PREPARED FOR
Colorado River Water Conservation District

Colorado River Water Bank Feasibility Study

PHASE 2 | March 2013

FINAL DRAFT REPORT

MWH
BUILDING A BETTER WORLD

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COLORADO RIVER WATER BANK FEASIBILITY STUDY – PHASE 2

Final Draft Report

March 2013

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1.0 INTRODUCTION

1.1 Project Objective

The Colorado River Water Bank is envisioned as a potential strategy for the State of Colorado to use pre-Compact agricultural water rights on the West Slope to meet a portion of East Slope and West Slope uses supplied by post-Compact water rights that could be affected during periods of shortage due to requirements of the Colorado River Compact. The Feasibility Study was intended to determine the viability of a Water Bank to help mitigate effects of water rights administration in the Colorado River Basin during times of shortage. The Feasibility Study is being conducted in three phases:

- Phase 1 – Supply and Demand
- Phase 2 – Test Cases
- Phase 3 – Resource Considerations

The purpose of Phase 1 was to estimate the amount of supplies that could be associated with the Water Bank, and to estimate the potential demand for those supplies. Results of the Phase 1 investigation are summarized in the Phase 1 Feasibility Report (MWH, 2012). Phase 1 estimated potential supplies from consumptive use (CU) associated with pre-Compact agricultural water rights from West Slope irrigators is about 970,000 acre-feet per year (AFY) on average[1]. The amount of that supply available to the Water Bank would be dependent on the percentage of irrigated acreage fallowed or deficit irrigated for the purpose of contributing the reduced CU from pre-Compact water rights to the Water Bank, climatic variables, and other factors. The total municipal and industrial demands met with post-Compact water that currently could be affected Colorado River shortages and possible curtailments may be up to 350,000 AFY. That number could be higher in the future.

At the completion of Phase 1 the Water Bank Group – which is comprised of representatives of West Slope agricultural organizations, East Slope municipal water providers, the State of Colorado, and The Nature Conservancy – determined that the feasibility of the Water Bank was sufficiently promising to authorize Phase 2 of the Feasibility Study.

1.2 Purpose

The purpose of Phase 2 was to assess the feasibility of implementing the Water Bank for a number of representative pre-Compact irrigation systems. This involved defining requirements and preferences for candidate irrigation systems; screening and selecting candidate irrigation systems; and conducting assessments of irrigation operation, deficit irrigation and fallowing benefits and impacts at the irrigation system level. In addition, Phase 2 involved a parallel outreach program to the West Slope agricultural community (performed by the Water Bank Group) and compilation of available research on the feasibility of deficit irrigation for the crop types and climate zones that could potentially supply water to the Water Bank.

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[1] Previous estimates from other entities vary but are higher. Conservative assumptions were purposely used for Phase 1 of this study.

The Phase 2 Scope of Work was based on the proposed scope in the grant application to the Colorado Water Conservation Board (CWCB) under the Alternative Agricultural Water Transfer Program, November 24, 2010. Additions and modifications to this original scope were made based on results of Phase 1 and direction from the Water Bank Group based on the current understanding of the requirements of Phase 2 to further test the feasibility of the Water Bank.

1.3 Authority

Phase 2 was a cooperative effort between the Water Bank Group, West Slope agricultural entities, and the MWH consulting team that was comprised of MWH Americas, Inc. and Natural Resources Consulting Engineers, Inc. (NRCE). MWH work was performed under contract to the Colorado River Water Conservation District.

1.4 Scope of Work

The scope of work for the technical aspects of Phase 2 of the Water Bank Feasibility Study is summarized as follows.

- Defining requirements and preferences for candidate irrigation systems to be considered as test cases for conducting on-site interviews and inspections
- Identifying candidate systems for further evaluation
- Screening candidate irrigation systems to select eight irrigation systems as test cases
- Conducting on-site assessments of potential fallowing and deficit irrigation operations for the test case systems to evaluate how water could be contributed to the Water Bank
- Describing alternatives for Water Bank operations at the farm and basin level
- Describing potential economic impacts at the irrigation system level for the test case systems.

2.0 CANDIDATE SYSTEM IDENTIFICATION AND EVALUATION

The objective of this section is to present a summary of the information for candidate systems in the West Slope study area (Water Divisions 4-7) and document the process for selecting test case systems from the list of candidate systems. The section presents the screening criteria that were adopted in cooperation with the Water Bank Technical Group to evaluate the selected candidate irrigation systems. Characteristics of the candidate irrigation systems in terms of location, return flow patterns, monthly and annual flows, water rights, associated consumptive use (CU), etc. are also presented. The data assembled for the candidate irrigation systems provide the basis for selecting the final test case systems and performing the field visits with owners/operators of those systems. A complete description of the identification and evaluation of candidate systems is included in **Appendix A**.

2.1 Candidate System Screening Criteria

The screening criteria used to identify and prioritize candidate irrigation systems cover a wide range of characteristics in terms of system acreage, elevation, consumptive use, water supply, crop type, irrigation type, etc. MWH and the Water Bank Technical Group agreed on a list of screening criteria for candidate systems. These criteria, along with the corresponding categories into which each system were placed, are shown in **Table 1**.

Table 1 – Candidate Irrigation Systems Screening Criteria

Screening Criteria	Categories
System Acreage	Large Medium Small
Elevation	High Medium Low
Supply Limited Consumptive Use (CU)	Pre-Compact Post-Compact
Type of System Organization	District Incorporated ditch Individual Federal
Priority of Water Supply	All pre-Compact Combination of pre- and post-Compact
Amount of Water Supply	Mostly full supply Mostly partial supply Storage
Tract Size Within System	Nearly all large tracts (>35 acres) Combination of large and small tracts
Crop Type	Grass Alfalfa Row Crops

Screening Criteria	Categories
Method of Water Delivery	One ditch Combination of ditches
Location on River	Diverts from main river Diverts from a tributary
Location Relative to Other Water Rights	Few if any downstream rights Numerous downstream rights
Location by Basin	Gunnison Colorado Yampa/White San Juan/Dolores
Salinity Effects	Not affected Marginally affected

The screening criteria were used to select candidate systems representing a broad range of characteristics.

2.2 Selection of Candidate Systems

The Water Bank Technical Group and MWH conducted a workshop to review the criteria and select candidate irrigation systems. Candidate systems were identified based on the personal knowledge of the study areas by members of the Technical Group. After making minor changes based on gathering additional information, 14 candidate systems were selected as shown in **Table 2**. Of the 14 candidate systems, eight were given higher priority and were put in Group A. Systems in this group were the preferred systems for conducting test case evaluations. The remaining six systems were given lower priority and were put in Group B. In case the owner of a candidate system in Group A did not wish to participate, a replacement candidate system from Group B would be selected. The placement in Group A or B was decided by the Technical Group based on the amount of diversity that these candidate systems encompass in terms of the screening criteria and their assumed willingness to participate in the Water Bank Feasibility Study. The Uncompahgre Project irrigation system in the Gunnison River Basin (Division 4) has the largest area with system acreage of 68,900 irrigated acres, while the Ekhart Ditch (Fetcher Ranch) in the Yampa River Basin (Division 6) is the smallest system with 193 irrigated acres. Of the 14 candidate systems, five are in the Upper Colorado River Basin, four are in the Gunnison River Basin, three are in the Yampa River Basin, and two are in the San Juan/Dolores River Basin.

Table 2 – Candidate Systems for Test Cases

Category	Candidate System	Division	Source of Irrigation Water
A	Colorado Cooperative Ditch	4 – Gunnison River Basin	San Miguel River
A	Dr. Morrison Ditch	7 – San Juan River Basin	Pine River
A	Cold Mountain Ranch	5 – Colorado River Basin	Crystal River
A	Ekhart Ditch	6 – Yampa River Basin	Elk River
A	Grand Valley Canal	5 – Colorado River Basin	Colorado River
A	Grand Valley Project	5 – Colorado River Basin	Colorado River
A	Trampe Ranch	4 – Gunnison River Basin	Gunnison River
A	Uncompahgre Project	4 – Gunnison River Basin	Uncompahgre River
B	Walker Ditch	6 – Yampa River Basin	Yampa River
B	King Ditch	7 – San Juan River Basin	Pine River
B	Divide Creek Highline	5 – Colorado River Basin	West Divide Creek
B	Paonia Area	5 – Gunnison River Basin	North Fork Gunnison and Minnesota Creek
B	Meeker Area	6 – Yampa River Basin	White River
B	Plateau Creek Area	5 – Colorado River Basin	Plateau Creek

2.3 Candidate System Data

Descriptive data was developed for the screening criteria in **Table 1** for each of the Group A candidate systems. Below is a short description of the data and methods used for each criterion and for the additional hydrologic and mapping data assembled for the potential test case systems.

System Acreage: This criterion quantifies the acreage planted in each major crop type category. Total irrigated acreage and distribution of irrigated acreages based on crop types has been observed to vary over time because of a number of factors including water availability and economic conditions. In order to address this condition the irrigated acreage GIS layers for the years 1993, 2005, and 2010 as obtained from the CDSS website were used to compute the irrigated acreages for the candidate systems. Results are shown in **Table 3** through **Table 6**. It is important to address the differences in acreages based on different irrigated acreage GIS layers and crop types because estimation of consumptive use depends on the crop type and corresponding total irrigated acreage. The irrigated acreage GIS layer for the year 2005 is the most recent available coverage for all the candidate systems and therefore it was decided to use the 2005 coverage for this study. Presently, the CWCB is updating the irrigated acreage GIS layer for 2010, and it may be appropriate to use this information in future work.

Elevation: Average elevations for candidate systems were computed based on 30-meter digital elevation model (DEM) data obtained from the Geospatial Data Gateway (GDG) website. Elevation is important because it affects the crop CU requirements.

Supply Limited Consumptive Use: Pre- and post-Compact supply limited CU for the candidate systems were computed using the State of Colorado's Stream Simulation Model (StateMod) obtained from the CDSS website. Supply limited CU is less than the theoretical CU and is limited by historical availability of irrigation water to the system. Distribution of supply limited CU between pre- and post- Compact water rights for a candidate system was based on distribution of water supply to diversion structures associated with the candidate system in terms of pre- and post- Compact decreed water rights. StateMod input datasets for Water Divisions 4-7 were obtained from the CDSS website. Distribution of irrigated acreages in terms of crop types in input datasets was hard-coded in StateMod and was based on 1993 irrigated acreage GIS coverage. The same datasets were used by Leonard Rice Engineers, Inc. ("Leonard Rice") for historic crop consumptive use analyses used in the Water Bank Phase 1 CU analyses.

Pre- and Post-Compact Supply limited CU for crop types in a candidate system were also estimated for irrigated acreage distributions based on 2005 irrigated acreage GIS coverage (Water Divisions 4-7) and 2010 irrigated acreage GIS coverage (Water Division 5 only). Ratios of irrigated acreages based on 2005 and 2010 irrigated acreage distribution and 1993 irrigated acreage distribution were computed and multiplied by pre- and post-Compact supply limited CU based on the 1993 irrigated acreage distribution to estimate supply limited CU for crop types in a candidate system in 2005 and 2010. (It is noted that CDSS is a basin-level analytical tool and does not necessarily accurately represent individual farms or ditches. More detailed analyses may be required for refinement of estimates for individual farms or ditch systems.)

Table 3 – Irrigated Areas for the Candidate Systems in Gunnison River Basin (Division 4)

Pilot Study Area	1993 Irrigated Coverage	2005 Irrigated Coverage	2010 Irrigated Coverage
Colorado Cooperative Ditch	4,232 Acres	5,288 Acres	Not Available Yet
	• Grass Pasture: 4,059 Acres (95.91%) • Alfalfa: 35 Acres (0.83%) • Row Crops: 117 Acres (2.76%) • Orchards: 21 Acres (0.50%)	• Grass Pasture: 5,002 Acres (94.59%) • Alfalfa: 160 Acres (3.03%) • Row Crops: 126 Acres (2.38%)	
Trampe Ranch	• 74,679 Acres • Grass Pasture: 2,012 Acres (100%)	• 79,201 Acres • Grass Pasture: 1,969 Acres (100%)	Not Available Yet
Note: 2010 Irrigated acreage not available for Division 4, Gunnison River Basin.			

Table 4 – Irrigated Areas for the Candidate Systems in Colorado River Basin (Division 5)

Pilot Study Area	1993 Irrigated Coverage	2005 Irrigated Coverage	2010 Irrigated Coverage
Cold Mountain Ranch	720 Acres	543 Acres	571 Acres
	• Grass Pasture: 260 Acres (36%) • Alfalfa: 460 Acres (64%)	• Grass Pasture: 432 Acres (79.56%) • Alfalfa: 77 Acres (14.18%) • Bluegrass: 34 Acres (6.26%)	• Grass Pasture: 283 Acres (49.58%) • Alfalfa: 124 Acres (21.78%) • Row Crops: 129 Acres (22.64%) • Bluegrass: 34 Acres (5.95%)
Grand Valley Irrigation Canal	28,112 Acres	18,435 Acres	17,390 Acres
	• Grass Pasture: 13,714 Acres (48.78%) • Alfalfa: 5,512 Acres (19.61%) • Row Crops: 8,725 Acres (31.04%) • Orchards: 161 Acres (0.57%)	• Grass Pasture: 5,248 Acres (28.47%) • Alfalfa: 7,999 Acres (43.39%) • Row Crops: 4,688 Acres (25.43%) • Orchards: 51 Acres (0.28%) • Bluegrass: 449 Acres (2.44%)	• Grass Pasture: 3,698 Acres (21.27%) • Alfalfa: 8,958 Acres (51.51%) • Row Crops: 4,172 Acres (23.99%) • Orchards: 76 Acres (0.44%) • Bluegrass: 486 Acres (2.79%)
Grand Valley Project	30,970 Acres	24,561 Acres	23,254 Acres
	• Grass Pasture: 9,690 Acres (31.29%) • Alfalfa: 8,205 Acres (26.49%) • Row Crops: 12,229 Acres (39.49%) • Orchards: 846 Acres (2.73%)	• Grass Pasture: 7,930 Acres (32.29%) • Alfalfa: 9,525 Acres (38.78%) • Row Crops: 6,274 Acres (25.54%) • Orchards: 697 Acres (2.84%) • Bluegrass: 135 Acres (0.55%)	• Grass Pasture: 3,064 Acres (13.18%) • Alfalfa: 14,165 Acres (60.91%) • Row Crops: 5,173 Acres (22.25%) • Orchards: 720 Acres (3.10%) • Bluegrass: 132 Acres (0.57%)

Table 5 – Irrigated Areas for the Candidate System in Yampa River Basin (Division 6)

Pilot Study Area	1993 Irrigated Coverage	2005 Irrigated Coverage	2010 Irrigated Coverage
Ekhart Ditch (Fetcher Ranch)	160 Acres	193 Acres	Not Available Yet
	• Grass Pasture: 160 Acres (100%)	• Grass Pasture: 193 Acres (100%)	
Note: 2010 Irrigated Acreage not available for Division 6, Yampa River Basin.			

Table 6 – Irrigated Areas for the Candidate System in San Juan/Dolores River Basin (Division 7)

Pilot Study Area	1993 Irrigated Coverage	2005 Irrigated Coverage	2010 Irrigated Coverage
Dr. Morrison Ditc	2,869 Acres	2,133 Acres	Not Available Yet
	• Grass Pasture: 2,856 Acres (99.55%) • Alfalfa: 13 Acres (0.45%)	• Grass Pasture: 2,062 Acres (96.67%) • Alfalfa: 71 Acres (3.33%)	
Note: 2010 Irrigated Acreage not available for Division 7, San Juan River Basin.			

Type of System Organization: Information on the type of system organization or governance (e.g., irrigation district, individual system) was obtained during the Water Bank group meetings from people familiar with the subject systems. The type of system organization would affect how decisions are made for fallowing or deficit irrigation to supply water to a Water Bank, how those practices are implemented, and how accounting for water contributed to a Water Bank would be performed.

Priority of Water Supply: Priority of water supply for each of the candidate systems in terms of pre- and post-Compact water rights was decided based on the available information in the CDSS Hydrobase. For purposes of the candidate system evaluation, all the water rights decreed on or before June 25, 1929 were considered as pre-Compact while the water rights decreed after June 25, 1929 were considered as post-Compact water rights.

Amount of Water Supply: Information on the amount of water supply typically available to the system relative to the full irrigation requirement was obtained during the Water Bank group meetings from people familiar with the systems.

Tract Size within System: Information on the typical size of irrigated tracts within the overall irrigation system was obtained based on 2005 irrigated area GIS data. Systems with many small tracts versus those with a few large tracts could have different management and accounting requirements if participating in a Water Bank.

Crop Type: The primary crop type in each candidate system was determined based on 2005 irrigated area GIS data. Crop type influences the potential CU savings available to a Water Bank from fallowing or deficit irrigation, and the potential for success of deficit irrigation practices.

Method of Water Delivery: Information on the method of water delivery (one ditch or multiple ditches from the headgate(s) to the fields) was obtained from 2005 irrigated area GIS data and the CDSS Hydrobase. Estimation of CU savings and impacts on downstream water users for systems with one headgate and ditch may be simpler than for systems with multiple headgates and ditches.

Location On River: Whether an irrigation ditch receives water from a main stem or a tributary was determined based on 2005 irrigated area GIS data and the source of water as documented in the CDSS Hydrobase. Systems diverting from a main stem river may have fewer Water Bank administration issues compared to systems diverting from more remote tributaries.

Location Relative to Other Water Rights: Location of a candidate system compared to other downstream irrigated areas in the water division was determined based on 2005 irrigated area GIS data. Systems with many downstream water users have a greater risk of having water saved through fallowing or deficit irrigation diverted by downstream users and therefore not contributing to Colorado River streamflow at the state line.

Location by Basin: The basin and water division in which the candidate system is located was determined from 2005 irrigated area GIS data and water division boundaries.

Areas Affected by Salinity: Soil and groundwater salinity were used as a surrogate for estimating whether a candidate irrigation system could have potential productivity issues during drought periods that would make it a better candidate for temporarily taking lands out of production. Whether a candidate system has potential salinity related issues was determined based on a GIS coverage that has salt loading rates (tons/acre) in return flows from irrigated areas. The GIS coverage was developed by the U.S. Geological Survey (USGS) Utah Water Science Center for the Upper Colorado River Basin USGS SPARROW model.

Historical Diversions: Data on historical diversions to the test case irrigation systems were provided to MWH by the Colorado Division of Water Resources (CDWR). Water rights and historical diversion records were based on information retrieved from Hydrobase.

Return Flow Locations and Patterns: Implementation of fallowing or deficit irrigation practices could affect return flows that are a source of inflow to downstream river segments and water supply to downstream water users. Locations of return flows from test case irrigation systems were based on the link-node system definition in the StateMod model. Monthly return flow patterns were also adopted from the data in the StateMod model.

Screening criteria data for the Group A irrigation systems are presented in **Tables 7A and 7B**.

2.4 Selection of Test Case Systems

Owners and managers of the Group A candidate systems were contacted, and each agreed to participate in a site visit and interview. The test case systems examined are as follows.

- Small High Mountain Ranches
  - Ekhart Ditch
  - Trampe Ranch
  - Cold Mountain Ranch
- Private Ditch Companies
  - Colorado Cooperative Ditch
  - Grand Valley Irrigation Company

- Reclamation Projects
  - Uncompahgre Project
  - Grand Valley Project
- Indian Irrigation Project
  - Dr. Morrison Ditch

Summary data sheets compiled for each test case irrigation system are provided with the candidate system TM in **Appendix A**. The summary sheets include information based on the methods described previously for water rights, historical diversions, location and pattern of return flows, and maps showing the location of test case systems in a water division along with associated crop types, headgates and salinity affected areas.

3.0 TEST CASE SYSTEM EVALUATIONS

The eight test case systems identified above and shown in **Figure 1** were evaluated as representative examples of agricultural systems that could contribute water to the Water Bank. The goals of the test case system evaluations were as follows.

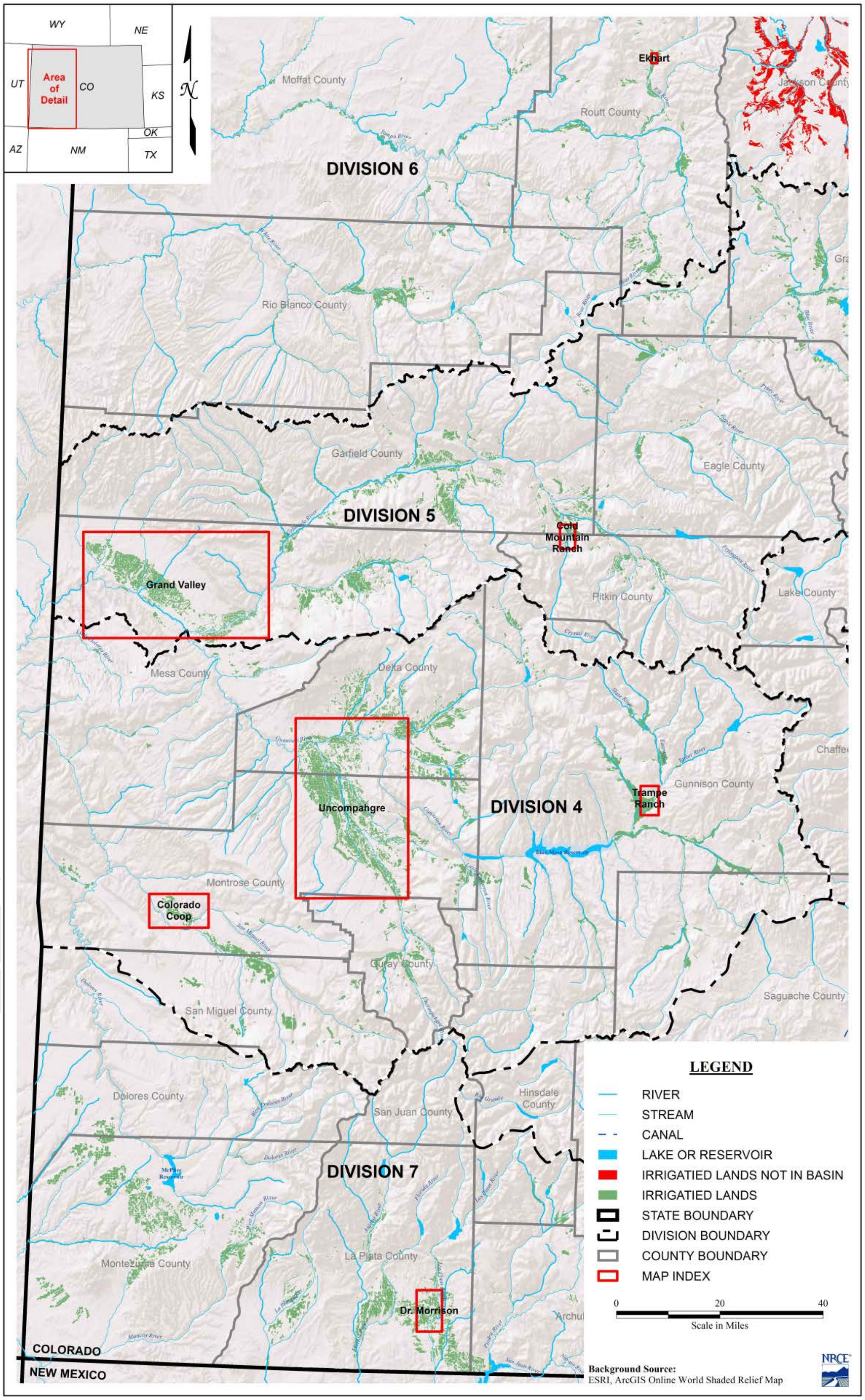
- Refine the estimated pre-Compact consumptive use information gathered for the irrigation system in Phase 1
- Determine the mix of pre-Compact and post-Compact water rights associated with the irrigation system
- Evaluate how the land could be temporarily fallowed or deficit irrigated
- Evaluate the influence of groundwater and sub-irrigation on meeting crop water requirements
- Estimate costs of fallowing and replanting
- Review estimates of physical and legal availability of water in priority during a curtailment based on historical experience
- Review administration and operation within the irrigation system if there are multiple shareholders
- Document their experience with deficit irrigation in the past, and their experience during recent drought periods (e.g., 2002 and 2012)
- Evaluate possible changes in return flows and downstream impacts that could result from deficit irrigation
- Assess willingness to participate in future deficit irrigation research studies on their fields

To meet these goals, a group representing the Water Bank team met with representatives of each of the test case systems. The following representatives of the Water Bank team met with the various irrigation system landowners and operators.

- **Water Bank Work Group:**
  - Dan Birch, Deputy General Manager of the Colorado River Water Conservation District (CRWCD);
  - Steve Harris of the Southwestern Water Conservation District (SWCD);
  - Aaron Derwingson, Agricultural Outreach Coordinator of the Nature Conservancy (TNC);
- **Water Bank Work Group Consultants (Report Authors):**
  - Chip Paulson, Principal Engineer from MWH Americas, Inc. (MWH)
  - Jordan Lanini, Senior Engineer with NRCE Inc. (NRCE);
  - Niel Allen, Senior Engineer with NRCE.

Four general categories of irrigated lands comprised the site visits. These included high elevation cattle operations with irrigated pasture; private ditch companies; Federal (U.S. Bureau of Reclamation; USBR) projects; and Indian projects. The site visits are described below, and comprehensive site visit reports appear in **Appendix B**.

Figure 1 – Location of Test Case Systems



3.1 Test Case System Site Visits

High Elevation Cattle Operations

The Water Bank Work Group representatives visited three high elevation cattle operations with irrigated pasture. The three operations were located in three river basins (Yampa, Colorado, and Gunnison) and represented both alfalfa and grass hay production, with one or two cuttings a year. The three operations had numerous similarities, however. All utilized irrigated pastures for winter hay production and fall and spring grazing. All three incorporated Federal grazing leases into their operations for summer feed. The majority of hay produced was used on-site as cattle feed, with any surpluses resulting as an insurance policy for winter feed. All the operators had honed their operations over decades to maximize the cattle production from their land. This included not only irrigation and hay production but also cattle genetics and weed control.

Furthermore, a recurring theme during the high elevation cattle operations interviews was that money is not the only important factor in operational decisions. Typically, the real estate value of the ranches exceeds the value as determined from agricultural production. Other factors under consideration included local aesthetics, groundwater for residential use, baseflows to local streams for fisheries and wildlife, and sustenance of wetlands.

Private Irrigation Companies

The Water Bank Work Group visited the Grand Valley Irrigation Company (GVIC) and the Colorado Cooperative Ditch (CCD) as representatives of private irrigation companies. These two systems were substantially different in many aspects, including crop types and operations.

The CCD is a smaller, private ditch company in a regional economy that is highly dependent on the coal-fired power plant at Nucla and the associated New Horizon Mine. Similar to the high elevation ranches, the hay crops (and a small amount of grain) produced are almost entirely used for cattle feed locally. Also, the water banking decision would not be purely economic for CCD water users and fallowing would result in long-lasting effects on regional cattle herds.

The GVIC is located in the Grand Valley, with widely variable crop types that are frequently sold outside the valley as commodities. The GVIC's territory is highly urbanized in some areas, as portions of Grand Junction have encroached on the service area.

Both companies allow for the trading of water rights, and the water is not tied to the land. However, the water can only be used on lands within the service areas of the companies.

Indian Irrigation Projects

The Water Bank Work Group visited the Dr. Morrison Ditch as representative of Indian Irrigation Projects. The Dr. Morrison Ditch is part of the Pine River Indian Irrigation Project (PRIIP), which is administered by the Bureau of Indian Affairs (BIA). In addition, the Project contains storage rights in Vallecito Reservoir, a USBR reservoir. The lands have varying ownership status with administration by both the Southern Ute Indian Tribe and BIA. The lands served by the Dr. Morrison Ditch are operated in a similar fashion to the CCD and the high elevation cattle operations. The majority of production is hay or alfalfa.

USBR Projects

The Water Bank Work Group representatives visited the Uncompahgre Valley Water Users Association (UVWUA) and the Grand Valley Water Users Association (GVWUA) as representative Federal irrigation projects. The water rights in these projects are tied to lands assessed as arable. USBR holds the water rights in these projects and the water users associations manage the distribution of irrigation water. These projects are at lower elevations and accordingly have higher consumptive use and multiple hay cuttings, more variable crops including row crops and orchards, and are also typified by crops sold as commodities rather than used directly for animal feed. These two projects are also underlain by Mancos shales, which are a source of salinity and selenium problems in the Colorado River basin. Salinity and groundwater levels are variable throughout the project lands.

Project farmers typically use flood or furrow irrigation with some sprinkler and drip irrigation also used. Urbanization is occurring in the lands served by both projects.

3.2 General Conclusions from Site Visits

Overall Findings

All of the landowners and irrigation system managers that met with the Water Bank Group members were very helpful and thoughtful in considering the factors associated with participating in a Water Bank. They were open about their operations and the pros and cons of participating in a Water Bank, and offered to discuss the situation further if necessary. While there was general skepticism about how a Water Bank would work and whether it could be successfully administered, the agricultural community is open to considering involvement under the right circumstances as more details are developed.

Fetcher Ranch hay meadow and on-farm diversion structure

All of the eight test case systems reported differences between their values for irrigated acreage, crop distribution, and/or the connection between specific diversions and irrigated areas compared to the 2005 CDSS information. For small high mountain ranches these differences are small and would not affect the Phase 1 water availability estimates. However, for the larger systems such as UVWUA GVIC, and GVWUA, these differences are more substantial. They indicate the variability in total irrigated land and crop distribution from year to year (e.g., 2005 vs 2012), and point out potential issues with adopting standard irrigated acreages and baseline CU values for irrigation systems desiring to participate in a Water Bank. The difference in acreage between what was reported by GVIC (32,000 acres) and what is in the CDSS database for GVIC (17,390 acres in 2010) is particularly large. Attempts to resolve this difference with GVIC were unsuccessful. It is recommended that CWCB contact GVIC to investigate the reason for this large disparity.

Pre- and post-Compact water right information in the CDSS was confirmed by the test case system interviews. None of the system operators had independent estimates of CU and could not verify the historical diversion data in Hydrobase. However, seasonal patterns in the historical data were generally thought to be reasonable overall; if differences were found they occurred during spring and fall shoulder months.

High Elevation Cattle Operations

Small cattle operations, such as Fetcher Ranch, Trampe Ranch, and Cold Mountain Ranch, would be difficult to fallow or deficit irrigate due to the fact that the size of the cattle operation is dependent on the entire irrigated acreage. For this reason, fallowing or deficit irrigation would require a reduction in herd size, which could take years to recover from, or importing supplemental feed. These operations are dependent on herd genetics, with cattle adapted to cold weather, local hazards, and local feed sources. Introducing replacement cattle or replacement feed from an outside source could subsequently increase mortality.

Lowline Ditch and irrigated hay fields on Cold Mountain Ranch

The following physical and operational conclusions were noted with fallowing/deficit irrigation of high elevation cattle operations.

1. High country cattle operations are typically operated to produce enough hay for winter feed for the herd. Fallowing or deficit irrigation would require a proportionate herd reduction or importation of hay.
2. Replacing foregone hay production with alternative hay sources may have longer lasting effects through weed introduction to the ranches.
3. Fallowing/deficit irrigation may be feasible for cattle operations not sized based upon winter feed availability (i.e., they are summer range limited or sell extra hay).
4. Fields chosen for fallowing/deficit irrigation would be carefully selected to avoid groundwater influences that would make it difficult to account for reduced consumptive use from irrigation diversion.

Area served by Colorado Cooperative Ditch

5. Irrigation results in regional, non-agricultural benefits to these areas, including increased baseflow to streams, water and habitat for wildlife, aquifer recharge for domestic well protection in areas close to urban development, and aesthetic benefits.
6. Fallowing or deficit irrigation has the highest potential for success for those operations with multiple cuttings of grass hay or alfalfa. However, many of the high elevation ranch systems only get one or two cuttings per year. The approximate elevation break above which grass pastures get only one cutting is about 7000 ft, although this can vary based on exposure and other factors (Brummer 2013). 32 percent of pre-Compact CU is associated with pastures above 7000 ft, so the effectiveness of fallowing or deficit irrigation for these systems is significant for Water Bank feasibility. There may be potential to incorporate fallowing into an alfalfa seeding rotation.
7. Typically farm management decisions are made at the family level, with only a few neighbors potentially needing to be consulted on a water bank participation decision.

8. Farm management decisions such as participating in a water bank are not necessarily based only upon maximizing profit, but would also consider family history, social values, and quality of life preferences.
9. Consistent fallowing of a portion of the ranch may be preferable to as-needed fallowing for the Water Bank during infrequent drought periods. This would allow ranchers to permanently reduce the herd size, avoiding the difficulties associated with annually varying herds and hay production.

The following administrative conclusions were noted with fallowing/deficit irrigation of high elevation cattle operations.

1. Irrigation diversions and return flows are rarely measured or recorded, making direct accounting of foregone CU difficult. Other methods of estimating CU (i.e., remote sensing, yield records, or meteorological estimates of CU) will be required.
2. For properties encumbered by a conservation easement that ties the water right of interest to the land, the landowner would need the approval of the organization holding the conservation easement to make any changes to their historic use of the water. The organization would look at the impacts this would have to the property's conservation values they want to protect (wildlife habitat, wetlands, scenic views, etc.). Whether or not it's feasible will depend greatly on the organization and the specific wording of the conservation easement. It may also require the involvement and/or approval of any agencies involved in funding of the conservation easement, which could include the State or Federal government.

Trampe Ranch hay field and irrigation ditch

3. High elevation ranches are primarily located far from the Colorado state line, and are often located on tributaries to main stem rivers. Most are served by direct diversions with no supplies from upstream storage. These factors will make it more difficult to shepherd foregone CU from these areas to locations benefitting Colorado's standing relative to the Compact.

While the three high elevation test case systems were similar, they are not necessarily representative of all such systems. Some landowners may be involved in producing grass hay and alfalfa as a commodity or leasing pasture rather than operating a cow/calf operation. A number of cattle operations in higher elevations over-winter their cattle on lower elevation sites (ground in the UVWUA for example) so they are not limited by winter feed production. In these cases there may be more opportunity for water banking than is indicated by the three high elevation ranch test cases,

Private Irrigation Companies

The following physical and operational conclusions were noted for the private irrigation companies:

Grand Valley Irrigation Company lined canals

1. Both companies noted some diversion of water outside of individuals' water rights. This may result in paying irrigators without corresponding reductions in CU.
2. The variable crops sold as commodities in systems like the GVIC may make water banking easier, whereas the depressed nature of the local economy in areas like Nucla and the CCD may make water banking attractive.
3. There is variable groundwater influence in both the CCD and GVIC. In larger private systems preference should be given to fallowing/deficit irrigating fields without subirrigation.
4. Return flows are used by downstream users in both companies. When this is the case, the irrigation company Board will have to set policies to assure that foregone CU for water banking purposes is passed through the system or not diverted at the headgate, and will have to assure no injury to other irrigators in its system.

The following administrative conclusions were noted with fallowing/deficit irrigation of the private ditch systems.

1. Diversions and return flows are not adequately measured to directly calculate foregone consumptive use.
2. Water rights not tied to land may make enforcement of fallowing/deficit irrigation more difficult, as the water is frequently moved among irrigators' fields. This may result in water being "shared" with fields under a Water Bank and therefore not reducing CU.
3. Trading/selling of water rights currently occurs in private systems, potentially making water banking administration easier to set up. These marketing systems already in place may have utility in leasing water for the bank.
4. Water banking would require the participation of the companies, even if contracts were with individual landowners or operators.

Indian Irrigation Projects

The following physical and operational conclusions were noted for the Indian irrigation project:

Fields irrigated by Dr. Morrison Ditch

1. Certain lands are "socially irrigated," or deficit-irrigated through inadequate management. This provides an opportunity for water banking because there is currently available CU that is legally allocated to the project but not being used and could be made available to a Water Bank without affecting current agricultural production. This also suggests that there could be local interest in Water Bank participation

2. Groundwater importance is variable throughout the Project. Fields for fallowing/deficit irrigating should be selected to avoid areas with subirrigation and to avoid negative impacts to other irrigators and benefits of groundwater return flows (wildlife habitat, fisheries, etc).

The following administrative conclusions were noted with fallowing/deficit irrigation of the Indian irrigation project.

1. Insufficient measurements of diversions and return flows make calculation of foregone CU impractical.
2. The Federally reserved water rights of the Southern Ute Indian Tribe are not subject to forfeiture or abandonment if not used, making longer-term banking more feasible.
3. There are no significant diversions or downstream water uses between the lands served by the Dr. Morrison Ditch and the Colorado/New Mexico State Line, making shepherding out of the State of Colorado easier.
4. The varying land ownership and administration may add an additional layer of difficulty to water banking.
5. The multiple layers of project administration on Tribal lands (e.g., Southern Ute Indian Tribe, BIA, and USBR) may make banking more difficult. However, the Southern Ute Tribe has expressed willingness to consider water banking and other leasing arrangements, and other tribes in the Colorado River Basin have been successful in creating workable long-term and short-term water leasing agreements.

USBR Projects

The following physical and operational conclusions were noted for the USBR Projects.

Irrigated hay fields in Uncompahgre Project area

1. The Grand Valley Project and Uncompahgre Project lands produce hay crops with multiple cuttings and row crops. Much of the production is sold as a commodity. This likely makes water banking more feasible than it would be in the high elevation ranches, as hay production does not need to be directly replaced.
2. Salinity and selenium issues may make fallowing or deficit irrigation more attractive to Project farmers, as impacted lands might be taken out of production with less impact on overall yields. In addition, reduced irrigation of these lands may have benefits in improved quality of return flows.
3. Return flow reuse with the Project is common to both systems, so fallowing/deficit irrigation may affect other Project water users. This is a particularly important issue for UVWUA because protecting saved CU throughout the system would require a change in how UVWUA delivers water. UVWUA is currently involved in an optimization study that could result in changes to how the project manages water deliveries.

The following administrative conclusions were noted with fallowing/deficit irrigation of the USBR projects:

Grand Valley Project irrigated area

1. While these projects have higher levels of water measurement, it is still not adequate for determining foregone consumptive use. These projects would also require estimation of reduced CU through remote sensing, meteorological data, or yield estimates.
2. The Uncompahgre and Grand Valley regions both have Colorado Agricultural Meteorological (CoAgMet) stations which estimate consumptive use on a daily, real-time basis. This may provide an additional method of CU determination not available in other areas.
3. Foregone water is currently passed along to other Project water users, reducing potential shortages in both areas. This may make shepherding water out of the Projects difficult if Water Bank participation is only at the individual farm level. Action by the water users associations would be needed to leave foregone CU for water banking in the river at the headgate or in upstream storage where that is available.
4. The water users associations would likely need to be involved to ensure water is foregone, even if water banking contracts are at the farmer level.
5. The UVWUA has unique water banking opportunities as its water rights – including those associated with direct flow diversions from the Uncompahgre River – are usable to extinction. It also holds storage rights in Taylor Park Reservoir; these storage rights may be useful for water banking purposes.

General Conclusions

All of the site visits revealed difficulties in water banking administration. First, none of the systems had adequate measurement of diversions and return flows to directly calculate foregone CU through a mass balance. This indicates the need for CU calculations based on remote sensing, meteorological data, or use of standard water requirements by crop type, elevation and irrigation type. Second, the majority of the systems showed difficulty in shepherding water out of the project area, not to mention to the State Line. Finally, administration of water banking for systems with multiple shareholders will likely require the participation of each project's management (i.e., water user's association or ditch company board) to be successful.

While the majority of West Slope consumptive use is from irrigated grass or alfalfa, much of this is in high elevation systems providing hay for cattle. These systems have an added level of complexity as the herd size is dependent on the hay produced by each irrigator. Therefore, crop reduction due to fallowing/deficit irrigation may result in herd reductions, making water banking more difficult for these producers. Those areas where crops are sold as a commodity appear to be more feasible for water banking, as banking would only require payments in exchange for fallowing/deficit irrigation.

Deficit irrigation may be feasible and more acceptable than rotational fallowing in some systems, particularly those with multiple cuttings of hay/alfalfa or with seasonal crop rotations. However, developing accurate estimates of CU savings through deficit irrigation would be more challenging than for fallowing due to lack of on-farm flow measurements and the effects of subirrigation and return flows.

In all private, federal and Indian cooperative irrigation systems, involvement of the managing Boards and agencies will be critical to implementing water banking operations. Success of the Water Bank will be dependent (among other things) on educating Boards and agencies regarding the bank's objectives, and working with them to develop acceptable administration and operation policies. However, in all test case systems with multiple shareholders, irrigation system operators expressed a strong preference that the ditch company or water users association not be directly involved in administration of the Water Bank. This could create an administrative burden on the Water Bank if not set up properly.

The test case system interviews made it clear that all systems are unique, and the economic and non-economic factors that will drive decisions regarding Water Bank participation are not uniform across the West Slope or across categories of agricultural water users. A one-size-fits-all approach to Water Bank administration, contracts, economics, and other factors is not likely to be successful. It is likely that answers to all complex administration, economic and institutional questions will not be resolved ahead of time, and that some will only be addressed as a bank is actually operated and adjusted to meet the needs of the willing participants.

Finally, while it has been understood from the outset that developing a Colorado River Water Bank would be challenging, the test case system interviews reaffirmed this understanding and demonstrated that the challenges may be broad and complex. Developing a Water Bank will require a concerted, consistent effort at many levels and a sensitivity to the variability in perspectives, constraints and desires across Colorado's West Slope agricultural community.

3.3 Financial Impacts of Fallowing on Agricultural Operations

In order to prepare a rough estimate of the costs of fallowing, two cases were examined. The first is the high elevation cattle ranches. The second is the Uncompahgre Project and Grand Valley Project irrigators where the majority of crops are sold as a commodity. The analysis utilizes historical price data for various crops to estimate revenue and crop enterprise budgets from Colorado State University (CSU) to estimate costs such as planting and harvesting. These values are subsequently used to estimate foregone revenues, as well as expenses for producers as a result of fallowing or deficit irrigation. Each is described below.

It is noted that the economic analysis presented in this section is based on a number of assumptions and approximate data with a high degree of uncertainty. The results presented should be used for comparative, order-of-magnitude purposes only and not for detailed planning or decision making.

High Elevation Cattle Ranches

The high elevation cattle-producing irrigators interviewed produce hay primarily to provide winter feed to local cattle. Therefore, fallowing on these ranches would require either supplemental purchase of hay or reduction of herd size. It was assumed the acquisition of supplemental hay would be the preferred option, as producers would incur multi-year expenses with herd reductions as opposed to the single-year cost of replacement hay.

The costs of fallowing to producers were assumed to be the cost of supplemental hay for cattle plus the price of transporting hay to the ranch. Annual purchase prices of crops in Colorado are available from the United States Department of Agriculture's National Agricultural Statistics Service (USDA-NASS) for 2008 to 2012, shown in **Table 7** (USDA NASS Colorado Field Office, 2008-2012). The three areas examined were the Western Slope Area (Uncompahgre and Grand Valley Projects, and Grand Valley Irrigation Company); Southwestern Colorado (Colorado Cooperative Ditch Company and Dr. Morrison Ditch); and the Mountain Area (Fetcher Ranch, Trampe Ranch, and Cold Mountain Ranch).

Table 7 – Average Purchase Prices of Feed Crops in Colorado by Year. Minimum and Maximum Prices are in Bold

		GRASS HAY – Large Square Bales				
		2008	2009	2010	2011	2012
Location	Grade	$/ton	$/ton	$/ton	$/ton	$/ton
Western Slope Area, Colorado	Fair	$127	$111	**$94**	$150	$150
	Good	$147	$125	$113	$164	$170
	Premium	$162	$156	$137	$161	**$190**
Southwestern Colorado	Fair	-	-	-	-	-
	Good	$148	$165	-	-	$215
	Premium	$201	$165	$156	$166	**$238**
Mountain Area, Colorado	Fair	$126	$111	**$93**	$150	$150
	Good	$147	$125	$112	$164	$184
	Premium	$163	$156	$137	$161	**$214**
		ALFALFA HAY – Large Square Bales				
		2008	2009	2010	2011	2012
Location	Grade	$/ton	$/ton	$/ton	$/ton	$/ton
Western Slope Area, Colorado	Fair	$135	-	**$115**	$170	$170
	Good	$155	-	-	$170	$170
	Premium	$175	$150	$125	$165	**$205**
Southwestern Colorado	Fair	$141	$130	**$94**	$145	$198
	Good	$158	$147	$113	$176	$218
	Premium	$165	$154	$134	$200	**$235**
Mountain Area, Colorado	Fair	$135	-	$115	$170	$170
	Good	$155	-	-	$170	$170
	Premium	$175	$150	$125	$166	**$230**

Prices for three grades of hay (fair, good, and premium) were examined for each region. USDA-NASS presents data for another grade (supreme), but adequate data were not available for the purposes of this analysis. The prices shown in **Table 7** are the mean between the high and low bid prices reported by USDA-NASS. USDA-NASS presents prices for large round, large square, and small square bales. We used prices for large square bales as values were reported for the majority of years, whereas large round bale prices were not. Small square bales were assumed to be more costly and would not likely be used for supplemental cattle feed. These prices can be considered conservative, as monthly maximum prices may exceed the annual averages presented in **Table 7**.

In addition to the purchase price of hay, transportation of the hay adds to the cost of supplemental feed. Hay transportation costs were estimated using Colorado State University Crop Enterprise Budgets (Colorado State University, 2011a) (Colorado State University, 2011b) & (Colorado State University, 2009a).

While purchasing supplemental hay is typically more expensive than utilizing hay grown on the ranch, there are savings associated with fallowing or deficit irrigation. These savings include less crop inputs such as fertilizer, irrigation water and labor (described in tables as preharvest costs), and harvesting costs. Anticipated fallowing/deficit irrigation savings will vary widely among the interviewed producers, and from year to year due to variables such as weather, soil, insect and disease pressure, and management practices. Operational costs such as land costs, purchase of machinery, etc. typically incurred by an agricultural enterprise were assumed to be constant with or without fallowing/deficit irrigation. Therefore, these costs were not included in the pre-harvest costs to isolate the costs only associated with fallowing.

Costs can range anywhere from $130 per acre to $500 per acre just in the state of Colorado, based on the CSU Crop Enterprise Budgets. Because of the variations among different ranches, harvest and preharvest costs and savings for these five areas were quantified as the per-ton average provided in (Colorado State University, 2010a). For example, if Trampe Ranch assumed the total cost per acre described in the Crop Enterprise Budget, it would likely not break even on the production of grass hay. Their management practices are altered to maximize efficiency of the resources available and likely have lower costs for pre-harvest.

Table 8 shows the annual costs per acre to purchase supplemental hay to provide winter feed to cattle. Yields were estimated based on reported yields during the test case system interviews. The minimum and maximum purchase prices for hay and alfalfa were the minimum and maximum annual values within the five-year period from 2008 to 2012 for "Premium" hay. The average price was the mean of the five-year "Premium" hay price. Prices for Fetcher and Trampe Ranches were for grass hay in the Mountain Area. The price for Cold Mountain Ranch was the average of grass and alfalfa hay in the Mountain Area, as the hay produced there is a mixture of alfalfa and grass. Southwestern alfalfa hay prices were used for Colorado Cooperative Ditch and Dr. Morrison Ditch. Yields were reported during the interviews.

Table 8 – Annual Fallowing Costs for High elevation Cattle Operators

	Jay Fetcher Ranch[1]			Trampe Ranch[1]			Cold Mountain Ranch[2]			Colorado Cooperative Ditch[3]			Dr. Morrison Ditch[3]		
	Avg.	**Min.**	**Max.**	**Avg.**	**Min.**	**Max.**	**Avg.**	**Min.**	**Max.**	**Avg.**	**Min.**	**Max.**	**Avg.**	**Min.**	**Max.**
Yield (tons/acre)	3.5			1.5			3			2.75			2.5		
Purchase Price ($/ton)	$166	$137	$214	$166	$137	$214	$168	$131	$222	$177	$134	$235	$177	$134	$235
Haul Price ($/ton)	$15			$15			$15			$15			$15		
Pre-harvest costs ($/ton)	$26			$26			$26			$26			$26		
Harvest costs ($/ton)	$47			$47			$47			$47			$47		
Purchase Cost ($/acre):	$581	$480	$749	$581	$480	$749	$588	$459	$777	$620	$469	$823	$620	$469	$823
Foregone pre-harvest costs ($/acre)	-$90			-$39			-$77			-$71			-$64		
Foregone harvest costs ($/acre)	-$164			-$70			-$141			-$129			-$117		
Establishment Costs ($/acre)	$115	$0	$230	$52	$0	$104	$84	$0	$167	$98	$0	$195	$98	$0	$195
Cost per Acre	**$380**	**$279**	**$548**	**$495**	**$393**	**$663**	**$416**	**$286**	**$605**	**$462**	**$311**	**$665**	**$476**	**$325**	**$679**
Cost per Acre-Foot	**$279**	**$212**	**$403**	**$295**	**$235**	**$397**	**$221**	**$152**	**$322**	**$230**	**$155**	**$331**	**$307**	**$210**	**$438**

[1] Mountain Area, Premium Grass Hay.
[2] Mountain Area, average of Premium Grass and Premium Alfalfa Hay.
[3] Southwestern Area, Premium Alfalfa Hay.

Pre-harvest costs include costs such as fertilizers, herbicide and insecticide, and machine repairs and maintenance. They do not include allocated costs of seeding, property and ownership costs, and taxes. Harvest costs include typical costs of baling, hauling and stacking, and swathing. Establishment costs are not allocated, as they are assumed to be an additional expense solely due to fallowing/deficit irrigation.

Additionally, establishment costs of alfalfa and grass hay should be considered if fallowing is practiced. The level of re-establishment following fallowing/deficit irrigation is not clear for these high elevation ranches, and it may not require the full efforts described in a Crop Enterprise Budget. Re-establishment costs will vary substantially by region, and more research is needed into forecasting these costs for fallowing and different levels of deficit irrigation. Establishment costs for alfalfa were estimated from (Israelsen, Curtis, Lee, & Snyder, 2012) and establishment costs for grass hay were estimated from (Painter, 2011). They were estimated as the difference between full production revenue per acre and establishment revenue per acre. This incorporates costs of establishment as well as the reduced yields for the establishment year. It should be noted that the magnitude of reestablishment costs for grass hay and alfalfa would likely be less than full establishment costs as provided in crop budgets as the stand may not have to be completely reestablished. Thus, for the "On-Farm Establishment Costs" in **Table 8**, the average scenario uses 50% of the estimated establishment cost, with the minimum at zero and the maximum at 100%.

As can be seen from **Table 8**, the cost of fallowing varies widely based on the price of alfalfa and grass hay. The cost of securing replacement hay during years with high hay prices can be three to four times greater than those with low hay prices. Because the price of hay can vary considerably over a few years, planning for the cost of replacement hay would be a challenge for landowners and for setting the price of water contributed to the water bank.

Uncompahgre and Grand Valleys

Unlike the aforementioned ranches, Grand Valley Irrigation Company, Uncompahgre Valley Water Users Association and Grand Valley Water Users Association primarily sell hay and grain crops as a commodity. Three primary crops examined include feed corn, alfalfa hay, and grass hay. Therefore, fallowing on these areas would cost irrigators the profit they would have made from selling the crops based on the purchase prices shown in Table 7. The savings associated with harvest and preharvest costs, obtained from CSU Crop Enterprise Budgets, were also incorporated into the fallowing costs as a benefit (CSU, 2009a-c; 2010a-b; 2011a-c). Establishment, pre-harvest, and harvestcosts are calculated as described above. No establishment costs are included for corn as it is replanted annually.

Table 9 shows the annual costs in terms of foregone crop sales revenue to the farmers and ranchers per acre fallowed.

Table 9 – Fallowing Costs (foregone revenue) Incurred by Irrigators Operating in the Grand and Uncompahgre Valleys for Average, Minimum, and Maximum Five-year Commodity Prices

	Average	Minimum	Maximum
CORN			
Estimated Yield (Bu/ac)		155	
Purchase Price ($/Bu)	$4.95	$3.30	$7.60
Crop Value ($/ac)	$767	$512	$1,178
Preharvest Savings ($/ac)	-$391	-$391	-$391
Harvest Savings ($/ac)	-$44	-$44	-$44
Total Fallowing Cost ($/ac)	**$332**	**$77**	**$743**
GRASS HAY			
Estimated Yield (T/ac)		5	
Purchase Price ($/T)	$144	$94	$190
Crop Value ($/ac)	$720	$470	$950
Preharvest Savings ($/ac)	-$39	-$39	-$39
Harvest Savings ($/ac)	-$117	-$117	-$117
Establishment costs ($/ac)	**$115**	**$0**	**$230**
ALFALFA HAY			
Estimated Yield (T/ac)		5	
Purchase Price ($/T)	$160	$115	$205
Crop Value ($/ac)	$800	$575	$1,025
Preharvest Savings ($/ac)	-$105	-$105	-$105
Harvest Savings ($/ac)	-$205	-$205	-$205
Establishment costs ($/ac)	**$97**	**$0**	**$195**

In **Table 9**, yields were estimated using USDA's Web Soil Survey, which reports crop yields in a given area of interest (USDA-NRCS, 2012). Preharvest costs in this table include costs of fertilizers, herbicides, and insecticides as well as costs associated with operating irrigation equipment, such as fuel, repairs, and maintenance. Harvest costs in this table refer to labor and transportation cost of crops.

As with the high elevation cattle operations, fallowing costs vary widely based on commodity prices. The cost of fallowing for a row crop such as corn during years of high commodity prices might be as much as 10 times the cost during years of low commodity prices.

Costs and foregone revenue due to deficit irrigation would be less than the values shown in Tables 8 and 9. Lost yield and the need for supplemental replacement hay would be less, as would impacts to on-farm pre-harvest and harvest costs. The relationship between percent of deficit irrigation and percent of foregone revenue compared to full fallowing has not been investigated in this study.

Data in **Tables 8 and 9** indicate that there is a wide range of possible compensation that could be required for irrigators who choose to participate in the Water Bank. Crop types, commodity prices, local crop yields, hydrologic conditions and other factors will affect the potential revenue that would be lost through fallowing or deficit irrigation. Opportunity costs may also have to be considered in certain cases, as some farmers/ranchers may have opportunities to pursue other sources of income if they are paid to reduce their farming/ranching activities. This suggests that future costs for Water Bank subscribers such as Front Range water providers that would utilize the Water Bank to meet infrequent water shortages could be difficult to predict. It also suggests that auctions or other flexible pricing mechanisms may be needed rather than fixed price contracts to attract the largest number of willing sellers.

