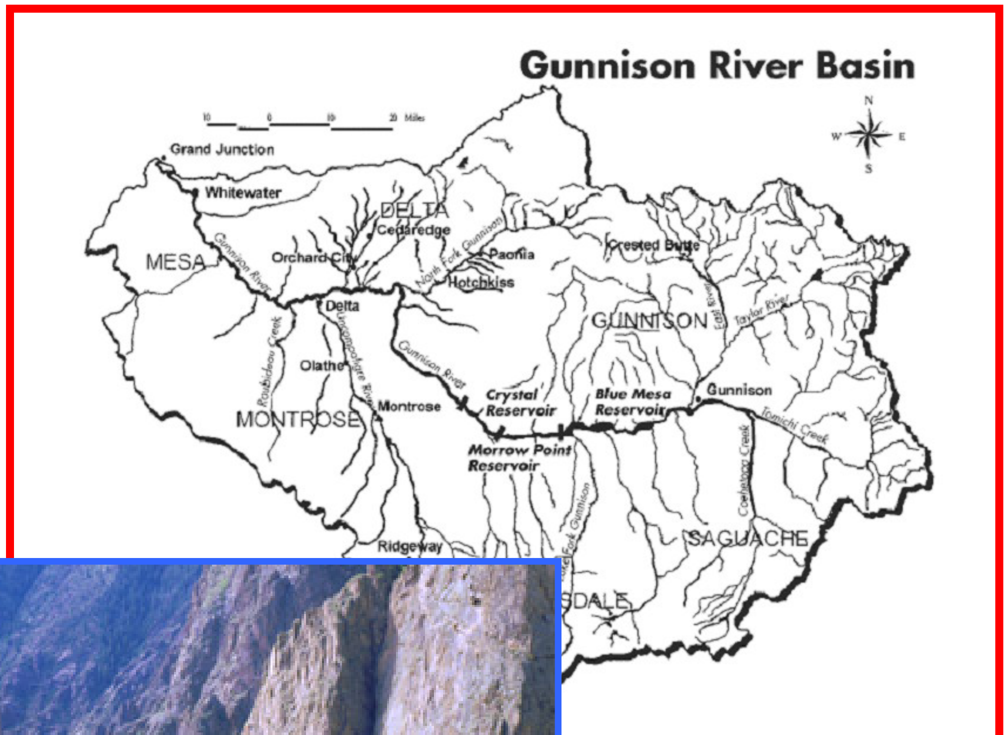
# Gunnison River Basin
# Water Resources Planning Model
# User's Manual




**October 2009**

COLORADO'S DECISION SUPPORT SYSTEMS

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# 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 Gunnison River Basin Water Resources Planning Model (Gunnison 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 Gunnison Model “Baseline” data set, which this document describes, extends from the most currently available hydrologic year back to 1909. 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 Gunnison 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.

## 1.2 Development of the Gunnison River Basin Water Resources Planning Model

The Gunnison Model was developed in a series of phases that spanned 1998 through the present. Unlike the other basins modeled on Colorado’s Western slope, the Gunnison Model was developed in two steps, Phase IIIa and Phase IIIb. The Phase IIIa model was developed to represent 100 percent of the consumptive use in the basin. Approximately 75 percent of the use was represented as individual diversions and the remaining 25 percent of use was added to the model as 41 aggregations of numerous small users. The model operated on a monthly time-step with a study period of 1975 through 1991, which also served as the model’s calibration period.

The objective of Phase IIIb was to extend the model study period, using automated data filling techniques as well as “old-fashioned” 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 reviewed, focusing on the period 1975 through 1996.

The State continues to refine the Gunnison Model. In 2003, the study period was extended through 2002, 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 State refined the Gunnison Model again in 2006, adding the “variable efficiency” method for determining irrigation consumptive use and return flows, extending the study period through 2005, and creating daily simulation input files.  The model input files were enhanced during the CRWAS project in 2009 to include the following:

- More accurate representation of the North Fork of the Gunnison projects including Overland, Paonia, Crawford, and Fruitland reservoir operations.
- Addition of the Black Canyon of the Gunnison federal instream flow requirements.
- Enhancements to Fruitgrowers Reservoir operations.

Calibration was reviewed after each major enhancement.

## 1.3 Results

The key results of the Gunnison modeling 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 Gunnison basin.  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 2005.

- 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 2005.  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 Gunnison 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.

## 1.4 Future Enhancements

The Gunnison Model was developed to include 100 percent of the basin’s consumptive use through a combination of explicit and aggregated structures.  The Gunnison 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.

## 1.5 Acknowledgements

CDSS is a project of the Colorado Water Conservation Board (CWCB), with support from the Colorado Division of Water Resources. The Gunnison Model has been developed and enhanced at different stages by Boyle Engineering Corporation, Leonard Rice Engineers, and CWCB staff.

# 2. What's in This Document

## 2.1 Scope of this Manual

This reference manual describes the CDSS Gunnison 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 Gunnison River Basin development or management scenario
- Is interested in estimated conditions in the Gunnison 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 Gunnison 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 Gunnison 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 Gunnison 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 West Slope models and the Rio Grande model, although the section refers specifically to the Gunnison 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 is advised, before appropriating the data set, to become fully aware of 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 Gunnison 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.

**Section 8 Daily Baseline Results –** describes the Daily Baseline data set and presents summarized results of the Daily Baseline simulation. It shows the state of the basin as the Gunnison model characterizes it under Baseline conditions, and compares available and simulated flows to the Monthly Baseline simulation.

**Appendices A through C –** present historical technical memoranda specific to the Gunnison model, written at various phases of the model's development. 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.

**Appendix D –** discusses the comparison of historical measured data to the Calculated data set simulation.  The Calculated data set expands on the historical calibration by using calculated irrigation demands based on crop requirements, in lieu of demands based on historical irrigation diversions. Comparisons of streamflow, diversions, and reservoir levels are presented.

**Appendix E –** discusses the comparison of historical measured data to the Daily Historical data set simulation.  The daily time-step is capable of simulating diversions based on the large and small flow events that occur within a monthly time step. Comparisons of streamflow, diversions, and reservoir levels are presented.

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 well 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 Gunnison model to implement specific future operations
- introduce changes that require regenerating the baseflow 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 he needs. This list of descriptions is intended to help in selecting the most relevant data source:

**Basin Information** – the report "Gunnison 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.

**CDSS Procedures Manual** (under development) – provides an overview of the CDSS modeling environment, encompassing not only the water resources planning model, but StateCU, StateWB, and the CDSS groundwater model. The documentation describes file naming conventions and directory structures for an integrated CDSS development environment; procedures for assembling data sets; and conventions in engineering approach that have been adopted in CDSS. Following the standards presented in this documentation will promote consistency among CDSS models.

**DMI user documentation –** user documentation for the DMI's **makenet, watright, demandts,** and **tstool** is currently available, and covers all aspects of executing these codes against the Hydrobase database. (Creating data sets for StateMod is only one aspect of their capabilities.) The DMI's preprocess some of the StateMod input data. For example, **makenet** computes coefficients for distributing baseflow gains throughout the model, **watright** can aggregate water rights for numerous small structures, and **demandts** 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.

**StateDMI documentation** (under development) – StateDMI is a new product that will incorporate the functionality of **makenet, watright,** and **demandts.** The documentation is currently under development.

**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 Gunnison model user's understanding of results. If the user is modifying input files, he should consult Section 4 Input Description to determine how to format files. To analyze model results in detail, he should 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. Historical technical memoranda and reports for these activities are available on the CDSS website:

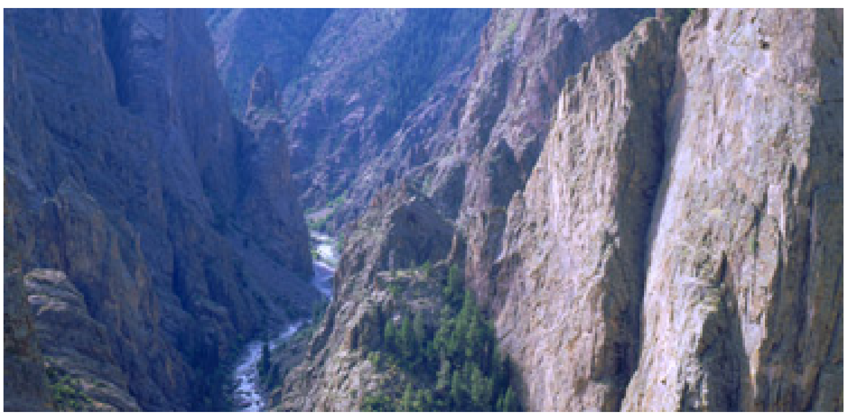
- Phase IIIb Task Memorandum 10.1 – Data Extension Feasibility
- Task Memorandum 10.2 – Evaluate Extension of Historical Data
- Task Memorandum 11.5 – Characterize Streamflow Data
- Task Memorandum 11.7 – Verify Diversion Estimates
- Task Memorandum 11.10 – Fill Missing Baseflow data (include Mixed Station 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 1.14-23 – Non-Evapotranspiration (Other Uses) Consumptive Uses and Losses in the Gunnison river Basin
- Gunnison River Basin Historical Crop Consumptive Use Report

# 3. The Gunnison River Basin

The Gunnison River basin extends from the Continental Divide to Grand Junction, where it joins the Colorado River. The basin encompasses all of Gunnison, Delta, and Ouray counties, and parts of Montrose, Saguache, Hinsdale, and Mesa counties in Colorado. Figure 3.1 is a map of the basin. The Gunnison River and its largest tributary the Uncompahgre River flow through forested mountains and rural irrigated valleys.

## 3.1 Physical Geography

The Gunnison River basin is approximately 7,800 square miles in size, ranging in elevation from 14,000 feet in the headwaters to 4,550 feet at Grand Junction. Across this expanse, average annual rainfall varies from more than 40 inches in the high mountains to as little as 8 inches in the Uncompaghre Valley near the town of Delta. Temperatures generally vary inversely with elevation, and variations in the growing season follow a similar trend. The town of Gunnison has an average growing season of 144 days, while the growing season at Grand Junction has been estimated at approximately 228 days.



The Gunnison River begins at the confluence of the East and Taylor rivers, about 10 miles upstream from the city of Gunnison. The flow is increased as the river is joined by Cochetopa and Tomichi Creeks near the town of Gunnison. Just downstream, the river has carved through Precambrian rocks to form the Black Canyon of the Gunnison. Annual flow through the town of Gunnison is 547,000 acre-feet per year (United States Geological Survey [USGS] gage near Gunnison).

The Uncompahgre River is the largest tributary to the Gunnison River, entering from the south near the town of Delta. Average annual flow of the Uncompahgre near the confluence is 220,000 acre-feet (USGS gage at Delta). The average annual flow of the Gunnison River near Grand Junction is over 1.8 million acre-feet (USGS gage near Grand Junction). Approximately 60 percent of this flow is attributable to snowmelt runoff in May, June, and July.

## 3.2 Human and Economic Factors

The first permanent populations of white settlers came to the upper Gunnison basin in the 1800s to mine for silver. With the exception of continued mining of coal in the basin, the mineral industry is no longer a key economic sector. Farming and ranching, as well as recreation and tourism, are the primary activities in the basin today.


**Figure 3.1 – Gunnison River Basin**

The area remains relatively sparsely populated, with the 2001 census estimates placing the combined populations of Gunnison, Delta, and Ouray Counties at approximately 46,250. Montrose and Delta are the major population centers in the basin, with approximately 12,300 and 6,400 residents respectively. Gunnison and Delta Counties grew by just over 30 percent from 1990 to 2000, and Ouray County grew by over 60 percent in the same time period. Growth is concentrated in the lower Gunnison Valley near Grand Junction and along the Uncompahgre River near Montrose. This growth attests to the importance of recreation-based activities, as the ski area and other outdoor recreation opportunities draw people to the basin and increase tourism within the basin. Tourism serves as an important part of the basin's economy.

Much of the upper basin is predominately forest and rangeland, with irrigation becoming the principle consumptive use of water in the lower Gunnison basin. Irrigation is used for various crops including pasture, hay, fruit, corn, alfalfa, and small grains. The total irrigated acreage in the basin is estimated to be approximately 263,000 acres for the year 2000, according to the Colorado Water Conservation Board (CWCB). While diversions from many of the small irrigation ditches average one or two thousand acre-feet per year, the Gunnison Tunnel diverts approximately 320,000 acre-feet per year to supply large irrigators in the Uncompahgre River Basin.

Primary use of surface water throughout the entire basin is for hydropower generation, which has historically diverted over approximately 3 million acre-feet per year, according to the CWCB. Note that this use is non-consumptive. The Aspinall Unit of the Colorado River Storage Project encompasses the major power plants within the basin. Hydroelectric power plants are located in series at the dams of the Blue Mesa, Morrow Point, and Crystal reservoirs. The three power plants have the capability to generate up to 208,000 kilowatts of power for the basin and surrounding areas.

There are also diversions for municipal and industrial use in Delta and Montrose, as well as in a number of smaller towns. One major transbasin diversion, the Redlands Canal, exports water from the Gunnison River basin to the Colorado Mainstem basin. The diversion's senior water rights account for 750 cfs, which can be used for irrigation and power generation. There are also a number of smaller transbasin diversions from one tributary drainage basin to another.

In addition to the direct ditch diversions, there are eleven major reservoirs (greater than 4,000 acre-feet in capacity) in the Gunnison River basin. Three of the largest reservoirs, Blue Mesa, Morrow Point, and Crystal, were constructed pursuant to the Colorado River Storage Project, which was enacted in 1956. The reservoirs, with normal capacities of 940,800 acre-feet, 117,190 acre-feet, and 26,000 acre-feet respectively, were constructed to normalize and maintain the delivery of Colorado River Compact water to the lower basin in years of limited precipitation. Two reservoirs, Taylor Park and Ridgway, are predominately used to store water for supplemental irrigation water supply and release for fish flows. The remaining reservoirs include Paonia, Crawford, Silverjack, Gould, Overland, and Fruitgrowers reservoirs, which are predominantly used for irrigation.

## 3.3 Water Resources Development

The Gunnison River basin has seen substantial water resources developments in the form of private irrigation systems, municipal and industrial diversions, and federal projects. Table 3.1 summarizes key development and agreements within the basin over time.

**Table 3.1 – Key Water Resources Developments**

| Date | Description | Date | Description |
|---|---|---|---|
| 1908 | Gunnison Tunnel and Diversion Dam | 1973 | Vader Right Adjudicated |
| 1937 | Taylor Park Reservoir | 1975 | Taylor Park Exchange Agreement |
| 1962 | Paonia and Crawford Reservoirs | 1976 | Crystal Reservoir |
| 1966 | Blue Mesa Reservoir | 1986 | Taylor Park Refill |
| 1968 | Morrow Point Reservoir | 1987 | Ridgway Reservoir |
| 1971 | Silverjack Reservoir | | |

## 3.4 Water Rights Administration and Operations

Historical water rights administration in the Gunnison River basin can be divided into three distinct time periods. The first time period was from 1902 through 1937 when the Gunnison Tunnel dominated administration. Prior to the construction of Taylor Park Reservoir, water rights were administrated on the basis of direct flow priorities. The senior direct flow rights of the Uncompahgre Valley Water User's Association (UVWUA) on the Uncompahgre and Gunnison Rivers regularly called out junior diverters in both basins in the summer months. Late season irrigation shortages in the Uncompahgre River basin were still relatively common even for those with senior water rights.

The second significant time period was from 1937 through 1966 when the Taylor Park Reservoir dominated administration. Prior to the Aspinall Unit, yet with the construction of Taylor Park Reservoir, junior diverters were still subjected to senior river calls by UVWUA. However, UVWUA typically had late season water that effectively eliminated the late summer shortages in the Uncompahgre River basin, except in the extreme dry year 2002.

The final significant time period is from 1966 to present time, whereby the Aspinall Unit was constructed and currently dominates flows in the Gunnison River and water rights administration in the basin. The Aspinall Unit gave the UVWUA the ability to draw its Taylor Park storage water from Blue Mesa Reservoir. This resulted in three major impacts on water rights administration. First, it eliminated the need to "Shepard" Taylor Park releases past intervening upper basin headgates to the Gunnison Tunnel. Second, subordination of the Aspinall water rights to 60,000 acre-feet of upstream junior depletions (a condition of the transfer of the project's water rights from the Colorado River Water Conservation District to the United States) meant that the Aspinall Unit could not call out water users above Blue Mesa. Lastly, Aspinall Unit releases for power generation created substantial amounts of "free water" which effectively eliminated the large senior downstream calls by the Austin and Redlands water rights.

Future administration of the Gunnison may be affected by the National Park Service (NPS) decreed reserved water right for instream flow purposes on the Gunnison River through the Black Canyon of the Gunnison. In addition to this reserved water right, the U.S. Fish and Wildlife Services have also adopted flow recommendations for the Gunnison River that could potentially affect administration.

Future administration and/or reservoir operations in the Gunnison may also be affected by activities and projects in the Recovery Program for Endangered Fish. Under the Endangered Species Act, four Colorado River native fish species are listed as endangered: Colorado pikeminnow (a.k.a. Colorado squawfish), humpback chub, bonytail chub, and razorback sucker. In 1988, the States of Colorado, Utah, and Wyoming, water users, hydropower customers, environmental organizations, and federal agencies developed a program to recover these species while allowing water use to continue and up to 50,000 acre-feet/year of new consumptive use to be developed.

As part of the recovery efforts, The Bureau of Reclamation has altered the timing and releases from the Aspinall Unit dams to help researchers refine habitat requirements of the endangered fish. The result of this research will help in preparing new biological opinions on current reservoir operations and, potentially, determine future revisions to operations.

The Colorado River Salinity Control Program is an on-going effort to decrease salinity levels from the upper Colorado River basin mainstem and tributaries. The Bureau of Reclamation and the Natural Resources Conservation Service have recommended a variety of salinity control measures in the lower Gunnison basin, including the Uncompahgre River, that could affect future irrigation methods and basin operations.

## 3.5 Section 3 References


1. Colorado River Decision Support System Gunnison River Basin Water Resources Planning Model, Boyle Engineering Corporation, December 1999.

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

3. USBR: Colorado River Storage Project, available at http://www.usbr.gov/dataweb/html/crsp.html

4. Black Canyon of the Gunnison National Park Reserved Water Right Facts, Colorado Water Conservation Board, 2001.

5. Colorado River Basin Salinity Control Program Lower Gunnison Basin Unit, Colorado, available at http://wwww.usbr.gov/dataweb/html/lowergun.html

# 4. Modeling Approach

This section describes the approach taken in modeling the Gunnison 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 Gunnison River 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

**Figure 4.1** is the network diagram for the Gunnison Model. It includes almost 500 nodes, beginning with instream flow reaches near the headwaters of both East River and Taylor River and ending at the Gunnison River confluence with the Colorado River, near Grand Junction. The network can downloaded and viewed through StateDMI.

### 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, a 9 cubic feet per second (cfs) cutoff value was selected for the Gunnison River basin. Key diversion structures are generally those with total absolute water rights equal to or greater than 9.0 cfs. The Gunnison Model includes approximately 320 key diversion structures.

**Where to find more information**

- Section 3 of the CDSS document "Gunnison 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 Gunnison Basin Information Section "Division 4 Meeting".

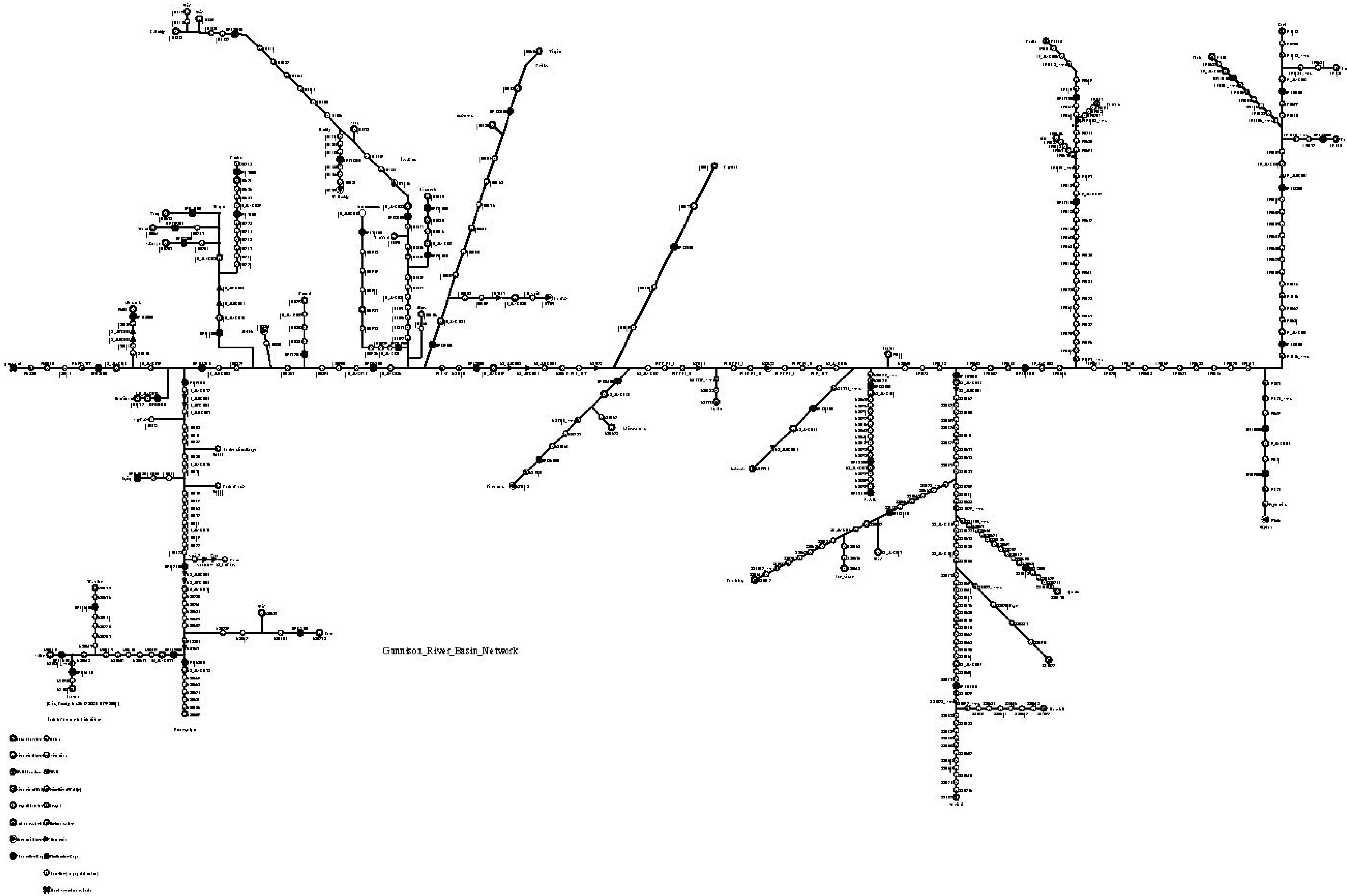



**Figure 4.1 Network Diagram – Gunnison River Planning Model**

#### 4.2.2.2 Aggregation Of Irrigation Structures

In general, the use associated with irrigation diversions having total absolute rights less than 9.0 cfs 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 Gunnison Model, 42 aggregated nodes were identified, representing over 61,000 acres of irrigated crops. These nodes were placed in the model at the most downstream position within the aggregated area.

Aggregated irrigation nodes were attributed 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

Three nodes in the model represent the combined small diversions for municipal, industrial, and livestock use (M&I) in three water districts in the basin. Total non-irrigation consumptive use in the Gunnison basin was estimated, as documented in the task memorandum "Non-Evapotranspiration (Other Uses) Consumptive Uses and Losses in the Gunnison River Basin." 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 40, 41, and 62 in accordance with a general distribution of M&I use.

The three aggregated M&I nodes in the Gunnison Model represent approximately 4,600 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 BBC investigation cited above.

Project 7 Water Authority municipal diversion is represented explicitly. A component of the Dallas Creek Project, Project 7 provides treated domestic and municipal water for the Uncompahgre Valley including the towns of Montrose and Delta. Although not a basin consumptive use, M&I water "exported" from the Gunnison for power generation through the Redlands Canal and water "exported" from Kannah Creek for the City of Grand Junction are also represented.

**Where to find more information**

- Appendix B includes a memorandum describing the task in which municipal and industrial uses were aggregated. Appendix B also includes CRDSS Task 1.14-23 Memorandum "Non-Evapotranspiration (Other Uses) consumptive Uses and Losses in the Gunnison River Basin", May 1995.

### 4.2.3. Reservoirs

#### *4.2.3.1 Key Reservoirs*

Reservoirs with decreed capacities equal to or in excess of 6,000 acre-feet are considered key reservoirs, and are explicitly modeled. There are 11 key reservoirs with a combined total capacity of approximately 1,931,000 af, or 94 percent of the total absolute storage rights of the basin. In addition, two smaller reservoirs are explicitly modeled due to their importance in water administration and project deliveries.

#### *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 14 aggregated reservoir structures.

Nine 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) | % |
|---|---|---|---|---|
| 28_ARG001 | 28 | AGG_RES_Tomichi | 6,395 | 6 |
| 40_ARG001 | 40 | AGG_RES_Surface | 23,268 | 22 |
| 40_ARG002 | 40 | AGG_RES_Ngunn | 23,268 | 22 |
| 41_ARG001 | 41 | AGG_RES_Uncomp | 3,226 | 4 |
| 42_ARG001 | 42 | AGG_RES_Kannah | 17,876 | 17 |
| 59_ARG001 | 59 | AGG_RES_East | 9,826 | 9 |
| 62_ARG001 | 62 | AGG_RES_Lake | 6,475 | 6 |
| 62_ARG002 | 62 | AGG_RES_Main | 6,475 | 6 |
| 68_ARG001 | 68 | AGG_RES_Upper Uncomp | 8,359 | 8 |
| | | Total | 105,168 | 100 |

The five remaining reservoirs represented stockpond use, as documented in CDSS Task 1.14-23 Memorandum "Non-Evapotranspiration (Other Uses) consumptive Uses and Losses in the Gunnison river Basin", May 1995. The total storage was divided into five aggregated stockponds, located to correspond with the major stock-use areas. The stockponds were modeled as 10-foot deep straight-sided pits.

Neither the aggregated reservoirs nor the stockponds release to the river in the model. 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) | % |
|---|---|---|---|---|
| 40_ASG001 | 40 | AGG_STOCK_Surface | 1,727 | 20 |
| 41_ASG001 | 41 | AGG_STOCK_Uncomp | 1,727 | 20 |
| 42_ASG001 | 42 | AGG_STOCK_Kannah | 1,727 | 20 |
| 62_ASG001 | 62 | AGG_STOCK_Main | 1,727 | 20 |
| 68_ASG001 | 68 | AGG_STOCK_UpperUncomp | 1,727 | 20 |
| | | Total | 8,635 | 100 |

**Where to find more information**

- Appendix B includes a task memo describing the original effort to aggregate small reservoir use, as well as some later simplifying changes. Appendix B also includes CRDSS Task 1.14-23 Memorandum "Non-Evapotranspiration (Other Uses) consumptive Uses and Losses in the Gunnison river Basin", May 1995.

### 4.2.4. Instream Flow Structures

The model includes 33 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 Gunnison Model data set extends from 1909 through 2005 and operates on USGS water year (October 1 through September 30). The calibration period was 1975 through 2005, 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) 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 West 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 *(Appendix E.1)*

  -Evaluate Extension of Historical Data *(Appendix E.2)*

## 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 Gunnison 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 Gunnison Model.

### 4.4.1. Historical Data Extension For Major Structures

#### *4.4.1.1 Historical Diversions*

Fourteen major diversions in the Gunnison 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, 1956 through the current year. Available records prior to 1956 were digitized from SEO records to complete historic diversions. Redlands Power Canal, which diverts from the Gunnison River for use in the Colorado River Basin, was filled using SEO and other available records then divided into irrigation diversion and power diversion. Diversion records for South Canal, which diverts from the Gunnison Tunnel, were estimated based on a percentage of historic Montrose and Delta Canal diversions.

**Table 4.3**
**Investigated and Extended Major Structures**

| WDID | Name | 1909-2005 Annual Diversion |
|---|---|---|
| 420541 | Redlands Power Canal | 412,747 |
| 620617 | Gunnison Tunnel + S Canal | 301,799 |
| 410545 | Montrose + Delta Canal | 157,950 |
| 410534 | Ironstone Canal | 102,346 |
| 410559 | Selig Canal | 58,414 |
| 410577 | West Canal | 47,615 |
| 410520 | East Canal | 44,974 |
| 401133 | Fire Mountain Canal | 35,643 |
| 410537 | Loutsenhizer Canal | 39,402 |
| 620560 | Cimmaron Canal | 28,354 |
| 410527 | Garnet Canal | 20,517 |
| 400863 | Bonafide Ditch | 18,482 |
| 400900 | Relief Ditch | 16,382 |
| 410578 | South Canal | 36,180 |

#### *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 some 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 Gunnison 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 three streamflow characterizations in the Gunnison basin, based on three indicator gages: Gunnison River near Grand Junction (09152500), East River at Almont (09112500), and Uncompahgre River at Colona (09147500). The characterization for the Gunnison River gage is used when filling in time series for structures in District 41 and District 42. Similarly, the East River gage characterization pertains to Districts 28, 59, 62, and 40. The Uncompahgre River gage characterization pertains to District 68.

Months with gage flows at or below the 25$^{th}$ percentile for that month are characterized as "Dry", while months at or above the 75$^{th}$ 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 1950's, 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.
- Crop irrigation water requirements for each diversion are calculated for the period 1950 through the current year, based on historical climate data and current irrigated acreage and crop type. Irrigation water requirements are filled back to 1909 using the wet/dry/average approach adopted for historic diversion.

> **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 (*Appendix E.1)*
>
>   -Evaluate Extension of Historical Data *(Appendix E.2)*
>
>   -Characterize Streamflow Data (*Appendix E.6)*
>
>   -Verify Diversion Estimates (*Appendix E.7*)
>
>   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 and demandts 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.

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 only eight gages in the Gunnison 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 56 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" (*Appendix E.8*) and is in the CDSS (*Technical Papers).* It describes a sensitivity investigation of the use of historical gage data in lieu of baseflow estimates when the latter is unavailable.

## 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 Gunnison 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 3 percent of the non-consumed water, returns to the stream.

The 3 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 Gunnison basin, 3 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 CRDSS basins, and is the same value used in the StateCU estimate of Consumptive Use and Losses in the Colorado River Basin. (Consumptive Uses and Losses Report, Comparison between StateCU CU & Losses Report and the USBR CU & Losses Report (1998-1995), October 1999, Leonard Rice Engineers)

The Gunnison Model is supplied with time series of irrigation water requirements for each structure, based on its crop type and irrigated acreage. This information can be generated using the CDSS StateCU model. Maximum efficiency is also input to the Gunnison Model. For the Gunnison Basin, maximum system efficiency in the upper reaches, defined as above the Aspinall Unit, is estimated to be 40 percent. In the remaining portions of the basin, maximum system efficiency is estimated to be 50 percent.

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 potential ET 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 50 percent, therefore a maximum of 50 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 3 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 50 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 50 percent of the diversion deemed unable to reach the field (non-consumed), less 3 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 Gunnison 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 Gunnison Model, irrigation water requirements have been developed for all irrigation diversions. The two basin exporters in the Gunnison Model (Redlands Power Canal and the Grand Junction Pipeline from Kannah Creek) 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 system, Project 7, and the aggregated municipal demands have been modeled using historical consumptive use, not withdrawals. Therefore, they have been assigned a diversion efficiency of 1.0 in all months. Reservoir feeders and other carriers that do not irrigate lands have also been assigned a diversion efficiency of 1.00 in all months. These feeders include the following:

- Aspen Ditch
- Aspen Canal
- Fruitland Canal
- Smith Fork Feeder Canal
- Transfer Ditch
- Cimmarron Canal
- Gunnison Tunnel

### 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 Disposition of 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 Gunnison Model. One represents instantaneous (or within the same month as the diversion) returns and is applied to municipal and non-consumptive diversions. A second pattern places 100 percent of the diversion return in the fourth month following the diversion. This pattern is used for returns from artificial snowmaking.

The last two patterns are generalized irrigation return patterns, applicable to irrigated lands “close” to the stream (center of acreage is approximately 600 feet from the stream), and “further” from the stream (center of acreage is approximately 1500 feet from the stream). The two patterns 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 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 600 feet from the recharge center to the stream, and 1500 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 4.2**.** Month 1 is the month in which the diversion takes place. Note that the patterns shown reflect 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 Gunnison Model are estimated to be 3 percent of unused water.

**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 6 personnel. Some return flow locations were modified during calibration.

**Table 4.4**
**Percent of Return Flow Entering Stream in Month *n* after Diversion**

| Month *n* | For Lands "Close" to Stream (%) | For lands "Further" from Stream (%) |
|---|---|---|
| 1 | 78.6 | 60.4 |
| 2 | 11.3 | 14.5 |
| 3 | 3.2 | 7.2 |
| 4 | 2.2 | 5.0 |
| 5 | 1.6 | 3.7 |
| 6 | 1.2 | 2.7 |
| 7 | 0.8 | 2.0 |
| 8 | 0.6 | 1.5 |
| 9 | 0.5 | 1.1 |
| 10 | 0 | 0.8 |
| 11 | 0 | 0.6 |
| 12 | 0 | 0.5 |

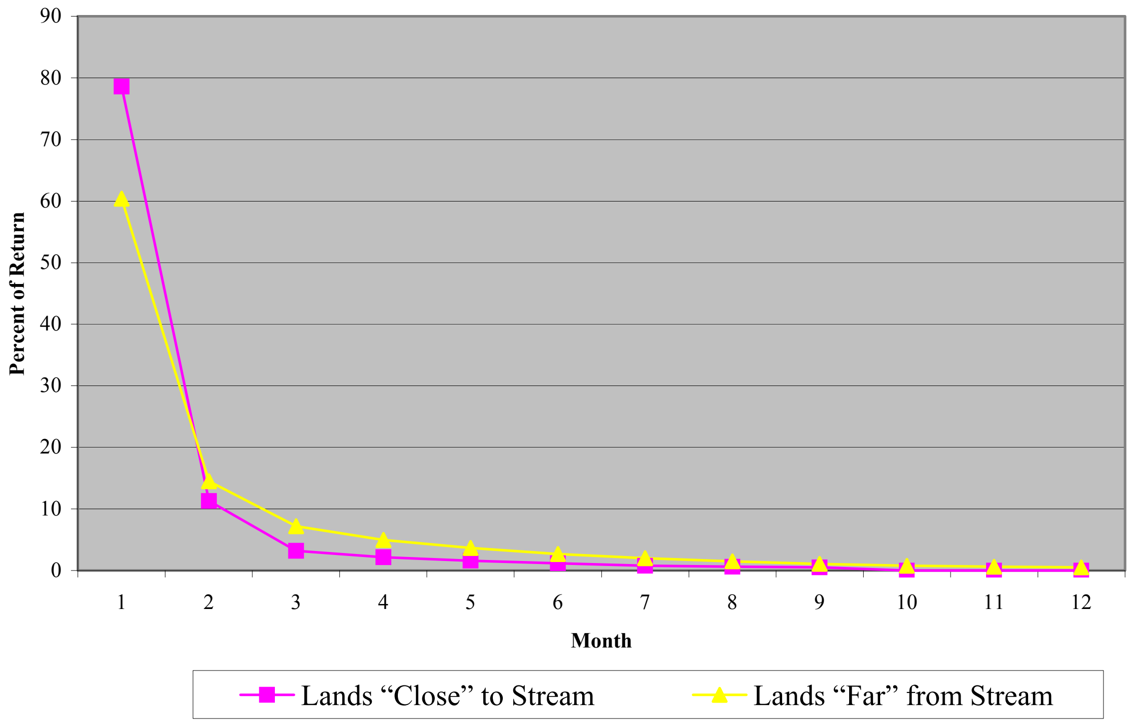



**Figure 4.2 Percent of Return in Months After Division**

## 4.7 Baseflow Estimation

In order to simulate river basin operations, the model must have at hand 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:

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

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 and soil storage 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**

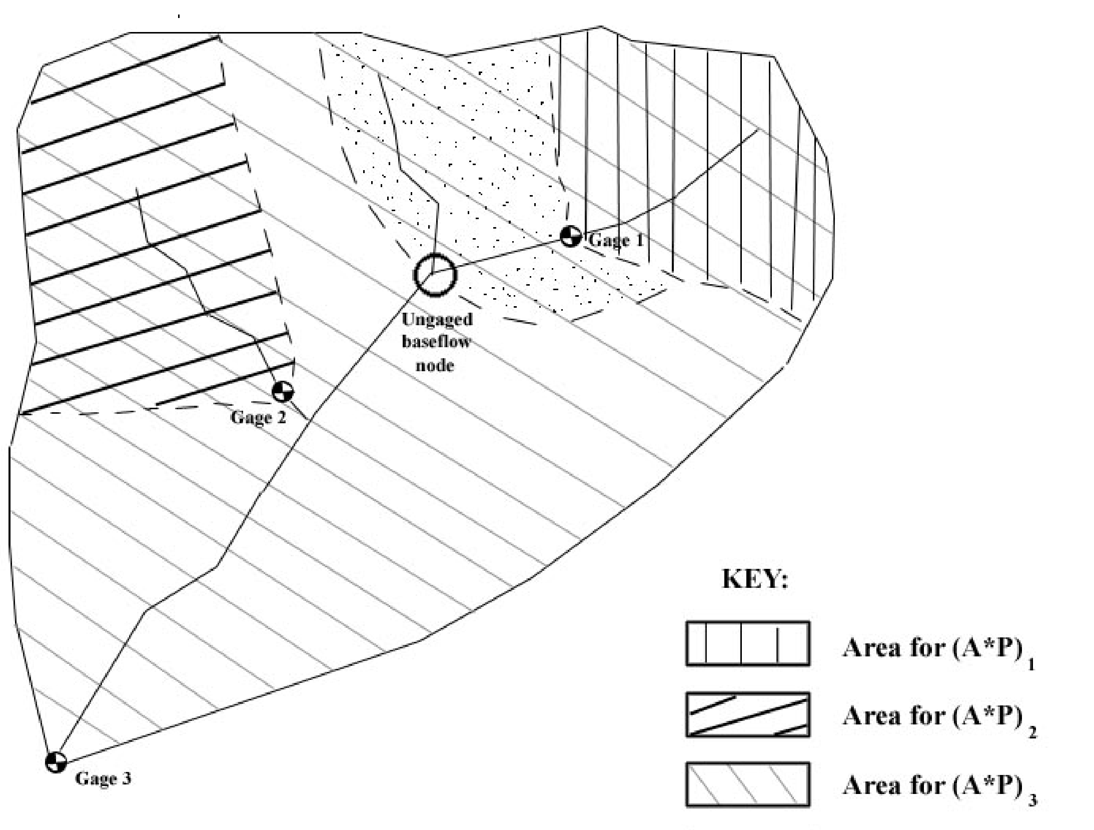
- When StateMod is executed to estimate baseflows at gages, it creates a Baseflow Information file *(*.xbi)* that shows this computation for each gage and each month of the time step.

### 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 a water supply to allocate in tributary headwaters, baseflow must be estimated at all ungaged headwater nodes. In addition, baseflow gains between gages are modeled as entering the system at ungaged points, to better simulate the river's growth due to generalized groundwater contributions and unmodeled tributaries. As a matter of convention, key reservoir nodes were designated baseflow nodes in order for the model to "see" all the water supply estimated to be available at the site. During calibration, other ungaged nodes were sometimes made baseflow nodes to better simulate a water supply that would support historical operations.




$$BFungaged = BF_1 + \frac{(A*P)ungaged}{(A*P)_3 - (A*P)_2 - (A*P)_1} *(BF_3 - BF_2 - BF_1)$$

**Figure 4.3 Hypothetical Basin Illustration**

StateMod has an operating mode in which, given baseflows at gaged sites and physical parameters of the gaged and ungaged sub-basins, it distributes baseflow gains spatially. The default method ("gain approach") for assigning baseflow to ungaged locations pro-rates baseflow gain above or between gages according to the product of drainage area and average annual precipitation. That is, each gage is assigned an "Area*Precipitation" (A*P) term, equal to the product of total area above the gage, and average annual precipitation over the gage's entire drainage area. Ungaged baseflow points are assigned an incremental "A*P", the product of the incremental drainage area above the ungaged baseflow point and below any upstream gages, and the average annual precipitation over that area. Figure 4.3 illustrates a hypothetical basin and the areas associated with each of three gages and an ungaged location.

The portion of the baseflow gain below Gages 1 and 2 and above Gage 3, at the Ungaged location between the gages, is the gage-to-gage baseflow gain ($BF_3$ minus ($BF_2 + BF_1$)) times the ratio $(A*P)_{ungaged}/[(A*P)_{downstream\ gage} - \Sigma\ (A*P)_{upstream\ gage(s)}]$. Total baseflow at the ungaged location is equal to this term, plus the sum of baseflows at upstream gages. In the example there is only one upstream gage, having baseflow $BF_1$.

A second option for estimating headwater baseflows was sometimes invoked if the default method created results that did not seem credible. This method, referred to as the "neighboring gage approach", created a baseflow time series by multiplying the baseflow series at a specified gage by the ratio $(A*P)_{headwater}/(A*P)_{gage}$. This approach was effective, for example, for an ungaged tributary parallel and close to a gaged tributary.

**Where to find more information**

- Documentation for **makenet** 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 Gunnison 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 Gunnison basin, 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 Gunnison Model.

## 4.9 Baseline Data Set

The Baseline data set is intended as a generic representation of recent conditions on the Gunnison River, 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 junior 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 irrigation efficiency may not exceed the defined maximum efficiency (50 percent), however, which represents a practical upper limit on efficiency for flood irrigation systems. Thus Calculated demand for a perennially shorted diversion (irrigation water requirement divided by diversions is, on average, greater than 0.50) will 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.

Prior to 1975, Calculated demands were filled using the automated time series filling technique described in Section 4.4.2. This is done because historical diversion records are generally not available until 1975 in the Gunnison basin.

### 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 Gunnison 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 Gunnison 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 simply 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, onstream 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 *gm2009B.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 |
|---|---|---|
| gm2009.ctl | Control file – specifies execution parameters, such as run title, modeling period, options switches | Section 5.2 |
| gm2009.rin | River Network file – lists every model node and specifies connectivity of network | Section 5.3.1 |
| gm2009.ris | River Station file – lists model nodes, both gaged and ungaged, where hydrologic inflow enters the system | Section 5.3.2 |
| gm2009.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 |
| gm2009.rih | Historical Streamflow file – Monthly time series of streamflows at modeled gages | Section 5.3.4 |
| gm2009x.xbm | Baseflow Data file – time series of undepleted flows at nodes listed in gm2009.ris | Section 5.3.5 |
| gm2009.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 |
| gm2009.dly | Delay Table file – 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 |

| File Name | Description | Reference |
|---|---|---|
| gm2009.ddh | Historical Diversions file – Monthly time series of historical diversions | Section 5.4.3 |
| gm2009B.ddm | Monthly Demand file – monthly time series of headgate demands for each direct diversion structure | Section 5.4.4 |
| gm2009.ddr | Direct Diversion Rights file – lists water rights for direct diversion | Section 5.4.5 |
| gm2009.str | StateCU Structure file – soil moisture capacity by structure, for variable efficiency structures | Section 5.5.1 |
| gm2009.ipy | CU Irrigation Parameter Yearly file – maximum efficiency and irrigated acreage by year and by structure, for variable efficiency structures | Section 5.5.2 |
| gm2009B.iwr | Irrigation Water Requirement file – monthly time series of crop water requirement by structure, for variable efficiency structures | Section 5.5.3 |
| gm2009B.res | Reservoir Station file – lists physical reservoir characteristics such as volume, area-capacity table, and some administration parameters | Section 5.6.1 |
| gm2009.eva | Evaporation file – gives monthly rates for net evaporation from free water surface | Section 5.6.2 |
| gm2009.eom | Reservoir End-of-Month Contents file – Monthly time series of historical reservoir contents | Section 5.6.3 |
| gm2009B.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 |
| gm2009B.rer | Reservoir Rights file – lists storage rights for reservoirs | Section 5.6.5 |
| gm2009.ifs | Instream Flow Station file – lists instream flow reaches | Section 5.7.1 |
| gm2009.ifa | Instream Flow Annual Demand file – gives the decreed monthly instream flow demand rates | Section 5.7.2 |
| gm2009.ifm | Instream Flow Monthly Demand file – gives the decreed monthly instream flow demand ratesthat vary by year | Section 5.7.3 |
| gm2009.ifr | Instream Flow Right file – gives decreed amount and administration number of instream flow rights associated with instream flow reaches | Section 5.7.4 |
| gm2009B.opr | Operational Rights file – specifies many different kinds of operations that were more complex than a direct diversion or an on-stream storage right. Operational rights could 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 was not downstream, or a direct diversion to fill a reservoir via a feeder | Section 5.9 |

### 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 gm2009.rsp. The baseflow response file calls for different reservoir station, operational rights, and reservoir target files from the Baseline response file, in these 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 gm2009.xbf. The response file for the third step, in which StateMod distributes baseflow to ungaged points, is named gm2009x.rsp. The only difference between the first-step response file gm2009.rsp and third-step response file gm2009x.rsp is that the name gm2009.xbf replaces the historical gage file gm2009.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 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 Gunnison 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 was created by StateDMI from the graphical network representation file created within StateDMI – StateMod Network interface (gm2009.net). 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 had exactly one downstream node.

Figure 4.1 in Section 4.2.1 illustrates the network, which starts at an instream flow reach at the headwaters of East River and ends just upstream of the Gunnison River confluence with the Colorado River.

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. Other nodes are locations in the basin where information is desired, such as water quality monitoring locations. Table 5.1 shows how many nodes of each type are in the Gunnison Model.

**Table 5.1**
**River Network Elements**

| Type | Number |
|---|---|
| Diversion | 362 |
| Instream Flow | 33 |
| Reservoirs | 27 |
| Stream Gages [1)] | 53 |
| | |
| Total | 475 |

1) Includes Leon Tunnel Canal import from the Colorado Basin

**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 was 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 52 gages in the model, 1 basin import, and 81 ungaged baseflow locations, for a total of 134 hydrologic inflows to the Gunnison Model. Ungaged baseflow nodes include all ungaged headwater nodes, six key reservoir nodes, 26 aggregated diversion nodes, and any other nodes where calibration revealed a need for it. In the last case, 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 contains 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 computed proration factors based on the network structure and *area* multiplied by *precipitation* values supplied for both gages and ungaged baseflow nodes. This information is in the network file, which was 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 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 |
|---|---|---|
| Hot Springs Creek | 281077 | 9118000 |
| Alum Gulch | 400506 | 9134050 |
| Smith Fork | 400586 | 9128500 |
| Hubbard Creek | 401190 | 9131200 |
| Alfalfa Run | 403365 | 9137050 |
| Iron Creek | 403395 | 9128500 |
| North Beaver Creek | 590544 | 9127500 |
| Mill Creek | 590606 | 9113300 |
| Carbon Creek | 591402 | 9113300 |
| Cimarron River | 620672 | 9124500 |
| Big Blue Creek | 621339 | 9124500 |
| Cow Creek | 680683 | 9147100 |

**Where to find more information**

- 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 1909-2005, 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 HydroBase. Missing values, when the gage was not in operation, are denoted as such, using the value “-999.” In addition to historical gage records, the historical streamflow file also contains the single import into the Gunnison Basin from Plateau Creek, tributary to the Colorado River. Leon Tunnel Canal (720758) is included in the historical streamflow file as historic inflow into the basin. Table 5.2 lists the USGS gages used, their periods of record, and their average annual flows over the period of record.

**Table 5.2**
**Historical Average Annual Flows for Modeled Gunnison Stream Gages**

| Gage ID | Gage Name | Period of Record | Historical Flow (acre-feet/year) |
|---|---|---|---|
| 09109000 | Taylor River Below Taylor Park Reservoir | 1938 – 2008 | 141,624 |
| 09110000 | Taylor River at Almont | 1910 – 2008 | 238,801 |
| 09110500 | East River Near Crested Butte | 1939 – 1951 | 96,443 |
| 09111500 | Slate River Near Crested Butte | 1940 – 1951<br>1994 - 2006 | 97,350 |
| 09112000 | Cement Creek Near Crested Butte | 1910 – 1914<br>1940 – 1951 | 26,489 |
| 09112200 | East River Below Cement Creek NR Crested Butte | 1964 – 1972<br>1980 – 1981<br>1994 – 2008 | 233,117 |
| 09112500 | East River at Almont | 1910 – 1922<br>1934 – 2008 | 241,221 |
| 09113300 | Ohio Creek at Baldwin | 1958 - 1970 | 33,709 |
| 09113500 | Ohio Creek Near Baldwin | 1940 – 1950<br>1959 – 1971<br>1980 – 1981 | 65,798 |
| 09114500 | Gunnison River Near Gunnison | 1910 – 1928<br>1945 – 2008 | 538,170 |
| 09115500 | Tomichi Creek at Sargents | 1916 – 1922<br>1938 – 1972<br>1993 – 2008 | 44,633 |
| 09118000 | Quartz Creek Near Ohio City | 1937 – 1950<br>1960 – 1970 | 38,941 |
| 09118450 | Cochetopa Creek Below Rock Creek Near Parlin | 1981 - 2008 | 30,724 |
| 09119000 | Tomichi Creek at Gunnison | 1937 - 2008 | 122,049 |
| 09121500 | Cebolla Creek Near Lake City | 1946 - 1954 | 10,982 |
| 09121800 | Cebolla Creek Near Powderhorn | 1960 - 1963 | 52,563 |
| 09122000 | Cebolla Creek at Powderhorn | 1937 - 1955 | 75,711 |
| 09124500 | Lake Fork at Gateview | 1937 – 2008 | 169,372 |
| 09126000 | Cimarron River Near Cimarron | 1954 – 2008 | 67,791 |
| 09126500 | Cimarron River at Cimarron | 1902 – 1906<br>1962 – 1967 | 79,158 |
| 09127500 | Crystal Creek Near Maher | 1945 – 1954<br>1961 – 1969 | 21,202 |
| 09128000 | Gunnison River Below Gunnison Tunnel | 1910 - 2008 | 919,411 |
| 09128500 | Smith Fork Near Crawford | 1935 - 1994 | 31,061 |
| 09129600 | Smith Fork Near Lazear | 1976 - 1987 | 27,243 |
| 09130500 | East Muddy Creek Near Bardine | 1934 - 1953 | 65,205 |
| 09131200 | West Muddy Creek Near Somerset | 1961 - 1973 | 21,596 |
| 09132500 | North Fork Gunnison River Near Somerset | 1933 - 2008 | 328,380 |
| 09134000 | Minnesota Creek Near Paonia | 1936 – 1947<br>1986 – 2008 | 15,680 |
| 09134050 | Minnesota Creek at Paonia | 1976 - 1979 | 6,498 |
| 09134500 | Leroux Creek Near Cedaredge | 1936 – 1956 | 34,419 |

| Gage ID | Gage Name | Period of Record | Historical Flow (acre-feet/year) |
|---|---|---|---|
| | | 1961 – 1969 | |
| 09135900 | Leroux Creek at Hotchkiss | 1976 - 1996 | 21,557 |
| 09136200 | Gunnison River Near Lazear | 1961 - 1985 | 1,219,151 |
| 09137050 | Currant Creek Near Read | 1976 - 1987 | 10,495 |
| 09137800 | Dirty George Creek Near Grand Mesa | 1957 - 1969 | 4,595 |
| 09139200 | Ward Creek Near Grand Mesa | 1957 - 1969 | 8,464 |
| 09141500 | Youngs Creek Near Cedaredge | 1942 - 1946 | 1,605 |
| 09143000 | Surface Creek Near Cedaredge | 1939 – 1999<br>2000 – 2008 1) | 31,417 |
| 09143500 | Surface Creek at Cedaredge | 1917 - 2008 | 20,250 |
| 09144200 | Tongue Creek at Cory | 1957 – 1968<br>1977 – 1987 | 35,703 |
| 09144250 | Gunnison River at Delta | 1976 – 2008 | 1,406,581 |
| 09146200 | Uncompahgre River Near Ridgway | 1958 – 2008 | 119,205 |
| 09146400 | West Fork Dallas Creek Near Ridgway | 1955 – 1970 | 9,024 |
| 09146500 | East Fork Dallas Creek Near Ridgway | 1948 – 1953<br>1961 – 1970 | 17,985 |
| 09146550 | Beaver Creek Near Ridgway | 1960 – 1968 | 2,949 |
| 09147000 | Dallas Creek Near Ridgway | 1922 – 1927<br>1955 – 1971<br>1980 – 2008 | 27,594 |
| 09147100 | Cow Creek Near Ridgway | 1945 – 1954<br>1961 – 1969 | 44,132 |
| 09147500 | Uncompahgre River at Colona | 1912 – 2008 | 191,460 |
| 09149420 | Spring Creek Near Montrose | 1977 – 1981 | 41,468 |
| 09149500 | Uncompahgre River at Delta | 1938 – 2008 | 218,856 |
| 09150500 | Roubideau Creek at Mouth, Near Delta | 1938 – 1954<br>1976 – 1983 | 89,198 |
| 09152000 | Kannah Creek Near Whitewater | 1917 – 1982 | 21,834 |
| 09152500 | Gunnison River Near Grand Junction | 1896 – 1899<br>1902 – 1906<br>1917 – 2008 | 1,832,257 |

1) Irrigation season records only

### 5.3.5 Baseflow Files (*.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 13 gages that operated throughout the calibration period (1975-2005). The difference between the two represents estimated historical consumptive use over this period.

**Table 5.3**
**Baseflow Comparison**
**1975-2005 Average (af/yr)**

| Gage ID | Gage Name | Baseflow | Historical | Difference |
|---|---|---|---|---|
| 09109000 | Taylor River Below Taylor Park Reservoir | 147,344 | 143,392 | 3,952 |
| 09110000 | Taylor River at Almont | 234,382 | 228,583 | 5,799 |
| 09112500 | East River at Almont | 257,446 | 234,391 | 23,054 |
| 09114500 | Gunnison River Near Gunnison | 579,874 | 514,682 | 65,192 |
| 09119000 | Tomichi Creek at Gunnison | 199,668 | 122,463 | 77,205 |
| 09124500 | Lake Fork at Gateview | 170,840 | 165,397 | 5,443 |
| 09126000 | Cimarron River Near Cimarron | 70,720 | 69,572 | 1,148 |
| 09128000 | Gunnison River Below Gunnison Tunnel | 1,418,110 | 839,169 | 578,941 |
| 09132500 | North Fork Gunnison River Near Somerset | 366,119 | 348,092 | 18,028 |
| 09146200 | Uncompahgre River Near Ridgway | 126,512 | 121,279 | 5,233 |
| 09147500 | Uncompahgre River at Colona | 228,576 | 189,763 | 38,814 |
| 09149500 | Uncompahgre River at Delta | 333,292 | 231,002 | 102,290 |
| 09152500 | Gunnison River Near Grand Junction | 2,468,227 | 1,841,073 | 627,154 |

### Where to find more information

- Sections 4.7.1 through 4.7.3 explain how StateMod and the Mixed Station Model were 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, gm2009.*sum* and gm2009.*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.

## 5.4 Diversion Files

### 5.4.1 Direct Diversion Station File (*.dds)

StateDMI was used in two steps to create the direct diversion station file.

The direct diversion station file describes the physical properties of each diversion simulated in the Gunnison Model. Table 5.4 is a summary of the Gunnison Model's diversion station file contents, including each structure's diversion capacity, irrigated acreage served in 2000, and average annual system efficiency. The table also includes average annual headgate demand. 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.

Generally, the diversion station ID, name, diversion capacity, and irrigated acreage were gathered from HydroBase, by StateDMI. Return flow locations were specified to StateDMI in a hand-edited file gm2009.rtn. The return flow locations and distribution were based on physical location of irrigated lands, discussions with Division 4 personnel, as well as calibration efforts. StateCU computed monthly system efficiency for irrigation structures from historical diversions and historical crop irrigation requirements, and StateDMI wrote them into the final *.dds file.

For non-irrigation structures, monthly efficiency was specified by the user as input to StateDMI. Baseline irrigation demand was assigned to primary structures of multi-structure systems, therefore primary and secondary structures of multi-structure systems were assigned the average monthly efficiencies calculated for the irrigation system based on irrigation water requirements and water delivered from all sources. If efficiency was constant for each month, it could be specified in the hand-edited file gm2009.rtn.

Note that unknown capacity was set to 999 by StateDMI. This number was significantly large so as not to limit diversions.

**Table 5.4**
**Direct Flow Diversion Summary Average**
**1975-2005**

| # | Model ID # | Name | Cap (cfs) | 1993 Area (acres) | Average System Efficiency (percent) | Average Annual Demand (af) |
|---|---|---|---|---|---|---|
| 1 | 280500 | ADAMS NO 1 DITCH | 14 | 170 | 35 | 2,018 |
| 2 | 280503 | AGATE NO 2 DITCH | 4 | 19 | 24 | 595 |
| 3 | 280510 | ARCH IRRIGATING DITCH | 147 | 1,662 | 35 | 18,279 |
| 4 | 280515 | BIEBEL DITCHES NOS 1&2 | 57 | 457 | 35 | 5,256 |

| # | Model ID # | Name | Cap (cfs) | 1993 Area (acres) | Average System Efficiency (percent) | Average Annual Demand (af) |
|---|---|---|---|---|---|---|
| 5 | 280520 | CAIN BORSUM DITCH | 22 | 120 | 29 | 2,459 |
| 6 | 280526 | CHITTENDEN DITCH | 21 | 335 | 37 | 3,339 |
| 7 | 280527 | CLARK NO 1 DITCH | 5 | 14 | 26 | 427 |
| 8 | 280528 | CLARK NO 2 DITCH | 10 | 31 | 30 | 700 |
| 9 | 280529 | CLARK NO 3 DITCH | 12 | 58 | 33 | 953 |
| 10 | 280530 | CLOVIS METROZ NO 1 DITCH | 12 | 41 | 28 | 917 |
| 11 | 280532 | COATS BROS DITCH | 19 | 210 | 35 | 2,430 |
| 12 | 280535 | COLE NOS 1 2 & 3 DITCHES | 11 | 65 | 33 | 759 |
| 13 | 280536 | COX AND MCCONNELL DITCH | 22 | 30 | 23 | 1,731 |
| 14 | 280542 | CUTJO DITCH | 23 | 146 | 33 | 2,073 |
| 15 | 280543 | D A MCCONNELL DITCH | 4 | 192 | 40 | 1,112 |
| 16 | 280550 | DUNN AND WATTERS DITCH | 27 | 91 | 32 | 1,994 |
| 17 | 280554 | ELSEN VADER DITCH | 16 | 162 | 34 | 2,019 |
| 18 | 280557 | FIELD AND VADER DITCH | 9 | 274 | 40 | 1,627 |
| 19 | 280564 | TOMI_GILBERTSON NO 1 | 20 | 61 | 31 | 1,483 |
| 20 | 280566 | GOODRICH DITCH | 32 | 157 | 32 | 2,526 |
| 21 | 280567 | GOODWIN AND WRIGHT DITCH | 20 | 130 | 30 | 3,028 |
| 22 | 280568 | LOS _GOVERNMENT DITC | 67 | 1,223 | 39 | 7,992 |
| 23 | 280571 | TOMI_GRIFFING NO 1 D | 50 | 575 | 38 | 5,090 |
| 24 | 280576 | GULLETT TOMICHI IRG D | 41 | 383 | 37 | 3,855 |
| 25 | 280577 | HANNAH J WINTERS NO 2D | 21 | 145 | 33 | 1,853 |
| 26 | 280580 | HAWES-BERGEN-GILBERTSON | 16 | 99 | 34 | 1,406 |
| 27 | 280581 | HAZARD DITCH | 23 | 137 | 35 | 1,817 |
| 28 | 280583 | HEAD AND CORTAY NO 4 D | 8 | 132 | 38 | 1,099 |
| 29 | 280587 | HOME DITCH DITCH NO 81 | 25 | 118 | 35 | 1,440 |
| 30 | 280588 | HOME DITCH DITCH NO 182 | 24 | 25 | 23 | 1,155 |
| 31 | 280590 | HOT SPRINGS NOS 1&2 D | 999 | 109 | 40 | 631 |
| 32 | 280604 | KANE DITCH | 9 | 46 | 34 | 632 |
| 33 | 280607 | KENDALL NO 3 DITCH | 36 | 34 | 33 | 701 |
| 34 | 280608 | KENDALL NO 4 DITCH | 11 | 59 | 37 | 678 |
| 35 | 280622 | LOBDELL NO 2 DITCH | 2 | 125 | 40 | 710 |
| 36 | 280624 | LOCKWOOD MUNDELL DITCH | 57 | 98 | 30 | 3,338 |

| # | Model ID # | Name | Cap (cfs) | 1993 Area (acres) | Average System Efficiency (percent) | Average Annual Demand (af) |
|---|---|---|---|---|---|---|
| 37 | 280631 | MCCANNE NO 1 DITCH | 29 | 333 | 37 | 2,837 |
| 38 | 280632 | MCCANNE 2 DITCH | 46 | 296 | 33 | 4,457 |
| 39 | 280633 | MCCANNE 3 DITCH | 9 | 103 | 32 | 1,707 |
| 40 | 280636 | MCDONOUGH DITCH | 43 | 435 | 38 | 3,558 |
| 41 | 280638 | TOMI_MCGOWAN IRRIGAT | 38 | 254 | 34 | 3,243 |
| 42 | 280642 | MEANS BROS NO 13 DITCH | 15 | 32 | 32 | 700 |
| 43 | 280645 | MEANS BROS NO 4 DITCH | 5 | 21 | 29 | 437 |
| 44 | 280646 | MEANS BROS NO 5 DITCH | 9 | 33 | 31 | 566 |
| 45 | 280647 | MEANS BROS NO 6 DITCH | 8 | 10 | 26 | 439 |
| 46 | 280648 | MEANS BROS NO 7 DITCH | 5 | 25 | 32 | 365 |
| 47 | 280649 | MEANS BROS NO 12 DITCH | 12 | 18 | 28 | 697 |
| 48 | 280650 | MEANS BROS NO 8 DITCH | 18 | 141 | 37 | 1,525 |
| 49 | 280651 | MESA DITCH | 88 | 1,874 | 39 | 11,283 |
| 50 | 280652 | MILLER DITCH | 12 | 185 | 38 | 1,432 |
| 51 | 280654 | MONSON & MCCONNELL D | 20 | 243 | 37 | 2,278 |
| 52 | 280660 | NORMAN DITCH | 22 | 46 | 27 | 1,071 |
| 53 | 280662 | OFALLON NO 3 DITCH | 20 | 26 | 24 | 1,174 |
| 54 | 280663 | OFALLON NO 4 DITCH | 14 | 17 | 22 | 971 |
| 55 | 280665 | OREGAN NO 1 DITCH | 4 | 139 | 40 | 877 |
| 56 | 280667 | OWEN NO 1 DITCH | 20 | 35 | 29 | 1,296 |
| 57 | 280668 | OWEN REDDEN DITCH | 63 | 493 | 37 | 4,548 |
| 58 | 280670 | PARLIN NO 2 DITCH | 20 | 181 | 38 | 1,625 |
| 59 | 280671 | PARLIN QUARTZ CREEK D | 42 | 465 | 34 | 4,757 |
| 60 | 280673 | PERRY IRRIGATING DITCH | 42 | 585 | 39 | 4,137 |
| 61 | 280674 | PIONEER DITCH | 57 | 400 | 35 | 5,134 |
| 62 | 280679 | ROGERS METROZ DITCH | 27 | 98 | 30 | 1,949 |
| 63 | 280680 | S DAVIDSON&CO FDR D NO 1 | 15 | 36 | 23 | 2,843 |
| 64 | 280681 | SARGENTS NO 1 D | 5 | 15 | 28 | 360 |
| 65 | 280682 | SARGENTS NO 2 D | 7 | 12 | 25 | 386 |
| 66 | 280686 | SMITH FORD NO 2 DITCH | 66 | 593 | 38 | 4,722 |
| 67 | 280690 | SORRENSON IRRIGATING D | 30 | 275 | 36 | 2,941 |
| 68 | 280692 | SOUTH SIDE DITCH | 28 | 182 | 35 | 2,132 |

| # | Model ID # | Name | Cap (cfs) | 1993 Area (acres) | Average System Efficiency (percent) | Average Annual Demand (af) |
|---|---|---|---|---|---|---|
| 69 | 280693 | STEPHENSON DITCH | 33 | 204 | 35 | 2,741 |
| 70 | 280697 | SUTTON NO 3 AMENDED D | 0 | 18 | 40 | 104 |
| 71 | 280703 | TARBELL & ALEXANDER D | 14 | 401 | 40 | 2,292 |
| 72 | 280707 | TORNAY HIGHLINE DITCH | 32 | 382 | 34 | 4,306 |
| 73 | 280709 | VADER RAUSIS DITCH | 14 | 174 | 38 | 1,437 |
| 74 | 280711 | WATERMAN METROZ DITCH | 12 | 100 | 32 | 1,419 |
| 75 | 280714 | WICKS ROWSER DITCH | 1 | 185 | 40 | 1,028 |
| 76 | 280715 | WOOD AND GEE DITCH | 27 | 176 | 36 | 2,110 |
| 77 | 280716 | WOODBRIDGE DITCH | 28 | 126 | 36 | 1,378 |
| 78 | 280823 | MCDONALD BERDEL EX D | 1 | 131 | 40 | 731 |
| 79 | 28_ADG009 | 28_ADG009_UTOMICHI | 88 | 1,413 | 36 | 13,759 |
| 80 | 28_ADG010 | 28_ADG010_TOMICHI1 | 260 | 2,681 | 37 | 24,617 |
| 81 | 28_ADG011 | 28_ADG011_COCHETOPA | 143 | 1,947 | 39 | 13,832 |
| 82 | 28_ADG012 | 28_ADS_012_TOMICHI2 | 340 | 2,534 | 31 | 40,233 |
| 83 | 28_ADG043 | 28_ADG043_COCHET | 37 | 1,054 | 40 | 6,167 |
| 84 | 28_ADG044 | 28_ADG044_RAZOR | 128 | 1,586 | 39 | 11,395 |
| 85 | 400500 | CRAWFORD CLIPPER DITCH | 164 | 3,190 | 47 | 19,588 |
| 86 | 400501 | NEEDLE ROCK DITCH | 60 | 1,636 | 49 | 9,223 |
| 87 | 400502 | SADDLE MT HIGHLINE D | 84 | 1,454 | 52 | 7,861 |
| 88 | 400503 | GRANDVIEW CANAL | 155 | 3,049 | 47 | 18,175 |
| 89 | 400504 | CEDAR CANON IRON SPR D | 55 | 2,642 | 40 | 19,041 |
| 90 | 400506 | ALUM GULCH DITCH | 675 | 499 | 49 | 3,940 |
| 91 | 400508 1) | ASPEN DITCH | 58 | 0 | 0 | 0 |
| 92 | 400509 1) | ASPEN CANAL | 150 | 0 | 0 | 0 |
| 93 | 400533 | CRYSTAL VALLEY DITCH | 16 | 828 | 40 | 4,631 |
| 94 | 400536 | DAISY DITCH | 19 | 242 | 42 | 2,451 |
| 95 | 400543 | DYER FORK DITCH | 13 | 314 | 40 | 1,943 |
| 96 | 400549 2) | FRUITLAND CANAL | 537 | 5,794 | 0 | 0 |
| 97 | 400566 | LARSON BROTHERS DITCH | 6 | 245 | 40 | 1,737 |
| 98 | 400568 | LONE ROCK DITCH | 10 | 19 | 25 | 879 |
| 99 | 400576 | MEEK DIVERSION TUNNEL | 12 | 762 | 50 | 4,187 |
| 100 | 400585 2) | OVERLAND DITCH | 150 | 3,934 | 0 | 8,531 |

| # | Model ID # | Name | Cap (cfs) | 1993 Area (acres) | Average System Efficiency (percent) | Average Annual Demand (af) |
|---|---|---|---|---|---|---|
| 101 | 400586 | PILOT ROCK DITCH | 20 | 583 | 50 | 3,297 |
| 102 | 400605 [2)] | SMITH FORK FEEDER CANAL | 150 | 0 | 0 | 0 |
| 103 | 400616 | VIRGINIA DITCH | 10 | 284 | 48 | 1,605 |
| 104 | 400632 | CHILDS DITCH | 36 | 66 | 14 | 3,807 |
| 105 | 400661 | SURFACE CR D AKA BIG D | 117 | 3,023 | 49 | 15,365 |
| 106 | 400675 | CEDAR MESA DITCH | 52 | 961 | 49 | 5,723 |
| 107 | 400683 | HORSESHOE DITCH | 11 | 433 | 50 | 2,159 |
| 108 | 400686 | LONE PINE DITCH | 53 | 566 | 48 | 4,551 |
| 109 | 400701 | CEDAR PARK DITCH | 30 | 451 | 29 | 5,249 |
| 110 | 400703 | DIRT_EAGLE DITCH | 13 | 202 | 48 | 1,362 |
| 111 | 400713 | GRANBY DITCH FR WARD CR | 11 | 228 | 44 | 1,773 |
| 112 | 400751 [2)] | ALFALFA DITCH | 87 | 0 | 0 | 8,408 |
| 113 | 499751_I [6)] | ALFALFA D IRR DEMAND | 87 | 1,049 | 45 | 6,922 |
| 114 | 400753 | SURF_BONITA DITCH | 15 | 262 | 44 | 1,893 |
| 115 | 400754 | BUTTES DITCH | 50 | 249 | 38 | 2,616 |
| 116 | 400758 | FORREST DITCH | 19 | 607 | 47 | 3,608 |
| 117 | 400774 | ORCHARD RANCH DITCH | 22 | 393 | 45 | 2,899 |
| 118 | 400778 | SETTLE DITCH | 16 | 439 | 50 | 2,200 |
| 119 | 400797 | DURKEE DITCH | 25 | 443 | 43 | 2,817 |
| 120 | 400808 | MORTON DITCH | 18 | 189 | 48 | 1,208 |
| 121 | 400820 | ALFA_STELL DITCH | 78 | 1,916 | 45 | 12,123 |
| 122 | 400821 [2)] | TRANSFER DITCH | 60 | 0 | 0 | 0 |
| 123 | 400863 | BONAFIDE DITCH | 76 | 1,571 | 24 | 23,057 |
| 124 | 400879 | HARTLAND DITCH | 59 | 1,114 | 21 | 18,270 |
| 125 | 400891 | GUNN_NORTH DELTA CAN | 103 | 1,956 | 29 | 21,676 |
| 126 | 400900 | RELIEF DITCH | 75 | 1,213 | 24 | 19,640 |
| 127 | 400918 | COW CREEK DITCH | 16 | 568 | 50 | 3,243 |
| 128 | 400919 | CURRANT CREEK DITCH | 15 | 287 | 29 | 3,438 |
| 129 | 400923 | HIGHLINE DITCH | 54 | 1,417 | 43 | 9,729 |
| 130 | 400926 | LEROUX CREEK DITCH | 198 | 888 | 45 | 8,618 |
| 131 | 400929 | JESSIE DITCH | 26 | 228 | 46 | 1,870 |
| 132 | 400932 | MIDKIFF & ARNOLD D | 19 | 340 | 46 | 2,438 |

| # | Model ID # | Name | Cap (cfs) | 1993 Area (acres) | Average System Efficiency (percent) | Average Annual Demand (af) |
|---|---|---|---|---|---|---|
| 133 | 400944 | LERO_OVERLAND DITCH | 119 | 4,591 | 54 | 20,886 |
| 134 | 401012 | LONE CABIN DITCH | 10 | 246 | 50 | 1,185 |
| 135 | 401020 | MINNESOTA CANAL | 60 | 1,140 | 46 | 7,777 |
| 136 | 401056 | TURNER DITCH | 12 | 129 | 32 | 2,136 |
| 137 | 401087 | BLACK SAGE DITCH | 4 | 27 | 35 | 486 |
| 138 | 401105 | COYOTE DITCH | 25 | 465 | 50 | 2,565 |
| 139 | 401106 | COYOTE DITCH | 6 | 319 | 50 | 1,754 |
| 140 | 401112 | DEER DITCH | 6 | 279 | 50 | 1,542 |
| 141 | 401114 | DITCH NO 2 DITCH | 7 | 79 | 48 | 510 |
| 142 | 401118 | DRIFT CREEK DITCH | 9 | 1,581 | 50 | 8,682 |
| 143 | 401119 | DUGOUT DITCH | 4 | 731 | 50 | 4,008 |
| 144 | 401120 | DOWNING DITCH | 6 | 101 | 46 | 857 |
| 145 | 401122 | DYKE NO 2 DITCH | 5 | 156 | 50 | 899 |
| 146 | 401127 | ELKS BEAVER DITCH | 7 | 68 | 49 | 467 |
| 147 | 401132 | FILMORE DITCH | 20 | 707 | 50 | 3,918 |
| 148 | 401133 | FIRE MT CANAL | 238 | 6,709 | 40 | 51,904 |
| 149 | 401145 | GROUSE CREEK DITCH | 5 | 113 | 50 | 679 |
| 150 | 401166 | MUDD_LARSON NO 2 DIT | 9 | 453 | 50 | 2,598 |
| 151 | 401168 | LEE CREEK D NO 2 | 10 | 122 | 50 | 718 |
| 152 | 401172 | LOST CABIN DITCH | 28 | 35 | 38 | 784 |
| 153 | 401183 | MONITOR DITCH | 15 | 246 | 37 | 2,552 |
| 154 | 401185 | NORTH FORK FARMERS D | 282 | 1,073 | 36 | 9,905 |
| 155 | 401189 | PAONIA DITCH | 32 | 310 | 24 | 6,997 |
| 156 | 401190 | PILOT KNOB DITCH | 3 | 78 | 49 | 453 |
| 157 | 401195 | SHEPARD & WILMONT DITCH | 16 | 288 | 29 | 3,247 |
| 158 | 401196 | SHORT DITCH | 44 | 593 | 38 | 5,700 |
| 159 | 401197 | SMITH AND MCKNIGHT DITCH | 12 | 400 | 49 | 2,452 |
| 160 | 401201 | SPATAFORE DITCH NO 1 | 3 | 120 | 50 | 666 |
| 161 | 401206 | STEWART DITCH | 77 | 2,887 | 43 | 17,742 |
| 162 | 401207 | STREBER DITCH | 13 | 256 | 48 | 1,921 |
| 163 | 401213 | VANDEFORD DITCH | 15 | 79 | 24 | 1,944 |
| 164 | 401214 | WADE DITCH | 2 | 115 | 50 | 630 |

| # | Model ID # | Name | Cap (cfs) | 1993 Area (acres) | Average System Efficiency (percent) | Average Annual Demand (af) |
|---|---|---|---|---|---|---|
| 165 | 401218 | WELCH MESA DITCH | 21 | 233 | 49 | 1,532 |
| 166 | 401221 | WILLIAMS CR DITCH | 4 | 222 | 50 | 1,221 |
| 167 | 401437 | ROUB_HAWKINS DITCH | 42 | 66 | 40 | 945 |
| 168 | 40_ADG019 | 40_ADG019_GUNNTUN | 25 | 198 | 40 | 1,447 |
| 169 | 40_ADG020 | 40_ADG020_IRON | 40 | 1,209 | 40 | 9,117 |
| 170 | 40_ADG021 | 40_ADG021_SMITH | 28 | 298 | 47 | 2,194 |
| 171 | 40_ADG022 | 40_ADG022_NFGUNN | 57 | 1,173 | 50 | 6,798 |
| 172 | 40_ADG023 | 40_ADG023_MINN | 19 | 466 | 50 | 2,816 |
| 173 | 40_ADG024 | 40_ADG024_NFGUNN2 | 538 | 2,159 | 50 | 12,629 |
| 174 | 40_ADG025 | 40_ADG025_LEROUX | 33 | 1,011 | 50 | 5,971 |
| 175 | 40_ADG026 | 40_ADG026_GUNNL | 73 | 1,783 | 46 | 11,167 |
| 176 | 40_ADG027 | 40_ADG027_CURRANT | 44 | 1,342 | 46 | 8,852 |
| 177 | 40_ADG028 | 40_ADG028_UTONGUE | 127 | 2,640 | 48 | 16,870 |
| 178 | 40_ADG029 | 40_ADG029_SURFACE | 33 | 1,141 | 50 | 6,143 |
| 179 | 40_ADG030 | 40_ADG030_TONGUE | 109 | 3,172 | 49 | 18,034 |
| 180 | 40_ADG031 | 40_ADG031_GUNND | 44 | 937 | 35 | 7,267 |
| 181 | 40_ADG038 | 40_ADG038_ROUBIN | 127 | 765 | 49 | 4,628 |
| 182 | 40_ADG039 | 40_ADG039_GUNNBLD | 87 | 2,417 | 53 | 12,153 |
| 183 | 40_ADG045 | 40_ADG045_PAONIA | 79 | 383 | 39 | 5,203 |
| 184 | 40_ADG046 | 40_ADG046_CRAWFORD | 13 | 303 | 48 | 2,036 |
| 185 | 40_AMG002 [3)] | Lower_M&I | 2 | 0 | 100 | 1,449 |
| 186 | 40_Fruitl | Fruitland | 537 | 7,024 | 52 | 38,987 |
| 187 | 410508 | BOLES & MANNEY D | 18 | 206 | 23 | 3,865 |
| 188 | 410515 | CHIPETA BEAUDRY DITCH | 32 | 422 | 27 | 4,074 |
| 189 | 410519 | EAGLE DITCH | 999 | 1,270 | 41 | 8,313 |
| 190 | 410520 | EAST CANAL | 354 | 4,831 | 26 | 54,126 |
| 191 | 410527 | GARNET DITCH | 156 | 1,045 | 19 | 24,438 |
| 192 | 410534 | UNCO_IRONSTONE CANAL | 532 | 18,218 | 35 | 122,745 |
| 193 | 410537 | LOUTSENHIZER CANAL | 232 | 4,551 | 28 | 49,319 |
| 194 | 410538 | LYRA DITCH | 16 | 393 | 37 | 3,186 |
| 195 | 410545 | MONTROSE & DELTA CANAL | 627 | 20,936 | 29 | 195,839 |
| 196 | 410549 | OURAY DITCH | 36 | 1,168 | 47 | 6,630 |

| # | Model ID # | Name | Cap (cfs) | 1993 Area (acres) | Average System Efficiency (percent) | Average Annual Demand (af) |
|---|---|---|---|---|---|---|
| 197 | 410554 | ROSS BROS DITCH | 22 | 55 | 17 | 3,629 |
| 198 | 410559 | SELIG CANAL | 367 | 10,699 | 38 | 75,743 |
| 199 | 410560 | SHAVANO VALLEY DITCH | 14 | 39 | 29 | 1,339 |
| 200 | 410568 | SUNRISE DITCH(HAPPY CYN) | 10 | 82 | 21 | 1,949 |
| 201 | 410577 | WEST CANAL | 999 | 4,799 | 26 | 58,549 |
| 202 | 410578 | SOUTH CANAL | 999 | 5,916 | 37 | 44,484 |
| 203 | 41_ADG035 | 41_ADG035_UNCOMPH3 | 96 | 1,557 | 48 | 10,135 |
| 204 | 41_ADG036 | 41_ADG036_UNCOMPH4 | 127 | 2,845 | 49 | 18,419 |
| 205 | 41_ADG037 | 41_ADG037_UNCOMPH5 | 61 | 767 | 26 | 10,261 |
| 206 | 41_AMG003 [3)] | Uncomp_M&I | 2 | 0 | 100 | 1,272 |
| 207 | 420510 | BROWN & CAMPION D | 36 | 669 | 50 | 4,639 |
| 208 | 420529 | KANNAH CREEK HIGHLINE D | 89 | 1,192 | 47 | 9,710 |
| 209 | 420541 [3)] | REDLANDS POWER CANAL | 790 | 0 | 0 | 456,717 |
| 210 | 420545 | SMITH IRR DITCH | 29 | 577 | 50 | 3,427 |
| 211 | 42_ADG040 | 42_ADG040_GUNNGJ | 490 | 2,824 | 48 | 21,356 |
| 212 | 590501 | ACME DITCH | 70 | 857 | 39 | 5,685 |
| 213 | 590509 | ANDERS BOTTOM D | 6 | 19 | 31 | 351 |
| 214 | 590510 | ANNA ROZMAN DITCH | 15 | 72 | 30 | 1,347 |
| 215 | 590522 | BOCKER DITCH | 40 | 208 | 29 | 4,309 |
| 216 | 590524 | BOURNE DITCH | 14 | 154 | 40 | 968 |
| 217 | 590527 | BUCKEY DITCH | 26 | 373 | 40 | 2,129 |
| 218 | 590528 | BUCKEY LEHMAN DITCH | 16 | 121 | 40 | 752 |
| 219 | 590537 | CEMENT CREEK DITCH | 26 | 171 | 25 | 4,042 |
| 220 | 590542 | CUNNINGHAM DITCH | 24 | 525 | 40 | 2,952 |
| 221 | 590544 | DEAN IRRIGATING DITCH | 15 | 110 | 35 | 1,394 |
| 222 | 590546 | DILLSWORTH DITCH | 48 | 365 | 25 | 7,667 |
| 223 | 590549 | EAST RIVER NO 1 DITCH | 137 | 985 | 30 | 17,549 |
| 224 | 590550 | EAST RIVER NO 2 DITCH | 73 | 511 | 25 | 11,013 |
| 225 | 590556 | FISHER DITCH ENLARGEMENT | 42 | 351 | 29 | 4,795 |
| 226 | 590558 | FRANK ADAMS NO 1 DITCH | 40 | 317 | 34 | 3,725 |
| 227 | 590560 | GARDEN DITCH | 29 | 346 | 37 | 3,374 |
| 228 | 590563 | GLEASON IRRIGATING DITCH | 48 | 460 | 40 | 2,926 |

| # | Model ID # | Name | Cap (cfs) | 1993 Area (acres) | Average System Efficiency (percent) | Average Annual Demand (af) |
|---|---|---|---|---|---|---|
| 229 | 590566 | GOOSEBERRY MESA IRG D | 28 | 287 | 33 | 3,871 |
| 230 | 590569 | GUNNISON & OHIO CR CANAL | 169 | 953 | 29 | 15,396 |
| 231 | 590570 | GUNNISON R OHIO CR IRG D | 102 | 1,160 | 26 | 19,026 |
| 232 | 590572 | GUNNISON TOWN DITCH | 75 | 84 | 22 | 7,704 |
| 233 | 590578 | HARRIS BOHM POTATO DITCH | 53 | 612 | 38 | 5,683 |
| 234 | 590580 | HENRY PURRIER OHIO CR D | 31 | 174 | 40 | 973 |
| 235 | 590581 | HENRY PURRIER OHIO CR 2D | 9 | 125 | 50 | 598 |
| 236 | 590584 | HIGHLAND DITCH | 8 | 46 | 31 | 680 |
| 237 | 590587 | HILDEBRAND NO 2 DITCH | 29 | 146 | 37 | 1,651 |
| 238 | 590588 | HINKLE HAMILTON DITCH | 28 | 355 | 39 | 2,589 |
| 239 | 590589 | HINKLE IRG DITCH | 10 | 97 | 44 | 943 |
| 240 | 590591 | HOPE RESICH DITCH | 33 | 335 | 40 | 2,004 |
| 241 | 590593 | HOWE & SHERWOOD IRR D | 26 | 232 | 32 | 2,620 |
| 242 | 590596 | HYZER VIDAL MILLER D | 35 | 377 | 40 | 2,424 |
| 243 | 590597 | IMOBERSTEG DITCH | 32 | 185 | 29 | 3,141 |
| 244 | 590600 | JAMES WATT DITCH | 47 | 197 | 26 | 5,561 |
| 245 | 590602 | JOHN B OUTCALT NO 2 D | 43 | 484 | 39 | 3,499 |
| 246 | 590606 | JUDY NORTH HIGH LINE D | 21 | 280 | 39 | 2,079 |
| 247 | 590607 | KELMEL OWENS NO 1 DITCH | 74 | 542 | 32 | 6,815 |
| 248 | 590608 | KELMEL OWENS NO 2 DITCH | 54 | 390 | 39 | 3,711 |
| 249 | 590609 | KUBIACK DITCH | 26 | 151 | 24 | 3,374 |
| 250 | 590616 | LIGHTLEY D & LINTON ENLT | 28 | 288 | 32 | 3,527 |
| 251 | 590617 | LONE PINE DITCH | 72 | 762 | 39 | 5,048 |
| 252 | 590622 | MARSHALL NO 1 DITCH | 17 | 215 | 34 | 2,129 |
| 253 | 590623 | MARSHALL NO 2 DITCH | 43 | 425 | 38 | 3,395 |
| 254 | 590624 | MARSTON DITCH | 18 | 99 | 28 | 1,676 |
| 255 | 590625 | MAY BOHM & ENLD M B H P | 70 | 921 | 39 | 6,144 |
| 256 | 590627 | MCCORMICK DITCH | 10 | 232 | 40 | 1,317 |
| 257 | 590630 | MCGLASHAN N SIDE MILL CR | 8 | 140 | 40 | 793 |
| 258 | 590631 | MCGLASHAN S SIDE MILL CR | 18 | 197 | 40 | 1,189 |
| 259 | 590644 | OHIO CREEK NO 2 DITCH | 16 | 162 | 40 | 976 |
| 260 | 590645 | OTIS MOORE DITCH | 33 | 243 | 40 | 1,502 |

| # | Model ID # | Name | Cap (cfs) | 1993 Area (acres) | Average System Efficiency (percent) | Average Annual Demand (af) |
|---|---|---|---|---|---|---|
| 261 | 590646 | PALISADES DITCH | 8 | 90 | 33 | 1,039 |
| 262 | 590649 | PASS CREEK DITCH | 14 | 61 | 32 | 1,094 |
| 263 | 590651 | PILONI DITCH | 48 | 505 | 40 | 3,177 |
| 264 | 590653 | POWER DITCH | 23 | 237 | 22 | 4,804 |
| 265 | 590655 | PURRIER DITCH | 10 | 144 | 40 | 877 |
| 266 | 590658 | RICHARD BALL DITCH | 41 | 371 | 31 | 4,704 |
| 267 | 590667 | SCHUPP DITCH | 17 | 163 | 38 | 1,109 |
| 268 | 590668 | SEVENTY FIVE DITCH | 78 | 458 | 35 | 6,224 |
| 269 | 590671 | SIMINEO DITCH | 28 | 189 | 40 | 1,127 |
| 270 | 590672 | SLIDE DITCH | 47 | 262 | 30 | 4,878 |
| 271 | 590679 | SPRING CR IRG DITCH | 43 | 280 | 27 | 4,802 |
| 272 | 590680 | SQUIRREL CREEK NO1 DITCH | 10 | 90 | 40 | 552 |
| 273 | 590684 | STRAND DITCH NO 1 | 24 | 186 | 32 | 2,650 |
| 274 | 590691 | TEACHOUT DITCH | 48 | 711 | 40 | 4,877 |
| 275 | 590692 | TEACHOUT-FAIRCHILD DITCH | 23 | 225 | 38 | 1,901 |
| 276 | 590699 | VERZUH DITCH | 44 | 117 | 21 | 6,137 |
| 277 | 590700 | VERZUH YOUNG BIFANO D | 49 | 403 | 28 | 6,768 |
| 278 | 590704 | WHIPP DITCH | 37 | 354 | 33 | 4,290 |
| 279 | 590707 | WILLOW RUN DITCH | 13 | 125 | 40 | 772 |
| 280 | 590709 | WILSON DITCH | 12 | 126 | 38 | 1,173 |
| 281 | 590711 | WILSON OHIO CREEK DITCH | 26 | 298 | 40 | 1,994 |
| 282 | 590720 | PIONEER DITCH | 9 | 125 | 39 | 931 |
| 283 | 590847 | CUNNINGHAM WASTEWATER D | 14 | 140 | 29 | 2,495 |
| 284 | 59_ADG001 | 59_ADG001_TAYLOR | 68 | 738 | 30 | 10,273 |
| 285 | 59_ADG002 | 59_ADG002_EAST1 | 88 | 1,296 | 38 | 9,423 |
| 286 | 59_ADG003 | 59_ADS_003_SLATE | 379 | 1,469 | 40 | 8,234 |
| 287 | 59_ADG004 | 59_ADG004_EAST2 | 174 | 2,178 | 38 | 16,066 |
| 288 | 59_ADG005 | 59_ADG005_EAST3 | 104 | 693 | 33 | 9,098 |
| 289 | 59_ADG006 | 59_ADG006_OHIO1 | 142 | 918 | 38 | 6,407 |
| 290 | 59_ADG007 | 59_ADG007_OHIO2 | 132 | 1,944 | 40 | 10,978 |
| 291 | 59_ADG008 | 59_ADG008_GUNN | 268 | 2,056 | 20 | 44,427 |
| 292 | 620506 | ANDREWS DITCH | 11 | 49 | 31 | 863 |

| # | Model ID # | Name | Cap (cfs) | 1993 Area (acres) | Average System Efficiency (percent) | Average Annual Demand (af) |
|---|---|---|---|---|---|---|
| 293 | 620528 | BIG BLUE DITCH | 66 | 529 | 31 | 6,463 |
| 294 | 620529 | BIG DITCH | 39 | 126 | 27 | 3,656 |
| 295 | 620560 [2)] | CIMARRON CANAL | 185 | 9,321 | 0 | 0 |
| 296 | 620567 | COLLIER DITCH | 13 | 526 | 40 | 2,972 |
| 297 | 620602 | FOSTER DITCH NO 1 | 11 | 41 | 34 | 855 |
| 298 | 620604 | FOSTER IRG D NO 4 | 5 | 68 | 40 | 440 |
| 299 | 620605 | FRANK ADAMS D NO 2 | 45 | 130 | 32 | 2,655 |
| 300 | 620617 [2)] | GUNNISON TUNNEL&S CANAL | 1,175 | 0 | 0 | 0 |
| 301 | 620670 | M B & A DITCH | 28 | 155 | 34 | 2,446 |
| 302 | 620672 | MCKINLEY DITCH | 35 | 685 | 36 | 5,531 |
| 303 | 620732 | RUDOLPH IRG DITCH | 16 | 104 | 31 | 1,918 |
| 304 | 620734 | SAMMONS DITCH NO 2 | 15 | 22 | 27 | 699 |
| 305 | 620736 | CEBO_SAMMONS IRG D N | 18 | 25 | 30 | 796 |
| 306 | 620737 | SAMMONS IRG D NO 5 | 8 | 15 | 31 | 598 |
| 307 | 620738 | SAMMONS IRG D NO 6 | 10 | 75 | 35 | 896 |
| 308 | 620779 | UPPER CEBOLLA DITCH | 22 | 173 | 36 | 1,950 |
| 309 | 620783 | VEO DITCH | 16 | 302 | 38 | 2,608 |
| 310 | 620789 | WARRANT DITCH | 21 | 46 | 32 | 1,110 |
| 311 | 620809 | YOUMANS IRG D NO 1 | 28 | 53 | 27 | 1,486 |
| 312 | 62_ADG013 | 62_ADG013_CEBOLLA1 | 159 | 780 | 38 | 17,164 |
| 313 | 62_ADG014 | 62_ADG014_CEBOLLA2 | 105 | 1,206 | 43 | 12,655 |
| 314 | 62_ADG015 | 62_ADG015_LAKE | 195 | 1,725 | 38 | 17,912 |
| 315 | 62_ADG016 | 62_ADG016_GUNNBM | 223 | 1,672 | 37 | 26,965 |
| 316 | 62_ADG017 | 62_ADG017_GUNNM | 43 | 376 | 39 | 2,618 |
| 317 | 62_ADG018 | 62_ADG018_CIM | 50 | 874 | 38 | 6,529 |
| 318 | 62_AMG001 [3)] | Upper_M&I | 2 | 0 | 100 | 1,449 |
| 319 | 62_IrrCim | Cimmaron_Canal | 185 | 6,745 | 48 | 32,746 |
| 320 | 680501 | ALKALI DITCH D NO 80 | 42 | 1,470 | 49 | 7,345 |
| 321 | 680502 | ALKALI NO 2 DITCH | 37 | 724 | 42 | 5,195 |
| 322 | 680514 | BURKHART EDDY DITCH | 15 | 606 | 50 | 2,872 |
| 323 | 680526 | CHARLEY LOGAN DITCH | 31 | 153 | 28 | 3,546 |
| 324 | 680538 | CRONENBERG DITCH | 12 | 221 | 50 | 985 |

| # | Model ID # | Name | Cap (cfs) | 1993 Area (acres) | Average System Efficiency (percent) | Average Annual Demand (af) |
|---|---|---|---|---|---|---|
| 325 | 680543 | DALLAS DITCH | 41 | 755 | 45 | 4,743 |
| 326 | 680559 | DOC WADE DITCH | 21 | 430 | 48 | 2,405 |
| 327 | 680603 | HENRY TRENCHARD DITCH | 12 | 147 | 37 | 1,303 |
| 328 | 680607 | HOMESTRETCH DITCH | 22 | 292 | 23 | 4,444 |
| 329 | 680609 | HOSNER BROWNYARD DITCH | 20 | 93 | 29 | 2,236 |
| 330 | 680610 | HOSNER ROWELL DITCH | 18 | 432 | 47 | 2,438 |
| 331 | 680613 | HYDE SNEVA DITCH | 19 | 455 | 47 | 2,817 |
| 332 | 680636 | LEOPARD CREEK DITCH | 51 | 627 | 46 | 3,811 |
| 333 | 680647 | MARTIN DITCH | 10 | 140 | 37 | 1,254 |
| 334 | 680652 | MAYOL LATERAL DITCH | 15 | 75 | 31 | 986 |
| 335 | 680653 | MAYOL SISSON DITCH | 13 | 85 | 28 | 1,063 |
| 336 | 680668 | MOODY DITCH | 18 | 214 | 36 | 2,399 |
| 337 | 680669 | MOODY NO1 DITCH | 26 | 441 | 43 | 2,913 |
| 338 | 680671 | MORRISON DITCH | 16 | 59 | 35 | 1,519 |
| 339 | 680681 | OLD AGENCY DITCH | 13 | 321 | 28 | 2,526 |
| 340 | 680683 | OWL CREEK DITCH | 12 | 193 | 39 | 1,585 |
| 341 | 680685 | PARK DITCH | 21 | 259 | 36 | 2,693 |
| 342 | 680692 | PINION DITCH | 23 | 293 | 27 | 4,398 |
| 343 | 680703 | REED OVERMAN DITCH | 27 | 91 | 28 | 1,374 |
| 344 | 680710 | RIDGWAY DITCH | 27 | 57 | 26 | 974 |
| 345 | 680720 | ROSWELL HOTCHKISS DITCH | 12 | 200 | 31 | 1,268 |
| 346 | 680729 | SHORTLINE D COW CREEK | 10 | 82 | 41 | 727 |
| 347 | 680738 | SNEVA DITCH | 36 | 939 | 48 | 4,698 |
| 348 | 680765 | UPPER UNCOMPAHGRE DITCH | 13 | 274 | 28 | 3,197 |
| 349 | 68_ADG032 | 68_ADG032_UNCOMPH1 | 94 | 1,014 | 32 | 15,604 |
| 350 | 68_ADG033 | 68_ADG033_DALLAS | 109 | 1,281 | 41 | 9,606 |
| 351 | 68_ADG034 | 68_ADG034_UNCOMPH2 | 149 | 2,505 | 49 | 12,514 |
| 352 | 95CSUB_I [5)] | Subordinate_Crystal_Irr | 999 | 0 | 25 | 0 |
| 353 | 95CSUB_M [5)] | Subordinate_Crystal_M&I | 999 | 0 | 20 | 0 |
| 354 | 95L_MY [5)] | Lower_Market_Yield | 999 | 0 | 25 | 0 |
| 355 | 95MSUB_I [5)] | Subordinate_Morrow_Irr | 999 | 0 | 25 | 0 |
| 355 | 95MSUB_M [5)] | Subordinate_Morrow_M&I | 999 | 0 | 20 | 0 |

| # | Model ID # | Name | Cap (cfs) | 1993 Area (acres) | Average System Efficiency (percent) | Average Annual Demand (af) |
|---|---|---|---|---|---|---|
| 357 | 95USUB_I [5)] | Subordinate_Upper_Irr | 999 | 0 | 25 | 0 |
| 358 | 95USUB_M [5)] | Subordinate_Upper_M&I | 999 | 0 | 20 | 0 |
| 359 | 95U_MY [5)] | Upper_Market_Yield | 999 | 0 | 100 | 0 |
| 360 | 960050 | REDLANDS_POWER_CANAL-IRR | 140 | 3,002 | 44 | 29,268 |
| 361 | 960051 [4)] | Grand_Junction_Demand | 21 | 0 | 100 | 6,589 |
| 362 | Proj_7 [3)] | Project_7 | 999 | 0 | 20 | 6,670 |

1) Secondary Structure of a Multi-structure System
2) Reservoir Feeder or Carrier Ditch
3) Municipal/Industrial Diversion
4) Basin Export
5) Node for Future Modeling of Aspinall Unit Subordination and Marketable Yield Demands
6) Irrigation demand node

#### *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 only. In the Gunnison Model, diversion structures with water rights totaling 9 cfs or more 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 majority of the diversion structures in the Gunnison basin are for irrigation, although these exceptions divert to non-irrigation use:

| WDID | Name | Diversion Type |
|---|---|---|
| 400508 | Aspen Ditch | Secondary structure in Multistructure system |
| 400509 | Aspen Canal | Secondary structure in Multistructure system |
| 400549 | Fruitland Canal | Trans-tributary carrier and reservoir feeder |
| 400585 | Overland Ditch | Trans-tributary carrier |
| 400605 | Smith Fork Feeder Canal | Trans-tributary reservoir feeder |
| 400821 | Transfer Ditch | Trans-tributary reservoir feeder |
| 420541 | Redlands Power Canal | Industrial |
| 620560 | Cimarron Canal | Trans-tributary carrier and reservoir feeder |
| 620617 | Gunnison Tunnel | Trans-tributary carrier and reservoir feeder |
| 960051 | Grand Junction Demand | Municipal |
| Proj_7 | Project 7 Demand | Municipal |

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 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. For example, Proj_7 municipal use is assigned a monthly efficient of 20 percent. Reservoir feeders and other carriers are assigned an efficiency of 0 percent, meaning their diversions are delivered without loss. Exports from the basin, such as the Kannah Creek diversion to the City of Grand Junction, 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 was generally taken directly from the database. In preparing the direct diversion station file, however, the DMIs determine whether historical records of diversion indicate diversions greater than the database capacity. If so, the diversion capacity was 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
- 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_ADGxxx”, where “wd” is the water District number, and “ADG” stands for Aggregated Diversions Gunnison;

the “xxx” ranges from 001 to 046. Similarly, aggregated municipal and industrial structures were named “WD_AMGxxx” for Aggregated Municipal Gunnison.

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 – Task 10 Memorandum describes the Gunnison aggregation, updated from the 2000 irrigated acreage assessment.

### *5.4.1.3 Special Structures*

#### *5.4.1.3.1 Fruitland Canal*

Fruitland Mesa encompasses Fruitland Reservoir (Gould Reservoir) and a trans-tributary diversion from Crystal Creek, which provides most of the water for irrigation in the Iron Creek and Smith Fork drainages and storage water for Fruitland Reservoir. The irrigated lands, and the corresponding demand, are included in the model under the node 40_Fruitl. Fruitland Canal (400549) is modeled as a carrier to both Fruitland Reservoir and to the 40_Fruitl demand. 40_Fruitl demand can also be satisfied from releases from Fruitland Reservoir.

#### *5.4.1.3.2 Cimarron Canal*

62_IrrCim represents the irrigated acreage demand of the Bostwick Park Project. The key components of the Bostwick Park Project are Silver Jack Reservoir (623548) and the Cimarron Canal (620560). The Cimarron Canal (620560) delivers water to both supply irrigators in the Bostwick Park area and to fill Cerro Reservoir, a small storage facility of Project 7 Water Authority, and is modeled as a carrier only.

#### *5.4.1.3.3 Project 7*

Project 7 Water Authority provides domestic and municipal treated water to its members. Project 7 owns no water rights, but a portion of the supply is delivered from the City of Montrose’s ownership in the Cimarron Canal and from water purchased from storage in Cerro and Fairview Reservoirs. Proj_7 represents the municipal demand for the Project 7 Water Authority.

##### *5.4.1.3.4 Redlands Canal*

The Redlands Water and Power Company diverts water from the Gunnison River for irrigation and power generation in the Colorado River Basin. The Upper Colorado River Basin Water Resources Planning Model separates the irrigation and power use accurately model return flows to the basin. To be consistent with the Colorado model, the use types are also modeled separately in the Gunnison Model. Structure 420541 represents transbasin diversion from the Gunnison to the Colorado for power generation. Structure 950050 represents transbasin diversion for irrigation.

##### *5.4.1.3.5 Grand Junction*

960051 represents water exported from Kannah Creek for the City of Grand Junction. The city has several water sources – this structure represents only their diversions from Kannah Creek.

##### *5.4.1.3.6 Water Quality Nodes*

Two nodes were added to the model to assist with estimating flows at two water quality monitoring locations in the Uncompahgre River basin. These "other" type nodes are located on Loutsenhizer Arroyo and Cedar Creek, both just upstream of their confluences with the Uncompahgre.

##### *5.4.1.3.7 Future Use Diversion Structures*

Several diversion structures in the network are "placeholders" for modeling future anticipated demands in the Gunnison 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:

- 95USUB_I, 95USUB_M, 95MSUB_I, 95MSUB_M, 95CSUB_I, and 95CSUB_M. There structures are included in the model so, if desired, future analyses can represent full subordination of the Aspinall water rights, as discussed in Section 3.4 of this document.
- 95U_MY and 95L_MY are included in the model so, if desired, future analyses can investigate the use of a "marketable yield" account in Blue Mesa Reservoir.

### 5.4.2 Return Flow Delay Tables (*.dly)

The crdss.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 3 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 3 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 Gunnison Model as follows:

StateCU Total Basin Crop Consumptive Use (Ave 1950 – 2002) = 358,272 acre-feet

Incidental loss = 10% of Total Crop CU = 35,827 acre-feet

StateCU Unused Water (Ave 1950 – 2002) = 1,352,071

Incidental Loss as percent of Unused Water = 35,892 / 1,352,071 = 2.65%

Five patterns are available to the model in this file, 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 is not used in the CRDSS models.  Pattern 4 represents immediate returns, as for municipal and industrial uses. Pattern 5 is applicable to snowmaking diversions.  In the Gunnison Model, all irrigation use is assigned the first pattern.

**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 |
|---|---|---|---|---|---|
| 1 | 75.6 | 57.4 | 53.8 | 100 | 0 |
| 2 | 11.3 | 14.5 | 5.6 | 0 | 0 |
| 3 | 3.2 | 7.2 | 3.6 | 0 | 0 |
| 4 | 2.2 | 5.0 | 2.9 | 0 | 0 |
| 5 | 1.6 | 3.7 | 2.5 | 0 | 100 |
| 6 | 1.2 | 2.7 | 2.2 | 0 | 0 |
| 7 | 0.8 | 2.0 | 2.0 | 0 | 0 |
| 8 | 0.6 | 1.5 | 1.8 | 0 | 0 |
| 9 | 0.5 | 1.1 | 1.8 | 0 | 0 |
| 10 | 0 | 0.8 | 1.6 | 0 | 0 |
| 11 | 0 | 0.6 | 1.6 | 0 | 0 |
| 12 | 0 | 0.5 | etc. | 0 | 0 |
| Total | 97 | 97 | 97 | 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 was created by StateDMI, which filled missing records as described in Section 4.4.2. StateMod uses the file for baseflow estimations at stream gage locations, and for comparison output during calibration.

The file was referenced by StateDMI when developing the 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 accessed HydroBase for historical diversion records. Historical diversions were 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 read. These include the diverters in the Uncompahgre Valley who are recipients of Gunnison Tunnel water plus other larger diverters as follows:

| WDID | Name |
|---|---|
| 400900 | Relief Ditch |
| 400863 | Bonafide Ditch |
| 401133 | Fire Mountain Canal |
| 410520 | East Canal |
| 410527 | Garnet Ditch |
| 410534 | Ironstone Canal |
| 410537 | Loutsenhizer Canal |
| 410545 | Montrose & Delta Canal |
| 410559 | Selig Canal |
| 410577 | West Canal |
| 410578 | South Canal |
| 620617 | Gunnison Tunnel |

#### *5.4.3.2 Aggregate Structures*

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

Three nodes in the model represent the combined small diversion for municipal, industrial, and livestock use in three 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 Gunnison basin was estimated, as documented in the task memorandum "Non-Evapotranspiration (Other Uses) Consumptive Uses and Losses in the Gunnison river Basin." 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 40, 41, and 62 in accordance with a general distribution of M&I use.

The use is the same each year of the study.

#### *5.4.3.3 Special Structures*

##### *5.4.3.3.1 Fruitland Canal Irrigation*

Diversion time series for the node representing the historical irrigation demand of the Fruitland Irrigation Company (40_Fruitl) was by estimating the total irrigation demand from all sources using the average monthly efficiency of the nearby Needle Rock Ditch (400501). The Needle Rock Ditch was chosen because it has similar water rights administration numbers. As noted previously, the lands under this structure receive water from the Fruitland Canal and Fruitland Reservoir.

##### *5.4.3.3.2 Cimarron Canal*

Diversion time series for the node representing the historical irrigation demand of the Bostwick Project (62_IrrCim) was created by subtracting the estimated Project 7 Water Authority demand from the historical Cimarron Canal (620560).

##### *5.4.3.3.3 Project 7*

Diversion time series for the node representing the Project 7 Water Authority M&I historical diversions (Proj_7) was created from information obtained directly from the water authority.

##### *5.4.3.3.4 Redlands Canal*

Diversion time series for the two nodes that represent the historical irrigation (960050) and power (420541) demands of the Redlands Canal were created from SEO records.

##### *5.4.3.3.5 Grand Junction*

Diversion time series for the node representing water exported from Kannah Creek for the City of Grand Junction (960051) was from information obtained directly from the city.

##### *5.4.3.3.6 Future Use Diversion Structures*

All future use structures have historical diversions set to zero because they did not divert historically.

**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 *(Appendix E.1)*

  -Evaluate Extension of Historical Data *(Appendix E.2)*

### 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 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 (1950 through 2005) but capped at 0.50.

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, diversions are summed across all constituent structures, and average efficiency is based on efficiency of the aggregation as a unit. Demand for aggregated M&I structures is the same as it is in the historical diversion file.

#### *5.4.4.3 Future Use Diversion Structures*

Demands of 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 filling historical diversion time series. Based on the appropriation dates expressed in the administration number located in the rights file, StateDMI determines the total amount of the water right during the time of the missing data in the Historical dataset, and constrains the diversion estimates 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 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 historical study period could be simulated. The Baseline dataset is not limited to the historic diversion rights but rather incorporates the current right regime of the river.

All diversion rights were set “on” in the Gunnison Model. Operating rules and/or demands are used to limit direct diversion rights for some structures, for example structures that only carry water to demands at other structures.

#### *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. In addition, many structures have been assigned a “free water 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 Gunnison Model, aggregated structures can include more than 40 individual structures. Therefore, aggregated irrigation structures were assigned up to 11 water rights, one for each of 11 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*

#### *5.4.5.3.7 Fruitland Canal Irrigation*

Direct diversion water rights for the Fruitland Canal are extracted directly from Hydrobase and assigned to the feeder canal 400549. The direct diversion rights for the irrigation demand (40_Fruitl) are set to zero and water is only delivered via the feeder canal or from Fruitland Reservoir.

#### *5.4.5.3.8 Cimarron Canal*

Water is delivered through the Cimarron Canal to meet both the irrigation demand of the Bostwick Project, and to the storage and direct use demand for Project 7 Water Authority. For both Baseline simulation and historical simulation for calibration, water is delivered from the Cimarron Canal (620560) to the Bostwick area as an import to the system. The Cimarron Canal irrigation demand (60_IrrCim) is assigned a 999 cfs water right with the senior priority of 1.0000 to divert the delivered water, which is the only inflow to the subbasin. The water right remains on during the Baseline simulation, however, there is no inflow to the node and, therefore, no diversion under this direct flow water right. In the Baseline simulation, an operating rule satisfies the Cimarron Canal irrigation demand (62_IrrCim) based on the Cimarron Canal (620560) direct water right.

#### *5.4.5.3.9 Project 7*

Project 7 does not have a direct diversion water right - water is only delivered through operating rules in all simulations.

#### *5.4.5.3.10 Redlands Canal*

Redlands Canal irrigation rights are store in Hydrobase under the Redlands Power Canal (420541). They are assigned to the Redlands Canal Irrigation Structure (960050) as follows: 60 cfs with an administration number of 22283.20300 and 80 cfs with an administration number of 34419.33414

##### *5.4.5.3.11 Grand Junction*

A senior water right for 999 cfs, with an administration number of 1.0000, was assigned to the City of Grand Junction (960051) export from Kannah Creek.

##### *5.4.5.3.12 South and West Canals*

The South and West Canals obtain their water directly from the Gunnison Tunnel and do not have water rights decreed from the Uncompahgre River. Both structures are included in the model network as diversions on the Uncompahgre River. For the historical simulation for calibration, water is delivered from the Gunnison Tunnel (620617) to the Uncompahgre River as an import to the system. To enable the modeled South and West Canals to benefit from modeled Tunnel deliveries, they are assigned 999 cfs direct flow rights with an administration number just junior to the Tunnel. These two direct flow rights are turned off in the Baseline data set, because they are supplied via operating rules that deliver Gunnison Tunnel water, either under the tunnel's direct flow rights or from storage in Blue Mesa and Taylor Park Reservoirs.

##### *5.4.5.3.13 Other Uncompahgre Water Users Association Canals*

To simulate the Uncompahgre Valley Water Users Association (UVWUA) good neighbor policy, all UVWUA rights junior to 13917.000 were turned off in the Baseline data set. This has the effect of UVWUA using Gunnison Tunnel water before exercising their Uncompahgre direct flow rights to the maximum extent

##### *5.4.5.3.14 Future Use Diversion Structures*

Future use structures are listed in the direct diversion rights file, but the rights are turned off. This effectively disables the structures with regard to having an impact of the river.

## 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 contains the soil moisture capacity of each irrigation structure 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 Gunnison basin, all acreage has been assigned flood irrigation type. Maximum system efficiency in the upper reaches, defined as above the Aspinall Unit, is estimated to be 40 percent. In the remaining portions of the basin, maximum system efficiency is estimated to be 50 percent. 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.

### 5.5.3 Irrigation Water Requirement File (*.iwr)

Data for the irrigation water requirement file was generated by StateCU for the period 1975 through 2005, 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 1993 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 Gunnison basin. It was assembled by StateDMI, using considerable amount of information provided in the commands file. Thirteen (13) key reservoirs were modeled explicitly. Fourteen 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 | 403365 | FRUIT GROWERS RES | 4,540 | 2 |
| 2 | 403395 | FRUITLAND RESERVOIR | 8,100 | 1 |
| 3 | 403399 | OVERLAND RES NO 1 | 6,200 | 2 |
| 4 | 403416 | PAONIA RESERVOIR | 18,700 | 4 |
| 5 | 403553 | CRAWFORD RESERVOIR | 14,395 | 2 |
| 6 | 593666 | TAYLOR PARK RESERVOIR | 108,490 | 3 |
| 7 | 623532 | BLUE MESA RESERVOIR | 940,800 | 3 |
| 8 | 623545 | MORROW POINT RESERVOIR | 118,764 | 2 |
| 9 | 623548 | SILVERJACK RESERVOIR | 13,520 | 2 |
| 10 | 623578 | CRYSTAL RESERVOIR | 25,236 | 1 |
| 11 | 683675 | Ridgway | 84,467 | 6 |
| 12 | 28_ARG001 | AGG_RES_Tomichi | 6,395 | 1 |
| 13 | 40_ARG001 | AGG_RES_Surface | 23,268 | 1 |
| 14 | 40_ARG002 | AGG_RES_Ngunn | 23,268 | 1 |
| 15 | 40_ASG001 | AGG_STOCK_Surface | 1,727 | 1 |
| 16 | 41_ARG001 | AGG_RES_Uncomp | 3,226 | 1 |
| 17 | 41_ASG001 | AGG_STOCK_Uncomp | 1,727 | 1 |
| 18 | 42_ARG001 | AGG_RES_Kannah | 17,876 | 1 |
| 19 | 42_ASG001 | AGG_STOCK_Kannah | 1,727 | 1 |
| 20 | 59_ARG001 | AGG_RES_East | 9,826 | 1 |
| 21 | 62_ARG001 | AGG_RES_Lake | 6,475 | 1 |
| 22 | 62_ARG002 | AGG_RES_Main | 6,475 | 1 |
| 23 | 62_ASG001 | AGG_STOCK_Main | 1,727 | 1 |
| 24 | 68_ARG001 | AGG_RES_UpperUncomp | 8,359 | 1 |
| 25 | 68_ASG001 | AGG_STOCK_UpperUncomp | 1,727 | 1 |
| 26 | Cerro | Cerro | 650 | 1 |
| 27 | Fairview | Fairview | 350 | 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-Evapotranspiration (Other Uses) Consumptive Uses and Losses in the Gunnison river Basin." (see Appendix B). Surface area for the 14 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, based on available dam safety records. Initial contents were set to full.

