CRWAS Phase I
Gunnison River – StateMod Model Brief

1. Introduction

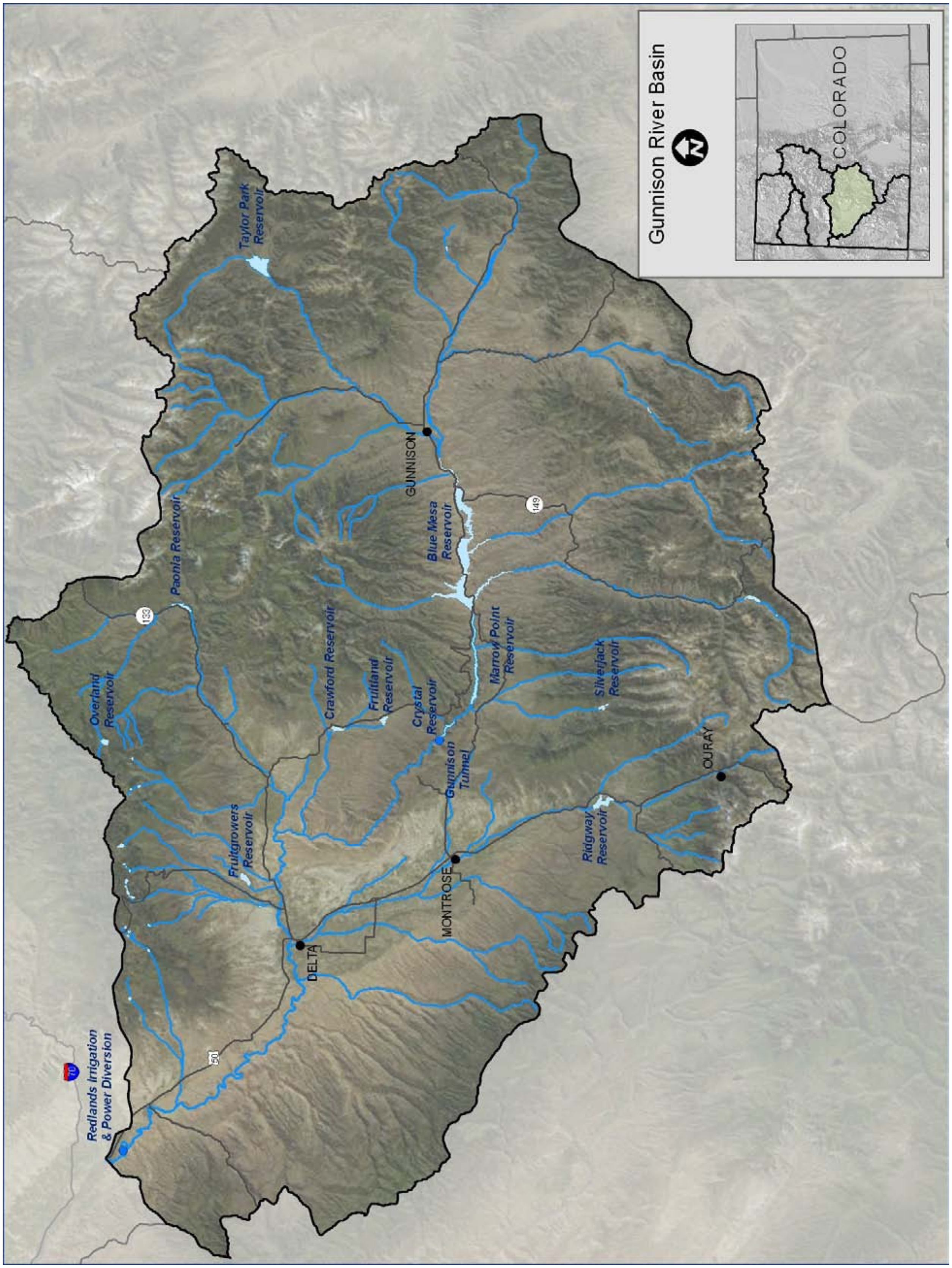
This document provides general descriptions of Gunnison River Basin model development, calibration, and potential enhancements. It is a companion document to ***"Overview of the Colorado Decision Support System"***, which summarizes the integrated Colorado Decision Support System (CDSS) and its primary components (including StateMod, StateCU and HydroBase). The following sections describe:

- the four primary aspects of the Gunnison River Basin StateMod model: 1) inflow hydrology; 2) physical infrastructure; 3) water demands; and 4) legal and administrative conditions (Section 2) and
- the process used for model calibration (Section 3).

Each section concludes with cross-references (denoted in gray boxes entitled "Where to find more detailed information:") that guide the reader to specific sections of existing CDSS documentation for further reading (e.g., Model User's Manual, Information Reports, and other CDSS documents). An Appendix describes primary water supply project operations.