The regional economic impact of Water Bank participation has not been evaluated in this phase of the feasibility study, but could be significant. For example, owners of Trampe Ranch pointed out that if they reduce irrigation to participate in the Water Bank, their cheapest and most convenient source of supplemental hay would be from the Uncompahgre Valley. However, if UVWUA irrigators are also reducing irrigation and hay production to participate in the Water Bank, supplemental hay from this source would be limited and expensive. Reduced irrigation for banking over multiple consecutive years could weaken the regional agricultural infrastructure and economy. This topic should be addressed in future phases of the feasibility study.

4.0 OPERATIONAL SCENARIOS AND CRITERIA

Phase 2 of the Colorado River Water Bank Feasibility Study included a task for reviewing possible operational criteria and scenarios for the Water Bank at the farm level and within the overall Colorado River Basin in Colorado. The objective of this task was to describe the various options for operating a Water Bank and identify their primary strengths and weaknesses. It is too early in the development of the Water Bank to select a preferred operational strategy. At this stage, many different options will be described and assessed qualitatively. Scenarios and criteria were developed based on the findings of the test case interviews and input from the Water Bank Work Group.

4.1 Description of Operational Scenarios

Operational scenarios were identified for several categories of on-farm practices and basin-level practices involved in eventual implementation of the Water Bank. The categories and scenarios are described below.

Scenarios for Frequency of Activating Water Bank Contracts

This category includes options for the frequency with which pre-Compact water rights owners desiring to participate in the bank would be asked to reduce depletions and contribute supplies to the bank.

- **Shortage Triggered, Proactive –** The need to reduce depletions would be determined based on anticipated or forecasted deficits at Lee Ferry relative to the 75 MAF over 10 years requirement in Art. III of the Colorado River Compact ("deficits at Lee Ferry"), as determined by system reservoir storage amounts, accumulated Colorado River streamflow, or other metrics. Water Bank activation would be proactive to reduce or avoid more severe depletion reductions required during deficits at Lee Ferry.
- **Shortage Triggered, Reactive –** The need to reduce depletions would be triggered by actual deficits at Lee Ferry. Water Bank activation would be reactive to allow junior water rights to divert out of priority during deficit periods.
- **Annual –** Depletions would be reduced by a relatively constant amount every year based on commitments made by participating pre-Compact irrigators. Reduced depletions would contribute to increased Colorado River streamflows relative to the 75 MAF threshold to reduce the risk (frequency and magnitude) of future deficits at Lee Ferry.
- **Economically Triggered –** Depletions would be reduced to contribute to increased Colorado River streamflows relative to the requirement not to deplete more than 75 MAF every 10 years in years when commodity prices are low and financial compensation for fallowing/deficit irrigation is most attractive to pre-Compact agricultural water users.

Methods of Reducing Depletions

This category includes on-farm options for reducing depletions such that the saved consumptive use (CU) could be deposited in the Water Bank.

- **Rotational Fallowing –** Different fields within large single-owner systems or different tracts within large multi-user systems would be fallowed on a planned rotational basis to meet predetermined commitments for reduced depletions.
- **Split-Season Irrigation –** Irrigation would be terminated prior to the end of the historical irrigation season and the saved consumptive use (CU) would be committed to the Water Bank. Split-season irrigation would be most practical on lands supporting multiple annual crops or on hay and alfalfa fields that produce more than one cutting per year and that are located on bench lands and not sub-irrigated.
- **Split-Field Irrigation –** The full amount of the irrigation water right would be applied to a smaller section of the historically irrigated land to reduce on-farm losses and improve irrigation efficiency. Recent research has identified this as a method of reducing water use.
- **Longer-term Rotational Fallowing –** Irrigated lands would be converted to a native or low CU grass for a longer period (i.e., three to 10 years). This would be modeled after the Natural Resources Conservation Service (NRCS) Conservation Reserve Program (CRP).
- **Permanent Fallowing –** Irrigated lands would be permanently taken out of production and the saved CU would be committed to the Water Bank every year.
- **Changes to Crop Type –** The Water Bank program would incentivize planting lower water use crops than have historically been grown, and the reduced CU would be committed to the Water Bank. This could be a temporary or permanent change, and may require a change in current water administration processes to allow the saved CU to be banked.
- **Water Efficiency Projects –** Agricultural water efficiency projects would be implemented to reduce diversions needed to obtain the same historical crop yields. The Water Bank would only get credit for saved CU associated with reduced carriage and other losses, since CU associated with the historical crop yields would be unchanged.

Methods of Crediting Reduced Depletions to the Water Bank

This category includes operational scenarios for making reduced depletions by pre-Compact agricultural water users available at times and places that would satisfy the purposes of the Water Bank.

- **Direct River Deliveries to Lee Ferry –** Saved CU contributed to the Water Bank would be delivered from the headgate where diversions were curtailed to Lee Ferry via the natural river system. Water would not be stored in Lake Powell but would be passed through to Lee Ferry. A method of administering the water from the headgate to Lee Ferry would be required to prevent its diversion or storage by intervening water rights holders.
- **Direct River Deliveries to Lake Powell –** Saved CU contributed to the Water Bank would be delivered from the headgate where diversions were curtailed to Lake Powell via the natural river system. Water would be stored in an if-and-when account in Lake Powell to be managed by the Water Bank. A method of administering the water from the headgate to Lake Powell would be required to prevent its diversion by intervening water rights holders.
- **Upper Basin Exchanges to Front Range –** Saved CU contributed to the Water Bank would be exchanged from the headgate where diversions were curtailed to the upper Colorado River basin for diversion by junior Front Range water users that are participants in the Water Bank. Exchanges would be required to current points of diversion by Front Range water users, and would be dependent on avoiding injury to water rights holders.

- **Reduced Reservoir Releases –** Deliveries from upstream reservoirs serving irrigated areas with pre-Compact water participating in the Water Bank would be reduced in an amount equivalent to the saved CU. For example, saved CU in the lands under the Uncompahgre Project water could be held in Taylor Park Reservoir and then moved to Aspinall Unit storage with first fill water. Water would be held in storage for future Water Bank use, possibly in a specified Water Bank storage account. Details of reservoir account management would have to be worked out in specific cases to accommodate Water Bank storage.
- **Exchanges to Upper Basin Storage –** Saved CU contributed to the Water Bank would be exchanged from the headgate where diversions were curtailed to upper basin reservoirs for storage. Exchanges would be dependent on avoiding injury to water rights holders. Water would be held in storage for future Water Bank use, possibly in a specified Water Bank storage account.
- **Direct Deliveries to Mid-Basin Storage –** Saved CU from high elevation irrigated areas would be left in the river and then stored in downstream reservoirs for subsequent in-state use or to increase stream flows at the state line..

Methods of Accounting for Reduced Depletions

This category includes optional methods of accounting for reduced depletions that are committed to the Water Bank at a level that would be suitable for Water Bank administration and Compact administration.

- **Direct Measurement –** Reduced depletions would be computed from direct on-farm measurements of total diversions less total return flows for full CU conditions versus reduced CU conditions from fallowing or deficit irrigation. Surface water and groundwater return flows would be measured.
- **Crop Yield Differences –** CU savings would be inferred based on changes in crop yield, using relationships between acre-feet of water used per ton of crop produced. Actual crop yield with reduced depletions from fallowing or deficit irrigation would be compared against the yield that had been generated historically by a full water supply.
- **Remote Methods of Estimation –** Crop yields and water use would be estimated based on aerial photography or satellite imagery used to estimate irrigated acreage, evapotranspiration (directly or indirectly), crop yields, and other agricultural data.
- **Meteorological Calculations of Consumptive Use –** Water use would be estimated from the nearest Colorado Agricultural Meteorological Network (CoAgMet) station or other meteorological data. Calculations could be constant throughout time or vary daily depending on data available.
- **Standard Crop Water Requirements –** Standard crop water requirements adopted from research data based on crop type, elevation, soil conditions, irrigation practices, and regional factors would be adopted. Standard values could be used for all years, or wet year / average year / dry year values could be adopted.

Operation at Ditch System Level

This category describes the various options for operating individual ditch systems for Water Bank participation. These options are tied to the type of governance structure or water rights ownership differences among ditch systems. They are not choices to be made as much as different situations that must be accommodated by a Water Bank institution.

- **Water Rights Ownership –** In individually owned ditch systems, water rights are owned and controlled by the landowner, and CU savings at the farm level can be contributed directly to the Water Bank. In corporately owned ditch systems, water rights are owned and controlled by the organization, and CU savings at the farm level revert to the organization for use at other locations in the ditch system. Corporate ownership of water rights requires involvement by the ditch system board to assure that saved CU would accrue to the Water Bank.
- **Relationship Between Water and Land –** In individually owned systems and in some corporately owned systems, water rights are property rights and can be managed, traded, sold, etc. independent of land ownership and operation. In some systems (e.g., Uncompahgre Project) water is tied to the land and is allocated in fixed amounts based on irrigated acreage (acre-feet/acre). In this case if individual farmers reduce CU on their own, it would not administratively free up water for the Water Bank, as it would remain within the system for use by other shareholders. Participation at the irrigation project Board level would be required to assure reduced CU is left in the river or kept in storage.
- **Water Delivery Point –** In individually owned systems and many corporate systems, the system delivers water directly to the farm level. In this case on-farm savings can translate directly into reduced diversions at the headgate. In some corporate systems (e.g., Grand Valley Irrigation Company) the system delivers water to laterals that are owned and operated by individuals or lateral boards. In these cases it is more difficult to assure that on-farm CU savings can be translated to equal reductions in diversions at the system headgate(s).
- **Private or Federal Ownership –** Most ditch systems are owned and operated by private individuals or private irrigation companies. These systems can make their own decisions regarding Water Bank participation, and create their own internal policies as needed. Projects established by the federal Bureau of Reclamation or Bureau of Indian Affairs will require federal action and approval before these systems or their shareholders can participate in the Water Bank.

Table 10 presents a qualitative discussion of strengths and weaknesses of the operational scenarios and criteria for each of the categories described in Section 2.0. The qualitative evaluation provides a screening-level assessment that identifies scenarios with fatal flaws and highlights the primary challenges and opportunities offered by each scenario.

Table 10 – Strengths and Weaknesses of Water Bank Operational Scenarios

Categories	Operational Scenarios	Strengths	Weaknesses
Frequency of Activating Water Bank Contracts	Shortage Triggered, Reactive	WB activated infrequently	• Difficult to involve enough acreage to generate enough CU to emerge from curtailment situation quickly • Does not avoid deficits at Lee Ferry • Greater uncertainty about having the expected WB supply • During droughts, water supply would be limited, constraining the amount of potential CU savings through fallowing or deficit irrigation
	Shortage Triggered, Proactive	• WB activated infrequently • Could be used to avoid deficit at Lee Ferry	• Greater uncertainty about having the expected WB supply • During droughts, water supply would be limited, constraining the amount of potential CU savings through fallowing or deficit irrigation
	Annual	• Irrigators can plan more easily • May be preferred by small ranchers growing feed for their own cattle • Greater certainty about how much water will be available to post-Compact users • WB supplies can be generated during normal or wet years when irrigators are not already in a shortage condition	May be larger regional socioeconomic impacts than shortage triggered scenarios
	Economically Triggered	Allows irrigators to contribute water when it is most economically beneficial	Difficult to give post-Compact WB users certainty on amount of supply available

Table 10 – Strengths and Weaknesses of Water Bank Operational Scenarios

Categories	Operational Scenarios	Strengths	Weaknesses
Methods of Reducing Depletions	Rotational Fallowing	• Allows irrigators to plan ahead • Possible strategy for large systems with mix of crop types • WB supplies can be generated during normal or wet years when irrigators are not already in a shortage condition	Permanent reduction in regional agricultural production
	Split Season Irrigation	• Preserves some crop yields annually • Most feasible for systems getting 3 hay cuttings or rotating crops on same acreage	• More difficult to estimate saved CU compared to fallowing • Limited applicability to high elevation pastures where significant pre-Compact CU occurs
	Split Field Irrigation	• Preserves some crop yields annually • Could be combined with rotational planting strategies • Method of reducing overall water use	More difficult to estimate saved CU compared to fallowing
	Permanent Fallowing	• Most certain CU annual deposit in WB • Easiest approach for measuring CU savings	• Permanent reduction in regional agricultural production • Largest impact on agricultural yields in region
	Changes to Crop Types	• May be minimal long-term financial impact on agricultural community where feasible	• Only applies to larger mixed crop systems • Will not be feasible for pastures supplying feed for ranches (except changes between alfalfa and grass hay)
	Longer term Rotational Fallowing	• More ability for advance planning • Avoids some erosion problems	• Would require a cover crop (i.e., low CU grasses) • Maintains CU from precipitation • May require an establishment year
	Water Efficiency Projects	• Supplemental benefits on downstream water quality • Funding available for salinity control and other programs	WB only benefits from saved CU, e.g., from reduced evaporation or phreatophyte use in canals and ditches

Table 10 – Strengths and Weaknesses of Water Bank Operational Scenarios

Categories	Operational Scenarios	Strengths	Weaknesses
Methods of Crediting Reduced Depletions to the Water Bank	Direct River Deliveries to Lee Ferry	Simplest method of water administration	• Only helps Front Range users by contributing to increased stream flows at Lee Ferry and reducing frequency and magnitude of shortages • No ability to manage Water Bank supplies for specific purposes
	Direct River Deliveries to Lake Powell	Once water is in Lake Powell, can directly affect flows at Lee Ferry by releasing from storage	• Requires establishment of Water Bank storage account in Lake Powell • Requires cooperation and management by Reclamation • High evaporation losses
	Upper Basin Exchanges to Front Range	• Delivers wet water to Front Range WB users • All within Colorado; would not require UCRC involvement	• Exchange potential is limited during dry seasons • Exchanges may have adverse environmental impacts in some river segments • Water administration is complex • May require dedicated WB reservoir storage accounts
	Reduced Reservoir Releases	• Puts WB water in storage for future use • Would not require UCRC involvement if stored water is used to satisfy Colorado water needs	• Evaporation losses • May require dedicated WB reservoir storage accounts
	Exchanges to Upper Basin Storage	• Puts WB water in storage for future use • Would not require UCRC involvement if stored water is used to satisfy Colorado water needs	• Evaporation losses • Exchange potential is limited during dry seasons • Exchanges may have adverse environmental impacts in some river segments • Water administration is complex • May require dedicated WB reservoir storage accounts
	Direct Deliveries to Mid-Basin Storage	• Puts WB water in storage for future use • Would not require UCRC involvement if stored water is used to satisfy Colorado water needs	• Limited irrigated acreage is tributary to mid-basin reservoirs • Evaporation losses • May require dedicated WB reservoir storage accounts

Table 10 – Strengths and Weaknesses of Water Bank Operational Scenarios

Categories	Operational Scenarios	Strengths	Weaknesses
Methods of Accounting for Reduced Depletions	Direct Measurement	Most accurate and defensible method	• No reliable data for current operations • Very difficult to measure diversions and surface/subsurface return flows at all participating fields • Dependent on data reported by irrigators
	Crop Yield Differences	• Related directly to CU • Irrigators will have good data for applied water and crop production	• Dependent on data reported by irrigators • Other factors besides applied water affect crop yield
	Remote Methods of Estimation	• Most cost-effective method • Most centralized method (i.e., can be done by WB institution)	Potentially least accurate approach, but new technologies are increasingly more accurate and being used in administration so may be more feasible in the future
	Meteorological Calculations	• Most crop water uses are estimated on a real-time (daily) basis at CoAgMet stations • Data are readily available and can be easily verified by all parties	• Stations are only available in major agricultural areas • Requires agreement on ET calculation method, especially for high elevation fields • Requires additional field verification of fallowing • Would require soil moisture accounting for applicability to deficit irrigation
	Standard Crop Water Requirements	• Easiest method to apply across the entire Upper Basin area • Research data is available and could be readily expanded or improved to support the WB	• Standardized values may not account for localized differences in soils, climate, etc. • Standardized values may not account for weather related factors in extremely wet or dry years

Table 10 – Strengths and Weaknesses of Water Bank Operational Scenarios

Categories	Operational Scenarios	Strengths	Weaknesses
Operation at Ditch System Level	Water Rights Ownership	• By Individual – Individuals make own decisions; direct transfer of on-farm savings to WB • By System – potential for single WB agreements with Board rather than individuals; can make system-wide changes to save CU; rotational fallowing program can be done within system	• By Individual – must have separate WB agreements with all individual owners • By System – may be more complex administration of saved CU from farm to WB
	Relationship Between Water and Land	• Water with Land – standard CU accounting by acreage • Water Separate from Land – can change water right beneficial use or point of diversion to WB subscriber	Water with Land – cannot change water right beneficial use or point of diversion
	Water Delivery Point	• To Farm – no intermediate institutions between location of saved CU and headgate • To Lateral – if lateral association, WB could have agreement with association rather than individual farms	To Lateral – System organization does not control use of water under the lateral; may need lateral association to approve WB operations
	Private or Federal Ownership	Federal – if get federal approval, could work with system Board, and Board could work with individual farmers; large systems provide rotational fallowing opportunities	Federal – need to negotiate operations with USBR; not all federal systems operate under same policies

Notes:
WB = Colorado River Water Bank
CU = consumptive use UCRC = Upper Colorado River Commission

Of the scenarios investigated, two are either impractical or fail to satisfy one of the main goals of a water bank.

- Permanent fallowing will not meet the overall objective of preserving the current level of agricultural activity and associated socioeconomic benefits in the basin.
- Direct measurement of reduced depletions at the field level is not practical due to the difficulty of measuring all surface water and groundwater return flows as well as any deep percolation, and to the lack of historical information for depletions measured in this manner when a full water supply is available.

Many of the other scenarios have significant challenges, but should be considered in more detail in subsequent phases of the Water Bank feasibility study.

Two other complex operational issues need to be addressed in the future as the feasibility process progresses.

- Grand Valley Project and Uncompahgre Project are USBR irrigation projects with their own governing principles. Reclamation will have to determine policies and guidelines for shareholders in these projects to participate in the Water Bank. Similarly, the Dr. Morrison Ditch (under the Pine River Indian Irrigation Project; PRIIP) is owned by the BIA, and has storage rights in a USBR reservoir. It is possible that federal action will be required to modify current operating principles to accommodate Water Bank activities. At this time neither USBR nor BIA have been approached regarding Water Bank feasibility issues.
- Any of the possible methods of crediting reduced depletions to the Water Bank will require water administration rules and regulations to assure that saved CU is ultimately available either at the state line for Compact purposes or at diversion points for entities withdrawing wet water from the Water Bank. This may require deliberation and rule-making by the Colorado Water Conservation Board and Colorado Division of Water Resources.

4.2 Consistency with Alternative Agricultural Water Transfer Methods Research

The Colorado Water Conservation Board is funding a review of alternative agricultural water transfer methods (ATM; CDM Smith, 2012). To date this review has developed findings that are related to the Water Bank operational feasibility. These are summarized in the following paragraphs.

Barriers to Implementation of ATMs

- Potentially high transaction costs associated with water rights transfers
- Water rights administration uncertainties and water rights accounting questions
- Certainty of long-term supply and desire for water providers to have permanence of long-term supply
- Infrastructure needs and water quality issues

The Water Bank could have many of the same issues related to water rights administration, transaction costs, and dependability for municipal water users.

Concerns of Municipal Water Providers to Participate in ATMs

- The need for a permanent supply
- Ownership of water rights
- Need for certainty and reliable yield
- The unwillingness to develop water supplies that may not be permanent at the end of the agreement period

These concerns could apply to the Water Bank, although it is clear that the Water Bank would be a temporary measure and not a source of ongoing base supply.

5.0 ADJUSTMENTS TO PHASE 1 WATER BANK SUPPLY ESTIMATES

One of the objectives of Phase 2 of the Water Bank Feasibility Study was to determine whether the Phase 1 estimates of potential supply to the bank could be refined based on a closer evaluation of a handful of specific irrigation systems. The following observations were made.

- UVWUA noted that it uses a value of 80,000 irrigated acres under the Uncompahgre Project for planning purposes. By comparison, Phase 1 of the Water Bank feasibility study only accounted for 68,921 acres of irrigated land in the study area located in the Gunnison River basin (Division 4). This is because the irrigated acreages associated with the South Canal and the West Canal were not included in the Phase 1 analysis. The two canals receive water from the Gunnison Tunnel and have no water rights associated with them directly. Thus the Phase 1 methodology based on linking irrigated parcels to diversion structures with water rights was not able to account for these irrigated acreages. The irrigated acreage associated with the two canals is about 10,280 acres, comprised of 1,042 acres of alfalfa, 8,007 acres of grass pasture, 1209 acres of row crops, and 22 acres of other crop types. Adding this acreage results in an increase of 22,366 ac-ft/yr of pre-Compact supply-limited CU and 4,074 ac-ft/yr of post-Compact supply-limited CU for the Uncompahgre region compared to data in the Phase 1 report.
- GVIC reported that its total irrigated acreage is about 33,000 acres, This is substantially higher than the value of 17,390 acres reported in CDSS for 2010, or 18,435 acres for 2005 used in the Phase 1 analysis. Attempts to resolve this discrepancy were not successful. If the value of 33,000 acres is correct, this would increase the Phase 1 estimate of pre-Compact supply-limited CU by about 23,000 ac-ft/yr based on the average pre-Compact supply-limited CU of 1.6 ac-ft/ac for the GVIC system.
- For the smaller test case systems, there were no consistent trends in owner-reported irrigated acreage or water rights compared to CDSS data. No adjustment to Phase 1 pre-Compact CU estimates are warranted based on this comparison.

If the above adjustments to UVWUA and GVIC pre-Compact CU are justified, the Phase 1 estimate of maximum potential pre-Compact water that could supply a Water Bank would increase by about 45,000 ac-ft, from about 973,000 ac-ft to 1,018,000 ac-ft (4.6 percent increase).

The Phase 1 analysis was based on irrigated acreage estimated in 2005. The Statewide Water Supply Investigation has estimated that irrigated acreage in Colorado will decrease in the future due to urban development, agricultural-to-municipal transfers, and other factors. **Table 11** summarizes data taken from the State's "Alternative Agricultural Water Transfer Methods Grant Program Summary and Status Update" Technical Memorandum (CDM Smith, 2012). It shows that West Slope irrigated acreage could decrease by 9 to 20 percent by 2050. This could be expected to reduce potential Water Bank supplies by a similar percentage.

The Phase 1 feasibility report estimated that under a variety of feasible assumptions for pre-Compact irrigated acreage, pre-Compact agricultural water rights, and level of participation from West Slope irrigators, the maximum annual use that could potentially be met from the Water Bank is in the range of 100,000 ac-ft. Based on updates to current irrigated acreage and the potential for future decreases in water tied to West Slope agriculture, the maximum annual use supportable by a Water Bank in the future could be 4 to 15 percent less, or roughly 90,000 ac-ft.

Table 11 – Forecast of Future Changes in West Slope Irrigated Acreage by 2050

Basin	Current Irrigated Acres	Estimated Irrigated Acres by 2050		Estimated Percent Reduction by 2050	
		Low	High	High	Low
Colorado	268,000	190,800	216,800	29	19
Gunnison	272,000	244,000	251,000	10	8
Southwest	259,000	246,000	252,000	5	3
Yampa-White	119,000	53,000	115,000	55	3
West Slope Total	**918,000**	**733,800**	**834,800**	**20**	**9**

6.0 SUMMARY, CONCLUSIONS AND NEXT STEPS

6.1 Summary and Conclusions

The Water Bank Group selected eight test case irrigation systems for investigation of the potential challenges and opportunities involved in participating in the Water Bank. Screening criteria were applied to a longer list of candidate irrigation systems to select eight systems that represented diversity in key characteristics including water division, type of ownership, type of crops, elevation, and mix of pre- and post-Compact water rights, and whose owners were willing to participate in the study.

Members of the Water Bank Group met onsite with landowners or irrigation system managers to describe the Water Bank development status and goals, and to gather information on a number of issues related to how voluntary fallowing or deficit irrigation on their fields could be accomplished for the purpose of contributing foregone CU to the Water Bank. Where possible, data in the State's Hydrobase were checked against practices and observations of the landowners and irrigation system managers. Information was gathered on types of irrigation methods, importance of subirrigation to crop production, location and reuse of return flows, water distribution systems and policies, crop yields, water quality issues, experience during 2002 and 2012 droughts, and experience with past fallowing or deficit irrigation. Landowners and managers provided opinions on how participation in a Water Bank might affect their operations, their preferences for the type and level of involvement, and some of the financial and non-monetary factors that would influence their decision to participate. All of the landowners and managers who were interviewed were very cooperative and provided insightful feedback for the Water Bank feasibility investigation.

The primary conclusions of the test case investigations are summarized as follows.

- In all systems there were some differences between the CDSS Hydrobase data and actual conditions for irrigated acreage, historical diversion patterns, and/or crop types. Differences may be due to changes from year to year, inaccuracies in the CRDSS database, or other factors. CDSS data is adequate for Water Bank planning, but further refinement of the acreage, crop types and CU may be needed more often than the current methodology of five year validations to support water rights administration and accounting for Water Bank operations.
- High elevation grass pasture systems generally are used entirely to support the landowner's own cattle herd. These systems only get 1-2 cuttings per year. Fallowing or deficit irrigating on these systems without significant impacts to landowners will be challenging.
- For individual ranchers, reduction in grass/alfalfa yield due to fallowing or deficit irrigation would affect the size and quality of their cattle herd. In general these ranchers are not supportive of using imported supplemental hay to compensate for reduced yield from their fields.
- Lower elevation systems that support multiple plantings per year (e.g., row crops and alfalfa) or that have 2 or more grass hay/alfalfa cuttings provide an opportunity for fallowing or deficit irrigation. These systems also generally treat crops as commodities for sale rather than for use in their own operations.
- It is unlikely that any irrigation systems will have measurement capabilities or historical data sufficient to accurately compute actual CU savings for Water Bank contributions based on the difference between diversions and return flows.

- On most high elevation ranches and in substantial portions of lower elevation systems, subirrigation is not a significant factor and will not affect estimates of saved CU through fallowing or deficit irrigation.
- For ranchers, and to a lesser extent other irrigators, the decision to participate in a Water Bank is not only about economics. They are also concerned about their way of life, family heritage, land conservation, and the local environment and economy.
- Interest by the agricultural community in participating in the Water Bank will vary from year to year based on hydrologic conditions (e.g., wet year vs dry year), general economic conditions, commodity prices, and other regional and personal factors.
- Extensive education of and cooperation with ditch company boards and managers will be required in USBR projects and private systems with multiple shareholders. No discussions have been held with USBR yet regarding policies and procedures for water banking within Federal irrigation projects.
- Shepherding of foregone CU is an important issue that has legal, administrative, and policy implications, and which has not been addressed at this time.

Conceptual level estimates were developed for on-farm economic impacts of fallowing irrigated acreage. Crop prices over the past five years used to estimate crop values have varied widely, and thus the potential farm income impacts cover a broad range. For high elevation ranches growing grass and alfalfa for cattle feed, the economic impact of fallowing could vary from about $125/acre to $675/acre for grass hay and alfalfa. For large systems in which crops are primarily grown as commodities to be sold at market, the economic impact of fallowing could vary from about $75/acre to $750/acre for corn and about $675/acre to $1,125/acre for grass hay and alfalfa. Irrigators will consider these impacts when assessing their need for compensation to contribute forgone CU to the Water Bank.

Several categories of potential issues for administering the Water Bank were identified. These included the frequency of activating Water Bank contracts, methods of reducing on-farm depletions, methods of crediting reduced depletions to the Water Bank, methods of accounting for reduced depletions, and operations at the ditch system level. Scenarios and options within each category were identified based on discussions by the Water Bank Group and interviews with the test case irrigation systems. At this stage in the Water Bank feasibility study, only a few options were determined to be infeasible or not meeting the goals of this water bank study, and will be dropped from further consideration. All others will need to be evaluated in subsequent phases of the feasibility study.

6.2 Next Steps

Based on the findings of Phase 1 and Phase 2 of the Water Bank feasibility study, it is recommended that the following activities be considered for subsequent phases of the study. These next steps would help to address uncertainties or unknowns in factors affecting the feasibility or operation of the Water Bank that must be better understood by those agencies and water users contemplating formation of, or participation in, a Water Bank for the Colorado River Basin in Colorado.

1. Conduct research, or support research to be done by others, into the feasibility and impacts of fallowing or deficit irrigation on high elevation pastures.
2. Estimate the potential impacts of fallowing or deficit irrigation on downstream streamflows and environmental resources due to changes in return flows.
3. Further explore water rights issues affecting Water Bank administration under Colorado water law.

4. Investigate the feasibility, advantages, and disadvantages of different methods of measuring or estimating reduced consumptive use at the irrigation system level for the purpose of Water Bank accounting.
5. Investigate water banking issues unique to Reclamation irrigation projects on the West Slope.
6. Formulate and analyze specific potential water banking scenarios for the large, complex irrigation systems (e.g., UVWUA, GVWUA, GVIC) that have a significant amount of associated CU.
7. Resolve differences in GVIC irrigated acreage between CDSS records and GVIC records.
8. Estimate the extent and location of irrigated lands currently encumbered by conservation easements that could affect the ability to participate in a water bank, A simple approach for this would be to overlay irrigation data from CDSS with easement boundaries from CoMAP,
9. Estimate the percentage of high elevation ranches involved in onsite cow/calf operations compared to those producing grass hay or alfalfa for sale or leased pasture.
10. Estimate the extent and importance of fertilizer use on grass pasture operations to determine whether it is an important component of on-farm economics for these types of operations.
11. Estimate the cost of re-establishing productive irrigated lands in different crop types and regions after fallowing or deficit irrigation.
12. Evaluate the regional economic impacts of Water Bank participation by one or more large irrigators in a river basin over multiple consecutive years.
13. Continue to reach out to the West Slope agricultural community to explain the Water Bank concept and obtain input from agricultural water users on their needs and concerns.

In addition to these next steps, the Colorado Water Conservation ATM studies have resulted in the following recommendations related to the Water Bank (CDM Smith, 2012).

- Advance the Colorado River Compact Water Banking Study and its focus on rotational fallowing by integration using the results from the Aspinall Water Bank study and Yampa ATM study.
- Continue the Yampa ATM study to determine the acceptability by ranchers of an ATM and the concurrent benefits to fish habitat. These identified lands and associated water can also be used for the Compact Water Banking project and should be integrated.
- Continue the study by Colorado State University and others on the suitability of pasture grass for rotational fallowing.

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APPENDIX A

Candidate System Identification and Evaluation TM

BUILDING A BETTER WORLD

TECHNICAL MEMORANDUM

TO:	Dan Birch	DATE:	December 5, 2012
FROM:	Chip Paulson	REFERENCE:	1011690

SUBJECT: ***Candidate Irrigation Systems Selection and Screening - DRAFT***

1.0 INTRODUCTION

The goal of Phase 2 of the Colorado River Water Bank Feasibility Study is to assess the feasibility of implementing the Water Bank for representative irrigation systems having pre-Compact water rights that could be used to supply water to the Water Bank. This includes the following activities:

- defining requirements and preferences for candidate irrigation systems
- screening candidate irrigation systems to select 8 irrigation systems as test cases
- conducting on-site of assessments potential fallowing and deficit irrigation operations for the test case systems to evaluate how water could be contributed to the Water Bank
- describing potential economic impacts at the irrigation system level for the test case systems.

The objective of this technical memorandum (TM) is to present information for candidate systems in the West Slope study area (Water Divisions 4-7) and document the process for selecting test case systems from the list of candidate systems. The TM presents the screening criteria that were adopted in cooperation with the Water Bank Technical Group to evaluate the selected candidate irrigation systems. Characteristics of the candidate irrigation systems in terms of location, return flow patterns, monthly and annual flows, water rights, associated consumptive use (CU), etc. are also presented. The data assembled for the candidate irrigation systems provides the basis for selecting the final test case systems and performing the field visits with owners/operators of those systems.

2.0 SCREENING CRITERIA

The screening criteria used to identify and prioritize candidate irrigation systems cover a wide range of characteristics in terms of system acreage, elevation, consumptive use, water supply, crop type, etc. Initially, MWH assembled preliminary information for the irrigated acreages in four Water Divisions in the Colorado River Basin for the following criteria: elevation, priority of water supply, crop type, water district, irrigation type, and location on river (main stem or tributary). The Water Bank Technical Group revised this list of criteria and added additional criteria. These combined criteria, along with the corresponding categories into which each system would be placed, are shown in Table 1. The screening criteria were used to select candidate systems representing a broad range of characteristics.

Table 1. Candidate Irrigation System Screening Criteria

Screening Criteria	Categories
System Acreage	Large Medium Small
Elevation	High Medium Low
Supply Limited Consumptive Use (CU)	Pre-Compact Post-Compact
Type of System Organization	District Incorporated ditch Individual Federal
Priority of Water Supply	All pre-Compact Combination of pre- and post-Compact
Amount of Water Supply	Mostly full supply Mostly partial supply

Screening Criteria	Categories
	Storage
Tract Size Within System	Nearly all large tracts (>35 acres) Combination of large and small tracts
Crop Type	Grass Alfalfa Row Crops
Method of Water Delivery	One ditch Combination of ditches
Location on River	Diverts from main river Diverts from a tributary
Location Relative to Other Water Rights	Few if any downstream rights Numerous downstream rights
Location by Basin	Gunnison Colorado Yampa/White San Juan/Dolores
Salinity Effects	Not affected Marginally affected

3.0 CANDIDATE SYSTEMS FOR TEST CASES

The Water Bank Technical Group and MWH conducted a workshop to review the criteria and select candidate irrigation systems. Candidate systems were identified based on the personal knowledge of the study areas by members of the Technical Group. The Technical Group selected 15 candidate systems as shown in Table 2. Of the 15 candidate systems, nine were given higher priority and were put in Group A while the remaining six given lower priority and were put in Group B. Candidate systems in Group A were given preference for test case studies; however, in case the owner of a candidate system in Group A does not wish to participate, a replacement candidate system from Group B will be selected. The placement in Group A or B was decided by the Technical Group based on the amount of diversity that these candidate systems encompass in terms of the screening criteria and their assumed willingness to participate in the Water Bank Feasibility Study.

The short-listed candidate systems are located throughout Water Divisions 4-7 and exhibit diversity in terms of the screening criteria shown in Table 1. The Uncompahgre Project irrigation system in the Gunnison River Basin (Division 4) has the largest area with system acreage of 68,900 irrigated acres, while the Ekhart Ditch in the Yampa River Basin (Division 6) is the smallest system with 193 irrigated acres. Of the 15 candidate systems, six are in the

Colorado River Basin, four are in the Gunnison River Basin, three are in in the Yampa River Basin, and two are in the San Juan/Dolores River Basin.

The goal of the candidate system evaluation process was to select eight irrigation systems that would be willing to participate in Phase 2 of the Colorado River Water Bank Feasibility Study. Nine systems were placed in Group A. The Technical Group selected eight after initial contacts were made with the irrigators.

Table 2. Candidate Systems for Test Cases

Category	Candidate System	Division	Source of Irrigation Water
A	Colorado Cooperative Ditch	4 - Gunnison River Basin	San Miguel River
A	Dr. Morrison Ditch	7 - San Juan River Basin	Pine River
A	East Mesa Ditch	5 - Colorado River Basin	Crystal River
A	Ekhart Ditch	6 - Yampa River Basin	Elk River
A	Grand Valley Canal	5 - Colorado River Basin	Colorado River
A	Grand Valley Project	5 - Colorado River Basin	Colorado River
A	Redtop Valley Ditch	5 - Colorado River Basin	Stillwater Creek
A	Trampe Ranch	4 - Gunnison River Basin	Gunnison River
A	Uncompahgre Region	4 - Gunnison River Basin	Uncompahgre River
B	Walker Ditch	6 - Yampa River Basin	Yampa River
B	King Ditch	7 - San Juan River Basin	Pine River
B	Divide Creek Highline	5 - Colorado River Basin	West Divide Creek
B	Paonia Area	5 - Gunnison River Basin	North Fork Gunnison and Minnesota Creek
B	Meeker Area	6 - Yampa River Basin	White River
B	Plateau Creek Area	5 - Colorado River Basin	Plateau Creek

4.0 PREPARATION OF DATA FOR EACH CANDIDATE SYSTEM

Preliminary data developed for the candidate system identification process was refined and further quantified for the Group A irrigation systems listed in Table 2. Below is a short description of the data and methods used for each criterion and for the additional hydrologic and mapping data assembled for the test case systems.

System acreage: This criterion quantifies the acreage planted in each major crop type category. Total irrigated acreage and distribution of irrigated acreages based on crop types has been observed to vary over time because of a number of factors including water availability and economic conditions. In order to address this condition the irrigated acreage GIS layers for the years 1993, 2005, and 2010 as obtained from the CDSS website were used to compute the irrigated acreages for the candidate systems. Results are shown in Table 3 through Table 6. It is important to address the differences in acreages based on different irrigated acreage GIS layers and crop types because estimation of consumptive use (CU) depends on the crop type and corresponding total irrigated acreage. The CU (volume) estimates based on the pre-Compact water rights could be used in Water Bank planning as a guideline to estimate the amount of water supply from pre-Compact rights that could be provided to post-Compact water users during a period of critical water need. The irrigated acreage GIS layer for the year 2005 is the most recent available coverage for all the candidate systems and therefore it was decided to use the 2005 coverage for this study.

Table 3. Irrigated Areas for the Candidate Systems in Gunnison River Basin (Division 4)

Pilot Study Area	1993 Irrigated Coverage	2005 Irrigated Coverage	2010 Irrigated Coverage
Colorado Cooperative Ditch	**4,232 Acres** Grass Pasture: 4,059 Acres (95.91%) Alfalfa: 35 Acres (0.83%) Row Crops: 117 Acres (2.76%) Orchards: 21 Acres (0.5%)	**5,288 Acres** Grass Pasture: 5,002 Acres (94.59%) Alfalfa: 160 Acres (3.03%) Row Crops: 126 Acres (2.38%)	Not Available Yet
Uncompahgre Project	**70,997 Acres** Grass Pasture: 24,155 Acres (34.02%) Alfalfa: 14,503 Acres (20.43%) Row Crops: 31,965 Acres (45.02%) Orchards: 374 Acres (0.53%)	**72,170 Acres** Grass Pasture: 35,591 Ac (49.32%) Alfalfa: 8,887 Acres (12.31%) Row Crops: 26,710 Acres (37.01%) Orchards: 565 Acres (0.78%) Bluegrass: 417 Acres (0.58%)	Not Available Yet
Trampe Ranch	**2012 Acres** Grass Pasture: 2,012 Acres (100%)	**1876 Acres** Grass Pasture: 1,876 Acres (100%)	Not Available Yet

Note: 2010 Irrigated acreage not available for Division 4, Gunnison River Basin.
Categorization of candidate systems in Group B based on crop types has not been performed and will be done depending on the need of Group B candidate systems in test case studies.

Table 4. Irrigated Areas for the Candidate Systems in Colorado River Basin (Division 5)

Pilot Study Area	1993 Irrigated Coverage	2005 Irrigated Coverage	2010 Irrigated Coverage
East Mesa Ditch	**550 Acres** Grass Pasture: 247 Acres (44.91%) Alfalfa: 237 Acres (43.09%) Row Crops: 66 Acres (12%)	**458 Acres** Grass Pasture: 458 Acres (100%)	**392 Acres** Grass Pasture: 392 Acres (100%)
Redtop Valley Ditch	**1,920 Acres** Grass Pasture: 1,920 Acres (100%)	**2,102 Acres** Grass Pasture: 2,102 Acres (100%)	**2,066 Acres** Grass Pasture: 2,066 Acres (100%)
Grand Valley Irrigation Company	**28,112 Acres** Grass Pasture: 13,714 Acres (48.78%) Alfalfa: 5,512 Acres (19.61%) Row Crops: 8,725 Acres (31.04%) Orchards: 161 Acres (0.57%)	**18,435 Acres** Grass Pasture: 5,248 Acres (28.47%) Alfalfa: 7,999 Acres (43.39%) Row Crops: 4,688 Acres (25.43%) Orchards: 51 Acres (0.28%) Bluegrass: 449 Acres (2.44%)	**17,390 Acres** Grass Pasture: 3,698 Acres (21.27%) Alfalfa: 8,958 Acres (51.51%) Row Crops: 4,172 Acres (23.99%) Orchards: 76 Acres (0.44%) Bluegrass: 486 Acres (2.79%)
Grand Valley Project	**30,970 Acres** Grass Pasture: 9,690 Acres (31.29%) Alfalfa: 8,205 Acres (26.49%) Row Crops: 12,229 Acres (39.49%) Orchards: 846 Acres (2.73%)	**24,561 Acres** Grass Pasture: 7,930 Acres (32.29%) Alfalfa: 9,525 Acres (38.78%) Row Crops: 6,274 Acres (25.54%) Orchards: 697 Acres (2.84%) Bluegrass: 135 Acres (0.55%)	**23,254 Acres** Grass Pasture: 3,064 Acres (13.18%) Alfalfa: 14,165 Acres (60.91%) Row Crops: 5,173 Acres (22.25%) Orchards: 720 Acres (3.1%) Bluegrass: 132 Acres (0.57%)

Note: Categorization of candidate systems in Group B based on crop types has not been performed and will be done depending on the need of Group B candidate systems in test case studies.

Table 5. Irrigated Areas for the Candidate System in Yampa River Basin (Division 6)

Pilot Study Area	1993 Irrigated Coverage	2005 Irrigated Coverage	2010 Irrigated Coverage
Ekhart Ditch	**160 Acres** Grass Pasture: 160 Acres (100%)	**193 Acres** Grass Pasture: 193 Acres (100%)	Not Available Yet

Note: 2010 Irrigated Acreage not available for Division 6, Yampa River Basin.
Categorization of candidate systems in Group B based on crop types has not been performed and will be done depending on the need of Group B candidate systems in test case studies.

Table 6. Irrigated Areas for the Candidate System in San Juan/Dolores River Basin (Division 7)

Pilot Study Area	1993 Irrigated Coverage	2005 Irrigated Coverage	2010 Irrigated Coverage
Dr. Morrison Ditch	**2,869 Acres** Grass Pasture: 2,856 Acres (99.55%) Alfalfa: 13 Acres (0.45%)	**2,133 Acres** Grass Pasture: 2,062 Acres (96.67%) Alfalfa: 71 Acres (3.33%)	Not Available Yet

Note: 2010 Irrigated Acreage not available for Division 7, San Juan River Basin.
Categorization of candidate systems in Group B based on crop types has not been performed and will be done depending on the need of Group B candidate systems in test case studies.

Elevation: Average elevations for candidate systems were computed based on 30 meter digital elevation model (DEM) data obtained from the Geospatial Data Gateway (GDG) website. Elevation is important because it affects the crop CU requirements.

Supply Limited Consumptive Use: Pre- and post-Compact supply limited CU for the candidate systems was computed using the State of Colorado's Stream Simulation Model (StateMod) obtained from the CDSS website. Distribution of supply limited CU between pre- and post-Compact water rights for a candidate system was based on distribution of water supply to diversion structures associated with the candidate system in terms of pre- and post- Compact decreed water rights. StateMod input datasets for Water Divisions 4-7 were obtained from the CDSS website. Distribution of irrigated acreages in terms of crop types in input datasets was hard-coded in StateMod and was based on 1993 irrigated acreage GIS coverage. The same datasets were used by Leonard Rice for historic crop consumptive use analyses used in the Water Bank Phase 1 CU analyses.

Distribution of pre- and post-Compact supply limited CU in terms of crop types in a candidate system was based on a weighted approach as shown in Equation 1 –Equation 3. This approach accounts for irrigated area of a crop type in a candidate system along with the consumptive irrigation requirement (CIR) of a crop obtained from the Phase 1 Water Supply Technical Memorandum (NRCE, 2011).

$$Warea_i = \frac{Area_i}{\sum_{i=1}^{n} Area_i} \qquad (1)$$

where, $Warea_i$ is the weighted area factor for a crop type i computed based on irrigated area of that crop in a candidate system denoted by $Area_i$ divided by the summation of irrigated acreages of all the crop types in a candidate system as shown in denominator of Equation 1.

$$WCIR_i = \frac{CIR_i}{\sum_{i=1}^{n} CIR_i} \qquad (2)$$

where, $WCIR_i$ is the weighted CIR factor for a crop type i in a candidate system computed based on CIR of that crop in a candidate system denoted by CIR_i divided by summation of CIR's of all the crops in a candidate system as shown in the denominator of Equation 2.

Separate weighted factors ($WareaCIR_i$) for each crop type in a candidate system were computed based on weighted area factor and weighted CIR factor as shown in Equation 3. Pre- and post-Compact supply limited CU for a candidate system were multiplied by the weighted factors ($WareaCIR_i$) in order to distribute supply limited CU's based on crop types in a candidate system as shown in Equation 4 and Equation 5.

$$WareaCIR_i = \frac{WArea_i * WCIR_i}{\sum_{i=1}^{n}(WArea_i * WCIR_i)} \quad (3)$$

$$SLCUpre_i = SLCUpre * WareaCIR_i \quad (4)$$

$$SLCUpost_i = SLCUpost * WareaCIR_i \quad (5)$$

where $SLCUpre_i$, $SLCUpost_i$ are the pre- and post-Compact supply limited CU for a crop type i in a candidate system, and $SLCUpre$, $SLCUpost$ are the total pre-Compact and the total post-Compact supply limited CU's for a candidate system. All the variables in the above equations were computed based on the 1993 irrigated acreage distribution incorporated in the current StateMod model.

Pre- and post-Compact supply limited CU for crop types in a candidate system were also estimated for irrigated acreage distributions based on 2005 irrigated acreage GIS coverage (Water Divisions 4-7) and 2010 irrigated acreage GIS coverage (Water Division 5 only). Ratios of irrigated acreages based on 2005 and 2010 irrigated acreage distribution and 1993 irrigated acreage distribution were computed and multiplied by pre- and post-Compact supply limited CU based on the 1993 irrigated acreage distribution to estimate supply limited CU for crop types in a candidate system in 2005 and 2010. Methods of analysis are shown in Equations 6 and 7.

$$SLCUpre_{2005/2010i} = \frac{Area_{2005/2010i}}{Area_i} * SLCUpre_i \quad (6)$$

$$SLCUpost_{2005/2010i} = \frac{Area_{2005/2010i}}{Area_i} * SLCUpost_i \quad (7)$$

where $SLCUpre_{2005/2010i}$, $SLCUpost_{2005/2010i}$ are the pre- and the post-Compact supply limited CU for a crop type i in a candidate system based on 2005 or 2010 irrigated acreage distribution, and $Area_{2005/2010i}$ is irrigated acreage for a crop type i in a candidate system based on 2005 or 2010 irrigated acreage distribution.

Type of system organization: Information on the type of system organization or governance (e.g., irrigation district, individual system) was obtained during the Water Bank group meetings from people familiar with the subject systems. The type of system organization would affect how decisions are made for fallowing or deficit irrigation to supply water to a Water Bank, how those practices are implemented, and how accounting for water contributed to a Water Bank would be performed.

Priority of water supply: Priority of water supply for each of the candidate systems in terms of pre- and post-Compact water rights was decided based on the available information in the CDSS Hydrobase. For purposes of the candidate system evaluation, all the water rights decreed on or before June 25, 1929 were considered as pre- Compact while the water rights decreed after June 25, 1929 were considered as post- Compact water rights.

Amount of water supply: Information on the amount of water supply typically available to the system relative to the full irrigation requirement was obtained during the Water Bank group meetings from people familiar with the systems.

Tract size within system: Information on the typical size of irrigated tracts within the overall irrigation system was obtained based on 2005 irrigated area GIS data. Systems with many small tracts versus those with a few large tracts could have different management and accounting requirements if participating in a Water Bank.

Crop type: The primary crop type in each candidate system was determined based on 2005 irrigated area GIS data. Crop type influences the potential CU savings available to a Water Bank from fallowing or deficit irrigation, and the potential for success of deficit irrigation practices.

Method of water delivery: Information on the method of water delivery (one ditch or multiple ditches from the headgate(s) to the fields) was obtained from 2005 irrigated area GIS data and the CDSS Hydrobase. Monitoring of CU savings and assessment of impacts on downstream water users for systems with one headgate and ditch would be simpler than for systems with multiple headgates and ditches.

Location on river: Whether an irrigation ditch receives water from a main stem or a tributary was determined based on 2005 irrigated area GIS data and the source of water as documented in the CDSS Hydrobase. Systems diverting from a main stem river may have fewer water administration issues relative to a Water Bank compared to systems diverting from more remote tributaries.

Location relative to other water rights: Location of a candidate system compared to other downstream irrigated areas in the basin was determined based on 2005 irrigated area GIS data. Systems with many downstream water users have a greater risk of having water saved through fallowing or deficit irrigation diverted by downstream users and therefore not contributing to Colorado River streamflow at Lee Ferry.

Location by basin: The basin and water division in which the candidate system is located was determined from 2005 irrigated area GIS data and water division boundaries.

Areas affected by salinity: Soil and groundwater salinity were used as a surrogate for estimating whether a candidate irrigation system could have potential productivity issues during drought periods that would make it a better candidate for temporarily taking lands out of production. Whether a candidate system has potential salinity related issues was determined based on a GIS coverage that has salt loading rates (tons/acre) in return flows from irrigated areas. The GIS coverage was developed by the U.S. Geological Survey (USGS) Utah Water Science Center for the Upper Colorado River Basin USGS SPARROW model.

Historical diversions: Data on historical diversions to the test case irrigation systems was provided to MWH by the Colorado Division of Water Resources (CDWR). Water rights and historical diversion records were based on information retrieved from Hydrobase.

Return flow locations and patterns: Implementation of fallowing or deficit irrigation practices could affect return flows that are a source of inflow to downstream river segments and water supply to downstream water users. Locations of return flows from test case irrigation systems were based on the link-node system definition in the StateMod model. Monthly return flow patterns were also adopted from the data in the StateMod model.

5.0 RESULTS

Screening criteria data for the test case irrigation systems are presented in Tables 7A and 7B. Summary sheets are also provided for each test case irrigation system listed in Group A. The summary sheets include information based on the methods described in the previous section for water rights, historical diversions, location and pattern of return flows, and maps showing the location of test case systems in a water division along with associated crop types, head gates and salinity affected areas.

After the initial identification of candidate systems and potential test case systems, two changes were made to the list of test case systems.

- Redtop Valley Ditch was dropped as a potential test case system because of its involvement in the 10825 Project. Acreage in the Redtop Valley Ditch system would be retired to provide supplemental flows to the 15-Mile Reach of the Colorado River as part of the Upper Colorado River Endangered Fish Recovery Program. Participants in the 10825 Project did not want potential Water Bank involvement to compromise use of the ditch system to provide environmental flows.

- East Mesa Ditch was replaced by Cold Mountain Ranch, which is a similar ranch with irrigated grass pasture and is located in the same Crystal River basin.

Incorporating these changes, the final test case systems to be visited are:

Small High Mountain Ranches
- Ekhart Ditch
- Trampe Ranch
- Cold Mountain Ranch

Private Ditch Companies
- Colorado Cooperative Ditch
- Grand Valley Irrigation Company

Reclamation Projects
- Uncompahgre Project
- Grand Valley Project

6.0 REFERENCES

Leonard Rice Engineers, Inc. (2009a). Historic Crop Consumptive Use Analysis - Colorado River Basin, Final Report.

Leonard Rice Engineers, Inc. (2009b). Historic Crop Consumptive Use Analysis - San Juan/Dolores River Basin; Final Report.

Leonard Rice Engineers, Inc. (2009c). Historic Crop Consumptive Use Analysis - Yampa River Basin; Final Report.

Leonard Rice Engineers, Inc. (2009d). Historic Crop Consumptive Use Analysis - Gunnison River Basin; Final Report.

NRCE, Inc. (2011). Water Supply Technical Memorandum, Colorado River Compact, Colorado Water Bank Feasibility Study.