#### *5.6.1.3 Reservoir Accounts*

##### *5.6.1.3.15 Fruit Growers Reservoir*

Fruit Growers Reservoir (403365) furnishes a dependable irrigation water supply in the Tongue Creek and Alfalfa Run area. Inflow to the reservoir, which is in the Alfalfa Run drainage, originates from Tongue and Surface Creeks. Water releases are delivered to project lands through a privately owned system of canals and laterals. Although the decreed capacity is 7,360 acre-feet, the estimated actual capacity is 4,540 acre-feet including an 80 acre-feet dead pool. An irrigation account with a capacity of 4,460 acre-feet for Stell Ditch, and a dead pool account of 80 acre-feet, are modeled for Fruit Growers Reservoir.

##### *5.6.1.3.16 Fruitland Reservoir*

Fruitland Mesa encompasses Fruitland Reservoir (aka Gould Reservoir, aka Onion Valley Reservoir, 403395) and a transbasin diversion from Crystal Creek, which irrigate lands in the Iron Creek and Smith Fork drainages. These systems obtain the majority of their water from Crystal Creek. Fruitland Canal (400549) is used to irrigate land in the Iron Creek drainage as well as fill Fruitland Reservoir. The model node 40_Fruitl was included to simulate the water diverted directly for irrigation by Fruitland Canal.

Although the decreed capacity is over 10,100 acre-feet, the estimated actual capacity is 8,100 acre-feet. A single irrigation account, with a capacity of 8,100 acre-feet, is modeled for supplemental water to 40_Fruitl.

##### *5.6.1.3.17 Overland Reservoir*

Overland Reservoir #1 (403399) is located on West Muddy Creek, a tributary of the North Fork of the Gunnison River. Water released is carried by Upper Overland Ditch (400585) to Leroux Creek, and then picked up by the Lower Overland Ditch

(400944). A single irrigation account with a capacity of 6,148 and a dead pool account of 52 acre-feet are modeled for Overland Reservoir.

#### *5.6.1.3.18 Paonia Reservoir*

The Paonia Project provides fill and supplemental irrigation water to land near Paonia and Hotchkiss. The Paonia Project consists of Paonia Reservoir (403416) and Fire Mountain Canal (401133), which diverts from the North Fork of the Gunnison River downstream of the reservoir.

In accordance with the Ragged Mountain Exchange Agreement, the Paonia Project provides supplemental irrigation water, by exchange, for up to 2,400 acres of land upstream of Paonia Reservoir, along East and West Muddy Creeks. As a result of this agreement, the storage in Paonia Reservoir is allocated as follows:

| Structure (Account) | Structure ID | Storage (ac-ft) |
|---|---|---|
| Fire Mountain Canal | 401133 | 12,650 |
| Ragged Mountain Exchange Account | 401120, 401121, 401119, 401106, 401105, 401145, 401168, 401112, 401201, 401214, 401166, 401122, 401087, 401114, 401127, 401118, 401132, 401207, 401218, 40_ADG045 | 2,000 |
| Endangered Fish | | 1,500 |
| Inactive Pool | | 2,550 |
| TOTAL | | 18,700 |

#### *5.6.1.3.19 Crawford Reservoir*

Crawford Reservoir (403553) is the key component of the Smith Fork Project. The Smith Fork Project, located east of Delta, provides a full irrigation water supply to lands not previously irrigated, and a supplemental irrigation water supply to already existing irrigated lands in the Iron Creek and Smith Fork river basins. Crawford Reservoir is filled in part by natural inflows from Iron Creek, although the majority of inflow originates from Smith Fork by way of the Smith Fork Feeder Canal (400605).

Numerous irrigation diversion structures use Crawford Reservoir water directly or by exchange, including 400500, 400501, 400502, 400503, 400509, 400536, and 400616. An irrigation account with a capacity of 10,350 acre-feet and a recreation account with a capacity of 4,045 acre-feet are modeled for Crawford Reservoir.

#### *5.6.1.3.20 Taylor Park Reservoir*

The U.S. Bureau of Reclamation constructed Taylor Park Reservoir (593666) as part of the Uncompahgre Project to store and deliver supplemental irrigation water to irrigable lands in the Uncompahgre Valley.  Located in the upper Gunnison Basin on the Taylor River, the reservoir was decreed in 1941, with a priority date of August 3, 1904, for irrigation and other purposes.  The Upper Gunnison River Water Conservancy District (UGRWCD) obtained a decree in Case No. 86CW203 for the right to refill Taylor Park Reservoir, for a total amount of 106,230 acre-feet, with an appropriation date of August 28, 1975.

The reservoir is owned by the United States and is operated by the Uncompahgre Valley Water Users Association (UVWUA).  Historically, releases were made from Taylor Park Reservoir to provide a supplemental water supply for the Gunnison Tunnel.  Decree 86CW203 requires continued releases for fishery, and has provided significant fishery and recreation benefits.

Taylor Park Reservoir is modeded with a first-fill irrigation account for UVWUA and a refill account for the UGRWCD.  Both accounts have a capacity of 106,200 acre-feet.    Note that the UGRWCD account occupies the same space as the original decree.  In addition, an inactive pool is modeled with a capacity of 2,290 acre-feet.

#### *5.6.1.3.21 Aspinall Unit - Blue Mesa, Morrow Point, and Crystal Reservoirs*

The Aspinall Unit was constructed as part of the Colorado River Storage Project.  The unit is located along the main stem of the Gunnison River between the Black Canyon of the Gunnison National Monument and the City of Gunnison.  Three reservoirs form the Aspinall Unit: Blue Mesa (623532), Morrow Point (623545), and Crystal (623578).

The flows of the Gunnison River are largely controlled by the operation of Blue Mesa Reservoir.  Water releases through Blue Mesa power plants receive short-term re-regulation by Morrow Point and Crystal Reservoirs.  Water releases from Morrow Point are primarily for peaking power, while releases from Crystal power plant are more uniform to satisfy downstream water rights.

As part of the 1975 Taylor Park Reservoir Operations and Storage Exchange Agreement, UVWUA stores and releases their water from Blue Mesa Reservoir with the goal of stabilizing the Taylor and Gunnison river flows throughout the year, to provide flood control and irrigation uses, and to minimize abrupt changes that would adversely affect fisheries and recreation uses.

Blue Mesa is modeled with a 748,520 acre-feet capacity "USA" account for power releases and a 106,200 acre-feet capacity account that provides water to the UVWUA.  Blue Mesa also has a 192,270 acre-feet dead-pool account.

Morrow Point Reservoir is modeled with a re-regulation account of 42,120 and a dead-pool account of 76,644.  Crystal Reservoir has a single re-regulation account with capacity of 25,236 acre-feet.

### *5.6.1.3.22 SilverJack Reservoir*

Bostwick Park Water Conservancy District was formed in 1962 to supplement irrigation water in the Bostwick Park area. The Bostwick Park Project was authorized as a participating project of the Colorado River Storage Project. The key components of the project are Silverjack Reservoir (623548) and the Cimarron Canal (620560). Cimarron Canal diverts water to supply irrigators in the Bostwick Park area and to fill Cerro Reservoir, a small storage facility of Project 7 Water Authority. Model node 62_IrrCim represents the irrigation demands only. Note that Project 7 does not own any storage in Silverjack Reservoir.

An irrigation account with a capacity of 12,837 acre-feet is modeled to supplement 62_IrrCim demands. There is also a dead-pool account with a capacity of 683 acre-feet.

### *5.6.1.3.23 Ridgway Reservoir*

Dallas Creek Project, and its principal component Ridgway Reservoir (683675), provide supplemental water supplies for municipal, industrial, and irrigation uses in the Uncompahgre Valley. Project 7 Water Authority, though not a component of the Dallas Creek Project, is a main provider of water to domestic and municipal members using Ridgway Reservoir and has been grouped with the Dallas Creek Project in the application.

In addition to irrigation and municipal accounts, Ridgway is modeled with an exchange account that receives book-over water from Blue Mesa Reservoir as part of the 1991 Ridgway Reservoir Exchange Agreement, and a recreation account as follows:

| **Structure (Account)** | **Structure ID** | **Storage (ac-ft)** |
|---|---|---|
| Project 7 | Proj_7 | 28,200 |
| UVWUA | 410520, 410527, 410534, 410537, 410545, 410559, 410577, 410578 | 10,300 |
| Recreation | | 20,000 |
| Inactive Pool | | 25,067 |
| Unallocated | | 900 |
| Exchange | | 15,000 |
| TOTAL | | 99,467 |

##### *5.6.1.3.24 Cerro and Fairview Reservoirs*

Cerro and Fairview Reservoirs are essentially flow-through reservoirs that were added to model Project 7 water use. They are each modeled with a single account for Project 7 use – 650 acre-feet capacity for Cerro Reservoir and 350 acre-feet capacity for Fairview Reservoir.

### 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 |

Four evaporation stations were used in the calculation of annual net evaporation in the Gunnison River basin:

1. Shadow Mountain Reservoir Station (10009) was used to calculate evaporation for the following reservoirs: Fruitgrowers, Fruitland, Crawford, 40_ARG001, and 40_ARG002.
2. Taylor Park Reservoir Station (10010) was used to calculate evaporation for the following reservoirs: Overland, Taylor Park, and 28ARG001.

3. Blue Mesa Reservoir Station (10011) was used to calculate evaporation for the following reservoirs: Paonia, Blue Mesa, Morrow Point, 62_ARG001, 62_ARG002, 68_ARG001, and 68_ARG002.
4. Ridgway Reservoir Station (10012) was used to calculate evaporation for the following reservoirs: Silverjack, Cerro, Fairview, 68_ARG001, 41_ARG001, 42_ARG001, 59_ARG001, and all aggregated stock ponds.

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

| Station | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10009 | 0.03 | 0.01 | -0.06 | -0.06 | 0.01 | 0.05 | 0.07 | 0.29 | 0.38 | 0.32 | 0.22 | 0.08 | 1.34 |
| 10010 | 0.08 | 0.01 | -0.02 | -0.01 | 0.01 | 0.04 | 0.12 | 0.18 | 0.24 | 0.21 | 0.18 | 0.16 | 1.20 |
| 10011 | 0.14 | 0.07 | 0.02 | 0.03 | 0.05 | 0.13 | 0.24 | 0.33 | 0.40 | 0.35 | 0.31 | 0.29 | 2.36 |
| 10012 | 0.08 | -0.02 | 0.05 | 0.04 | 0.06 | 0.02 | 0.19 | 0.31 | 0.44 | 0.33 | 0.28 | 0.18 | 1.96 |

### 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 was created by TSTool, which reads data from HydroBase and filled missing data with a variety of user-specified algorithms.

#### *5.6.3.1 Key Reservoirs*

Data for the Gunnison Model key reservoirs was either provided by Division 4, reservoir owners, the USBR, or generated by converting sporadic 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. 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 |
|---|---|---|---|
| 403365 | Fruitgrowers | 1959 | USBR |
| 403395 | Fruitland | 1962 | Hydrobase Daily |
| 403399 | Overland No. 1 | 1962 | USBR |
| 403416 | Paonia | 1962 | USBR |
| 403553 | Crawford | 1963 | USBR |
| 593666 | Taylor Park | 1937 | USBR |
| 623532 | Blue Mesa | 1965 | USBR |
| 623545 | Morrow Point | 1970 | USBR |
| 623548 | Silverjack | 1971 | USBR |
| 623578 | Crystal | 1977 | USBR |
| 683675 | Ridgway | 1987 | USBR |
| Cerro | Cerro | 1932 | Capacity Used |
| Fairview | Fairview | 1968 | Capacity Used |

#### *5.6.3.2 Aggregate Reservoirs*

Aggregated reservoirs were assigned contents equal to their capacity, because there is no actual data. Aggregated reservoirs were modeled as through 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 capacity for regulating reservoirs (Morrow Point and Crystal reservoirs.) Maximum targets were set to operational targets according to rule curves provided by USBR for reservoirs that operate for flood control or power generation (Paonia, Taylor Park, and Blue Mesa reservoirs.) When the model was originally developed, Ridgway Reservoir had just recently been completed, and operators were still determining “normal” operating targets. Therefore, historic end-of-month contents were used as targets for Ridgway Reservoir. Targets allow maximum control of reservoir levels by storage rights and releases to meet demands. The file was created by TSTool.

### 5.6.5 Reservoir Right File (*.rer)

The reservoir right file contains 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 was used as a first or second fill. 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.

#### *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*

##### *5.6.5.3.25 Ridgway Reservoir*

Ridgway Reservoir (683675) has a decreed absolute storage right for 84,594. It also has an absolute decreed storage right for 14.9 acre-feet that is assigned in HydroBase to structure ID 683679. This right has been re-assigned for modeling purposes to structure 683675.

##### *5.6.5.3.26 Cerro and Fairview Reservoirs*

Cerro and Fairview Reservoirs are essentially flow-through reservoirs that were added to model Project 7 water use. They were both assigned a senior water right for their modeled capacity (650 acre-feet for Cerro and 350 acre-feet for Fairview) with an administration number of 1.0000.

## 5.7 Instream Flow Files

### 5.7.1 Instream Flow Station File (*.ifs)

Thirty-three instream flow reaches are defined in this file, which was 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. Table 5.8 lists each instream flow station included in the Gunnison Model along with their location and average annual 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 Taylor Park Reservoir (Taylormin).
- An instream flow node was added to reflect the National Park Service Black Canyon filing (95NPS).
- An instream flow node was added to reflect the U.S. Fish and Wildlife Service filing (96USFS) for future modeling efforts. It is disabled in the Baseline data set and has no impact on the river.
- The Tri-County Water Conservancy District and the USBR have coordinated a "no spill" policy for the reservoir in order to prevent a fishery loss over the spillway of Ridgway. Operations of Ridgway are handled in the Baseline data set through reservoir release targets, however, a "no spill" node was added below the reservoir to represent the condition for future modeling efforts (NoSpill). It is disabled in the Baseline data set and has no impact on the river.

### 5.7.2 Instream Flow Annual Demand File (*.ifa)

Instream flow demands were developed from decreed amounts and comments in the State Engineer's water rights tabulation. 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 Gunnison Model except for structures included in the Instream Demand Monthly File (*.ifm), see below.

### 5.7.3 Instream Flow Monthly Demand File (*.ifm)

There are two instream flow structures with variable demands. Structure 95NPS –National Park Instream Flow varies depending on inflows to Blue Mesa Reservoir and water stored in Taylor Park Reservoir. Structure Taylormin – Minimum Bypass from Taylor Park Resevoir's targets are reduced during extremely dry years according to reservoir operators. Twelve monthly instream flow demands were developed for each of the years in the study period.

### 5.7.4 Instream Right File (*.ifr)

Water rights for each instream flow reach modeled in the Gunnison Model are contained in the instream flow right file, and shown in Table 5.8. 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 | Location | Decree (cfs) |
|---|---|---|---|---|
| 1 | 281057 | Cochetopa Creek | Headwaters to Nutras Creek | 4.00 |
| 2 | 281072 | Tomichi Creek | Triano Creek to Marshall Creek | 9.00 |
| 3 | 281077 | Hot Springs Creek | Headwater to Tomichi Creek | 1.50 |
| 4 | 281078 | Cochetopa Creek | Pauline Creek to Tomichi Creek | 8.0 |
| 5 | 281079 | Tomichi Creek | Marshall Creek to Quartz Creek | 118.00 |
| 6 | 281097 | Marshall Creek | Tank 7 Creek to Indian Creek | 8.00 |
| 7 | 281100 | Quartz Creek | Gold Creek to Tomichi Creek | 5.00 |
| 8 | 402347 | North Fork Gunnison | Coal Creek to Elk Creek | 60.00 |
| 9 | 591402 | Carbon Creek | Headwaters to Ohio Creek | 3.00 |
| 10 | 591412 | East River | Copper Creek to Brush Creek | 25.00 |
| 11 | 591485 | Brush Creek | West Brush Creek to Jarvis Ditch Headgate | 12.00 |
| 12 | 591493 | Ohio Creek Seg 3 | Mill Creek to Gunnison River | 12.00 |
| 13 | 591495 | Ohio Creek Seg 2 | Castle Creek to Mill Creek | 10.00 |
| 14 | 591505 | Slate River Loc C | Oh-Be-Joyful Creek to Coal Creek | 20.00 |
| 15 | 591506 | Slate River Loc D | Coal Creek to East River | 23.00 |
| 16 | 591516 | East River | Alkali Creek to Taylor River | 50.00 |
| 17 | 591550 | Cement Creek | Headwaters to East River | 10.00 |
| 18 | 591552 | Castle Creek | Confluence N. and S. Castle Creek to Acme Ditch Headgate | 7.00 |
| 19 | 591583 | Taylor River | Spring Creek to East River | 55.00 |
| 20 | 591610 | East River | Brush Creek to Alkali Creek | 10.0 |
| 21 | 620579 | Cebolla Creek | Confluence E.Fork and W.Fork Cebolla Creek to Brush Creek | 4.00 |
| 22 | 621331 | Lake Fork Gunnison | Henson Creek to Blue Mesa Reservoir | 45.00 |
| 23 | 621339 | Blue Creek | Little Blue Creek to Morrow Point Reservoir | 7.00 |
| 24 | 621340 | Cimarron River | Fox Creek to Little Cimarron River | 25.00 |
| 25 | 681084 | Beaver Creek | Headwaters to Dallas Creek | 1.50 |
| 26 | 681153 | West Fork Dallas Ck | Headwaters to Burkhart Eddy Ditch | 2.50 |

#### *5.7.4.1 Special Instream Flow rights*

Several reservoir bypass agreements and other operations are represented as instream flow reaches as follows:

- The Taylor River instream flow right (591273) above the confluence with East Creek is stored in Hydrobase with a use type of “RECFISSTK”. Only use types of “MIN” are extracted using StateDMI. Therefore, the 445 cfs instream flow right with an administration number of 49673.45896 was set.

- The CWCB Black Canyon instream flow right (621540) is stored in Hydrobase with a use type of "OTH". Therefore, the 300 cfs instream flow right with an administration number of 42347.00000 was set.
- The instream flow right used to represent the Taylor minimum bypass requirements at Taylor Park Reservoir (Taylormin) was set to reflect the 400 cfs bypass with an administration number of 30667.19939.
- The recreational in-channel diversion associated with the Gunnison Whitewater Course (591327) was included as a placeholder, but was turned off pending the final decree.
- The National Park Service instream flow agreement (96NPS) right was set to 2500 cfs with an administration number of 30376.0000.
- The U.S. Fish and Wildlife Service request for an instream flow upstream of the Redland Power Canal (96USFWS) was included in the model as a placeholder. It was given a free river water right and turned off for the simulation.

## 5.8 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 Gunnison Model, seven different types of operating rights are used:

- **Type 1 –** a release from storage to the stream to satisfy an instream flow demand. In the Gunnison Model, this rule is used to satisfy minimum reservoir release requirements at Taylor Park Reservoir.
- **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. For example, in the Gunnison Model, water is transferred from the Blue Mesa Reservoir

USA account to the UVWUA account whenever releases are made from Taylor Park Reservoir's UVWUA account.

- **Type 9 –** a release from storage to the river to meet a reservoir target. This operation is used in the Gunnison Baseline data set for the reservoirs that operate for flood control or power generation (Paonia, Taylor Park, and Blue Mesa reservoirs.) 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 Gunnison 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 through the Gunnison Tunnel to Garnet Canal on the Uncompahgre; the demand is the Garnet Canal demand. This rule type is also used to deliver water to Crawford Reservoir through the Smith Fork Feeder Canal; the demand is Crawford Reservoir's capacity.

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 Gunnison Model is generally organized according to the projects involved:

| **Section** | **Description** |
|---|---|
| 5.8.1 | Taylor Park Reservoir |
| 5.8.2 | Overland Reservoir and Ditch |
| 5.8.3 | Paonia Project |
| 5.8.4 | Aspinall Unit |
| 5.8.5 | Uncompahgre Project |
| 5.8.6 | Dallas Creek Project |
| 5.8.7 | Smith Fork Project |
| 5.8.8 | Fruitland Mesa |
| 5.8.9 | Bostwick Park Project |
| 5.8.10 | Project 7 Water Authority |
| 5.8.11 | Fruitgrowers Dam Project |
| 5.8.12 | Other Operating Rules |

**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 "Gunnison River Projects and Special Operations" in the document "Gunnison Basin Information" describes each reservoir's typical operations.

### 5.8.1 Taylor Park Reservoir

Taylor Park Reservoir (593666) is part of the Uncompahgre Project, and delivers supplemental water for irrigation in the Uncompahgre Valley via the Gunnison Tunnel from the Uncompahgre Valley Water Users Association (UVWUA) account. The Upper Gunnison River Water Conservancy District (UGRWCD) has a junior right to refill Taylor Park Reservoir. Note that the refill storage occupies the same space as the UVWUA storage.

| Account | Owner | Capacity (acre-feet) |
|---|---|---|
| 1 | UVWUA | 106,200 |
| 2 | UGRWCD | 106,200 |
| 3 | Inactive Pool | 2,290 |

Thirteen operating rights are used to specify Taylor Park Reservoir operations:

| Right # | Destination | Resvr Account | Admin # | Right Type | Description |
|---|---|---|---|---|---|
| 1 | Gunnison Tunnel | 1 | 20393.18781 | 2 | Release to direct diversion |
| 2 | Taylor Park Min Release | 1 | 49348.22950 | 1 | Release to instream flow demand |
| 3 | Taylor Park Min Release | 2 | 49348.22950 | 1 | Release to instream flow demand |
| 4 | Opr Taylor Park Target | 1 and 2 | 99999.99999 | 9 | Release to river by target |
| 5 | South Canal | 1 | 49348.22951 | 2 | Release to river to carrier |
| 6 | West Canal | 1 | 49348.22951 | 2 | Release to river to carrier |
| 7 | Montrose and Delta Canal | 1 | 49348.22951 | 2 | Release to river to carrier |
| 8 | Loutsenhizer Canal | 1 | 49348.22951 | 2 | Release to river to carrier |
| 9 | Selig Canal | 1 | 49348.22951 | 2 | Release to river to carrier |
| 10 | Ironstone Canal | 1 | 49348.22951 | 2 | Release to river to carrier |
| 11 | East Canal | 1 | 49348.22951 | 2 | Release to river to carrier |
| 12 | Garnet Canal | 1 | 49348.22951 | 2 | Release to river to carrier |
| 13 | Opr Taylor Park Bookover | 2 to 1 | 99999.99999 | 6 | Reservoir account bookover |

Operating rule 1 provides water to the Gunnison Tunnel (620617) from the UVWUA account. The senior administration number, which is junior to the Tunnel's direct flow decree, insures this rule is operated and water is released to the Gunnison Tunnel prior to any other Taylor Park Reservoir releases. This operating rule is only turned on for the historical simulation; during the Baseline simulations water is delivered through the Gunnison Tunnel based on the destination canal demands.

Operating rules 2 and 3 release water from the UVWUA and UGRWCD accounts, respectively, to meet the minimum release (Taylormin) demand located downstream of the reservoir. Taylormin demands reflect releases outlined in the 1975 exchange agreement. This operating rule was given an administration date senior to Taylor Park Reservoir second fill decree to replicate required releases for fisheries.

Operating rule 4 releases water from the UVWUA and UGRWCD accounts proportionally to operational targets per USBR operations. The junior administration number insures this is the last operating rule to fire.

Operating rules 5 through 12 provide supplemental water to eight Uncompahgre Valley diversion structures. The water is released and the Gunnison Tunnel is used as the carrier. The rules are given an administration number just junior to the minimum release right, per the 1975 exchange agreement. The amount of water released is restricted by the amount currently available in the account, and the unsatisfied demand at the individual canals.

Operating rule 13 implements the Taylor Park "bookover", part of the 1975 Exchange agreement. This operating right moves water from the UGRWCD account to UVWUA's account on October 31 of each year. It has a very junior administration number.

### 5.8.2 Overland Reservoir and Ditch

Overland Reservoir (403399) is located on West Muddy Creek, a tributary of the North Fork of the Gunnison River. Water released is carried by Upper Overland Ditch (400585) to Leroux Creek, then picked up by the Lower Overland Ditch (400944). Overland Reservoir is operated with two accounts.

| Acct | Owner | Capacity (acre-feet) |
|---|---|---|
| 1 | Irrigation | 6148 |
| 2 | Dead Pool | 52 |

Six operating rules are used to simulate Overland Ditch and Reservoir operations:

| Right # | Destination | Account or Carrier | Admin # | Right Type | Description |
|---|---|---|---|---|---|
| 1 | Lower Overland Ditch | 1 | 35997.00001 | 3 | Release to carrier |
| 2 | Opr Overland to Target | 1 | 99999.99999 | 9 | Release to river by target |

| | | | | | |
|---|---|---|---|---|---|
| 3 | Lower Overland Ditch | Overland Ditch | 21263.15919 | 11 | Carrier to diversion |
| 4 | Lower Overland Ditch | Overland Ditch | 21263.15919 | 11 | Carrier to diversion |

Operating rule 1 allows Lower Overland Ditch (400944) to get reservoir releases by using Overland Ditch (400585) as a carrier. The amount of water released to the carrier is restricted by the amount currently available in the account, and the unsatisfied demand at the destination ditch.

Operating rule 2 releases water to meet storage target values. The junior administration number insures this is the last operating rule to fire. This rule is specifically used in the historical simulation for calibration efforts, when end-of-month target values are set to historical end-of-month reservoir contents. For the Baseline data set, end-of-month targets for Overland Reservoir are set to capacity, so releases to target are never made.

Operating rule 3 allows Lower Overland Ditch (400944) river water to be carried by the Overland Ditch (400585) senior water right. The amount diverted at the Overland Ditch headgate is restricted by the amount of water physically and legally available based on Overland Ditch's senior water right, and unsatisfied demand at Lower Overland Ditch. As noted previously, Type 11 Operating rule 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.

Operating rule 4 allows Lower Overland Ditch (400944) water to be carried by the Upper Overland Ditch (400585) junior water right. The amount diverted at the Overland Ditch headgate is restricted by the amount of water physically and legally available based on Overland Ditch's junior water right, and unsatisfied demand at Lower Overland Ditch. As noted previously, Type 11 Operating rule 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.

### 5.8.3 Paonia Project

The Paonia Project provides full and supplemental irrigation water to land near Paonia and Hotchkiss, Colorado. The Paonia Project consists of the Paonia Reservoir (403416) and the Fire Mountain Canal (401133), which diverts from the North Fork of the Gunnison River downstream of the reservoir. In accordance with the Ragged Mountain Exchange Agreement, the Paonia Project provides supplemental irrigation water, by exchange, for up to 2,400 acres of land upstream of Paonia Reservoir, along East and West Muddy Creeks. Paonia Reservoir is operated with four accounts, which are listed below and described in more detail in Section 5.6.1.3.4.

| Acct | Owner | Capacity (acre-feet) |
|---|---|---|
| 1 | Fire_Mtn | 12,650 |
| 2 | Ragged_Mtn | 2,000 |
| 3 | Endangered_F | 1,500 |
| 4 | Inactive Pool | 2,550 |

Twenty-two operating rules are used to simulate Paonia Project operations:

| Right # | Destination | Acct # | Admin # | Right Type | Description |
|---|---|---|---|---|---|
| 1 | Fire Mountain Canal | 1 | 43829.43799 | 2 | Release to direct diversion |
| 2 | Downing Ditch | 2 | 43829.43799 | 4 | Exchange to direct diversion |
| 3 | Williams Creek Ditch | 2 | 43829.43799 | 4 | Exchange to direct diversion |
| 4 | Dugout Ditch | 2 | 43829.43799 | 4 | Exchange to direct diversion |
| 5 | Coyote Ditch (401105) | 2 | 43829.43799 | 4 | Exchange to direct diversion |
| 6 | Coyote Ditch (401106) | 2 | 43829.43799 | 4 | Exchange to direct diversion |
| 7 | Grouse Creek Ditch | 2 | 43829.43799 | 4 | Exchange to direct diversion |
| 8 | Lee Creek D No 2 | 2 | 43829.43799 | 4 | Exchange to direct diversion |
| 9 | Deer Ditch | 2 | 43829.43799 | 4 | Exchange to direct diversion |
| 10 | Spatafora Ditch No 1 | 2 | 43829.43799 | 4 | Exchange to direct diversion |
| 11 | Wade Ditch | 2 | 43829.43799 | 4 | Exchange to direct diversion |
| 12 | Larson No 2 Ditch | 2 | 43829.43799 | 4 | Exchange to direct diversion |
| 13 | Dyke No 2 Ditch | 2 | 43829.43799 | 4 | Exchange to direct diversion |
| 14 | Black Sage Ditch | 2 | 43829.43799 | 4 | Exchange to direct diversion |
| 15 | Ditch No 2 Ditch | 2 | 43829.43799 | 4 | Exchange to direct diversion |
| 16 | Elks Beaver Ditch | 2 | 43829.43799 | 4 | Exchange to direct diversion |
| 17 | Drift Creek Ditch | 2 | 43829.43799 | 4 | Exchange to direct diversion |
| 18 | Filmore Ditch | 2 | 43829.43799 | 4 | Exchange to direct diversion |
| 19 | Streber Ditch | 2 | 43829.43799 | 4 | Exchange to direct diversion |
| 20 | Welch Mesa Ditch | 2 | 43829.43799 | 4 | Exchange to direct diversion |
| 21 | Paonia Aggregate | 2 | 43829.43799 | 4 | Exchange to direct diversion |
| 22 | Opr Paonia to Target | 1 and 2 | 99999.99999 | 9 | Release to river by target |

Operating rule 1 releases Paonia Reservoir water directly to Fire Mountain Canal (401133). The administration number reflects project administration, and has been set just senior to Paonia Reservoir's storage right. The amount of water released is restricted by the amount currently available in the Fire Mountain account, and the unsatisfied demand at Fire Mountain Canal headgate.

Operating rules 2 through 21 release water from Paonia Reservoir to the various Ragged Mountain water users by exchange, up to 2,000 acre-feet per year, their account limit. The administration number reflects project administration, and has been set just senior to Paonia Reservoir's storage right. The amount of water released to each direct diversion is restricted by the amount currently available in the account, unsatisfied demand at each ditch, and available water in Muddy Creek from the ditch to below Paonia Reservoir.

Operating rule 22 releases water to meet operational targets per USBR operations. The junior administration number insures this is the last operating rule to fire.

### 5.8.4 Aspinall Unit

The Aspinall Unit was constructed as part of the Colorado River Storage Project. The unit is located along the main stem of the Gunnison River between the Black Canyon of the Gunnison National Monument and the City of Gunnison. Three reservoirs form the Aspinall Unit, Blue Mesa (623532), Morrow Point (623545), and Crystal (623578).

The flows of the Gunnison River are largely controlled by the operation of Blue Mesa Reservoir. Water released through Blue Mesa power plants receives short-term re-regulation by Morrow Point and Crystal Reservoirs. Water releases from Morrow Point are primarily for peaking power, while releases from Crystal power plant are more uniform to satisfy downstream water rights. The three reservoirs are operated by the model with a USA active account. In addition, the model represents the Uncompahgre Valley Water Users Association (UVWUA) account in Blue Mesa, as described in more detail in section 5.6.1.3.7:

| Reservoir | Acct | Owner | Capacity (acre-feet) |
|---|---|---|---|
| Blue Mesa | 1 | USA | 748,530 |
| Blue Mesa | 2 | UVWUA | 106,200 |
| Blue Mesa | 3 | Inactive Pool | 192,270 |
| Morrow Point | 1 | USA | 42,120 |
| Morrow Point | 2 | Inactive Pool | 76,644 |
| Crystal | 1 | USA | 25,236 |

Seventeen operating rules are used to simulate Aspinall Unit operations:

| Right # | Destination | Acct # | Admin # | Right Type | Description |
|---|---|---|---|---|---|
| 1 | Opr Blue Mesa Bookover | 1 to 2 | 1.00000 | 6 | Reservoir account bookover |
| 2 | Opr Blue Mesa Bookover | 1 to 2 | 1.00000 | 6 | Reservoir account bookover |
| 3 | Opr Blue Mesa to Target | 1 and 2 | 99999.99999 | 9 | Release to river by target |
| 4 | Gunnison Tunnel | 2 | 20393.18780 | 2 | Release to direct diversion |
| 5 | Fairview Reservoir | 2 | 20393.18780 | 2 | Release to river to carrier |
| 6 | Black Canyon Instream Flow | 1 | 56156.00000 | 1 | Release to instream flow demand |
| 7 | South Canal | 2 | 20393.18780 | 2 | Release to river to carrier |
| 8 | West Canal | 2 | 20393.18780 | 2 | Release to river to carrier |
| 9 | Montrose and Delta Canal | 2 | 20393.18780 | 2 | Release to river to carrier |
| 10 | Loutsenhizer Canal | 2 | 20393.18780 | 2 | Release to river to carrier |
| 11 | Selig Canal | 2 | 20393.18780 | 2 | Release to river to carrier |
| 12 | Ironstone Canal | 2 | 20393.18780 | 2 | Release to river to carrier |
| 13 | East Canal | 2 | 20393.18780 | 2 | Release to river to carrier |
| 14 | Garnet Canal | 2 | 20393.18780 | 2 | Release to river to carrier |
| 15 | NPS Black Canyon Instream Flow | 1 | 30376.00000 | 1 | Release to instream flow demand |
| 16 | Opr Morrow Point Target | 1 | 99999.99999 | 9 | Release to river by target |
| 17 | Opr Crystal to Target | 1 | 99999.99999 | 9 | Release to river by target |

Operating rules 1 and 2 allow the booking over of water, part of the 1975 Exchange Agreement. These operating rules move water from the USA account in Blue Mesa Reservoir to the UVWUA's account whenever releases are made from either Taylor Park Reservoir UVWUA's account (rule 1), or from the UGRWCD’s refill account (rule 2).

Operating rule 3 releases water to meet operational targets per USBR operations. The junior administration number insures this is the last operating rule to fire.

Operating rule 4 allows the Gunnison Tunnel to use Blue Mesa storage water for UVWUA needs. This operating rule is only turned on during the historical simulation when the demand for UVWUA water is placed at the tunnel, not at the individual ditch headgates. The administration number assigned to this operating rule is just junior to the Gunnison Tunnel direct diversion right. This operating rule is used for historical calibration only, and is disabled for the Baseline data set.

Operating rule 5 provides Blue Mesa Reservoir storage water to Project 7, by way of Fairview Reservoir. The administration number assigned to this operating rule is just junior to the Gunnison Tunnel direct diversion right. The amount of water released is restricted by the amount of water currently available in the UVWUA account, and by the available capacity for storage in Fairview Reservoir.

Operating rule 6 provides Blue Mesa Reservoir storage water to the CWCB Black Canyon instream flow water right. The administration number has been set to reflect the date for spring flows requested in the settlement with the National Park Service. The amount of water released is restricted by the amount of water currently available in the USA account and the current flow through the instream flow reach. Note that in the historical data set, the administration date is just junior to the instream flow right, to reflect historic operations.

Operating rules 7 through 14 provide supplemental water to the eight Uncompahgre Valley canal recipients. The water is carried through the Gunnison Tunnel. The administration number assigned to these operating rules is just junior to the Gunnison Tunnel direct diversion right. The amount of water released is limited by the amount currently in the UVWUA account, and unsatisfied demand at the individual ditch headgates. These operating rules are turned off during the historical simulation.

Operating rule 15 provides Blue Mesa Reservoir storage water from the USA account to a NPS Black Canyon instream flow node. This operating rule is included for future modeling efforts, and is disabled for the Baseline, and other, simulations.

Operating rule 16 releases water to meet the storage target values for Morrow Point Reservoir. The junior administration number insures this is the last operating rule to fire. Because Morrow Point Reservoir essentially operates as a re-regulation reservoir, end-of-month targets are set to historic contents in the Baseline data set.

Operating rule 17 releases water to meet the storage target values for Crystal Reservoir. The junior administration number insures this is the last operating rule to fire. Because Crystal Reservoir essentially operates as a re-regulation reservoir, end-of-month targets are set to historic contents in the Baseline data set.
Uncompahgre Project

### 5.8.5 Uncompahgre Project

The Uncompahgre Project was one of the first major irrigation projects constructed by the USBR under the Reclamation Act of 1902. The project was developed to provide supplemental irrigation water supplies for lands in the Uncompahgre River basin between Montrose and Delta, Colorado. The irrigation supplies are obtained from direct flow rights from the Uncompahgre River, direct flow rights from the Gunnison River via the Gunnison Tunnel (620617), storage in Taylor Park, Blue Mesa and Ridgway reservoirs.

The operating rules associated with the storage for the Uncompahgre Project are detailed in sections 5.8.1, 5.8.4, and 5.8.6. Water diversions under the Gunnison Tunnel direct diversion right on the Gunnison are discussed in this section:

| Right # | Destination | Carrier | Admin # | Right Type | Description |
|---|---|---|---|---|---|
| 1 | South Canal | Gunnison Tunnel | 20393.18779 | 11 | Carrier to diversion |
| 2 | West Canal | Gunnison Tunnel | 20393.18779 | 11 | Carrier to diversion |
| 3 | Montrose and Delta Canal | Gunnison Tunnel | 20393.18779 | 11 | Carrier to diversion |
| 4 | Loutsenhizer Canal | Gunnison Tunnel | 20393.18779 | 11 | Carrier to diversion |
| 5 | Selig Canal | Gunnison Tunnel | 20393.18779 | 11 | Carrier to diversion |
| 6 | Ironstone Canal | Gunnison Tunnel | 20393.18779 | 11 | Carrier to diversion |
| 7 | East Canal | Gunnison Tunnel | 20393.18779 | 11 | Carrier to diversion |
| 8 | Garnet Canal | Gunnison Tunnel | 20393.18779 | 11 | Carrier to diversion |
| 9 | Fairview Reservoir | Gunnison Tunnel | 20393.18779 | 11 | Carrier to diversion |

Operating rules 1 through 8 provide supplemental water to eight Uncompahgre diversion structures. The water is diverted directly from the Gunnison River using the Gunnison Tunnel administration number. The water diverted is limited by the amount physically and legally available at the Gunnison Tunnel headgate (based on the Gunnison Tunnel priority), and the unsatisfied demand at the recipient canal headgates. Note that these operating rules are turned off during the historical simulation.

Operating rule 9 delivers Project 7 water through the Gunnison Tunnel to Fairview Reservoir. The water diverted is limited by the amount physically and legally available at the Gunnison Tunnel headgate (based on the Gunnison Tunnel priority), and the available capacity of Fairview Reservoir. Note that this operating rule is turned off during the historical simulation.

### 5.8.6 Dallas Creek Project

The Dallas Creek Project and its principal component, Ridgway Reservoir (683675), provide supplemental water supplies for municipal, industrial and irrigation uses in the Uncompahgre valley. Project 7 Authority, though not a component of the Dallas Creek Project, is a main provider of water to domestic and municipal member using Ridgway Reservoir and has been grouped with the Dallas Creek Project in the application. It has a modeled account in Ridgway Reservoir to represent actual operations. Ridgway Reservoir is modeled with six accounts, which are listed below and described in more detail in Section 5.6.1.3.9.

| Acct | Owner | Capacity (acre-feet) |
|---|---|---|
| 1 | Project 7 | 28,200 |
| 2 | UVWUA | 10,300 |
| 3 | Recreation | 20,000 |
| 4 | Inactive Pool | 25,067 |
| 5 | Unallocated | 900 |
| 6 | Exchange | 15,000 |

Seventeen operating rules are used to simulate Ridgway operations:

| Right # | Destination | Acct # | Admin # | Right Type | Description |
|---|---|---|---|---|---|
| 1 | Opr Ridgway Bookover | 1 to 6 | 1.00000 | 6 | Reservoir account bookover |
| 2 | Opr Ridgway Bookover | 1 to 6 | 1.00000 | 6 | Reservoir account bookover |
| 3 | Montrose and Delta Canal | 6 | 20393.18782 | 2 | Release to direct diversion |
| 4 | Loutsenhizer Canal | 6 | 20393.18782 | 2 | Release to direct diversion |
| 5 | Selig Canal | 6 | 20393.18782 | 2 | Release to direct diversion |
| 6 | Ironstone Canal | 6 | 20393.18782 | 2 | Release to direct diversion |
| 7 | East Canal | 6 | 20393.18782 | 2 | Release to direct diversion |
| 8 | Garnet Canal | 6 | 20393.18782 | 2 | Release to direct diversion |
| 9 | West Canal | 6 | 20393.18782 | 2 | Release to direct diversion |
| 10 | Montrose and Delta Canal | 2 | 20393.18783 | 2 | Release to direct diversion |
| 11 | Loutsenhizer Canal | 2 | 20393.18783 | 2 | Release to direct diversion |
| 12 | Selig Canal | 2 | 20393.18783 | 2 | Release to direct diversion |
| 13 | Ironstone Canal | 2 | 20393.18783 | 2 | Release to direct diversion |
| 14 | East Canal | 2 | 20393.18783 | 2 | Release to direct diversion |
| 15 | Garnet Canal | 2 | 20393.18783 | 2 | Release to direct diversion |
| 16 | West Canal | 2 | 20393.18783 | 2 | Release to direct diversion |
| 17 | Opr Ridgway to Target | 1 to 6 | 99999.99999 | 9 | Release to river by target |

Operating rule 1 allows Project 7 to move water (bookover) from account 1 to the exchange account (6) whenever UVWUA account releases are made from Blue Mesa Reservoir to Fairview Reservoir under Blue Mesa operating rule 5. Water stored in this exchange account (6) can then be used directly by the UVWUA canals, per operating rules 3 through 9.

Operating rule 2 allows Project 7 to move water (bookover) from account 1 to the exchange account (6) whenever UVWUA diverts water through the Gunnison Tunnel to Fairview Reservoir under Gunnison Tunnel operating rule 9. Water stored in this exchange account (6) can then be used directly by the UVWUA canals, per operating rules 3 through 9.

Operating rules 3 through 9 allow releases to meet the supplemental needs of the Uncompahgre Project from the exchange account. The administration number assigned to these operating rules is just junior to the Gunnison Tunnel priority, but senior to releases from the UVWUA account (operating rules 10 through 16). The amount of water released is limited by the amount currently in the exchange account and the unsatisfied demand at the individual ditch headgates. Note that although the South Canal receives project water from the Gunnison Tunnel, Taylor Park Reservoir, and Blue Mesa Reservoir, Ridgway cannot physically deliver water to the canal, as there is no headgate on the Uncompahgre River. The headgate is directly off the Gunnison Tunnel.

Operating rules 10 through 16 allow releases to meet the supplemental needs of the Uncompahgre Project from the UVWUA account. The administration number assigned to these operating rules is junior to releases from the exchange account (operating rules 3 through 9), allowing exchange water to be used before water from the UVWUA account. The amount of water released is limited by the amount currently in the UVWUA account and the unsatisfied demand at the individual ditch headgates.

Operating rule 17 releases water to meet storage target values for Ridgway Reservoir. The junior administration number insures this is the last operating rule to fire. For the Baseline data set, end-of-month targets for Ridgway Reservoir are set to historical storage values.

### 5.8.7 Smith Fork Project

The Smith Fork Project, located east of Delta, Co., provides a full irrigation water supply to lands not previously irrigated and a supplemental irrigation water supply to already existing irrigated lands in the Iron Creek and Smith Fork river basins. The key component of the Smith Fork Project is Crawford Reservoir (403553). This reservoir is filled in part by natural inflows from Iron Creek, although the majority of inflow originates from Smith Fork by way of the Smith Fork Feeder Ditch. Numerous diversion structures use Crawford Reservoir water directly or by exchange and are reflected in the operating rules. Crawford Reservoir is modeled with two accounts, which are listed below and described in more detail in Section 5.6.1.3.5.

| Acct | Owner | Capacity (acre-feet) |
|---|---|---|
| 1 | Irrigation | 10,350 |
| 2 | Recreation | 4,045 |

Fifteen operating rules are used to simulate Crawford Reservoir and Smith Fork Project operations:

| Right # | Destination | Account or Carrier | Admin # | Right Type | Description |
|---|---|---|---|---|---|
| 1 | Clipper Ditch | 1 | 31924.12152 | 3 | Release to carrier |
| 2 | Crawford Aggregate | | 37985.000011 | 2 | Release to direct diversion |
| 3 | Grandview Ditch | 1 | 31924.18488 | 3 | Release to carrier |
| 4 | Needle Rock Ditch | 1 | 31924.29261 | 4 | Exchange to direct diversion |
| 5 | Saddle Mountain Ditch | 1 | 31924.29276 | 4 | Exchange to direct diversion |
| 6 | Daisy Ditch | 1 | 31924.13697 | 4 | Exchange to direct diversion |
| 7 | Virginia Ditch | 1 | 31924.13868 | 4 | Exchange to direct diversion |
| 8 | Needle Rock Ditch | 1 | 38064.35308 | 2 | Release to direct diversion |
| 9 | Opr Crawford to Target | 1 and 2 | 99999.99999 | 9 | Release to river by target |
| 10 | Grandview Ditch | Aspen Ditch | 21263.18487 | 11 | Carrier to diversion |
| 11 | Grandview Ditch | Aspen Ditch | 25807.23557 | 11 | Carrier to diversion |
| 12 | Grandview Ditch | Aspen Ditch | 31924.18487 | 11 | Carrier to diversion |
| 13 | Needle Rock Ditch | Aspen Canal | 38064.35309 | 11 | Carrier to diversion |
| 14 | Crawford Reservoir | Smith Fork Feeder | 38064.35309 | 11 | Carrier to reservoir |
| 15 | Crawford Reservoir | Smith Fork Feeder | 47847.47095 | 11 | Carrier to reservoir |

Operating rule 1 provides Crawford Reservoir storage water from the irrigation account to the Clipper Ditch (400500) by a carrier structure that diverts from the reservoir directly. The administration number for this operating right is just junior to the direct flow rights for Clipper Ditch. The amount of water released is limited by the amount currently in the irrigation account and the unsatisfied demand at the ditch.

Operating rule 2 provides Crawford Reservoir storage water from the irrigation account to the Crawford Aggregate (40_ADG046) by a direct release from the reservoir. The administration number for this operating right is just junior to the most junior direct flow right for the aggregate. The amount of water released is limited by the amount currently in the irrigation account and the unsatisfied demand at the ditch.

Operating rule 3 provides Crawford Reservoir storage water from the irrigation account to the Grandview Canal (400503) by a carrier structure that diverts from the reservoir directly. The administration number for this operating right is just junior to the direct flow rights for the Grandview Canal. The amount of water released is limited by the amount currently in the irrigation account and the unsatisfied demand at the ditch.

Operating rules 4 through 7 provide Crawford Reservoir storage water from the irrigation account to the Needle Rock Ditch (400501), Saddle Mountain Ditch (400502), Daisy Ditch (400536) and Virginia Ditch (400616) by exchange. The administration numbers for these operating rules are just junior to the direct flow rights for the ditches. The amount of water released is limited by the amount currently in the irrigation account, the unsatisfied demand at each ditch, and available water in Smith Fork from each ditch to the confluence with Iron Creek, below Crawford Reservoir.

Operating rule 8 provides Crawford Reservoir storage water to Needle Rock Ditch via Aspen Canal. The administration number for this operating right is just senior to Aspen Canal's most junior water right. The amount of water released is limited by the amount currently in the irrigation account, and the unsatisfied demand at the ditch. Note that this is not active during the historic simulation.

Operating rule 9 releases water to meet storage target values for Crawford Reservoir. The junior administration number insures this is the last operating rule to fire. This rule is specifically used in the historical simulation for calibration efforts, when end-of-month target values are set to historical end-of-month reservoir contents. For the Baseline data set, end-of-month targets for Crawford Reservoir are set to capacity, so releases to target are never made.

Operating rules 10 through 12 deliver water carried through Aspen Ditch (400508) to Grandview Ditch (400503). The administration number for these operating rules correspond to the three direct diversion rights for the Aspen Ditch. The amount of water delivered is limited to water physically and legally available under the carrier ditch (Aspen Ditch) rights, and unsatisfied demand at each ditch. Note that these rules are not active during the historic simulation.

Operating rule 13 delivers water carried through Aspen Canal (400509) to Needle Rock Ditch (400501). The administration number for this operating rule corresponds to the direct diversion right for Aspen Canal. The amount of water delivered is limited to water physically and legally available under the carrier ditch (Aspen Canal) right, and unsatisfied demand at the ditch. Note that this rule is not active during the historic simulation.

Operating rules 14 and 15 deliver Smith Fork Feeder (400605) water to Crawford Reservoir (403553). The administration number for these operating rules correspond to the two direct diversion rights for the Smith Fork Feeder. The amount of water delivered is limited to water physically and legally available under the Smith Fork Feeder rights, and storage capacity in Crawford Reservoir.

### 5.8.8 Fruitland Mesa

Fruitland Mesa encompasses Fruitland Reservoir (Gould Reservoir, 403395) and a transbasin diversion from Crystal Creek, which irrigate lands in the Iron Creek and Smith Fork drainages. All of these systems obtain the majority of their water from Crystal Creek. The Fruitland Canal (400549) is used to irrigate land in the Iron Creek drainage as well as fill Fruitland Reservoir. The model node 40_Fruitl was included in the model network to simulate the water diverted directly for irrigation by the Fruitland Canal (400549).

Fruitland Reservoir is modeled with a single irrigation account, with capacity of 8,100 acre-feet. Fifteen operating rules are used to simulate Fruitland Reservoir and Fruitland Canal operations:

| Right # | Destination | Account or Carrier | Admin # | Right Type | Description |
|---|---|---|---|---|---|
| 1 | 40_Fruitl | Fruitland Canal | 21263.18764 | 11 | Carrier to diversion |
| 2 | Fruitland Reservoir | Fruitland Canal | 21263.18764 | 11 | Carrier to reservoir |
| 3 | 40_Fruitl | Fruitland Canal | 25807.18764 | 11 | Carrier to diversion |
| 4 | Fruitland Reservoir | Fruitland Canal | 25807.18764 | 11 | Carrier to reservoir |
| 5 | 40_Fruitl | Fruitland Canal | 25807.23557 | 11 | Carrier to diversion |
| 6 | Fruitland Reservoir | Fruitland Canal | 25807.23557 | 11 | Carrier to reservoir |
| 7 | 40_Fruitl | Fruitland Canal | 31924.18764 | 11 | Carrier to diversion |
| 8 | Fruitland Reservoir | Fruitland Canal | 31924.18764 | 11 | Carrier to reservoir |
| 9 | 40_Fruitl | 1 | 31924.18766 | 2 | Release to direct diversion |
| 10 | Opr Fruitland to Target | 1 | 99999.99999 | 9 | Release to river by target |

Operating rules 1 through 8 divert water from Crystal Creek to 40_Fruitl and Fruitland Reservoir by way of Fruitland Canal (400549). The administration numbers for these operating rules correspond to the four direct diversion rights for Fruitland Canal. The amount of water delivered is limited to water physically and legally available under the carrier ditch (Fruitland Canal) rights, and either unsatisfied demand at 40_Fruitl or storage capacity in Fruitland Reservoir.

Operating rule 9 releases water from Fruitland Reservoir to 40_Fruitl to provide supplemental water for irrigation. The administration number for this operating right is junior to Fruitland Canal’s direct water rights. The amount of water released is limited by the amount currently in the irrigation account, and the unsatisfied demand at 40_Fruitl.

Operating rule 10 releases water to meet storage target values for Fruitland Reservoir. The junior administration number insures this is the last operating rule to fire. This rule is specifically used in the historical simulation for calibration efforts, when end-of-month target values are set to historical end-of-month reservoir contents. For the Baseline data set, end-of-month targets for Fruitland Reservoir are set to capacity, so releases to target are never made.

### 5.8.9 Bostwick Park Project

Bostwick Park Water Conservancy District was formed in 1962 to supplement irrigation water in the Bostwick Park area. The project was authorized as a participating project of CRSP.

The key components of the Bostwick Park Project are Silverjack Reservoir (623548) and the Cimarron Canal (620560). Cimarron Canal diverts water to supply irrigators in the Bostwick Park area and to fill Cerro Reservoir, a small storage facility of Project 7 Water Authority. Model node 62_IrrCim represents the irrigation demand only.

Operating rules allow Cimarron Canal to divert under 3 direct flow decrees for 62_IrrCim and Cerro Reservoir. Additional operating rules allow releases from Silverjack Reservoir via the Cimarron Canal for 62_IrrCim. Project 7 does not own any storage in Silverjack Reservoir.

Silverjack Reservoir is modeled with two accounts, which are listed below.

| Acct | Owner | Capacity (acre-feet) |
|---|---|---|
| 1 | Irrigation | 12,837 |
| 2 | Dead Pool | 683 |

Eight operating rules are used to simulate Silverjack Reservoir and Bostwick Park Project operations:

| Right # | Destination | Account or Carrier | Admin # | Right Type | Description |
|---|---|---|---|---|---|
| 1 | 62_IrrCim | 1 | 38532.00001 | 2 | Reservoir to river to carrier |
| 2 | Opr Silverjack to Target | 1 | 99999.99999 | 9 | Release to river by target |
| 3 | 62_IrrCim | Cimarron Canal | 19810.19448 | 11 | Carrier to diversion |
| 4 | Cerro Reservoir | Cimarron Canal | 19810.19448 | 11 | Carrier to reservoir |
| 5 | 62_IrrCim | Cimarron Canal | 20393.20175 | 11 | Carrier to diversion |
| 6 | Cerro Reservoir | Cimarron Canal | 20393.20175 | 11 | Carrier to reservoir |
| 7 | 62_IrrCim | Cimarron Canal | 27585.27545 | 11 | Carrier to diversion |
| 8 | Cerro Reservoir | Cimarron Canal | 27585.27545 | 11 | Carrier to reservoir |

Operating rule 1 releases water from Silverjack Reservoir to the irrigation component (62_IrrCim) of the Bostwick Park Project via the Cimarron Canal. The administration number for this operating rule is just junior to Silverjack Reservoir's storage right. The amount of water released is limited by the amount currently in the irrigation account, and the unsatisfied demand at the ditch.

Operating rule 2 releases water to meet storage target values for Silverjack Reservoir. The junior administration number insures this is the last operating rule to fire. This rule is specifically used in the historical simulation for calibration efforts, when end-of-month target values are set to historical end-of-month reservoir contents. For the Baseline data set, end-of-month targets for Silverjack Reservoir are set to capacity, so releases to target are never made.

Operating rules 3 and 8 allow both the irrigation (62_IrrCim) and municipal demands (Cerro Reservoir) to be served by the Cimarron Canal's three water rights. The administration numbers for these operating rules correspond to the three Cimarron Canal direct diversion rights. The amount of water delivered is limited to water physically and legally available under the carrier ditch (Cimarron Canal) rights, and either unsatisfied demand at 62_IrrCim or storage capacity in Cerro Reservoir.

Cerro Reservoir is operated to meet demands of Project 7 water users and has very little holding capacity. There is no modeled inflow to Cerro Reservoir – all water is delivered through the Cimarron Canal.

### 5.8.10 Project 7 Water Authority

Project 7 (Proj_7) provides domestic and municipal water treatment and is responsible for supplying a raw water supply to its members. Project 7 has no direct diversion or storage rights. Demand in the Gunnison Model is satisfied from releases from Cerro and Fairview reservoirs. A portion of Project 7 supply is delivered from the City of Montrose's ownership in the Cimarron Canal to Cerro Reservoir. Montrose does not have any entitlement to Silverjack Reservoir storage water. Project 7 is also provided water, by agreement, from UVWUA sources via the Gunnison tunnel to Fairview Reservoir, in exchange for storage in Ridgway Reservoir.

Both Cerro Reservoir and Fairview Reservoir are modeled with one Project 7 account for 650 and 350 acre-feet respectively. Two operating rules are used to simulate Cerro and Fairview Reservoir releases to meet Project 7 demands:

| Right # | Destination | Account or Carrier | Admin # | Right Type | Description |
|---|---|---|---|---|---|
| 1 | Project 7 | Cerro Reservoir | 27585.27547 | 2 | Release to direct diversion |
| 2 | Project 7 | Fairview Reservoir | 27585.27547 | 2 | Release to direct diversion |

Operating rule 1 releases water from Cerro Reservoir to Project 7 demand. The administration number for this operating rule is just junior to the Cimarron Canal rights. The amount of water released is limited by the available capacity in Cerro Reservoir, and the unsatisfied Project 7 demand.

Operating rule 2 releases water from Fairview Reservoir to Project 7 demand. The administration number for this operating rule is just junior to the Cimarron Canal rights. The amount of water released is limited by the available capacity in Fairview Reservoir, and the unsatisfied Project 7 demand.

### 5.8.11 Fruitgrowers Dam Project

The Fruitgrowers Dam Project furnishes a dependable irrigation water supply in the Tongue Creek and Alfalfa Run area. Inflow to the reservoir originates from Alfalfa Run from Tongue and Surface Creeks. Water releases are delivered to project lands through a privately owned system of canals and laterals.

Fruitgrowers Reservoir is modeled with two accounts, which are listed.

| Acct | Owner | Capacity (acre-feet) |
|---|---|---|
| 1 | Irrigation | 4,460 |
| 2 | Dead Pool | 80 |

Eleven operating rules are used to simulate Fruitgrowers operations:

| Right # | Destination | Account or Carrier | Admin # | Right Type | Description |
|---|---|---|---|---|---|
| 1 | Alfalfa D Irrigation | Alfalfa Ditch | 11674.00000 | 11 | Carrier to diversion |
| 2 | Alfalfa D Irrigation | Alfalfa Ditch | 22370.00000 | 11 | Carrier to diversion |
| 3 | Alfalfa D Irrigation | Alfalfa Ditch | 29260.23550 | 11 | Carrier to diversion |
| 4 | Alfalfa D Irrigation | Alfalfa Ditch | 56978.11674 | 11 | Carrier to diversion |
| 5 | Fruitgrowers Reservoir | Alfalfa Ditch | 20501.17820 | 11 | Carrier to reservoir |
| 6 | Fruitgrowers Reservoir | Alfalfa Ditch | 38064.17820 | 11 | Carrier to reservoir |
| 7 | Fruitgrowers Reservoir | Transfer Ditch | 27528.00000 | 11 | Carrier to reservoir |
| 8 | Fruitgrowers Reservoir | Transfer Ditch | 29261.00000 | 11 | Carrier to reservoir |
| 9 | Alfalfa Irrigation | 1 | 56978.11675 | 7 | Exchange to Carrier |
| 10 | Stell Enlargement Ditch | 1 | 38064.31951 | 2 | Release to direct diversion |
| 11 | Opr Fruitgrowers to Target | 1 | 99999.99999 | 9 | Release to river by target |

Operating

Operating rules 1 through 4 allow water to be carried to the Alfalfa Ditch Irrigation (400751_I) demand via Alfalfa Ditch (400751). The administration numbers for these operating rules correspond to Alfalfa Ditch's irrigation water rights. The amount of water delivered is limited to water physically and legally available under the carrier ditch (Alfalfa ditch) rights, and irrigation demand.

Operating rules 5 and 6 allow Fruitgrowers Reservoir to fill through the Alfalfa Ditch (400751). The administration numbers for these two operating rules correspond to the Alfalfa Ditch diversion rights that include storage as a use. The amount of water delivered is limited to water physically and legally available under the carrier ditch (Alfalfa Ditch) rights, and storage capacity in Fruitgrowers Reservoir.

Operating rules 7 and 8 allow Fruitgrowers Reservoir to fill through the Transfer Ditch (400821). The administration numbers for these two operating rules correspond to the two Transfer Ditch direct diversion rights. The amount of water delivered is limited to water physically and legally available under the carrier ditch (Transfer Ditch) rights, and storage capacity in Fruitgrowers Reservoir.

Operating rule 9 allows releases from Fruitgrowers Reservoir irrigation account to meet the supplemental needs of Alfalfa Ditch Irrigation demands (400751_I). The administration number is just junior to Alfalfa Ditch's direct diverion rights. The amount of water delivered is limited to water available in the irrigation account and unsatisfied irrigation demand.

Operating rule 10 allows releases from Fruitgrowers Reservoir irrigation account to meet the supplemental needs of Stell Enlargement Ditch (aka Fogg Ditch 400820). The administration number is just junior to Fruitgrowers first two storage rights. The amount of water delivered is limited to water available in the irrigation account and unsatisfied ditch demand.

Operating rule 11 releases water to meet storage target values for Fruitgrowers Reservoir. The junior administration number insures this is the last operating rule to fire. This rule is specifically used in the historical simulation for calibration efforts, when end-of-month target values are set to historical end-of-month reservoir contents. For the Baseline data set, end-of-month targets for Fruitgrowers Reservoir are set to capacity, so releases to target are never made.

### 5.8.12 Other Operating Rules

A type 22 operating rule is also used in the Baseline data set. This 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 Gunnison 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 structure parameter file (*.par).

# 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 Gunnison model characterizes it, under these assumptions.

## 6.1 Baseline Streamflows

Table 6.1 shows, for each gage, the average annual flow from the Baseline simulation, based on the entire simulation period (1909 – 2005). 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 than 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. Variations of the Baseline data set could include conditional rights within the Gunnison basin, 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 6.11 for selected gages. Each figure shows two graphs: overlain hydrographs of historical gage flow, simulated gage flow, and simulated available flow for 1975 through 2005; and an average annual hydrograph based on the entire modeling 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 2005.

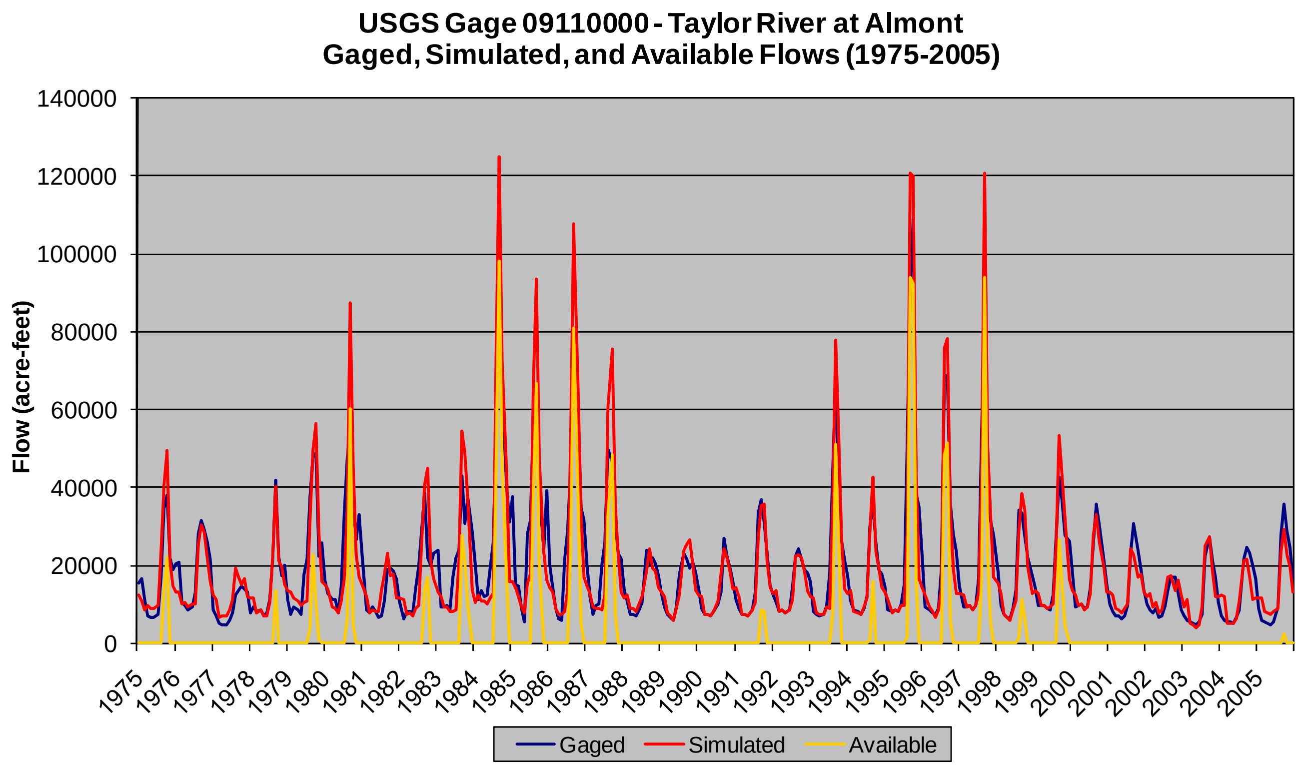
Baseline flows are generally higher than historical flows during the irrigation season on tributaries with significant storage and on the mainstem. This is, in part, due to increased reservoir releases required to meet the higher Baseline demands. In addition, all of the reservoirs included in the Gunnison model came on-line during the simulation period, and most of them came on-line since the 1960s. Their ability to re-regulate natural flow and provide supplemental water during the late irrigation season is not represented in the historical record for much of the study period, therefore not fully represented in the 1909 through 2005 graphs.

On the Gunnison River below Blue Mesa Reservoir, average monthly available flows exceed historical gaged flows during the irrigation season. This flow represents return flows as a result of increased use of storage water to meet Baseline demands. These increased return flows are available for downstream use.

**Table 6.1**
**Simulated and Available Baseline Average Annual Flows for Gunnison Model Gages (1909-2005)**

| Gage ID | Gage Name | Simulated Flow (af) | Simulated Available Flow (af) |
|---|---|---|---|
| 9109000 | Taylor River Below Taylor Park Reservoir | 148,666 | 42,853 |
| 9110000 | Taylor River at Almont | 238,981 | 50,601 |
| 9110500 | East River Near Crested Butte | 103,934 | 65,354 |
| 9111500 | Slate River Near Crested Butte | 97,609 | 64,245 |
| 9112000 | Cement Creek Near Crested Butte | 25,899 | 13,237 |
| 9112200 | East River Below Cement Creek NR Crested Butte | 234,855 | 147,033 |
| 9112500 | East River at Almont | 236,450 | 155,635 |
| 9113300 | Ohio Creek at Baldwin | 39,113 | 23,947 |
| 9113500 | Ohio Creek Near Baldwin | 57,921 | 36,006 |
| 9114500 | Gunnison River Near Gunnison | 512,649 | 323,835 |
| 9115500 | Tomichi Creek at Sargents | 45,507 | 16,045 |
| 9118000 | Quartz Creek Near Ohio City | 40,559 | 21,227 |
| 9118450 | Cochetopa Creek Below Rock Creek Near Parlin | 26,118 | 12,834 |
| 9119000 | Tomichi Creek at Gunnison | 123,164 | 89,625 |
| 9121500 | Cebolla Creek Near Lake City | 11,137 | 7,917 |
| 9121800 | Cebolla Creek Near Powderhorn | 52,983 | 32,421 |
| 9122000 | Cebolla Creek at Powderhorn | 72,392 | 51,299 |
| 9124500 | Lake Fork at Gateview | 174,664 | 115,411 |
| 9126000 | Cimarron River Near Cimarron | 70,083 | 28,003 |
| 9126500 | Cimarron River at Cimarron | 80,234 | 67,308 |
| 9127500 | Crystal Creek Near Maher | 23,824 | 1,185 |
| 9128000 | Gunnison River Below Gunnison Tunnel | 831,620 | 545,383 |
| 9128500 | Smith Fork Near Crawford | 32,937 | 7,663 |
| 9129600 | Smith Fork Near Lazear | 26,201 | 26,076 |
| 9130500 | East Muddy Creek Near Bardine | 63,349 | 56,367 |
| 9131200 | West Muddy Creek Near Somerset | 23,597 | 20,884 |
| 9132500 | North Fork Gunnison River Near Somerset | 338,325 | 252,096 |
| 9134000 | Minnesota Creek Near Paonia | 17,089 | 6,512 |
| 9134050 | Minnesota Creek at Paonia | 8,296 | 7,709 |
| 9134500 | Leroux Creek Near Cedaredge | 36,829 | 12,046 |

| Gage ID | Gage Name | Simulated Flow (af) | Simulated Available Flow (af) |
|---|---|---|---|
| 9135900 | Leroux Creek at Hotchkiss | 17,477 | 17,457 |
| 9136200 | Gunnison River Near Lazear | 1,211,298 | 1,118,564 |
| 9137050 | Currant Creek Near Read | 8,204 | 8,184 |
| 9137800 | Dirty George Creek Near Grand Mesa | 5,551 | 1,060 |
| 9139200 | Ward Creek Near Grand Mesa | 8,979 | 3,311 |
| 9141500 | Youngs Creek Near Cedaredge | 2,753 | 1,518 |
| 9143000 | Surface Creek Near Cedaredge | 31,707 | 2,890 |
| 9143500 | Surface Creek at Cedaredge | 22,204 | 2,891 |
| 9144200 | Tongue Creek at Cory | 32,811 | 32,668 |
| 9144250 | Gunnison River at Delta | 1,378,872 | 1,242,429 |
| 9146200 | East Fork Dallas Creek Near Ridgway | 123,264 | 73,724 |
| 9146400 | Dallas Creek Near Ridgway | 9,913 | 3,694 |
| 9146500 | Beaver Creek Near Ridgway | 18,821 | 8,394 |
| 9146550 | West Fork Dallas Creek Near Ridgway | 2,950 | 1,300 |
| 9147000 | Uncompahgre River Near Ridgway | 26,993 | 18,581 |
| 9147100 | Cow Creek Near Ridgway | 47,029 | 34,642 |
| 9147500 | Uncompahgre River at Colona | 190,284 | 87,606 |
| 9149420 | Spring Creek Near Montrose | 41,842 | 38,883 |
| 9149500 | Uncompahgre River at Delta | 228,090 | 225,635 |
| 9150500 | Roubideau Creek at Mouth, Near Delta | 95,292 | 94,982 |
| 9152000 | Kannah Creek Near Whitewater | 22,137 | 11,195 |
| 9152500 | Gunnison River Near Grand Junction | 1,814,855 | 1,374,027 |



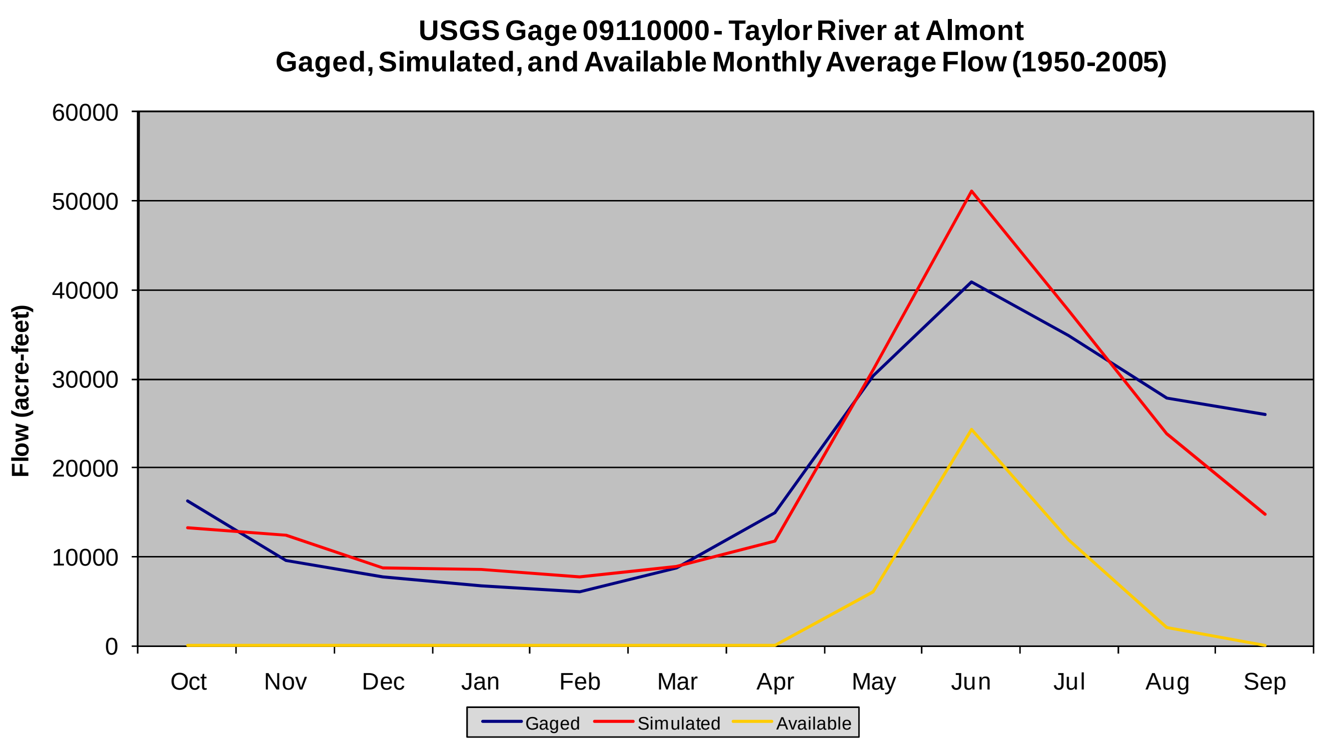
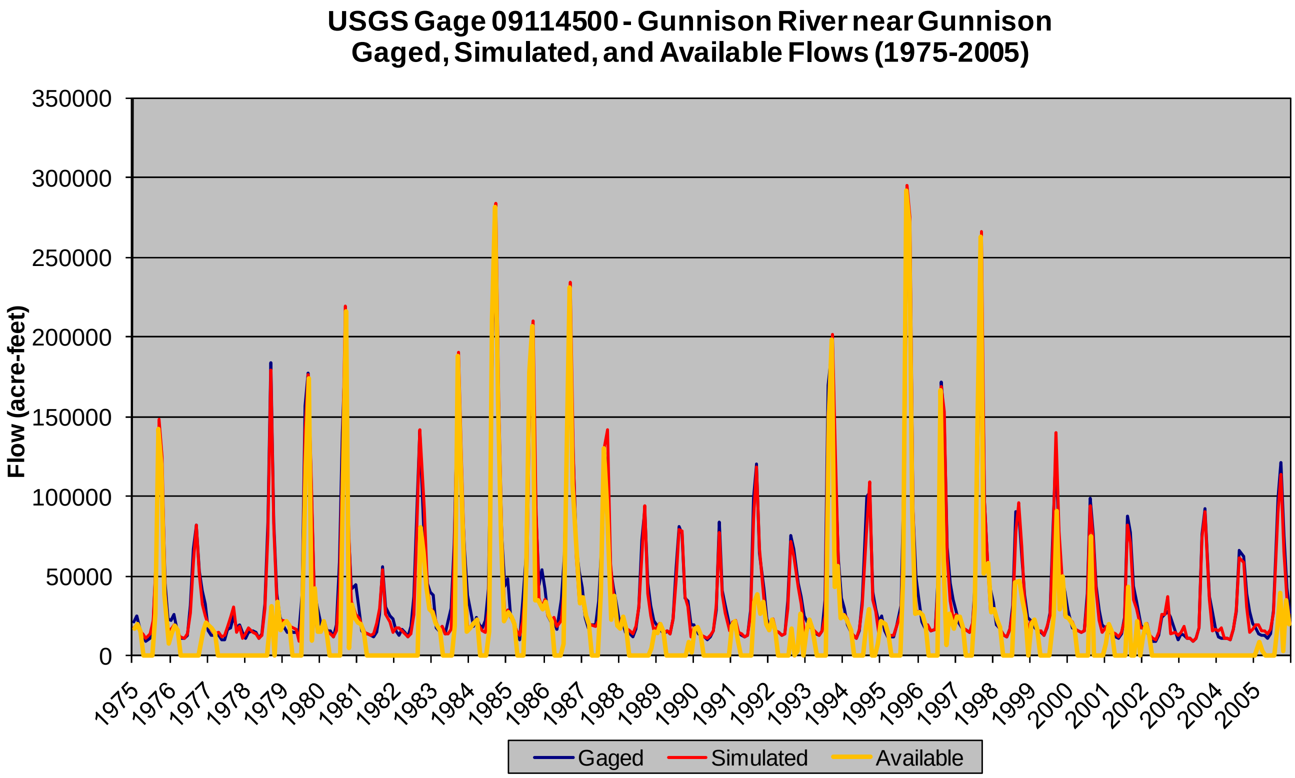




**Figure 6.1 Baseline Results – Taylor River at Almont**



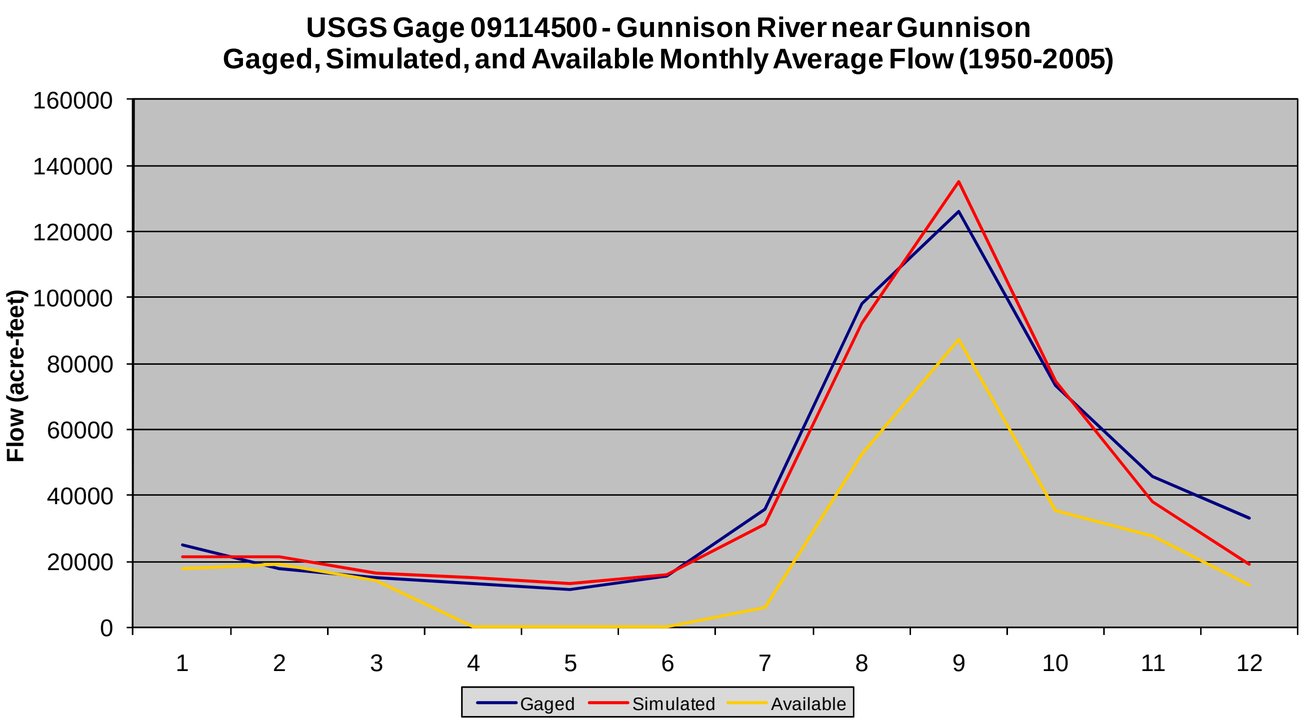
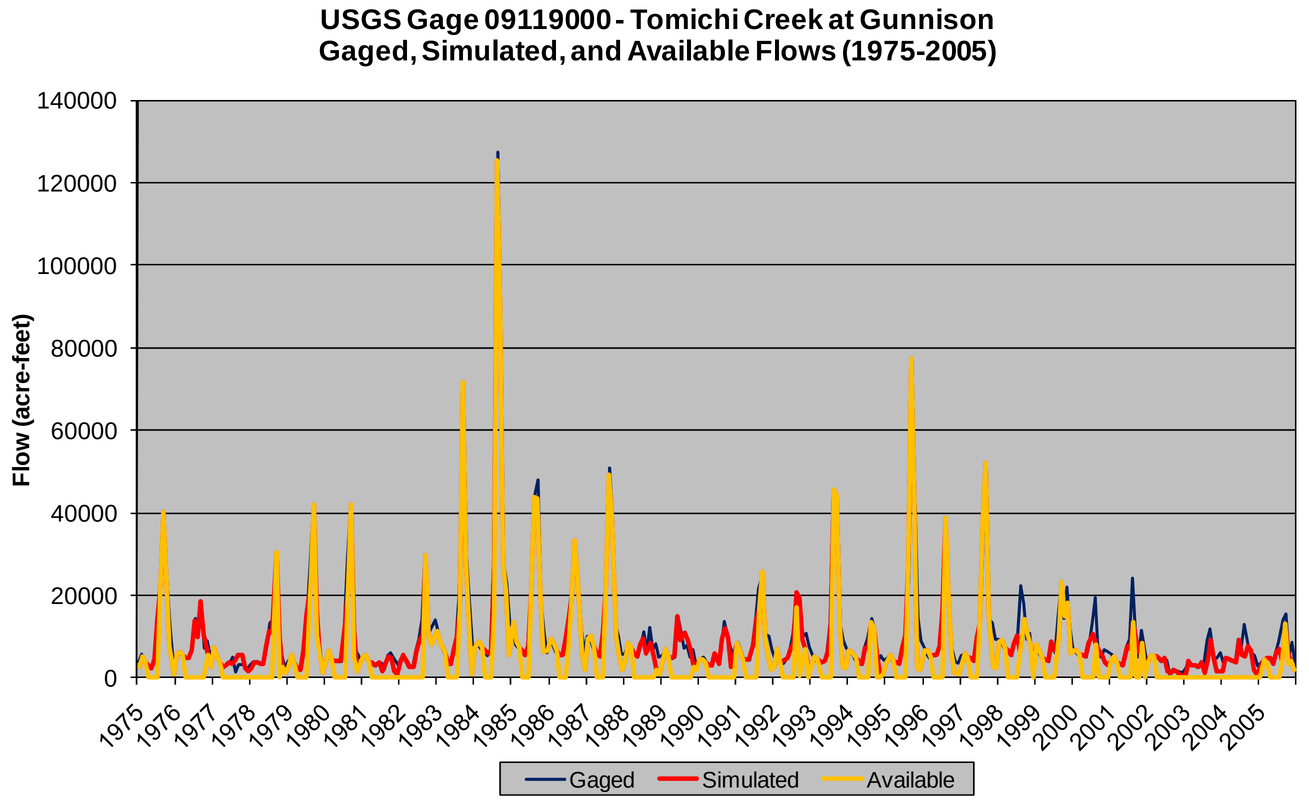




**Figure 6.2 Baseline Results – Gunnison River near Gunnison**



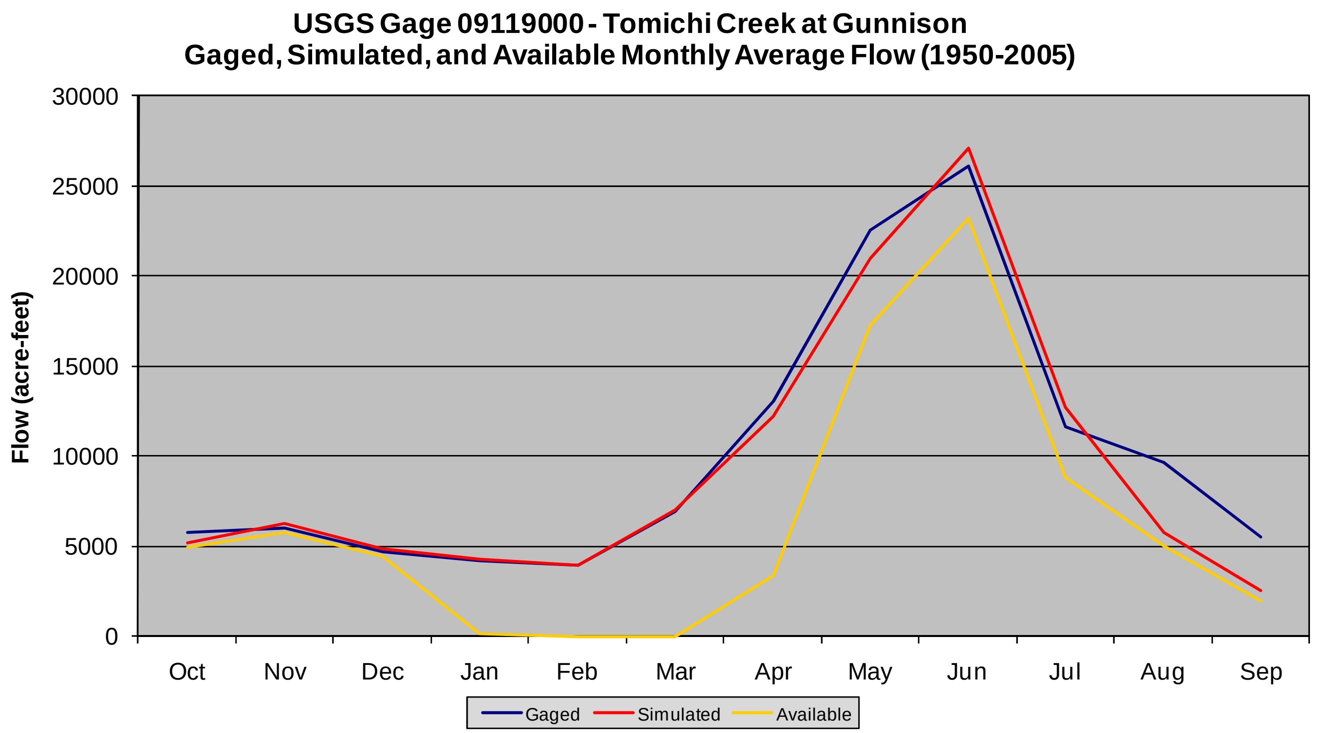
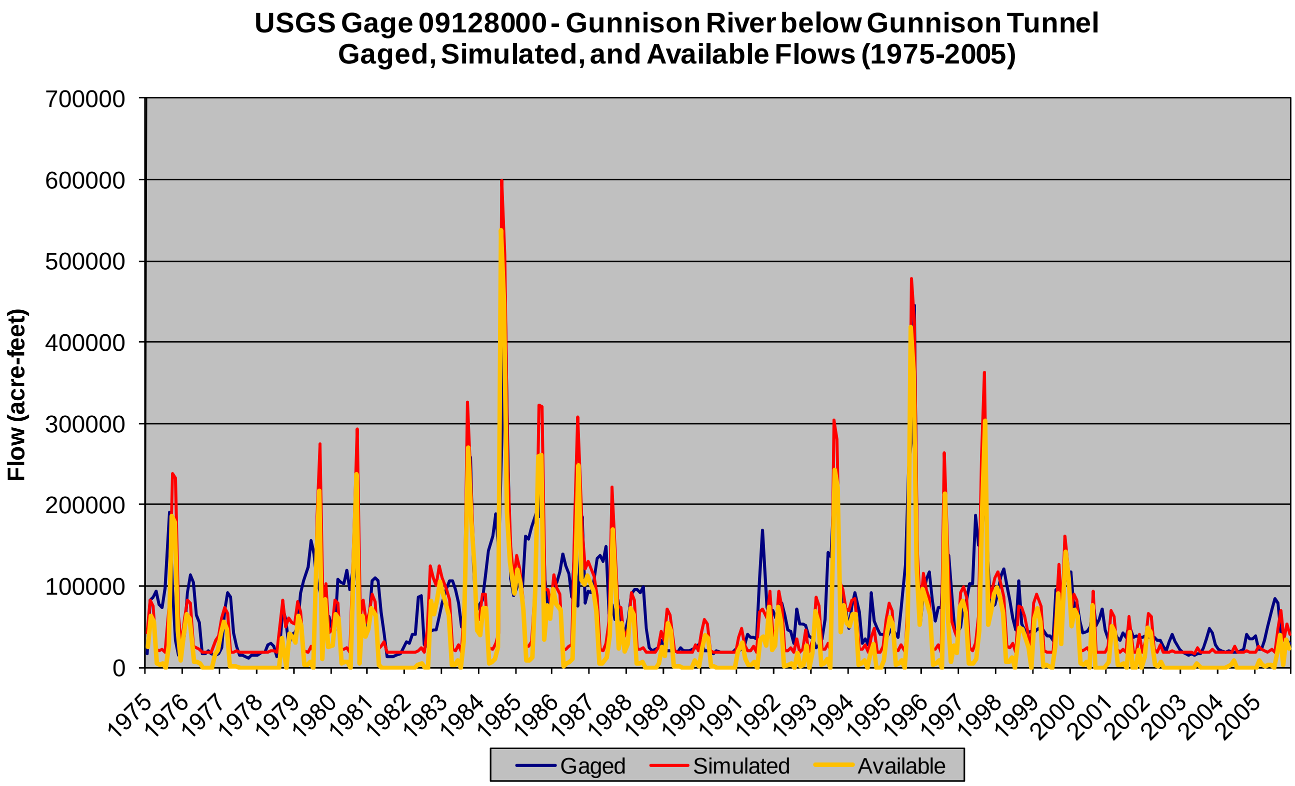




**Figure 6.3 Baseline Results – Tomichi Creek at Gunnison**



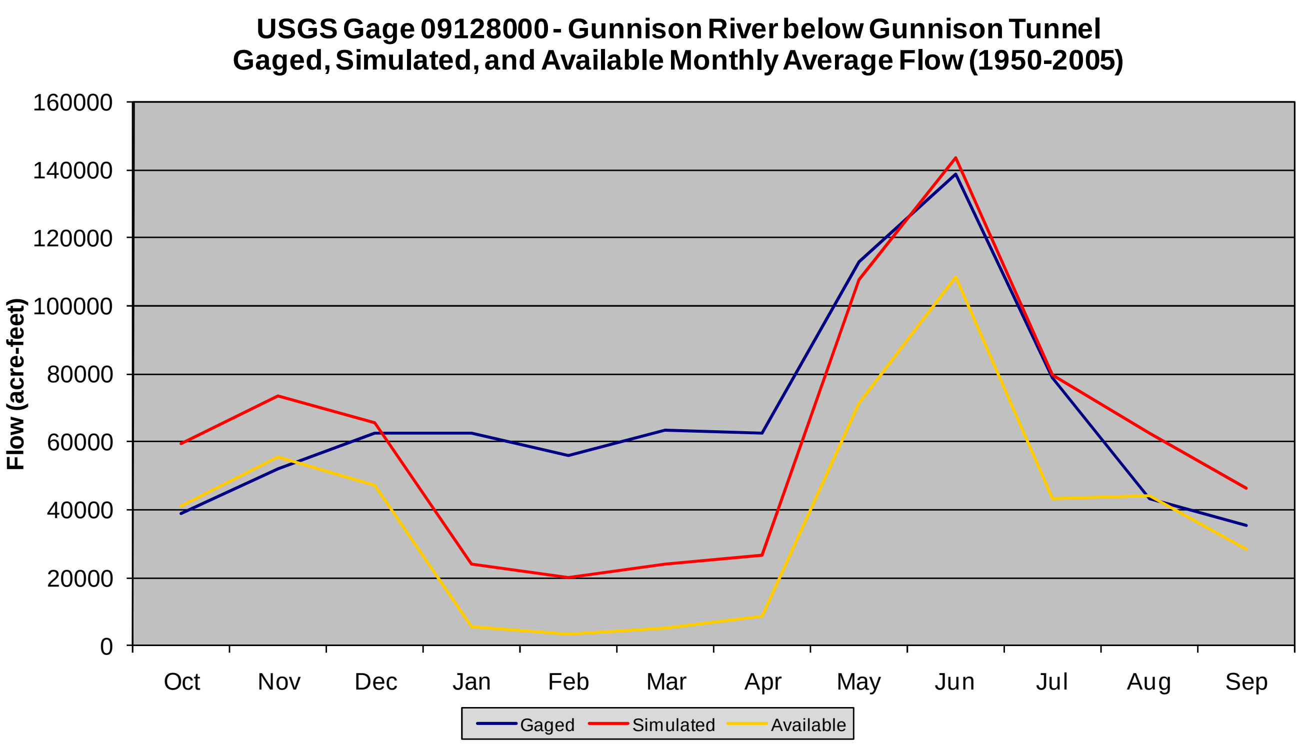
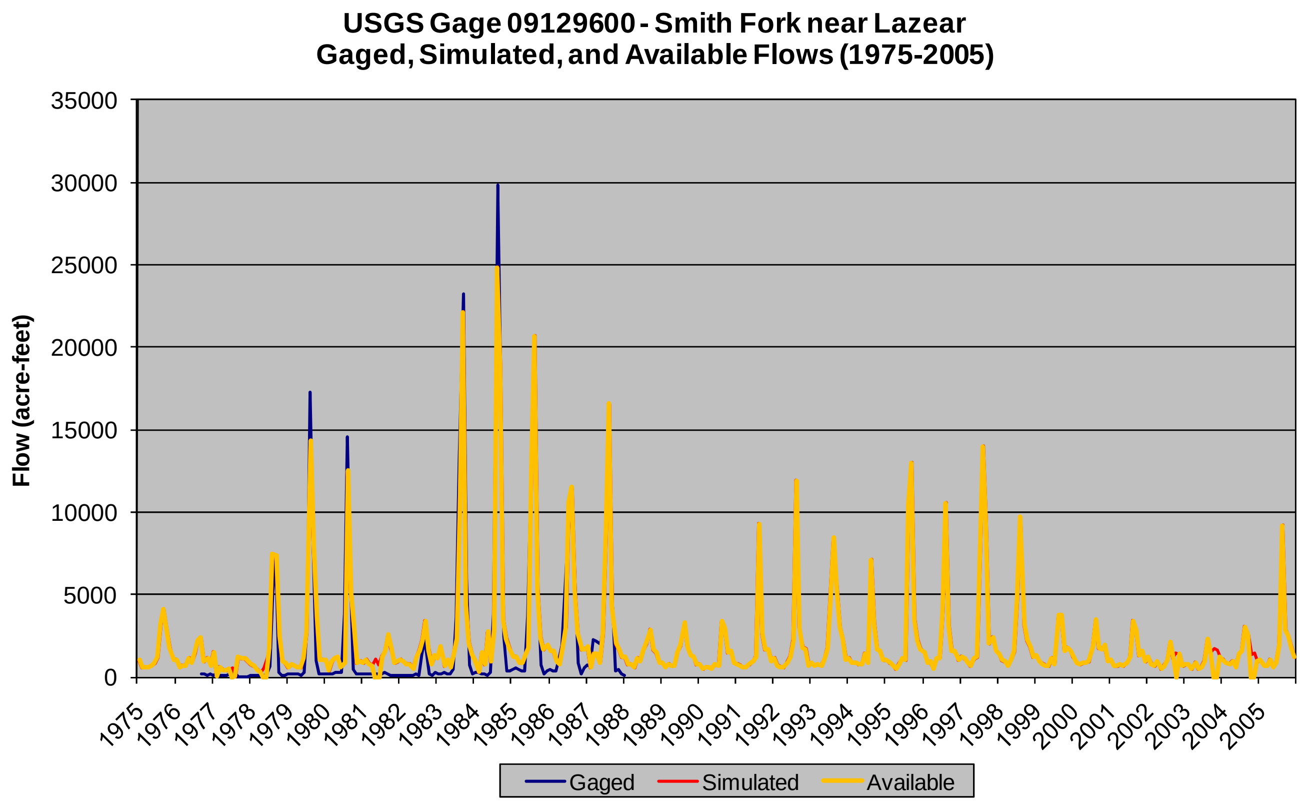




**Figure 6.4 Baseline Results – Gunnison River below Gunnison Tunnel**



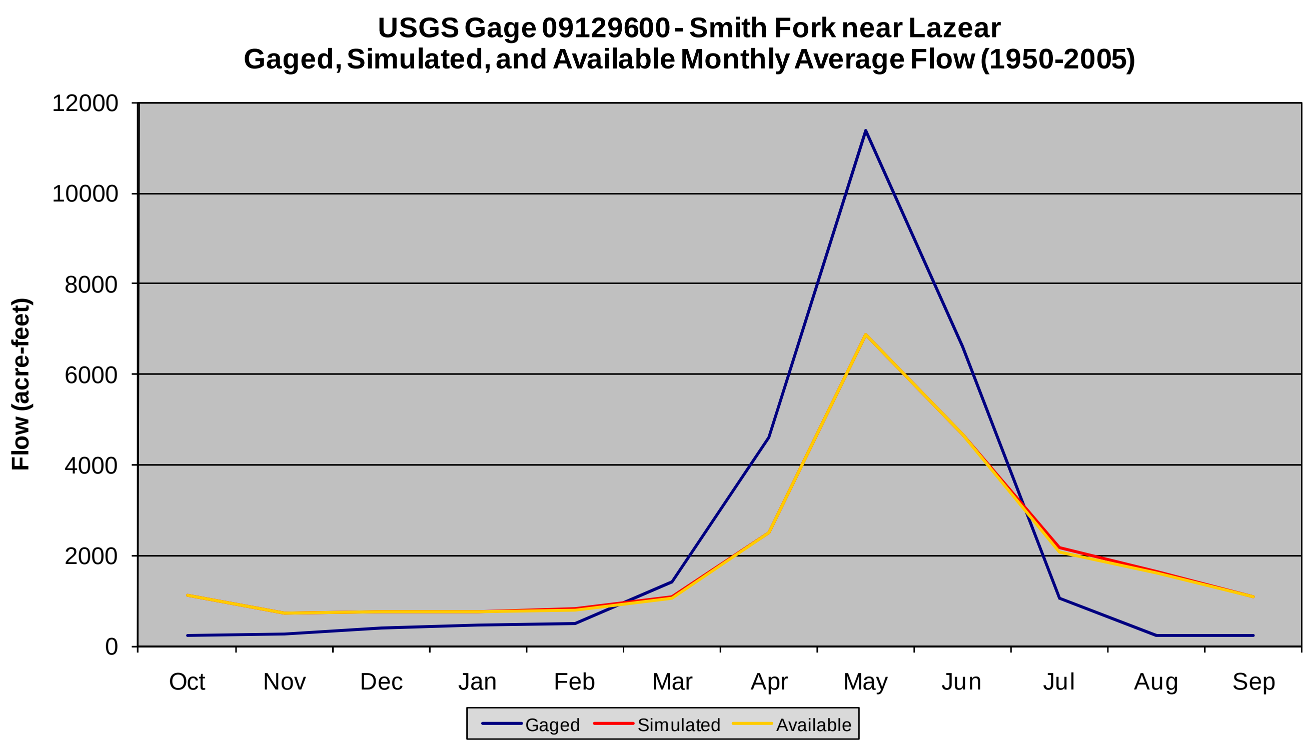
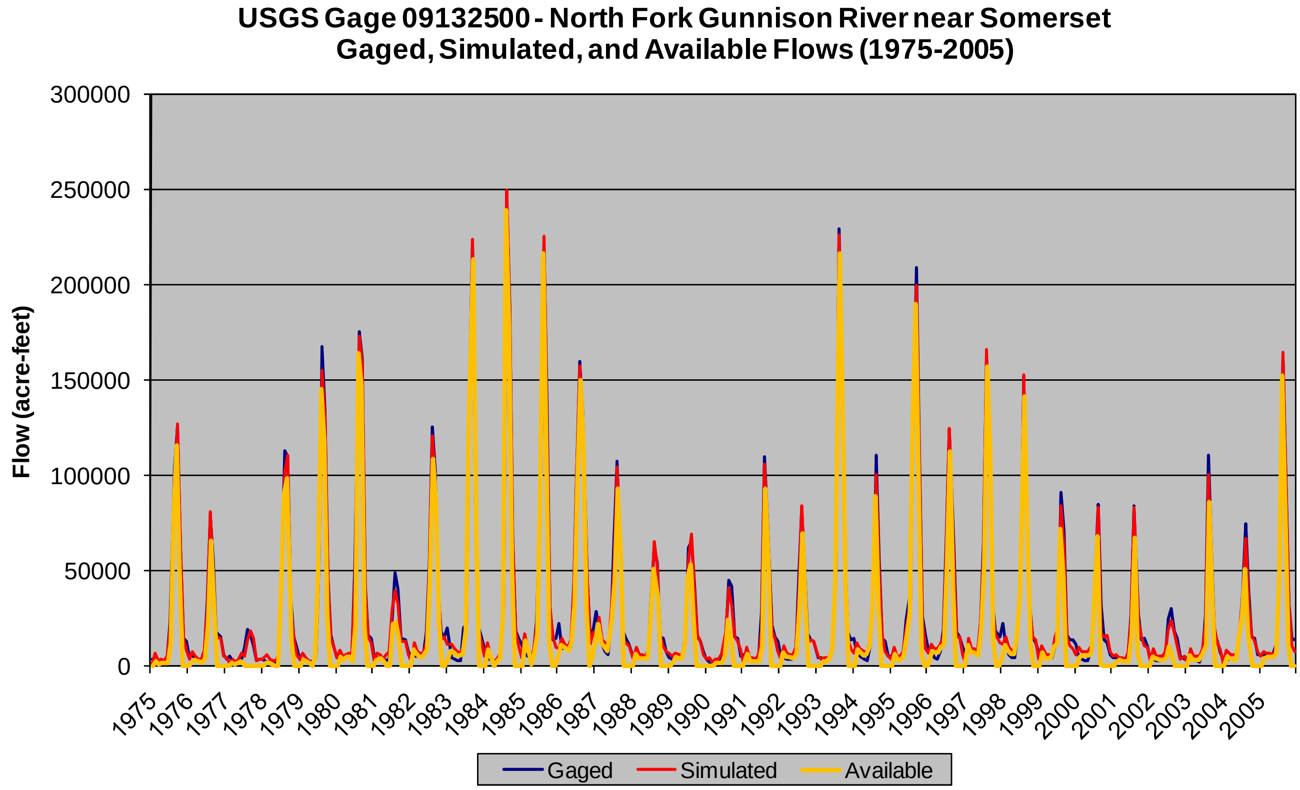




**Figure 6.5 Baseline Results – Smith Fork near Lazear**



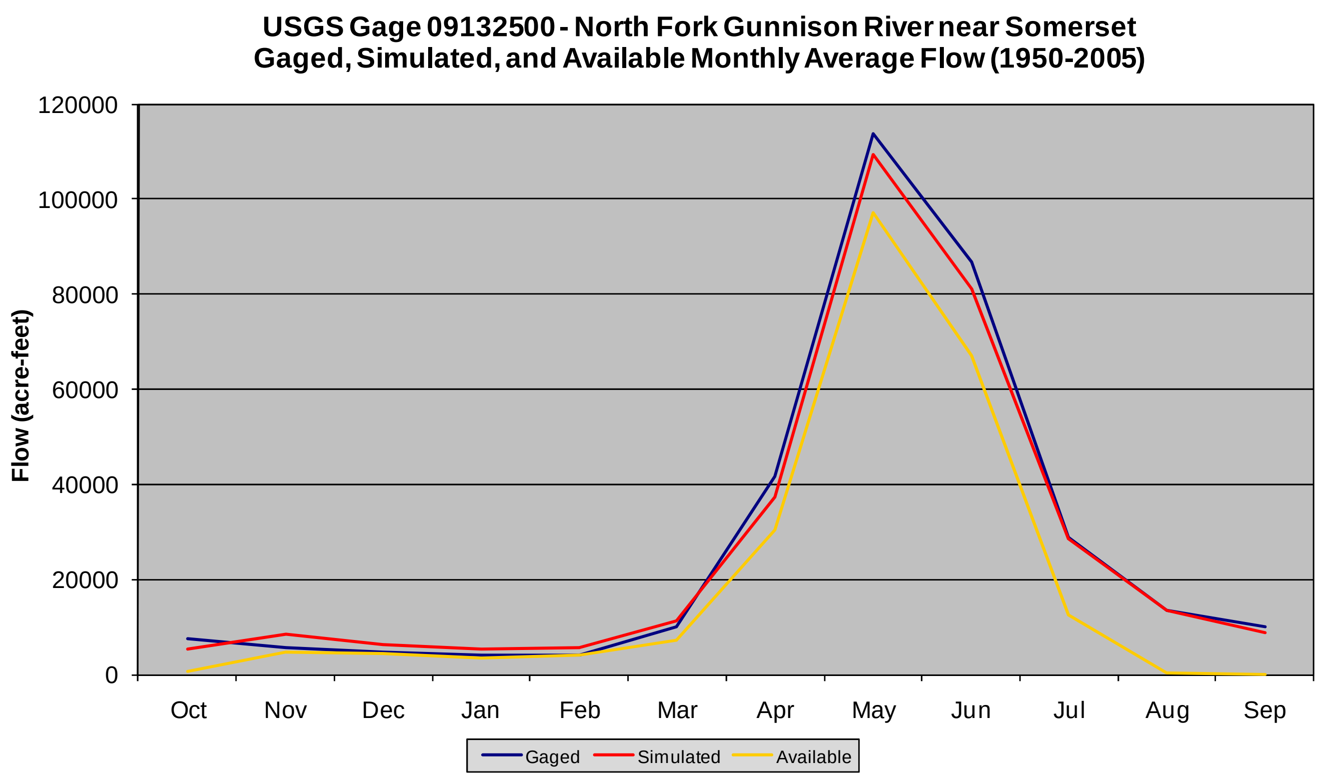
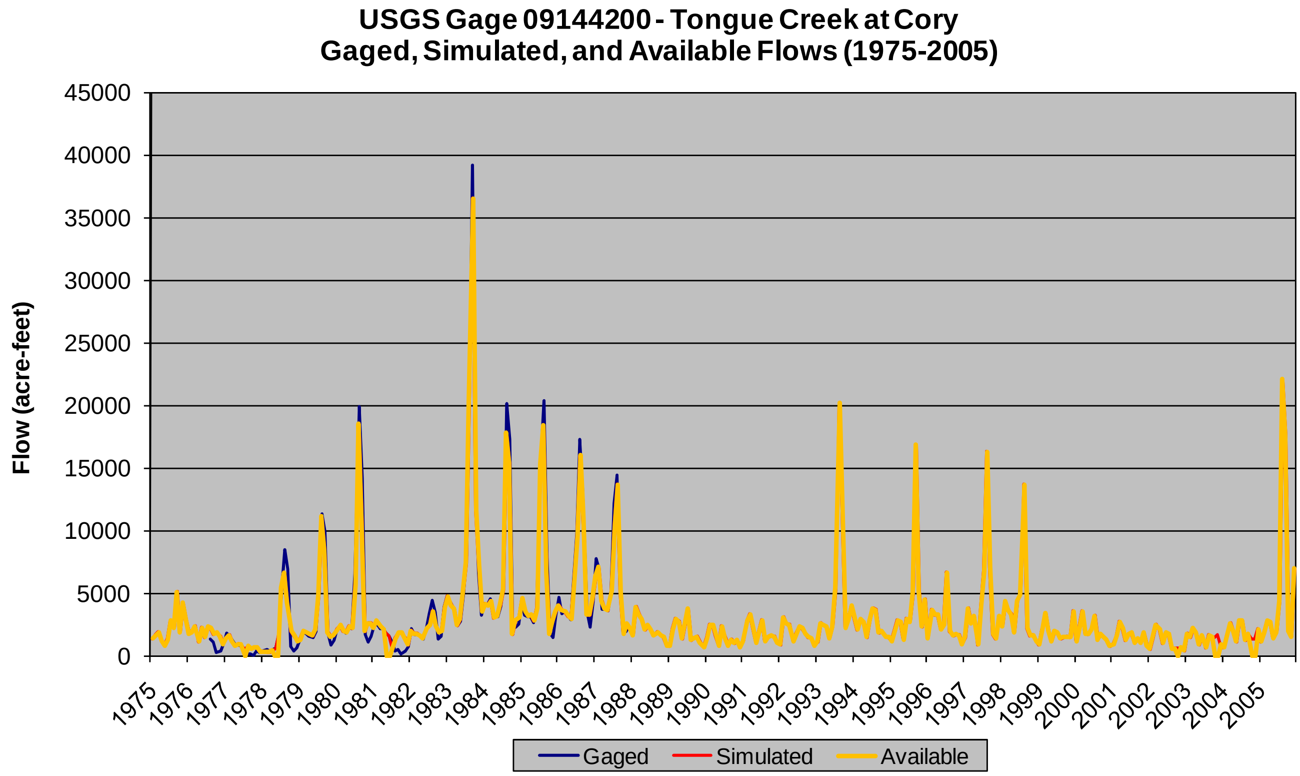




**Figure 6.6 Baseline Results – North Fork Gunnison River near Somerset**



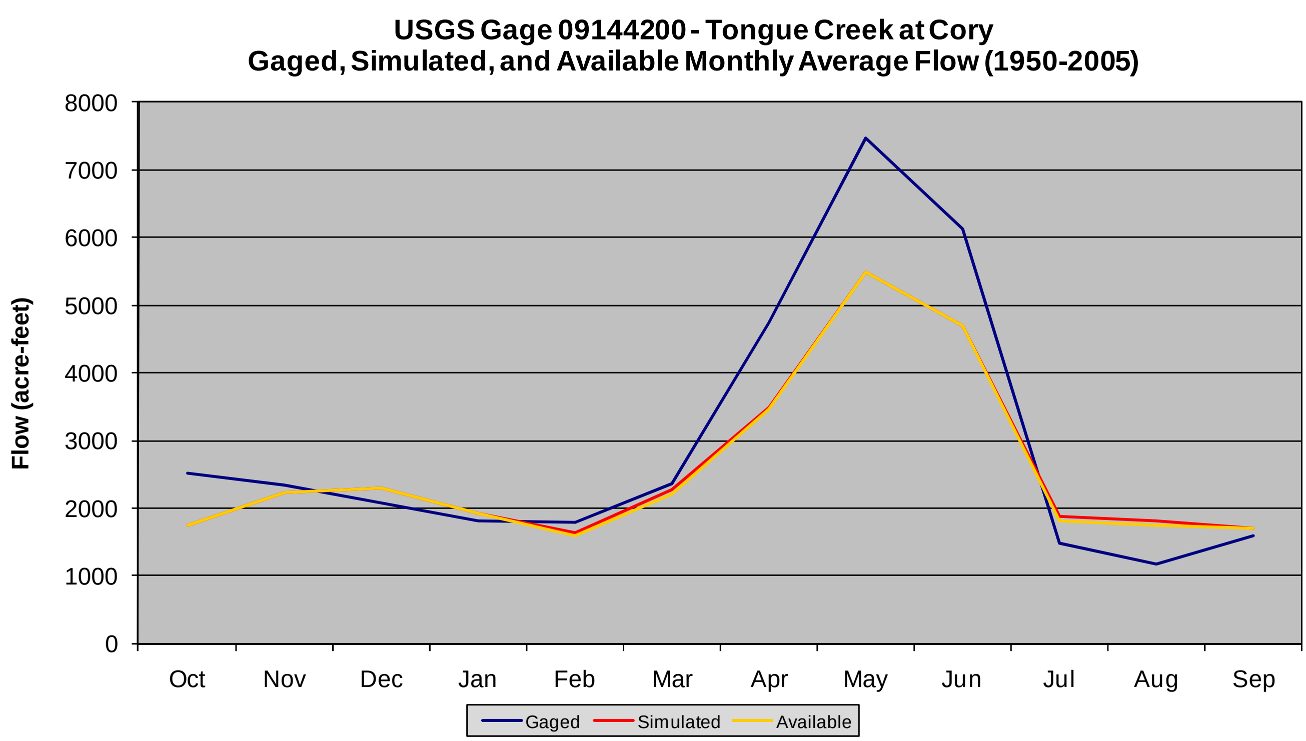
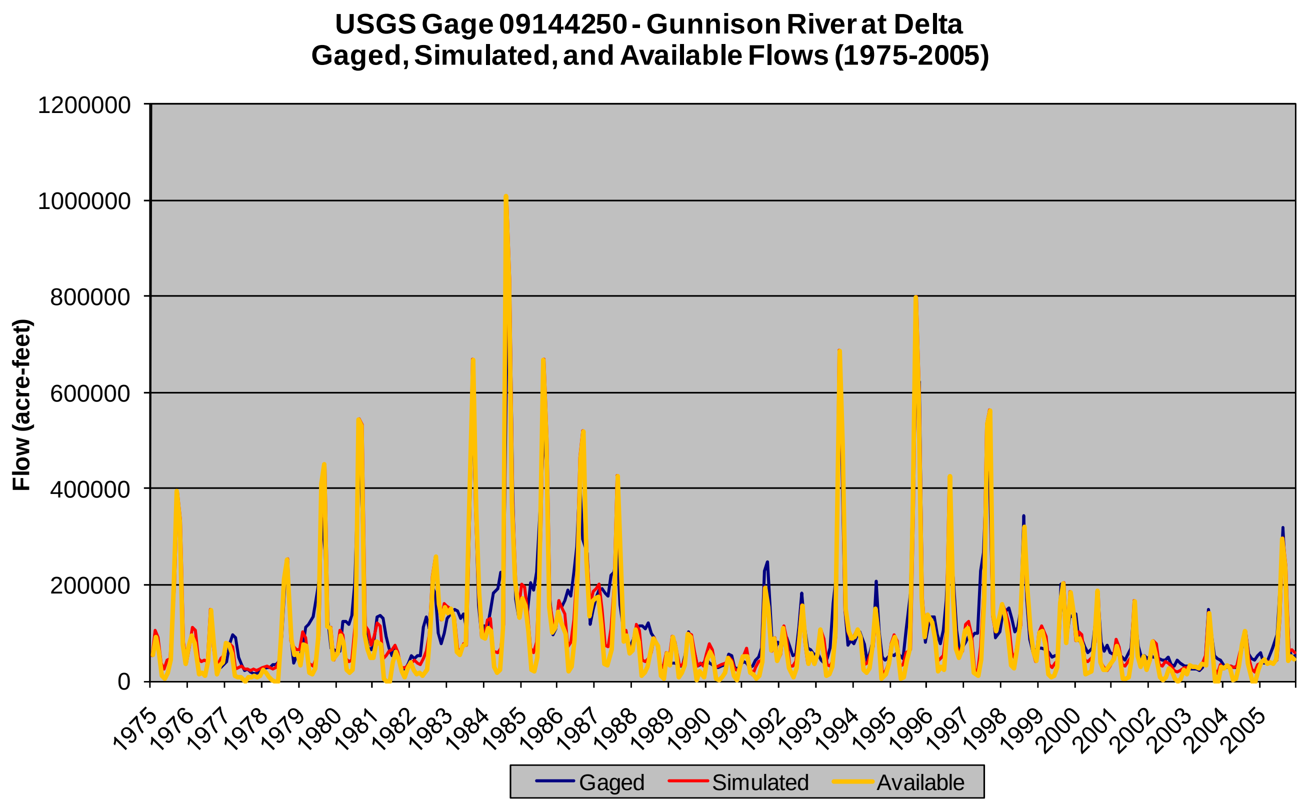




