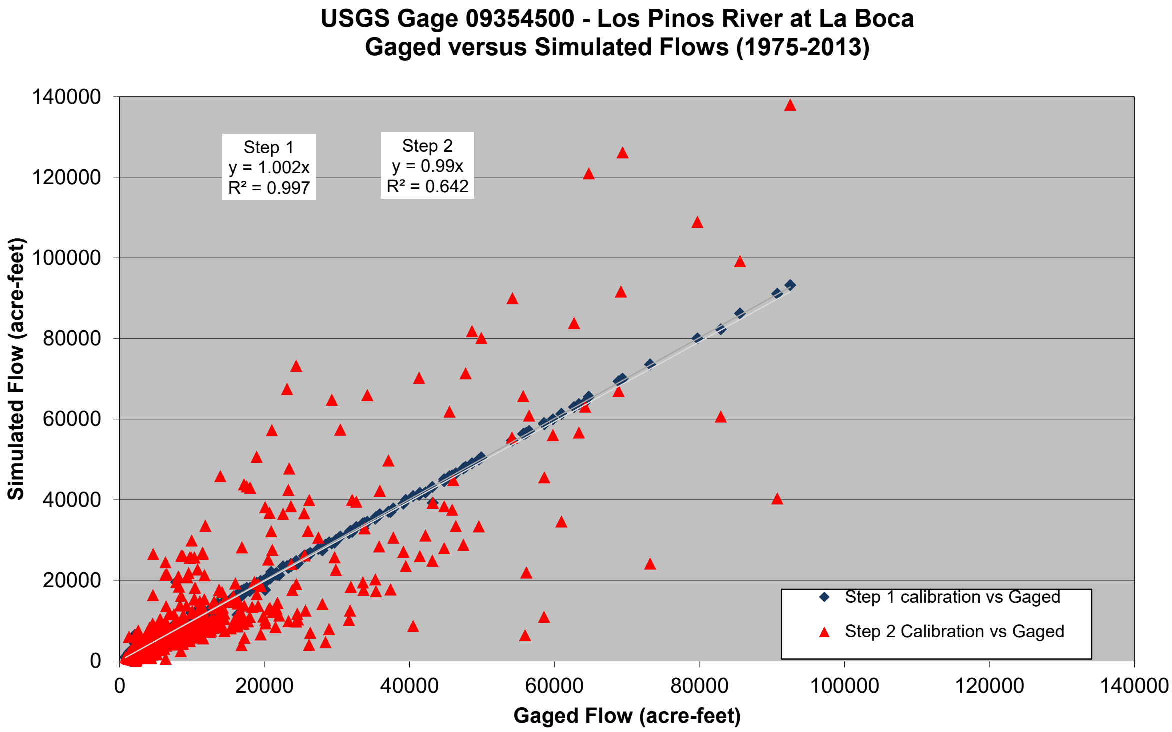


Figure 7.3 Streamflow Calibration – Piedra River near Arboles



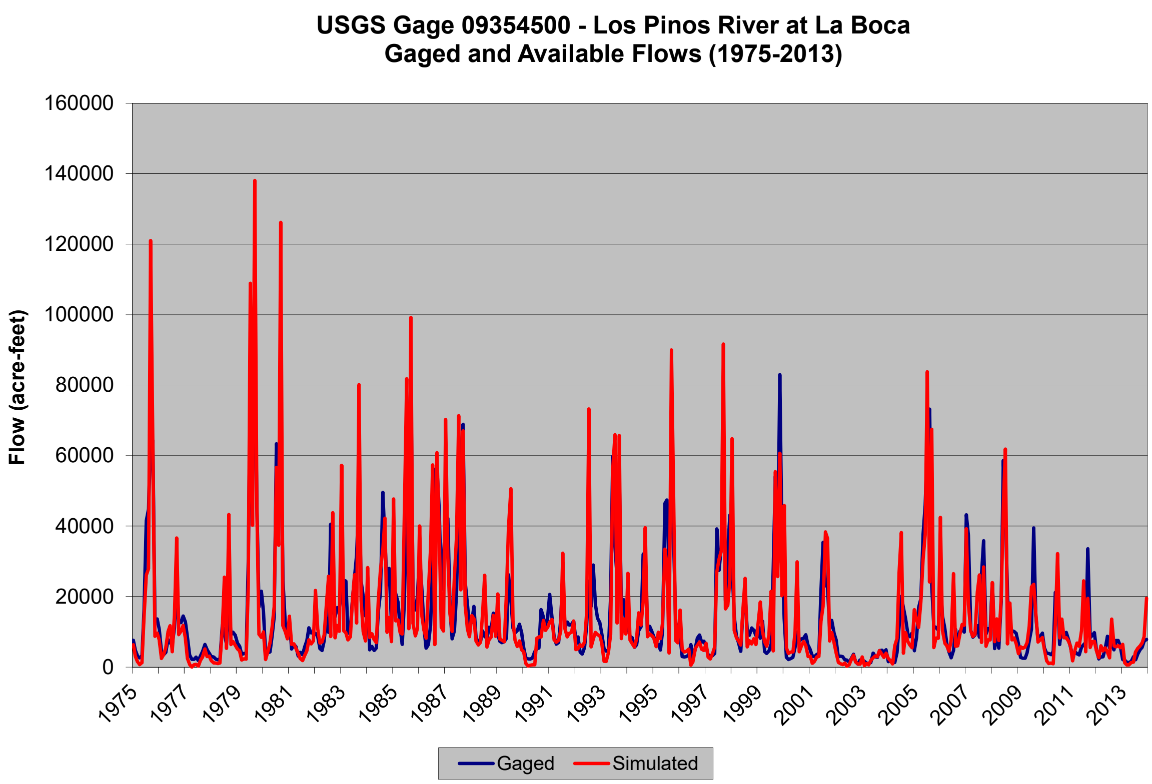
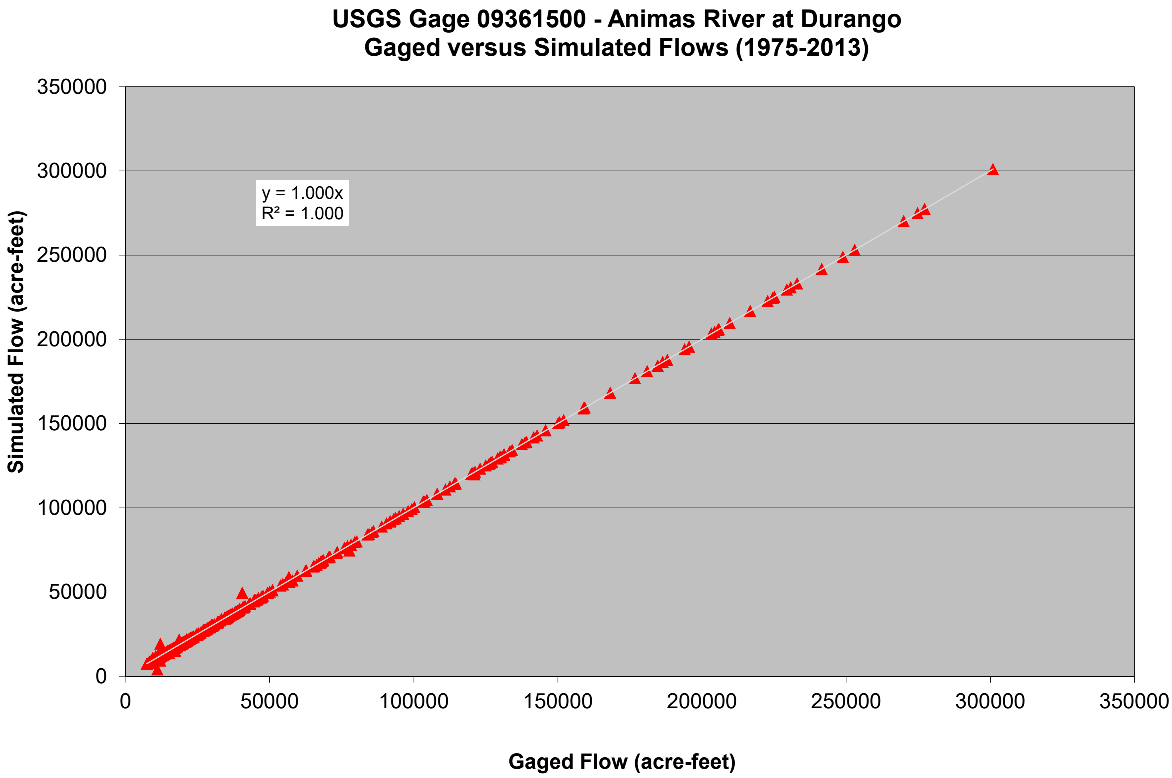


Figure 7.4 Streamflow Calibration – Los Pinos River at La Boca



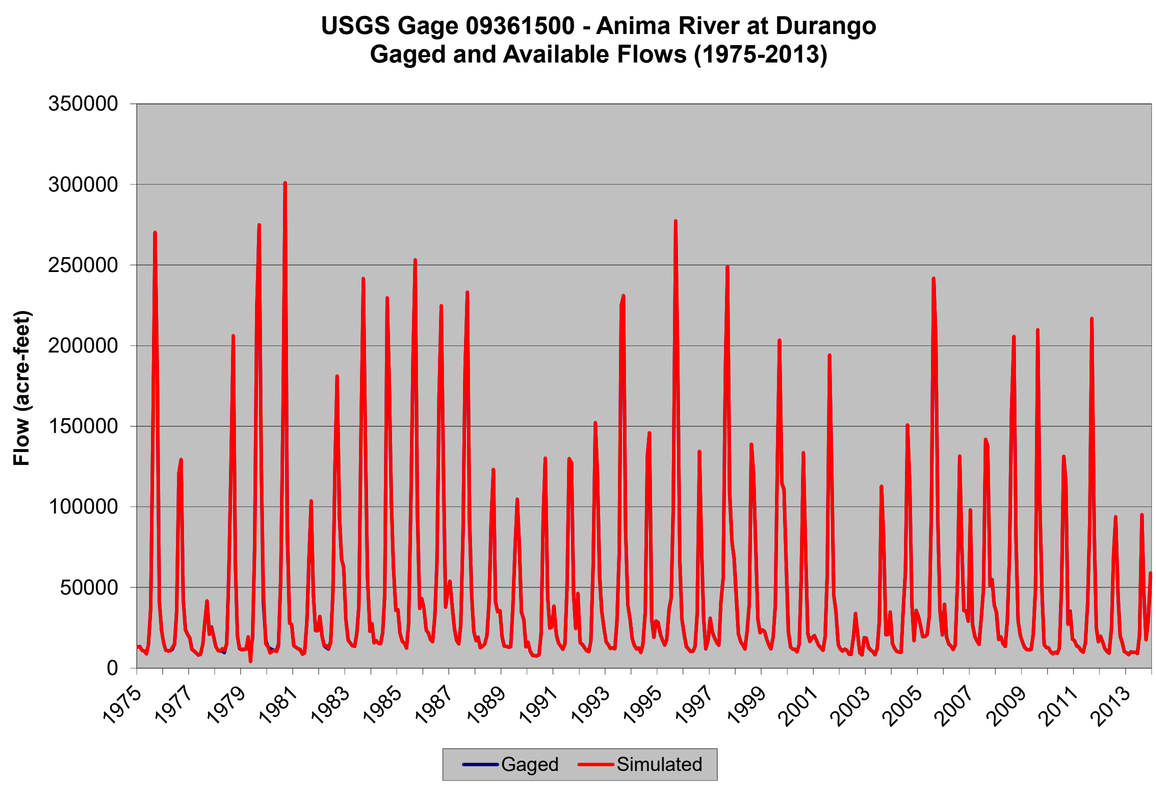
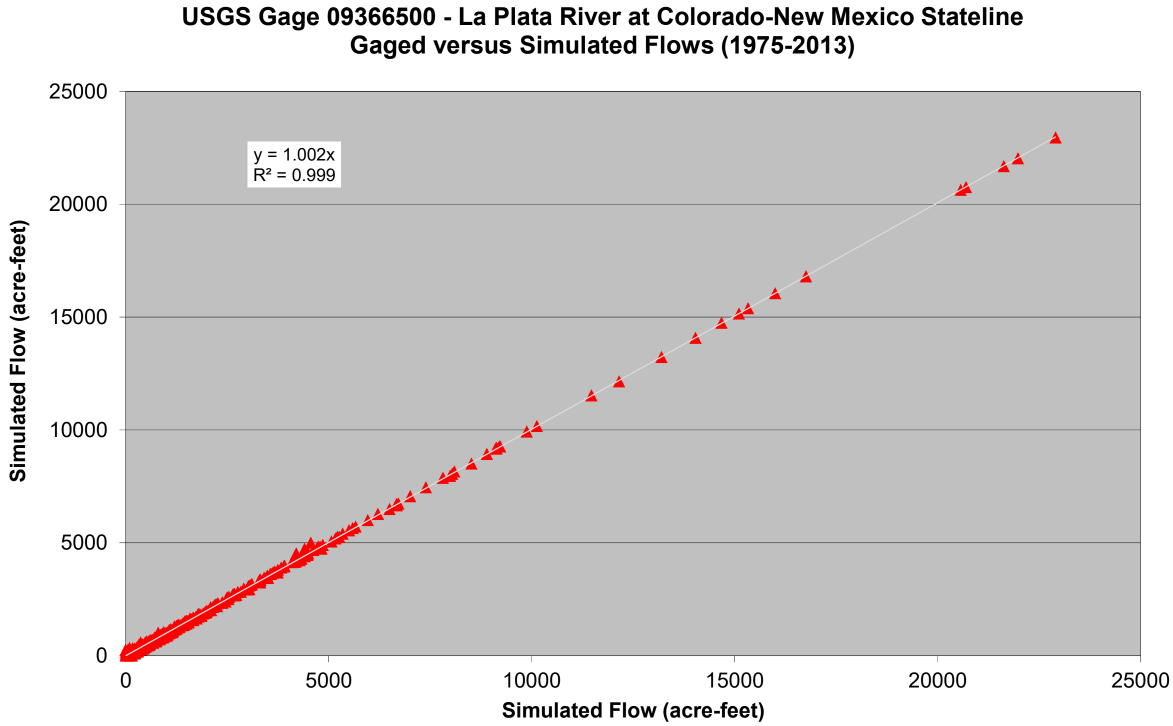


