Historical Crop Consumptive Use Analysis

Yampa River Basin

Final Report

2015

Acknowledgments

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Yampa River Basin

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1.0 Executive Summary

The Yampa River Basin historical crop consumptive use analysis was performed on a monthly basis for the period from 1950 through 2013 as part of the Colorado Decision Support System (CDSS). The CDSS project was developed jointly by the State of Colorado Water Conservation Board and the Division of Water Resources. The objective of the historical crop consumptive use portion was to quantify 100 percent of the basin's historical crop consumptive use. This report documents the input and results of the historical crop consumptive use analysis updated in April 2015.

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

1.1 Background

The Yampa River Basin is located in northwestern Colorado and encompasses approximately 7,660 square miles. The Yampa River headwaters flow from the Rocky Mountains near Yampa, Colorado at an elevation of 12,200 feet and flows westerly into Utah near Dinosaur National Monument at an elevation of 5,600 feet. Major tributaries to the Yampa River include Fish Creek, Elk River, the Williams Fork River and the Little Snake River. Most stream flow originates from snowmelt in the surrounding mountains. Average annual precipitation in the basin ranges from 10 inches near the Stateline to more than 60 inches at Rabbit Ears Pass.

1.2 Approach

The Yampa River historical crop consumptive use analysis was performed using StateCU, a generic, data driven consumptive use model and graphical user interface. The objective of the model is to develop monthly consumptive use estimates for the assessment of historical and future water management policies. Key information used by the model to assess historical consumptive use includes irrigated acreage, crop types, monthly climate data, and diversion records.

The historical crop consumptive use analysis also provides information and consumptive use estimates for the basin surface water model (StateMod) analysis of the Yampa River Basin.

1.3 Results

Table 1 presents the average annual acreage and historical crop consumptive use analyses results for the 1950 to 2013 study period. As shown, the irrigation water requirement averages 161,237 acre-feet per year while water supply-limited consumptive use averages 128,205 acre-feet per year. The average annual shortage in the basin is 20 percent. Shortages are greater in Water Districts 44, 54, and 58 due primarily to physical supply limitations on the smaller tributaries in the late irrigation season.

Table 1: Average Annual Acreage and Consumptive Use Results 1950 through 2013

Water District-Basin	Average Acres	Irrigation Water Requirement (acre-feet)	Supply-Limited CU (acre-feet)	Percent Short
44 – Lower Yampa	26,964	51,346	37,499	27%
54 – Slater/Timerlake	13,496	27,398	22,611	17%
55 – Little Snake	1,531	2,082	1,878	9%
56 – Green River	1,508	1,820	1,781	2%
57 – Middle Yampa	9,678	15,211	13,657	10%
58 – Upper Yampa	32,194	63,379	50,780	20%
Basin Total	85,373	161,237	128,205	20%

Figure 1 presents historical acreage by crop type for the 2010 irrigated acreage assessment. The irrigated lands coverage for 1993, 2005, and 2010 were considered in the analysis. The total irrigated acreage from 1950 to 2013 averaged 85,373 acres. As shown, pasture grass is grown on the majority of irrigated land in the basin to support cattle ranching.

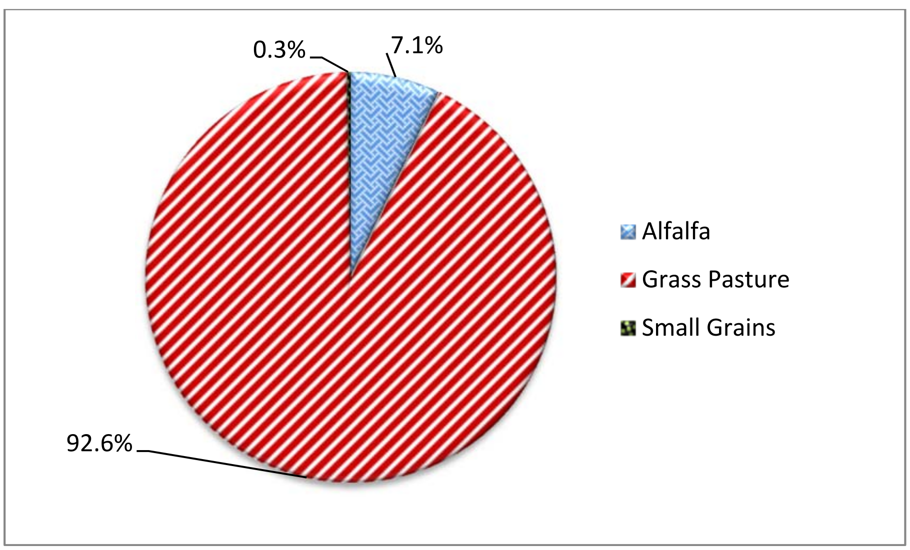


Figure 1: 2010 Irrigated Acreage by Crop Type

Figure 2 presents the annual historical acreage, irrigation water requirement, and supply limited consumptive use for the study period. Although there are minor changes in irrigated acreage between 1993, 2005, and 2010, the pronounced yearly variations in irrigation water requirement are due to climate variability in the analysis (temperature and precipitation). The percent of irrigation water requirement not satisfied averaged 20 percent over the study period. Greater shortages from 2000 to 2004, averaging 25 percent, represent below average stream flows. Shortages averaging 20 percent from 1995 through 1997 are consistent with normal to above average stream flows. Shortages reached a maximum in 2002 at 35 percent due to drought conditions.

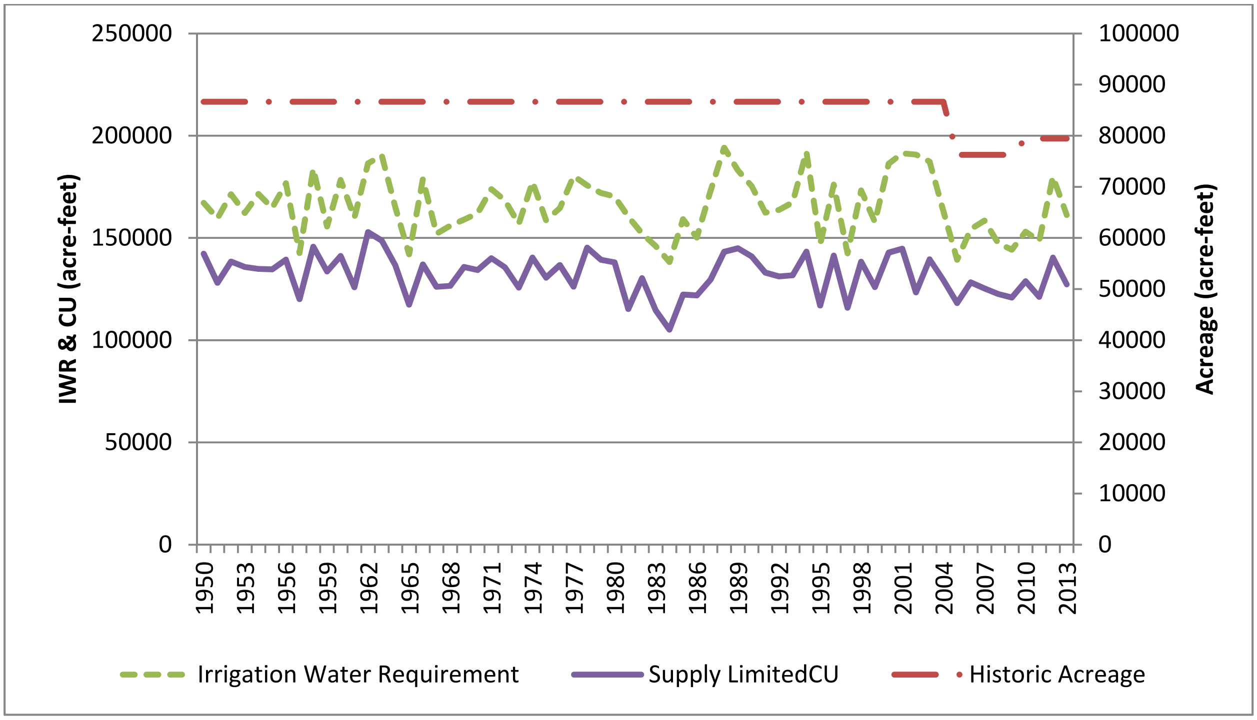


Figure 2: Historical Acreage, Irrigation Water Requirement, and Supply Limited CU 1950 through 2013

Figure 3 shows the annual estimated diversions from surface water to meet crop irrigation requirement. The average annual surface water diversions from 1950 through 2013 were 417,004 acre-feet.

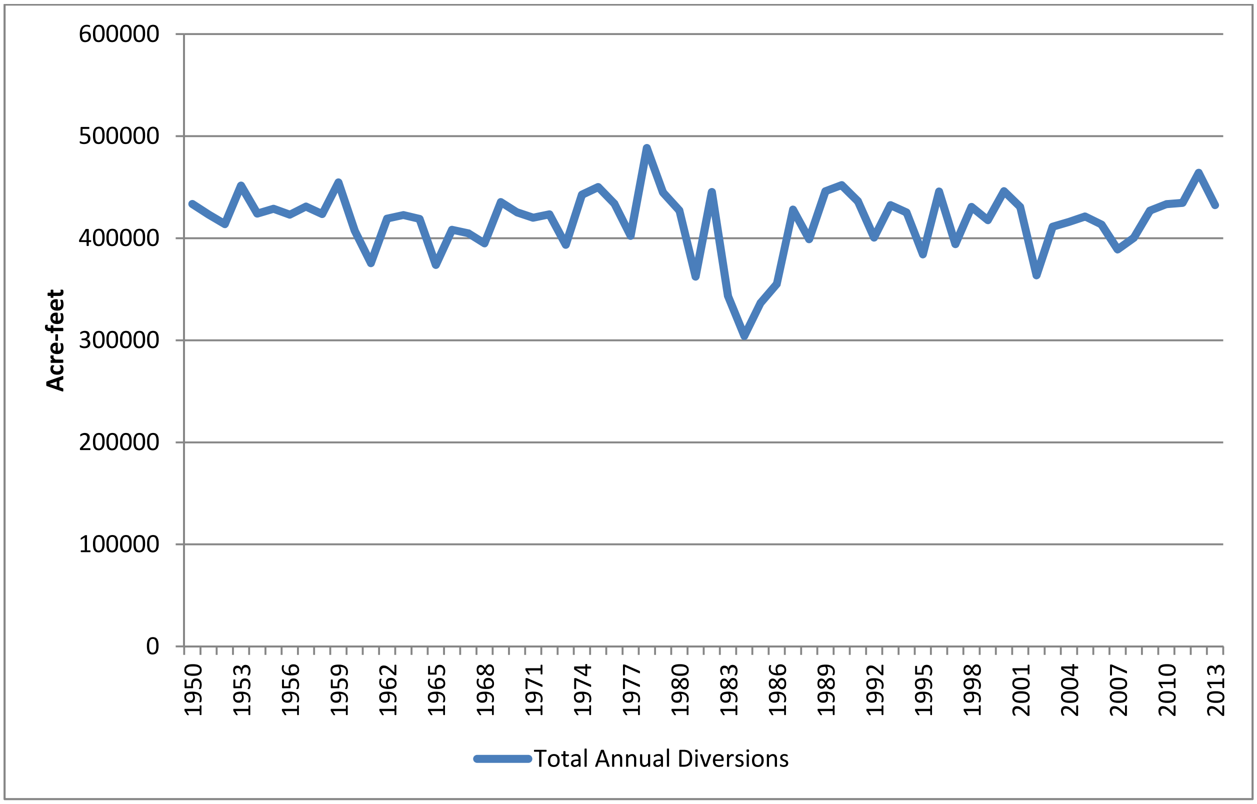


Figure 3: Annual Surface Water Diversions 1950 through 2013

2.0 Introduction

The estimation of historical crop consumptive use in the Yampa River Basin and the tool used to perform the analysis are documented in three major reports as follows:

1. This report describes climate and crop data from HydroBase used in the historical consumptive use analysis, and the parameters used in analysis, including Blaney-Criddle crop coefficients and characteristics. This document summarizes the results of the analysis; total irrigation water requirement and the supply-limited total consumptive use for the Yampa River Basin.

2. Yampa River Basin Water Resources Planning Model User's Manual describes the development of the Yampa River Basin StateMod surface water model. The document summarizes the process and results of developing the historic diversions and the structure list for the historic consumptive use analysis.

3. The StateCU Documentation describes the consumptive use model and graphical user interface used to perform all consumptive use analyses conducted as part of the Yampa River Decision Support System.

This Historical Crop Consumptive Use Analysis Report has not attempted to reiterate the detailed analyses and results of the previous efforts performed in support of the final historical crop consumptive use analysis. Instead, it summarizes the major results of each technical memorandum. Supporting memorandum and reports are available on the CDSS website.