**Figure 6.7 Baseline Results – Tongue Creek at Cory**



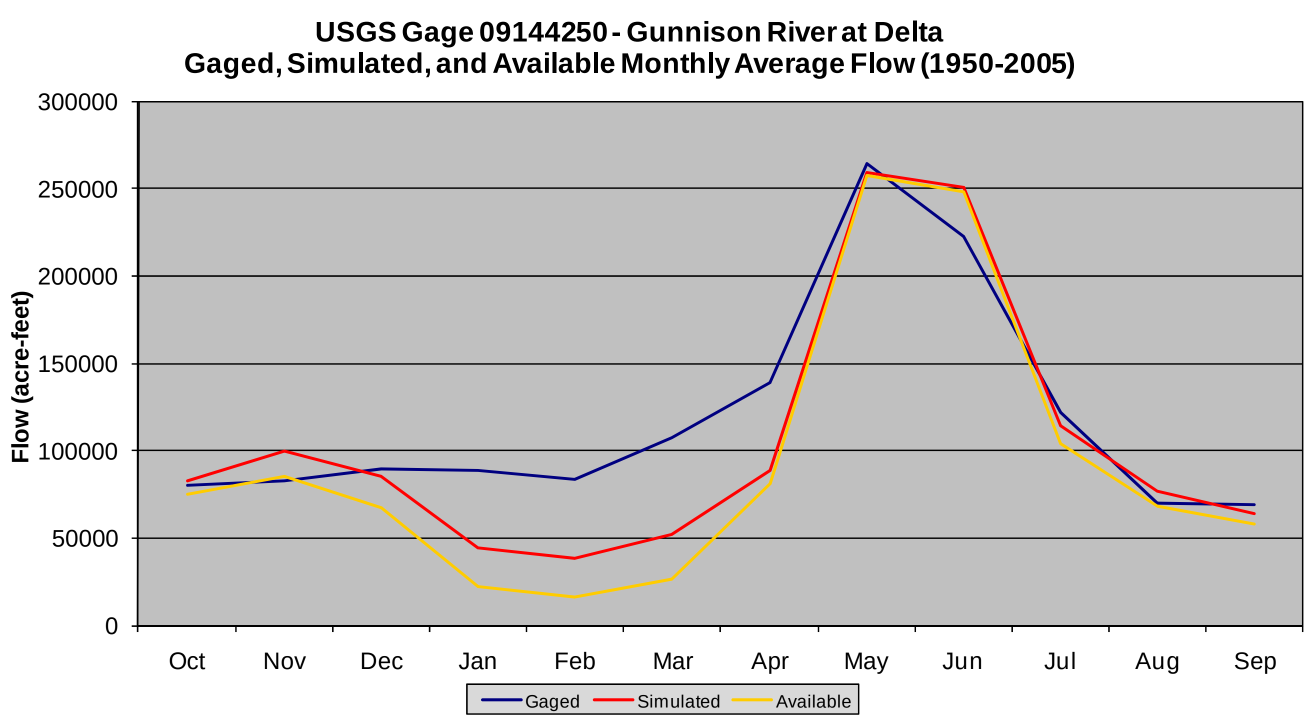
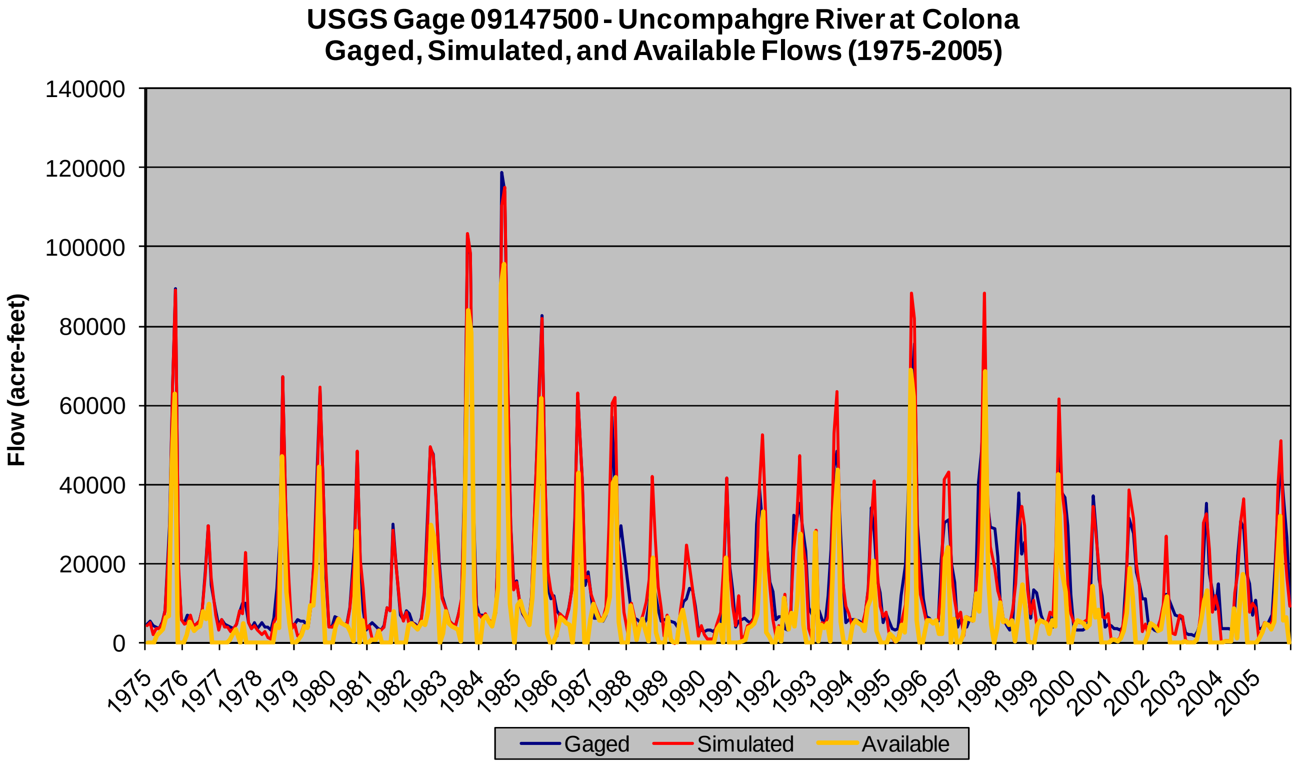




**Figure 6.8 Baseline Results – Gunnison River at Delta**



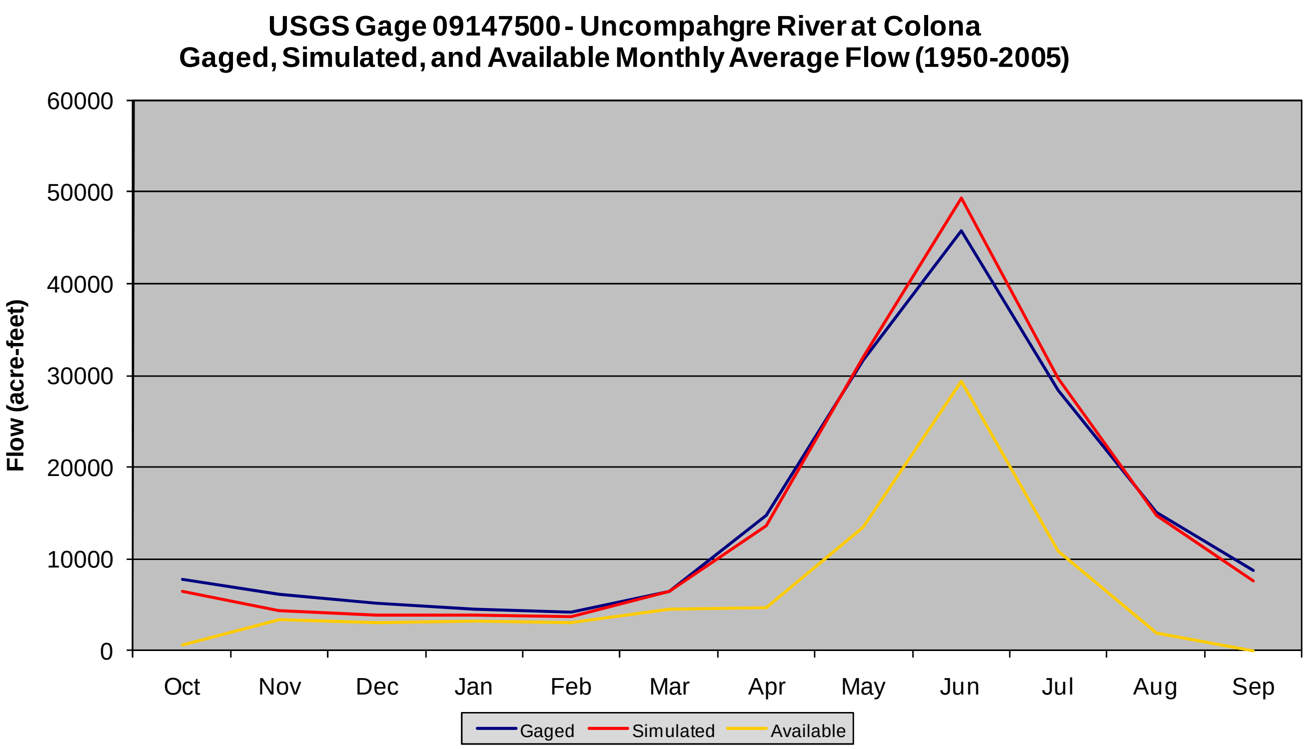
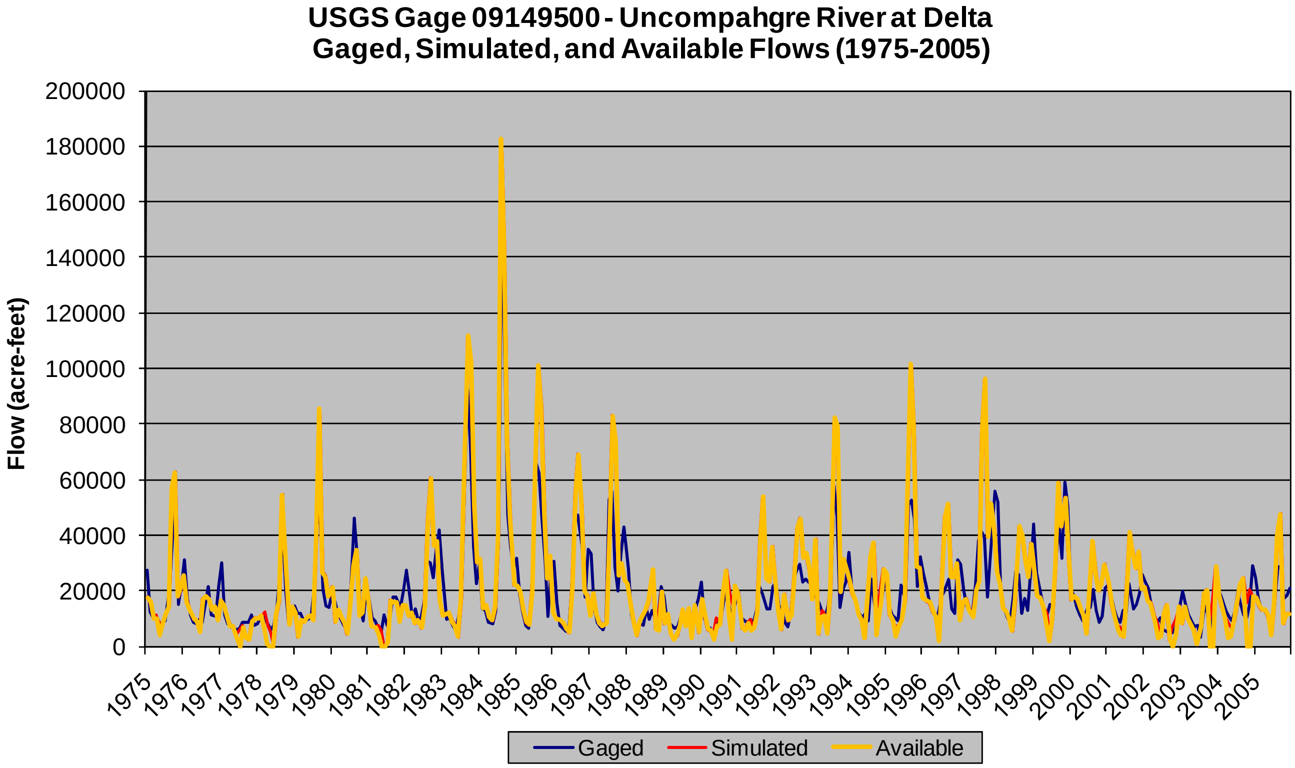




**Figure 6.9 Baseline Results – Uncompahgre River at Colona**



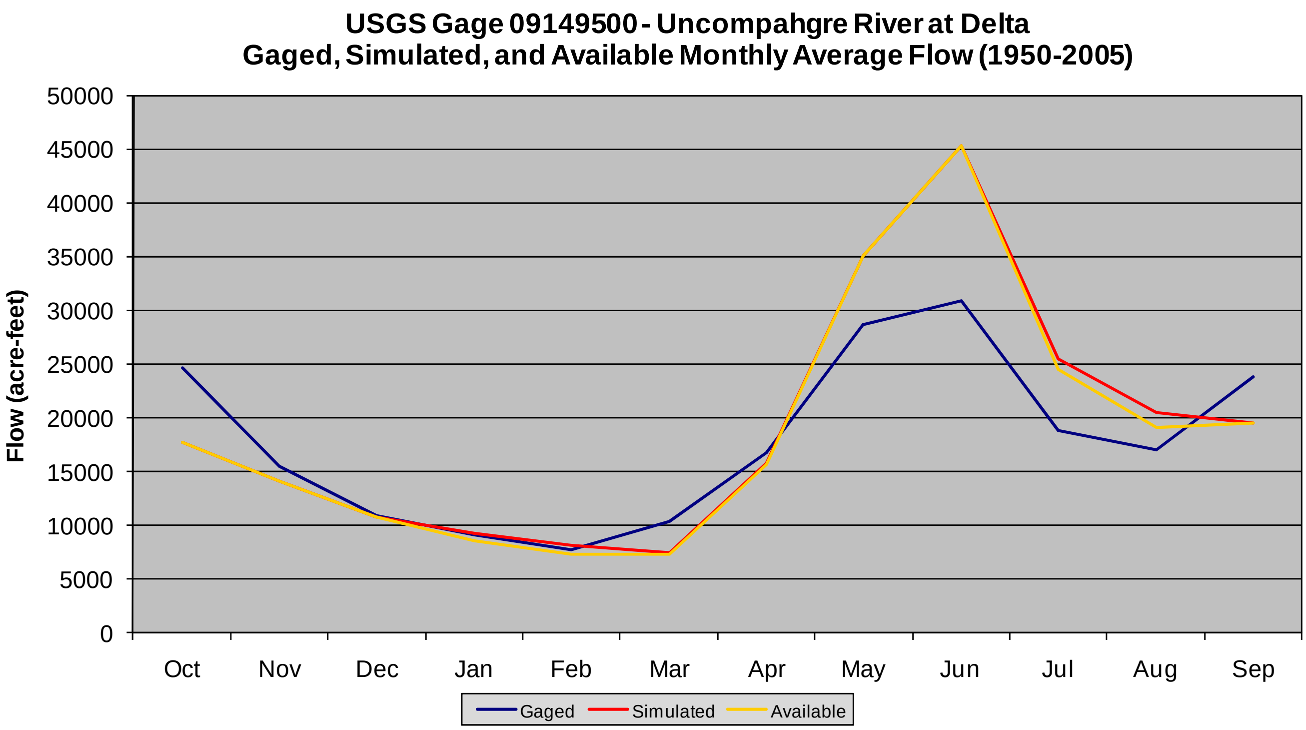
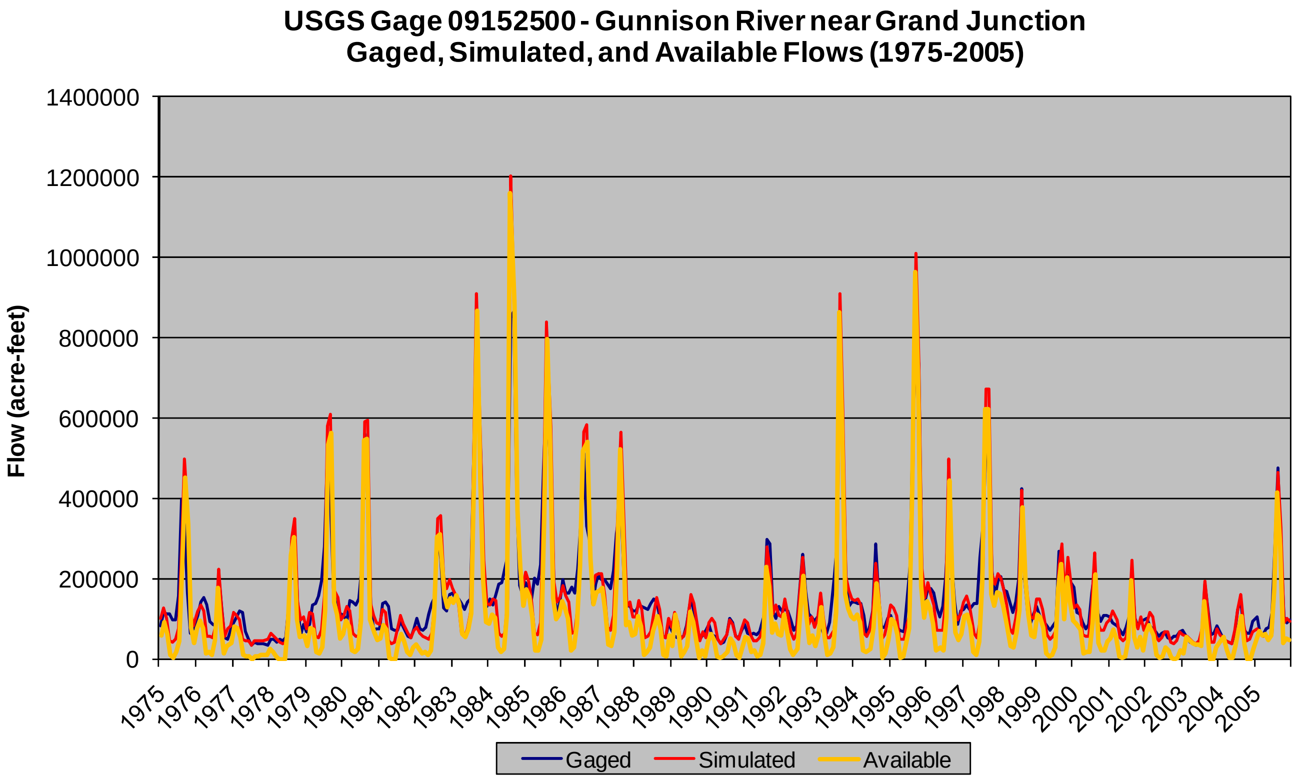




**Figure 6.10 Baseline Results – Uncompahgre River at Delta**



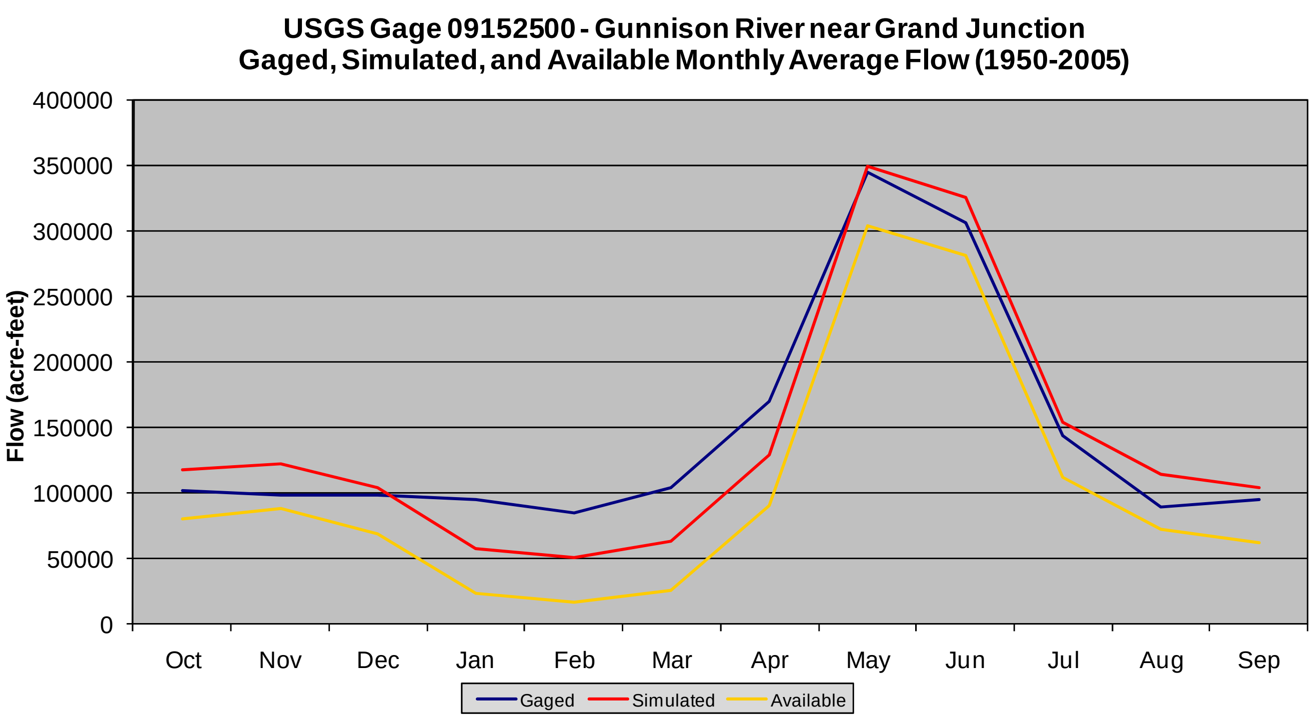




**Figure 6.11 Baseline Results – Gunnison River near Grand Junction**

# 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 Gunnison model. It describes specific areas of the basin that were worked on, and it presents summaries comparing modeled results for 1975 through 2005 with historical values for the period.

## 7.1 Calibration Process

The Gunnison model was calibrated in a two-step process, based on the period 1975 through 2005. 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 occured. 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, operations were generalized. Reservoirs responded to demands, and were permitted to seek the level required to meet the demands. Model results were again scrutinized, 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. 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 the vagaries of operations that cannot be predicted – headgate maintenance, dry-up periods, and so on.

Demands for irrigation multi-structures and carrier structure diversions were placed at the point of diversion. These include the Gunnison Tunnel (620617), the Cimarron Canal (620560), the multi-structure system of Aspen Canal (400509), and Needle Rock Ditch (400501), and the multi-structure system of Aspen Ditch (400508) and Grandview Canal (400503). In the Baseline data set, these demands were placed at the destination node, and operating rules drove the diversion from the individual headgates.

### 7.2.2. Direct Diversion Right File

The South and West Canals obtain their water directly from the Gunnison Tunnel and do not have water rights decreed from the Uncompahgre River. Both structures are included in the model network as diversions on the Uncompahgre River. For the historical simulation for calibration, water is delivered from the Gunnison Tunnel (620617) to the Uncompahgre River as an import to the system. To enable the modeled South and West Canals to benefit from modeled Tunnel deliveries, they are assigned 999 cfs direct flow rights with an administration number just junior to the Tunnel. These two direct flow rights are turned off in the Baseline data set, because they are supplied via operating rules that deliver Gunnison Tunnel water, either under the Tunnel's direct flow rights or from storage in Blue Mesa and Taylor Park Reservoirs. In the Historical calibration, these rights are turned on.

As noted above, for the historical simulation for calibration, water is delivered from the Gunnison Tunnel (620617) to the Uncompahgre River as an import to the system. Therefore, the UVWUA's good neighbor policy is represented by historical diversions through the tunnel. All water rights assigned to the UVWUA ditches are active in the Historical data set.

### 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 to zero (as they were historically in 1909), 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, storage targets are set to the reservoir's capacity as soon as the reservoir comes on-line. Exceptions were made for reservoirs known to operate by power or flood control curves, and regulating reservoirs. In these cases, which include Taylor Park, Blue Mesa, and Paonia reservoirs, targets were developed to express the operations. Targets were set to historical end-of-month contents for Morrow Point and Crystal Reservoirs; both operate essentially as regulating reservoirs for Aspinall Unit power generation. In addition, as discussed below in Section 7.3.5, Ridgway Reservoir targets were also set to historical end-of-month.  If capacity of a reservoir changed midway through the study period, the Historical model takes the enlargement into account (not applicable in the Gunnison model.)

### 7.2.4.  Operational Rights File

The reservoir storage targets and the operating rules (the *.opr file) 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 7.2.2. 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 relased 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 supply, based on historical efficiency<br>▪ Non-irrigation structures – estimated current demand<br>▪ Demands placed on primary structures of multi-structure systems and demands placed at carrier structure headgates | ▪ Historical diversions<br>▪ Historical diversions for multi-structures and carrier structures are set to historical diversions |
| Direct Rights (*.ddr) | ▪ Uncompahgre Valley Water Users Association Junior Rights are turned off | ▪ Uncompahgre Valley Water Users Association Junior Rights are turned on and direct diversion water rights are set for South and West Canals |
| Reservoir station (*.res) | ▪ Initial content = average September end-of month content | ▪ Initial content = 0. |
| Reservoir target (*.tar) | ▪ Current maximum capacity except reservoirs that release for flood control or power generation | ▪ First step – historical eom contents, 0 prior to historical operation<br>▪ Second step – historical maximum capacity, 0 prior to historical operation except Taylor Park, Blue Mesa, Paonia, and Ridgway as discussed above |
| Operational right (*.opr) | ▪ Operating rules drive diversions to demand destination through multi-structure and carrier structures<br>▪ 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<br>▪ 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 calibrations of the Gunnison model.

### 7.3.1. Aggregated Structures

Several revisions have taken place to aggregated structures throughout the modeling process, generally in attempt to reduce shortages. The 1993 Irrigated Acreage Coverage, used as the basis for the aggregation of smaller structures, was revised by Division 4 after the initial modeling efforts were completed. The revisions concentrated on correcting assignments of irrigated lands to the supplying ditch on the mainstem Gunnison and tributaries above the Aspinall Reservoirs. As a result of these revisions, new key structures were added to the model, and the aggregate structures were revised to represent the corrected acreage to supply associations. These efforts greatly helped to reduce shortages to aggregate structures in the upper basin.

### 7.3.2. Uncompahgre River Return Flows

In the first execution of the model in baseflow mode, the baseflow reach of the Uncompahgre River between the Delta gage and the Colona gage appeared to lose close to 100,000 af on an average annual basis. This value represented approximately 35 percent of the baseflow at the Delta gage. Furthermore, there were many negative baseflow estimates, which the model sets to zero. In the historical calibration simulation, the Uncompahgre River at Delta gage was high because when negative baseflows are set to zero, the total amount of water in the system is not conserved.

USGS topo quad maps were reviewed and return flow locations for the Uncompahgre Project ditches were re-examined. The maps indicated that a greater proportion of the ditches' returns might reach Roubideau Creek or the Gunnison River directly, rather than re-enter the Uncompahgre River. Modeled return flow locations were modified accordingly. In addition, discrepancies were found in the 1993 Irrigated Acreage Coverage, used in the modeling efforts to determine acreage, crop type, and corresponding crop irrigation water requirements. Approximately 10,000 acres of land in the Uncompahgre Valley were identified as irrigated, but had not been assigned to an irrigation structure. Based on review of the GIS coverage and conversations with Division 4, most of these lands were assigned to the Ironstone Canal.

Simulation of the Uncompahgre River at Delta gage, and both the gage and diversions on Roubideau Creek were greatly improved by these modifications. Historical simulation results in the Uncompahgre River at Delta gage are within 5 percent on average of historical gaged flows.

### 7.3.3. Tomichi Creek Basin

Many of the diversions on upper Tomichi Creek and its tributary, Cochetopa Creek, were shorted by more than 10 percent of their demand in the historical data simulation.  The basin-wide shortage for diversions on Tomichi Creek and its tributaries was 15 percent of demand.

Original work to aggregate irrigation structures placed an aggregate of 1,084 acres (28_ADG009) on Upper Tomichi Creek, and one of 1,855 acres (28_ADG011) on Cochetopa Creek. Flows were estimated for USGS gage 09117000 Tomichi Creek at Parlin, because there were no historical records available during the study period. The section above this gage was particularly water short. Thirteen structures originally aggregated in 28_ADG009, and seven structures originally aggregated in 28_ADG011, were removed from their respective aggregations and modeled explicitly. The simulation improved because (formerly aggregated) explicit structures were able to benefit from return flows from other (formerly aggregated) explicit structures. The filled USGS gage 09117000 was simply removed from the model. Node 28_ADG009 was made a baseflow node, and given the area and precipitation values originally assigned to gage 09117000.

The diversions on Hot Springs continued to be shorted more than on other Tomichi Creek tributaries.  The method for determining baseflow to Hot Springs was revised from the "gain" approach to the "neighboring gage" approach.

Shortages on Tomichi Creek were greatly reduced. Although many diverters in this sub-basin are still shorted in the Historical simulation, shortages are small in magnitude.  The basin-wide shortage has been reduced from 15 percent of demand to 5 percent of demand

### 7.3.4. Surface and Currant Creeks

Surface and Currant Creeks are related because many of the Surface Creek diversions return to Currant Creek. In addition, Fruitgrowers Reservoir, an offstream reservoir, is filled from Alfalfa Ditch on Surface Creek, and Transfer Ditch on Current Creek. The model did not simulate historical conditions well on either tributary in the preliminary runs. Many structures were shorted, and the tributary gages were overestimated.

Several different kinds of adjustments were made in these basins. The standard approach of making aggregate nodes above a gage into baseflow nodes was invoked. Return flows from Surface Creek to Currant Creek (as well as Alfalfa Run) were adjusted many times, always considering topography per USGS quad maps. The aggregated node 40_ADG031 on the mainstem was moved upstream, from below Tongue Creek to above Currant Creek. This step was taken because 40_ADG031 was calling out diverters on Tongue Creek, Surface Creek, and Current Creek. The aggregation area terminates above gage 09144250 Gunnison River at Delta, and the standard approach is to place the aggregated node at the downstream end of the aggregation area. In this case, however, nearly all the land lies above Currant Creek, and 40_ADG031 was calling out structures in the model that its component structures cannot actually call out.

Surface Creek and Currant Creek are better represented in the model, but both still experience basin-wide shortages. Because they are relatively small tributaries in the basin, additional calibration efforts were not warranted. Remaining shortages may be attributable to several factors as follows:

- diverters in the Tongue and Surface Creek basins are known to use small reservoirs on the south end of the Grand Mesa, and enjoy a neighborly trade-and-share approach to water management; facilities apparently exist to move water around, and diversion records may not reflect actual operations.

- data for the gage at the bottom of Tongue Creek and the gage at the bottom of Currant Creek had to be estimated from 1988 through 2005. Simulation is worse in these years than in the years when the gages were operating.

### 7.3.5. North Fork Reservoirs

Operations on several reservoirs on tributaries to the North Fork Gunnison River, including Overland Reservoir, Crawford Reservoir, and Fruitland Reservoir were not fully understood, and calibration of reservoir use was poor during the initial model development. Additional meetings were held with reservoir owner during the Colorado Water Availability Study to better understand and represent operations. Additional historical reservoir contents information was gathered to fill in missing data gaps, improving both baseflow estimates and calibration results. Several aggregate structures were split, and operating rules included to deliver reservoir water based on a complete list of reservoir users provided by the Water Commissioner. These revisions resulted in improve reservoir calibration for all reservoirs in Water District 40.

### 7.3.6. Calibration Reservoir Targets

In step 1 of calibration, EOM targets for all reservoirs were set to historical contents. In step 2, the standard approach for reservoirs that are supplemental irrigation or municipal supply is to set their targets to reservoir capacity. Reservoirs falling into this category are:

- Fruitgrowers Reservoir
- Fruitland Reservoir
- Overland Reservoir
- Crawford Reservoir
- Silverjack Reservoir
- Cerro Reservoir
- Fairview Reservoir

Reservoirs that operate to provide flood control (storage capacity for spring runoff), or for hydropower generation, are operated using StateMod's forecast feature, based on rules provided by the USBR. These reservoirs include Paonia and Blue Mesa. Although Taylor Park Reservoir provides an irrigation supply, the USBR also operates the reservoir on a pre-set schedule; therefore, the forecasting feature is used based on operating curves provided.

The following concerns were noted during initial calibration efforts:

- The Blue Mesa target worked well from 1975 through 1988, but did not seem to reflect historical practices after that year. Furthermore, when modeled Blue Mesa releases are not realistic, the impact to the downstream gages is very evident, because of the size of Blue Mesa.

- Morrow Point and Crystal Reservoirs help to regulate Blue Mesa releases. As evidenced by the historical record of end-of-month contents, their contents fluctuate greatly around a point well below capacity. Neither capacity targets nor forecasting was appropriate for these reservoirs.

- Ridgway Reservoir provides supplemental supply for irrigation and municipal use, and under the standard approach, should have targets set to capacity in the calculated data set. However, the reservoir came on line in 1986 and required several annual cycles to fill. The period of "normal" operations was too small to deduce a pattern that reflects current operations. Ridgway's impact to the downstream gages was great enough to have an effect on the overall simulation of the Uncompahgre River.

A meeting was held with USBR to find out more about operations since 1988. As a result, Blue Mesa has one set of targets for 1975-1988 and a different set for 1989-2005. Note that the recent targets are used in the Baseline data set. Morrow Point and Crystal Reservoir targets were set to historical end-of-month content in the calculated data set. This approach is reasonable for regulating reservoirs. Ridgway Reservoir targets were set to historical end-of-month contents throughout the study period. In the future, as more history with this reservoir has developed, the targets can be changed.

The forecasting enhancements and use of historical contents for reservoir targets, when justified, resulted in good simulation of reservoir operations throughout the Gunnison model.

## 7.4 Calibration Results

Calibration of the Gunnison River 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 less than 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 Gunnison River model, for the calibration period (1975-2005). Following are observations based on the summary table:

- Stream water inflow to the basin averages 2.47 million acre-feet per year, and stream water outflow averages 1.84 million acre-feet per year.

- Annual diversions amount to approximately 2.65 million acre-feet on average, indicating that there is extensive re-diversion of return flows in the basin.

- Approximately 585,500 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 Gunnison River Model 1975-2005 (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 | 93,141 | 168,585 | 1,397 | 263,124 | 177,259 | 3,766 | 121,978 | -41,277 | 5,636 | -4,240 | 263,124 | 0 | 20,705 |
| NOV | 71,317 | 69,871 | 180 | 141,367 | 46,674 | 1,426 | 130,152 | -37,063 | 1,351 | -1,171 | 141,367 | 0 | 2,488 |
| DEC | 61,135 | 61,268 | 0 | 122,403 | 48,259 | 530 | 110,684 | -37,070 | 1,099 | -1,099 | 122,403 | 0 | 1,418 |
| JAN | 59,078 | 55,875 | 0 | 114,954 | 46,964 | 685 | 79,287 | -11,983 | 897 | -897 | 114,954 | 0 | 1,520 |
| FEB | 57,310 | 49,791 | 0 | 107,101 | 44,093 | 1,339 | 75,877 | -14,208 | 671 | -671 | 107,101 | 0 | 2,039 |
| MAR | 89,814 | 55,300 | 873 | 145,987 | 53,546 | 2,928 | 94,872 | -6,232 | 639 | 234 | 145,987 | 0 | 5,029 |
| APR | 219,979 | 139,138 | 3,363 | 362,480 | 171,938 | 6,441 | 135,208 | 45,530 | 4,769 | -1,406 | 362,480 | 0 | 22,704 |
| MAY | 623,189 | 274,861 | 5,712 | 903,762 | 398,186 | 10,702 | 370,672 | 118,489 | 9,990 | -4,278 | 903,762 | 0 | 84,979 |
| JUN | 642,144 | 370,837 | 7,814 | 1,020,795 | 552,241 | 14,204 | 313,960 | 132,576 | 8,146 | -332 | 1,020,795 | 0 | 144,899 |
| JUL | 300,441 | 351,312 | 14,113 | 665,866 | 492,087 | 12,247 | 166,262 | -18,842 | 3,351 | 10,762 | 665,866 | 0 | 145,033 |
| AUG | 141,043 | 278,917 | 8,146 | 428,107 | 357,259 | 10,112 | 124,277 | -71,687 | 4,834 | 3,313 | 428,106 | 0 | 97,835 |
| SEP | 109,637 | 224,244 | 4,975 | 338,856 | 264,645 | 8,103 | 115,838 | -54,706 | 5,594 | -619 | 338,856 | 0 | 56,880 |
| | | | | | | | | | | | | | |
| AVG | 2,468,228 | 2,100,281 | 46,435 | 4,614,943 | 2,653,382 | 72,483 | 1,839,115 | 3,528 | 46,837 | -403 | 4,614,942 | 0 | 585,468 |

*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 2005, 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 7.11 (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 by the $R^2$ value shown on each scatter graph.

Calibration based on streamflow simulation is generally very good in terms of both annual volume and monthly pattern. Exceptions include Smith Fork, Surface Creek, and Currant Creek drainages. Several structures are shorted in the basin and Smith Fork Feeder ditch is diverting less than historical to fill Crawford Reservoir. Streamflows at both Surface Creek and Currant Creek gages are overestimated. As noted above, interactions between the two tributaries and Fruitgrowers Reservoir are not completely understood. These exceptions do not affect mainstem or major tributary calibration. Future enhancements could include additional efforts to understand water use on these tributaries.

Simulation of streamflow on the mainstem of the Gunnison River below Blue Mesa Reservoir accurately models annual volume, but the monthly patterns vary from gaged. Blue Mesa is modeled using a forecasting curve provided by the USBR that is intended to mimic hydropower operations. It is clear that the rule curve is used only as a guideline by the USBR, and decisions based on other factors drive actual operations. Because of the large volume of water stored and released from the reservoir, relatively small deviations from historic reservoir operations result in large deviations in downstream flow. Step 1 calibration results, when Blue Mesa was "releasing to targets" of historical end-of-month contents, are also shown on Figure 7.4, Gunnison River below Gunnison Tunnel, further reinforcing the conclusion regarding streamgages below Blue Mesa.

**Table 7.3**
**Historical and Simulated Average Annual Streamflow Volumes (1975-2005)**
**Calibration Run (acre-feet/year)**

| | | | Historical minus Simulated | | |
|---|---|---|---|---|---|
| Gage ID | Historical | Simulated | Volume | Percent | Gage Name |
| 9109000 | 143,392 | 142,787 | 605 | 0 | Taylor River Below Taylor Park Reservoir |
| 9110000 | 228,583 | 227,904 | 678 | 0 | Taylor River at Almont |
| 9110500 | *No gage during calibration period* | | | 0 | East River Near Crested Butte |
| 9111500 | 94,920 | 94,923 | -3 | 0 | Slate River Near Crested Butte |
| 9112000 | *No gage during calibration period* | | | 0 | Cement Creek Near Crested Butte |
| 9112200 | 224,178 | 224,573 | -396 | 0 | East River Below Cement Creek NR Crested Butte |
| 9112500 | 234,391 | 234,409 | -18 | 0 | East River at Almont |
| 9113300 | *No gage during calibration period* | | | 0 | Ohio Creek at Baldwin |
| 9113500 | 56,954 | 56,986 | -32 | 0 | Ohio Creek Near Baldwin |

| Gage ID | Historical | Simulated | Historical minus Simulated | | Gage Name |
|---|---|---|---|---|---|
| | | | Volume | Percent | |
| 9114500 | 514,682 | 514,171 | 511 | 0 | Gunnison River Near Gunnison |
| 9115500 | 42,653 | 42,828 | -175 | 0 | Tomichi Creek at Sargents |
| 9118000 | *No gage during calibration period* | | | 0 | Quartz Creek Near Ohio City |
| 9118450 | 30,984 | 31,703 | -719 | -2 | Cochetopa Creek Below Rock Creek Near Parlin |
| 9119000 | 122,463 | 124,166 | -1,703 | -1 | Tomichi Creek at Gunnison |
| 9121500 | *No gage during calibration period* | | | 0 | Cebolla Creek Near Lake City |
| 9121800 | *No gage during calibration period* | | | 0 | Cebolla Creek Near Powderhorn |
| 9122000 | *No gage during calibration period* | | | 0 | Cebolla Creek at Powderhorn |
| 9124500 | 165,397 | 165,410 | -13 | 0 | Lake Fork at Gateview |
| 9126000 | 69,572 | 69,653 | -81 | 0 | Cimarron River Near Cimarron |
| 9126500 | *No gage during calibration period* | | | 0 | Cimarron River at Cimarron |
| 9127500 | *No gage during calibration period* | | | 0 | Crystal Creek Near Maher |
| 9128000 | 839,169 | 838,525 | 644 | 0 | Gunnison River Below Gunnison Tunnel |
| 9128500 | 33,416 | 35,104 | -1,688 | -5 | Smith Fork Near Crawford |
| 9129600 | 28,116 | 33,615 | -5,498 | -20 | Smith Fork Near Lazear |
| 9130500 | *No gage during calibration period* | | | 0 | East Muddy Creek Near Bardine |
| 9131200 | *No gage during calibration period* | | | 0 | West Muddy Creek Near Somerset |
| 9132500 | 348,092 | 350,833 | -2,741 | -1 | North Fork Gunnison River Near Somerset |
| 9134000 | 14,930 | 15,171 | -241 | -2 | Minnesota Creek Near Paonia |
| 9134050 | 10,181 | 10,244 | -63 | -1 | Minnesota Creek at Paonia |
| 9134500 | *No gage during calibration period* | | | 0 | Leroux Creek Near Cedaredge |
| 9135900 | 20,892 | 19,964 | 928 | 4 | Leroux Creek at Hotchkiss |
| 9136200 | 1,446,348 | 1,465,906 | -19,558 | -1 | Gunnison River Near Lazear |
| 9137050 | 10,559 | 11,314 | -754 | -7 | Currant Creek Near Read |
| 9137800 | *No gage during calibration period* | | | 0 | Dirty George Creek Near Grand Mesa |
| 9139200 | *No gage during calibration period* | | | 0 | Ward Creek Near Grand Mesa |
| 9141500 | *No gage during calibration period* | | | 0 | Youngs Creek Near Cedaredge |
| 9143000 | 32,964 | 32,964 | 0 | 0 | Surface Creek Near Cedaredge |
| 9143500 | 22,602 | 23,415 | -812 | -4 | Surface Creek at Cedaredge |
| 9144200 | 52,621 | 54,979 | -2,358 | -4 | Tongue Creek at Cory |
| 9144250 | 1,429,446 | 1,425,369 | 4,076 | 0 | Gunnison River at Delta |
| 9146200 | 121,279 | 121,279 | 0 | 0 | Uncompahgre River Near Ridgway |
| 9146400 | *No gage during calibration period* | | | 0 | West Fork Dallas Creek nr Ridgway |
| 9146500 | *No gage during calibration period* | | | 0 | East Fork Dallas Creek nr Ridgway |
| 9146550 | *No gage during calibration period* | | | 0 | Beaver Creek nr Ridgway |
| 9147000 | 28,563 | 28,779 | -216 | -1 | Dallas Creek nr Ridgway |
| 9147100 | *No gage during calibration period* | | | 0 | Cow Creek Near Ridgway |
| 9147500 | 189,763 | 190,268 | -505 | 0 | Uncompahgre River at Colona |
| 9149420 | 39,881 | 39,881 | 0 | 0 | Spring Creek Near Montrose |
| 9149500 | 231,002 | 242,778 | -11,776 | -5 | Uncompahgre River at Delta |
| 9150500 | 88,629 | 88,665 | -36 | 0 | Roubideau Creek at Mouth, Near Delta |
| 9152000 | 17,378 | 17,728 | -350 | -2 | Kannah Creek Near Whitewater |
| 9152500 | 1,841,072 | 1,848,181 | -7,109 | 0 | Gunnison River Near Grand Junction |

### 7.4.3. Diversion Calibration Results

Table 7.4 summarizes the average annual shortage for water years 1975 through 2005, by Water District/tributary. Table 7.6 (at the end of this section) shows the average annual shortages for water years 1975 through 2005 by structure. On a basin-wide basis, average annual diversions differ from historical diversions by 2.5 percent in the calibration run.

**Table 7.4**
**Historical and Simulated Average Annual Diversions by Sub-basin (1975-2005)**
**Calibration Run (acre-feet/year)**

| Water District/Tributary | Historical | Simulated | Historical minus Simulated | |
|---|---|---|---|---|
| | | | Volume | Percent |
| WD 28 – Tomichi Creek | 224,092 | 212,868 | 11,223 | 5% |
| WD 40 – North Fork Gunnison/Tribs | 484,244 | 464,201 | 20,044 | 4% |
| WD 41 – Lower Uncompahgre River | 637,117 | 615,574 | 21,543 | 3% |
| WD 42 – Lower Gunnison River | 515,926 | 513,967 | 1,959 | 0% |
| WD 59 – East River | 301,995 | 296,313 | 5,681 | 2% |
| WD 62 – Upper Gunnison River | 506,056 | 499,003 | 7,054 | 1% |
| WD 68 – Upper Uncompahgre River | 95,958 | 95,317 | 640 | 1% |
| Basin Total | 2,765,387 | 2,697,243 | 68,145 | 2.5% |

Estimated diversions are within a few percentages of recorded diversions except in a couple areas:

- The Crystal River drainage (WD 40) irrigation demands are generally met, with the exception of Fruitland Canal. Fruitland Canal is shorted, on average, 1,000 acre-feet per year. Diversions through the canal are simulated using an operationg rule where demand is driven by both storage levels in Fruitland Reservoir, and irrigation demand on Fruitland Mesa. The project also receives water from Smith Fork tributaries, and the order in which they use their various sources may not be completely understood. The irrigation demand is generally satisfied, therefore additional calibration efforts were not conducted as part of this modeling phase.

- Shortages on Currant Creek and Surface Creek (WD 40) are fairly uniform throughout. As discussed above, the shortages were greatly reduced through calibration efforts. Many of the diversions on Surface Creek return to Currant Creek, and it is likely that interactions between the two tributaries, irrigated lands in the Alfalfa Run drainage, and the filling of Fruitgrowers Reservoir are not completely understood; therefore, not as accurately modeled as other areas in the basin. Additional calibration efforts were not conducted as part of this modeling phase.

### 7.4.4. Reservoir Calibration Results

Figures 7.12 through 7.20 (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:

- Fruitgrowers Reservoir is underused in the calibration run. The irrigation structures receiving supplemental water from Fruitgrowers Reservoir are completely satisfied. However, other diverters on Surface and Currant Creek are shorted. As noted above, operations on these tributaries are not completely understood and future investigation may indicate more demand on the reservoir than is currently modeled.

- In general, Fruitland Reservoir simulation matches historical patterns. During the period 1988 through 1990, water was not stored so structural repairs could take place. The calibration simulation models normal operations during this period.

- Overland Reservoir is greatly underused in the calibration run. This could be, in part, because Overland Reservoir contents were estimated by the USBR for use in their modeling efforts, and may not reflect actual operations. Most structures are shorted on West Muddy Creek, indicating that future investigation may indicate more demand on the reservoir than currently modeled.

### 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. 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, the StateMod structure summary file (*.xss) results were “filtered” to only include the structures in the StateCU analysis.

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 basin total. 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 near 1 percent difference is slightly consistent less than the overall basin diversion shortages simulated by the model.

**Table 7.5**
**Average Annual Crop Consumptive Use Comparison (1975-2005)**

| Comparison | StateCU Results (af/yr) | Calibration Run Results (af/yr) | % Difference |
|---|---|---|---|
| Explicit Structures | 383,968 | 382,530 | 0.37 |
| Aggregate Structures | 126,389 | 123,043 | 2.65 |
| Basin Total | 510,357 | 505,573 | 0.94 |

**Table 7.6**
**Historical and Simulated Average Annual Diversions (1975-2005)**
**Calibration Run (acre-feet/year)**

| WDID | Historical | Simulated | Historical minus Simulated | | Structure Name |
|---|---|---|---|---|---|
| | | | Volume | Percent | |
| 280500 | 1,570 | 1,546 | 24 | 2 | ADAMS NO 1 DITCH |
| 280503 | 485 | 272 | 213 | 44 | AGATE NO 2 DITCH |
| 280510 | 14,505 | 13,880 | 624 | 4 | ARCH IRRIGATING DITCH |
| 280515 | 4,097 | 4,093 | 4 | 0 | BIEBEL DITCHES NOS 1&2 |
| 280520 | 1,950 | 1,816 | 134 | 7 | CAIN BORSUM DITCH |
| 280526 | 2,609 | 2,540 | 69 | 3 | CHITTENDEN DITCH |
| 280527 | 349 | 309 | 40 | 11 | CLARK NO 1 DITCH |
| 280528 | 571 | 475 | 96 | 17 | CLARK NO 2 DITCH |
| 280529 | 743 | 659 | 84 | 11 | CLARK NO 3 DITCH |
| 280530 | 691 | 673 | 19 | 3 | CLOVIS METROZ NO 1 DITCH |
| 280532 | 1,858 | 1,657 | 201 | 11 | COATS BROS DITCH |
| 280535 | 567 | 403 | 164 | 29 | COLE NOS 1 2 & 3 DITCHES |
| 280536 | 1,493 | 1,339 | 154 | 10 | COX AND MCCONNELL DITCH |
| 280542 | 1,629 | 1,616 | 13 | 1 | CUTJO DITCH |
| 280543 | 563 | 487 | 76 | 13 | D A MCCONNELL DITCH |
| 280550 | 1,535 | 1,332 | 203 | 13 | DUNN AND WATTERS DITCH |
| 280554 | 1,569 | 1,553 | 16 | 1 | ELSEN VADER DITCH |
| 280557 | 847 | 778 | 69 | 8 | FIELD AND VADER DITCH |
| 280564 | 1,215 | 1,053 | 161 | 13 | TOMI_GILBERTSON NO 1 |
| 280566 | 1,990 | 1,851 | 139 | 7 | GOODRICH DITCH |
| 280567 | 2,518 | 2,393 | 125 | 5 | GOODWIN AND WRIGHT DITCH |
| 280568 | 4,420 | 4,128 | 292 | 7 | LOS _GOVERNMENT DITC |
| 280571 | 3,640 | 3,624 | 17 | 0 | TOMI_GRIFFING NO 1 D |
| 280576 | 2,747 | 2,747 | 0 | 0 | GULLETT TOMICHI IRG D |
| 280577 | 1,356 | 1,198 | 158 | 12 | HANNAH J WINTERS NO 2D |
| 280580 | 1,038 | 920 | 119 | 11 | HAWES-BERGEN-GILBERTSON |
| 280581 | 1,341 | 1,291 | 50 | 4 | HAZARD DITCH |
| 280583 | 729 | 724 | 5 | 1 | HEAD AND CORTAY NO 4 D |
| 280587 | 1,053 | 1,043 | 10 | 1 | HOME DITCH DITCH NO 81 |
| 280588 | 908 | 885 | 23 | 2 | HOME DITCH DITCH NO 182 |
| 280590 | 338 | 327 | 11 | 3 | HOT SPRINGS NOS 1&2 D |
| 280604 | 470 | 341 | 129 | 27 | KANE DITCH |

| WDID | Historical | Simulated | Historical minus Simulated | | Structure Name |
|---|---|---|---|---|---|
| | | | Volume | Percent | |
| 280607 | 574 | 351 | 223 | 39 | KENDALL NO 3 DITCH |
| 280608 | 511 | 339 | 172 | 34 | KENDALL NO 4 DITCH |
| 280622 | 287 | 280 | 6 | 2 | LOBDELL NO 2 DITCH |
| 280624 | 2,852 | 2,838 | 14 | 1 | LOCKWOOD MUNDELL DITCH |
| 280631 | 1,916 | 1,890 | 26 | 1 | MCCANNE NO 1 DITCH |
| 280632 | 3,562 | 3,481 | 81 | 2 | MCCANNE 2 DITCH |
| 280633 | 1,288 | 1,282 | 6 | 0 | MCCANNE 3 DITCH |
| 280636 | 2,191 | 1,864 | 326 | 15 | MCDONOUGH DITCH |
| 280638 | 2,619 | 2,004 | 616 | 24 | TOMI_MCGOWAN IRRIGAT |
| 280642 | 589 | 414 | 175 | 30 | MEANS BROS NO 13 DITCH |
| 280645 | 350 | 292 | 58 | 17 | MEANS BROS NO 4 DITCH |
| 280646 | 451 | 431 | 20 | 4 | MEANS BROS NO 5 DITCH |
| 280647 | 363 | 235 | 128 | 35 | MEANS BROS NO 6 DITCH |
| 280648 | 254 | 193 | 61 | 24 | MEANS BROS NO 7 DITCH |
| 280649 | 591 | 434 | 157 | 27 | MEANS BROS NO 12 DITCH |
| 280650 | 1,107 | 1,020 | 87 | 8 | MEANS BROS NO 8 DITCH |
| 280651 | 6,615 | 6,129 | 486 | 7 | MESA DITCH |
| 280652 | 888 | 833 | 55 | 6 | MILLER DITCH |
| 280654 | 1,573 | 1,526 | 47 | 3 | MONSON & MCCONNELL D |
| 280660 | 828 | 805 | 23 | 3 | NORMAN DITCH |
| 280662 | 924 | 907 | 17 | 2 | OFALLON NO 3 DITCH |
| 280663 | 800 | 757 | 43 | 5 | OFALLON NO 4 DITCH |
| 280665 | 574 | 567 | 7 | 1 | OREGAN NO 1 DITCH |
| 280667 | 1,113 | 1,042 | 70 | 6 | OWEN NO 1 DITCH |
| 280668 | 3,402 | 3,359 | 43 | 1 | OWEN REDDEN DITCH |
| 280670 | 1,067 | 1,067 | 0 | 0 | PARLIN NO 2 DITCH |
| 280671 | 3,927 | 3,883 | 45 | 1 | PARLIN QUARTZ CREEK D |
| 280673 | 2,958 | 2,714 | 243 | 8 | PERRY IRRIGATING DITCH |
| 280674 | 3,918 | 3,918 | 0 | 0 | PIONEER DITCH |
| 280679 | 1,507 | 1,423 | 84 | 6 | ROGERS METROZ DITCH |
| 280680 | 2,534 | 1,551 | 983 | 39 | S DAVIDSON&CO FDR D NO 1 |
| 280681 | 288 | 178 | 110 | 38 | SARGENTS NO 1 D |
| 280682 | 313 | 240 | 72 | 23 | SARGENTS NO 2 D |
| 280686 | 3,502 | 3,391 | 111 | 3 | SMITH FORD NO 2 DITCH |
| 280690 | 2,166 | 2,132 | 35 | 2 | SORRENSON IRRIGATING D |
| 280692 | 1,641 | 1,608 | 32 | 2 | SOUTH SIDE DITCH |
| 280693 | 2,106 | 1,986 | 120 | 6 | STEPHENSON DITCH |
| 280697 | 56 | 56 | 0 | 0 | SUTTON NO 3 AMENDED D |
| 280703 | 887 | 800 | 87 | 10 | TARBELL & ALEXANDER D |
| 280707 | 3,380 | 3,167 | 212 | 6 | TORNAY HIGHLINE DITCH |
| 280709 | 1,061 | 1,055 | 5 | 0 | VADER RAUSIS DITCH |
| 280711 | 1,033 | 1,019 | 15 | 1 | WATERMAN METROZ DITCH |
| 280714 | 210 | 206 | 3 | 1 | WICKS ROWSER DITCH |
| 280715 | 1,554 | 1,477 | 77 | 5 | WOOD AND GEE DITCH |
| 280716 | 1,024 | 892 | 132 | 13 | WOODBRIDGE DITCH |
| 280823 | 232 | 219 | 13 | 6 | MCDONALD BERDEL EX D |

| WDID | Historical | Simulated | Historical minus Simulated Volume | Percent | Structure Name |
|---|---|---|---|---|---|
| 28_ADG009 | 11,747 | 11,315 | 432 | 4 | 28_ADG009_UTOMICHI |
| 28_ADG010 | 20,697 | 20,393 | 304 | 1 | 28_ADG010_TOMICHI1 |
| 28_ADG011 | 10,970 | 10,959 | 12 | 0 | 28_ADG011_COCHETOPA |
| 28_ADG012 | 35,409 | 35,395 | 14 | 0 | 28_ADS_012_TOMICHI2 |
| 28_ADG043 | 4,518 | 2,823 | 1,695 | 38 | 28_ADG043_COCHET |
| 28_ADG044 | 7,778 | 7,778 | 0 | 0 | 28_ADG044_RAZOR |
| 400500 | 15,809 | 15,227 | 582 | 4 | CRAWFORD CLIPPER DITCH |
| 400501 | 6,424 | 6,152 | 272 | 4 | NEEDLE ROCK DITCH |
| 400502 | 3,428 | 1,993 | 1,435 | 42 | SADDLE MT HIGHLINE D |
| 400503 | 13,325 | 12,574 | 751 | 6 | GRANDVIEW CANAL |
| 400504 | 7,508 | 7,261 | 247 | 3 | CEDAR CANON IRON SPR D |
| 400506 | 2,839 | 1,552 | 1,287 | 45 | ALUM GULCH DITCH |
| 400508 | 6,373 | 6,550 | -177 | -3 | ASPEN DITCH |
| 400509 | 1,092 | 1,680 | -589 | -54 | ASPEN CANAL |
| 400533 | 1,089 | 1,022 | 67 | 6 | CRYSTAL VALLEY DITCH |
| 400536 | 2,141 | 1,831 | 310 | 14 | DAISY DITCH |
| 400543 | 948 | 854 | 95 | 10 | DYER FORK DITCH |
| 400549 | 9,555 | 11,816 | -2,260 | -24 | FRUITLAND CANAL |
| 400566 | 1,399 | 1,391 | 8 | 1 | LARSON BROTHERS DITCH |
| 400568 | 785 | 667 | 118 | 15 | LONE ROCK DITCH |
| 400576 | 556 | 125 | 431 | 77 | MEEK DIVERSION TUNNEL |
| 400585 | 8,531 | 5,872 | 2,659 | 31 | OVERLAND DITCH |
| 400586 | 1,266 | 1,215 | 51 | 4 | PILOT ROCK DITCH |
| 400605 | 4,054 | 7,633 | -3,579 | -88 | SMITH FORK FEEDER CANAL |
| 400616 | 1,131 | 790 | 341 | 30 | VIRGINIA DITCH |
| 400632 | 3,417 | 3,129 | 288 | 8 | CHILDS DITCH |
| 400661 | 10,081 | 9,886 | 195 | 2 | SURFACE CR D AKA BIG D |
| 400675 | 3,953 | 3,615 | 338 | 9 | CEDAR MESA DITCH |
| 400683 | 1,130 | 1,097 | 33 | 3 | HORSESHOE DITCH |
| 400686 | 3,022 | 2,675 | 347 | 11 | LONE PINE DITCH |
| 400701 | 4,749 | 3,880 | 869 | 18 | CEDAR PARK DITCH |
| 400703 | 852 | 620 | 232 | 27 | DIRT_EAGLE DITCH |
| 400713 | 1,312 | 1,114 | 198 | 15 | GRANBY DITCH FR WARD CR |
| 400751 | 8,408 | 7,566 | 842 | 10 | ALFALFA DITCH |
| 499751_I | 5,619 | 5,564 | 55 | 1 | ALFALFA D IRR DEMAND |
| 400753 | 1,571 | 1,547 | 25 | 2 | SURF_BONITA DITCH |
| 400754 | 2,253 | 2,192 | 60 | 3 | BUTTES DITCH |
| 400758 | 2,881 | 2,483 | 397 | 14 | FORREST DITCH |
| 400774 | 2,413 | 2,398 | 16 | 1 | ORCHARD RANCH DITCH |
| 400778 | 992 | 987 | 5 | 0 | SETTLE DITCH |
| 400797 | 2,177 | 888 | 1,289 | 59 | DURKEE DITCH |
| 400808 | 732 | 668 | 64 | 9 | MORTON DITCH |
| 400820 | 9,802 | 8,641 | 1,161 | 12 | ALFA_STELL DITCH |
| 400821 | 1,523 | 2,746 | -1,222 | -80 | TRANSFER DITCH |
| 400863 | 22,238 | 22,236 | 2 | 0 | BONAFIDE DITCH |
| 400879 | 16,583 | 16,583 | 0 | 0 | HARTLAND DITCH |

| WDID | Historical | Simulated | Historical minus Simulated Volume | Historical minus Simulated Percent | Structure Name |
|---|---|---|---|---|---|
| 400891 | 20,083 | 20,065 | 18 | 0 | GUNN_NORTH DELTA CAN |
| 400900 | 18,663 | 18,647 | 16 | 0 | RELIEF DITCH |
| 400918 | 992 | 958 | 35 | 3 | COW CREEK DITCH |
| 400919 | 3,022 | 2,908 | 114 | 4 | CURRANT CREEK DITCH |
| 400923 | 8,186 | 6,679 | 1,507 | 18 | HIGHLINE DITCH |
| 400926 | 6,025 | 5,977 | 48 | 1 | LEROUX CREEK DITCH |
| 400929 | 1,111 | 1,056 | 55 | 5 | JESSIE DITCH |
| 400932 | 1,745 | 1,193 | 552 | 32 | MIDKIFF & ARNOLD D |
| 400944 | 10,203 | 10,203 | 0 | 0 | LERO_OVERLAND DITCH |
| 401012 | 606 | 398 | 208 | 34 | LONE CABIN DITCH |
| 401020 | 6,103 | 5,760 | 343 | 6 | MINNESOTA CANAL |
| 401056 | 1,930 | 1,727 | 202 | 10 | TURNER DITCH |
| 401087 | 422 | 418 | 4 | 1 | BLACK SAGE DITCH |
| 401105 | 375 | 374 | 1 | 0 | COYOTE DITCH |
| 401106 | 391 | 375 | 16 | 4 | COYOTE DITCH |
| 401112 | 440 | 408 | 32 | 7 | DEER DITCH |
| 401114 | 289 | 287 | 2 | 1 | DITCH NO 2 DITCH |
| 401118 | 582 | 561 | 21 | 4 | DRIFT CREEK DITCH |
| 401119 | 240 | 224 | 16 | 7 | DUGOUT DITCH |
| 401120 | 618 | 593 | 25 | 4 | DOWNING DITCH |
| 401122 | 205 | 125 | 80 | 39 | DYKE NO 2 DITCH |
| 401127 | 269 | 243 | 26 | 10 | ELKS BEAVER DITCH |
| 401132 | 1,635 | 1,521 | 114 | 7 | FILMORE DITCH |
| 401133 | 46,742 | 44,525 | 2,217 | 5 | FIRE MT CANAL |
| 401145 | 414 | 400 | 14 | 3 | GROUSE CREEK DITCH |
| 401166 | 471 | 275 | 196 | 42 | MUDD_LARSON NO 2 DIT |
| 401168 | 391 | 369 | 22 | 6 | LEE CREEK D NO 2 |
| 401172 | 633 | 603 | 30 | 5 | LOST CABIN DITCH |
| 401183 | 2,287 | 2,281 | 6 | 0 | MONITOR DITCH |
| 401185 | 8,876 | 8,871 | 5 | 0 | NORTH FORK FARMERS D |
| 401189 | 6,296 | 5,971 | 325 | 5 | PAONIA DITCH |
| 401190 | 110 | 104 | 6 | 5 | PILOT KNOB DITCH |
| 401195 | 2,883 | 2,883 | 0 | 0 | SHEPARD & WILMONT DITCH |
| 401196 | 5,075 | 5,075 | 0 | 0 | SHORT DITCH |
| 401197 | 1,736 | 1,729 | 7 | 0 | SMITH AND MCKNIGHT DITCH |
| 401201 | 167 | 160 | 7 | 4 | SPATAFORE DITCH NO 1 |
| 401206 | 14,965 | 14,695 | 270 | 2 | STEWART DITCH |
| 401207 | 1,518 | 1,183 | 335 | 22 | STREBER DITCH |
| 401213 | 1,772 | 1,772 | 0 | 0 | VANDEFORD DITCH |
| 401214 | 74 | 73 | 1 | 2 | WADE DITCH |
| 401218 | 928 | 901 | 27 | 3 | WELCH MESA DITCH |
| 401221 | 102 | 97 | 4 | 4 | WILLIAMS CR DITCH |
| 401437 | 825 | 823 | 2 | 0 | ROUB_HAWKINS DITCH |
| 40_ADG019 | 438 | 438 | 0 | 0 | 40_ADG019_GUNNTUN |
| 40_ADG020 | 4,180 | 2,384 | 1,797 | 43 | 40_ADG020_IRON |
| 40_ADG021 | 1,766 | 1,760 | 5 | 0 | 40_ADG021_SMITH |

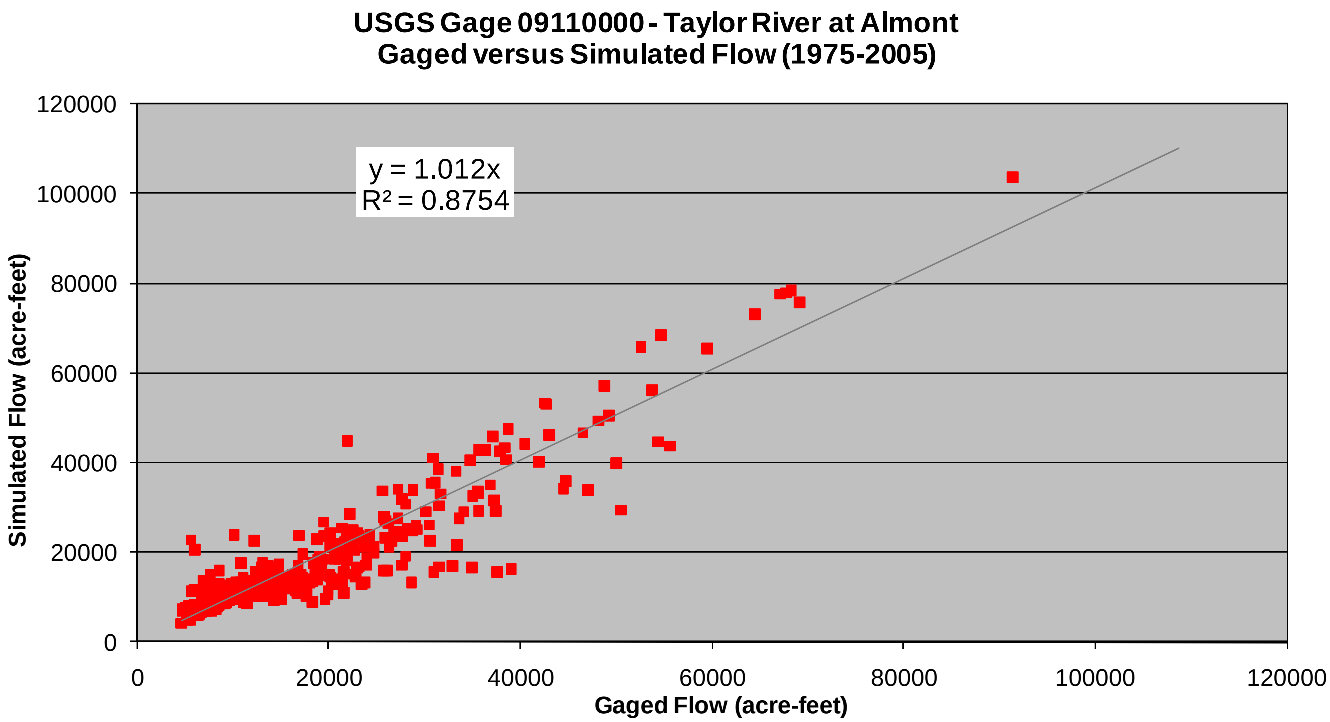
| WDID | Historical | Simulated | Historical minus Simulated Volume | Percent | Structure Name |
|---|---|---|---|---|---|
| 40_ADG022 | 2,686 | 2,683 | 3 | 0 | 40_ADG022_NFGUNN |
| 40_ADG023 | 1,875 | 1,759 | 116 | 6 | 40_ADG023_MINN |
| 40_ADG024 | 7,960 | 7,960 | 0 | 0 | 40_ADG024_NFGUNN2 |
| 40_ADG025 | 4,167 | 3,558 | 609 | 15 | 40_ADG025_LEROUX |
| 40_ADG026 | 9,419 | 9,419 | 0 | 0 | 40_ADG026_GUNNL |
| 40_ADG027 | 7,189 | 5,384 | 1,805 | 25 | 40_ADG027_CURRANT |
| 40_ADG028 | 12,180 | 12,056 | 124 | 1 | 40_ADG028_UTONGUE |
| 40_ADG029 | 2,465 | 2,324 | 142 | 6 | 40_ADG029_SURFACE |
| 40_ADG030 | 14,418 | 14,371 | 48 | 0 | 40_ADG030_TONGUE |
| 40_ADG031 | 6,655 | 6,643 | 12 | 0 | 40_ADG031_GUNND |
| 40_ADG038 | 3,299 | 3,261 | 38 | 1 | 40_ADG038_ROUBIN |
| 40_ADG039 | 9,478 | 9,478 | 0 | 0 | 40_ADG039_GUNNBLD |
| 40_ADG045 | 4,558 | 4,548 | 10 | 0 | 40_ADG045_PAONIA |
| 40_ADG046 | 1,656 | 1,620 | 36 | 2 | 40_ADG046_CRAWFORD |
| 40_AMG002 | 1,449 | 1,448 | 1 | 0 | Lower_M&I |
| 40_Fruitl | 14,049 | 12,900 | 1,148 | 8 | Fruitland |
| 410508 | 3,256 | 3,246 | 9 | 0 | BOLES & MANNEY D |
| 410515 | 3,622 | 3,622 | 0 | 0 | CHIPETA BEAUDRY DITCH |
| 410519 | 7,130 | 0 | 7,130 | 100 | EAGLE DITCH |
| 410520 | 49,747 | 46,935 | 2,812 | 6 | EAST CANAL |
| 410527 | 22,105 | 22,105 | 0 | 0 | GARNET DITCH |
| 410534 | 110,671 | 105,531 | 5,140 | 5 | UNCO_IRONSTONE CANAL |
| 410537 | 45,812 | 42,893 | 2,919 | 6 | LOUTSENHIZER CANAL |
| 410538 | 2,707 | 2,692 | 15 | 1 | LYRA DITCH |
| 410545 | 183,622 | 183,622 | 0 | 0 | MONTROSE & DELTA CANAL |
| 410549 | 4,245 | 4,243 | 2 | 0 | OURAY DITCH |
| 410554 | 3,175 | 3,173 | 2 | 0 | ROSS BROS DITCH |
| 410559 | 69,585 | 66,377 | 3,207 | 5 | SELIG CANAL |
| 410560 | 1,129 | 1,129 | 0 | 0 | SHAVANO VALLEY DITCH |
| 410568 | 1,706 | 1,706 | 0 | 0 | SUNRISE DITCH(HAPPY CYN) |
| 410577 | 54,409 | 54,226 | 184 | 0 | WEST CANAL |
| 410578 | 41,223 | 41,102 | 122 | 0 | SOUTH CANAL |
| 41_ADG035 | 8,154 | 8,154 | 0 | 0 | 41_ADG035_UNCOMPH3 |
| 41_ADG036 | 14,728 | 14,728 | 0 | 0 | 41_ADG036_UNCOMPH4 |
| 41_ADG037 | 8,819 | 8,819 | 0 | 0 | 41_ADG037_UNCOMPH5 |
| 41_AMG003 | 1,272 | 1,272 | 0 | 0 | Uncomp_M&I |
| 420510 | 2,825 | 2,704 | 121 | 4 | BROWN & CAMPION D |
| 420529 | 5,596 | 4,794 | 802 | 14 | KANNAH CREEK HIGHLINE D |
| 420541 | 456,717 | 456,382 | 336 | 0 | REDLANDS POWER CANAL |
| 420545 | 1,299 | 1,177 | 122 | 9 | SMITH IRR DITCH |
| 42_ADG040 | 15,754 | 15,759 | -5 | 0 | 42_ADG040_GUNNGJ |
| 590501 | 3,684 | 3,459 | 225 | 6 | ACME DITCH |
| 590509 | 267 | 230 | 36 | 14 | ANDERS BOTTOM D |
| 590510 | 1,160 | 1,053 | 107 | 9 | ANNA ROZMAN DITCH |
| 590522 | 3,791 | 3,667 | 124 | 3 | BOCKER DITCH |
| 590524 | 565 | 557 | 8 | 1 | BOURNE DITCH |

| WDID | Historical | Simulated | Historical minus Simulated Volume | Percent | Structure Name |
|---|---|---|---|---|---|
| 590527 | 779 | 777 | 2 | 0 | BUCKEY DITCH |
| 590528 | 312 | 312 | 0 | 0 | BUCKEY LEHMAN DITCH |
| 590537 | 3,619 | 3,453 | 167 | 5 | CEMENT CREEK DITCH |
| 590542 | 598 | 584 | 14 | 2 | CUNNINGHAM DITCH |
| 590544 | 1,047 | 1,024 | 23 | 2 | DEAN IRRIGATING DITCH |
| 590546 | 6,933 | 6,496 | 438 | 6 | DILLSWORTH DITCH |
| 590549 | 15,272 | 14,973 | 300 | 2 | EAST RIVER NO 1 DITCH |
| 590550 | 9,695 | 9,358 | 337 | 3 | EAST RIVER NO 2 DITCH |
| 590556 | 3,957 | 3,867 | 90 | 2 | FISHER DITCH ENLARGEMENT |
| 590558 | 3,100 | 3,082 | 18 | 1 | FRANK ADAMS NO 1 DITCH |
| 590560 | 2,683 | 2,551 | 132 | 5 | GARDEN DITCH |
| 590563 | 1,614 | 1,600 | 15 | 1 | GLEASON IRRIGATING DITCH |
| 590566 | 3,173 | 3,164 | 9 | 0 | GOOSEBERRY MESA IRG D |
| 590569 | 13,794 | 13,794 | 0 | 0 | GUNNISON & OHIO CR CANAL |
| 590570 | 17,272 | 16,959 | 313 | 2 | GUNNISON R OHIO CR IRG D |
| 590572 | 7,067 | 7,067 | 0 | 0 | GUNNISON TOWN DITCH |
| 590578 | 4,158 | 4,147 | 11 | 0 | HARRIS BOHM POTATO DITCH |
| 590580 | 50 | 50 | 0 | 0 | HENRY PURRIER OHIO CR D |
| 590581 | 215 | 215 | 0 | 0 | HENRY PURRIER OHIO CR 2D |
| 590584 | 529 | 509 | 21 | 4 | HIGHLAND DITCH |
| 590587 | 1,144 | 1,083 | 61 | 5 | HILDEBRAND NO 2 DITCH |
| 590588 | 1,614 | 1,604 | 9 | 1 | HINKLE HAMILTON DITCH |
| 590589 | 693 | 689 | 4 | 1 | HINKLE IRG DITCH |
| 590591 | 1,106 | 1,106 | 0 | 0 | HOPE RESICH DITCH |
| 590593 | 2,157 | 2,121 | 35 | 2 | HOWE & SHERWOOD IRR D |
| 590596 | 1,123 | 1,123 | 0 | 0 | HYZER VIDAL MILLER D |
| 590597 | 2,635 | 2,252 | 384 | 15 | IMOBERSTEG DITCH |
| 590600 | 4,985 | 4,859 | 126 | 3 | JAMES WATT DITCH |
| 590602 | 2,197 | 2,192 | 5 | 0 | JOHN B OUTCALT NO 2 D |
| 590606 | 1,318 | 1,301 | 16 | 1 | JUDY NORTH HIGH LINE D |
| 590607 | 5,792 | 5,780 | 12 | 0 | KELMEL OWENS NO 1 DITCH |
| 590608 | 3,243 | 3,185 | 58 | 2 | KELMEL OWENS NO 2 DITCH |
| 590609 | 2,905 | 2,754 | 152 | 5 | KUBIACK DITCH |
| 590616 | 3,031 | 3,017 | 14 | 0 | LIGHTLEY D & LINTON ENLT |
| 590617 | 3,116 | 3,116 | 0 | 0 | LONE PINE DITCH |
| 590622 | 1,781 | 1,772 | 9 | 1 | MARSHALL NO 1 DITCH |
| 590623 | 2,671 | 2,654 | 17 | 1 | MARSHALL NO 2 DITCH |
| 590624 | 1,445 | 1,407 | 39 | 3 | MARSTON DITCH |
| 590625 | 3,501 | 3,501 | 0 | 0 | MAY BOHM & ENLD M B H P |
| 590627 | 393 | 386 | 6 | 2 | MCCORMICK DITCH |
| 590630 | 229 | 229 | 0 | 0 | MCGLASHAN N SIDE MILL CR |
| 590631 | 455 | 443 | 11 | 2 | MCGLASHAN S SIDE MILL CR |
| 590644 | 444 | 444 | 0 | 0 | OHIO CREEK NO 2 DITCH |
| 590645 | 522 | 522 | 0 | 0 | OTIS MOORE DITCH |
| 590646 | 801 | 790 | 11 | 1 | PALISADES DITCH |
| 590649 | 891 | 836 | 55 | 6 | PASS CREEK DITCH |

| WDID | Historical | Simulated | Historical minus Simulated | | Structure Name |
|---|---|---|---|---|---|
| | | | Volume | Percent | |
| 590651 | 1,359 | 1,344 | 15 | 1 | PILONI DITCH |
| 590653 | 4,418 | 4,298 | 120 | 3 | POWER DITCH |
| 590655 | 397 | 397 | 0 | 0 | PURRIER DITCH |
| 590658 | 4,081 | 3,941 | 141 | 3 | RICHARD BALL DITCH |
| 590667 | 730 | 698 | 32 | 4 | SCHUPP DITCH |
| 590668 | 5,470 | 5,388 | 82 | 2 | SEVENTY FIVE DITCH |
| 590671 | 381 | 381 | 0 | 0 | SIMINEO DITCH |
| 590672 | 4,262 | 3,887 | 375 | 9 | SLIDE DITCH |
| 590679 | 4,153 | 4,084 | 68 | 2 | SPRING CR IRG DITCH |
| 590680 | 196 | 192 | 4 | 2 | SQUIRREL CREEK NO1 DITCH |
| 590684 | 2,262 | 2,069 | 193 | 9 | STRAND DITCH NO 1 |
| 590691 | 3,189 | 3,185 | 3 | 0 | TEACHOUT DITCH |
| 590692 | 1,285 | 1,272 | 13 | 1 | TEACHOUT-FAIRCHILD DITCH |
| 590699 | 5,568 | 5,355 | 213 | 4 | VERZUH DITCH |
| 590700 | 5,964 | 5,346 | 618 | 10 | VERZUH YOUNG BIFANO D |
| 590704 | 3,708 | 3,635 | 73 | 2 | WHIPP DITCH |
| 590707 | 406 | 406 | 0 | 0 | WILLOW RUN DITCH |
| 590709 | 839 | 826 | 13 | 2 | WILSON DITCH |
| 590711 | 1,120 | 1,087 | 34 | 3 | WILSON OHIO CREEK DITCH |
| 590720 | 532 | 532 | 0 | 0 | PIONEER DITCH |
| 590847 | 2,284 | 2,142 | 142 | 6 | CUNNINGHAM WASTEWATER D |
| 59_ADG001 | 9,252 | 9,116 | 135 | 1 | 59_ADG001_TAYLOR |
| 59_ADG002 | 7,217 | 7,215 | 3 | 0 | 59_ADG002_EAST1 |
| 59_ADG003 | 2,517 | 2,517 | 0 | 0 | 59_ADS_003_SLATE |
| 59_ADG004 | 13,466 | 13,421 | 45 | 0 | 59_ADG004_EAST2 |
| 59_ADG005 | 8,104 | 8,109 | -5 | 0 | 59_ADG005_EAST3 |
| 59_ADG006 | 5,045 | 4,950 | 95 | 2 | 59_ADG006_OHIO1 |
| 59_ADG007 | 6,417 | 6,382 | 34 | 1 | 59_ADG007_OHIO2 |
| 59_ADG008 | 41,852 | 42,030 | -178 | 0 | 59_ADG008_GUNN |
| 620506 | 693 | 572 | 121 | 17 | ANDREWS DITCH |
| 620528 | 5,526 | 5,470 | 57 | 1 | BIG BLUE DITCH |
| 620529 | 2,981 | 2,752 | 229 | 8 | BIG DITCH |
| 620560 | 28,661 | 28,292 | 368 | 1 | CIMARRON CANAL |
| 620567 | 1,497 | 1,461 | 36 | 2 | COLLIER DITCH |
| 620602 | 707 | 651 | 57 | 8 | FOSTER DITCH NO 1 |
| 620604 | 239 | 207 | 32 | 14 | FOSTER IRG D NO 4 |
| 620605 | 2,214 | 2,204 | 10 | 0 | FRANK ADAMS D NO 2 |
| 620617 | 335,869 | 335,508 | 362 | 0 | GUNNISON TUNNEL&S CANAL |
| 620670 | 1,989 | 1,912 | 77 | 4 | M B & A DITCH |
| 620672 | 4,561 | 4,436 | 125 | 3 | MCKINLEY DITCH |
| 620732 | 1,541 | 1,476 | 65 | 4 | RUDOLPH IRG DITCH |
| 620734 | 584 | 527 | 56 | 10 | SAMMONS DITCH NO 2 |
| 620736 | 662 | 613 | 49 | 7 | CEBO_SAMMONS IRG D N |
| 620737 | 447 | 417 | 29 | 7 | SAMMONS IRG D NO 5 |
| 620738 | 657 | 583 | 74 | 11 | SAMMONS IRG D NO 6 |
| 620779 | 1,461 | 1,291 | 170 | 12 | UPPER CEBOLLA DITCH |

| WDID | Historical | Simulated | Historical minus Simulated | | Structure Name |
|---|---|---|---|---|---|
| | | | Volume | Percent | |
| 620783 | 1,945 | 1,817 | 129 | 7 | VEO DITCH |
| 620789 | 944 | 737 | 207 | 22 | WARRANT DITCH |
| 620809 | 1,248 | 998 | 251 | 20 | YOUMANS IRG D NO 1 |
| 62_ADG013 | 15,956 | 15,178 | 779 | 5 | 62_ADG013_CEBOLLA1 |
| 62_ADG014 | 11,065 | 11,039 | 25 | 0 | 62_ADG014_CEBOLLA2 |
| 62_ADG015 | 16,457 | 16,459 | -2 | 0 | 62_ADG015_LAKE |
| 62_ADG016 | 24,596 | 24,597 | -1 | 0 | 62_ADG016_GUNNBM |
| 62_ADG017 | 1,978 | 1,978 | 0 | 0 | 62_ADG017_GUNNM |
| 62_ADG018 | 5,131 | 5,104 | 27 | 1 | 62_ADG018_CIM |
| 62_AMG001 | 1,449 | 1,448 | 1 | 0 | Upper_M&I |
| 62_IrrCim | 28,331 | 27,292 | 1,039 | 4 | Cimmaron_Canal |
| 680501 | 5,239 | 5,231 | 8 | 0 | ALKALI DITCH D NO 80 |
| 680502 | 4,317 | 4,163 | 153 | 4 | ALKALI NO 2 DITCH |
| 680514 | 1,912 | 1,852 | 59 | 3 | BURKHART EDDY DITCH |
| 680526 | 3,112 | 3,099 | 14 | 0 | CHARLEY LOGAN DITCH |
| 680538 | 424 | 399 | 26 | 6 | CRONENBERG DITCH |
| 680543 | 3,788 | 3,722 | 67 | 2 | DALLAS DITCH |
| 680559 | 1,759 | 1,705 | 53 | 3 | DOC WADE DITCH |
| 680603 | 1,087 | 1,047 | 41 | 4 | HENRY TRENCHARD DITCH |
| 680607 | 3,939 | 3,910 | 29 | 1 | HOMESTRETCH DITCH |
| 680609 | 1,958 | 1,956 | 2 | 0 | HOSNER BROWNYARD DITCH |
| 680610 | 1,956 | 1,938 | 18 | 1 | HOSNER ROWELL DITCH |
| 680613 | 2,135 | 2,124 | 11 | 1 | HYDE SNEVA DITCH |
| 680636 | 3,039 | 3,029 | 10 | 0 | LEOPARD CREEK DITCH |
| 680647 | 979 | 978 | 1 | 0 | MARTIN DITCH |
| 680652 | 826 | 813 | 13 | 2 | MAYOL LATERAL DITCH |
| 680653 | 911 | 890 | 21 | 2 | MAYOL SISSON DITCH |
| 680668 | 2,041 | 2,040 | 0 | 0 | MOODY DITCH |
| 680669 | 2,416 | 2,414 | 2 | 0 | MOODY NO1 DITCH |
| 680671 | 1,321 | 1,311 | 10 | 1 | MORRISON DITCH |
| 680681 | 2,247 | 2,246 | 1 | 0 | OLD AGENCY DITCH |
| 680683 | 1,317 | 1,298 | 19 | 1 | OWL CREEK DITCH |
| 680685 | 2,312 | 2,311 | 1 | 0 | PARK DITCH |
| 680692 | 3,963 | 3,963 | 0 | 0 | PINION DITCH |
| 680703 | 1,134 | 1,134 | 0 | 0 | REED OVERMAN DITCH |
| 680710 | 850 | 784 | 66 | 8 | RIDGWAY DITCH |
| 680720 | 1,094 | 1,094 | 0 | 0 | ROSWELL HOTCHKISS DITCH |
| 680729 | 530 | 530 | 0 | 0 | SHORTLINE D COW CREEK |
| 680738 | 3,586 | 3,576 | 10 | 0 | SNEVA DITCH |
| 680765 | 2,822 | 2,820 | 2 | 0 | UPPER UNCOMPAHGRE DITCH |
| 68_ADG032 | 14,146 | 14,144 | 2 | 0 | 68_ADG032_UNCOMPH1 |
| 68_ADG033 | 8,493 | 8,487 | 6 | 0 | 68_ADG033_DALLAS |
| 68_ADG034 | 10,305 | 10,309 | -4 | 0 | 68_ADG034_UNCOMPH2 |
| 95CSUB_I | 0 | 0 | 0 | 0 | Subordinate_Crystal_Irr |
| 95CSUB_M | 0 | 0 | 0 | 0 | Subordinate_Crystal_M&I |
| 95L_MY | 0 | 0 | 0 | 0 | Lower_Market_Yield |

| WDID | Historical | Simulated | Historical minus Simulated | | Structure Name |
|---|---|---|---|---|---|
| | | | Volume | Percent | |
| 95MSUB_I | 0 | 0 | 0 | 0 | Subordinate_Morrow_Irr |
| 95MSUB_M | 0 | 0 | 0 | 0 | Subordinate_Morrow_M&I |
| 95USUB_I | 0 | 0 | 0 | 0 | Subordinate_Upper_Irr |
| 95USUB_M | 0 | 0 | 0 | 0 | Subordinate_Upper_M&I |
| 95U_MY | 0 | 0 | 0 | 0 | Upper_Market_Yield |
| 960050 | 27,147 | 26,778 | 369 | 1 | REDLANDS_POWER_CANAL-IRR |
| 960051 | 6,589 | 6,374 | 215 | 3 | Grand_Junction_Demand |
| Proj_7 | 6,670 | 3,985 | 2,684 | 40 | Project_7 |
| Basin Total | 2,765,388 | 2,697,243 | 68,145 | 2.5 | |



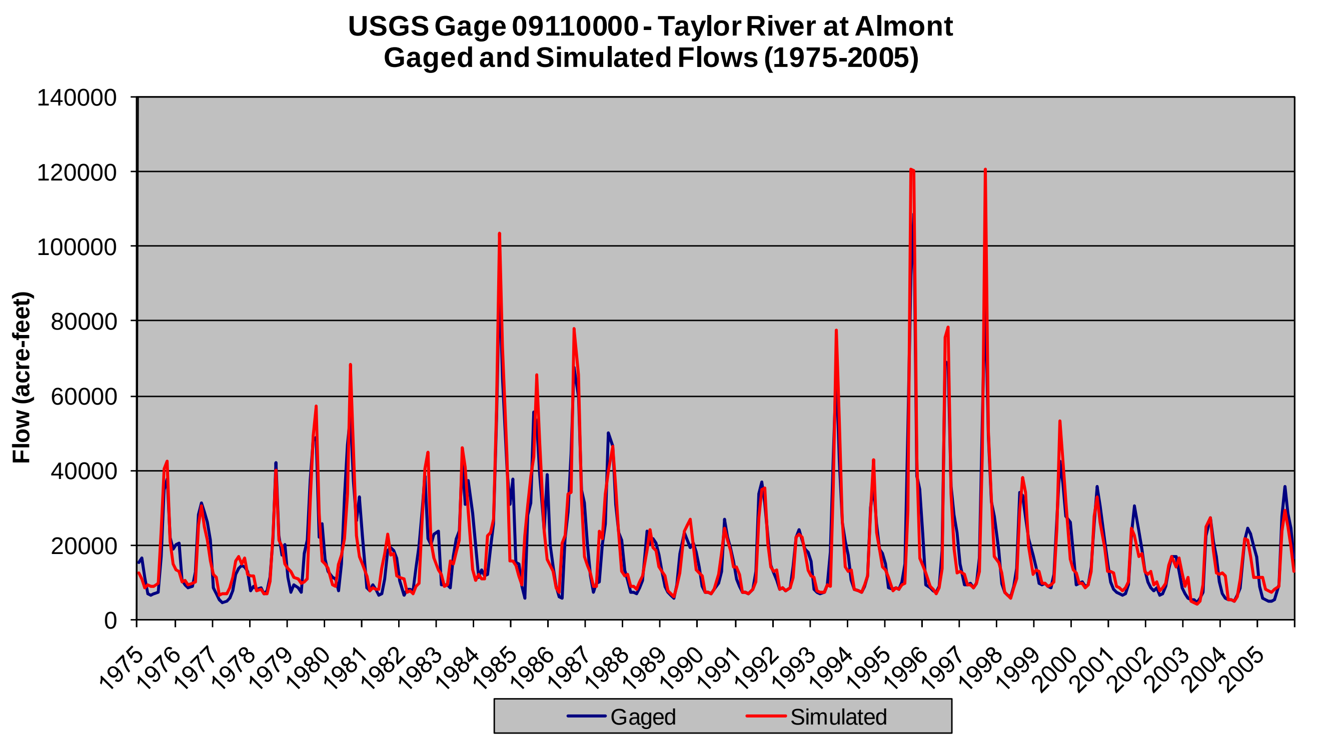
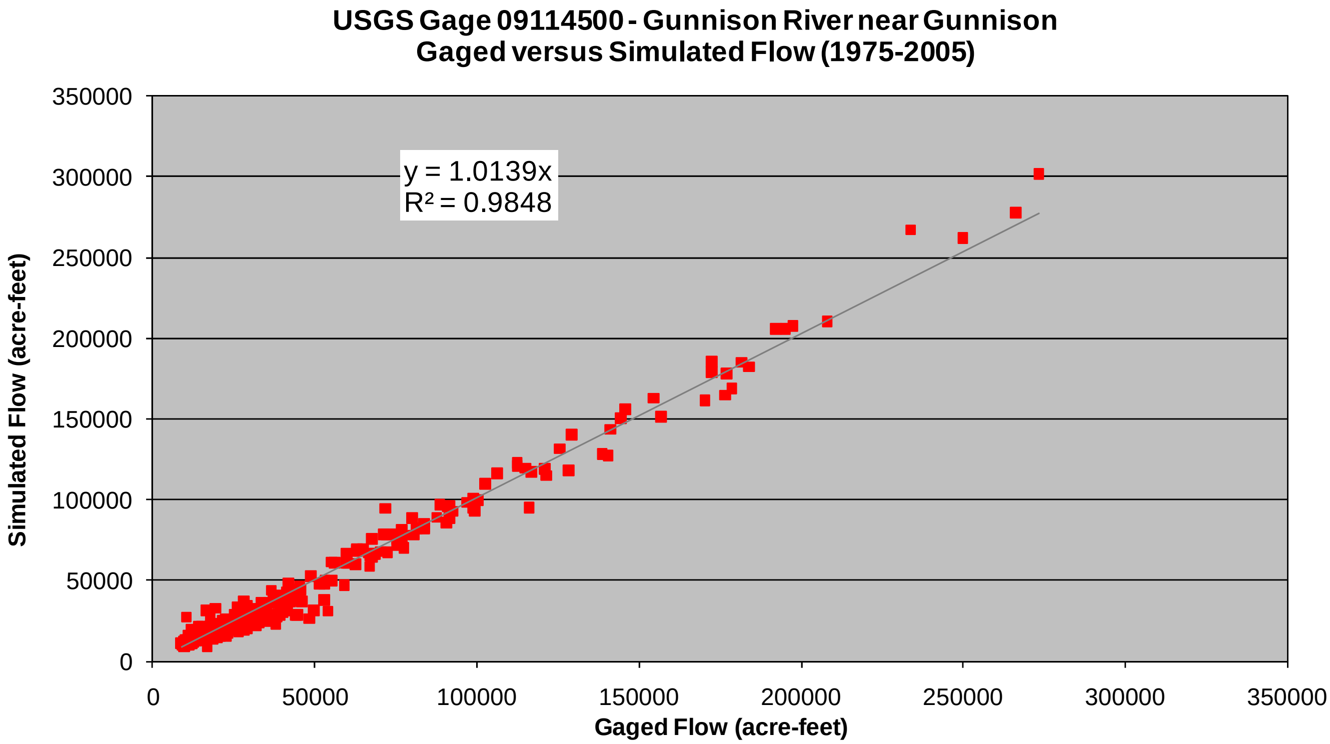




**Figure 7.1 Streamflow Calibration – Taylor River at Almont**



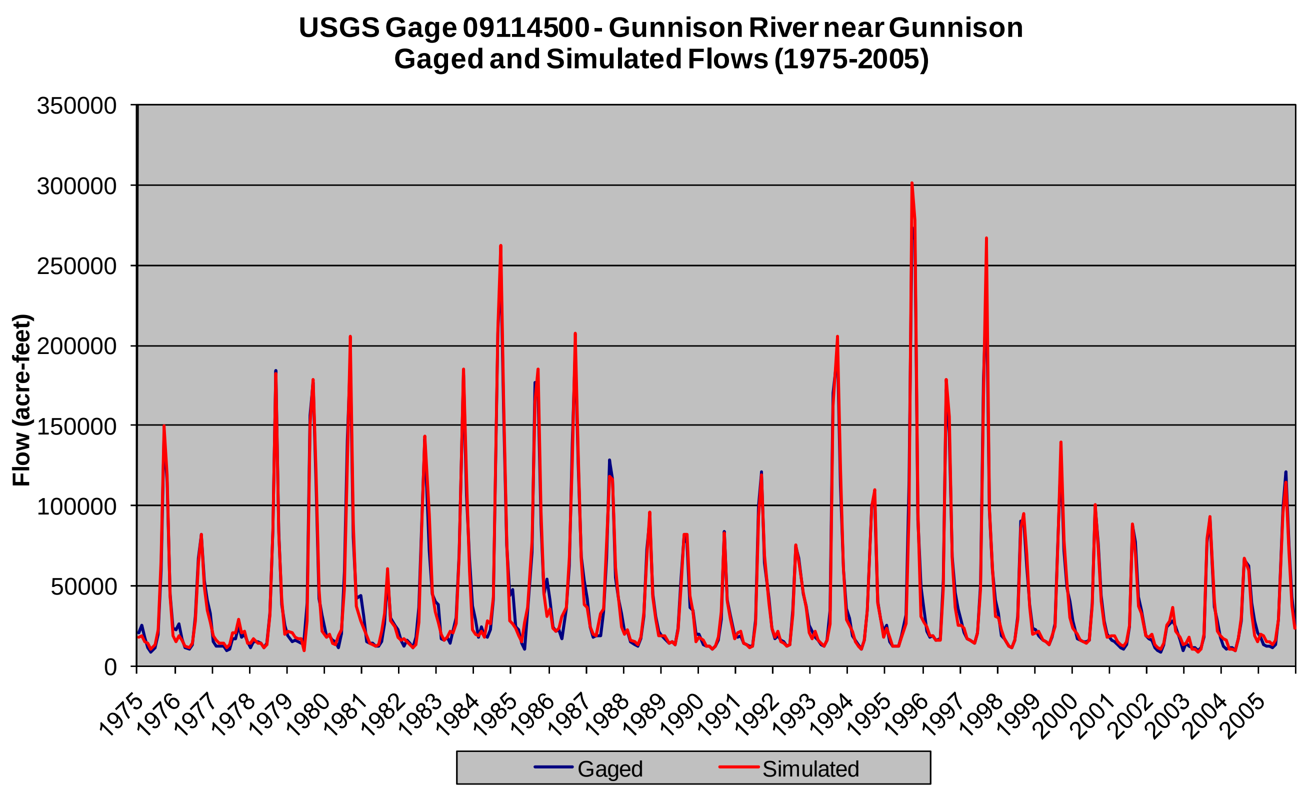
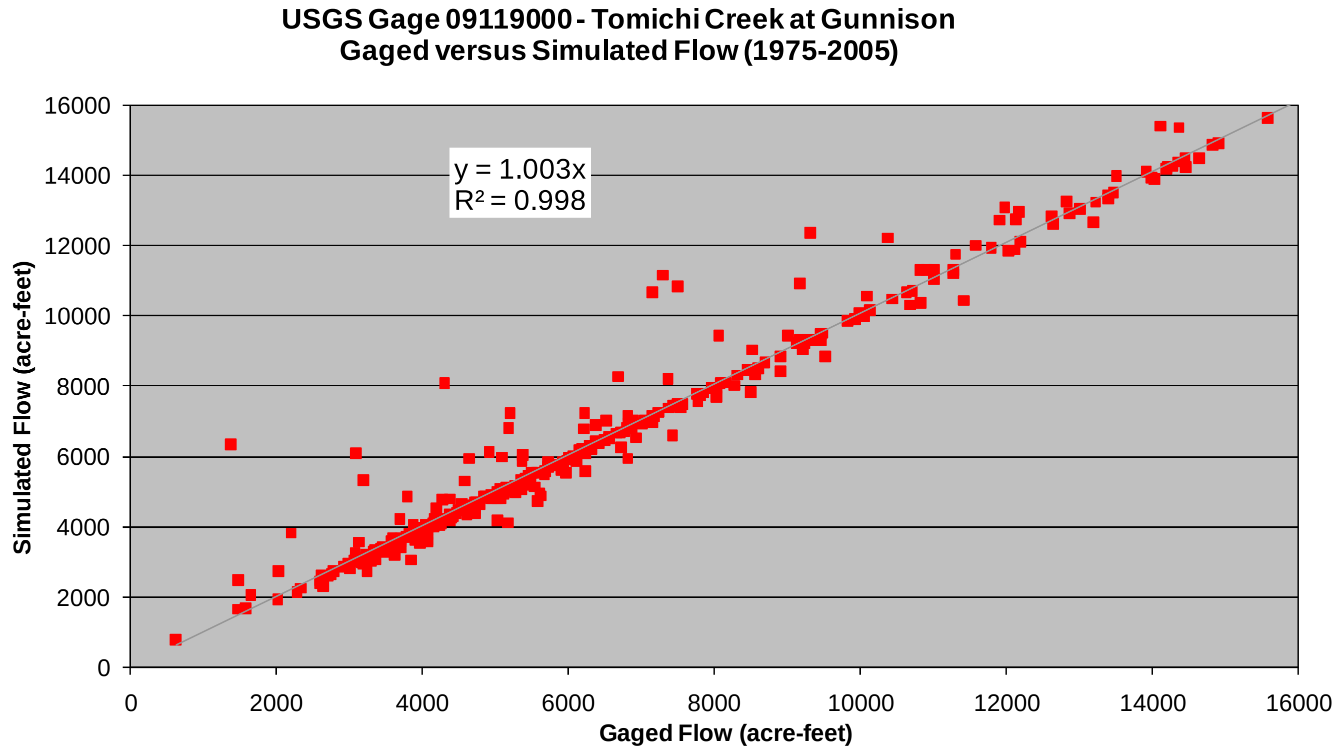




**Figure 7.2 Streamflow Calibration – Gunnison River near Gunnison**



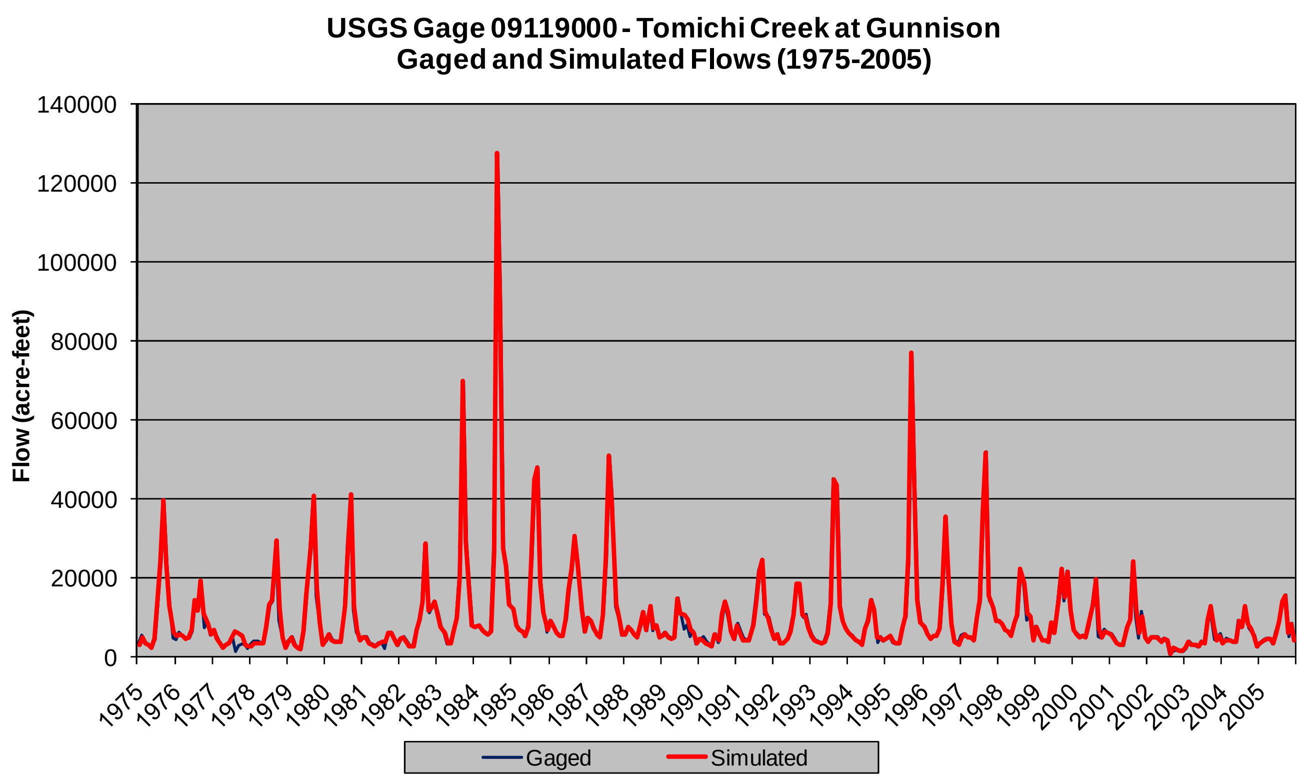
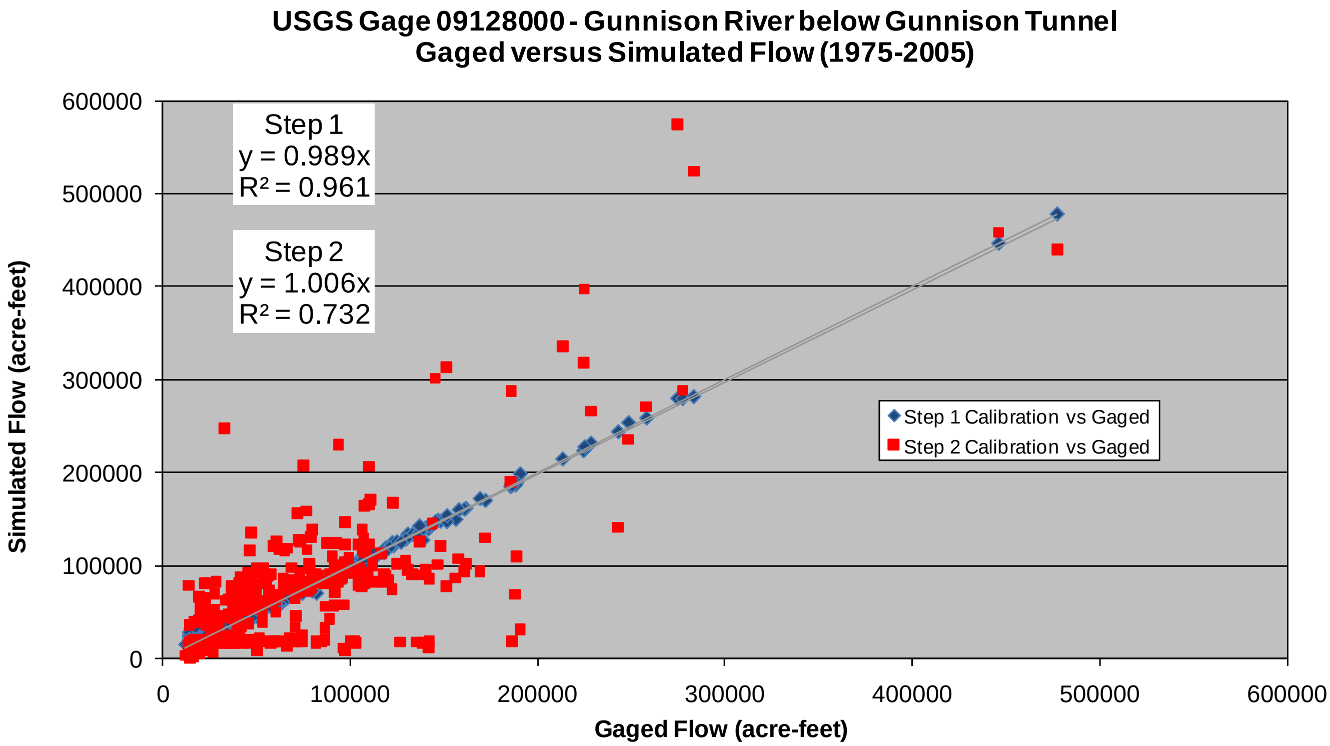




**Figure 7.3 Streamflow Calibration – Tomichi Creek at Gunnison**



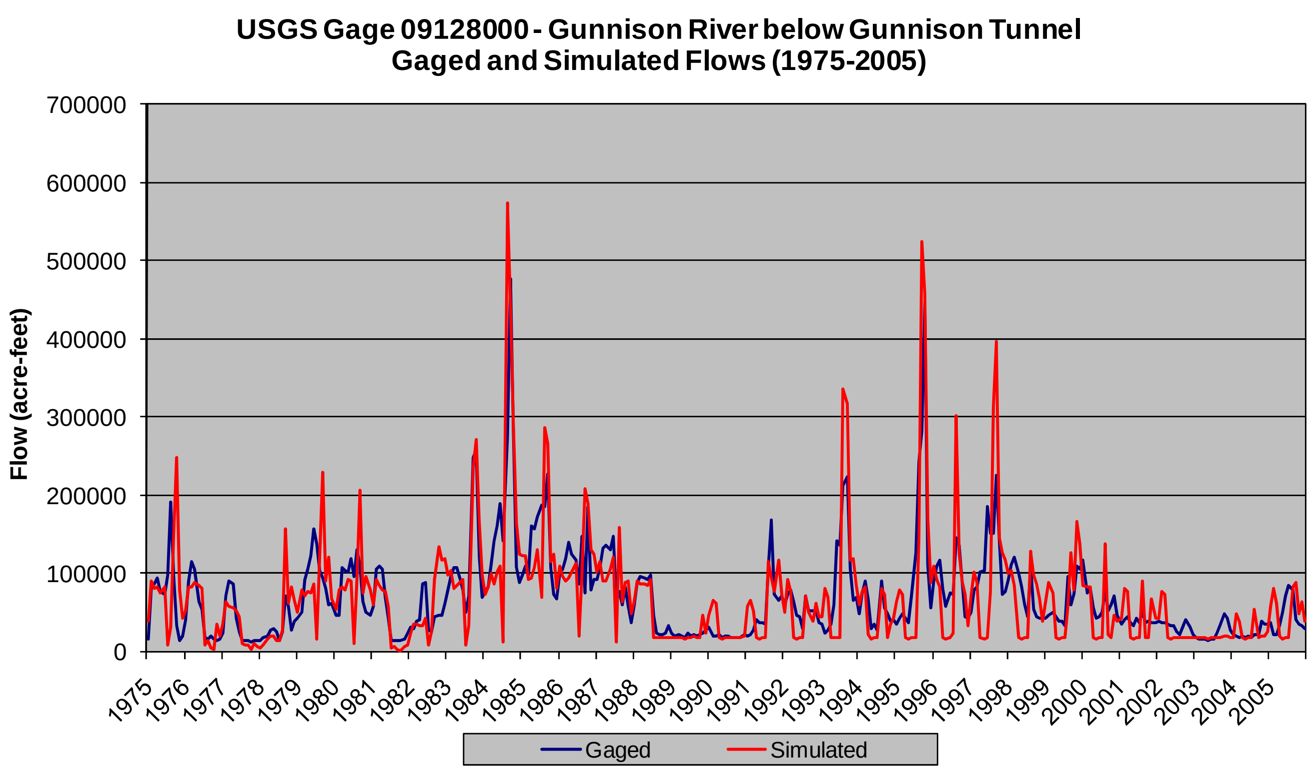
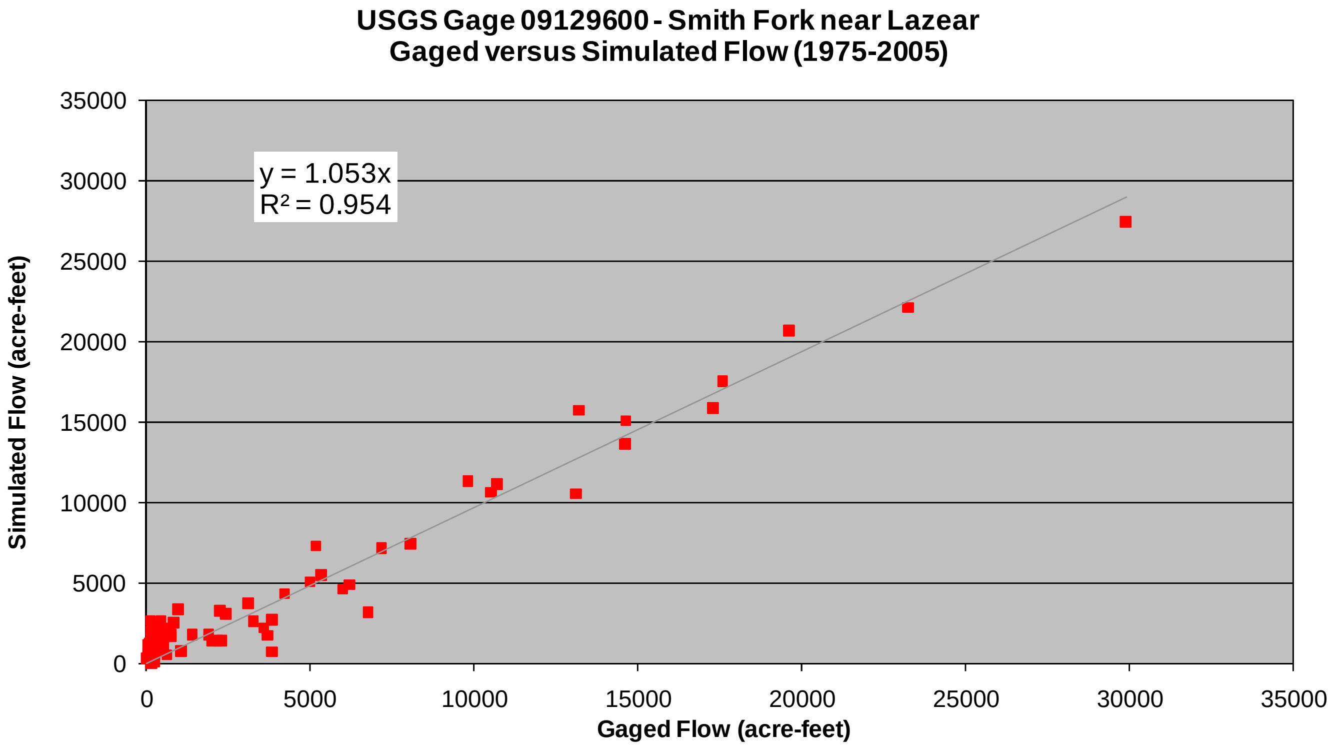