TABLE 7A - TEST CASES SELECTION CRITIERA

CRITERIA	GROUP A							
	Uncompahgre	Grand Valley Water Users Association	Grand Valley Irrigation Company	Trampe Ranch	Cold Mountain Ranch	Dr. Morrison	Ekhart Ditch	Colorado Cooperative Ditch
System Acreage, 2005 (acres)								
Large	68921	24562	18435					
Medium								5288
Small				1969	543	2133	193	
Elevation (ft)								
High				7905			7211	
Medium	5551				6391	6698		
Low		4681	4573					5735
Supply Limited CU (ac-ft), 1993 Acreage								
Pre-Compact	157804 (Alfalfa: 40156, Grass Pasture: 63395, Row Crops: 53334, and Others: 919)	75142 (Alfalfa: 24974, Grass Pasture: 25347, Row Crops: 22560, and Others: 2261)	42348 (Alfalfa: 10270, Grass Pasture: 21961, Row Crops: 9853, and Others: 263)	4356 (Grass Pasture: 4356)	828 (Alfalfa: 532, and Grass Pasture: 296)	6919 (Alfalfa: 29, and Grass Pasture: 6890)	286 (Grass Pasture: 286)	6839 (Alfalfa: 60, Grass Pasture: 6625, Row Crops: 121, and Others: 32)
Post-Compact	1275 (Alfalfa: 324, Grass Pasture: 512, Row Crops: 431, and Others: 7)		8612 (Alfalfa: 2089, Grass Pasture: 4466, Row Crops: 2004, and Others: 54)	290 (Grass Pasture: 290)	356 (Alfalfa: 229, and Grass Pasture: 127)	99 (Grass Pasture: 99)	31 (Grass Pasture: 31)	917 (Alfalfa: 8, Grass Pasture: 888, Row Crops: 16, and Others: 4)
Supply Limited CU (ac-ft), 2005 Acreage								
Pre-Compact	164995 (Alfalfa: 24606, Grass Pasture: 93409, Row Crops: 44566, and Others: 2413)	63533 (Alfalfa: 28991, Grass Pasture: 20743, Row Crops: 11574, and Others: 2223)	29421 (Alfalfa: 14904, Grass Pasture: 8404, Row Crops: 5294, and Others: 818)	4062 (Grass Pasture: 4062)	582 (Alfalfa: 89, and Grass Pasture: 494)	5133 (Alfalfa: 158, and Grass Pasture: 4975)	345 (Grass Pasture: 345)	8571 (Alfalfa: 276, Grass Pasture: 8164, and Row Crops: 131)
Post-Compact	1333 (Alfalfa: 199, Grass Pasture: 755, Row Crops: 360, and Others: 19)		5983 (Alfalfa: 3031, Grass Pasture: 1709, Row Crops: 1077, and Others: 166)	270 (Grass Pasture: 270)	250 (Alfalfa: 38, and Grass Pasture: 212)	73 (Grass Pasture: 71, and Alfalfa: 2)	37 (Grass Pasture: 37)	1149 (Alfalfa: 37, Grass Pasture: 1095, and Row Crops: 18)
Supply Limited CU (ac-ft), 2010 Acreage								
Pre-Compact	Acreage Data Not Available	62949 (Alfalfa: 43114, Grass Pasture: 8015, Row Crops: 9543, and Others: 2277)	28244 (Alfalfa: 16691, Grass Pasture: 5922, Row Crops: 4712, and Others: 919)	Acreage Data Not Available	467 (Alfalfa: 144, and Grass Pasture: 323)	Acreage Data Not Available	Acreage Data Not Available	Acreage Data Not Available
Post-Compact			5744 (Alfalfa: 3394, Grass Pasture: 1204, Row Crops: 958, and Others: 187)		201 (Alfalfa: 62, and Grass Pasture: 139)			
Type of System Organization								
District						X		
Incorporated Ditch	X		X		X			X
Individual(s)				X			X	
Federal		X						
Priority of Water Supply								
All Pre-Compact		X				X		
Combination of Pre- and Post-Compact	X		X	X	X		X	X
Amount of Water Supply								
Mostly full supply	X	X	X		X	X		
Mostly partial supply				X			X	X
Storage	X	X				X		
Tract Size Within System								
Nearly all large tracts (>35 acres)							X	
Combination of large and small tracts	X	X	X	X	X	X		X
Crop Type, 2005 Acreage								
Mostly grass	33310	7930	5248	1969	432	2062	193	5002
Mostly alfalfa	8482	9525	7999		77	71		160
Row Crops	26169	6274	4688					126
Others	960	833	500		34			
Method of Water Delivery								
One ditch		Grand Valley Project	Grand Valley Canal			Dr. Morrison Ditch	Ekhart Ditch	Highline Canal
Combination of ditches	X			X	X			
Location on River								
Diverts from main river	X	X	X				X	X
Diverts from a tributary				X	X	X		
Location Relative to Other Water Rights								
Few if any downstream rights	X		X					X
Numerous downstream rights		X		X	X	X	X	
Location by Basin								
Yampa/White							X	
Gunnison	X			X				X
San Juan/Dolores						X		
Colorado		X	X		X			
Area Affected by Salinity								
No Problem (< 1 tons/acre)				X		X	X	
Marginal (>1 tons/acre)	X	X	X		X			X

A: Higher priority
B: Lower priority
2010 irrigated acreage distribution was only available for Division 5 - Colorado River Basin
Row Crops include: Corn grains, small grains, Dry beans, and vegetables
CU = Consumptive Use

TABLE 7B - TEST CASES SELECTION CRITIERA

CRITERIA	GROUP B					
	Walker Ditch	King Ditch	Divide Creek Highline	Paonia Area TBD	Meeker Area TBD	Plateau Creek TBD
System Acreage, 2005 (acres)						
Large					14585 (Area irrigated by White River around Meeker)	
Medium		4669	5422			3146
Small	1313			305 (Paonia Ditch)	253 (Meeker Ditch)	
				4409 (Paonia+Stewart+Minnesota Canal)		
Elevation (ft)						
High						
Medium	6357	6768	6334		6252, 6297	6592
Low				5550, 5714		
Supply Limited CU (ac-ft), 1993 Acreage						
Pre-Compact	-	-	-	-	-	-
Post-Compact	-	-	-	-	-	-
Supply Limited CU (ac-ft), 2005 Acreage						
Pre-Compact	-	-	-	-	-	-
Post-Compact	-	-	-	-	-	-
Supply Limited CU (ac-ft), 2010 Acreage						
Pre-Compact	-	-	-	-	-	-
Post-Compact	-	-	-	-	-	-
Type of System Organization						
District						
Incorporated Ditch		X	X			
Individual(s)	X					
Federal						
Priority of Water Supply						
All Pre-Compact				X		
Combination of Pre- and Post-Compact	X	X	X		X	X
Amount of Water Supply						
Mostly full supply	X	X				
Mostly partial supply			X		X	
Storage		X				
Tract Size Within System						
Nearly all large tracts (>35 acres)	X					
Combination of large and small tracts		X	X			
Crop Type, 2005 Acreage						
Mostly grass	1313	4654	5038	132, 3468	216, 14201	2482
Mostly alfalfa			384	54	13, 273	664
Row Crops				25, 691		
Others						
Method of Water Delivery						
One ditch	Walker Ditch	King Ditch	Divide Creek Highline	Paonia Ditch	Meeker Ditch	
Combination of ditches	X	X		Paonia, Stewart, and Minnesota Canal	X	X
Location on River						
Diverts from main river	X					
Diverts from a tributary		X	X	X		
Location Relative to Other Water Rights						
Few if any downstream rights						
Numerous downstream rights	X	X	X			
Location by Basin						
Yampa/White	X				X	
Gunnison						
San Juan/Dolores		X				
Colorado			X	X		X
Area Affected by Salinity						
No Problem (< 1 tons/acre)						
Marginal (>1 tons/acre)						

A: Higher priority
B: Lower priority
2010 irrigated acreage distribution was only available for Division 5 - Colorado River Basin
Row Crops include: Corn grains, small grains, Dry beans, and vegetables
CU = Consumptive Use
Supply limited CU for candidate systems in Group B will be computed depending on their selection in the study

2012

MWH Global

[PILOT STUDY: CANDIDATE SYSTEM SELECTION]

Division 4 (Gunnison River Basin): Uncompahgre Region

Structure Name: EAST CANAL
Source: Uncompahgre River

Q10 Q40 Q160 Section Twnshp Range PM
NE NE NW 22 50N 10W N

Water District: 41 Structure ID Number: 520

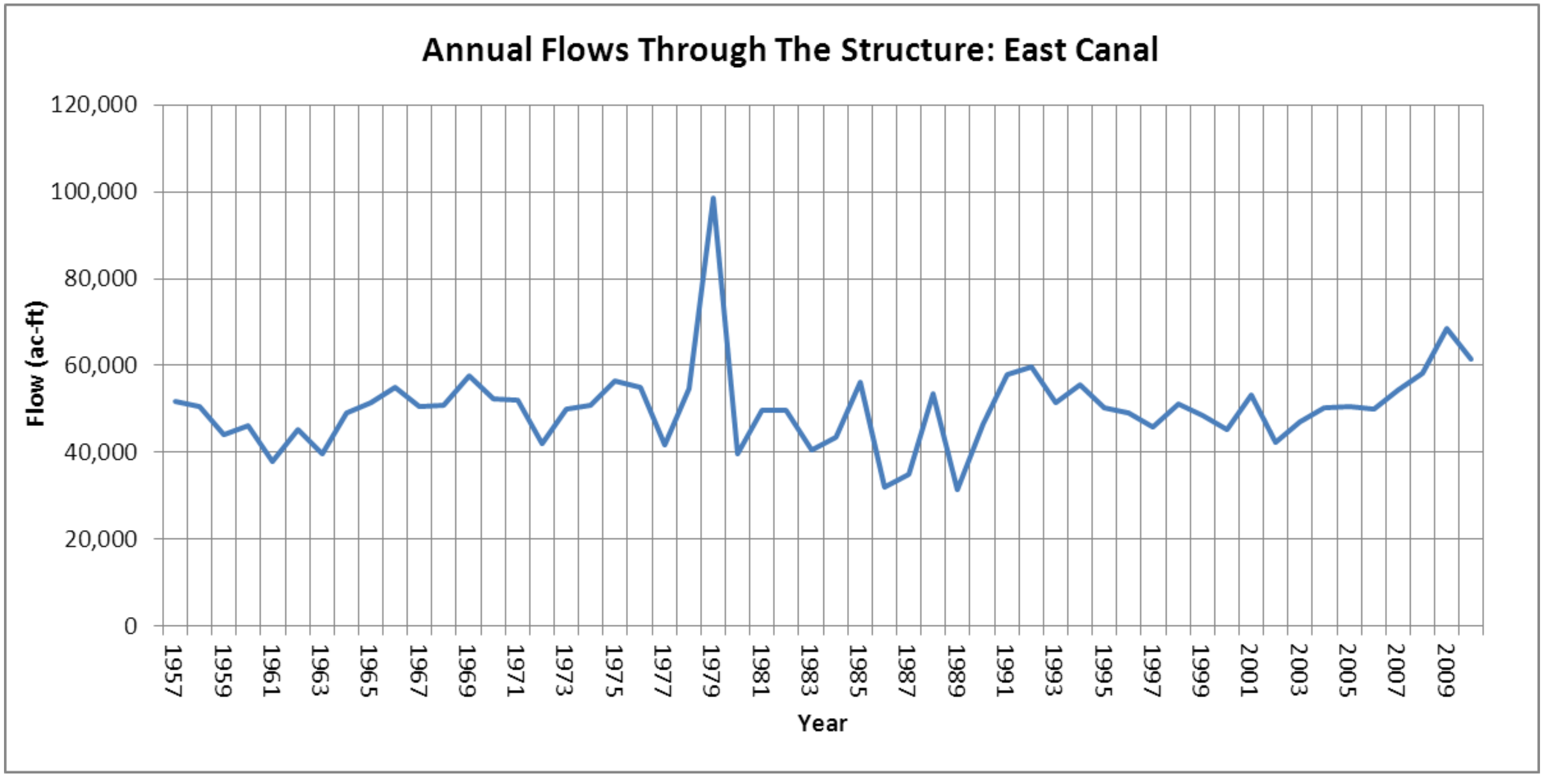
UTM Coordinates (NAD 83): Northing (UTM y): 4275549 Easting (UTM x): 240590
Spotted from PLSS distances from section lines

Water Rights Summary			
Parameter	Absolute	conditional	AP/EX
Total Decreed Rate(s) (CFS)	60.44	0.00	0.00
Total Decreed Volume(s) (AF)	0.00	0.00	0.00

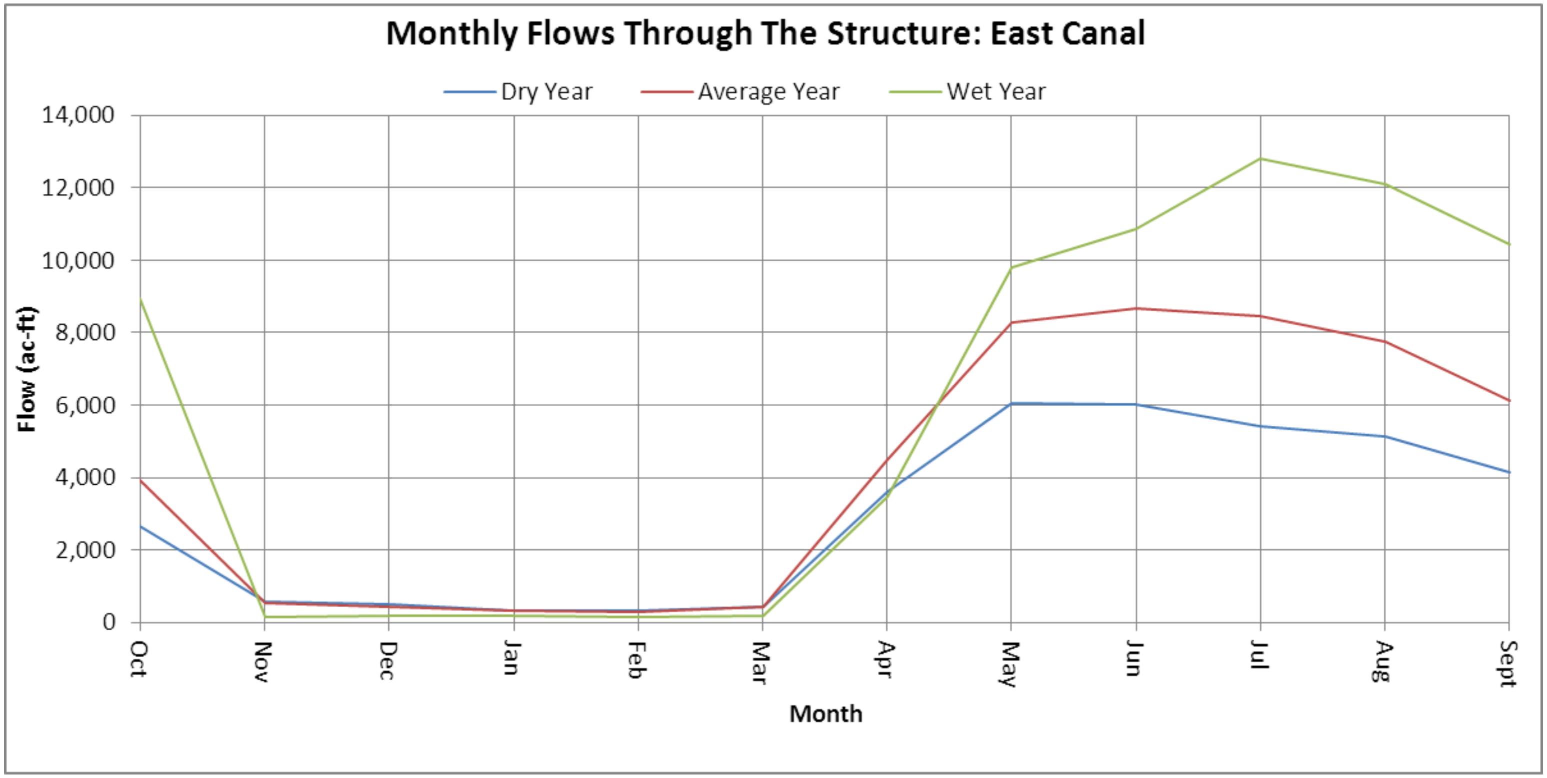
	Pre Compact
	Post compact

Water Rights - Transactions											
Case Number	Adj-Date	App-Date	Admin. No.	Order No.	Priority No.	Decreed Amt	Adj Type	Status Type	Transfer Type	Use	Action Comment
CA6915	6/30/1890	5/1/1882	11809.00	0.00	16	5.50	O	A	TT	IRR	TF SWANSON D 3/31/1953 P351
CA6915	6/30/1890	5/10/1882	11818.00	0.00	18	3.12	O	A	TT	IRR	TF EAST SIDE D 3/31/1953 P351
CA6915	6/30/1890	8/25/1883	12290.00	0.00	36	25.00	O	A	TT	IRR	TF HOME RUN D 3/31/1953 P351
CA6915	6/30/1890	11/14/1888	14198.00	0.00	94	4.94	O	A	TT	IRR	TF SWANSON D 3/31/1953 P351
CA6915	6/30/1890	11/14/1888	14198.00	0.00	105	21.88	O	A	TT	IRR	TF HOME RUN D 3/31/1953 P351

Water Rights - Net Amounts										
				Priority/Case	Rate (CFS)			Volume (Ac-Ft)		
Adj-Date	App-Date	Admin. No.	Order No.	Number	Absolute	Conditional	AP/EX	Absolute	Conditional	AP/EX
6/30/1890	5/1/1882	11809.00	0.00	16	5.50	0.00	0.00	0.00	0.00	0.00
4/29/1941	11/10/1902	30667.19	0.00	392.00	35.00	0.00	0.00	0.00	0.00	0.00
4/29/1941	7/1/1907	30667.21	0.00	411.00	37.66	0.00	0.00	0.00	0.00	0.00



Annual Flows Through The Structure: East Canal
120,000
100,000
80,000
60,000
40,000
20,000
0
Flow (ac-ft)
1957
1959
1961
1963
1965
1967
1969
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
Year



Note: Based on the available monthly flow dataset for the structure annual values were computed and the top and bottom 10% values in terms of magnitude were used to select the wet and the dry years while the rest of years were considered as representatives of average years. Monthly averages were computed based on those years and were used to generate the above plot.

Structure Name: GARNET DITCH
Source: Uncompahgre River

Q10 Q40 Q160 Section Twnshp Range PM
SE SE SE 20 51N 10W N

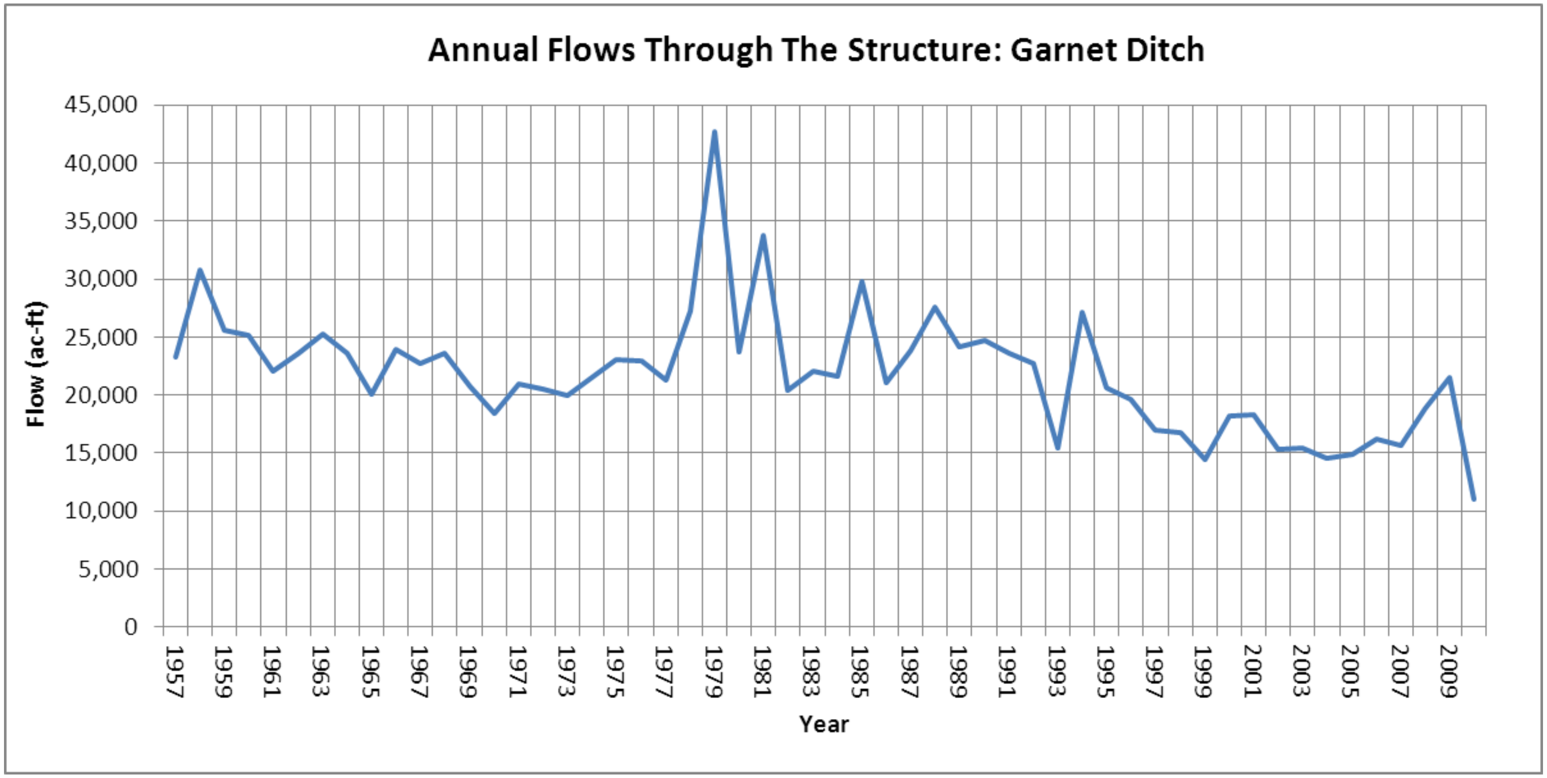
Water District: 41 Structure ID Number: 527

UTM Coordinates (NAD 83): Northing (UTM y): 4283799 Easting (UTM x): 238558
Spotted from PLSS distances from section lines

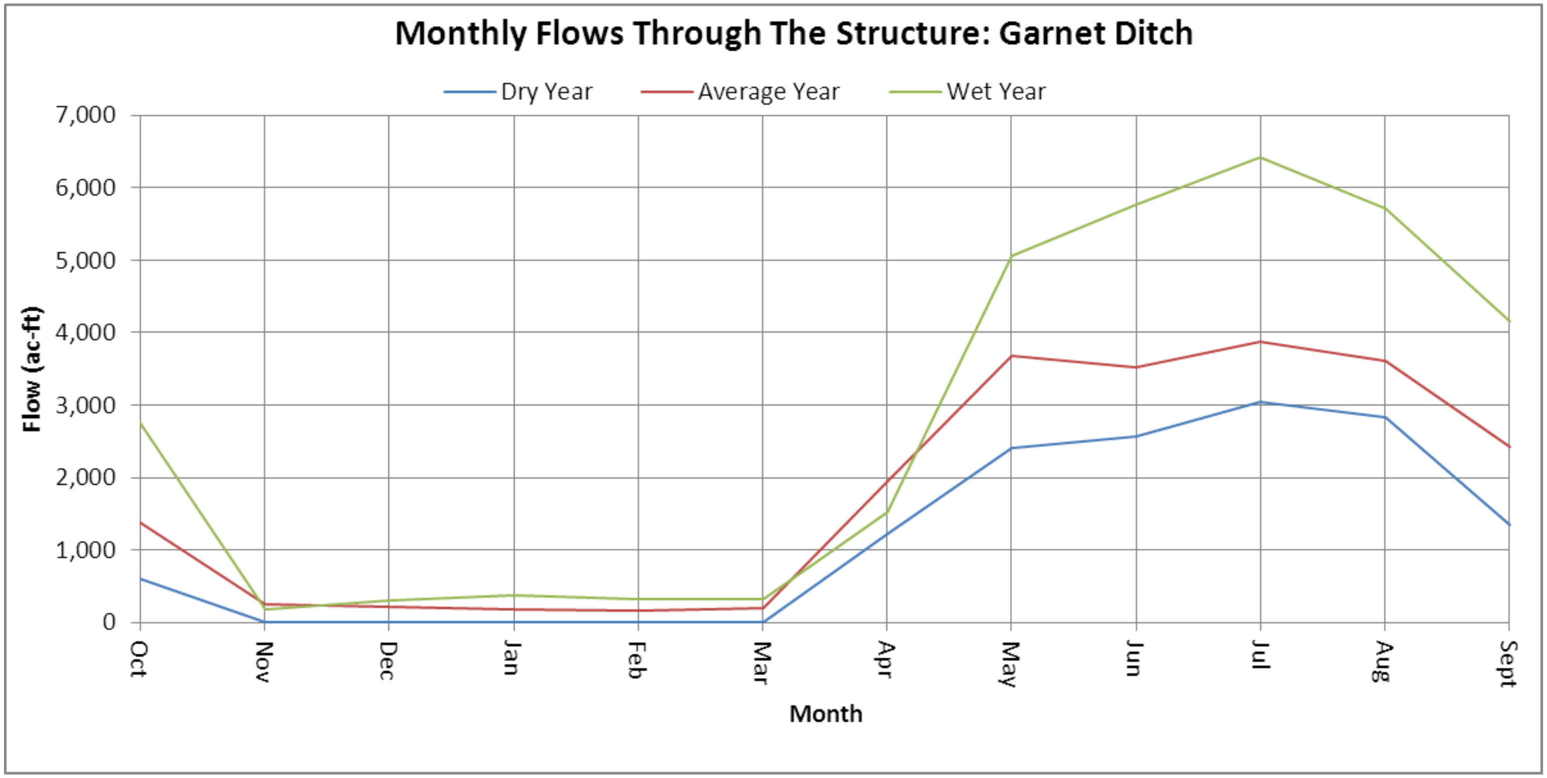
Water Rights Summary			
Parameter	Absolute	conditional	AP/EX
Total Decreed Rate(s) (CFS)	93.33	0.00	0.00
Total Decreed Volume(s) (AF)	0.00	0.00	0.00

Water Rights - Transactions											
Case Number	Adj-Date	App-Date	Admin. No.	Order No.	Priority No.	Decreed Amt	Adj Type	Status Type	Transfer Type	Use	Action Comment
CA0149	6/30/1890	6/18/1883	12222.00	0.00	35	45.00	O	A		IRR	CA 11/14/1888 P16
CA0149	6/30/1890	11/14/1888	14198.00	0.00	104	48.33	O	A		IRR	CA 11/14/1888 P16

Water Rights - Net Amounts										
				Priority/Case	Rate (CFS)			Volume (Ac-Ft)		
Adj-Date	App-Date	Admin. No.	Order No.	Number	Absolute	Conditional	AP/EX	Absolute	Conditional	AP/EX
6/30/1890	6/18/1883	12222.00	0.00	35	45.00	0.00	0.00	0.00	0.00	0.00
6/30/1890	11/14/1888	14198.00	0.00	104	48.33	0.00	0.00	0.00	0.00	0.00



Annual Flows Through The Structure: Garnet Ditch
Flow (ac-ft)
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
1957
1959
1961
1963
1965
1967
1969
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
Year


Monthly Flows Through The Structure: Garnet Ditch
Dry Year
Average Year
Wet Year
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Flow (ac-ft)
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sept
Month

Structure Name: GUNNISON TUNNEL&S CANAL
Source: Gunnison River

Q10 Q40 Q160 Section Twnshp Range PM
NE NE SW 10 49N 7W N

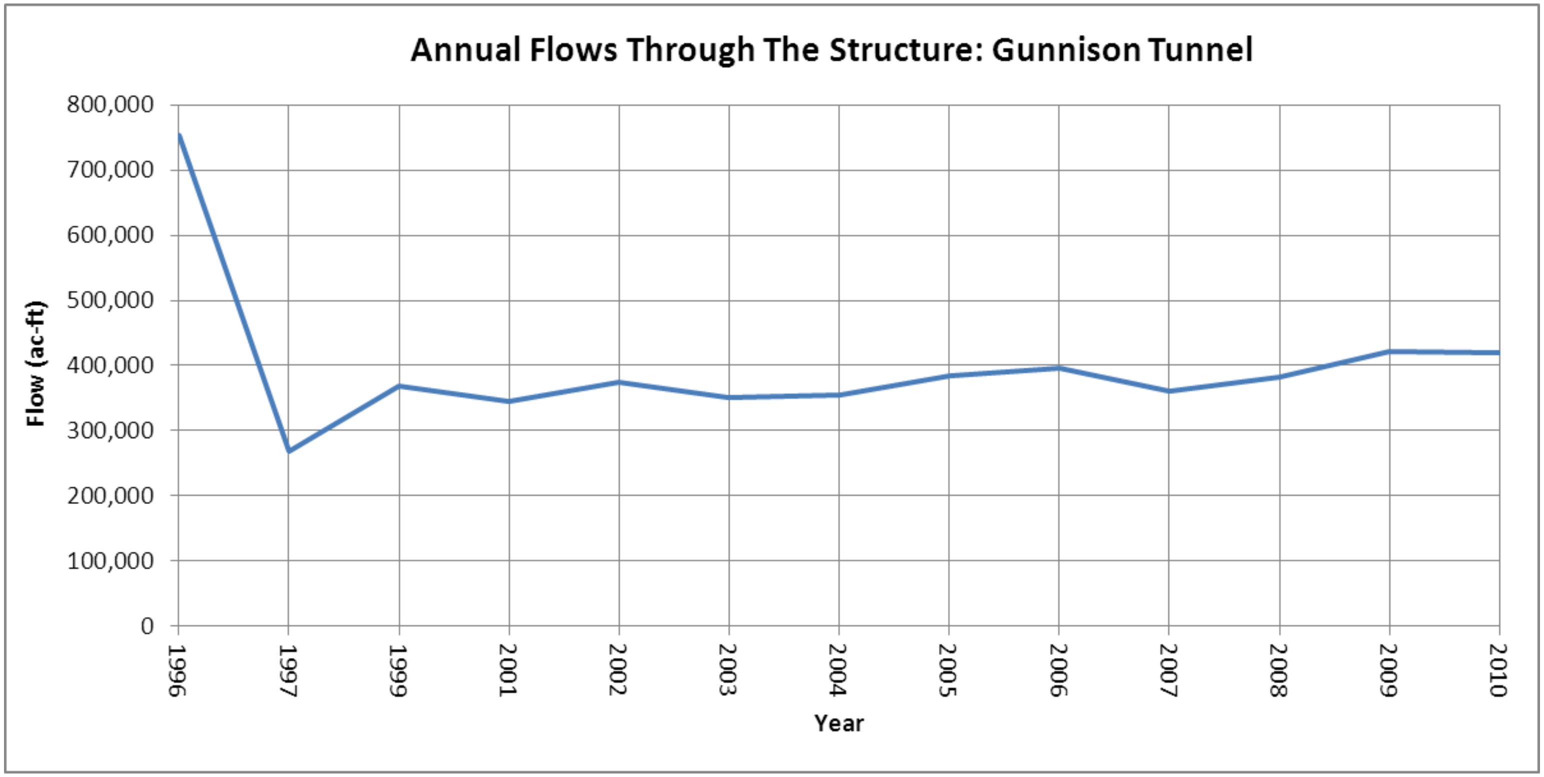
Water District: 62 Structure ID Number: 617

UTM Coordinates (NAD 83): Northing (UTM y): 4267302 Easting (UTM x): 268993
Spotted from PLSS distances from section lines

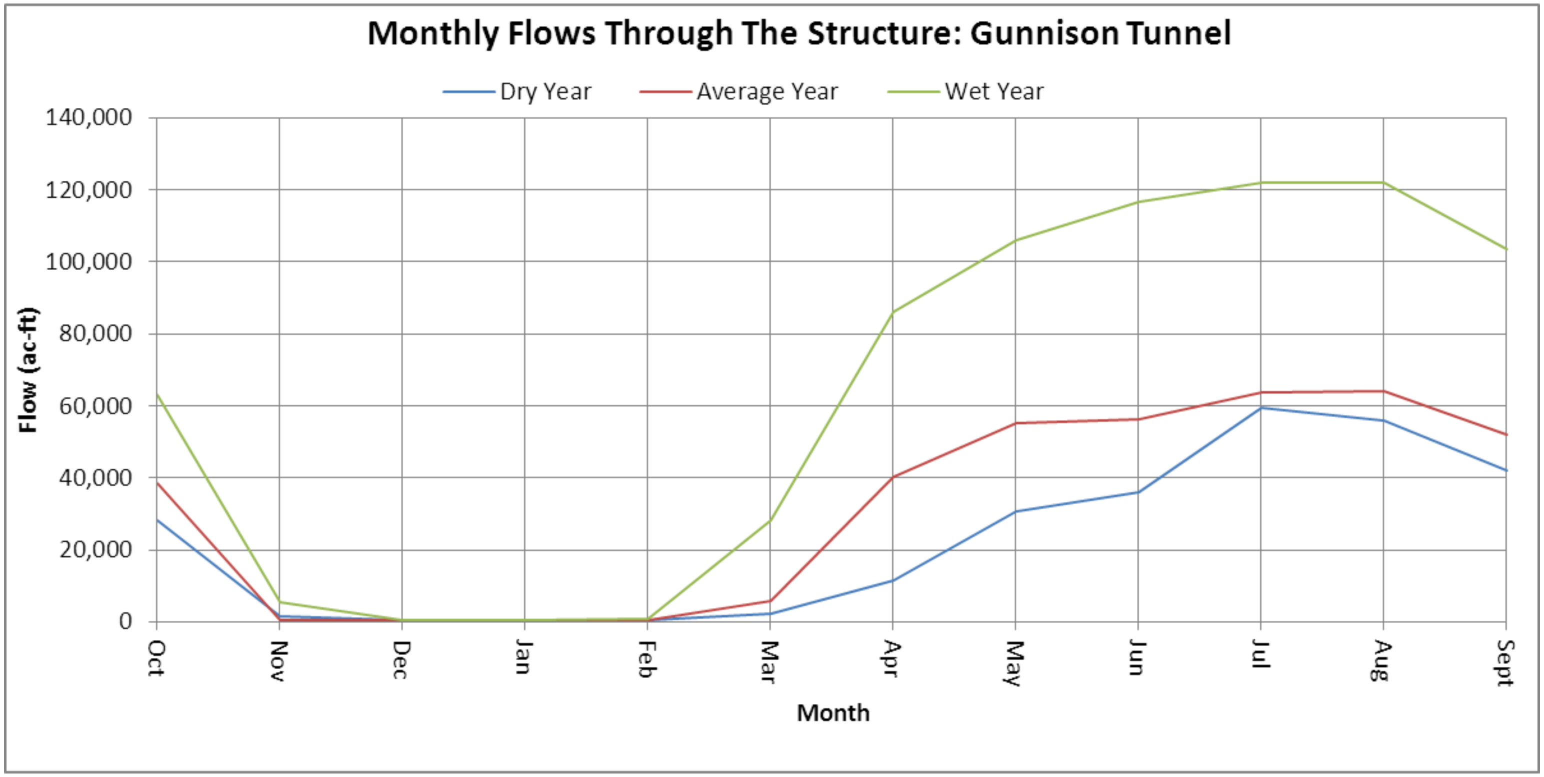
Water Rights Summary			
Parameter	Absolute	conditional	AP/EX
Total Decreed Rate(s) (CFS)	1175.00	1260.00	50.00
Total Decreed Volume(s) (AF)	0.00	0.00	0.00

Water Rights - Transactions											
Case Number	Adj-Date	App-Date	Admin. No.	Order No.	Priority No.	Decreed Amt	Adj Type	Status Type	Transfer Type	Use	Action Comment
87CW0231	5/8/1913	6/1/1901	20393.19	0.00	111 1/4	13.00	S	CA		IRRMUNST	13 CFS OF 239 CFS COND. MADE ABSOLUTE
84CW0142	5/8/1913	6/1/1901	20393.19	0.00	111 1/4	239.00	S	C	TT	IRRMUNST	STIP OF 1984 ABANDONMENT 239CFS OF ORIG 1300CFS BECOMES COND
86CW0001	5/8/1913	6/1/1901	20393.19	0.00	111 1/4	61.00	S	CA		IRRMUNST	61 CFS OF 239 CFS COND. MADE ABSOLUTE SEE 84CW93
94CW0033	5/8/1913	6/1/1901	20393.19	0.00	111 1/4	40.00	S	CA		IRRSTK	125CFS LEFT COND
84CW0142	5/8/1913	6/1/1901	20393.19	0.00	111 1/4	239.00	S	A	TF	IRRMUNST	STIP OF 1984 ABANDONMENT 239CFS OF ORIG 1300CFS BECOMES COND
CA1745	5/8/1913	6/1/1901	20393.19	0.00	111 1/4	1300.00	S	A		IRRMUNST	1/4 P93
W0030	3/20/1954	1/15/1951	36904.00	0.00	J383	50.00	S	A		MUNDOM	ALT PT FROM GUNNISON PIPELINE J-307 WD40
82CW0324	12/31/1982	2/16/1981	48212.48	0.00		900.00	S	C		PWR	AKA UNCOMPAHGRE VALLEY HYDRO PROJECT
87CW0273	12/31/1988	10/31/1984	50403.49	0.00		235.00	S	C		PWR	WATER TO BE USED AT AB LATERAL HYDRO OR M&D POWER

Water Rights - Net Amounts										
				Priority/Case	Rate (CFS)			Volume (Ac-Ft)		
Adj-Date	App-Date	Admin. No.	Order No.	Number	Absolute	Conditional	AP/EX	Absolute	Conditional	AP/EX
5/8/1913	6/1/1901	20393.19	0.00	111 1/4	1175.00	125.00	0.00	0.00	0.00	0.00
3/20/1954	1/15/1951	36904.00	0.00	J383	0.00	0.00	50.00	0.00	0.00	0.00
12/31/1982	2/16/1981	48212.48	0.00	82CW0324	0.00	900.00	0.00	0.00	0.00	0.00
12/31/1988	10/31/1984	50403.49	0.00	87CW0273	0.00	235.00	0.00	0.00	0.00	0.00



Annual Flows Through The Structure: Gunnison Tunnel
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
Flow (ac-ft)
1996
1997
1999
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Year

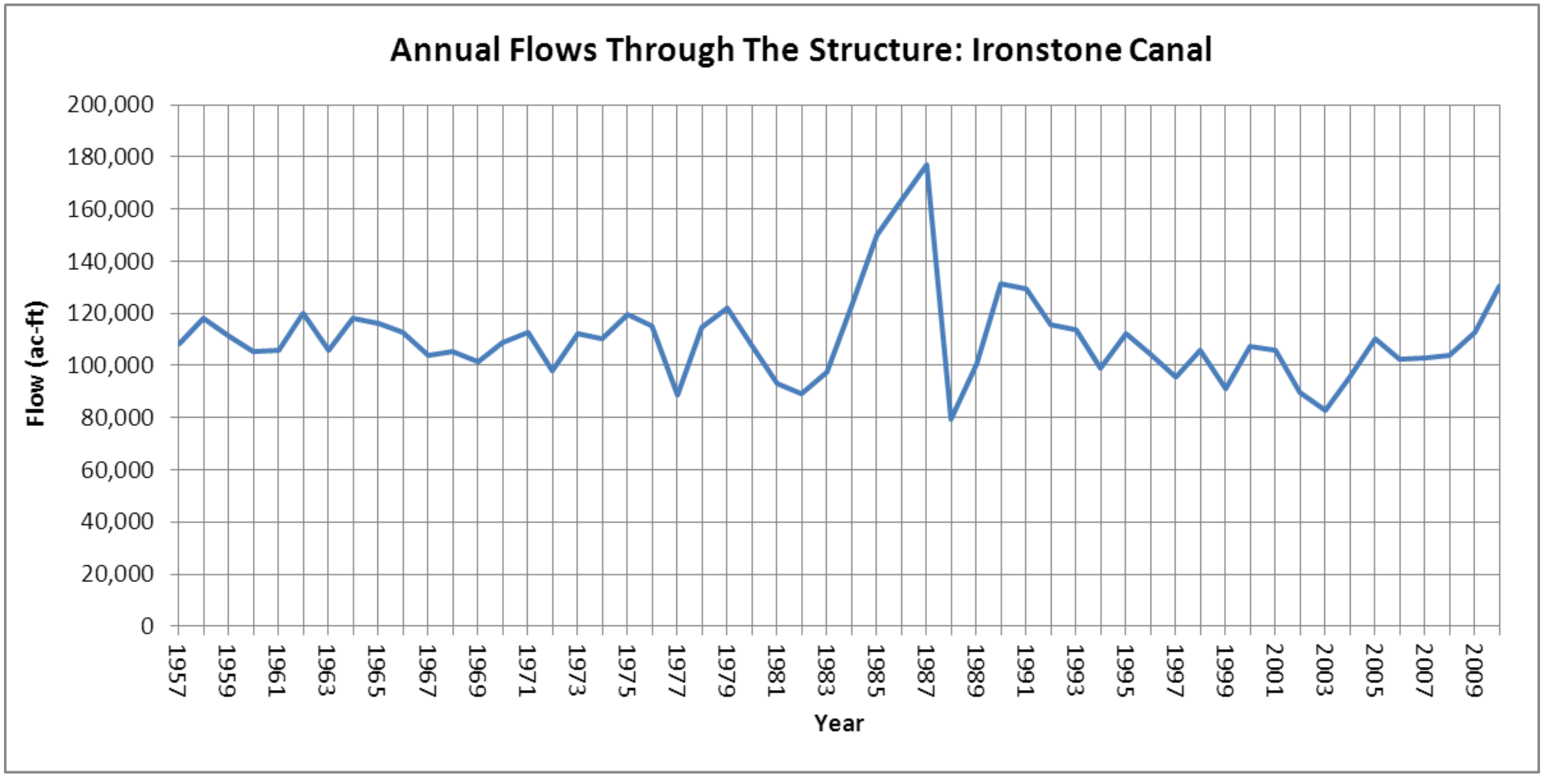

Monthly Flows Through The Structure: Gunnison Tunnel
Dry Year
Average Year
Wet Year
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
Flow (ac-ft)
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sept
Month

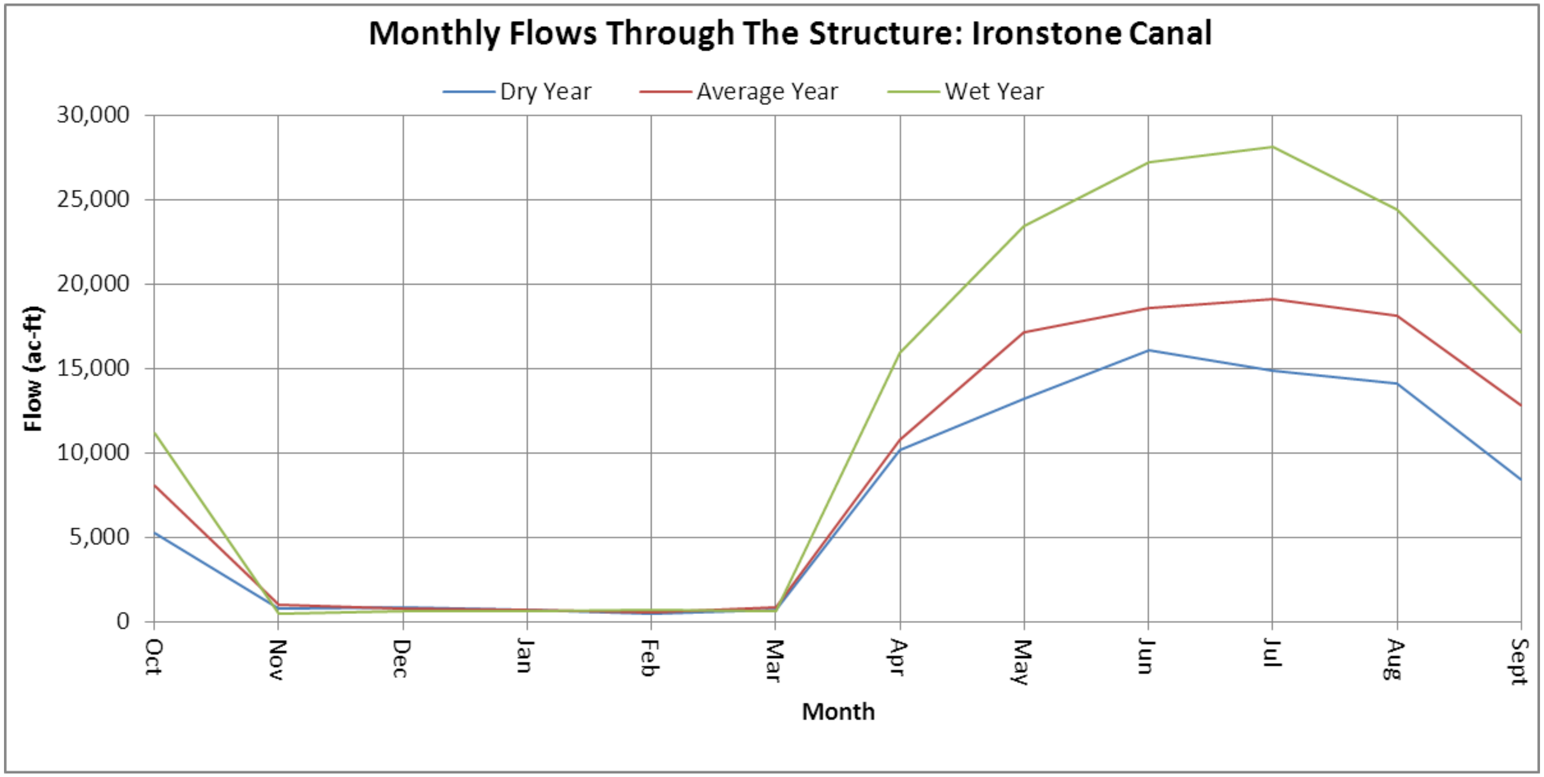
Structure Name: IRONSTONE CANAL
Source: Uncompahgre River
Q10 Q40 Q160 Section Twnshp Range PM
SW NW SE 27 50N 10W N
Water District: 41 Structure ID Number: 534
UTM Coordinates (NAD 83): Northing (UTM y): 4272843 Easting (UTM x): 240944
Spotted from PLSS distances from section lines

Water Rights Summary			
Parameter	Absolute	conditional	AP/EX
Total Decreed Rate(s) (CFS)	202.72	0.00	0.00
Total Decreed Volume(s) (AF)	0.00	0.00	0.00

Water Rights - Transactions											
Case Number	Adj-Date	App-Date	Admin. No.	Order No.	Priority No.	Decreed Amt	Adj Type	Status Type	Transfer Type	Use	Action Comment
CA6929	6/30/1890	1/5/1882	11693.00	0.00	5.00	1.05	O	A	TT	IRR	TF HOMESTAKE D 4/7/1953 P359
CA6929	6/30/1890	1/5/1882	11693.00	0.00	5.00	1.66	O	A	TT	IRR	TF HOMESTAKE D 4/7/1953 P359
CA6929	6/30/1890	1/5/1882	11693.00	0.00	5.00	1.10	O	A	TT	IRR	TF HOMESTAKE D 4/7/1953 P359
CA6929	6/30/1890	1/5/1882	11693.00	0.00	5.00	0.60	O	A	TT	IRR	TF HOMESTAKE D 4/7/1953 P359
CA6917	6/30/1890	1/5/1882	11693.00	0.00	5.00	0.23	O	A	TT	IRR	TF HOMESTAKE D 3/31/1953 P356
CA6929	6/30/1890	1/5/1882	11693.00	0.00	5.00	0.26	O	A	TT	IRR	TF COREY D 4/7/1953 P359
CA6962	6/30/1890	10/1/1882	11962.00	0.00	21.00	2.50	O	A	TT	IRR	TF FOSTER D 12/11/1956 P391
CA0149	6/30/1890	11/7/1882	11999.00	0.00	25.00	37.50	O	A	1/0/1900	IRR	CA 11/14/1888 P15
CA6962	6/30/1890	11/21/1882	12013.00	0.00	26.00	1.83	O	A	TT	IRR	TF FOSTER D 12/11/1956 P391
CA6917	6/30/1890	8/24/1884	12655.00	0.00	53.00	21.00	O	A	TT	IRR	TF DELTA CHIEF D 3/31/1953 P355
CA0149	6/30/1890	3/31/1886	13239.00	0.00	72.00	76.00	O	A	1/0/1900	IRR	CA 11/14/1888 P15
CA6917	6/30/1890	11/14/1888	14198.00	0.00	112.00	21.50	O	A	TT	IRR	TF DELTA CHIEF D 3/31/1953
CA0149	6/30/1890	11/14/1888	14198.00	0.00	99.00	37.50	O	A	1/0/1900	IRR	CA 11/14/1888 P15

Water Rights - Net Amounts										
				Priority/Case	Rate (CFS)			Volume (Ac-Ft)		
Adj-Date	App-Date	Admin. No.	Order No.	Number	Absolute	Conditional	AP/EX	Absolute	Conditional	AP/EX
6/30/1890	1/5/1882	11693.00	0.00	5.00	4.90	0.00	0.00	0.00	0.00	0.00
6/30/1890	10/1/1882	11962.00	0.00	21.00	2.50	0.00	0.00	0.00	0.00	0.00
6/30/1890	11/7/1882	11999.00	0.00	25.00	37.50	0.00	0.00	0.00	0.00	0.00
6/30/1890	11/21/1882	12013.00	0.00	26.00	1.83	0.00	0.00	0.00	0.00	0.00
6/30/1890	8/24/1884	12655.00	0.00	53.00	21.00	0.00	0.00	0.00	0.00	0.00
6/30/1890	3/31/1886	13239.00	0.00	72.00	76.00	0.00	0.00	0.00	0.00	0.00
6/30/1890	11/14/1888	14198.00	0.00	99.00	59.00	0.00	0.00	0.00	0.00	0.00


Annual Flows Through The Structure: Ironstone Canal
Flow (ac-ft)
200,000
180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
1957
1959
1961
1963
1965
1967
1969
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
Year



Monthly Flows Through The Structure: Ironstone Canal
Dry Year
Average Year
Wet Year
Flow (ac-ft)
30,000
25,000
20,000
15,000
10,000
5,000
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sept
Month

Structure Name: LOUTSENHIZER CANAL
Source: Uncompahgre River

Q10 Q40 Q160 Section Twnshp Range PM
SW SW SE 4 48N 9W N
Q10 Q40 Q160 Section Twnshp Range PM

Water District: 41 Structure ID Number: 537

UTM Coordinates (NAD 83): Northing (UTM y): 4258243 Easting (UTM x): 250210
Spotted from PLSS distances from section lines

Water Rights Summary

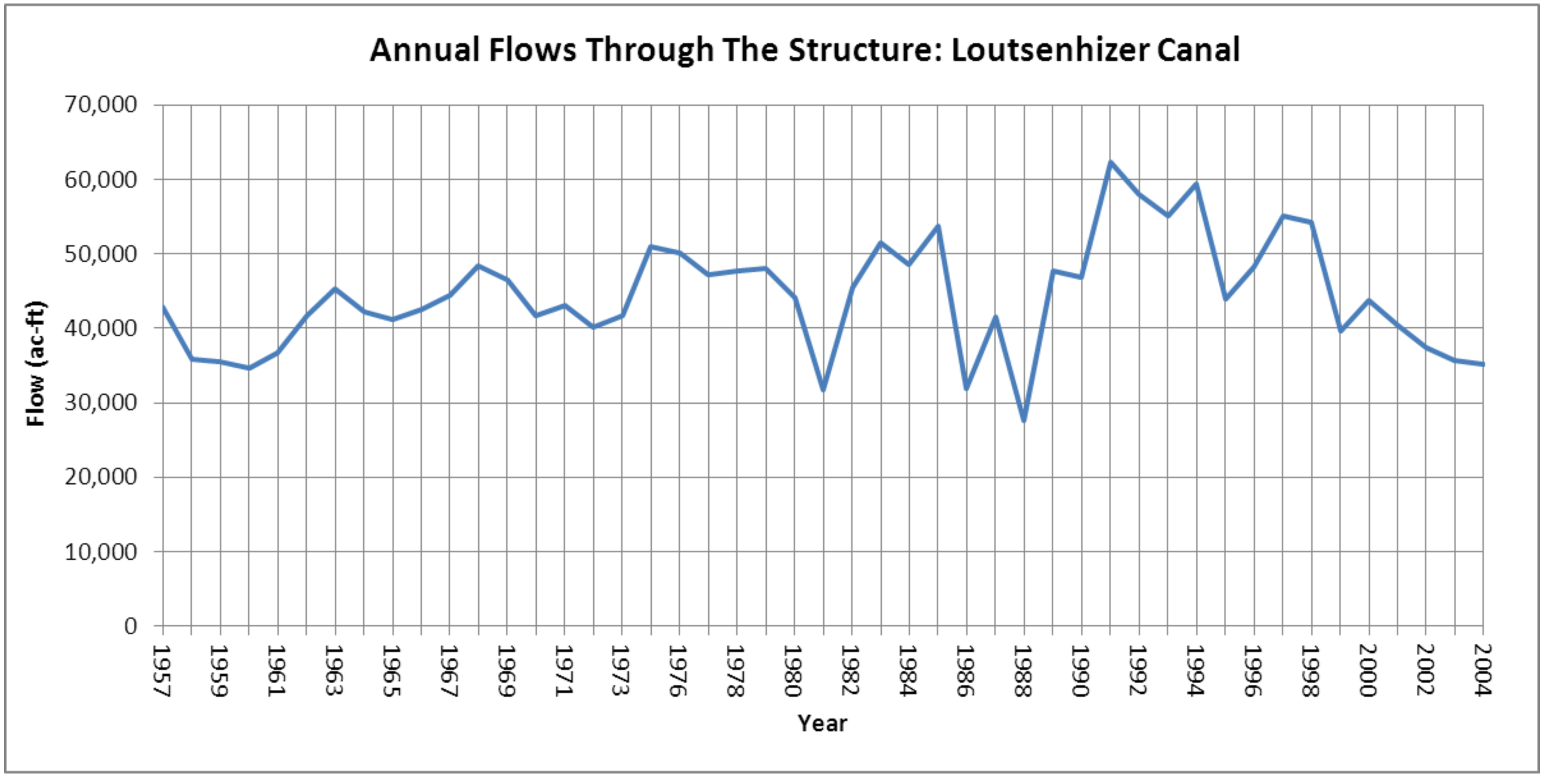
Parameter	Absolute	conditional	AP/EX
Total Decreed Rate(s) (CFS)	46.37	0.00	0.00
Total Decreed Volume(s) (AF)	0.00	0.00	0.00