2.1 Basin Description

The Yampa River basin within Colorado is approximately 7,660 square miles in size, ranging in elevation from 12,200 feet in the headwaters near the town of Yampa to 5,600 feet near Dinosaur National Monument. Across this expanse, average annual rainfall varies from more than 60 inches near Rabbit Ears Pass, to approximately 10 inches near the Stateline. Temperatures generally vary inversely with elevation, and variations in the growing season follow a similar trend. Steamboat Springs has an average growing season of 86 days, while the growing season at Craig, Hayden, and Maybell has been estimated at approximately 120 days.

The Yampa River is the primary stream in the basin. It begins at the confluence of the Bear River and Chimney Creek, and other major tributaries include Walton Creek, Fish Creek, Trout Creek, Elk River, Elkhead Creek, Fortification Creek, the Williams Fork River, and the Little Snake River. Most of the water yield in the basin is attributable to snowmelt from the higher elevation areas near the Continental Divide. Average annual streamflow in the upper portions of the drainage (United States Geological Survey [USGS] gage near Stagecoach Reservoir) is approximately 59,000 acre-feet, which increases to an annual average of 1,534,000 acre-feet at the Dinosaur

Monument (USGS gage near Deerlodge Park). Over 60 percent of this runoff occurs in May and June. Crop irrigation accounts for the largest water use in the basin.

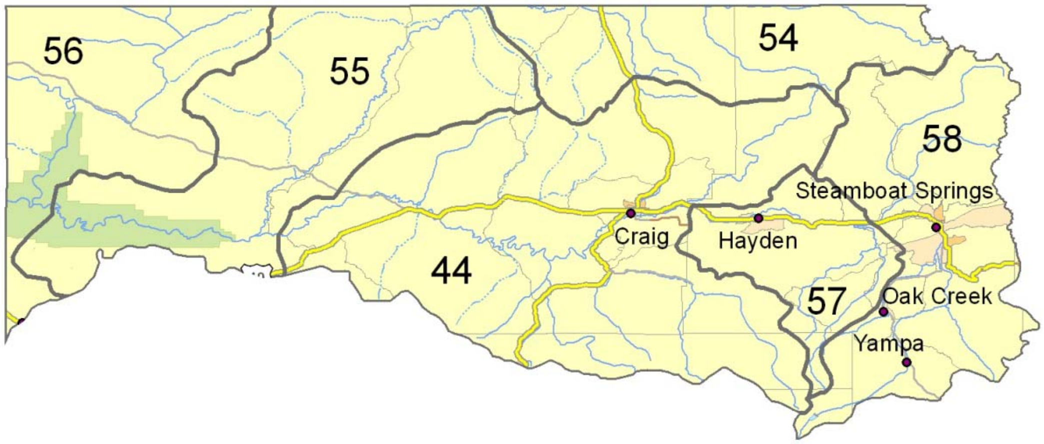


Figure 4: Yampa River Basin and Water District Boundaries

2.2 Definitions

Several terms used in this report have been broadly used in other studies. The following definitions are consistent with the American Society of Civil Engineers Manuals and Reports on Engineering Practice No. 70 - Evapotranspiration and Irrigation Water Requirements.

Potential Evapotranspiration (ET) The total amount of water that would be used for crop growth if provided with an ample water supply, also called potential consumptive use.

Effective Precipitation The portion of precipitation falling during the crop-growing season that is available to meet the evapotranspiration requirements of the crop.

Winter Effective Precipitation The portion of precipitation falling during the non-growing season that is available for storage in the soil reservoir, and subsequently available to crops during the next growing season.

Irrigation Water Requirement The amount of water required from surface or ground water diversions to meet crop consumptive needs. Calculated as potential evapotranspiration less effective precipitation and stored winter precipitation.

Water Supply-Limited Consumptive Use The amount of water actually used by the crop, limited by water availability. Also called actual consumptive use.

The following terms are commonly used in the CDSS efforts:

Irrigated Parcel An irrigated "field" having the same crop type, irrigation method (sprinkler or flood), and water source - not divided by a large feature, such as river or highway.

Ditch Service Area The area of land that a ditch system has either the physical ability or the legal right to irrigate. Note that a ditch service area often includes farmhouses, roads, ditches, fallow fields and undeveloped lands. Therefore a ditch service area is typically greater than the land irrigated under that ditch.

Key Diversion Structure A ditch system that is modeled explicitly in both the StateCU historic consumptive use model efforts and the StateMod water resources planning model. Ditch systems are generally defined as key if they have relatively large diversions, have senior water rights, or are important for administration.

Diversion System Structure A group of diversion structures on the same tributary that operate in a similar fashion to satisfy a common demand.

Aggregated Diversion Structure A group of non-key structures. Aggregated diversions are typically aggregated based on location; e.g. diverting from the same river reach or tributary.

HydroBase The State of Colorado's relational database used in the CDSS efforts. HydroBase contains historic, real-time, and administrative water resources data.

Data Management Interface (DMI) A CDSS program that allows data to flow from HydroBase to the CDSS models using an automated data-centered approach.

StateMod The CDSS water allocation model used to analyze historic and future water management policies.

3.0 Model Development

The Yampa River historical crop consumptive use analysis was performed using StateCU, a generic data driven consumptive use model and graphical user interface. The objective of the model is to develop consumptive use estimates for the assessment of historical and future water management policies.

The model originated at the USBR and has undergone substantial enhancements while being applied to the Colorado Decision Support System, the Rio Grande Decision Support System, and the South Platte Decision Support System. The *StateCU Documentation* provides a complete description of the model and its capabilities.

3.1 Modeling Approach

The general methodology used to estimate historical consumptive use for the Yampa River Basin is as follows (See the *StateCU Documentation* for a more complete description of the calculation methods):

1. A Yampa River Basin structure scenario was developed that includes 100% of the 2005 and 2010 irrigated acreage in the Yampa River using the key, diversion system, and aggregated structures and their associated acreage and crop patterns (see **Section 4.3**).
2. Climate stations were assigned to each structure based on spatial determination of climate station weights by hydrologic unit code (HUC).
3. Potential ET was determined using the SCS Modified Blaney-Criddle consumptive use methodology with TR-21 crop characteristics for acreage below 6500 feet and the Original Blaney-Criddle consumptive use methodology with high-altitude crop coefficients developed for Denver Water for pasture above 6,500 feet. As recommended in the ASCE Manuals and Reports on Engineering Practice No. 70, Evapotranspiration and Irrigation Water Requirements (1990), an elevation adjustment of 10 percent adjustment upward for each 1,000 meters increase in elevation above sea level was applied to the Modified Blaney-Criddle method, i.e. for crops below 6,500 feet. The SCS effective rainfall method outlined in the SCS publication Irrigation Water Requirement Technical Release No. 21 (TR-21) was used to determine the amount of water available from precipitation, resulting in irrigation water requirement.
4. Water supply-limited consumptive use was determined by including diversion records, conveyance efficiencies, application efficiencies, and soil moisture interactions. The model determined water supply-limited consumptive use by first applying surface water to meet irrigation water requirement for land under the ditch system. If excess surface water still remained, it was stored in the soil moisture reservoir. Then if the irrigation water requirement was not satisfied, surface water stored in the soil moisture reservoir was used to meet remaining irrigation water requirement.

3.2 File Directory Convention

To assist in the file organization and maintenance of official State data, the files associated with a historic consumptive use analysis will install to the default subdirectory \cdss\data\ *Analysis_description*\StateCU. *Analysis_description* is **ym2015** for the Yampa River crop consumptive use analysis, updated in 2015. Note that these directory conventions are not a requirement of the model, simply a data management convention for official State data.

3.3 File Naming Convention

Specific file names or extensions are not a requirement of the model except for the StateCU response file (*.rcu). Standard extensions have been adopted by the State for data management purposes, and are outlined in **Section 4.0 Data Development**.

3.4 Data Centered Model Development

Nearly all the StateCU input files have been generated from HydroBase using the data management interfaces StateDMI (Version 3.12.02, 4/17/2013) and TSTool (Version 10.20.00, 4/21/2013). A description of these tools as applied to StateCU is included in **Section 4 Data Description,** where applicable.

3.5 Product Distribution

The StateCU model, CDSS input files, and associated documentation can be downloaded from the State of Colorado's CDSS web page at http://cdss.state.co.us.

4.0 Data Description

The following sections provide a description of each input file, the source of the data contained in the input file, and the procedure for generating the input file. More detailed information regarding the file contents and formats can be found in the *StateCU Documentation*.

1. Simulation information files
   - StateCU Response File ***Section 4.1***
   - StateCU Control File ***Section 4.2***
2. Structure specific files
   - StateCU Structure File ***Section 4.3***
   - Crop Distribution File ***Section 4.4***
   - Annual Irrigation Parameter File ***Section 4.5***
   - Historical Diversion File ***Section 4.6***
3. Climate data related files
   - Climate Station Information File ***Section 4.7***
   - Climate Data Files ***Section 4.8***
4. Blaney-Criddle specific files
   - Blaney-Criddle Crop Coefficient File ***Section 4.9***
   - Crop Characteristics File ***Section 4.10***

4.1 StateCU Response File (ym2015.rcu)

The StateCU response file contains the names of input files used for a StateCU analysis. The StateCU response file was created using a text editor for the Yampa River Basin. Input file names in the response file can be revised through the StateCU Interface.

4.2 StateCU Model Control File (ym2015.ccu)

The StateCU Model control file contains the following information used in the historic consumptive use analysis:

- Beginning and ending year for simulation – The simulation period for the analysis was 1950 through 2013.
- Consumptive use analysis method – Monthly SCS Modified Blaney-Criddle, described in TR-21, and the monthly Original Blaney-Criddle analysis were used.
- Effective precipitation method – The SCS Effective Precipitation method, defined in TR-21 was used.
- Scenario type – The analysis was defined as a “structure” scenario.
- Soil moisture consideration – The soil moisture switch was set to “1” indicating the analysis should include soil moisture accounting.

- Initial soil moisture information – The initial soil moisture was set to 50 percent of the capacity for each structure.
- Winter carry-over precipitation percent – The winter carry-over precipitation defines the amount of non-irrigation season precipitation that is available for storage in the soil moisture reservoir. Winter carry-over precipitation was not used for this scenario; set to zero.
- Output options – The output summary switch was set to "3" indicating a detailed water budget output should be generated.

The StateCU model control file was created using a text editor for the Yampa River Basin. Options in the model control file can be revised through the StateCU Interface.

4.3 StateCU Structure File (ym2015.str)

A structure file defines the structures to be used in the analysis. The structure file contains physical information and structure-specific information that does not vary over time including location information; available soil capacity; and assignments of climate stations to use in the analysis. Location information includes the latitude and county for each structure. The latitude is used in the Blaney-Criddle method to determine the hours of daylight during the growing season.

Key and Aggregate Structures

The structure file used in the historical consumptive use analysis was created using **StateDMI** to extract diversion structure location information stored in HydroBase. Early in the CDSS process it was decided that, while all consumptive use should be represented in the model, it was not practical to model each and every water right or diversion structure individually. With this objective in mind, key structures to be "explicitly" modeled were determined 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 basin-wide total decreed amount in the ranked list
- Generating a structures/water rights list consisting of structures at or above the threshold decreed amount
- Field verifying structures/water rights, or confirming their significance with basin water commissioners, and making adjustments

Based on this procedure, 5 cubic feet per second (cfs) cutoff was selected for the Yampa River basin in Colorado. Key diversion structures are those with total absolute water rights equal to or greater than 5.0 cfs. The Yampa River model includes 259 key diversion structures.

The use associated with irrigated diversions having total absolute rights less than 5.0 cfs were included as "aggregate structures". Additional details on the aggregate structures are found in **Appendix A**.

As presented in **Table 3**, 76 percent of 2010 acreage was assigned to key structures or diversion systems. The approach and results for selecting key structures and aggregations are outlined in more detail in **Section 4.2.2** and **Appendix A**.

Table 2: Key and Aggregate Structure Summary

Structure Type	2005 Acres	Percent of Total Acreage	2010 Acres	Percent of Total Acreage	Number of Structures
Key/Diversion System	53,424	70%	55,216	76%	258
Aggregated	22,824	30%	24,220	24%	41 (1) (577)
Total Structures	**76,248**	**100%**	**79,436**	**100%**	**300**

(1) There are a total of 41 aggregate structures representing 576 individual structures.

Available Soil Moisture Capacities

Available soil moisture capacities were estimated from Natural Resources Conservation Service (NRCS) digital mapping and assigned to individual structures in the structure file. Soil moisture capacities for each structure, in inches of holding capacity per inch of soil depth, were provided for key and aggregate structures from comma separated list files. Structure soil moisture capacity by structure ranges from 0.0462 to 0.1876 inches per inch. **Table 4** summarizes the average soil moisture capacities used in the consumptive use analysis by Water District.

Table 3: Average Soil Moisture Capacity (inches/inch)

District	Average AWC
44	0.1391
54	0.1259
55	0.0788
56	0.0788
57	0.1389
58	0.1295
WY	0.1259
Basin Average	**0.1173**

Climate Station Assignment

Climate stations were selected for use in the consumptive use calculation based on their period of records and location with respect to irrigated land (see **Section 4.7** for more information on climate stations). Climate stations and respective weights were assigned to county/hydrologic unit code (HUC) combinations, originally based on USBR assignments. Climate station weights were then assigned to structures based on this county/HUC area combination method..