Figure 7.5 Streamflow Calibration – Animas River at Durango



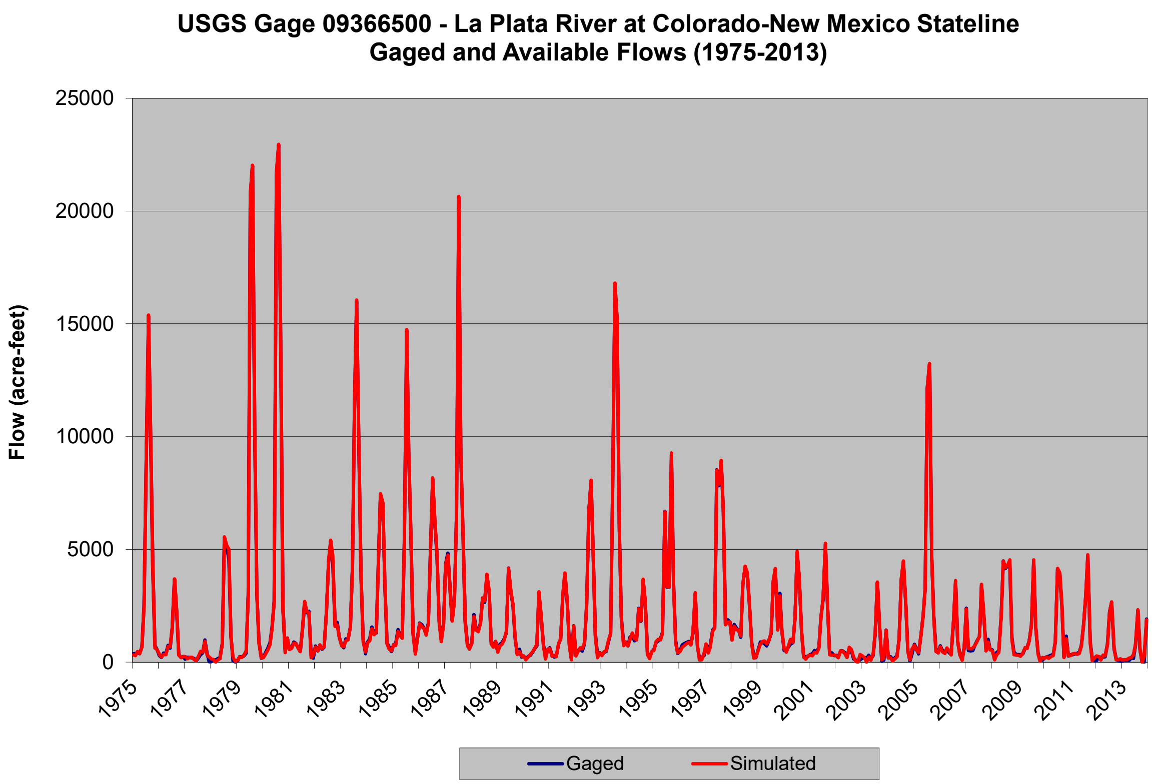
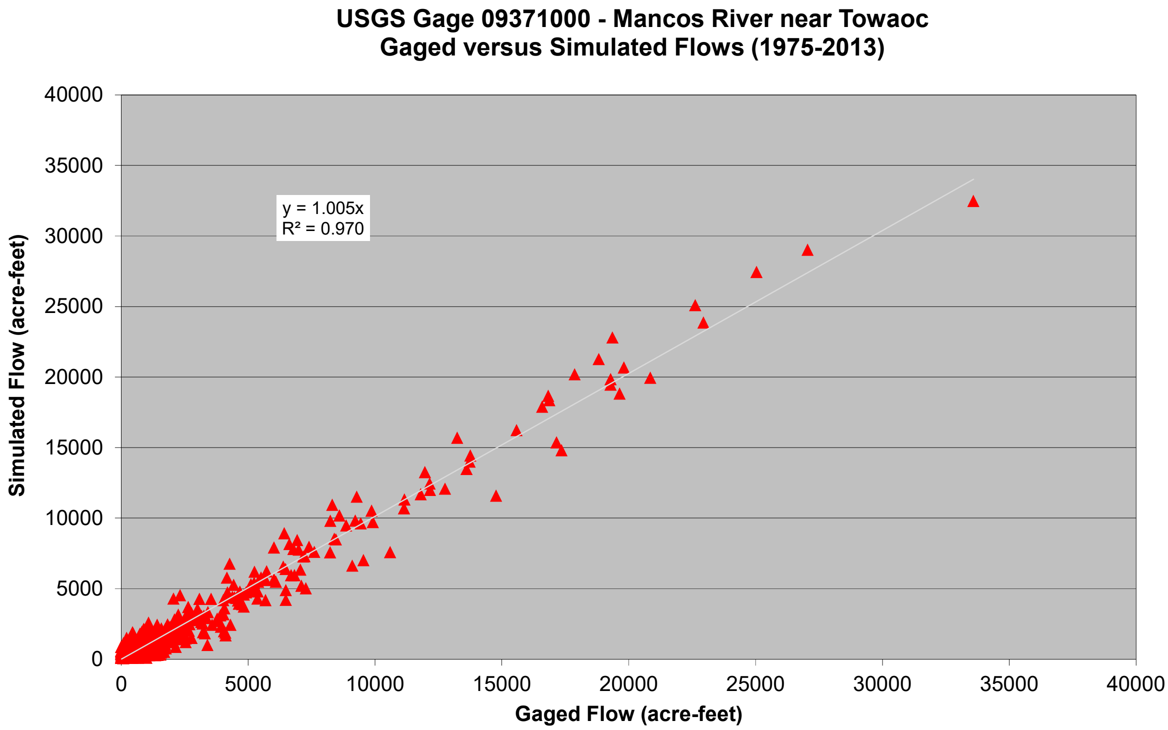


Figure 7.6 Streamflow Calibration – La Plata River at Colorado-New Mexico Stateline



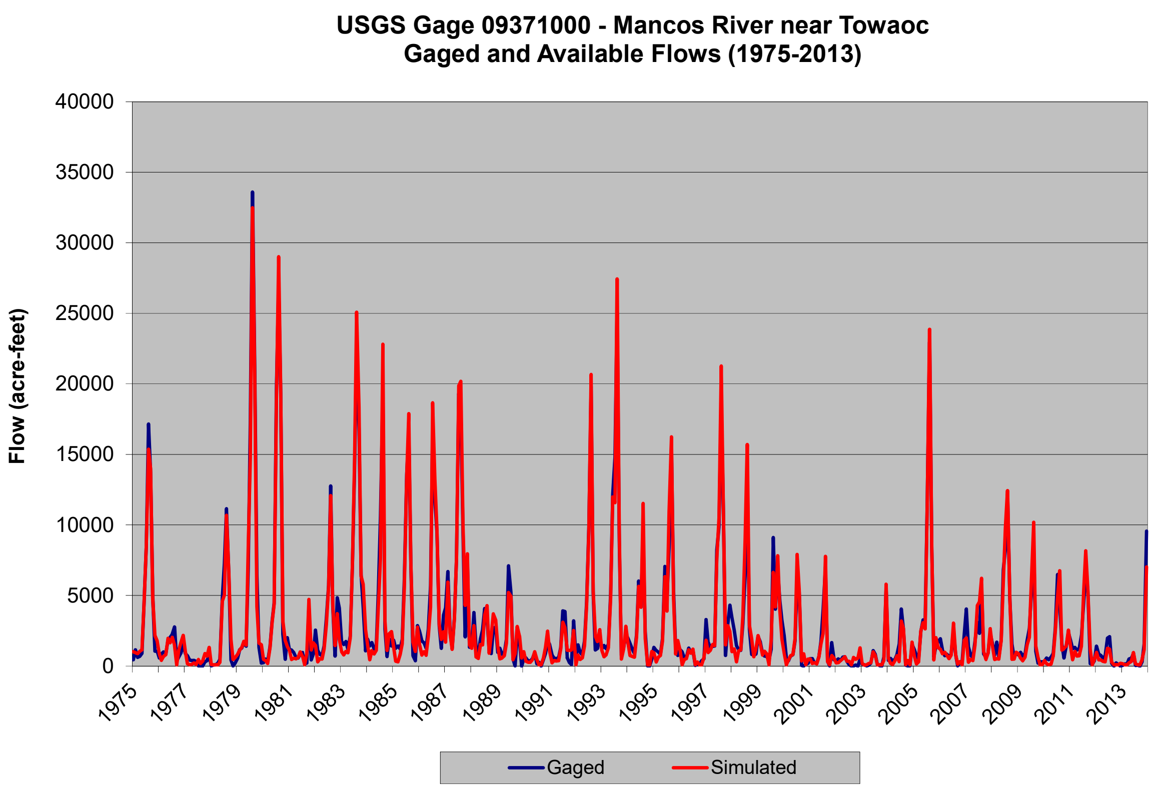
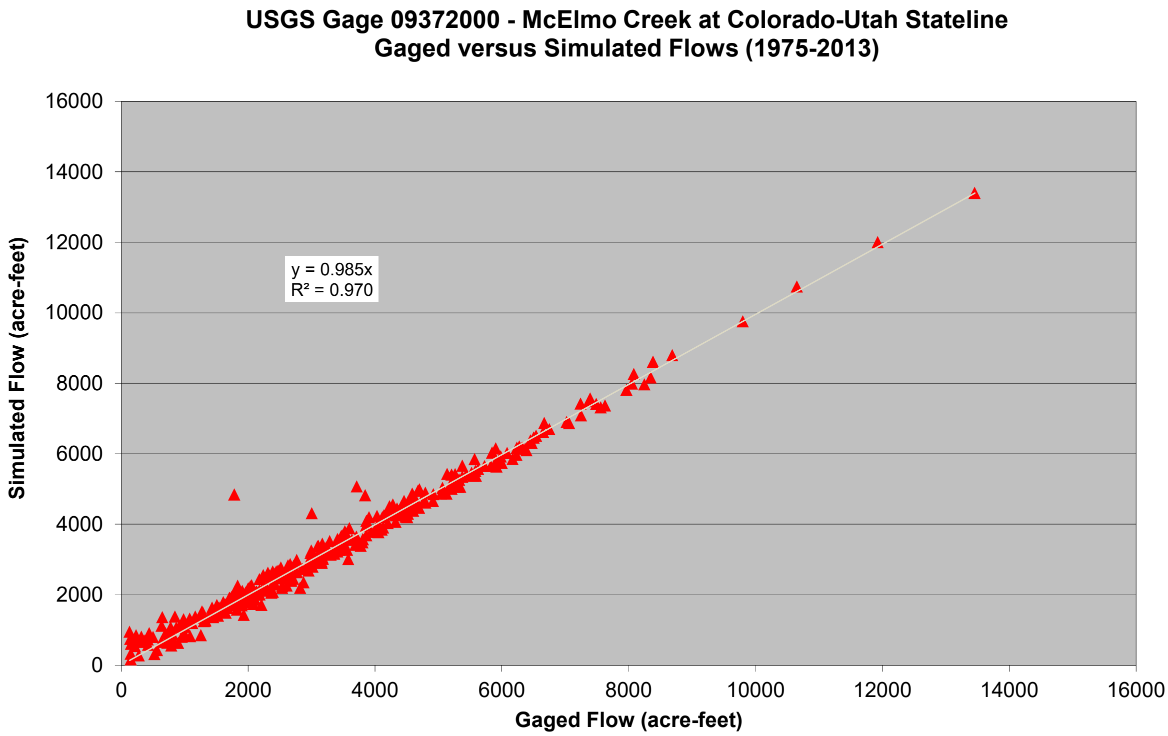


Figure 7.7 Streamflow Calibration – Mancos River near Towaoc



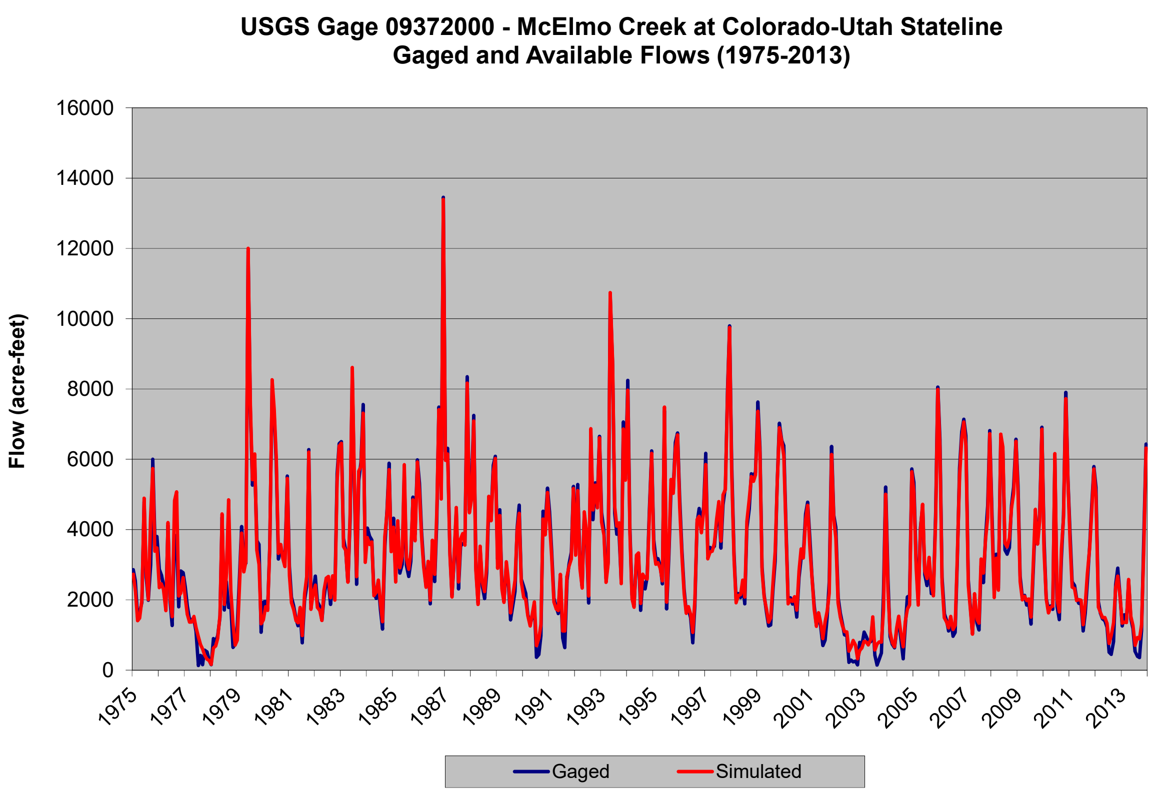
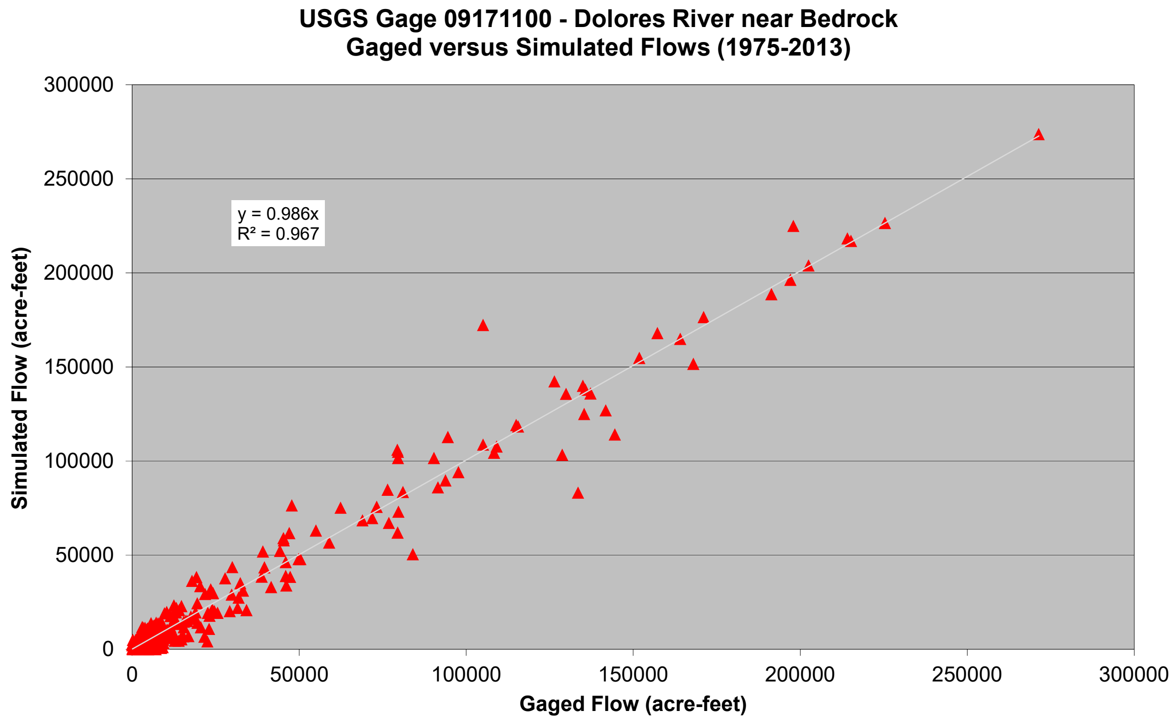