Water Rights - Transactions

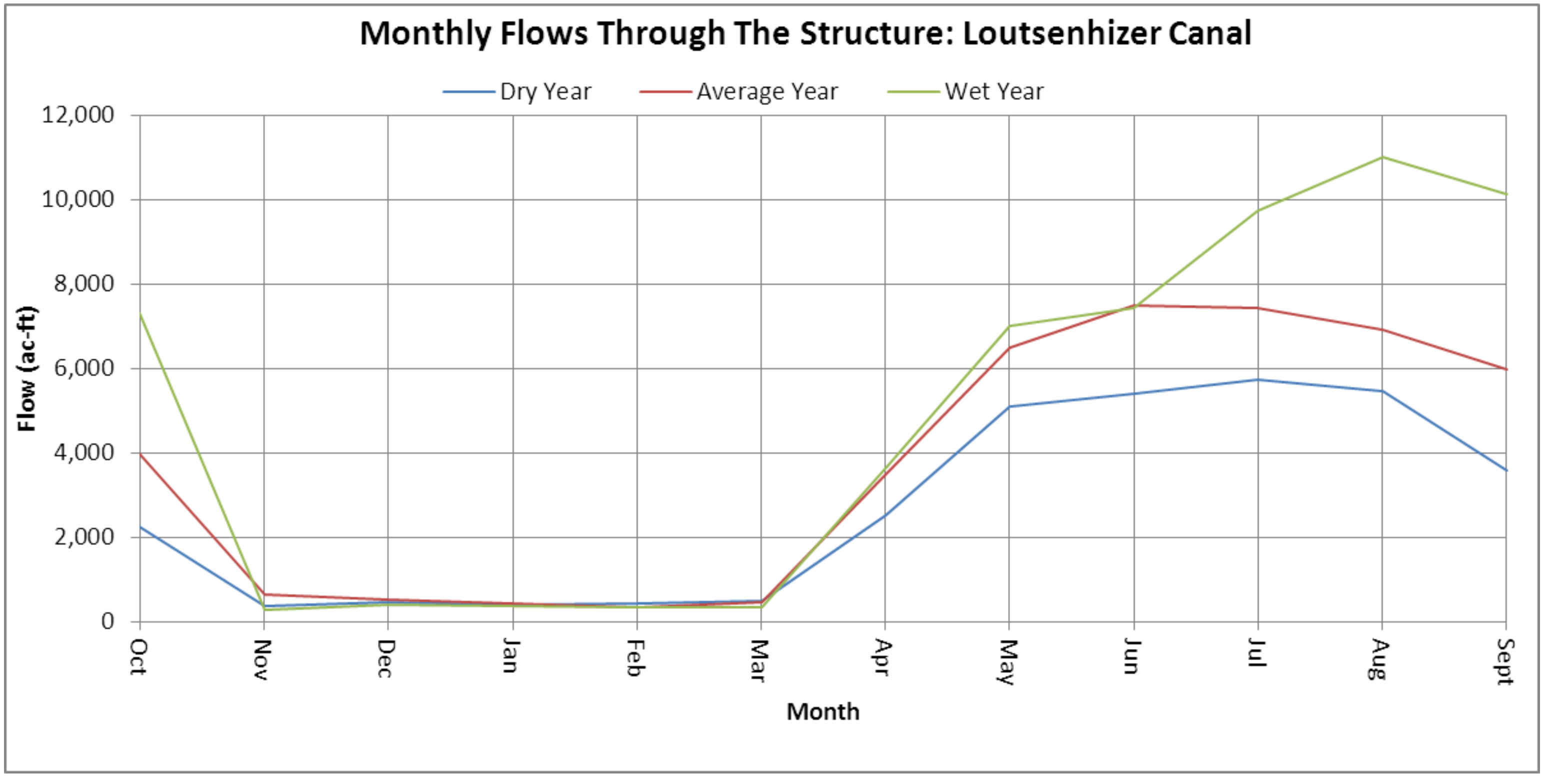
Case Number	Adj-Date	App-Date	Admin. No.	Order No.	Priority No.	Decreed Amt	Adj Type	Status Type	Transfer Type	Use	Action Comment
CA1389	6/30/1890	11/1/1881	11628.00	0.00	2.00	0.47	O	A	TT	IRR	TF EGGLESTON D 4/29/1916 17.938 CSI P82
CA1389	6/30/1890	11/1/1881	11628.00	0.00	2.00	0.07	O	A	TT	IRR	TF EGGLESTON D 4/29/1916 2.562 CSI P82
CA6910	6/30/1890	1/27/1882	11715.00	0.00	6.00	0.46	O	A	TT	IRR	TF GUS FROST D 3/31/1953 P341
01CW0035	6/30/1890	1/27/1882	11715.00	0.00	0.00	0.46	O	A	TF	IRR	TT SELIG CANAL ORIGINAL WATER AT GUS FROST D
CA6918	6/30/1890	11/30/1883	12387.00	0.00	38.00	7.00	O	A	TT	IRR	TF GEO B JONES N MESA D 3/31/1953 P357
CA6918	6/30/1890	7/12/1886	13342.00	0.00	76.00	33.33	O	A	TT	IRR	TF GEO G JONES D 3/31/1953 P357
CA6918	6/30/1890	11/14/1888	14198.00	0.00	107.00	5.50	O	A	TT	IRR	TF GEO B JONES A N MESA D 3/31/1953 P357
02CW0299	12/31/2003	5/25/2002	55882.56	0.00	0.00	1.30	S	C		IRRRECFIS	CANCELED BY COURT 8/6/2009
02CW0299	12/31/2003	5/25/2002	55882.56	0.00	0.00	1.30	S	C		IRRRECFIS	MKCJ DECREE TO SUPPLY PIPELINE & RES. PROTECTED BY P/A

Water Rights - Net Amounts

				Priority/Case	Rate (CFS)			Volume (Ac-Ft)		
Adj-Date	App-Date	Admin. No.	Order No.	Number	Absolute	Conditional	AP/EX	Absolute	Conditional	AP/EX
6/30/1890	11/1/1881	11628.00	0.00	2	0.54	0.00	0.00	0.00	0.00	0.00
6/30/1890	11/30/1883	12387.00	0.00	38	7.00	0.00	0.00	0.00	0.00	0.00
6/30/1890	7/12/1886	13342.00	0.00	76	33.33	0.00	0.00	0.00	0.00	0.00
6/30/1890	11/14/1888	14198.00	0.00	107	5.50	0.00	0.00	0.00	0.00	0.00



Annual Flows Through The Structure: Loutsenhizer Canal
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
Flow (ac-ft)
1957
1959
1961
1963
1965
1967
1969
1971
1973
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
Year



Monthly Flows Through The Structure: Loutsenhizer Canal
Dry Year
Average Year
Wet Year
12,000
10,000
8,000
6,000
4,000
2,000
0
Flow (ac-ft)
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sept
Month

Structure Name: MONTROSE & DELTA CANAL
Source: Uncompahgre River

Q10 Q40 Q160 Section Twnshp Range PM
SE SW SE 23 48N 9W N

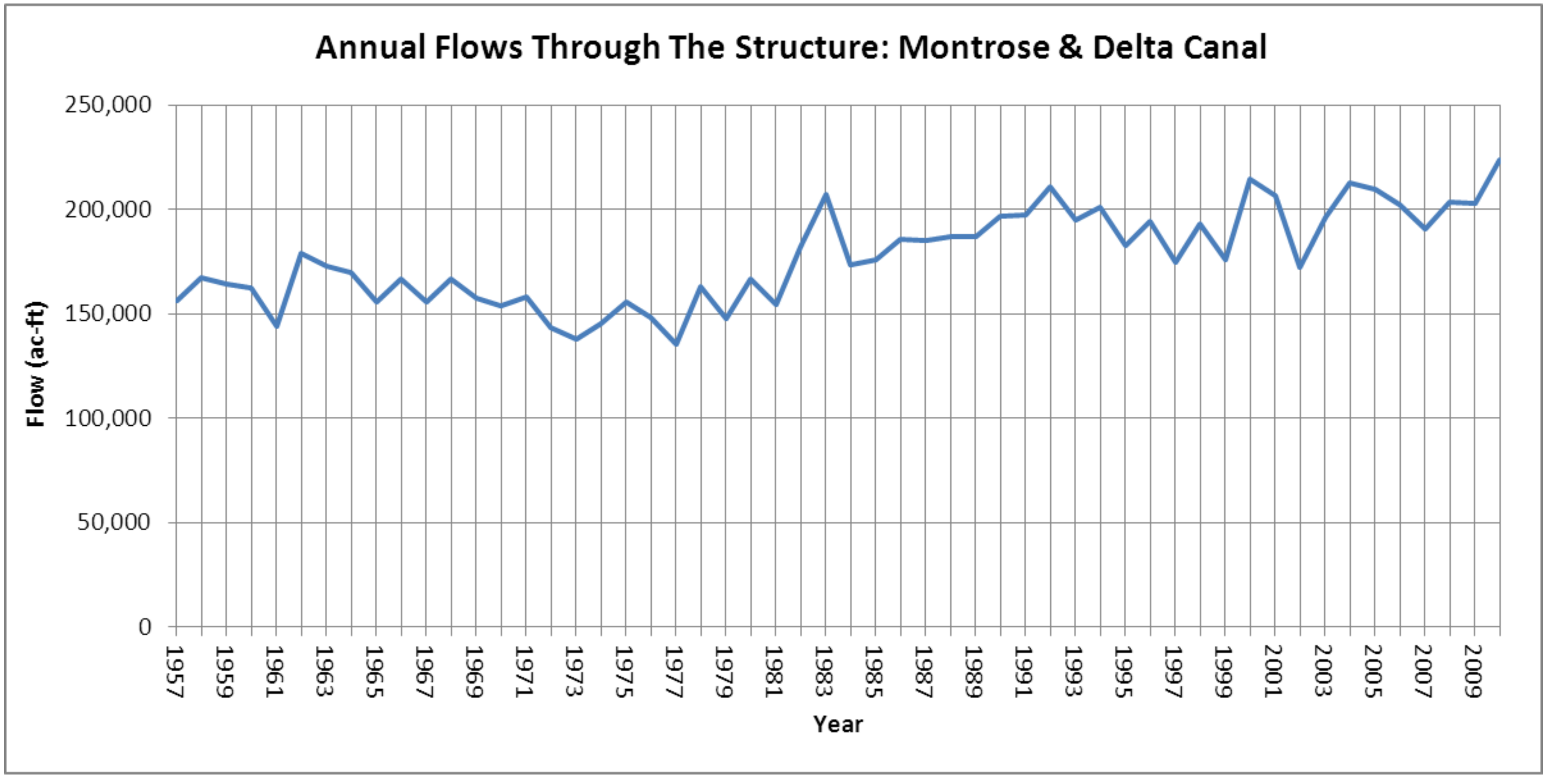
Water District: 41 Structure ID Number: 545

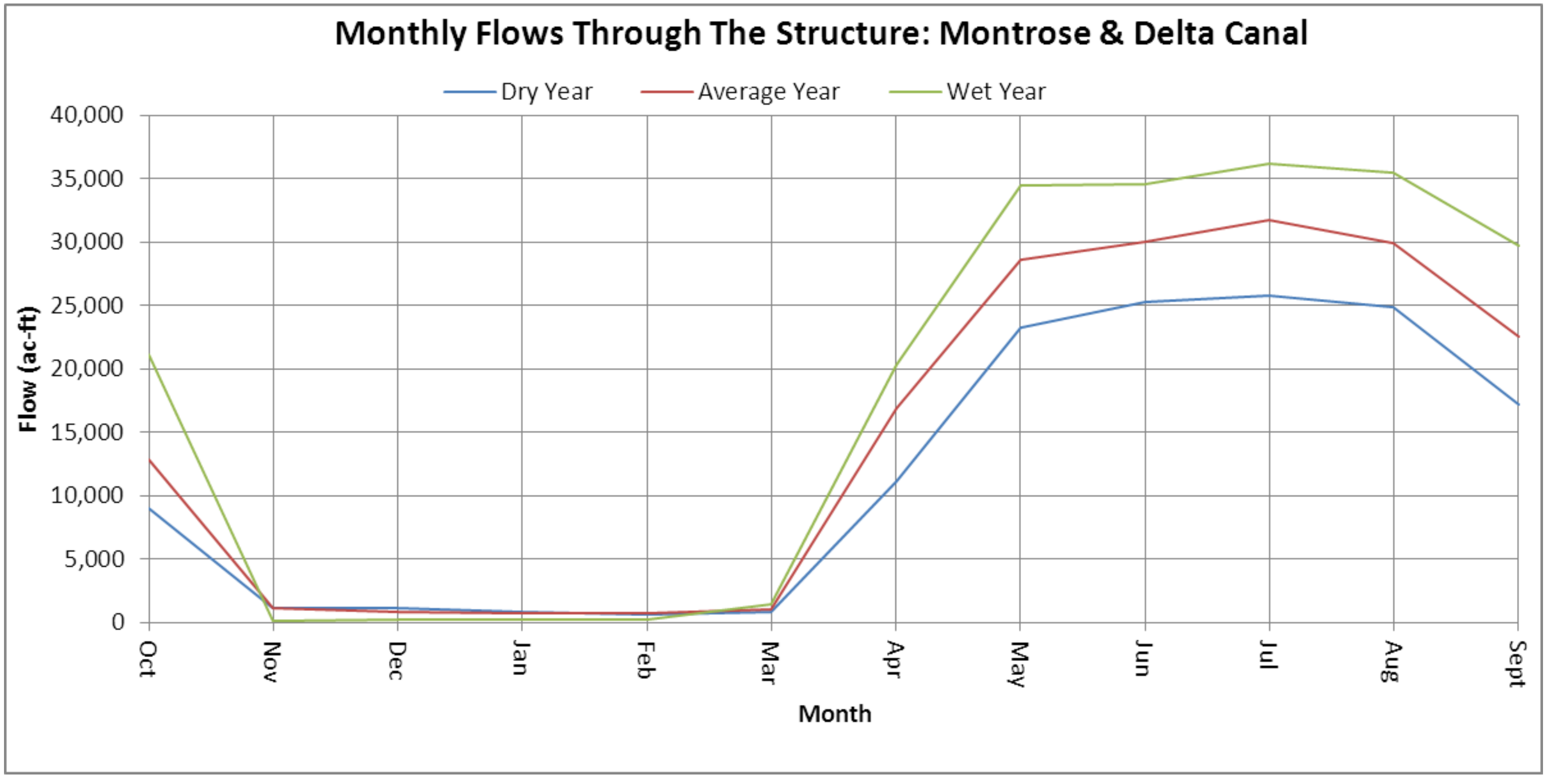
UTM Coordinates (NAD 83): Northing (UTM y): 4253151 Easting (UTM x): 253387
Spotted from PLSS distances from section lines

Water Rights Summary			
Parameter	Absolute	conditional	AP/EX
Total Decreed Rate(s) (CFS)	626.96	300.00	0.00
Total Decreed Volume(s) (AF)	0.00	0.00	0.00

Water Rights - Transactions											
Case Number	Adj-Date	App-Date	Admin. No.	Order No.	Priority No.	Decreed Amt	Adj Type	Status Type	Transfer Type	Use	Action Comment
CA1586	6/30/1890	11/1/1881	11628.00	0.00	2.00	1.73	O	A	TT	IRR	TF EGGLESTON D 11/1/1907 66.5CSI P58
CA1389	6/30/1890	11/1/1881	11628.00	0.00	2.00	0.54	O	A	TT	IRR	TF EGGLESTON D 4/29/1916 20.6 CSI P82
CA1586	6/30/1890	11/1/1881	11628.00	0.00	2.00	0.91	O	A	TT	IRR	TF EGGLESTON D 11/1/1907 35CSI P61
CA1389	6/30/1890	11/1/1881	11628.00	0.00	2.00	1.80	O	A	TT	IRR	TF EGGLESTON D 4/29/1916 70.0 CSI P82
CA1586	6/30/1890	12/8/1881	11665.00	0.00	3.00	1.30	O	A	TT	IRR	TF UNCOMPAHGRE D 11/1/1907 50.0 CSI P59
CA1262	6/30/1890	12/8/1881	11665.00	0.00	3.00	1.63	O	A	TT	IRR	TF UNCOMPAHGRE D 12/22/1900 62.8 CSI P36
CA1389	6/30/1890	12/8/1881	11665.00	0.00	3.00	0.47	O	A	TT	IRR	TF UNCOMPAHGRE D 4/29/1916 18.0 CSI P82
CA1586	6/30/1890	12/8/1881	11665.00	0.00	3.00	0.94	O	A	TT	IRR	TF UNCOMPAHGRE D 11 1 1907 P60 36 3/11 CSI
CA1586	6/30/1890	12/8/1881	11665.00	0.00	3.00	0.65	O	A	TT	IRR	TF UNCOMPAHGRE D 11/1/1907 25.0 CSI P60
CA1586	6/30/1890	12/8/1881	11665.00	0.00	3.00	0.65	O	A	TT	IRR	TF UNCOMPAHGRE D 11/1/1907 25.0 CSI P60
CA1586	6/30/1890	12/8/1881	11665.00	0.00	3.00	0.52	O	A	TT	IRR	TF UNCOMPAHGRE D 11/1/1907 20.0 CSI P60
CA1586	6/30/1890	12/8/1881	11665.00	0.00	3.00	0.20	O	A	TT	IRR	TF UNCOMPAHGRE D 11/1/1907 7.8CSI P59
CA1586	6/30/1890	12/8/1881	11665.00	0.00	3.00	4.10	O	A	TT	IRR	TF UNCOMPAHGRE D 11/1/1907 157.5 CSI P58
CA1586	6/30/1890	12/8/1881	11665.00	0.00	3.00	0.90	O	A	TT	IRR	TF UNCOMPAHGRE D 11/1/1907 34.4 CSI P61
CA1586	6/30/1890	12/8/1881	11665.00	0.00	3.00	0.78	O	A	TT	IRR	TF UNCOMPAHGRE D 11/1/1907 30.0 CSI P61
CA1586	6/30/1890	1/5/1882	11693.00	0.00	5.00	1.10	O	A	TT	IRR	TF HOMESTAKE D 11/1/1907 42.24CSI P62
CA1251	6/30/1890	1/5/1882	11693.00	0.00	5.00	2.20	O	A	TT	IRR	TF HOMESTAKE D 4/14/1900 2 1/5 CFS P33
CA1586	6/30/1890	1/5/1882	11693.00	0.00	5.00	2.20	O	A	TT	IRR	TF HOMESTAKE D 11/1/1907 84.48CSI P62
CA1273	6/30/1890	1/5/1882	11693.00	0.00	5.00	0.55	O	A	TT	IRR	TF HOMESTAKE D 3/30/1901 11/20 CFS OR P38 21.12 CSI
CA1249	6/30/1890	1/27/1882	11715.00	0.00	6.00	0.65	O	A	TT	IRR	TF GUS FROST D 4/6/1900 25.0 CSI P29
CA1248	6/30/1890	2/11/1882	11730.00	0.00	9.00	3.00	O	A	TT	IRR	TF SATISFACTION D 4/6/1900 P31
CA6916	6/30/1890	2/11/1882	11730.00	0.00	9.00	1.00	O	A	TT	IRR	TF CHIPETA D 3/31/1953 P354
CA0149	6/30/1890	4/7/1883	12150.00	0.00	31.00	100.00	O	A		IRR	CA 11/14/1888 P18 AKA UNCOMPAGHRE CANAL
CA6916	6/30/1890	1/24/1884	12442.00	0.00	43.00	17.37	O	A	TT	IRR	TF CHIPETA D 3/31/1953 P353
CA0149	6/30/1890	4/7/1884	12516.00	0.00	48.00	100.00	O	A		IRR	CA 11/14/1888 P16 AKA UNCOMPAGHRE CANAL
CA0149	6/30/1890	3/31/1885	12874.00	0.00	64.00	50.00	O	A		IRR	A 11/14/1888 P16 AKA UNCOMPAGHRE CANAL
CA6916	6/30/1890	4/1/1885	12875.00	0.00	65.00	25.00	O	A	TT	IRR	TF UNCOM CEDAR CR VAL D 3/31/1953 P353
CA6916	6/30/1890	11/14/1888	14198.00	0.00	109.00	17.37	O	A		IRR	TFRD FR CHIPETA D 3/31/1953 P353
CA0149	6/30/1890	11/14/1888	14198.00	0.00	102.00	30.00	O	A		IRR	CA 11/14/1888 P16 AKA UNCOMPAGHRE CANAL
CA6916	6/30/1890	11/14/1888	14198.00	0.00	119.00	58.40	O	A	TT	IRR	TF UNCOMPAHGRE CEDAR CR VALLEY D 3/31/1953 P353
CA0149	6/30/1890	11/14/1888	14198.00	0.00	118.00	201.00	O	A		IRR	CA 11/14/1888 P16 AKA UNCOMPAGHRE CANAL
82CW0324	12/31/1982	2/16/1981	48212.48	0.00	0.00	300.00	S	C		PWR	

Water Rights - Net Amounts										
				Priority/Case	Rate (CFS)			Volume (Ac-Ft)		
Adj-Date	App-Date	Admin. No.	Order No.	Number	Absolute	Conditional	AP/EX	Absolute	Conditional	AP/EX
6/30/1890	11/1/1881	11628.00	0.00	2	4.98	0.00	0.00	0.00	0.00	0.00
6/30/1890	12/8/1881	11665.00	0.00	3	12.14	0.00	0.00	0.00	0.00	0.00
6/30/1890	1/5/1882	11693.00	0.00	5	6.05	0.00	0.00	0.00	0.00	0.00
6/30/1890	1/27/1882	11715.00	0.00	6	0.65	0.00	0.00	0.00	0.00	0.00
6/30/1890	2/11/1882	11730.00	0.00	9	4.00	0.00	0.00	0.00	0.00	0.00
6/30/1890	4/7/1883	12150.00	0.00	31	100.00	0.00	0.00	0.00	0.00	0.00
6/30/1890	1/24/1884	12442.00	0.00	43	17.37	0.00	0.00	0.00	0.00	0.00
6/30/1890	4/7/1884	12516.00	0.00	48	100.00	0.00	0.00	0.00	0.00	0.00
6/30/1890	3/31/1885	12874.00	0.00	64	50.00	0.00	0.00	0.00	0.00	0.00
6/30/1890	4/1/1885	12875.00	0.00	65	25.00	0.00	0.00	0.00	0.00	0.00
6/30/1890	11/14/1888	14198.00	0.00	102	306.77	0.00	0.00	0.00	0.00	0.00
12/31/1982	2/16/1981	48212.48	0.00	82CW0324	0.00	300.00	0.00	0.00	0.00	0.00


Annual Flows Through The Structure: Montrose & Delta Canal
Flow (ac-ft)
250,000
200,000
150,000
100,000
50,000
0
1957
1959
1961
1963
1965
1967
1969
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
Year

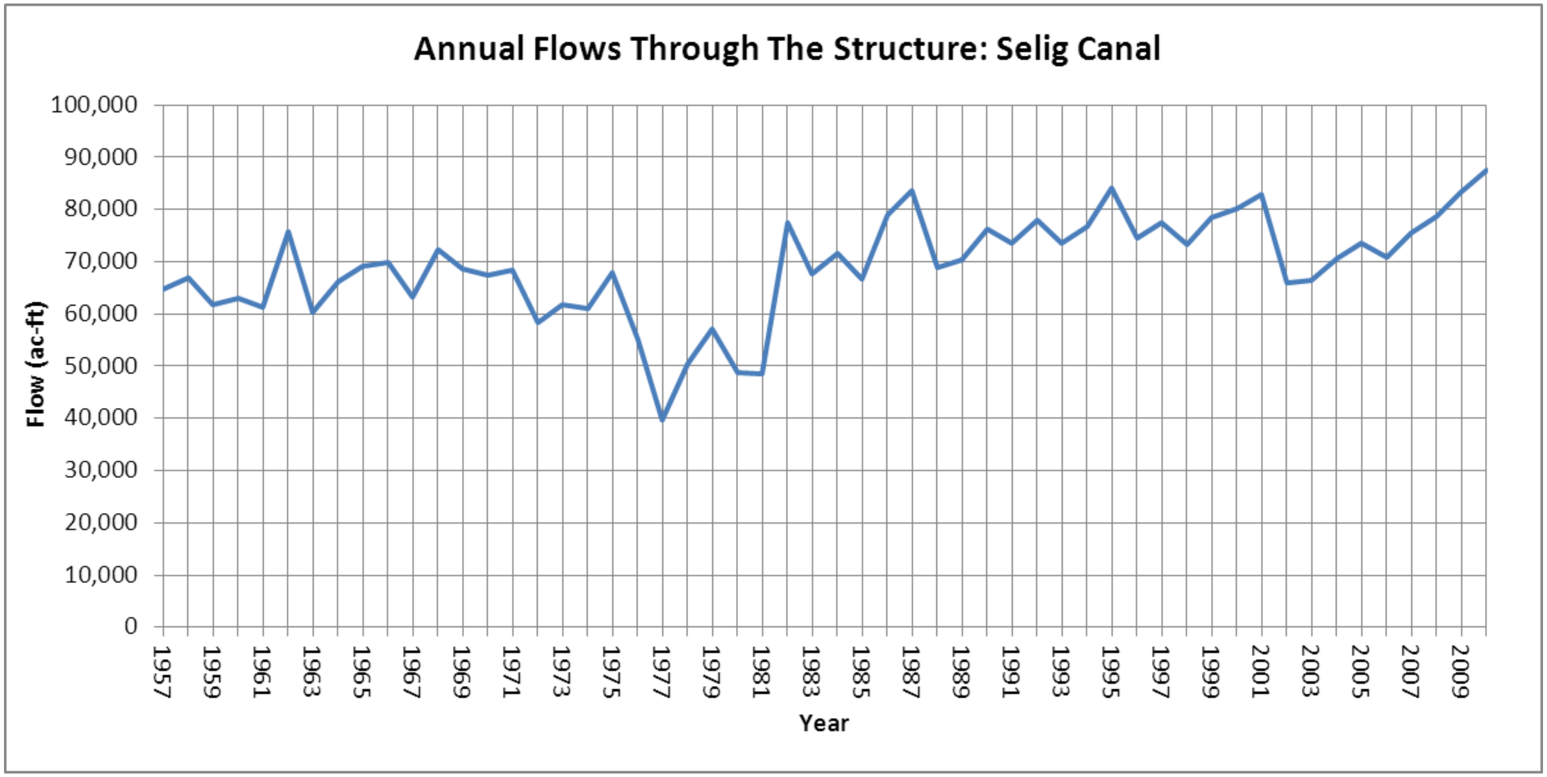

Monthly Flows Through The Structure: Montrose & Delta Canal
Dry Year
Average Year
Wet Year
Flow (ac-ft)
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sept
Month

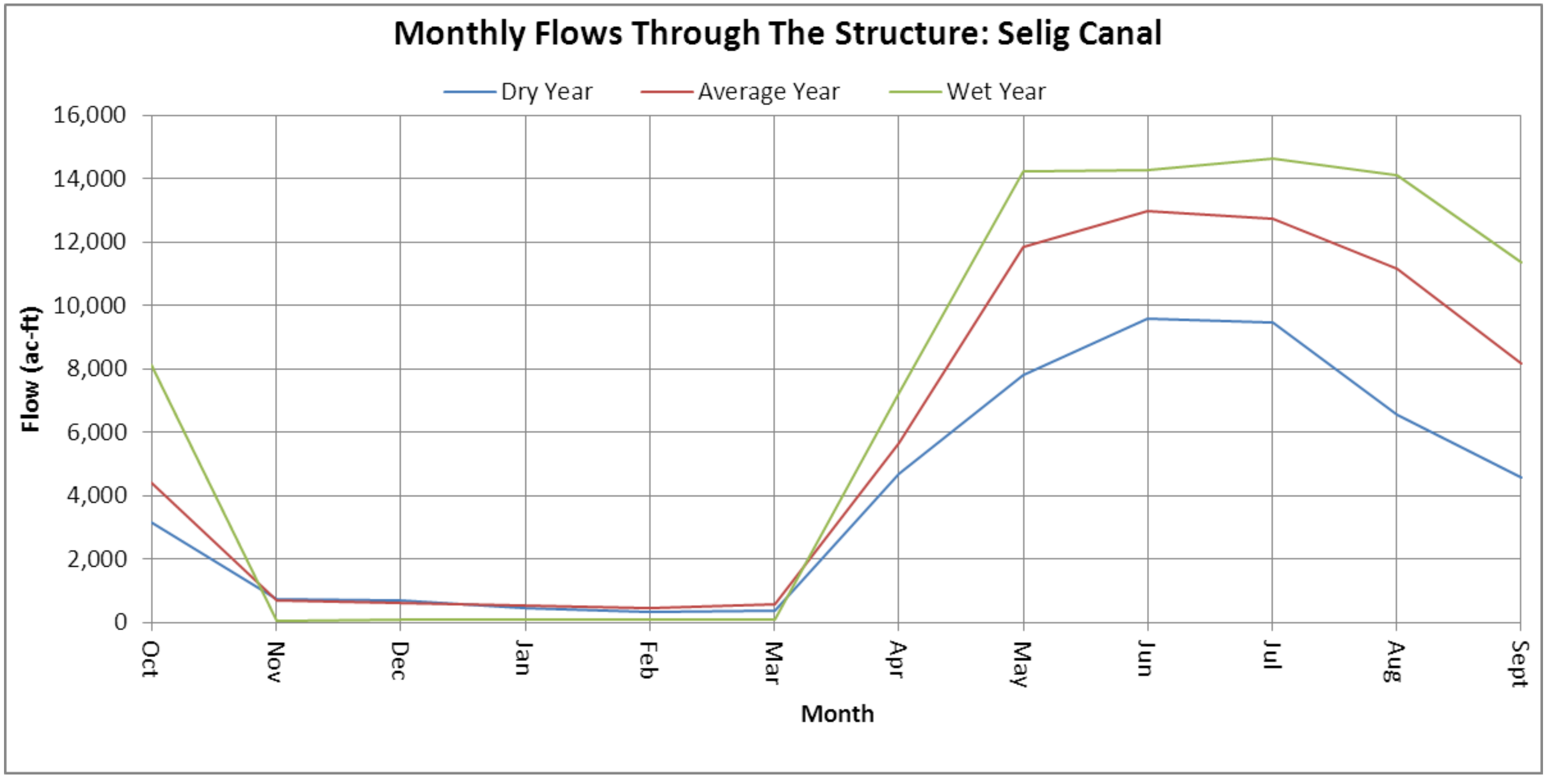
Structure Name: SELIG CANAL
Source: Uncompahgre River
Q10 Q40 Q160 Section Twnshp Range PM
SW SW SW 17 49N 9W N
Water District: 41 Structure ID Number: 559
UTM Coordinates (NAD 83): Northing (UTM y): 4265760 Easting (UTM x): 246126
Spotted from PLSS distances from section lines

Water Rights Summary			
Parameter	Absolute	conditional	AP/EX
Total Decreed Rate(s) (CFS)	121.91	0.00	0.00
Total Decreed Volume(s) (AF)	0.00	0.00	0.00

Water Rights - Transactions											
Case Number	Adj-Date	App-Date	Admin. No.	Order No.	Priority No.	Decreed Amt	Adj Type	Status Type	Transfer Type	Use	Action Comment
CA6985	6/30/1890	1/27/1882	11715.00	0.00	6.00	0.95	O	A	TT	IRR	TF GUS FROST D 6/7/1957 P393 CHANGE OF USE
01CW0035	6/30/1890	1/27/1882	11715.00	0.00	0.00	0.46	O	A	TT	IRR	TF LOUTZENHIZER CANAL ORIGINAL WATER AT GUS FROST D
06CW0128	6/30/1890	2/10/1882	11729.00	0.00	8.00	17.85	O	A	TT	IRR	TF EAGLE DITCH ID519
CA6923	6/30/1890	4/30/1882	11808.00	0.00	15.00	1.10	O	A	TT	IRR	TF RICE D 6/15/1953 P364
CA0149	6/30/1890	10/29/1883	12355.00	0.00	37.00	14.50	O	A		IRR	CA 11/14/1888 P17
CA1388	6/30/1890	10/29/1883	12355.00	0.00	37.00	14.50	O	A	TT	IRR	TF 3/26/1904 SELIG DITCH P55
CA1388	6/30/1890	10/29/1883	12355.00	0.00	37.00	14.50	O	A	TF	IRR	TT 3/26/1904 SELIG DITCH P55
CA0149	6/30/1890	2/7/1888	13917.00	0.00	79.00	58.10	O	A		IRR	CA 11/14/1888 P17
CA1388	6/30/1890	2/7/1888	13917.00	0.00	79.00	58.10	O	A	TT	IRR	TF SELIG D 3/26/1904 P55
CA1388	6/30/1890	2/7/1888	13917.00	0.00	79.00	58.10	O	A	TF	IRR	TT SELIG DITCH 3/26/1904 P55
06CW0128	6/30/1890	11/14/1888	14198.00	0.00	86.00	14.96	O	A	TT	IRR	TF EAGLE DITCH ID519
96CW0040	6/30/1890	11/14/1888	14198.00	0.00	0.00	2.00	O	A	TT	IRR	TF GUS FROST DITCH
CA0149	6/30/1890	11/14/1888	14198.00	0.00	106.00	12.00	O	A		IRR	CA 11/14/1888 P17
CA1388	6/30/1890	11/14/1888	14198.00	0.00	106.00	12.00	O	A	TF	IRR	TT SELIG CANAL 3/26/1904 P55
CA1388	6/30/1890	11/14/1888	14198.00	0.00	106.00	12.00	O	A	TT	IRR	TF 3 24 1904 SELIG DITCH

Water Rights - Net Amounts										
				Priority/Case	Rate (CFS)			Volume (Ac-Ft)		
Adj-Date	App-Date	Admin. No.	Order No.	Number	Absolute	Conditional	AP/EX	Absolute	Conditional	AP/EX
6/30/1890	1/27/1882	11715.00	0.00	6	1.41	0.00	0.00	0.00	0.00	0.00
6/30/1890	2/10/1882	11729.00	0.00	8	17.85	0.00	0.00	0.00	0.00	0.00
6/30/1890	4/30/1882	11808.00	0.00	15	1.10	0.00	0.00	0.00	0.00	0.00
6/30/1890	10/29/1883	12355.00	0.00	37	14.50	0.00	0.00	0.00	0.00	0.00
6/30/1890	2/7/1888	13917.00	0.00	79	58.10	0.00	0.00	0.00	0.00	0.00
6/30/1890	11/14/1888	14198.00	0.00	106	28.96	0.00	0.00	0.00	0.00	0.00


Annual Flows Through The Structure: Selig Canal
Flow (ac-ft)
100,000
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
1957
1959
1961
1963
1965
1967
1969
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
Year


Monthly Flows Through The Structure: Selig Canal
Dry Year
Average Year
Wet Year
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
Flow (ac-ft)
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sept
Month

Structure Name: SOUTH CANAL
Source: Cedar Creek

Q10 Q40 Q160 Section Twnshp Range PM
NE SW NW 26 49N 8W N

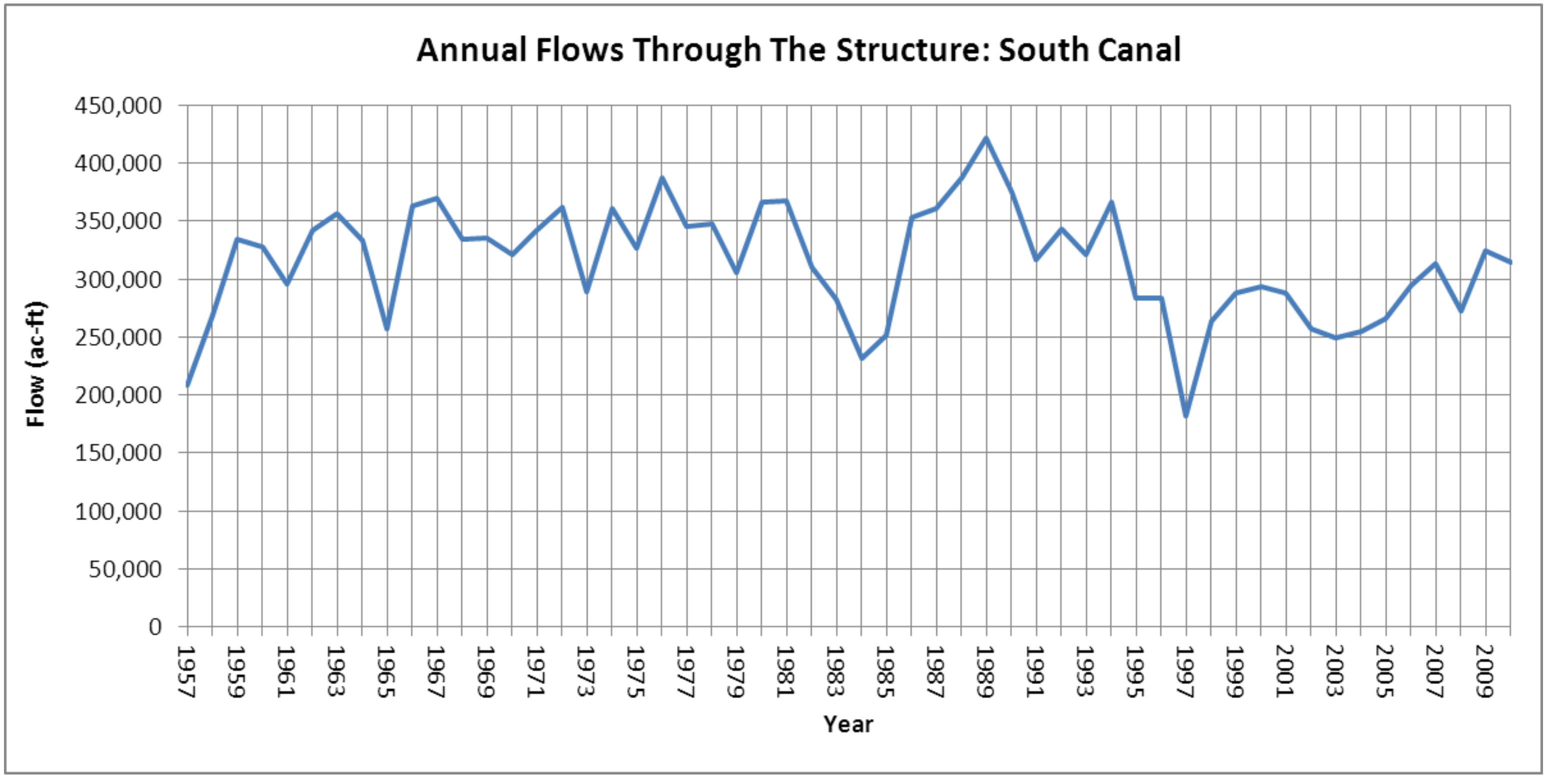
Water District: 41 Structure ID Number: 578

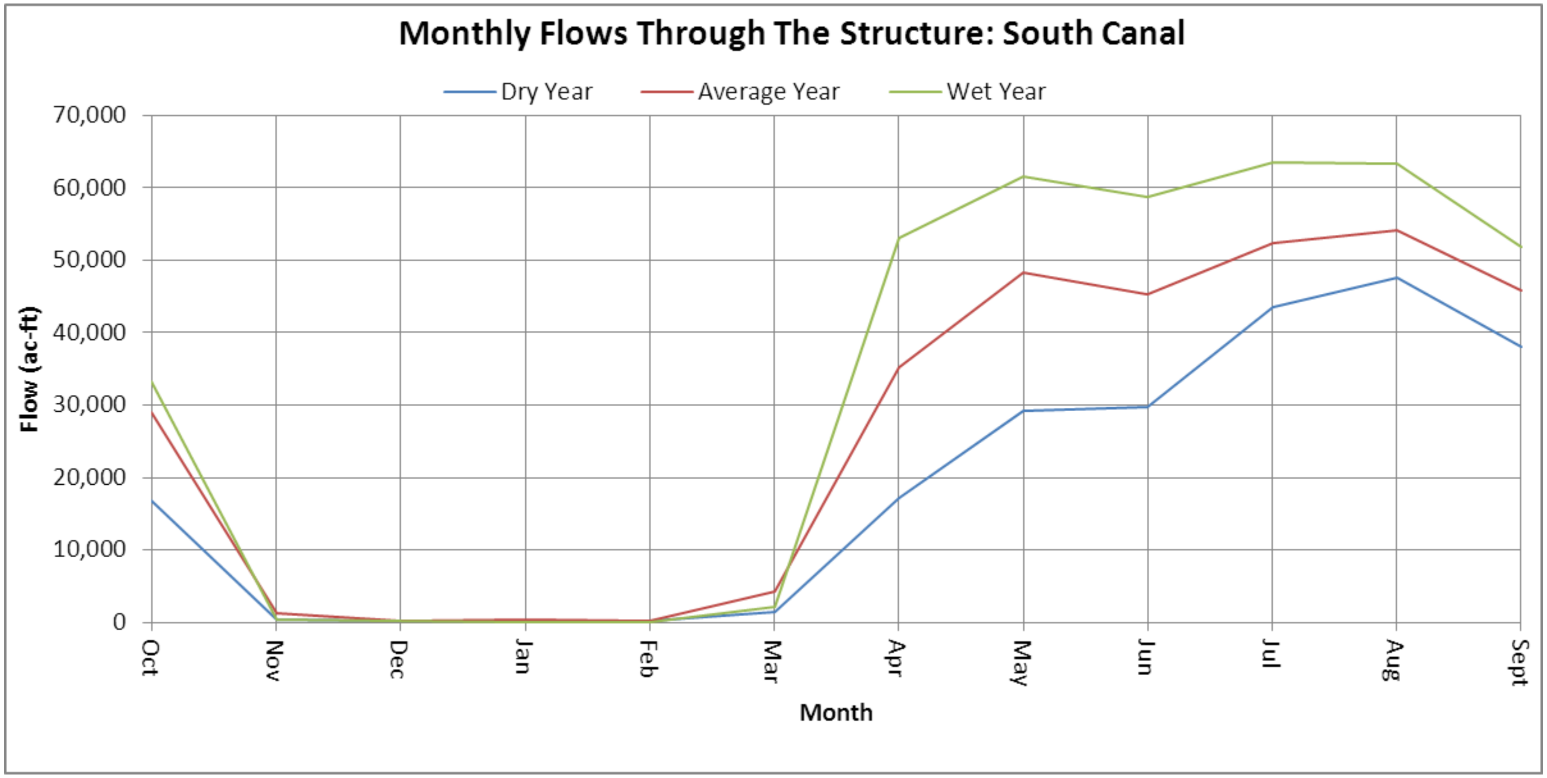
UTM Coordinates (NAD 83): Northing (UTM y): 4263096 Easting (UTM x): 260691
Spotted from PLSS distances from section lines

Water Rights Summary			
Parameter	Absolute	conditional	AP/EX
Total Decreed Rate(s) (CFS)	0.00	0.00	0.00
Total Decreed Volume(s) (AF)	0.00	0.00	0.00

Water Rights - Transactions											
Case Number	Adj-Date	App-Date	Admin. No.	Order No.	Priority No.	Decreed Amt	Adj Type	Status Type	Transfer Type	Use	Action Comment
No available Data											

Water Rights - Net Amounts										
				Priority/Case	Rate (CFS)			Volume (Ac-Ft)		
Adj-Date	App-Date	Admin. No.	Order No.	Number	Absolute	Conditional	AP/EX	Absolute	Conditional	AP/EX
No available Data										


Annual Flows Through The Structure: South Canal
450,000
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
Flow (ac-ft)
1957
1959
1961
1963
1965
1967
1969
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
Year

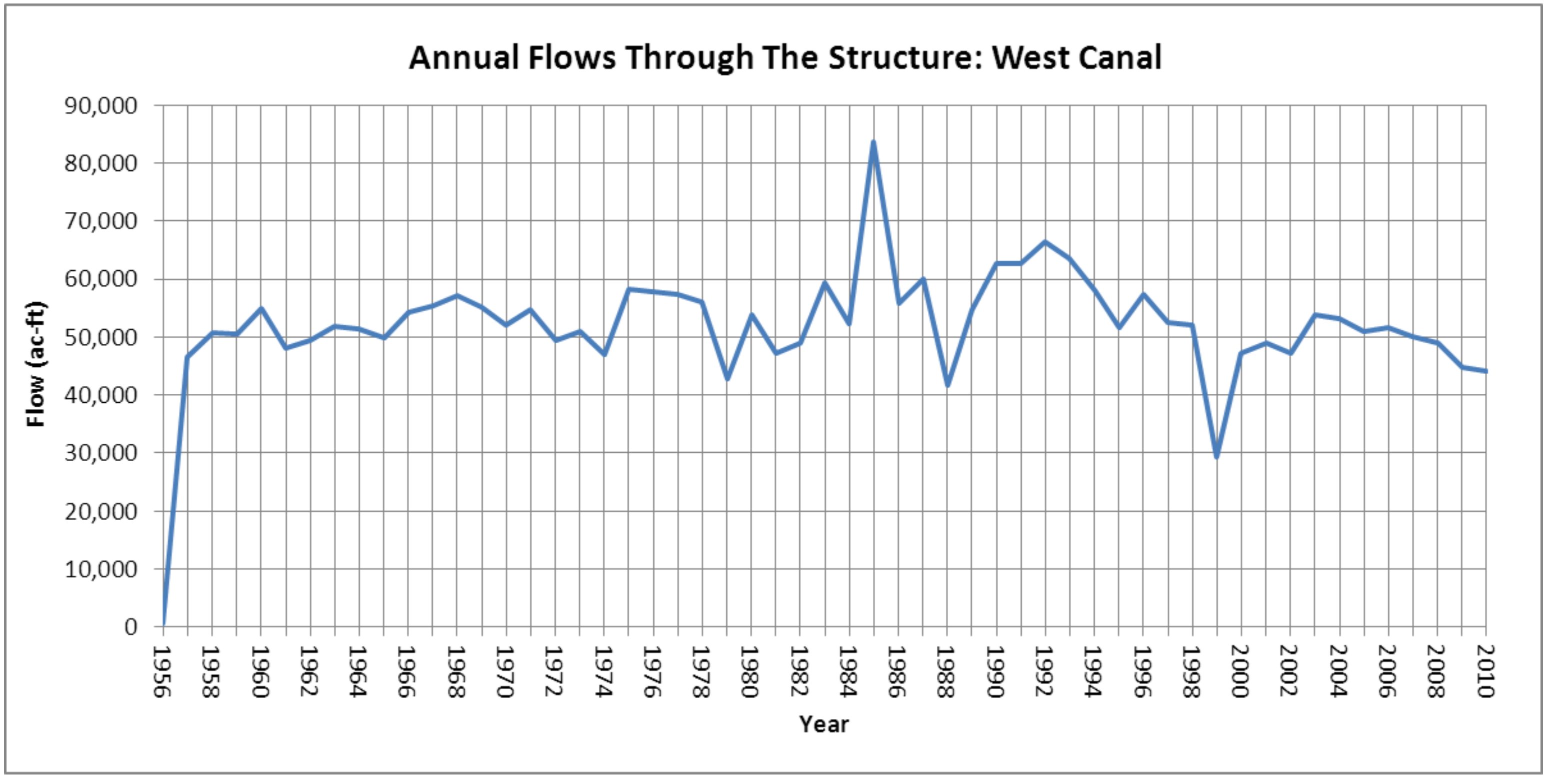

Monthly Flows Through The Structure: South Canal
Dry Year
Average Year
Wet Year
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
Flow (ac-ft)
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sept
Month

Structure Name: WEST CANAL
Source: Uncompahgre River
Q10 Q40 Q160 Section Twnshp Range PM
NE NE SE 36 48N 9W N
Water District: 41 Structure ID Number: 577
UTM Coordinates (NAD 83): Northing (UTM y): 4250653 Easting (UTM x): 255372
Spotted from PLSS distances from section lines

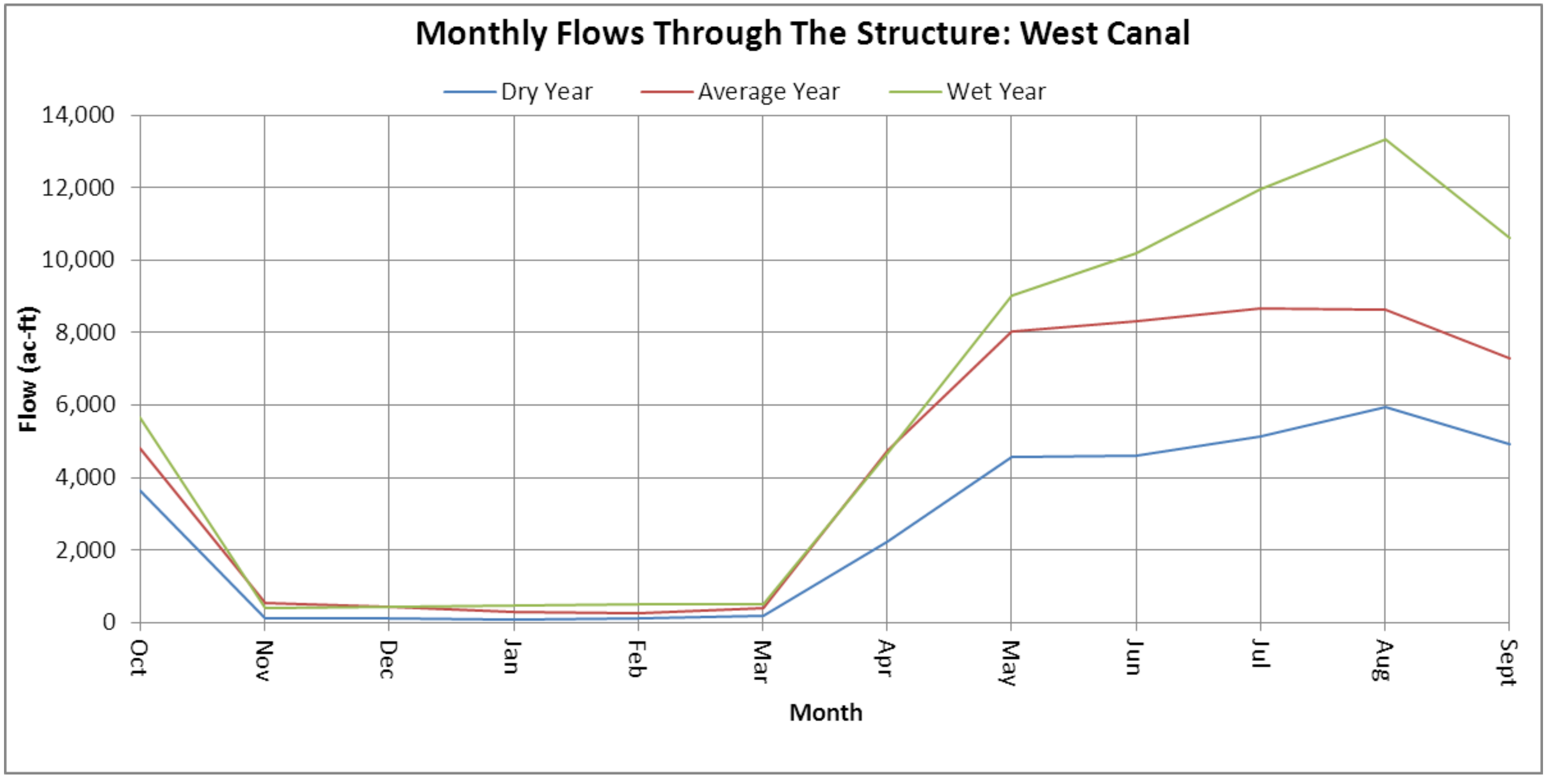
Water Rights Summary			
Parameter	Absolute	conditional	AP/EX
Total Decreed Rate(s) (CFS)	0.00	0.00	0.00
Total Decreed Volume(s) (AF)	0.00	0.00	0.00

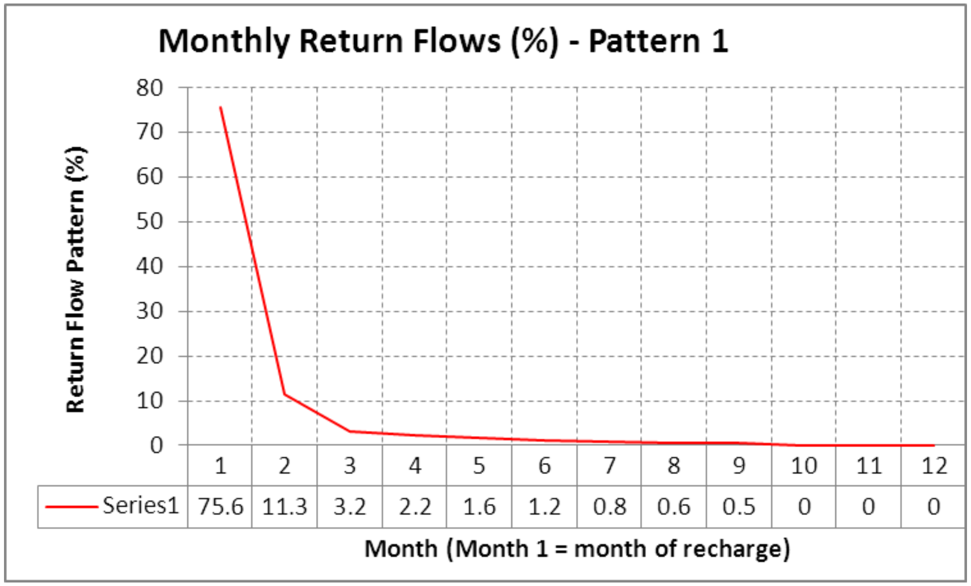
Water Rights - Transactions											
Case Number	Adj-Date	App-Date	Admin. No.	Order No.	Priority No.	Decreed Amt	Adj Type	Status Type	Transfer Type	Use	Action Comment
No available Data											

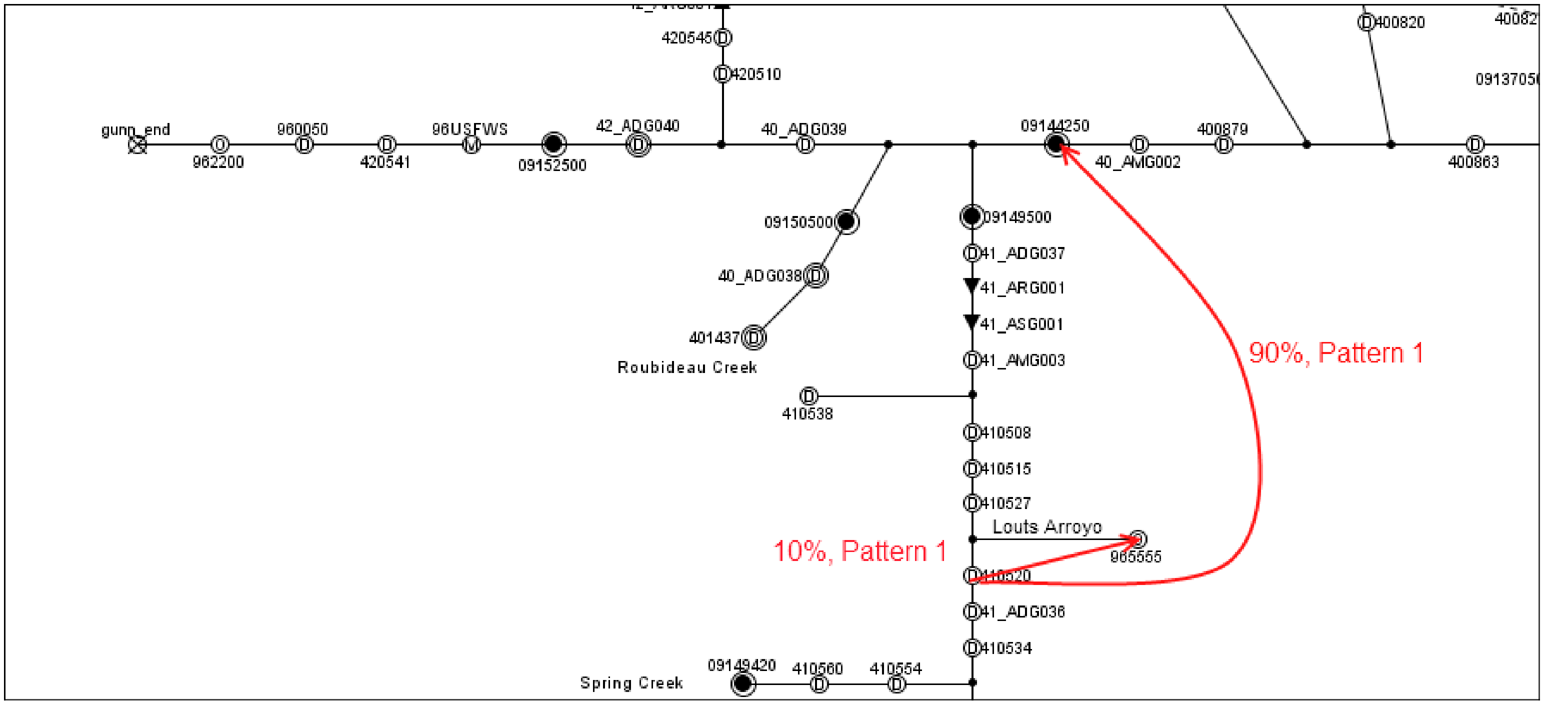
Water Rights - Net Amounts										
				Priority/Case	Rate (CFS)			Volume (Ac-Ft)		
Adj-Date	App-Date	Admin. No.	Order No.	Number	Absolute	Conditional	AP/EX	Absolute	Conditional	AP/EX
No available Data										