4.4 Crop Distribution File (ym2015.cds)

The crop distribution file contains acreage and associated crop types for each key and aggregate surface water structure for every year in the analysis period (1950 through 2013). The irrigated acreage assessment for 1993 was originally developed by the State Engineer's Office and the USBR. Each irrigated parcel was assigned a crop type and tied to a structure that provides water to the parcel. Acreage assessments representing 2005 and 2010 were also used in the analysis. The irrigated acreage, along with crop type identification, is available spatially through GIS shapefiles and is stored in HydroBase. **Table 5** summarizes 2005 and 2010 acreage by crop type.

Table 4: Irrigated Acreage by Crop Type

Crop	2005 Acreage	2010 Acreage
Alfalfa	3,711	5,643
Grass Pasture	72,521	73,549
Vegetables		
Small Grains	17	244
Spring Grains		
Total Acreage	**76,248**	**79,436**

1993 acreage and crop types were assigned to years 1950 through 2004 reflecting the limited change in irrigated acreage in the Colorado River Basin. The year 2005 acreage and crop types were assigned to years 2005 through 2009. The year 2010 acreage and crop types were assigned to years 2010 through 2013. Note that the year 2000 coverage is omitted from the analysis. The crop distribution file used in the historic consumptive use analysis was created using **StateDMI. StateDMI** was used to extract the acreage and crop type information from HydroBase and develop the crop distribution file.

4.5 Annual Irrigation Parameter File (ym2015.ipy)

The annual irrigation parameter file contains yearly (time series) structure information required to run consumptive use simulations, including the following:

- conveyance efficiencies
- maximum flood irrigation efficiencies
- maximum sprinkler irrigation efficiencies
- acreage flood irrigated with surface water only
- acreage sprinkler irrigated with surface water only
- acreage flood irrigated with ground water only or supplemental to surface water
- acreage sprinkler irrigated with ground water only or supplemental to surface water
- maximum permitted or decreed monthly pumping capacity
- ground water use mode (ground water primary or secondary source)

The conveyance efficiency accounts for losses between the river headgate and the farm headgate, including losses through canals, ditches and laterals. The maximum flood irrigation and sprinkler efficiencies account for application losses between the farm headgate and the crops. Note that conveyance and maximum application efficiency data input data were not adjusted by year. However, a structure's overall system efficiency may change by year due to changes in the percent of land served by sprinkler or flood application methods, or due to surface water supply in excess of crop requirement.

Ditch and lateral coverages for the Yampa River Basin are not available to use in estimating individual structure ditch loss, therefore conveyance efficiency for all structures in the Yampa River Basin is set at 100 percent. Maximum flood irrigation and sprinkler irrigation efficiencies, that represent maximum overall system efficiency, were estimated to be 54 percent and 72 percent respectively. The maximum flood and sprinkler irrigation system efficiencies were derived based on a maximum application efficiency of 60 percent and 80 percent respectively, and 90 percent conveyance efficiency. Efficiency numbers are derived and are not stored in HydroBase. Irrigation methods (flood vs sprinkler), however, are stored in HydroBase. **StateDMI** was used to extract the time series information from HydroBase, set the derived efficiency values, and create the annual irrigation parameter file.

4.6 Historical Irrigation Diversion File (ym2015_cu.ddh)

The historical diversion file provides surface water supply information required to estimate supply-limited consumptive use. Irrigation diversions are provided for each modeled key and aggregate surface water diversion structure. **Figure 5** shows how surface water diversions for irrigation in the basin have changed over time. Surface water diversions for irrigation averaged approximately 417,004 acre-feet per year over the 1950 through 2013 study period. The variation seen in **Figure 5** is due to water supply limitations resulting from varying snowpack.

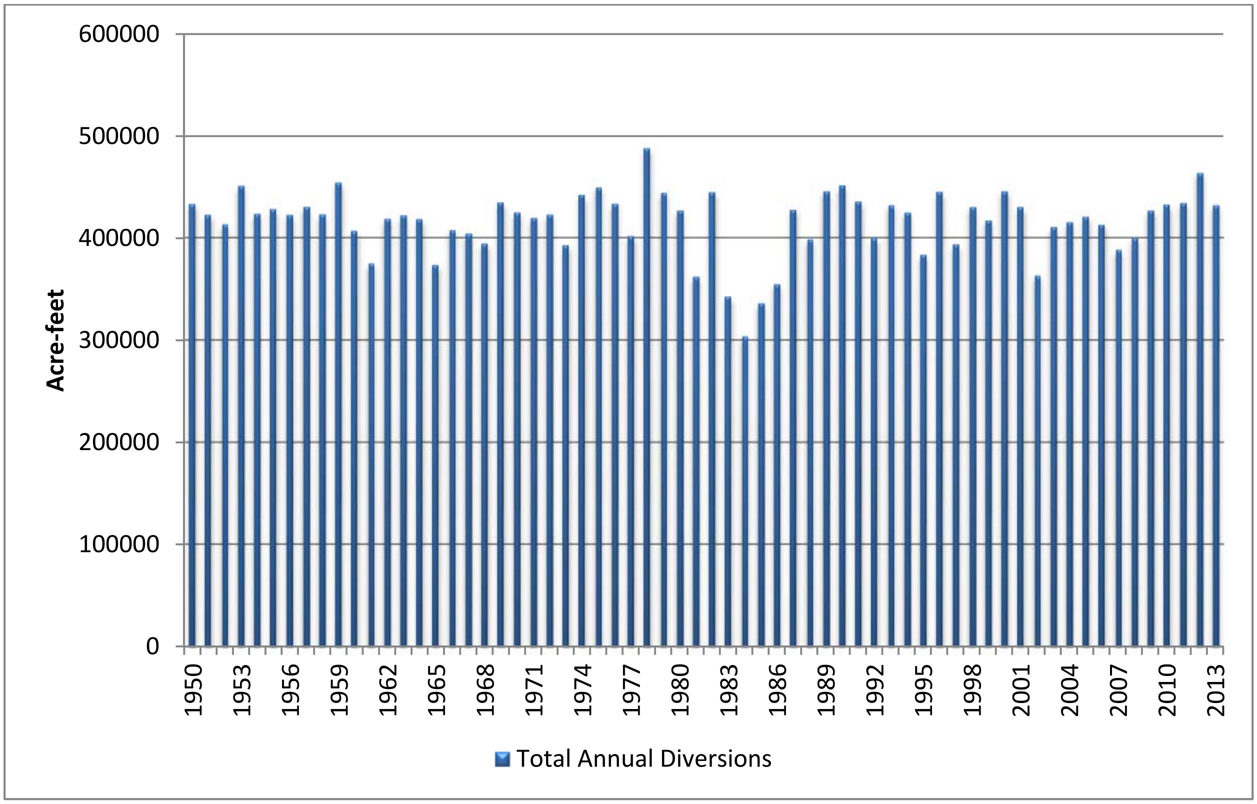


Figure 5: Total Annual Surface Water Irrigation Diversions

StateDMI was used to extract diversion records for Colorado structures from HydroBase and fill missing diversion data**.** Diversion data for structures included in a diversion system or aggregate structure are first extracted and filled, then combined with other structures' diversion data in the diversion system or aggregate structure. Note that diversion comments were considered when extracting data from HydroBase; for instance, if the diversion comment for a specific structure indicated the structure was not usable for a specific year, that year of data for that structure was set to zero.

Missing data was filled using a wet/dry/average pattern according to an 'indicator' gage. Each month of streamflow at the indicator gage was categorized as a wet/dry/average month through a process referred to as 'streamflow characterization'. 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 remaining months are characterized as 'average'. Using this characterization, missing data points were filled based on the wet, dry, or average pattern. For example, a data point missing for a wet March was filled with the average of other wet Marches in the partial time series, rather than all Marches. The pattern streamflow gages used in the Yampa River basin are: Little Snake River at Lily (09260000), Yampa River at Maybell (09251000), and Yampa River at Steamboat Springs (09239500). If missing data still existed after filling with a pattern file, historical monthly averages were used to fill the remaining data.

4.7 Climate Station Information File (COclim2015.cli)

The climate station information file provides climate station location information for climate stations used in the analysis, including latitude, elevation, county and HUC. A single climate station information file was developed for the entire western slope and therefore includes all key climate stations used in the Yampa River basin models (Gunnison, White, Yampa, Upper Colorado, San Juan/Dolores). **Table 6** lists the subset of climate stations used in the Yampa River analysis including their period of record and their percent complete for temperature and precipitation data. The climate station information file was created using **StateDMI** to extract location information stored in HydroBase based on a list of climate stations to be used in the analyses.

Table 5: Key Climate Station Information

Station Name	Station ID	WD	Period of Record	Elevation (feet)	Percent Complete (1950 – 2013)	
					Temperature	Precipitation
Baggs	USC00480484	WY	1979-2014	6240	51.56%	50.13%
Craig *	USC00051928	44	1948-2010	6440	90.76%	89.06%
Hamilton	USC00053738	44	1948-2007	6230	-	88.41%
Hayden	USC00053867	57	1948-2015	6440	99.22%	99.35%
Marvine Ranch	USC00055414	43	1972-1998	7800	40.49%	39.71%
Maybell	USC00055446	44	1958-2014	5908	74.22%	75.91%
Pyramid	USC00056797	57	1948-2005	8009	-	85.29%
Steamboat Springs	USC00057936	58	1908-2015	6636	97.79%	95.18%
Yampa	USC00059265	58	1948-2014	7890	74.22%	98.96%

* Represents a combined climate station whereby the data from two or more stations has been combined to create a single key climate station.

4.8 Climate Data Files (COclim2015.tem, COclim2015.prc, COclim2015.fd)

StateCU requires historical time series data, in calendar year, for temperature, frost dates, and precipitation. The CDSS climate data files, developed using the **TSTool**, contain monthly data for fifty-four stations. Note that a single set of climate data files were developed for the entire western slope and therefore include data for all key climate stations used in the Yampa River basin models (Gunnison, White, Yampa, Upper Colorado, San Juan/Dolores). **Table 7** summarizes the average annual temperature, frost dates and precipitation based on filled data for the subset of stations used in the Yampa River analysis.

Table 6: Average Annual Filled Climate Values 1950 through 2013

Station Name	Station ID	Average Annual		Frost Dates - Degrees F			
		Temperature (Degrees F)	Precipitation (Inches)	Spring 28 Deg	Spring 32 Deg	Fall 32 Deg	Fall 28 Deg
Baggs - WY	USC00480484	41.8	10.20	5/12	6/8	9/2	9/24
Craig*	USC00051928	42.9	14.08	5/15	6/4	9/11	9/27
Hamilton	USC00053738	-	18.47	-	-	-	-
Hayden	USC00053867	42.8	17.11	5/15	6/5	9/8	9/27

Marvine Ranch	USC00055414	36.7	26.11	6/17	6/23	7/12	8/8
Maybell	USC00055446	42.1	12.18	5/27	6/13	8/28	9/15
Pyramid	USC00056797	-	20.06	-	-	-	-
Steamboat Springs	USC00057936	39.3	23.89	5/30	6/19	8/6	9/9
Yampa	USC00059265	39.4	16.42	6/3	6/16	8/24	9/19

* Represents a combined climate station whereby the data from two or more stations has been combined to create a single key climate station.