Figure 7.8 Streamflow Calibration – McElmo Creek at Colorado-Utah Stateline



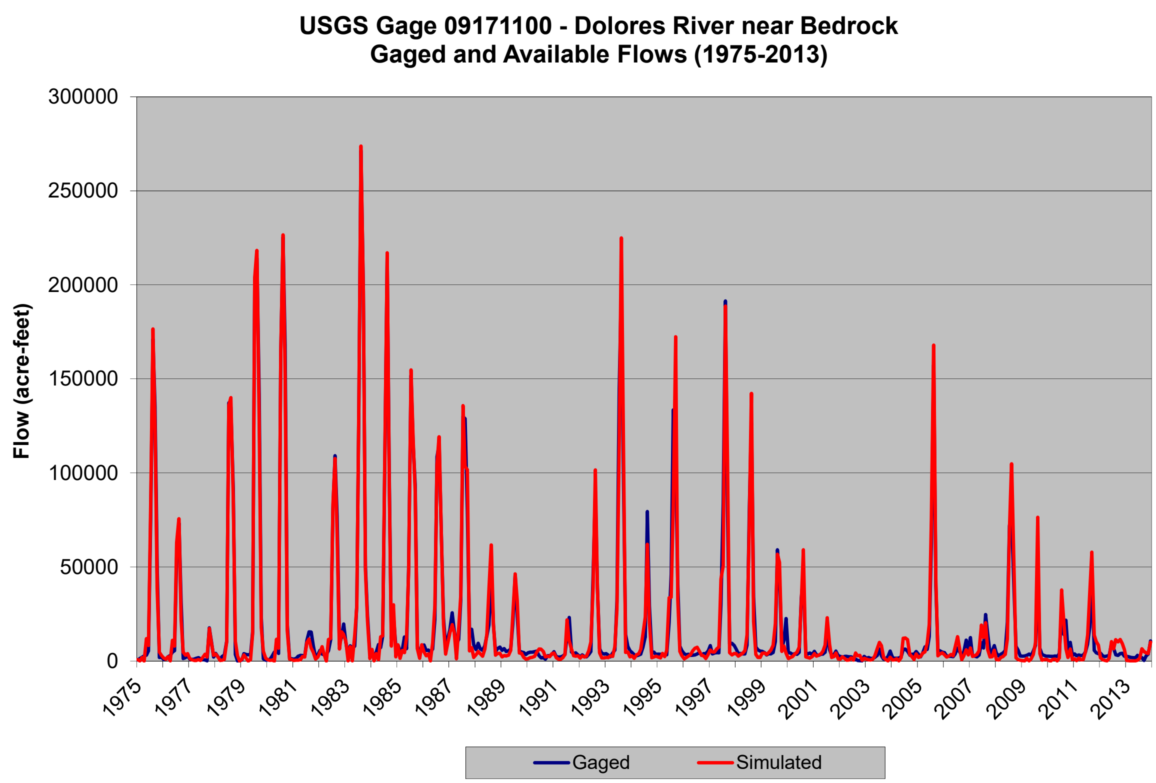
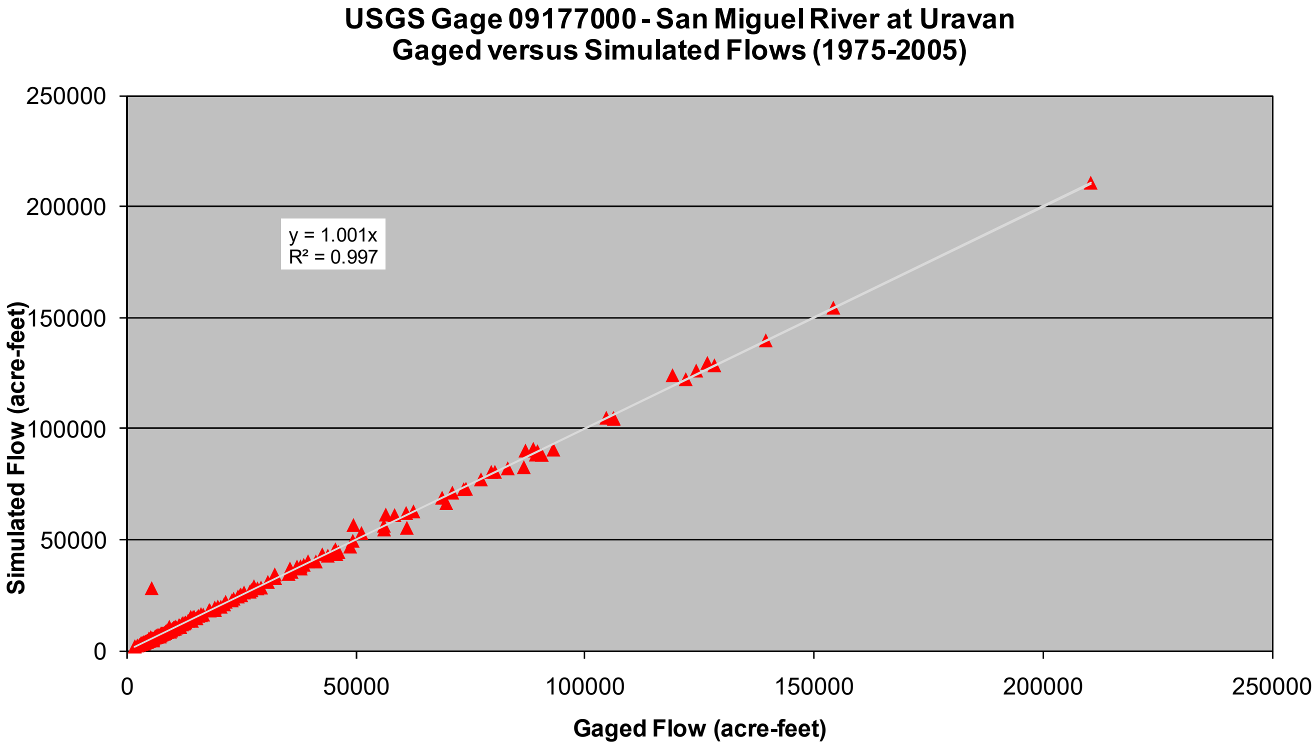