**Figure 7.4 Streamflow Calibration – Gunnison River below Gunnison Tunnel**



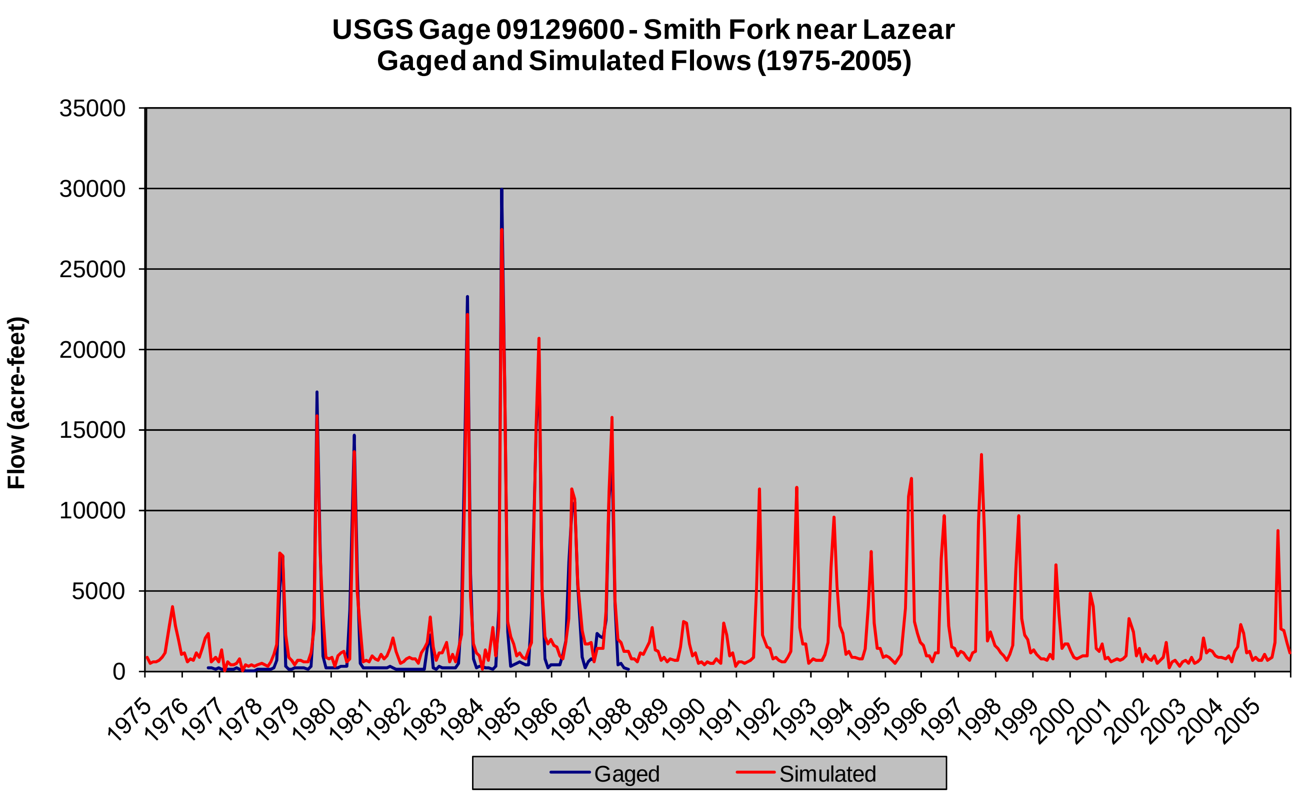
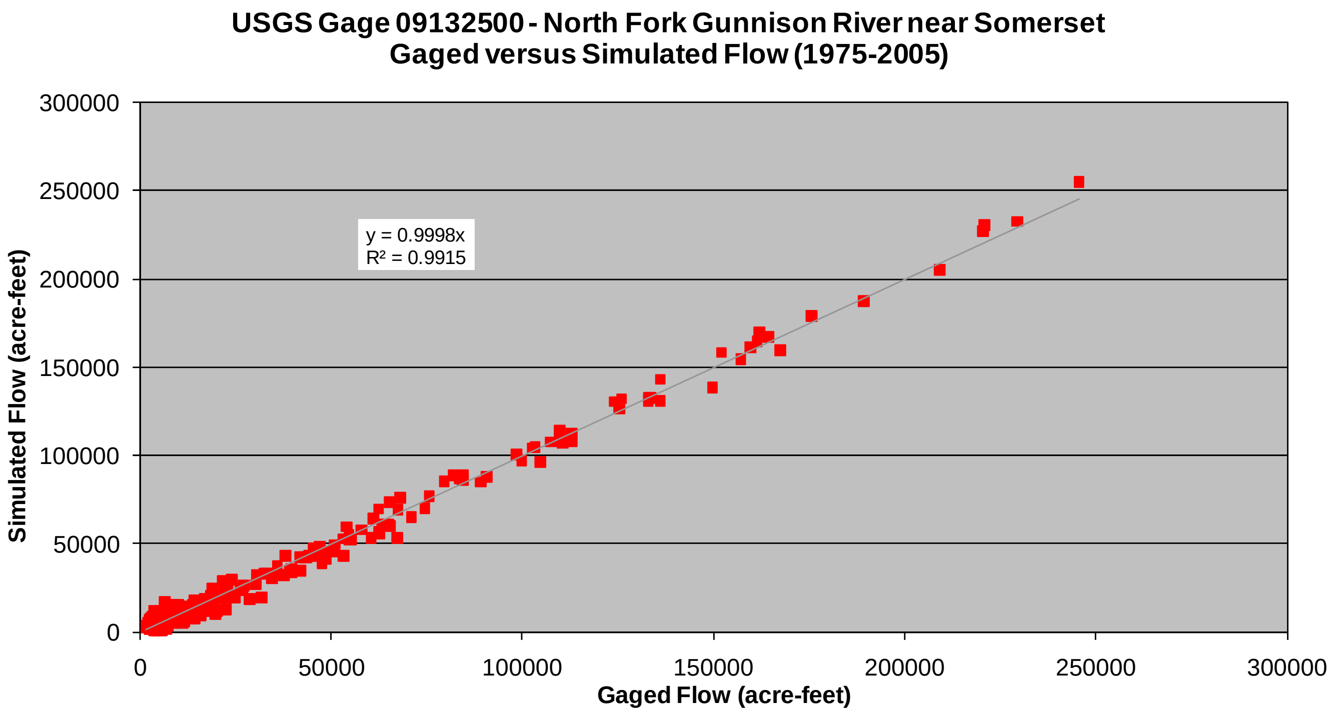




**Figure 7.5 Streamflow Calibration – Smith Fork near Lazear**



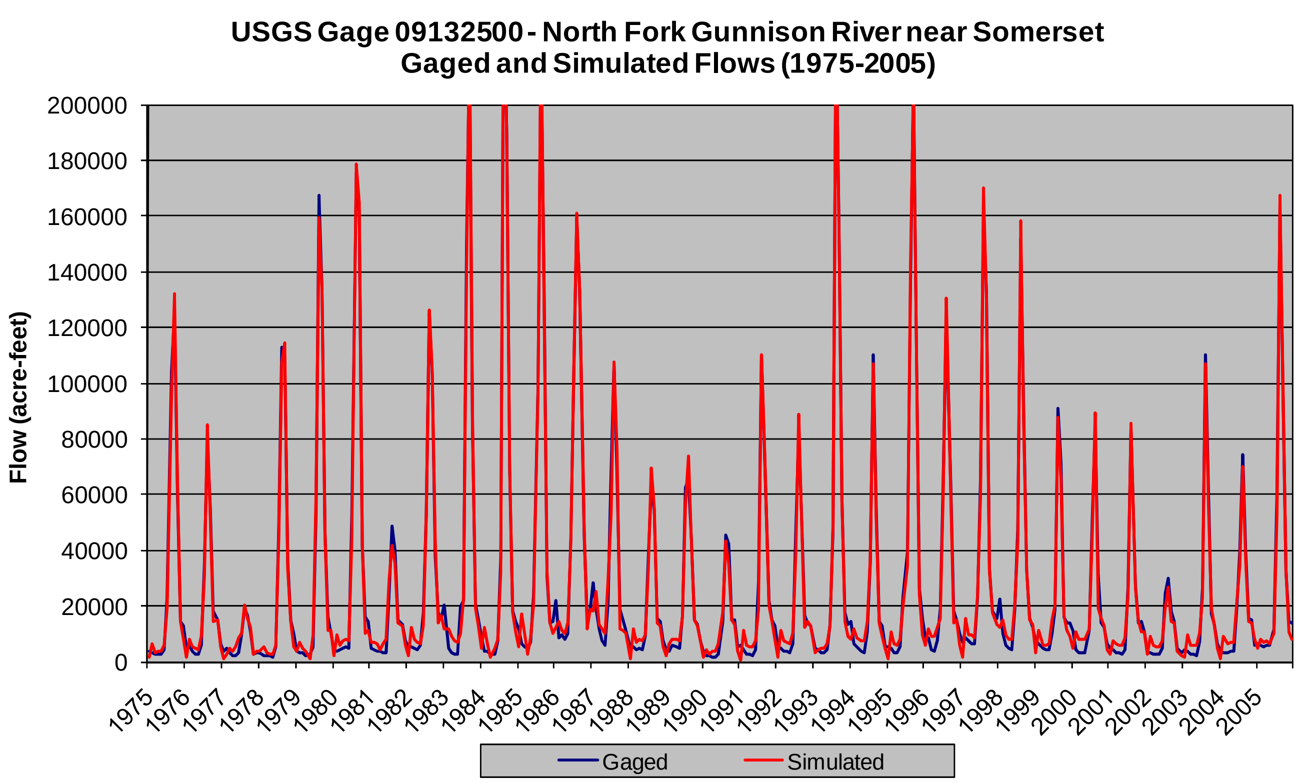
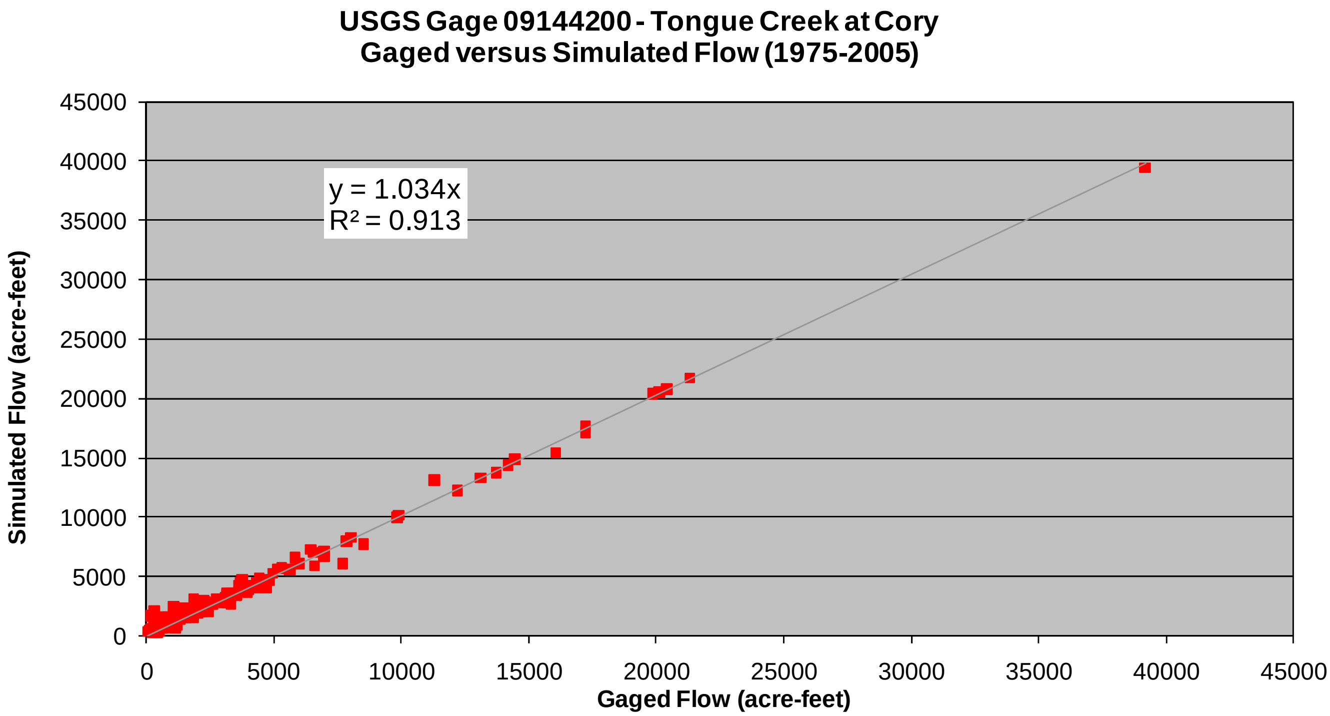




**Figure 7.6 Streamflow Calibration – North Fork Gunnison River near Somerset**



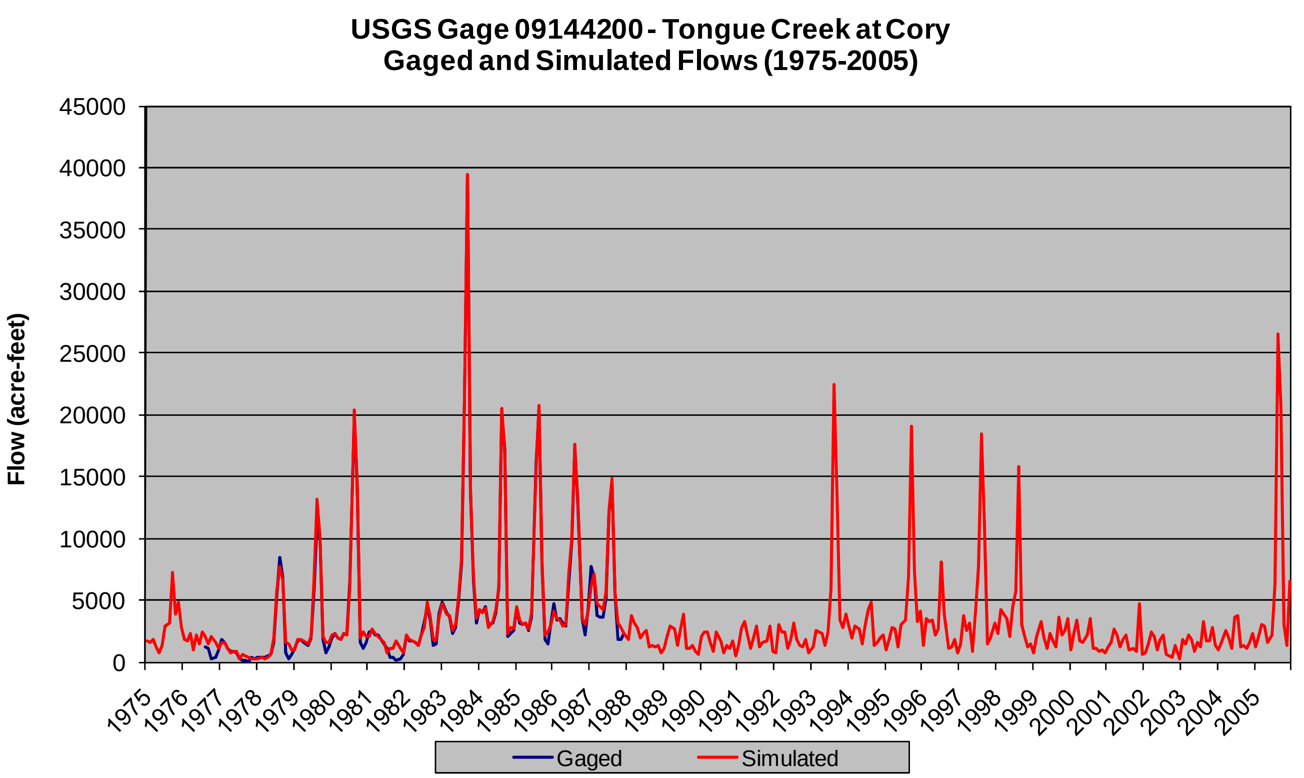
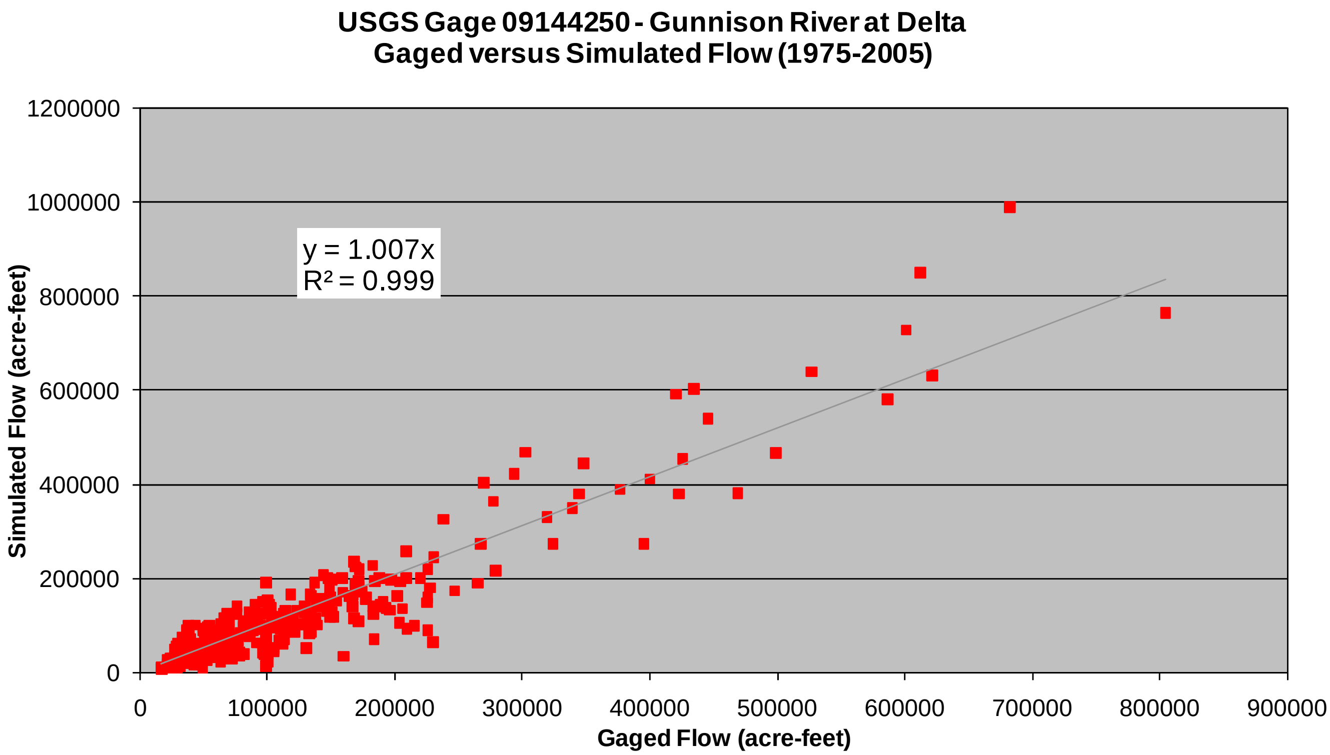




**Figure 7.7 Streamflow Calibration – Tongue Creek at Cory**



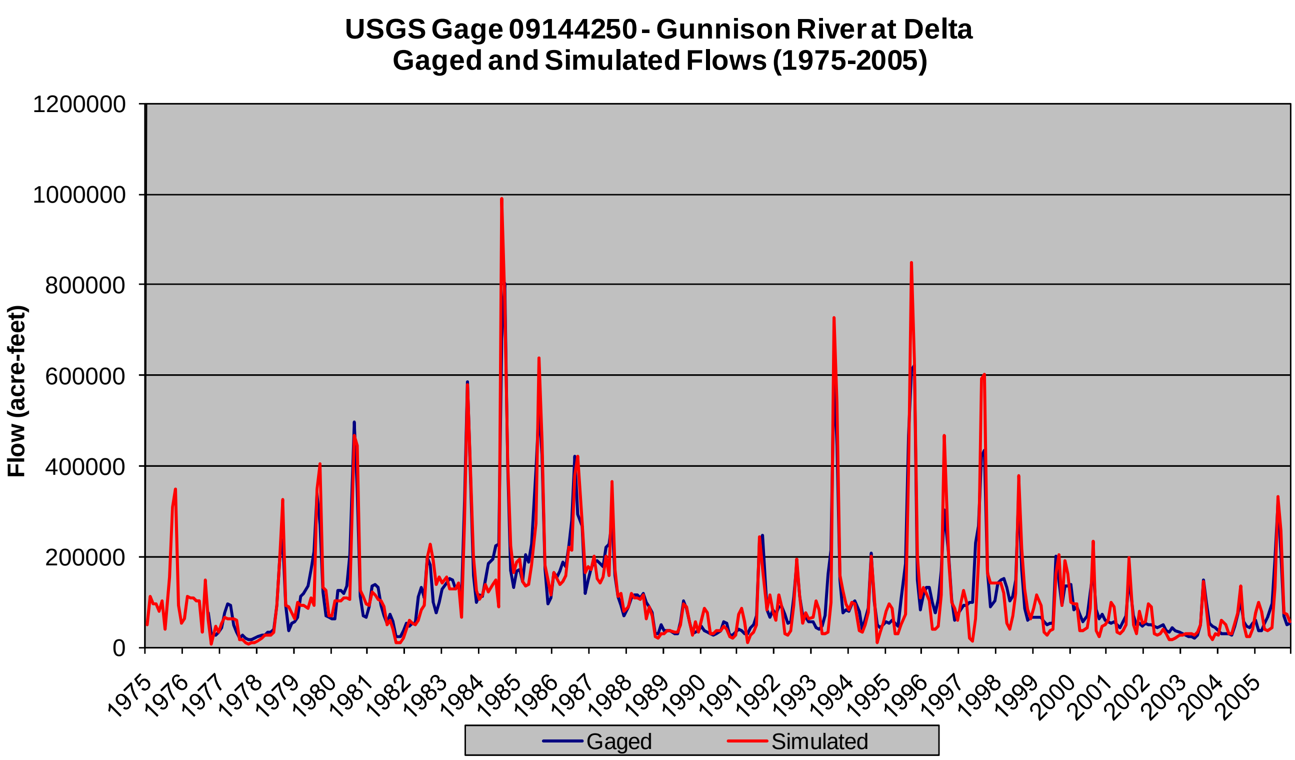
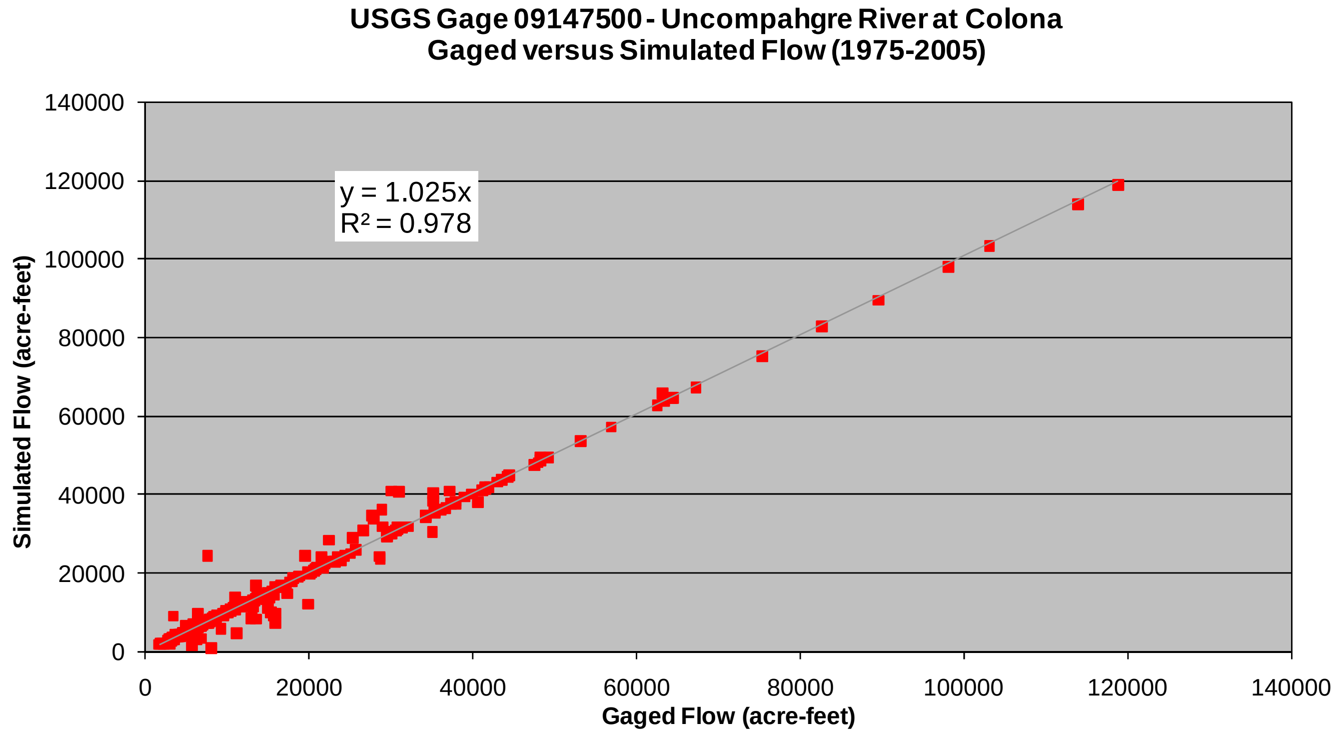




**Figure 7.8 Streamflow Calibration – Gunnison River at Delta**



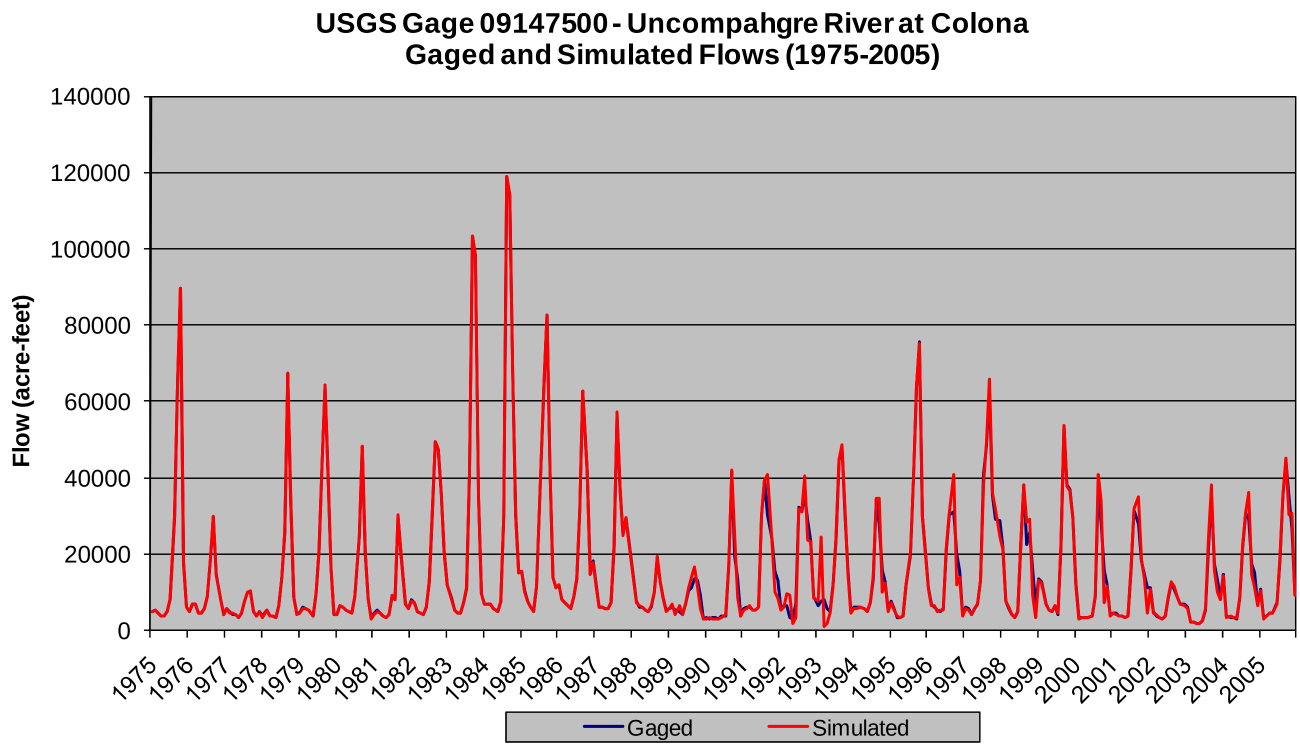
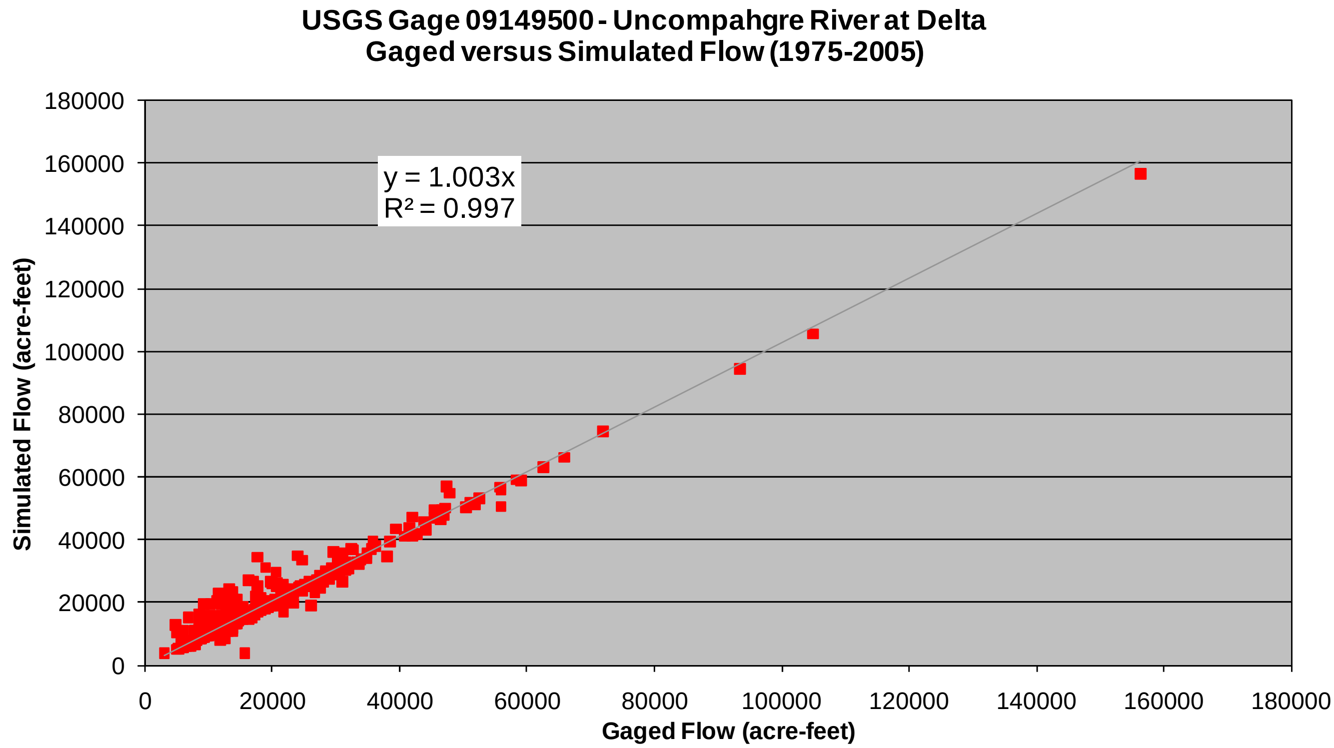




**Figure 7.9 Streamflow Calibration – Uncompahgre River at Colona**



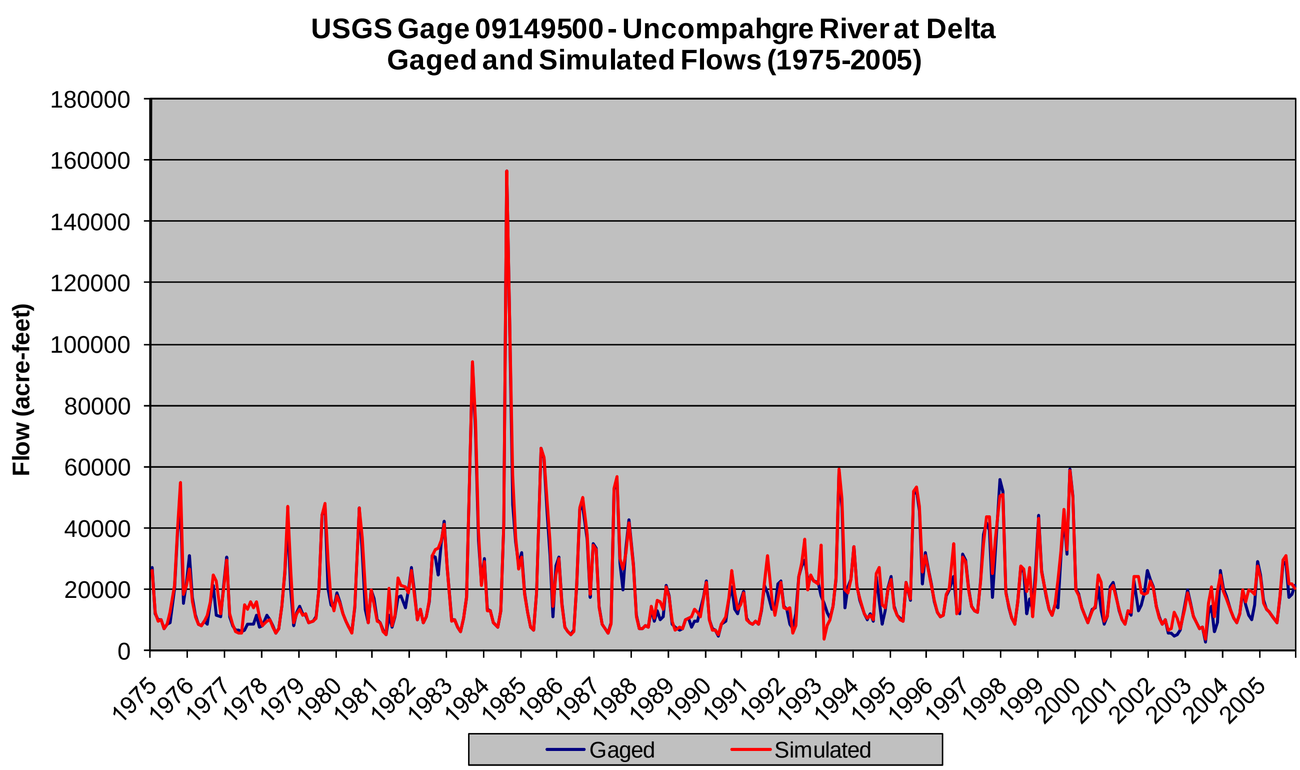
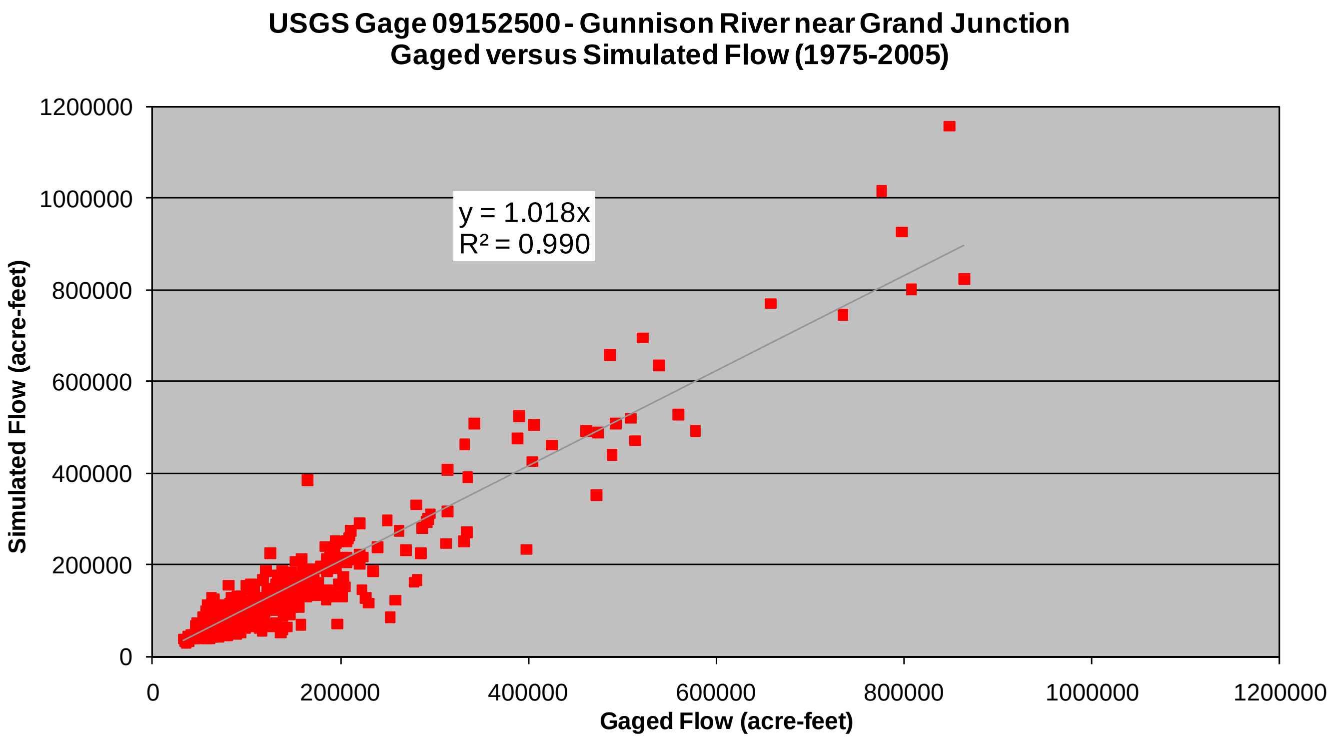




**Figure 7.10 Streamflow Calibration – Uncompahgre River at Delta**



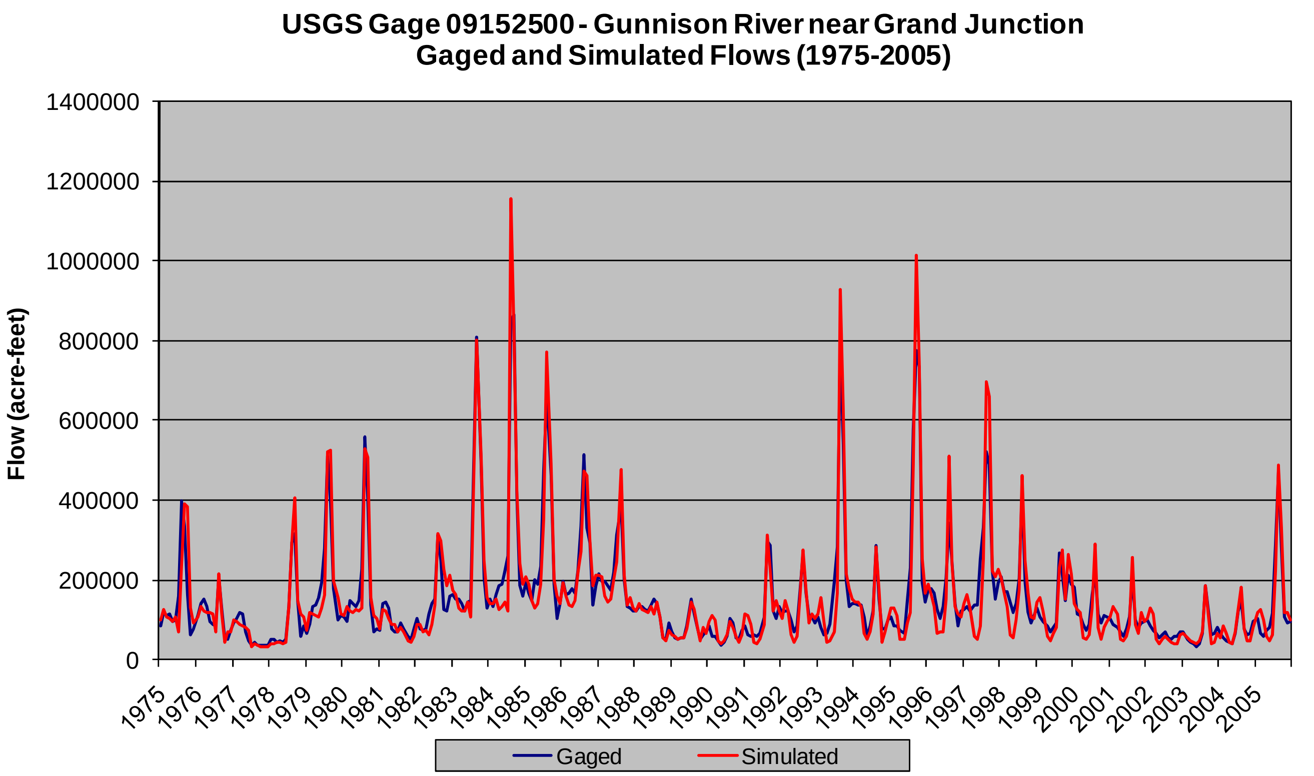




**Figure 7.11 Streamflow Calibration – Gunnison River near Grand Junction**

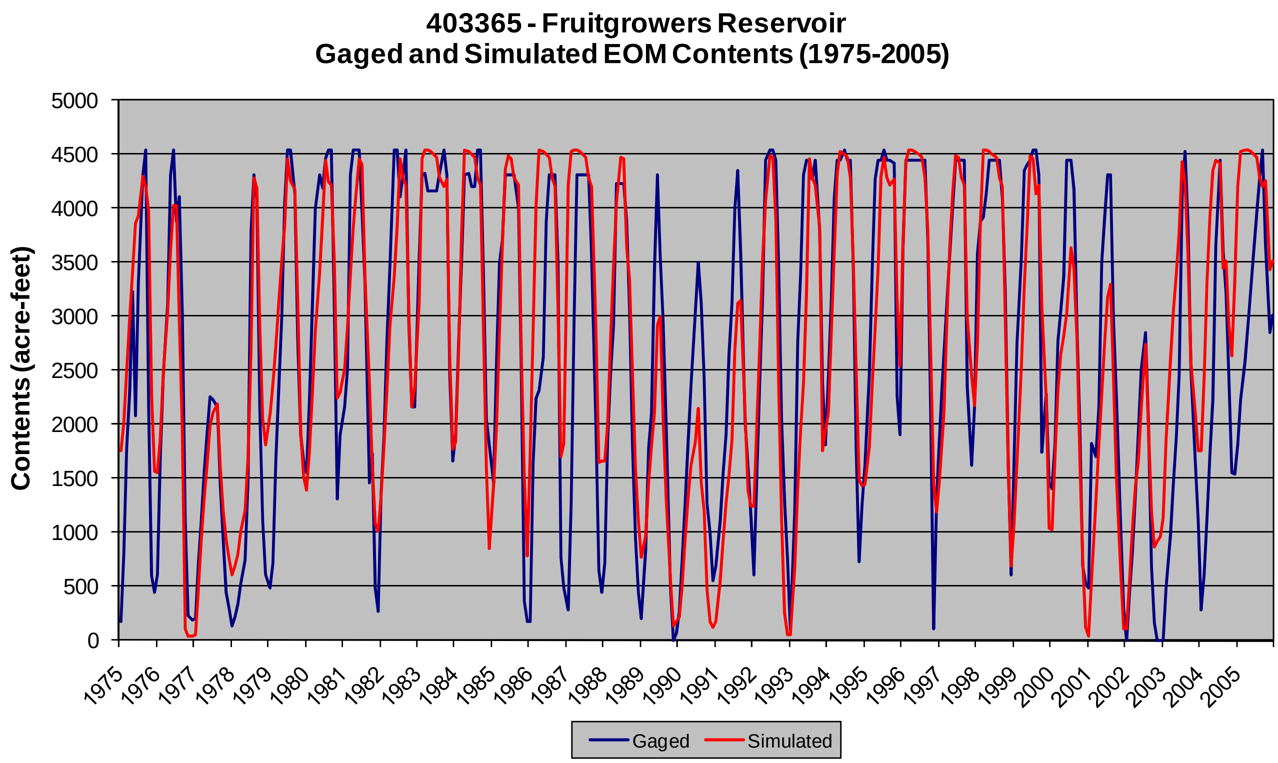



**Figure 7.12 Reservoir Calibration – Fruitgrowers Reservoir**

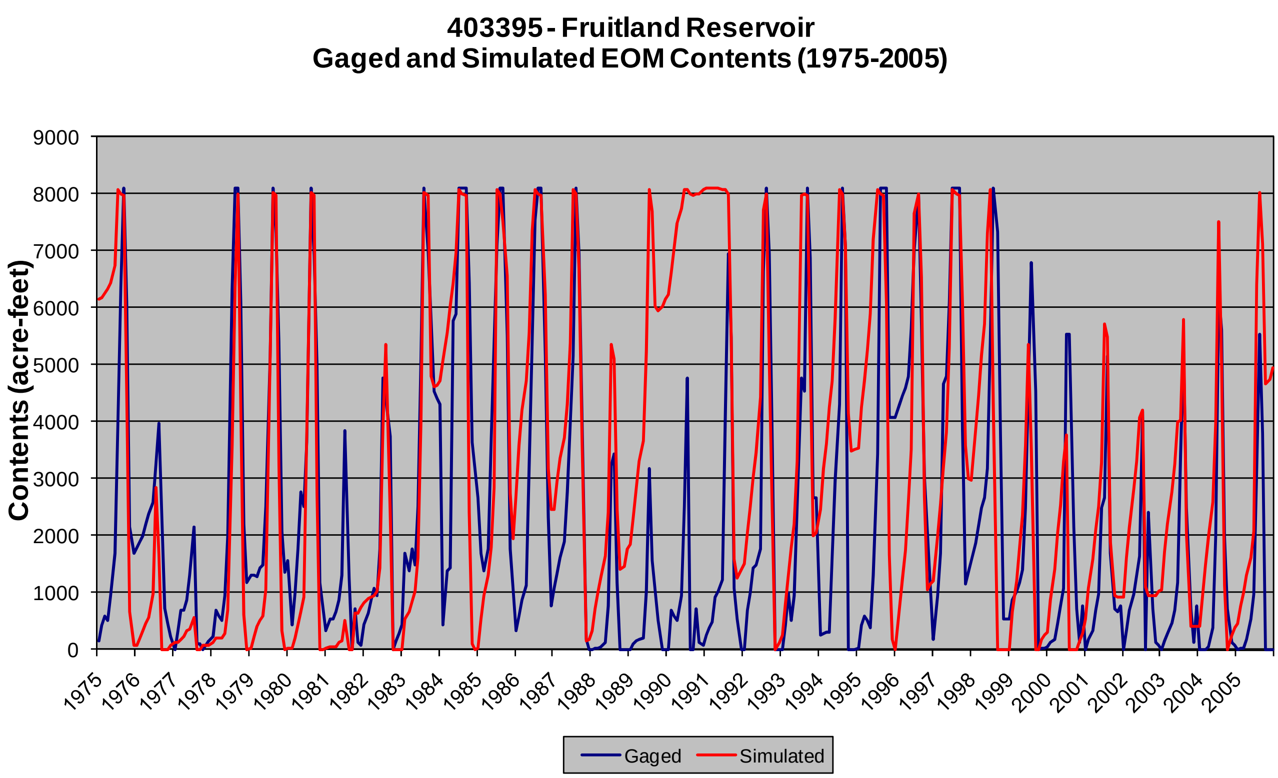



**Figure 7.13 Reservoir Calibration – Fruitland Reservoir**

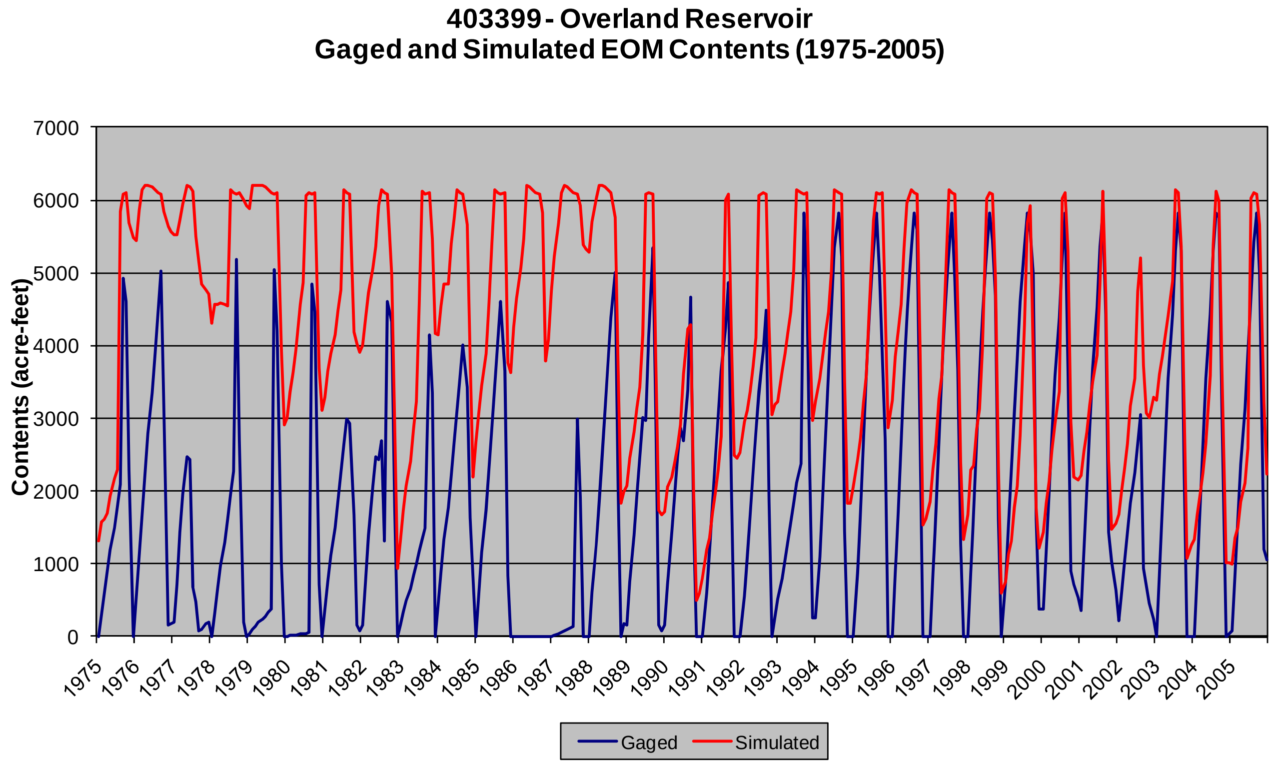



**Figure 7.14 Reservoir Calibration – Overland Reservoir**

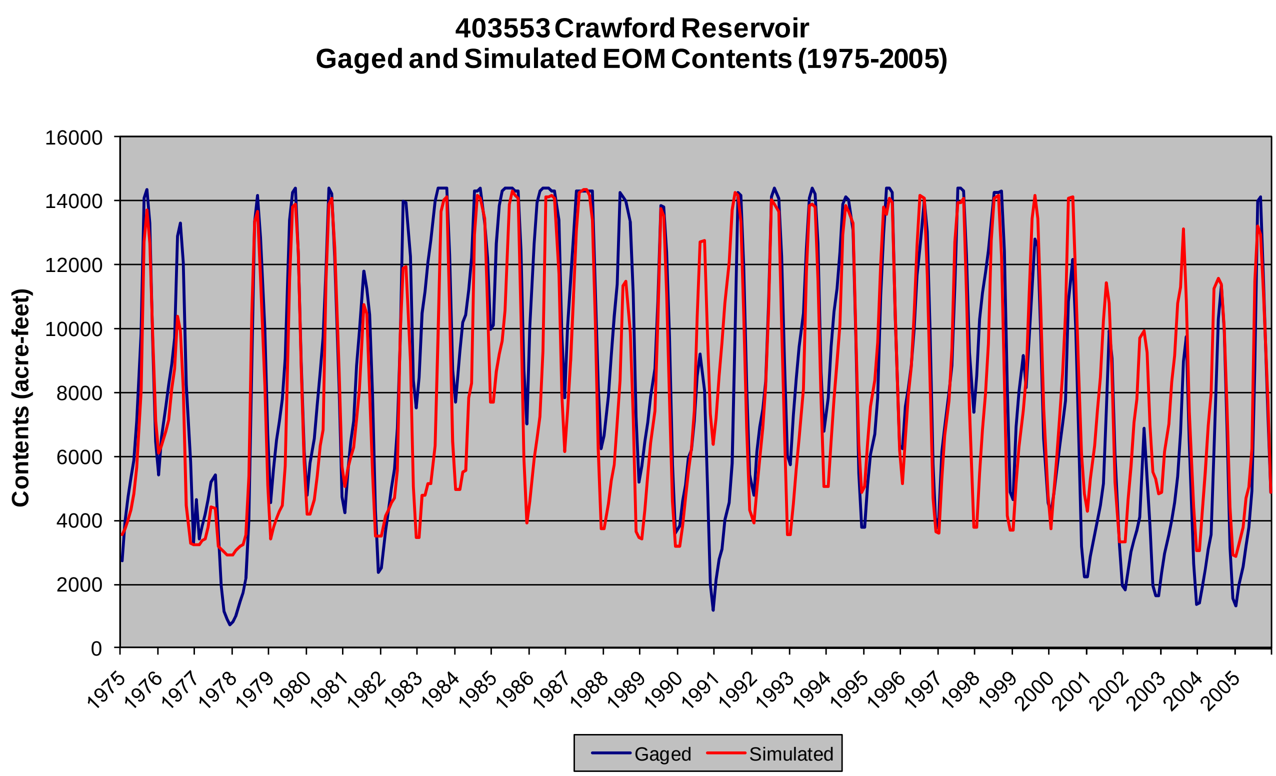



**Figure 7.15 Reservoir Calibration – Crawford Reservoir**

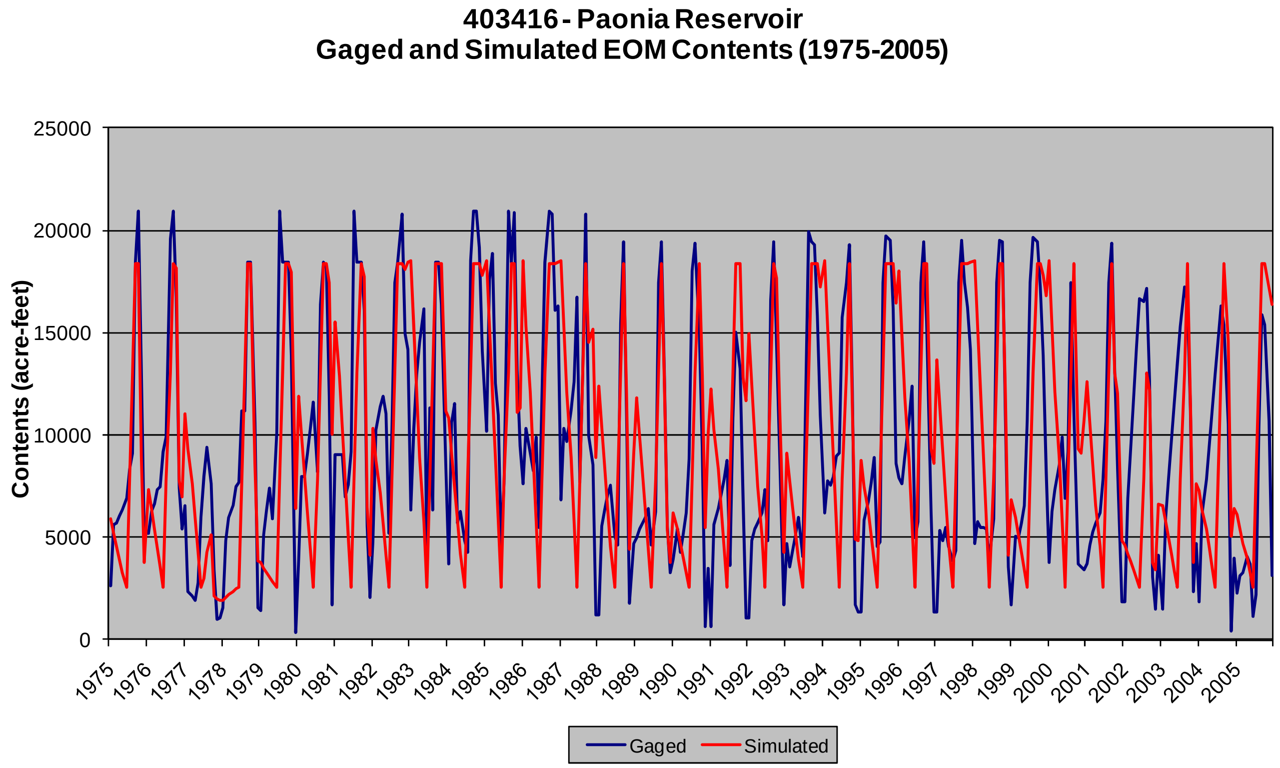



**Figure 7.16 Reservoir Calibration – Paonia Reservoir**

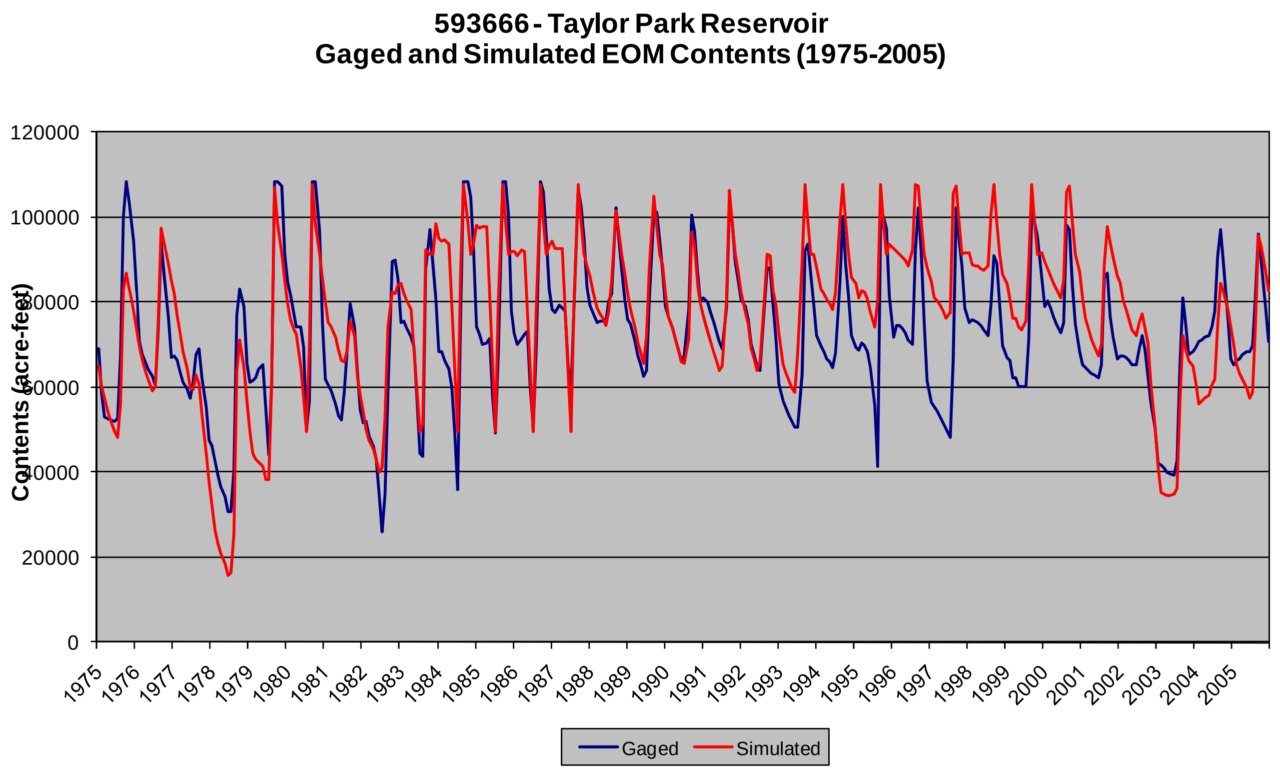



**Figure 7.17 Reservoir Calibration – Taylor Park Reservoir**

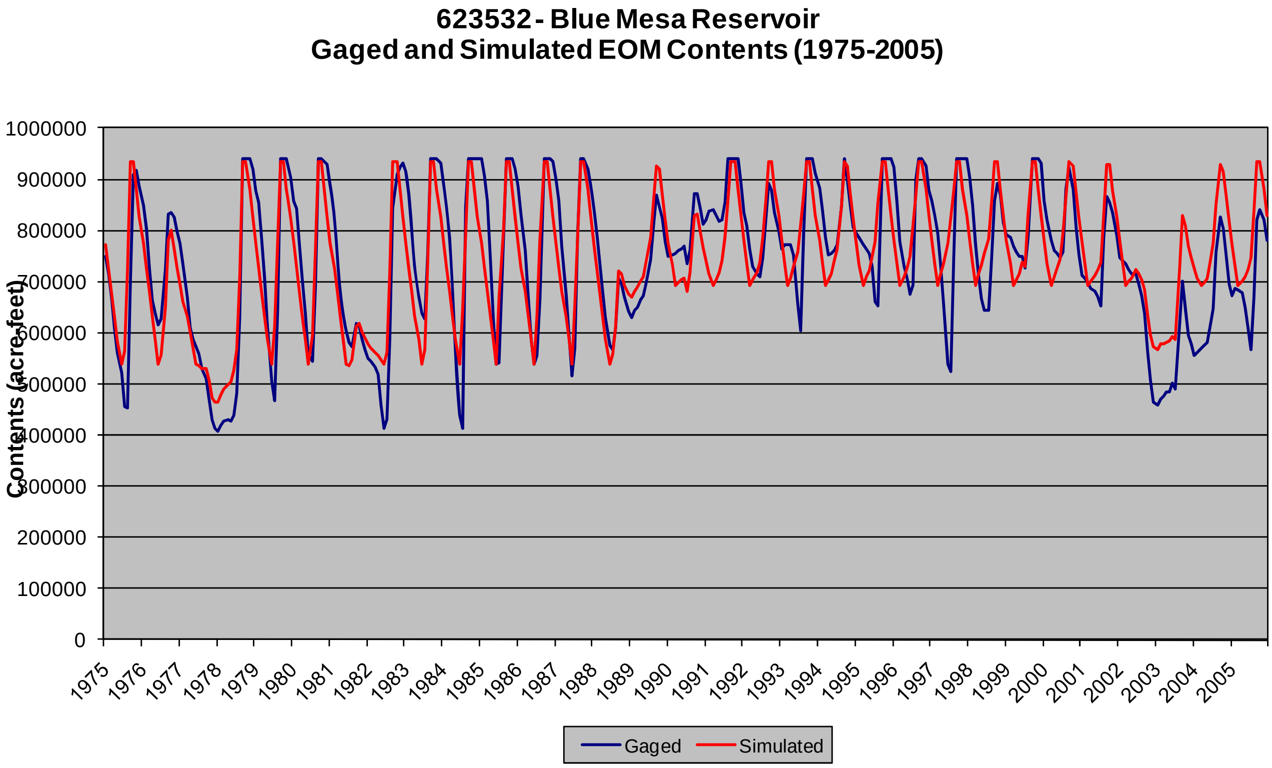



**Figure 7.18 Reservoir Calibration – Blue Mesa Reservoir**

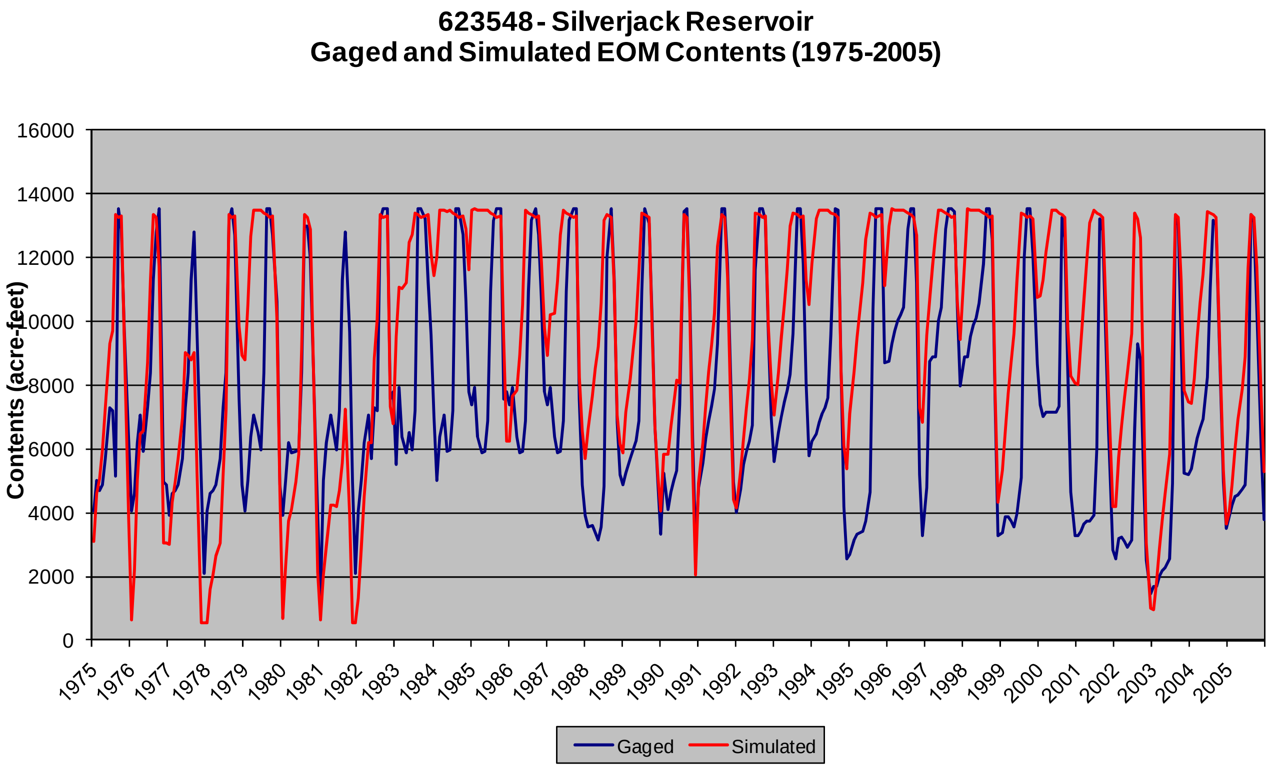



**Figure 7.19 Reservoir Calibration – Silverjack Reservoir**

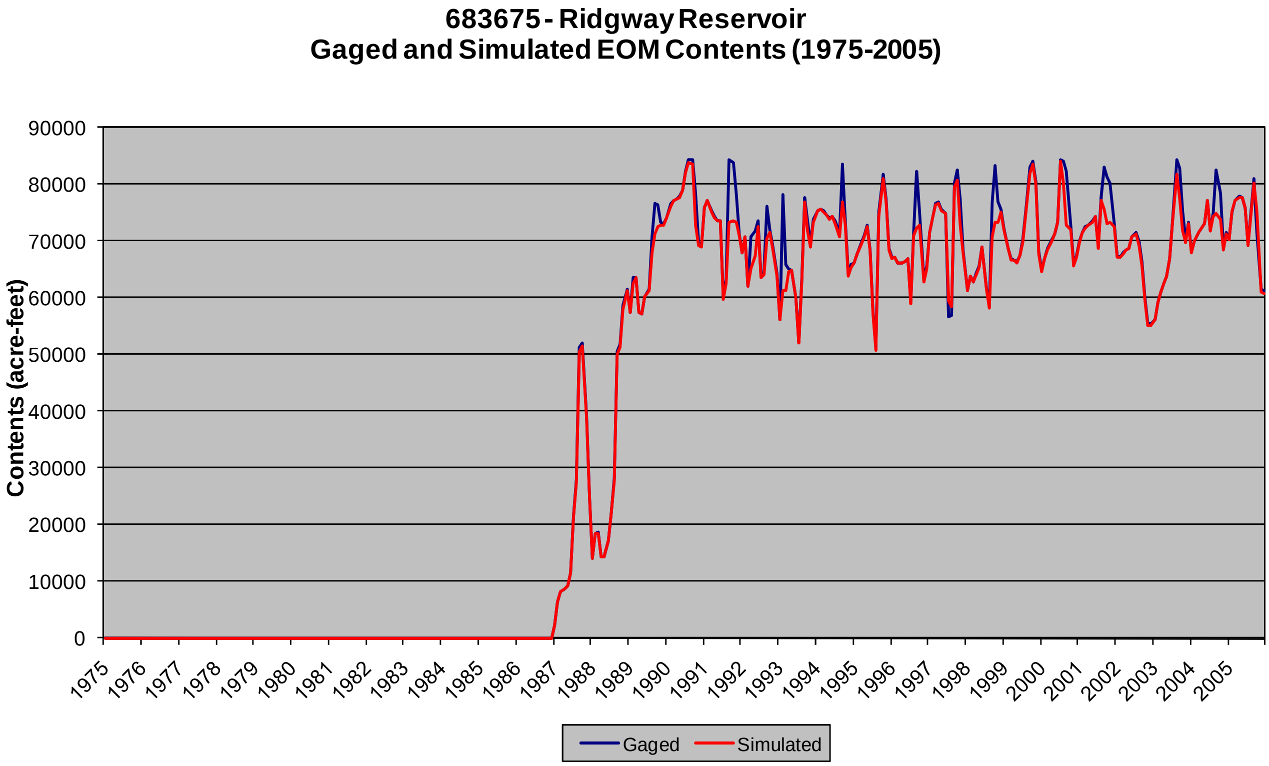



**Figure 7.20 Reservoir Calibration – Ridgway Reservoir**

# 8. Daily Baseline Results

*Note*: This section describes a Daily Baseline Data Set that was completed in July 2004. The monthly Gunnison Model Historical (calibration), Calculated and Baseline data files were updated in October 2009, and the 2009 calibration and Baseline data sets are described in this user manual. Inconsistencies between the 2004 and 2009 Daily Baseline Data Set are minor, and include:

1) extended analysis period through 2005,
2) differences in IWR for fields below 6,500 ft in elevation, because an elevation adjustment was applied to crop coefficients in the Blaney-Criddle analysis in the 2009 model,
3) updated operations for reservoirs in the North Fork Gunnison basin, and
4) inclusion of the final Black Canyon of the Gunnison National Park Service instream flow agreement.

The approach described for the Daily Baseline Data Set is accurate, except for the items listed above. Table values in this appendix are expected to be similar to, but not exactly, what would be produced with an updated Daily Baseline Data Set.

The “Daily 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 on a daily time-step.  The purpose of the Daily model data set is to capture daily variations in streamflow and call regime. The simulation period for the Daily model is 1975 through 2002. This is the period for which diversion data, and associated irrigation efficiencies, are most complete.

The most difficult part of developing a basin model is understanding the system. By first developing a monthly model, the system operation was investigated without the volume of information ultimately required for a daily model.  The Daily model was developed to be able to simulate large and small flow events that occur within a monthly time step. Therefore, although daily baseflows are used, other terms required for daily analysis, such as diversion demands and reservoir targets, are developed using a simplified approach.

Daily baseflows are estimated using StateMod’s Daily Pattern approach.  StateMod calculates each day’s baseflow by disaggregating monthly baseflows using the daily pattern of flow at selected historical gages. These “pattern gages” are representative of baseflows in subbasins throughout the Gunnison River basin.

Monthly Baseline demands were disaggregated to daily demands by connecting the midpoints of the monthly demand data. Reservoir targets were disaggregated by connecting the end points of monthly target data. Instream flow demands were disaggregated by setting them to the average daily value. Daily return flow delay patterns were used. The operating rights file is the same file used in the monthly Baseline simulation.

## 8.1 Daily Baseline Data Set

This section describes unique StateMod input files in the Daily Baseline Data Set. The data set is expected to be a starting point for users who want to apply the Gunnison River water resources planning model to a particular management issue on a daily basis. As with the monthly Baseline Data set, the investigator may want 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 Daily Baseline data set provides a basis against which to compare future scenarios. Users may opt to modify the Daily Baseline data set for their own interpretation of current or near-future conditions.

The daily Baseline data set, and corresponding daily results, does not include any consideration for Colorado River Compact obligations, nor are conditional water rights represented in the daily Baseline data set. Variations of the daily Baseline data set could include conditional rights within the Gunnison Basin, and would likely result in less available flow than presented here.

The following detailed, file-by-file description is intended to provide enough detail that this can be done with confidence. Only files that are different from the Baseline Data Set are described here. Other Baseline Data Set files are described in Section 5.

This section is divided into the following subsections:

- Section 8.1.1 describes the response file, which simply lists names of the rest of the data files. The section tells briefly what is contained in each of the named files, and whether they are different in the Daily Baseline data set.

- Section 8.1.2 describes the control file, which sets the execution parameter for the daily simulation.

- Section 8.1.3 describes the two streamflow files that define the disaggregation of monthly baseflow files.

- Section 8.1.4 includes files that define the methodology for disaggregating monthly demands and reservoir targets for the daily simulation.

- Section 8.1.5 describes the daily return flow delay pattern file.

**Where to find more information**

- The CDSS Technical memorandum "CDSS Daily Yampa Model – Task 2 Pilot Study" described the investigation into StateMod's daily modeling approaches and the recommended approach for subsequent daily modeling of CDSS basins.
- For generic information on every daily input file listed below, see the StateMod documentation. It describes how input parameters are used, as well as format of the files.
- The input files used in both the Baseline data set and the Daily Baseline data set are described in detail in Section 5 – Baseline Data Set.

### 8.1.1. Response File (*.rsp)

The response file (gunndlyB.rps) contains the names of all other data files required to run the model. New file names have been used for the files that are used only in daily modeling. The file is changed by hand-editing. Many files are used in both the monthly Baseline and Daily Baseline simulations and the applicable sections are referenced. The file *GunnV.dum* is an empty dummy file, and is referenced in the response file for all the StateMod input file types that are not needed for this particular simulation.

| File Name | Description | Reference |
|---|---|---|
| gunndlyB.ctl | Control file – specifies execution parameters, such as run title, modeling period, options switches | Section 8.1.2 |
| gunnV.rin | River network file – lists every model node and specifies connectivity of network | Section 5.3.1 |
| gunnVB.res | Reservoir station file – lists physical reservoir characteristics such as volume, area-capacity table, and some administration parameters | Section 5.6.1 & Section 8.1.4 |
| gunnV.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 & Section 8.1.4 |
| gunndly.ris | River station file – lists model nodes, both gaged and ungaged, where hydrologic inflow enters the system | Section 8.1.3 |
| gunnV.ifs | Instream flow station file – lists instream flow reaches | Section 5.7.1 |
| gunnVH.dum | Well station file (not used in the Gunnison model) | N/a |
| gunnV.ifr | Instream flow right file – gives decreed amount and administration number of instream flow rights associated with instream flow reaches | Section 5.7.3 |
| gunnV.rer | Reservoir rights file – lists storage rights for all reservoirs | Section 5.6.5 |
| gunnVC.ddr | Direct diversion rights file – lists water rights for direct diversion | Section 5.4.5 |
| gunnVB.opr | Operational rights file – specifies many different kinds of operations that are more complex than a direct diversion or an onstream 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 |
| gunnVH.dum | Well rights file (not used in the Gunnison model) | N/a |
| gunnVH.dum | Precipitation file – Annual (not used in the Gunnison model) | N/a |
| gunnF.eva | Evaporation file – gives monthly rates for net evaporation from free water surface | Section 5.6.2 |
| gunnVx.xbm | Baseflow data file – time series of undepleted flows at all nodes listed in *gunnV.ris* | Section 5.3.5 |
| gunnVB.ddm | Monthly demand file – monthly time series of headgate demands for each direct diversion structure | Section 5.4.4 |
| gunnVH.dum | DD demand overwrite file – Monthly (not used in the Gunnison model) | N/a |
| gunnVH.dum | DD demand file – Annual (not used in the Gunnison model) | N/a |
| gunnV.ifa | Instream flow demand file – gives the decreed monthly instream flow rates | Section 5.7.2 |

| File Name | Description | Reference |
|---|---|---|
| gunnVH.dum | Well demand file (not used in the Gunnison model) | N/a |
| crdss.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 |
| gunnVB.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 |
| gunnV.tsp | CU Time series file – maximum efficiency and irrigated acreage by year and by structure, for variable efficiency structures | Section 5.5.2 |
| gunnV.iwr | Irrigation Water Requirement file – monthly time series of crop water requirement by structure, for variable efficiency structures | Section 5.5.3 |
| gunnV.par | Soil Parameter file – soil moisture capacity by structure, for variable efficiency structures | Section 5.5.1 |
| gunnV.eom | Reservoir End of month contents file – Monthly time series of historical reservoir contents | Section 5.6.3 |
| gunnV.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 |
| gunnV.rih | Historical streamflow file – Monthly time series of streamflows at modeled gages | Section 5.3.4 |
| gunnV.ddh | Historical Diversions – Monthly time series of historical diversions | Section 5.4.3 |
| gunnVH.dum | Historical well pumping (not used in the Gunnison model) | N/a |
| gunnF.gis | GIS file | N/a |
| gunndly.xou | Output control file | N/a |
| gunndly.rid | Daily historical streamflow file | Section 8.1.3 |
| gunnVH.dum | Daily direct flow demand file (not used in the Gunnison model) | N/a |
| gunnVH.dum | Daily instream flow demand file (not used in the Gunnison model) | N/a |
| gunnVH.dum | Daily well demand file (not used in the Gunnison model) | N/a |
| gunnVH.dum | Daily reservoir target file (not used in the Gunnison model) | N/a |
| crdss.dld | Daily return flow delay pattern file | Section 8.1.5 |
| gunndly.rid | Daily historical streamflow file | Section 8.1.3 |
| gunnvH.dum | Daily historical diversion file (not used in the Gunnison model) | N/a |
| gunnVH.dum | Historical reservoir end-of-day content file (not used in the Gunnison model) | N/a |

### 8.1.2. Control File

The control file, which is created and maintained by editing manually, contains information that controls the model simulation. Only one change was made to the monhly Baseline control file. The *iday* variable was set to “1” to indicate the simulation should be performed using a daily time-step.

### 8.1.3. River System Files

The daily pattern approach can be described as distributing monthly baseflows to daily baseflows based on the daily distribution of selected historical gages, or pattern gages. Statemod disaggregates the monthly baseflows by multiplying the daily historical gage flow $QD_{gage}$ by the factor $QM_{bf}/QM_{gage}$, where $QM_{bf}$ is the monthly baseflow and $QM_{gage}$ is the monthly historical gage flow.

Two files work in conjunction to define the daily baseflows used in the Daily Baseline simulations; the river station file (gunndly.ris) and the daily streamflow file (gunndly.rid). The river station file assigns each baseflow node to a representative historical streamflow gage with daily flow records in the daily streamflow file. Representative streamflow gages were identified based on the following criteria:

- Completeness of Daily Records. The streamflow gages within the Gunnison Model were reviewed for completeness of daily records over the 1975 through 2002 study period. Note that although the recommended daily modeling period for the CRDSS basins is 1975 through 2002, many streamflow gages in the Gunnison basin have continuous records extending from the early 1900s.
- Basin and Baseflow Representation. Representative pattern gages were then selected based on the location and minimal upstream effects. Ideally, pattern gages should closely represent baseflows – they should have minimal influence from upstream diversions or storage. In the Gunnison basin this generally means they are relatively upstream on the tributaries.
- Historic Flow and Baseflow Comparison. Average historical monthly flows were compared to the average baseflows calculated using StateMod to quantify the upstream effects and verify the gage selections.

Table 8.1 shows the historical gages selected for use as pattern gages, and their period of record. The daily historic streamflow file (*.rid) contains daily streamflows extracted from HydroBase for these gages. Baseflow nodes in each sub-basin or drainage were assigned to the pattern gages in the river station file (*.ris) as shown. Figure 8.1 displays the assignments of pattern gages.

**Table 8.1**
**Daily Pattern Gages Used for Gunnison River Sub-basins**

| Recommended Pattern Gage | Gage Period of Record | Basin Subdivision Assignment |
|---|---|---|
| 09112500 - East River at Almont | 1910 to 1922<br>1935 to current | East, Taylor, Slate, Cement, Ohio, and Castle Creeks (District 59), and the mainstem Gunnison |
| 09119000 - Tomichi Creek at Gunnison | 1938 to current | Tomichi Creek (District 28) |
| 09124500 - Lake Fork at Gateway | 1938 to current | Lake Fork, Cimarron, and Cebolla Creeks (District 62) |
| 09132500 - North Fork Gunnison River near Somerset | 1934 to current | E. Muddy, W. Muddy, North Fork, Smith Fork, Iron, Alum, Virginia, and Crystal Creeks (Portion of District 40) |
| 09143500 - Surface Creek at Cedaredge | 1918 to current | Surface, Currant, Kannah, and Lereaux Creeks, along with the Fruit Growers Area (Portion of District 40) |
| 09146200 - Uncompahgre River near Ridgeway | 1959 to current | Uncompahgre River (Districts 41 & 68) |

### Where to find more information

- Documentation for **makenet** describes the assignments of pattern gages to baseflow nodes.
- The StateMod documentation describes the procedure used to disaggregate monthly baseflows to daily baseflows.
- Appendix C includes a memorandum describing the task in which pattern gages were selected for the daily Gunnison modeling efforts.

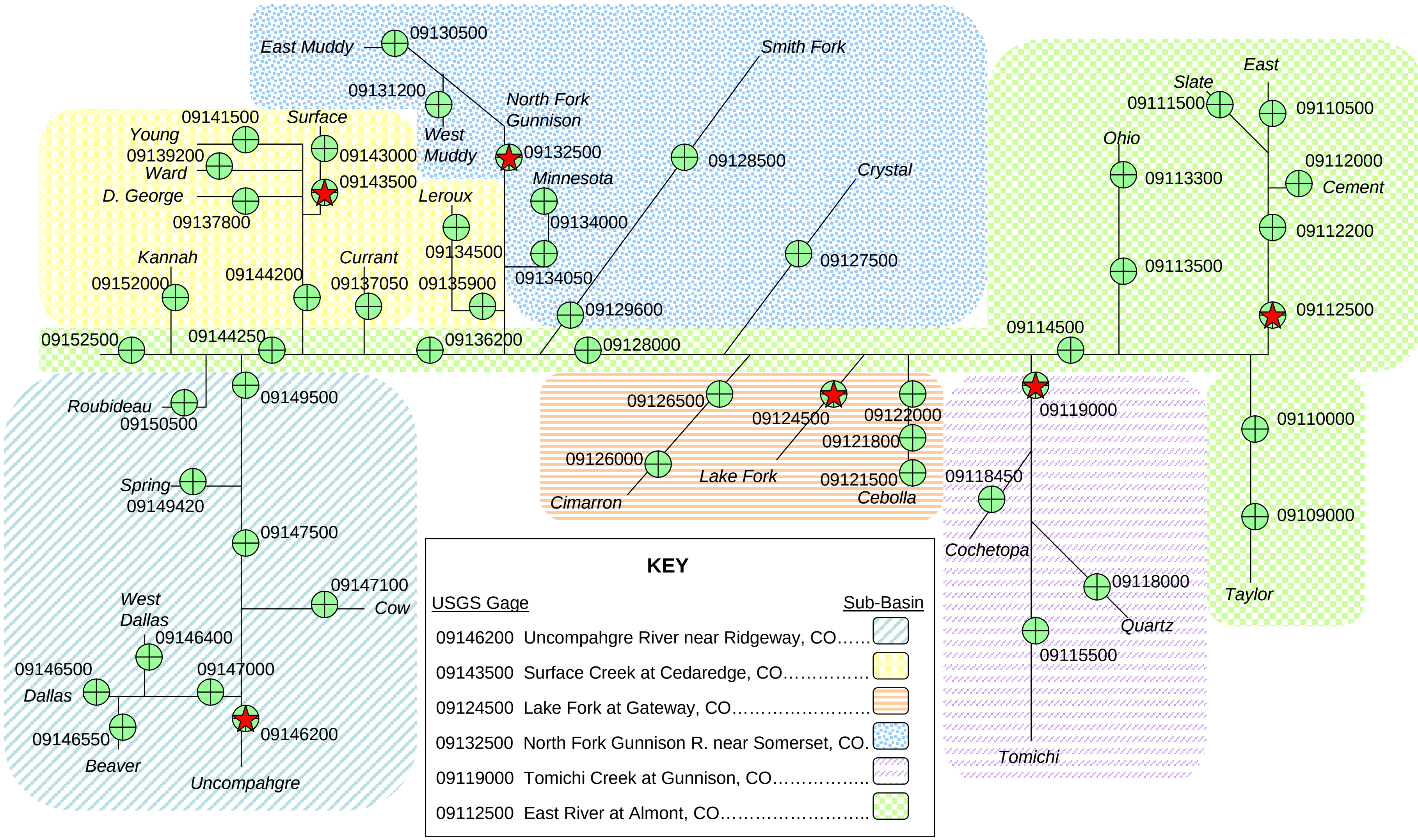



**Figure 8.1 – Recommended Application of Daily Pattern Gages**

### 8.1.4. Daily Demands and Reservoir Targets

The daily flag variable (*cdividy)* was set equal to "4" for all diversion stations in the direct diversion station file (gunnV.dds). This flag instructs StateMod, while in daily simulation mode, to disaggregate the monthly diversion demands found in the diversion demand file (gunnVB.ddm) by connecting the midpoints of the monthly data.

The daily flag variable (*cresidy* ) was set equal to "5" for all reservoirs in the Baseline reservoir station file (gunnVB.res). This flag instructs StateMod, while in daily simulation mode, to develop daily targets by linearly "connecting" monthly reservoir targets found in the reservoir target file (gunnVB.tar).

The daily flag variable (*cifrdy*) was set equal to "0" for all instream flow nodes in the instream flow station file (gunnV.ifs). This flag instructs StateMod, while in daily simulation mode, to disaggregate the monthly instream flow demand found in the monthly annual instream flow file (gunnV.ifa) to daily values by setting them to the average daily value.

Note that the variables described in this section are set when developing the monthly Baseline data set, but are only used by StateMod when the daily option is selected in the control file.

### 8.1.5. Daily Return Flow Delay Patterns File

The crdss.dld file, which is hand-built with a text editor, describes the estimated re-entry of return flows into the river system on a daily basis. They are the daily equivalent of the monthly return flow patterns used in the Baseline simulation.

**Where to find more information**

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

## 8.2 Daily Baseline Streamflows

Table 8.1 shows, for each gage, the average annual available flow from the Daily Baseline simulation compared to the average annual available flow from the Monthly Baseline simulation, based on the same simulation period (1975 through 2002). 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. In general, available flow is greater for the Daily Baseline simulation than the Monthly Baseline simulation. Daily simulation better represents large flow events that occur within a monthly time step, and in general, available flow is greater for the daily simulation than the monthly simulation.

Junior diverting structures can take advantage of these flows even if they are out-of-priority for much of the month.

Temporal variability of the Daily Baseline and Monthly Baseline simulated flows are illustrated in Figures 8.1 through 8.27 for three selected years for each of the daily pattern gages and for three downstream gages; Gunnison River below Gunnison Tunnel, Uncompahgre River at Delta, and Gunnison River near Grand Junction. The selected years represent wet (1995), average (1982) and dry (1977) years in the Gunnison Basin. The historical gaged streamflow is also shown on these graphs. As shown, daily simulated streamflow represents the daily large and small flow events that occur within a monthly time step.

On average, Baseline demands are greater than historical demands; representing current levels of municipal and industrial use and full crop irrigation requirements. During the representative wet year, however, annual basin-wide Baseline demands are about 5 percent lower than historic demands. Simulated flows at the pattern gages, which are not affected by storage, are similar to gaged flows with slight monthly variations. However, simulated flows at gages below the major Aspinall unit reservoirs and below UVWUA canals vary significantly from gaged flows during the spring and summer months. As discussed in the daily Baseline comparison (Appendix E), these gages are affected by the reservoir forecasting curve provided by the USBR to mimic general operations. It is clear that the rule curve is used only as a guideline by the USBR, and operations change during extreme hydrologic years.

In the daily modeling efforts, the release to target rule used to mimic hydropower operations uses a monthly storage target. At this time, there appears to be a discrepancy between the releases to this monthly target on the first day of each simulated year (October 1) compared to the releases to this monthly target for the remaining months in the year. This is particularly noticeable downstream of Blue Mesa Reservoir, due to the relatively large amount of monthly target releases. Therefore, as shown on Figures 8.7, 8.9, 8.25, and 8.27, in some years large flows are seen at the downstream gages on October 1. It is important to note that this “spike” flow does not affect overall results or usefulness of the model. It is expected that future StateMod code enhancements will correct this discrepancy.

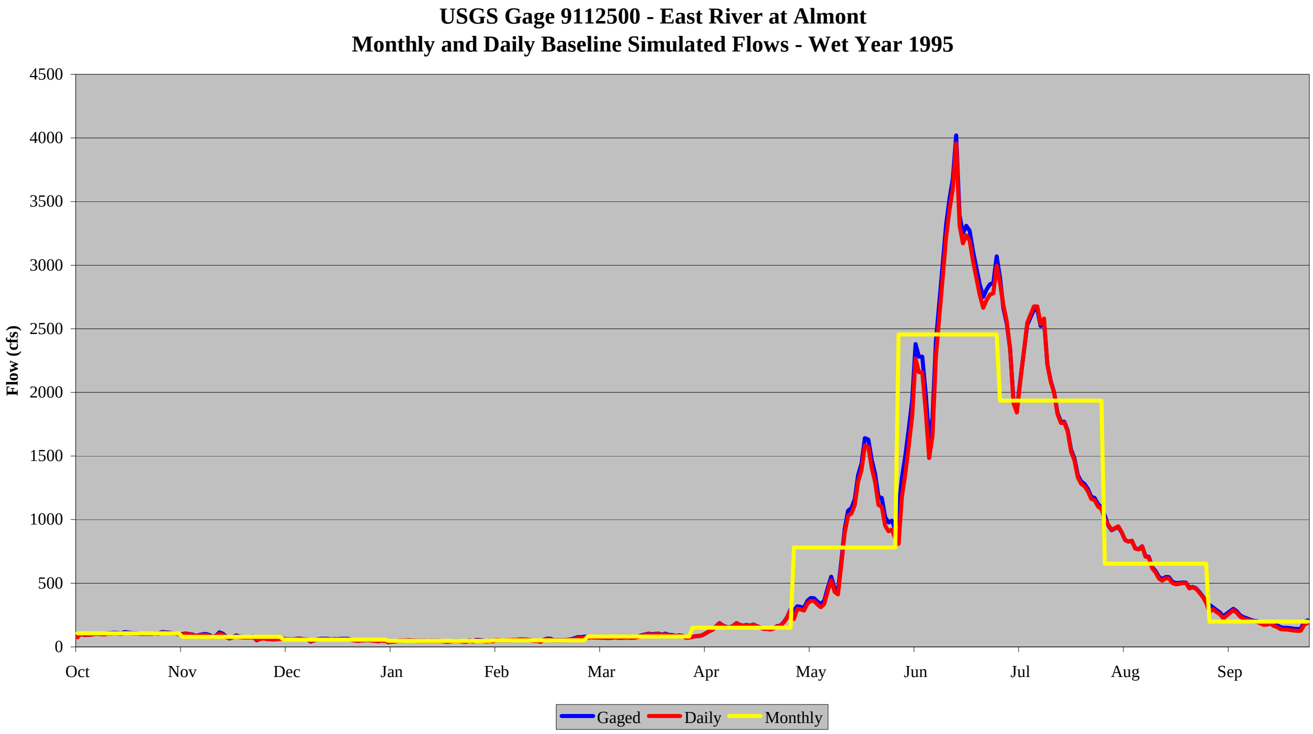
During the representative dry year, annual basin-wide Baseline demands are about 20 percent higher than historic demands. Simulated flows at the pattern gages, which are not affected by storage, are greater than gaged flows, as water is called through the tributaries for senior diverters downstream. However, simulated flows at gages below the major Aspinall unit reservoirs and below UVWUA canals are lower during much of the irrigation season, as less reservoir water is available to meet the higher demands. Again, these gages are affected by the forecasting curves used to mimic USBR operations, which likely change during extreme hydrologic years.

**Table 8.2**
**Baseline Average Annual Flows for Gunnison model Gages (1975-2002)**
**Daily Simulation Compared to Monthly Simulation**

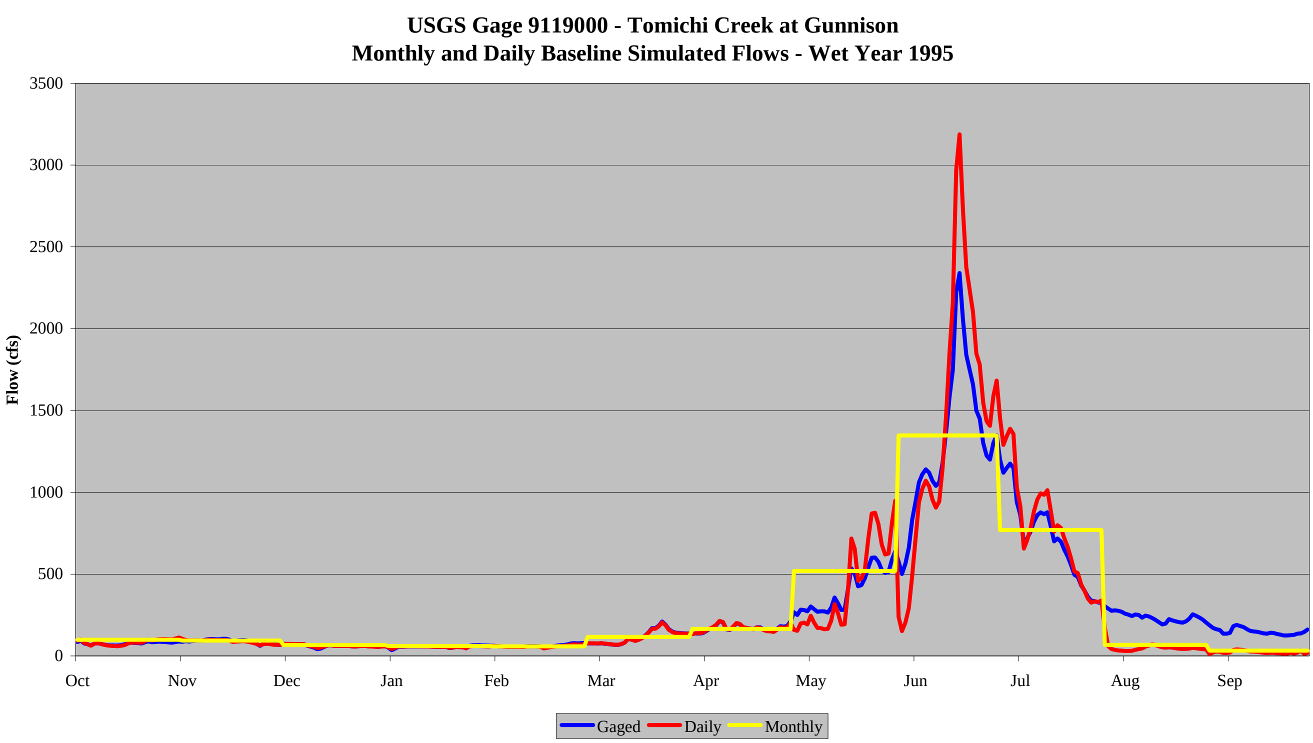
| Gage ID | Gage Name | Daily Simulated Available Flow (af) | Monthly Simulated Available Flow (af) | Difference Daily less Monthly (af) | % Different |
|---|---|---|---|---|---|
| 9109000 | Taylor River Below Taylor Park Reservoir | 44,970 | 43,417 | 1,553 | 3% |
| 9110000 | Taylor River at Almont | 54,522 | 52,928 | 1,594 | 3% |
| 9110500 | East River Near Crested Butte | 80,043 | 71,205 | 8,838 | 11% |
| 9111500 | Slate River Near Crested Butte | 75,541 | 68,384 | 7,157 | 9% |
| 9112000 | Cement Creek Near Crested Butte | 14,694 | 13,394 | 1,300 | 9% |
| 9112200 | East River Below Cement Creek NR Crested Butte | 167,521 | 158,510 | 9,011 | 5% |
| 9112500 | East River at Almont | 176,646 | 167,806 | 8,840 | 5% |
| 9113300 | Ohio Creek at Baldwin | 28,910 | 25,908 | 3,002 | 10% |
| 9113500 | Ohio Creek Near Baldwin | 41,126 | 36,712 | 4,414 | 11% |
| 9114500 | Gunnison River Near Gunnison | 358,489 | 350,736 | 7,753 | 2% |
| 9115500 | Tomichi Creek at Sargents | 17,635 | 14,869 | 2,766 | 16% |
| 9118000 | Quartz Creek Near Ohio City | 23,795 | 20,142 | 3,653 | 15% |
| 9118450 | Cochetopa Creek Below Rock Creek Near Parlin | 16,312 | 13,882 | 2,430 | 15% |
| 9119000 | Tomichi Creek at Gunnison | 94,073 | 84,885 | 9,188 | 10% |
| 9121500 | Cebolla Creek Near Lake City | 9,845 | 8,148 | 1,697 | 17% |
| 9121800 | Cebolla Creek Near Powderhorn | 31,482 | 26,837 | 4,645 | 15% |
| 9122000 | Cebolla Creek at Powderhorn | 45,573 | 39,443 | 6,130 | 13% |
| 9124500 | Lake Fork at Gateview | 127,555 | 118,502 | 9,053 | 7% |
| 9126000 | Cimarron River Near Cimarron | 31,875 | 30,026 | 1,849 | 6% |
| 9126500 | Cimarron River at Cimarron | 70,871 | 64,106 | 6,765 | 10% |
| 9127500 | Crystal Creek Near Maher | 9,215 | 5,775 | 3,440 | 37% |
| 9128000 | Gunnison River Below Gunnison Tunnel | 585,850 | 591,024 | -5,174 | -1% |
| 9128500 | Smith Fork Near Crawford | 12,442 | 12,023 | 419 | 3% |

| Gage ID | Gage Name | Daily Simulated Available Flow (af) | Monthly Simulated Available Flow (af) | Difference Daily less Monthly (af) | % Different |
|---|---|---|---|---|---|
| 9129600 | Smith Fork Near Lazear | 22,308 | 21,489 | 819 | 4% |
| 9130500 | East Muddy Creek Near Bardine | 59,984 | 59,576 | 408 | 1% |
| 9131200 | West Muddy Creek Near Somerset | 18,395 | 18,096 | 299 | 2% |
| 9132500 | North Fork Gunnison River Near Somerset | 277,018 | 274,290 | 2,728 | 1% |
| 9134000 | Minnesota Creek Near Paonia | 7,347 | 7,014 | 333 | 5% |
| 9134050 | Minnesota Creek at Paonia | 8,966 | 8,568 | 398 | 4% |
| 9134500 | Leroux Creek Near Cedaredge | 14,511 | 13,614 | 897 | 6% |
| 9135900 | Leroux Creek at Hotchkiss | 19,590 | 18,921 | 669 | 3% |
| 9136200 | Gunnison River Near Lazear | 1,068,386 | 1,081,492 | -13,106 | -1% |
| 9137050 | Currant Creek Near Read | 8,117 | 9,071 | -954 | -12% |
| 9137800 | Dirty George Creek Near Grand Mesa | 1,456 | 1,031 | 425 | 29% |
| 9139200 | Ward Creek Near Grand Mesa | 5,528 | 4,342 | 1,186 | 21% |
| 9141500 | Youngs Creek Near Cedaredge | 2,166 | 1,666 | 500 | 23% |
| 9143000 | Surface Creek Near Cedaredge | 6,789 | 5,431 | 1,358 | 20% |
| 9143500 | Surface Creek at Cedaredge | 6,796 | 5,439 | 1,357 | 20% |
| 9144200 | Tongue Creek at Cory | 39,176 | 38,698 | 478 | 1% |
| 9144250 | Gunnison River at Delta | 1,210,914 | 1,228,366 | -17,452 | -1% |
| 9146200 | East Fork Dallas Creek Near Ridgway | 73,004 | 71,521 | 1,483 | 2% |
| 9146400 | Dallas Creek Near Ridgway | 4,998 | 4,430 | 568 | 11% |
| 9146500 | Beaver Creek Near Ridgway | 9,438 | 8,482 | 956 | 10% |
| 9146550 | West Fork Dallas Creek Near Ridgway | 1,578 | 1,249 | 329 | 21% |
| 9147000 | Uncompahgre River Near Ridgway | 20,960 | 19,433 | 1,527 | 7% |
| 9147100 | Cow Creek Near Ridgway | 36,569 | 34,693 | 1,876 | 5% |
| 9147500 | Uncompahgre River at Colona | 91,041 | 89,754 | 1,287 | 1% |
| 9149420 | Spring Creek Near Montrose | 34,728 | 32,450 | 2,278 | 7% |

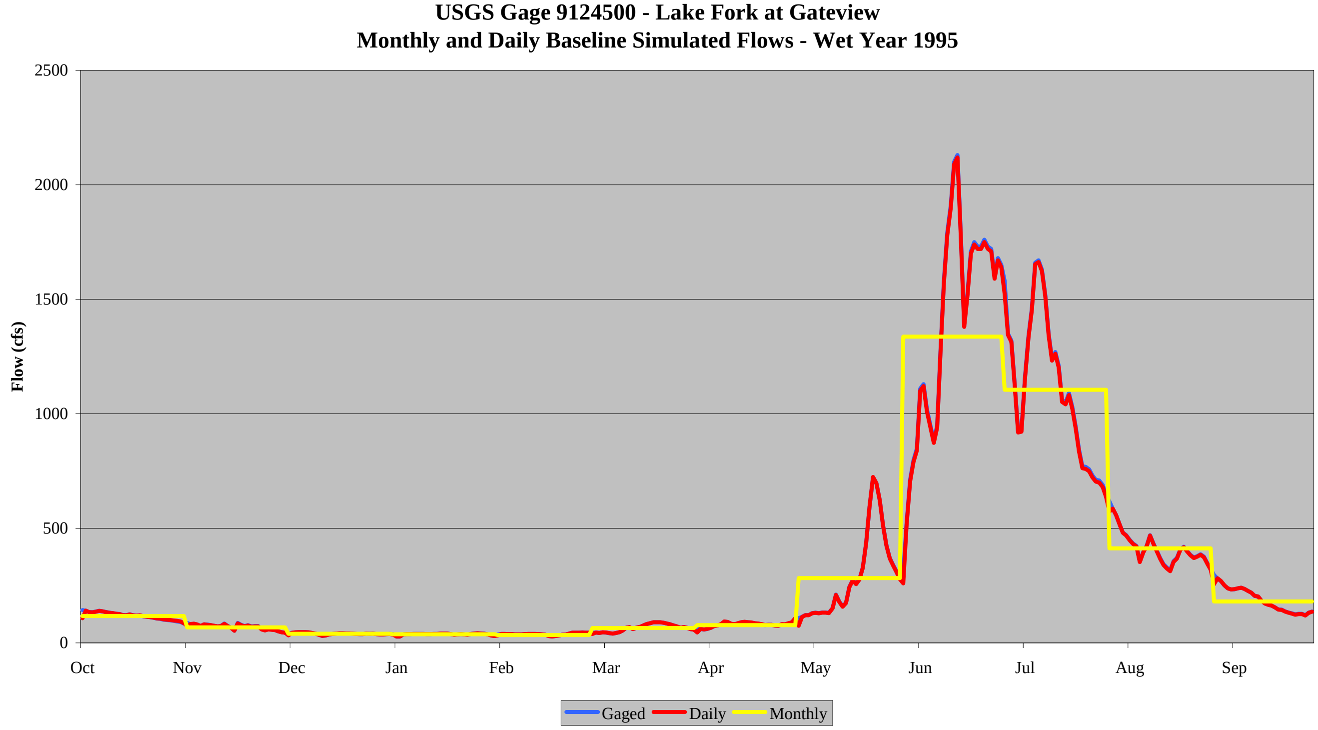
| Gage ID | Gage Name | Daily Simulated Available Flow (af) | Monthly Simulated Available Flow (af) | Difference Daily less Monthly (af) | % Different |
|---|---|---|---|---|---|
| 9149500 | Uncompahgre River at Delta | 235,864 | 236,195 | -331 | 0% |
| 9150500 | Roubideau Creek at Mouth, Near Delta | 95,384 | 95,040 | 344 | 0% |
| 9152000 | Kannah Creek Near Whitewater | 8,948 | 8,432 | 516 | 6% |
| 9152500 | Gunnison River Near Grand Junction | 1,328,742 | 1,348,642 | -19,900 | -1% |