Figures 6 and **7** show the 1950 through 2010 average monthly precipitation and temperature for the Yampa (USC00059267) climate station located in the northeastern portion of the Yampa River Basin. Historical missing data for these climate stations were filled from 1950 through 2013 using **TSTool.** Historical month averages were used to fill missing precipitation data and linear regression techniques were used to fill missing temperature data**.**

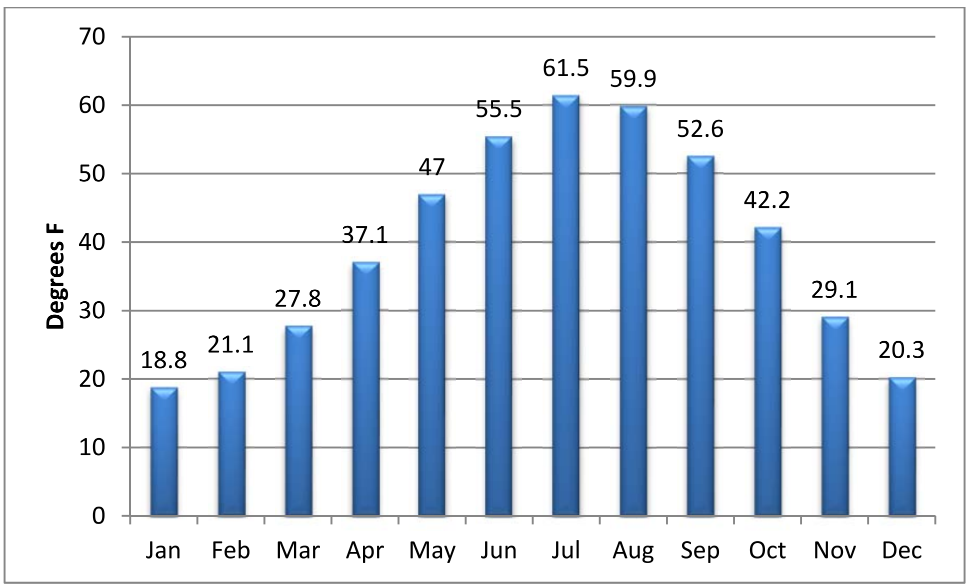


Figure 6: Average Mean Monthly Temperature Yampa Climate Station 1950 through 2013

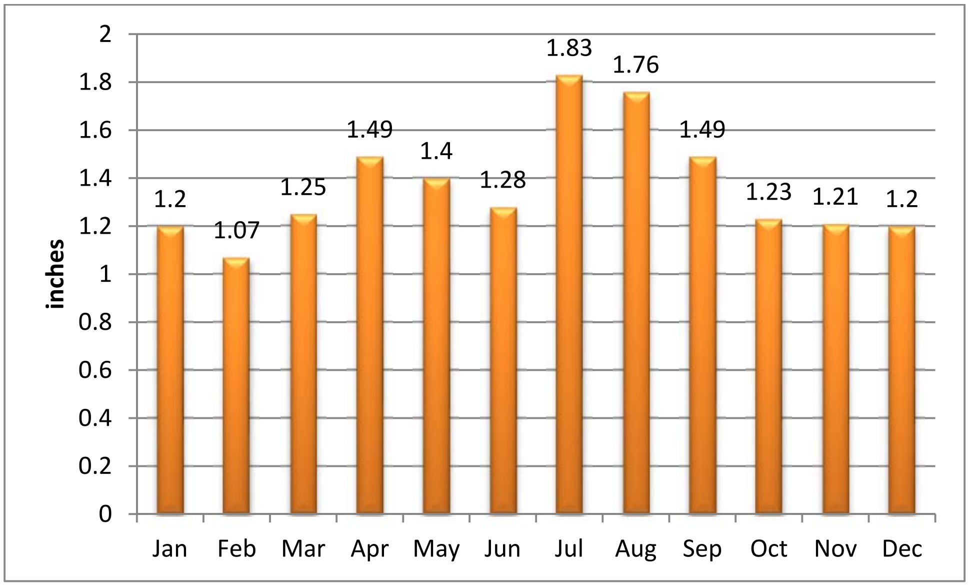


Figure 7: Average Mean Monthly Precipitation Yampa Climate Station 1950 through 2013

4.9 Blaney-Criddle Crop Coefficient File (CDSS_wEA.kbc)

The Blaney-Criddle crop coefficient file contains crop coefficient data used in the CDSS historical consumptive use analysis. Standard TR-21 Blaney-Criddle crop coefficient curve data is available for the Modified Blaney-Criddle method. The crop coefficient file contains TR-21 curve data for several crops, however only five TR-21 crops are modeled in the Yampa River Basin; grass pasture, alfalfa, orchard without cover, vegetables and spring grains.

Structures with irrigated grass pasture acreage located above 6500 feet in elevation were assigned the Denver Water High Altitude crop coefficients, included in the CDSS_wEA.kbc file, for use with the Original Blaney-Criddle methodology. Additional details on high altitude crop coefficients can be found the SPDSS Task 59.1 Technical Memorandum available on the CDSS website.

The flag to indicate an elevation adjustment to specific crops in the analysis is located in the crop coefficient file. It is recommended in the ASCE Manuals and Reports on Engineering Practice No. 70, Evapotranspiration and Irrigation Water Requirements (1990) that an elevation adjustment of 10 percent adjustment upward for each 1,000 meters increase in elevation above sea level be applied to the Modified Blaney-Criddle method when using TR-21 coefficients, i.e. for crops below 6500 feet. For this analysis, an elevation adjustment was applied for all Modified Blaney-Criddle crops. The elevation adjustment is applied based on the elevation of the structure, if provided in the structure file. However, in general, structure elevations are not available in HydroBase. If no structure elevation is provided, the elevation of the weighted climate station(s) is used for the elevation adjustment.

The crop coefficient file used in the historic consumptive use analysis was created using **StateDMI** to extract the crop coefficients stored in HydroBase.

4.10 Crop Characteristic File (CDSS.cch)

The crop characteristic file contains information on planting, harvesting, and root depth. Standard TR-21 Blaney-Criddle crop characteristics were used in the analysis. Crop characteristics from the Denver Water study were adapted for grass pasture above 6,500 feet in elevation. **Table 8** illustrates the crop characteristics for the crops grown in the Yampa River basin, including high altitude grass pasture.

The crop characteristic file used in the historic consumptive use analysis was created using **StateDMI** by extracting the representative crop characteristics from HydroBase and develop the crop characteristics input file.

Table 7: Characteristics of Yampa River Basin Crops

Crop Type	Source	Length of Season	Beginning Temperature	End Temperature
Alfalfa	TR-21	365	50	28
Grass Pasture	TR-21	365	45	45
Orchard w/out Cover	TR-21	365	50	45
Spring Grains	TR-21	137	45	32
Vegetables	TR-21	146	55	45
High Altitude Grass Pasture	Denver Water Study	365	42	42

5.0 Results

5.1 StateCU Model Results

The Yampa River Basin historical crop consumptive use results are a product of the input files described in **Section 4**. This section provides a summary of historical crop consumptive use and system efficiencies. Results for individual key and aggregated structures can be easily viewed and printed by obtaining the StateCU input files and StateCU model from the CDSS web site (see **Section 3.5**).

Tables 9 shows the average annual basin consumptive use water budget accounting for the period 1950 through 2013. The individual component results are discussed in detail in the following sections.

Table 8: Basin Average Annual Results 1950 through 2013 (acre-feet)

Water District-Basin	Irrigation Water Reqt.	Surface Water Diversion Accounting					Estimated Crop CU		
		River Headgate Diversion	Surface Water Diversion To:			Calculated System Efficiency	From SW	From Soil	Total
			CU	Soil	Non-Consumed				
44 – Lower Yampa	51,346	127,073	31,053	6,405	89,615	24%	31,053	6,445	37,499
54 – Slater/Timberlake	27,398	76,691	19,873	2,744	54,074	29%	19,873	2,739	22,611
55 – Little Snake	2,082	13,694	1,630	249	11,815	8%	1,630	248	1,878
56 – Green River	1,820	8,166	1,643	141	6,382	23%	1,643	138	1,781
57 – Middle Yampa	15,211	50,462	11,625	2,037	36,801	20%	11,625	2,032	13,657
58 – Upper Yampa	63,379	140,918	42,576	8,197	90,144	32%	42,576	8,203	50,780
Basin Total	**161,237**	**417,004**	**108,399**	**19,774**	**288,831**	**22%**	**108,399**	**19,805**	**128,205**

Irrigation Water Requirement is potential consumptive use less the amount of precipitation effective in meeting crop demands directly during the irrigation season. Note that a conveyance loss of 10 percent is factored directly into the maximum system application efficiencies, as presented in **Section 4.5**. Therefore the *River Headgate Diversion* is adjusted for conveyance and application efficiency through the maximum application efficiency value. The *Non-Consumed* represents the total water not consumed by the crops; lost through canal conveyance or during application of the irrigation water. The non-consumed portion of diversions return to the river and are available for re-diversion downstream.

5.2 Historic Crop Consumptive Use

Table 10 presents the historical crop consumptive use analysis results for the 1950 to 2013 study period. Irrigation water requirement in the Yampa River basin is satisfied from surface water diversions, resulting in an estimate of water supply limited consumptive use. The Yampa River basin averages 128,205 acre-feet of water supply limited consumptive use annually. The average annual shortage in the basin is 20 percent. Note the consumptive use from surface water includes excess surface water stored in the soil moisture and then subsequently used by crops.

Table 9: Average Annual Consumptive Use Results 1950 through 2013

Water District-Basin	Average Acres	Irrigation Water Requirement (acre-feet)	Supply-Limited CU (acre-feet)	Percent Short
44 – Lower Yampa	26,964	51,346	37,499	27%
54 – Slater/Timberlake	13,496	27,398	22,611	17%
55 – Little Snake	1,531	2,082	1,878	9%
56 – Green River	1,508	1,820	1,781	2%
57 – Middle Yampa	9,678	15,211	13,657	10%
58 – Upper Yampa	32,194	63,379	50,780	20%
Basin Total	85,373	161,237	128,205	20%

Figure 8 presents basin crop consumptive use results by year. As shown, the percent of irrigation water requirement is directly related to water supply. Greater shortages from 2000 to 2004, averaging 26 percent, represent below average stream flows. Shortages averaging 20 percent from 1995 through 1997 are consistent with normal to above average stream flows. Shortages reached a maximum in 2002 at 34 percent due to drought conditions.

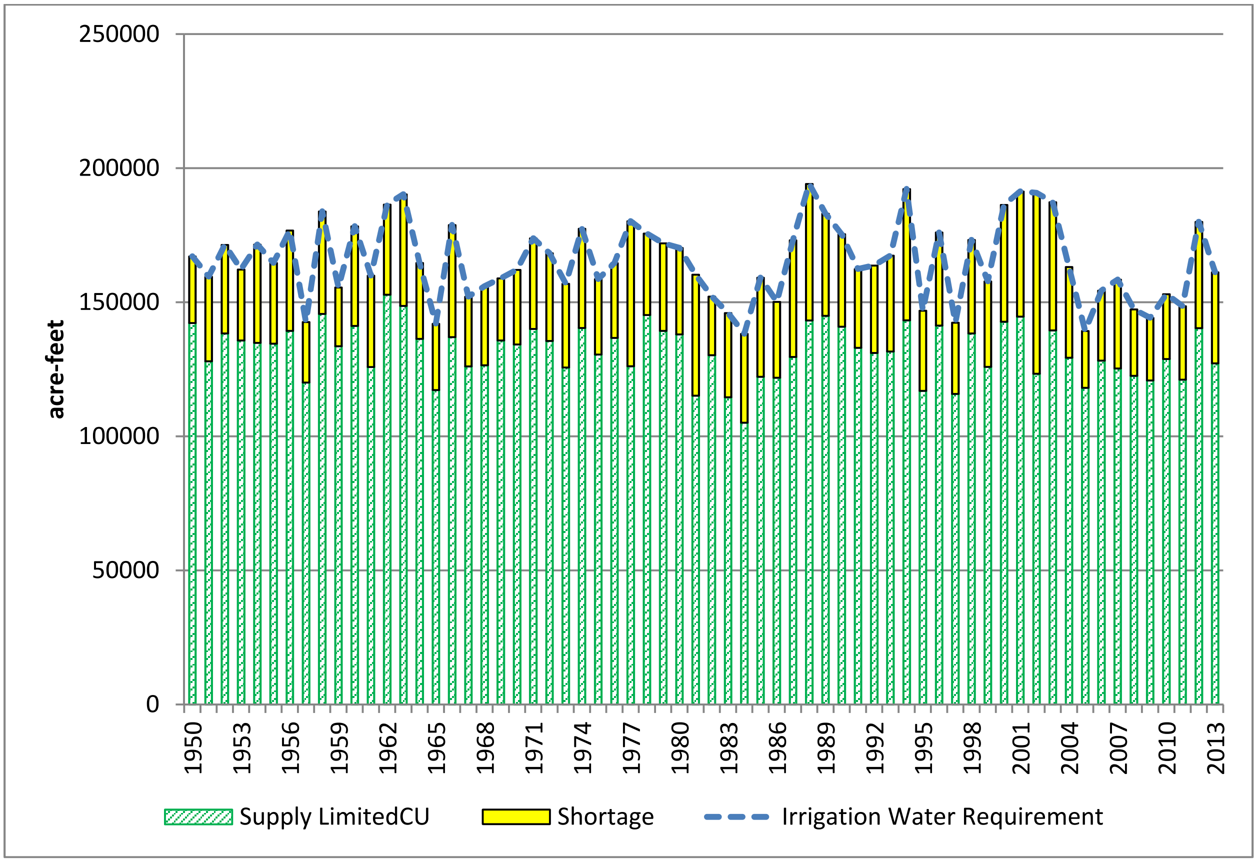


Figure 8: Irrigation Water Requirement and Supply Limited CU

Average monthly shortages for the study period vary from a low of 10 percent in June to a high of 40 percent in October, as shown in **Table 11**. Late season shortages may be due to physical supply limitations or indicative of irrigation practices whereby a land owner will choose to stop irrigating prior to the end of the full growing season as estimated based on temperature triggers.