Figure 7.9 Streamflow Calibration – Dolores River near Bedrock



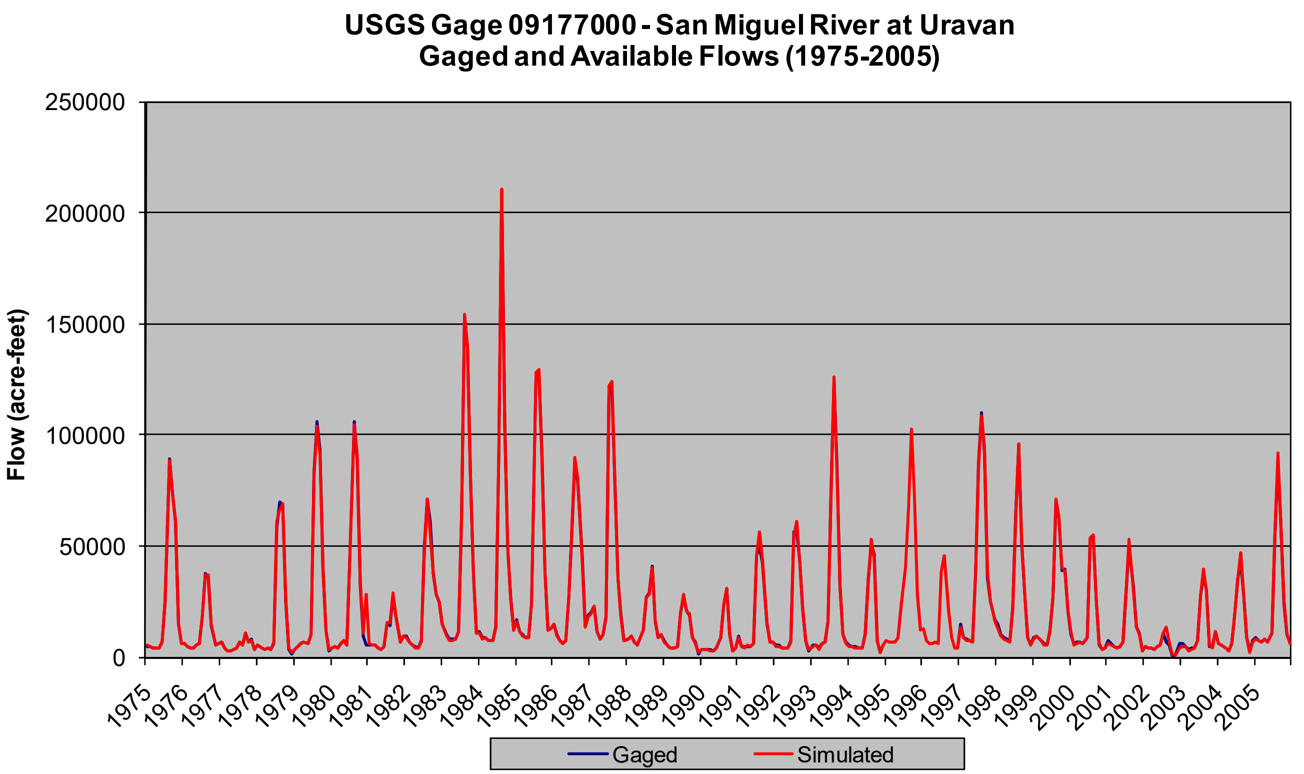


Figure 7.10 Streamflow Calibration – San Miguel River at Uravan

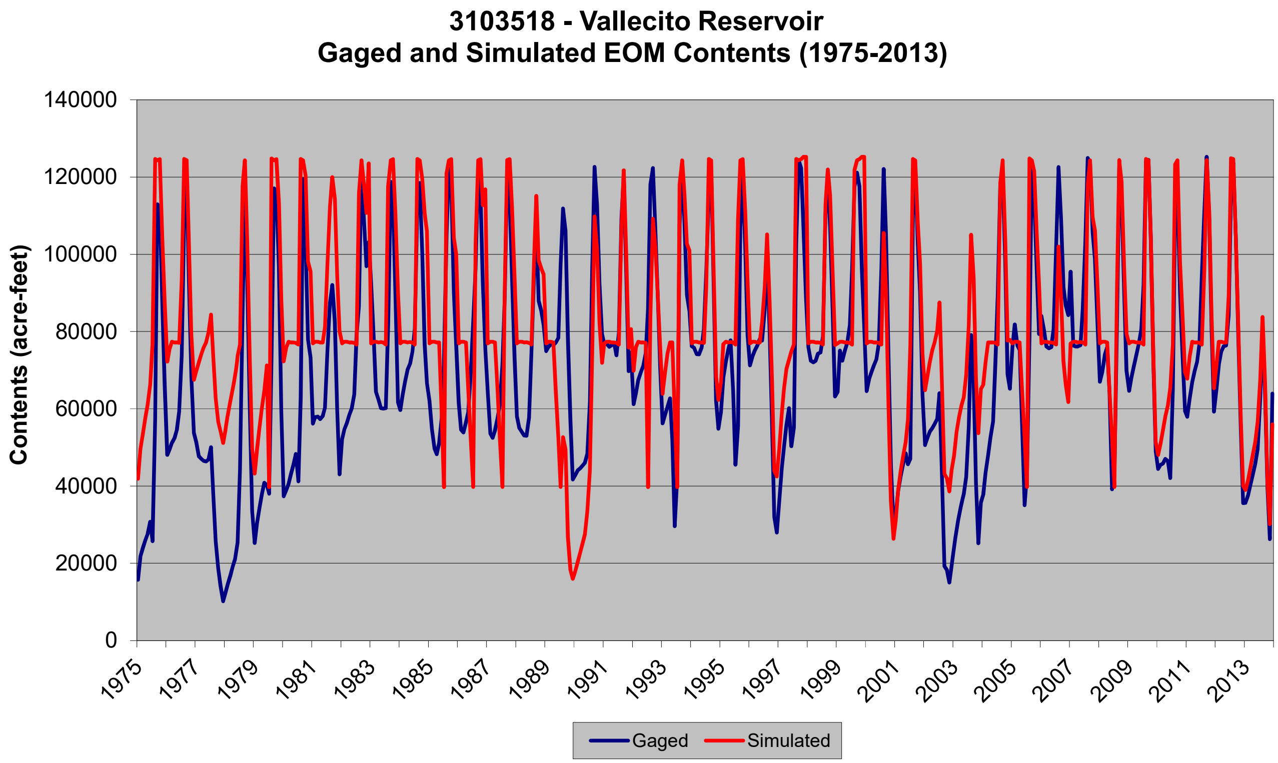


Figure 7.11 Reservoir Calibration – Vallecito Reservoir

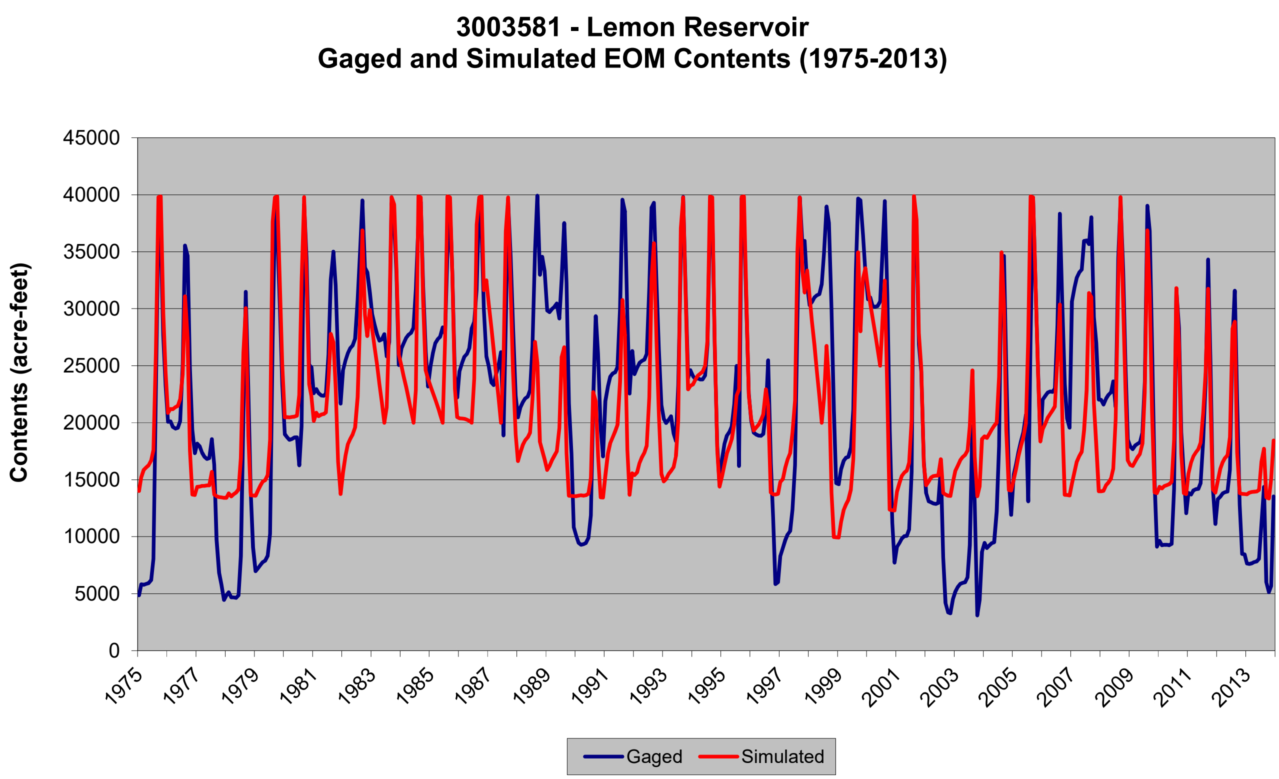


Figure 7.12 Reservoir Calibration – Lemon Reservoir

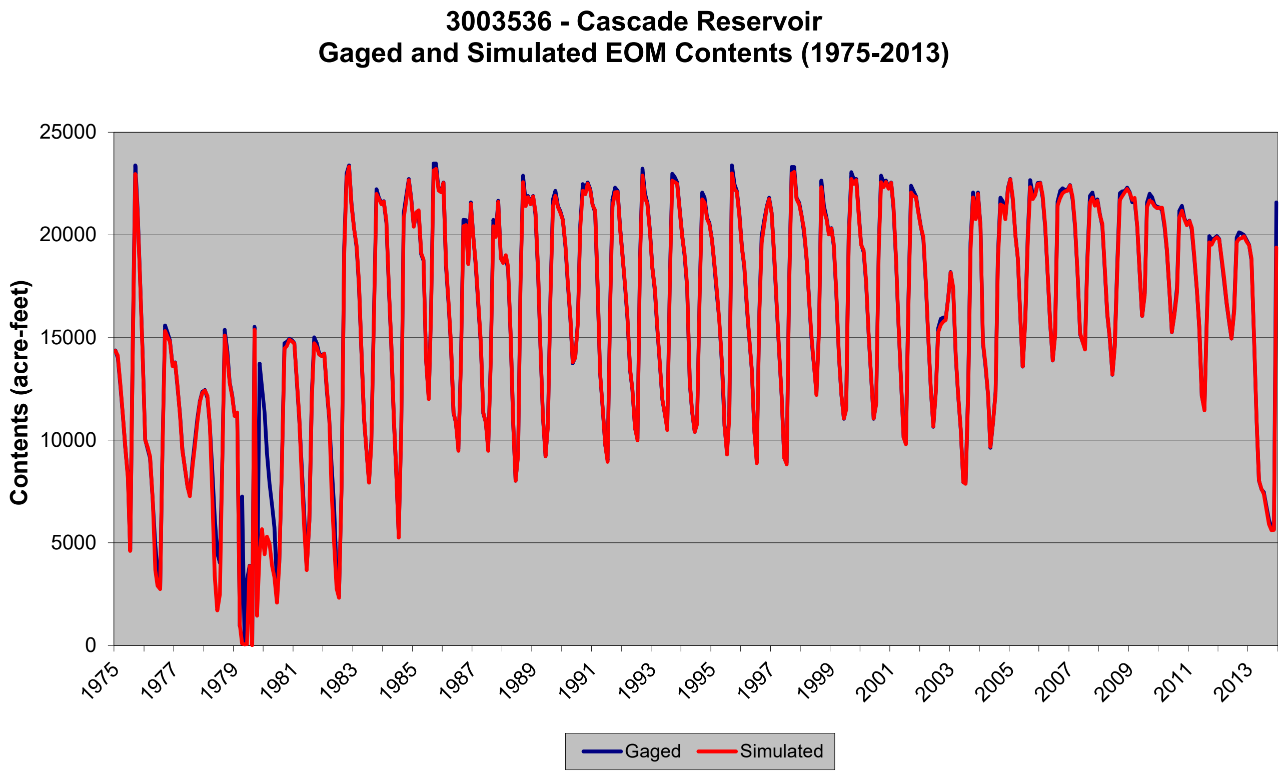


Figure 7.13 Reservoir Calibration – Cascade Reservoir

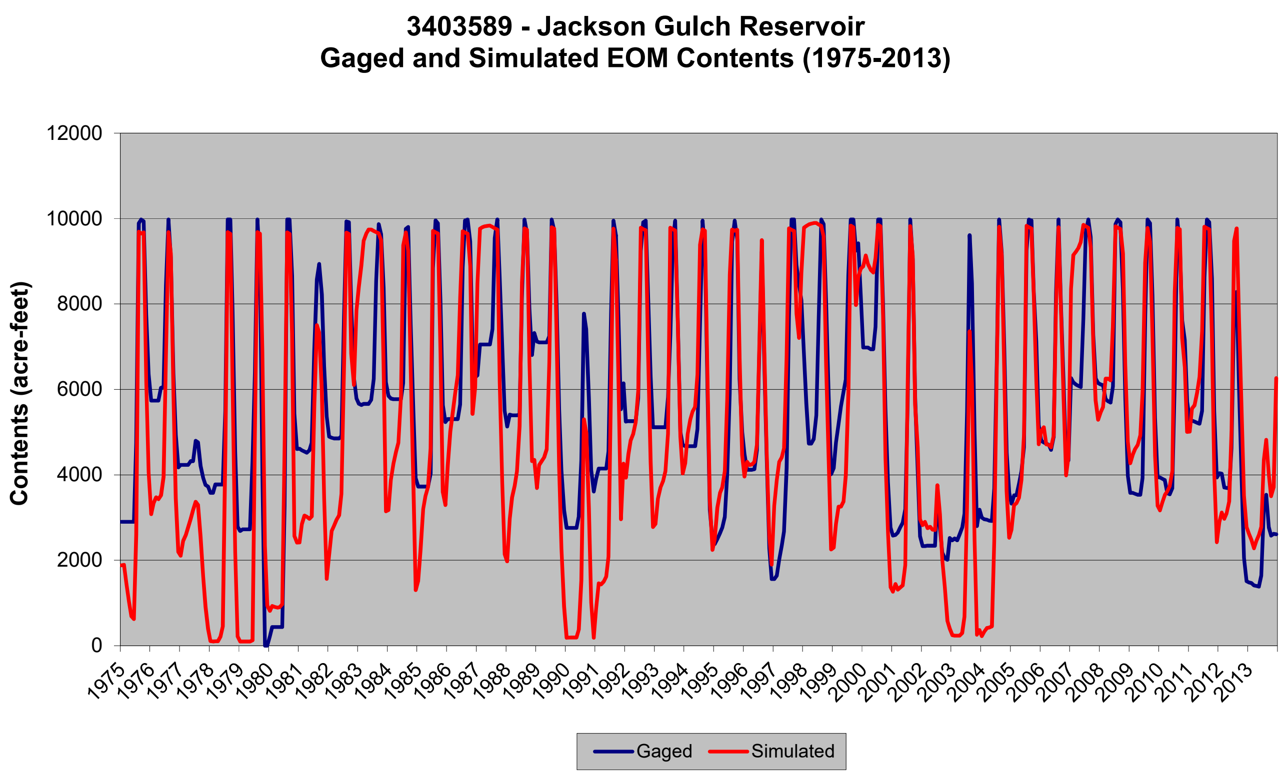


Figure 7.14 Reservoir Calibration – Jackson Gulch Reservoir

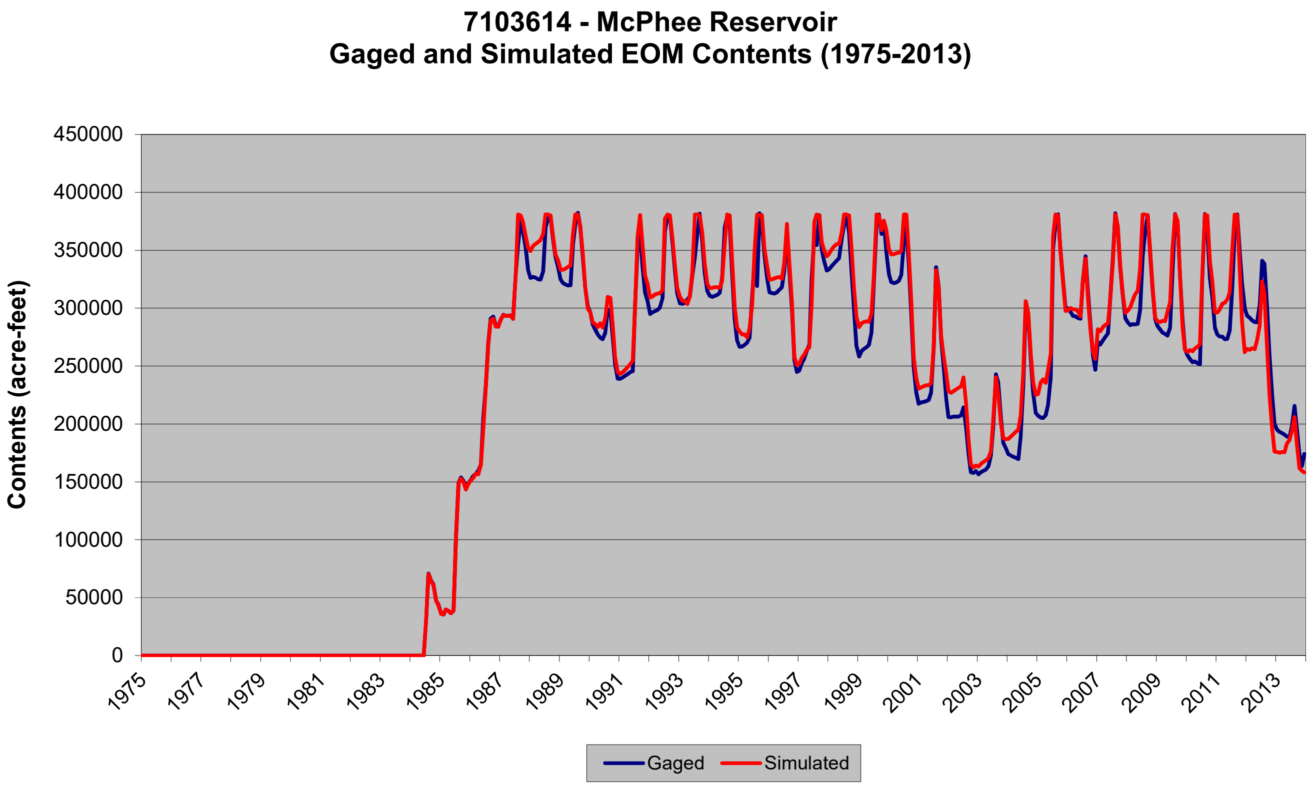


Figure 7.15 Reservoir Calibration – McPhee Reservoir

Appendix A

Aggregation of Irrigation Structures

1. San Juan/Dolores River Basin Aggregated Irrigation structures

2. Identification of Associated Structures (Diversion Systems and Multi-Structures)

A-1: SAN JUAN/DOLORES RIVER BASIN AGGREGATED IRRIGATION STRUCTURES

Introduction

The original CDSS StateMod and StateCU modeling efforts were based on the 1993 irrigated acreage coverage developed during initial CRDSS efforts. Irrigated acreage assessments representing 2005 and 2010 have now been completed for the western slope basins. A portion of the 2005 and 2010 acreage was tied to structures that did not have identified acreage in the 1993 coverage, and, consequently, are not currently represented in the CDSS models. As part of this task, aggregate and diversion system structure lists for the western slope basins were revised to include 100 percent of the irrigated acreage based on both the 2005 and 2010 assessments. The update also included identification of associated structures and the development of “no diversion” aggregates—groups of structures that have been assigned acreage but do not have current diversion records.

The methodology for identifying associated structures is described more in-depth in **Section A-2** of this appendix. In general, associated structures—which divert to irrigate a common parcel of land—were updated to more accurately model combined acreage, diversions, and demands. These updates include the integration of the 2005 irrigated acreage, the 2010 irrigated acreage, as well as verification based on diversion comments and water right transaction comments. In StateCU, the modeling focus is on the irrigated parcels of land. Therefore, all associated structures are handled in the same way. The acreage is assigned to a single primary node, which can be supplied by diversions from any of the associated structures. In StateMod, there are two types of associated structures. Diversion systems represent structures located on the same tributary that irrigate common land. Diversions systems combine acreage, headgate demands, and water rights; StateMod treats them as a single structure. In contrast, multi-structure systems represent structures located on different tributaries that irrigate common land. Multi-structure systems have the combined acreage and demand assigned to a primary structure; however, the water rights are represented at each individual structure, and the model meets the demand from each structure when their water right is in priority.

“No diversion” aggregates are included in StateCU in order to capture 100 percent of irrigated acreage. However, they were not included in the StateMod modeling effort. Because the individual structures included in these aggregates do not have current diversion records, their effect on the stream cannot be accounted for in the development of natural flows. Therefore, it is appropriate that their diversions also not be included in simulation. The individual structures in the “no diversion” aggregates generally irrigate minimal acreage, often with spring water as a source. There is an assumption that the use will not change in future “what-if” modeling scenarios.

Approach

The following approach was used to update the aggregated structures in the San Juan/Dolores River Basin.

1. Identify structures assigned irrigated acreage in either the 2005 or 2010 CDSS acreage coverages.
2. Identify Key structures represented explicitly in the model. The process for determining key structures is outlined in **Section 4** of the report.
3. Identify Key structures that should be represented as diversion systems or multi-structures, based on their association with other structures as outlined in **Section A-2** of this appendix.
4. Aggregate remaining irrigation structures identified in either the 2005 or 2010 irrigated acreage coverages based on the aggregate spatial boundaries shown in Figure A-1. The boundaries were developed during previous San Juan/Dolores River Basin modeling effort to general group structures by tributaries with combined acreage less than 2,200.
5. Further split the aggregations based on structures with and without current diversions during the period 2000 through 2012.

Results

Table A-1 indicates the number of structures in the aggregation and the total the 2005 and 2010 aggregated acreage. All of the individual structures in the aggregates have recent diversion records.

Table A-1: San Juan/Dolores River Basin Aggregation Summary

Aggregation ID	Aggregation Name	Number of Structures	2005 Acres	2010 Acres
29_ADS002	San Juan at Pagosa Springs	32	1,129	1,262
29_ADS003	San Juan at Carracas	47	1,621	1,662
30_ADS007	Animas River at Durango	18	581	579
30_ADS008	Florida R abv Salt Creek	39	1,130	1,408
30_ADS009	Florida River at Bondad	28	759	817
30_ADS010	Animas River at State Line	14	254	236
31_ADS005	Los Pinos River at Dry Creek	13	612	697
31_ADS006	Los Pinos River at State Line	39	1,365	1,454
32_ADS015	McElmo Creek abv Alkali	46	1,123	1,233
32_ADS016	McElmo Creek nr State line	49	1,186	1,232
33_ADS011	La Plata River	22	863	1,089
34_ADS012	Mancos River abv W Mancos	8	576	590
34_ADS013	Mancos River abv Chicken Creek	4	149	138
34_ADS014	Mancos River nr State Line	15	639	983

Aggregation ID	Aggregation Name	Number of Structures	2005 Acres	2010 Acres
60_ADS020	San Miguel River nr Placerville	11	551	674
60_ADS021	San Miguel River abv W Nat Crk	6	608	798
60_ADS022	San Miguel River at Naturita	19	1,908	2,952
61_ADS019	Paradox Creek	15	963	962
63_ADS023	Dolores River at Gateway	20	949	1,007
63_ADS024	West Creek	35	1,281	1,213
69_ADS018	Disappointment Creek	10	407	379
71_ADS017	Dolores River abv McPhee River	16	390	412
71_ADS019	Dolores River abv Big Gypsum	2	163	146
73_ADS025	Little Dolores River	30	1,764	1,714
77_ADS001	Navajo River	20	1,131	1,131
78_ADS004	Piedra River	34	2,486	1,977
Total		**592**	**24,588**	**26,744**

Table A-2 shows the number of structures in the “no diversions” (AND) aggregates and the total 2005 and 2010 acreage. None of the individual structures in the aggregates have recent diversion records.

Table A-2: No Diversion Aggregation Summary

Aggregation ID	Aggregation Name	Number of Structures	2005 Acres	2010 Acres
29_AND002	San Juan at Pagosa Springs	14	331	371
29_AND003	San Juan at Carracas	11	663	499
30_AND007	Animas River at Durango	24	578	642
30_AND008	Florida R abv Salt Creek	8	146	155
30_AND009	Florida River at Bondad	3	51	51
30_AND010	Animas River at State Line	8	40	54
31_AND005	Los Pinos River at Dry Creek	15	139	425
31_AND006	Los Pinos River at State Line	12	339	389
32_AND015	McElmo Creek abv Alkali	2	5	10
32_AND016	McElmo Creek nr State line	2	32	32
33_AND011	La Plata River	14	297	256
34_AND013	Mancos River abv Chicken Creek	1	30	30
60_AND020	San Miguel River nr Placerville	1	145	145
60_AND021	San Miguel River abv W Nat Crk	2	135	135
61_AND019	Paradox Creek	1	0	42
63_AND023	Dolores River at Gateway	3	9	82
63_AND024	West Creek	3	211	211
71_AND017	Dolores River abv McPhee River	5	120	120
71_AND019	Dolores River abv Big Gypsum	3	38	77

Aggregation ID	Aggregation Name	Number of Structures	2005 Acres	2010 Acres
73_AND025	Little Dolores River	4	66	93
77_AND001	Navajo River	3	220	94
78_AND004	Piedra River	8	758	762
Total		**147**	**4,350**	**4,672**

Table A-3 indicates the structures in the diversion systems and multi-structures.

Table A-3: Diversion System and Multi-Structure Summary

Diversion System	Diversion System Name	WDID
3204675 Dolores_Tunnel	DOLORES TUNNEL	3204675
	DOLORES TUNNEL	7104675
3200772 MVI_U_Lateral	MVI U LATERAL	3200772
	GREAT CUT DIKE	7104676
	GREAT CUT DIKE	3204676
2900519 BEIGHLEY NO 1_DIVSYS	BEIGHLEY NO 1 DITCH	2900519
	BEIGHLEY NO 2 DITCH	2900520
2900601 FOUR-MILE_DIVSYS	FOUR-MILE DITCH	2900601
	MESA DITCH	2900669
	HYDEAWAY RANCH DITCH	2900625
	MCGIRR-SNOWBALL DITCH	2900911
2900613 HALLETT DITCH_DIVSYS	HALLETT DITCH	2900613
	COLTON AND MONTROY DITCH	2900566
2900588 ECHO DITCH_DIVSYS	ECHO DITCH	2900588
	RAY SPRING	2900834
2900653 LONG HORN_MEE_DIVSYS	LONG HORN AND MEE DITCH	2900653
	HARE DRAINAGE D NO 1 & 2	2900616
2900560 CHAPSON HOWE_DIVSYS	CHAPSON AND HOWE DITCH	2900560
	CORRAL DITCH	2900568
	ELK CREEK DITCH	2900593
3001011 FLORIDA_FARMERS_CANAL	FLORIDA FARMERS DITCH	3001011
	FLORIDA CANAL	3001013
	BLOHM WASTE WATER SYSTEM	3001465
3001219 SITES-KERN_DIVSYS	SITES-KERN DITCH	3001219
	APPERSON-SITES DITCH	3001026
3100505 DR MORRISON_DIVSYS	DR MORRISON DITCH	3100505
	DR MORRISON DITCH	3100664
3100511 THOMPSON-EPPERSON DITCH	THOMPSON-EPPERSON DITCH	3100511
	COUCH D NO 1 & PUMP PLT	3100602
	COUCH D NO 2 & PUMP PLT	3100603
3100519	KING DITCH	3100519