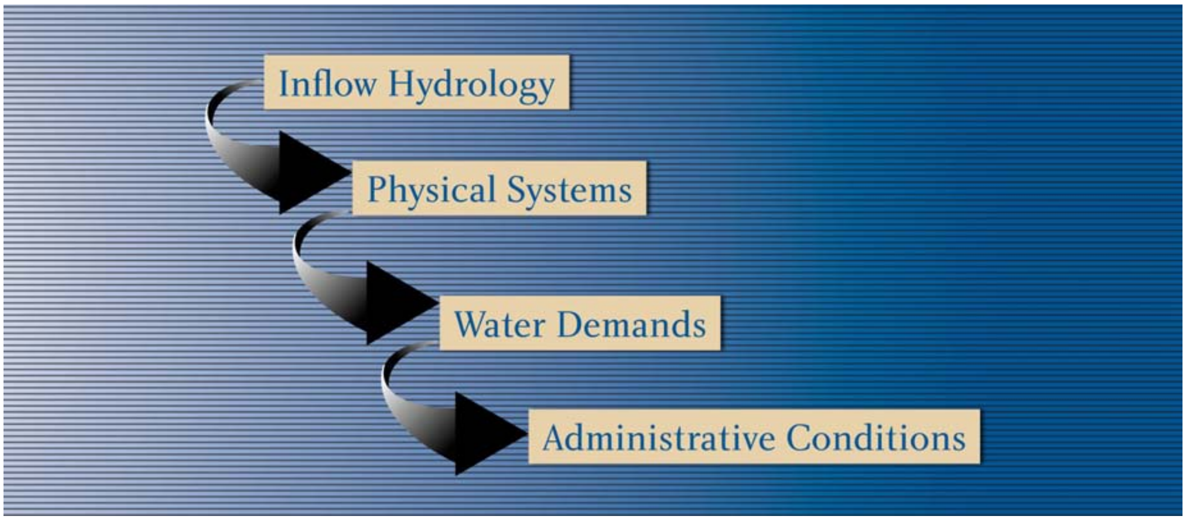
Figure 1 highlights the extent of the Gunnison Basin Model and key rivers, streams, towns and water storage facilities.

Figure 1: Gunnison River Basin Key Hydrography and Facilities



2. Model Components

The major components of the Gunnison Model are input files representing the basin's unique hydrology, diversions, water demands, and legal and administrative conditions affecting project operations. The model consists of the following four major components:

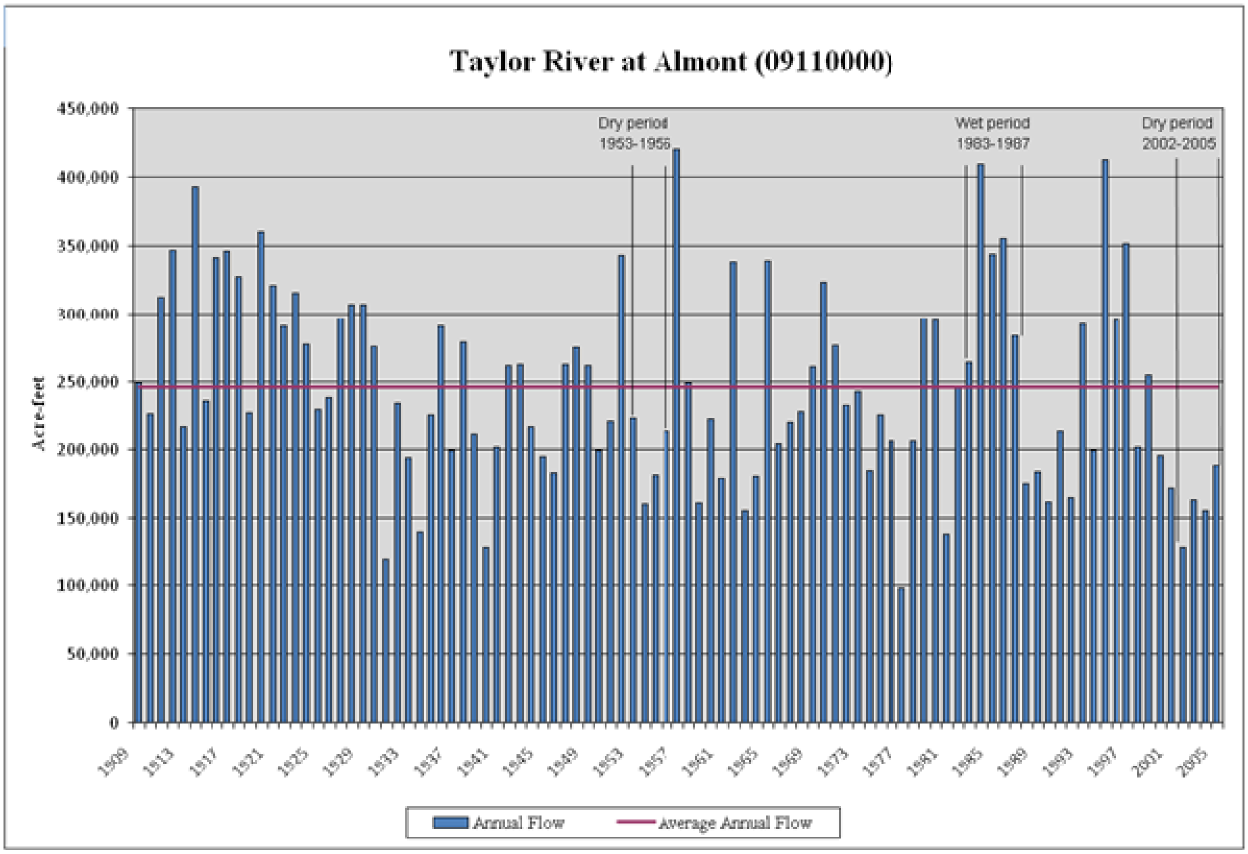


2.1 Inflow Hydrology

In order to simulate river basin operations, the model starts with the amount of water that would have been in the stream if none of the operations being modeled had taken place. These undepleted flows are called natural flows. Note that "baseflow" is synonymous with natural flow, and is the term used the Gunnison River Basin Water Resources Planning Model User's Manual. Natural flows represent the conditions upon which simulated diversion, reservoir, and minimum streamflow demands were superimposed. StateMod estimates natural flows 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 natural flow at gage sites to ungaged locations using proration factors representing the fraction of the reach gain estimated to be tributary to a natural flow point.

Given data on historical diversions; estimated timing and location of return flows; and reservoir operations; StateMod can estimate natural flow time series at specified discrete inflow nodes. Gunnison River basin natural flows were estimated in three steps: 1) remove affects of man at USGS stream gage flows using historical records of operations to get natural flow time series for the gage period of record; 2) fill the gage location natural flow time series by regression against other natural flow time series; 3) distribute natural flow gains above and between gages to user-specified, ungaged inflow nodes.

Monthly natural flows for the USGS water year period 1909 through 2005 were developed to allow a long hydrologic period to "drive" the model. Because measured data was limited in the early period, and the development of natural flows required significant data-filling, the period 1950 through 2005 was chosen for the purposes of the Colorado River Water Availability Study (CRWAS). Additional discussion on this chosen model period is provided in this Model Brief's companion document entitled "Overview of the Colorado Decision Support System." This period includes extended wet, dry, and average periods plus both extreme drought and high runoff years. The wide variation in hydrology provides the ability to check that the model adequately represents historical river administration and operations under differing flow regimes. The following natural flow graph, representing the Taylor River at Almont gage, illustrates that wet, dry, and average years are all represented in the modeling period. Successive years with annual flows below the average (e.g.,1953-1956) constitute extended dry periods; conversely, successive years with flows above the average (e.g., 1983-1987) constitute extended wet periods.



Natural flows are introduced to the Gunnison Model at 135 gaged and headwater locations on more than 50 Gunnison River tributaries. Extended hydrology based on tree-ring data and alternate hydrology based on climate change and forest modification scenarios will replace the natural flows at the 52 USGS stream gage locations, and the automated process developed as part of CDSS will allow the distribution of these new natural flows to the remaining ungaged inflow nodes.

In addition to the main stem Gunnison River, main tributaries represented include:

- Taylor River
- Tomichi Creek
- Smith Fork
- East River
- Cimarron River
- Uncompahgre River
- Ohio Creek
- North Fork Gunnison River

In addition, nearly 50 other sub-tributaries are included. The decision on which streams to include in the model was generally based on the extent of acreage irrigated served by diversions.

2.1.1 Data Sources and Filling Techniques

Data required to generate natural flows include historical streamflow data, diversion records, reservoir storage data, irrigation water requirements, and net evaporation rates.

<u>Historical streamflow</u> data used to generate natural flows were recorded by the USGS and by Division of Water Resources (DWR). Historical streamflow data from both sources (USGS and DWR) are stored in HydroBase. The natural flow algorithm does not require that historical streamflow records be complete. Gaps in the data are filled only for natural flows estimated at gage locations, after the affects of man have been removed, using the automated USGS Mixed Station Model. The name refers to its ability to use regression correlations to fill missing natural flows for many stations, using natural flows from available stations.

<u>Historical diversions</u> are recorded by water commissioners and stored in HydroBase. For most water districts in the Gunnison River basin, diversion records have been digitized from field notebooks and are generally complete from 1974 on. Many of the larger structures have diversion records in HydroBase back to the early 1950s. Diversion records are filled prior to being used in the natural flow calculation using a wet/dry/average month approach using an automated algorithm available in the CDSS DMIs. Each water district is associated with a long-term gage used to statistically assign each month in the study period a wet, dry, or average hydrologic designation. If diversion records for a ditch are missing in a designated “wet” month, then the average of diversion records for available “wet” months for that ditch will be used.

<u>Historical reservoir end-of-month contents</u> for the larger reservoirs are generally measured by the reservoir operators. In recent years, this information is provided to the water commissioners and stored in HydroBase. Several of the reservoirs included in the Gunnison Model are USBR projects, and generally pre-1974 end-of-month contents data were supplied directly from the Grand Junction USBR office. Historical records are generally between 80 and 95 percent complete for most reservoirs. Missing records are filled based on linear interpolation if a maximum of three consecutive months are missing, then remaining missing data is filled using the wet/dry/average approach. Again, this filling procedure has been automated using the CDSS DMIs.