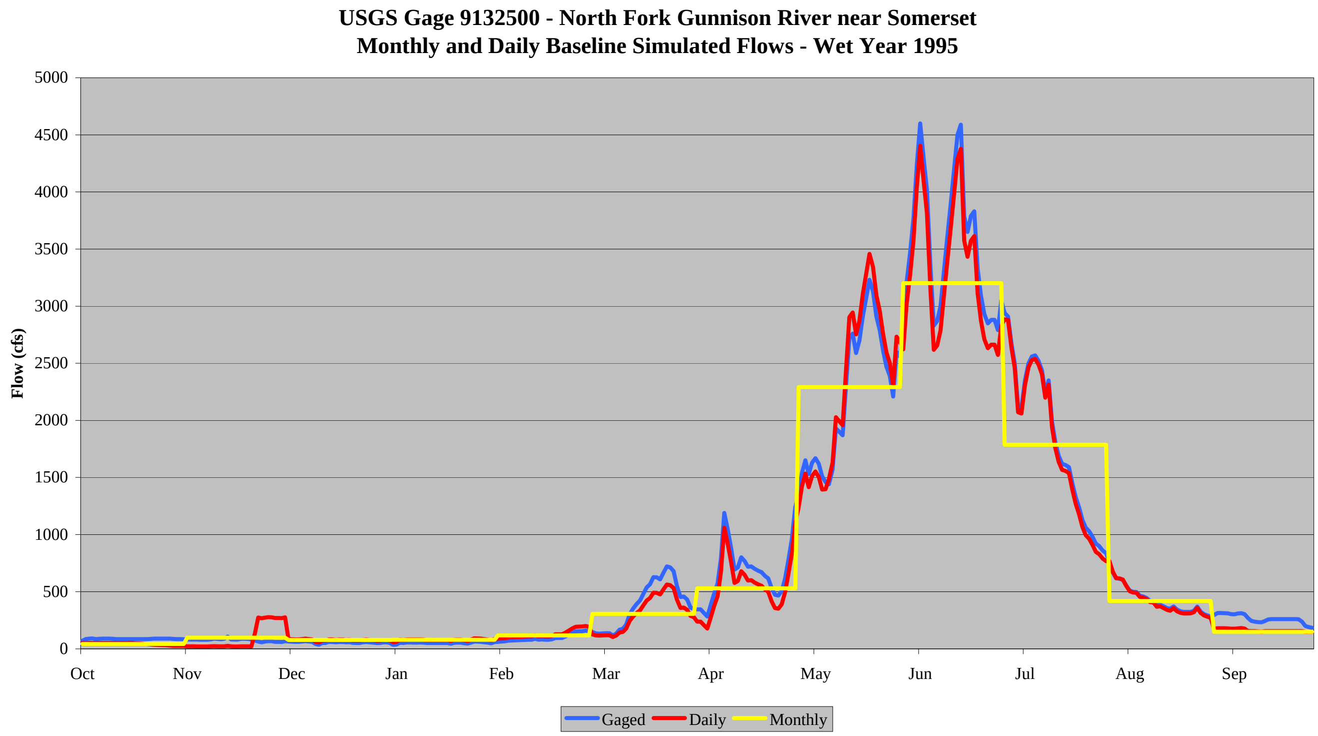

# Figure 8.2 Daily Baseline Comparison, Wet Year – East River at Almont




# Figure 8.3 Daily Baseline Comparison, Wet Year – Tomichi Creek at Gunnison




## Figure 8.4 Daily Baseline Comparison, Wet Year – Lake Fork at Gateview




## Figure 8.5 Daily Baseline Comparison, Wet Year – North Fork Gunnison River near Somerset

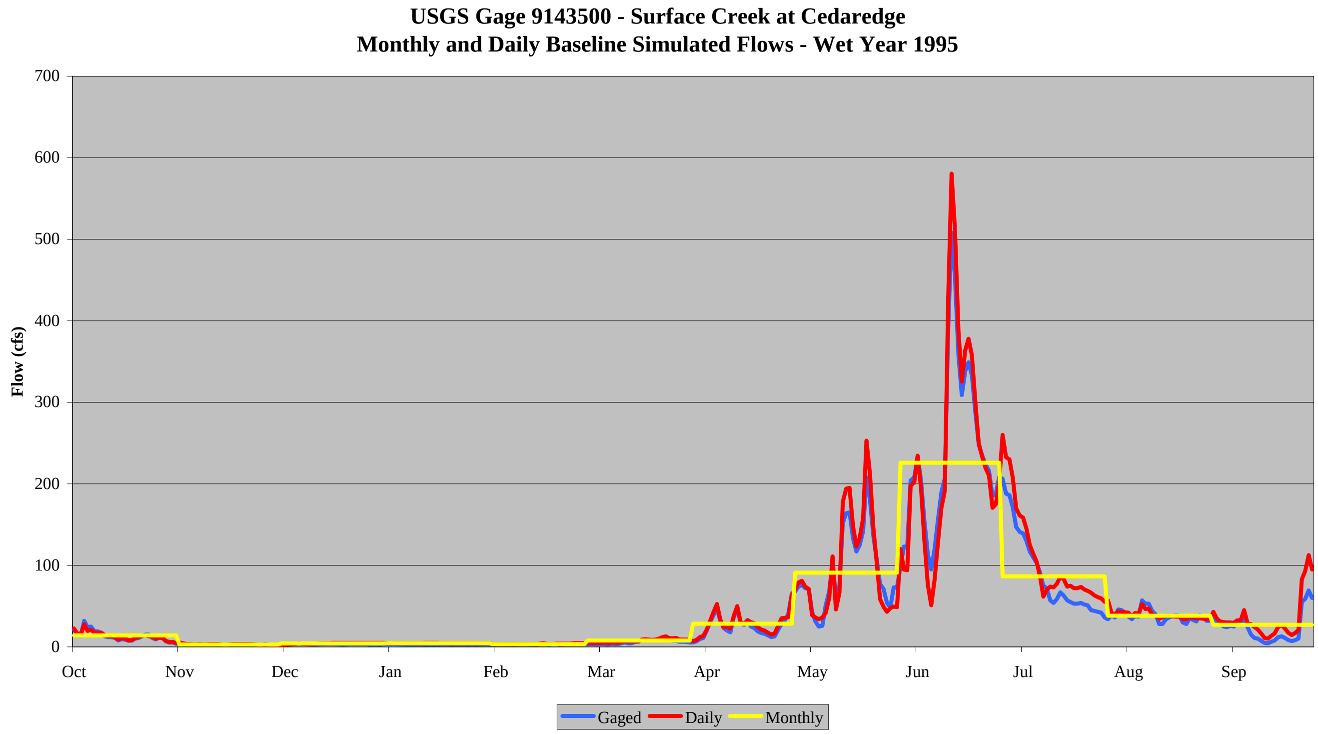



**Figure 8.6 Daily Baseline Comparison, Wet Year – Surface Creek at Cedaredge**

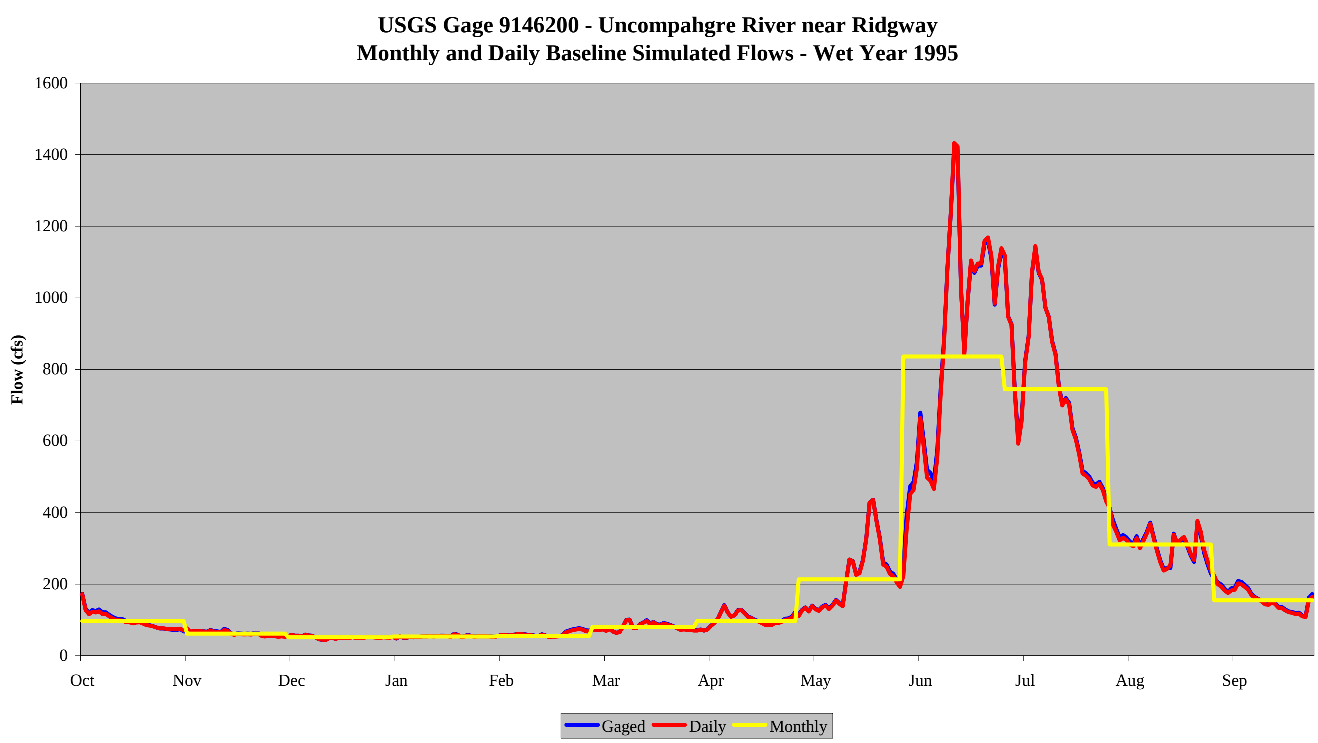
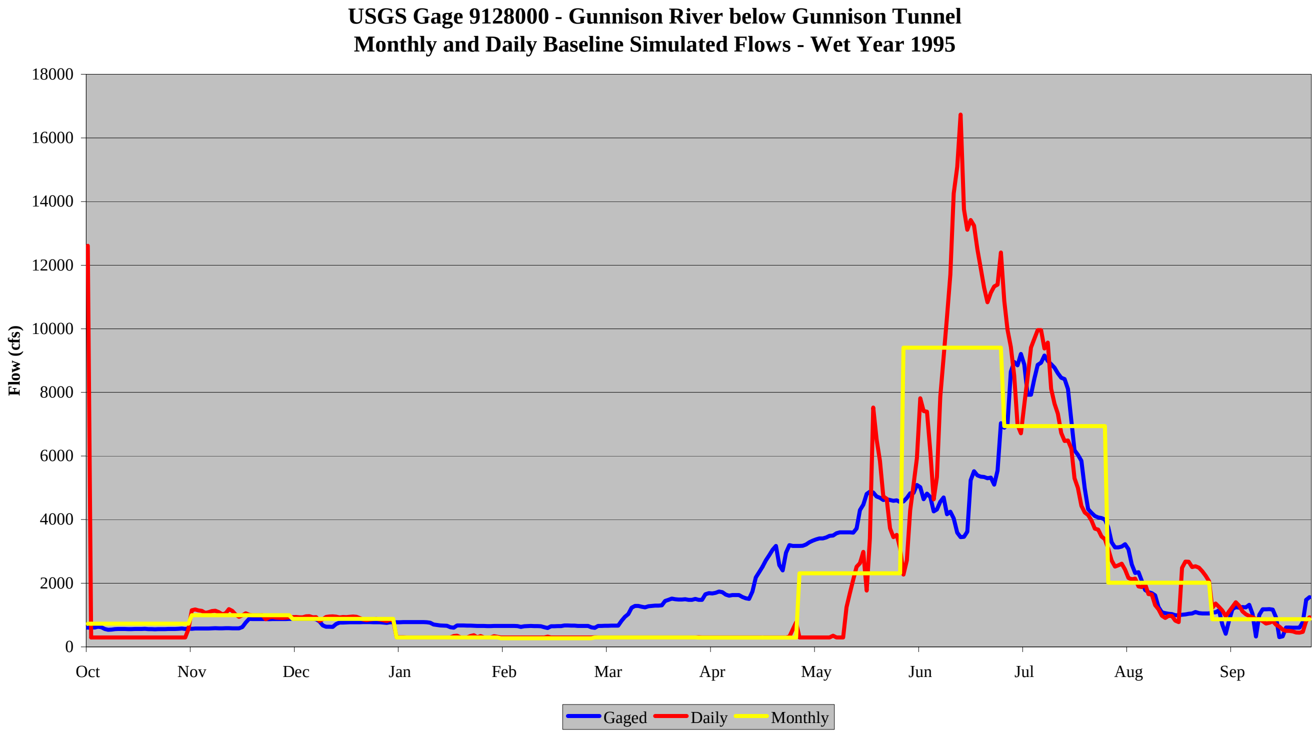
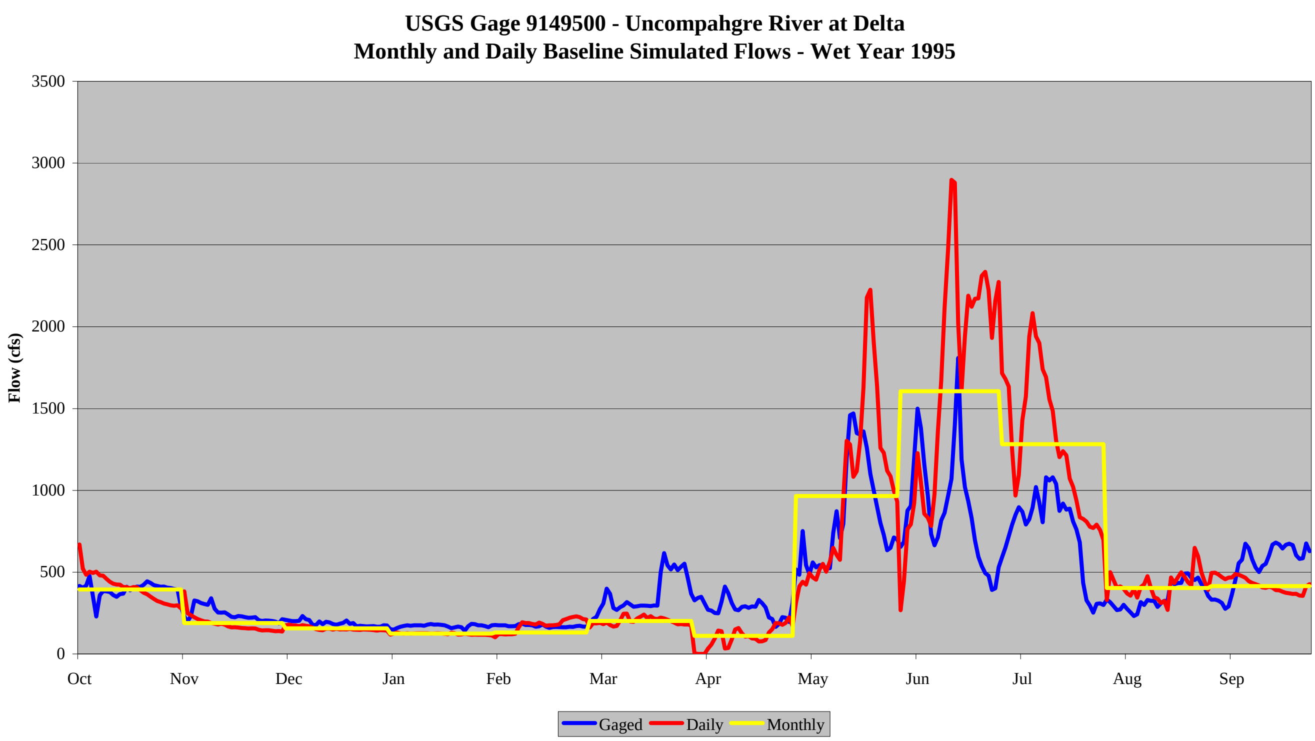


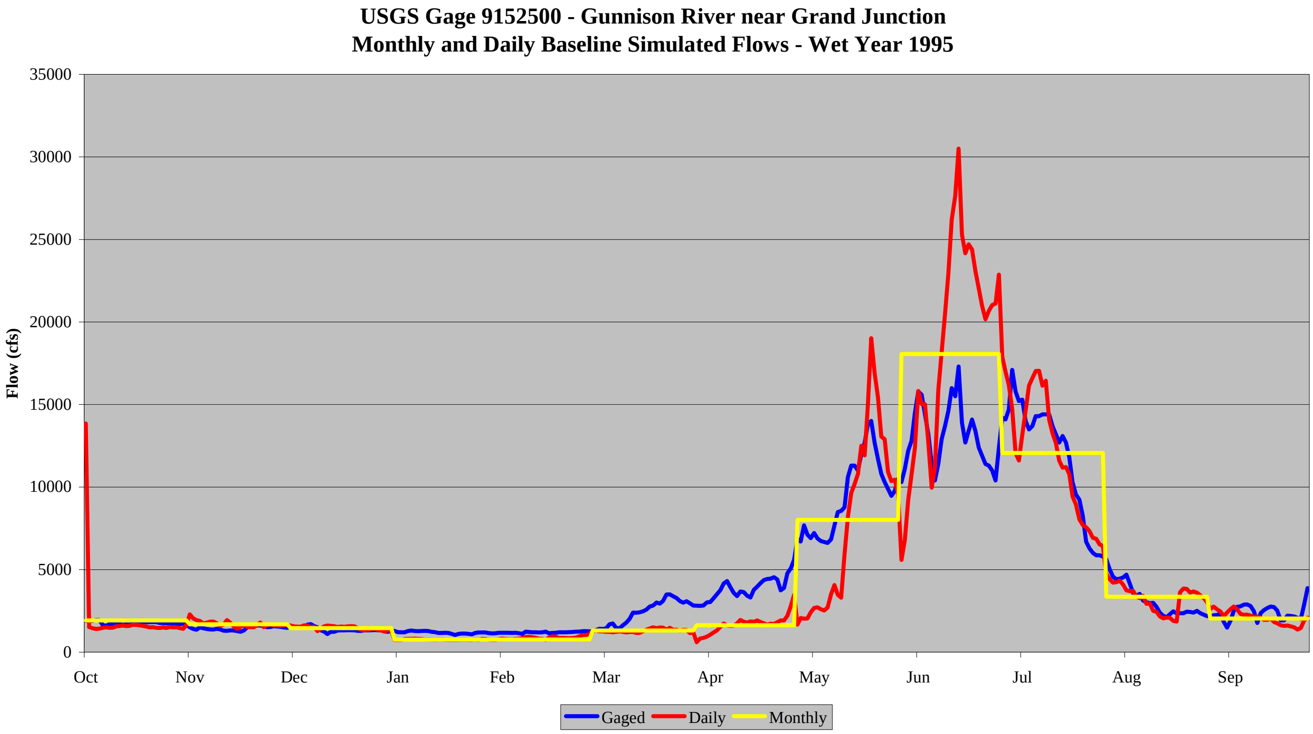

**Figure 8.7 Daily Baseline Comparison, Wet Year – Uncompahgre River near Ridgway**



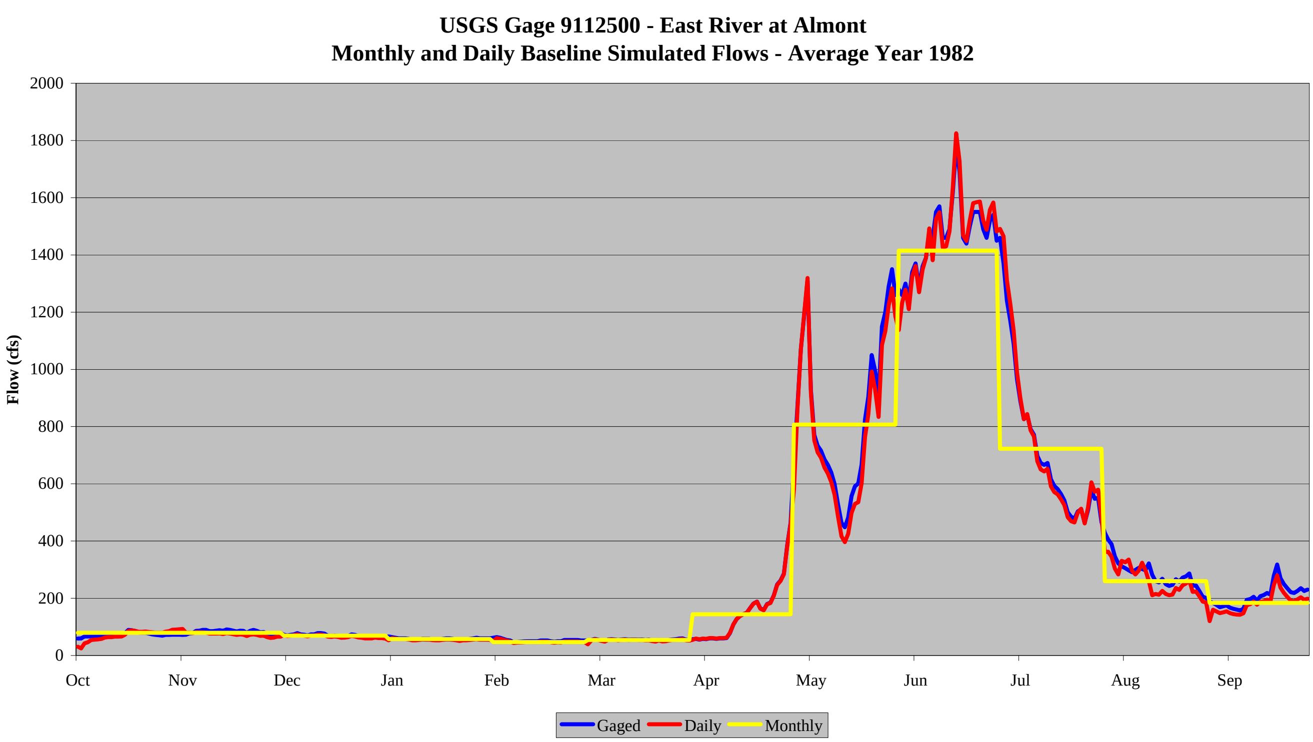

# Figure 8.8 Daily Baseline Comparison, Wet Year – Gunnison River below Gunnison Tunnel



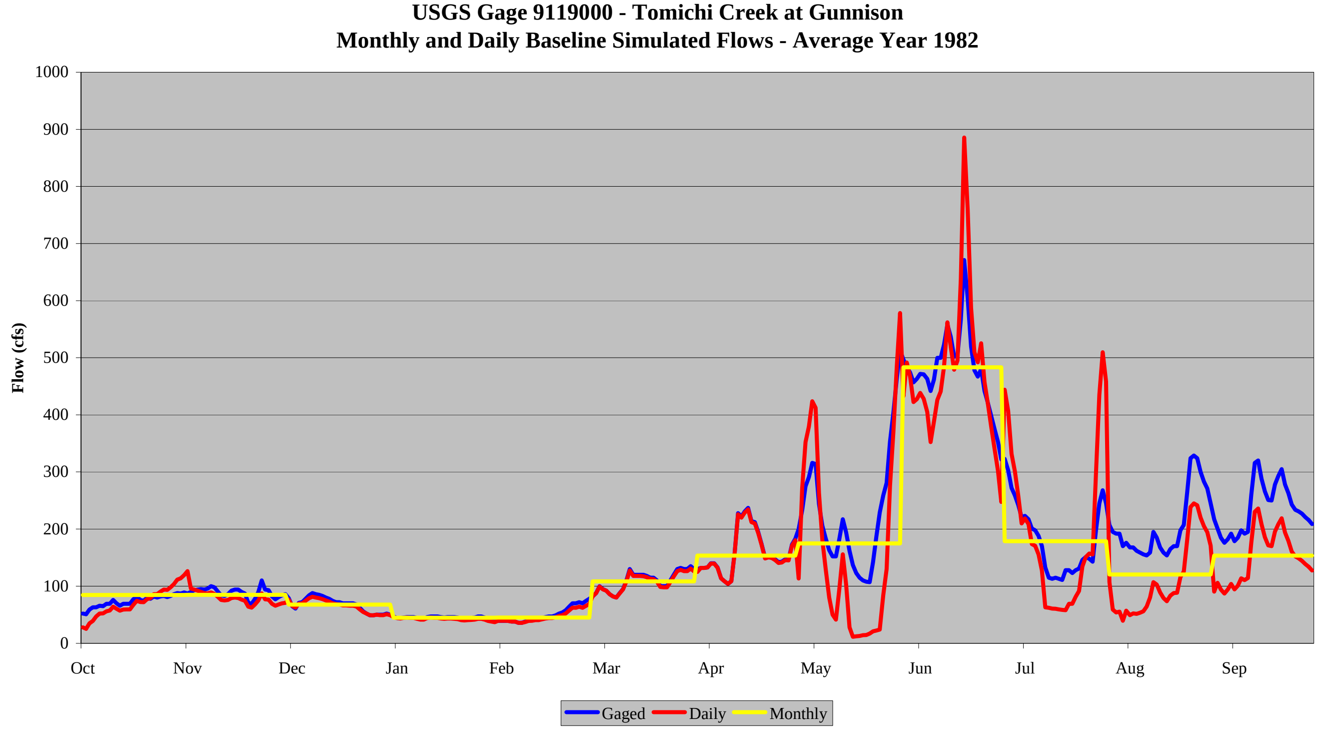

# Figure 8.9 Daily Baseline Comparison, Wet Year – Uncompahgre River at Delta



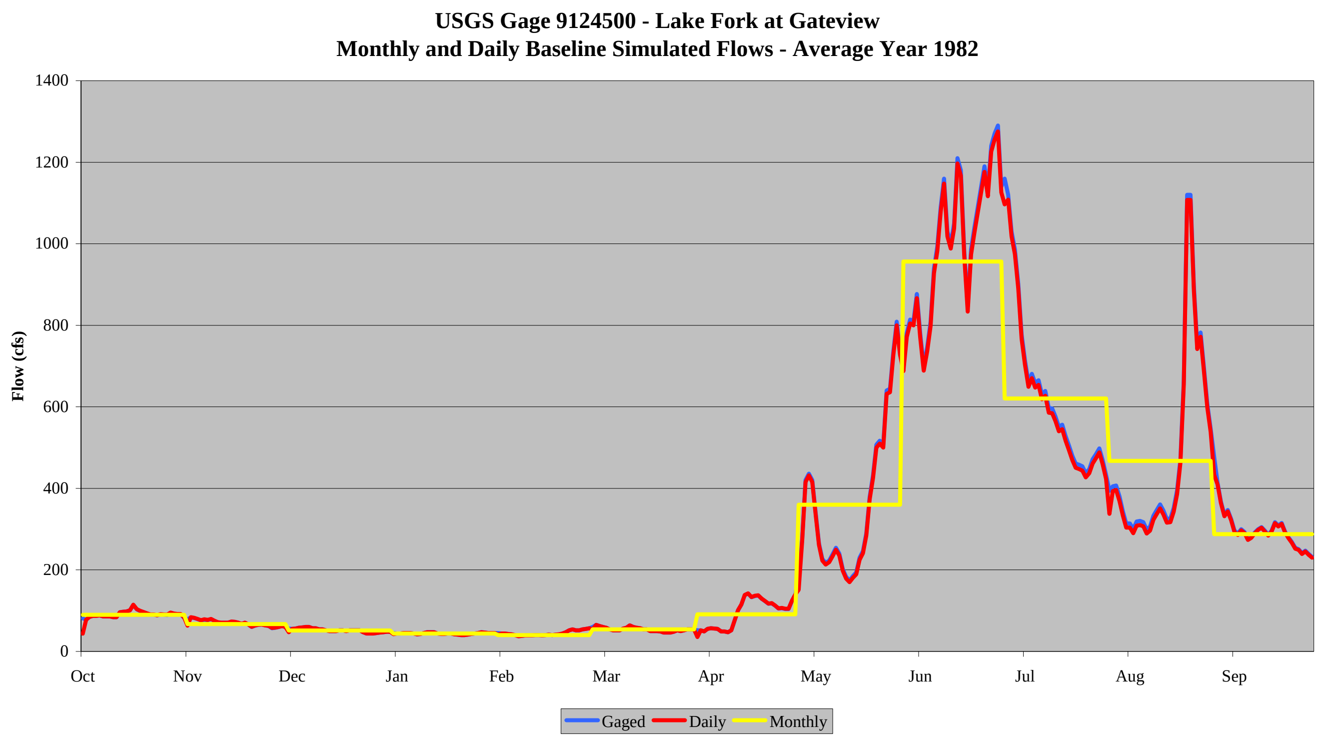

# Figure 8.10 Daily Baseline Comparison, Wet Year – Gunnison River near Grand Junction




# Figure 8.11 Daily Baseline Comparison, Average Year – East River at Almont




## Figure 8.12 Daily Baseline Comparison, Average Year – Tomichi Creek at Gunnison




## Figure 8.13 Daily Baseline Comparison, Average Year – Lake Fork at Gateview

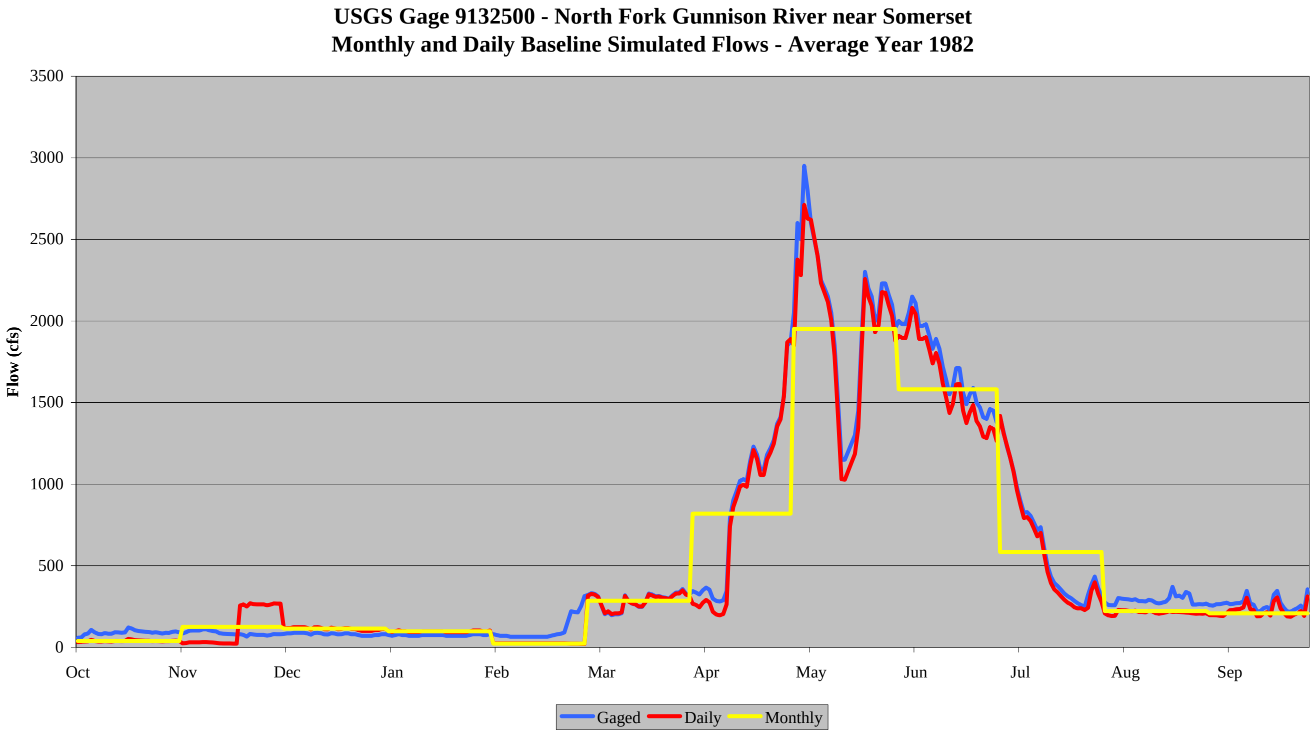



**Figure 8.14 Daily Baseline Comparison, Average Year – North Fork Gunnison River nr Somerset**

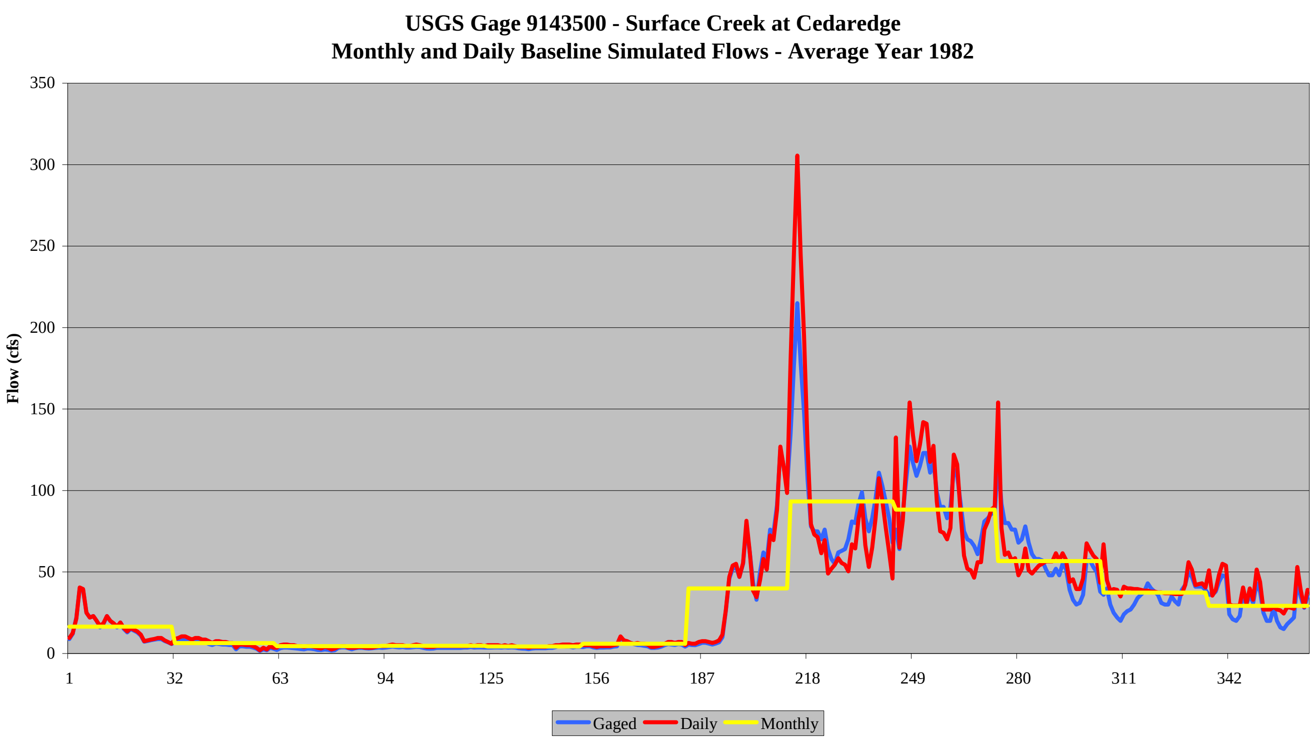
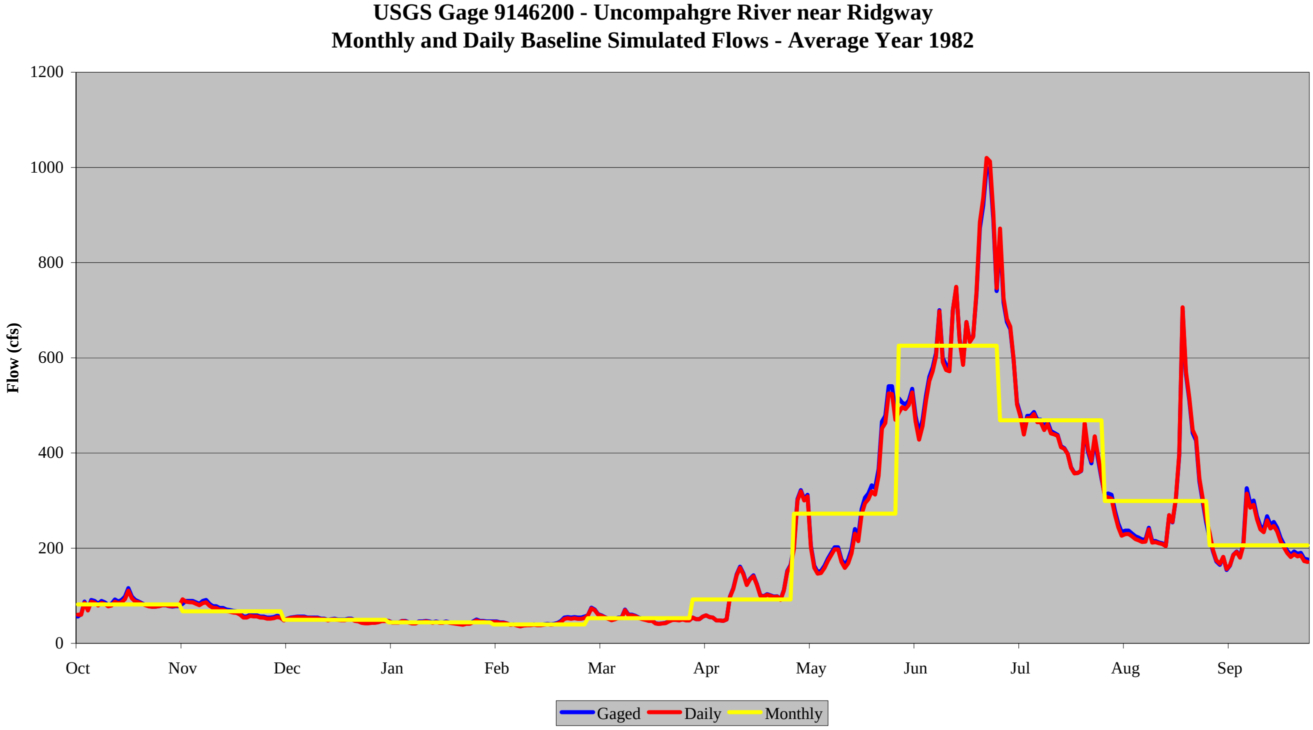
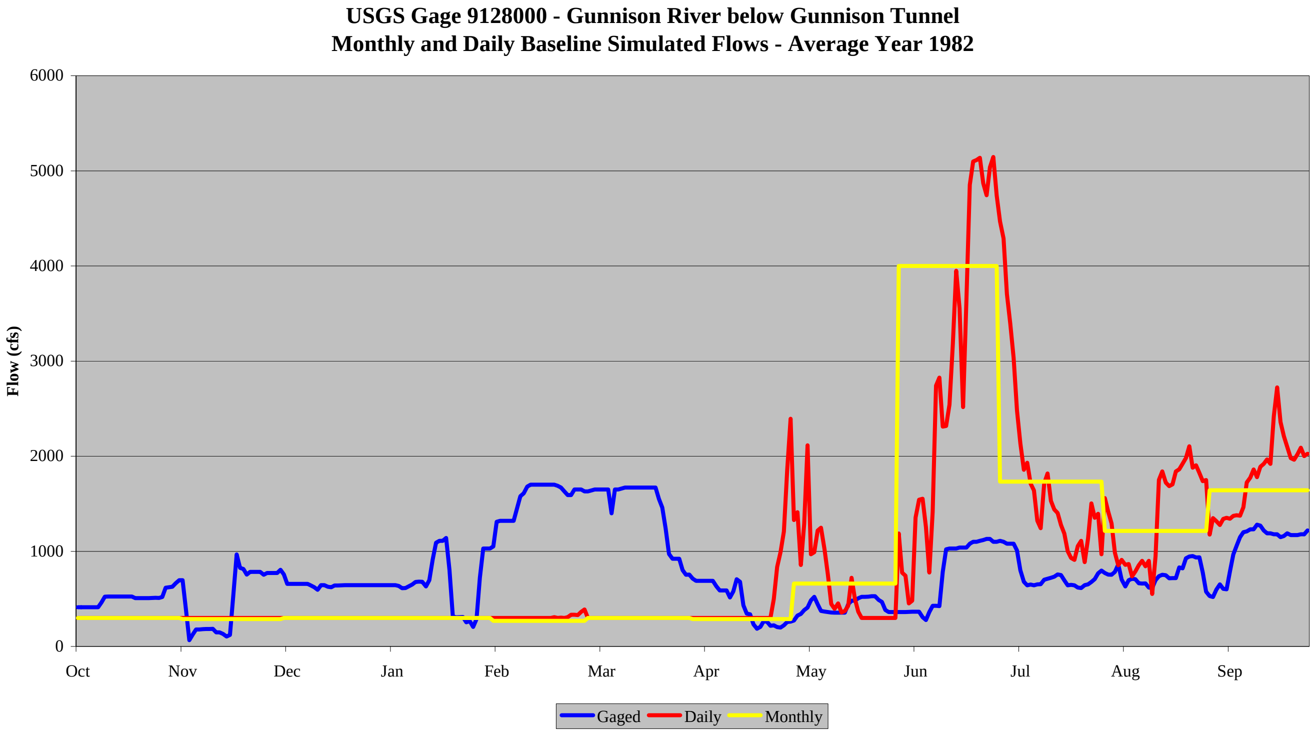


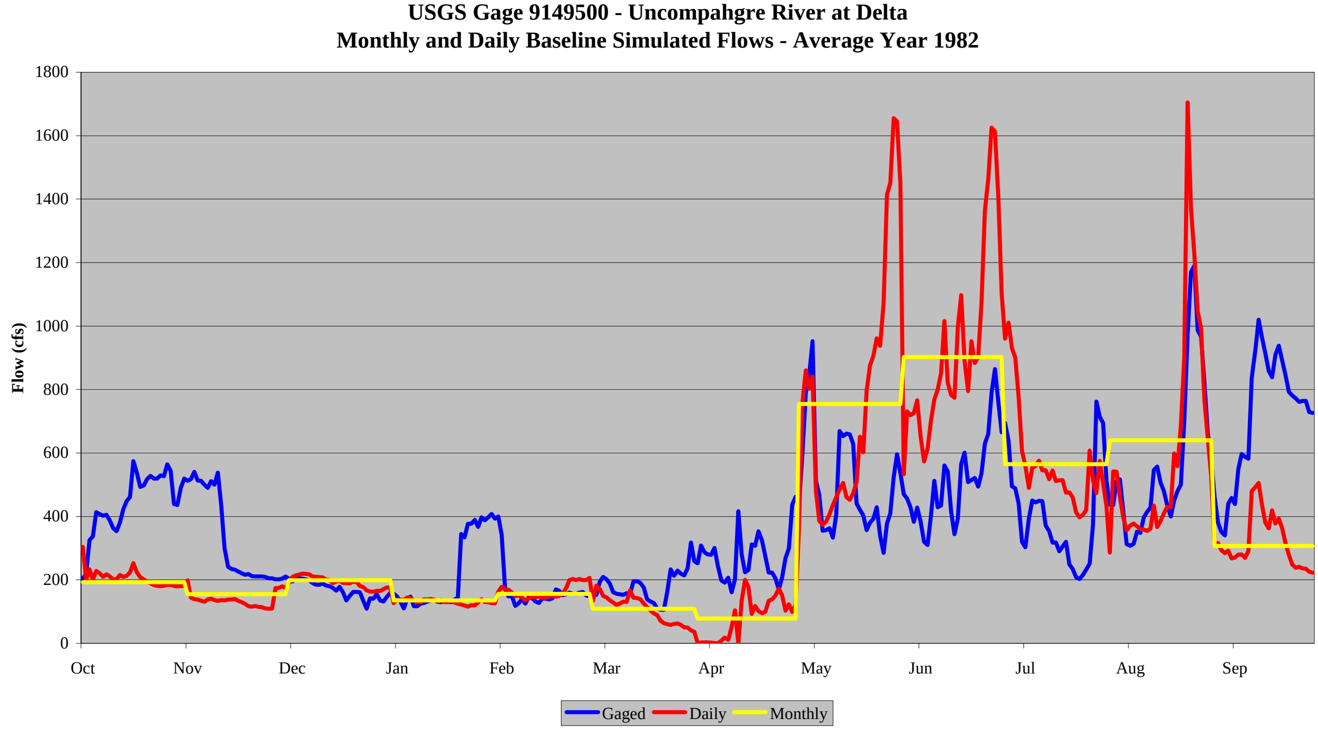

**Figure 8.15 Daily Baseline Comparison, Average Year – Surface Creek at Cedaredge**



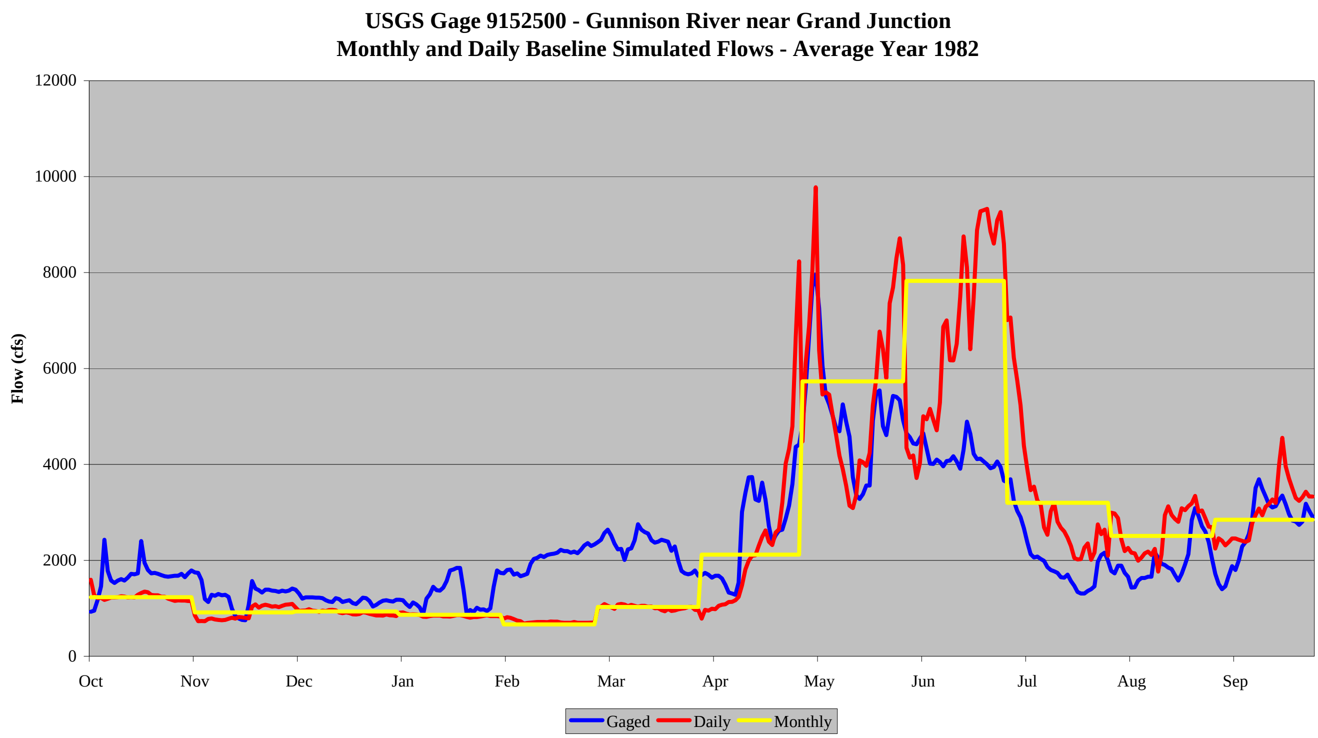

## Figure 8.16 Daily Baseline Comparison, Average Year – Uncompahgre River near Ridgway



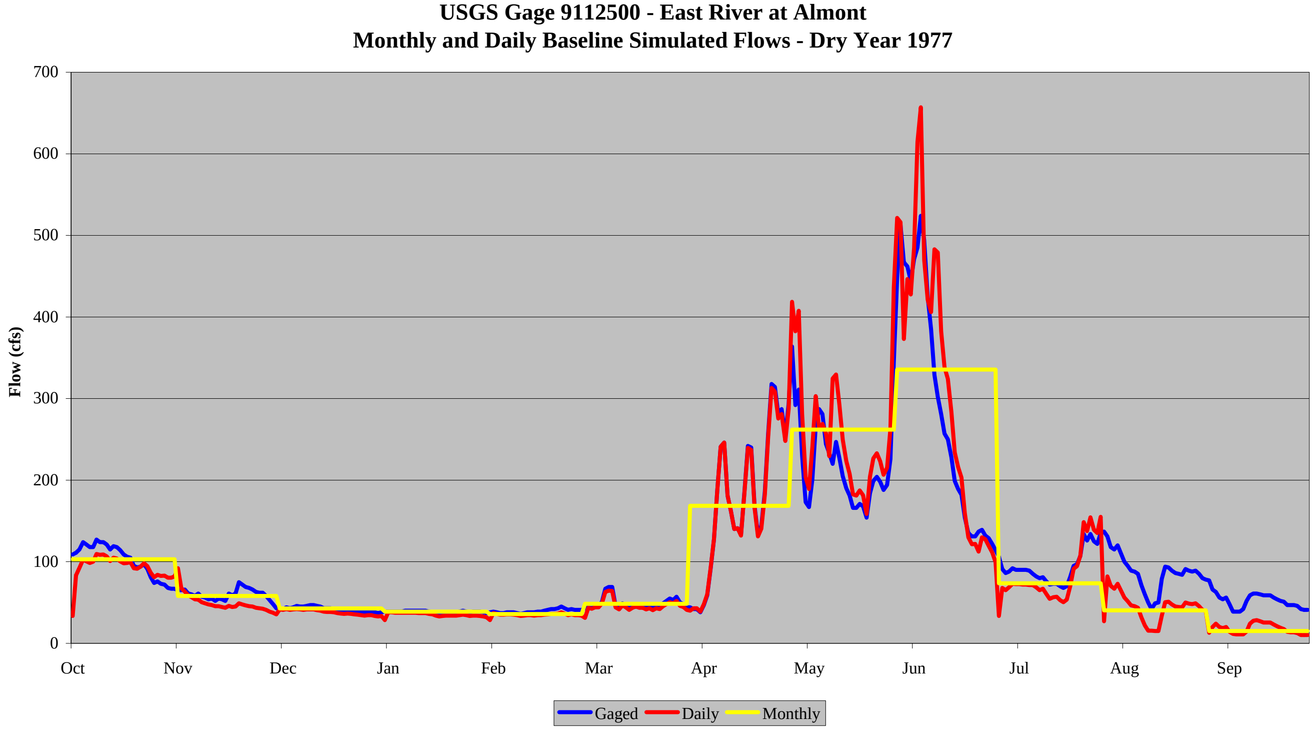

## Figure 8.17 Daily Baseline Comparison, Average Year – Gunnison River below Gunnison Tunnel



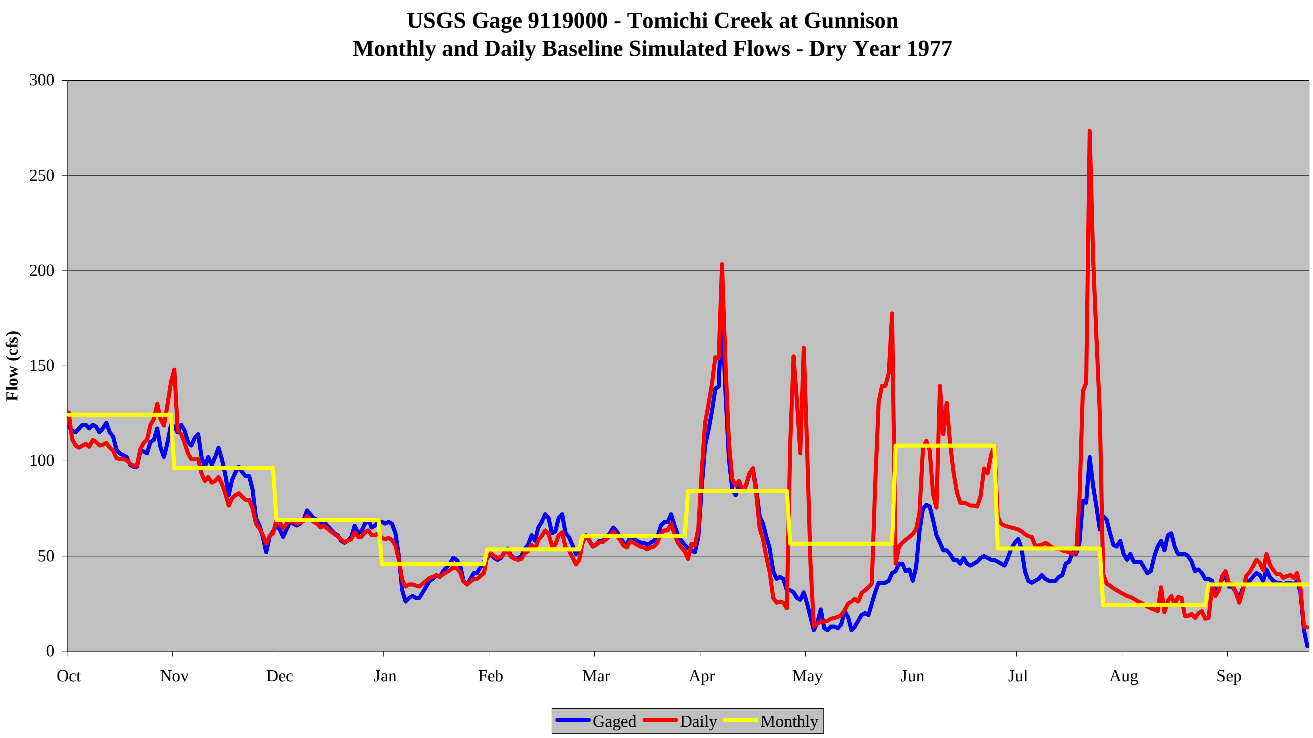

# Figure 8.18 Daily Baseline Comparison, Average Year – Uncompahgre River at Delta



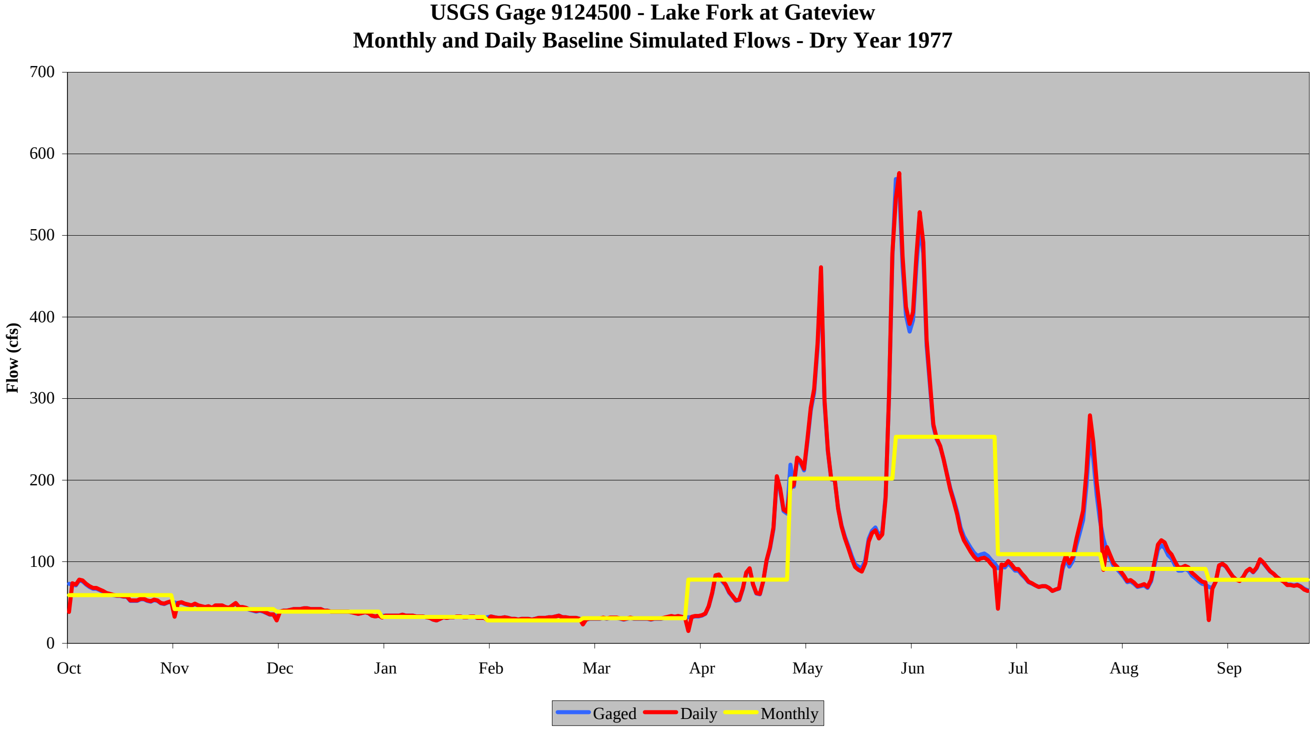

# Figure 8.19 Daily Baseline Comparison, Average Year – Gunnison River near Grand Junction



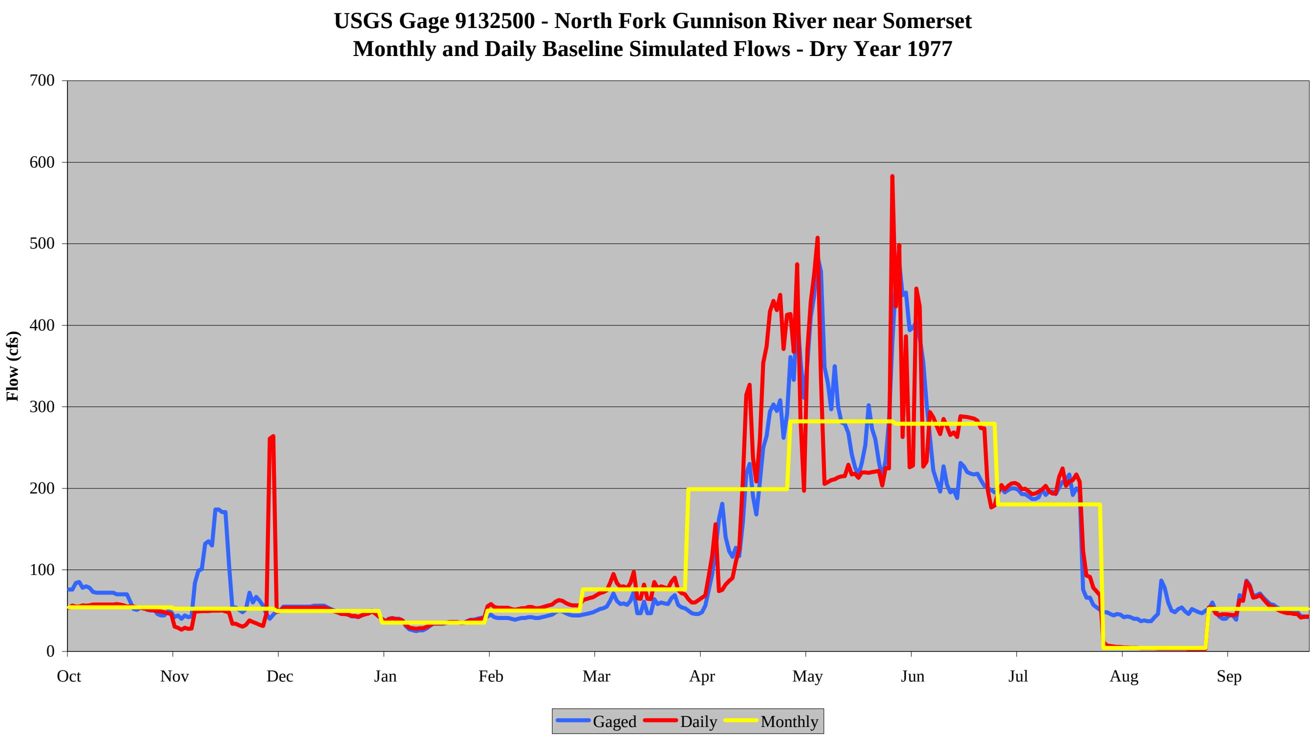

## Figure 8.20 Daily Baseline Comparison, Dry Year – East River at Almont




## Figure 8.21 Daily Baseline Comparison, Dry Year – Tomichi Creek at Gunnison




# Figure 8.22 Daily Baseline Comparison, Dry Year – Lake Fork at Gateview




# Figure 8.23 Daily Baseline Comparison, Dry Year – North Fork Gunnison River near Somerset

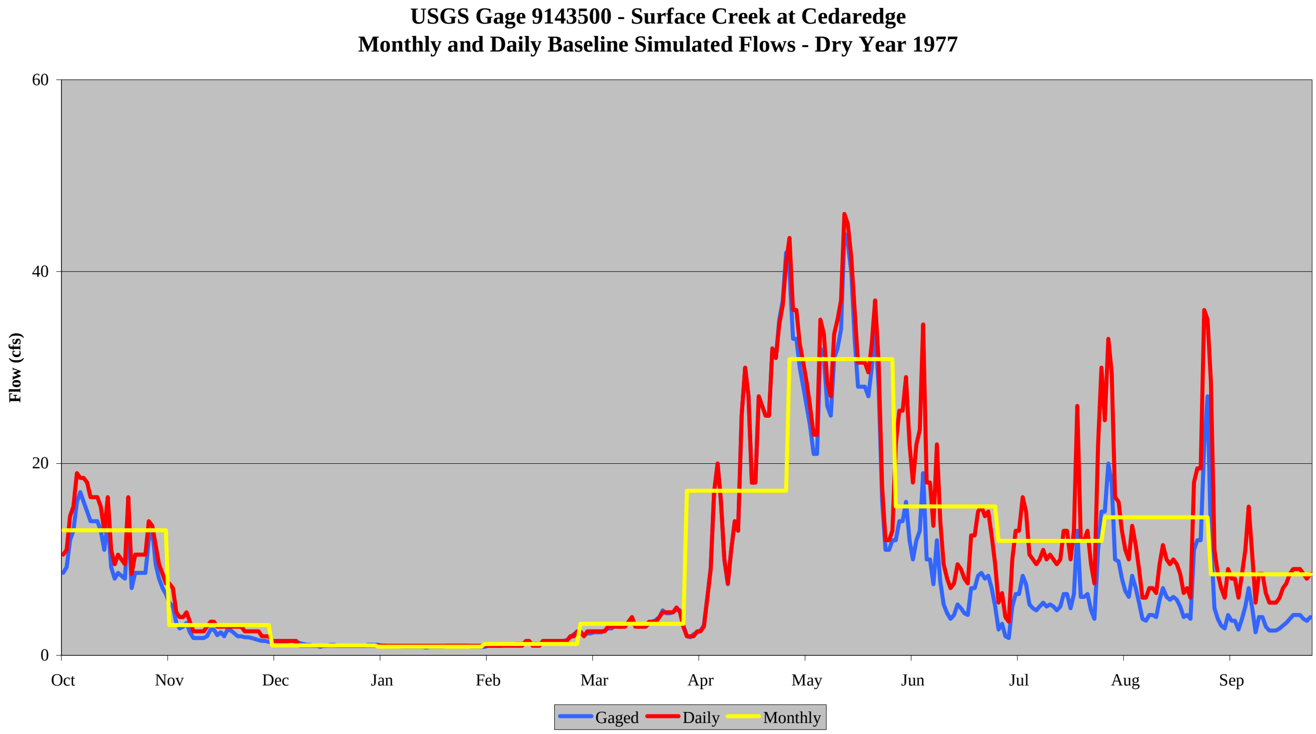



**Figure 8.24 Daily Baseline Comparison, Dry Year – Surface Creek at Cedaredge**

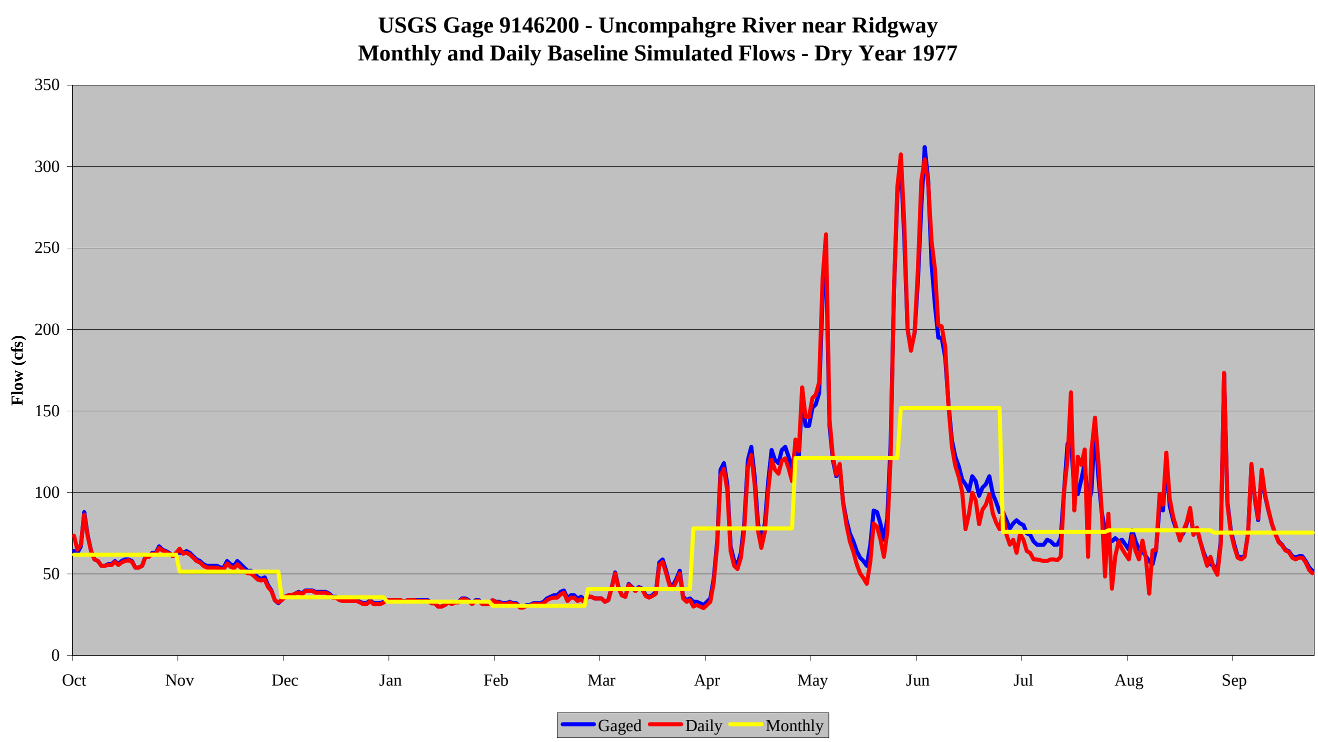



**Figure 8.25 Daily Baseline Comparison, Dry Year – Uncompahgre River near Ridgway**

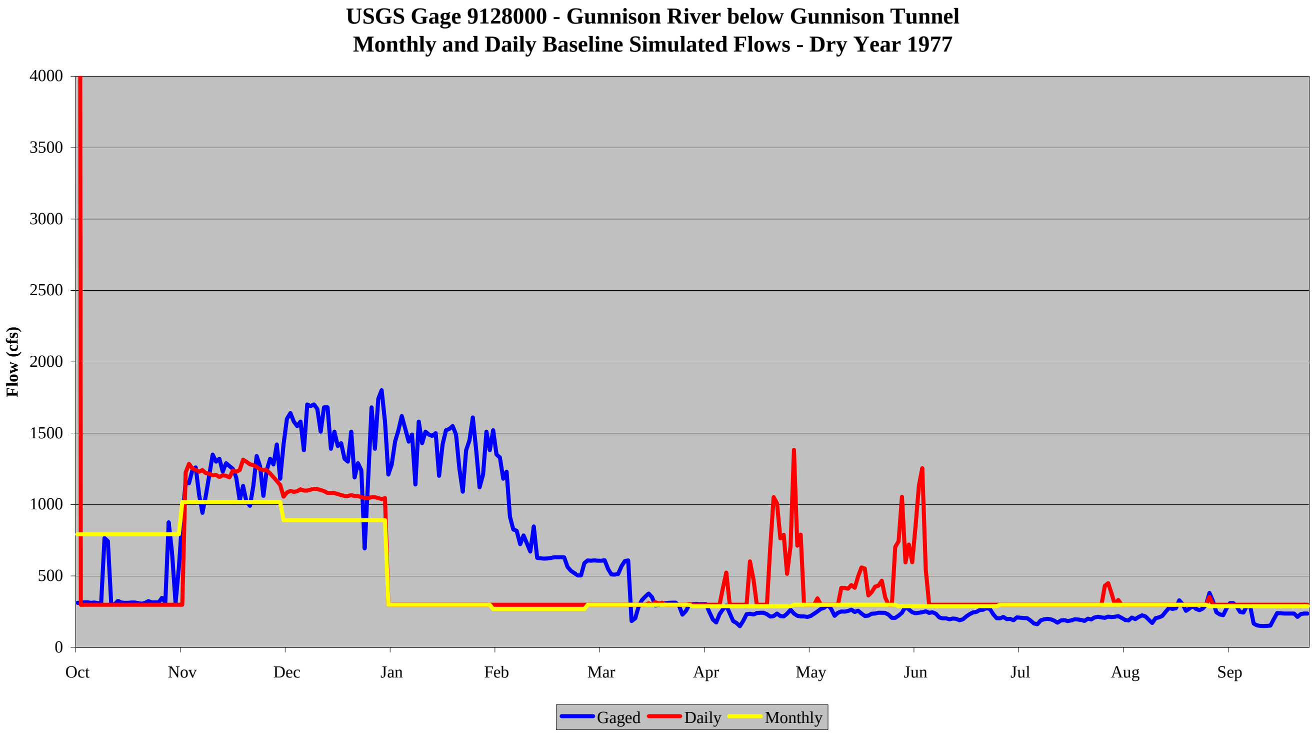



**Figure 8.26 Daily Baseline Comparison, Dry Year – Gunnison River below Gunnison Tunnel**

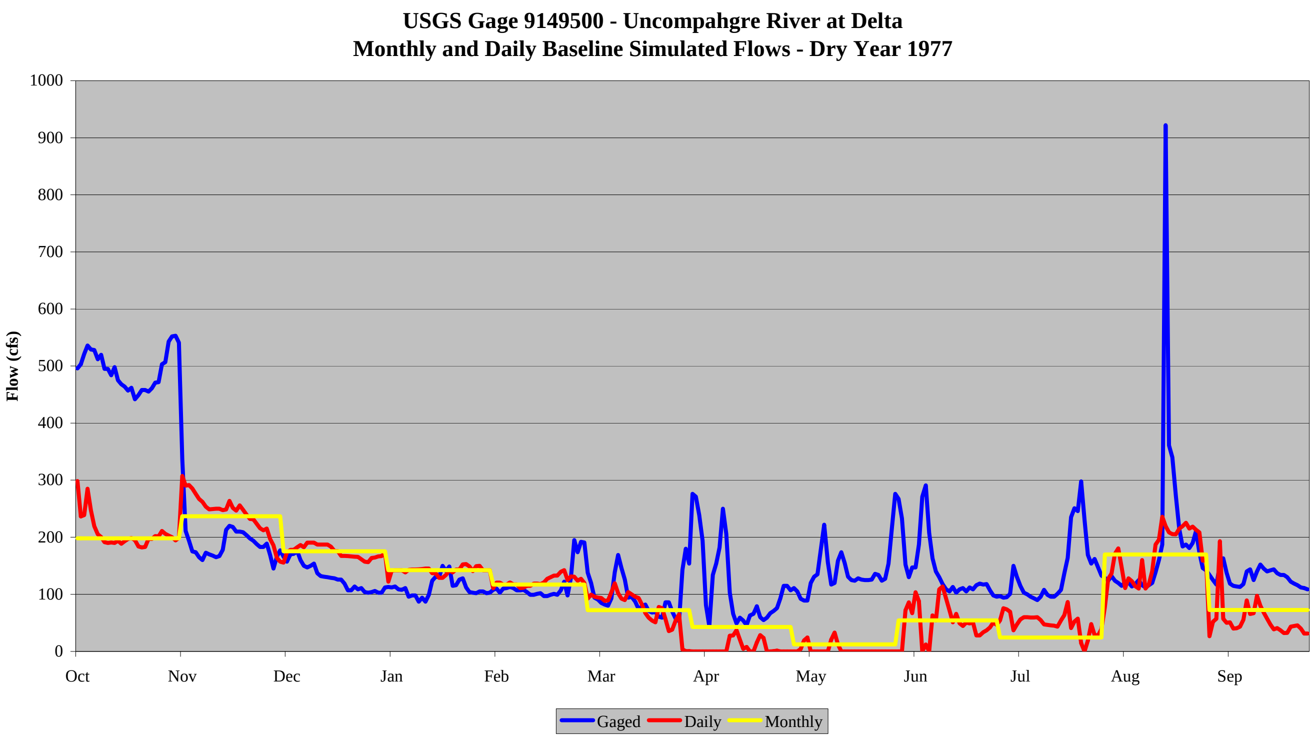
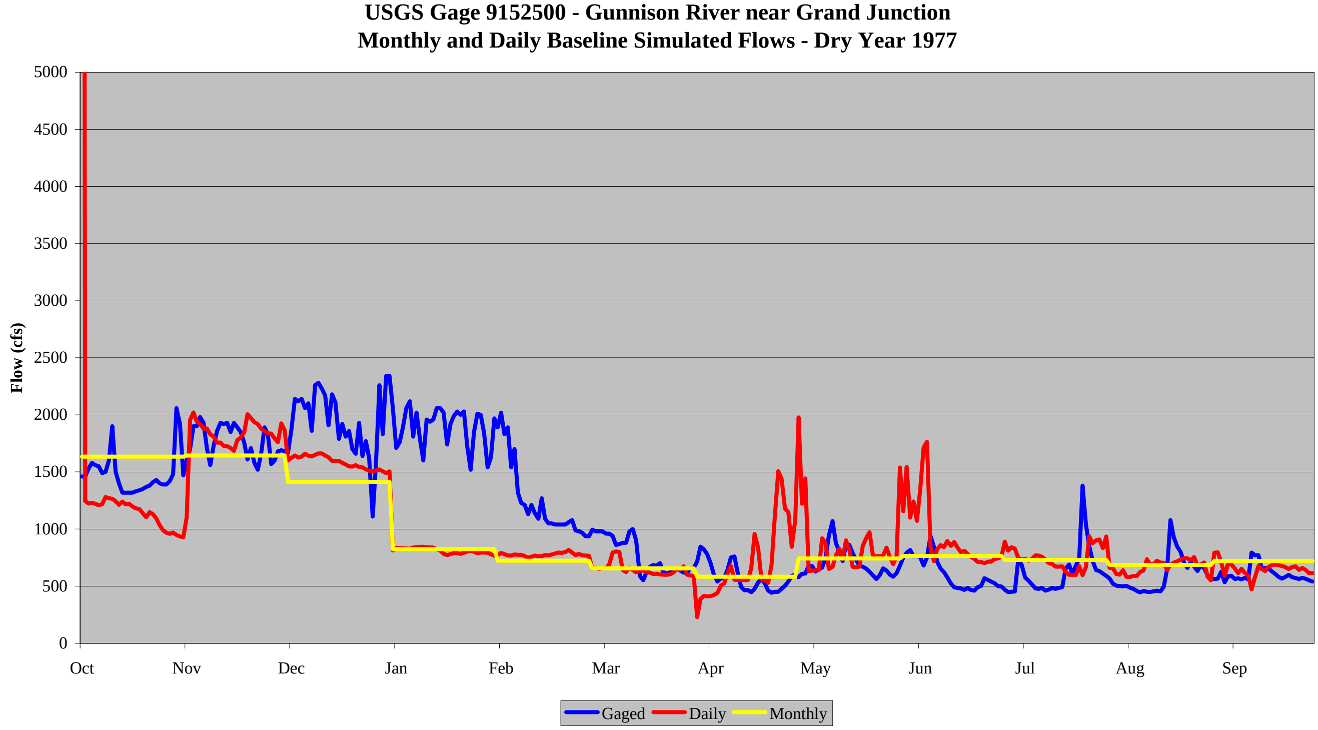



**Figure 8.27 Daily Baseline Comparison, Dry Year – Uncompahgre River at Delta**




## Figure 8.28 Daily Baseline Comparison, Dry Year – Gunnison River near Grand Junction

# Appendix A

## Aggregation of Irrigation Diversion Structures

## Gunnison River Aggregated Irrigation Structures
## StateCU and Water Budget Maintenance - Task 5.8

# CDSS Memorandum
# Final

**To:** Ray Alvarado

**From:** LRE, Erin Wilson and Jennifer Ashworth

**Subject:** Gunnison River Aggregated Irrigation Structures
StateCU and Water Budget Maintenance - Task 10

**Date:** June 12, 2004

## Introduction

The original CRDSS StateMod and StateCU modeling efforts were based on the 1993 irrigated acreage coverage developed during initial CRDSS efforts. An irrigated acreage assessment representing year 2000 was recently performed for the CRDSS (western slope) basins. In each of the four Water Divisions (4, 5, 6, and 7), a portion of the 2000 acreage was tied to structures that did not have identified acreage in the 1993 coverage, therefore are not currently represented in the CRDSS models. In addition, structures that were identified as "Key" during the initial CRDSS efforts, in part based on irrigated acreage from the 1993 assessment, were no longer shown as irrigated in 2000. As part of this task, key and aggregate structure lists for the western slope basins were revised to include 100 percent of the irrigated acreage based on both the 1993 and 2000 assessment.

As part of the re-aggregation task, discrepancies in both the 1993 and 2000 irrigated acreages were identified. These discrepancies included:

- 1993 irrigated parcels were not assigned to a water source (structure)
- 1993 and 2000 parcels irrigating the same lands were assigned to different water sources
- Structures identified as "Key" during efforts based on the 1993 coverage were not shown as irrigated in 2000
- Structure identifiers were incorrectly assigned to water districts where the acreage is located, instead of where the headgate is located. For example, acreage located in water district 40 was assigned by the water commissioner to structure 519. In the 2000 irrigated acreage coverage, the full WDID was entered as 4000519. However, the headgate for this structure is located in water district 41, and the correct WDID is 4100519.

Identified discrepancies were highlighted, and maps were sent to the Division Engineers for review. Both the 1993 and 2000 irrigated acreage coverages in each Water Division were revised based on the Division Engineers' comments prior to revising the key and aggregated structures.

## Approach

The following approach was followed to update the designation of key and aggregated irrigated structures in the Gunnison basin.

1. Move Key structures to aggregations for future model updated based on comments received from the Division Engineer. In general, Key structures were removed if the Division Engineer indicated that they no longer irrigated lands in 2000 or where incorrectly assigned to irrigated lands in 1993.

2. Aggregate remaining irrigation structures identified in either the 1993 or 2000 irrigated acreage coverages based on the aggregate spatial boundaries defined during the previous Gunnison modeling effort, as described in memorandum "Subtask 5.8 - Gunnison River Aggregated Irrigation Structures, April 22, 2002."

## Results

**Table 1** indicates the number of structures in the updated aggregation and provides a comparison of the aggregated acreage from the previous modeling effort to the acreage assigned to the aggregation based on the 1993 Updated GIS coverage and the 2000 GIS coverage.

**Table 1**
**Updated Aggregation Summary**

| Aggregation ID | 1.1.1.1 Aggregatio | # of Structures | Previous Acres | 1993 Acres | 2000 Acres |
|---|---|---|---|---|---|
| 59_ADG001 | Taylor R @ Almont | 15 | 588 | 738 | 709 |
| 59_ADG002 | East R nr Crested Butte | 10 | 1,296 | 1,296 | 587 |
| 59_ADG003 | Slate R nr Crested Butte | 19 | 1,469 | 1,469 | 1,047 |
| 59_ADG004 | EastR BLCementCkNrCButte | 22 | 2,178 | 2,178 | 1,894 |
| 59_ADG005 | East R @ Almont | 12 | 917 | 693 | 824 |
| 59_ADG006 | Ohio Ck @ Baldwin | 21 | 900 | 918 | 1,046 |
| 59_ADG007 | Ohio Ck nr Baldwin | 32 | 1,944 | 1,944 | 2,065 |
| 59_ADG008 | Gunnison R nr Gunnison | 33 | 2,070 | 2,056 | 1,891 |
| 28_ADG009 | Upper Tomichi Ck | 33 | 1,413 | 1,413 | 1,382 |
| 28_ADG010 | Tomichi Ck @ Parlin | 38 | 2,622 | 2,681 | 2,546 |
| 28_ADG011 | Cochetopa Ck nr Parlin | 25 | 1,941 | 1,946 | 1,196 |
| 28_ADG012 | Tomichi Ck @ Gunnison | 77 | 2,363 | 2,534 | 2,430 |
| 62_ADG013 | Cebolla Ck nr Powderhorn | 36 | 796 | 780 | 1,053 |
| 62_ADG014 | Cebolla Ck @Powderhorn | 20 | 1,115 | 1,206 | 1,074 |
| 62_ADG015 | Lake Fork @ Gateview | 42 | 1,685 | 1,725 | 1,710 |
| 62_ADG016 | GunnisonR abvBlueMesaRes | 40 | 1,609 | 1,672 | 1,790 |
| 62_ADG017 | GunnisonRabvMorrowPtRsvr | 5 | 376 | 376 | 1,779 |
| 62_ADG018 | Cimmarron R @ Cimmarron | 9 | 1,161 | 875 | 854 |
| 40_ADG019 | Gunnison R bl Gunnison Tunnel | 6 | 192 | 197 | 75 |
| 40_ADG020 | Iron Ck nr Crawford | 8 | 1,209 | 1,209 | 1,312 |
| 40_ADG021 | Smith Fork nr Lazear | 13 | 613 | 601 | 444 |
| 40_ADG022 | NForkGunnison nrSomerset | 28 | 1,274 | 1,556 | 1,666 |
| 40_ADG023 | Minnesota Ck @ Paonia | 9 | 382 | 466 | 440 |
| 40_ADG024 | Mid N Fork of Gunnison R | 29 | 2,027 | 2,160 | 1,498 |
| 40_ADG025 | Leroux Ck @ Hotchkiss | 12 | 957 | 1,011 | 819 |
| 40_ADG026 | Gunnison R nr Lazear | 35 | 2,265 | 1,783 | 1,772 |
| 40_ADG027 | Currant Ck nr Read | 17 | 1,235 | 1,342 | 1,603 |
| 40_ADG028 | Upper Tongue Ck | 50 | 2,282 | 2,640 | 2,131 |
| 40_ADG029 | Surface Ck @ Cedaredge | 15 | 825 | 1,141 | 946 |

| | | | | | |
|---|---|---|---|---|---|
| 40_ADG030 | Tongue Ck @ Cory | 26 | 2,590 | 3,172 | 2,318 |
| 40_ADG031 | Gunnison R @ Delta | 8 | 937 | 937 | 577 |
| 68_ADG032 | UncompahgreR nr Ridgeway | 26 | 1,042 | 1,014 | 1,264 |
| 68_ADG033 | Dallas Ck nr Ridgeway | 21 | 1,244 | 1,281 | 1,530 |
| 68_ADG034 | Uncompahgre R @ Colona | 31 | 2,315 | 2,505 | 2,261 |
| 41_ADG035 | UncompahgreR abvM&Dcanal | 7 | 1,695 | 1,557 | 977 |
| 41_ADG036 | UncompahgreAbvOlatheGage | 27 | 2,547 | 2,845 | 3,928 |
| 41_ADG037 | Uncompahgre R @ Delta | 8 | 657 | 767 | 761 |
| 40_ADG038 | RoubideauCk@mouth, Delta | 10 | 684 | 765 | 642 |
| 40_ADG039 | Gunnison R BL Delta | 32 | 2,496 | 2,417 | 2,098 |
| 42_ADG040 | Gunnison R nr G Junction | 43 | 2,582 | 2,823 | 2,106 |
| 28_ADG043 | Cochetopa Creek | 17 | 1,054 | 1,054 | 917 |
| 28_ADG044 | Razor Creek | 20 | 1,677 | 1,586 | 1,463 |
| Total | | 987 | 61,229 | 63,328 | 59,424 |

No structures identified as Key in the previous CDSS efforts were changed to be included in aggregated structures. However, two key structure water rights have recently been transferred to other ditches. Diversions continue to be reported under the original ditch as alternate points. Therefore, these ditches are now modeled as divsystems, with the original ditch WDID, so the water rights associated with both ditches are included as follows:

divsystem(6200809,6200809,6200812)
divsystem(4100568,4100568,4101680)

Figure 1 shows the spatial boundaries of each aggregation. **Exhibit A**, attached, lists the diversion structures represented in each aggregate.

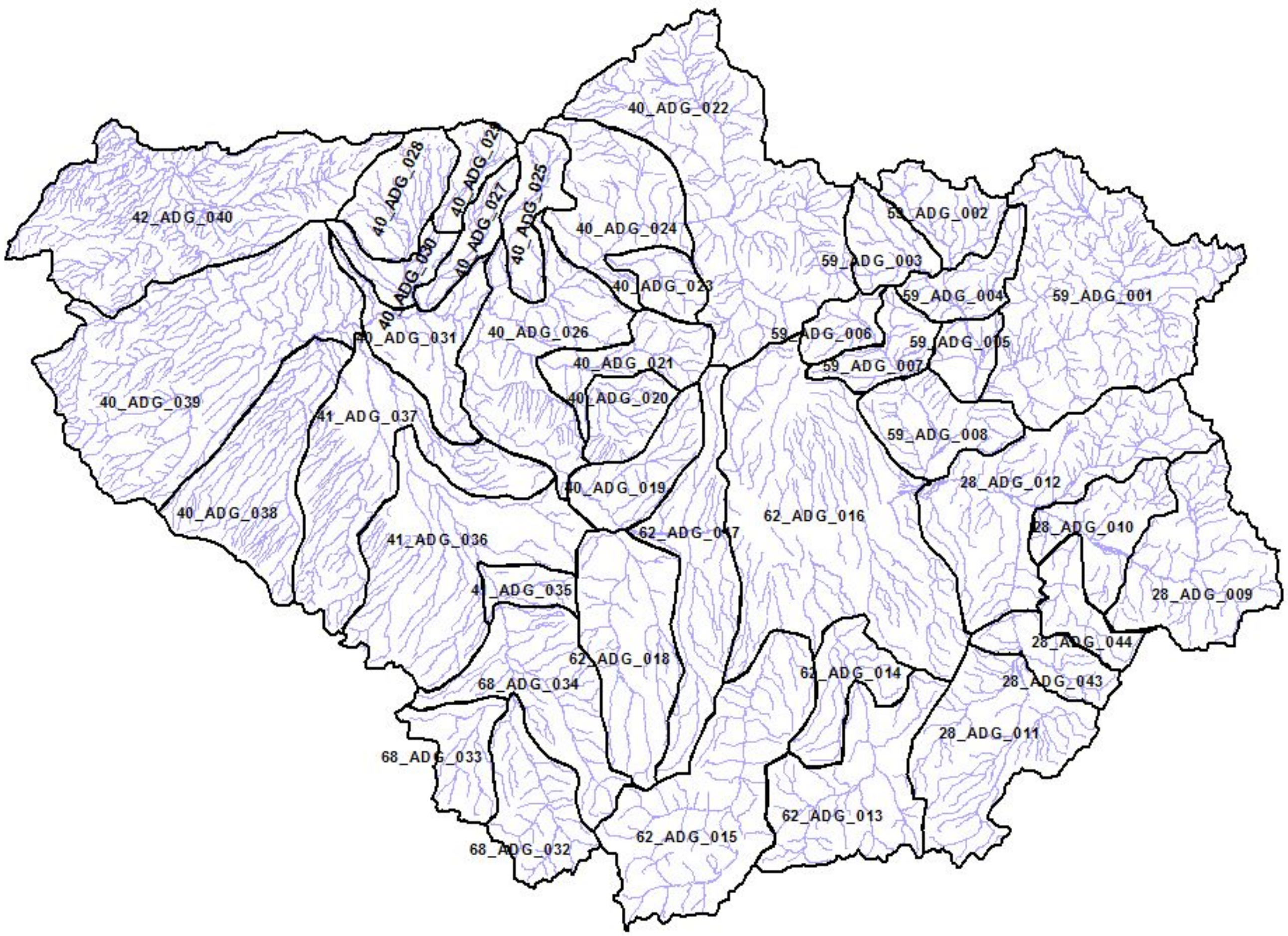



**Figure 1 – Aggregate Structure Boundaries**

**Table 2** shows the estimated total irrigated acreage associated with key and aggregated structures, by water district, for the original 1993 coverage, the updated 1993 coverage, and the 2000 coverage. The irrigated acreage decreased by about 2 percent between the updated 1993 coverage and the 2000 coverage.

**Table 2**
**Gunnison River Basin Acreage**

| Water District | Original 1993 Acreage | Updated 1993 Acreage | 2000 Acreage |
|---|---|---|---|
| 28 | 28,718 | 28,441 | 28,049 |
| 40 | 82,560 | 90,238 | 76,145 |
| 41 | 60,493 | 79,796 | 84,714 |
| 42 | 4,762 | 5,261 | 4,565 |
| 59 | 33,726 | 33,786 | 31,605 |
| 62 | 12,681 | 16,503 | 22,826 |
| 68 | 14,967 | 14,926 | 15,621 |
| Total | 237,907 | 268,951 | 263,524 |

### Comments and Concerns

None.

### Recommendations

We recommend that consultants or State personnel performing future irrigated acreage updates understand the modeling concept of Key versus Aggregated structures. During updates, each Key structure should either be assigned to irrigated acreage, or an adequate explanation provided.

## EXHIBIT A
## Diversion Structures in Aggregates

| Aggregation ID | Aggregation Name | WDID | 1993 Acres | 2000 Acres |
|---|---|---|---|---|
| 59_ADG001 | Taylor R @ Almont | 5900513 | 42.20 | 30.70 |
| | | 5900514 | 19.80 | 0.00 |
| | | 5900552 | 36.30 | 29.00 |
| | | 5900618 | 37.50 | 45.50 |
| | | 5900656 | 70.60 | 70.50 |
| | | 5900685 | 51.50 | 54.80 |
| | | 5900714 | 34.30 | 53.60 |
| | | 5900718 | 94.20 | 75.70 |
| | | 5900726 | 9.30 | 11.40 |
| | | 5900861 | 2.30 | 2.30 |
| | | 5900862 | 6.60 | 7.70 |
| | | 5900959 | 85.20 | 89.70 |
| | | 5901026 | 25.00 | 30.20 |
| | | 5901063 | 149.80 | 148.60 |
| | | 5901168 | 73.30 | 59.00 |
| 59_ADG002 | East R nr Crested Butte | 5900500 | 160.60 | 85.00 |
| | | 5900517 | 64.20 | 24.30 |
| | | 5900555 | 84.40 | 34.40 |
| | | 5900601 | 128.50 | 48.60 |
| | | 5900635 | 259.40 | 162.00 |
| | | 5900636 | 21.90 | 18.00 |
| | | 5900683 | 96.30 | 36.40 |
| | | 5900751 | 192.70 | 48.60 |
| | | 5901055 | 34.80 | 26.30 |
| | | 5901218 | 253.10 | 103.30 |
| 59_ADG003 | Slate R nr Crested Butte | 5900525 | 358.60 | 282.50 |
| | | 5900539 | 6.50 | 4.20 |
| | | 5900575 | 73.10 | 66.50 |
| | | 5900638 | 150.20 | 128.60 |
| | | 5900661 | 132.10 | 101.80 |
| | | 5900665 | 16.30 | 0.00 |
| | | 5900666 | 31.90 | 0.00 |
| | | 5900708 | 88.20 | 58.00 |
| | | 5900830 | 15.50 | 12.10 |
| | | 5900853 | 15.50 | 12.10 |
| | | 5900854 | 31.00 | 24.20 |
| | | 5900912 | 27.70 | 29.10 |
| | | 5900968 | 15.10 | 9.70 |
| | | 5901177 | 15.50 | 12.10 |
| | | 5901208 | 15.40 | 0.00 |
| | | 5901209 | 46.20 | 35.00 |
| | | 5901225 | 21.90 | 13.70 |
| | | 5901376 | 175.80 | 75.90 |
| | | 5903684 | 232.70 | 181.90 |
| 59_ADG004 | EastR BLCementCkNrCButte | 5900502 | 9.30 | 5.10 |
| | | 5900515 | 175.00 | 168.50 |

| | | | | |
|---|---|---|---|---|
| | | 5900523 | 391.70 | 275.90 |
| | | 5900536 | 61.50 | 42.80 |
| | | 5900540 | 0.00 | 36.70 |
| | | 5900598 | 28.30 | 0.00 |
| | | 5900605 | 32.00 | 44.30 |
| | | 5900612 | 65.80 | 14.40 |
| | | 5900613 | 304.10 | 378.50 |
| | | 5900626 | 76.30 | 101.40 |
| | | 5900637 | 152.60 | 207.00 |
| | | 5900662 | 26.00 | 26.90 |
| | | 5900663 | 50.30 | 39.40 |
| | | 5900706 | 138.10 | 137.60 |
| | | 5900712 | 196.20 | 38.30 |
| | | 5900727 | 40.40 | 14.90 |
| | | 5900757 | 26.00 | 21.50 |
| | | 5900829 | 246.20 | 140.60 |
| | | 5900921 | 33.80 | 30.80 |
| | | 5901140 | 97.10 | 126.30 |
| | | 5901250 | 22.20 | 18.20 |
| | | 5901736 | 4.80 | 24.50 |
| 59_ADG005 | East R @ Almont | 5900503 | 130.90 | 151.40 |
| | | 5900506 | 7.10 | 10.30 |
| | | 5900516 | 245.30 | 151.50 |
| | | 5900545 | 45.40 | 160.70 |
| | | 5900576 | 60.30 | 64.40 |
| | | 5900603 | 24.80 | 40.00 |
| | | 5900611 | 95.00 | 66.00 |
| | | 5900628 | 23.10 | 90.00 |
| | | 5900664 | 0.00 | 33.70 |
| | | 5900669 | 14.70 | 16.50 |
| | | 5900703 | 33.40 | 24.80 |
| | | 5900716 | 13.30 | 14.40 |
| 59_ADG006 | Ohio Ck @ Baldwin | 5900532 | 40.30 | 36.40 |
| | | 5900533 | 40.30 | 36.40 |
| | | 5900534 | 14.00 | 14.70 |
| | | 5900554 | 99.90 | 126.70 |
| | | 5900559 | 48.90 | 47.60 |
| | | 5900585 | 60.50 | 63.80 |
| | | 5900610 | 57.10 | 69.60 |
| | | 5900652 | 57.20 | 66.40 |
| | | 5900654 | 78.60 | 89.60 |
| | | 5900670 | 80.40 | 107.70 |
| | | 5900687 | 11.70 | 23.80 |
| | | 5900688 | 8.30 | 9.70 |
| | | 5900698 | 79.50 | 76.70 |
| | | 5900705 | 9.00 | 8.10 |
| | | 5900717 | 57.80 | 65.70 |
| | | 5900797 | 18.60 | 19.60 |
| | | 5900974 | 46.80 | 35.70 |

| | | | | |
|---|---|---|---|---|
| | | 5901013 | 19.10 | 25.00 |
| | | 5901139 | 57.20 | 79.40 |
| | | 5901171 | 19.10 | 25.00 |
| | | 5901469 | 14.00 | 18.60 |
| 59_ADG007 | Ohio Ck nr Baldwin | 5900508 | 49.60 | 51.70 |
| | | 5900511 | 9.90 | 9.80 |
| | | 5900529 | 152.60 | 132.30 |
| | | 5900530 | 83.50 | 87.10 |
| | | 5900535 | 100.60 | 111.00 |
| | | 5900543 | 46.60 | 45.60 |
| | | 5900629 | 94.70 | 92.90 |
| | | 5900632 | 46.60 | 45.60 |
| | | 5900633 | 246.20 | 212.50 |
| | | 5900634 | 68.30 | 68.10 |
| | | 5900639 | 49.20 | 53.60 |
| | | 5900642 | 18.10 | 20.40 |
| | | 5900643 | 45.00 | 34.30 |
| | | 5900648 | 37.30 | 40.10 |
| | | 5900676 | 46.50 | 60.10 |
| | | 5900681 | 100.70 | 141.20 |
| | | 5900682 | 146.40 | 100.70 |
| | | 5900721 | 28.60 | 35.90 |
| | | 5900722 | 25.40 | 35.10 |
| | | 5900723 | 19.20 | 23.10 |
| | | 5900724 | 47.00 | 53.10 |
| | | 5900725 | 12.60 | 82.40 |
| | | 5900776 | 13.80 | 13.30 |
| | | 5900863 | 167.60 | 180.60 |
| | | 5900905 | 6.20 | 5.30 |
| | | 5900954 | 20.10 | 16.20 |
| | | 5901006 | 9.40 | 11.10 |
| | | 5901007 | 18.20 | 15.70 |
| | | 5901141 | 79.60 | 114.60 |
| | | 5901180 | 91.60 | 111.10 |
| | | 5901200 | 25.70 | 28.70 |
| | | 5901361 | 37.50 | 31.80 |
| 59_ADG008 | Gunnison R nr Gunnison | 5900519 | 75.50 | 75.10 |
| | | 5900520 | 75.50 | 75.10 |
| | | 5900538 | 34.30 | 0.00 |
| | | 5900547 | 12.60 | 15.60 |
| | | 5900553 | 69.10 | 62.90 |
| | | 5900561 | 23.10 | 6.10 |
| | | 5900562 | 39.30 | 35.90 |
| | | 5900565 | 43.50 | 43.50 |
| | | 5900571 | 22.50 | 0.00 |
| | | 5900577 | 18.60 | 21.30 |
| | | 5900590 | 144.70 | 109.10 |
| | | 5900594 | 137.20 | 135.30 |
| | | 5900595 | 193.20 | 167.10 |

| | | | | |
|---|---|---|---|---|
| | | 5900599 | 92.90 | 66.10 |
| | | 5900615 | 80.40 | 80.90 |
| | | 5900647 | 33.00 | 30.20 |
| | | 5900650 | 12.50 | 62.40 |
| | | 5900673 | 50.50 | 45.40 |
| | | 5900674 | 56.60 | 76.90 |
| | | 5900675 | 72.50 | 50.00 |
| | | 5900690 | 39.20 | 22.20 |
| | | 5900694 | 46.80 | 45.90 |
| | | 5900695 | 93.50 | 91.80 |
| | | 5900701 | 34.30 | 67.60 |
| | | 5900710 | 69.10 | 62.90 |
| | | 5900713 | 138.20 | 125.90 |
| | | 5900792 | 26.80 | 42.40 |
| | | 5900793 | 26.80 | 10.00 |
| | | 5900864 | 10.00 | 11.10 |
| | | 5900967 | 207.40 | 188.80 |
| | | 5900982 | 18.30 | 6.40 |
| | | 5901165 | 34.30 | 33.80 |
| | | 5901564 | 23.40 | 23.00 |
| 28_ADG009 | Upper Tomichi Ck | 2800502 | 19.10 | 0.00 |
| | | 2800518 | 22.30 | 22.90 |
| | | 2800534 | 59.90 | 63.50 |
| | | 2800563 | 81.50 | 85.70 |
| | | 2800598 | 107.00 | 63.90 |
| | | 2800605 | 58.60 | 109.70 |
| | | 2800606 | 25.10 | 42.90 |
| | | 2800618 | 93.30 | 99.50 |
| | | 2800625 | 26.00 | 24.80 |
| | | 2800626 | 9.30 | 12.40 |
| | | 2800627 | 1.80 | 5.50 |
| | | 2800630 | 6.10 | 5.80 |
| | | 2800639 | 15.00 | 20.10 |
| | | 2800640 | 15.90 | 17.00 |
| | | 2800641 | 18.20 | 19.40 |
| | | 2800666 | 40.20 | 43.80 |
| | | 2800705 | 23.80 | 18.20 |
| | | 2800708 | 16.90 | 22.20 |
| | | 2800746 | 445.90 | 329.50 |
| | | 2800802 | 3.40 | 6.10 |
| | | 2800826 | 18.80 | 15.40 |
| | | 2800849 | 40.20 | 43.80 |
| | | 2800962 | 59.30 | 42.10 |
| | | 2800965 | 36.30 | 42.30 |
| | | 2800969 | 24.00 | 25.40 |
| | | 2800996 | 13.80 | 25.40 |
| | | 2800997 | 13.80 | 25.40 |
| | | 2801118 | 30.30 | 54.70 |
| | | 2801152 | 9.20 | 13.60 |

| | | | | |
|---|---|---|---|---|
| | | 2801153 | 6.10 | 5.50 |
| | | 2801162 | 4.30 | 6.90 |
| | | 2801184 | 44.00 | 50.00 |
| | | 2801586 | 23.80 | 18.20 |
| 28_ADG010 | Tomichi Ck @ Parlin | 2800513 | 77.20 | 118.80 |
| | | 2800514 | 14.50 | 10.20 |
| | | 2800516 | 48.80 | 56.50 |
| | | 2800537 | 22.10 | 36.70 |
| | | 2800570 | 15.80 | 22.80 |
| | | 2800575 | 91.30 | 56.90 |
| | | 2800589 | 65.50 | 70.70 |
| | | 2800601 | 39.20 | 91.70 |
| | | 2800602 | 78.30 | 57.70 |
| | | 2800603 | 83.90 | 65.00 |
| | | 2800611 | 85.10 | 78.10 |
| | | 2800612 | 76.40 | 67.00 |
| | | 2800613 | 7.90 | 8.90 |
| | | 2800614 | 7.90 | 8.90 |
| | | 2800615 | 4.70 | 5.30 |
| | | 2800616 | 9.50 | 10.70 |
| | | 2800617 | 43.70 | 47.10 |
| | | 2800628 | 60.20 | 59.40 |
| | | 2800629 | 19.70 | 14.70 |
| | | 2800656 | 9.00 | 12.60 |
| | | 2800657 | 9.20 | 17.00 |
| | | 2800658 | 263.80 | 86.80 |
| | | 2800684 | 39.10 | 34.80 |
| | | 2800685 | 47.90 | 57.10 |
| | | 2800694 | 58.80 | 68.70 |
| | | 2800710 | 64.80 | 81.40 |
| | | 2800893 | 70.40 | 46.90 |
| | | 2800936 | 77.60 | 88.80 |
| | | 2800953 | 58.80 | 68.70 |
| | | 2800958 | 0.00 | 10.60 |
| | | 2800985 | 6.40 | 10.90 |
| | | 2801147 | 81.40 | 63.10 |
| | | 2801148 | 81.40 | 63.10 |
| | | 2801151 | 374.90 | 225.50 |
| | | 2801185 | 1.60 | 1.80 |
| | | 2801572 | 479.20 | 582.80 |
| | | 2801580 | 50.20 | 69.10 |
| | | 2801581 | 54.80 | 69.30 |
| 28_ADG011 | Cochetopa Ck nr Parlin | 2800517 | 51.20 | 158.10 |
| | | 2800533 | 344.10 | 0.00 |
| | | 2800539 | 105.50 | 81.70 |
| | | 2800540 | 25.40 | 11.90 |
| | | 2800541 | 29.60 | 35.30 |
| | | 2800555 | 29.70 | 59.20 |
| | | 2800556 | 28.60 | 0.00 |

| | | | | |
|---|---|---|---|---|
| | | 2800593 | 97.20 | 127.40 |
| | | 2800595 | 134.40 | 46.90 |
| | | 2800596 | 31.80 | 11.10 |
| | | 2800597 | 134.40 | 46.90 |
| | | 2800661 | 403.80 | 113.00 |
| | | 2800717 | 11.70 | 19.50 |
| | | 2800718 | 49.80 | 30.60 |
| | | 2800721 | 69.30 | 27.20 |
| | | 2800748 | 11.70 | 11.80 |
| | | 2800752 | 13.10 | 12.80 |
| | | 2800813 | 53.00 | 18.50 |
| | | 2800884 | 89.60 | 94.00 |
| | | 2800897 | 8.00 | 12.30 |
| | | 2800898 | 78.40 | 64.40 |
| | | 2800928 | 59.60 | 49.90 |
| | | 2800935 | 20.50 | 20.70 |
| | | 2801012 | 60.60 | 133.50 |
| | | 2801050 | 5.40 | 9.20 |
| 28_ADG012 | Tomichi Ck @ Gunnison | 2800501 | 78.20 | 78.30 |
| | | 2800504 | 14.40 | 14.10 |
| | | 2800512 | 10.80 | 0.00 |
| | | 2800519 | 59.00 | 18.20 |
| | | 2800521 | 12.70 | 10.20 |
| | | 2800524 | 36.50 | 38.30 |
| | | 2800531 | 78.60 | 97.70 |
| | | 2800548 | 37.90 | 45.70 |
| | | 2800549 | 42.10 | 33.90 |
| | | 2800551 | 6.50 | 5.80 |
| | | 2800552 | 10.20 | 30.50 |
| | | 2800553 | 32.30 | 28.80 |
| | | 2800558 | 31.00 | 0.00 |
| | | 2800559 | 9.70 | 70.80 |
| | | 2800560 | 17.40 | 27.90 |
| | | 2800561 | 0.00 | 9.60 |
| | | 2800569 | 94.50 | 77.20 |
| | | 2800573 | 26.60 | 34.30 |
| | | 2800574 | 10.00 | 12.90 |
| | | 2800579 | 127.60 | 120.80 |
| | | 2800582 | 17.00 | 15.70 |
| | | 2800584 | 15.40 | 13.40 |
| | | 2800585 | 17.00 | 15.70 |
| | | 2800591 | 15.20 | 16.40 |
| | | 2800619 | 8.20 | 11.90 |
| | | 2800620 | 43.90 | 42.40 |
| | | 2800621 | 42.40 | 28.80 |
| | | 2800623 | 97.60 | 102.90 |
| | | 2800653 | 2.20 | 2.40 |
| | | 2800655 | 39.60 | 40.80 |
| | | 2800659 | 97.60 | 102.90 |

| | | | | |
|---|---|---|---|---|
| | | 2800664 | 43.90 | 43.40 |
| | | 2800669 | 75.10 | 75.70 |
| | | 2800676 | 73.40 | 69.00 |
| | | 2800677 | 42.10 | 38.00 |
| | | 2800683 | 16.20 | 23.00 |
| | | 2800691 | 3.70 | 8.10 |
| | | 2800695 | 3.60 | 3.50 |
| | | 2800696 | 36.40 | 35.90 |
| | | 2800699 | 27.10 | 26.80 |
| | | 2800704 | 96.30 | 90.60 |
| | | 2800720 | 41.60 | 27.00 |
| | | 2800726 | 38.50 | 34.20 |
| | | 2800774 | 41.70 | 41.50 |
| | | 2800777 | 12.10 | 9.90 |
| | | 2800803 | 8.90 | 9.30 |
| | | 2800804 | 7.60 | 4.60 |
| | | 2800805 | 11.50 | 11.80 |
| | | 2800862 | 13.90 | 13.80 |
| | | 2800869 | 208.70 | 215.20 |
| | | 2800872 | 10.90 | 14.00 |
| | | 2800873 | 4.10 | 5.20 |
| | | 2800874 | 6.80 | 8.70 |
| | | 2800875 | 5.40 | 7.00 |
| | | 2800938 | 28.40 | 33.00 |
| | | 2800943 | 53.50 | 45.00 |
| | | 2800959 | 73.60 | 57.20 |
| | | 2800960 | 73.60 | 57.20 |
| | | 2800970 | 19.20 | 0.00 |
| | | 2801008 | 9.20 | 11.10 |
| | | 2801068 | 0.80 | 0.70 |
| | | 2801069 | 0.80 | 0.70 |
| | | 2801093 | 5.90 | 6.90 |
| | | 2801094 | 4.60 | 4.40 |
| | | 2801585 | 3.40 | 4.10 |
| | | 2801592 | 77.70 | 28.90 |
| | | 2801615 | 2.10 | 2.70 |
| | | 2801616 | 2.10 | 2.30 |
| | | 2801617 | 16.30 | 16.10 |
| | | 2801618 | 5.30 | 7.40 |
| | | 2801619 | 4.50 | 5.80 |
| | | 2801620 | 7.00 | 8.10 |
| | | 2801621 | 4.90 | 5.40 |
| | | 2801622 | 1.00 | 1.20 |
| | | 2801623 | 2.20 | 1.90 |
| | | 5900504 | 50.40 | 47.20 |
| | | 5900697 | 126.00 | 117.90 |
| 62_ADG013 | Cebolla Ck nr Powderhorn | 6200501 | 29.10 | 36.90 |
| | | 6200552 | 22.30 | 38.20 |
| | | 6200562 | 49.40 | 59.00 |

| | | | | |
|---|---|---|---|---|
| | | 6200563 | 20.90 | 24.50 |
| | | 6200575 | 24.10 | 24.10 |
| | | 6200585 | 8.90 | 7.20 |
| | | 6200596 | 8.90 | 7.20 |
| | | 6200619 | 28.80 | 44.60 |
| | | 6200636 | 14.30 | 24.90 |
| | | 6200645 | 10.20 | 16.20 |
| | | 6200646 | 12.90 | 11.70 |
| | | 6200664 | 24.50 | 27.50 |
| | | 6200669 | 34.20 | 48.70 |
| | | 6200677 | 19.70 | 30.50 |
| | | 6200684 | 38.70 | 65.80 |
| | | 6200685 | 43.90 | 53.30 |
| | | 6200686 | 9.20 | 11.30 |
| | | 6200687 | 16.70 | 24.50 |
| | | 6200696 | 18.80 | 26.90 |
| | | 6200697 | 17.00 | 18.60 |
| | | 6200699 | 17.00 | 18.60 |
| | | 6200730 | 3.80 | 13.50 |
| | | 6200731 | 26.80 | 25.80 |
| | | 6200762 | 15.10 | 16.00 |
| | | 6200792 | 37.40 | 38.30 |
| | | 6200805 | 1.70 | 10.30 |
| | | 6200810 | 43.10 | 43.30 |
| | | 6200811 | 14.00 | 31.60 |
| | | 6200825 | 23.00 | 34.10 |
| | | 6200841 | 0.80 | 1.30 |
| | | 6200894 | 4.70 | 9.90 |
| | | 6201080 | 6.00 | 20.10 |
| | | 6201180 | 19.20 | 31.80 |
| | | 6201187 | 2.70 | 0.60 |
| | | 6201334 | 112.50 | 125.30 |
| | | 6201513 | 0.00 | 31.30 |
| 62_ADG014 | Cebolla Ck @Powderhorn | 6200520 | 32.60 | 31.10 |
| | | 6200521 | 9.90 | 0.00 |
| | | 6200565 | 21.50 | 32.20 |
| | | 6200582 | 341.10 | 136.10 |
| | | 6200603 | 14.00 | 14.60 |
| | | 6200637 | 15.30 | 19.30 |
| | | 6200643 | 20.80 | 20.60 |
| | | 6200671 | 26.80 | 34.50 |
| | | 6200693 | 16.80 | 26.20 |
| | | 6200712 | 48.50 | 61.40 |
| | | 6200713 | 106.60 | 207.10 |
| | | 6200719 | 23.70 | 34.80 |
| | | 6200735 | 76.10 | 62.70 |
| | | 6200739 | 21.80 | 53.50 |
| | | 6200741 | 81.70 | 61.90 |
| | | 6200743 | 152.40 | 71.70 |

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|---|---|---|---|---|
| | | 6200791 | 30.00 | 30.00 |
| | | 6200813 | 121.50 | 101.30 |
| | | 6201089 | 44.90 | 31.70 |
| | | 6201519 | 0.00 | 42.80 |
| 62_ADG015 | Lake Fork @ Gateview | 6200500 | 0.00 | 47.00 |
| | | 6200508 | 63.00 | 60.90 |
| | | 6200519 | 92.90 | 103.70 |
| | | 6200548 | 29.10 | 27.50 |
| | | 6200549 | 7.60 | 13.20 |
| | | 6200551 | 7.70 | 9.30 |
| | | 6200559 | 9.70 | 9.90 |
| | | 6200570 | 105.40 | 103.10 |
| | | 6200580 | 38.90 | 18.10 |
| | | 6200594 | 6.80 | 6.60 |
| | | 6200606 | 17.20 | 15.20 |
| | | 6200607 | 10.40 | 10.70 |
| | | 6200608 | 41.70 | 58.40 |
| | | 6200609 | 4.60 | 6.50 |
| | | 6200611 | 6.50 | 5.40 |
| | | 6200639 | 96.70 | 33.00 |
| | | 6200644 | 22.30 | 25.50 |
| | | 6200652 | 26.20 | 21.50 |
| | | 6200653 | 116.60 | 93.50 |
| | | 6200722 | 50.80 | 55.60 |
| | | 6200723 | 6.30 | 7.00 |
| | | 6200724 | 6.30 | 7.00 |
| | | 6200729 | 28.90 | 43.10 |
| | | 6200746 | 0.00 | 12.90 |
| | | 6200763 | 12.80 | 18.60 |
| | | 6200766 | 87.50 | 95.40 |
| | | 6200775 | 42.20 | 37.70 |
| | | 6200776 | 168.90 | 150.90 |
| | | 6200777 | 27.60 | 40.30 |
| | | 6200785 | 22.20 | 11.80 |
| | | 6200786 | 26.00 | 18.00 |
| | | 6200794 | 12.00 | 18.40 |
| | | 6200802 | 54.80 | 52.40 |
| | | 6200808 | 42.40 | 29.80 |
| | | 6200822 | 90.60 | 102.00 |
| | | 6200876 | 168.90 | 27.60 |
| | | 6201146 | 31.70 | 0.00 |
| | | 6201147 | 3.30 | 0.00 |
| | | 6201459 | 3.70 | 0.00 |
| | | 6201493 | 107.70 | 165.60 |
| | | 6201709 | 0.00 | 110.50 |
| | | 6201794 | 27.50 | 36.70 |
| 62_ADG016 | GunnisonR abvBlueMesaRes | 5900505 | 49.40 | 58.00 |
| | | 5900512 | 82.80 | 147.80 |
| | | 5900526 | 26.00 | 27.40 |

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|---|---|---|---|---|
| | | 5900531 | 18.20 | 17.50 |
| | | 5900564 | 89.90 | 91.40 |
| | | 5900568 | 76.20 | 107.30 |
| | | 5900604 | 57.80 | 66.60 |
| | | 5900614 | 56.90 | 60.60 |
| | | 5900686 | 4.60 | 4.90 |
| | | 5900693 | 6.10 | 5.50 |
| | | 5900715 | 1.10 | 1.30 |
| | | 5901341 | 0.00 | 17.40 |
| | | 5901473 | 29.10 | 44.40 |
| | | 6200502 | 14.50 | 16.10 |
| | | 6200510 | 72.20 | 76.90 |
| | | 6200525 | 87.90 | 69.00 |
| | | 6200530 | 39.20 | 39.70 |
| | | 6200536 | 56.90 | 57.50 |
| | | 6200547 | 0.00 | 4.30 |
| | | 6200569 | 205.10 | 177.10 |
| | | 6200572 | 15.70 | 11.00 |
| | | 6200576 | 0.00 | 63.50 |
| | | 6200612 | 128.50 | 113.90 |
| | | 6200613 | 105.40 | 91.10 |
| | | 6200641 | 86.10 | 61.40 |
| | | 6200642 | 105.40 | 91.10 |
| | | 6200651 | 6.90 | 7.30 |
| | | 6200661 | 0.00 | 14.80 |
| | | 6200689 | 11.70 | 10.40 |
| | | 6200690 | 29.30 | 26.10 |
| | | 6200752 | 27.90 | 31.70 |
| | | 6200753 | 27.90 | 31.70 |
| | | 6200754 | 30.10 | 22.80 |
| | | 6200756 | 19.90 | 21.60 |
| | | 6200784 | 20.70 | 0.00 |
| | | 6201000 | 0.00 | 18.40 |
| | | 6201008 | 0.00 | 11.90 |
| | | 6201047 | 0.00 | 4.30 |
| | | 6201249 | 59.00 | 50.50 |
| | | 6201250 | 23.70 | 15.30 |
| 62_ADG017 | GunnisonRabvMorrowPtRsvr | 6200535 | 0.00 | 240.30 |
| | | 6200537 | 31.90 | 0.00 |
| | | 6200708 | 238.40 | 1,539.00 |
| | | 6200760 | 52.60 | 0.00 |
| | | 6200761 | 52.60 | 0.00 |
| 62_ADG018 | Cimmarron R @ Cimmarron | 6200542 | 438.30 | 192.60 |
| | | 6200673 | 42.40 | 76.60 |
| | | 6200674 | 12.90 | 0.00 |
| | | 6200707 | 43.40 | 24.30 |
| | | 6200715 | 173.70 | 0.00 |
| | | 6200742 | 14.80 | 114.90 |
| | | 6200765 | 148.60 | 174.50 |

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|---|---|---|---|---|
| | | 6200782 | 0.40 | 6.70 |
| | | 6200892 | 0.00 | 264.20 |
| 40_ADG019 | Gunnison R bl Gunnison Tunnel | 4000510 | 43.60 | 0.00 |
| | | 4000539 | 0.00 | 50.60 |
| | | 4000540 | 18.50 | 17.60 |
| | | 4000541 | 35.40 | 6.80 |
| | | 4000542 | 56.30 | 0.00 |
| | | 4000601 | 43.60 | 0.00 |
| 40_ADG020 | Iron Ck nr Crawford | 4000519 | 99.90 | 121.70 |
| | | 4000528 | 325.90 | 357.00 |
| | | 4000544 | 487.70 | 512.00 |
| | | 4000550 | 35.60 | 0.00 |
| | | 4000557 | 0.00 | 87.00 |
| | | 4000563 | 47.50 | 0.00 |
| | | 4000569 | 45.10 | 52.00 |
| | | 4000573 | 166.90 | 181.90 |
| 40_ADG021 | Smith Fork nr Lazear | 4000507 | 37.70 | 31.60 |
| | | 4000512 | 82.30 | 57.80 |
| | | 4000514 | 13.60 | 12.40 |
| | | 4000518 | 33.30 | 29.10 |
| | | 4000554 | 72.80 | 74.20 |
| | | 4000558 | 35.20 | 37.50 |
| | | 4000561 | 97.00 | 83.00 |
| | | 4000570 | 78.50 | 38.30 |
| | | 4000587 | 13.50 | 10.20 |
| | | 4000594 | 55.80 | 0.00 |
| | | 4000604 | 52.10 | 36.80 |
| | | 4000614 | 24.60 | 25.10 |
| | | 4000619 | 5.00 | 7.50 |
| 40_ADG022 | NForkGunnison nrSomerset | 4001071 | 116.70 | 0.00 |
| | | 4001082 | 0.00 | 183.80 |
| | | 4001085 | 54.40 | 22.50 |
| | | 4001086 | 21.70 | 12.50 |
| | | 4001090 | 118.00 | 125.40 |
| | | 4001091 | 32.00 | 0.00 |
| | | 4001108 | 37.00 | 0.00 |
| | | 4001115 | 0.00 | 71.10 |
| | | 4001116 | 0.00 | 172.90 |
| | | 4001121 | 39.00 | 91.40 |
| | | 4001125 | 61.10 | 0.00 |
| | | 4001137 | 22.30 | 18.60 |
| | | 4001138 | 45.20 | 0.00 |
| | | 4001139 | 0.00 | 47.00 |
| | | 4001148 | 0.00 | 44.40 |
| | | 4001151 | 0.00 | 88.80 |
| | | 4001157 | 199.60 | 84.30 |
| | | 4001167 | 20.20 | 13.90 |
| | | 4001175 | 51.00 | 50.20 |