Diversion System	Diversion System Name	WDID
DUNCAN DIVSYS	HUNTER WASTE WATER DITCH	3100823
	WAGNER DITCH	3100828
3100523 SCHRODER IRG_DIVSYS	SCHRODER IRRIGATION DITC	3100523
	CITIZENS IRR DITCH	3100515
	DUNHAM IRRIGATION DITCH	3100550
	HARPER POND & DIV #1	3100811
3100547 ROBERT MORISON DIVSYS	ROBERT MORRISON DITCH	3100547
	FASSETT DITCH	3100596
3100575 SEMLER DITCH_DIVSYS	SEMLER DITCH	3100575
	SEMLER DITCH E AND E	3100593
3100583 GOOSEBERRY_DIVSYS	PORTER DITCH	3100583
	INDIAN CREEK DITCH	3100588
3100665 SPRING CREEK_DIVSYS	SPRING CREEK DITCH	3100665
	WEIGANDT DITCH	3100568
	GENTRY DITCH	4600514
	BABCOCK DITCH 26	4600519
	SCHALLES DITCH NO 1	3100586
	DANNELS-SPG CR WW DIVR	3100614
	HORNER-HEATH DITCH	4600500
	AUSTIN NO 2 DITCH	4600509
	SWANEMYR DITCH NO 1	4600525
	GUFFEY DITCH NO 1	4600532
	MARQUEZ DITCH	4600537
	YOUNGS ALLISON DITCH	4600542
	WASTE WATER SET DITCH	4600547
	ALLISON LATERAL WW DITCH	4600548
	ODESSA DITCH	7800695
	JOHN DARLINGTON DITCH	4600520
	OCHSNER DITCH	3100582
	TIFFANY DITCH	3100577
	GREEN POND (WELL)	4605000
3400560 RUSH RESERVOIR DIVSYS	RUSH RESERVOIR DITCH	3400560
	BAUER RESERVOIR NO 1	3403585
	L A BAR RESERVOIR	3403590
3400582 WILLIAMS DITCH_DIVSYS	WILLIAMS DITCH	3400582
	A T ROBB NORTH DITCH	3400501
7100531 WEST DOLORES	EAST EDER DITCH	7100531
	EAST EDER DITCH AP	7100701
7102002 SUMMIT_IRRIG	SUMMIT RES OUTLET	7102002
	SUMMIT IRRIG SYSTEM	7102004

Diversion System	Diversion System Name	WDID
	BIG PINE RES OUTLET	3402000
	A M PUETT RES OUTLET	3200704
	SUMMIT OUTLET	3202002
	SELLERS & MCCLANE RES	3403592
7100586 RIEVA DITCH_DIVSYS	RIEVA DITCH	7100586
	RIEVA DITCH AP2	7100690
7700531 ENTERPRISE_DIVSYS	ENTERPRISE DITCH	7700531
	ENTERPRISE DITCH (BEAL)	7700513
7800507 BARNES-MEUSER_DIVSYS	BARNES-MEUSER AND SHAW D	7800507
	PATTERSON IRRIGATION D	7800597
	C R MARTIN DITCH	7800519
6100512 AMENDED LAURA_DIVSYS	AMENDED LAURA DITCH	6100512
	ROBERTS PLACE WELL 1	6105010
7800562 HOPE SPRINGS_DIVSYS	HOSSACK CREEK DITCH	7800562
	LINDNER SPRING NO 3	7800577
	HOSSACK CREEK DIT ALT PT	7800699
3400577 WEBER RESERVOIR INLET D	WEBER RESERVOIR INLET D	3400577
	WEBER RESERVOIR	3403594
2900686 PARK MULTISYS	PARK DITCH	2900686
	HALLETT DITCH DIVSYS	2900613
	COLTON AND MONTROY DITCH	2900566
2900718 TURKEY MULTISYS	SNOWBALL DITCH	2900718
	FOUR-MILE DIVSYS	2900601
	MESA DITCH	2900669
	HYDEAWAY RANCH DITCH	2900625
	MCGIRR-SNOWBALL DITCH	2900911
3000506 ANIMAS CONS. MULTISYS	ANIMAS CONSOLIDATED D	3000506
	J P LAMB DITCH	3000581
3100665 SPRING CREEK MULTISYS	SPRING CREEK DIVSYS	3100665
	BRIGGS DITCH	4600503
	CAMPBELL DITCH	3100567
3300533 PINE RIDGE MULTISYS	PINE RIDGE DITCH	3300533
	BODO PINE RIDGE DITCH	3001056
6100502 GALLOWAY MULTISYS	GALLOWAY DITCH	6100502
	A E L R P & PL	6100602
7800507 BARNES-MEUSER-SHAW MULTISYS	BARNES-MEUSER AND SHAW DIVSYS	7800507
	BARNES DITCH	7800506
7800544	F S MOCKLER IRR DITCH	7800544

Diversion System	Diversion System Name	WDID
F S MOCKLER MULTISYS	CIMARRON DITCH	7800524
7800590 PAGOSA MULTISYS	NICKLES BROTHERS DITCH	7800590
	STEVENS AND CLAYTON D	7800617
	CLAYTON-REED DITCH	7800525
7800604 PIEDRA FALLS MULTISYS	PIEDRA FALLS DITCH	7800604
	LITTLE PAGOSA CREEK DIVR	7800659
	CARL AND WEBB DITCH	7800523
	PAGOSA DITCH	7800594

1) Acreage is assigned to both structures and combined for consumptive use analysis
2) Historical diversions are calculated based on diversion to irrigation and reservoir releases to irrigation
3) Diversion system also a Multisystem component

Figure A-1 shows the spatial boundaries of each aggregation. **Exhibit A**, attached, lists the diversion structures represented in each aggregate. **Exhibit B** lists the diversion structures represented in each no diversion aggregate. Both **Exhibit A** and **Exhibit B** provide a comparison of the 2005 and 2010 irrigated acreage assigned to each structure.

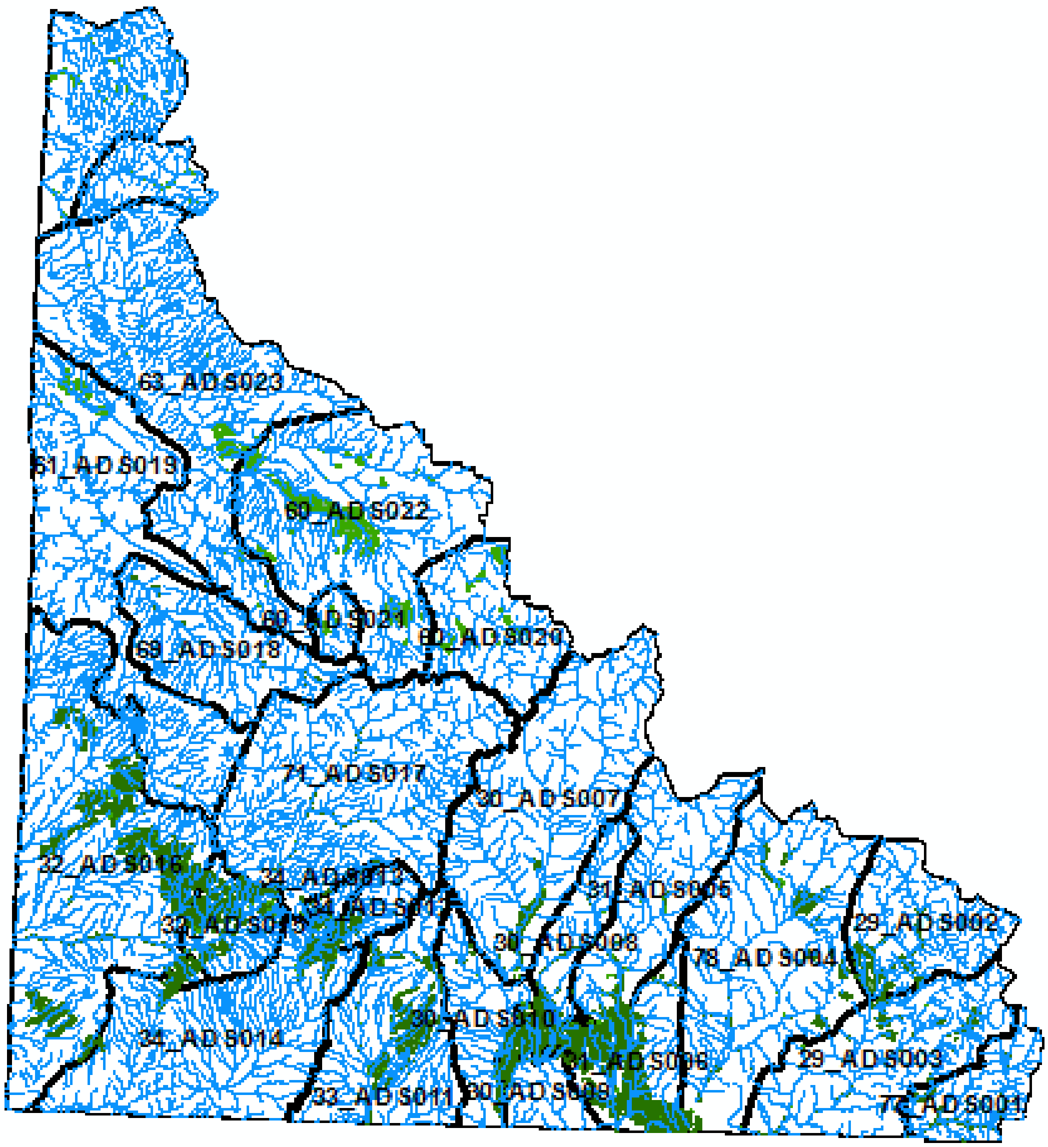


Figure A-1: Aggregate Structure Boundaries

Recommendations

As part of this modeling update, various lists have been developed for review and reconciliation by the Water Commissioner. The lists include:

- Structures tied to irrigated acreage that do not have current diversion records
- Structures tied to irrigated acreage that do not have water rights for irrigation
- Structures that have current diversion records coded as irrigation use, but do not have irrigated acreage in either 2005 or 2010
- Structures that have irrigation water rights, but do not have irrigated acreage in either 2005 or 2010
- More than one structure is assigned to the same irrigated parcel, however there was no indication that the structures serve the same acreage in either diversion comments or water rights transaction comments.

Exhibit A: Diversion Structures in each Aggregate

Aggregation ID	Diversion Structure Name	WDID	2005 Acres	2010 Acres
29_ADS002 San Juan at Pagosa Springs	Allen Ditch	2900502	48	48
	Bruce Spruce Ditch	2900610	2	2
	Canon Creek Ditch	2900644	0	44
	Cockrell Ditch	2900680	67	67
	Deer Creek Ditch	2900702	30	30
	Diamond Ditch	2900737	9	9
	Falls Creek Ditch	2900755	38	38
	Flaugh Ditch	2900781	120	120
	Girardin Ditch	2900548	24	24
	Gomez Ditch No 1	2900574	8	8
	Goodman-Gomez Ditch	2900575	23	23
	Johnny Creek Ditch	2900607	36	36
	K O Harman Ditch No 1	2900672	17	17
	Lake Fork Ditch	2900674	5	5
	Lane Creek Ditch	2900728	66	66
	Lost Ditch	2900758	24	24
	Masco-Masco Ditch	2900794	63	63
	Murphy Ditch	2900926	37	37
	New Ditch	2900997	38	38
	Old Strong Ditch	2900594	19	19
	Pangborn Ditch	2900608	0	44
	Power Line Ditch	2900639	0	44
	Roesler Ditch	2900565	178	178
	Strawn Ditch	2900598	5	5

Aggregation ID	Diversion Structure Name	WDID	2005 Acres	2010 Acres
	Sunset Cottages D No 1	2900636	8	8
	Turkey Creek No 2 Ditch	2900643	2	2
	Will Macht Ditch	2900656	24	24
	Young Ditch	2900666	38	38
	Garden Ditch	2900730	8	8
	Bruce Spruce Ditch Alt	2900553	14	14
	Horse Gulch Ditch	2900696	173	173
	Joe Hersch Ditch No 1Ap #2	2900685	6	6
29_ADS003 San Juan at Carracas	Arroyo Ditch	2900529	0	7
	Berryhill Ditch No 1	2900546	91	91
	Berryhill Ditch No 2	2900558	16	16
	Brown Ditch	2900561	10	10
	Cabe Ditch	2900577	14	15
	Carls Ditch	2900658	39	39
	Carrico Ditch	2900694	3	3
	Catchpole Meadow Ditch	2900723	66	66
	Catchpole Mill-Creek D	2900754	48	48
	Chavez Ditch	2900761	18	0
	Chavez No 2 Ditch-1968	2900783	27	27
	Chavez No 2 Ditch	2900925	9	9
	Dillinger Blanco Ditch	2900528	13	13
	Dillinger Fish Creek D	2900551	81	89
	Dillinger Spring Ditch	2900554	10	10
	Echo Waste Water Ditch	2900563	12	12
	John M Rippy Ditch	2900576	50	50
	John T Tiernan No 1 D	2900578	58	58
	John T Tiernan No 2 D	2900591	24	24
	Latham Ditch	2900646	65	65
	Lippert No 2 Ditch	2900652	27	27
	Little Blanco Highline D	2900663	63	63
	M O Brown Ditch	2900753	7	7
	Martinez Pipeline And D	2900762	36	36
	O-Waste Water Ditch	2900802	40	40
	Oppenheimer Waste Wtr D	2900920	22	22
	Porcupine Ditch	2900556	87	87
	R N Snow Ditch No 1	2900557	15	15
	Sam Teeson Ditch	2900634	29	29
	Sheep Cabin	2900635	85	85
	Sig Brown Ditch	2900679	38	38
	Spring Run Ditch	2900705	82	82

Aggregation ID	Diversion Structure Name	WDID	2005 Acres	2010 Acres
	Square Top Ditch	2900722	72	72
	Sweede Ditch	2900759	39	39
	Villarreal Ditch And Pl	2900822	31	31
	White Creek No 1 Ditch	2900846	40	40
	White Creek No 2 Ditch	2900959	17	17
	Zabriskie Ditch	2900564	15	14
	Harman Ditch No 1	2900633	17	17
	Harman Ditch No 2	2900651	13	13
	Campbell Ditch No 1	2900681	39	39
	Little Blanco Highline D	2900699	64	64
	Mees Ditch	2900711	8	8
	Wunderlich Pump Site	2900713	36	36
	3R Ranch Diversion	2900731	3	3
	Cattey Pump No 1	2900742	2	2
	Espinosa No 1 Ditch	2900505	41	85
30_ADS007 Animas River at Durango	Ambold Ditch (Jeckel)	3000521	78	78
	Ambold Ditch No 2	3000536	34	34
	Animas City Ditch	3000551	13	11
	Canon No 2 Ditch	3000614	33	33
	Conley Ditch	3000667	11	24
	Elbert No 1 Ditch (J)	3000925	15	15
	F Steinegger Irg Ditch	3000503	159	159
	Gaines-Buchanan Ditch	3000543	22	22
	Kroulik Ditch	3000642	22	16
	Pomona Ditch	3000649	8	8
	Quinn-Naegelin Ditch	3000505	19	19
	Ragsdale Ditch	3000525	10	10
	Shaffer Ditch	3000611	2	4
	Talley Ditch	3000615	7	7
	Falls Creek Div Pts Pt 1	3000502	21	21
	Walter Ditch	3000584	9	0
	Three Sisters Ditch	3000632	105	105
	Falls Creek Div Pts Ap Pt 2	3000752	11	11
30_ADS008 Florida River above Salt Creek	Abling And Cash Ditch	3001004	24	24
	Conway Ditch	3001012	26	26
	Aberson Ditch	3001014	75	75
	Campion Ditch	3001015	4	4
	Pennington-Conway Ditch	3001109	79	79
	Stewart Ditch	3001171	25	34
	Prescott North Side D	3001176	49	49

Aggregation ID	Diversion Structure Name	WDID	2005 Acres	2010 Acres
	Prescott South Side D	3001191	46	46
	Waring Irrigating Ditch	3001196	43	43
	Banks Ditch	3001210	1	1
	Cash 1888 Ditch	3001463	0	126
	Crandall Ditch	3001001	3	0
	Freienmuth-Mccoy Ditch	3001002	71	71
	Hedges-Clark Ditch	3001120	75	75
	Highline Ditch	3001136	31	31
	Jones No 1 Ditch	3001144	6	6
	Lyman Ditch	3001224	6	6
	Mccaw Ditch	3001230	35	42
	Miller Ditch	3001244	0	54
	Moons Return Flow Ditch	3001263	3	3
	Nathan Bird Ditch	3001267	38	45
	Palmer Horse Gulch Ditch	3001604	21	21
	Parker Ditch	3001005	33	33
	Payne Canyon Ditch	3001008	17	17
	Reynolds-Brasher Ditch	3001017	5	5
	Rosa Waldner Ditch	3001080	99	99
	Schalles Seepage Ditch	3001121	19	19
	Sherer Ditch	3001150	2	2
	Spring Ditch	3001165	83	99
	Stratman Ditch	3001169	21	21
	Thornton-Smith Ditch	3001406	0	46
	Tyner West Side Ditch	3001032	92	92
	Wawona Ditch	3001161	8	8
	Williamson Ditch	3001200	20	28
	Robertson Spring	3001457	0	7
	Dashner #2 Ditch	3001238	21	21
	Darin And Jeff Ditch	3001158	22	22
	Harshfield Ditch	3001067	18	18
	Stratman Combined Ditch	3001385	10	10
30_ADS009 Florida River at Bondad	Barnes No 1 Ditch	3001060	33	33
	Big Cottonwood D No 1	3001110	12	12
	Big Cottonwood No 2 D	3001188	85	85
	Brown Ditch	3001201	8	8
	Brown Ditch	3001330	27	23
	Gaines Ditch	3001348	7	7
	George P White Ditch	3001553	25	25
	Home Ditch	3001044	26	27