Table 10: Average Monthly Shortages 1950 through 2013

Water District-Basin	Apr	May	Jun	Jul	Aug	Sep	Oct
44 – Lower Yampa	45%	21%	12%	24%	35%	49%	59%
54 – Slater/Timberlake	28%	21%	10%	13%	20%	26%	29%
55 – Little Snake	21%	3%	2%	4%	12%	24%	33%
56 – Green River	1%	0%	0%	1%	4%	3%	3%
57 – Middle Yampa	21%	17%	4%	6%	11%	19%	27%
58 – Upper Yampa	27%	30%	9%	13%	24%	33%	37%
Basin Total	37%	24%	10%	16%	25%	35%	40%

Figure 9 presents shortages by year. Shortages increased dramatically in the drought years in the early 2000s, reaching a recent maximum in 2002.

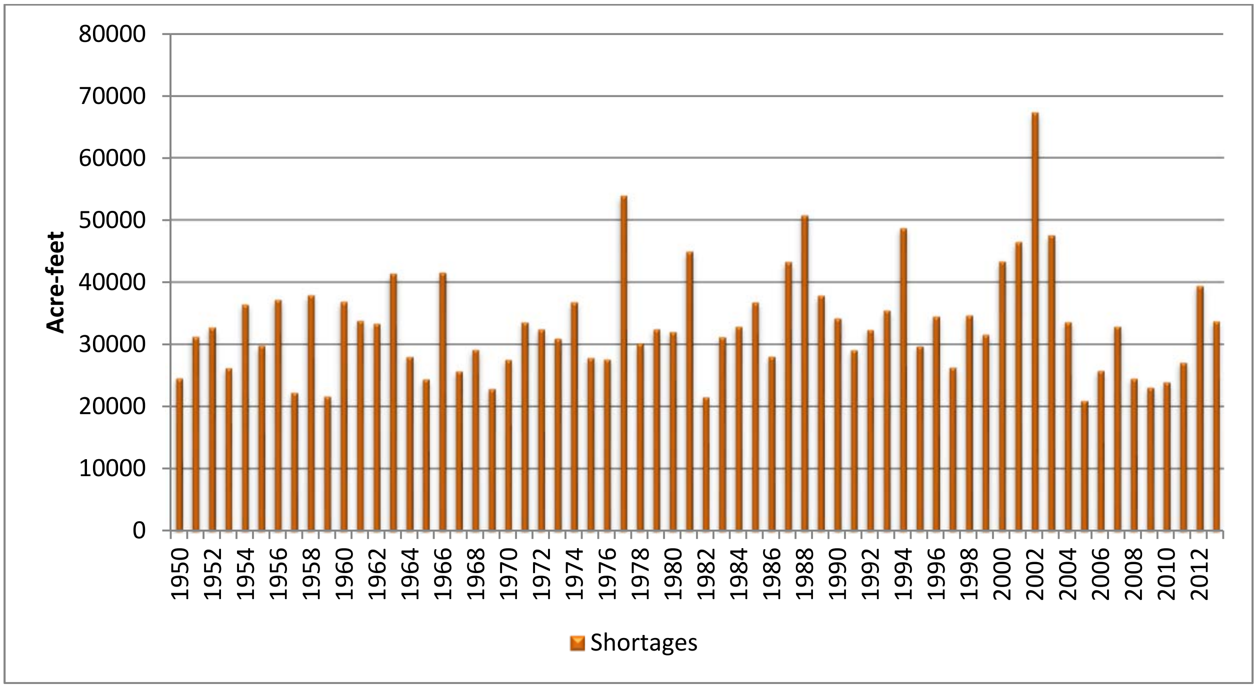


Figure 9 Annual Shortages

5.3 Estimated Actual Efficiencies

As described in the StateCU Documentation, the amount of surface water available to meet the crop demand is the river headgate diversion less conveyance losses and application losses. If the surface water supply exceeds the irrigation water requirement, water can be stored in the soil moisture up to its water holding capacity.

Maximum system efficiencies for surface water diversions are provided as input to StateCU, as described in **Section 4.5**. Actual system efficiencies are calculated based on the amount of water available to meet crop demands and the application method (e.g. flood or sprinkler). In the 1993 irrigated acreage assessment, only 2,830 acres, or about 3 percent of the total irrigated acreage in the basin, was served by sprinklers. The acreage increased in 2005 to about 4,883 acres (6 percent) and again in 2010 to about 6,731 acres (8 percent). The remaining acreage is irrigated with flood irrigation practices.

Table 12 provides the average monthly calculated system efficiencies for surface water supplies. Surface water system efficiencies have remained relatively constant throughout the study period, with variations due to water availability. Efficiencies tend to be lower during the peak runoff months of May and June.

Table 11: Average Monthly Calculated System Efficiencies 1950 through 2013

Water District-Basin	Apr	May	Jun	Jul	Aug	Sep	Oct
44 – Lower Yampa	32%	31%	30%	33%	31%	25%	18%
54 – Slater/Timberlake	29%	32%	29%	34%	35%	36%	30%
55 – Little Snake	11%	11%	12%	17%	22%	16%	7%

56 – Green River	5%	10%	28%	48%	53%	45%	30%
57 – Middle Yampa	31%	31%	27%	30%	34%	26%	17%
58 – Upper Yampa	33%	44%	37%	34%	39%	39%	33%
Basin Total	23%	31%	31%	33%	33%	31%	23%

6.0 Comments and Concerns

The historical crop consumptive use estimates are based on measured and recorded data; information from other studies; information provided by local water commissioners and users; and engineering judgment. The results developed for this project are considered appropriate to use for CDSS planning efforts. Areas of potential improvement or concern include:

- Historic Acreage. The irrigated acreage assessed for year 1993 serves as the basis for estimating historical acreage from 1950 to 2004 and is considered relatively accurate, as are irrigated acreage estimates for years 2005 and 2010. Diversion structures with irrigated acreage in either 2005 or 2010 were represented in the model. The model is not intended to represent all of the area that was historically irrigated.
- System Efficiencies. Maximum system efficiency estimates were set for the basin as a whole. Limited conveyance efficiency information based on actual canal loss studies exists. Canal loss studies, specifically for the larger systems, could improve the estimate of maximum system efficiencies used in the historical consumptive use estimate. Additionally, conveyance efficiency estimates based on soil type and ditch length, determined by the GIS soil type and canal coverages, could be used to also increase the accuracy of the maximum system efficiency estimates. Note that canal coverage does not exist for the Yampa River Basin.
- Water Use. The results presented are based on an approach that attempts to represent how water is actually applied to crops in the basin. The approach used is based on engineering judgement and informal discussions with water users. The effort did not include determining surface water shares for each owner under a ditch or determining different application rates based on crop types. Instead water was shared equally based on acreage. Therefore, this basin-wide historical crop consumptive use analysis is appropriate for CDSS planning purposes. However, it should be used as a starting point only for a more detailed ditch level analysis.

Appendix A: Aggregation of Irrigation Diversion Structures

A-1. Yampa River Basin Aggregated Irrigation Structures

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

A-1. Yampa River Basin Aggregated Irrigation Structures

Introduction

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

The methodology for identifying associated structures is described more in-depth in Part 2 of this appendix. In general, associated structures—which divert to irrigate a common parcel of land—were updated to more accurately model combined acreage, diversions, and demands. These updates include the integration of the 2005 irrigated acreage, the 2010 irrigated acreage, as well as verification based on diversion comments and water right transaction comments.

"No diversion" aggregates were not included in the StateMod modeling effort. Because the individual structures included in these aggregates do not have current diversion records, their effect on the stream cannot be accounted for in the development of natural flows. Therefore, it is appropriate that their diversions also not be included in simulation. The individual structures in the "no diversion" aggregates generally irrigate minimal acreage, often with spring water as a source. Since the water use for these structures is included in the natural flow, there is an assumption that the use will not change in future "what-if" modeling scenarios.

Approach

The following approach was used to update the aggregated structures in the Yampa River Basin.

1. Identify structures assigned irrigated acreage in either the 2005 or 2010 CDSS acreage coverages.
2. Identify Key structures represented explicitly in the model. The process for determining key structures is outlined in Section 4.
3. Identify Key structures that should be represented as diversion systems, based on their association with other structures as outlined in Part 2 of this appendix.
4. Aggregate remaining irrigation structures identified in either the 2005 or 2010 irrigated acreage coverages based on the aggregate spatial boundaries shown in Figure 1. The boundaries were developed during previous Yampa River Basin modeling effort to general group structures by tributaries with combined acreage less than 3,000.
5. Further split the aggregations based on structures with and without current diversions during the period 2000 through 2012.

Results

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

Table A-1: Yampa River Basin Aggregation Summary

Aggregation ID	Aggregation Name	Number of Structures	2005 Acres	2010 Acres
44_ADY012	Elkhead Creek	10	377	346
44_ADY013	Yampa River bl Craig	27	955	1,077
44_ADY014	East Fork Williams Fork	28	1,086	1,144
44_ADY015	South Fork Williams Fork	18	571	561
44_ADY016	Williams Fork	30	866	885
44_ADY017	Milk Creek above G Spring	6	263	189
44_ADY018	Milk Creek	10	470	551
44_ADY019	Yampa River near Maybell	15	632	1,123
44_ADY025	Yampa River at Deerlodge	10	383	491
54_ADY020	Little Snake river near Slater	15	1,463	1,520
54_ADY021	Little Snake River above Slater	11	377	354
54_ADY022	Slater Creek	18	1,624	1,636
54_ADY023	Little Snake above Dry Gulch	22	3,900	3,250
55_ADY024	Little Snake river near Lily	3	156	114
55_ADY026	Yampa River at Green River	2	23	9
56_ADY027	Green River	27	1,244	1,185
57_ADY009	Below Trout Creek Reservoir	11	301	303
57_ADY010	Yampa River near Hayden	18	260	267
57_ADY011	Yampa River above Elkhead	21	726	744
57_ADY012	Above Trout Creek Reservoir	11	318	321
58_ADY001	Upper Bear River	10	245	250
58_ADY002	Chimney Creek	23	706	742
58_ADY003	Bear River above Hunt Creek	23	844	1,004
58_ADY004	Bear River above Stagecoach	19	588	601
58_ADY005	Yampa River above Steamboat	42	1,043	1,342
58_ADY006	Elk River near Clark	20	638	848
58_ADY007	Middle Elk River	34	1,185	1,561
58_ADY008	Lower Elk River	33	957	1,019

Table A-2 shows the number of structures in the aggregation and the total the 2005 and 2010 aggregated acreage. None of the individual structures in the aggregates have recent diversion records.

Table A-2: No Diversion Aggregation Summary

Aggregation ID	Aggregation Name	Number of Structures	2005 Acres	2010 Acres
44_AND012	Elkhead Creek	5	138	135

44_AND013	Yampa River bl Craig	3	123	110
44_AND016	Williams Fork	5	23	212
44_AND018	Milk Creek	1	0	3
44_AND019	Yampa River near Maybell	3	66	28
54_AND021	Little Snake River above Slater	3	63	86
57_AND011	Yampa River above Elkhead	1	15	15
58_AND003	Bear River above Hunt Creek	1	104	104
58_AND004	Bear River above Stagecoach	2	49	50
58_AND005	Yampa River above Steamboat	1	6	6
58_AND006	Elk River near Clark	1	3	3
58_AND007	Middle Elk River	3	6	6
58_AND008	Lower Elk River	1	26	23