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|---|---|---|---|---|
| | | 4001184 | 124.20 | 102.40 |
| | | 4001188 | 328.20 | 0.00 |
| | | 4001194 | 139.80 | 0.00 |
| | | 4001198 | 0.00 | 116.00 |
| | | 4001202 | 116.70 | 0.00 |
| | | 4001203 | 0.00 | 125.00 |
| | | 4001204 | 0.00 | 28.50 |
| | | 4001205 | 28.50 | 0.00 |
| | | 4001212 | 0.00 | 267.30 |
| 40_ADG023 | Minnesota Ck @ Paonia | 4000964 | 70.50 | 13.30 |
| | | 4000977 | 0.00 | 78.00 |
| | | 4000981 | 42.00 | 25.80 |
| | | 4000993 | 24.20 | 39.60 |
| | | 4001009 | 0.00 | 59.20 |
| | | 4001048 | 43.20 | 0.00 |
| | | 4001051 | 134.30 | 72.60 |
| | | 4001232 | 114.40 | 109.00 |
| | | 4001250 | 37.70 | 42.90 |
| 40_ADG024 | Mid N Fork of Gunnison R | 4000951 | 65.10 | 64.50 |
| | | 4000960 | 29.30 | 30.60 |
| | | 4000962 | 44.60 | 0.00 |
| | | 4000979 | 89.40 | 0.00 |
| | | 4000983 | 15.90 | 0.00 |
| | | 4000988 | 102.50 | 0.00 |
| | | 4000989 | 13.10 | 16.00 |
| | | 4000991 | 109.10 | 80.40 |
| | | 4001018 | 21.80 | 24.50 |
| | | 4001027 | 137.40 | 78.90 |
| | | 4001028 | 18.90 | 18.00 |
| | | 4001033 | 204.00 | 384.10 |
| | | 4001057 | 34.90 | 44.30 |
| | | 4001069 | 165.90 | 0.00 |
| | | 4001089 | 72.40 | 0.00 |
| | | 4001093 | 63.40 | 25.20 |
| | | 4001094 | 19.70 | 0.00 |
| | | 4001113 | 15.40 | 89.80 |
| | | 4001130 | 12.80 | 11.40 |
| | | 4001155 | 9.40 | 9.90 |
| | | 4001169 | 55.20 | 50.40 |
| | | 4001173 | 15.60 | 14.10 |
| | | 4001208 | 279.80 | 276.30 |
| | | 4001215 | 105.00 | 88.70 |
| | | 4001219 | 43.90 | 20.90 |
| | | 4001223 | 58.30 | 0.00 |
| | | 4001276 | 12.70 | 15.00 |
| | | 4001282 | 89.40 | 0.00 |
| | | 4003411 | 254.60 | 155.40 |
| 40_ADG025 | Leroux Ck @ Hotchkiss | 4000920 | 95.00 | 87.70 |
| | | 4000921 | 14.90 | 13.10 |

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|---|---|---|---|---|
| | | 4000934 | 43.80 | 49.30 |
| | | 4000938 | 96.40 | 91.70 |
| | | 4000939 | 29.00 | 34.00 |
| | | 4000940 | 53.40 | 29.40 |
| | | 4000941 | 143.50 | 122.30 |
| | | 4000943 | 124.20 | 46.50 |
| | | 4001001 | 163.40 | 151.30 |
| | | 4001019 | 133.30 | 57.50 |
| | | 4001034 | 56.00 | 84.90 |
| | | 4001059 | 58.00 | 51.40 |
| 40_ADG026 | Gunnison R nr Lazear | 4000537 | 44.10 | 40.40 |
| | | 4000547 | 44.40 | 5.80 |
| | | 4000603 | 7.80 | 62.00 |
| | | 4000606 | 0.00 | 61.40 |
| | | 4000915 | 224.60 | 143.50 |
| | | 4000922 | 0.00 | 29.30 |
| | | 4000925 | 0.00 | 61.20 |
| | | 4000927 | 12.20 | 56.50 |
| | | 4000957 | 131.20 | 143.00 |
| | | 4000961 | 6.30 | 0.00 |
| | | 4000963 | 79.80 | 42.10 |
| | | 4000968 | 106.30 | 0.00 |
| | | 4000971 | 107.40 | 63.60 |
| | | 4000982 | 50.10 | 54.90 |
| | | 4000995 | 4.80 | 0.00 |
| | | 4000998 | 46.10 | 76.10 |
| | | 4000999 | 25.10 | 0.00 |
| | | 4001000 | 58.60 | 53.40 |
| | | 4001004 | 0.80 | 0.00 |
| | | 4001006 | 69.10 | 91.30 |
| | | 4001007 | 16.20 | 11.70 |
| | | 4001023 | 11.80 | 0.00 |
| | | 4001025 | 140.50 | 183.50 |
| | | 4001039 | 121.80 | 106.40 |
| | | 4001045 | 38.90 | 0.00 |
| | | 4001047 | 38.90 | 82.70 |
| | | 4001064 | 129.20 | 133.90 |
| | | 4001066 | 43.50 | 46.80 |
| | | 4001068 | 47.00 | 23.30 |
| | | 4001233 | 12.00 | 10.20 |
| | | 4001247 | 45.00 | 41.70 |
| | | 4001257 | 14.60 | 74.20 |
| | | 4001614 | 9.40 | 15.50 |
| | | 4001678 | 61.60 | 18.70 |
| | | 4002163 | 34.00 | 39.10 |
| 40_ADG027 | Currant Ck nr Read | 4000788 | 8.11 | 7.98 |
| | | 4000790 | 27.27 | 37.17 |
| | | 4000792 | 20.52 | 38.65 |
| | | 4000793 | 107.74 | 36.88 |

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|---|---|---|---|---|
| | | 4000796 | 214.63 | 266.57 |
| | | 4000799 | 111.55 | 129 |
| | | 4000801 | 21.14 | 8.82 |
| | | 4000802 | 77.73 | 75.41 |
| | | 4000803 | 171.94 | 164.67 |
| | | 4000804 | 19.96 | 16.16 |
| | | 4000807 | 10.64 | 11.4 |
| | | 4000813 | 305.88 | 265.41 |
| | | 4000817 | 83.37 | 98.89 |
| | | 4000823 | 43.03 | 106.52 |
| | | 4000824 | 9.02 | 10.83 |
| | | 4000826 | 0 | 211.32 |
| | | 4001272 | 109.16 | 117.49 |
| 40_ADG028 | Upper Tongue Ck | 4000629 | 5.60 | 9.30 |
| | | 4000631 | 34.80 | 25.20 |
| | | 4000640 | 31.90 | 26.50 |
| | | 4000643 | 6.80 | 3.10 |
| | | 4000652 | 48.90 | 45.10 |
| | | 4000657 | 37.60 | 22.50 |
| | | 4000659 | 7.00 | 0.00 |
| | | 4000660 | 9.10 | 10.50 |
| | | 4000697 | 182.80 | 59.70 |
| | | 4000698 | 66.90 | 30.90 |
| | | 4000699 | 19.60 | 17.70 |
| | | 4000700 | 90.40 | 81.80 |
| | | 4000704 | 9.90 | 6.30 |
| | | 4000705 | 44.80 | 40.40 |
| | | 4000707 | 12.00 | 17.70 |
| | | 4000708 | 48.40 | 34.60 |
| | | 4000710 | 11.80 | 10.40 |
| | | 4000712 | 15.40 | 19.00 |
| | | 4000714 | 11.00 | 20.70 |
| | | 4000716 | 34.00 | 29.70 |
| | | 4000724 | 0.00 | 24.10 |
| | | 4000729 | 14.70 | 22.40 |
| | | 4000731 | 89.90 | 147.80 |
| | | 4000734 | 11.30 | 11.20 |
| | | 4000735 | 45.60 | 59.10 |
| | | 4000737 | 0.00 | 11.20 |
| | | 4000738 | 36.60 | 37.00 |
| | | 4000741 | 283.50 | 267.40 |
| | | 4000742 | 0.00 | 12.20 |
| | | 4000743 | 37.80 | 41.50 |
| | | 4000745 | 54.10 | 28.30 |
| | | 4000746 | 156.60 | 115.00 |
| | | 4000747 | 178.60 | 196.80 |
| | | 4000748 | 0.00 | 8.00 |
| | | 4000749 | 0.00 | 12.50 |
| | | 4000841 | 316.90 | 211.70 |

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| | | 4000843 | 65.50 | 70.70 |
| | | 4000847 | 65.20 | 52.70 |
| | | 4000848 | 65.50 | 27.30 |
| | | 4000852 | 95.60 | 56.60 |
| | | 4001231 | 0.00 | 14.10 |
| | | 4001235 | 123.50 | 0.00 |
| | | 4001253 | 13.90 | 0.00 |
| | | 4001266 | 57.50 | 70.00 |
| | | 4001269 | 139.40 | 72.70 |
| | | 4001294 | 22.60 | 0.00 |
| | | 4001295 | 10.60 | 6.40 |
| | | 4001296 | 5.60 | 12.50 |
| | | 4001408 | 15.20 | 13.80 |
| | | 4002256 | 5.60 | 17.30 |
| 40_ADG029 | Surface Ck @ Cedaredge | 4000638 | 160.60 | 159.20 |
| | | 4000648 | 103.50 | 89.70 |
| | | 4000671 | 19.50 | 38.70 |
| | | 4000672 | 57.10 | 54.90 |
| | | 4000677 | 65.20 | 52.50 |
| | | 4000679 | 12.30 | 4.00 |
| | | 4000680 | 416.00 | 374.20 |
| | | 4000681 | 25.70 | 27.40 |
| | | 4000684 | 27.00 | 13.30 |
| | | 4000685 | 55.00 | 69.80 |
| | | 4000687 | 3.90 | 23.20 |
| | | 4000689 | 38.50 | 36.40 |
| | | 4000690 | 113.20 | 0.00 |
| | | 4000691 | 11.50 | 0.00 |
| | | 4000694 | 32.40 | 3.10 |
| 40_ADG030 | Tongue Ck @ Cory | 4000693 | 243.80 | 162.20 |
| | | 4000696 | 26.10 | 26.50 |
| | | 4000706 | 228.50 | 168.00 |
| | | 4000715 | 58.40 | 72.40 |
| | | 4000720 | 101.90 | 144.10 |
| | | 4000726 | 0.00 | 28.50 |
| | | 4000733 | 186.90 | 175.20 |
| | | 4000736 | 63.10 | 65.00 |
| | | 4000752 | 34.30 | 29.80 |
| | | 4000755 | 327.20 | 50.30 |
| | | 4000763 | 111.10 | 111.80 |
| | | 4000773 | 174.90 | 215.00 |
| | | 4000779 | 9.30 | 11.70 |
| | | 4000780 | 60.50 | 50.30 |
| | | 4000782 | 8.70 | 9.20 |
| | | 4000787 | 76.50 | 146.40 |
| | | 4000791 | 0.00 | 110.30 |
| | | 4000839 | 0.00 | 15.50 |
| | | 4000840 | 0.00 | 35.20 |
| | | 4000844 | 146.40 | 119.20 |

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| | | 4000845 | 745.10 | 278.80 |
| | | 4000849 | 151.10 | 150.20 |
| | | 4001292 | 81.00 | 52.60 |
| | | 4001293 | 16.00 | 0.00 |
| | | 4001473 | 233.40 | 89.30 |
| | | 4001474 | 87.80 | 0.00 |
| 40_ADG031 | Gunnison R @ Delta | 4000646 | 333.00 | 121.10 |
| | | 4000795 | 0.00 | 40.70 |
| | | 4000805 | 53.30 | 0.00 |
| | | 4000811 | 251.10 | 99.30 |
| | | 4000812 | 257.30 | 296.40 |
| | | 4000903 | 22.90 | 12.30 |
| | | 4001341 | 11.60 | 0.00 |
| | | 4001385 | 7.50 | 7.20 |
| 68_ADG032 | UncompahgreR nr Ridgeway | 6800516 | 54.10 | 63.60 |
| | | 6800527 | 0.00 | 10.40 |
| | | 6800532 | 72.00 | 35.30 |
| | | 6800570 | 68.60 | 49.70 |
| | | 6800579 | 11.30 | 0.00 |
| | | 6800587 | 41.30 | 0.00 |
| | | 6800590 | 4.50 | 0.00 |
| | | 6800602 | 0.00 | 21.60 |
| | | 6800612 | 6.50 | 19.50 |
| | | 6800617 | 0.00 | 38.20 |
| | | 6800621 | 57.30 | 123.80 |
| | | 6800655 | 20.10 | 0.00 |
| | | 6800656 | 108.00 | 0.00 |
| | | 6800660 | 41.30 | 0.00 |
| | | 6800664 | 47.40 | 178.50 |
| | | 6800690 | 39.30 | 12.60 |
| | | 6800697 | 15.80 | 14.30 |
| | | 6800737 | 26.00 | 0.00 |
| | | 6800747 | 65.10 | 128.50 |
| | | 6800750 | 6.30 | 0.00 |
| | | 6800751 | 97.70 | 358.50 |
| | | 6800771 | 34.40 | 13.20 |
| | | 6800777 | 69.20 | 51.70 |
| | | 6800781 | 77.20 | 145.00 |
| | | 6800907 | 35.10 | 0.00 |
| | | 6801026 | 15.20 | 0.00 |
| 68_ADG033 | Dallas Ck nr Ridgeway | 6800506 | 277.40 | 0.00 |
| | | 6800513 | 15.00 | 17.10 |
| | | 6800573 | 144.60 | 330.80 |
| | | 6800597 | 17.00 | 18.20 |
| | | 6800608 | 11.80 | 72.30 |
| | | 6800622 | 35.00 | 0.00 |
| | | 6800640 | 17.90 | 0.00 |
| | | 6800641 | 34.30 | 62.00 |
| | | 6800643 | 57.30 | 245.10 |

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|---|---|---|---|---|
| | | 6800663 | 32.20 | 0.00 |
| | | 6800679 | 145.90 | 262.50 |
| | | 6800680 | 119.70 | 226.00 |
| | | 6800708 | 37.00 | 11.00 |
| | | 6800724 | 84.50 | 46.60 |
| | | 6800727 | 143.90 | 43.70 |
| | | 6800731 | 42.70 | 43.20 |
| | | 6800752 | 42.10 | 60.60 |
| | | 6800763 | 0.00 | 90.40 |
| | | 6800766 | 10.70 | 0.00 |
| | | 6800779 | 10.10 | 0.00 |
| | | 6800817 | 1.90 | 0.00 |
| 68_ADG034 | Uncompahgre R @ Colona | 6800505 | 82.40 | 133.10 |
| | | 6800510 | 71.40 | 68.70 |
| | | 6800511 | 144.50 | 57.30 |
| | | 6800520 | 7.20 | 0.00 |
| | | 6800522 | 9.00 | 0.00 |
| | | 6800523 | 74.40 | 70.80 |
| | | 6800531 | 52.30 | 0.00 |
| | | 6800542 | 22.20 | 0.00 |
| | | 6800565 | 71.50 | 39.60 |
| | | 6800581 | 103.50 | 110.70 |
| | | 6800601 | 12.60 | 0.00 |
| | | 6800624 | 83.70 | 94.70 |
| | | 6800651 | 55.10 | 120.50 |
| | | 6800673 | 144.50 | 141.90 |
| | | 6800675 | 66.30 | 94.40 |
| | | 6800676 | 68.80 | 43.20 |
| | | 6800677 | 17.00 | 0.00 |
| | | 6800701 | 23.40 | 38.50 |
| | | 6800704 | 82.20 | 34.80 |
| | | 6800715 | 30.60 | 69.40 |
| | | 6800716 | 12.30 | 0.00 |
| | | 6800717 | 41.00 | 34.80 |
| | | 6800725 | 27.80 | 0.00 |
| | | 6800744 | 125.20 | 95.30 |
| | | 6800749 | 50.40 | 65.00 |
| | | 6800755 | 120.50 | 103.70 |
| | | 6800756 | 448.70 | 362.60 |
| | | 6800767 | 233.80 | 267.90 |
| | | 6800778 | 69.60 | 50.40 |
| | | 6800945 | 0.00 | 164.00 |
| | | 6801041 | 152.60 | 0.00 |
| 41_ADG035 | UncompahgreR abvM&Dcanal | 4100506 | 200.80 | 0.00 |
| | | 4100509 | 515.70 | 373.10 |
| | | 4100550 | 59.30 | 77.10 |
| | | 4100681 | 13.50 | 0.00 |
| | | 4100692 | 243.20 | 0.00 |

| | | | | |
|---|---|---|---|---|
| | | 6800604 | 228.80 | 149.50 |
| | | 6800657 | 295.40 | 377.20 |
| 41_ADG036 | UncompahgreAbvOlatheGage | 4100500 | 156.10 | 136.00 |
| | | 4100503 | 204.20 | 203.70 |
| | | 4100511 | 9.20 | 7.80 |
| | | 4100512 | 0.00 | 21.90 |
| | | 4100518 | 76.40 | 0.00 |
| | | 4100521 | 512.10 | 480.00 |
| | | 4100522 | 87.70 | 222.30 |
| | | 4100529 | 58.00 | 17.90 |
| | | 4100533 | 43.30 | 29.40 |
| | | 4100535 | 216.40 | 210.40 |
| | | 4100536 | 20.80 | 23.90 |
| | | 4100539 | 0.00 | 27.20 |
| | | 4100541 | 335.50 | 264.00 |
| | | 4100543 | 17.80 | 72.60 |
| | | 4100544 | 50.00 | 54.10 |
| | | 4100546 | 25.00 | 23.30 |
| | | 4100551 | 77.20 | 91.70 |
| | | 4100555 | 45.40 | 50.80 |
| | | 4100556 | 70.50 | 73.20 |
| | | 4100569 | 30.00 | 35.90 |
| | | 4100572 | 40.60 | 1,009.50 |
| | | 4100579 | 43.70 | 0.00 |
| | | 4100686 | 24.30 | 53.00 |
| | | 4100772 | 0.00 | 27.20 |
| | | 6800566 | 39.50 | 0.00 |
| | | 6800759 | 563.40 | 748.60 |
| | | 6800784 | 97.70 | 43.80 |
| 41_ADG037 | Uncompahgre R @ Delta | 4100505 | 36.10 | 36.30 |
| | | 4100517 | 109.80 | 98.90 |
| | | 4100524 | 257.60 | 286.30 |
| | | 4100531 | 184.80 | 159.50 |
| | | 4100565 | 109.50 | 100.60 |
| | | 4100567 | 64.60 | 79.20 |
| | | 6200610 | 2.90 | 0.00 |
| | | 6200714 | 1.40 | 0.00 |
| 40_ADG038 | RoubideauCk@mouth, Delta | 4000534 | 80.10 | 52.60 |
| | | 4001307 | 23.50 | 0.00 |
| | | 4001313 | 14.20 | 0.00 |
| | | 4001324 | 23.50 | 0.00 |
| | | 4001425 | 17.70 | 20.10 |
| | | 4001426 | 148.60 | 142.20 |
| | | 4001428 | 14.20 | 0.00 |
| | | 4001435 | 315.10 | 256.80 |
| | | 4001436 | 42.10 | 50.20 |
| | | 4002495 | 85.70 | 120.00 |
| 40_ADG039 | Gunnison R BL Delta | 4000516 | 182.90 | 214.20 |
| | | 4000854 | 208.10 | 219.70 |

| | | | | |
|---|---|---|---|---|
| | | 4000857 | 19.20 | 0.00 |
| | | 4000858 | 116.20 | 108.50 |
| | | 4000859 | 108.00 | 38.90 |
| | | 4000860 | 0.00 | 67.10 |
| | | 4000862 | 41.50 | 9.90 |
| | | 4000864 | 7.80 | 4.70 |
| | | 4000866 | 74.00 | 80.60 |
| | | 4000867 | 77.50 | 21.20 |
| | | 4000872 | 78.70 | 42.90 |
| | | 4000875 | 122.40 | 61.70 |
| | | 4000876 | 90.70 | 43.50 |
| | | 4000878 | 27.00 | 65.60 |
| | | 4000882 | 0.00 | 117.80 |
| | | 4000884 | 142.60 | 3.30 |
| | | 4000887 | 98.60 | 75.10 |
| | | 4000888 | 42.40 | 15.50 |
| | | 4000890 | 10.60 | 7.00 |
| | | 4000892 | 289.10 | 278.90 |
| | | 4000894 | 192.10 | 239.50 |
| | | 4000897 | 98.30 | 22.60 |
| | | 4000898 | 22.80 | 21.80 |
| | | 4000899 | 53.80 | 44.70 |
| | | 4000901 | 43.70 | 0.00 |
| | | 4000905 | 39.50 | 38.80 |
| | | 4000907 | 63.40 | 60.90 |
| | | 4000910 | 56.30 | 64.90 |
| | | 4000911 | 0.00 | 33.20 |
| | | 4001244 | 19.90 | 40.20 |
| | | 4001997 | 53.50 | 40.70 |
| | | 4002269 | 36.80 | 14.20 |
| 42_ADG040 | Gunnison R nr G Junction | 4200501 | 52.50 | 52.30 |
| | | 4200502 | 17.50 | 0.00 |
| | | 4200503 | 39.30 | 44.40 |
| | | 4200504 | 391.20 | 451.90 |
| | | 4200505 | 2.70 | 0.00 |
| | | 4200507 | 98.90 | 107.80 |
| | | 4200508 | 7.60 | 0.00 |
| | | 4200509 | 381.60 | 228.70 |
| | | 4200515 | 23.00 | 26.30 |
| | | 4200516 | 4.90 | 7.90 |
| | | 4200517 | 24.20 | 20.10 |
| | | 4200521 | 91.00 | 90.90 |
| | | 4200522 | 83.30 | 44.20 |
| | | 4200525 | 38.80 | 0.00 |
| | | 4200526 | 67.30 | 80.90 |
| | | 4200527 | 18.50 | 27.70 |
| | | 4200528 | 93.10 | 94.60 |
| | | 4200530 | 339.80 | 324.70 |
| | | 4200531 | 39.90 | 47.80 |

| | | | | |
|---|---|---|---|---|
| | | 4200532 | 54.70 | 0.00 |
| | | 4200536 | 148.30 | 108.60 |
| | | 4200538 | 23.30 | 27.90 |
| | | 4200540 | 32.10 | 33.00 |
| | | 4200542 | 39.10 | 31.30 |
| | | 4200543 | 101.30 | 0.00 |
| | | 4200546 | 51.60 | 22.80 |
| | | 4200547 | 34.90 | 24.80 |
| | | 4200548 | 48.30 | 0.00 |
| | | 4200549 | 66.40 | 54.70 |
| | | 4200550 | 20.20 | 0.00 |
| | | 4200551 | 4.30 | 0.00 |
| | | 4200552 | 11.60 | 12.70 |
| | | 4200553 | 92.30 | 0.00 |
| | | 4200554 | 26.20 | 31.00 |
| | | 4200556 | 12.50 | 17.90 |
| | | 4200608 | 7.50 | 0.00 |
| | | 4200609 | 49.80 | 71.00 |
| | | 4200622 | 23.60 | 0.00 |
| | | 4200631 | 10.50 | 0.00 |
| | | 4200635 | 91.00 | 0.00 |
| | | 4200639 | 18.80 | 20.40 |
| | | 4200684 | 36.00 | 0.00 |
| | | 4200723 | 4.00 | 0.00 |
| 28_ADG043 | Cochetopa Creek | 2800505 | 27.30 | 32.70 |
| | | 2800522 | 74.80 | 86.10 |
| | | 2800523 | 48.40 | 60.60 |
| | | 2800546 | 101.80 | 103.10 |
| | | 2800547 | 20.70 | 21.40 |
| | | 2800562 | 100.20 | 76.80 |
| | | 2800578 | 2.90 | 3.50 |
| | | 2800792 | 90.10 | 79.10 |
| | | 2800793 | 48.40 | 60.60 |
| | | 2800794 | 43.00 | 27.00 |
| | | 2800814 | 7.90 | 7.70 |
| | | 2800851 | 30.80 | 38.10 |
| | | 2800883 | 48.40 | 60.60 |
| | | 2800887 | 111.40 | 30.10 |
| | | 2800892 | 140.20 | 107.50 |
| | | 2801011 | 90.10 | 79.10 |
| | | 2801027 | 67.30 | 42.60 |
| 28_ADG044 | Razor Creek | 2800507 | 62.90 | 98.70 |
| | | 2800508 | 31.40 | 73.70 |
| | | 2800509 | 12.50 | 11.60 |
| | | 2800511 | 48.20 | 60.00 |
| | | 2800586 | 55.30 | 14.20 |
| | | 2800672 | 76.80 | 89.20 |
| | | 2800687 | 219.00 | 182.90 |
| | | 2800689 | 16.70 | 12.40 |

| | | | | |
|---|---|---|---|---|
| | | 2800719 | 82.40 | 77.60 |
| | | 2800781 | 47.10 | 64.10 |
| | | 2800806 | 138.20 | 92.20 |
| | | 2800807 | 207.20 | 70.90 |
| | | 2800808 | 46.10 | 17.80 |
| | | 2800809 | 76.80 | 25.00 |
| | | 2800810 | 107.50 | 124.90 |
| | | 2800880 | 82.40 | 121.90 |
| | | 2801055 | 24.20 | 32.00 |
| | | 2801146 | 30.30 | 16.80 |
| | | 2801272 | 13.80 | 100.00 |
| | | 2801273 | 207.20 | 177.40 |
| **Total** | | | 63,328 | 59,424 |

# Appendix B

## Aggregation of Non-Irrigation Structures

**1. CDSS Memorandum 4.10**
**Gunnison River Basin Aggregated Municipal and Industrial Use**

**2. CDSS Memorandum 4.11**
**Gunnison River Basin Aggregated Reservoirs and Stock Ponds**

**CDSS Memorandum**
**Final**

TO: File

FROM: Ray Bennett

SUBJECT: **Subtask 4.10 – Gunnison River Basin Aggregated Municipal and Industrial Use**

## Introduction

This memo describes the results of Subtask 4.10 Gunnison 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

**Explicitly Modeled M&I Use** The following table presents the 1975 to 1991 average annual Municipal and Industrial depletions that are explicitly modeled. These were determined by identifying structures with no irrigated acreage, and structures with a non-agricultural return flow pattern, excluding exports from the basin.

**Explicitly Modeled M&I Consumptive Use**

| **ID** | **Name** | **Total** |
|---|---|---|
| Proj_7 | Project 7 | 706 |
| **Total** | | **706** |

**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 1.14-23, Non-Evapotranspiration (Other Uses) Consumptive Uses and Losses in the Gunnison River Basin (05/01/95). Note that this table does not include exports from the basin, which is why exports (*e.g.,* Redlands Power Canal and City of Grand Junction) were excluded from the search for explicitly model M&I users above.

**Phase II Consumptive Use and Loss M&I Consumptive Use**

| Category | Total |
|---|---|
| Municipal | 3,680 |
| Mineral | 0 |
| Livestock | 1,610 |
| Thermal | 0 |
| **Total** | **5,290** |

**Aggregated M&I Diversion** Based on the above data a total aggregated demand of **4,584 acft/yr** (5,290 - 706) was added in Phase IIIa. Based on the county information provided in the Consumptive Uses and Losses memo, three aggregated M&I demands were added to the model; one (62_AMG001) for the Upper Gunnison River Basin just above the Gunnison River below the Tunnel gage (09128000); one (40_AMG002) for the Lower Gunnison at the Gunnison River at Delta gage (09144250) and one (41_AMG003) for the Uncompahgre River Basin located at the Uncompahgre River at Delta gage. Section D.6 has a network diagram which includes the aggregated M&I nodes.

As summarized below, the Upper Gunnison Aggregated M&I Demand (62_AMG001) was assigned a depletive demand (efficiency of 100%) of **1,532 af/yr**. The Lower Gunnison Aggregated M&I Demand (40_AMG002) was assigned depletive demand (efficiency of 100%) of **1,780 af/yr**. The Uncompahgre Aggregated M&I Demand (41_AMG003) was assigned depletive demand (efficiency of 100%) of **1,272 af/yr**. Each aggregated M&I demand was distributed evenly over 12 months, 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 62_AMG001.stm, 40_AMG002.stm and 41_AMG003.stm for the Upper Gunnison, Lower Gunnison and Uncompahgre Aggregated M&I demands respectively.

**Phase IIIa Aggregated M&I Consumptive Use Summary**

| Aggregated Node | Aggregated M&I ID | Depletive Demand af/yr. | Water Right cfs |
|---|---|---|---|
| Upper Gunnison | 62_AMG001 | 1,532 | 2 |
| Lower Gunnison | 40_AMG002 | 1,780 | 2 |
| Uncompahgre | 41_AMG003 | 1,272 | 2 |
| **Total** | | **4,584** | **6** |

# CDSS Memorandum
# Final

TO: File

FROM: Ray Alvarado

SUBJECT: **Subtask 4.11-Gunnison River Basin**
**Aggregate Reservoirs and Stock Ponds**

## Introduction

This memorandum describes the approach and results obtained under Subtask 4.11, 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 are explicitly modeled and those to be added as aggregated reservoirs in Phase IIIa, and stock ponds to be added as aggregated stock ponds in Phase IIIa. Running **watright** for storage structures (see Section D.8) produced the absolute decree amount presented in Table 1 for "Total Aggregated Reservoirs". The storage presented in Table 1 for the "Total Aggregated Stock Ponds" was taken from the year 1 Task Memorandum 1.14-23 "Consumptive Use Model Non-Evaporation (Other Uses) Consumptive Uses and Losses in the Gunnison River Basin" (5/1/95).

**TABLE 1**

| Reservoir | Absolute Decree | Percent of Total |
|---|---|---|
| FRUIT GROWERS RES | 7,360 | <1% |
| FRUITLAND RES(GOULD) | 10,168 | <1% |
| OVERLAND RES. NO. 1 | 6,120 | <1% |
| PAONIA RESERVOIR | 284,424 | 14% |
| CRAWFORD RESERVOIR | 14,395 | <1% |
| TAYLOR PARK RESERVOIR | 155,964 | 8% |
| BLUE MESA RESERVOIR | 940,800 | 46% |
| MORROW POINT RESRVOIR | 119,053 | 6% |
| SILVERJACK RESERVOIR | 140,000 | 7% |
| CRYSTAL RESERVOIR | 30,000 | 2% |
| RIDGWAY | 223,061 | 11% |
| Subtotal | 1,931,345 | 94% |
| Total Aggregated Reservoirs | 105,168 | 5% |
| Total Aggregated Stock Ponds | 8,635 | <1% |
| Subtotal | 113,803 | 6% |
| Total | 2,045,148 | 100% |

**Number of Structures and Locations:** Based on general location, the Phase IIIa reservoirs and stock ponds were incorporated into the model as 14 aggregated structures. Nine operational reservoirs were used to model the net absolute decreed storage. Storage was assigned to the nine nodes by summing the decreed amounts of the absolute storage rights in each Water District, excepting the explicitly modeled structure rights. Using a criterion that no aggregated reservoir should be greater than 25,000 af, the storage for Water District 40 was divided into two nodes. In District 62, the storage was divided into two nodes to allow more realistic location representation. Results of the capacity assignment are shown in **Table 2**. The five non-operational reservoirs were used to model the stock ponds, 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 was assumed to be 25 feet deep, based on available dam safety records, stock ponds were assumed to be 10 foot deep. 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 25 feet for reservoirs and 10 feet for stock ponds. The net evaporation station as described in Phase II Gunnison 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**

**Operational Reservoirs**

| Model ID | Name | Capacity (AF) | Percent |
|---|---|---|---|
| 28_ARG001 | 28_ARG001 | 6,395 | 6 |
| 40_ARG001 | 40_ARG001 | 23,268 | 22 |
| 40_ARG002 | 40_ARG002 | 23,268 | 22 |
| 41_ARG001 | 41_ARG001 | 3,226 | 4 |
| 42_ARG001 | 42_ARG001 | 17,876 | 17 |
| 59_ARG001 | 59_ARG001 | 9,826 | 9 |
| 62_ARG001 | 62_ARG001 | 6,475 | 6 |
| 62_ARG002 | 62_ARG002 | 6,475 | 6 |
| 68_ARG001 | 68_ARG001 | 8,359 | 8 |
| | Total | 105,168 | 100 |

**Stock Ponds**

| Model ID | Name | Capacity (AF) | Percent |
|---|---|---|---|
| 42_ASG001 | 42_ASG001 | 1,727 | 20 |
| 62_ASG001 | 62_ASG001 | 1,727 | 20 |
| 40_ASG001 | 40_ASG001 | 1,727 | 20 |
| 68_ASG001 | 68_ASG001 | 1,727 | 20 |
| 41_ASG001 | 41_ASG001 | 1,727 | 20 |
| | Total | 8,635 | 100 |

**Target Contents, and End-of-Month Data:** The maximum targets for both aggregated reservoirs and aggregated stock ponds were set to structure capacity in the target (*.tar*) file. Capacities were also used in the end-of-month data file (**.eom*) used in the baseflow calculation.

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

# Appendix C

## Pattern Streamgages

## CDSS Daily Gunnison Model – Task 6.1 Recommendation of Pattern Streamgages for Full Basin Model

**CDSS MEMORANDUM**
**FINAL**

**TO:** File – 1111CWB01

**FROM:** Jennifer Ashworth

**DATE:** December 20, 2002

**RE:** CDSS Daily Gunnison Model – Task 6.1 Recommendation of Pattern Streamgages for Full Basin Model

---

## Introduction

The purpose of this memorandum is to outline the approach used to select pattern streamgages within the Gunnison Basin for the daily model. The objective of Task 6.1 was to "select streamgages with good daily records to represent appropriate sub-basins or model areas." These pattern gages were then used to distribute monthly baseflow estimate results to daily baseflows at nearby gages.

## Background

Boyle Engineering completed a pilot study for the CDSS Daily Yampa Model, in which they determined that the best approach to creating a daily model was to use the daily pattern approach (see September 28, 2001 "CDSS Daily Yampa Model – Task 2 Pilot Study" by Meg Frantz and Linda Williams).

The daily pattern approach can be described as distributing monthly baseflows to daily baseflows based on the daily distribution of selected historical gages, or pattern gages. Statemod is used to disaggregate the monthly baseflows by multiplying the daily historical gage flow $QD_{gage}$ by the factor $QM_{bf}/QM_{gage}$, where $QM_{bf}$ is the monthly baseflow and $QM_{gage}$ is the monthly historical gage flow.

For this approach, monthly demands are disaggregated to daily demands by connecting the midpoints of the monthly data. Reservoir targets are disaggregated by connecting the endpoints of end of month contents. Instream flow demands are disaggregated by setting them to the average daily value.

The study period chosen for the Daily Gunnison Model was 1975 through 2000. The start of the period, 1975, is consistent with the start of the Daily Yampa Model. The end of the study period is last year of the most recent updated Monthly Gunnison Model.

**Approach and Results**

The daily streamflow pattern gages were selected for use in the Gunnison Model by using the following approach:

1) ***Review Completeness of Daily Records*** - The streamflow gages within the Gunnison Model were reviewed for completeness of daily records over the 1975 through 2000 study period.
2) ***Select Representative Gages*** - Representative gages were selected based on the location and minimal upstream effects.
3) ***Compare Historic Flows and StateMod Calculated baseflows*** – Average historical monthly flows were compared to the average baseflows calculated using StateMod to quantify the upstream effects and verify the gage selections from Step 2.
4) ***Fill Missing Daily Data*** – Selected pattern gages missing daily data over the 1975 through 2000 study period were filled using the monthly regression models from Phase IIIa.
5) ***Generate the Historic Daily Streamflow File*** – The historic daily streamflow file, *gunndaily.rid*, was created using the command file *filldaily.cmd* in TSTool.

***Approach - Review Completeness of Daily Records***

Within the Monthly Gunnison Model, a total of fifty-two streamgages are used. Each of these gages was reviewed to determine which gages would be selected for the daily pattern gages. Two primary criteria were used in the selection of daily pattern gages:

(1) Completeness of the daily data set over the study period (1975 – 2000),
(2) Location of the gage.

Of the fifty-two gages in the Gunnison Model, only thirteen gages had a complete daily data set over the 1975 – 2000 study period. Additionally, two gages were missing only 2% of the daily data over the study period, and one gage was missing 6%. The remaining thirty-six gages were missing 20% or more of the daily data over the 1975 – 2000 study period, which was considered to be an unreasonably high number of missing data to serve as a pattern gage. The sixteen gages with a complete or near complete data set are listed below:

- 09109000 Taylor River below Taylor Reservoir
- 09110000 Taylor River at Almont
- 09112500 East River at Almont
- 09114500 Gunnison River near Gunnison
- 09119000 Tomichi Creek at Gunnison
- 09124500 Lake Fork at Gateway
- 09126000 Cimarron River near Cimarron
- 09128000 Gunnison River below Gunnison Tunnel
- 09132500 North Fork Gunnison River near Somerset
- 09143000 Surface Creek near Cedaredge (missing 2% of daily data during study period)
- 09143500 Surface Creek at Cedaredge (missing 2% of daily data during study period)
- 09144250 Gunnison River at Delta (missing 6% of daily data during study period)
- 09146200 Uncompahgre River near Ridgeway
- 09147500 Uncompahgre River at Colona

- 09149500 Uncompahgre River at Delta
- 09152500 Gunnison River near Grand Junction

***Approach - Select Representative Gages***

The location of the gage was the second criterion for selecting pattern gages. It was determined that to best match the baseflows of other gages, the historic flows at the selected pattern gages needed to be as close to baseflow conditions as possible. Gages located downstream of key reservoirs, imports, or gages affected by large upstream diversions were not as favorable for pattern gages as gages located above these structures. Gages located downstream of such structures are impacted by the fluctuations of reservoirs, the amount of water imported, or quantities and timing of diversions and associated return flows, therefore the historic flows are not representative of baseflow conditions.

Six streamflow gages from the bulleted list above were identified as being located where historic flows would be similar to baseflow conditions. These gages are as follows:

- 09112500 – East River at Almont
- 09119000 – Tomichi Creek at Gunnison
- 09124500 – Lake Fork at Gateway
- 09143000 – Surface Creek near Cedaredge
- 09143500 – Surface Creek at Cedaredge
- 09146200 – Uncompahgre River near Ridgeway

Five of the six gages listed above were assigned to represent an appropriate sub-basin. Gage 09143000 was not assigned to a sub-basin due to its close proximity to gage 09143500. Since gage 09143500 is missing 2% of the data set over the study period, the missing data will be filled using the monthly regression models used in Phase IIIa. Once the missing data is filled, gage 09143500 can be used as a pattern gage.

The five selected pattern gages were assigned to represent all of the sub-basins in the Gunnison model, with the exception of the North Fork, Smith Fork, and Crystal Creek sub-basins. Gage 09132500 was selected as the pattern gage for these sub-basins. Although 09132500 has a complete data set and was part of the original sixteen gages identified as possible pattern gages, it is located downstream of Paonia Reservoir. After reviewing the effects from Paonia Reservoir, it was determined that the historic flow at gage 09132500 would be representative of baseflow conditions. Table 1 summarizes the pattern gages selected for each sub-basin in the Gunnison Model.

**Table 1**
**Recommended Daily Pattern Gages for Gunnison River Sub-basins**

| Basin Subdivision | Recommended Pattern Gage |
|---|---|
| Uncompahgre River (Districts 41 & 68) | 09146200 - Uncompahgre River near Ridgeway, CO |
| Surface, Currant, Kannah, and Lereaux Creeks, along with the Fruit Growers Area | 09143500 - Surface Creek at Cedaredge, CO |
| Lake Fork, Cimarron, and Cebolla Creeks (District 62) | 09124500 - Lake Fork at Gateway, CO |
| E. Muddy, W. Muddy, North Fork, Smith Fork, Iron, Alum, Virginia, and Crystal Creeks | 09132500 - North Fork Gunnison River near Somerset, CO |
| Tomichi Creek (District 28) | 09119000 - Tomichi Creek at Gunnison, CO |
| East, Slate, Cement, Ohio, and Castle Creeks (District 59) | 09112500 - East River at Almont, CO |

A brief description of why each pattern gage was chosen to represent the corresponding sub-basins follows:

- Gage 09146200 was selected to represent the entire Uncompahgre basin and its tributaries because the gage is located above Ridgeway Reservoir and the imports from the Cimarron Project and the Gunnison Tunnel. The Roubideau Creek sub-basin is also represented by this gage because of its close proximity to the Uncompahgre basin and because Roubideau has the same North facing aspect as the Uncompahgre.
- Gage 09143500 was selected to represent Surface Creek and its tributaries, along with Currant Creek, Kannah Creek, Lereaux Creek, and the Fruit Growers area because these sub-basins all are within close proximity and have the same South facing aspect.
- Gage 09124500 was selected to represent all of District 62, which includes Lake Fork, Cimarron and Cebolla. This was the only gage within this sub-basin that had a complete data set over the study period, and was not located below a key reservoir. These sub-basins all have the same North facing aspect and are within close proximity to each other.
- Gage 09119000 was selected to represent all of District 28, Tomichi Creek, because it was the only gage in this basin that had a complete data set. The gage does not have any key reservoirs, imports or exports located above it.
- Gage 09112500 was selected to represent all of District 59 (East, Slate, Cement, Ohio, Castle, and Taylor), along with the mainstem Gunnison River. This gage was the only streamflow gage within District 59 which had a complete data set over the study period. Additionally, the gage does not have any key reservoirs, imports or exports located above it. To determine which gage would best represent the mainstem of the Gunnison River, average monthly baseflows (determined using StateMod) for mainstem gages 09152500 and 09144250 were compared to the historic average monthly flows for gages 09112500, 09146200, and 09132500. The 09112500 gage most closely matched both 09152500 and 09144250. An example of this comparison is provided below in Figure 1.
- Gage 09132500 was selected to represent E. Muddy, W. Muddy, North Fork Gunnison, Iron Creek, Alum, Virginia, and Crystal Creek because this gage was the only gage within these sub-basins that had a complete data set over the period of record.

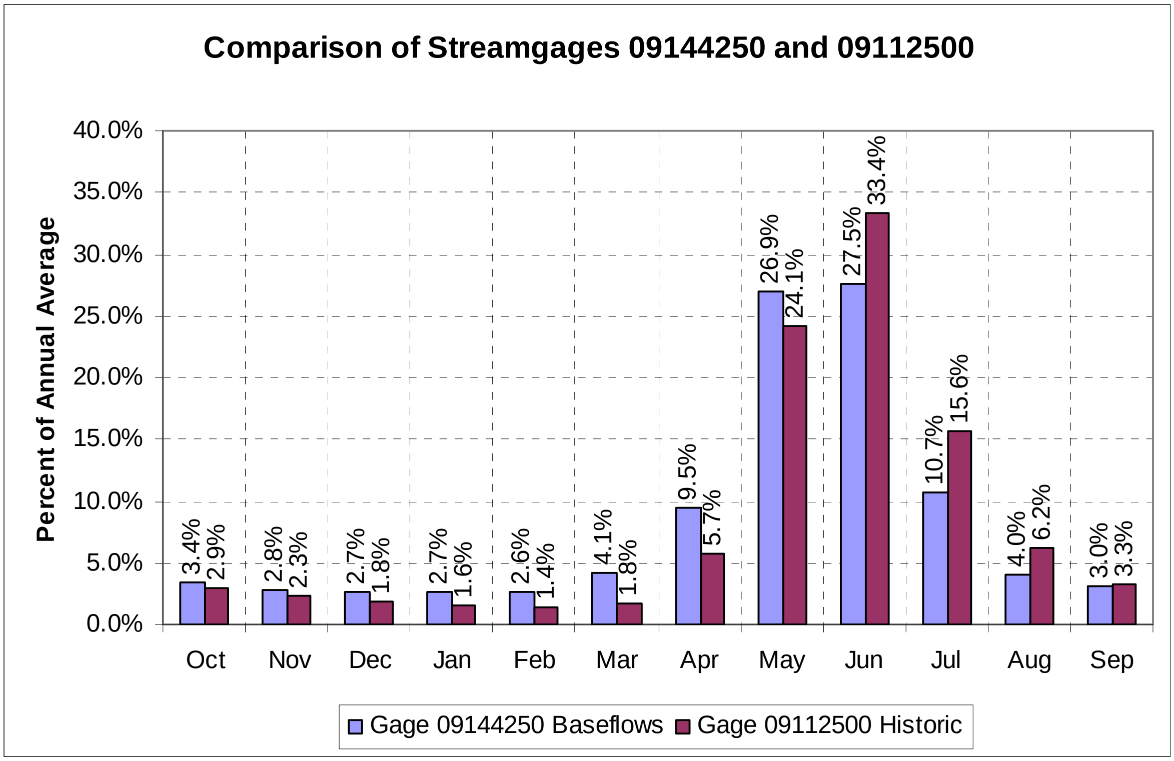



*Figure 1 – Comparison of 09144250 baseflows and 09112500 historic flows. An example of the comparison used to determine which gage would best represent the mainstem of the Gunnison River.*

Figure 2, attached, illustrates all of the gages with in the Gunnison Model and the recommended pattern gages that will be used to represent them in the daily model.

### *Approach - Compare Historic Flows and StateMod Calculated Baseflows*

Each of the selected pattern gages was analyzed to determine how well the historical flow at the gage represented the calculated baseflow at the gage. Table 2 compares the historic flow and StateMod determined baseflow at each of these selected pattern gages. The difference between the baseflow and the historical flow represents the amount of consumptive use above the selected gage.

**Table 2**
**Potential Pattern Gages for Gunnison Daily Model**

| Station No. | Station Name | Period of Record | Average Annual Baseflow (af)(2) | Average Annual Historical Flow (af)(3) | Difference (af) | Difference (%) |
|---|---|---|---|---|---|---|
| 09146200 | Uncompahgre River near Ridgeway, CO | 1975 - 2000 | 126,645 | 124,937 | 1,708 | 1.3 |
| 09143500 | Surface Creek at Cedaredge, CO | 1975-2000(1) | 29,968 | 22,603 | 7,365 | 24.6 |
| 09124500 | Lake Fork at Gateway, CO | 1975-2000 | 173,968 | 172,503 | 1,465 | 0.8 |
| 09132500 | North Fork Gunnison River near Somerset, CO | 1975-2000 | 380,133 | 367,874 | 12,259 | 3.2 |
| 09119000 | Tomichi Creek at Gunnison, CO | 1975-2000 | 184,993 | 132,717 | 52,276 | 28.3 |
| 09112500 | East River at Almont, CO | 1975-2000 | 259,068 | 246,556 | 12,512 | 4.8 |

(1) Gage 09143500 does not have any data for Nov. through Dec. 1999 and Jan. through Mar 2000. This missing data accounts for approximately 2% of study period.
(2) Averaging period is 1975 through 2000. Source is file gunnvx.xbm, dated 12/05/02.
(3) Averaging period is 1975 through 2000. Source file is gunnvh.xsc dated 12/05/02.

### *Approach - Fill Missing Daily Data*

Gage 09143500, Surface Creek at Cedaredge, was missing 2% of the daily data over the 1975 through 2000 study period. The missing daily data was filled in using the monthly regression models used in Phase IIIa. Gage 09112500 was selected as the independent gage for correlating to gage 09143500 because of the high correlation coefficient determined from the file *gunnv.sum*. The non-cyclical correlation coefficient between gage 09112500 and gage 09143500 was 0.89. Although two other gages had a slightly better non-cyclical correlation coefficient with gage 09143500, gage 09112500 had a correlation coefficient for each month in the cyclical correlation, whereas the others did not. The following commands were used in TSTool to fill the missing daily data in gage 09143500:

- FillRegression() – used to fill in the missing monthly data for gage 09143500 with monthly logarithmic regression equations using gage 09112500.
- FillDayTSFrom2MonthTSAnd1DayTS() – used to fill in the missing daily data for gage 09143500 using the relationship: $D_{1i} = D_{2i}*(M_{1i}/M_{2i})$,

  where $D_{1i}$ is the daily data for gage 09143500, $D_{2i}$ is the daily data for gage 09112500, $M_{1i}$ is the monthly data for gage 09143500, and $M_{2i}$ is the monthly data for gage 09112500.

*Approach - Generate the Historic Daily Streamflow File*

The daily historic streamflow file was created using a new command file, *filldaily.cmd*, in TSTool. The resulting output file, *gunndaily.rid*, calculates the daily streamflow for each gage in the basin over the 1975 through 2000 study period based on the representative pattern gages.

**Conclusions**

The Daily Pattern approach was used to develop the daily model for the Gunnison River Basin. Six streamgages within the basin were selected as pattern gages, which will be used to represent the remaining gages in the daily model. These six streamgages were selected based on the completeness of the daily data set over the study period (1975 – 2000), and the location of the streamgage. The streamgages selected and the sub-basin that they will represent are summarized in Table 1 and illustrated in Figure 2.

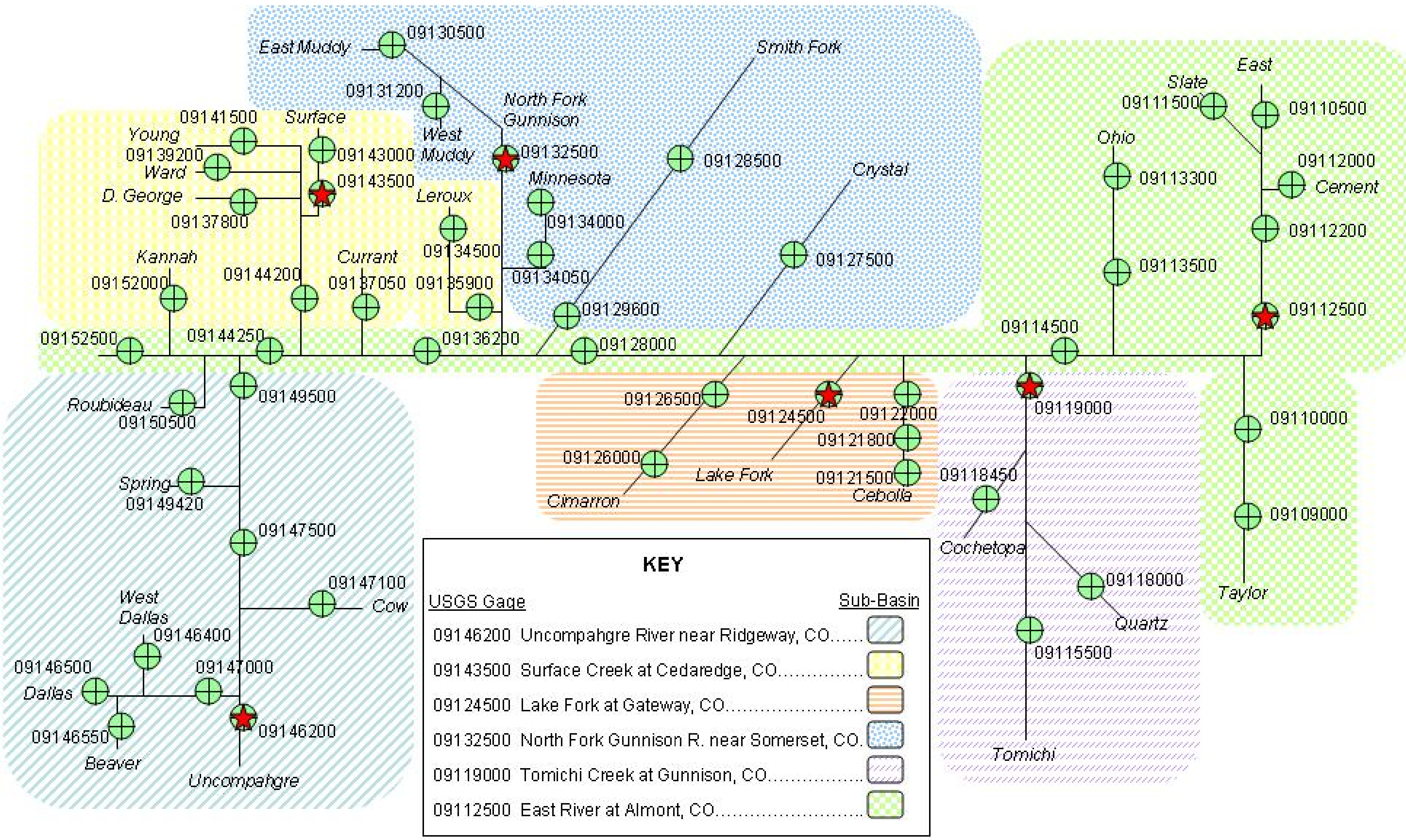
**Comments and Concerns**

When comparing the historical streamgage flows to the baseflows calculated from StateMod (see Table 2), the following two gages showed a high percent difference:

- Gage 09143500 – 24.6% difference
- Gage 09119000 – 28.3% difference

For these two gages, most of the difference between historic flows and calculated baseflows is attributed to upstream depletions. Even with the depletions upstream, the average monthly pattern for these gages is similar between the historic flows and calculated baseflows.

Figure 2. Division 4 - Recommended Application of Daily Pattern Gages

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C:\Projects\1111CWB\pattern_gages.ppt

# Appendix D

## Simulation Results with Calculated Irrigation Demand

# Calculated Data Set

*Note*: This section describes a Calculated Data Set that was completed in July 2004. The monthly Gunnison Model Historical (calibration), Calculated and Baseline data files were updated in October 2009, and the 2009 calibration and Baseline data sets are described in this user manual. Inconsistencies between the 2004 and 2009 Calculaed Data Set are minor, and include:

1) extended analysis period through 2005,
2) differences in IWR for fields below 6,500 ft in elevation, because an elevation adjustment was applied to crop coefficients in the Blaney-Criddle analysis in the 2009 model,
3) updated operations for reservoirs in the North Fork Gunnison basin, and
4) inclusion of the final Black Canyon of the Gunnison National Park Service instream flow agreement.

The approach described for the Calculaed Data Set is accurate, except for the items listed above. Table values in this appendix are expected to be similar to, but not exactly, what is produced by the updated Calculated Data Set.

The “Calculated Data Set” is a data set that was created to further look at simulation of the Gunnison River basin model. The unique characteristic of this data set is the demand file. Demand for irrigation users in this scenario is estimated outside the model, based on crop consumptive use and historical efficiency. Unlike the Baseline data set, the scenario is historical in the sense that is uses historical operating rules, and reservoirs come on-line when they did historically, but the irrigation demand is not strictly historical. In the Historical calibration run, demand was set to historical diversions, so that it reflects an irrigator’s operational decisions or circumstances that are unrelated to use by crops. For example, if a headgate was damaged in spring flooding and didn’t become usable until several weeks into the normal irrigation season, it would be reflected in historical diversions, therefore in the Historical calibration data set. Demand in the Calculated data set reflects the theoretical crop needs - that is the amount that needs to be diverted if the crop is to acquire a full supply.

## Calculated Demand

Calculated demands must account for both crop needs and irrigation practices. Monthly calculated demand for 1975 through 2002 is generated directly, by taking the maximum of crop irrigation water requirement divided by average monthly irrigation efficiency, and historic diversions. The irrigation efficiency may not exceed the defined maximum efficiency (50 percent), however, which represents an estimated practical upper limit on efficiency for flood irrigation systems in the Gunnison basin. Thus

Calculated demand for a consistently shorted structure, and demand for months when a structure historically operated more efficiently than the average, will be greater than the historical diversion. 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.

Prior to 1975, Calculated demands were filled using the automated time series filling technique described in Section 4.4.2. This is done because historical diversion records are generally not available until 1975 in the Gunnison basin.

Basinwide Calculated demand over the calibration period (1975-2002) amounts to 2,725,600 acre-feet per year on average. This compares with historical diversion which averaged 2,264,400 acre-feet per year over the same period. The Calculated demand represents an increase of more than 17 percent over historical diversions. Note that historical diversions for carriers and feeder canals, set to zero in the Calculated data set because demand is placed at the destination, are not included in the historical diversion average presented here.

Demands are calculated using the same methodology as the Baseline demands except Calculated demands are limited to historical water rights, whereas Baseline demands reflect the current water right regime.

## Calculated Data Set Calibration Efforts

In preliminary simulations of the Calculated data set, the Gunnison Tunnel exported less water to the Uncompahgre basin than it did historically, and Uncompahgre users were significantly shorted. The UVWUA attempts to operate its system to avoid, to the extent possible, placing an administrative call against junior rights in the Uncompahgre and Gunnison River basins. When project demand is not satisfied by direct flow water, UVWUA can elect to take water from storage (Ridgway Reservoir in any case, and Blue Mesa if the Tunnel is flowing less than full) or to place a call against junior water rights.

This is a subjective decision considering the amount of water in storage, climatic conditions, and how much of the irrigation season remains. If UVWUA places a call against Uncompahgre junior rights, the UVWUA and Division Engineer have an informal agreement whereby UVWUA will only call up to approximately 245 cfs. This amount will be delivered to the headgate of the M&D Canal, the largest and most upstream project structure. All other project demands are supplied from UVWUA's other sources, including the Gunnison Tunnel direct flow rights, and from upgradient irrigation return flows.

Simulating the good neighbor policy with the Historical Data set was not an issue, because the Gunnison Tunnel demand is set to the tunnel's historical diversions. Decisions about how soon to bring Gunnison Tunnel water to the Uncompahgre, or how much to bring over, are reflected in the diversion record. In the Calculated Data set, however, Gunnison Tunnel diversions are driven by the unmet UVWUA demand after direct flow rights have been used to their full extent. To simulate UVWUA's practice of limiting their calls under their Uncompahgre direct flow rights, some of the UVWUA direct flow rights were turned off.

Direct flow rights for UVWUA structures were turned off in successive runs, beginning with the most junior administration number (other than free water rights) and working toward the most senior. The amount of water diverted through the Gunnison Tunnel was compared to historical tunnel diversions until the comparison was reasonable. The best match between simulated and historical Gunnison Tunnel diversions was achieved when rights at or junior to and administration number of 14198.00000, which corresponds to a priority date of November 5, 1888, were turned off.

## Calculated Data Set Simulation Results

Simulation of the Calculated Gunnison River model is considered good, with most streamflow gages deviating less than one percent from historical values on an average annual basis. The basinwide shortage, determined to be simulated diversions divided by Calculated demand, is about 6.5 percent per year, on average. Basinwide, 12 percent more water is being diverted during Calculated simulation, determined by dividing simulated diversions by historic diversions. Simulated reservoir contents are representative of historical values.

### Water Balance Results

Table D.1 summarizes the water balance for the Gunnison River model, for the calibration period (1975-2002). Following are observations based on the summary table:

- Surface water inflow to the basin averages 2.40 million acre-feet per year, and stream outflow averages 1.86 million acre-feet per year.

- Annual diversions amount to approximately 2.53 million acre-feet on average. Note that even though basinwide diversions are approximately 12 percent greater than historical diversions, the 2,530,000 acre-feet value is less than reported water balance diversion simulated under the historical simulation. This is because historical demands for carriers were included in the historical calibration model - the Gunnison Tunnel alone accounted for around 333,000 acre-feet of diversions reported in the historical water balance.

- Approximately 495,000 acre-feet per year is consumed in the Calculated simulation. Note that this value is representative of the basin-wide consumptive use and losses and includes crop consumptive use, municipal and industrial consumptive use, reservoir evaporation, and 100 percent of exports from the basin.

- 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 D.1**
**Average Annual Water Balance for Calculated Simulation (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 | 90,413 | 164,014 | 236 | 254,663 | 163,294 | 1,875 | 131,130 | -41,872 | 2,555 | -2,319 | 254,663 | 0 | 12,890 |
| NOV | 67,182 | 84,583 | 8 | 151,773 | 56,382 | 711 | 133,243 | -38,570 | 583 | -575 | 151,773 | 0 | 1,855 |
| DEC | 61,706 | 68,815 | 0 | 130,521 | 51,419 | 291 | 116,429 | -37,618 | 351 | -351 | 130,520 | 0 | 1,142 |
| JAN | 59,552 | 61,031 | 0 | 120,583 | 48,885 | 364 | 83,900 | -12,567 | 250 | -250 | 120,583 | 0 | 1,191 |
| FEB | 56,427 | 53,501 | 0 | 109,928 | 45,816 | 699 | 79,869 | -16,456 | 188 | -188 | 109,928 | 0 | 1,429 |
| MAR | 87,816 | 56,342 | 92 | 144,249 | 55,060 | 1,451 | 95,486 | -7,839 | 281 | -190 | 144,249 | 0 | 3,710 |
| APR | 214,684 | 123,959 | 293 | 338,936 | 162,229 | 3,248 | 125,597 | 47,570 | 832 | -539 | 338,936 | 0 | 19,706 |
| MAY | 612,543 | 267,840 | 1,878 | 882,262 | 389,506 | 5,386 | 368,283 | 117,209 | 2,876 | -998 | 882,262 | 0 | 69,014 |
| JUN | 625,364 | 356,241 | 2,355 | 983,960 | 517,647 | 7,158 | 323,826 | 132,974 | 2,213 | 141 | 983,960 | 0 | 113,870 |
| JUL | 291,394 | 328,969 | 4,178 | 624,541 | 462,479 | 6,109 | 172,128 | -20,353 | 716 | 3,462 | 624,541 | 0 | 120,860 |
| AUG | 133,796 | 251,139 | 5,248 | 390,183 | 330,351 | 5,067 | 119,540 | -70,022 | 626 | 4,622 | 390,183 | 0 | 93,464 |
| SEP | 99,433 | 209,202 | 4,557 | 313,192 | 249,568 | 4,041 | 110,828 | -55,801 | 719 | 3,838 | 313,192 | 0 | 56,267 |
| | | | | | | | | | | | | | |
| AVG | 2,400,308 | 2,025,639 | 18,845 | 4,444,792 | 2,532,634 | 36,399 | 1,860,259 | -3,345 | 12,192 | 6,653 | 4,444,792 | -1 | 495,396 |

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

## Streamflow Results

Table D.2 summarizes the average annual streamflow for water years 1975 through 2002, as estimated in the Calculated 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 D.1 through D.11 (at the end of this appendix) 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 by the $R^2$ value shown on each scatter graph.

Calculated calibration based on streamflow simulation is generally very good in terms of both annual volume and monthly pattern, and similar to the historical calibration results. Exceptions include the Uncompahgre River at Delta gage, where simulated streamflows are 4 percent more than historical streamflows, and the Gunnison River at Delta gage, where simulated streamflows are 5 percent less than historical streamflows. The average efficiencies for all the large irrigation diversions in the Uncompahgre Valley are less than 23 percent, therefore, in many months when the basin operated more efficiently, calculated demand is higher than historical diversions – in fact 14 percent higher on average for the Water District 41. More than 98 percent of that increased demand is met, much of it from direct diversions. The remaining demands are met from the Gunnison Tunnel, which is delivering 15 percent more than historical to the Uncompahgre. The increase in flows on the Uncompahgre is, in part, the results of return flows from this increased import.

**Table D.2**
**Historical and Simulated Average Annual Streamflow Volumes (1975-2002)**
**Calculated Simulation (acre-feet/year)**

| Gage ID | Historical | Simulated | Historical minus Simulated | | Gage Name |
|---|---|---|---|---|---|
| | | | Volume | Percent | |
| 9109000 | 147,968 | 148,493 | -525 | 0 | Taylor River Below Taylor Park Reservoir |
| 9110000 | 236,375 | 236,633 | -259 | 0 | Taylor River at Almont |
| 9110500 | *No gage during simulation period* | | | 0 | East River Near Crested Butte |
| 9111500 | 98,931 | 97,500 | 1,431 | 1 | Slate River Near Crested Butte |
| 9112000 | *No gage during simulation period* | | | 0 | Cement Creek Near Crested Butte |
| 9112200 | 231,532 | 229,057 | 2,474 | 1 | East River Below Cement Creek NR Crested Butte |
| 9112500 | 238,733 | 235,275 | 3,457 | 1 | East River at Almont |
| 9113300 | *No gage during simulation period* | | | 0 | Ohio Creek at Baldwin |
| 9113500 | 56,954 | 46,618 | 10,335 | 18 | Ohio Creek Near Baldwin |
| 9114500 | 529,302 | 516,106 | 13,196 | 2 | Gunnison River Near Gunnison |
| 9115500 | 45,797 | 45,298 | 499 | 1 | Tomichi Creek at Sargents |
| 9118000 | *No gage during simulation period* | | | 0 | Quartz Creek Near Ohio City |
| 9118450 | 33,105 | 30,073 | 3,032 | 9 | Cochetopa Creek Below Rock Creek Near Parlin |
| 9119000 | 127,952 | 116,045 | 11,908 | 9 | Tomichi Creek at Gunnison |
| 9121500 | *No gage during simulation period* | | | 0 | Cebolla Creek Near Lake City |

| Gage ID | Historical | Simulated | Historical minus Simulated | | Gage Name |
|---|---|---|---|---|---|
| | | | Volume | Percent | |
| 9121800 | *No gage during simulation period* | | | 0 | Cebolla Creek Near Powderhorn |
| 9122000 | *No gage during simulation period* | | | 0 | Cebolla Creek at Powderhorn |
| 9124500 | 167,999 | 167,460 | 539 | 0 | Lake Fork at Gateview |
| 9126000 | 70,457 | 71,543 | -1,086 | -2 | Cimarron River Near Cimarron |
| 9126500 | *No gage during simulation period* | | | 0 | Cimarron River at Cimarron |
| 9127500 | *No gage during simulation period* | | | 0 | Crystal Creek Near Maher |
| 9128000 | 888,915 | 810,093 | 78,822 | 9 | Gunnison River Below Gunnison Tunnel |
| 9128500 | 33,416 | 34,225 | -809 | -2 | Smith Fork Near Crawford |
| 9129600 | 28,116 | 28,659 | -543 | -2 | Smith Fork Near Lazear |
| 9130500 | *No gage during simulation period* | | | 0 | East Muddy Creek Near Bardine |
| 9131200 | *No gage during simulation period* | | | 0 | West Muddy Creek Near Somerset |
| 9132500 | 352,863 | 342,203 | 10,660 | 3 | North Fork Gunnison River Near Somerset |
| 9134000 | 15,138 | 15,266 | -128 | -1 | Minnesota Creek Near Paonia |
| 9134050 | 10,181 | 9,683 | 499 | 5 | Minnesota Creek at Paonia |
| 9134500 | *No gage during simulation period* | | | 0 | Leroux Creek Near Cedaredge |
| 9135900 | 20,892 | 22,374 | -1,482 | -7 | Leroux Creek at Hotchkiss |
| 9136200 | 1,446,348 | 1,363,258 | 83,090 | 6 | Gunnison River Near Lazear |
| 9137050 | 10,560 | 11,981 | -1,421 | -13 | Currant Creek Near Read |
| 9137800 | *No gage during simulation period* | | | 0 | Dirty George Creek Near Grand Mesa |
| 9139200 | *No gage during simulation period* | | | 0 | Ward Creek Near Grand Mesa |
| 9141500 | *No gage during simulation period* | | | 0 | Youngs Creek Near Cedaredge |
| 9143000 | 32,964 | 32,964 | -1 | 0 | Surface Creek Near Cedaredge |
| 9143500 | 22,602 | 24,460 | -1,858 | -8 | Surface Creek at Cedaredge |
| 9144200 | 52,622 | 54,607 | -1,985 | -4 | Tongue Creek at Cory |
| 9144250 | 1,501,545 | 1,420,875 | 80,670 | 5 | Gunnison River at Delta |
| 9146200 | 121,827 | 121,678 | 149 | 0 | Uncompahgre River Near Ridgway |
| 9146400 | *No gage during simulation period* | | | 0 | West Fork Dallas Creek nr Ridgway |
| 9146500 | *No gage during simulation period* | | | 0 | East Fork Dallas Creek nr Ridgway |
| 9146550 | *No gage during simulation period* | | | 0 | Beaver Creek nr Ridgway |
| 9147000 | 29,636 | 29,727 | -91 | 0 | Dallas Creek nr Ridgway |
| 9147100 | *No gage during simulation period* | | | 0 | Cow Creek Near Ridgway |
| 9147500 | 192,969 | 192,336 | 633 | 0 | Uncompahgre River at Colona |
| 9149420 | 39,882 | 39,882 | 0 | 0 | Spring Creek Near Montrose |
| 9149500 | 236,296 | 246,854 | -10,558 | -4 | Uncompahgre River at Delta |
| 9150500 | 88,628 | 87,947 | 682 | 1 | Roubideau Creek at Mouth, Near Delta |
| 9152000 | 17,377 | 17,491 | -113 | -1 | Kannah Creek Near Whitewater |
| 9152500 | 1,910,511 | 1,868,806 | 41,706 | 2 | Gunnison River Near Grand Junction |

## Diversion Results

Table D.3 summarizes the average annual simulated diversions, by tributary or sub-basin, compared to historical diversions for water years 1975 through 2002. Table D.5 (at the end of this appendix) shows the average annual shortages for water years 1975 through 2002 by structure. On a basin-wide basis, average annual diversions are greater than historical diversions by about 13 percent in the Calculated calibration run. Note that both Table D.3 and D.5 include diversions through the Gunnison Tunnel and other carriers, compared to the water carried historically. These structures do not have specific demand in the Calculated data set, the demand is modeled at the final destination. Therefore, both tables show greater simulated diversions than the Calculated demands discussed above, and the diversion shown in Table D.1.

**Table D.3**
**Historical and Simulated Average Annual Diversions by Sub-basin (1975-2002)**
**Calculated Simulation (acre-feet/year)**

| | | | Historical minus Simulated | |
|---|---|---|---|---|
| Tributary or Sub-basin | Historical | Simulated | Volume | Percent |
| Taylor River | 9,264 | 10,205 | -941 | -10 |
| East River | 103,025 | 118,117 | -15,092 | -15 |
| Ohio Creek | 47,065 | 69,287 | -22,222 | -47 |
| Tomichi Creek | 198,034 | 235,774 | -37,740 | -19 |
| Cebolla Creek, Lake Fork, and Cimarron River | 70,891 | 81,925 | -11,034 | -16 |
| Crystal River | 19,688 | 22,406 | -2,718 | -14 |
| Smith Fork | 69,108 | 89,389 | -20,281 | -29 |
| N.F. Gunnison River | 168,663 | 206,732 | -38,069 | -23 |
| Currant Creek | 20,626 | 19,464 | 1,162 | 6 |
| Surface Creek | 77,987 | 76,166 | 1,821 | 2 |
| Uncompahgre River | 761,681 | 860,958 | -99,277 | -13 |
| Roubideau Creek | 2,942 | 4,490 | -1,548 | -53 |
| Kannah Creek | 16,700 | 18,481 | -1,781 | -11 |
| Gunnison River Mainstem | 1,074,732 | 1,178,840 | -104,108 | -10 |
| Basin Total | 2,640,406 | 2,992,234 | -351,828 | -13 |

As noted previously, the Calculated demand (not shown in Table D.3) represents an increase of more than 17 percent over historical diversions, compared to the Calculated simulated diversions shown in Table D.3 which represent a 13 percent increase over historical diversion. In general, calculated demands are being met. Shortage based on Calculated demand, intended to better estimate crop needs, is 4 percent basin-wide.

## Reservoir Results

Figures D.12 through D.20 (located at the end of this appendix) present reservoir EOM contents estimated by the model using the Calculated data set compared to historical observations at selected reservoirs. Most reservoirs exhibit slightly more use than in the Historical calibration simulation, as a result of higher Calculated demands.

### Consumptive Use 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 also includes consumptive use for municipal and industrial diversions. 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, the StateMod structure summary file (*.xss) results were "filtered" to only include the structures in the StateCU analysis.

Table D.4 shows the comparison of StateCU estimated potential crop consumptive use, StateCU estimated water-supply limited crop consumptive, and StateMod simulated crop consumptive use for the Calculated calibration. Table D.4 presents these values for explicit structures, aggregated structures, and total for the basin. Percent shortage values represent the difference between the amount of water the crops need to meet full demands (potential consumptive use) and what they received based on either historical diversions (StateCU results), or simulated diversions (Calculated StateMod results).

In the Calculated simulation, more of the potential consumptive use (crop demand) is met than in the StateCU analyses. Historical diversions are used by StateCU to estimate water supply-limited (actual) consumptive use. In the Calculated simulation, where demands are essentially set to meet potential CU, more water is being diverted compared to historical diversion. The approximately 7 percent increase in CU between StateCU results and Calculated simulation results could indicate any or a combination of the following:

- Historical irrigation practices do not take full advantage of water supply
- Historical irrigation practices do not utilize the entire potential growing season
- Blaney-Criddle methodology does not accurately reflect true crop demands

**Table D.4**
**Average Annual Crop Consumptive Use Comparison (1975-2002)**
**Calculated Simulation**

| Comparison | StateCU Potential CU (af/yr) | StateCU CU Results (af/yr) | StateCU Shortage (%) | Calculated Run CU Results (af/yr) | Calculated Run Shortage (%) |
|---|---|---|---|---|---|
| Explicit Structures | 374,514 | 318,883 | 15% | 337,674 | 10% |
| Aggregate Structures | 114,746 | 92,167 | 20% | 107,211 | 7% |
| Basin Total | 489,260 | 411,050 | 16% | 444,885 | 9% |

Not that the simulated crop consumptive use presented here represents only a portion of the approximately 495,000 acre-feet per year consumed in the basin, and reported above in Table D.1. The consumptive use reported in Table D.1 is representative of the total basin-wide consumptive use and losses, and includes municipal and industrial consumptive use, reservoir evaporation, and exports from the basin in addition to crop consumptive use.

**Table D.5**
**Historical and Simulated Average Annual Diversions (1975-2002)**
**Calculated Simulation (acre-feet/year)**

| WDID | Historical | Simulated | Historical minus Simulated | | Structure Name |
|---|---|---|---|---|---|
| | | | Volume | Percent | |
| 280500 | 1,553 | 1,824 | -271 | -17 | ADAMS NO 1 DITCH |
| 280503 | 500 | 310 | 190 | 38 | AGATE NO 2 DITCH |
| 280510 | 14,099 | 15,913 | -1,814 | -13 | ARCH IRRIGATING DITCH |
| 280515 | 4,260 | 5,479 | -1,219 | -29 | BIEBEL DITCHES NOS 1&2 |
| 280520 | 1,891 | 2,161 | -270 | -14 | CAIN BORSUM DITCH |
| 280526 | 2,716 | 3,036 | -320 | -12 | CHITTENDEN DITCH |
| 280527 | 346 | 370 | -24 | -7 | CLARK NO 1 DITCH |
| 280528 | 604 | 647 | -43 | -7 | CLARK NO 2 DITCH |
| 280529 | 777 | 872 | -95 | -12 | CLARK NO 3 DITCH |
| 280530 | 811 | 941 | -130 | -16 | CLOVIS METROZ NO 1 DITCH |
| 280532 | 1,830 | 2,142 | -312 | -17 | COATS BROS DITCH |
| 280535 | 609 | 483 | 126 | 21 | COLE NOS 1 2 & 3 DITCHES |
| 280536 | 1,667 | 1,847 | -180 | -11 | COX AND MCCONNELL DITCH |
| 280542 | 1,651 | 1,983 | -332 | -20 | CUTJO DITCH |
| 280543 | 586 | 699 | -113 | -19 | D A MCCONNELL DITCH |
| 280550 | 2,651 | 2,319 | 332 | 13 | DUNN AND WATTERS DITCH |
| 280554 | 1,473 | 1,827 | -354 | -24 | ELSEN VADER DITCH |
| 280557 | 894 | 1,122 | -228 | -26 | FIELD AND VADER DITCH |
| 280564 | 1,280 | 1,378 | -98 | -8 | TOMI_GILBERTSON NO 1 |
| 280566 | 1,990 | 2,507 | -517 | -26 | GOODRICH DITCH |
| 280567 | 2,542 | 2,612 | -70 | -3 | GOODWIN AND WRIGHT DITCH |
| 280568 | 4,491 | 5,928 | -1,437 | -32 | LOS _GOVERNMENT DITC |
| 280571 | 3,930 | 4,809 | -879 | -22 | TOMI_GRIFFING NO 1 D |
| 280576 | 3,025 | 3,969 | -944 | -31 | GULLETT TOMICHI IRG D |
| 280577 | 1,357 | 1,518 | -161 | -12 | HANNAH J WINTERS NO 2D |
| 280580 | 1,179 | 1,293 | -114 | -10 | HAWES-BERGEN-GILBERTSON |
| 280581 | 1,542 | 1,775 | -233 | -15 | HAZARD DITCH |
| 280583 | 876 | 1,061 | -185 | -21 | HEAD AND CORTAY NO 4 D |
| 280587 | 1,166 | 1,353 | -187 | -16 | HOME DITCH DITCH NO 81 |
| 280588 | 915 | 1,149 | -234 | -26 | HOME DITCH DITCH NO 182 |
| 280590 | 361 | 440 | -79 | -22 | HOT SPRINGS NOS 1&2 D |
| 280604 | 522 | 480 | 42 | 8 | KANE DITCH |
| 280607 | 456 | 440 | 16 | 4 | KENDALL NO 3 DITCH |
| 280608 | 514 | 463 | 51 | 10 | KENDALL NO 4 DITCH |
| 280622 | 283 | 382 | -99 | -35 | LOBDELL NO 2 DITCH |
| 280624 | 2,846 | 3,718 | -872 | -31 | LOCKWOOD MUNDELL DITCH |
| 280631 | 1,912 | 2,680 | -768 | -40 | MCCANNE NO 1 DITCH |
| 280632 | 3,464 | 4,117 | -653 | -19 | MCCANNE 2 DITCH |
| 280633 | 1,278 | 1,429 | -151 | -12 | MCCANNE 3 DITCH |
| 280636 | 2,363 | 2,534 | -171 | -7 | MCDONOUGH DITCH |
| 280638 | 1,898 | 1,857 | 41 | 2 | TOMI_MCGOWAN IRRIGAT |
| 280642 | 605 | 564 | 41 | 7 | MEANS BROS NO 13 DITCH |

| WDID | Historical | Simulated | Historical minus Simulated Volume | Percent | Structure Name |
|---|---|---|---|---|---|
| 280645 | 333 | 331 | 2 | 1 | MEANS BROS NO 4 DITCH |
| 280646 | 387 | 421 | -34 | -9 | MEANS BROS NO 5 DITCH |
| 280647 | 448 | 349 | 99 | 22 | MEANS BROS NO 6 DITCH |
| 280648 | 334 | 290 | 44 | 13 | MEANS BROS NO 7 DITCH |
| 280649 | 604 | 605 | -1 | 0 | MEANS BROS NO 12 DITCH |
| 280650 | 1,147 | 1,406 | -259 | -23 | MEANS BROS NO 8 DITCH |
| 280651 | 6,921 | 7,447 | -526 | -8 | MESA DITCH |
| 280652 | 977 | 1,184 | -207 | -21 | MILLER DITCH |
| 280654 | 1,668 | 2,280 | -612 | -37 | MONSON & MCCONNELL D |
| 280660 | 834 | 955 | -121 | -15 | NORMAN DITCH |
| 280662 | 1,103 | 1,314 | -211 | -19 | OFALLON NO 3 DITCH |
| 280663 | 823 | 908 | -85 | -10 | OFALLON NO 4 DITCH |
| 280665 | 603 | 688 | -85 | -14 | O'REGAN NO 1 DITCH |
| 280667 | 1,185 | 1,429 | -244 | -21 | OWEN NO 1 DITCH |
| 280668 | 3,449 | 4,384 | -935 | -27 | OWEN REDDEN DITCH |
| 280670 | 1,086 | 1,566 | -480 | -44 | PARLIN NO 2 DITCH |
| 280671 | 3,992 | 4,359 | -367 | -9 | PARLIN QUARTZ CREEK D |
| 280673 | 3,072 | 3,409 | -337 | -11 | PERRY IRRIGATING DITCH |
| 280674 | 3,967 | 5,366 | -1,399 | -35 | PIONEER DITCH |
| 280679 | 1,624 | 1,781 | -157 | -10 | ROGERS METROZ DITCH |
| 280680 | 2,628 | 1,838 | 790 | 30 | S DAVIDSON&CO FDR D NO 1 |
| 280681 | 314 | 243 | 71 | 23 | SARGENTS NO 1 D |
| 280682 | 337 | 313 | 24 | 7 | SARGENTS NO 2 D |
| 280686 | 3,538 | 4,193 | -655 | -19 | SMITH FORD NO 2 DITCH |
| 280690 | 2,150 | 2,713 | -563 | -26 | SORRENSON IRRIGATING D |
| 280692 | 1,642 | 1,919 | -277 | -17 | SOUTH SIDE DITCH |
| 280693 | 2,162 | 2,682 | -520 | -24 | STEPHENSON DITCH |
| 280697 | 63 | 76 | -13 | -21 | SUTTON NO 3 AMENDED D |
| 280703 | 917 | 1,141 | -224 | -24 | TARBELL & ALEXANDER D |
| 280707 | 3,377 | 3,457 | -80 | -2 | TORNAY HIGHLINE DITCH |
| 280709 | 958 | 1,227 | -269 | -28 | VADER RAUSIS DITCH |
| 280711 | 1,055 | 1,199 | -144 | -14 | WATERMAN METROZ DITCH |
| 280714 | 228 | 322 | -94 | -41 | WICKS ROWSER DITCH |
| 280715 | 1,611 | 2,076 | -465 | -29 | WOOD AND GEE DITCH |
| 280716 | 965 | 1,125 | -160 | -17 | WOODBRIDGE DITCH |
| 280823 | 266 | 271 | -5 | -2 | MCDONALD BERDEL EX D |
| 400500 | 15,732 | 20,195 | -4,463 | -28 | CRAWFORD CLIPPER DITCH |
| 400501 | 6,428 | 7,372 | -944 | -15 | NEEDLE ROCK DITCH |
| 400502 | 3,393 | 2,614 | 779 | 23 | SADDLE MT HIGHLINE D |
| 400503 | 6,891 | 16,816 | -9,925 | -144 | GRANDVIEW CANAL |
| 400504 | 7,514 | 8,755 | -1,241 | -17 | CEDAR CANON IRON SPR D |
| 400506 | 1,539 | 2,121 | -582 | -38 | ALUM GULCH DITCH |
| 400508 | 6,356 | 3,358 | 2,998 | 47 | ASPEN DITCH |
| 400509 | 1,097 | 2,100 | -1,003 | -91 | ASPEN CANAL |
| 400533 | 1,084 | 1,413 | -329 | -30 | CRYSTAL VALLEY DITCH |
| 400536 | 2,132 | 2,106 | 26 | 1 | DAISY DITCH |

| WDID | Historical | Simulated | Historical minus Simulated | | Structure Name |
|---|---|---|---|---|---|
| | | | Volume | Percent | |
| 400543 | 950 | 876 | 74 | 8 | DYER FORK DITCH |
| 400549 | 10,140 | 11,362 | -1,222 | -12 | FRUITLAND CANAL |
| 400566 | 1,450 | 1,730 | -280 | -19 | LARSON BROTHERS DITCH |
| 400568 | 771 | 834 | -63 | -8 | LONE ROCK DITCH |
| 400585 | 6,627 | 9,957 | -3,330 | -50 | OVERLAND DITCH |
| 400586 | 1,269 | 1,859 | -590 | -46 | PILOT ROCK DITCH |
| 400605 | 3,827 | 6,349 | -2,522 | -66 | SMITH FORK FEEDER CANAL |
| 400616 | 1,153 | 983 | 170 | 15 | VIRGINIA DITCH |
| 400632 | 3,377 | 2,845 | 532 | 16 | CHILDS DITCH |
| 400661 | 10,438 | 10,684 | -246 | -2 | SURFACE CR D AKA BIG D |
| 400675 | 4,027 | 2,777 | 1,250 | 31 | CEDAR MESA DITCH |
| 400683 | 1,147 | 1,133 | 14 | 1 | HORSESHOE DITCH |
| 400686 | 3,036 | 2,316 | 720 | 24 | LONE PINE DITCH |
| 400701 | 4,927 | 3,854 | 1,073 | 22 | CEDAR PARK DITCH |
| 400703 | 824 | 538 | 286 | 35 | DIRT_EAGLE DITCH |
| 400713 | 1,346 | 1,004 | 342 | 25 | GRANBY DITCH FR WARD CR |
| 400751 | 8,361 | 8,157 | 204 | 2 | ALFALFA DITCH |
| 400753 | 1,596 | 1,544 | 52 | 3 | SURF_BONITA DITCH |
| 400754 | 2,282 | 2,374 | -92 | -4 | BUTTES DITCH |
| 400758 | 2,972 | 2,346 | 626 | 21 | FORREST DITCH |
| 400774 | 2,415 | 2,408 | 7 | 0 | ORCHARD RANCH DITCH |
| 400778 | 983 | 1,565 | -582 | -59 | SETTLE DITCH |
| 400797 | 2,214 | 1,027 | 1,187 | 54 | DURKEE DITCH |
| 400808 | 780 | 758 | 22 | 3 | MORTON DITCH |
| 400820 | 8,826 | 9,851 | -1,025 | -12 | ALFA_STELL DITCH |
| 400821 | 1,583 | 1,899 | -316 | | TRANSFER DITCH |
| 400863 | 22,074 | 26,044 | -3,970 | -18 | BONAFIDE DITCH |
| 400879 | 16,642 | 18,904 | -2,262 | -14 | HARTLAND DITCH |
| 400891 | 19,511 | 21,976 | -2,465 | -13 | GUNN_NORTH DELTA CAN |
| 400900 | 18,623 | 21,916 | -3,293 | -18 | RELIEF DITCH |
| 400918 | 1,011 | 1,860 | -849 | -84 | COW CREEK DITCH |
| 400919 | 3,025 | 3,550 | -525 | -17 | CURRANT CREEK DITCH |
| 400923 | 8,143 | 7,481 | 662 | 8 | HIGHLINE DITCH |
| 400926 | 6,240 | 8,945 | -2,705 | -43 | LEROUX CREEK DITCH |
| 400929 | 1,084 | 1,498 | -414 | -38 | JESSIE DITCH |
| 400932 | 1,752 | 1,469 | 283 | 16 | MIDKIFF & ARNOLD D |
| 400944 | 10,320 | 23,903 | -13,583 | -132 | LERO_OVERLAND DITCH |
| 401012 | 574 | 503 | 71 | 12 | LONE CABIN DITCH |
| 401020 | 6,076 | 6,196 | -120 | -2 | MINNESOTA CANAL |
| 401056 | 1,890 | 1,715 | 175 | 9 | TURNER DITCH |
| 401087 | 432 | 520 | -88 | -20 | BLACK SAGE DITCH |
| 401105 | 429 | 1,242 | -813 | -190 | COYOTE DITCH |
| 401106 | 421 | 1,015 | -594 | -141 | COYOTE DITCH |
| 401112 | 474 | 398 | 76 | 16 | DEER DITCH |
| 401114 | 311 | 384 | -73 | -23 | DITCH NO 2 DITCH |
| 401118 | 609 | 1,600 | -991 | -163 | DRIFT CREEK DITCH |

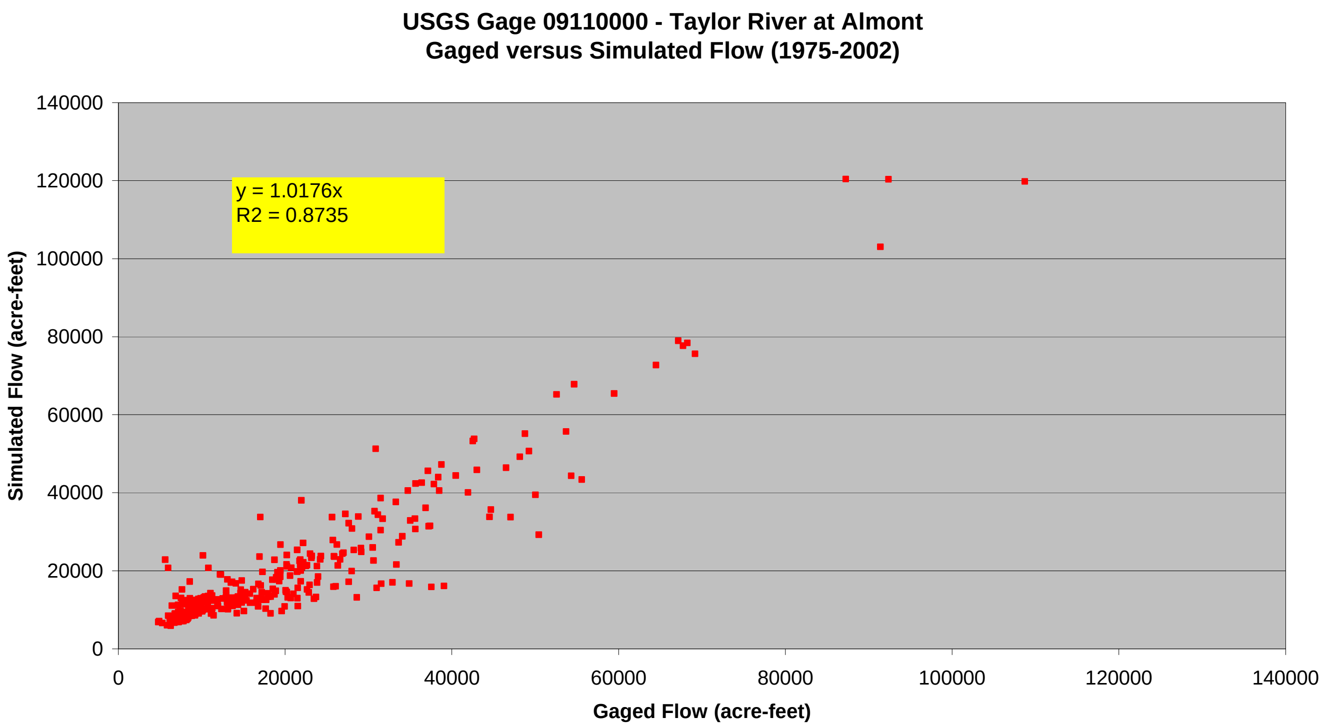
| WDID | Historical | Simulated | Historical minus Simulated Volume | Percent | Structure Name |
|---|---|---|---|---|---|
| 401119 | 226 | 1,081 | -855 | -378 | DUGOUT DITCH |
| 401120 | 631 | 766 | -135 | -21 | DOWNING DITCH |
| 401122 | 195 | 215 | -20 | -10 | DYKE NO 2 DITCH |
| 401127 | 317 | 367 | -50 | -16 | ELKS BEAVER DITCH |
| 401132 | 1,627 | 1,918 | -291 | -18 | FILMORE DITCH |
| 401133 | 45,470 | 47,284 | -1,814 | -4 | FIRE MT CANAL |
| 401145 | 432 | 519 | -87 | -20 | GROUSE CREEK DITCH |
| 401166 | 134 | 621 | -487 | -363 | MUDD_LARSON NO 2 DIT |
| 401168 | 383 | 529 | -146 | -38 | LEE CREEK D NO 2 |
| 401172 | 641 | 741 | -100 | -16 | LOST CABIN DITCH |
| 401183 | 2,285 | 2,620 | -335 | -15 | MONITOR DITCH |
| 401185 | 8,697 | 9,952 | -1,255 | -14 | NORTH FORK FARMERS D |
| 401189 | 6,359 | 6,561 | -202 | -3 | PAONIA DITCH |
| 401190 | 107 | 248 | -141 | -132 | PILOT KNOB DITCH |
| 401195 | 2,836 | 3,227 | -391 | -14 | SHEPARD & WILMONT DITCH |
| 401196 | 4,994 | 5,593 | -599 | -12 | SHORT DITCH |
| 401197 | 1,606 | 2,203 | -597 | -37 | SMITH AND MCKNIGHT DITCH |
| 401201 | 242 | 252 | -10 | -4 | SPATAFORE DITCH NO 1 |
| 401206 | 14,716 | 16,363 | -1,647 | -11 | STEWART DITCH |
| 401207 | 1,452 | 1,243 | 209 | 14 | STREBER DITCH |
| 401213 | 1,815 | 2,148 | -333 | -18 | VANDEFORD DITCH |
| 401214 | 97 | 186 | -89 | -92 | WADE DITCH |
| 401218 | 942 | 1,235 | -293 | -31 | WELCH MESA DITCH |
| 401221 | 111 | 680 | -569 | -513 | WILLIAMS CR DITCH |
| 401437 | 498 | 757 | -259 | -52 | ROUB_HAWKINS DITCH |
| 410508 | 3,302 | 4,212 | -910 | -28 | BOLES & MANNEY D |
| 410515 | 3,619 | 4,496 | -877 | -24 | CHIPETA BEAUDRY DITCH |
| 410519 | 6,843 | 8,109 | -1,266 | -19 | EAGLE DITCH |
| 410520 | 49,844 | 55,725 | -5,881 | -12 | EAST CANAL |
| 410527 | 22,870 | 25,575 | -2,705 | -12 | GARNET DITCH |
| 410534 | 114,743 | 129,619 | -14,876 | -13 | UNCO_IRONSTONE CANAL |
| 410537 | 46,974 | 54,308 | -7,334 | -16 | LOUTSENHIZER CANAL |
| 410538 | 2,627 | 3,149 | -522 | -20 | LYRA DITCH |
| 410545 | 181,440 | 200,998 | -19,558 | -11 | MONTROSE & DELTA CANAL |
| 410549 | 4,164 | 5,396 | -1,232 | -30 | OURAY DITCH |
| 410554 | 2,882 | 3,671 | -789 | -27 | ROSS BROS DITCH |
| 410559 | 69,557 | 79,391 | -9,834 | -14 | SELIG CANAL |
| 410560 | 1,150 | 1,617 | -467 | -41 | SHAVANO VALLEY DITCH |
| 410568 | 1,748 | 2,208 | -460 | -26 | SUNRISE DITCH(HAPPY CYN) |
| 410577 | 54,732 | 63,924 | -9,192 | -17 | WEST CANAL |
| 410578 | 44,362 | 49,718 | -5,356 | -12 | SOUTH CANAL |
| 420510 | 2,918 | 3,904 | -986 | -34 | BROWN & CAMPION D |
| 420529 | 5,886 | 5,920 | -34 | -1 | KANNAH CREEK HIGHLINE D |
| 420541 | 426,860 | 426,584 | 276 | 0 | REDLANDS POWER CANAL |
| 420545 | 1,315 | 2,138 | -823 | -63 | SMITH IRR DITCH |
| 590501 | 3,631 | 3,838 | -207 | -6 | ACME DITCH |

| WDID | Historical | Simulated | Historical minus Simulated | | Structure Name |
|---|---|---|---|---|---|
| | | | Volume | Percent | |
| 590509 | 358 | 364 | -6 | -2 | ANDERS BOTTOM D |
| 590510 | 1,138 | 1,119 | 19 | 2 | ANNA ROZMAN DITCH |
| 590522 | 3,560 | 3,984 | -424 | -12 | BOCKER DITCH |
| 590524 | 541 | 795 | -254 | -47 | BOURNE DITCH |
| 590527 | 780 | 1,454 | -674 | -86 | BUCKEY DITCH |
| 590528 | 313 | 595 | -282 | -90 | BUCKEY LEHMAN DITCH |
| 590537 | 3,555 | 3,893 | -338 | -10 | CEMENT CREEK DITCH |
| 590542 | 616 | 1,672 | -1,056 | -171 | CUNNINGHAM DITCH |
| 590544 | 1,023 | 1,332 | -309 | -30 | DEAN IRRIGATING DITCH |
| 590546 | 6,728 | 6,642 | 86 | 1 | DILLSWORTH DITCH |
| 590549 | 15,168 | 16,495 | -1,327 | -9 | EAST RIVER NO 1 DITCH |
| 590550 | 9,707 | 10,178 | -471 | -5 | EAST RIVER NO 2 DITCH |
| 590556 | 3,856 | 4,476 | -620 | -16 | FISHER DITCH ENLARGEMENT |
| 590558 | 3,047 | 3,684 | -637 | -21 | FRANK ADAMS NO 1 DITCH |
| 590560 | 2,698 | 3,043 | -345 | -13 | GARDEN DITCH |
| 590563 | 1,553 | 2,171 | -618 | -40 | GLEASON IRRIGATING DITCH |
| 590566 | 3,066 | 3,834 | -768 | -25 | GOOSEBERRY MESA IRG D |
| 590569 | 13,817 | 15,725 | -1,908 | -14 | GUNNISON & OHIO CR CANAL |
| 590570 | 17,011 | 18,269 | -1,258 | -7 | GUNNISON R OHIO CR IRG D |
| 590572 | 6,691 | 7,574 | -883 | -13 | GUNNISON TOWN DITCH |
| 590578 | 4,081 | 5,392 | -1,311 | -32 | HARRIS BOHM POTATO DITCH |
| 590580 | 190 | 604 | -414 | -218 | HENRY PURRIER OHIO CR D |
| 590581 | 260 | 494 | -234 | -90 | HENRY PURRIER OHIO CR 2D |
| 590584 | 512 | 562 | -50 | -10 | HIGHLAND DITCH |
| 590587 | 1,133 | 1,601 | -468 | -41 | HILDEBRAND NO 2 DITCH |
| 590588 | 1,534 | 2,065 | -531 | -35 | HINKLE HAMILTON DITCH |
| 590589 | 683 | 978 | -295 | -43 | HINKLE IRG DITCH |
| 590591 | 1,077 | 1,477 | -400 | -37 | HOPE RESICH DITCH |
| 590593 | 2,177 | 2,709 | -532 | -24 | HOWE & SHERWOOD IRR D |
| 590596 | 949 | 1,685 | -736 | -78 | HYZER VIDAL MILLER D |
| 590597 | 2,756 | 2,848 | -92 | -3 | IMOBERSTEG DITCH |
| 590600 | 5,212 | 5,894 | -682 | -13 | JAMES WATT DITCH |
| 590602 | 1,974 | 2,804 | -830 | -42 | JOHN B OUTCALT NO 2 D |
| 590606 | 1,335 | 1,614 | -279 | -21 | JUDY NORTH HIGH LINE D |
| 590607 | 5,740 | 6,751 | -1,011 | -18 | KELMEL OWENS NO 1 DITCH |
| 590608 | 3,269 | 3,719 | -450 | -14 | KELMEL OWENS NO 2 DITCH |
| 590609 | 2,907 | 3,114 | -207 | -7 | KUBIACK DITCH |
| 590616 | 3,081 | 3,558 | -477 | -15 | LIGHTLEY D & LINTON ENLT |
| 590617 | 3,059 | 4,464 | -1,405 | -46 | LONE PINE DITCH |
| 590622 | 1,807 | 2,152 | -345 | -19 | MARSHALL NO 1 DITCH |
| 590623 | 2,702 | 3,245 | -543 | -20 | MARSHALL NO 2 DITCH |
| 590624 | 1,390 | 1,695 | -305 | -22 | MARSTON DITCH |
| 590625 | 3,502 | 5,378 | -1,876 | -54 | MAY BOHM & ENLD M B H P |
| 590627 | 437 | 854 | -417 | -95 | MCCORMICK DITCH |
| 590630 | 232 | 485 | -253 | -109 | MCGLASHAN N SIDE MILL CR |
| 590631 | 402 | 651 | -249 | -62 | MCGLASHAN S SIDE MILL CR |

| WDID | Historical | Simulated | Historical minus Simulated Volume | Percent | Structure Name |
|---|---|---|---|---|---|
| 590644 | 497 | 809 | -312 | -63 | OHIO CREEK NO 2 DITCH |
| 590645 | 423 | 1,099 | -676 | -160 | OTIS MOORE DITCH |
| 590646 | 793 | 998 | -205 | -26 | PALISADES DITCH |
| 590649 | 796 | 804 | -8 | -1 | PASS CREEK DITCH |
| 590651 | 1,329 | 2,388 | -1,059 | -80 | PILONI DITCH |
| 590653 | 4,375 | 4,371 | 4 | 0 | POWER DITCH |
| 590655 | 430 | 711 | -281 | -65 | PURRIER DITCH |
| 590658 | 4,161 | 4,674 | -513 | -12 | RICHARD BALL DITCH |
| 590667 | 713 | 871 | -158 | -22 | SCHUPP DITCH |
| 590668 | 5,336 | 6,340 | -1,004 | -19 | SEVENTY FIVE DITCH |
| 590671 | 343 | 816 | -473 | -138 | SIMINEO DITCH |
| 590672 | 4,297 | 4,268 | 29 | 1 | SLIDE DITCH |
| 590679 | 3,988 | 4,201 | -213 | -5 | SPRING CR IRG DITCH |
| 590680 | 431 | 480 | -49 | -11 | SQUIRREL CREEK NO1 DITCH |
| 590684 | 2,357 | 2,461 | -104 | -4 | STRAND DITCH NO 1 |
| 590691 | 3,116 | 4,380 | -1,264 | -41 | TEACHOUT DITCH |
| 590692 | 1,226 | 1,707 | -481 | -39 | TEACHOUT-FAIRCHILD DITCH |
| 590699 | 5,374 | 5,623 | -249 | -5 | VERZUH DITCH |
| 590700 | 5,756 | 5,483 | 273 | 5 | VERZUH YOUNG BIFANO D |
| 590704 | 3,860 | 4,276 | -416 | -11 | WHIPP DITCH |
| 590707 | 412 | 674 | -262 | -64 | WILLOW RUN DITCH |
| 590709 | 826 | 1,056 | -230 | -28 | WILSON DITCH |
| 590711 | 1,070 | 1,676 | -606 | -57 | WILSON OHIO CREEK DITCH |
| 590720 | 536 | 838 | -302 | -56 | PIONEER DITCH |
| 590847 | 2,220 | 1,908 | 312 | 14 | CUNNINGHAM WASTEWATER D |
| 620506 | 711 | 780 | -69 | -10 | ANDREWS DITCH |
| 620528 | 5,322 | 6,317 | -995 | -19 | BIG BLUE DITCH |
| 620529 | 2,999 | 3,484 | -485 | -16 | BIG DITCH |
| 620560 | 28,726 | 29,807 | -1,081 | | CIMARRON CANAL |
| 620567 | 1,521 | 1,957 | -436 | -29 | COLLIER DITCH |
| 620602 | 719 | 893 | -174 | -24 | FOSTER DITCH NO 1 |
| 620604 | 223 | 332 | -109 | -49 | FOSTER IRG D NO 4 |
| 620605 | 2,180 | 2,776 | -596 | -27 | FRANK ADAMS D NO 2 |
| 620617 | 332,759 | 383,656 | -50,897 | -15 | GUNNISON TUNNEL&S CANAL |
| 620670 | 1,867 | 2,446 | -579 | -31 | M B & A DITCH |
| 620672 | 4,517 | 5,272 | -755 | -17 | MCKINLEY DITCH |
| 620732 | 1,458 | 1,765 | -307 | -21 | RUDOLPH IRG DITCH |
| 620734 | 600 | 689 | -89 | -15 | SAMMONS DITCH NO 2 |
| 620736 | 716 | 832 | -116 | -16 | CEBO_SAMMONS IRG D N |
| 620737 | 648 | 759 | -111 | -17 | SAMMONS IRG D NO 5 |
| 620738 | 578 | 720 | -142 | -25 | SAMMONS IRG D NO 6 |
| 620779 | 1,417 | 1,861 | -444 | -31 | UPPER CEBOLLA DITCH |
| 620783 | 1,818 | 2,208 | -390 | -21 | VEO DITCH |
| 620789 | 905 | 1,006 | -101 | -11 | WARRANT DITCH |
| 620809 | 1,015 | 1,149 | -134 | -13 | YOUMANS IRG D NO 1 |
| 680501 | 5,411 | 5,649 | -238 | -4 | ALKALI DITCH D NO 80 |

| WDID | Historical | Simulated | Historical minus Simulated Volume | Percent | Structure Name |
|---|---|---|---|---|---|
| 680502 | 4,432 | 4,137 | 295 | 7 | ALKALI NO 2 DITCH |
| 680514 | 1,840 | 2,172 | -332 | -18 | BURKHART EDDY DITCH |
| 680526 | 3,094 | 3,557 | -463 | -15 | CHARLEY LOGAN DITCH |
| 680538 | 469 | 434 | 35 | 7 | CRONENBERG DITCH |
| 680543 | 3,774 | 3,389 | 385 | 10 | DALLAS DITCH |
| 680559 | 1,849 | 2,143 | -294 | -16 | DOC WADE DITCH |
| 680603 | 1,106 | 1,215 | -109 | -10 | HENRY TRENCHARD DITCH |
| 680607 | 3,866 | 4,255 | -389 | -10 | HOMESTRETCH DITCH |
| 680609 | 1,997 | 2,344 | -347 | -17 | HOSNER BROWNYARD DITCH |
| 680610 | 1,983 | 2,260 | -277 | -14 | HOSNER ROWELL DITCH |
| 680613 | 2,261 | 2,482 | -221 | -10 | HYDE SNEVA DITCH |
| 680636 | 2,035 | 2,570 | -535 | -26 | LEOPARD CREEK DITCH |
| 680647 | 969 | 1,055 | -86 | -9 | MARTIN DITCH |
| 680652 | 865 | 1,012 | -147 | -17 | MAYOL LATERAL DITCH |
| 680653 | 807 | 986 | -179 | -22 | MAYOL SISSON DITCH |
| 680668 | 2,048 | 2,375 | -327 | -16 | MOODY DITCH |
| 680669 | 2,393 | 2,863 | -470 | -20 | MOODY NO1 DITCH |
| 680671 | 1,421 | 1,493 | -72 | -5 | MORRISON DITCH |
| 680681 | 2,137 | 2,524 | -387 | -18 | OLD AGENCY DITCH |
| 680683 | 1,294 | 1,472 | -178 | -14 | OWL CREEK DITCH |
| 680685 | 2,373 | 2,633 | -260 | -11 | PARK DITCH |
| 680692 | 3,891 | 3,955 | -64 | -2 | PINION DITCH |
| 680703 | 1,133 | 1,505 | -372 | -33 | REED OVERMAN DITCH |
| 680710 | 647 | 710 | -63 | -10 | RIDGWAY DITCH |
| 680720 | 1,035 | 1,237 | -202 | -20 | ROSWELL HOTCHKISS DITCH |
| 680729 | 609 | 731 | -122 | -20 | SHORTLINE D COW CREEK |
| 680738 | 3,551 | 4,286 | -735 | -21 | SNEVA DITCH |
| 680765 | 2,670 | 3,134 | -464 | -17 | UPPER UNCOMPAHGRE DITCH |
| 960050 | 79,630 | 91,453 | -11,823 | -15 | REDLANDS_POWER_CANAL-IRR |
| 960051 | 6,581 | 6,519 | 62 | 1 | Grand_Junction_Demand |
| 28_ADG009 | 6,776 | 8,306 | -1,530 | -23 | 28_ADG009_UTOMICHI |
| 28_ADG010 | 13,538 | 17,772 | -4,234 | -31 | 28_ADG010_TOMICHI1 |
| 28_ADG011 | 6,268 | 9,037 | -2,769 | -44 | 28_ADG011_COCHETOPA |
| 28_ADG012 | 26,830 | 31,508 | -4,678 | -17 | 28_ADS_012_TOMICHI2 |
| 28_ADG043 | 2,180 | 2,489 | -309 | -14 | 28_ADG043_COCHET |
| 28_ADG044 | 5,961 | 8,964 | -3,003 | -50 | 28_ADG044_RAZOR |
| 40_ADG019 | 389 | 978 | -589 | -151 | 40_ADG019_GUNNTUN |
| 40_ADG020 | 4,264 | 5,128 | -864 | -20 | 40_ADG020_IRON |
| 40_ADG021 | 3,083 | 3,558 | -475 | -15 | 40_ADG021_SMITH |
| 40_ADG022 | 6,952 | 8,941 | -1,989 | -29 | 40_ADG022_NFGUNN |
| 40_ADG023 | 1,736 | 2,008 | -272 | -16 | 40_ADG023_MINN |
| 40_ADG024 | 7,453 | 9,136 | -1,683 | -23 | 40_ADG024_NFGUNN2 |
| 40_ADG025 | 3,800 | 4,008 | -208 | -5 | 40_ADG025_LEROUX |
| 40_ADG026 | 8,940 | 10,594 | -1,654 | -19 | 40_ADG026_GUNNL |
| 40_ADG027 | 7,223 | 5,929 | 1,294 | 18 | 40_ADG027_CURRANT |
| 40_ADG028 | 12,299 | 12,949 | -650 | -5 | 40_ADG028_UTONGUE |

| WDID | Historical | Simulated | Historical minus Simulated Volume | Percent | Structure Name |
|---|---|---|---|---|---|
| 40_ADG029 | 2,443 | 2,582 | -139 | -6 | 40_ADG029_SURFACE |
| 40_ADG030 | 13,773 | 15,349 | -1,576 | -11 | 40_ADG030_TONGUE |
| 40_ADG031 | 5,890 | 6,753 | -863 | -15 | 40_ADG031_GUNND |
| 40_ADG038 | 2,444 | 3,733 | -1,289 | -53 | 40_ADG038_ROUBIN |
| 40_ADG039 | 9,208 | 11,403 | -2,195 | -24 | 40_ADG039_GUNNBLD |
| 40_AMG002 | 1,449 | 1,448 | 1 | 0 | Lower_M&I |
| 40_Fruitl | 12,712 | 16,117 | -3,405 | -27 | Fruitland |
| 41_ADG035 | 6,332 | 7,639 | -1,307 | -21 | 41_ADG035_UNCOMPH3 |
| 41_ADG036 | 13,087 | 17,626 | -4,539 | -35 | 41_ADG036_UNCOMPH4 |
| 41_ADG037 | 7,846 | 9,777 | -1,931 | -25 | 41_ADG037_UNCOMPH5 |
| 41_AMG003 | 1,272 | 1,272 | 0 | 0 | Uncomp_M&I |
| 42_ADG040 | 12,074 | 17,932 | -5,858 | -49 | 42_ADG040_GUNNGJ |
| 59_ADG001 | 4,764 | 5,442 | -678 | -14 | 59_ADG001_TAYLOR |
| 59_ADG002 | 3,370 | 5,203 | -1,833 | -54 | 59_ADG002_EAST1 |
| 59_ADG003 | 1,818 | 5,242 | -3,424 | -188 | 59_ADS_003_SLATE |
| 59_ADG004 | 10,119 | 12,826 | -2,707 | -27 | 59_ADG004_EAST2 |
| 59_ADG005 | 6,111 | 7,201 | -1,090 | -18 | 59_ADG005_EAST3 |
| 59_ADG006 | 2,747 | 3,702 | -955 | -35 | 59_ADG006_OHIO1 |
| 59_ADG007 | 3,055 | 7,380 | -4,325 | -142 | 59_ADG007_OHIO2 |
| 59_ADG008 | 15,362 | 16,361 | -999 | -7 | 59_ADG008_GUNN |
| 62_ADG013 | 5,861 | 6,768 | -907 | -15 | 62_ADG013_CEBOLLA1 |
| 62_ADG014 | 6,988 | 9,411 | -2,423 | -35 | 62_ADG014_CEBOLLA2 |
| 62_ADG015 | 4,981 | 6,613 | -1,632 | -33 | 62_ADG015_LAKE |
| 62_ADG016 | 16,176 | 19,430 | -3,254 | -20 | 62_ADG016_GUNNBM |
| 62_ADG017 | 1,641 | 2,638 | -997 | -61 | 62_ADG017_GUNNM |
| 62_ADG018 | 2,623 | 3,173 | -550 | -21 | 62_ADG018_CIM |
| 62_AMG001 | 1,449 | 1,448 | 1 | 0 | Upper_M&I |
| 62_IrrCim | 28,124 | 28,331 | -207 | -1 | Cimmaron_Canal |
| 68_ADG032 | 11,212 | 12,843 | -1,631 | -15 | 68_ADG032_UNCOMPH1 |
| 68_ADG033 | 7,480 | 8,509 | -1,029 | -14 | 68_ADG033_DALLAS |
| 68_ADG034 | 8,765 | 10,767 | -2,002 | -23 | 68_ADG034_UNCOMPH2 |
| 95CSUB_I | 0 | 0 | 0 | 0 | Default information |
| 95CSUB_M | 0 | 0 | 0 | 0 | Subordinate_Crystal_M&I |
| 95L_MY | 0 | 0 | 0 | 0 | Default information |
| 95MSUB_I | 0 | 0 | 0 | 0 | Default information |
| 95MSUB_M | 0 | 0 | 0 | 0 | Subordinate_Morrow_M&I |
| 95U_MY | 0 | 0 | 0 | 0 | Upper_Market_Yield |
| 95USUB_I | 0 | 0 | 0 | 0 | Default information |
| 95USUB_M | 0 | 0 | 0 | 0 | Subordinate_Upper_M&I |
| Proj_7 | 6,487 | 5,241 | 1,246 | 0 | Project_7 |
| Basin Total | 2,640,406 | 2,992,234 | -351,828 | -13.32 | |