Aggregation ID	Diversion Structure Name	WDID	2005 Acres	2010 Acres
	Park Ditch	3001123	7	7
	Paxton Ditch	3001170	8	38
	Rea Ditch	3001349	16	9
	Seale Waste Water Ditch	3001369	50	70
	Sisley Ditch	3001445	37	37
	Teti Canyon Ditch	3001569	10	10
	Sease Canon Ditch No 2	3001575	41	41
	Harper Irr System No 1	3001113	8	8
	Harper Irr System No 2	3001218	26	26
	Ball Ditch Pump Station	3001236	26	45
	Kennedy Waste Ditch No 2	3001294	40	40
	Kennedy Waste Ditch No 3	3001350	40	40
	Kennedy Waste Ditch No 4	3001515	40	40
	Clark Irrigation Ditch	3001035	18	18
	Watson Pump	3001045	65	65
	Seibert Ditch No 2	3001059	6	6
	John Barnes Ditch	3001175	45	45
	Big Canyon Ditch & Pump	3001331	37	37
	L Short Wastewater Pl	3001344	9	9
	Leroys Ditch	3001362	8	8
30_ADS010 Animas River at State Line	Cason Ditch	3001068	18	23
	Covert Ditch	3001135	28	29
	Harbaugh Ditch	3001119	28	0
	Johnson Ditch	3001225	16	16
	Jones Ditch	3001132	38	38
	Lemon Ditch	3001139	45	45
	Shields No 1 Ditch	3001212	0	6
	Shields No 2 Ditch	3001427	5	5
	Spring Ditch & Pipeline	3001074	4	4
	Steward Irrigating Ditch	3001227	60	47
	Taggart Ditch	3001234	9	9
	Mckee Diversion #1	3001211	0	4
	Mckee Diversion #2	3001415	0	6
	Harbison Ditch	3001416	5	5
31_ADS005 Los Pinos River at Dry Creek	Dale Ditch	3100504	26	26
	Palmer Ditch	3100530	39	39
	Ludewig Ditch	3100533	12	53
	Buhman Ditch	3100564	5	5
	Graham Creek No 1 Ditch	3100659	15	25
	Graham Creek No 2 Ditch	3100531	11	21

Aggregation ID	Diversion Structure Name	WDID	2005 Acres	2010 Acres
	Patrick Ditch	3100534	22	25
	Mitchell Ditch	3100601	34	44
	Gipson Ditch	3100677	34	44
	Potter-Pierce W Return D	3100691	103	103
	Nannice Ditch	3100522	298	298
	Coronado Divr And Pump	3100536	7	7
	Spring Gulch Ditch	3100562	6	6
31_ADS006 Los Pinos River at State Line	Dennie Ditch	3100506	48	33
	Goodnight Ditch	3100560	168	226
	Joe S & Char B Mack Irg	3100654	123	123
	John M King East Ditch	4600512	114	114
	John M King West Ditch	4600533	58	58
	Citizens Irr Canal	3100532	39	39
	Clara Wolf Ditch	3100578	0	22
	Ignacio Draw Ditch	3100645	33	33
	Carlson Ditch No 1	3100655	26	26
	Robt Morrison D Heair Ex	3100771	56	56
	Luter Ditch No 1	3100815	7	7
	Ainsworth Waste Water D	3100950	8	11
	Heair Ditch No 1	4600516	84	84
	Joe S & Char B Mack Irg Ap	4600518	0	8
	Larsen No 1 Ditch	3001312	12	12
	Linebarger Ditch	3100569	12	12
	Hecht Ditch No 1	3100653	14	14
	Denton Ditch	3100755	131	131
	Knight Ditch	3100920	27	27
	Clark-Campbell Diversion	4600501	83	83
	Flagg Ditch No 1	4600510	26	26
	Perino Ditch	4600511	8	8
	Buck Ditch	4600513	12	24
	Bryant Ditch	4600515	19	19
	Mills Ditch	4600530	15	15
	Austin No 1 Ditch	4600566	16	16
	Brown Ditch	3100561	26	26
	Briggs-Scofield Ditch	3100572	28	28
	Lonne Ditch	3100754	15	15
	Karl Ditch	3100767	23	23
	Shock Ditch No 1	4600505	14	14
	Shock Ditch No 2	4600506	14	14
	Babcock Ditch 25	4600507	9	9

Aggregation ID	Diversion Structure Name	WDID	2005 Acres	2010 Acres
	Young Ditch	4600508	54	54
	Knutson Ditch No 2	4600521	3	3
	Engler Ditch	4600527	0	14
	Frahm Ditch	3100570	13	0
	Girardin Irrigation Sys	3100681	9	9
	Kerrigan Ditch #2	4600529	18	18
32_ADS015 McElmo Creek above Alkali	Ausburn Ditch	3200506	29	29
	Blum Ditch	3200530	35	35
	Bord Ditch	3200532	21	21
	Cox Ditch	3200556	25	25
	Crow Canyon Ditch No 1	3200613	19	17
	Crow Canyon Ditch No 3	3200675	20	20
	Dunham Ditch	3200707	4	4
	Earl Hart Ditch	3200758	111	213
	Godfrey Ditch	3200821	12	12
	Green Ditch	3200898	55	55
	Hetherington Ditch	3200944	0	9
	Higman Pickup Ditch	3200945	42	42
	Holaday No 2 Ditch	3200512	49	60
	Jim Mann Ditch	3200548	34	34
	King Ditch	3200583	16	16
	Kirkeeng Ditch	3200587	8	3
	M And H Ditch	3200595	18	18
	Mac Porter Ditch	3200614	16	16
	Martin Ditch	3200646	9	9
	N E Carpenter Seepage D	3200658	57	57
	Powell And Cody Ditch	3200757	71	71
	Rauh Ditch	3200763	13	13
	Roelfs Ditch	3200834	34	11
	Runck Ditch	3200835	25	25
	Steve No 1 Ditch	3200880	15	34
	Stone Ditch	3200941	12	12
	West Carlisle Ditch	3200967	10	10
	Wilkerson Ditch	3201007	18	18
	Thomas Ditch No 1	3200569	7	5
	Mcdonald Ditch No 4	3200572	4	4
	Randol Ditch	3200601	10	10
	Frye Ditch #1	3200616	12	12
	Frye Ditch #2	3200644	53	53
	Carls Pump	3200685	7	6

Aggregation ID	Diversion Structure Name	WDID	2005 Acres	2010 Acres
	Poppy Patch Ditch	3200714	4	4
	Goode Ditch	3200878	24	24
	Antholz Ditch	3200511	19	19
	Mcnutt Ditch	3200534	18	17
	Hover Ditch	3200600	8	8
	Ancell Ditch	3200635	6	6
	Fox Ditch	3200653	25	25
	Leighton No. 1 Ditch	3200672	39	39
	Leighton No. 2 Ditch	3200689	56	56
	Tipton Ditch	3200706	39	39
	Mckinney Ditch	3200988	2	2
	Ertel Drainage Pipe	3200580	15	15
32_ADS016 McElmo Creek near State Line	Brixey-Comisky Ditch	3200514	65	65
	Brumley Draw Irr Ditch	3200520	46	46
	Charles Mattson Ditch	3200527	25	25
	Comisky Ditch No 3	3200552	2	2
	Comisky Ditch No 4	3200573	10	10
	Duran Ditch	3200588	9	9
	Duran Ditch No 1	3200599	3	3
	Fawell Ditch	3200612	31	31
	Gafford Ditch	3200629	57	57
	Gafford Ditch No 2	3200632	56	56
	Greenlee Ditch	3200664	47	47
	Higgins Ditch	3201023	10	15
	Hopper Ditch	3200513	21	21
	J A Leonard Ditch	3200526	60	60
	Jewell Ditch	3200594	100	100
	Juan Ditch No 1	3200626	10	10
	Keeler Ditch	3200628	0	4
	Keith Pump And Pipeline	3200660	1	1
	Koppenhaffer Ditch	3200661	31	0
	Larmore Collection Ditch	3200665	46	46
	Lynch Ditch	3200681	122	132
	Margwain Pump Sta No 1	3200841	2	26
	Mccall Ditch	3200893	25	25
	Messinger-Hampton D No 1	3200897	29	47
	Milligan No 1 Ditch	3201004	14	14
	Milligan No 2 Ditch	3200560	6	6
	Morgan Waste Water Ditch	3200564	9	9
	R G Whyman Ditch	3200592	19	19

Aggregation ID	Diversion Structure Name	WDID	2005 Acres	2010 Acres
	Sattley Ditch No 1	3200602	3	3
	Sattley Ditch No 2	3200617	11	1
	Sattley Ditch No 3	3200619	5	15
	Short Ditch	3200659	22	22
	Shumway Perkins Pmpg Sta	3200674	44	48
	Stevens No 1 Ditch	3200686	19	19
	Stevens No 2 Ditch	3200798	19	19
	Trail Canyon Ditch	3200928	73	78
	Westfall Ditch	3201059	26	0
	Anderson Ditch	3200551	6	6
	Stocks Ditch	3200563	11	11
	Wofford Ditch	3200581	6	6
	Leo S Pump	3200596	14	14
	Mcafee Ditch	3200605	27	27
	Devins Ditch And Pump	3200645	2	2
	Hindall Pump	3200673	5	5
	Coulon Ditch	3200777	7	28
	No 14 Pickup Ditch	3200951	11	19
	Cattail Spring	3200990	5	5
	Larmore Collection Dit Ap1	3201038	12	12
	Goodall Ditch	3200597	4	4
33_ADS011 La Plata River	Mccaleb Ditch	3300502	15	45
	Caviness Ditch	3300519	14	14
	Dick Ditch	3300522	40	97
	Keller Ditch	3300523	49	49
	Chidal Ditch	3300530	78	66
	Holder Ditch	3300541	20	20
	Lory Spring Ditch	3300546	24	24
	H C Strobel Ditch	3300557	46	120
	Spring Ditch (Hotter)	3300669	56	56
	John Sponsel Ditch	3300513	4	4
	Old Indian Ditch	3300516	99	99
	White-Roux And Owens D	3300527	81	74
	Upper Davis Ditch	3300539	128	128
	Morgan And Stambaugh D	3300592	26	73
	Schaefer Ditch	3300555	8	8
	M K And T Ditch	3300567	36	72
	Williams Ditch No 1	3300568	36	36
	Williams Ditch No 2	3300685	19	19
	Stinson-Spring Hollow D	3300505	32	32

Aggregation ID	Diversion Structure Name	WDID	2005 Acres	2010 Acres
	Real Erickson Ditch	3300515	40	40
	Gh Ditch	3300517	6	6
	Kowalski Pump	3300565	5	5
34_ADS012 Mancos River above West Mancos River	Cavu Ditch No 1	3400532	49	49
	Davenport Ditch	3400517	59	59
	Field Ditch	3400509	5	5
	Graybeal Ditch	3400525	9	9
	Samson Ditch	3400569	104	104
	Smith Ditch	3400681	91	104
	Spencer Ditch	3400562	257	257
	Jones Waste Water Ditch	3400566	2	2
34_ADS013 Mancos River above Chicken Creek	E C Smith Ditch	3400537	9	9
	Jim Beam Ditch	3400563	1	1
	John Carter Ditch	3400521	120	128
	Sellers Waste Water D	3400538	19	0
34_ADS014 Mancos River near State Line	Charles Ellis Sep & Ww D	3400519	39	43
	Decker Seepage Ditch	3400549	4	4
	Doerfer Ditch	3400581	16	16
	Exon Ditch	3400599	26	0
	John Seepage Ditch	3400511	8	0
	Mancos Canyon Ditch	3400539	22	61
	Mathews Ditch	3400575	0	185
	Michaels Seepage Ditch	3400611	3	3
	Weaver Seepage Ditch	3403586	12	12
	Willden & Brinkerhoff D	3400518	17	17
	Graf Ditch	3400524	14	14
	Garrett Ditch	3400545	36	36
	Jordan Ditch	3400586	11	11
	Janz No. 1 Ditch	3400694	9	0
	Bauer Reservoir No 2	3400546	423	582
60_ADS020 San Miguel River near Placerville	Agricultural Ditch	6000505	108	108
	Bank Of Delta Ditch	6000517	15	15
	Benson Ditch	6000524	27	27
	Champlin Ditch	6000553	72	72
	Eder Creek Ditch	6000586	28	28
	House Flood Waste	6000642	5	5
	Mill Creek Ditch No 1	6000693	75	75
	Muddy Creek Ditch	6000706	94	216
	Ohio Kokomo Flood & Wd	6000725	91	91
	Tabor Ditch	6000774	15	15

Aggregation ID	Diversion Structure Name	WDID	2005 Acres	2010 Acres
	Ptarmigan Ditch	6001554	20	21
60_ADS021 San Miguel River above W. Naturita Creek	Cone Grove Camp Ditch	6000563	38	38
	Curtis Stockdale No 1&2	6000570	11	11
	Jay Bar	6000653	30	18
	Stockdale Bennett Ditch	6000768	57	45
	Spectacle Ditch	6001164	0	157
	Redd Harmon Collector D	6000814	471	530
60_ADS022 San Miguel River at Naturita	Barry No1 Ditch	6000518	19	19
	Black Springs Ditch	6000526	6	6
	Carpenter Ditch	6000548	56	56
	Cole Seepage & Fld Wtr D	6000560	32	34
	Doing Ditch	6000582	57	111
	Dry Park Ditch	6000587	224	227
	Eggleston Ditch	6000624	39	57
	Flying H Ditch	6000634	0	326
	Hanks Valley Ditch No 1	6000648	62	362
	Highline Ditch	6000655	56	56
	Iowanna Ditch	6000701	86	86
	Jensen Seep Ditch (Nor)	6000702	57	57
	Morgan No 1 Ditch	6000738	114	114
	Morgan No 2 Ditch	6000792	671	671
	Priestly Ditch No 1	6000802	16	16
	W A Ross Ditch No 1	6001171	364	364
	Williams Ditch No 1	6000577	29	29
	Love Ditch No 3	6000598	17	17
	Swyhart Ditch No 1	6001627	0	342
61_ADS019 Paradox Creek	Tamarisk Ditch	6100505	40	57
	Goshorn Ditch No 1	6100506	563	601
	Ice Lake Ditch	6100509	21	17
	Jenny Ditch	6100510	21	17
	Lammert Ditch & Enlg	6100511	15	15
	Manning Ditch	6100514	12	12
	Robinson Ditch	6100530	20	26
	Spring Creek Ditch	6100533	9	8
	Sumner Ditch	6100534	17	17
	Swain Ditch Extension	6100536	39	39
	Talbert Ditch	6100539	26	30
	Waggoner Ditch	6100543	89	28
	Mary E Young Ditch	6100547	31	31
	Arrowhead Ditch	6100551	32	33

Aggregation ID	Diversion Structure Name	WDID	2005 Acres	2010 Acres
	Boiling Spring	6100663	26	30
63_ADS023 Dolores River at Gateway	Dry Creek Ditch No 1	6000581	33	33
	Elmer Ditch	6000590	48	51
	North Mt Ditch	6000721	365	365
	Merrifield Ditch	6000812	15	17
	Mike Young Ditch No 1	6000816	0	34
	Mike Young Ditch No 2	6000867	33	33
	Burbridge Ditch	6001692	79	79
	Spring Creek Ditch No 2	6300502	51	51
	Ben Ames Ditch	6300505	3	0
	Blue Creek Ditch	6300514	57	57
	Calamity Ditch	6300542	22	7
	Cottonwood Ditch	6300550	0	32
	Mesa Creek Ditch	6300555	44	44
	Patterson Ditch	6300563	36	37
	Rock Creek Ditch	6300571	29	29
	Tom Watkins Ditch	6300574	38	38
	West Ditch	6300578	22	22
	Willow Ditch	6000815	35	37
	Casto Pumping Plant	6300519	36	36
	Red Cross Ditch Pt A	6300734	0	3
63_ADS024 West Creek	Bennett Ditch	6300504	26	18
	Booth Ditch No 1	6300506	42	43
	Booth Ditch No 2	6300507	29	29
	Casement Ditch	6300515	93	79
	Cox Ditch	6300520	69	69
	Fields Ditch	6300523	3	3
	Foy & Tomlinson Ditch	6300525	17	17
	Gill Ditch	6300527	56	56
	Harms Ditch	6300528	4	4
	Highline Ditch	6300530	74	57
	Idlewild Highline D No 2	6300531	9	9
	J R Hatch Ditch	6300532	5	6
	L L Hall Ditch	6300533	15	15
	Loba Ditch No 4	6300537	6	7
	Loba Ditch No 5	6300538	42	42
	Lone Oak Ditch	6300539	14	14
	Lone Oak Ditch No 2	6300540	34	34
	Pansy Highline Ditch	6300549	44	48
	Pine Mesa Ditch Headgate No. 1	6300552	168	168