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

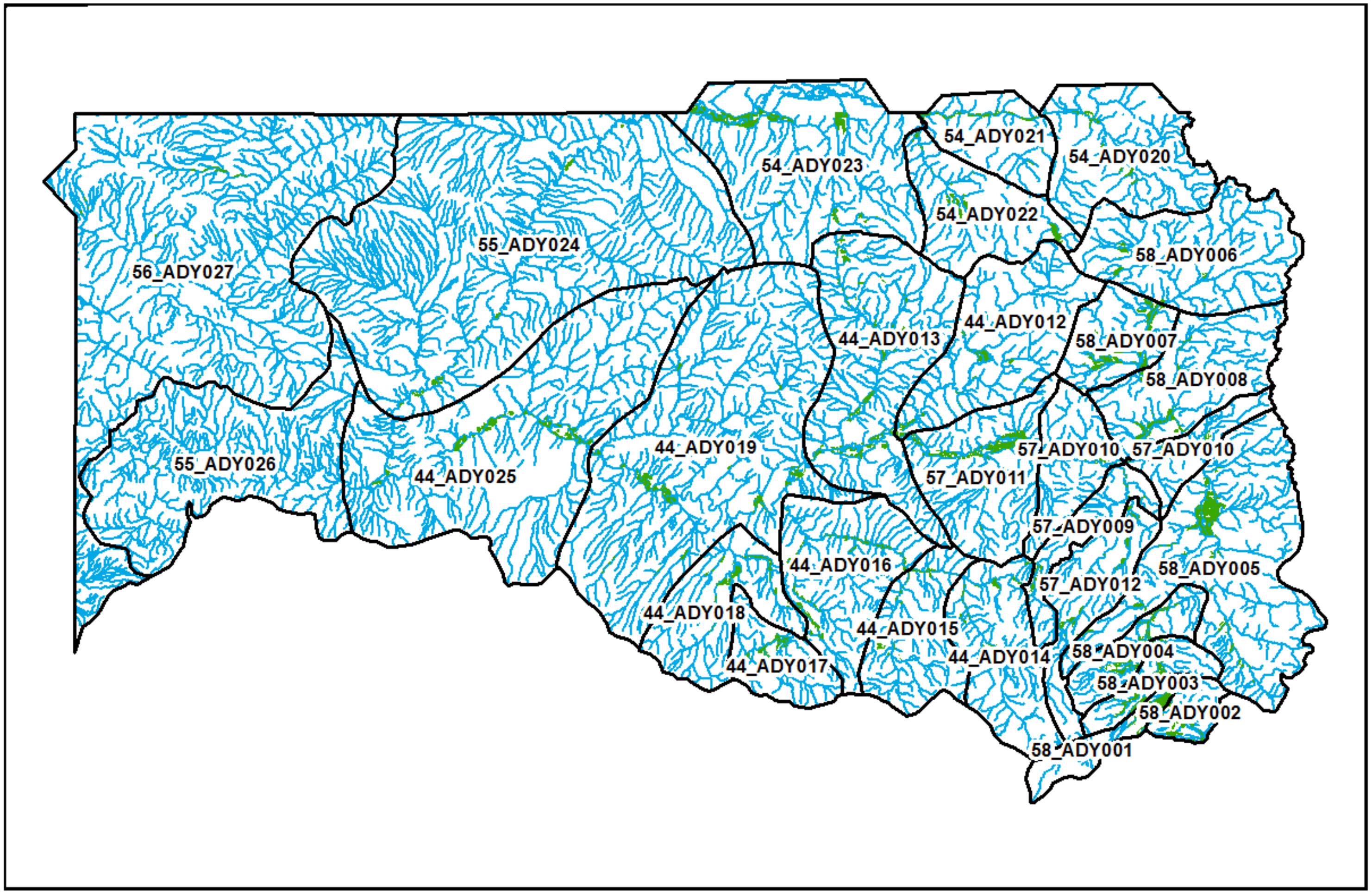
Table A-3: Diversion System and Multi-Structure Summary

Diversion System ID	Structure Name	WDID
5700544, Highland Ditch Multistructure	HIGHLAND DITCH	5700544
	WEST SIDE DITCH	5700612
5700611, Walker Irrigation Ditch Multistructure	WALKER IRRIG DITCH	5700611
	DRY CREEK DIVERSION	5702083
4400506_D, Wideman Ditch DivSys	WIDEMAN DITCH	4400506
	HUSTON DITCH	4400657
	MILK CK DITCH 1	4400707
4400607_D, Egry Mesa Ditch DivSys	EGRY MESA DITCH	4400607
	SCOTT ROBERTSON DITCH	4400759
4400808_D, Five Pines Pump DivSys	FIVE PINES PUMP NO 1	4400808
	FIVE PINES PUMP NO 2	4401247
4400863_D, Henry Sweeney Ditch	HENRY SWEENEY DITCH	4400863
	HENRY SWEENEY D ALT PT	4402326
5400574_D, Slater Park Ditch DivSys	SLATER PARK DITCH NO 3	5400572
	SLATER PARK DITCH NO 5	5400574
5401070_D, Anderson D Grieve DivSys	ANDERSON D GRIEVE HEADGT	5401070
	ANDERSON D GRIEVE HG AP1	5401171
5700508_D, Brock Ditch DivSys	BROCK DITCH	5700508
	EARLE IRR DIVERSION	5702046
5700555_D, Last Chance Ditch DivSys	LAST CHANCE DITCH	5700555
	LAST CHANCE EXT	5700750
5700576_D, Orno Ditch DivSys	ORNO DITCH	5700576
	KNOTT WASTE WATER DITCH	5701155
5700579_D, R E Clark Ditch DivSys, R E Clark Ditch DivSys	CHENEY DITCH	5700511
	MILNER CLARK GULCH D	5700567

	R E CLARK DITCH	5700579
5700623_D, Williams Park Ditch DivSys	WILLIAMS PARK DITCH	5700623
	SPENCER DIVERSION	5701034
	WM L YOAST D 1,2 ALT PT	5701240
5800583_D, Charles H Kemmer Ditch DivSys	CHARLES H KEMMER D	5800583
	WHITEWATER SEEPAGE DITCH	5801621
5800649_D, Franz Ditch DivSys	FRANZ DITCH	5800649
	WINTER IRR DITCH	5801096
5800826_D, Poney Creek Ditch DivSys	JUST DITCH	5800710
	PONY CREEK D	5800826
5800847_D, Sand Creek Ditch DivSys	SAND CREEK DITCH	5800847
	MCPHEE DIVERSION	5801595
5800895_D, Sunnyside Ditch 1 DivSys	COULTON CREEK DITCH	5800595
	SUNNYSIDE DITCH 1	5800895
5800915_D, Upper Elk River D Co DivSys	UPPER ELK RIVER D CO. D	5800915
	HEADACHE D NO 2	5801635
5800943_D, Woodchuck Ditch DivSys	WOODCHUCK D SODA CK HG	5800943
	WOODCHUCK D GUNN CK HG	5801091
5804685_D, Stillwater Ditch DivSys	ADOBE DITCH	5800501
	DESERT DITCH	5800611
	STILLWATER DITCH	5804685

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

Figure A-1. Aggregate Structure Boundaries.



Recommendations

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

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

Exhibit A: Diversion Structures in each Aggregate Structure

Aggregation ID	Structure Name	WDID	2005 Acres	2010 Acres
44_ADY012, Elkhead Creek	Herbert L Frink D	4400649	29	29
	Oldham D No 2	4400725	186	149
	Pitney Pump Station	4400840	12	12
	Pitney Ditch No 1	4400841	6	5
	Pitney Ditch No 2	4400842	29	31
	Pitney Ditch No 3	4400843	6	6
	Starr Irr Ditch Alt Pt	4401188	43	55
	Frentress Pump No. 1	4401962	17	16
	Pitney Ditch No 4	4402099	6	7
	Morgan Creek Ditch 2	5700569	43	37
44_ADY013, Yampa River below Craig	Wolfe Ditch	4400513	56	41
	Baker Cottonwood D	4400542	39	25
	Louie Pl & Ditch	4400689	80	75
	Mcdonald & Hall D	4400697	61	24
	Mesa Irr Ditch	4400704	0	127
	Millspaugh Ditch	4400710	32	36
	Taylor Ditch	4400783	20	20
	Van Dorn Irrig P L	4400791	34	34
	Cook Ditch	4400800	58	56
	Duzik Pump Div	4400805	48	48
	Johnson & Wyatt Enl D	4400817	0	59
	Mcnamara No 1	4400823	10	10
	Mcnamara No 2	4400824	10	10
	Yampa Valley Golf Div	4400836	62	62
	Benner Ditch	4400857	18	7
	Drescher Ditch	4400875	70	96
	Morton Ditch	4401102	69	76
	Andy Ditch	4401275	35	29
	Little Suzy Ditch	4401775	20	17
	Read Winslow Water	4401924	100	79
	Warner Ditch	4402026	8	0
	Pyeat Ditch No 1	4402100	0	8
	Elmer Bertha Mack Pump	4402371	38	29
	Craig Well #1	4405015	0	20
	Craig Well #2	4405016	0	20
	Mack Pump #2	4405075	49	38
	Mack Pump #3	4405076	38	29
44_ADY014, East Fork Williams Fork	Beardslee Ditch	4400543	40	40
	Beardslee Ditch No 1	4400544	4	4

	Beardslee Ditch No 2	4400545	4	9
	Beardslee Ditch No 3	4400546	5	5
	Beardslee Mesa D	4400547	15	15
	Beardslee West Side D	4400548	17	17
	Brush Ck Ditch	4400560	9	13
	Bunker Ditch No 2	4400563	119	119
	Carlos Ditch	4400571	17	17
	Dubeau & Dunckley Ditch	4400600	170	170
	East Side Grieser D	4400603	17	17
	Egry Ditch No 1	4400605	9	9
	Egry Ditch No 2	4400608	72	71
	Mcfadden Ditch	4400701	36	36
	Mesa Ditch	4400703	32	32
	Miller No 2 Ditch	4400709	22	22
	Post Ck Ditch	4400737	9	9
	Rider Ditch	4400743	9	9
	Sampson Ditch	4400755	70	70
	Sellers Crowell Ditch	4400761	170	170
	Taylor D No 1	4400780	37	37
	Turner Ditch	4400787	42	42
	Holderness Ditch	4400815	6	7
	Tutt Ditch No 1	4401068	0	16
	Tutt Ditch No 2	4401069	0	16
	Tutt Ditch No 3	4402107	0	16
	Marion Yoast Outlet D	5700562	107	107
	Mcsweeney Ditch	5701061	49	49
44_ADY015, South Fork Williams Fork	8 F Ditch No 2	4400520	21	13
	8 F Ditch No 1	4400521	63	59
	Alex Heron No 1 Ditch	4400531	39	34
	Butler Ditch	4400565	18	18
	Cabins Ct No 1	4400567	9	9
	Camp Ck Ditch	4400569	23	20
	Ellis Ditch	4400615	45	32
	Hobson Ditch	4400653	36	36
	Indian Run Ditch	4400658	30	26
	John Lyons Ditch	4400667	20	20
	Johnson Ditch	4400671	50	50
	Le Claire Ditch	4400683	15	15
	Pagoda Ck Ditch	4400727	71	75
	Sand Creek Ditch	4400756	45	66
	Scott Ditch	4400758	16	17
	South Fork Ditch	4400764	34	34

	Sullivan Ditch	4400773	36	36
	Fisher Ditch No 1	4400807	0	2
44_ADY016, Williams Fork	Weisbeck Ditch	4400504	14	23
	Worthington Ditch	4400515	61	59
	B Dayton Ditch	4400539	48	37
	Biggs Irr Ditch	4400556	138	79
	Deer Ck Ditch	4400591	29	32
	Deer Ditch	4400592	0	67
	Hughes Irrig D	4400655	0	5
	J T Jarvis Ditch	4400662	17	17
	J W Kellogg D 1	4400669	62	62
	Pagoda Ditch	4400728	20	18
	Pike Ditch	4400734	29	28
	Robertson Ditch	4400746	20	20
	Shears Deal Ditch	4400762	50	36
	Stanley Irrig Ditch	4400769	22	72
	White Rail Pump No 1 Ap	4400792	17	9
	Clark Pumpsite No. 1	4400802	13	14
	Hamill Ditch	4400850	67	67
	Jeffway Gulch Ditch	4400866	0	9
	Hathhorn Pump	4400915	4	3
	Shears Deal Ditch Ap 2	4401183	34	34
	South Side Ditch Ext	4401281	40	35
	Hathhorn Pumpsite No 1	4401356	6	6
	Deakins Field Sprinkler Alt Pt	4401418	8	14
	Berry Gulch Ditch 1	4401923	49	17
	Haggerty Ditch No 2	4402077	34	36
	Utley Pump	4402171	23	24
	Gilmar Ranch Irr D	4402284	23	23
	Clark Pumpsite Ap No. 2	4402352	6	7
	Clark Pumpsite Ap No. 4	4402354	13	13
	Hathhorn Pumpsite #3	4402390	20	22
44_ADY017, Milk Creek above G Spring	Aldrich Ditch	4400530	133	62
	Beaver No 1 Ditch	4400551	7	9
	Beaver No 2 Ditch	4400552	18	17
	John Roscorla Ditch	4400668	70	70
	Rye Grass Ditch	4400752	7	7
	Seilaff Ditch	4400760	28	25
44_ADY018, Milk Creek	Elk Horn Ditch	4400610	64	37
	Hulett & Torrence D	4400656	25	89
	James Pipeline	4400664	0	7
	Mountain Meadows D	4400715	145	145

	Peter Uehlein D	4400733	28	28
	Spring Creek Ditch 2	4400768	38	53
	Taylor Ditch	4400782	33	21
	John Collom And Spring Creek Ditch	4400859	100	105
	A Q Ditch	4401108	37	37
	H Kourlis Ranch D 3	4402227	0	29
44_ADY019, Yampa River near Maybell	Five Fifty Five Ditch	4400555	251	248
	Bogenschutz Ditch	4400557	71	67
	Hall & Harrison D	4400641	17	62
	Morgan Ditch	4400713	62	62
	Roberts Ditch	4400745	28	36
	Ellgen Ditch Ap Pump	4400981	37	38
	Big Gulch Pump Diversion	4401272	0	37
	Maudlin Gulch Ditch	4401288	0	131
	Big Gulch Diversion	4401361	0	18
	Stoffle Pump & Pl	4401392	1	0
	Lewis Pump	4402134	12	0
	Kourlis Ditch Ab1	4402309	0	163
	Ellgen Sprinkler	4402377	63	40
	Culverwell Ditch	4402480	0	66
	Bord Gulch Well	4405053	91	156
44_ADY025, Yampa River at Deerlodge	Buffams Ditch	4400561	0	34
	Myers Ditch No 2	4400719	57	39
	Nichols Ditch No 2	4400721	0	30
	Pearce Ditch	4400730	70	70
	Lily Park D Pump Sta No 2	4400819	147	147
	Cross Mtn Pump No 2	4400861	26	67
	Deception Cr Ditch	4401088	0	23
	Chew Pump	4401268	51	51
	Silver Water Pump	4401397	9	9
	Haskins Pump Diversion	4401707	22	22
54_ADY020, Little Snake near Slater	Bedrock Ck Ditch	5400506	0	58
	Behrman Ditch	5400508	84	84
	Brighton Ditch	5400510	197	197
	Hancock Ditch	5400528	53	53
	Honnold Ditch	5400533	22	22
	Independence Ck Ditch	5400534	32	32
	J B Temple Ditch	5400536	11	32
	Rathjen Ditch	5400557	72	72
	South Fork D No 2	5400577	140	140
	St Louis Ditch	5400578	77	57
	Summit Ck D	5400580	100	100