<u>Irrigation water requirements</u> are determined, by ditch, for the period 1950 through 2005 using StateCU. The calculation methods require mean monthly temperature and total monthly precipitation. Twelve climate stations are used to represent temperature and precipitation in the Gunnison River basin. The climate stations selected for the analysis are maintained by the National Oceanic and Atmospheric Administration (NOAA). NOAA provides recorded data to DWR, and it is stored in HydroBase. Most of the climate stations used in the analysis have

complete data for this period, therefore only minor filling was required. Mean monthly temperature was filled based on nearby climate station's data using monthly regression and monthly precipitation was filled based on monthly averages for the measured data, automated using the CDSS DMIs. Irrigation water requirements for the study period prior to 1950 are estimated using the automated wet/dry/average approach discussed above.

Average net monthly evaporation rates are based on annual pan evaporation and precipitation measurements made at several climate stations stored in HydroBase, many located at reservoir sites in the basin.

Where to find more detailed information:

- Section 4.7 of the Gunnison River Basin Water Resources Planning Model User's Manual, available on the CDSS website, provides details of the Baseflow (Natural Flow) Estimation process.
- Table 5.2 of the Gunnison River Basin Water Resources Planning Model User's Manual lists the gaged locations where natural flows are introduced to the model.
- Section 4.4.2 of the Gunnison River Basin Water Resources Planning Model User's Manual describes the automated time series filling algorithms.
- Section 4.4.3 of the Gunnison River Basin Water Resources Planning Model User's Manual describes the natural flow filling using the Mixed Station Model.
- Section 5.6.2 of the Gunnison River Basin Water Resources Planning Model User's Manual describes the evaporation rates and source used for each reservoir.

2.2 Physical Systems

The Gunnison Model includes active diversion structures, reservoirs, carrier systems, and instream flow reaches. Although every active diversion structure or reservoir is not explicitly included in the Gunnison Model, 100 percent of the estimated irrigated acreage and storage in the basin is represented. 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. Explicit structures were selected based on a variety of criteria including amount and seniority of water rights, quantity of historical diversions, importance in administration, and participation in reservoir projects.

Seventy-six percent of use in the basin is explicitly represented at correct river locations relative to other users, with correct priorities relative to other users. The remaining structures are grouped into "aggregates" based generally on tributary boundaries, gage locations, critical administrative reaches, and instream flow reaches. The model includes over 310 explicit structures and 42 aggregates.

Similarly, not every reservoir and stock pond is explicitly included in the Gunnison Model. Reservoirs with minimum decreed capacities of 4,000 acre-feet are considered key reservoirs, and are explicitly modeled. There are 13 key reservoirs with a combined total capacity of approximately 1,340,000 acre-feet, or 92 percent of the total modeled storage capacity of the basin. The remaining basin storage is grouped into nine aggregate reservoirs and five aggregate stock ponds.

There are 25 CWCB instream flow segments modeled, accounting for instream flow segments decreed prior to 2005 that may affect basin operations. Headwater instream flow segments above the most upstream modeled diversions have, in some cases, been excluded. Instream flow segments on tributaries not specifically represented in the model are also not included. There is a minimum bypass requirement modeled for Taylor Park Reservoir. In addition, an instream flow node is included to reflect the U.S. Fish and Wildlife Service Black Canyon filing for future modeling efforts.

The location of each structure or instream flow segment, in relationship to tributaries and other structures (upstream or downstream), is defined based on CDSS GIS coverages, available straight-line diagrams, and discussions with water commissioners. Physical information about diversion structures and reservoir capacities is required to constrain modeled water use – diversion structures are not allowed to divert more than canal capacity and reservoirs are not allowed to store more than reservoir storage capacity. In addition, the model will constrain controlled releases from reservoirs to downstream river channel capacity.

Physical information that represents the location of irrigated land, in terms of timing and location of return flows, is also incorporated into the model input files. Information required for reservoirs includes area/capacity curves, minimum reservoir pools, and user accounts within a reservoir.

2.2.1 Data Sources and Filling Techniques

Physical information regarding capacities (ditches and reservoirs) is stored in HydroBase. Little information was available from original permits and decrees, therefore ditch capacities were often set in HydroBase as the sum of direct water rights under the ditch and reservoir capacity was often set as the sum of storage rights. As information continues to be gathered during the CDSS efforts, capacity information in HydroBase is updated to reflect user-provided information. Therefore, for the larger ditches that warranted user interviews, ditch capacities are set based on user-supplied information. For the remaining ditches, the data centered DMI approach allows ditch capacity to be set based on the maximum daily diversion recorded.

Reservoir capacity, area-capacity curves, dead pool and user-account information was collected based on interviews with the reservoir owners and operators. As noted above, much of that information has now been incorporated into HydroBase and is extracted directly for use in the modeling effort.

Irrigation return flow locations have been estimated based on the location of irrigated land and topography, using CDSS GIS available coverages. Each irrigation structure has been assigned a generic return flow delay pattern that recognizes the proximity of the irrigated acreage to a surface stream or drainage. Glover or other lagging analyses have not been performed for each irrigation structure.