Aggregation ID	Diversion Structure Name	WDID	2005 Acres	2010 Acres
	Ren Hatch Ditch	6300554	4	4
	Silzell Ditch	6300558	76	75
	Smith D No 1 Ext	6300559	28	24
	Smith Ditch No 1	6300560	4	4
	Smith Ditch No 2	6300561	4	4
	South Loba Ditch	6300562	27	0
	Triangle Bar Ditch	6300564	131	131
	Unaweep Cattle Range D 2	6300565	39	40
	Unaweep Cattle Range D 3	6300566	47	47
	Unaweep Cattle Range D 4	6300567	30	30
	W S Lafair Ditch	6300569	14	14
	West Creek Ditch No 1	6300572	54	52
	Wild Rose Ditch	6300573	9	10
	Rachel Graham	6300577	3	3
	Columbine Ditch	6300682	5	5
	Turner Creek Ditch	6300735	55	55
69_ADS018 Disappointment Creek	Clark Ditch	6903531	67	75
	Evans Ditch	6900504	38	38
	Johnson And Davis Ditch	6900513	41	5
	Melvin A Irr Ditch	6900525	14	14
	Melvin A Waste-Water D	6900514	14	14
	Morrison Ditch	6900515	32	32
	Thomas Ditch	6900527	23	23
	Young Ditch	6900529	37	37
	Dunham Ditch	6900501	61	61
	Garner Reservoir	6900511	82	82
71_ADS017 Dolores River above McPhee Reservoir	Unnamed Ditch Or P-L	7100510	6	6
	Carter Ditch	7100562	7	7
	Frank Robinson Ditch	7100608	17	17
	Home Ditch	7100623	13	35
	Knoblock Ditch	7100558	15	15
	Leavensworth Ditch	7100589	20	20
	Lyons Ditch	7100593	36	36
	Ortiz Ditch	7100603	21	21
	Riverside Ditch	7100705	69	69
	Rogers Ditch	7100565	54	54
	Royce And Risley Ditch	7100588	13	13
	Starrett Ditch	7100601	35	35
	Stoner Creek Ditch	7100517	26	26
	Sulphur Gulch Ditch	7100534	12	12

Aggregation ID	Diversion Structure Name	WDID	2005 Acres	2010 Acres
	Wattles And Freeman D	7100547	40	40
	Kipper Ditch No 1	7100576	5	5
71_ADS019 Dolores River ab Big Gypsum	Geo P Moore Ditch	7100539	34	34
	Lone Dome Ditch	7100564	129	112
73_ADS025 Little Dolores River	Gateway West Side Ditch	6300526	10	10
	Wines Ditch No 1	6300575	52	55
	Wines Ditch No 2	6300576	13	11
	Bieser Ditch	7300501	32	29
	Brouse Ditch	7300502	13	7
	Chiquito Dolores Ditch	7300504	121	113
	Chiquito Dolores No 2	7300505	127	124
	Dierich Ditch	7300506	74	86
	Fruita Water Works Pl	7300507	19	0
	Hafey South Side Ditch	7300511	0	7
	Mcginley Ditch	7300512	21	20
	Murphy I S D Ex Ditch	7300513	187	33
	Nellie S Ditch	7300515	19	58
	Reed Ditch	7300516	81	86
	Robbins Ditch	7300517	105	105
	Roehm Ditch	7300519	19	23
	Upper Saxbury Ditch	7300530	169	174
	A R Hall Ditch	7300533	35	20
	H H Russel D	7300534	180	180
	Hill Ditch	7300537	42	42
	Moorland Ditch	7300538	174	254
	Selby Irrigating Ditch	7300541	134	154
	Kell Ditch No 1	7300542	19	16
	Kell Ditch No 2	7300543	6	6
	Eaches Ditch	7300561	12	18
	Lane Ditch	7300566	1	1
	Madden Ditch No 3	7300622	10	10
	Madden Ditch Extended	7300634	35	39
	Skinner Ditch	7300641	19	0
	Cook Irrigating D Pt A	7300508	34	34
77_ADS001 Navajo River	Bigbee Ditch No 1	7700504	428	428
	Bramwell Irr Ditch	7700509	55	55
	Brooks Ditch	7700511	37	37
	Buckhammer Ditch	7700552	24	24
	Confar And Russell Ditch	7700555	38	38

Aggregation ID	Diversion Structure Name	WDID	2005 Acres	2010 Acres
	Elmer Ditch No 2	7700572	64	64
	Gardner Lake Ditch	7700512	4	4
	Highfills Price Cr D No1	7700516	65	65
	Klondike Ditch	7700538	20	20
	L A Sappington Ditch	7700530	57	57
	Little Navajo Ditch	7700563	31	31
	Navajo Mill & Irg Ditch	7700575	97	97
	Paxman Ditch	7700582	2	2
	Peterson Creek Ditch	7700550	26	26
	Russell Ditch	7700573	9	9
	Spring Creek Ditch	7700581	78	78
	Spring Gulch Ditch	7700546	51	51
	Talamante Ditch No 1	7700580	7	7
	Weisel Creek Ditch	7700591	24	24
	New Bond House D(Iron)	7700636	14	14
78_ADS004 Piedra River	Lopez Ditch	4600523	44	44
	Lopez-Gallegos Ditch	4600522	26	26
	Hays Ditch	7800500	29	29
	Abeyta Ditch	7800510	22	22
	B O Thayer No 1 Ditch	7800515	49	49
	B O Thayer No 2 Ditch	7800526	49	49
	Big Pagosa Ditch	7800528	29	29
	Burkhard Ditch	7800610	77	77
	Coal Hill Ditch	7800611	20	20
	Cottonwood Ditch	7803624	77	77
	Dunnagan Ditch	7800505	284	0
	Dyke No 1 Ditch	7800575	41	41
	Ford Ditch	7800607	40	40
	Grimes Ditch	7800612	133	132
	H E Freeman No 1 Ditch	7800652	134	134
	J R Scott Ditch	4600524	46	46
	John R Stevens Ditch	7800504	49	49
	Jule Macht Spring And D	7800557	529	556
	Kerr Ditch	7800558	9	9
	Kleckner Ditch	7800566	110	110
	Lower Davis Ditch	7800572	28	28
	Pargin Ditch	7800579	0	26
	Plumteau Creek Ditch	7800616	89	89
	Ralph L Reno Ditch	7800648	29	29
	Riverview Ditch	7800722	50	54

Aggregation ID	Diversion Structure Name	WDID	2005 Acres	2010 Acres
	Ross Ditch	7800538	3	3
	Snow Ditch	7800539	10	14
	Vye Ditch No 1	7800546	12	12
	Wildwater Ditch	7800568	30	30
	Clara Fredricks Ditch	7800576	13	13
	Minor Ditch	7800642	3	3
	Lynd-Plumteau Ck Ditch	7800676	94	94
	Dunagan Reservoir	7803638	284	0
	Spring Creek Reservoir	7800595	43	43
Total			**24,588**	**26,744**

Exhibit B: Diversion Structures in each "No Diversion Records" Aggregate

Aggregation ID	Diversion Structure Name	WDID	2005 Acres	2010 Acres
29_AND002 San Juan at Pagosa Springs	At Last Spring No 1 W Side	2900506	2	2
	Brown Spring & Pipeline	2900547		44
	Cummings Ditch	2900570	33	28
	Cummings-Bear Cannon Ditch	2900571	27	27
	Davis Ranch Springs	2900573	7	7
	K O Harman Ditch No 2	2900640	18	18
	R B Cowden Irr D No 2	2900698	18	18
	W B Turner Irr System	2900746		
	Dermody Pump	2900789		
	Cummings-Bear Cannon Alt Pt	2900793		
	Coal Mine Draw	2900932		
	Hinds Pumpsite Alt Pt	2900991		
	Water Fall CR Min Flow	2901909		
	Wolf CR Village Well #1	2905045		
29_AND003 San Juan at Carracas	Baker Sprinker Pump Station	2900515	16	20
	Blake No 1 Pumping Sta	2900533	111	
	Bonds San Juan R P Plt	2900539	14	14
	Dirnberger Spg & Pl No 2	2900580	40	
	McGirr-Gomez Ditch	2900667	41	41
	Murray Ditch	2900673	26	
	Virginia Ditch Alt Pt	2900805	114	114
	Felix Gomez Irr System	2900810		
	Sophia's Pump	2900818		
	Adams Spring	2900838		
	Big Branch Ditch	2902003	137	137
30_AND007 Animas River at Durango	Bowman Pump No 1 w/ A-H	3000515	13	13
	Boyd Ditch	3000516		7
	Elbert No 1 Ditch (W)	3000537	9	9
	Gilmour Pipeline No 1	3000552	2	2
	Haynie Pump	3000564	18	18
	L Carson Ditch	3000585		3
	Macy Spring and PL Sys	3000595		3
	Spring Ditch	3000637		12
	Tamarron WW Effluent PL	3000643	4	4
	Tank Creek Ditch	3000644		7
	Wilderness Pipeline	3000684	4	4
	Tall Timber Ditch	3000694	52	52
	Dyar Pump Station	3000724		11
	Dyar-McCoy Diversion Sta	3000747	1	1

	Allen Pump #1	3000751	149	149
	Bridges Pump	3000785	4	4
	Redcliff Pump Station	3000811	27	27
	Darryl's Pump	3000843	15	15
	Val-air Pump	3000855	4	4
	Arnold Diversion	3000900	19	19
	Emmett Wastewater Divr	3000903		
	S Woods Diversion	3000951		
	Jenkins Ditch	3001128		
	Wielang Ditch	3001266	3	5
30_AND008 Florida River above Salt Creek	Upper Florida Ditch	3001010	26	26
	Gallaher Ditch	3001111	13	13
	Shreck Ditch	3001215	19	19
	West-Martin Ditch	3001368	37	29
	Black Ditch	3001374	10	10
	Willon Creek D 2ND Headgate	3001423		
	Rathjen Waste Water	3001594		
	K-K Bog Spring	3006023	36	36
30_AND009 Florida River at Bondad	Dore Pump	3001087	25	25
	Roundtree WW System	3001197	20	20
	Siebert Ditch	3001204	6	6
30_AND010 Animas River at State Line	Carleno Ditch	3001066	5	3
	Foy Cogburn Pipeline	3001107	6	5
	Sever Pipeline	3001205	9	9
	Van Endert Ditch	3001248	9	9
	Zinc Spring No 5	3001276	7	7
	Duane Cogburn Pipeline	3001345	4	3
	Wegs Pump	3001661		
	Peters Pump	3001669		13
31_AND005 Los Pinos River at Dry Creek	Robeson No 2 Ditch	3100542	25	25
	Montgomery Ditch	3100610	9	9
	Pixler Ditch	3100656		94
	Schroder Ditch Extension	3100662	27	27
	Wildorado Res East Ditch	3100705		46
	Colorado SW Ditch No 1	3100708	11	11
	Pine River Cemetary Pump	3100772		86
	Morgan Spring #2	3100840	13	13
	Morgan Diversion #A	3100842	7	7
	Moore Pond Diversion	3100909	10	10
	Benoit Irrigation Pump	3100933		2
	Cruson Pump	3100993	6	6
	Vallecito Reservoir	3103518		

	Gosney Storage System	3103711		21
	Duffy Diversion Pond	3103712	32	32
31_AND006 Los Pinos River at State Line	Agency Ditch	3100500	4	
	Baily Canon Ditch	3100548	121	121
	Beaver Valley Ditch	3100571	16	16
	Jaques Pond & Divr No 1	3100658	5	59
	McCoy Ditch	3100717	9	9
	Shelhamer Lower End D #1	3100834	15	15
	Pack Waste Water Ditch	3100873	3	3
	Hargreaves Ditch	3100880		
	Neil Waste Water Ditch	3100918		
	Black Draw Reservoir #1	3101069	30	30
	Phelps Diversion #1	4600550	130	130
	Phelps Diversion #2	4600563	3	3
32_AND015 McElmo Creek above Alkali	Bradford-Whilldin Div PL	3200710	1	7
	Bennys Pump	3200720		
32_AND016 McElmo nr State Line	Plemons Ditch	3200643		
	Sprickert No 1 Ditch	3200671		
33_AND011 La Plata River	P M Davis Ditch	3300503	16	
	Moss Ditch	3300509	39	39
	Sena Ditch	3300556	19	19
	John F Reit Ditch	3300558	68	68
	Eno Seepage Dit ch	3300570	4	4
	Hubbs Ditch No 1	3300579	12	12
	Hubbs Ditch No 2	3300580	11	11
	Paulek No 1 Ditch	3300583	6	6
	Lapp North Spring System	3300594		
	Townsend Spring No 1	3300596		
	Wheeler 2 Ditch	3300604		
	Isgar Irrigation System	3300616		
	Greer Ditch	3300626	9	29
	O.F.C. Ditch	3300673	11	
34_AND013 Mancos Riv ab Chicken Creek	Jackson Gulch Reservoir	3403589	30	30
60_AND020 Mancos River nr State Line	Prospect Cr Hole No 2/17	6001854	145	145
60_AND021 San Miguel R nr Placerville	Brewster Cr Ditch	6000537	90	90

	Homestead No2 Ditch	6000990		
61_AND019 Dolores River nr Bedrock	N Mid Met Draw Div Ditch	6100553		42
63_AND023 Dolores River at Gateway	Lonsway Ditch	6000674		
	Richards Pump St No 2	6001622		
	Cliff Dwellers Ditch	6300517		
63_AND024 West Creek	Burg Ditch No 1	6300509	168	168
	Craig Res No 2	6303640		
	Craig Res No 1	6303644	35	35
71_AND017 Dolores River above McPhee Reservoir	Jesse Love Ditch	7100553	7	7
	Silvey Ditch	7100599	16	16
	Ethel Belmear Reservoir	7103610	26	26
71_AND019 Dolores River ab McPhee Res	Lawrence E Rogers Ditch	7100561	15	15
	Suckla Pump Site	7100607	23	39
	Willis Rogers Ditch	7100636		22
73_AND025 Little Dolores River	Cook Irrigation Ditch	7300532	1	1
	Green Shaft Reservoir	7303602	1	1
	Madden Trout Pond No 2	7303603		
	Duvall Res. No. 1	7303612	19	58
77_AND001 Navajo River	Coyote-Boon Creek Ditch	7700519	141	15
	Krenz Ditch	7700551		
	Olen W Crowley Art Well	7705004		
78_AND004 Piedra River	Herrera Pump Site No 1	2900764	12	12
	Dutton Collection Ditch	2902007	11	11
	Don Thompson Pump No 1	7800535	19	19
	Don Thompson Pump No 2	7800536	300	300
	Bynum Pumpsite	7800669	14	14
	Town Center Pump	7800675		
	McWhirters Pond & Pump	7800677		
	Tishner Pumpsite	7800687	4	4
Total			**3,354**	**3,610**

A-2: IDENTIFICATION OF ASSOCIATED STRUCTURES (DIVERSION SYSTEMS AND MULTI-STRUCTURES)

Background

The previous CDSS Western Slope models include associated structures which divert to irrigate common parcels of land. These associations were primarily based on information provided directly during meetings with Water Commissioners, and were not based on information from the original 1993 irrigated acreage assessment. The original CDSS 1993 irrigated acreage assessment was based on the USBR identification of irrigated land enhanced with a water source (ditch identifier) that served that land. Many of the irrigated acreage parcels covered more than one ditch service area and, in lieu of spending significant time splitting the parcels by ditch service area, more than one ditch was assigned. For CDSS modeling purposes, the acreage was simply "split" and partially assigned to each ditch.

Introduction

For the recent 2005 and 2010 acreage assessments, there was significant effort spent trying to refine irrigated parcels based on the legal and physical ditch boundaries so, where possible, there was only one ditch assigned to each irrigated parcel in Divisions 5, 6, and 7. Division 4 efforts concentrated on a few areas, but not the entire basin. To model these ditches as accurately as possible, it is important to understand if the acreage that is still assigned to more than one ditch is actually irrigated by all assigned ditches in a comingled fashion or, alternatively, if the acreage should be "split" and the structures should be modeled as having no association. Ditches combined for modeling because the supplies are believed to be comingled are termed "associated structures" for the CDSS modeling effort.