	Unknown Ck Ditch	5400585	93	92
	West Fork Ditch	5401107	171	171
	Blackmore Ditch	5401108	79	79
	Dudley Ck Ditch	5401117	329	329
54_ADY021, Little Snake above Slater	Fleming Ditch	5400524	6	6
	Lake Fork Ditch	5400541	66	66
	North Side Ditch	5400550	15	15
	Oscar Beeler-Robidoux D	5400551	76	76
	Robidoux Ditch	5400562	61	61
	Fly Ditch	5400701	31	31
	Anderson Ditch No 2	5400711	30	30
	Porter Salisbury Pump1&2	5401038	16	16
	Eio Ditch	5401075	7	7
	Robidoux Ditch No 2	5402047	41	41
	Roy E Ditch	5402119	29	7
54_ADY022, Slater Creek	Basin Ditch	5400504	230	138
	Baxter Ditch	5400505	140	140
	Decker Ditch No 1	5400517	224	224
	Decker Ditch No 2	5400518	251	251
	Duncan Ditch No 1	5400519	289	289
	Duncan Ditch No 2	5400520	95	95
	Lake Ck Ditch	5400540	29	29
	Lester Ditch	5400542	82	82
	Mary E Hoffman Ditch 1	5400544	28	28
	Mary E Hoffman Ditch 2	5400545	32	32
	Peisker Ditch	5400552	39	39
	Showalter Ditch	5400565	3	3
	Skunk Creek Ditch	5400567	28	28
	Slater Park Ditch Hgd 2	5400569	97	97
	Slater Park Ditch No 4	5400573	25	25
	Vincent Ditch	5400588	0	105
	Rochelle Ditch No 2	5400625	12	12
	Rochelle Ditch No 1	5402085	20	20
54_ADY023, Little Snake above Dry Gulch	Davidson Ditch	5400515	112	74
	Davidson Dutton D	5400516	119	119
	Gold Valley Ditch	5400527	129	138
	Jebens Seep Waste Water	5400537	284	295
	Mccarger Ditch	5400547	119	115
	Read Winslow Ditch	5400558	181	81
	Rico Ditch	5400559	95	97
	Single Ditch	5400566	13	13
	Snake R Irrig Canal	5400575	312	312

	Wood Kettleson D	5400593	223	0
	Georgiou Ditch	5400653	112	74
	Jons Seep & Waste W D 1	5401044	193	193
	Jons Seep & Waste W D 2	5401045	162	162
	West Side C Peppler Ext	5401057	231	231
	West Side C Chrstnsn Ext	5401058	162	162
	West Side C Fourmile Lat	5401073	356	380
	Gibson Blair Ditch	5401076	736	736
	Mcstay Pump No 1	5402058	84	0
	Mcstay Pump No 2	5402059	84	0
	Timberlake Spg No 1	5402070	34	0
	Timberlake Spg No 2	5402071	121	30
	Norma Ryan Ditch	5402128	38	38
55_ADY024, Little Snake near Lily	Escalanta Pump 1	5500503	22	22
	Majors Pump No 1	5500505	43	43
	Gordon C. Winn Pump 1	5500514	91	49
55_ADY026, Yampa River at Green River	Hells Canyon Ditch	5502035	12	5
	Studebaker Pump	5502037	12	5
56_ADY027, Green River	Bassett Spring 1	5600521	33	33
	Bassett Spring 2	5600522	33	33
	Beaver Ditch	5600524	47	47
	Upper Buffham Ditch	5600528	19	11
	Cottonwood Ditch No 1	5600533	9	9
	Cottonwood Ditch No 2	5600534	20	20
	Guiterrez No 1	5600551	18	0
	Mcknight No 2	5600563	7	4
	Popper Ditch No 1	5600568	58	0
	Prestopitz Ditch	5600570	78	156
	Rouff No 2 Ditch	5600572	82	82
	Sparks Ditch	5600573	78	0
	Spitze Ditch	5600574	0	4
	Wilson Ditch (A.C.)	5600583	157	132
	Yarnell Ditch No 1	5600584	59	32
	Yarnell Ditch No 2	5600585	83	133
	Thomas Doudle No 2	5600586	11	12
	Watson Ditch	5600595	31	31
	Bull Canyon Gulch Ditch	5600596	5	3
	Sugarloaf D No 1	5600599	134	134
	Dickinson Ditch No 1	5600603	23	23
	Dickinson Ditch No 2	5600627	15	15
	Cove Ditch 1	5601045	0	13

	Vermillion Ditch	5601180	207	222
	Johnny S Spring	5601273	33	33
	Allen Ditch No 1	5602066	0	3
	Simpson Well 2	5605006	5	3
57_ADY009, Trout Creek	Bonas Ditch	5700507	34	34
	David M Chapman Ditch 2	5700518	16	16
	Helfenbein Seepage D	5700543	24	24
	Jones Kleckner Ditch	5700552	41	39
	Lieske Ditch	5700556	48	48
	Middle Creek Ditch	5700565	28	28
	Pine Grove Ditch	5700578	68	68
	Redbird Ditch	5700581	34	34
	Slough Ditch	5700593	16	23
	South Highland Ditch	5700594	17	17
	Spruce Hill Ditch	5700598	6	6
	Tempke Ditch	5700599	66	66
	Thompson Ditch 2	5700601	64	64
	William H Jones Ditch	5700620	54	49
	William R Appel D	5700621	23	23
	Rocky Ditch	5700749	3	6
	Alex Ditch	5701013	17	17
	Fuller Ditch	5701048	11	11
	Mitchem Diversion	5701064	2	2
	Burch Ditch	5703001	7	7
	Hunter No 1 Res	5703541	15	15
	Apple Res	5703549	28	29
57_ADY010, Yampa River near Hayden	Hammond Ditch	5700540	3	2
	Tow Creek Ditch 1	5700603	24	24
	Wolf Mountain Res	5703516	9	0
	Borland Ditch	5800548	26	26
	Homer Seepage D	5800693	3	4
	Murphy Ditch 1	5800792	2	4
	Steamboat Cemetery Pl	5801045	18	18
	Yampa Pump	5801655	2	2
	Blue Mountain Diversion	5801682	1	1
	Memorial Park Diversion	5801694	2	2
	Ninth Street Pumphouse	5801899	9	15
	Felix Borghi Alt Pt No 4	5801989	22	31
	Steamboat Springs Final Treatment Effluent Pl	5802117	72	72
	Duquette D - Sampson Hg	5802160	4	4
	Willett Ap To Woolery Ditch	5802177	18	18

	Eiteljorg Pump	5802502	8	8
	Steamboat Gc Pond 2	5803709	36	36
	Riverbend Well 1	5805079	1	1
57_ADY011, Yampa River above Elkhead	Bates Ditch	5700502	1	1
	Burback D & Pump Plant	5700509	22	22
	Flanders D & Pump Plant	5700536	79	79
	Frentress Pump & Pl	5700537	0	40
	J C Temple D 1	5700551	44	46
	Sage Creek Res Outlet	5700586	31	0
	Whiteman D & Pump Plant	5700618	72	72
	Yoast Pumping Plant	5700628	49	62
	Burback Pumping Plant	5700639	15	15
	Erwin Irr D Burrell Tran	5700752	20	20
	Bates Ditch South Hg	5700760	4	5
	Welsh #3	5701205	3	4
	Dry Ck Ditch Alt Pt B	5701211	83	83
	J C Temple D 2 Alt Pt 1	5701218	97	97
	J C Temple D 2 Alt Pt 2	5701219	66	54
	Hollatz Ditch Hdg 2	5701229	23	27
	Temple Diversion 1	5702088	23	23
	Hollatz Ditch Hdg 1	5702125	4	4
	Cottonwood Pond	5703655	80	78
	Cozzens Walrod Reservoir	5703775	9	10
	Yampa Park Well #1	5705041	1	1
58_ADY001, Upper Bear River	Baumfalk Ditch 1	5800528	11	11
	Cox Ditch	5800596	16	16
	Ekstrom Seep Waste D	5800624	9	10
	F D Hutchinson Irr Ditch	5800630	110	110
	Ira J Van Camp D	5800699	17	25
	Lancaster Ditch	5800723	58	58
	Pat Lucas Ditch	5800819	10	10
	Schalnus Ditch	5801271	7	0
	Hammer Ditch	5801795	3	6
	Nesbitt Ditch Alt Pt 2	5801975	5	5
58_ADY002, Chimney Creek	Beaver Ditch	5800533	37	37
	Bowers Ditch	5800552	63	63
	Crowner Res Dist D	5800598	41	41
	Daisy Ditch	5800602	25	25
	Finger Rock Ditch	5800636	25	25
	Gibbs Ditch	5800660	6	6
	Independent Highline D	5800698	48	48
	Kauffman Spg 2 & P L	5800712	13	13

	Little Mountain D	5800741	63	63
	North Side Adams D	5800802	14	14
	Kauffman Ditch	5800851	13	13
	South Side Ditch	5800867	40	42
	South Side Adams D	5800871	6	6
	Todd Cr D	5800904	3	3
	Wheeler D 6	5800929	11	11
	Wheeler D 7	5800931	4	4
	Wheeler D	5800932	0	25
	Beaver Creek Ditch 2	5801190	44	44
	Christensen D 1, Alt 2	5801403	24	35
	Crowner Ditch 1	5801405	75	75
	Bills Ditch	5801406	106	106
	Crowner Ditch 2	5801409	32	32
	Beaver Creek Ditch #3	5802604	9	9
58_ADY003, Bear River above Hunt Creek	Bluff Ditch	5800543	53	53
	Dora Irr D	5800615	31	31
	East Side Waste D	5800620	5	5
	Hardscrabble Ditch	5800676	0	18
	Hill Ditch	5800689	87	87
	Hoag Laughlin Ditch	5800691	63	63
	Homer Buttricks D	5800692	87	87
	Laramore Ditch	5800725	58	59
	Lawson Cr Ditch	5800732	23	23
	Meadow Brook D 1	5800770	20	34
	Meadow Brook D 2	5800771	20	21
	Meadow Brook D 3	5800772	20	21
	Mohr Ditch	5800781	0	68
	Patton Ditch	5800820	0	45
	Powell Ditch 1	5800827	62	66
	Powell Ditch 2	5800828	46	55
	Spring Branch D	5800875	46	46
	Watson Creek Ditch	5800921	45	45
	Whiteley Ditch	5800934	97	97
	Whiteley Nelson D Sys	5800935	67	0
	River Ditch	5801102	14	14
	Whiteley Nelson Ditch	5802880	0	14
	Nelson Ditch	5802881	0	53
58_ADY004, Bear River above Stagecoach	Barr Ditch	5800522	23	23
	Bomgardner Ditch	5800544	11	11
	Bull Creek D	5800566	111	110
	C R Brown Ditch	5800573	77	77

	C W Ditch	5800575	30	30
	Lower Hunt Creek Ditch	5800748	12	12
	Martin Ditch	5800764	31	31
	Max Hoff Ditch	5800765	34	34
	Osborne D	5800812	21	21
	Rockhill Ditch	5800838	24	24
	Rossi Irrigating Ditch	5800843	19	19
	Speckled Trout Ditch	5800873	26	26
	Tom Watson Ditch 1	5801081	16	16
	Rockwall Ditch 2	5801086	20	20
	Crawford Diversion 3	5801451	7	7
	Redmond Ditch No 1	5801541	25	25
	Upper Hoff Ditch	5801689	24	24
	Old Cabin D Alt Point	5801710	64	77
	Egeria D Alt Hg 3	5801798	14	14
58_ADY005, Yampa River above Steamboat	Agate Creek Ditch	5800502	42	42
	Andy Morrison D	5800509	30	24
	Bonard Ditch	5800545	16	15
	Bouton Ditch 1	5800550	0	15
	Bouton Ditch 2	5800551	0	19
	Cook Brothers Ditch	5800593	76	76
	Fahey Cole D	5800631	182	232
	First Ditch	5800641	81	81
	Grouse Creek Ditch	5800664	53	72
	J L Smiths Emma Smith Cr	5800703	24	24
	Lyon Ditch	5800755	43	43
	Morrison Creek Ditch 2	5800786	17	17
	Muddy Ditch 2	5800790	0	57
	Muddy Ditch 1	5800791	0	97
	Nay Ditch	5800794	32	32
	North Side Ditch	5800803	22	22
	Pioneer Ditch	5800825	8	8
	Steamboat Gardens D	5800884	31	31
	Summer S Goldsworthy D	5800894	63	63
	Trentaz Bear River D	5800905	25	25
	Zuffery Bear River Ditch	5800956	40	40
	Willow Run Ditch	5801063	2	2
	Balanced Rock Ditch	5801072	8	8
	Jones Ditch	5801073	27	27
	Locker Spring 1	5801108	4	4
	Evenson Davis Ditch 1	5801211	1	2
	Evenson Davis Ditch 2	5801212	1	1