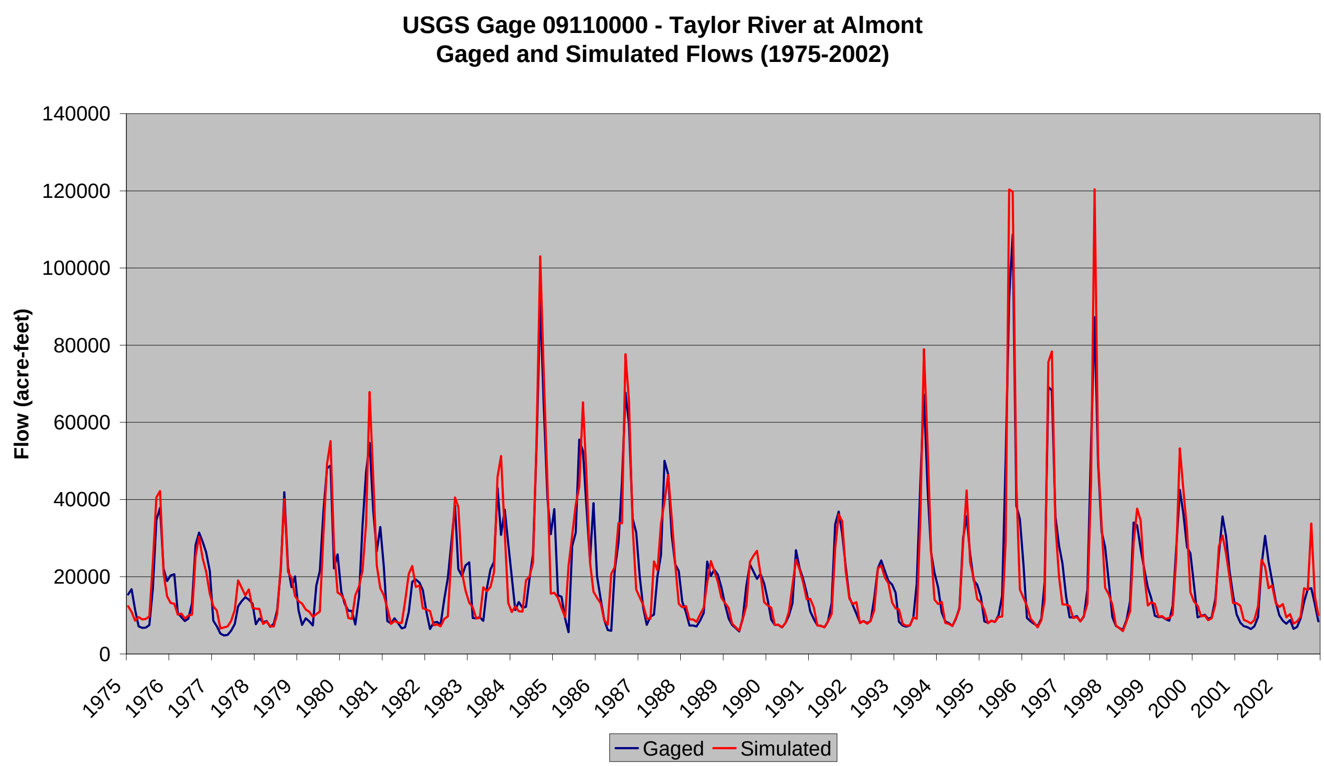
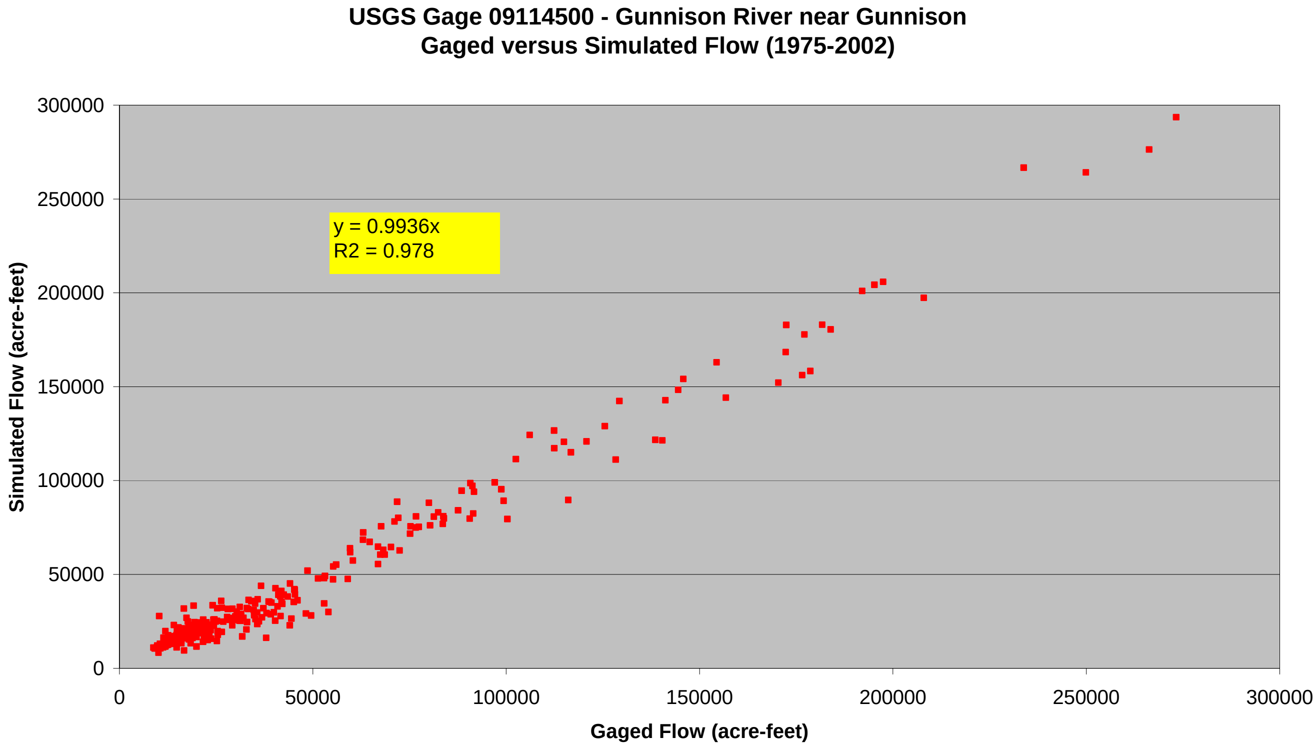




**Figure D.1 Calculated Streamflow Simulation – Taylor River at Almont**



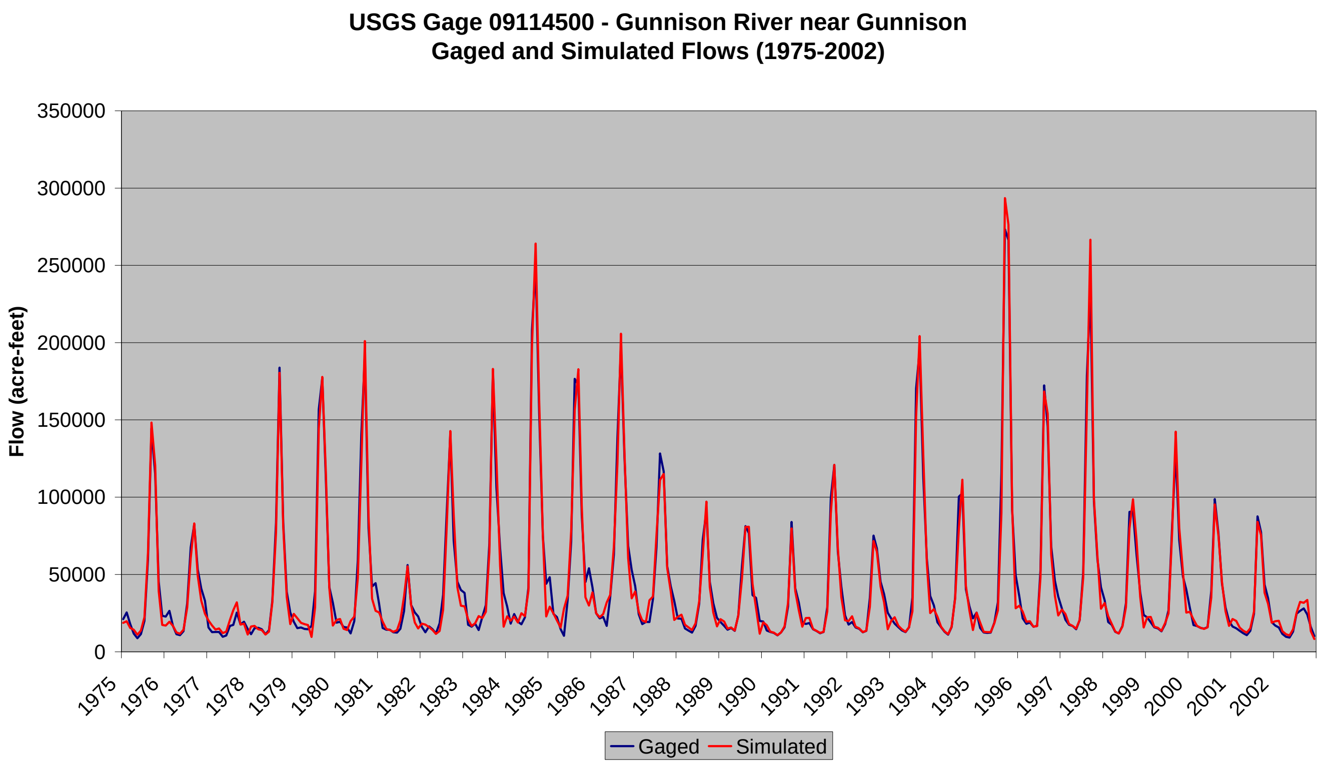
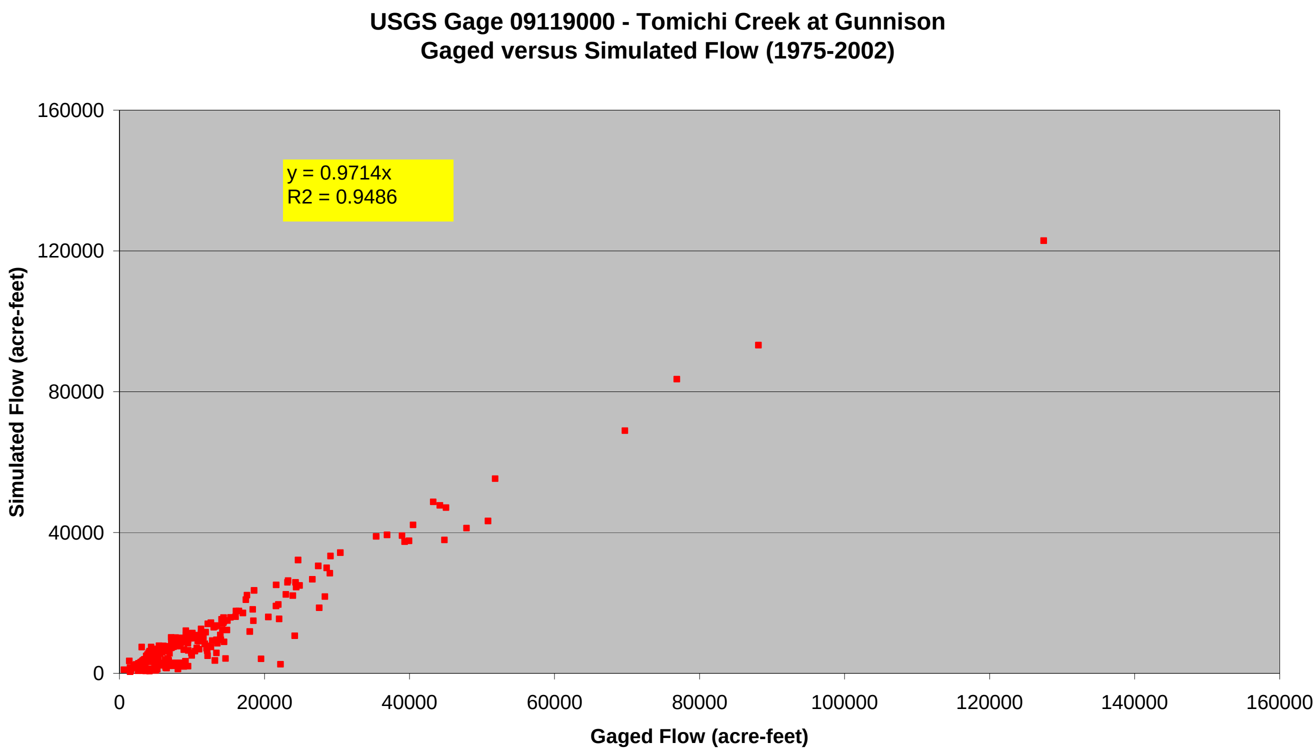




**Figure D.2 Calculated Streamflow Simulation – Gunnison River near Gunnison**



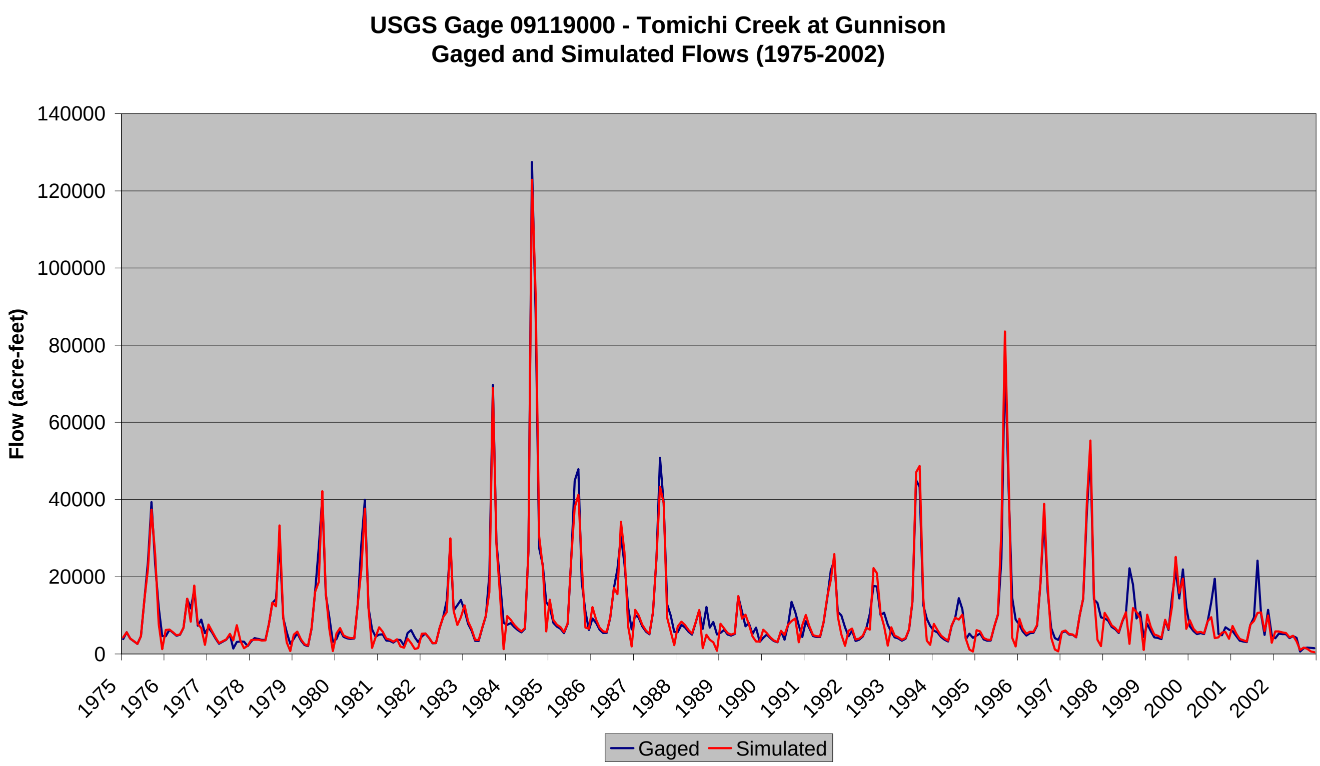
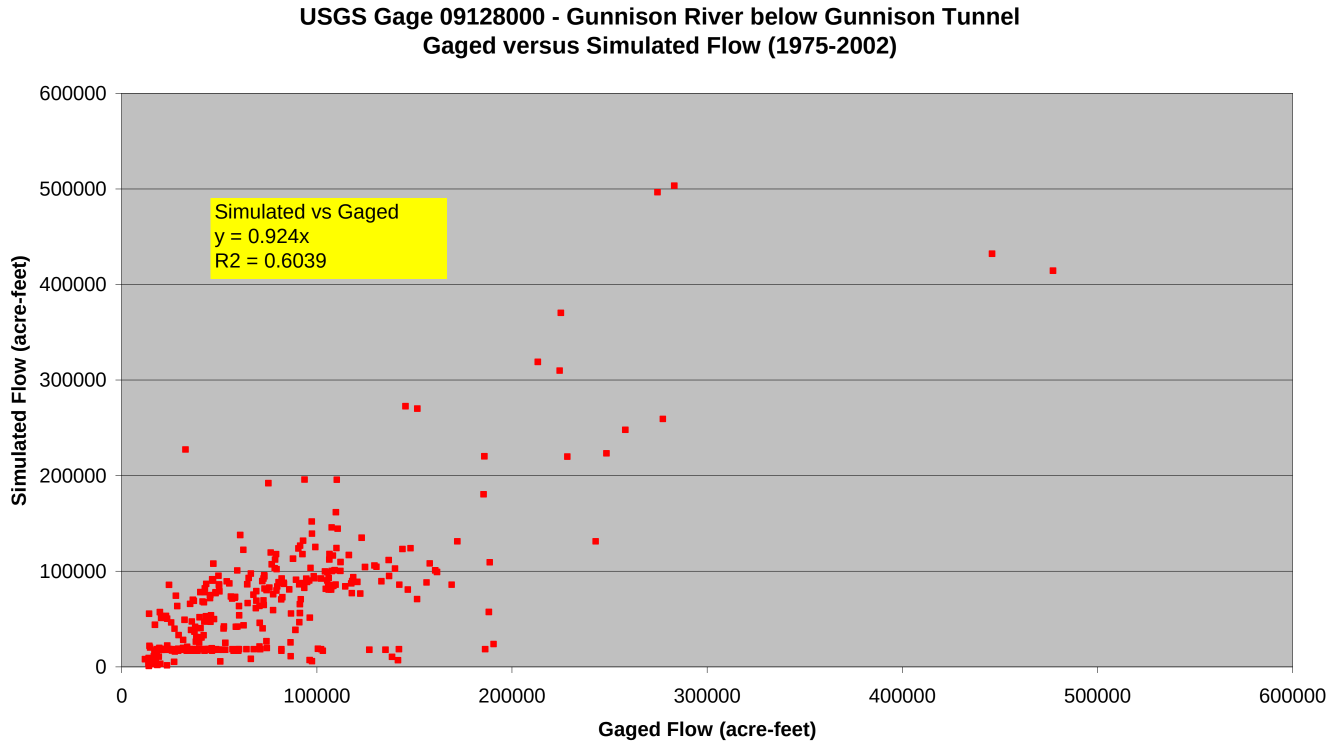




**Figure D.3 Calculated Streamflow Simulation – Tomichi Creek at Gunnison**



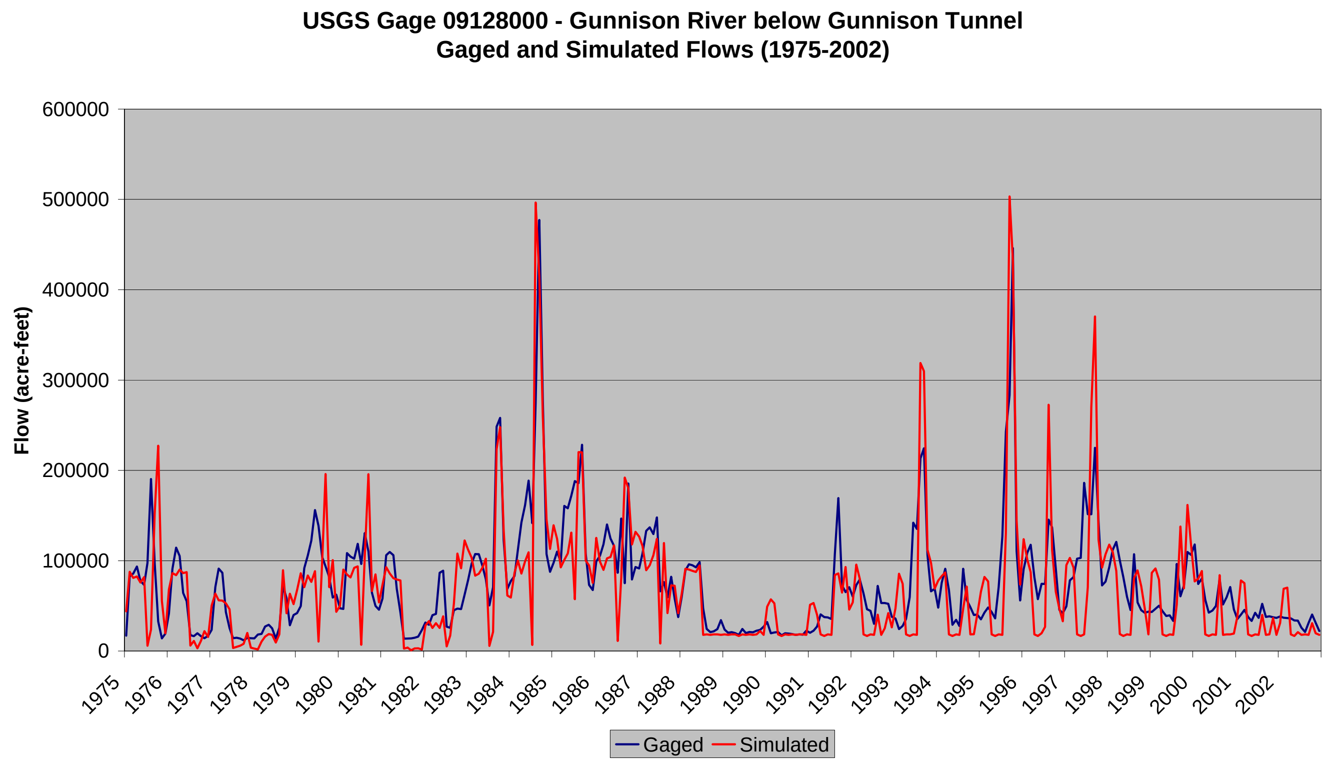
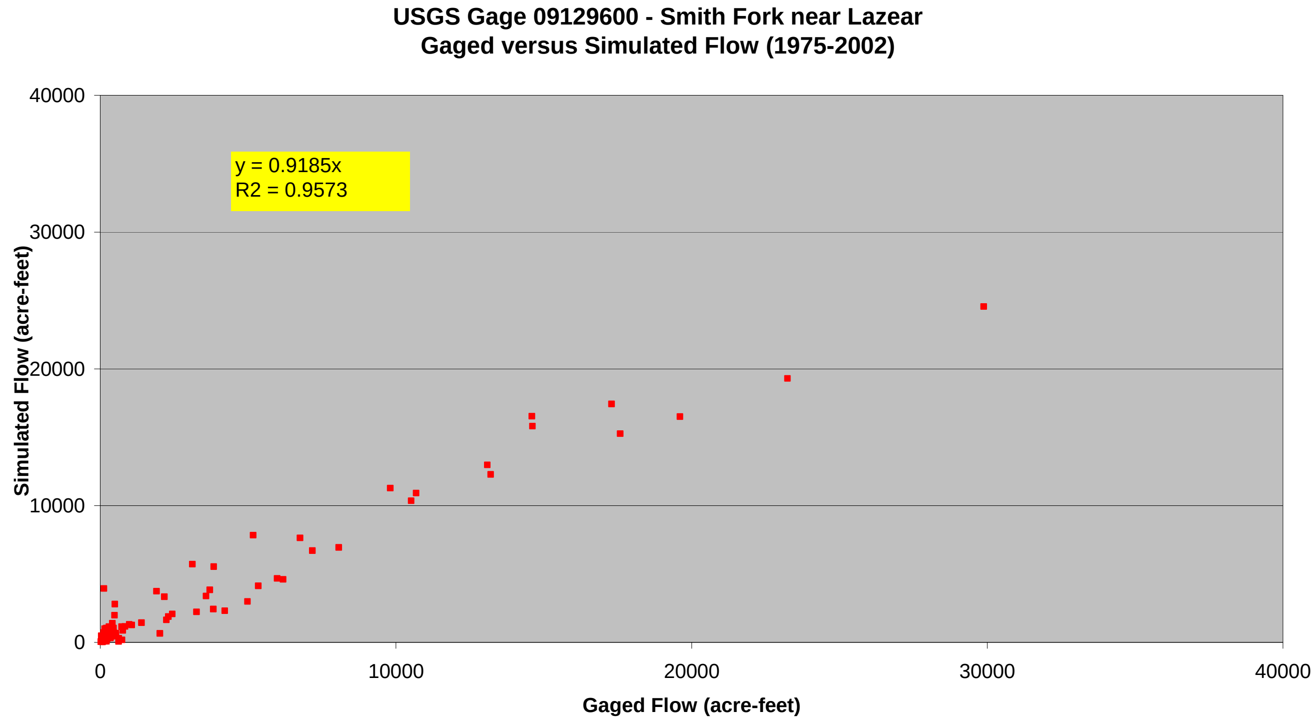




**Figure D.4 Calculated Streamflow Simulation – Gunnison River below Gunnison Tunnel**



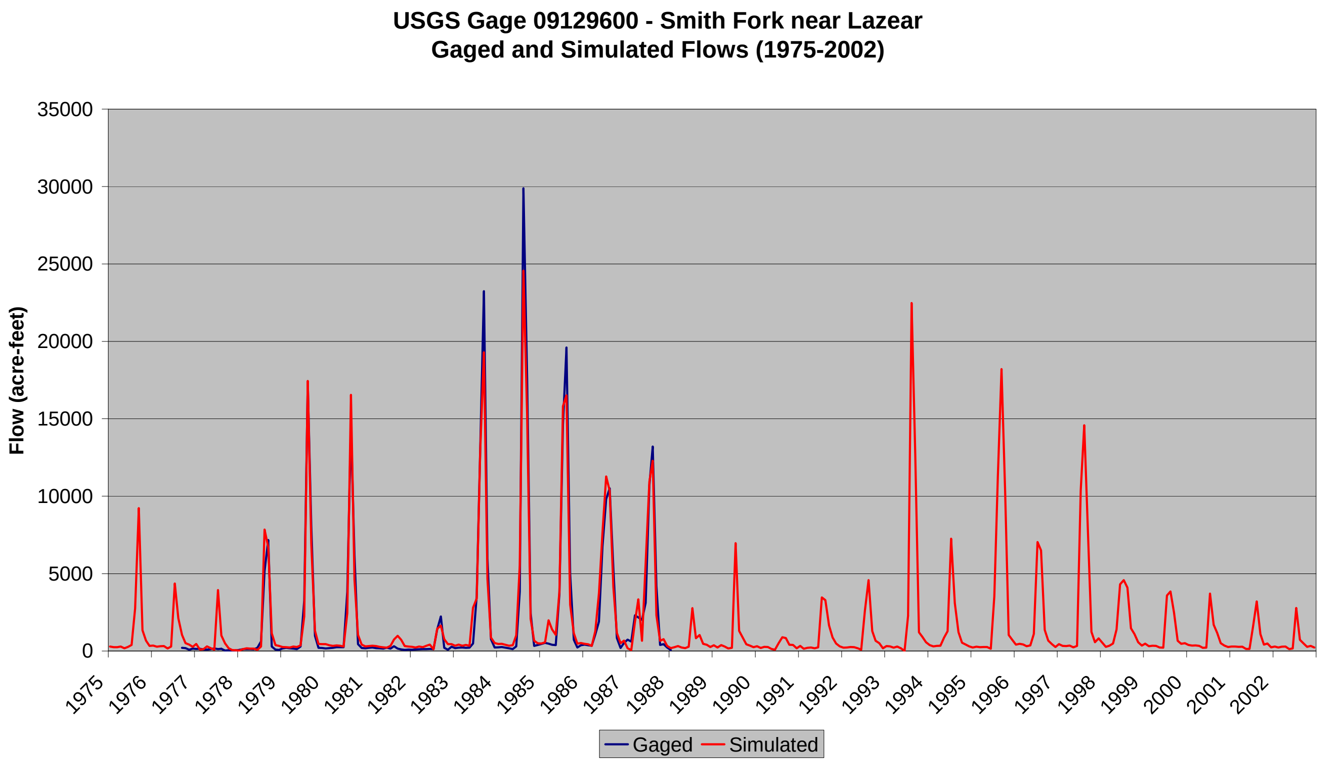
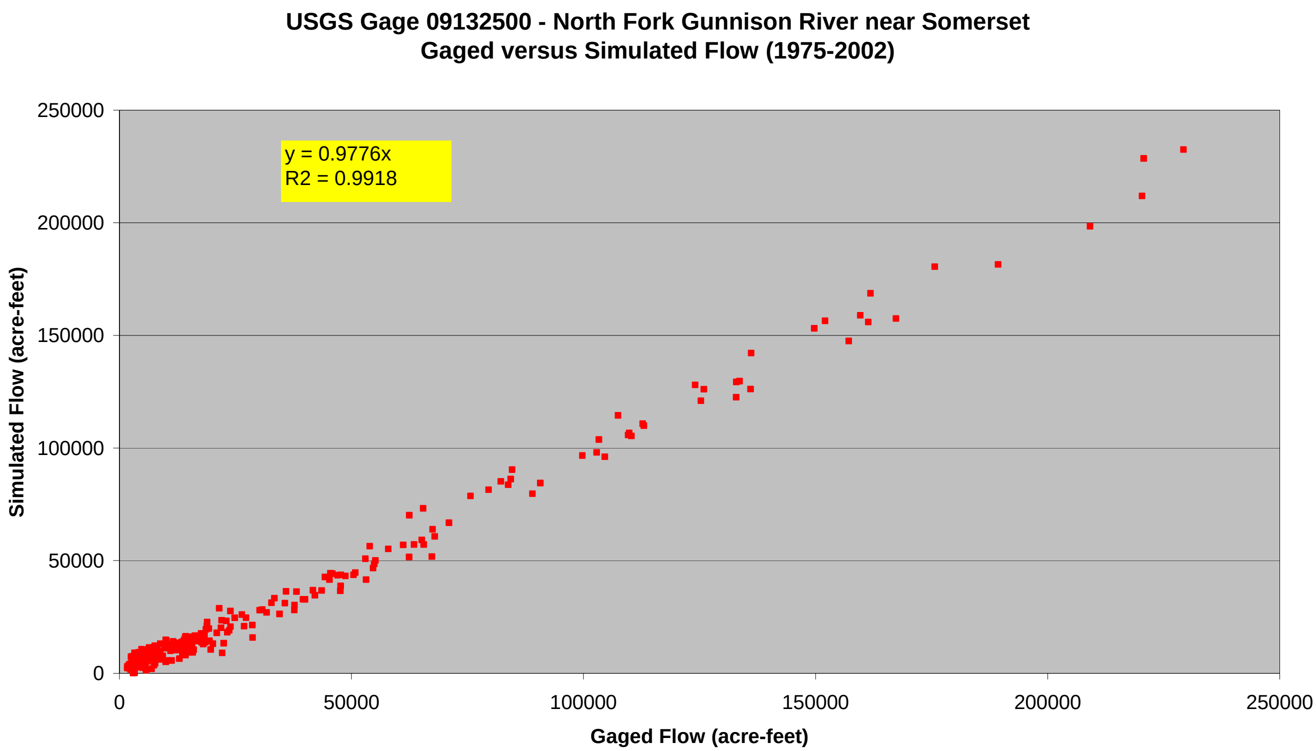




**Figure D.5 Calculated Streamflow Simulation – Smith Fork near Lazear**



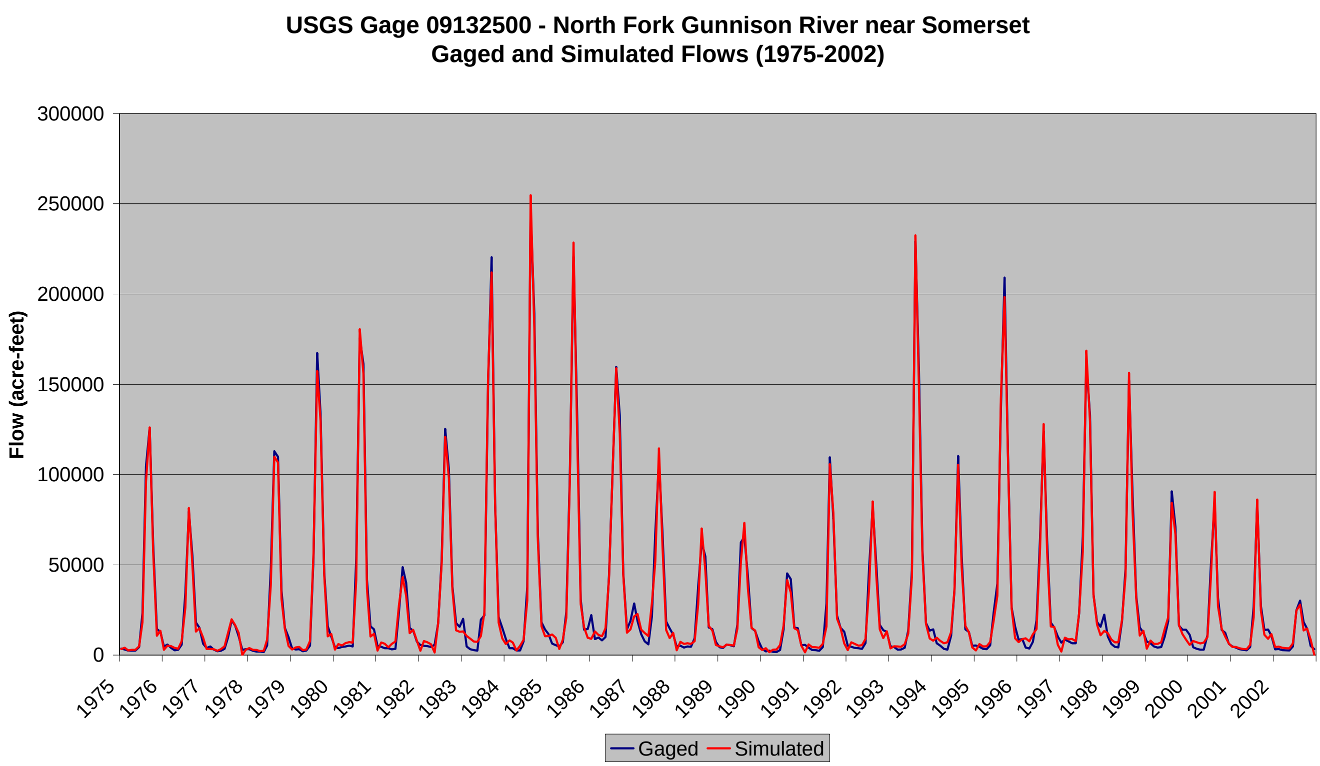
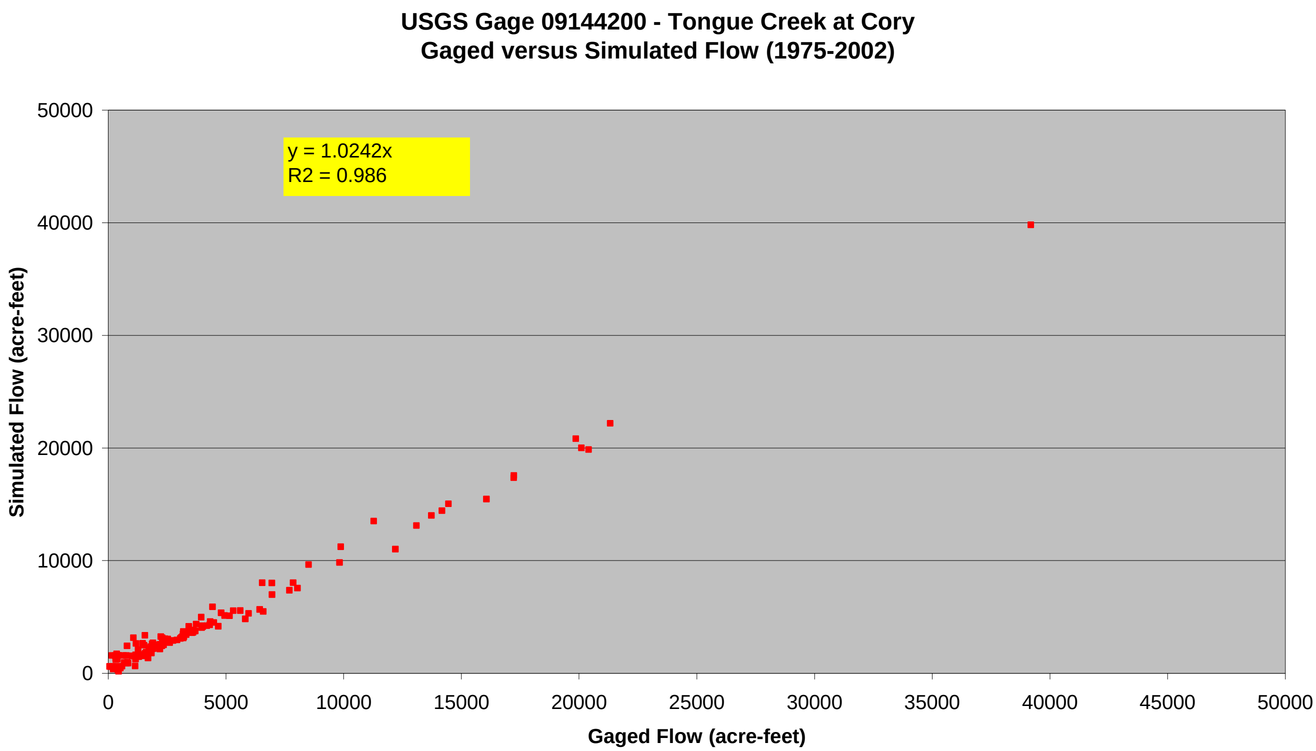




**Figure D.6 Calculated Streamflow Simulation – North Fork Gunnison River near Somerset**



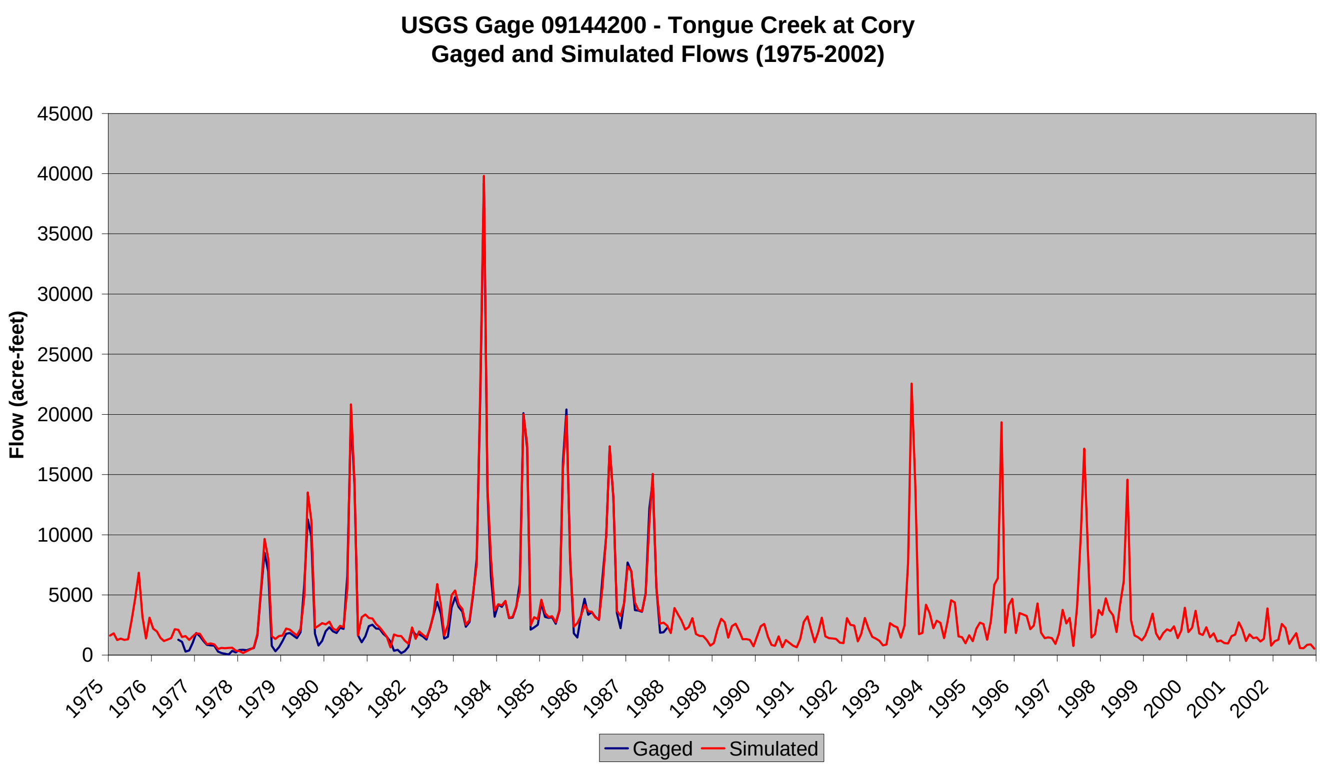
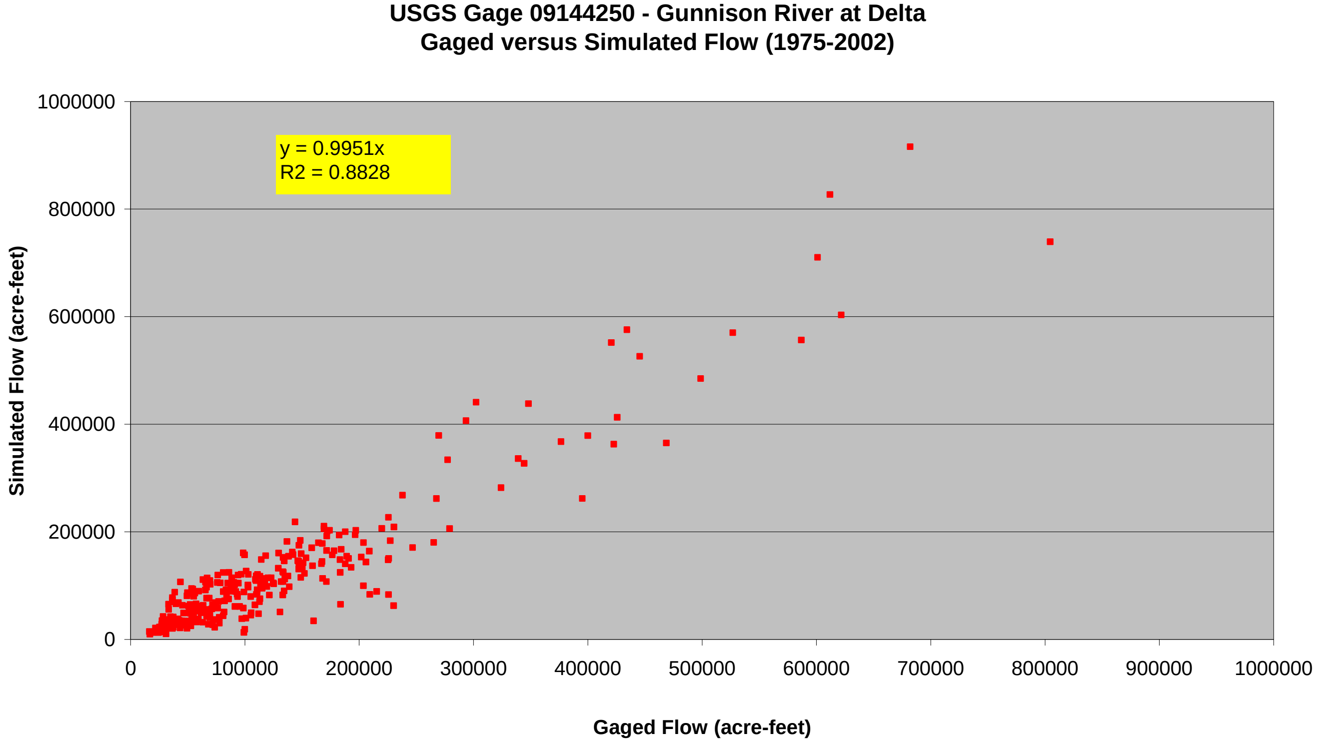




**Figure D.7 Calculated Streamflow Simulation – Tongue Creek at Cory**



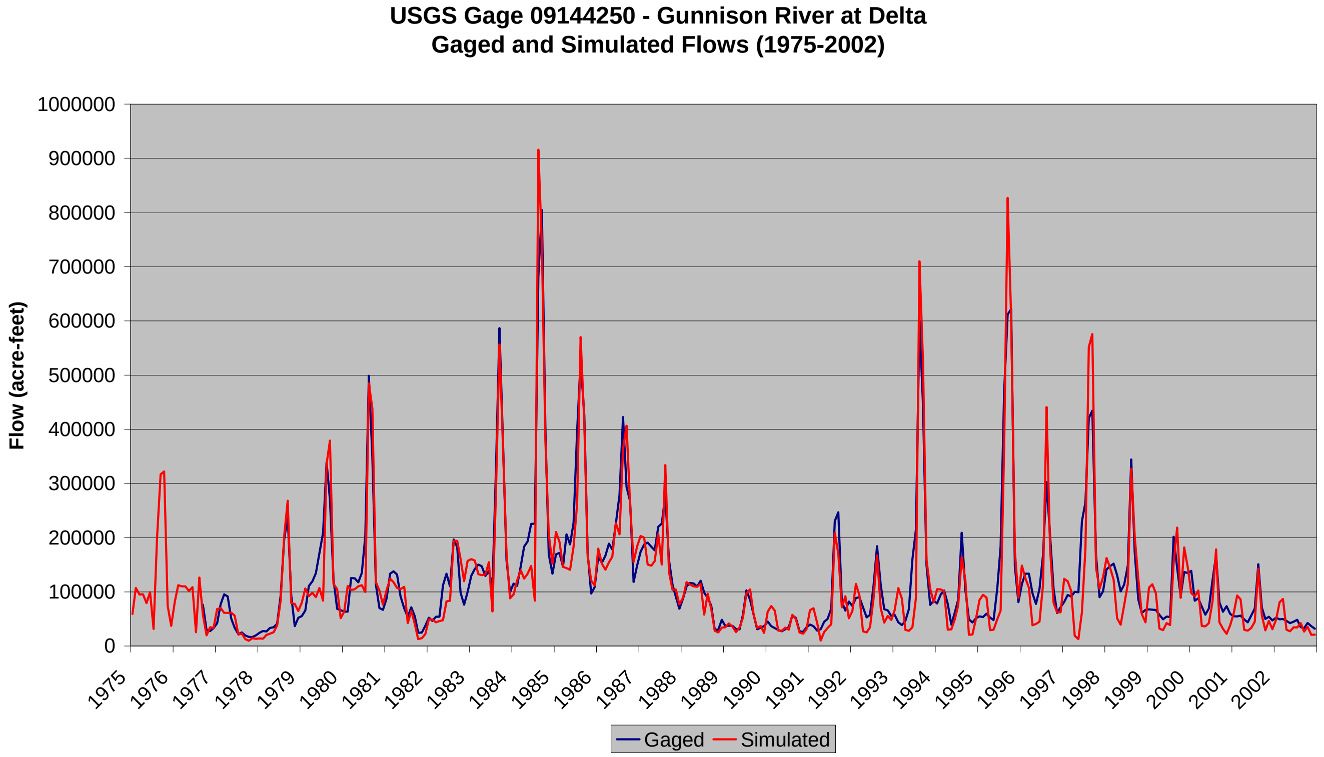
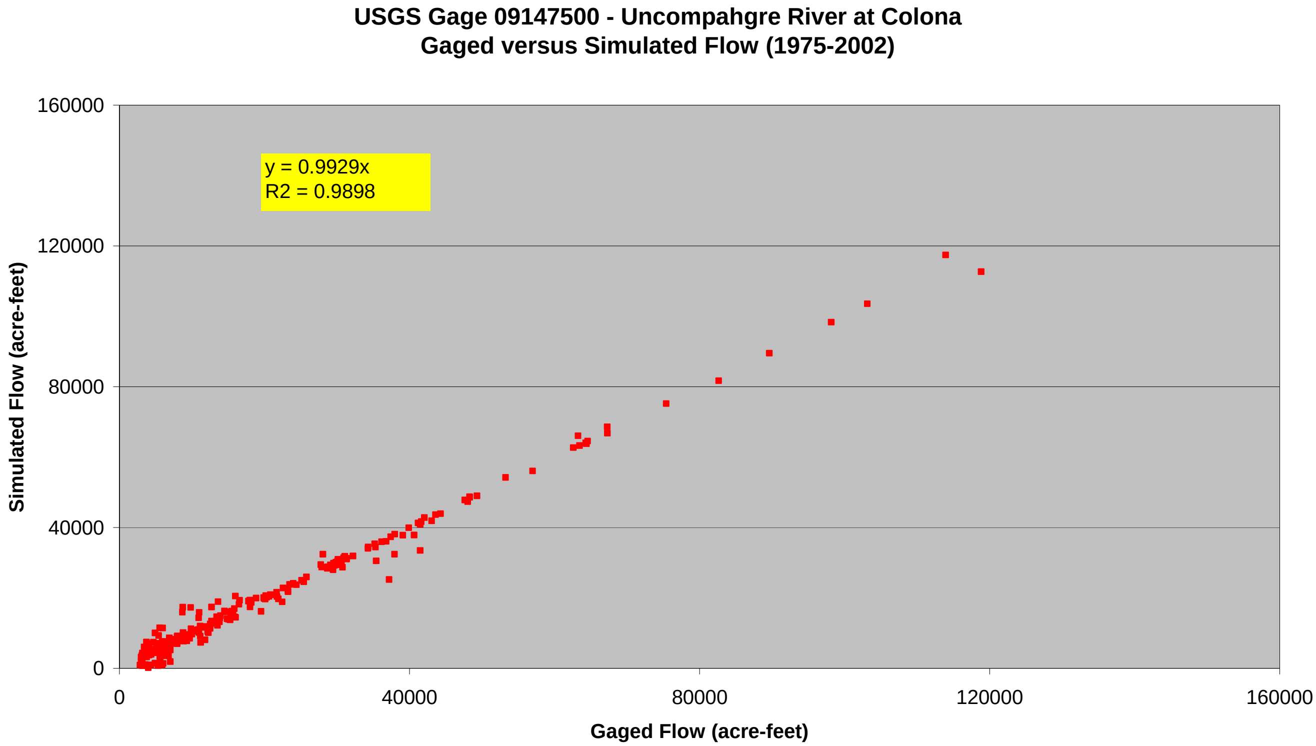




**Figure D.8 Calculated Streamflow Simulation – Gunnison River at Delta**



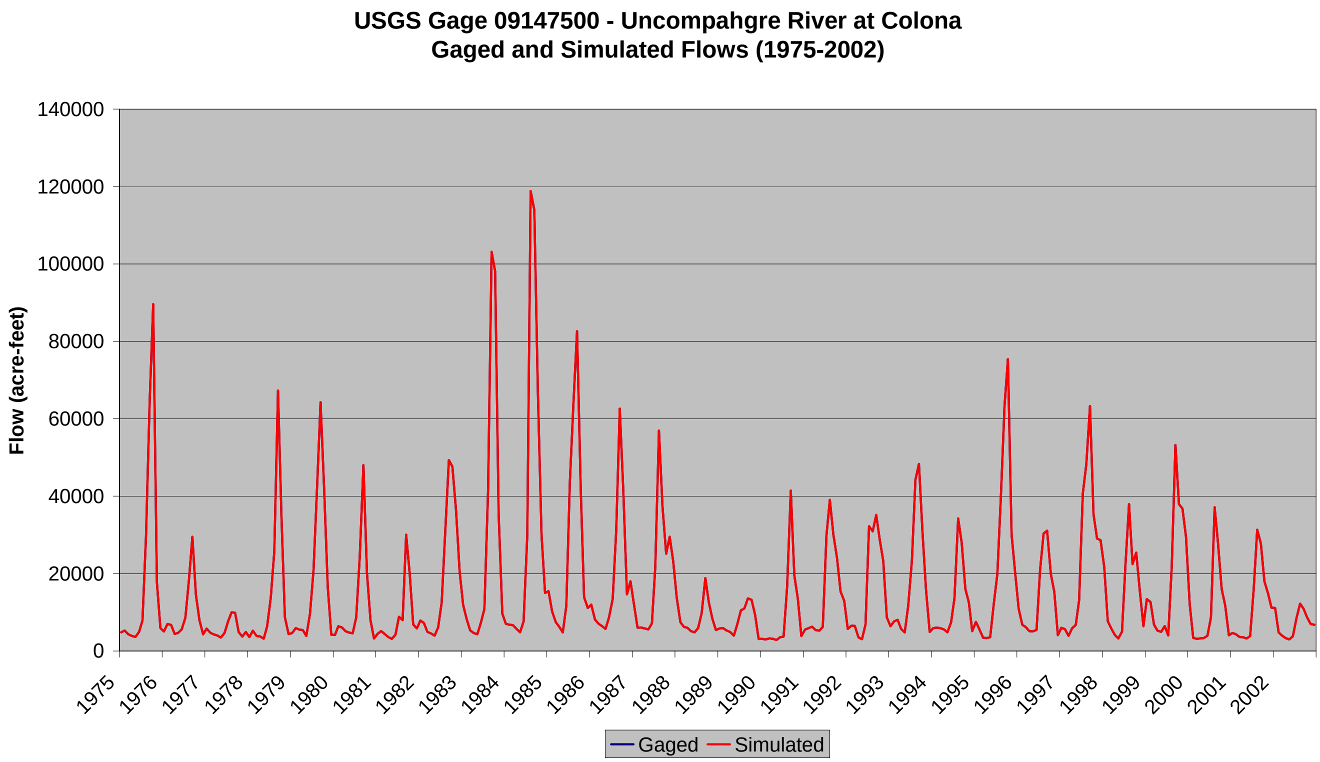
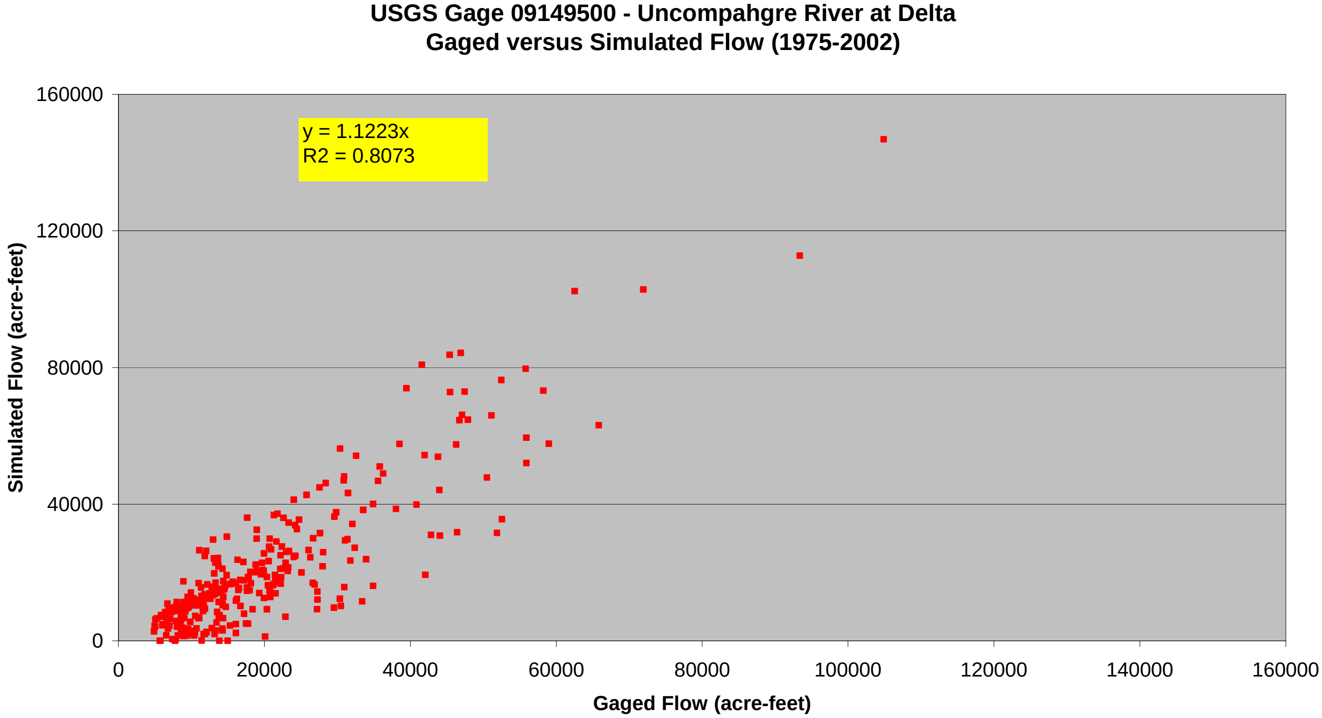




**Figure D.9 Calculated Streamflow Simulation – Uncompahgre River at Colona**



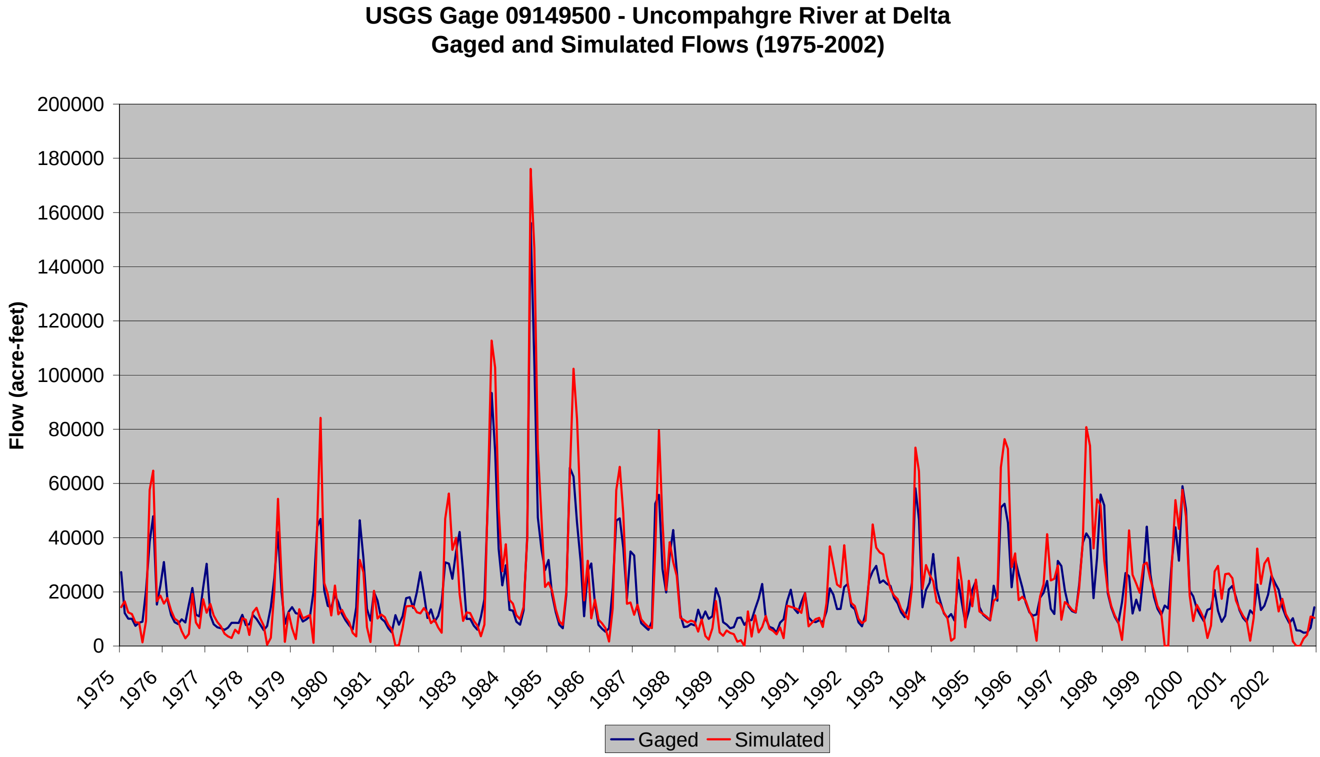
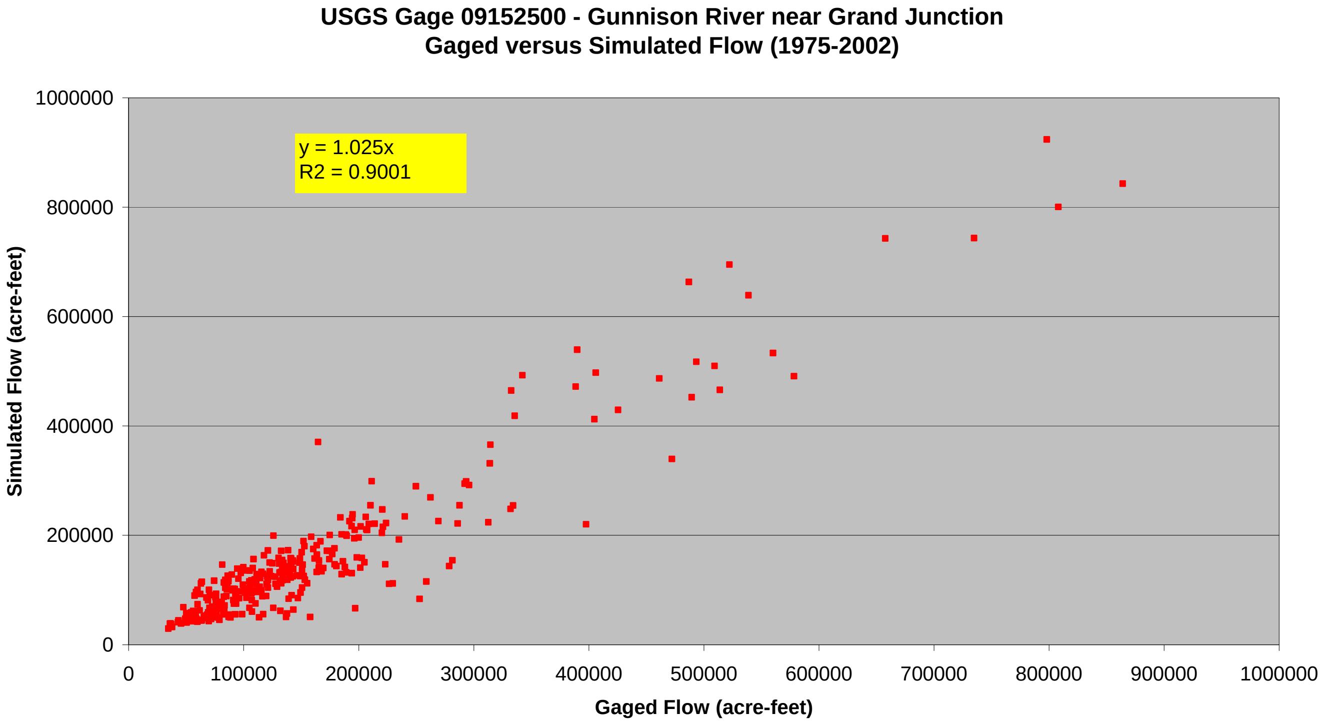




**Figure D.10 Calculated Streamflow Simulation – Uncompahgre River at Delta**



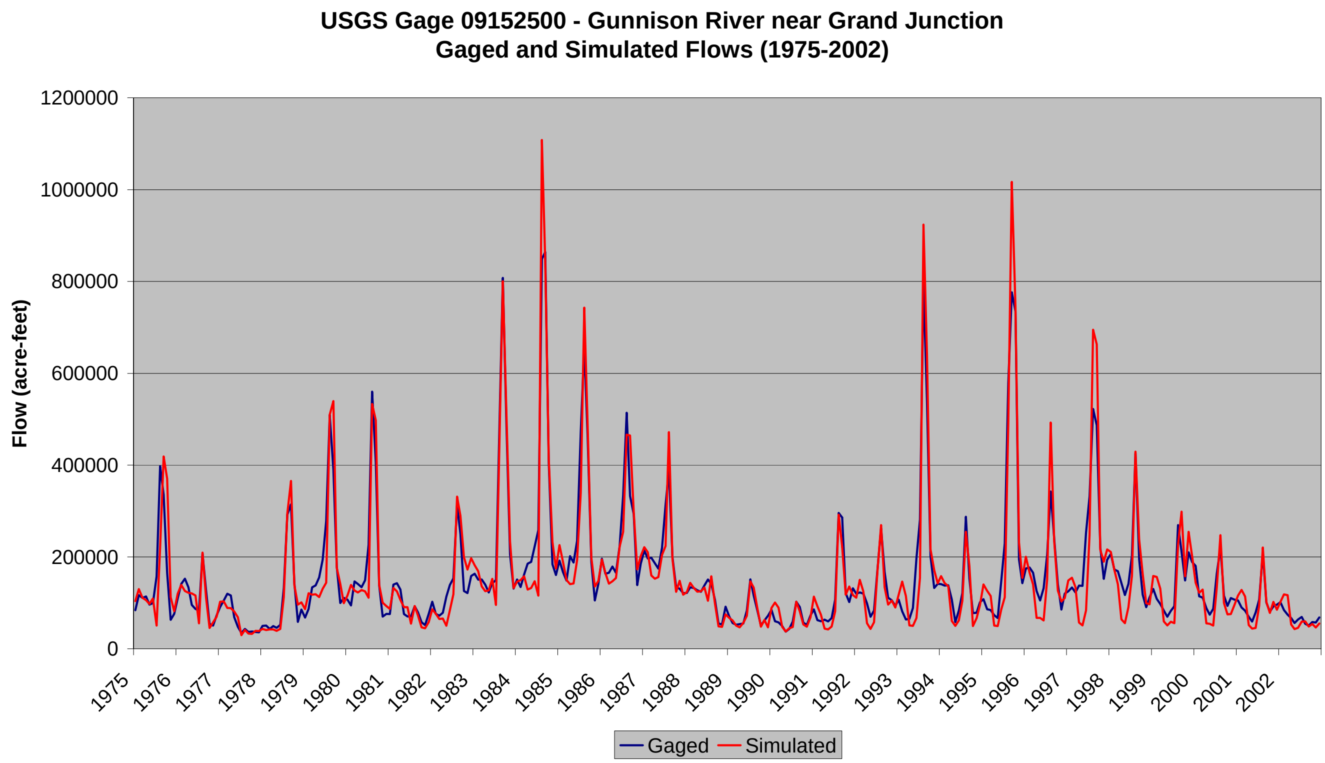




**Figure D.11 Calculated Streamflow Simulation – Gunnison River near Grand Junction**

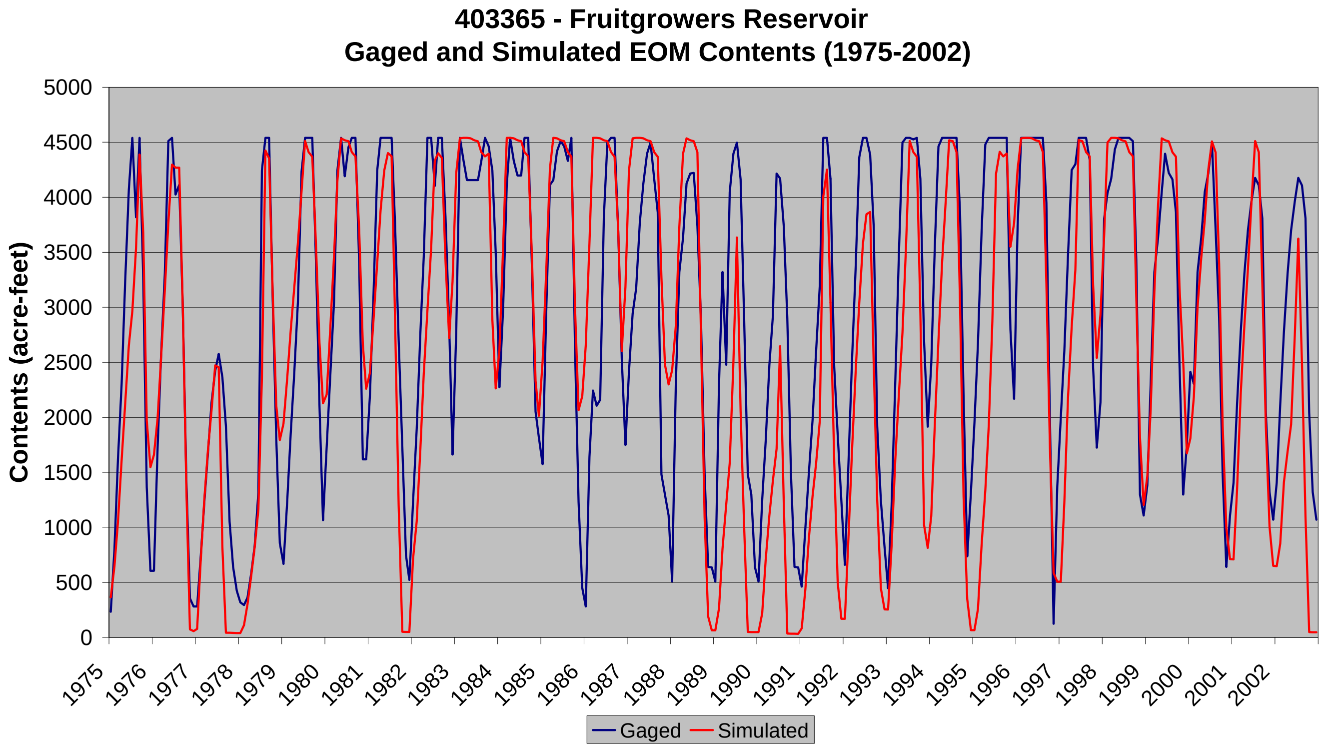



**Figure D.12 Calculated Reservoir Simulation – Fruitgrowers Reservoir**

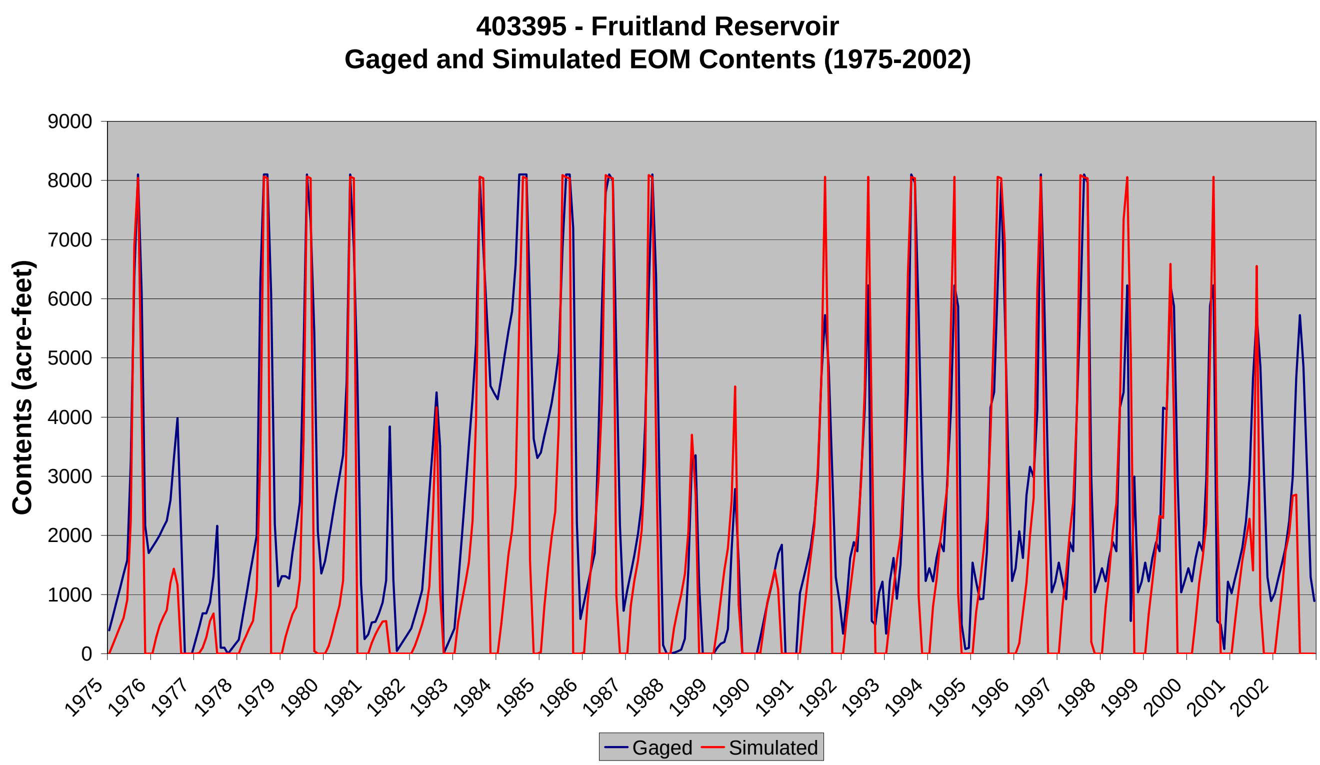



**Figure D.13 Calculated Reservoir Simulation – Fruitland Reservoir**

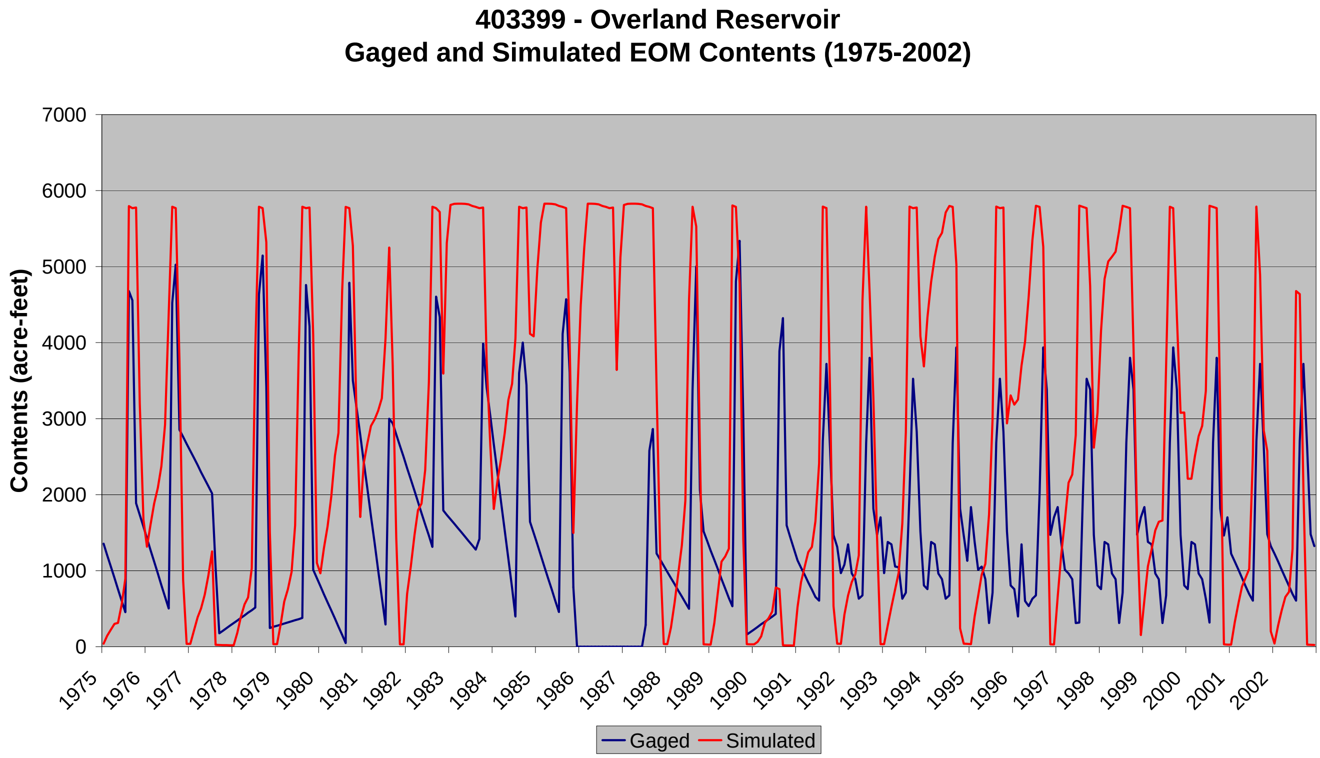



**Figure D.14 Calculated Reservoir Simulation – Overland Reservoir**

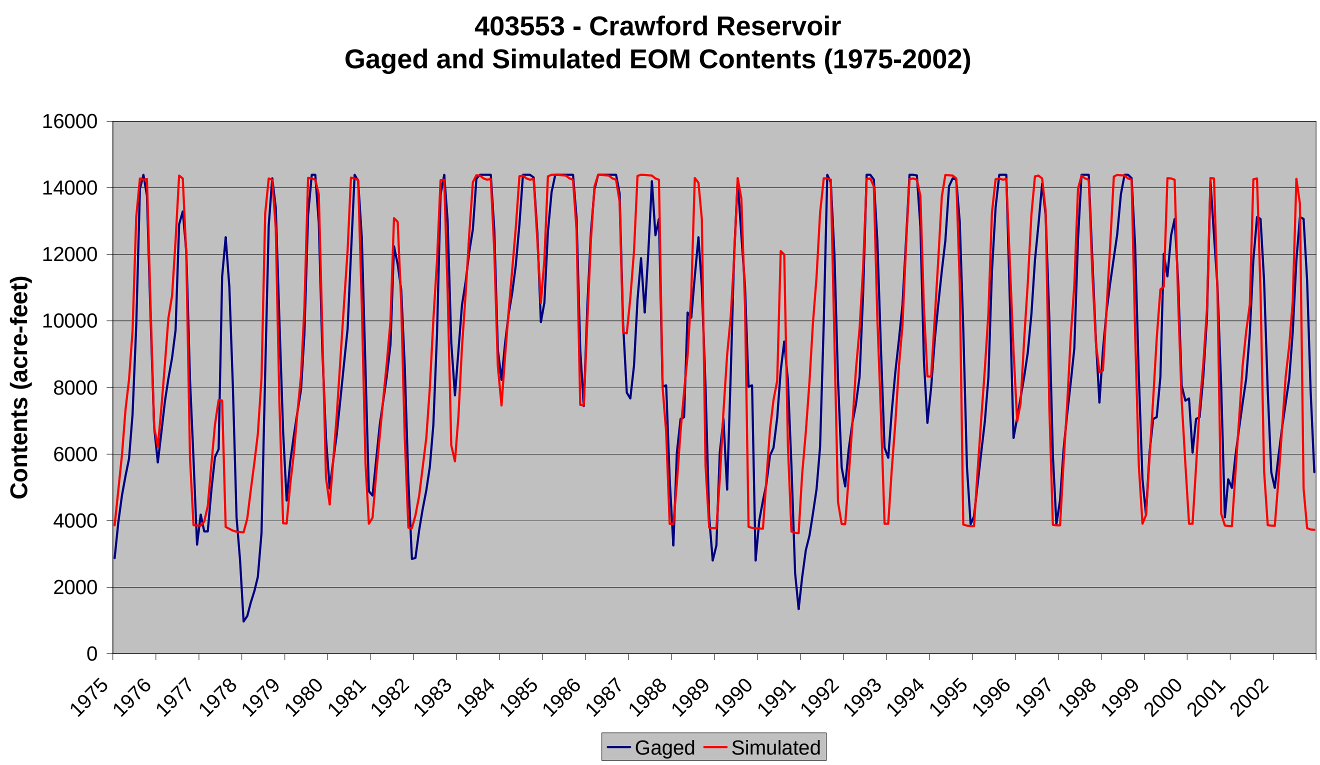



**Figure D.15 Calculated Reservoir Simulation – Crawford Reservoir**

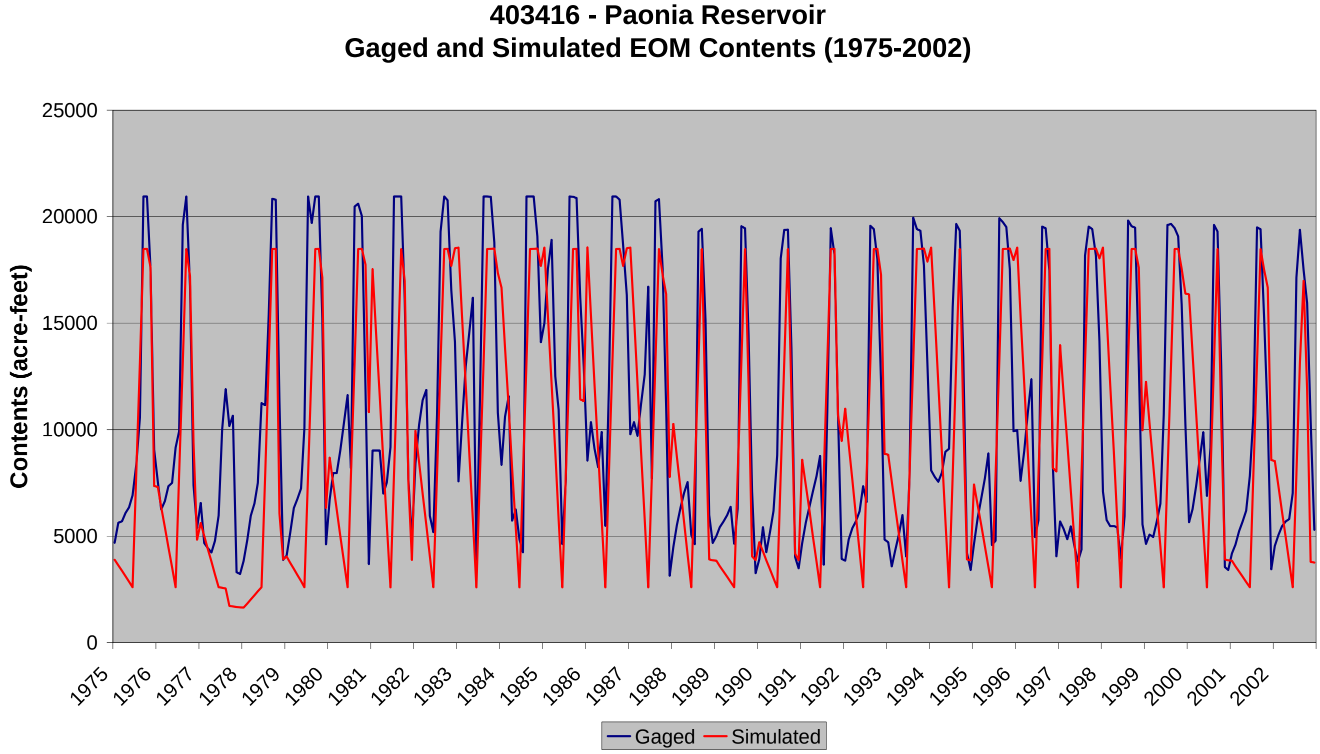



**Figure D.16 Calculated Reservoir Simulation – Paonia Reservoir**

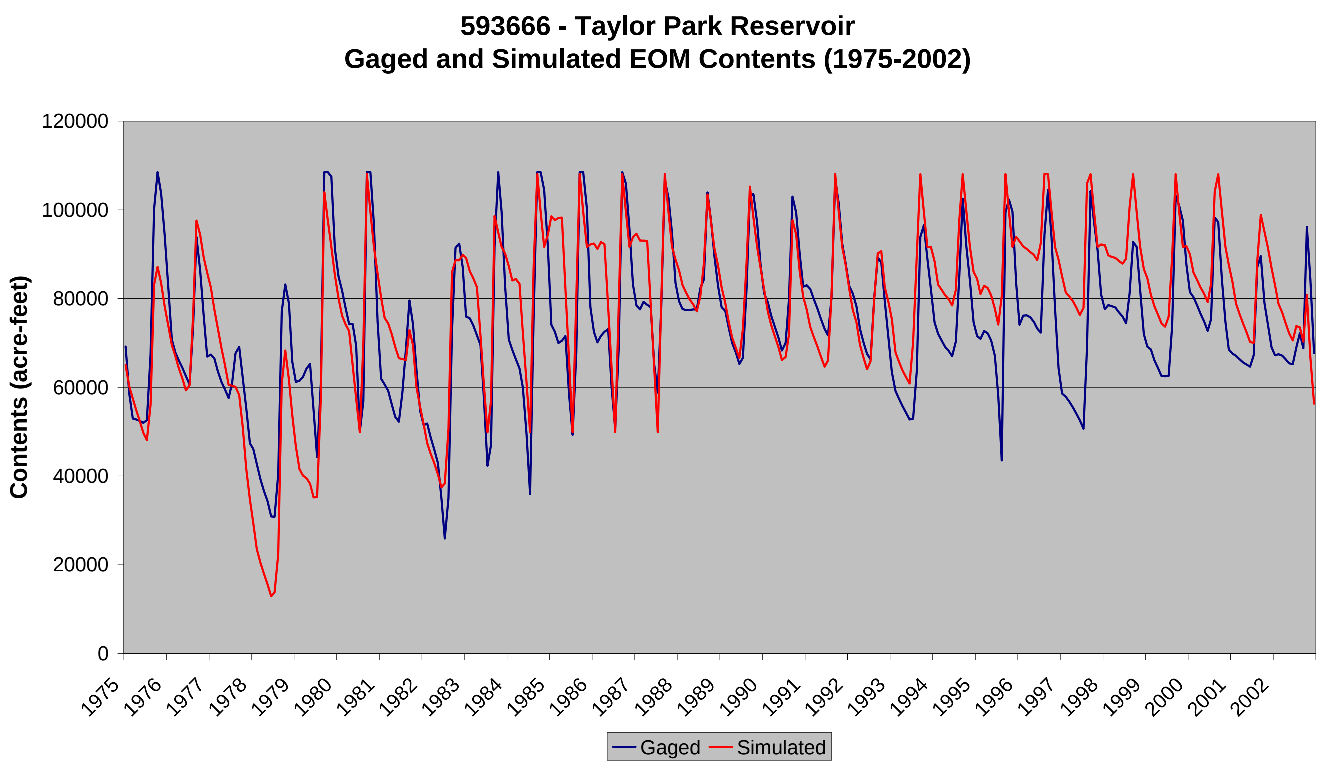



**Figure D.17 Calculated Reservoir Simulation – Taylor Park Reservoir**

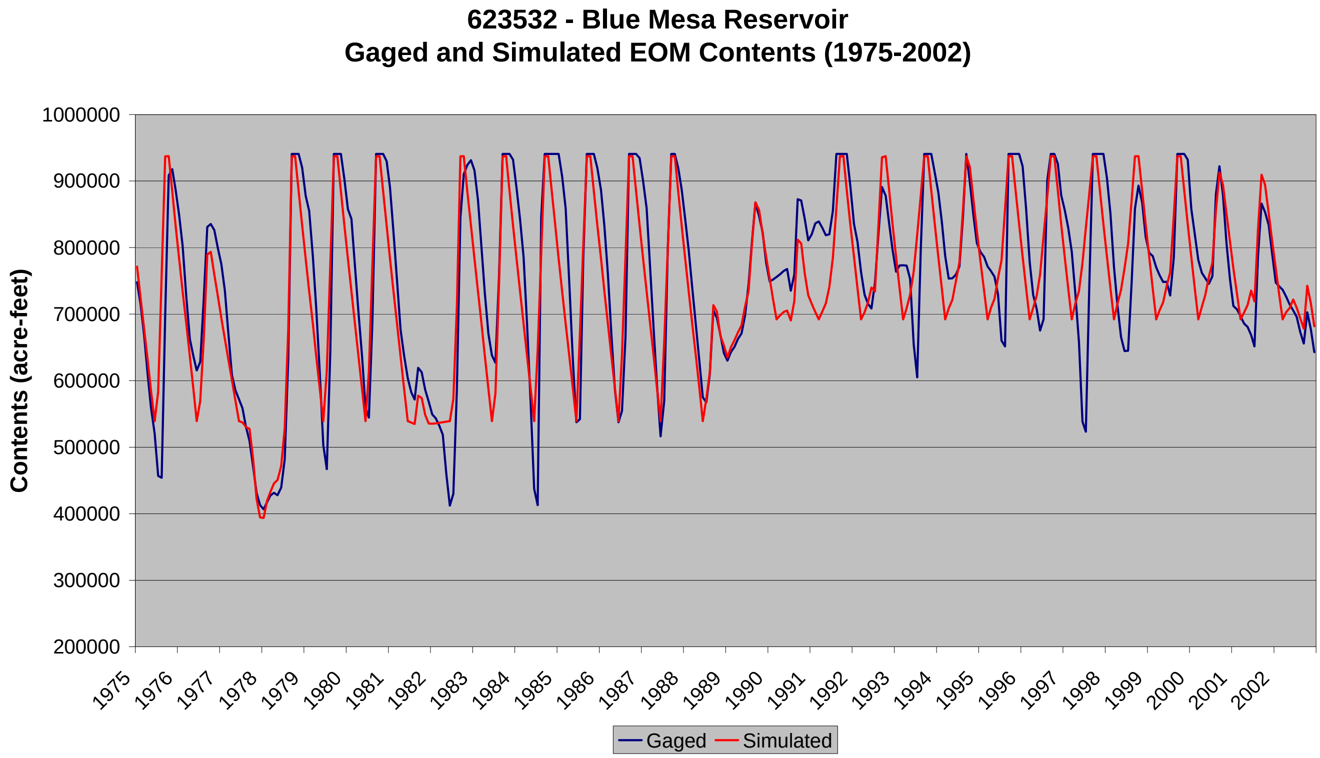



**Figure D.18 Calculated Reservoir Simulation – Blue Mesa Reservoir**

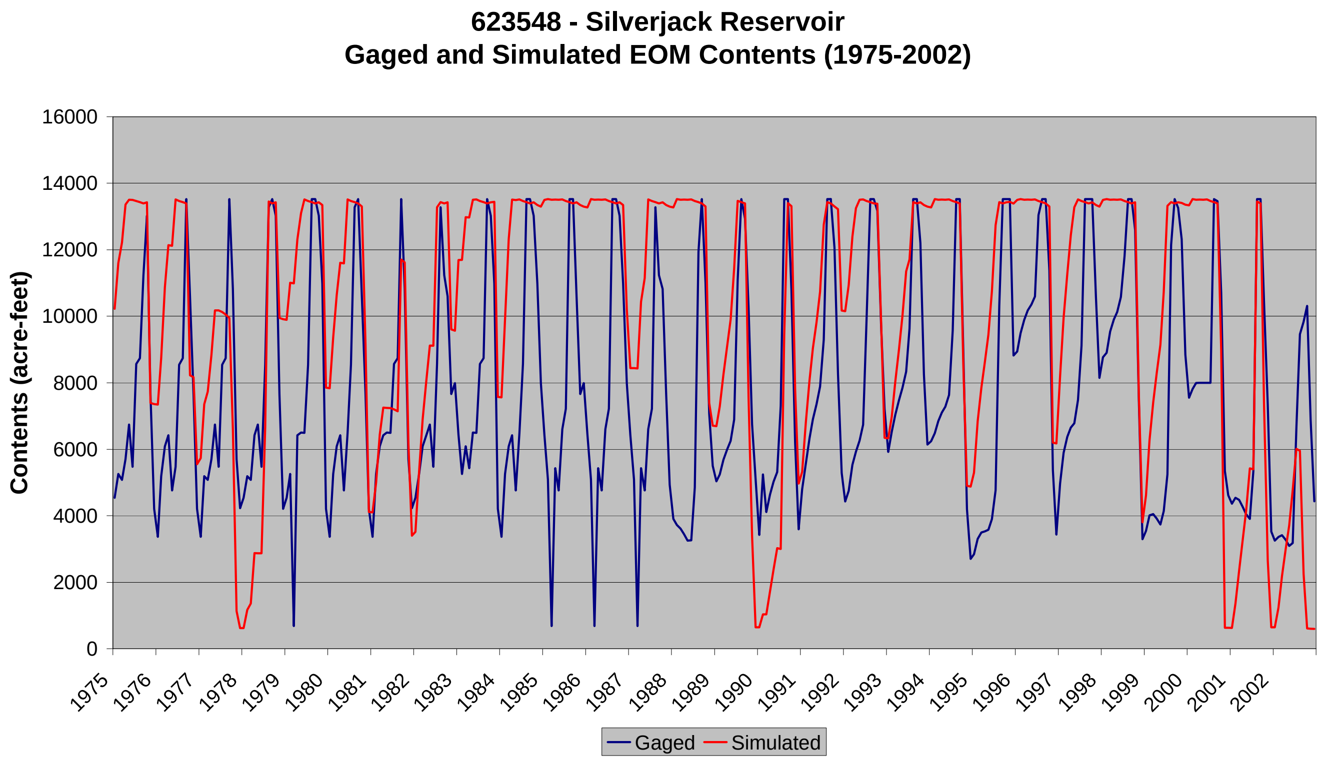



**Figure D.19 Calculated Reservoir Simulation – Silverjack Reservoir**

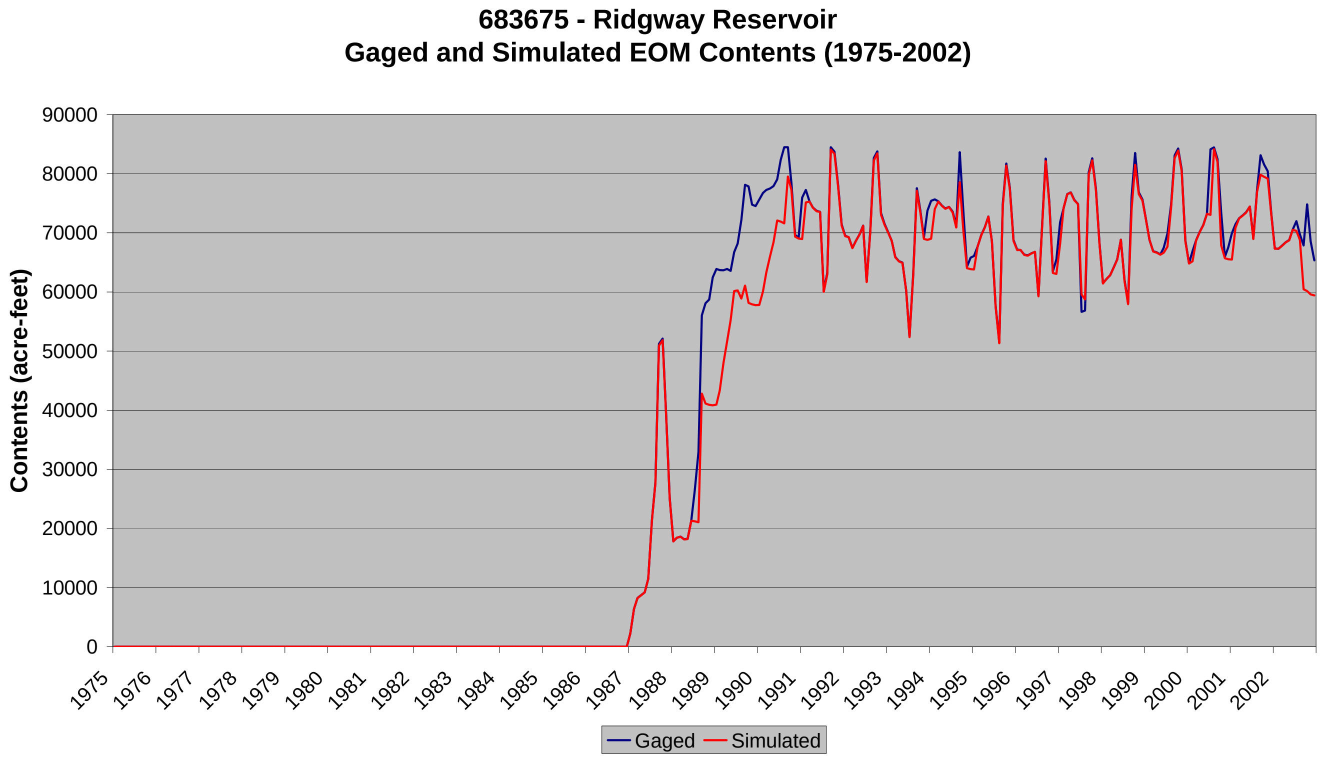



**Figure D.20 Calculated Reservoir Simulation – Ridgway Reservoir**

# Appendix E

## Historical Daily Simulation Results

# Historical Daily Data Set

*Note*: This section describes a Historical Daily Data Set that was completed in July 2004. The monthly Gunnison Model Historical (calibration), Calculated and Baseline data files were updated in October 2009, and the 2009 calibration and Baseline data sets are described in this user manual. Inconsistencies between the 2004 and 2009 Daily Baseline Data Set are minor, and include:

1) extended analysis period through 2005,
2) differences in IWR for fields below 6,500 ft in elevation, because an elevation adjustment was applied to crop coefficients in the Blaney-Criddle analysis in the 2009 model,
3) updated operations for reservoirs in the North Fork Gunnison basin, and
4) inclusion of the final Black Canyon of the Gunnison National Park Service instream flow agreement.

The approach described for the Historical Daily Data Set is accurate, except for the items listed above. Table values in this appendix are expected to be similar to, but not exactly, what would be produced with an updated Historical Daily Data Set.

The "Historical Daily" data set is a data set that was created to run on a daily time-step. The Historical Daily data set simulates the historical demands, infrastructure and projects, and administrative environment. The purpose of the Historical Daily model data set is to capture daily variations in streamflow and call regime. The simulation period for the Historical Daily model is 1975 through 2002. This is the period for which diversion data, and associated irrigation efficiencies, are most complete.

The most difficult part of developing a basin model is understanding the system. By first developing a monthly model, the system operation was investigated without the volume of information ultimately required for a daily model. The Historical Daily model was developed to be able to simulate large and small flow events that occur within a monthly time-step. Therefore, although daily baseflows are used, other terms required for daily analysis, such as diversion demands and reservoir targets, are developed using a simplified approach.

Daily baseflows are estimated using StateMod's Daily Pattern approach. StateMod calculates each day's baseflow by disaggregating monthly baseflows using the daily pattern of flow at selected historical gages. These "pattern gages" are representative of baseflows in subbasins throughout the Gunnison River basin. The selection and use of pattern gages is discussed in Section 8 Historical Daily Results.

## Historical Daily Data Set Calibration Efforts

The Historical Daily data set used existing input from the Historical Calibration data set. No additional calibration efforts were considered necessary for the Historical Daily Gunnison model.

## Historical Daily Simulation Results

Simulation of the Historical Daily Gunnison River model is considered good, with most streamflow gages deviating less than one percent from historical values on an average annual basis. The basinwide shortage, determined to be simulated diversions divided by historical demand, is less than 4 percent per year, on average. Simulated reservoir contents are representative of historical values.

### Water Balance Results

Table E.1 summarizes the water balance for the Historical Daily Gunnison River model, for the calibration period (1975-2002). Following are observations based on the summary table:

- Surface water inflow to the basin averages 2.40 million acre-feet per year, and stream outflow averages 1.88 million acre-feet per year.
- Annual diversions amount to approximately 2.52 million acre-feet on average.
- Approximately 448,000 acre-feet per year is consumed in the Historical Daily simulation. Note that this value is representative of the basin-wide consumptive use and losses, and includes crop consumptive use, municipal and industrial consumptive use, reservoir evaporation, and 100 percent of exports from the basin.
- 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). The small values are due to rounding on a daily basis, and indicate that the model correctly conserves mass.

## Table E.1
## Average Annual Water Balance for Historical Daily Simulation (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 | 90,413 | 166,740 | 755 | 257,907 | 171,974 | 1,882 | 129,554 | -46,250 | 6,018 | -5,264 | 257,915 | -8 | 11,952 |
| NOV | 67,182 | 68,525 | 130 | 135,836 | 49,106 | 717 | 125,017 | -39,125 | 1,163 | -1,033 | 135,844 | -8 | 1,751 |
| DEC | 61,706 | 62,534 | 0 | 124,239 | 51,303 | 273 | 111,555 | -38,890 | 929 | -929 | 124,240 | -1 | 1,155 |
| JAN | 59,552 | 56,821 | 0 | 116,373 | 49,091 | 355 | 81,093 | -14,166 | 764 | -764 | 116,373 | 0 | 1,176 |
| FEB | 56,427 | 49,523 | 0 | 105,950 | 45,914 | 699 | 77,586 | -18,241 | 619 | -619 | 105,959 | -9 | 1,419 |
| MAR | 87,816 | 55,119 | 641 | 143,577 | 53,765 | 1,462 | 100,038 | -12,324 | 589 | 52 | 143,583 | -6 | 3,315 |
| APR | 214,684 | 134,227 | 2,353 | 351,264 | 166,006 | 3,234 | 138,685 | 40,993 | 2,881 | -528 | 351,270 | -6 | 16,373 |
| MAY | 612,543 | 259,547 | 3,679 | 875,770 | 370,617 | 5,368 | 377,298 | 118,813 | 11,160 | -7,480 | 875,775 | -5 | 60,055 |
| JUN | 625,364 | 352,557 | 5,808 | 983,729 | 507,842 | 7,215 | 322,551 | 140,316 | 12,903 | -7,095 | 983,732 | -3 | 106,992 |
| JUL | 291,394 | 342,253 | 10,960 | 644,607 | 458,853 | 6,198 | 181,479 | -12,878 | 6,923 | 4,038 | 644,611 | -4 | 110,207 |
| AUG | 133,796 | 273,112 | 9,878 | 416,785 | 342,195 | 5,151 | 124,456 | -64,890 | 4,830 | 5,048 | 416,790 | -5 | 82,129 |
| SEP | 99,433 | 220,520 | 4,318 | 324,271 | 257,899 | 4,100 | 111,647 | -53,686 | 3,257 | 1,060 | 324,278 | -7 | 45,716 |
| | | | | | | | | | | | | | |
| AVG | 2,400,308 | 2,041,478 | 38,522 | 4,480,309 | 2,524,565 | 36,654 | 1,880,959 | -329 | 52,036 | -13,514 | 4,480,369 | -62 | 442,241 |

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

## Streamflow Results

Table E.2 summarizes the average annual streamflow for water years 1975 through 2002, as estimated in the Historical Daily simulation. 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. Calibration based on streamflow simulation is generally very good in terms of both annual volume and monthly pattern. In general, the daily simulation produces better streamflow calibration on most tributaries than the monthly simulation.

Temporal variability of the Historical Daily simulated flows are illustrated in Figures E.1 through E.27 for three selected years for each of the daily pattern gages and for three downstream gages; Gunnison River below Gunnison Tunnel, Uncompahgre River at Delta, and Gunnison River near Grand Junction. The selected years represent wet (1995), average (1982), and dry (1977) years in the Gunnison Basin. The historical gaged streamflow is shown on these graphs for comparison. As shown, daily simulated streamflow represents the daily large and small flow events that occur within a monthly time-step.

As with the Historical Monthly calibration, streamflow at the gages below Blue Mesa Reservoir (Gunnison River below Gunnison Tunnel and Gunnison River near Grand Junction) represent annual volume, but daily patterns vary from gages. Blue Mesa is modeled using a forecasting curve provided by the USBR that is intended to mimic hydropower operations. It is clear that the rule curve is used only as a guideline by the USBR, and decisions based on other factors drive actual operations. Because of the large volume of water stored and released from the reservoir, relatively small deviations from historic reservoir operations result in large deviations in down stream flow.

In the daily modeling efforts, the release-to-target rule used to mimic hydropower operations uses a monthly storage target. At this time, there appears to be a discrepancy between the releases to this monthly target on the first day of each simulated year (October 1) compared to the releases to this monthly target for the remaining months in the year. This is particularly noticeable downstream of Blue Mesa Reservoir, due to the relatively large amount of monthly target releases. Therefore, as shown on Figures E.7, E.9, E.16, E.25, and E.27, in some years large flows are seen at the downstream gages on October 1. It is important to note that this “spike” flow does not affect overall results or usefulness of the model. It is expected that future StateMod code enhancements will correct this discrepancy.

## Table E.2
## Historical and Simulated Average Annual Streamflow Volumes (1975-2002)
## Historical Daily Simulation (acre-feet/year)

| Gage ID | Historical | Simulated | Historical minus Simulated | | Gage Name |
|---|---|---|---|---|---|
| | | | Volume | Percent | |
| 9109000 | 147,968 | 148,680 | -711 | 0 | Taylor River Below Taylor Park Reservoir |
| 9110000 | 236,375 | 236,812 | -437 | 0 | Taylor River at Almont |
| 9110500 | *No gage during simulation period* | | | 0 | East River Near Crested Butte |
| 9111500 | 98,931 | 98,934 | -3 | 0 | Slate River Near Crested Butte |
| 9112000 | *No gage during simulation period* | | | 0 | Cement Creek Near Crested Butte |
| 9112200 | 231,532 | 231,756 | -224 | 0 | East River Below Cement Creek Near Crested Butte |
| 9112500 | 238,733 | 237,404 | 1,328 | 1 | East River at Almont |
| 9113300 | *No gage during simulation period* | | | 0 | Ohio Creek at Baldwin |
| 9113500 | 56,954 | 56,759 | 195 | 0 | Ohio Creek Near Baldwin |
| 9114500 | 529,302 | 526,348 | 2,954 | 1 | Gunnison River Near Gunnison |
| 9115500 | 45,797 | 46,087 | -290 | -1 | Tomichi Creek at Sargents |
| 9118000 | *No gage during simulation period* | | | 0 | Quartz Creek Near Ohio City |
| 9118450 | 33,105 | 33,062 | 43 | 0 | Cochetopa Creek Below Rock Creek Near Parlin |
| 9119000 | 127,952 | 126,558 | 1,395 | 1 | Tomichi Creek at Gunnison |
| 9121500 | *No gage during simulation period* | | | 0 | Cebolla Creek Near Lake City |
| 9121800 | *No gage during simulation period* | | | 0 | Cebolla Creek Near Powderhorn |
| 9122000 | *No gage during simulation period* | | | 0 | Cebolla Creek at Powderhorn |
| 9124500 | 167,999 | 167,912 | 87 | 0 | Lake Fork at Gateview |
| 9126000 | 70,457 | 71,319 | -862 | -1 | Cimarron River Near Cimarron |
| 9126500 | *No gage during simulation period* | | | 0 | Cimarron River at Cimarron |
| 9127500 | *No gage during simulation period* | | | 0 | Crystal Creek Near Maher |
| 9128000 | 888,915 | 882,372 | 6,543 | 1 | Gunnison River Below Gunnison Tunnel |
| 9128500 | 33,416 | 34,873 | -1,457 | -4 | Smith Fork Near Crawford |
| 9129600 | 28,116 | 29,740 | -1,624 | -6 | Smith Fork Near Lazear |
| 9130500 | *No gage during simulation period* | | | 0 | East Muddy Creek Near Bardine |
| 9131200 | *No gage during simulation period* | | | 0 | West Muddy Creek Near Somerset |
| 9132500 | 352,863 | 353,143 | -280 | 0 | North Fork Gunnison River Near Somerset |
| 9134000 | 15,138 | 15,421 | -283 | -2 | Minnesota Creek Near Paonia |
| 9134050 | 10,181 | 10,415 | -234 | -2 | Minnesota Creek at Paonia |
| 9134500 | *No gage during simulation period* | | | 0 | Leroux Creek Near Cedaredge |

| Gage ID | Historical | Simulated | Historical minus Simulated Volume | Historical minus Simulated Percent | Gage Name |
|---|---|---|---|---|---|
| 9135900 | 20,892 | 23,132 | -2,240 | -11 | Leroux Creek at Hotchkiss |
| 9136200 | 1,446,348 | 1,441,457 | 4,891 | 0 | Gunnison River Near Lazear |
| 9137050 | 10,560 | 11,329 | -769 | -7 | Currant Creek Near Read |
| 9137800 | *No gage during simulation period* | | | 0 | Dirty George Creek Near Grand Mesa |
| 9139200 | *No gage during simulation period* | | | 0 | Ward Creek Near Grand Mesa |
| 9141500 | *No gage during simulation period* | | | 0 | Youngs Creek Near Cedaredge |
| 9143000 | 32,964 | 32,964 | -1 | 0 | Surface Creek Near Cedaredge |
| 9143500 | 22,602 | 24,948 | -2,346 | -10 | Surface Creek at Cedaredge |
| 9144200 | 52,622 | 55,993 | -3,371 | -6 | Tongue Creek at Cory |
| 9144250 | 1,501,545 | 1,479,042 | 22,503 | 1 | Gunnison River at Delta |
| 9146200 | 121,827 | 121,616 | 211 | 0 | Uncompahgre River Near Ridgway |
| 9146400 | *No gage during simulation period* | | | 0 | West Fork Dallas Creek Near Ridgway |
| 9146500 | *No gage during simulation period* | | | 0 | East Fork Dallas Creek Near Ridgway |
| 9146550 | *No gage during simulation period* | | | 0 | Beaver Creek Near Ridgway |
| 9147000 | 29,636 | 29,671 | -34 | 0 | Dallas Creek Near Ridgway |
| 9147100 | *No gage during simulation period* | | | 0 | Cow Creek Near Ridgway |
| 9147500 | 192,969 | 191,565 | 1,404 | 1 | Uncompahgre River at Colona |
| 9149420 | 39,882 | 39,882 | 0 | 0 | Spring Creek Near Montrose |
| 9149500 | 236,296 | 243,294 | -6,998 | -3 | Uncompahgre River at Delta |
| 9150500 | 88,628 | 88,639 | -10 | 0 | Roubideau Creek at Mouth, Near Delta |
| 9152000 | 17,377 | 18,256 | -879 | -5 | Kannah Creek Near Whitewater |
| 9152500 | 1,910,511 | 1,889,226 | 21,285 | 1 | Gunnison River Near Grand Junction |

## Diversion Results

Table E.3 summarizes the average annual simulated diversions, by tributary or sub-basin, compared to historical diversions for water years 1975 through 2002. On a basin-wide basis, average annual diversions differ from historical diversions by about 3.5 percent in the daily calibration run. The tributaries showing the greatest simulated variance from historical diversions are also the problematic tributaries in the monthly Historical simulation. Basin-wide diversions are shorted by about 2 percent more when simulated using a daily time-step.

**Table E.3**
**Historical and Simulated Average Annual Diversions by Sub-basin (1975-2002)**
**Historical Daily Simulation (acre-feet/year)**

| Tributary or Sub-basin | Historical | Simulated | Historical minus Simulated | |
|---|---|---|---|---|
| | | | Volume | Percent |
| Taylor River | 9,264 | 8,916 | 348 | 4% |
| East River | 103,025 | 93,460 | 9,565 | 9% |
| Ohio Creek | 47,065 | 45,398 | 1,667 | 4% |
| Tomichi Creek | 198,034 | 178,434 | 19,600 | 10% |
| Cebolla Creek, Lake Fork, and Cimarron River | 70,891 | 68,281 | 2,610 | 4% |
| Crystal River | 19,688 | 17,521 | 2,167 | 11% |
| Smith Fork | 69,108 | 68,880 | 228 | 0% |
| N.F. Gunnison River | 168,663 | 160,913 | 7,750 | 5% |
| Currant Creek | 20,626 | 16,295 | 4,331 | 21% |
| Surface Creek | 77,987 | 67,590 | 10,397 | 13% |
| Uncompahgre River | 761,681 | 734,894 | 26,787 | 4% |
| Roubideau Creek | 2,942 | 2,904 | 38 | 1% |
| Kannah Creek | 16,700 | 14,770 | 1,930 | 12% |
| Gunnison River Mainstem | 1,074,732 | 1,069,478 | 5,254 | 0% |
| Basin Total | 2,640,406 | 2,547,734 | 92,672 | 3.5% |

## Reservoir Results

Figures E.29 through E.35 (located at the end of this chapter) present reservoir EOM contents estimated by the Historical Daily model simulation compared to historical observations at selected reservoirs. Simulated reservoir end-of-month contents using a daily time-step are very close to simulations using a monthly time-step. The issues identified in Section 7.4.4 are valid on a daily time-step.

## Consumptive Use 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 also includes consumptive use for municipal and industrial diversions. 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, the StateMod structure summary file (*.xss) results were “filtered” to only include the structures in the StateCU analysis.

Table E.4 shows the comparison of StateCU estimated crop consumptive use compared to StateMod estimate of crop consumptive use for explicit structures, aggregate structures, and basin total. 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 4.6 percent difference is close to the overall basin diversion shortages simulated by the model.