Some associated structures can be identified based on the HydroBase water rights transaction table because they are decreed alternate points or exchange points, while others can be identified based on Water Commissioner accounting procedures, generally documented in their comments accessible through Hydrobase. In the models, associated structures are represented as diversion systems if the structures are located on the same tributary or multi-structure systems if they are located on different tributaries. As part of Task 3, the associated structures were updated to more accurately model the combined acreage, diversions, and demands. These updates include the integration of the 2005 irrigated acreage, the 2010 irrigated acreage, as well as verification of associated structures based on diversion comments and water right transaction comments.

Approach

The following steps were used to identify associated structures in Divisions 5, 6, and 7. Because the Division 4 parcels have not yet been refined to the ditch service level, no effort was made to determine additional associated structures. Note, however, the parcels that require additional refinement have been identified and provided to Division 4. These updates should be included with the next acreage assessment.

Updating the associated structures was a multi-step process that involved 1) identifying potential associated structures by integrating the 2005 and 2010 CDSS irrigated acreage, 2) verifying the associated structures using the diversion and water right transaction comments, and 3) making recommendations on how to best represent the associated structures in the CDSS Western Slope models.

1) *Develop an Associated Structure List Based on Revised 2005and 2010 CDSS Irrigated Acreage*

   An initial associated structure list was developed by combining the CDSS revised 2005 and 2010 irrigated acreage. During this process the overlapping similarities between the two irrigated acreage coverages were integrated, resulting in a list of associated structures containing unique IDs. An illustrative example is presented below. In this example, the 2005 irrigated acreage coverage contains parcel A assigned to structures 1, 2, and 3; while the 2010 irrigate acreage coverage contains parcel B assigned to structures 2 and 4. Parcel A and B are integrated, resulting in an association comprised of structures 1, 2, 3, and 4.

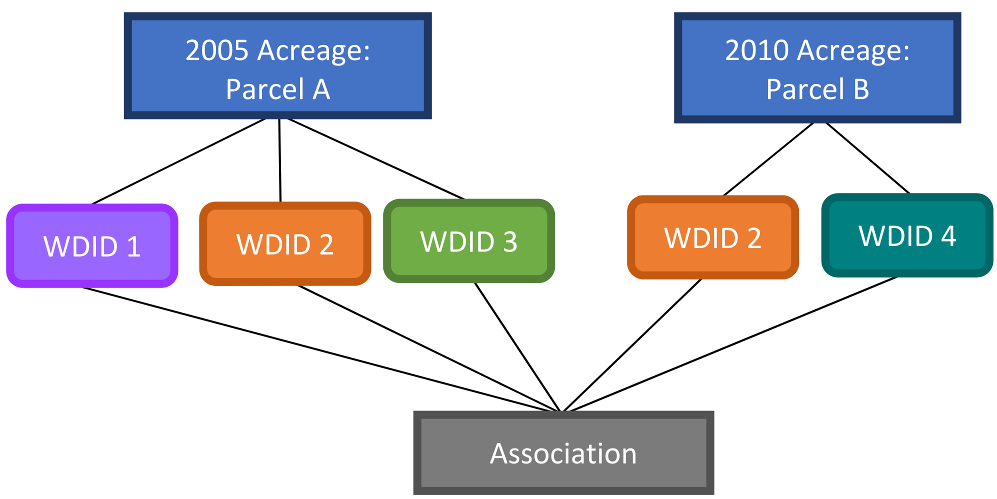


Figure A-2. Example of integrating the CDSS irrigated acreage coverage to identify associated structures.

2) *Verify the Associations Using Diversion and/or Water Right Transaction Comments*

Once a unique list of associated structures was developed, each association was verified using diversion comments and/or water right transaction comments. If the diversion comments and/or water right transaction comments could not verify structure associations, then unverified structures were removed from the list of associated structures (i.e., their diversions will not be treated as commingled). Types of verification included comments identifying structures as alternate points of diversion, points of exchange, acreage reported under alternative structure, same points of diversion, and water right transfers.

Below is an example of the verification methodology using the diversion and/or transaction comments for the association shown in step 1.

Table A-4. Example of Integrating the Diversion and Water Right Transaction Comments for Verification.

WDID	Verification Comment	Source	Verified?
1	Irrigates Y Ranch	Diversion Comment	N
2	Water right transferred to WDID 4	Transaction Comments	Y
3	Acreage is recorded under WDID 2	Diversion comments	Y
4	-	-	Y

Given this example, WDID 1 was not verified by the comments and, thus, not included in the final list of associated structures.

3) *Recommend a Modeling Approach for Representing Associated Structures in the CDSS Western Slope Models*

Using the refined associated structure list developed in step 2, recommendations on how to best represent the associated structures in the CDSS models were provided. These recommendations were based on the following criteria:

- If located on non-modeled tributaries, the associated structures were added to appropriate aggregates.
- Associated structures were explicitly modeled—either in diversion systems or multi-structure systems—if the net water rights for at least one structure in the association exceeded a specific threshold identified in previous modeling efforts. In general, the thresholds represent 75% of the net water rights and are listed in **Table A-5**.

Table A-5. Water Right Thresholds for Explicit Modeling

CDSS Model	Water Right Threshold (CFS)
Yampa	5
White	4.8
Upper Colorado	11
San Juan/Dolores	5/6.5

Structures located on the same tributary were modeled as diversion systems, while structures located on different tributaries were modeled as a multi-structure system. Note, diversions systems combine acreage, headgate demands, and water rights; and the model treats them as a single structure. Contrastingly, multi-structure systems have the combined acreage and demand assigned to a primary structure; however, the water rights are represented at each individual structure, and StateMod meets the demand from each structure when their water right is in priority. **Figure A-3** illustrates how a diversion system is modeled, while **Figure A-4** illustrates how a multi-structure system is modeled.

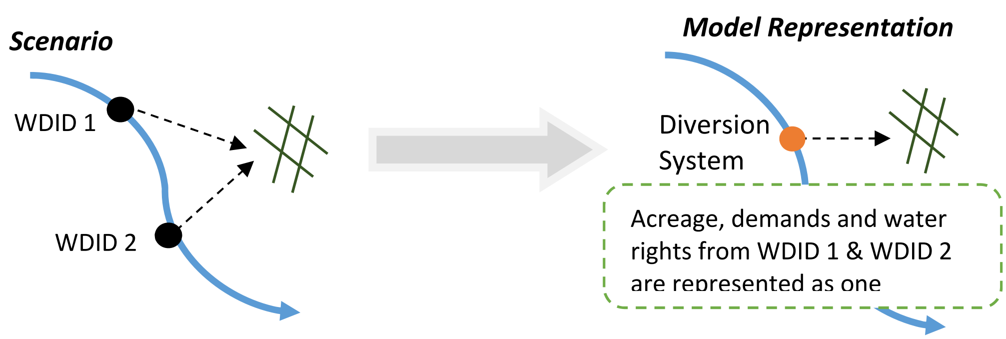


Figure A-3. Model Representation of a Diversion System.

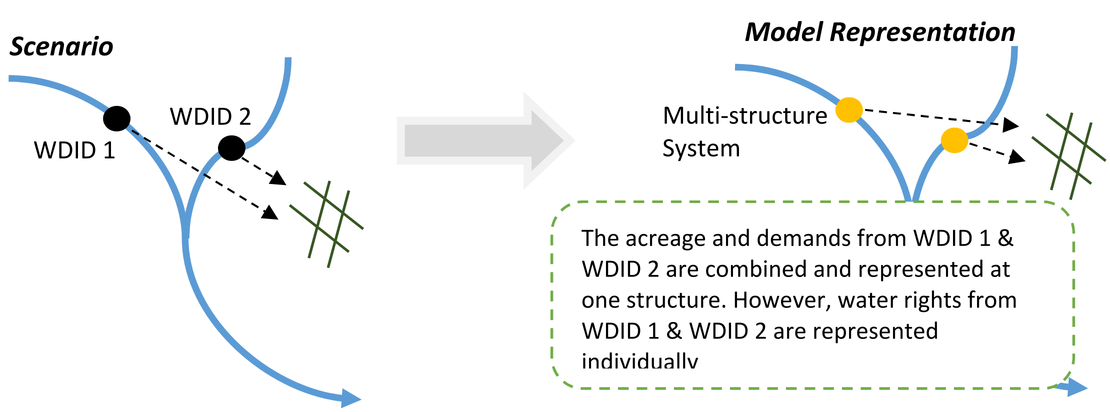


Figure A-4. Model Representation of a Multi-structure System.

    - The structure with the most irrigated acreage—based on the 2005 and 2010 CDSS coverages—was selected as the modeled structure for each diversion system.
    - The structure with the greatest net water rights was selected as the primary structure for multi-structure systems.
- If none of the structures in an association exceeded the water right threshold identified in Table 2 and have contemporary diversion records, the structures were modeled in an aggregate.
- If all structures in an associated did not have diversion records, the structures were placed in a “no diversion” aggregate.

Appendix B

Aggregation of Non-Irrigation Structures

1. San Juan/Dolores Basin Aggregated Municipal and Industrial Use

2. San Juan/Dolores Basin Aggregated Reservoirs and Stock Ponds

B-1: San Juan/Dolores River Basin Aggregated Municipal and Industrial Use

Introduction

This memo describes the results of Subtask 6.10 San Juan/Dolores River Basin Aggregated Municipal and Industrial Use. The objective of this task was as follows:

> *Aggregate municipal and industrial uses not explicitly modeled in Phase II to simulate their depletive effects in the basin.*

Approach and Results

Phase II Modeled M&I Use - **Table 1** presents the 1975 to 1991 average annual Municipal and Industrial depletions modeled in Phase II.

TABLE 1
Phase II Explicitly Modeled M&I Consumptive Use (acre-feet)

Ditch	San Juan	Dolores	Total
Durango City (301000)	2536	0	2,536
Town of Mancos (340573)	489	0	489
Original Rico Flume (71055)	0	104	104
Town of Cortez (320680)	1,531	0	1,531
Total	4,556	104	4,660

Phase II Consumptive Uses and Loss Estimates The following table presents the categories and values of M&I consumptive use presented in the task memorandum 2.09-13 “Non-Evapotranspiration (Other Uses) Consumptive Uses and Losses in the Dolores and San Juan River Basin” (11/26/96).

Phase II Consumptive Use and Loss M&I Consumptive Use

Category	San Juan	Dolores	Total
Municipal	4,202	791	4,993
Mineral	392	17	409
Livestock	1037	598	1,635
Total	**5,631**	**1,406**	**7,037**

Aggregated M&I Diversion Based on the above data and the relatively small amount of consumption, two aggregated M&I demands were added to the model; one (32_AMS001) for the San Juan River Basin above the Towaoc-Highline Canal (320884) and above San Juan near Bluff, Utah stream flow gage (09379500); and another (63_AMS002) for the Dolores River Basin just above the Dolores River at Gateway, CO gage (09179500). Exhibit 1 of Section D.6 is a network diagram which includes the aggregated M&I demand.

As summarized below, the San Juan Aggregated M&I Demand (32_AMS001) was assigned a depletive demand (efficiency of 100%) **of 1,075 af/yr**. (5,631 af - 4,556 af) distributed evenly over 12 months. The Dolores Aggregated M&I Demand (63_AMS002) was assigned depletive demand (efficiency of 100%) of **1,302 af/yr**. (1,406 af - 104 af) distributed evenly over 12 months. Both aggregated M&I demands were assigned a water right of 2 cfs and a senior administration number of 1.

The monthly aggregated demand files were built in an editor using a StateMod format. They were named *32_AMS001.stm* and *63_AMS002.stm* for the San Juan and Dolores respectively. These time series were incorporated in the demand files by using a -replace option with **demandts**.

Phase III Aggregated M&I Consumptive Use Summary

Basin	Aggregated M&I ID	Depletive Demand (af/yr)	Water Right (cfs)
San Juan	32_AMS001	1,075	2
Dolores	63_AMS002	1,302	2
Total		**2,377**	**4**

B-2: San Juan/Dolores River Basin Aggregated Reservoirs and Stock Ponds

Introduction

This memorandum describes the approach and results obtained under Subtask 6.11, Aggregate Reservoirs and Stock Ponds. The objective of this task was as follows:

> *Aggregate reservoirs and stock ponds not explicitly modeled in Phase II to allow simulation of effects of minor reservoirs and stock ponds in the basin.*

Approach and Results

Reservoirs and Stock Ponds: Table 1 presents the net absolute storage rights that were modeled in Phase II, those to be added as aggregated reservoirs in Phase IIIa, and stock ponds to be added as aggregated stock ponds in Phase IIIa. The Phase II reservoir information was obtained from the Phase II reservoir rights file, *sanjuan.rer*. The absolute decree amount presented in **Table 1** for "Total Aggregated Reservoirs " was produced by running **watright** with basin=sanjuan and basin=dolores with the -aggres option. The storage presented in **Table 1** for the "Total Aggregated Stock Ponds" was taken from the year 2 Task Memorandum 2.09-13 "Consumptive Use Model Non-Irrigation (Other Uses) Consumptive Uses and Losses in the Dolores and San Juan River Basins" (11/26/96).

TABLE 1

Phase	Reservoir	Absolute Decree (af)	Percent Total
Phase II	CASCADE RESERVOIR	23,254	3%
Phase II	LEMON RESERVOIR	48,000	6%
Phase II	VALLECITO RESERVOIR	129,674	16%
Phase II	JACKSON GULCH RESERVOIR	11,365	1%
Phase II	GURLEY RESERVOIR	8,233	1%
Phase II	NATURITA RESERVOIR	3,000	<1%
Phase II	LAKE HOPE RESERVOIR	2,315	<1%
Phase II	MIRAMONTE RESERVOIR	6,851	1%
Phase II	TROUT LAKE RESERVOIR	3,186	<1%
Phase II	NARRAGUINNEP RESERVOIR	22,455	3%
Phase II	GROUNDHOG RESERVOIR	21,709	3%
Phase II	MCPHEE RESERVOIR	381,200	48%
Phase II	SUMMIT RESERVOIR	4,442	1%
Subtotal		**665,684**	**84%**
Phase III	Total Aggregated Reservoirs	94,703	12%
Phase III	Total Aggregated Stock Ponds	35,271	4%
Subtotal		**129,974**	**16%**
Total		**795,658**	**100%**

Number of Structures and Locations: Based on general location, the Phase IIIa reservoirs and stock ponds were incorporated into the model as 8 aggregated structures. The Total Aggregated Reservoirs represent numerous small reservoirs that are administered as stock ponds. Five aggregated reservoirs were used to model the absolute decreed storage not already modeled in Phase II. Storage was assigned to the five non-operational reservoirs equally as shown in **Table 2**. The Total Aggregated Stock Ponds were modeled as three non-operational reservoirs; total capacity was partitioned to the three nodes equally, also shown in **Table 2**.

Each aggregated reservoir and stock pond was assigned one account and an initial storage equal to their capacity. Each aggregated reservoir and stock pond was assumed to be 10 foot deep. The eight aggregated structures were modeled as exempt from an annual one-fill limit. Each aggregated reservoir and stock pond was assigned a 2 point area-capacity curve. The first curve point is zero capacity and zero area. The second point on the area-capacity table is total capacity with the area equal to the total capacity divided by 10. The net evaporation station as described in Phase II San Juan River basin documentation (Section 4.3.2.1 "Estimation of Annual Net Evaporation") was assigned to each structure at 100 percent. All other parameters were left as the default to each structure.

TABLE 2

Aggregate Reservoirs

Model ID	Name	Capacity (AF)	Percent
63_ARS001	63_ARS001_Dolores	18,941	20
30_ARS002	30_ARS002_Animas	18,941	20
31_ARS003	31_ARS003_LosPinos	18,941	20
78_ARS004	78_ARS004_Piedra	18,941	20
29_ARS005	29_ARS005_SanJuan	18,941	20
Total		**94,703**	**100**

Aggregate Stock Ponds

Model ID	Name	Capacity (AF)	Percent
30_ASS001	30_ASS001_Animas	11,757	33.3
31_ASS002	31_ASS002_LosPinos	11,757	33.3
78_ASS003	78_ASS003_Piedra	11,757	33.3
Total		**35,271**	**100**

Target Contents, and End-of-Month Data: Each aggregated reservoir and stock pond was designed to maintain maximum volume, filling to account for evaporation losses. The end-of-month data used in the baseflow calculations was set to the target values.

Water Rights: Water rights associated with each aggregated reservoir and aggregated stock pond were assigned an administration number equal to 1.