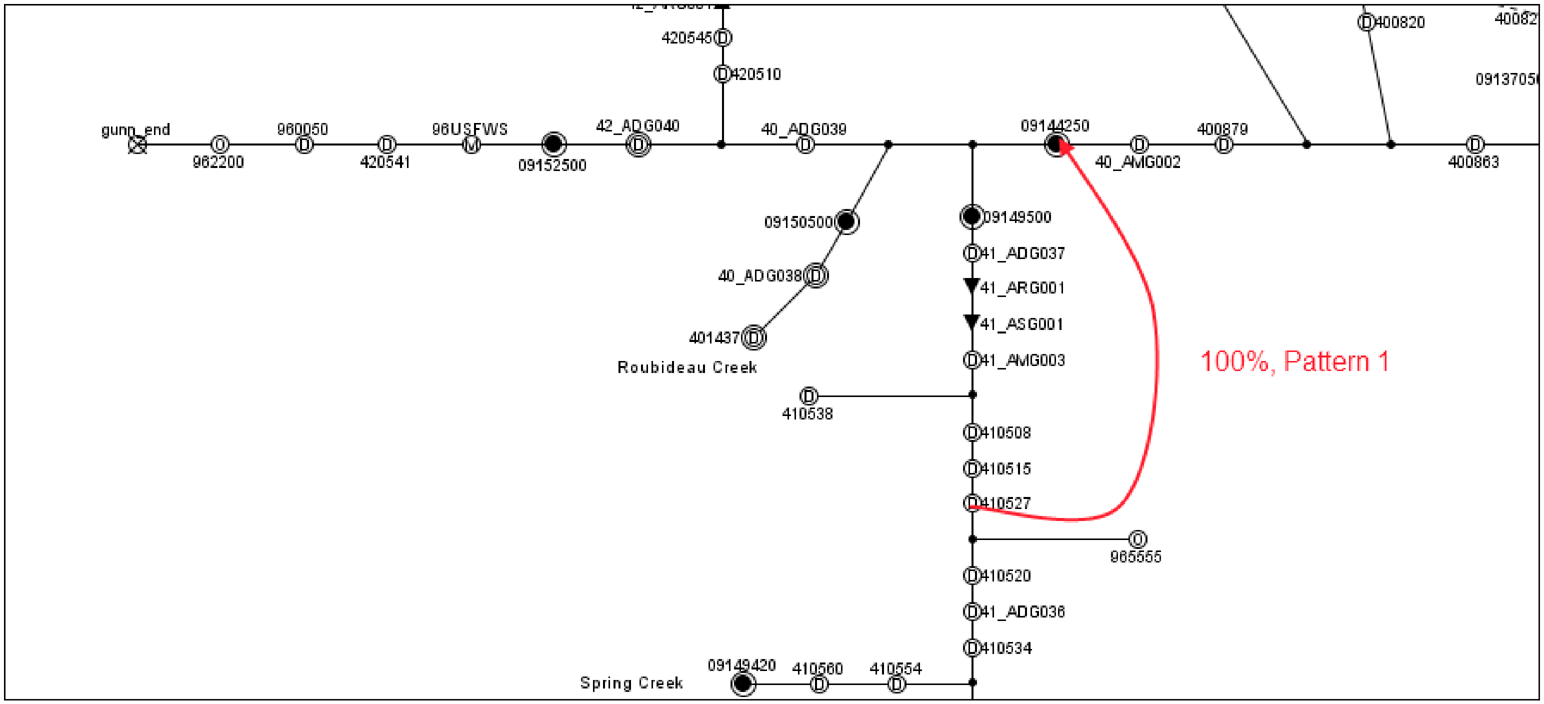
Annual Flows Through The Structure: West Canal
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
Flow (ac-ft)
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
Year


Monthly Flows Through The Structure: West Canal
Dry Year
Average Year
Wet Year
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
Flow (ac-ft)
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sept
Month

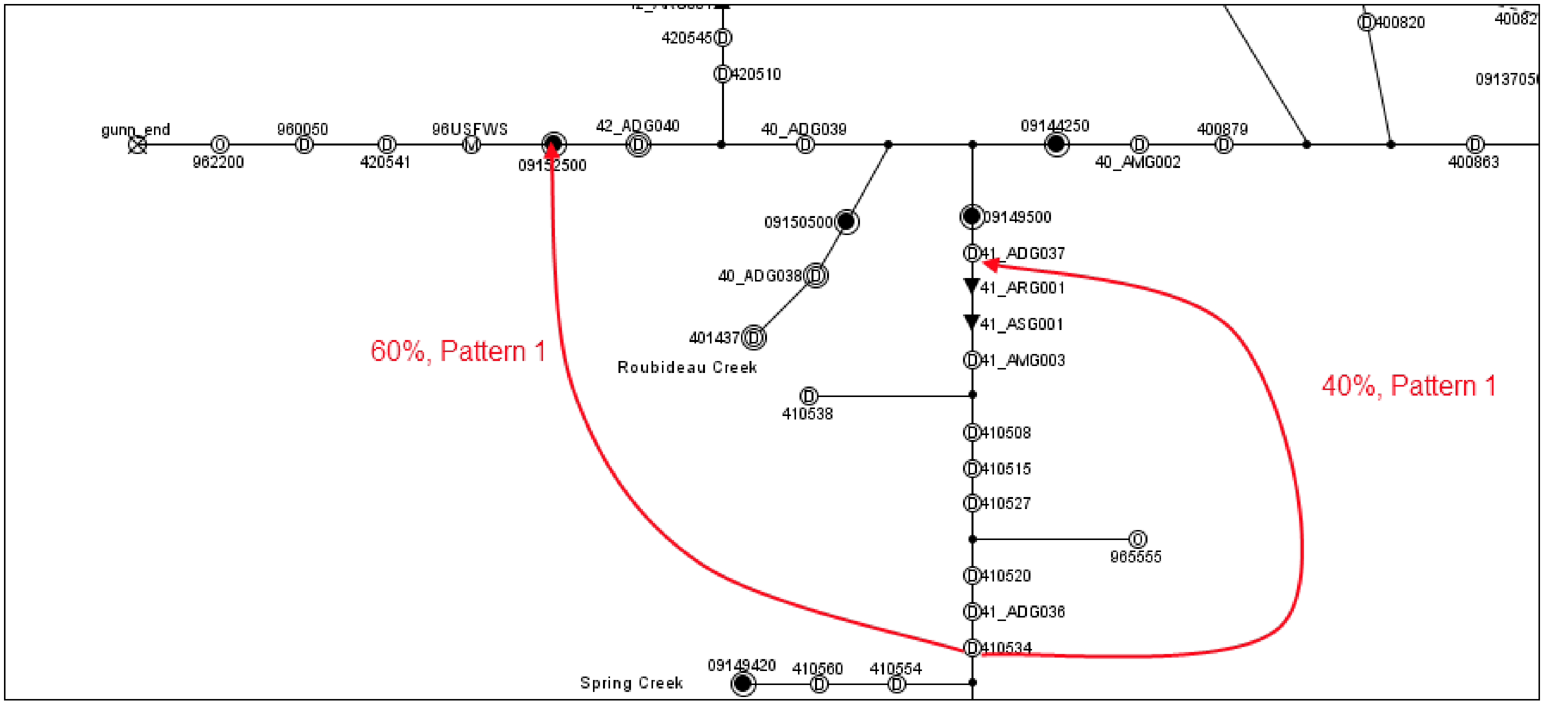

Monthly Return Flows (%) - Pattern 1
Return Flow Pattern (%)
80
70
60
50
40
30
20
10
0
1 2 3 4 5 6 7 8 9 10 11 12
Series1 75.6 11.3 3.2 2.2 1.6 1.2 0.8 0.6 0.5 0 0 0
Month (Month 1 = month of recharge)



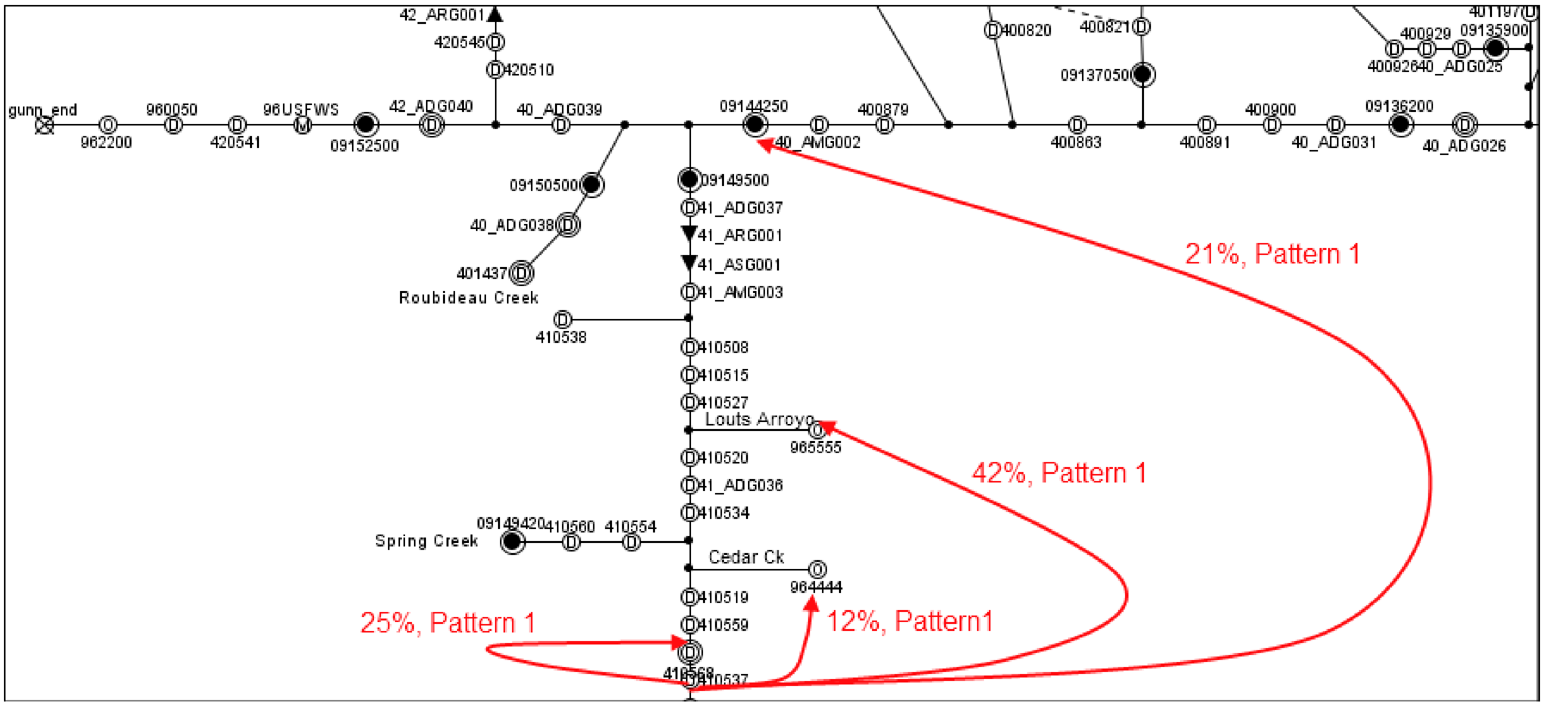
Pattern and Location of Return Flows – East Canal



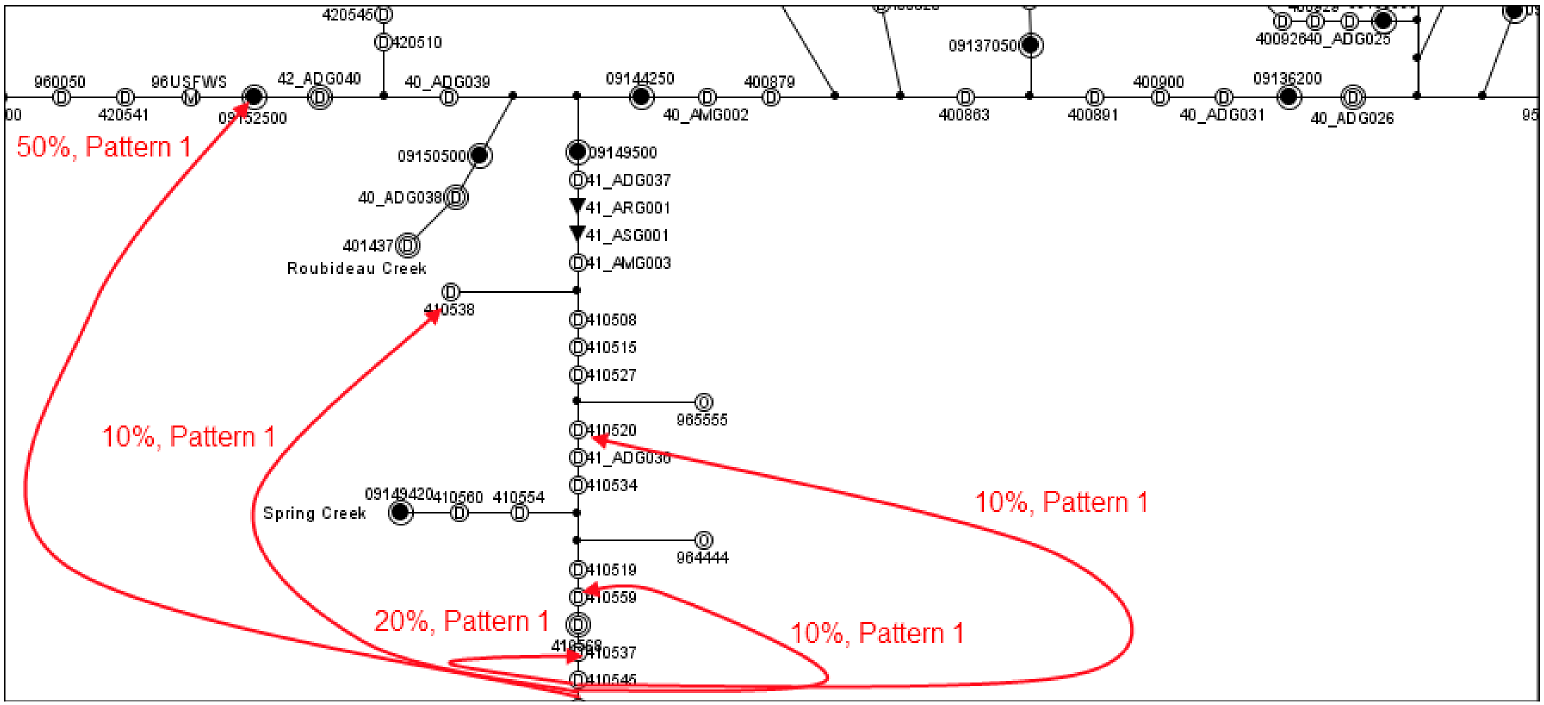
Pattern and Location of Return Flows – Garnet Ditch



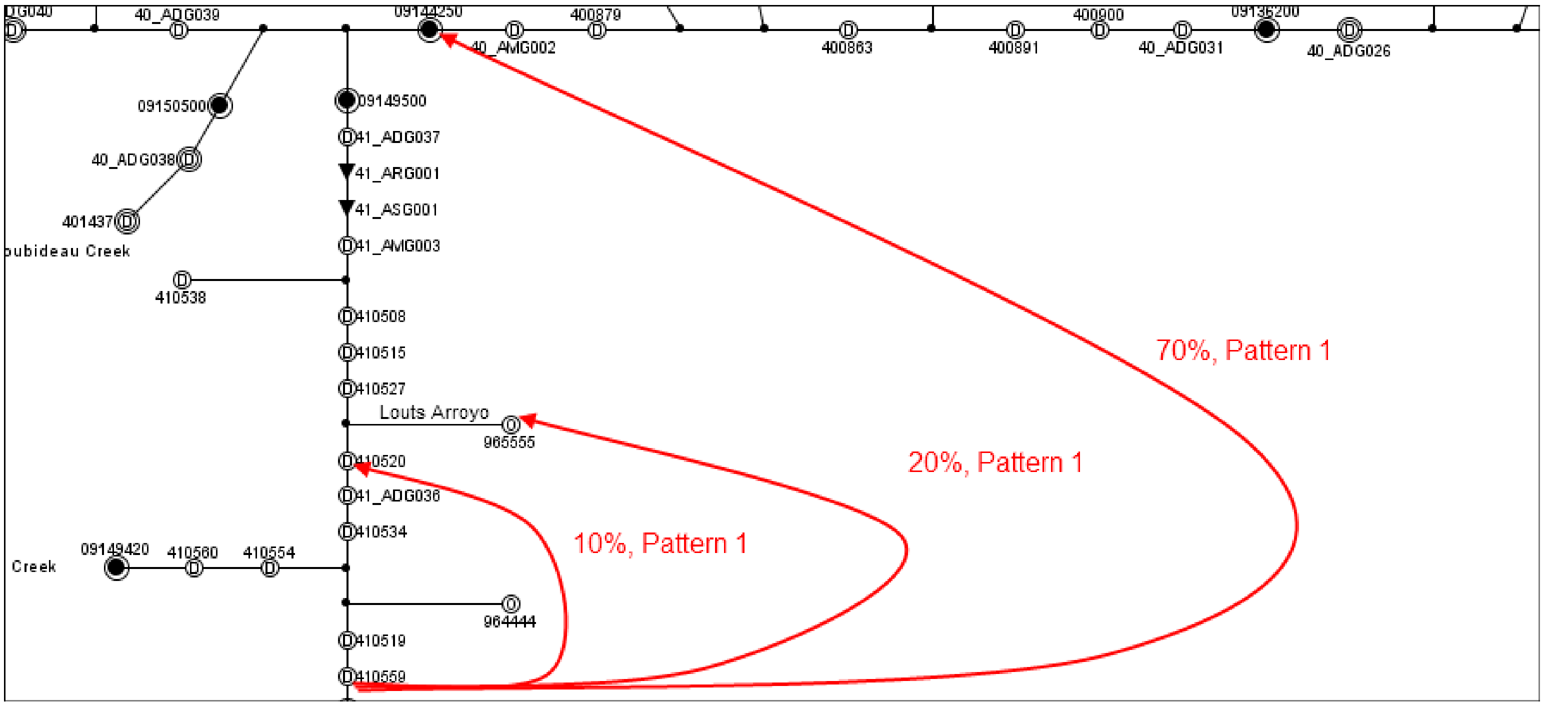
Pattern and Location of Return Flows – Ironstone Canal



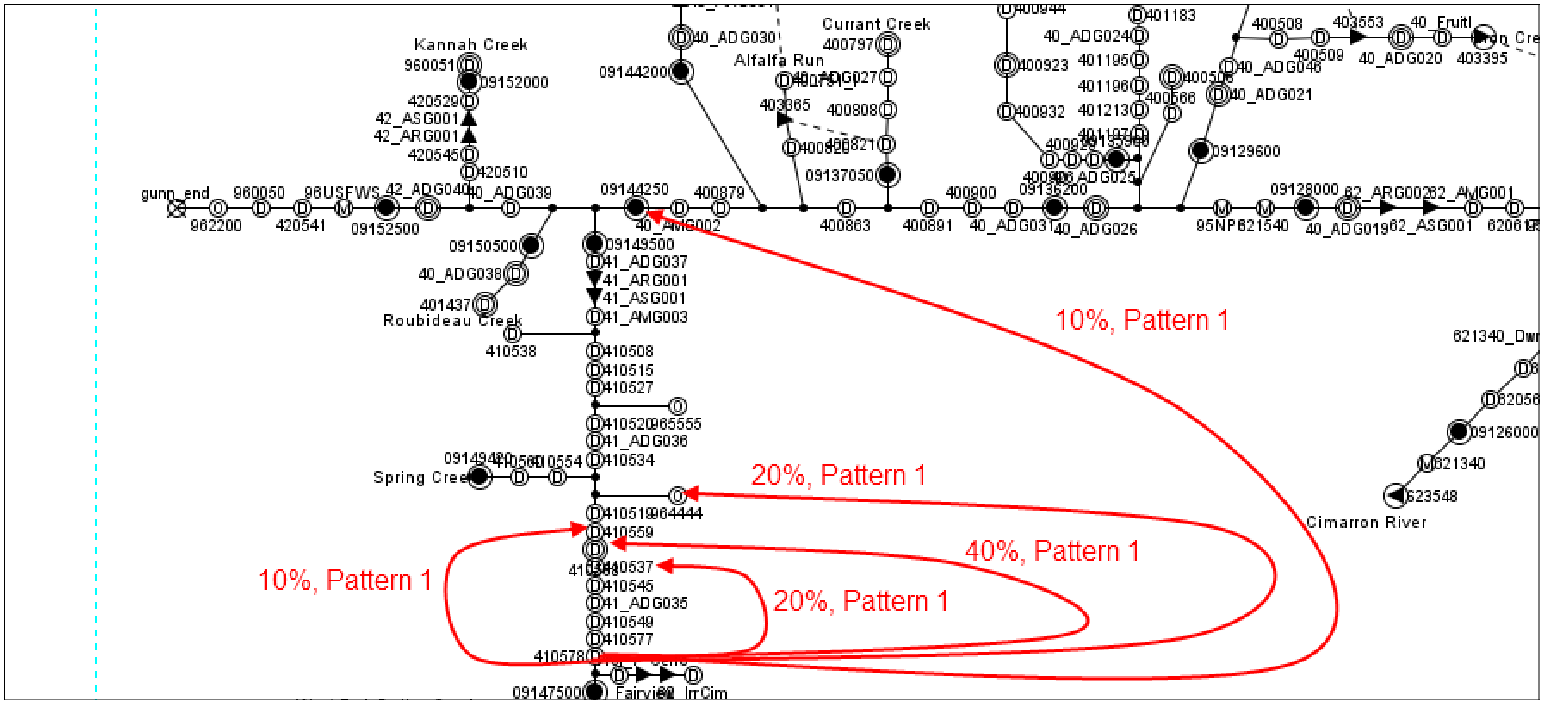
Pattern and Location of Return Flows – Loutsenhizer Canal



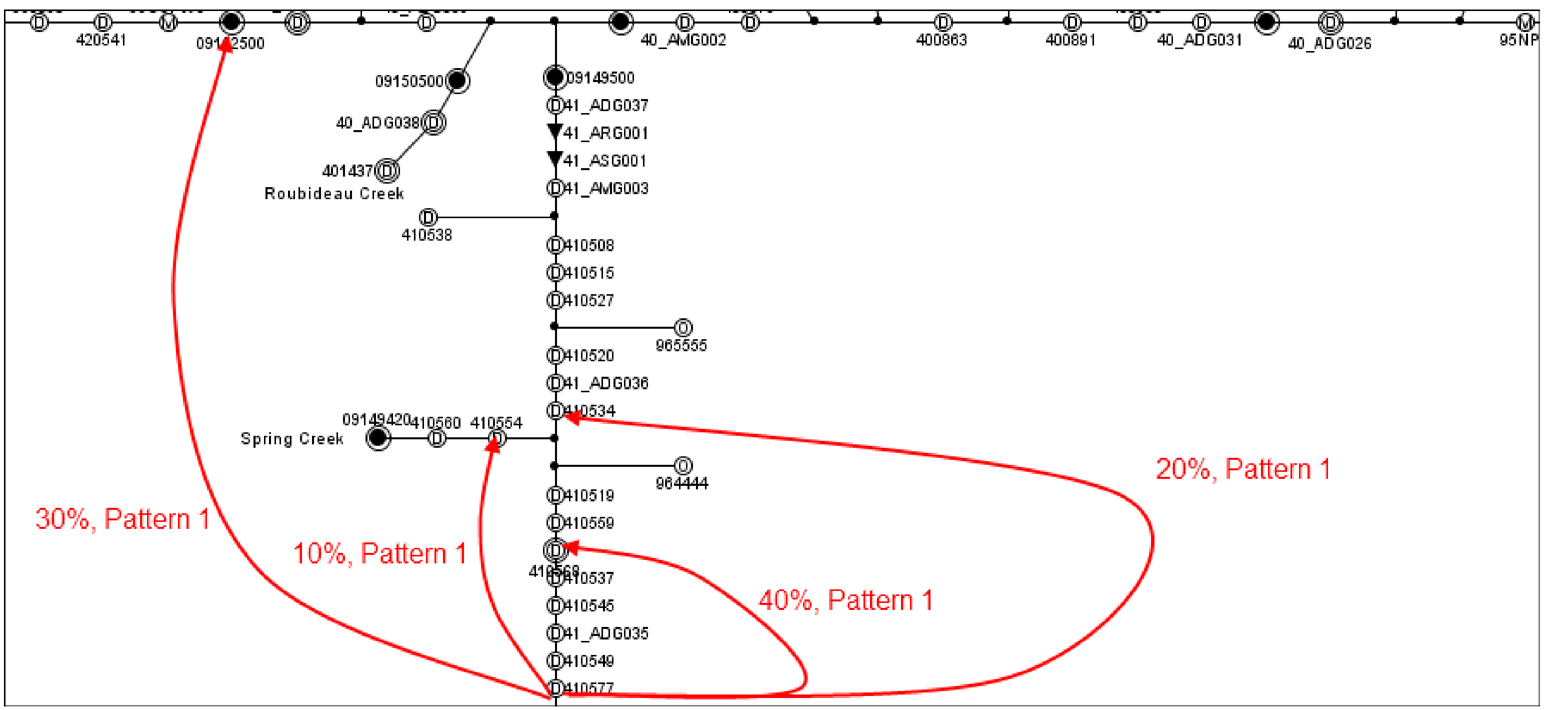
Pattern and Location of Return Flows – Montrose & Delta Canal



Pattern and Location of Return Flows – Selig Canal



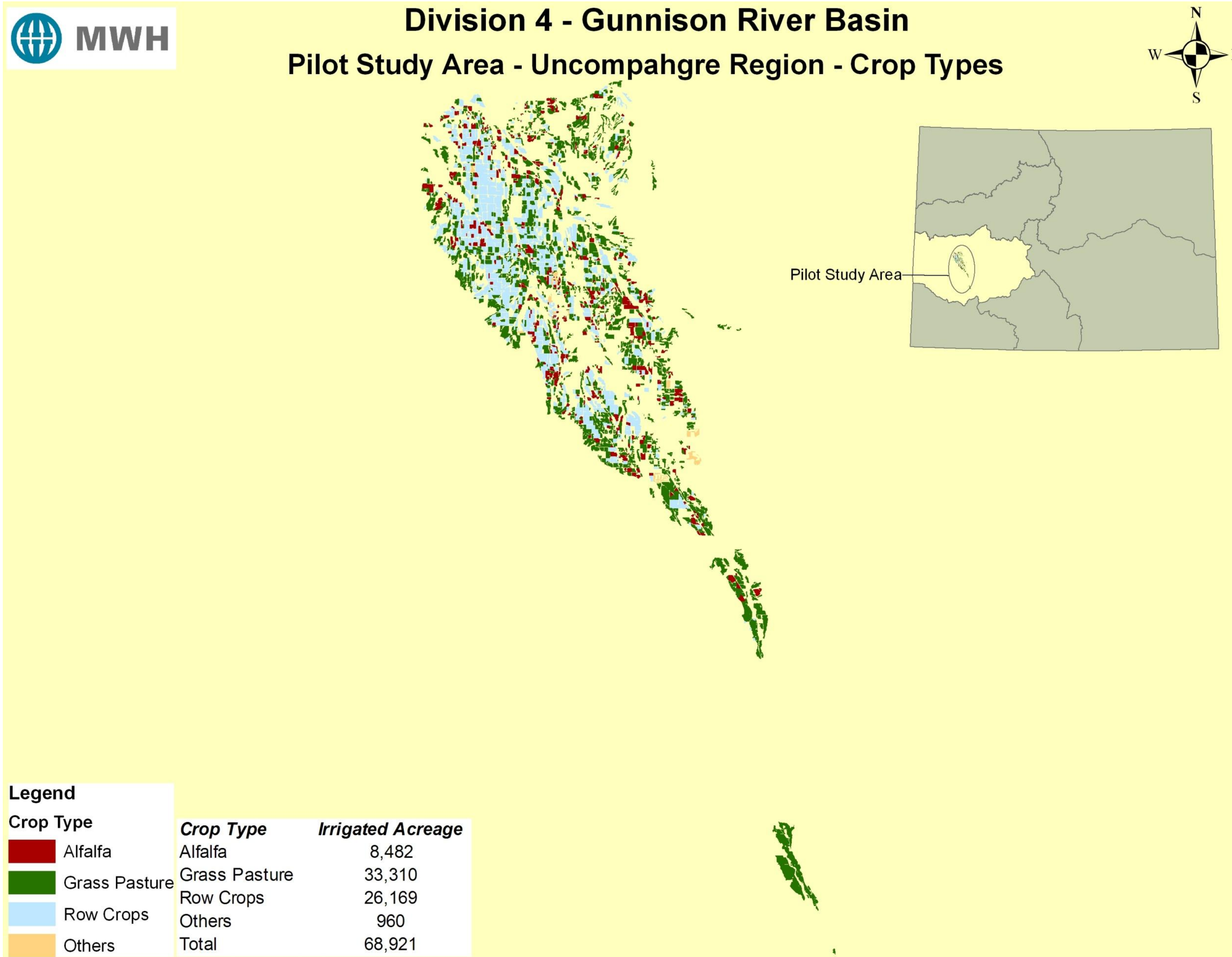
Pattern and Location of Return Flows – South Canal



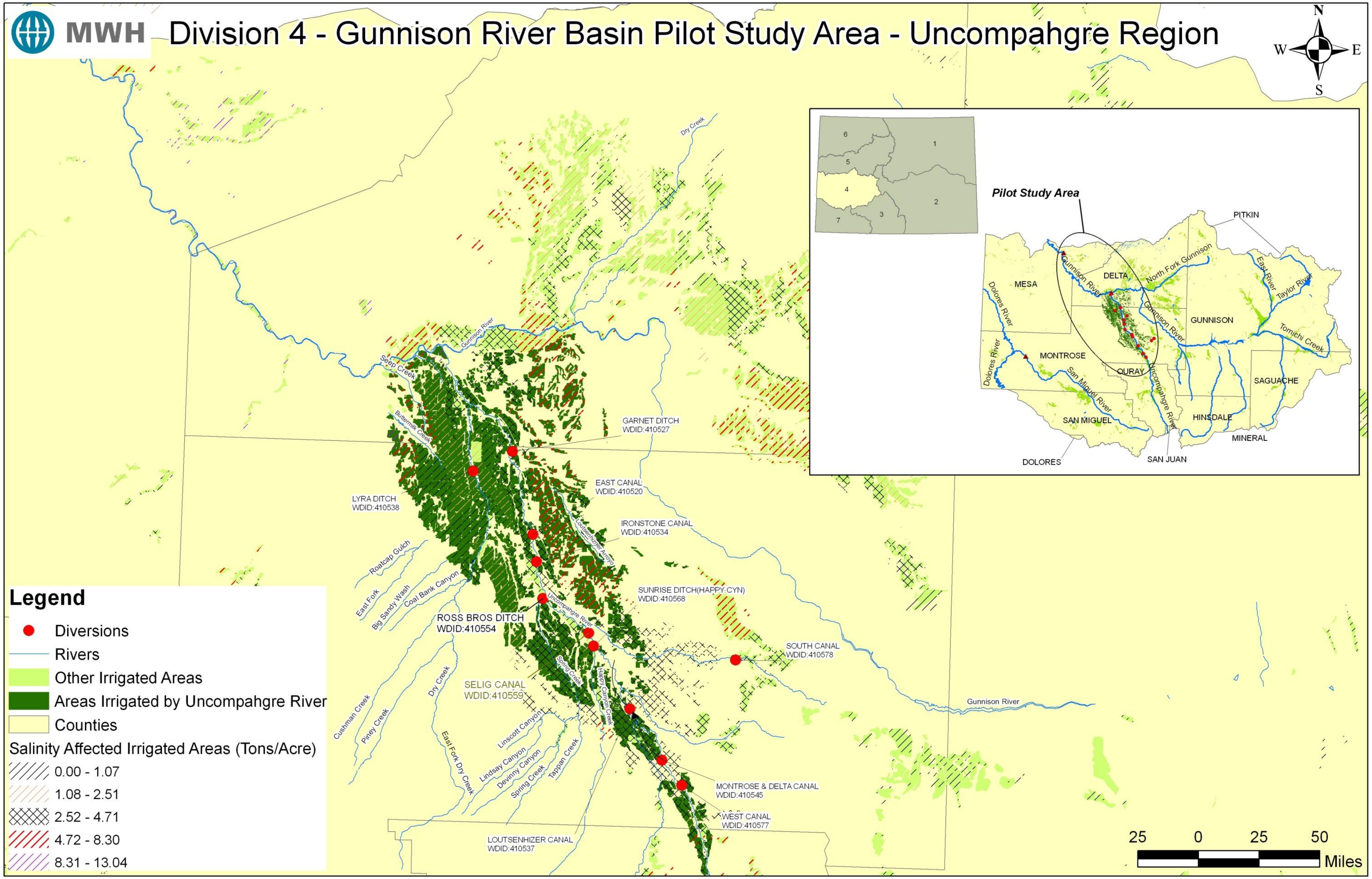
Pattern and Location of Return Flows – West Canal

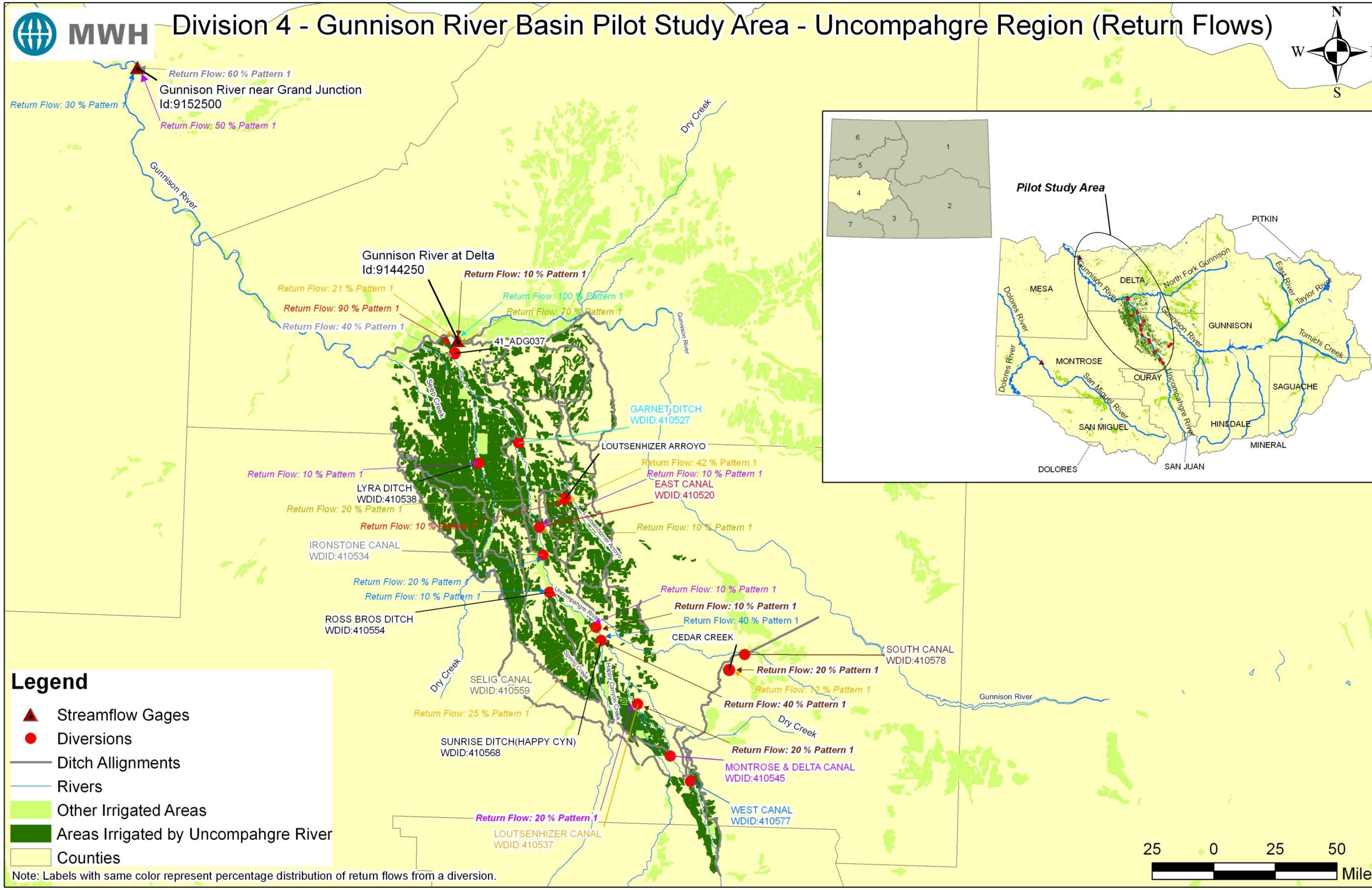
Division 4 - Gunnison River Basin

Pilot Study Area - Uncompahgre Region - Crop Types



Crop Type	*Irrigated Acreage*
Alfalfa	8,482
Grass Pasture	33,310
Row Crops	26,169
Others	960
Total	68,921


MWH
Division 4 - Gunnison River Basin Pilot Study Area - Uncompahgre Region
N
S
E
W
Pilot Study Area
PITKIN
DELTA
MESA
GUNNISON
MONTROSE
OURAY
SAGUACHE
SAN MIGUEL
HINSDALE
MINERAL
DOLORES
SAN JUAN
Gunnison River
North Fork Gunnison
East River
Taylor River
Tomichi Creek
Dolores River
San Miguel River
Uncompahgre River
GARNET DITCH
WDID:410527
EAST CANAL
WDID:410520
LYRA DITCH
WDID:410538
IRONSTONE CANAL
WDID:410534
SUNRISE DITCH(HAPPY CYN)
WDID:410568
ROSS BROS DITCH
WDID:410554
SOUTH CANAL
WDID:410578
SELIG CANAL
WDID:410559
MONTROSE & DELTA CANAL
WDID:410545
WEST CANAL
WDID:410577
LOUTSENHIZER CANAL
WDID:410537
Dry Creek
Roatcap Gulch
East Fork
Big Sandy Wash
Coal Bank Canyon
Cushman Creek
Piney Creek
East Fork Dry Creek
Linscott Canyon
Lindsay Canyon
Devinny Canyon
Spring Creek
Tappan Creek
Legend
Diversions
Rivers
Other Irrigated Areas
Areas Irrigated by Uncompahgre River
Counties
Salinity Affected Irrigated Areas (Tons/Acre)
0.00 - 1.07
1.08 - 2.51
2.52 - 4.71
4.72 - 8.30
8.31 - 13.04
25 0 25 50
Miles


MWH
Division 4 - Gunnison River Basin Pilot Study Area - Uncompahgre Region (Return Flows)
N
W
E
S
Return Flow: 60 % Pattern 1
Gunnison River near Grand Junction
Id:9152500
Return Flow: 30 % Pattern 1
Return Flow: 50 % Pattern 1
Gunnison River
Dry Creek
Gunnison River at Delta
Id:9144250
Return Flow: 10 % Pattern 1
Return Flow: 21 % Pattern 1
Return Flow: 100 % Pattern 1
Return Flow: 90 % Pattern 1
Return Flow: 70 % Pattern 1
Return Flow: 40 % Pattern 1
41_ADG037
Gunnison River
GARNET DITCH
WDID:410527
LOUTSENHIZER ARROYO
Return Flow: 42 % Pattern 1
Return Flow: 10 % Pattern 1
Return Flow: 10 % Pattern 1
EAST CANAL
WDID:410520
LYRA DITCH
WDID:410538
Return Flow: 20 % Pattern 1
Return Flow: 10 % Pattern 1
Return Flow: 10 % Pattern 1
IRONSTONE CANAL
WDID:410534
Return Flow: 20 % Pattern 1
Return Flow: 10 % Pattern 1
Return Flow: 10 % Pattern 1
Return Flow: 10 % Pattern 1
Return Flow: 40 % Pattern 1
ROSS BROS DITCH
WDID:410554
CEDAR CREEK
SOUTH CANAL
WDID:410578
Return Flow: 20 % Pattern 1
Return Flow: 12 % Pattern 1
Gunnison River
SELIG CANAL
WDID:410559
Return Flow: 25 % Pattern 1
Return Flow: 40 % Pattern 1
Dry Creek
SUNRISE DITCH(HAPPY CYN)
WDID:410568
Return Flow: 20 % Pattern 1
MONTROSE & DELTA CANAL
WDID:410545
WEST CANAL
WDID:410577
Return Flow: 20 % Pattern 1
LOUTSENHIZER CANAL
WDID:410537
Pilot Study Area
PITKIN
MESA
DELTA
North Fork Gunnison
East River
Taylor River
Dolores River
GUNNISON
Tomichi Creek
MONTROSE
OURAY
SAGUACHE
SAN MIGUEL
HINSDALE
MINERAL
DOLORES
SAN JUAN
Legend
Streamflow Gages
Diversions
Ditch Allignments
Rivers
Other Irrigated Areas
Areas Irrigated by Uncompahgre River
Counties
Note: Labels with same color represent percentage distribution of return flows from a diversion.
25 0 25 50
Miles

2012

MWH Global

[PILOT STUDY: CANDIDATE SYSTEM SELECTION]

Division 5 (Colorado River Basin): Grand Valley Irrigation Project

Structure Name: GRAND VALLEY PROJECT
Source: Colorado River

Q10 Q40 Q160 Section Twnshp Range PM
NW SE NW 13 10S 98W S

Water District: 72 Structure ID Number: 646

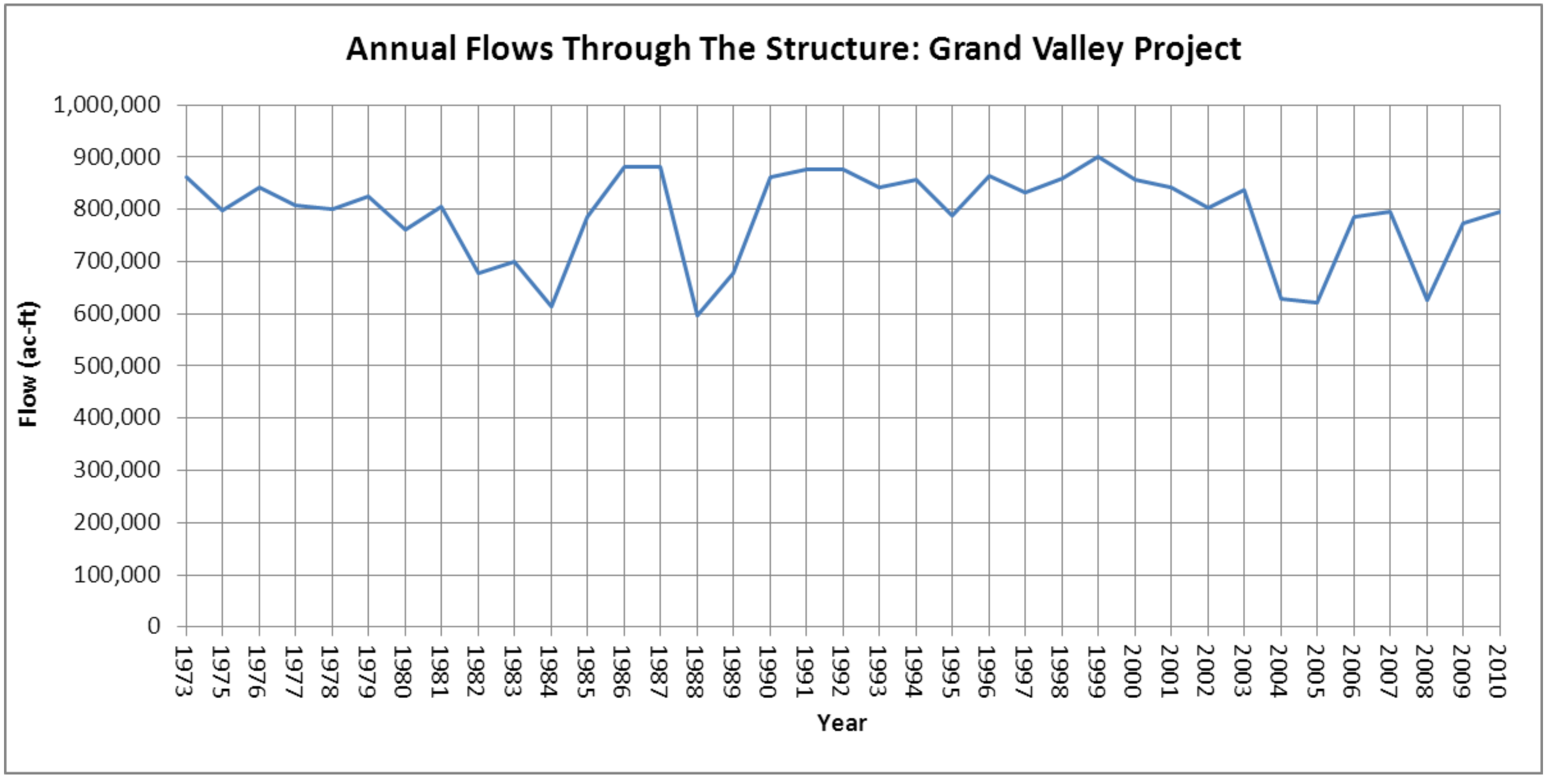
UTM Coordinates (NAD 83): Northing (UTM y): 4342863 Easting (UTM x): 216477.5
Spotted from PLSS distances from section lines

Water Rights Summary			
Parameter	Absolute	conditional	AP/EX
Total Decreed Rate(s) (CFS)	2313.70	0.00	40.00
Total Decreed Volume(s) (AF)	0.00	0.00	0.00

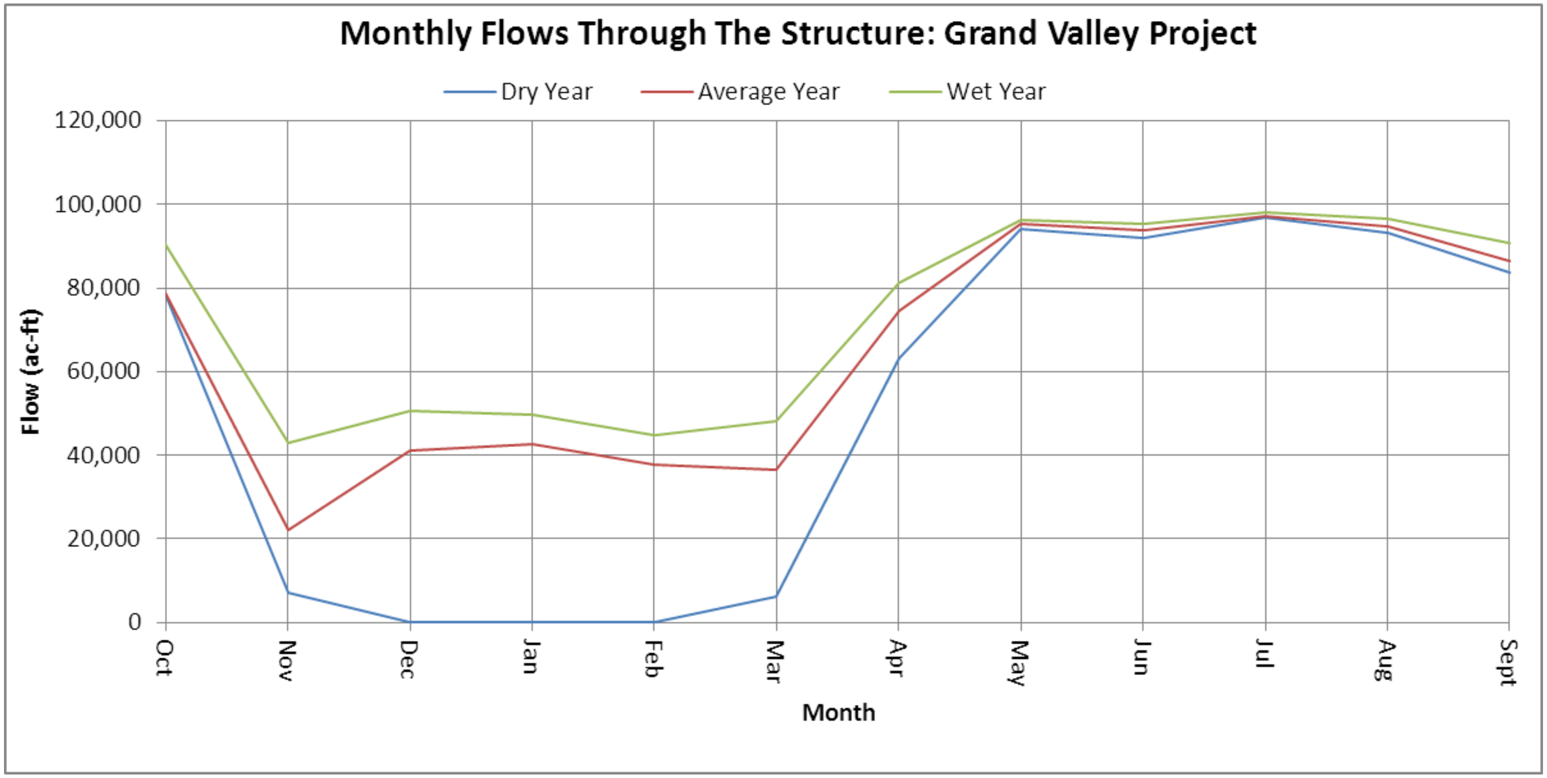
	Pre Compact
	Post compact

Water Rights - Transactions											
Case Number	Adj-Date	App-Date	Admin. No.	Order No.	Priority No.	Decreed Amt	Adj Type	Status Type	Transfer Type	Use	Action Comment
CA9529	7/22/1912	10/1/1889	22729.15	0.00		80.00	S	A	TT	IRR	80.00 CFS TRANS FROM PALISADE DI OR DG 6/19/1953 CA9529
86CW0091	7/22/1912	10/1/1900	22729.19	0.00		10.20	S	A	TT	IRR	TRANS FROM ID612 PALISADE IRR DIST
84CW0066	7/22/1912	7/6/1903	22729.20	0.00		40.00	S	A		IRR	
CA5812	7/22/1912	10/25/1907	22729.21	0.00		75.00	S	A	TT	IRR	TRANSFERRED FROM ID813 ORCHARD MESA IRR DIS SYS
CA5812	7/22/1912	10/25/1907	22729.21	0.00		55.00	S	A	TT	IRR	TRANSFERRED FROM ID813 ORCHARD MESA IRR DIS SYS
CA5812	7/22/1912	10/25/1907	22729.21	0.00		195.00	S	A	TT	IRR	TRANSFERRED FROM ID813 ORCHARD MESA IRR DIS SYS
CA5812	7/22/1912	10/25/1907	22729.21	0.00		50.00	S	A	TT	IRR	TRANSFERRED FROM ID813 ORCHARD MESA IRR DIS SYS
CA5812	7/22/1912	10/25/1907	22729.21	0.00		75.00	S	A	TT	IRRIND	TRANSFERRED FROM ID813 ORCHARD MESA IRR DIS SYS
CA1927	7/22/1912	2/27/1908	22729.21	0.00		730.00	S	C		IRR	
CA5812	7/22/1912	2/27/1908	22729.21	0.00		730.00	S	CA		IRR	730.00 CFS MADE ABS 9/25/1941
CA5812	7/25/1941	2/27/1908	30895.21	0.00		220.00	S	A		DOM	LIMITED TO NON IRRIGATING SEASON
CA5812	7/25/1941	2/27/1908	30895.21	0.00		800.00	S	A		COM	LIMITED TO 400 DURING THE IRRIGATION SEASON
CA5812	7/25/1941	6/1/1918	30895.25	0.00		23.50	S	A	TT	IRR	TRANSFERRED FROM ID817 PALISADE IRR DIST