**Table E.4**
**Average Annual Crop Consumptive Use Comparison (1975-2002)**

| Comparison | StateCU Results (af/yr) | Calibration Run Results (af/yr) | % Difference |
|---|---|---|---|
| Explicit Structures | 318,883 | 304,038 | 4.66 |
| Aggregate Structures | 92,167 | 87,946 | 4.58 |
| Basin Total | 411,050 | 391,984 | 4.64 |

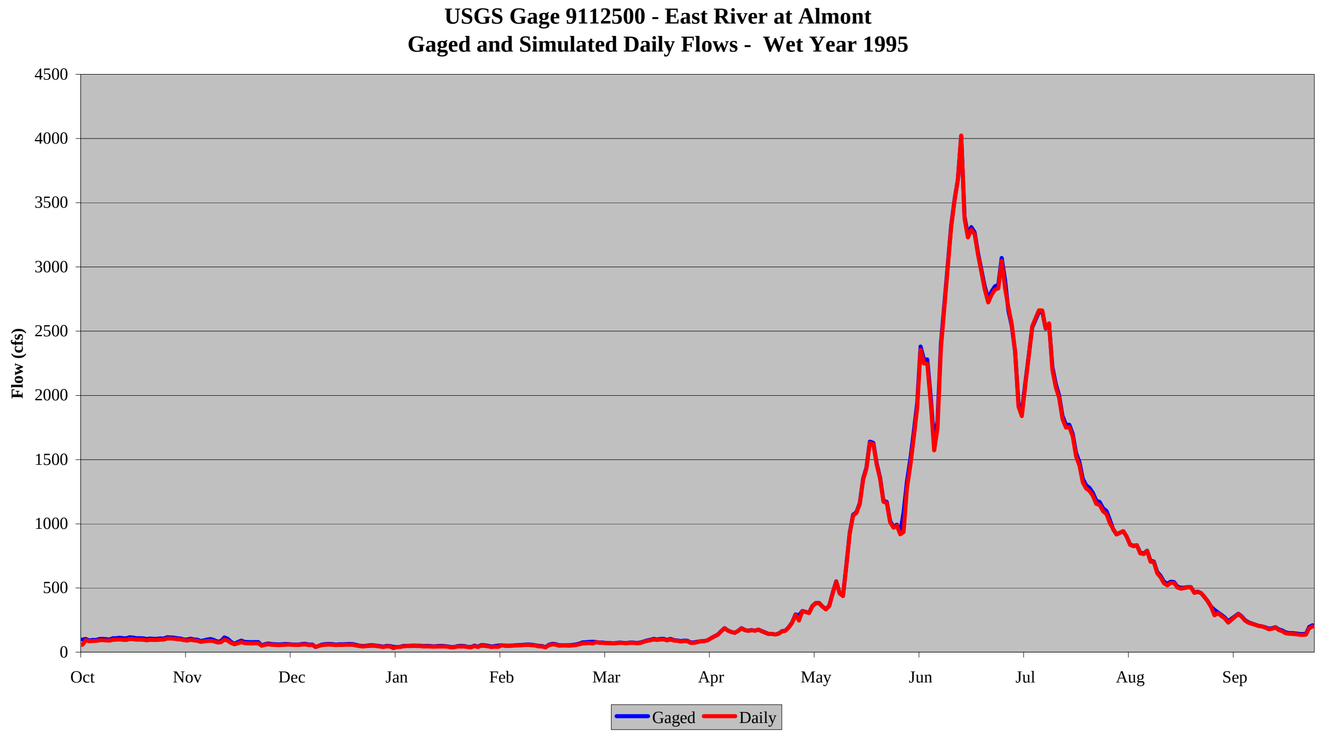



**Figure E.1 Historical Daily Comparison, Wet Year – East River at Almont**

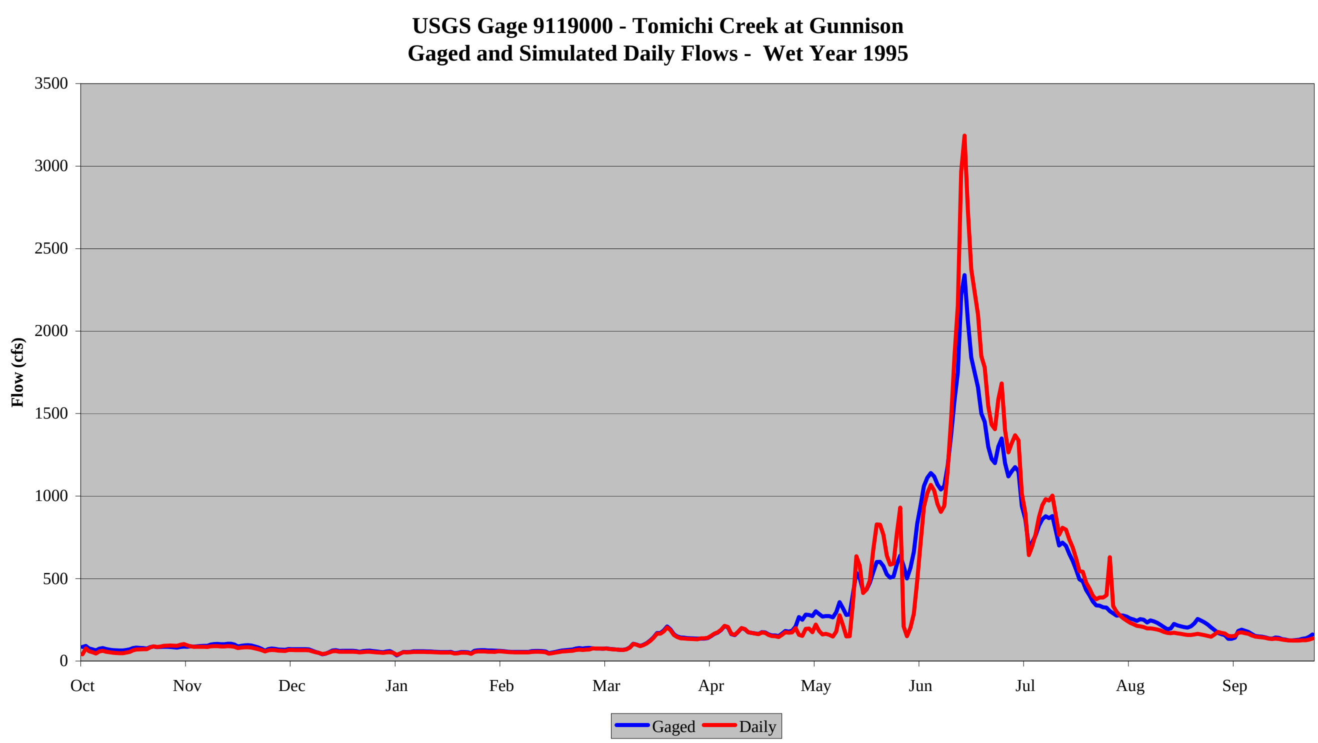



**Figure E.2 Historical Daily Comparison, Wet Year – Tomichi Creek at Gunnison**

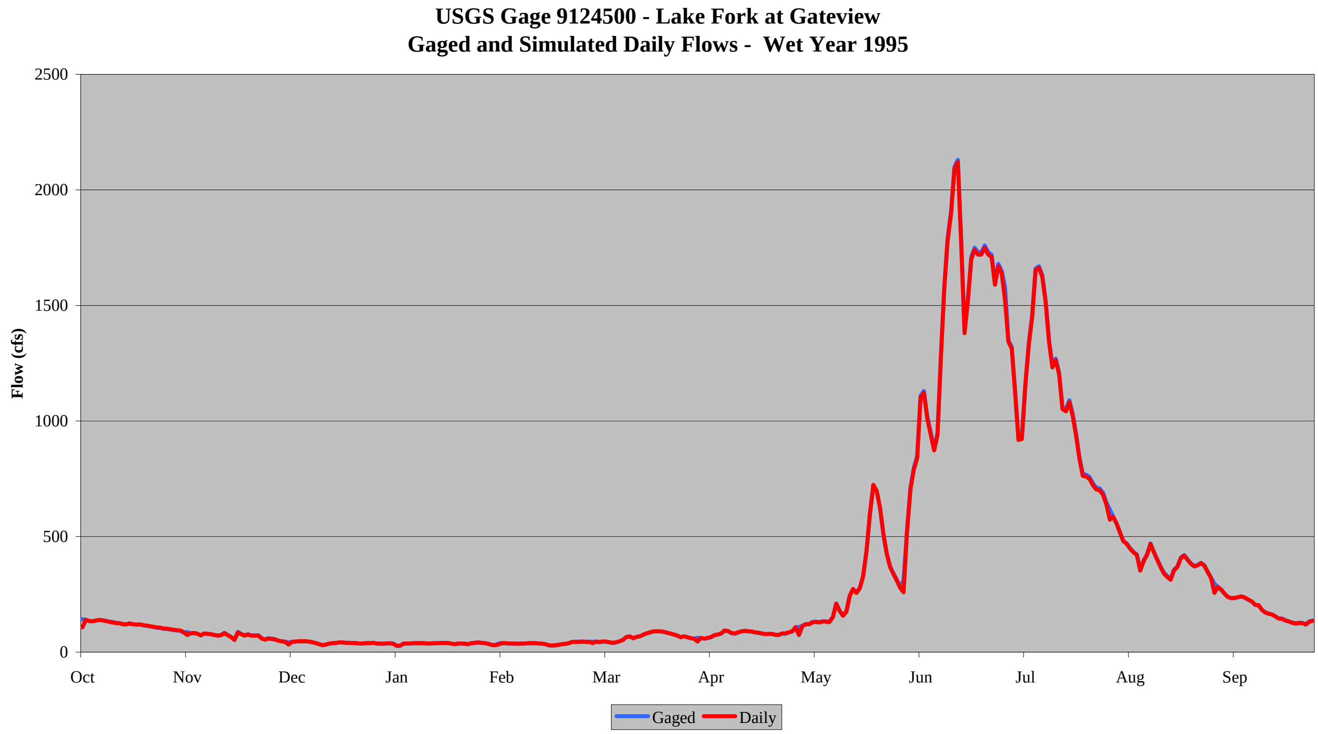



**Figure E.3 Historical Daily Comparison, Wet Year – Lake Fork at Gateview**

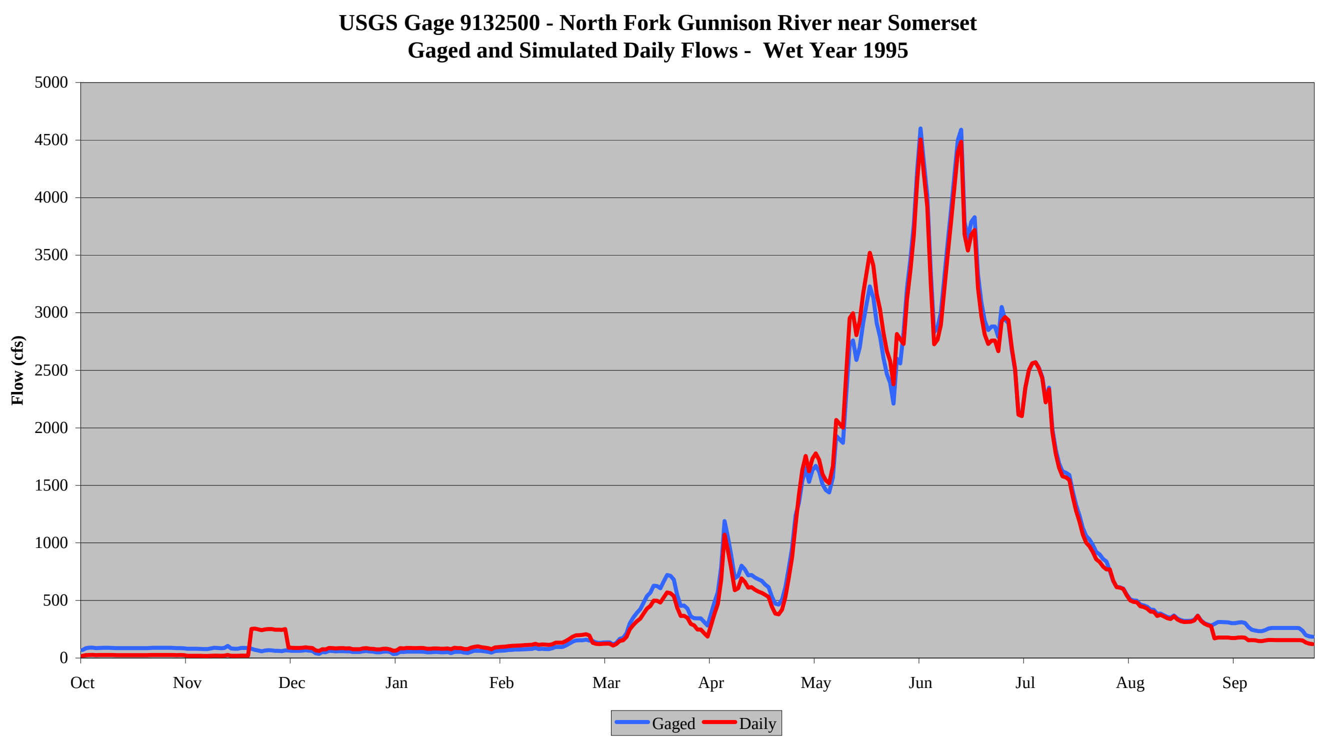
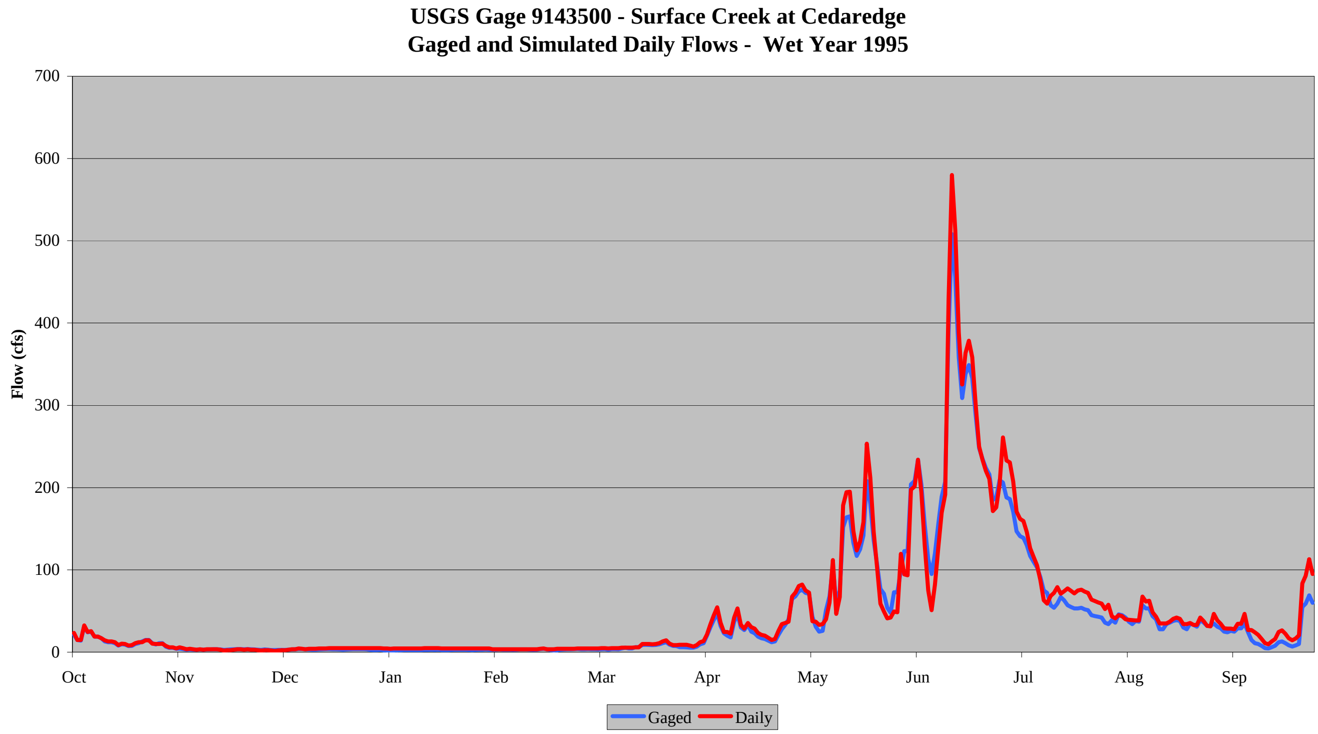
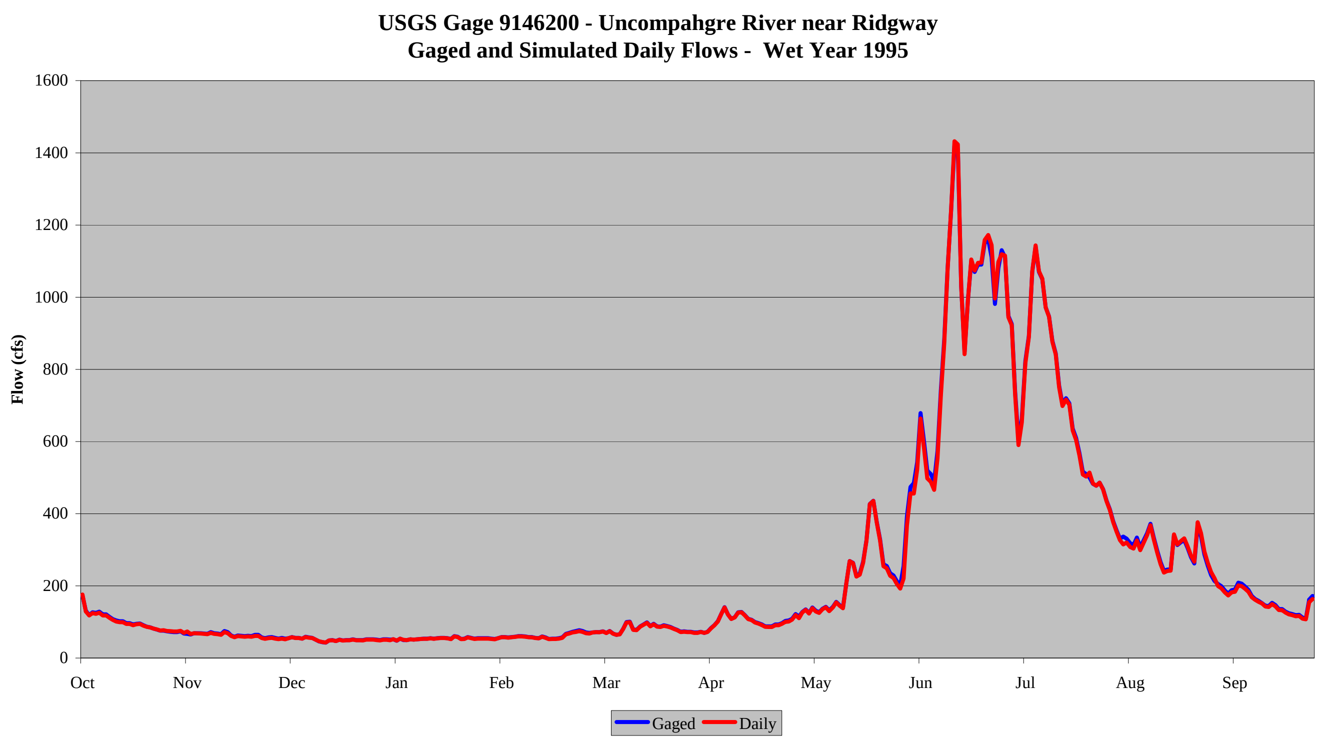



**Figure E.4 Historical Daily Comparison, Wet Year – North Fork Gunnison River near Somerset**




# Figure E.5 Historical Daily Comparison, Wet Year – Surface Creek at Cedaredge




# Figure E.6 Historical Daily Comparison, Wet Year – Uncompahgre River near Ridgway

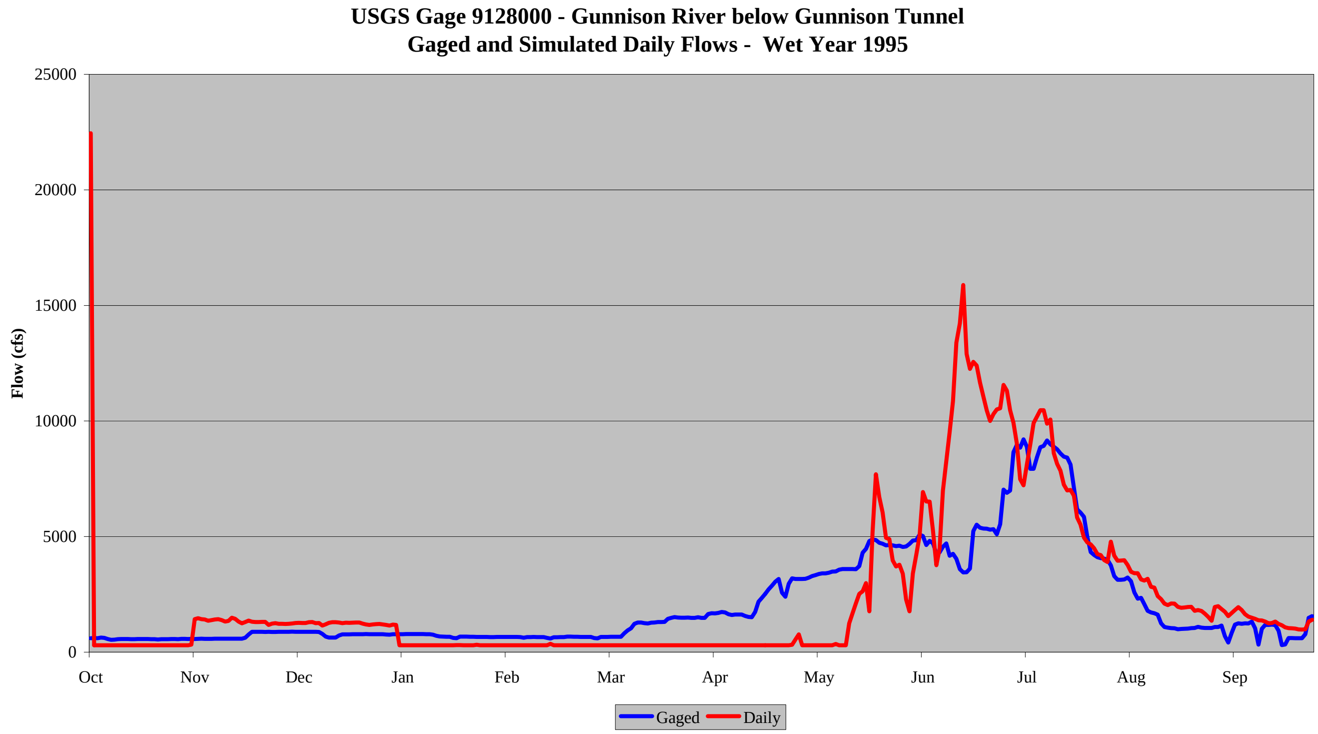



**Figure E.7 Historical Daily Comparison, Wet Year – Gunnison River below Gunnison Tunnel**

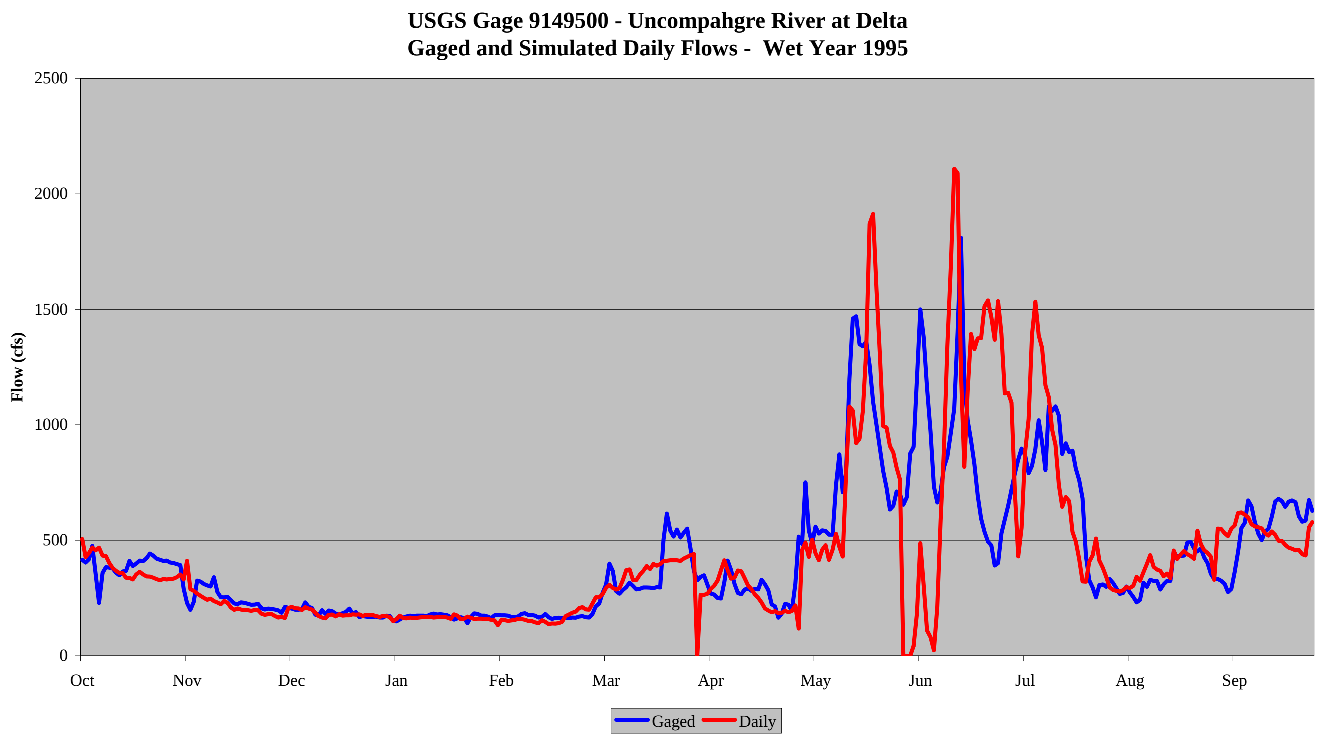



**Figure E.8 Historical Daily Comparison, Wet Year – Uncompahgre River at Delta**

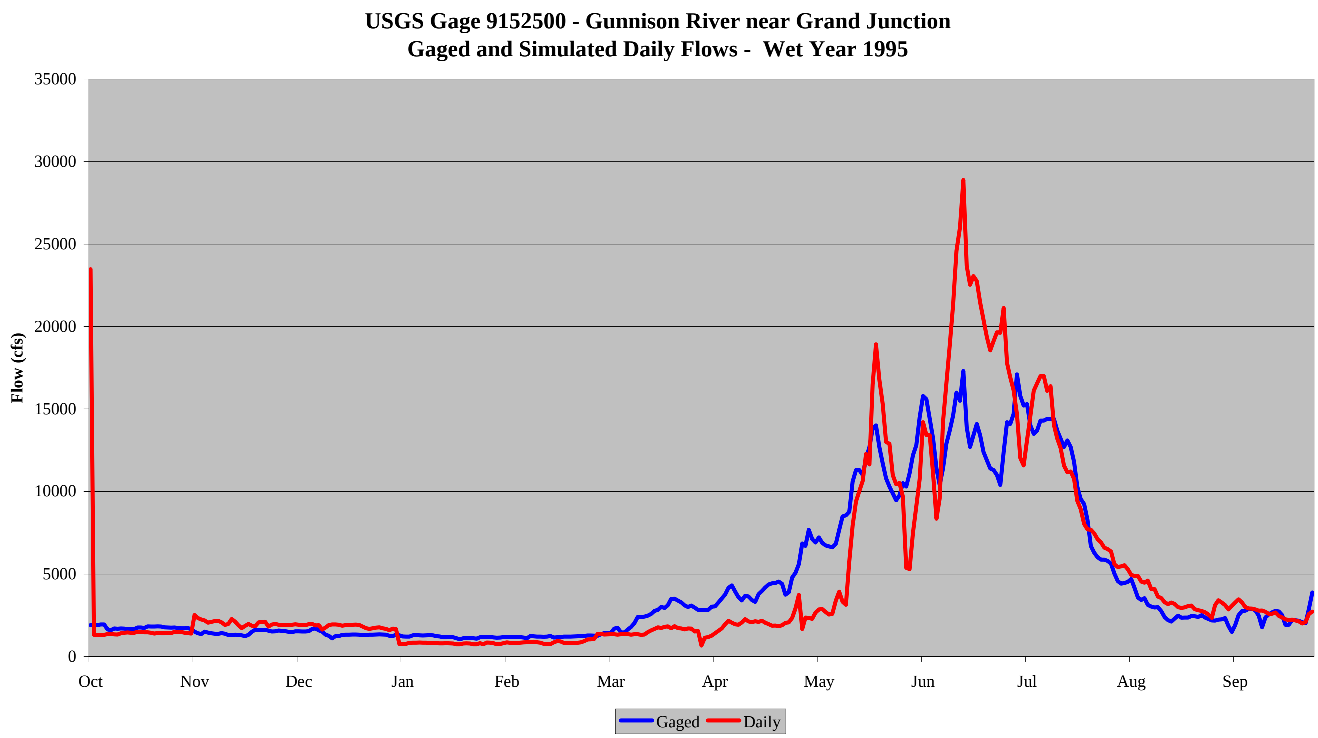



**Figure E.9 Historical Daily Comparison, Wet Year – Gunnison River near Grand Junction**

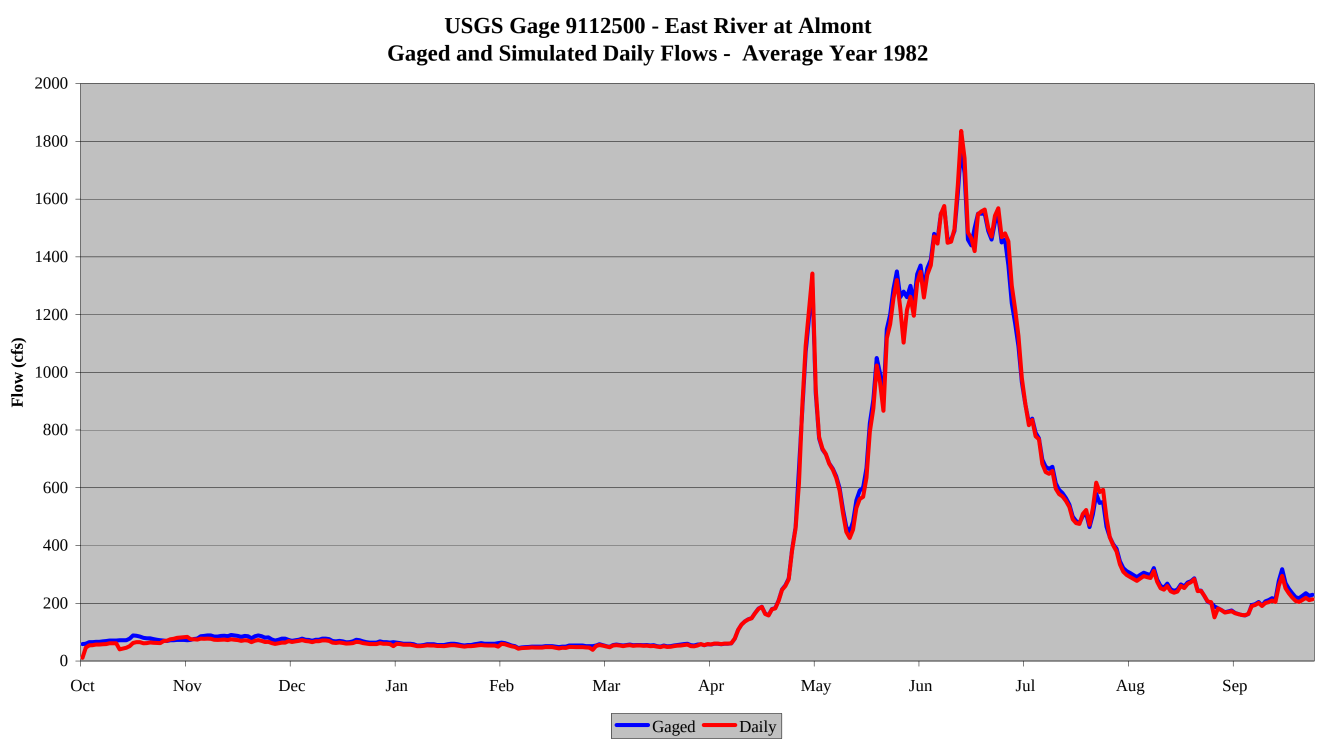



**Figure E.10 Historical Daily Comparison, Average Year – East River at Almont**

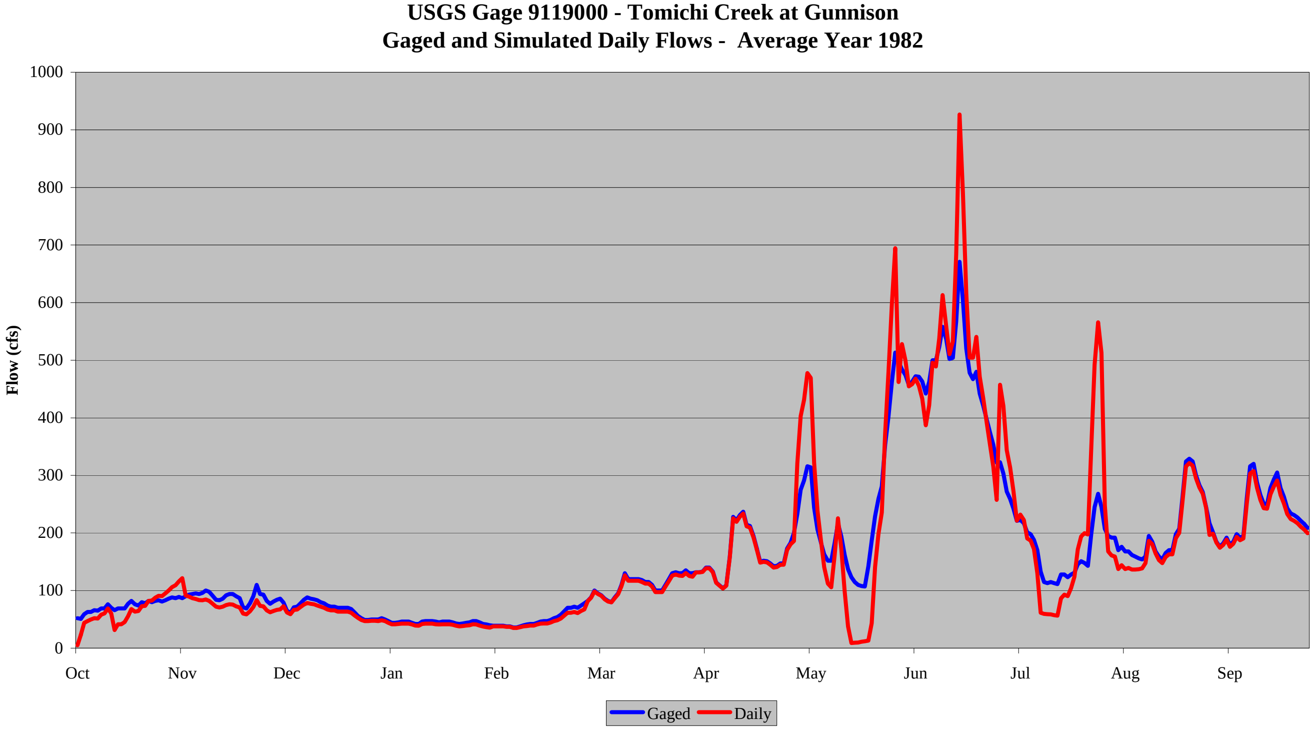



**Figure E.11 Historical Daily Comparison, Average Year – Tomichi Creek at Gunnison**

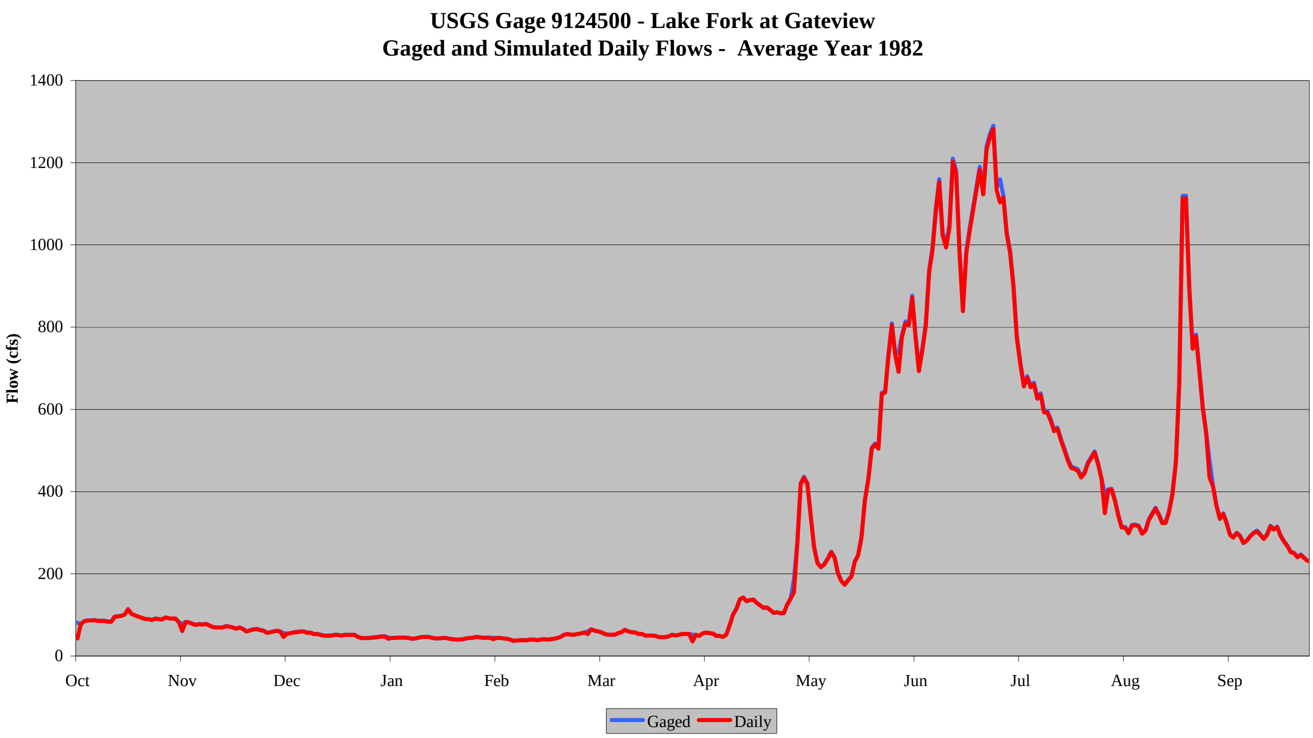



**Figure E.12 Historical Daily Comparison, Average Year – Lake Fork at Gateview**

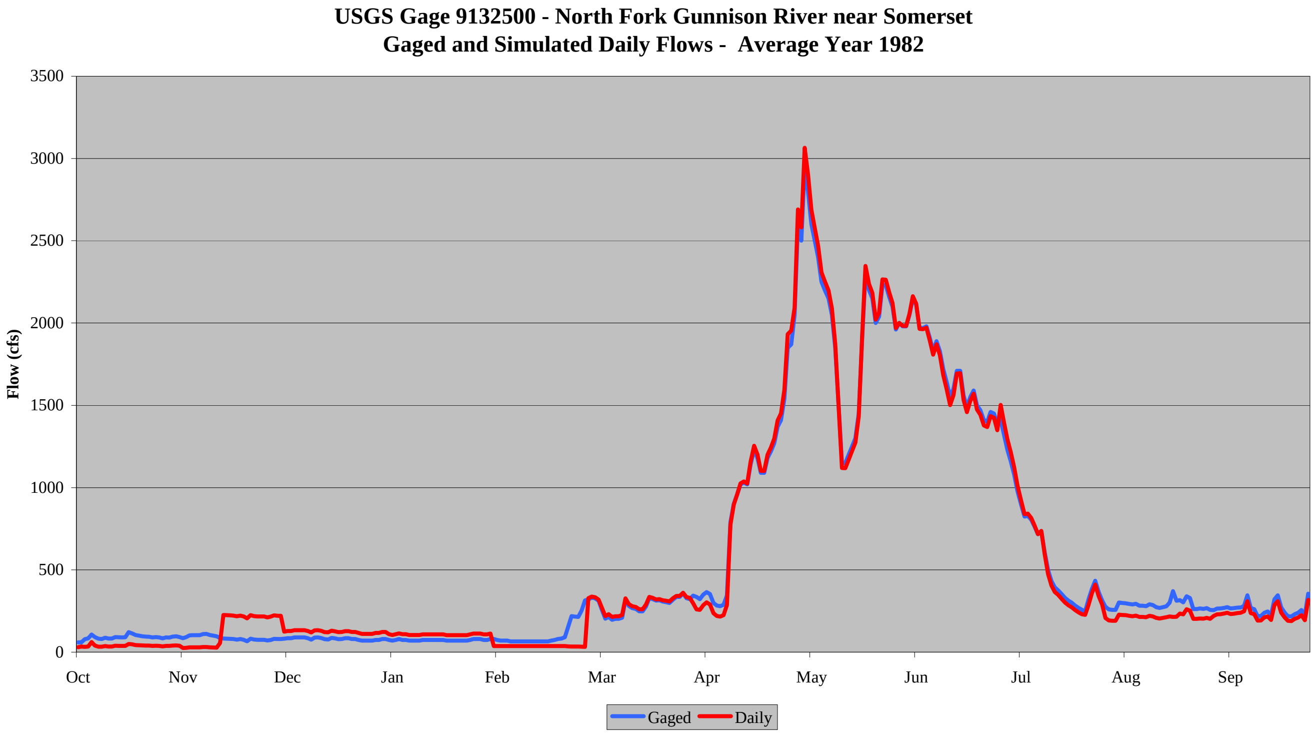



**Figure E.13 Historical Daily Comparison, Average Year – N. Fork Gunnison River nr Somerset**

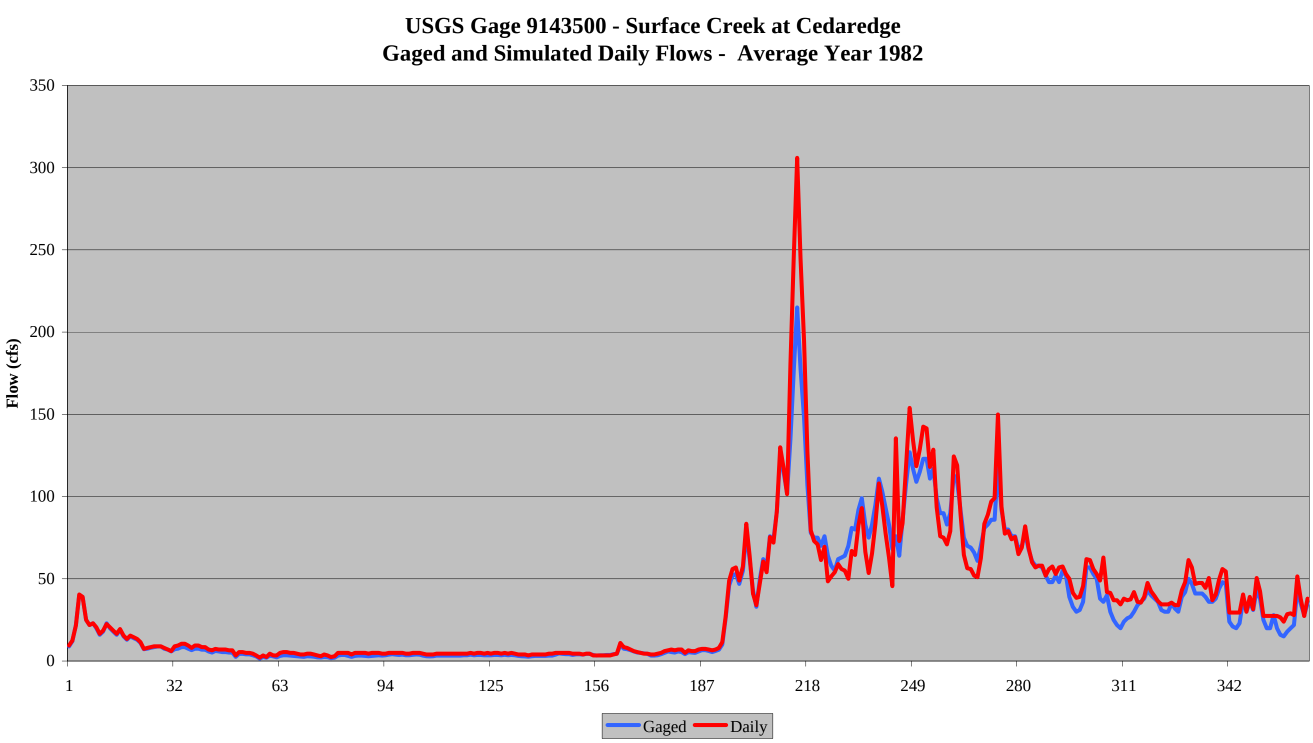



**Figure E.14 Historical Daily Comparison, Average Year – Surface Creek at Cedaredge**

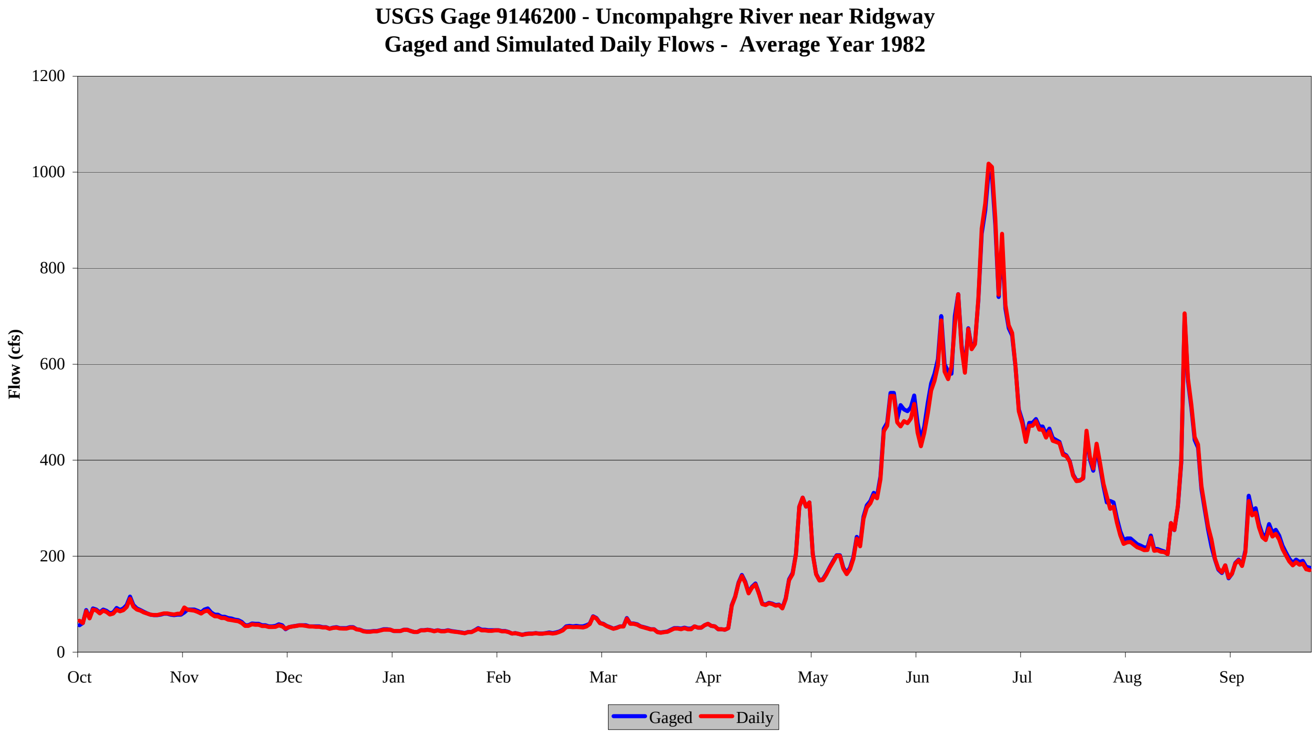



**Figure E.15 Historical Daily Comparison, Average Year – Uncompahgre River near Ridgway**

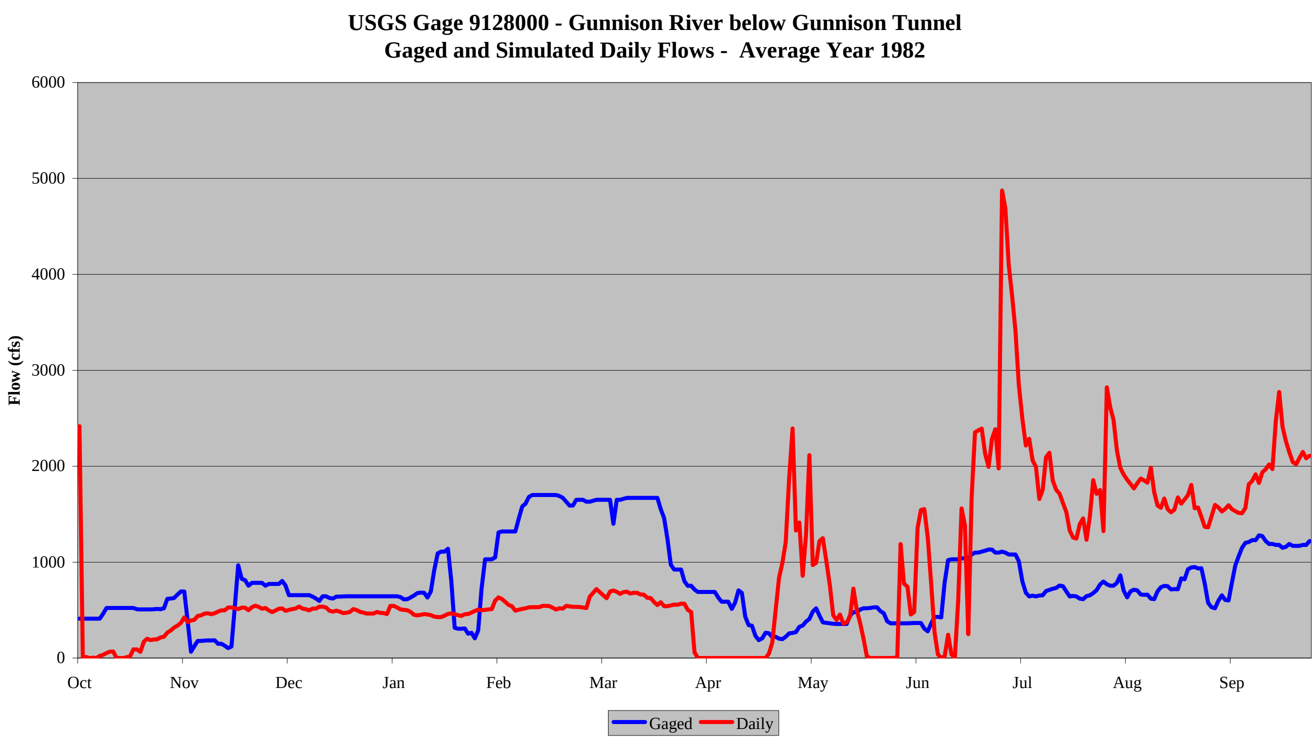



**Figure E.16 Historical Daily Comparison, Average Year – Gunnison River bl Gunnison Tunnel**

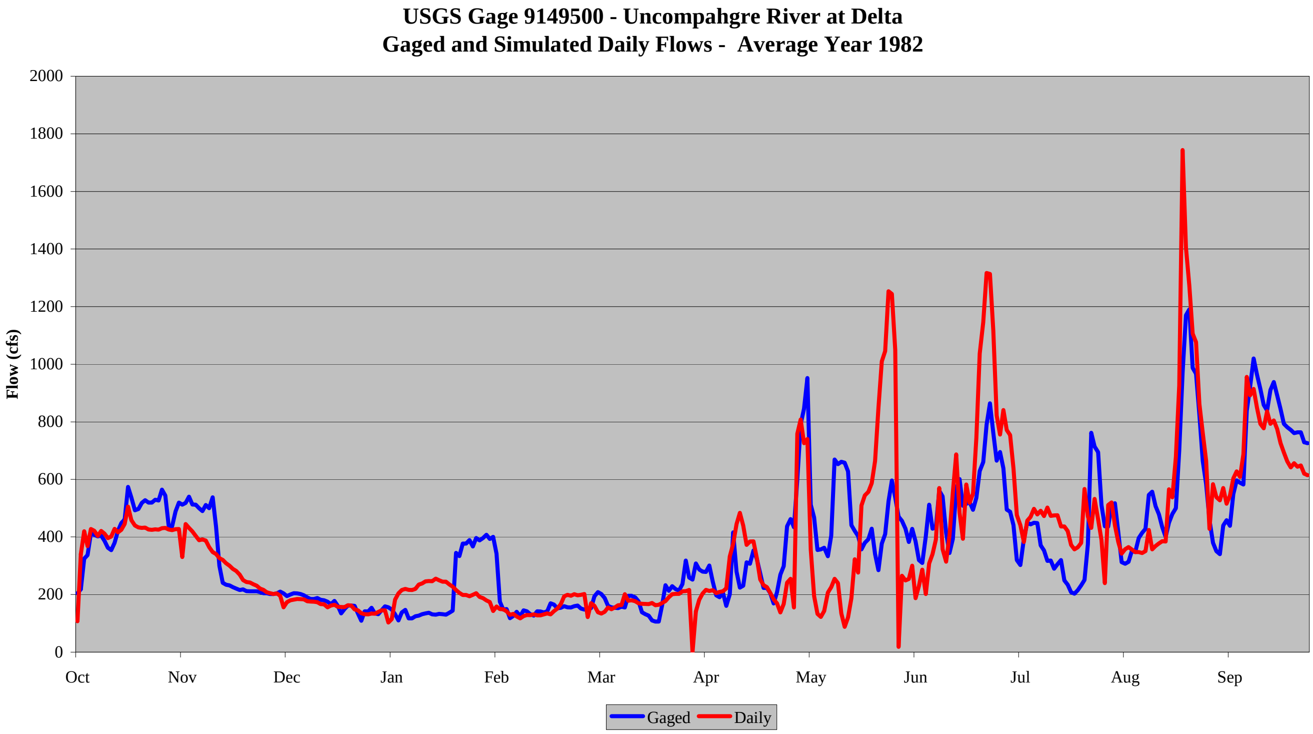



**Figure E.17 Historical Daily Comparison, Average Year – Uncompahgre River at Delta**

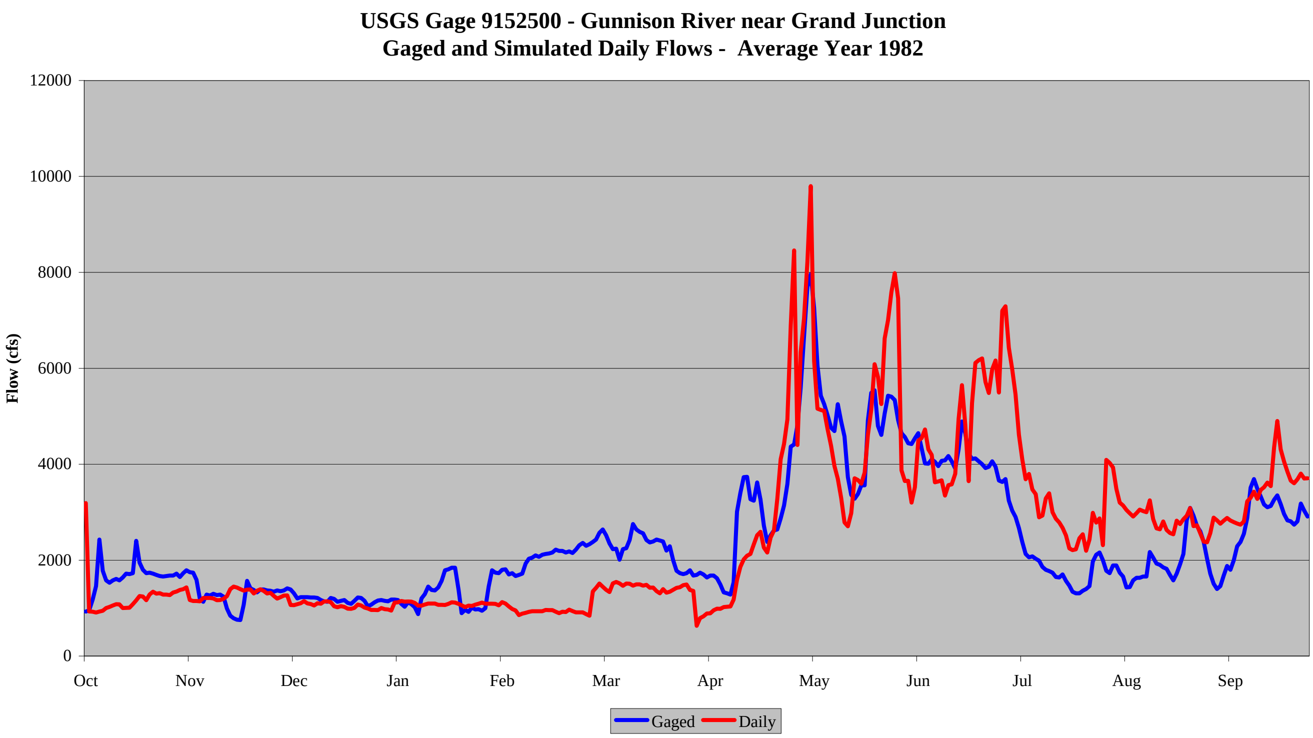



**Figure E.18 Historical Daily Comparison, Average Year – Gunnison River near Grand Junction**

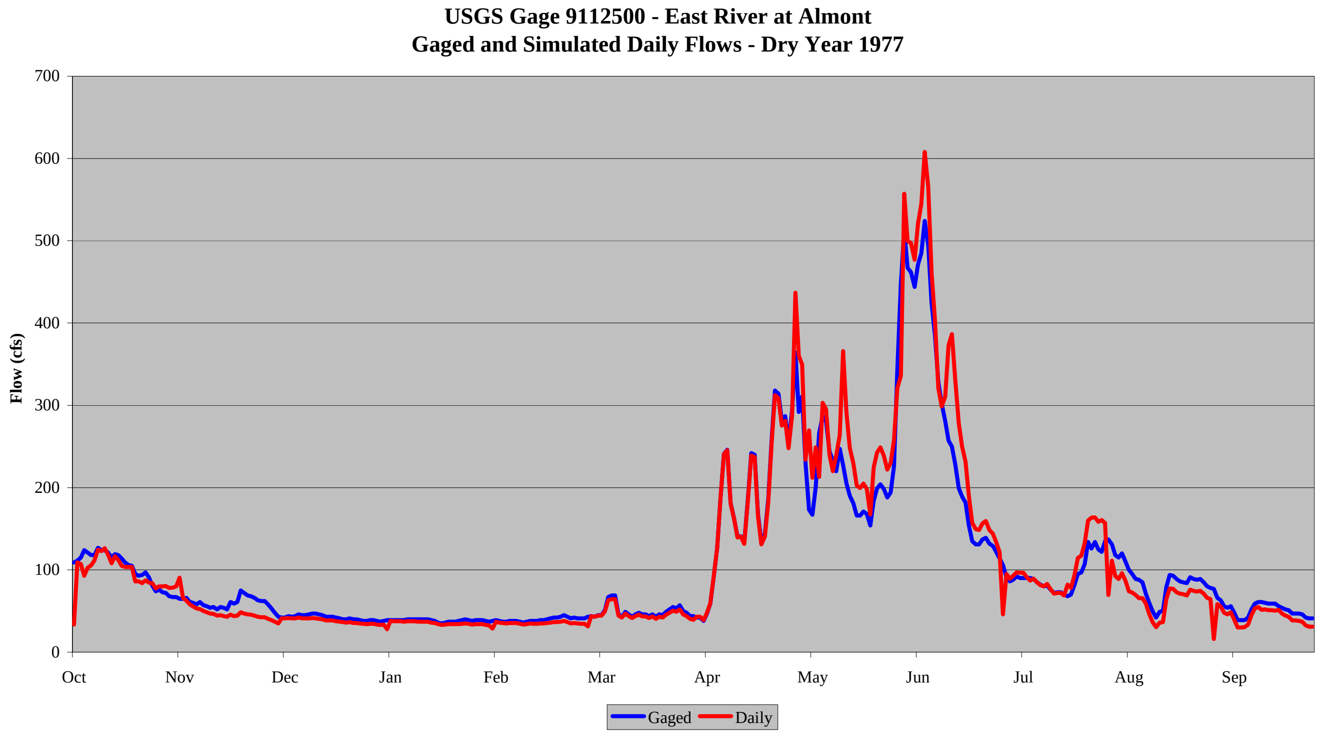



**Figure E.19 Historical Daily Comparison, Dry Year – East River at Almont**

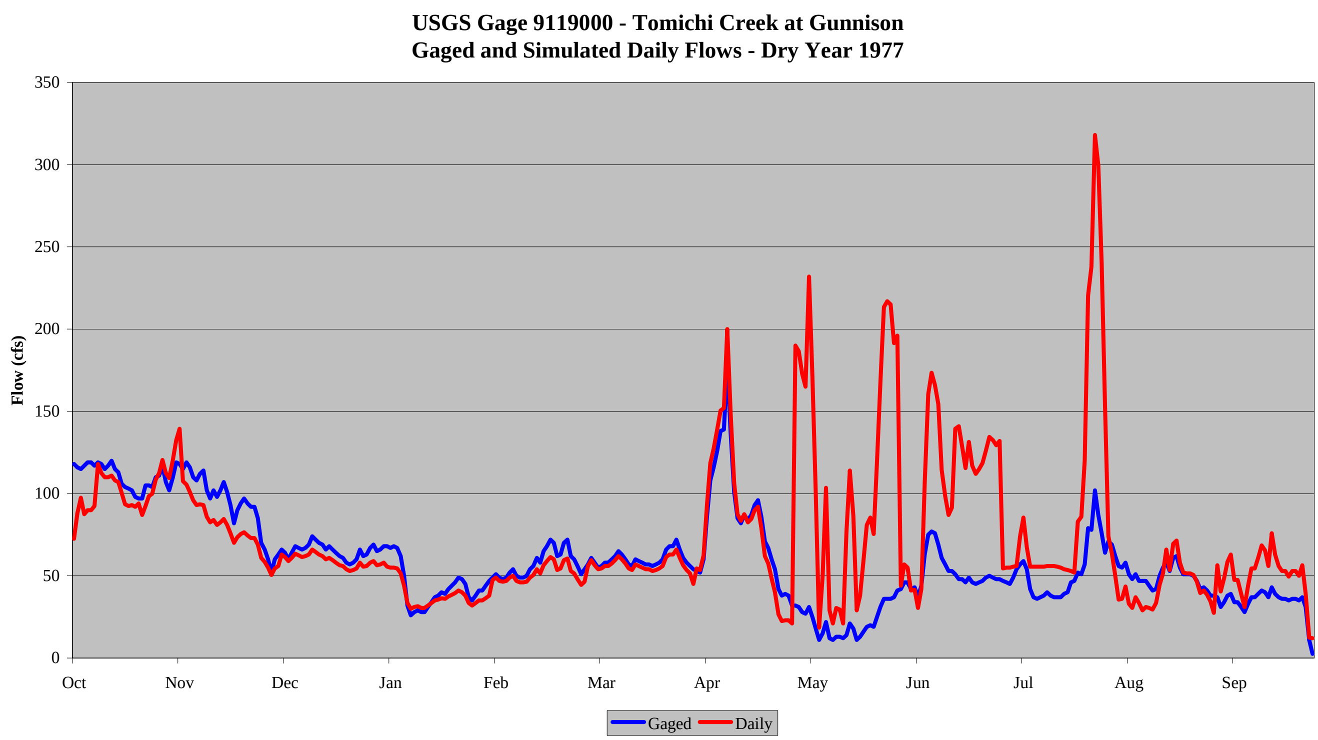



**Figure E.20 Historical Daily Comparison, Dry Year – Tomichi Creek at Gunnison**

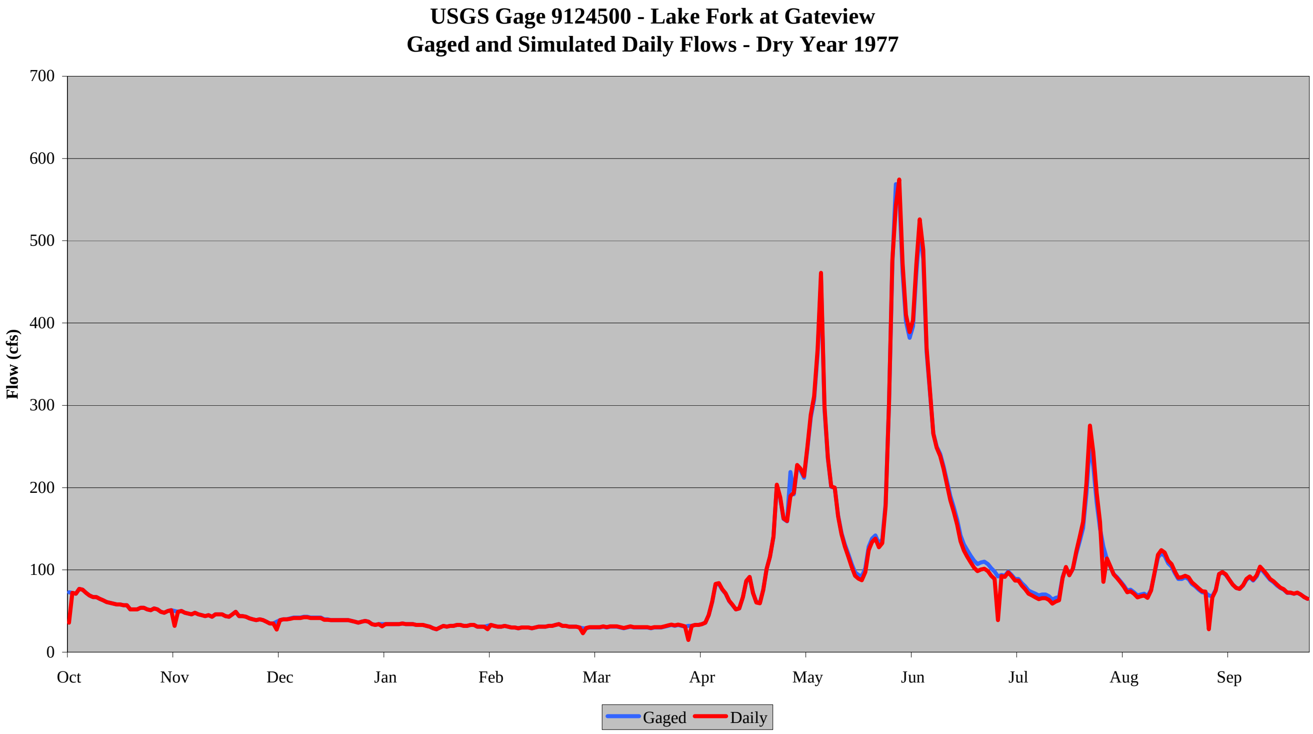



**Figure E.21 Historical Daily Comparison, Dry Year – Lake Fork at Gateview**

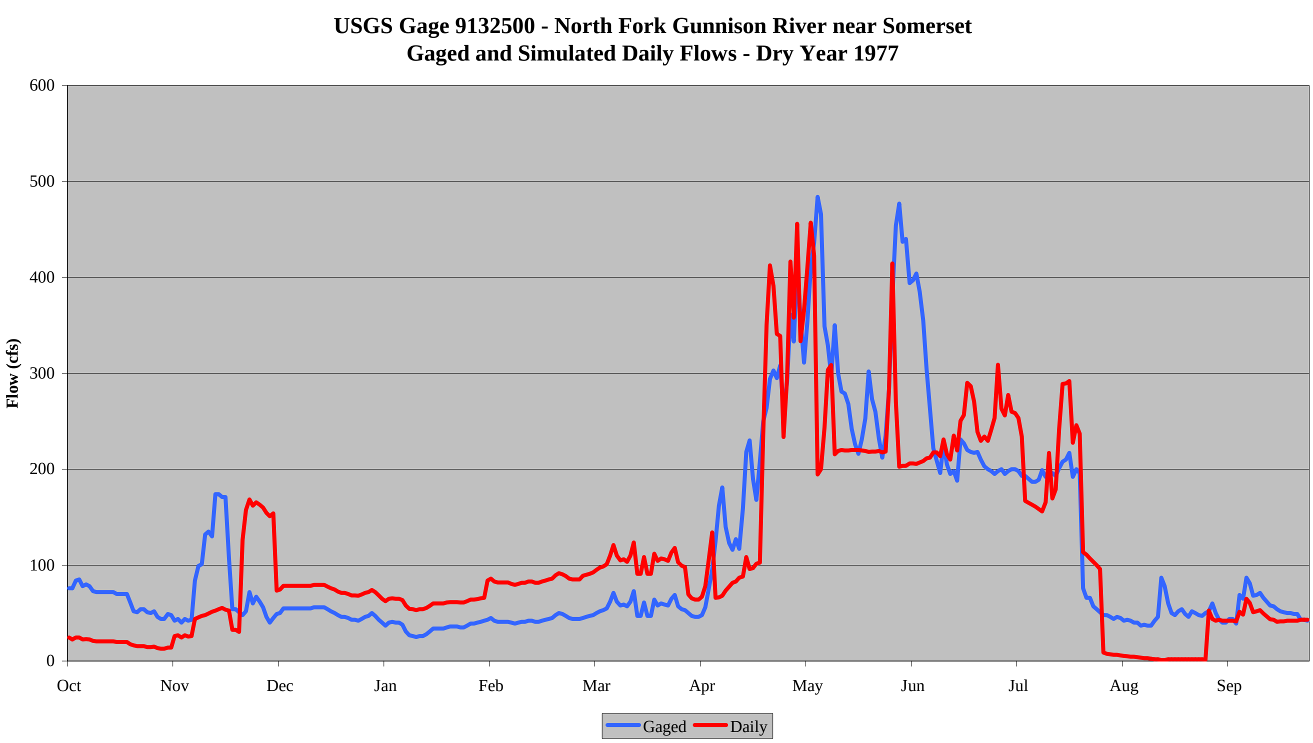



**Figure E.22 Historical Daily Comparison, Dry Year – North Fork Gunnison River near Somerset**

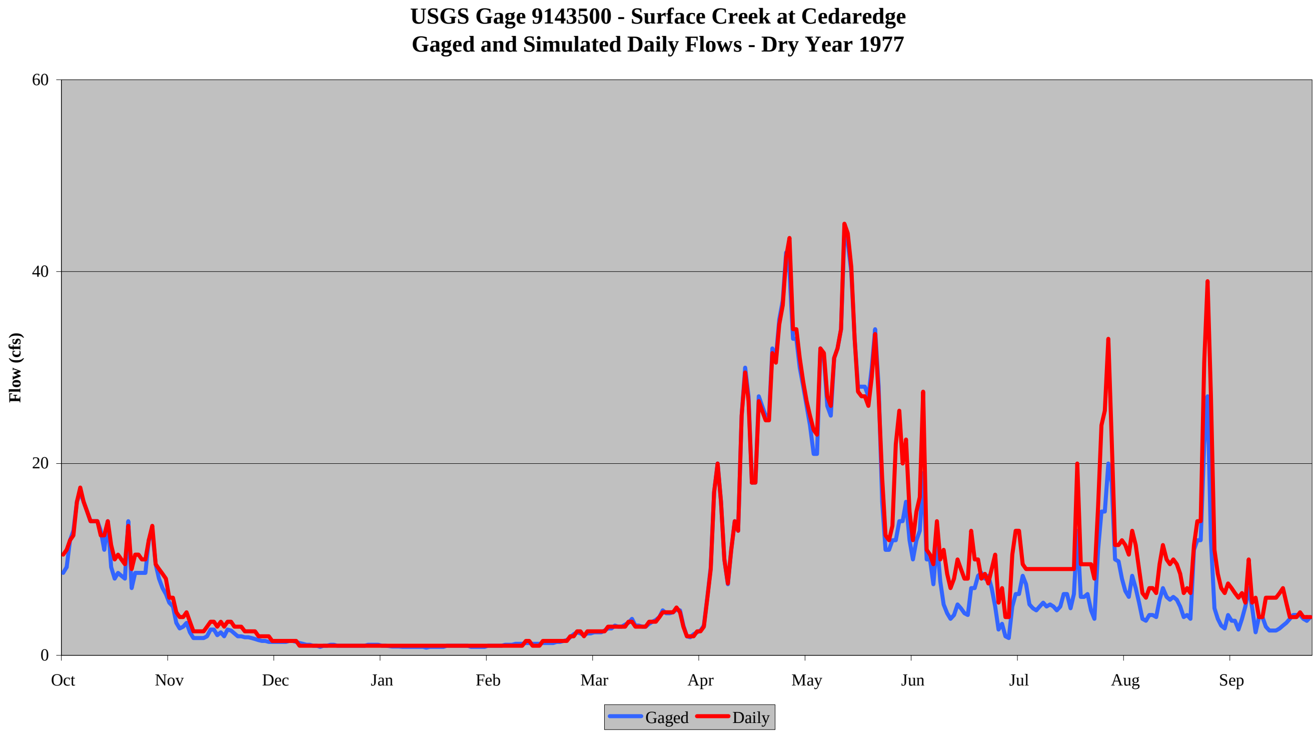



**Figure E.23 Historical Daily Comparison, Dry Year – Surface Creek at Cedaredge**

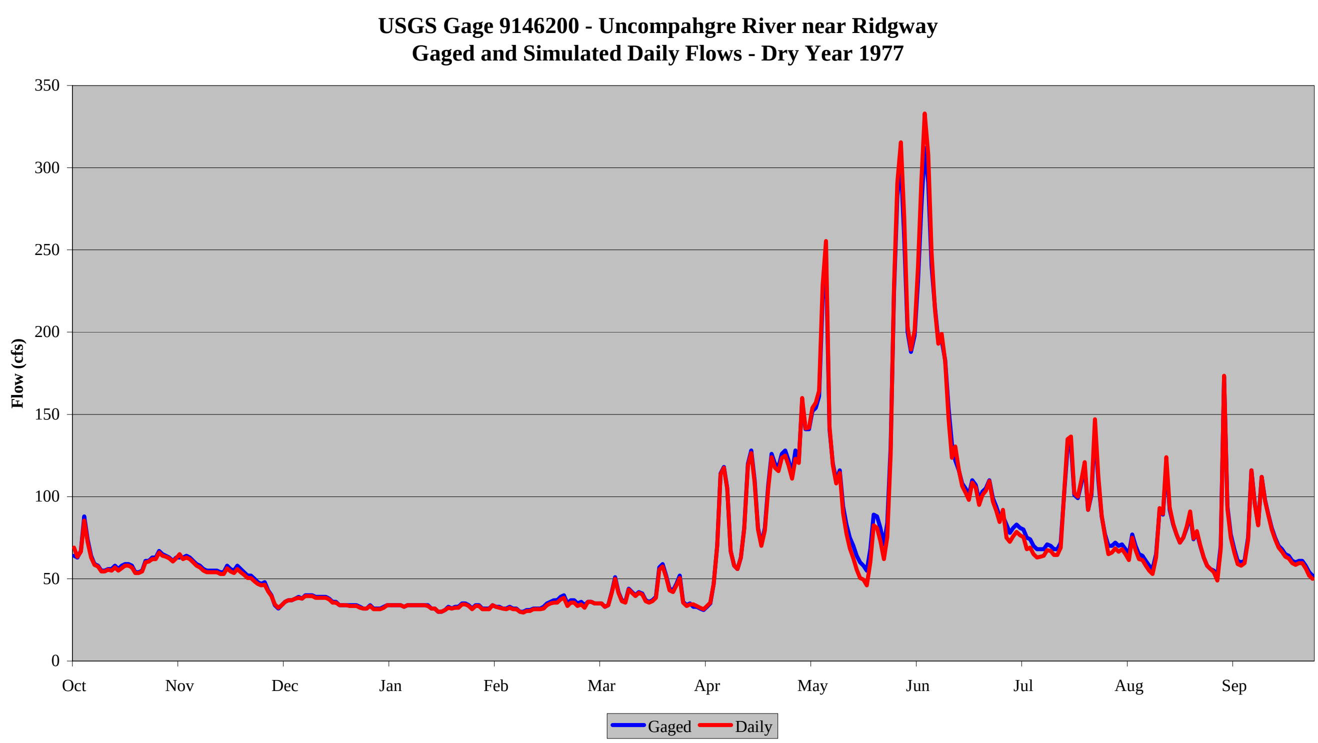



**Figure E.24 Historical Daily Comparison, Dry Year – Uncompahgre River near Ridgway**

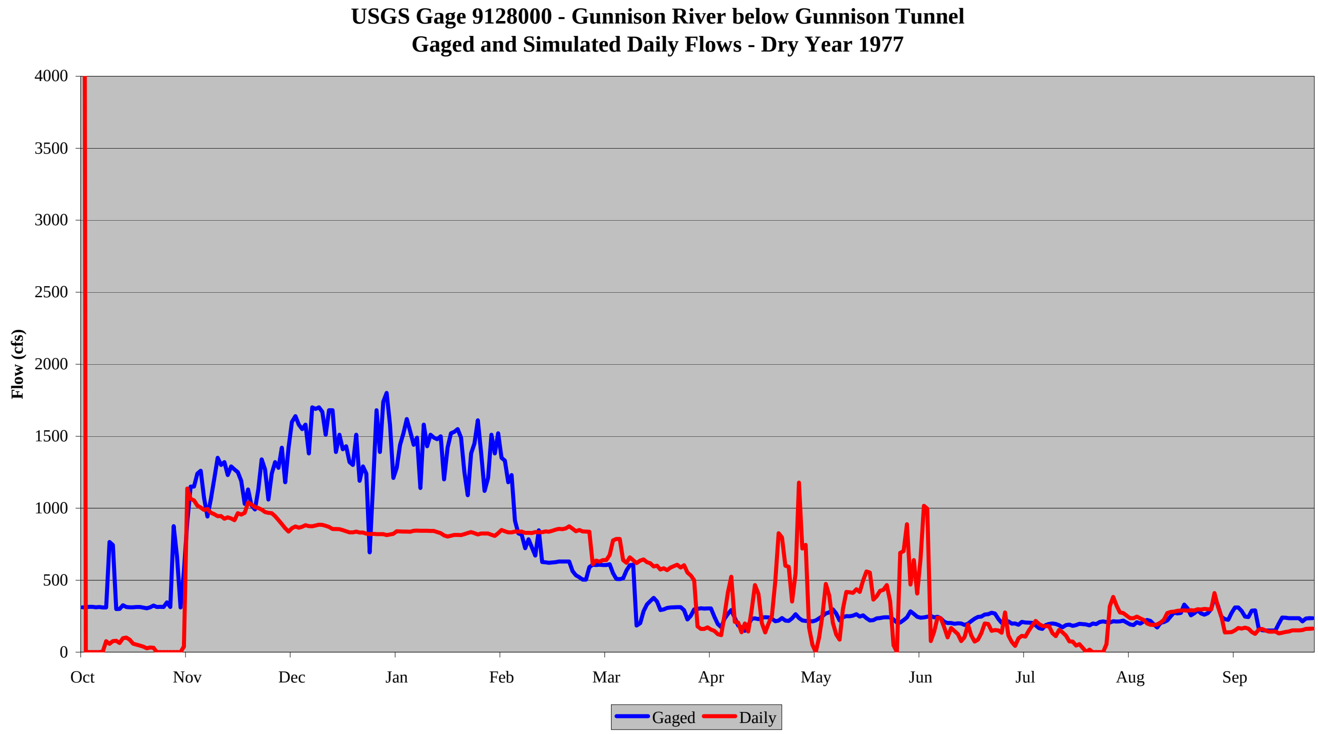



**Figure E.25 Historical Daily Comparison, Dry Year – Gunnison River below Gunnison Tunnel**

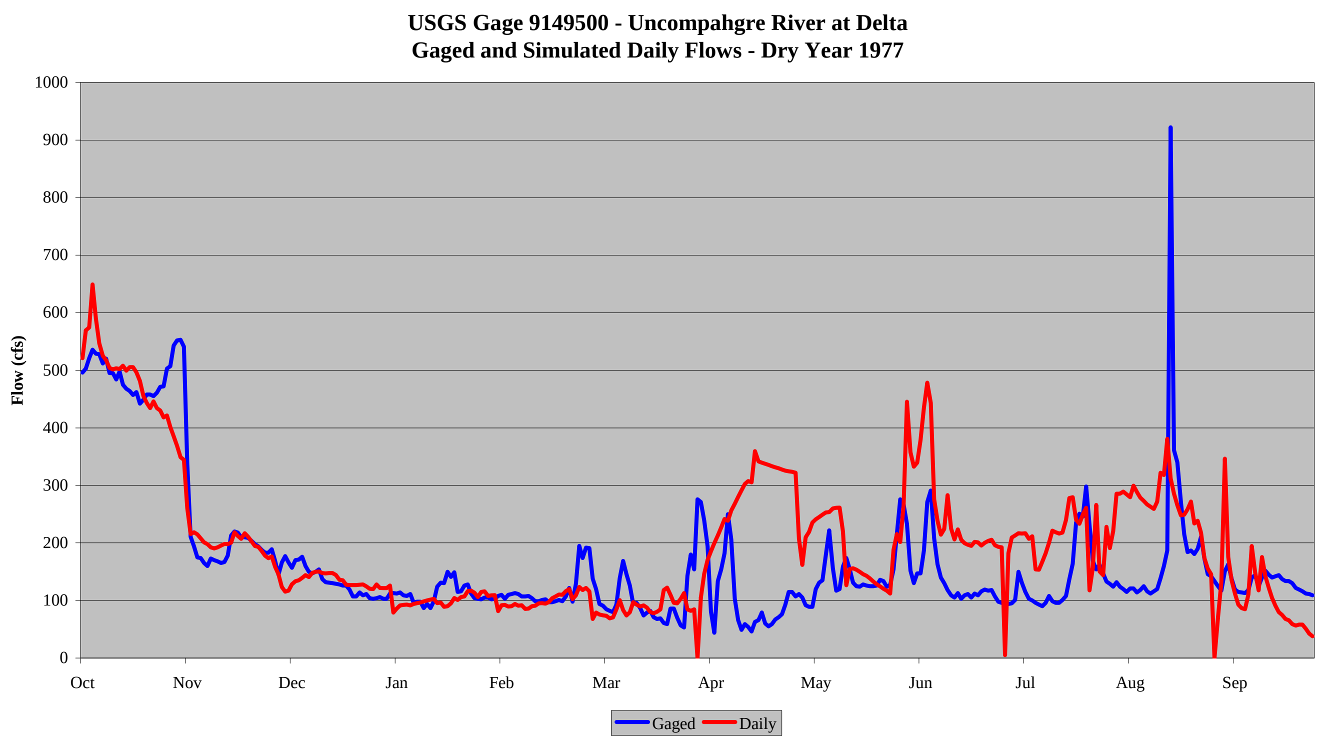
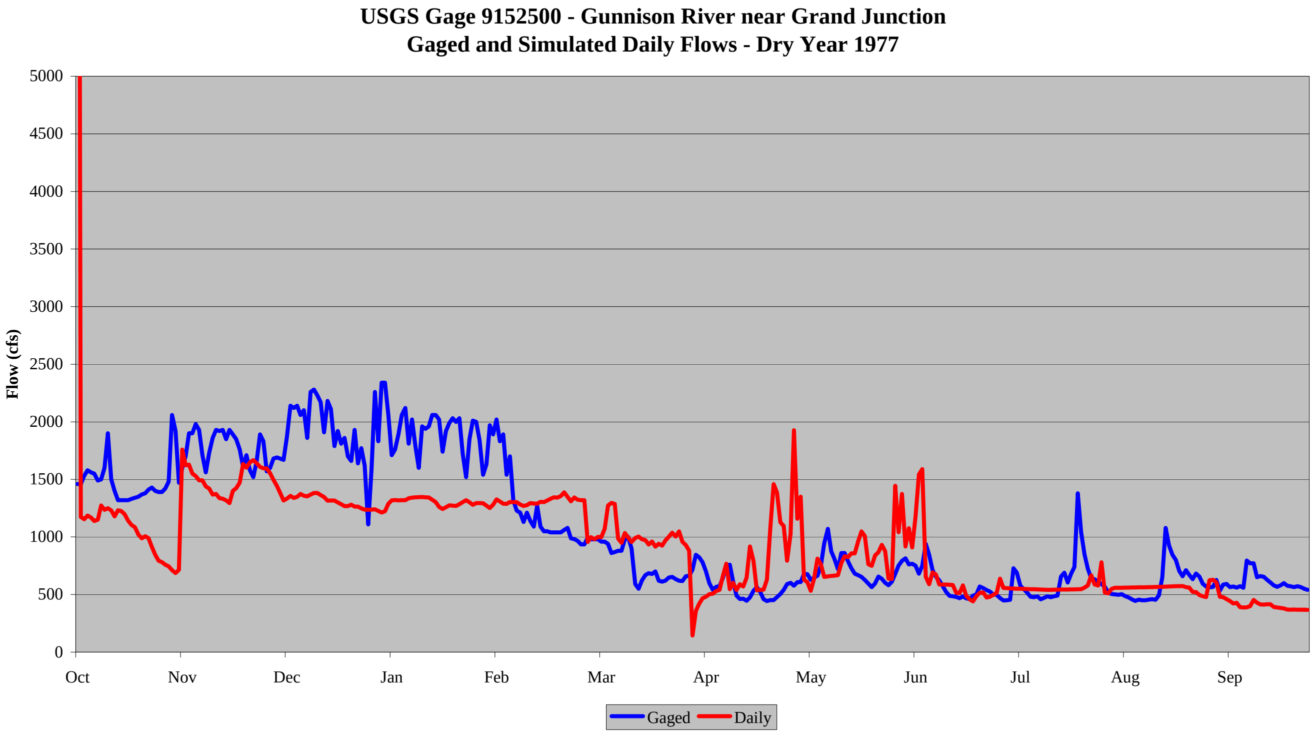



**Figure E.26 Historical Daily Comparison, Dry Year – Uncompahgre River at Delta**




# Figure E.27 Historical Daily Comparison, Dry Year – Gunnison River near Grand Junction

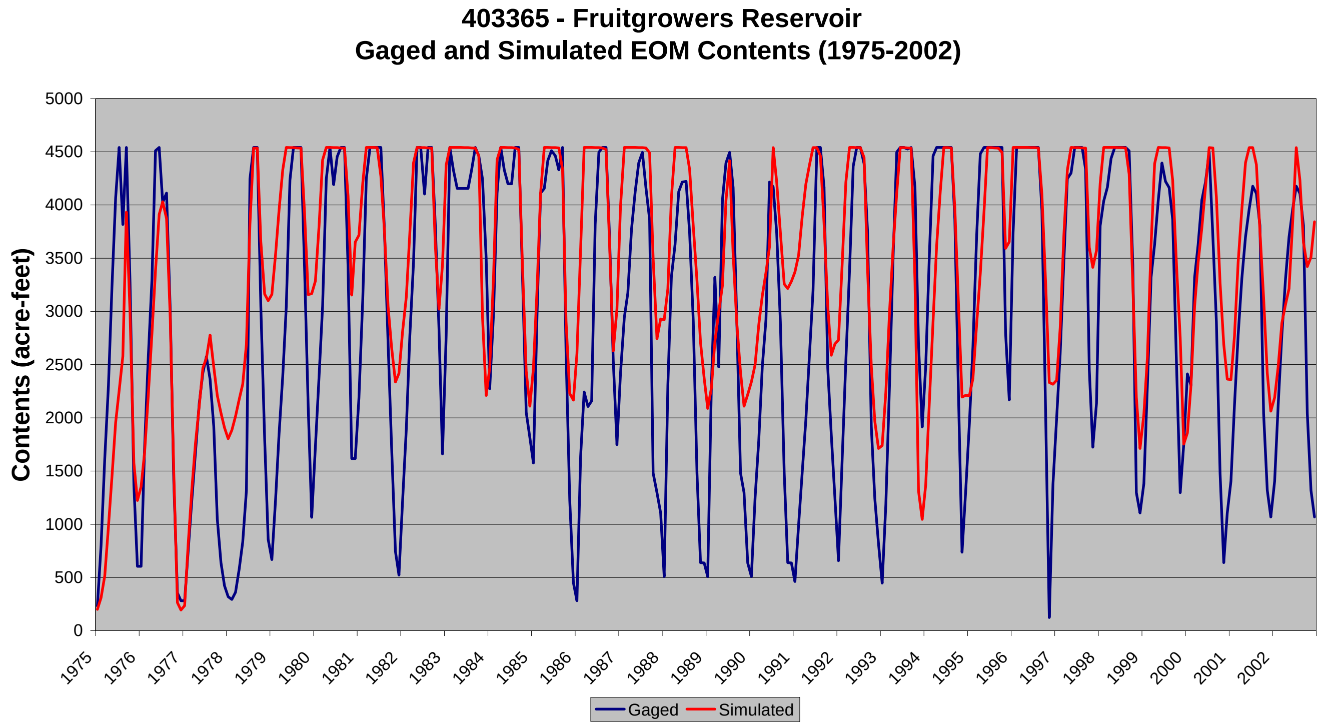



**Figure E.28 Historical Daily Reservoir Simulation – Fruitgrowers Reservoir**

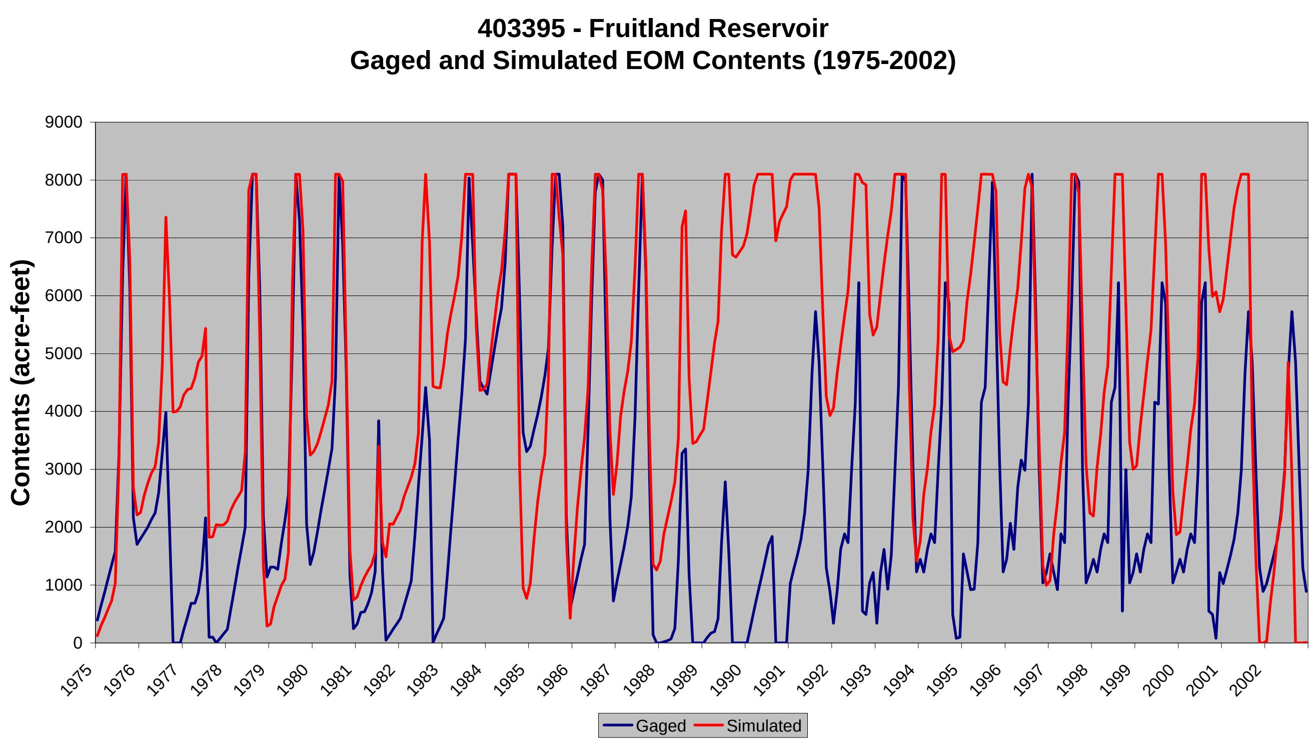



**Figure E.29 Historical Daily Reservoir Simulation – Fruitland Reservoir**

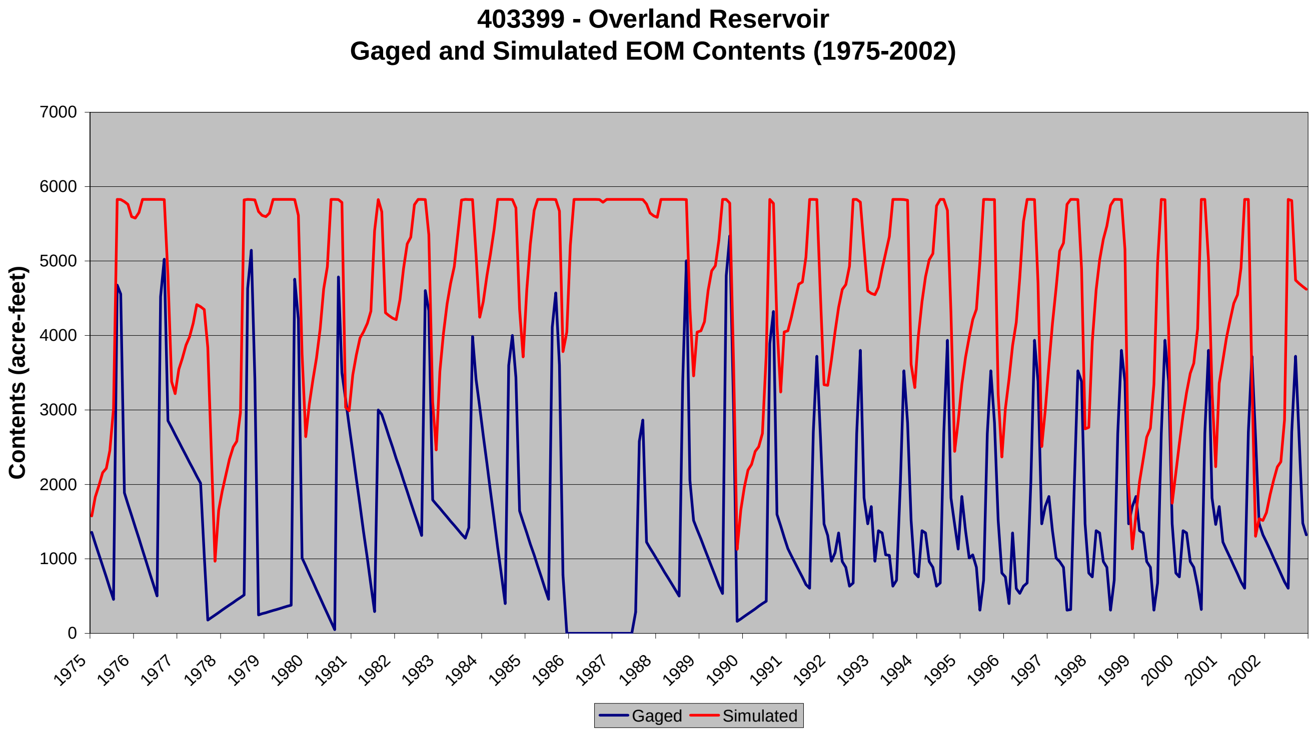



**Figure E.30 Historical Daily Reservoir Simulation – Overland Reservoir**

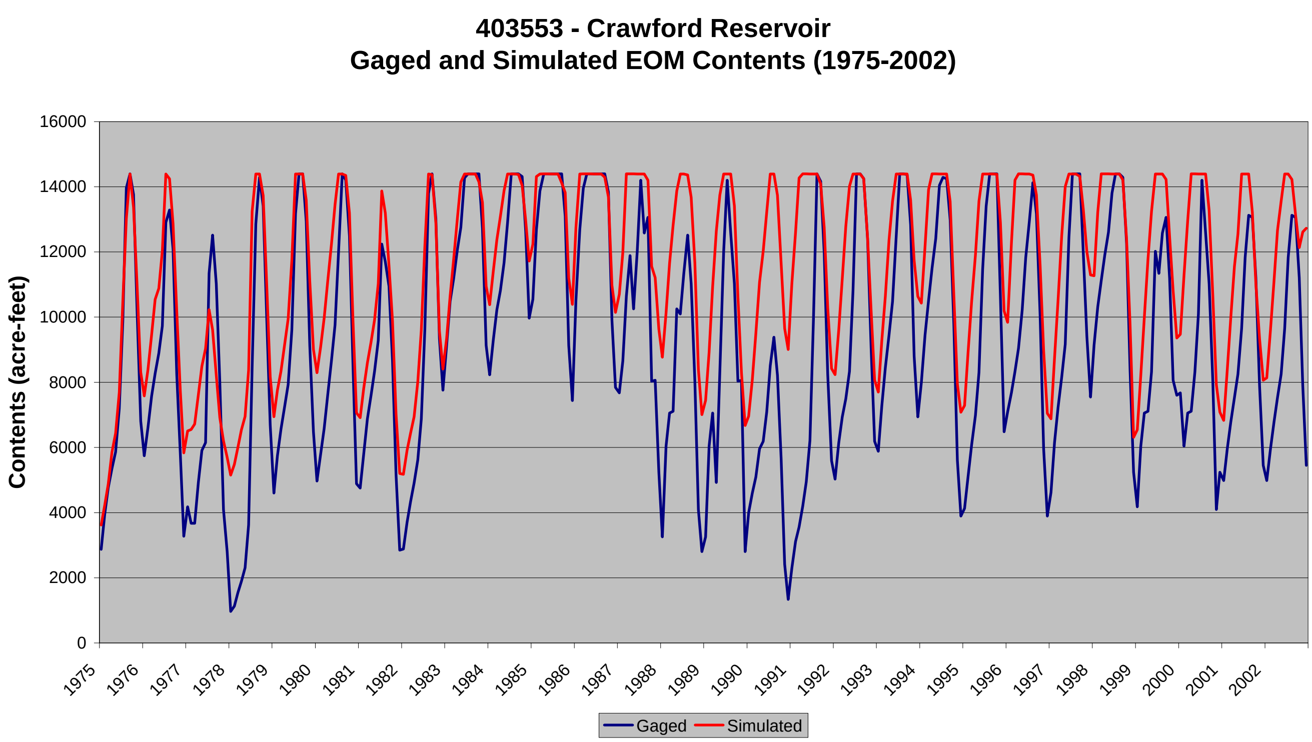



**Figure E.31 Historical Daily Reservoir Simulation – Crawford Reservoir**

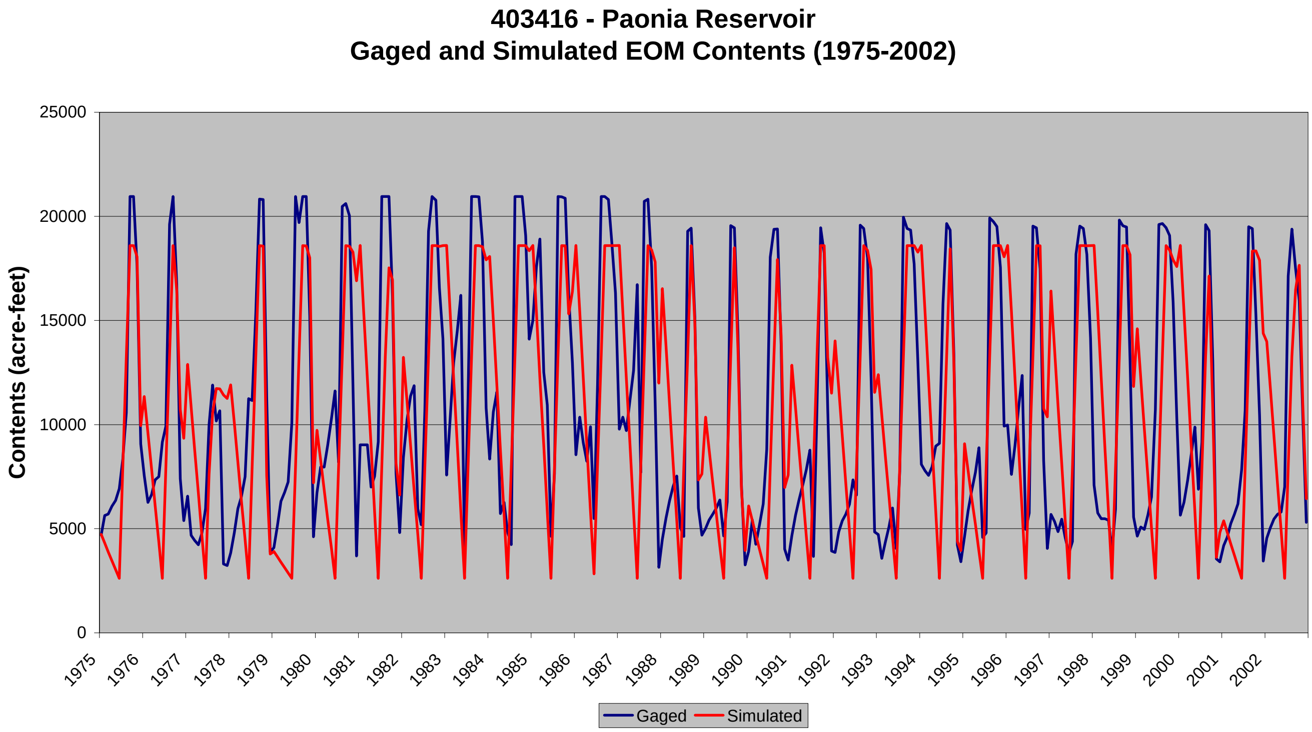



**Figure E.32 Historical Daily Reservoir Simulation – Paonia Reservoir**

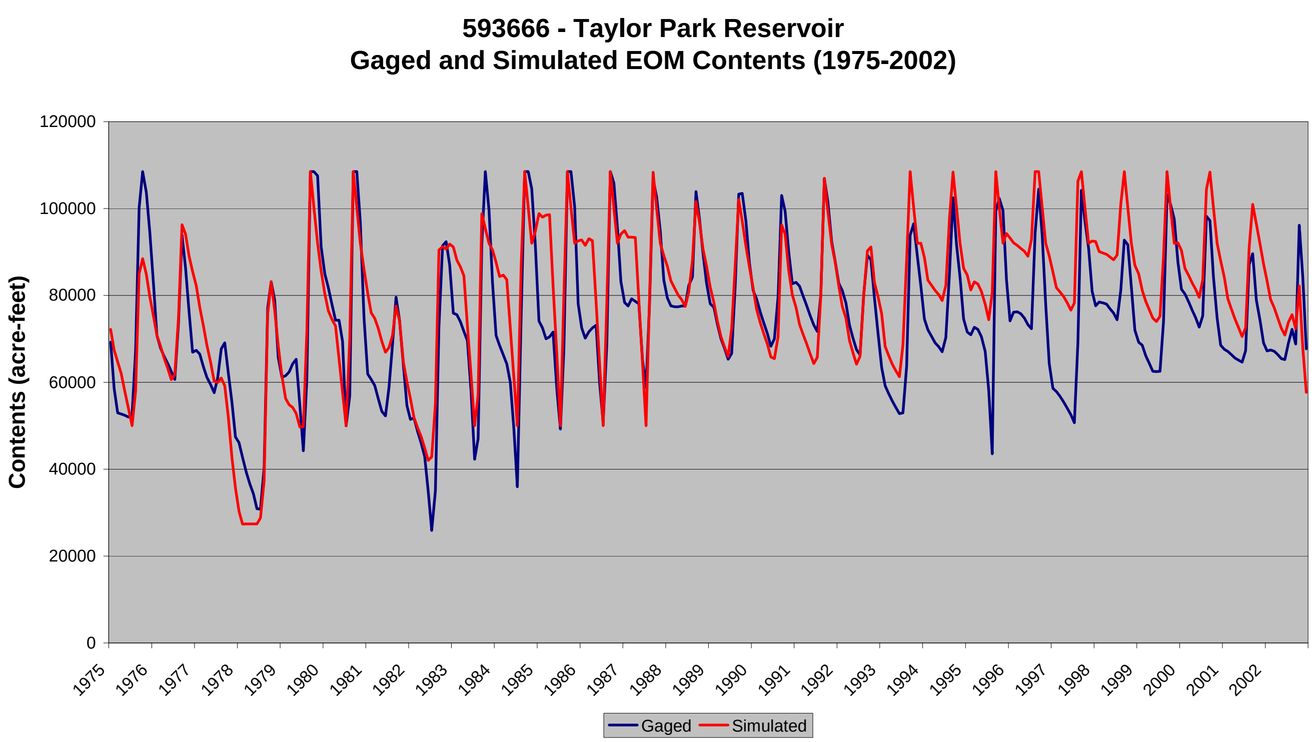



**Figure E.33 Historical Daily Reservoir Simulation – Taylor Park Reservoir**

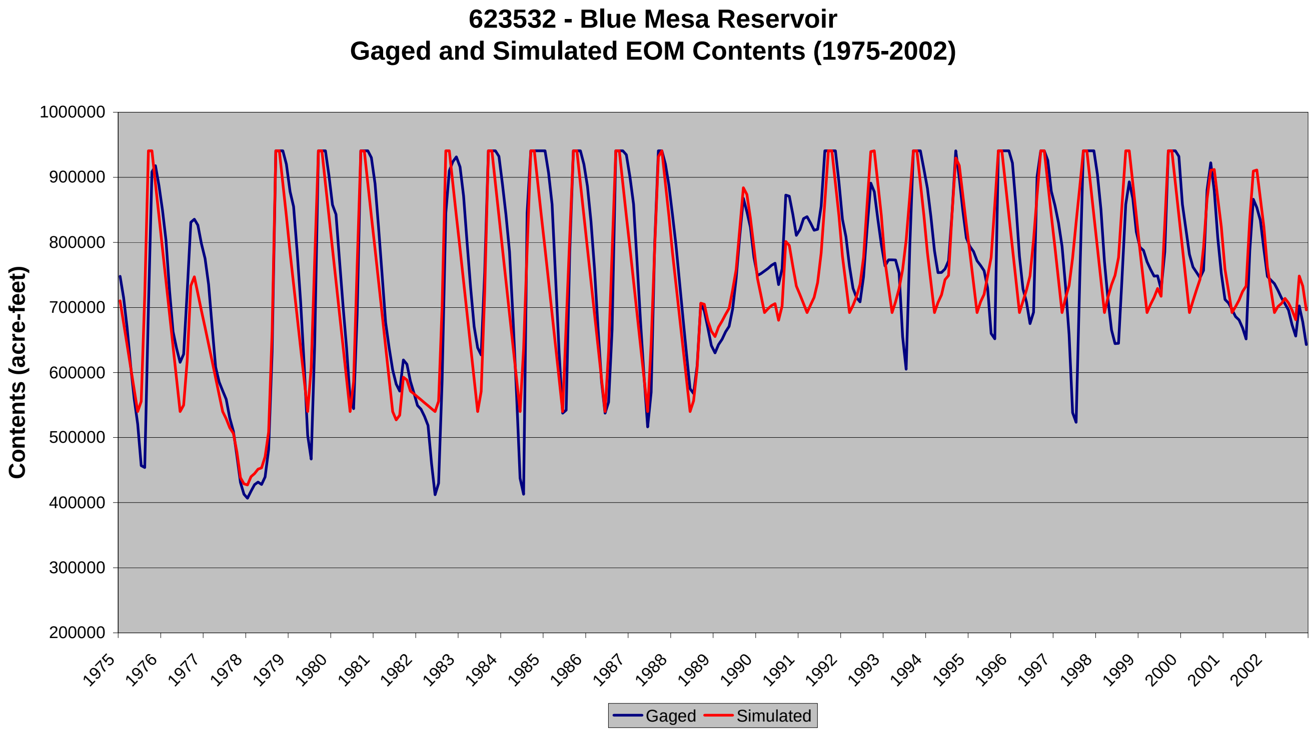



**Figure E.34 Historical Daily Reservoir Simulation – Blue Mesa Reservoir**

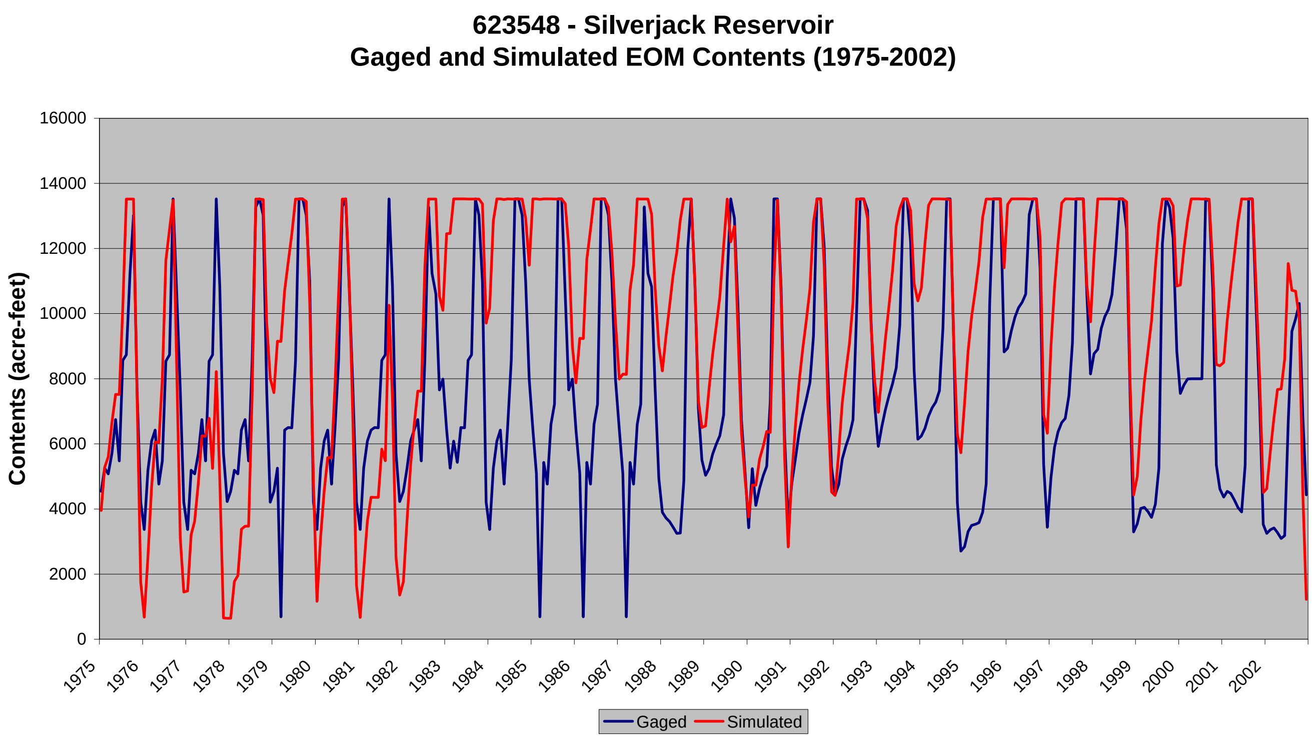



**Figure E.35 Historical Daily Reservoir Simulation – Silverjack Reservoir**

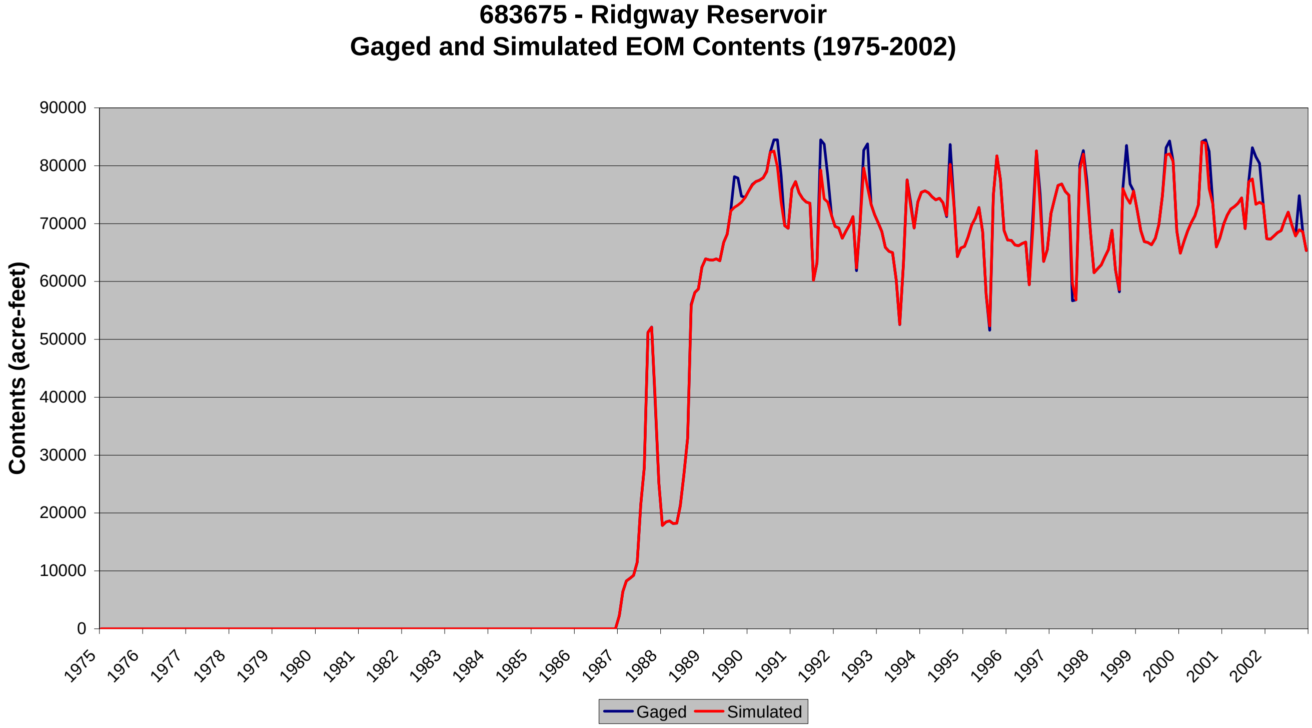



**Figure E.36 Historical Daily Reservoir Simulation – Ridgway Reservoir**