	Evenson Davis Ditch 3	5801213	2	3
	Evenson Davis Ditch 4	5801214	7	10
	Palmer Ditch No 5	5801562	11	11
	Sheraton Golf Course Pmp	5801591	87	87
	Lodwick Pond Outlet D	5801616	3	3
	Palmer Ditch No 6	5801656	0	23
	Trafalgar Park Irr Diver	5801782	19	19
	Bonard Ditch No 2	5801868	0	17
	Spencer Ditch	5801933	1	1
	J Hart Ditch Hg 2	5801981	22	22
	Bouton Ditch 3	5802004	0	4
	Silver View D Alt Pt. 2	5802151	50	50
	Gene & Georgia D	5802422	6	6
	Frank & Lena D	5802423	6	6
	Old Siegrist Pit Diversion	5805092	1	0
58_ADY006, Elk River near Clark	Centennial Placer D Hg 1	5800580	8	8
	Chris Fetcher Ditch	5800587	50	50
	Diamond Park Ditch	5800613	25	15
	Frye Syst D 2	5800651	14	23
	Frye Syst D 1	5800653	106	240
	James Wheeler Ditch	5800706	20	20
	Lula Park Ditch	5800754	24	34
	Morris Taylor D	5800784	17	29
	Reddert Ditch	5800833	18	26
	Reynolds Humphery D	5800835	46	68
	Rose Wheeler D 3	5800842	96	94
	Pirates Hideout Ditch	5801037	8	4
	Glenns Ditch	5801702	3	3
	Centennial Placer D Hg 2	5801703	35	35
	Boat House Pump & Pl	5801878	2	14
	Murphy Ditch Fetcher Ext And Enl	5801997	137	137
	Glenns Ditch Alt Pt	5802130	4	4
	Trullinger Irrigation Ditch	5802176	18	18
	Roy S Diversion	5802580	2	3
	Wildflower Pond	5803609	7	24
58_ADY007, Middle Elk River	Asher Ditch	5800513	25	25
	Borland Vail Ditch	5800549	24	79
	Cantrell Ditch 2	5800579	9	73
	Ducey Ditch	5800617	28	28
	E Coleman Ditch	5800619	35	35
	Follett Ditch	5800647	41	41
	Gates Savage Ditch	5800657	122	107

	Gates Williams Ditch	5800659	145	193
	H P Williams D 1	5800671	28	28
	Highline Ditch	5800688	160	248
	Lower Winkleman Creek Ditch	5800751	10	10
	Maddox Ditch	5800759	27	27
	Maddox Ditch 2	5800760	27	30
	May Ditch	5800766	4	4
	Miller Ditch	5800779	30	48
	Norman Ditch	5800800	42	42
	Semotan Ditch	5800857	34	36
	Smith Ditch	5800864	76	76
	Smith Ditch	5800865	70	66
	Stanton Fetcher D 2	5800880	17	17
	Stanton Fetcher D 1	5800881	24	24
	Tufly Ditch 1	5800910	16	16
	Tufly Ditch 2	5800911	10	10
	South Side D	5801044	20	24
	Wommer Ditch	5801068	3	30
	Jake Ditch	5801596	53	58
	Coleman Ditch Alt Pt	5801784	31	58
	Buckner Turner Miller Hg	5801785	23	41
	Norman Ditch Hg 2	5801999	20	20
	Norman Ditch Hg 3	5802000	6	8
	Semotan Ditch	5802413	6	11
	Pen No. 7 Ditch	5802653	3	26
	Lee Reservoir	5803520	11	13
	M&M Pond	5803735	7	11
58_ADY008, Lower Elk River	Baalhorn Ditch	5800516	23	0
	Belton Waste Ditch	5800534	3	5
	Big Creek Canal D	5800537	47	47
	H E Turner Ditch	5800670	11	11
	Harms Ditch	5800677	44	44
	Highland Ditch	5800686	41	41
	James Hangs Ditch	5800705	7	7
	Look Seepage D 1	5800743	22	23
	Look Waste Water D 1	5800746	49	50
	Look Waste Water D 2	5800747	42	39
	Mcfadden Ditch	5800768	7	8
	Mountain Meadow Ditch	5800789	39	39
	O Neal Ditch	5800804	18	18
	Price Ditch	5800829	95	95
	Rock Cr Ditch	5800837	11	11

	St Johns Ditch	5800878	47	48
	Trull Ditch	5800907	55	72
	Sandelin Ditch No1	5801038	18	17
	Sandelin Ditch No2	5801039	7	19
	Aultman Ditch	5801095	27	27
	Warrick Spring	5801151	2	2
	Felix Borghi Alt Pt No 3	5801773	23	28
	Price Ditch Alt Pt	5801962	12	24
	Keller D Cavanagh Ap	5801996	76	92
	Trissel Ditch Alt Pt	5802122	98	98
	Trull Morin D Alt Pt	5802123	21	25
	Wheeler Div Sys Alt 1	5802341	10	10
	Nicholson D Ditch Ck Hg	5802543	38	55
	Cabin Creek Ditch	5802566	25	25
	Brust Pump No. 2	5802764	3	5
	Keller Ditch Goose Ck Hg	5802795	29	30
	Moose Willow Pond	5803588	1	1

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

Aggregation ID	Structure Name	WDID	2005 Acres	2010 Acres
44_AND012, Elkhead Creek	Pitney Pump Diversion 2	4402322	8	6
	Pitney Pump Diversion 3	4402323	10	8
	Pitney Pump Diversion 4	4402324	10	9
	Pitney Pump Diversion 5	4402325	6	6
	Kitchens & Kleckner Res	4404437	105	105
44_AND013, Yampa River below Craig	Bill Ditch 1	4402116	14	14
	Drescher Res	4403686	70	96
	Biskup Reservoir	4403824	39	0
44_AND016, Williams Fork	Averill Ditch	4400538	0	184
	Spring Gulch Livestock Diversion	4401394	7	12
	Deer Run Pump	4401414	4	4
	Sulphur Ditch	4402350	4	4
	Clark Pumpsite Ap No. 3	4402353	9	8
44_AND018, Milk Creek	Jos Collom Desert Land D	4400673	0	3
44_AND019, Yampa River near Maybell	Floyd Ditch	4400809	0	20
	Bowers Pump Diversion	4402313	0	8
	Culverwell Reservoir	4403736	66	0
54_AND021, Little Snake River above Slater	Baggs Ditch	5400503	15	15
	Gold Blossom Ditch	5400526	22	44
	Kilgour Ditch	5400539	26	26

57_AND011, Yampa River above Elkhead	Headquarters Well	5705042	15	15
58_AND003, Bear River above Hunt Creek	Whiteley Nelson Res	5803547	104	104
58_AND004, Bear River above Stagecoach	Boor Ditch 3	5802610	25	25
	Boor Ditch 4	5802611	25	25
58_AND005, Yampa River above Steamboat	Bar Bee Lake	5803826	6	6
58_AND006, Elk River near Clark	Rock Creek Ranch Pond 2	5803637	3	3
58_AND007, Middle Elk River	Mikes Ditch	5801389	4	4
	Twin Creek Pump 1	5802796	1	1
	Twin Creek Pump 2	5802797	1	1
58_AND008, Lower Elk River	Lake Windemere Res	5803519	26	23

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

Background

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

Introduction

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

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

Approach

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

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

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

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

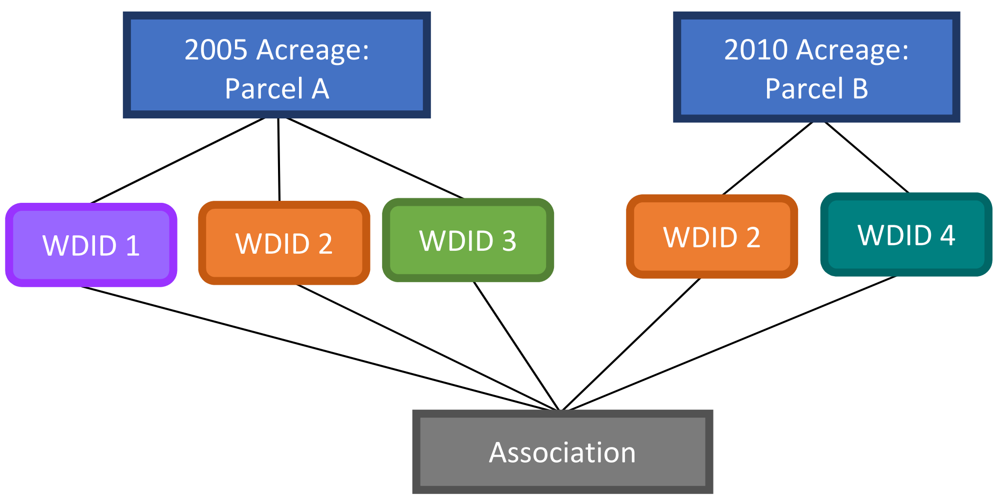


Figure A-2. Example of integrating the CDSS irrigated acreage coverage to identify associated structures.

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

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

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

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

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

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

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

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

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

Table A-5. Water Right Thresholds for Explicit Modeling.

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

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

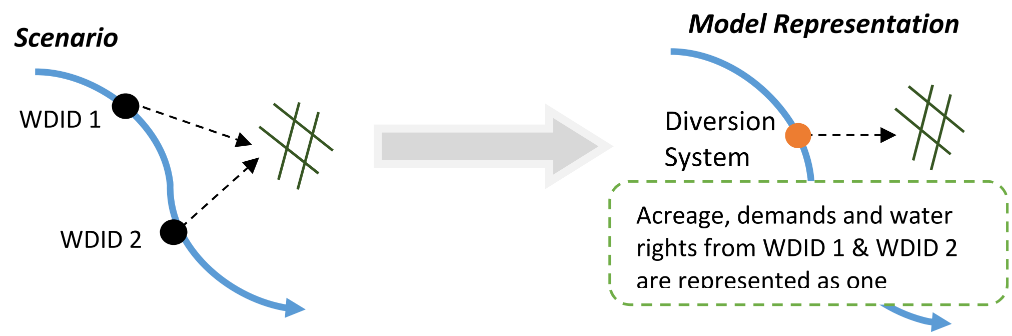


Figure A-3. Model Representation of a Diversion System.

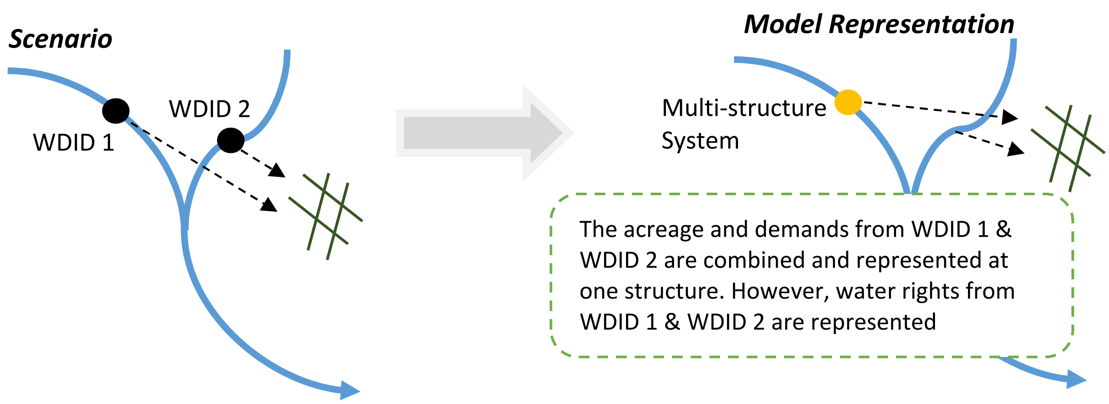


Figure A-4. Model Representation of a Multi-structure System.

- o The structure with the most irrigated acreage—based on the 2005 and 2010 CDSS coverages—was selected as the modeled structure for each diversion system.
- o The structure with the greatest net water rights was selected as the primary structure for multi-structure systems.

- If none of the structures in an association exceeded the water right threshold identified in Table 2 and have contemporary diversion records, the structures were modeled in an aggregate.
- If all structures in an associated did not have diversion records, the structures were placed in a "no diversion" aggregate.