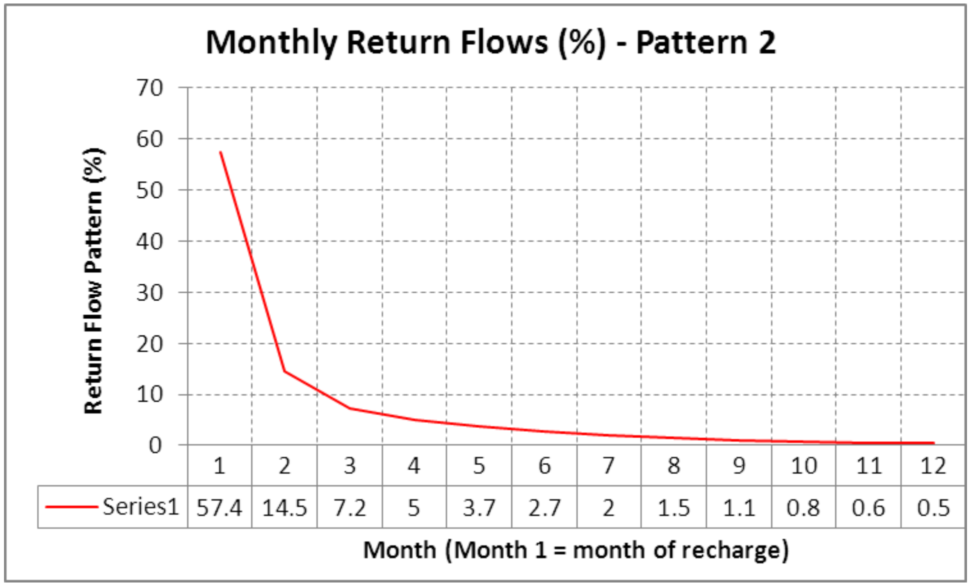
Water Rights - Net Amounts										
				Priority/Case	Rate (CFS)			Volume (Ac-Ft)		
Adj-Date	App-Date	Admin. No.	Order No.	Number	Absolute	Conditional	AP/EX	Absolute	Conditional	AP/EX
7/22/1912	10/1/1889	22729.15	0.00	CA9529	80.00	0.00	0.00	0.00	0.00	0.00
7/22/1912	10/1/1900	22729.19	0.00	86CW0091	10.20	0.00	0.00	0.00	0.00	0.00
7/22/1912	7/6/1903	22729.20	0.00	84CW0066	0.00	0.00	40.00	0.00	0.00	0.00
7/22/1912	10/25/1907	22729.21	0.00	CA5812	450.00	0.00	0.00	0.00	0.00	0.00
7/22/1912	2/27/1908	22729.21	0.00	CA5812	730.00	0.00	0.00	0.00	0.00	0.00
7/25/1941	2/27/1908	30895.21	0.00	CA5812	1020.00	0.00	0.00	0.00	0.00	0.00
7/25/1941	6/1/1918	30895.25	0.00	CA5812	23.50	0.00	0.00	0.00	0.00	0.00

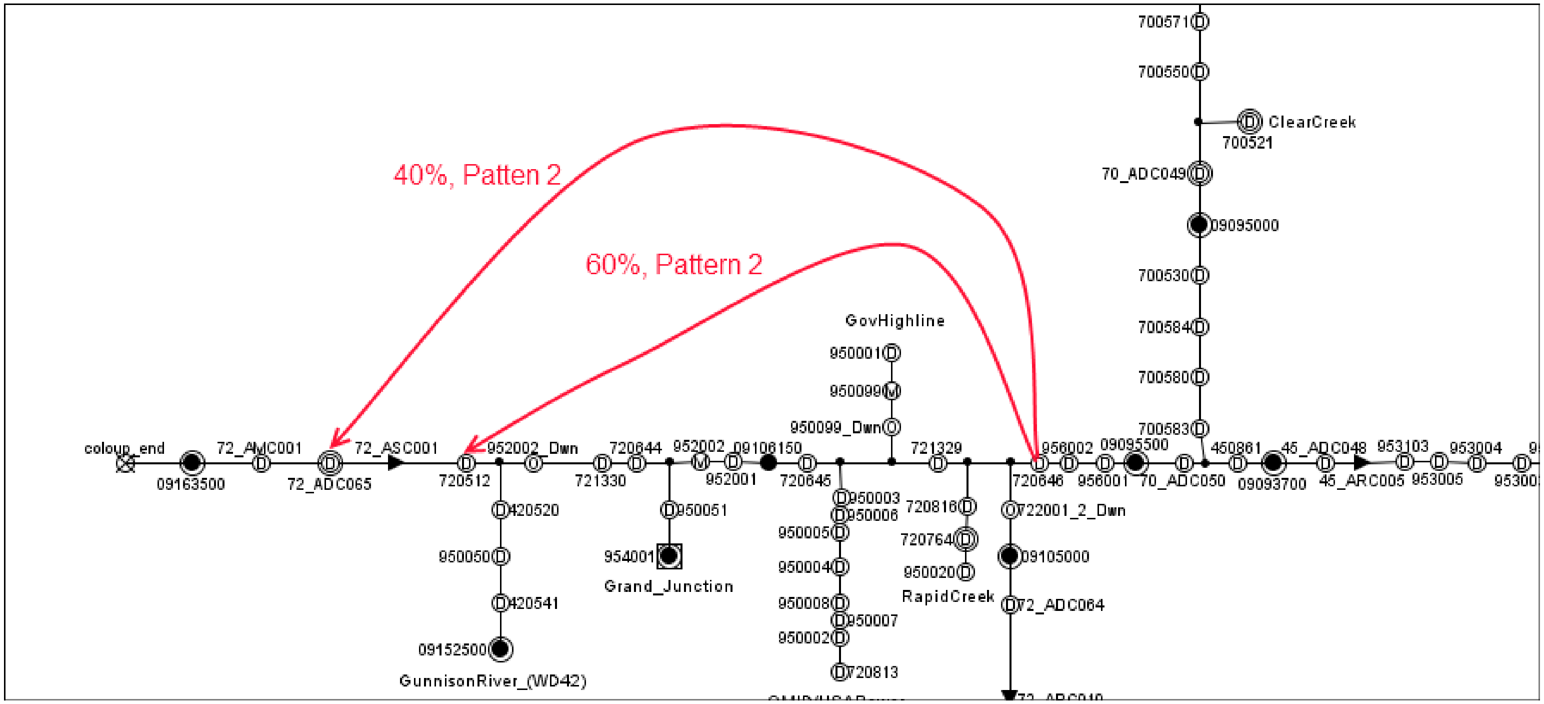


Annual Flows Through The Structure: Grand Valley Project
Flow (ac-ft)
1,000,000
900,000
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
1973
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Year

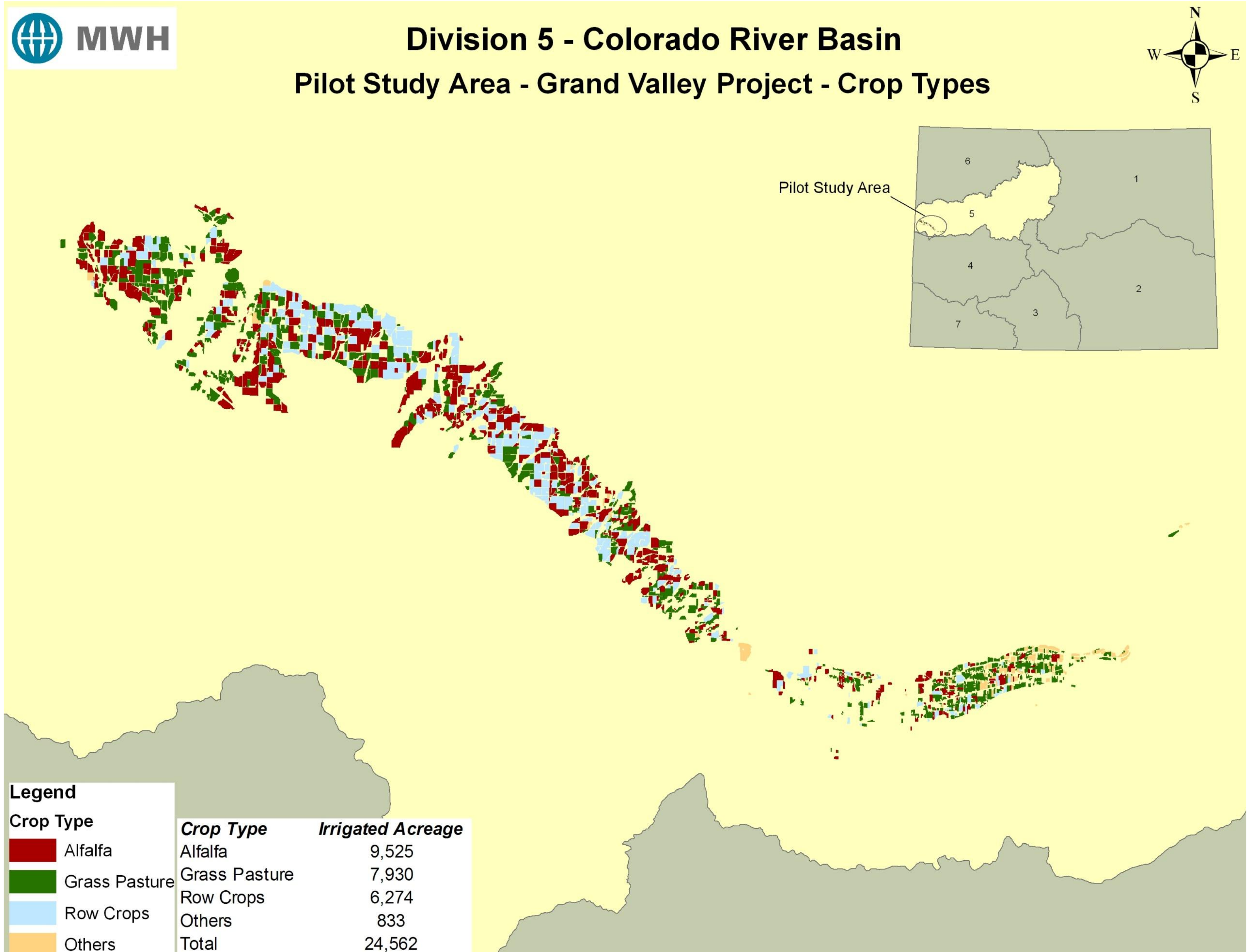


Note: Based on the available monthly flow dataset for the structure annual values were computed and the top and bottom 10% values in terms of magnitude were used to select the wet and the dry years while the rest of years were considered as representatives of average years. Monthly averages were computed based on those years and were used to generate the monthly plots.

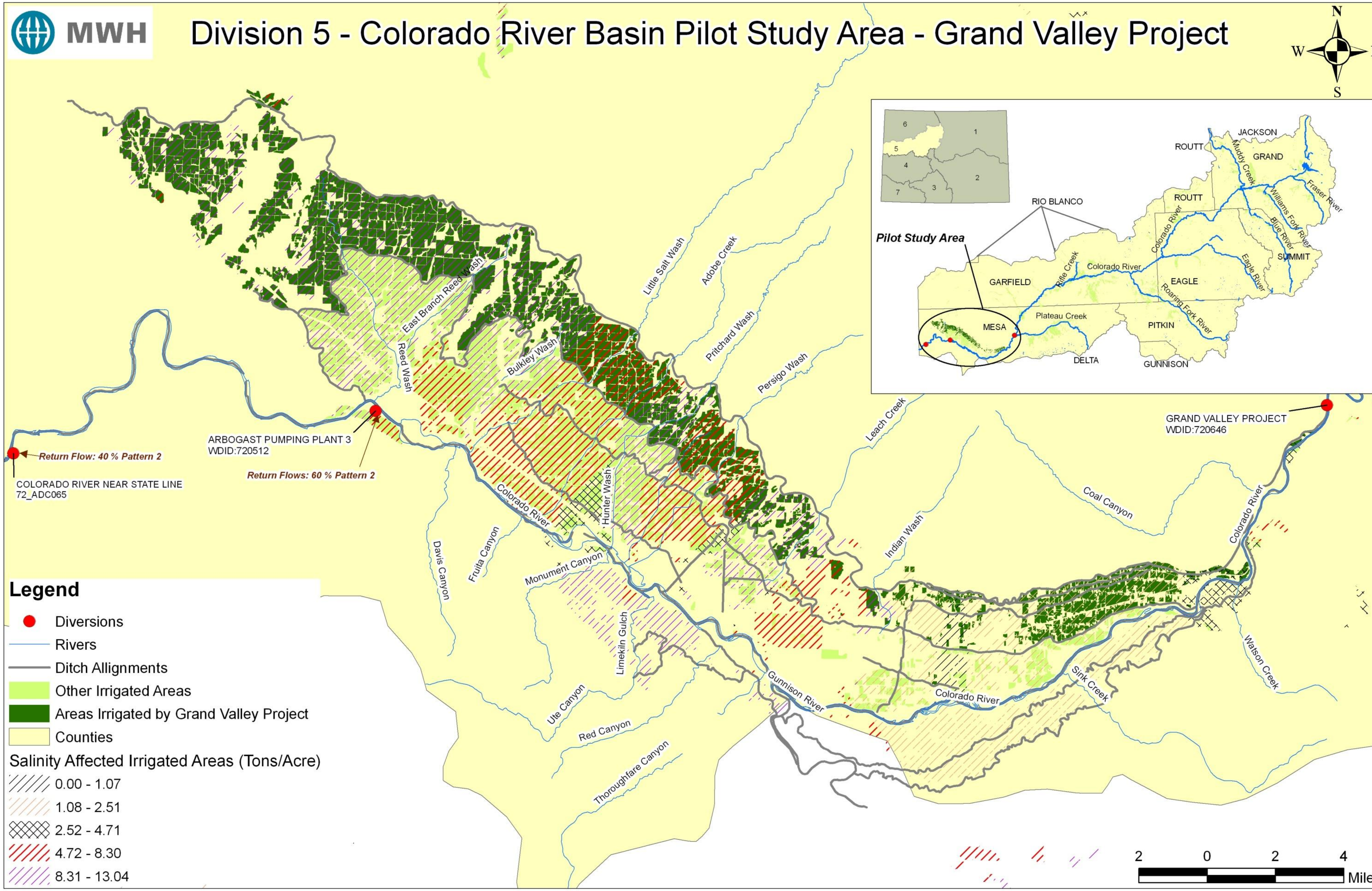

Monthly Return Flows (%) - Pattern 2
Return Flow Pattern (%)
70
60
50
40
30
20
10
0
1 2 3 4 5 6 7 8 9 10 11 12
Series1 57.4 14.5 7.2 5 3.7 2.7 2 1.5 1.1 0.8 0.6 0.5
Month (Month 1 = month of recharge)



Patterns and Locations of Return Flow



Crop Type	Irrigated Acreage
Alfalfa	9,525
Grass Pasture	7,930
Row Crops	6,274
Others	833
Total	24,562


MWH
Division 5 - Colorado River Basin Pilot Study Area - Grand Valley Project
N
W
E
S
Pilot Study Area
RIO BLANCO
GARFIELD
MESA
DELTA
GUNNISON
PITKIN
EAGLE
SUMMIT
ROUTT
JACKSON
GRAND
Colorado River
Plateau Creek
Rifle Creek
Roaring Fork River
Eagle River
Blue River
Williams Fork River
Fraser River
Muddy Creek
GRAND VALLEY PROJECT
WDID:720646
ARBOGAST PUMPING PLANT 3
WDID:720512
Return Flow: 40 % Pattern 2
Return Flows: 60 % Pattern 2
COLORADO RIVER NEAR STATE LINE
72_ADC065
East Branch Reed Wash
Reed Wash
Bulkley Wash
Little Salt Wash
Adobe Creek
Pritchard Wash
Persigo Wash
Leach Creek
Indian Wash
Coal Canyon
Hunter Wash
Colorado River
Davis Canyon
Fruita Canyon
Monument Canyon
Limekiln Gulch
Ute Canyon
Red Canyon
Thoroughfare Canyon
Gunnison River
Sink Creek
Watson Creek
Legend
Diversions
Rivers
Ditch Allignments
Other Irrigated Areas
Areas Irrigated by Grand Valley Project
Counties
Salinity Affected Irrigated Areas (Tons/Acre)
0.00 - 1.07
1.08 - 2.51
2.52 - 4.71
4.72 - 8.30
8.31 - 13.04
2 0 2 4
Miles

2012

MWH Global

[PILOT STUDY: CANDIDATE SYSTEM SELECTION]

Division 5 (Colorado River Basin): Grand Valley Irrigation Company

Structure Name: GRAND VALLEY CANAL
Source: Colorado River

Q10 Q40 Q160 Section Twnshp Range PM
NE SE NE 3 1S 2E U

Water District: 72 Structure ID Number: 645

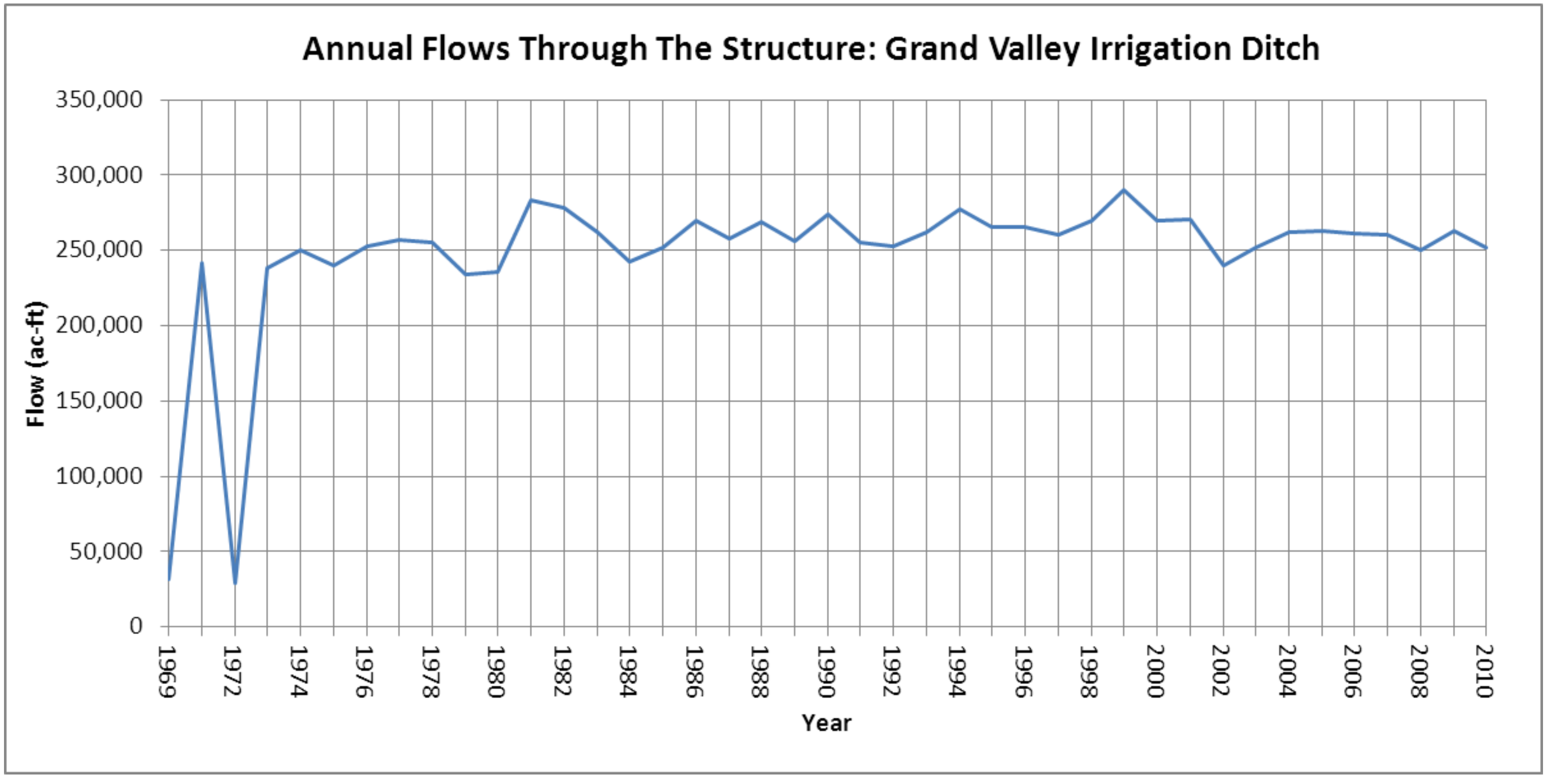
UTM Coordinates (NAD 83): Northing (UTM y): 4333370 Easting (UTM x): 210278.6
Spotted from PLSS distances from section lines

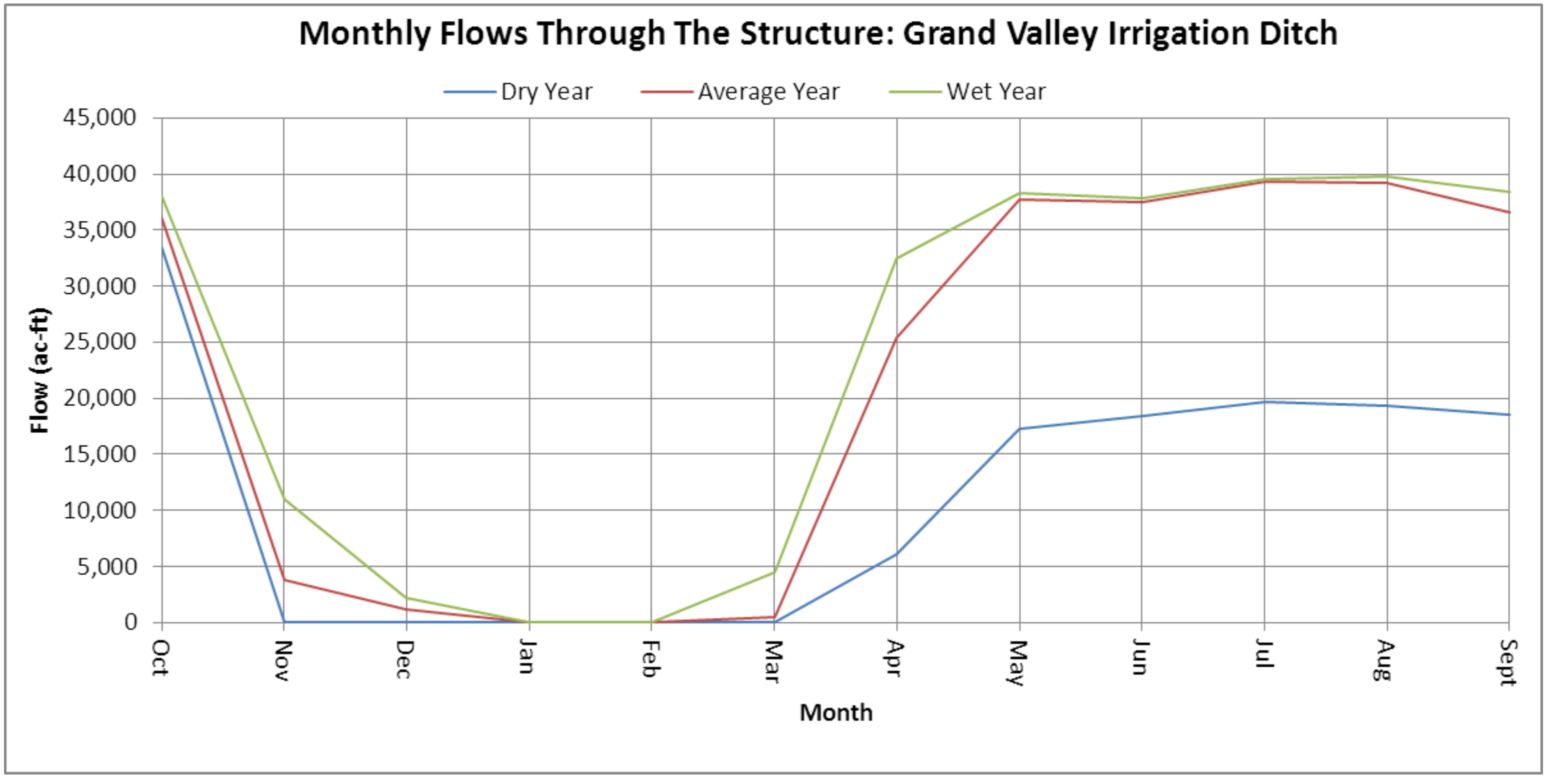
Water Rights Summary			
Parameter	Absolute	conditional	AP/EX
Total Decreed Rate(s) (CFS)	940.28	0.00	104.00
Total Decreed Volume(s) (AF)	0.00	0.00	0.00

	Pre Compact
	Post compact

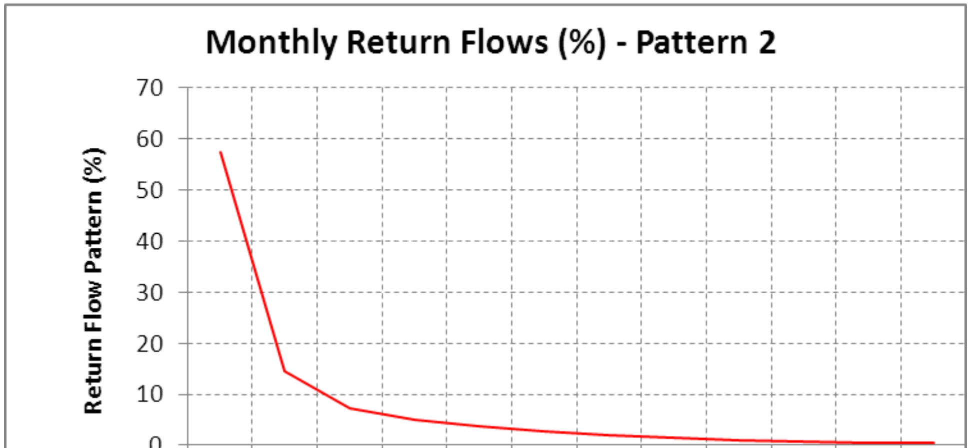
Water Rights - Transactions											
Case Number	Adj-Date	App-Date	Admin. No.	Order No.	Priority No.	Decreed Amt	Adj Type	Status Type	Transfer Type	Use	Action Comment
85CW0235	7/22/1912	8/22/1882	22729.1192	0	1	13.53	S	A	TF	IRR	MAY REDUCE CALL BY DIFF OF ACTUAL CLIFTON DIVR AND 13.53CFS
85CW0235	7/22/1912	8/22/1882	22729.1192	0	1	13.53	S	A	TT	IRRMUNIND	LIMIT 2618AF TOTAL DIVR APRIL-OCT SEE DECREE FOR MONTHLY LIMITS
CA1927	7/22/1912	8/22/1882	22729.1192	0		520.81	S	A		IRR	
CA5812	7/25/1941	8/22/1882	30895.1192	0		300	S	A		DOM	LIMITED TO NON IRRIGATING SEASON
84CW0218	7/25/1941	4/26/1914	30895.2349	0		75.86	S	C		IRR	
CA5812	7/25/1941	4/26/1914	30895.2349	0		119.47	S	A		IRR	
CA5812	7/25/1941	4/26/1914	30895.2349	0		75.86	S	C		IRR	
W3532	7/21/1959	2/17/1947	35476	0		100	S	A		MUNINDDOM	DIVERSION PT NO 2
84CW0414	7/21/1959	3/17/1947	35504	0		4	S	A		IRRMUNDOM	AKA L H HURT PUMP ALT NO 4

Water Rights - Net Amounts										
				Priority/Case	Rate (CFS)			Volume (Ac-Ft)		
Adj-Date	App-Date	Admin. No.	Order No.	Number	Absolute	Conditional	AP/EX	Absolute	Conditional	AP/EX
7/22/1912	8/22/1882	22729.11922	0	1	520.81	0	0	0	0	0
7/25/1941	8/22/1882	30895.11922	0	CA5812	300	0	0	0	0	0
7/25/1941	4/26/1914	30895.23491	0	CA5812	119.47	0	0	0	0	0
7/21/1959	2/17/1947	35476	0	W3532	0	0	100	0	0	0
7/21/1959	3/17/1947	35504	0	84CW0414	0	0	4	0	0	0

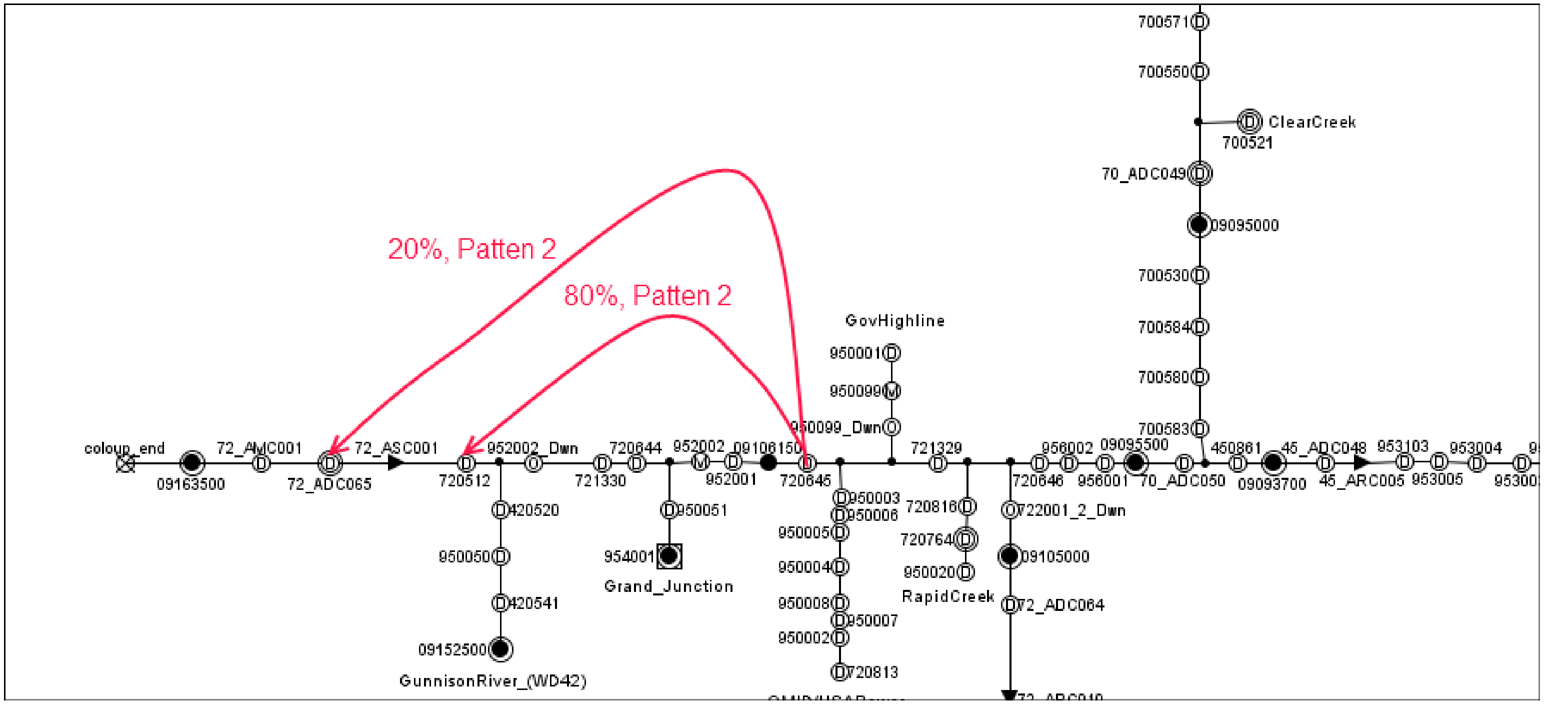

Annual Flows Through The Structure: Grand Valley Irrigation Ditch
Flow (ac-ft)
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
1969
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
Year



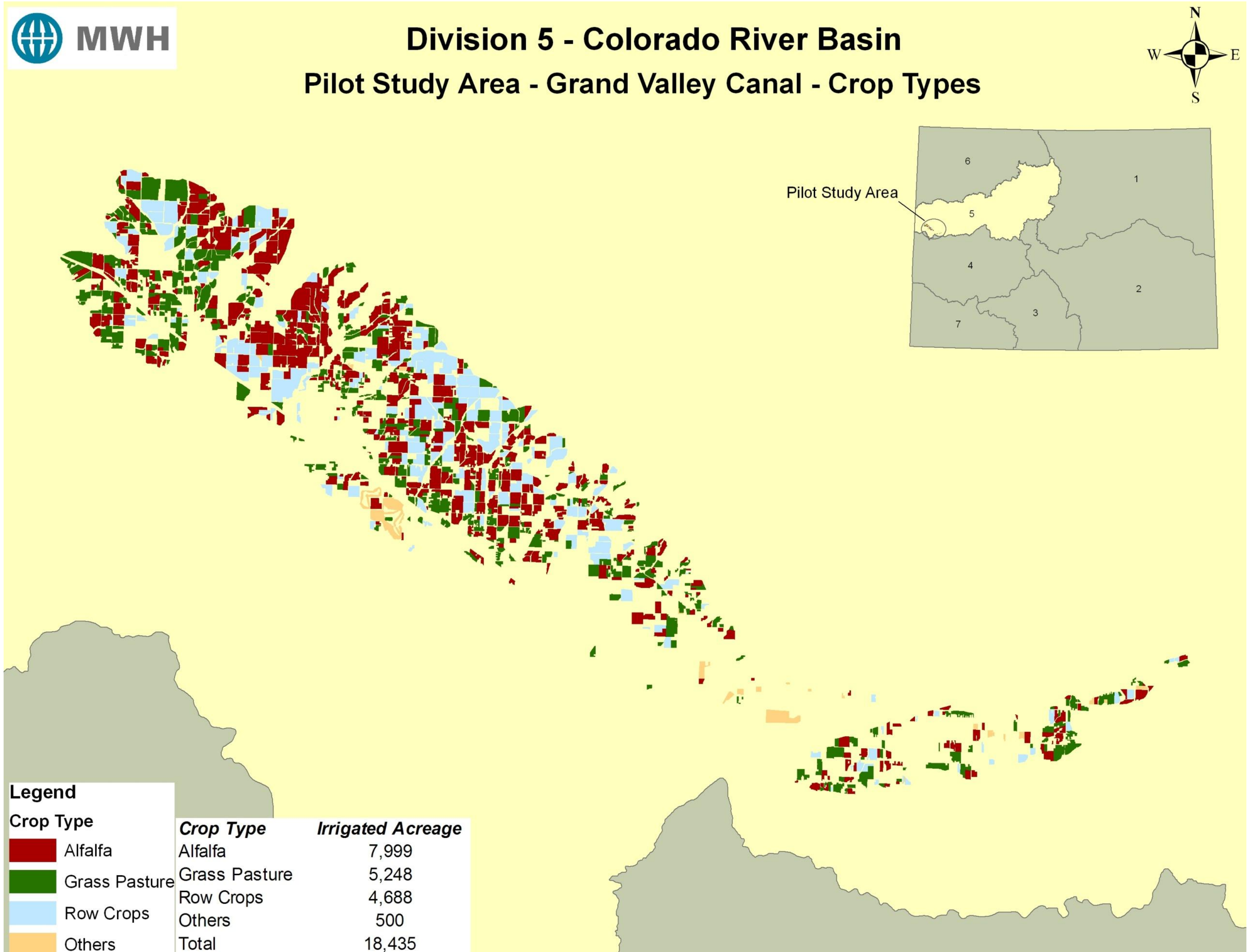
Note: Based on the available monthly flow dataset for the structure annual values were computed and the top and bottom 10% values in terms of magnitude were used to select the wet and the dry years while the rest of years were considered as representatives of average years. Monthly averages were computed based on those years and were used to generate the monthly plots.



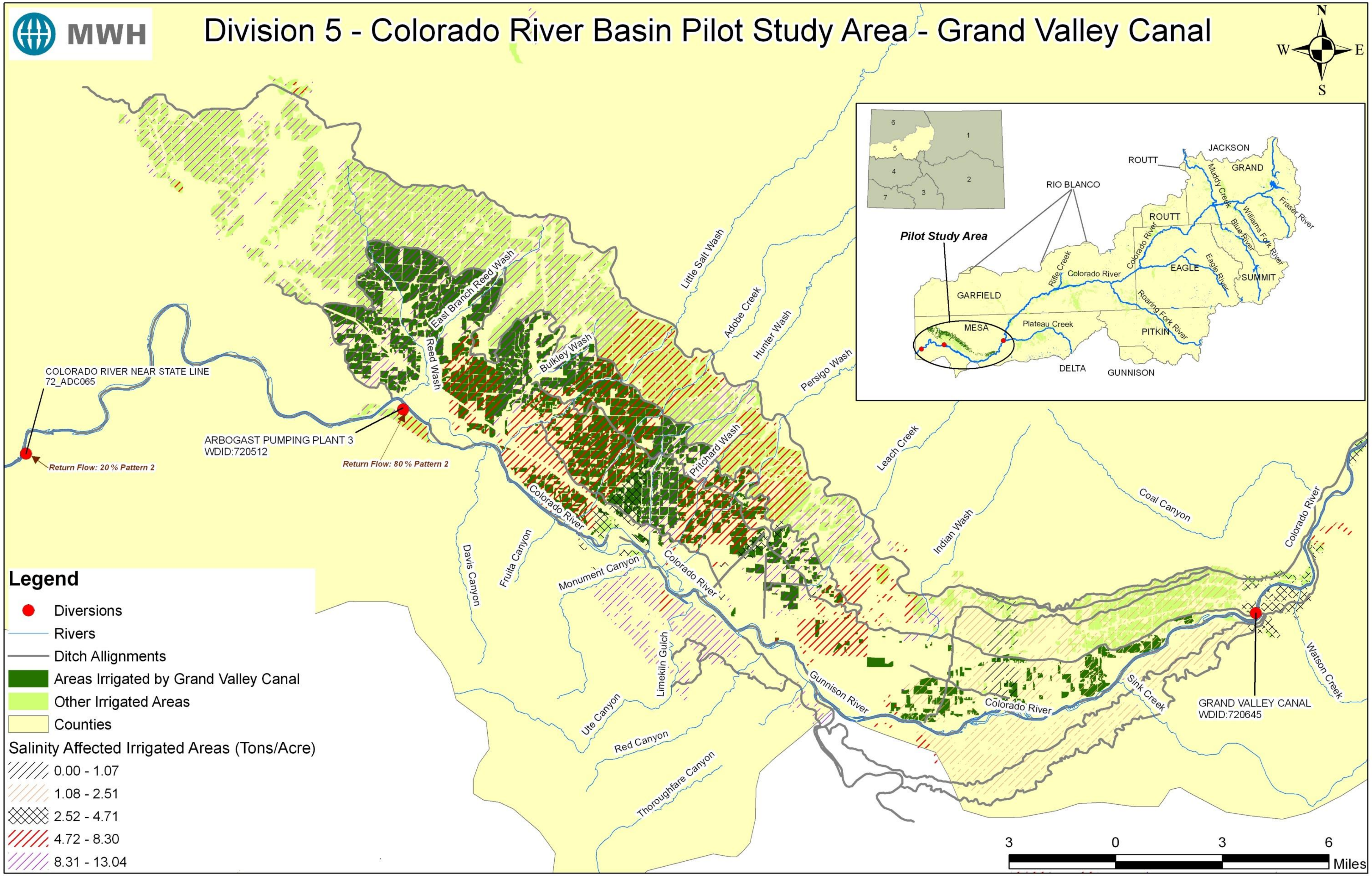
	1	2	3	4	5	6	7	8	9	10	11	12
Series1	57.4	14.5	7.2	5	3.7	2.7	2	1.5	1.1	0.8	0.6	0.5



Patterns and Locations of Return Flow



Crop Type	Irrigated Acreage
Alfalfa	7,999
Grass Pasture	5,248
Row Crops	4,688
Others	500
Total	18,435


MWH
Division 5 - Colorado River Basin Pilot Study Area - Grand Valley Canal
N
W
E
S
COLORADO RIVER NEAR STATE LINE
72_ADC065
Return Flow: 20 % Pattern 2
ARBOGAST PUMPING PLANT 3
WDID:720512
Return Flow: 80 % Pattern 2
GRAND VALLEY CANAL
WDID:720645
East Branch Reed Wash
Reed Wash
Bulkley Wash
Little Salt Wash
Adobe Creek
Hunter Wash
Persigo Wash
Pritchard Wash
Leach Creek
Indian Wash
Coal Canyon
Colorado River
Watson Creek
Sink Creek
Gunnison River
Davis Canyon
Fruita Canyon
Monument Canyon
Limekiln Gulch
Ute Canyon
Red Canyon
Thoroughfare Canyon
Pilot Study Area
RIO BLANCO
ROUTT
JACKSON
GRAND
GARFIELD
MESA
EAGLE
SUMMIT
PITKIN
DELTA
GUNNISON
Rifle Creek
Plateau Creek
Muddy Creek
Blue River
Williams Fork River
Fraser River
Eagle River
Roaring Fork River
Legend
Diversions
Rivers
Ditch Allignments
Areas Irrigated by Grand Valley Canal
Other Irrigated Areas
Counties
Salinity Affected Irrigated Areas (Tons/Acre)
0.00 - 1.07
1.08 - 2.51
2.52 - 4.71
4.72 - 8.30
8.31 - 13.04
3 0 3 6
Miles

2012

MWH Global

[PILOT STUDY: CANDIDATE SYSTEM SELECTION]

Division 4 (Gunnison River Basin): Trampe Ranch

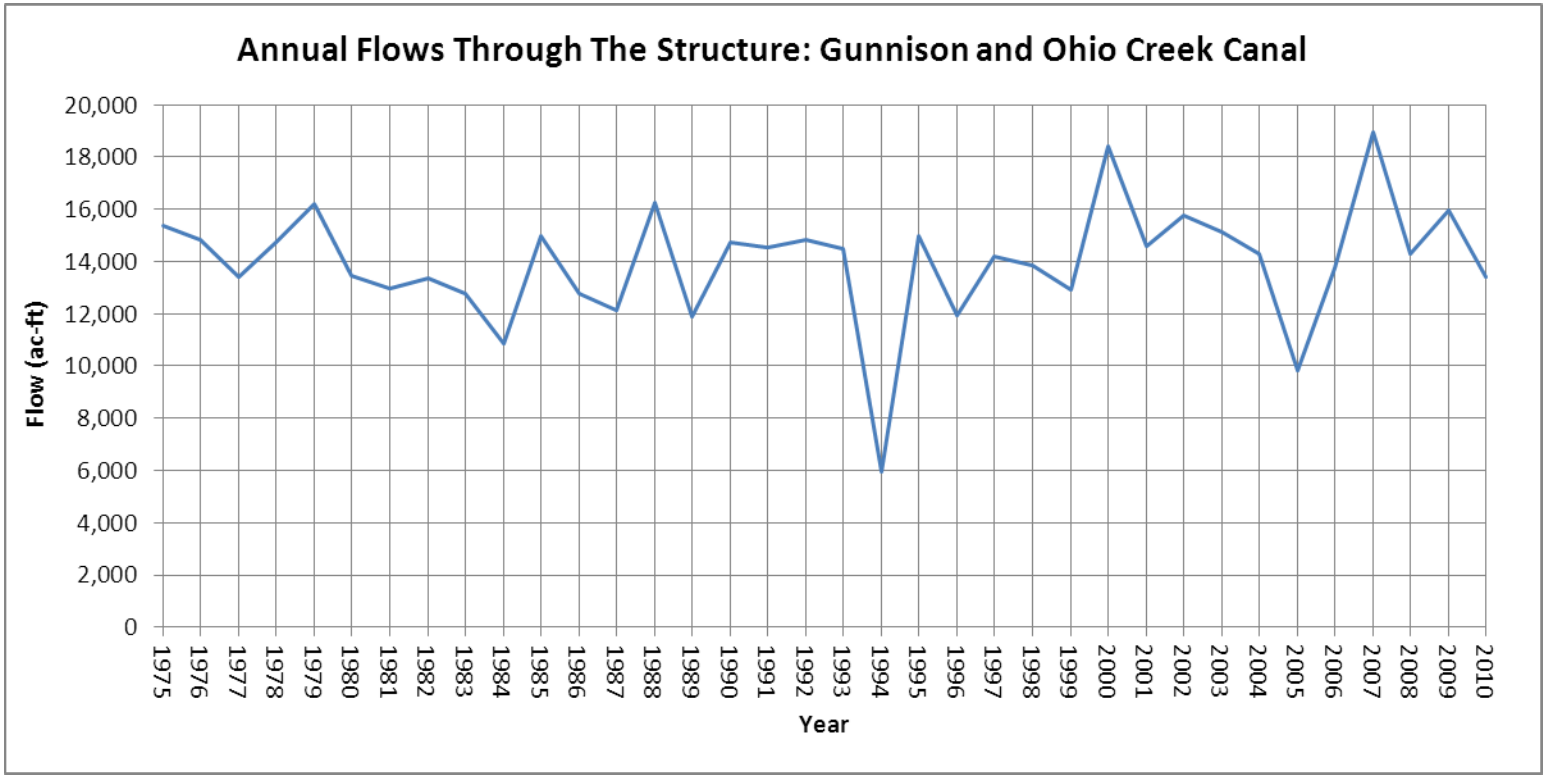
Structure Name: GUNNISON & OHIO CR CANAL
Source: Gunnison River
Q10 Q40 Q160 Section Twnshp Range PM
NW NW NW 9 50N 1E N
Water District: 59 Structure ID Number: 569
UTM Coordinates (NAD 83): Northing (UTM y): 4275890 Easting (UTM x): 336689.2
Spotted from PLSS distances from section lines

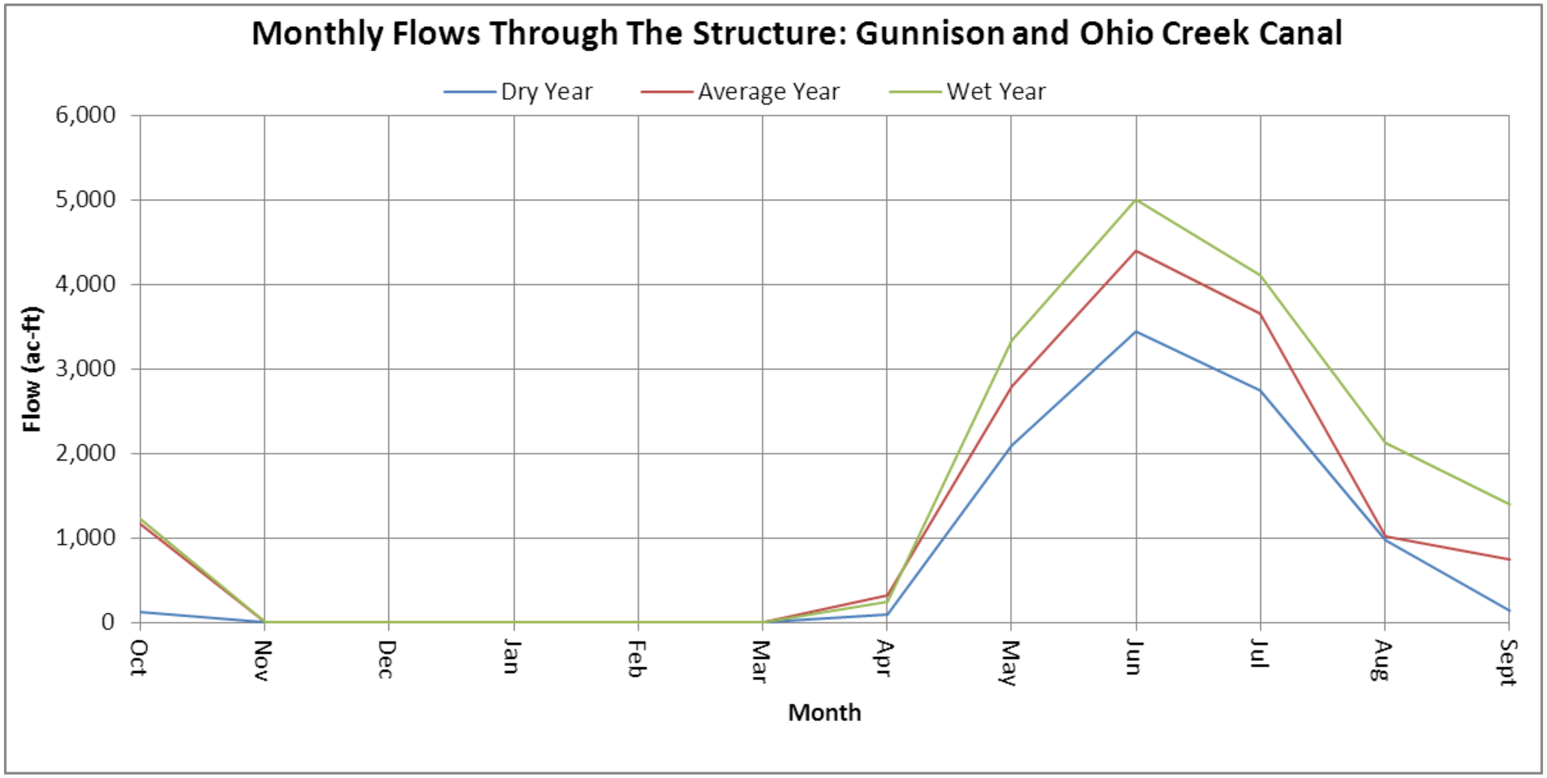
Water Rights Summary			
Parameter	Absolute	conditional	AP/EX
Total Decreed Rate(s) (CFS)	169.16	0.00	0.00
Total Decreed Volume(s) (AF)	0.00	0.00	0.00

Pre Compact
Post compact

Water Rights - Transactions											
Case Numbe	Adj-Date	App-Date	Admin. No.	Order No.	Priority No.	Decreed Amt	Adj Type	Status Type	Transfer Type	Use	Action Comment
03CW0068	9/14/1906	11/10/1902	19306.00	0.00	159	0.22	O	A	TT	IRRAU	REPL FOR ABRIL MEADOWS P/A; 6.25AF/IRG SEASON
03CW0068	9/14/1906	11/10/1902	19306.00	0.00	159	0.22	O	A	TF	IRR	USE ADDED
CA1325	9/14/1906	11/10/1902	19306.00	0.00	159	18.50	O	A		IRR	P106
CA1325	9/14/1906	11/10/1902	19306.00	0.00	159	39.00	O	A		IRR	P106
CA1325	9/14/1906	11/10/1902	19306.00	0.00		39.00	O	A		IRR	FOR AUGUMENTATION IN OHIO CR BELOW MOUTH OF CANAL P106
CA2021	4/29/1941	11/10/1902	30667.19	0.00	392	35.00	S	A		IRR	P429
CA2021	4/29/1941	7/1/1907	30667.21	0.00	411	37.66	S	A		IRR	P429

Water Rights - Net Amounts										
				Priority/Case	Rate (CFS)			Volume (Ac-Ft)		
Adj-Date	App-Date	Admin. No.	Order No.	Number	Absolute	Conditional	AP/EX	Absolute	Conditional	AP/EX
9/14/1906	11/10/1902	19306.00	0.00	159.00	96.50	0.00	0.00	0.00	0.00	0.00
4/29/1941	11/10/1902	30667.19	0.00	392.00	35.00	0.00	0.00	0.00	0.00	0.00
4/29/1941	7/1/1907	30667.21	0.00	411.00	37.66	0.00	0.00	0.00	0.00	0.00


Annual Flows Through The Structure: Gunnison and Ohio Creek Canal
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
Flow (ac-ft)
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Year



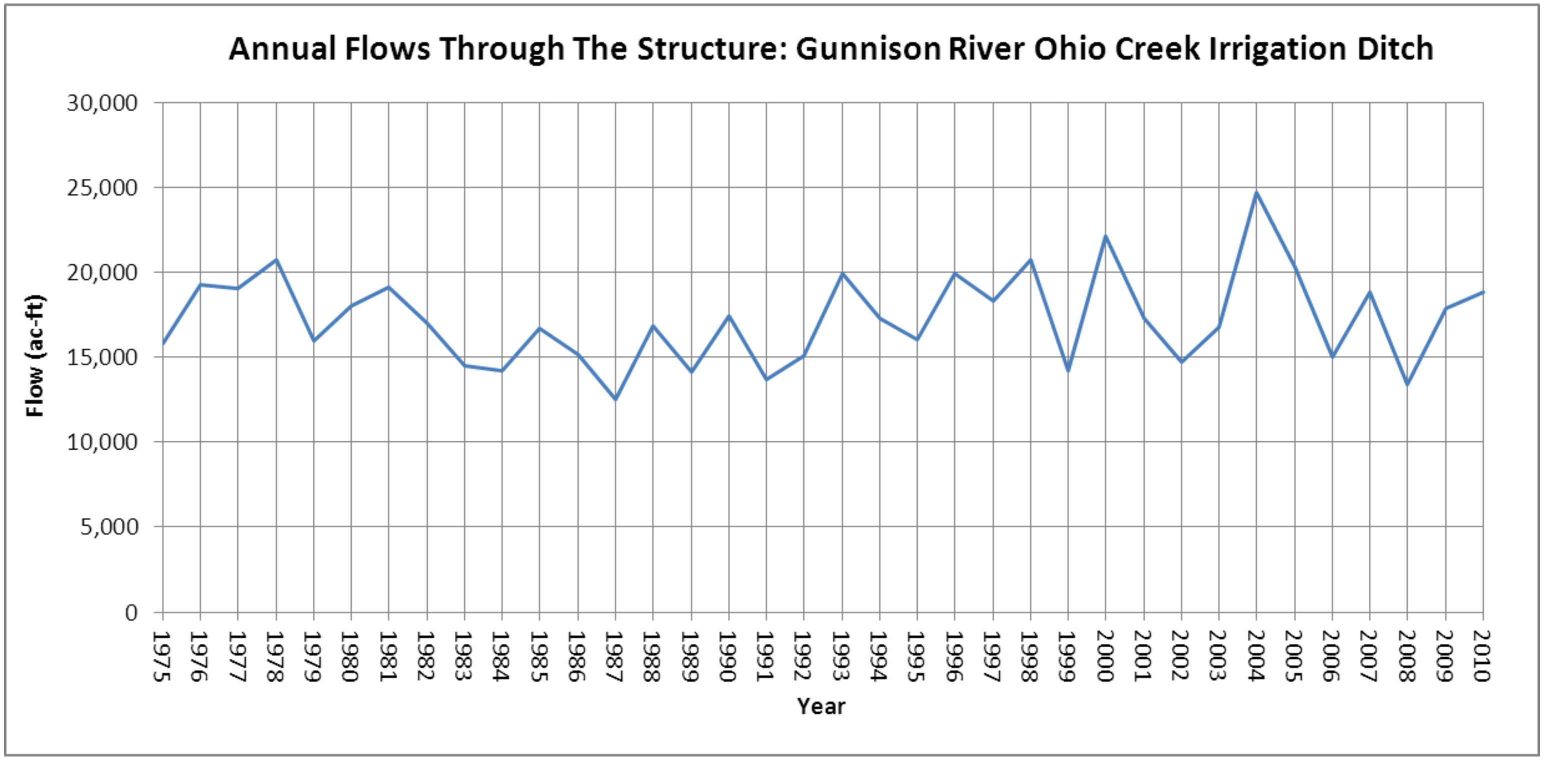
Note: Based on the available monthly flow dataset for the structure annual values were computed and the top and bottom 10% values in terms of magnitude were used to select the wet and the dry years while the rest of years were considered as representatives of average years. Monthly averages were computed based on those years and were used to generate the monthly plots.