Where to find more detailed information:

- Section 4.2.2 of the Gunnison River Basin Water Resources Planning Model User's Manual provides details and criteria used to select explicit versus aggregate structures. Section 4.2.3 of the Gunnison River Basin Water Resources Planning Model User's Manual provides details and criteria used to select explicit versus aggregate reservoir structures.
- Table 5.4 of the Gunnison River Basin Water Resources Planning Model User's Manual lists each of the key structures represented in Gunnison Model.
- Appendix A and Appendix B of the Gunnison River Basin Water Resources Planning Model User's Manual describes the aggregation process for irrigation and non-irrigation structures and reservoirs.

2.3 Water Demands

The Gunnison Baseline Model demands reflect current levels of irrigation, population, and reservoir capacity superimposed over historical natural flow hydrology from 1909 through 2005. Irrigation headgate demands are set to the irrigation water requirement for the specific time step and structure, divided by the historical efficiency for that month of the year. Irrigation water requirements allow demands to reflect full supply, and not be limited by water rights and administration. Historical system efficiencies reflect irrigation practices associated with application methods, conveyance losses, and other user choices such as early and late season diversions to fill the soil reservoir.

Municipal demands in the baseline data set are based on average monthly diversions over the recent period 1998 through 2005 for the entire model period of 1909 through 2005. Redlands Power Canal baseline demands are set to the 1975 through 1996 average monthly diversions.

Instream flow demands are set to the decreed monthly rates for the entire period of 1909 through 2005. The Taylor Reservoir Bypass flow requirement is set to the monthly amounts agreed to in the operational agreement.

Minimum and maximum reservoir target storage limits are set as reservoir “demands”. Reservoirs 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, and the maximum targets were set to capacity for reservoirs that operate primarily for agricultural and municipal diversion storage. Maximum targets were set to operational targets according to rule curves provided by USBR for Paonia, Taylor Park, and Blue Mesa Reservoirs.

2.3.1 Data Sources and Filling Techniques

Irrigation water requirements and average historical monthly efficiencies used to estimate irrigation demands are calculated by StateCU. Data sources and filling techniques used to determine Baseline irrigation water requirements are described in Section 4.9.1 of the Gunnison River Basin Water Resources Planning Model User’s Manual. Average historical monthly efficiency is the average system efficiency (combined conveyance and application efficiency) over the period 1975 through 2004, capped at 60 percent. These efficiencies are calculated by StateCU based on historical acreage for the period and historical diversions. Historical diversion records are extracted from HydroBase and filled if needed, as described in Section 4.4.1 of the Gunnison River Basin Water Resources Planning Model User’s Manual.

Monthly decreed demands for instream flow segments are extracted from the water rights tabulation stored in HydroBase. As discussed above, operational targets for some USBR reservoirs were obtained directly from those sources.

Where to find more detailed information:

- Section 4.9.1 and Section 5.4.4 of the Gunnison River Basin Water Resources Planning Model User’s Manual provides details and criteria used to estimate calculated demands for diverting structures.

2.4 Legal and Administrative Conditions

Legal and administrative conditions include water rights (direct, storage, instream flow); policies and agreements such as minimum bypass flows; and reservoir operations. The method used to impose these conditions on the demands highlights why StateMod is an appropriate tool for representing Colorado’s water rights system. Each water right and operational right is assigned an administration number. For water rights the administration number is calculated from the appropriation and adjudication dates.

The administration number assigned to an operating rule that defines a reservoir release to an irrigation structure with a direct flow right is just junior to the direct flow right. StateMod allocates water to meet the irrigation demand using the direct flow, and then allocates reservoir releases if the demand is not fully satisfied.

Primary project operations requiring operational rights in the model include the following, which are further described in the Appendix:

- Overland Reservoir and Ditch Operations
- Paonia Project Operations
- Taylor Park Reservoir Operations
- Aspinall Unit Operations
- Uncompahgre Project and Dallas Creek Project Operations
- Smith Fork Project Operations
- Fruitland Mesa Operations
- Bostwick Park Project Operations
- Fruitgrowers Reservoir Operations

More specific information on these primary project operations is presented in the Appendix at the end of this document.

2.4.1 Data Sources and Filling Techniques

Direct flow water rights are assigned to each diversion structure; storage rights are assigned to each reservoir; and instream flow rights are assigned to each instream flow segment. The CDSS DMIs automate the assignment of these rights directly from the water rights tabulation in HydroBase.

Seven different operating rules types are used in the Gunnison Model Baseline data set. The complexity of the basin requires a total of 118 operational rights. Typically, these are operations involving two or more structures, such as a release from a reservoir to a diversion structure, a release from one reservoir to a second reservoir, or a diversion to an off-stream reservoir. The appropriate rules to apply to each complex operation were generally determined based on information from reservoir operators and water administrators.