Structure Name: GUNNISON R OHIO CR IRG D
Source: Gunnison River
Q10 Q40 Q160 Section Twnshp Range PM
NE NE SE 28 50N 1E N
Water District: 59 Structure ID Number: 570
UTM Coordinates (NAD 83): Northing (UTM y): 4279893 Easting (UTM x): 338096.2
Spotted from PLSS distances from section lines

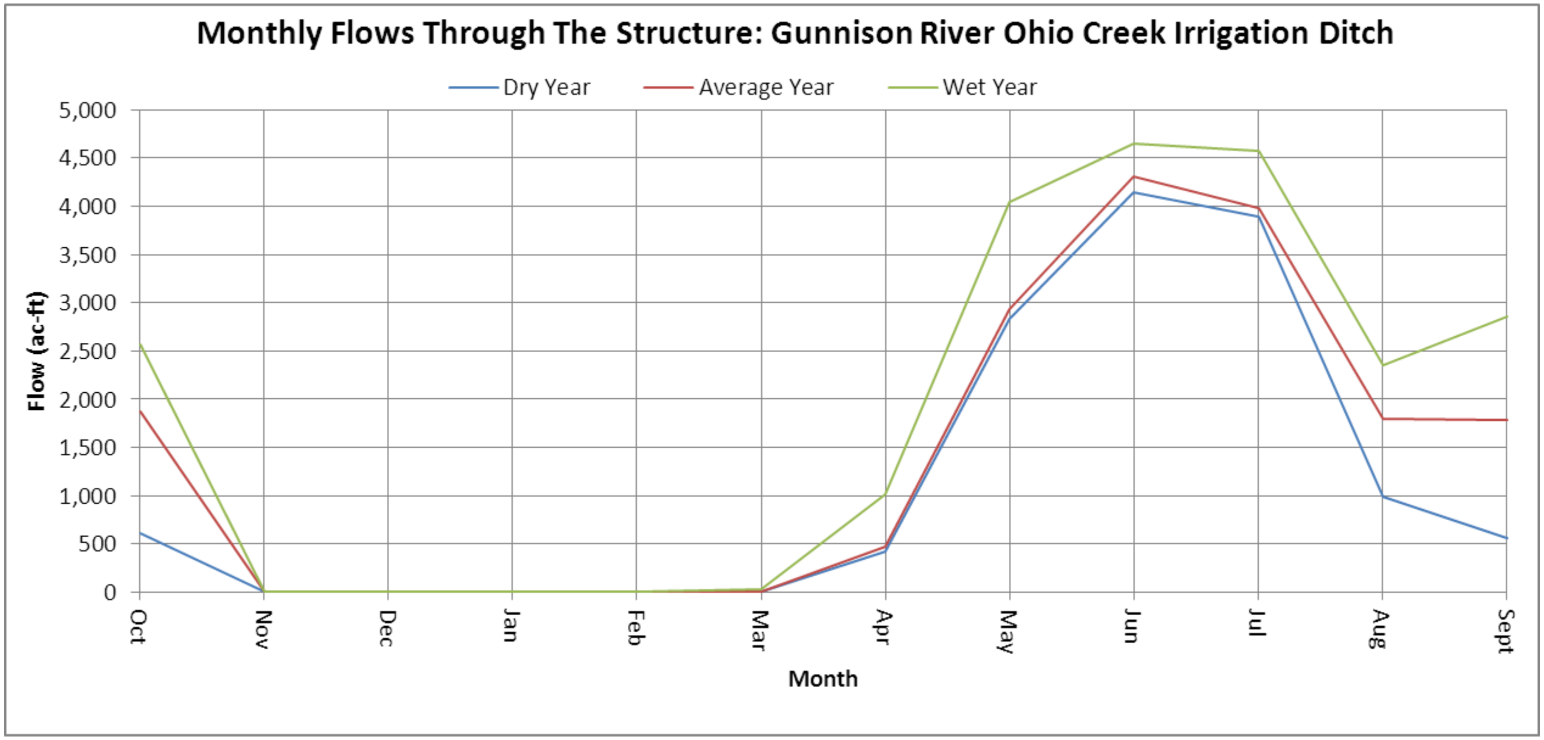
Water Rights Summary			
Parameter	Absolute	conditional	AP/EX
Total Decreed Rate(s) (CFS)	101.65	0.00	0.00
Total Decreed Volume(s) (AF)	0.00	0.00	0.00

Water Rights - Transactions												
Case Numbe	Adj-Date	App-Date	Admin. No.	Order No.	Priority No.	Decreed Amt	Adj Type	Status Type	Transfer Type	Use	Action Comment
CA1325	9/14/1906	3/15/1889	14319.00	0.00	73	9.25	O	A		IRR	P66
CA1325	9/14/1906	6/15/1901	18793.00	0.00	145	15.25	O	A		IRR	P66
CA1635	10/25/1921	5/17/1920	25704.00	0.00	234	1.50	S	A		IRR	P146
W0534	1/7/1924	7/1/1903	26230.20	0.00		0.25	S	A	TT	IRR	TF H W STANLEY D 12/31/1972
82CW0318	4/29/1941	5/15/1889	30667.14	0.00	258	0.58	S	A	TF	IRR	TT KING WELL 6GPM FOR DOM 258 GPM FOR IRR
CA2021	4/29/1941	5/15/1889	30667.14	0.00	334	66.37	S	A		IRR	GUNNISON R P353 LOC ERROR
W0534	4/29/1941	7/1/1903	30667.20	0.00		1.75	S	A	TT	IRR	TF H W STANLEY D 12/31/1972
CA2021	4/29/1941	5/17/1920	30667.26	0.00	448	4.86	S	A		IRR	IRG DITCH ASSN ENLT P354 LOC ER ROR CORRECT IS T50N R1E
CA5590	1/27/1961	7/1/1957	39263.00	0.00	564	3.00	S	A		IRR	R BK GUNNISON R P829

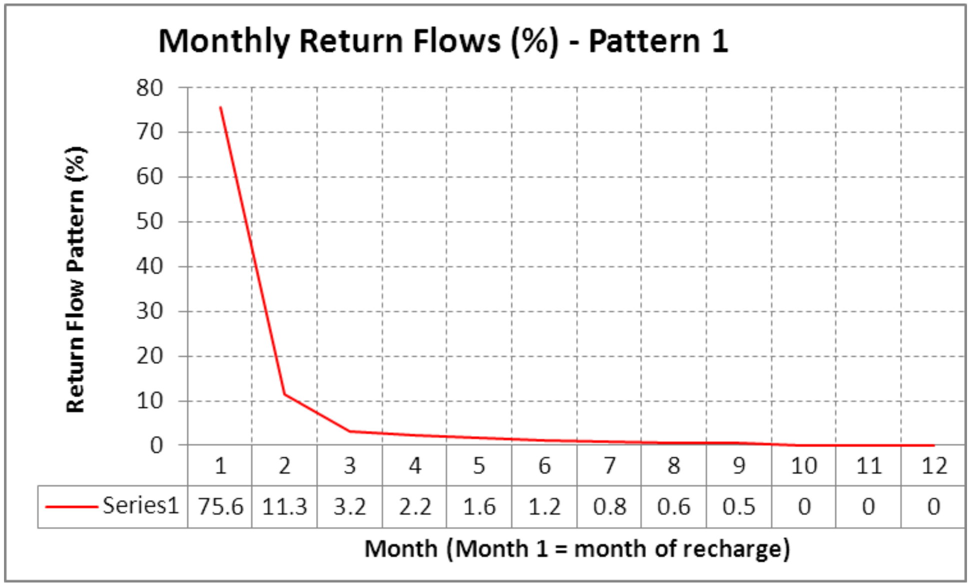
Water Rights - Net Amounts										
				Priority/Case	Rate (CFS)			Volume (Ac-Ft)		
Adj-Date	App-Date	Admin. No.	Order No.	Number	Absolute	Conditional	AP/EX	Absolute	Conditional	AP/EX
9/14/1906	3/15/1889	14319.00	0.00	73.00	9.25	0.00	0.00	0.00	0.00	0.00
9/14/1906	6/15/1901	18793.00	0.00	145.00	15.25	0.00	0.00	0.00	0.00	0.00
10/25/1921	5/17/1920	25704.00	0.00	234.00	1.50	0.00	0.00	0.00	0.00	0.00
1/7/1924	7/1/1903	26230.20	0.00	W0534	0.25	0.00	0.00	0.00	0.00	0.00
4/29/1941	5/15/1889	30667.14	0.00	334.00	65.79	0.00	0.00	0.00	0.00	0.00
4/29/1941	7/1/1903	30667.20	0.00	W0534	1.75	0.00	0.00	0.00	0.00	0.00
4/29/1941	5/17/1920	30667.26	0.00	448.00	4.86	0.00	0.00	0.00	0.00	0.00
1/27/1961	7/1/1957	39263.00	0.00	564.00	3.00	0.00	0.00	0.00	0.00	0.00

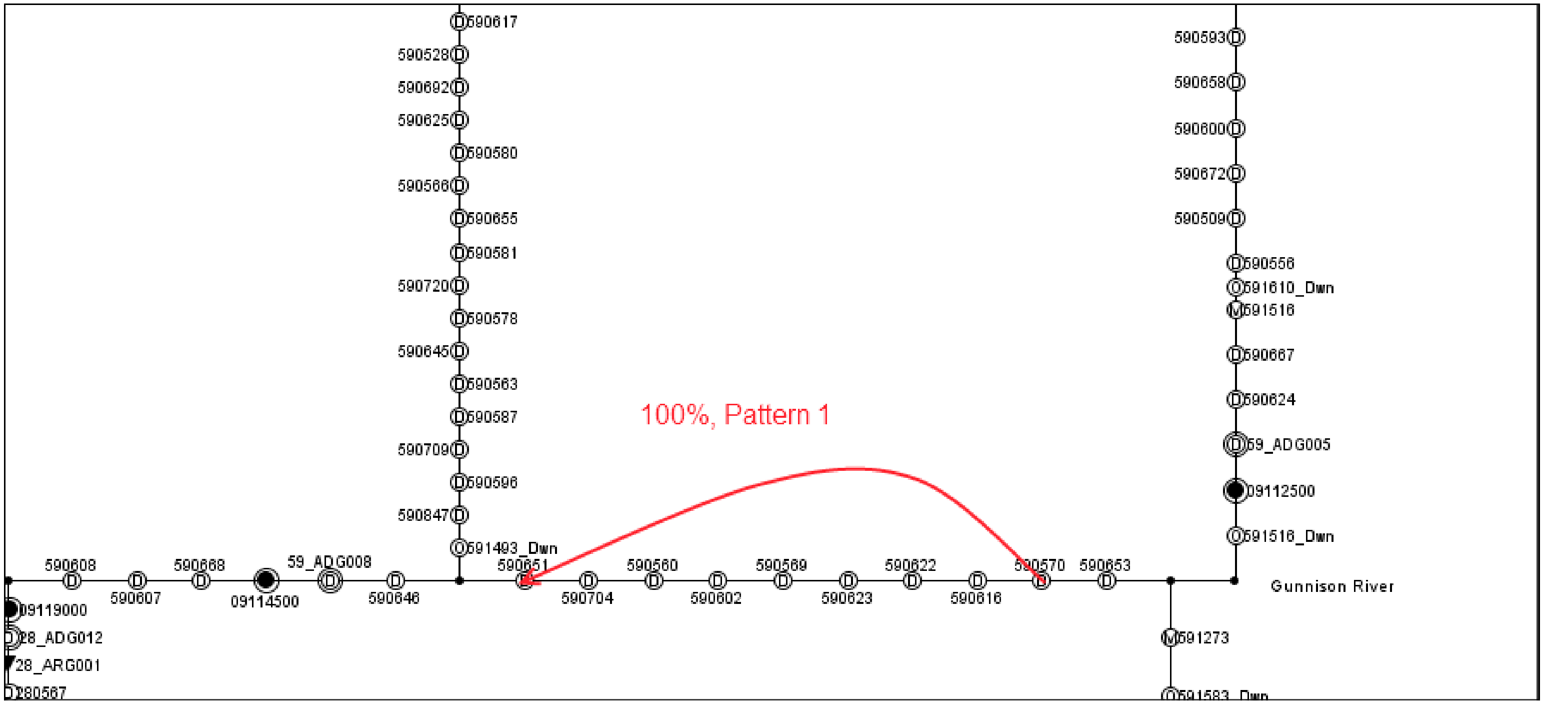


Annual Flows Through The Structure: Gunnison River Ohio Creek Irrigation Ditch
Flow (ac-ft)
30,000
25,000
20,000
15,000
10,000
5,000
0
1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010
Year

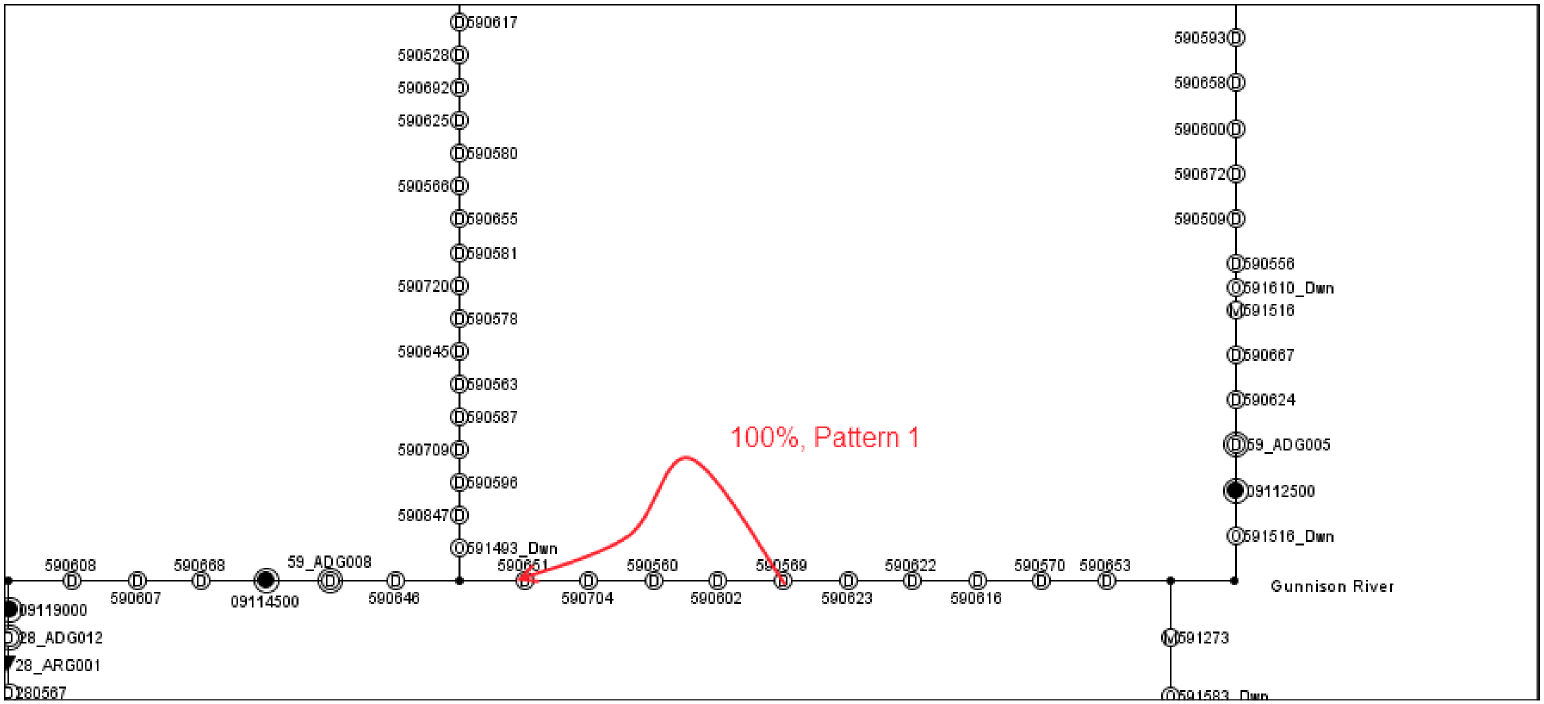


Monthly Flows Through The Structure: Gunnison River Ohio Creek Irrigation Ditch
Dry Year
Average Year
Wet Year
Flow (ac-ft)
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sept
Month

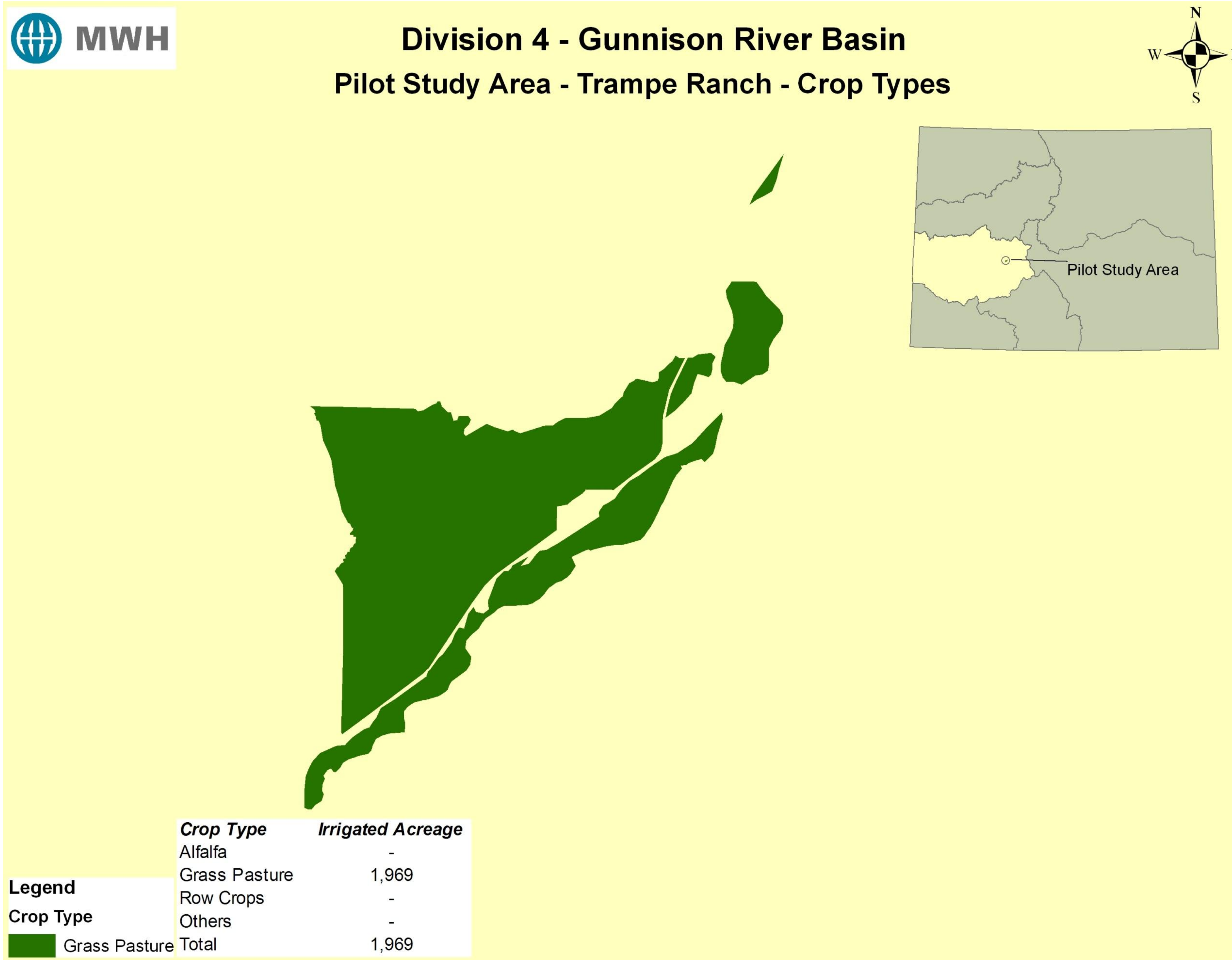

Monthly Return Flows (%) - Pattern 1
Return Flow Pattern (%)
80
70
60
50
40
30
20
10
0
1 2 3 4 5 6 7 8 9 10 11 12
Series1 75.6 11.3 3.2 2.2 1.6 1.2 0.8 0.6 0.5 0 0 0
Month (Month 1 = month of recharge)



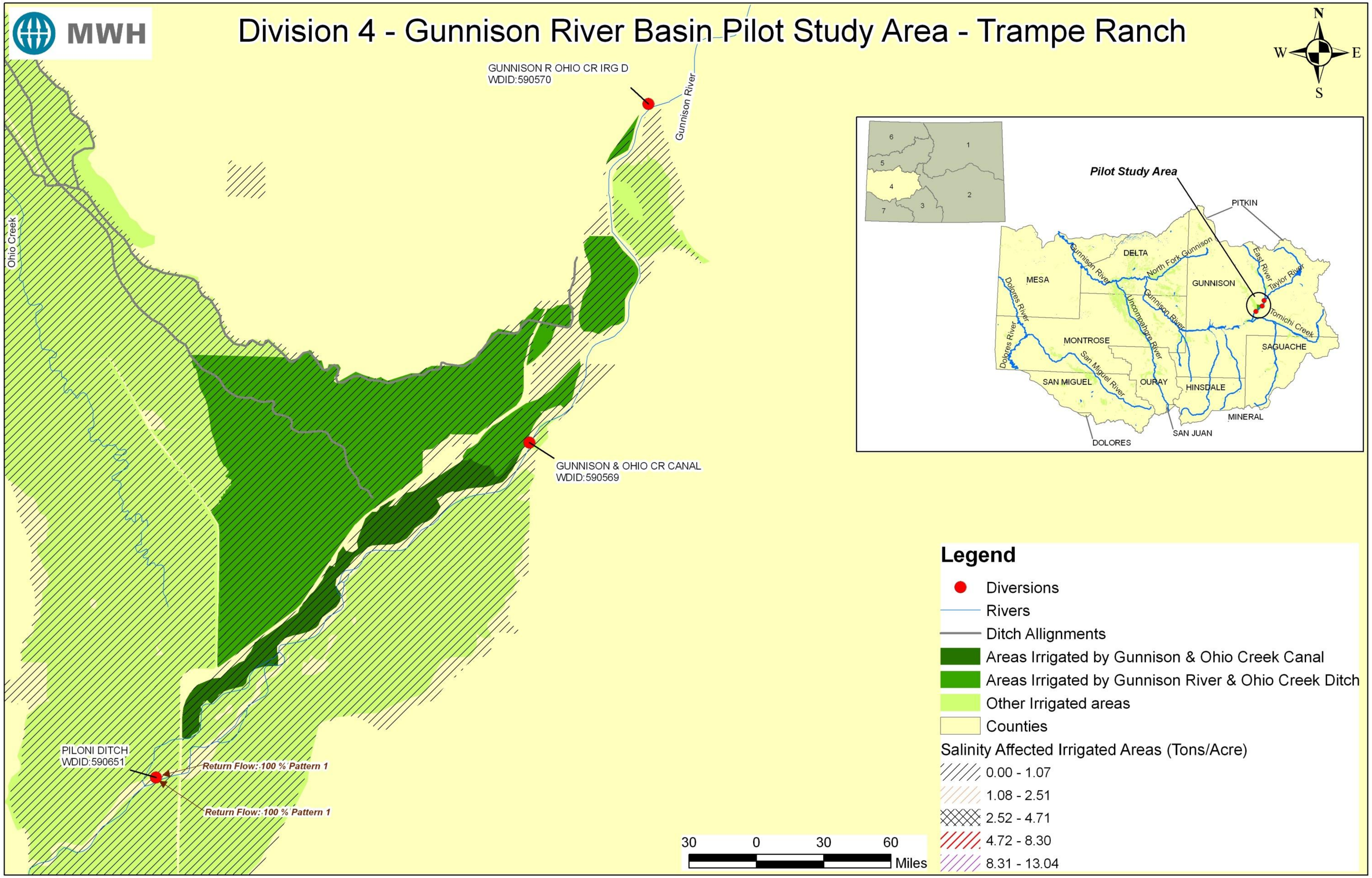
Patterns and Locations of Return Flow - Gunnison & Ohio Creek Canal



Patterns and Locations of Return Flow - Gunnison River Ohio Creek Irrigation Ditch



Crop Type	Irrigated Acreage
Alfalfa	-
Grass Pasture	1,969
Row Crops	-
Others	-
Total	1,969



MWH
Division 4 - Gunnison River Basin Pilot Study Area - Trampe Ranch
N
W
E
S
GUNNISON R OHIO CR IRG D
WDID:590570
Gunnison River
Ohio Creek
GUNNISON & OHIO CR CANAL
WDID:590569
PILONI DITCH
WDID:590651
Return Flow: 100 % Pattern 1
Return Flow: 100 % Pattern 1
Pilot Study Area
PITKIN
DELTA
MESA
GUNNISON
MONTROSE
SAGUACHE
SAN MIGUEL
OURAY
HINSDALE
MINERAL
SAN JUAN
DOLORES
Gunnison River
North Fork Gunnison
Dolores River
Uncompahgre River
San Miguel River
East River
Taylor River
Tomichi Creek
Legend
Diversions
Rivers
Ditch Allignments
Areas Irrigated by Gunnison & Ohio Creek Canal
Areas Irrigated by Gunnison River & Ohio Creek Ditch
Other Irrigated areas
Counties
Salinity Affected Irrigated Areas (Tons/Acre)
0.00 - 1.07
1.08 - 2.51
2.52 - 4.71
4.72 - 8.30
8.31 - 13.04
30 0 30 60
Miles

2012

MWH Global

[PILOT STUDY: CANDIDATE SYSTEM SELECTION]

Division 5 (Colorado River Basin): Cold Mountain Ranch

Structure Name: Pioneer Ditch
Source: Thompson Creek

Q10 Q40 Q160 Section Twnshp Range PM
SE NE 28 8S 88W S

Water District: 38 Structure ID Number: 939

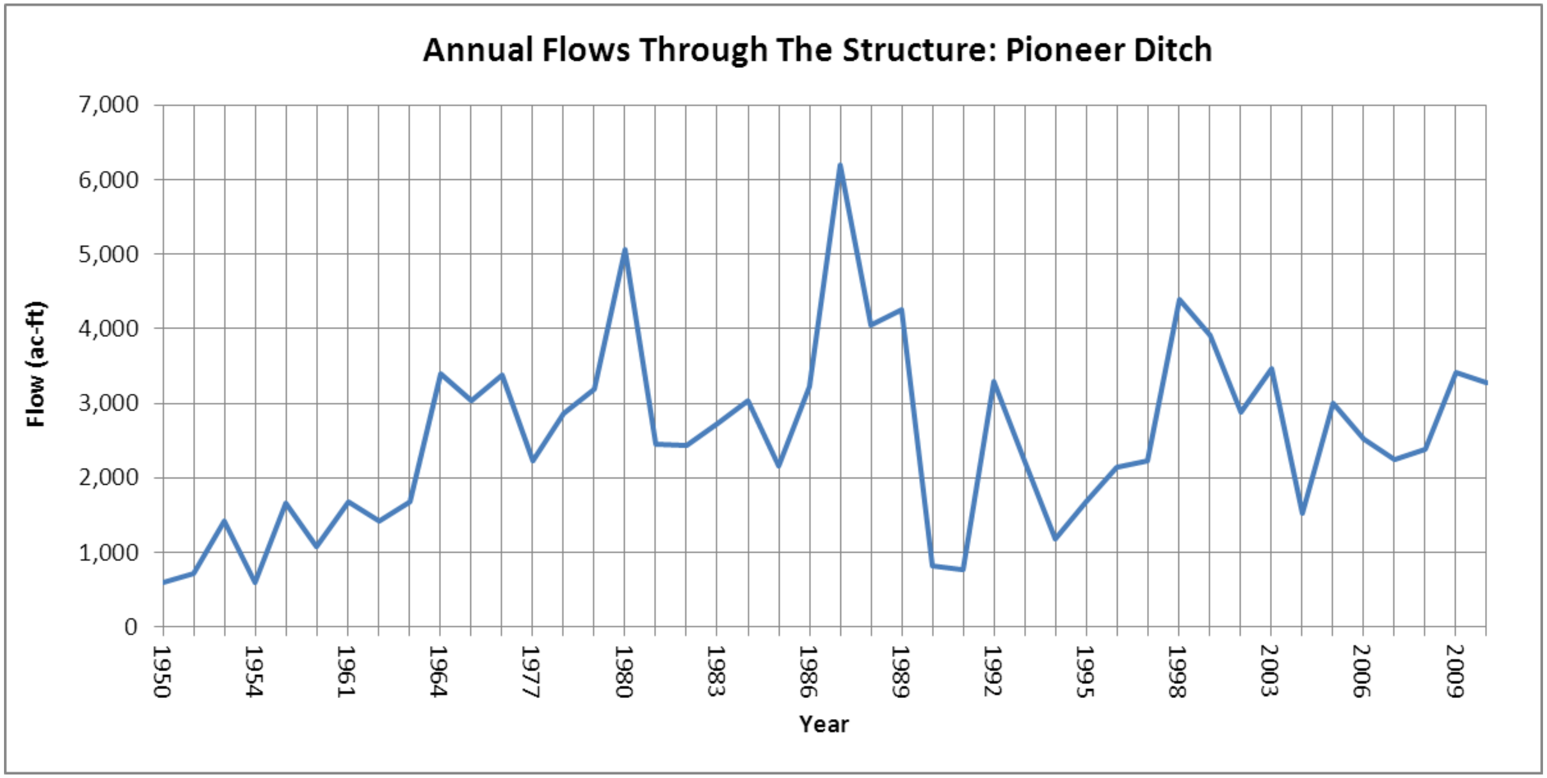
UTM Coordinates (NAD 83): Northing (UTM y): 4355946 Easting (UTM x): 308756
Spotted from PLSS distances from section lines

Water Rights Summary			
Parameter	Absolute	conditional	AP/EX
Total Decreed Rate(s) (CFS)	12.71	0.00	0.00
Total Decreed Volume(s) (AF)	0.00	0.00	0.00

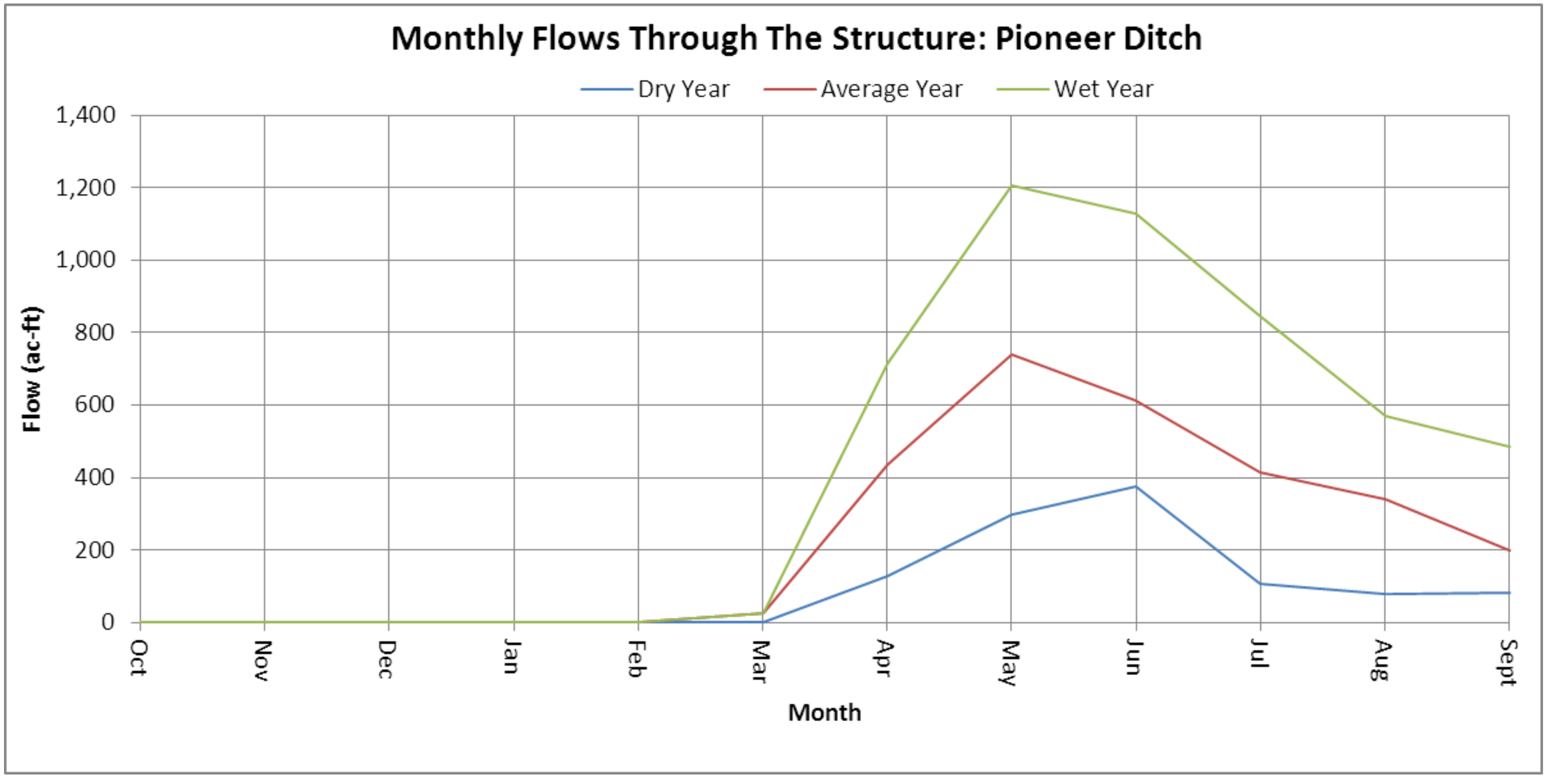
	Pre Compact
	Post Compact

Water Rights - Transactions											
Case Number	Adj-Date	App-Date	Admin. No.	Order No.	Priority No.	Decreed Amt	Adj Type	Status Type	Transfer Type	Use	Action Comment
CA0132	5/11/1889	5/1/1881	11444.00	0.00	7	5.00	O	A		IRR	
CA4019	5/11/1889	5/1/1881	11444.00	0.00	7	0.10	O	A	TF	IRR	TRANS TO THOMPSON DITCH
CA0132	5/11/1889	5/1/1881	11444.00	0.00	7	0.70	O	A		IRR	AMT ADDED 4/15/1890 REHEARING
CA0132	5/11/1889	5/20/1882	11828.00	0.00	32	4.70	O	A		IRR	
CA3082	8/25/1936	9/5/1900	30941.19	0.00	334	2.21	S	A		IRR	

Water Rights - Net Amounts										
				Priority/Case	Rate (CFS)			Volume (Acre-Feet)		
Adj-Date	App-Date	Admin. No.	Order No.	Number	Absolute	Conditional	AP/EX	Absolute	Conditional	AP/EX
5/11/1889	5/1/1881	11444.00	0.00	7.00	5.60	0.00	0.00	0.00	0.00	0.00
5/11/1889	5/20/1882	11828.00	0.00	32.00	4.70	0.00	0.00	0.00	0.00	0.00
8/25/1936	9/5/1900	30941.19	0.00	334.00	2.21	0.00	0.00	0.00	0.00	0.00



Annual Flows Through The Structure: Pioneer Ditch
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Flow (ac-ft)
1950
1954
1961
1964
1977
1980
1983
1986
1989
1992
1995
1998
2003
2006
2009
Year



Note: Based on the available monthly flow dataset for the structure annual values were computed and the top and bottom 10% values in terms of magnitude were used to select the wet and the dry years while the rest of years were considered as representatives of average years. Monthly averages were computed based on those years and were used to generate the monthly plots.

Structure Name: Lowline Ditch
Source: Crystal River

Q10 Q40 Q160 Section Twnshp Range PM
NE SE SW 27 8S 88W S

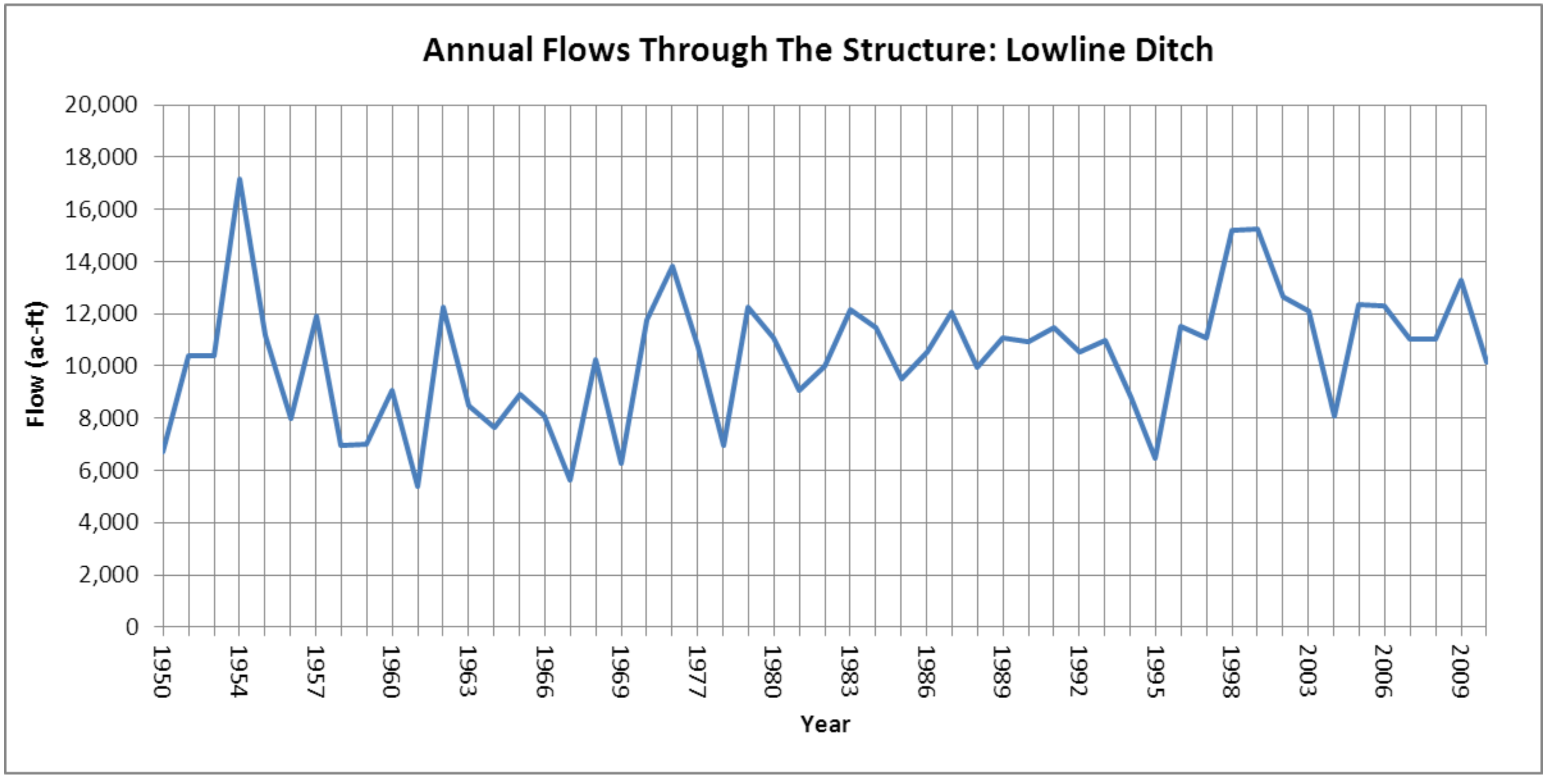
Water District: 38 Structure ID Number: 840

UTM Coordinates (NAD 83): Northing (UTM y): 4355324 Easting (UTM x): 309583
Spotted from PLSS distances from section lines

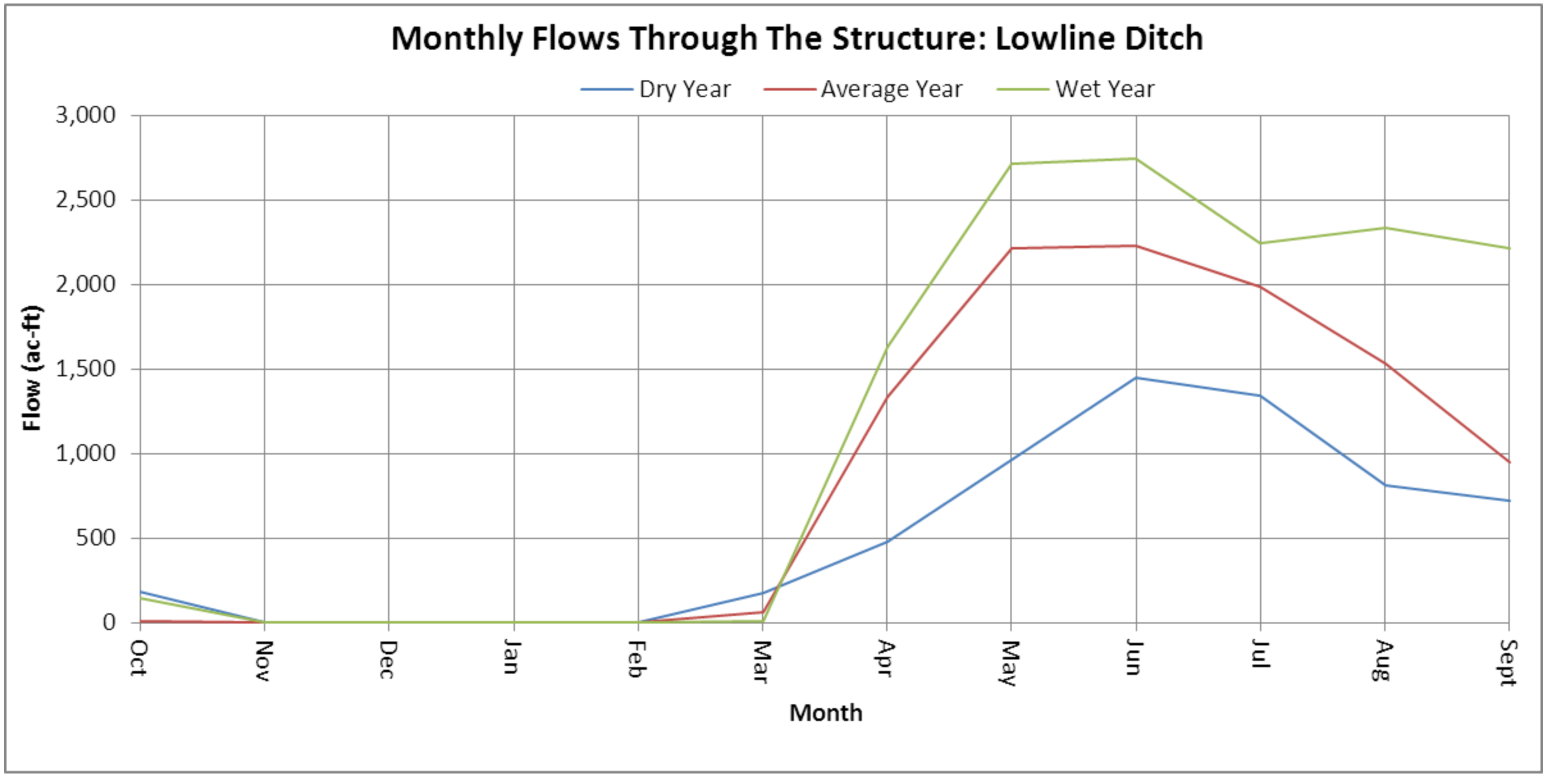
Water Rights Summary			
Parameter	Absolute	conditional	AP/EX
Total Decreed Rate(s) (CFS)	40.50	0.00	0.00
Total Decreed Volume(s) (AF)	0.00	0.00	0.00

Water Rights - Transactions											
Case Number	Adj-Date	App-Date	Admin. No.	Order No.	Priority No.	Decreed Amt	Adj Type	Status Type	Transfer Type	Use	Action Comment
CA1007	12/12/1902	9/25/1890	19313.14878	0	208C	19	S	A		IRR	
CA3082	8/25/1936	10/10/1923	30941.26945	1	417	21.5	S	A		IRR	

Water Rights - Net Amounts										
				Priority/Case	Rate (CFS)			Volume (Acre-Feet)		
Adj-Date	App-Date	Admin. No.	Order No.	Number	Absolute	Conditional	AP/EX	Absolute	Conditional	AP/EX
12/12/1902	9/25/1890	19313.14878	0	208C	19	0	0	0	0	0
8/25/1936	10/10/1923	30941.26945	1	417	21.5	0	0	0	0	0



Annual Flows Through The Structure: Lowline Ditch
Flow (ac-ft)
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1950
1954
1957
1960
1963
1966
1969
1977
1980
1983
1986
1989
1992
1995
1998
2003
2006
2009
Year

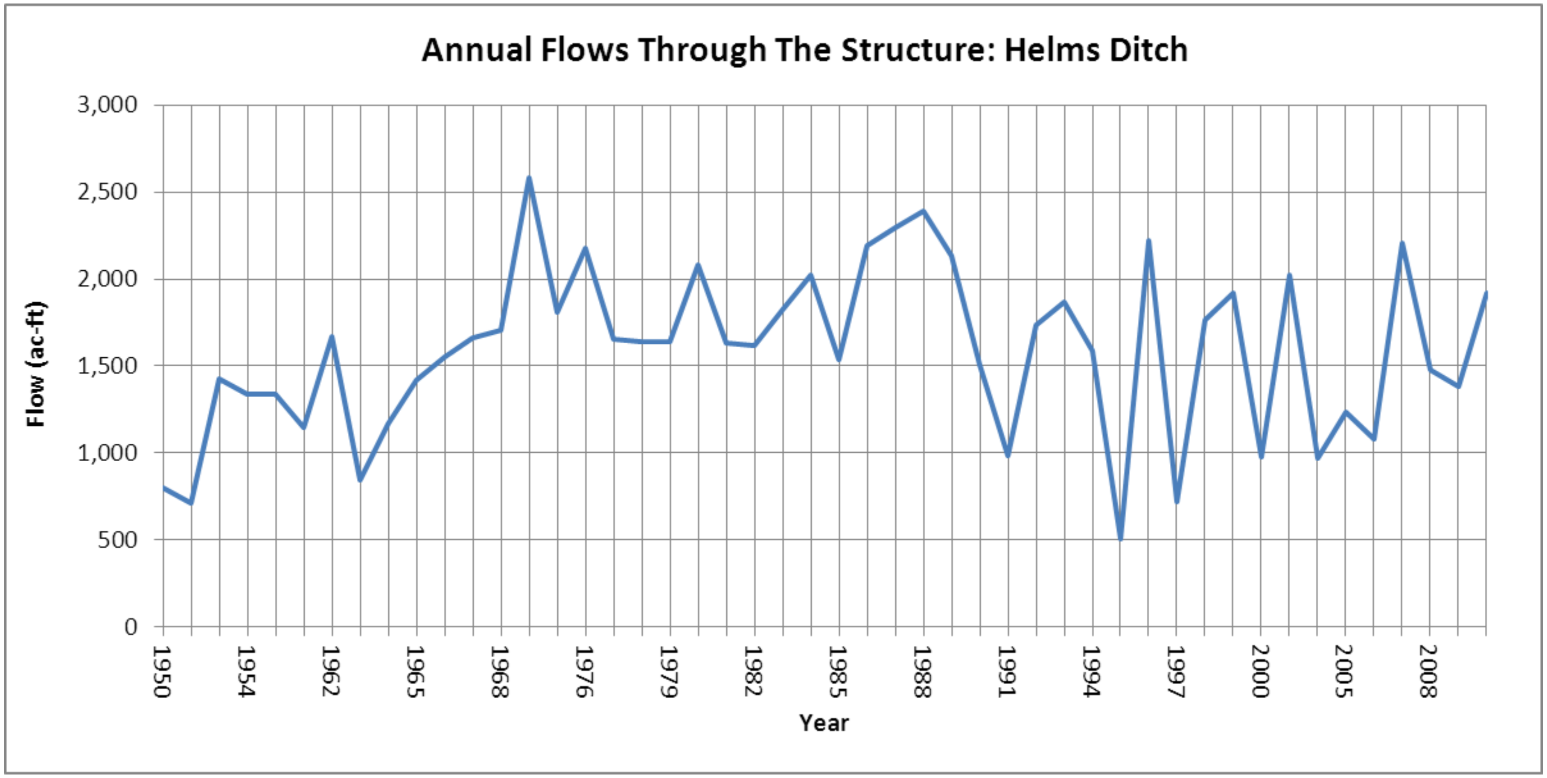

Monthly Flows Through The Structure: Lowline Ditch
Dry Year
Average Year
Wet Year
3,000
2,500
2,000
1,500
1,000
500
0
Flow (ac-ft)
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sept
Month

Structure Name: Helms Ditch
Source: Crystal River
Q10 Q40 Q160 Section Twnshp Range PM
NE NE NE 22 8S 88W S
Water District: 38 Structure ID Number: 747
UTM Coordinates (NAD 83): Northing (UTM y): 4356859 Easting (UTM x): 309672
Spotted from PLSS distances from section lines

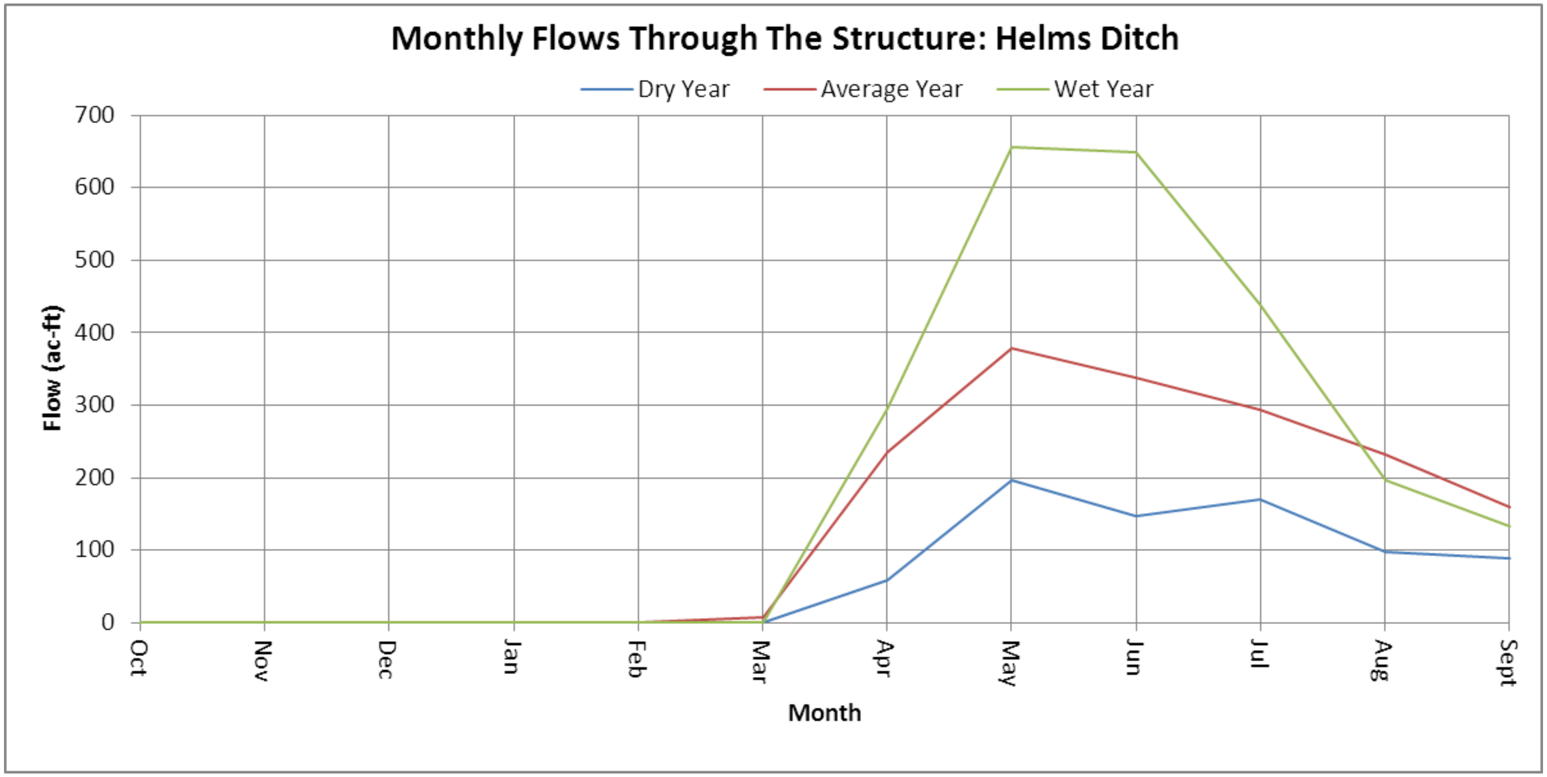
Water Rights Summary			
Parameter	Absolute	conditional	AP/EX
Total Decreed Rate(s) (CFS)	6.00	0.00	0.00
Total Decreed Volume(s) (AF)	0.00	0.00	0.00

Water Rights - Transactions											
Case Number	Adj-Date	App-Date	Admin. No.	Order No.	Priority No.	Decreed Amt	Adj Type	Status Type	Transfer Type	Use	Action Comment
CA1012	2/2/1903	11/17/1899	19341.18218	0	213A	2.93	S	A		IRR	
CA3082	8/25/1936	5/1/1924	30941.27149	0	420	3.07	S	A		IRR	

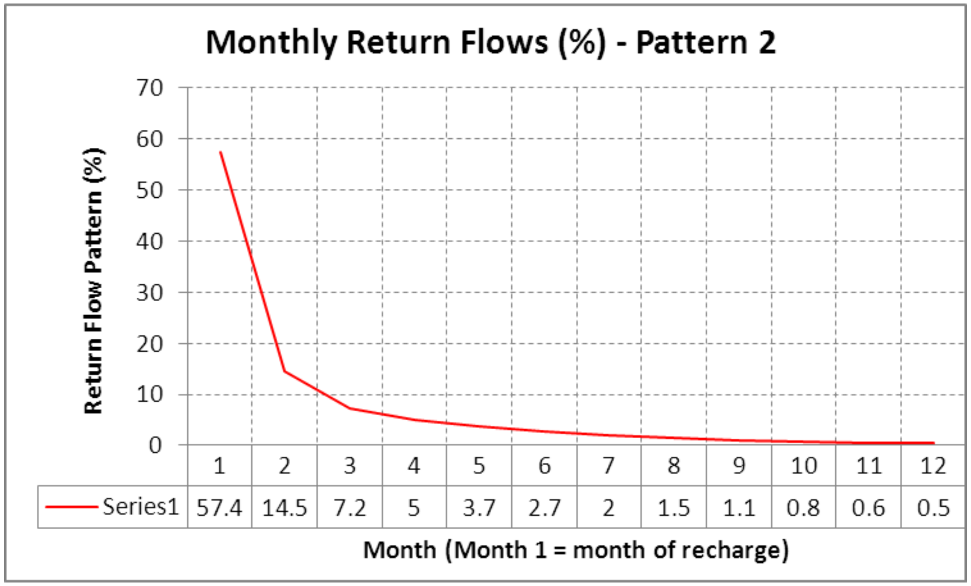
Water Rights - Net Amounts										
				Priority/Case	Rate (CFS)			Volume (Acre-Feet)		
Adj-Date	App-Date	Admin. No.	Order No.	Number	Absolute	Conditional	AP/EX	Absolute	Conditional	AP/EX
2/2/1903	11/17/1899	19341.18218	0	213A	2.9	0	0	0	0	0
8/25/1936	5/1/1924	30941.27149	0	420	3.1	0	0	0	0	0