3. Model Calibration

As noted above, the Gunnison River Model study period for CRWAS from 1950 through 2005 was selected to include representative hydrologic periods. A subset of the study period, 1975 through 2005 was selected for model calibration. This calibration period was selected because historical diversion data were readily available (limited data filling required) and the period includes both dry (1953-1956, 1977, 2002-2005) and wet cycles (1983-1987).

Calibration is the process of simulating the river basin under historical conditions, and judiciously adjusting parameter values to achieve agreement between observed and simulated values of streamflow gages, reservoir levels, and diversions. The Gunnison Model was calibrated in a two-step process as follows:

3.1 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-headgate collection systems would feature the historical diversion as the demand at each diversion point.

The objective of the first calibration run was to refine natural flow 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 natural flows were represented or with the location assigned to return flows back to the river. Natural flow issues were also evidenced by poor simulation of the historical gages. Generally, the parameters that were adjusted related to the distribution of natural flows (i.e., the method for distributing natural flows to ungaged locations), and locations of return flows.

3.2 Second Step Calibration

In the second calibration run, constraints on reservoir operations were relaxed. As in the first calibration run, reservoirs were simulated for the period in which they were on-line historically. Reservoir storage was limited by water rights and availability and reservoir releases were controlled by downstream demands. 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 gage flows, reservoir contents, and diversions with historical observations of these parameters. The model at the conclusion of the second step is considered the calibrated model.

The model is calibrated on a basin-wide level, meaning that major projects, diversions, and basin operations were specifically reviewed and modified, if necessary, so they are represented appropriately. Because calibration efforts concentrated on gage and reservoir locations, ungaged tributaries were not reviewed to the level of detail as gaged areas. The purpose of the Colorado River Water Availability Study is to determine the potential basin-wide effects of climate variability; therefore the calibrated model provides an appropriate prediction tool. When using this model for future analyses involving areas of the basin without historical stream gages that rely on derived hydrology, it is recommended that further stream flow evaluations be conducted. A refined calibration will improve results of local analyses. Average annual streamflow calibration results are presented in the **Table 3.1** for gages with complete records during the calibration period.

Table 3.1
Historical and Simulated Average Annual Streamflow Volumes (1975-2002)
Calibration Run (acre-feet/year)

Gage ID	Historical	Simulated	Historical minus Simulated		Gage Name
			Volume	Percent	
9109000	147,968	148,444	-476	0	Taylor River Below Taylor Park Reservoir
9110000	236,375	236,719	-344	0	Taylor River at Almont
9111500	98,931	98,942	-12	0	Slate River Near Crested Butte
9112500	238,733	238,850	-117	0	East River at Almont
9114500	529,302	529,762	-461	0	Gunnison River Near Gunnison
9119000	127,952	128,831	-879	-1	Tomichi Creek at Gunnison
9124500	167,999	168,003	-4	0	Lake Fork at Gateview
9126000	70,457	71,290	-834	-1	Cimarron River Near Cimarron
9128000	888,915	891,127	-2,212	0	Gunnison River Below Gunnison Tunnel
9132500	352,863	353,514	-651	0	North Fork Gunnison River Near Somerset
9143000	32,964	32,964	-1	0	Surface Creek Near Cedaredge
9143500	22,602	23,918	-1,315	-6	Surface Creek at Cedaredge
9144250	1,501,545	1,498,091	3,454	0	Gunnison River at Delta
9146200	121,827	121,827	0	0	Uncompahgre River Near Ridgway
9147500	192,969	193,024	-55	0	Uncompahgre River at Colona
9149500	236,296	245,597	-9,300	-4	Uncompahgre River at Delta
9152500	1,910,511	1,917,023	-6,512	0	Gunnison River Near Grand Junction

As shown in the Table 3.1, calibration at each complete stream gage is within one percent with the exception of the Surface Creek at Cedaredge gage and the Uncompahgre River at Delta gage. Surface Creek is 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. Calibration efforts, specifically with regard to return flow locations from project irrigation, greatly increased the simulation results at the Uncompahgre River at Delta gage. However, the Uncompahgre Project "good neighbor" operations are not specifically represented in the model.

Table 3.2 summarizes the average annual shortage for water years 1975 through 2005, by tributary or sub-basin. On a basin-wide basis, average annual diversions differ from historical diversions by around two percent in the calibration run. The Crystal River drainage irrigation demands are generally met, with the exception of Fruitland Canal. Diversions through the canal are simulated using an operations 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. Shortages on Currant Creek and Surface Creek are fairly uniform throughout. 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.

Table 3.2
Historical and Simulated Average Annual Diversions by Sub-basin (1975-2002)
Calibration Run (acre-feet/year)

Tributary or Sub-basin	Historical	Simulated	Historical minus Simulated	
			Volume	Percent
Taylor River	9,264	9,210	54	1%
East River	103,025	99,523	3,502	3%
Ohio Creek	47,065	46,389	676	1%
Tomichi Creek	198,034	191,965	6,069	3%
Cebolla Creek, Lake Fork, and Cimarron River	70,891	69,106	1,785	3%
Crystal River	19,688	18,068	1,620	8%
Smith Fork	69,108	68,738	370	1%
N.F. Gunnison River	168,663	164,776	3,887	2%
Currant Creek	31,186	28,720	2,466	8%
Surface Creek	77,987	72,715	5,272	7%
Uncompahgre River	751,121	732,821	18,300	2%
Roubideau Creek	2,942	2,922	20	1%
Kannah Creek	16,700	16,096	604	4%
Gunnison River Mainstem	1,074,732	1,073,312	1,420	0%
Basin Total	2,640,406	2,594,361	46,045	1.74%

Where to find more detailed information:

- Section 7 of the Gunnison River Basin Water Resources Planning Model User's Manual provides detailed calibration results, including time-series graphs and scatter plots of streamflow and reservoir calibrations.

Appendix: Gunnison River Basin Primary Project Operations

1. Overland Reservoir and Ditch Operations

Overland Reservoir is located on West Muddy Creek, a tributary of the North Fork of the Gunnison River. Water released is carried by Upper Overland Ditch to Leroux Creek, and then picked up by the Lower Overland Ditch or by Vanderford Ditch.

Four operating rules are used to simulate the Baseline operations associated with Overland Reservoir. Storage rights allow Overland Reservoir to store water from West Muddy Creek without the need to specify operating rules. Operating rules are used to allow the model to perform the following Overland Reservoir operations:

- Carry water available to the Overland Ditch direct rights via Overland Ditch to meet Lower Overland Ditch demands.
- Carry water from Overland Reservoir via Overland Ditch to meet remaining irrigation demands associated with Lower Overland Ditch and Vanderford Ditch.

2. Paonia Project Operations

The Paonia Project provides full and supplemental irrigation water to land near Paonia and Hotchkiss. The Paonia Project consists of the Paonia Reservoir and the Fire Mountain Canal 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 also provides supplemental irrigation water, by exchange, for up to 2,400 acres of land upstream of Paonia Reservoir, along East and West Muddy Creeks.

Sixteen operating rules are used to simulate the Baseline operations associated with the Paonia Project. Storage rights allow Paonia Reservoir to store water from Muddy Creek without the need to specify operating rules. Direct diversion rights on Muddy Creek allow water to be diverted directly for individual ditch demands without the need to specify operating rules. Operating rules are used to allow the model to perform the following project operations:

- Release water from Paonia Reservoir to meet downstream Fire Mountain Canal supplemental demands
- Release water from Paonia Reservoir in exchange for upstream supplemental diversions through the various Ragged Mountain water user ditches

3. Taylor Park Reservoir Operations

Taylor Park Reservoir is part of the Uncompahgre Project, and delivers supplemental water for irrigation in the Uncompahgre Valley via the Gunnison tunnel.

Eleven operating rules are used to simulate Taylor Park Reservoir Baseline operations. Storage rights allow Taylor Park Reservoir to store water from Taylor River without the need to specify operating rules. Operating rules used to allow the model to perform the following Taylor Park Reservoir operations:

- Release water from Taylor Park Reservoir to meet individual Uncompahgre Valley Water Users Association (UVWUA) demands via the Gunnison Tunnel (South Canal, West Canal, Montrose and Delta Canal, Loutsenhizer Canal, Selig Canal, Ironstone Canal, East Canal, and Garnet Canal)
- Release water from Taylor Park Reservoir to meet minimum reservoir bypass requirements
- Release water from Taylor Park Reservoir to meet USBR operational targets
- Operate the Taylor Park "bookover" as part of the 1975 Exchange agreement, moving remaining water in the Upper Gunnison River Water Conservancy District (UGRWCD) account to the UVWUA account on October 31 of each year

4. Aspinall Unit Operations

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 and includes Blue Mesa, Morrow Point, and Crystal Reservoirs.

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 model also represents the Uncompahgre Valley Water Users Association account in Blue Mesa.

Fourteen operating rules are used to simulate the Baseline operations associated with the Aspinall Unit. Storage rights allow the three reservoirs to store water from the Gunnison River without the need to specify operating rules. Operating rules are used to allow the model to perform the following project operations:

- Release water from Blue Mesa Reservoir to meet Project 7 Water Authority demands via Fairview Reservoir
- Release water from the UVWUA account in Blue Mesa via the Gunnison Tunnel to meet supplemental demands for the eight Uncompahgre Valley recipients
- Release water from Blue Mesa Reservoir to maintain the CWCB Black Canyon instream flow
- Operate the Blue Mesa Reservoir "bookover" operations as part of the 1975 Exchange agreement, moving water from the USA account to the UVWUA account whenever releases are made from either Taylor Park Reservoir's UVWUA account or UGRWCD refill account
- Release water from Blue Mesa Reservoir to meet USBR operational targets

5. Uncompahgre Project and Dallas Creek Project Operations

The Uncompahgre Project provides supplemental irrigation water supplies for lands in the Uncompahgre River basin between Montrose and Delta. The irrigation supplies are obtained from direct flow rights from the Uncompahgre River, direct flow rights from the Gunnison River via the Gunnison Tunnel, and from storage in Taylor Park, Blue Mesa and Ridgway reservoirs.

Dallas Creek Project and its principal component Ridgway Reservoir, provides supplemental water supply for users in the Uncompahgre River basin, including Project 7 municipal use.

In addition to operating rules discussed above that provide supplemental water to the UVWUA demands from Taylor Park and Blue Mesa reservoirs twenty-five operating rules are used to simulate the Baseline operations. Direct diversion rights on the Uncompahgre River allow water to be diverted directly to meet the individual ditch demands without the need to specify operating rules. Storage rights on Dallas Creek allow Ridgway Reservoir to fill without the need for specific operating rules. Operating rules are used to allow the model to perform the following project operations:

- Carry direct flow water through the Gunnison Tunnel to provide supplemental water to the eight UVWUA structures
- Carry direct flow water through the Gunnison Tunnel to provide water to meet Project 7 demands via Fairview Reservoir
- Operate the Ridgway Reservoir "bookover" to move water from the Project 7 account to a UVWUA exchange account when releases are made from Blue Mesa to meet Project 7 Water Authority demands
- Release water from Ridgway Reservoir UVWUA and exchange accounts to provide supplemental water to the UVWUA structures (except South Canal)
- Release water from Ridgway Reservoir Project 7 Water Authority account to meet Project 7 demands

In addition, two operating rules allow Project 7 Water Authority demands to be met from Fairview and Cerro Reservoirs.

6. Smith Fork Project Operations

Crawford Reservoir 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. 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.

Thirteen operating rules are used to simulate the Baseline operations associated with the Smith Fork project. Storage rights allow Crawford Reservoir to store available water from Iron Creek without the need to specify operating rules. Direct diversion rights on Smith Fork allow water to be diverted directly to individual ditch demands without the need to specify operating rules. Operating rules are used to allow the model to perform the following project operations:

- Carry water via Smith Fork Feeder for storage in Crawford Reservoir
- Release water directly from Crawford Reservoir directly to Clipper Ditch and Grandview Ditch demands
- Release water from Crawford Reservoir to supplement downstream Aspen Canal demand
- Release water from Crawford Reservoir in exchange for supplemental diversions through ditches upstream of the confluence of Iron Creek and Smith Fork (Needle Rock, Saddle Mountain, Daisy, and Virginia ditches)
- Carry water from Crawford Reservoir via Aspen Canal to meet Needle Rock Ditch supplemental demands
- Carry direct right water via Aspen Canal to meet Needle Rock Ditch and Grandview Ditch supplemental demands

7. Fruitland Mesa Operations

Fruitland Mesa encompasses Fruitland Reservoir 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 is used to irrigate land in the Iron Creek drainage as well as fill Fruitland Reservoir.

Nine operating rules are used to simulate the Baseline operations associated with the Fruitland Mesa. Operating rules are used to allow the model to perform the following project operations:

- Carry water from Crystal River via Fruitland Canal to irrigate lands below Fruitland Reservoir
- Carry water from Crystal River via Fruitland Canal for storage in Fruitland Reservoir
- Release supplemental water from Fruitland Reservoir to irrigate lands below Fruitland Reservoir

8. Bostwick Park Project Operations

Bostwick Park Water Conservancy District was formed in 1962 to supplement irrigation water in the Bostwick Park area. The key components of the Bostwick Park Project are Silverjack Reservoir and the Cimarron Canal. Cimarron Canal diverts water to supply irrigators in the Bostwick Park area and to fill Cerro Reservoir, one of Project 7 Water Authority storage facilities.

Seven operating rules are used to simulate the Baseline operations associated with the Bostwick Park Project operations. Storage rights allow Silverjack Reservoir to store available water from Cimarron River without the need to specify operating rules. Operating rules are used to allow the model to perform the following project operations:

- Release water from Silverjack Reservoir via Cimarron Canal to meet irrigation demands
- Release water from Silverjack Reservoir via Cimarron Canal for storage in Cerro Reservoir

9. Fruitgrowers Reservoir Operations

Fruitgrowers Reservoir provides supplemental irrigation water to the Tongue Creek and Alfalfa Run area. Inflow to the reservoir from Alfalfa Run is supplemented with diversions from Dry and Surface Creeks.

Three operating rules are used to simulate the Baseline operations associated with the Fruitgrowers Reservoir operations. Operating rules are used to allow the model to perform the following project operations:

- Carry water via Transfer Ditch for storage in Fruitgrowers Reservoir
- Release water from Fruitgrowers Reservoir to supplement Stell Enlargement Ditch irrigation demands

Where to find more detailed information:

- Section 5.8 of the Gunnison River Basin Water Resources Planning Model User's Manual provides details regarding project operations and operating rules.
- Section 2 of the Gunnison River Basin Information Report, available on the CDSS website, provides historical and overview information on Gunnison River Projects and Special Operations.
- Section 3 of the Gunnison River Basin Information Report provides Division 4 personnel recommendations on how to model basin project operations.
- Section 4.13 of the State of Colorado's Water Resources Model (StateMod) Documentation provides available operating rules, guidelines for selecting the appropriate rules based on water source and destination, and examples of how each operating rule has been applied to represent real Colorado operations.