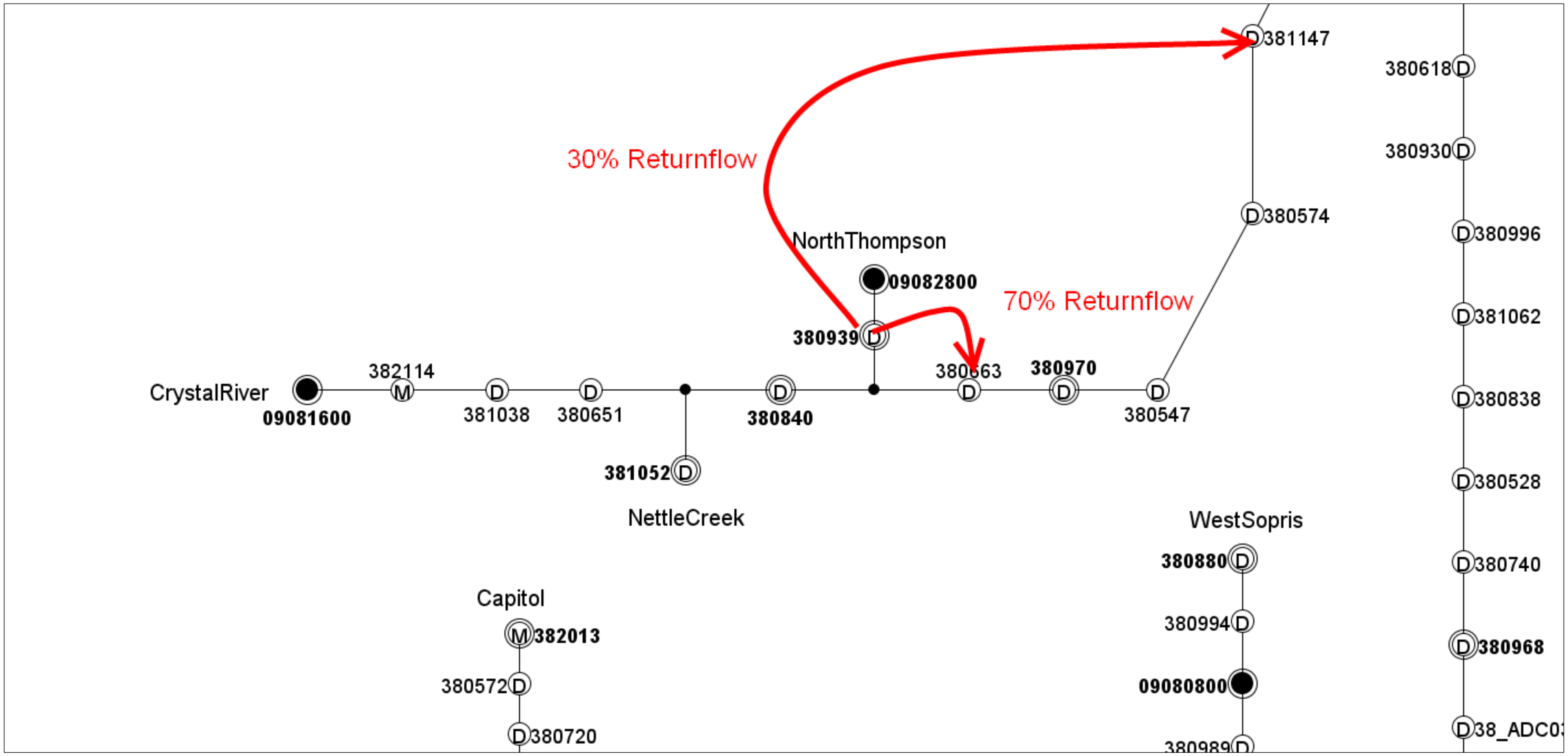


Annual Flows Through The Structure: Helms Ditch
Flow (ac-ft)
3,000
2,500
2,000
1,500
1,000
500
0
1950
1954
1962
1965
1968
1976
1979
1982
1985
1988
1991
1994
1997
2000
2005
2008
Year

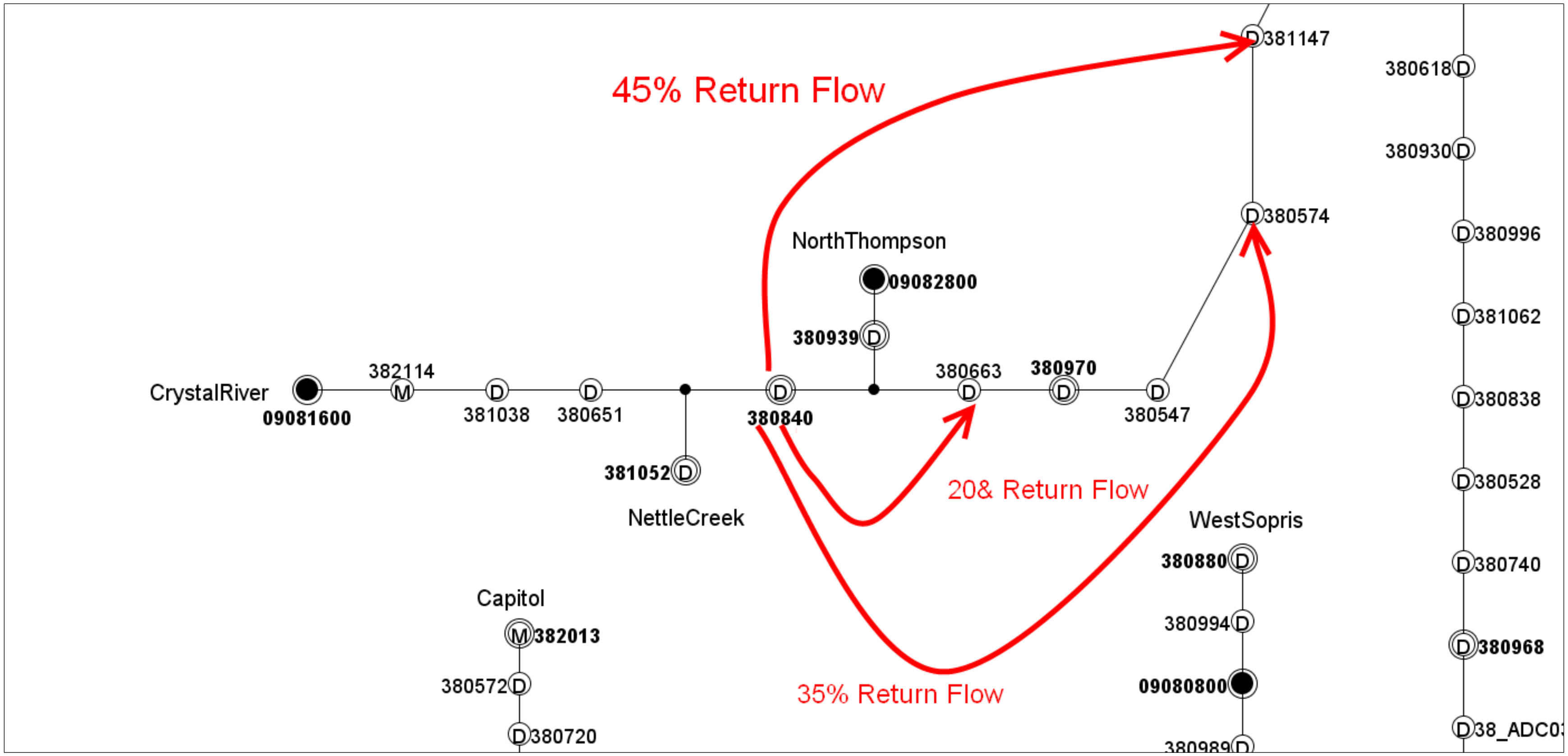


Monthly Flows Through The Structure: Helms Ditch
Dry Year
Average Year
Wet Year
700
600
500
400
300
200
100
0
Flow (ac-ft)
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sept
Month

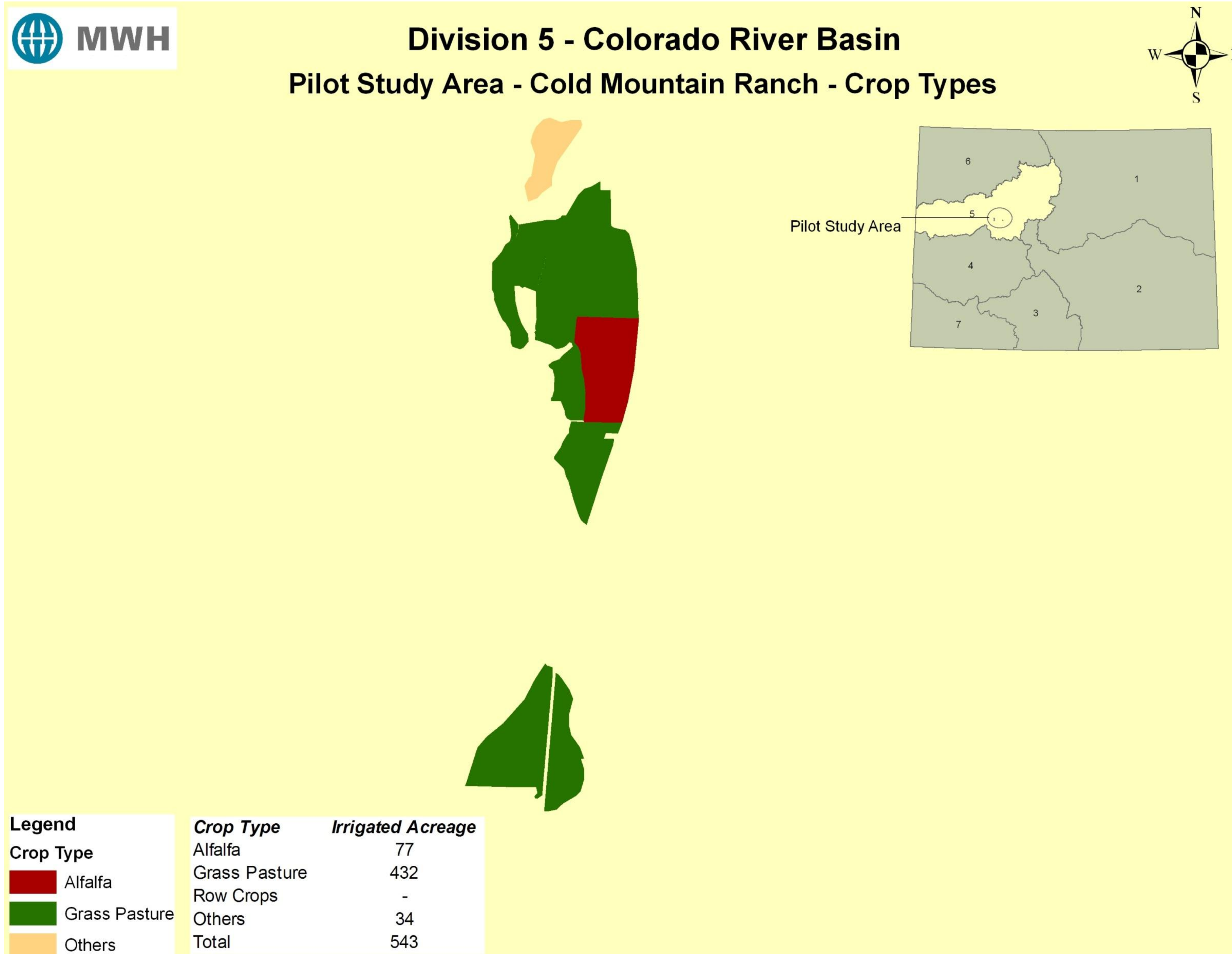

Monthly Return Flows (%) - Pattern 2
Return Flow Pattern (%)
70
60
50
40
30
20
10
0
1
2
3
4
5
6
7
8
9
10
11
12
Series1
57.4
14.5
7.2
5
3.7
2.7
2
1.5
1.1
0.8
0.6
0.5
Month (Month 1 = month of recharge)



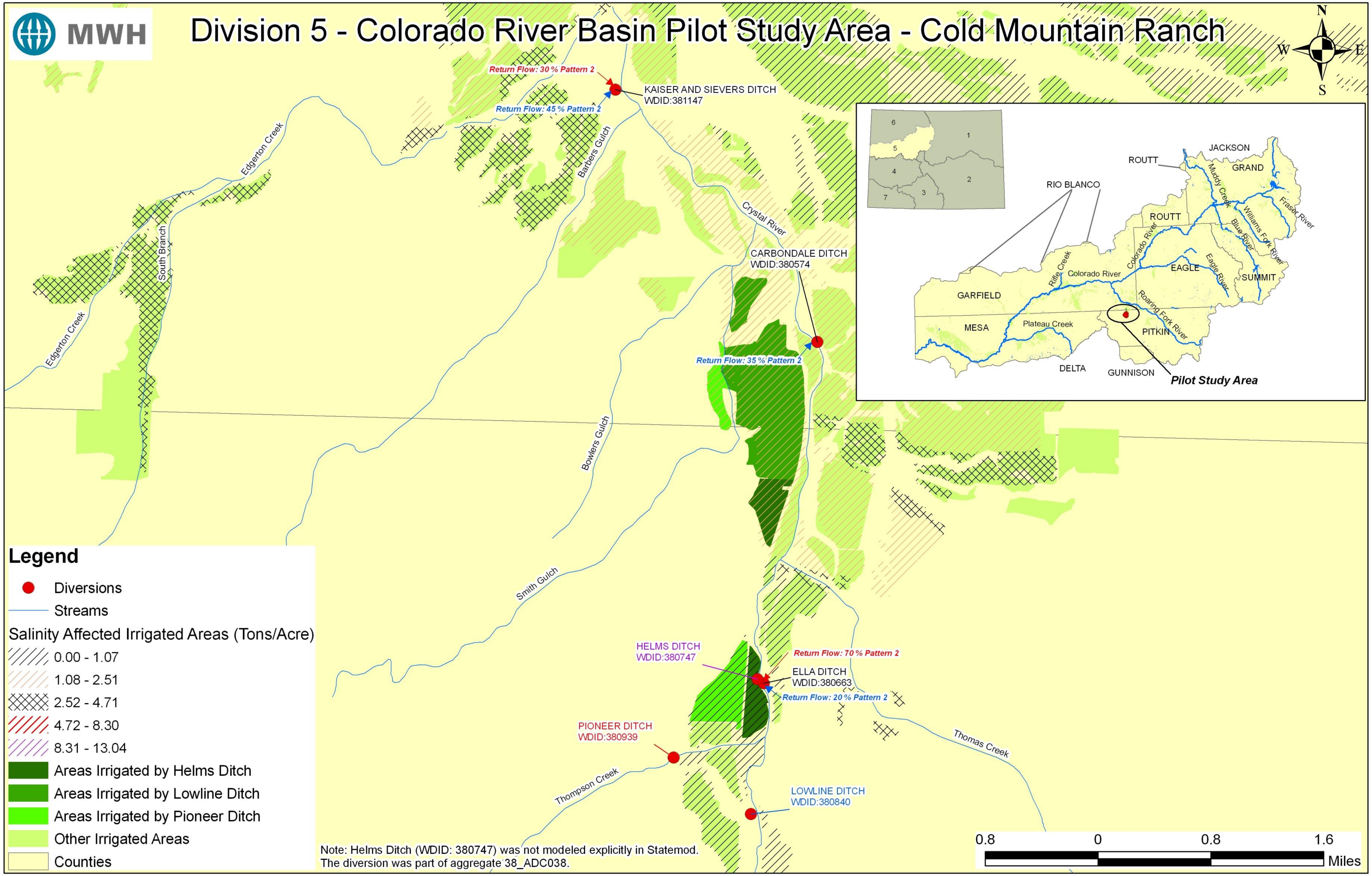
Pattern and Location of Return flow – Pioneer Ditch



Pattern and Location of Return flow – Lowline Ditch



Crop Type	*Irrigated Acreage*
Alfalfa	77
Grass Pasture	432
Row Crops	-
Others	34
Total	543


MWH
Division 5 - Colorado River Basin Pilot Study Area - Cold Mountain Ranch
N
W
E
S
Return Flow: 30 % Pattern 2
KAISER AND SIEVERS DITCH
WDID:381147
Return Flow: 45 % Pattern 2
Edgerton Creek
Barbers Gulch
South Branch
Crystal River
CARBONDALE DITCH
WDID:380574
Return Flow: 35 % Pattern 2
Bowlers Gulch
Smith Gulch
HELMS DITCH
WDID:380747
Return Flow: 70 % Pattern 2
ELLA DITCH
WDID:380663
Return Flow: 20 % Pattern 2
Thomas Creek
PIONEER DITCH
WDID:380939
Thompson Creek
LOWLINE DITCH
WDID:380840
JACKSON
ROUTT
GRAND
RIO BLANCO
Muddy Creek
Fraser River
Williams Fork River
Blue River
ROUTT
Colorado River
Rifle Creek
Colorado River
EAGLE
Eagle River
SUMMIT
GARFIELD
Roaring Fork River
MESA
Plateau Creek
PITKIN
DELTA
GUNNISON
Pilot Study Area
Legend
Diversions
Streams
Salinity Affected Irrigated Areas (Tons/Acre)
0.00 - 1.07
1.08 - 2.51
2.52 - 4.71
4.72 - 8.30
8.31 - 13.04
Areas Irrigated by Helms Ditch
Areas Irrigated by Lowline Ditch
Areas Irrigated by Pioneer Ditch
Other Irrigated Areas
Counties
Note: Helms Ditch (WDID: 380747) was not modeled explicitly in Statemod.
The diversion was part of aggregate 38_ADC038.
0.8
0
0.8
1.6
Miles

2012

MWH Global

[PILOT STUDY: CANDIDATE SYSTEM SELECTION]

Division 7 (San Juan River Basin): Dr Morrison Ditch

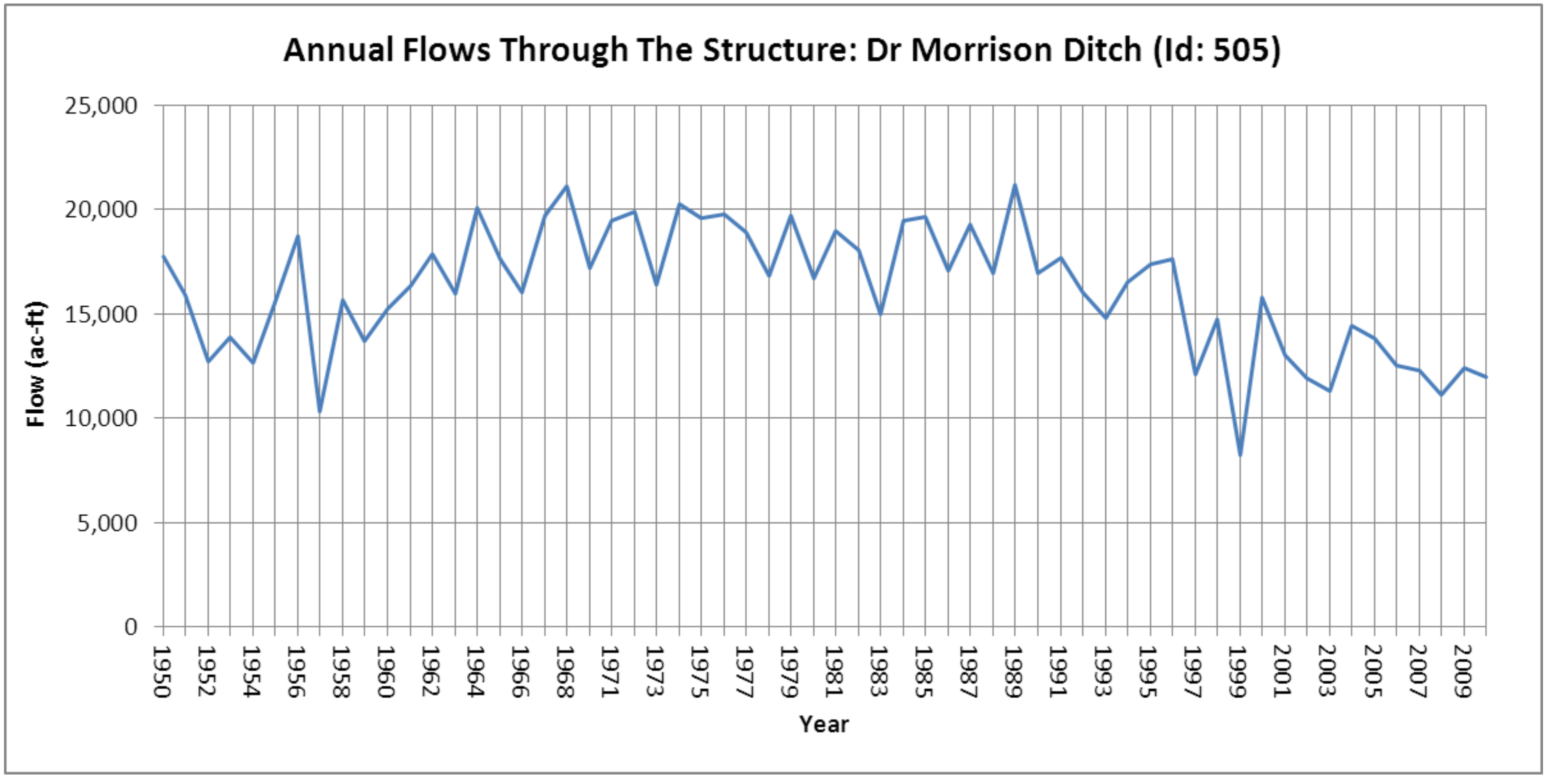
Structure Name: DR MORRISON DITCH
Source: Pine River
Q10 Q40 Q160 Section Twnshp Range PM
NE SE SE 14 34N 7W N
Water District: 31 Structure ID Number: 505
UTM Coordinates (NAD 83): Northing (UTM y): 4122069 Easting (UTM x): 269467.3
Spotted from PLSS distances from section lines

Water Rights Summary			
Parameter	Absolute	conditional	AP/EX
Total Decreed Rate(s) (CFS)	64.83	13.92	0.00
Total Decreed Volume(s) (AF)	0.00	0.00	0.00

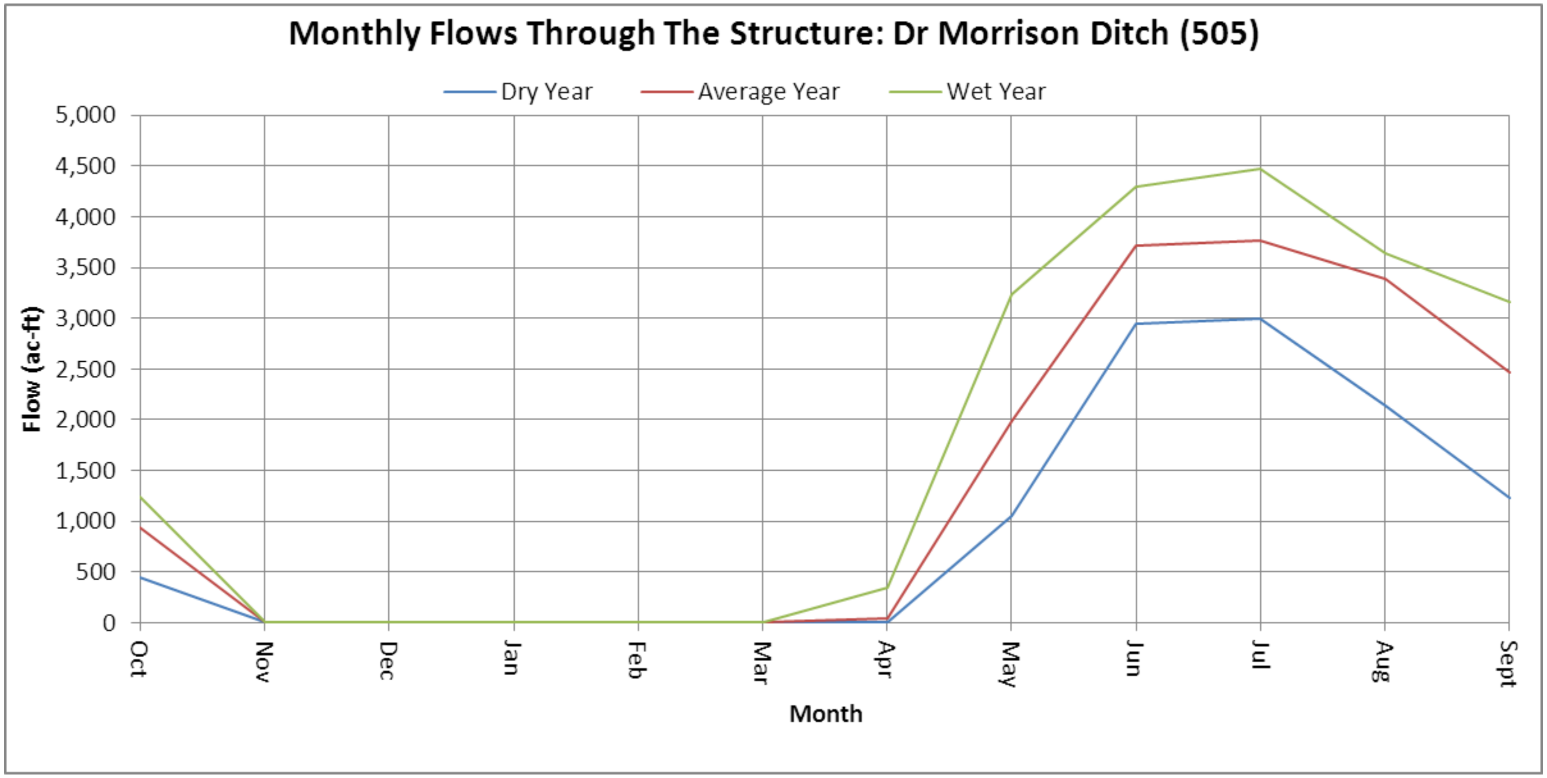
	Pre Compact
	Post compact

Water Rights - Transactions											
Case Numbe	Adj-Date	App-Date	Admin. No.	Order No.	Priority No.	Decreed Amt	Adj Type	Status Type	Transfer Type	Use	Action Comment
CA1248	10/25/1930	7/25/1868	6781.00	0.00	P- 1	1.00	O	A	TT	IRRDOM	TF MOORE DITCH
CA1248	10/25/1930	7/25/1868	6781.00	0.00	P- 1	0.50	O	A	TT	IRRDOM	TF NANNICE DITCH
CA7736	10/25/1930	7/25/1868	6781.00	0.00		7.50	O	C	TT	IRRDOM	TF WEST SIDE DITCH ID# 762
CA7736	10/25/1930	7/25/1868	6781.00	0.00	P- 1	38.58	O	A		IRRDOM	AKA WEST SIDE EXTENSION DITCH
CA7736	10/25/1930	7/25/1868	6781.00	0.00	P- 1	24.75	O	A	TT	IRRDOM	TF WEST-SIDE DITCH
CA7736	10/25/1930	7/25/1868	6781.00	0.00		6.42	O	C		IRRDOM	NON-INDIAN ALLOTMENT

Water Rights - Net Amounts										
				Priority/Case	Rate (CFS)			Volume (Ac-Ft)		
Adj-Date	App-Date	Admin. No.	Order No.	Number	Absolute	Conditional	AP/EX	Absolute	Conditional	AP/EX
10/25/1930	7/25/1868	6781.00	0.00	P-1	64.83	13.92	0.00	0.00	0.00	0.00



Annual Flows Through The Structure: Dr Morrison Ditch (Id: 505)
25,000
20,000
15,000
10,000
5,000
0
Flow (ac-ft)
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
Year



Note: Based on the available monthly flow dataset for the structure annual values were computed and the top and bottom 10% values in terms of magnitude were used to select the wet and the dry years while the rest of years were considered as representatives of average years. Monthly averages were computed based on those years and were used to generate the monthly plots.

Structure Name: DR MORRISON D (IGNACIO)
Source: Pine River

Q10 Q40 Q160 Section Twnshp Range PM
SE NW SE 24 34N 8W N

Water District: 31 Structure ID Number: 758

UTM Coordinates (NAD 83): Northing (UTM y): 4117925 Easting (UTM x): 263735.3
Spotted from PLSS distances from section lines

Water Rights Summary			
Parameter	Absolute	conditional	AP/EX
Total Decreed Rate(s) (CFS)	0.00	0.00	1.00
Total Decreed Volume(s) (AF)	0.00	0.00	0.00

Water Rights - Transactions											
Case Numbe	Adj-Date	App-Date	Admin. No.	Order No.	Priority No.	Decreed Amt	Adj Type	Status Type	Transfer Type	Use	Action Comment
CA7736	10/25/1930	7/25/1868	6781.00	0.00	P- 1	1.00	O	A		IRRDOM	24.75 CFS BUT ONLY 1.0 CFS ALLOWED IN CA 1248

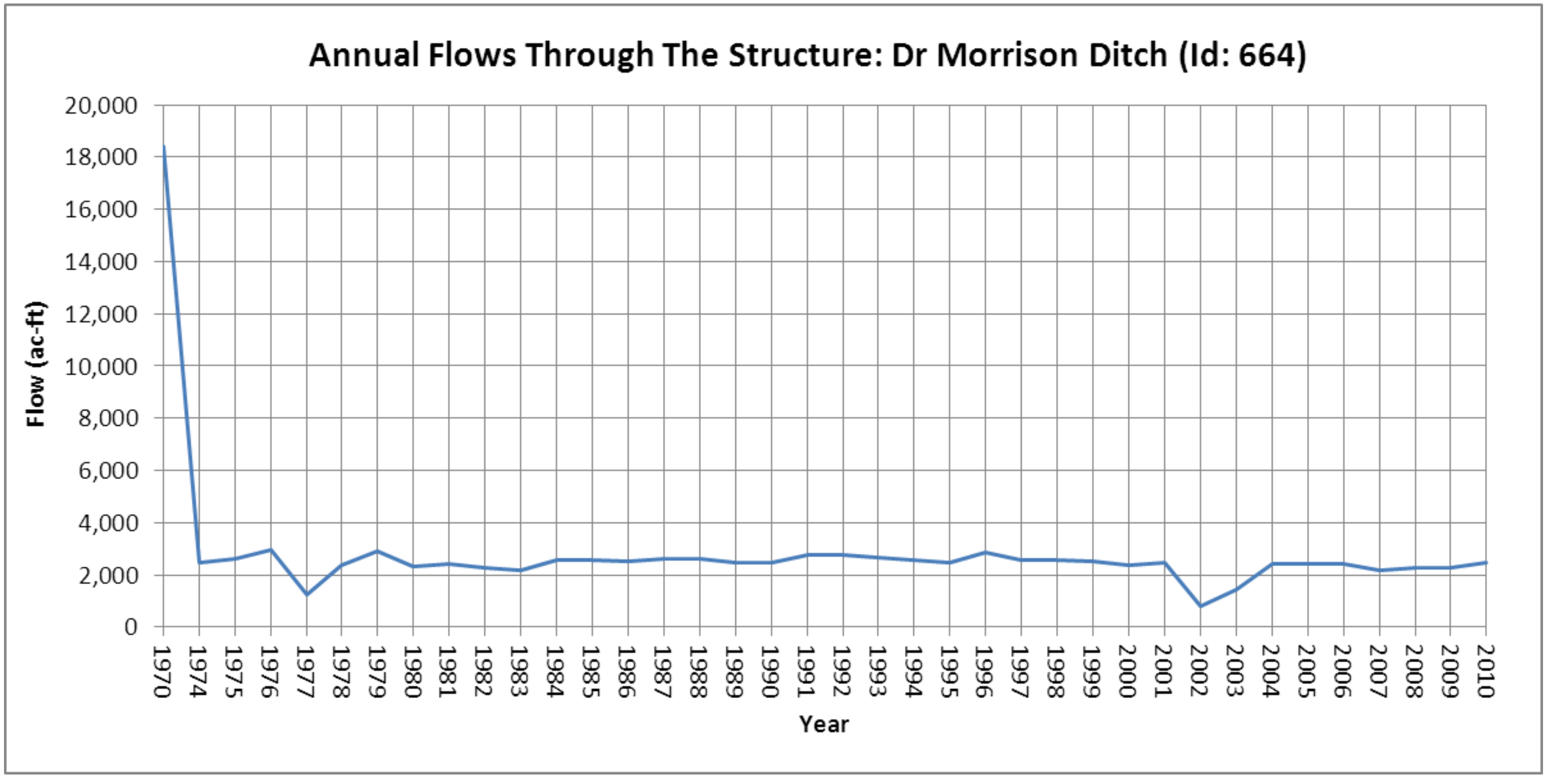
Water Rights - Net Amounts										
				Priority/Case	Rate (CFS)			Volume (Ac-Ft)		
Adj-Date	App-Date	Admin. No.	Order No.	Number	Absolute	Conditional	AP/EX	Absolute	Conditional	AP/EX
10/25/1930	7/25/1868	6781.00	0.00	P-1	0.00	0.00	1.00	0.00	0.00	0.00

Structure Name: DR MORRISON DITCH
Source: Pine River
Q10 Q40 Q160 Section Twnshp Range PM
NE SE SE 14 34N 7W N
Water District: 31 Structure ID Number: 664
UTM Coordinates (NAD 83): Northing (UTM y): 4122068 Easting (UTM x): 269467
Spotted from PLSS distances from section lines

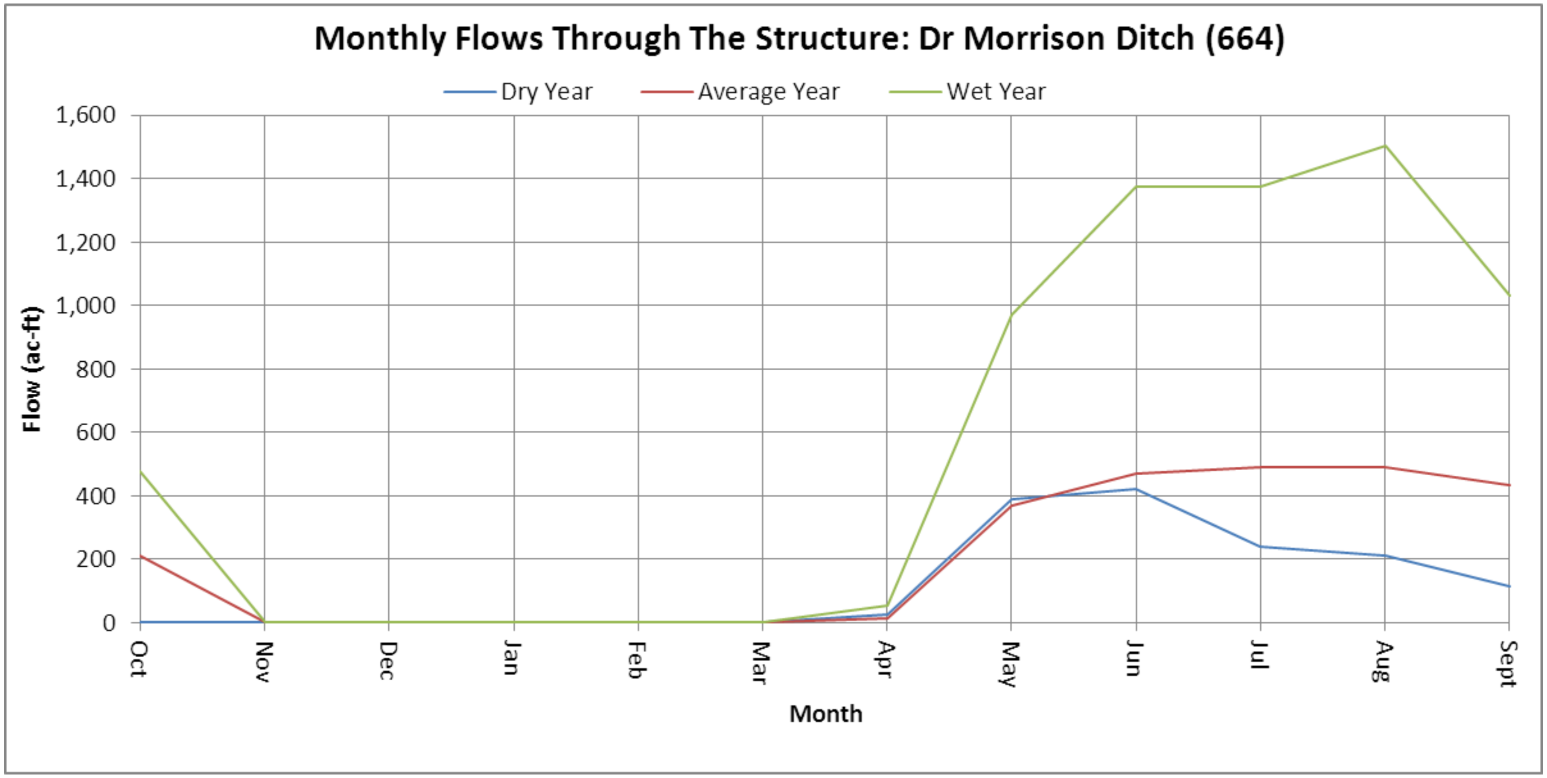
Water Rights Summary			
Parameter	Absolute	conditional	AP/EX
Total Decreed Rate(s) (CFS)	7.80	0.00	0.00
Total Decreed Volume(s) (AF)	0.00	0.00	0.00

Water Rights - Transactions											
Case Numbe	Adj-Date	App-Date	Admin. No.	Order No.	Priority No.	Decreed Amt	Adj Type	Status Type	Transfer Type	Use	Action Comment
CA1248	6/12/1934	10/1/1900	18536	0	P-26	7.8	O	A		IRRDOM	

Water Rights - Net Amounts										
				Priority/Case	Rate (CFS)			Volume (Ac-Ft)		
Adj-Date	App-Date	Admin. No.	Order No.	Number	Absolute	Conditional	AP/EX	Absolute	Conditional	AP/EX
6/12/1934	10/1/1900	18536.00	0.00	P-26	7.80	0.00	0.00	0.00	0.00	0.00



Annual Flows Through The Structure: Dr Morrison Ditch (Id: 664)
Flow (ac-ft)
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
1970
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Year


Monthly Flows Through The Structure: Dr Morrison Ditch (664)
Dry Year
Average Year
Wet Year
1,600
1,400
1,200
1,000
800
600
400
200
0
Flow (ac-ft)
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sept
Month

Structure Name: DR MORRISON D (DRY CR)

Source: Pine River

Q10 Q40 Q160 Section Twnshp Range PM
NW SW NE 21 34N 7W N

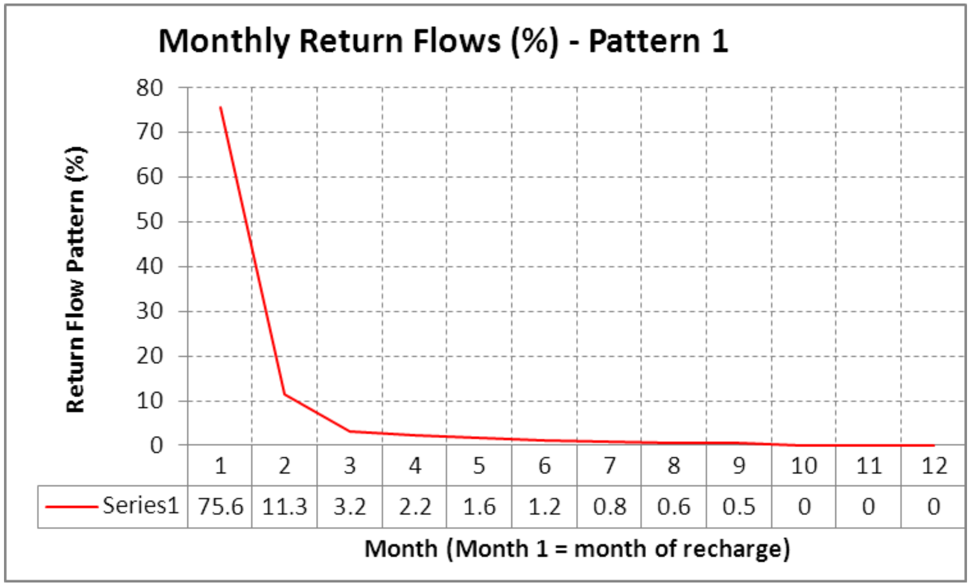
Water District: 31 Structure ID Number: 757

UTM Coordinates (NAD 83): Northing (UTM y): 4118019 Easting (UTM x): 268002.1
Spotted from PLSS distances from section lines

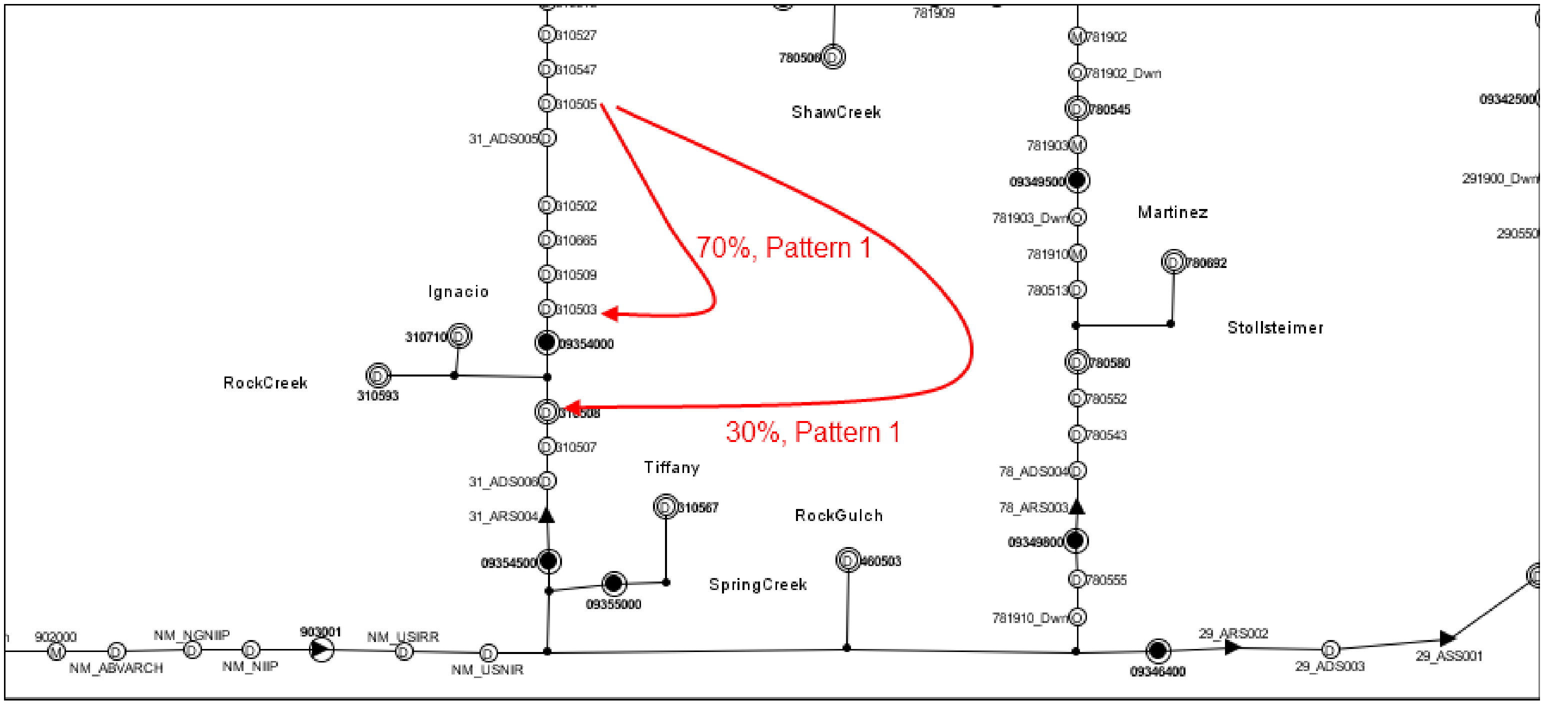
Water Rights Summary			
Parameter	Absolute	conditional	AP/EX
Total Decreed Rate(s) (CFS)	0.00	0.00	1.00
Total Decreed Volume(s) (AF)	0.00	0.00	0.00

Water Rights - Transactions											
Case Numbe	Adj-Date	App-Date	Admin. No.	Order No.	Priority No.	Decreed Amt	Adj Type	Status Type	Transfer Type	Use	Action Comment
CA7736	10/25/1930	7/25/1868	6781.00	0.00	P- 1	1.00	O	A		IRRDOM	24.75 CFS BUT ONLY 1.0 CFS ALLOWED IN CA 1248

Water Rights - Net Amounts										
				Priority/Case	Rate (CFS)			Volume (Ac-Ft)		
Adj-Date	App-Date	Admin. No.	Order No.	Number	Absolute	Conditional	AP/EX	Absolute	Conditional	AP/EX
10/25/1930	7/25/1868	6781.00	0.00	P-1	0.00	0.00	1.00	0.00	0.00	0.00



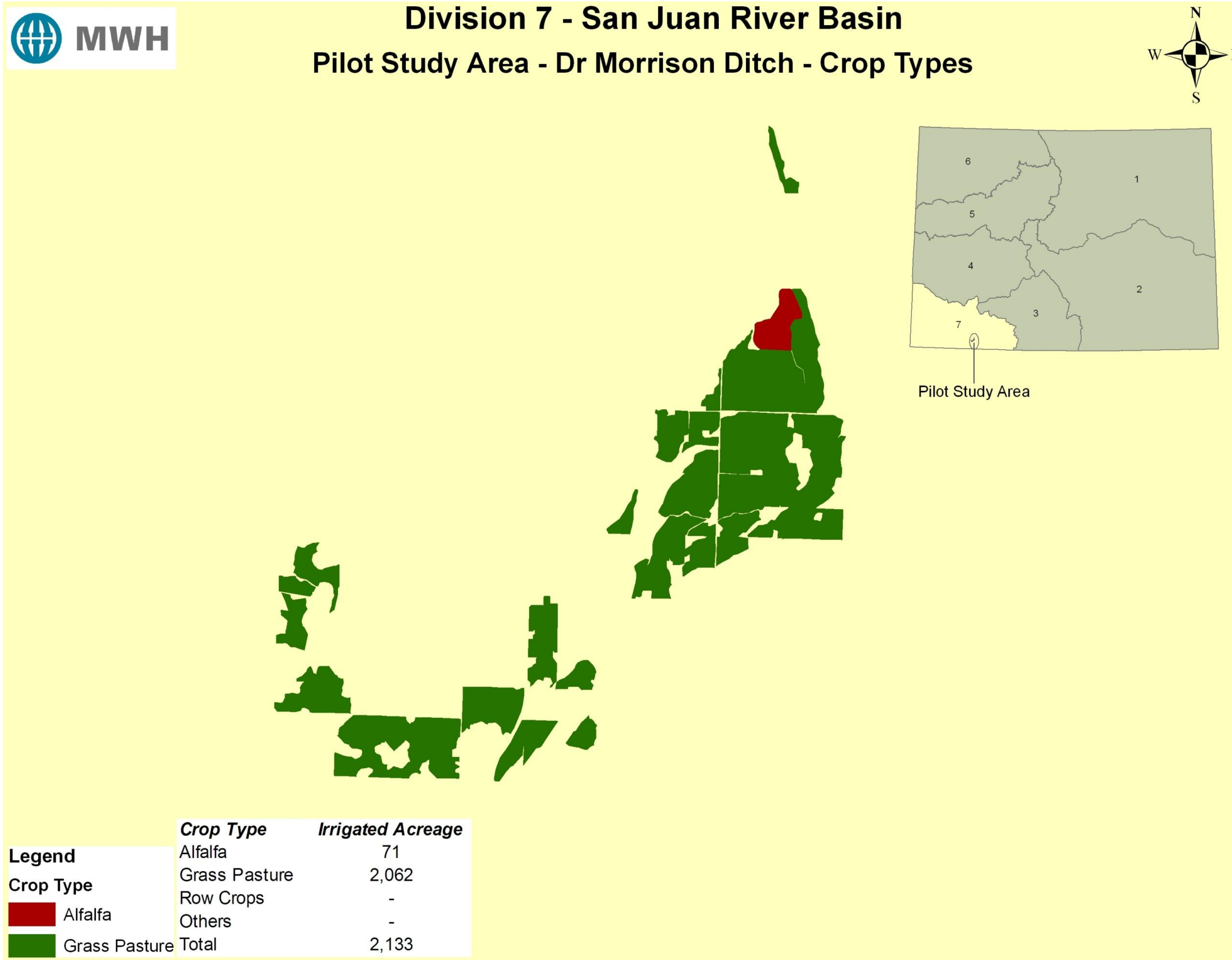
Monthly Return Flows (%) - Pattern 1
Return Flow Pattern (%)
80
70
60
50
40
30
20
10
0
1 2 3 4 5 6 7 8 9 10 11 12
Series1 75.6 11.3 3.2 2.2 1.6 1.2 0.8 0.6 0.5 0 0 0
Month (Month 1 = month of recharge)



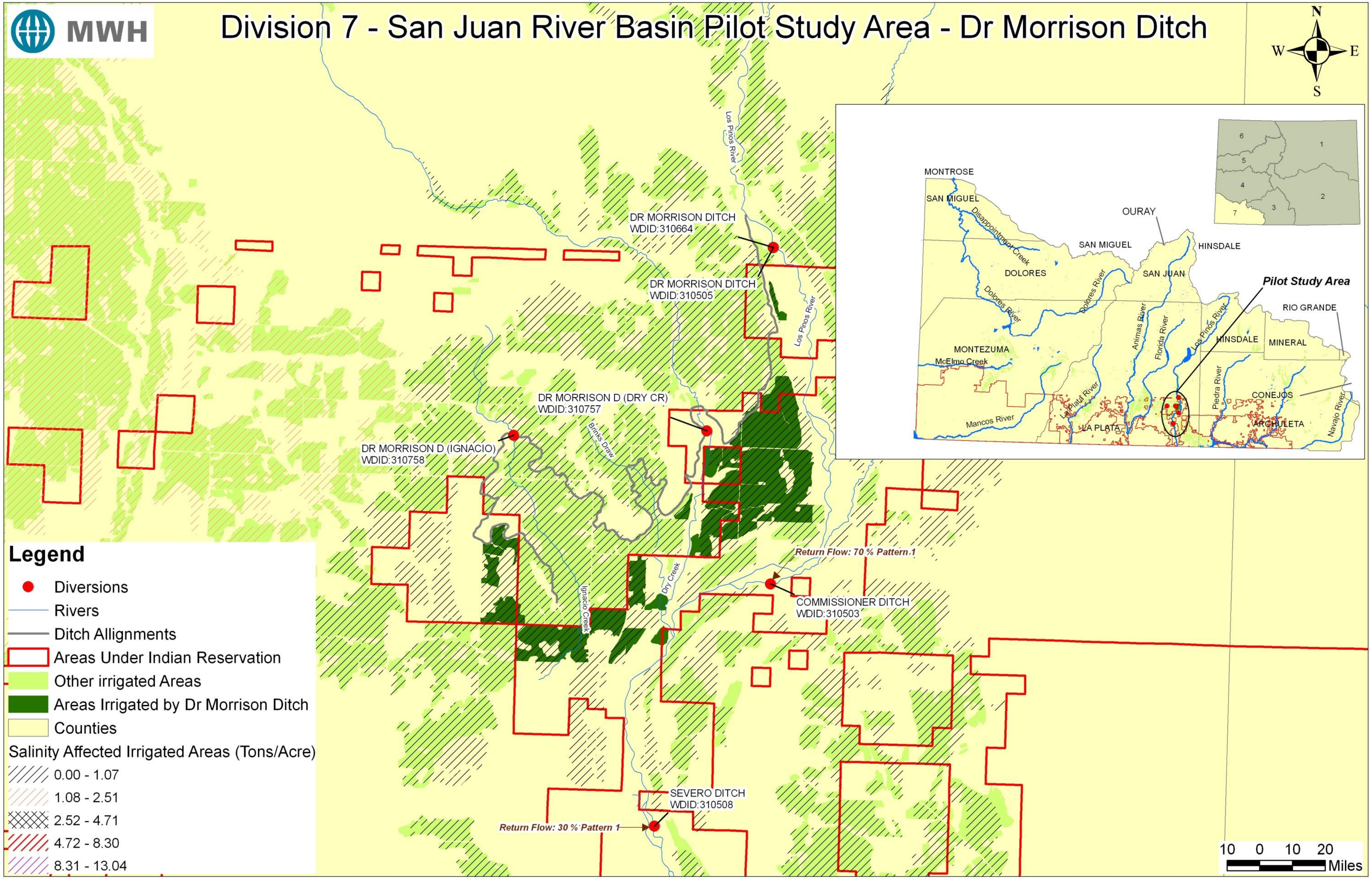
Patterns and Locations of Return Flow

Division 7 - San Juan River Basin

Pilot Study Area - Dr Morrison Ditch - Crop Types



Crop Type	*Irrigated Acreage*
Alfalfa	71
Grass Pasture	2,062
Row Crops	-
Others	-
Total	2,133



MWH
Division 7 - San Juan River Basin Pilot Study Area - Dr Morrison Ditch
N
W
E
S
DR MORRISON DITCH
WDID:310664
DR MORRISON DITCH
WDID:310505
DR MORRISON D (DRY CR)
WDID:310757
DR MORRISON D (IGNACIO)
WDID:310758
COMMISSIONER DITCH
WDID:310503
SEVERO DITCH
WDID:310508
Return Flow: 70 % Pattern 1
Return Flow: 30 % Pattern 1
Los Pinos River
Ignacio Creek
Dry Creek
Legend
Diversions
Rivers
Ditch Allignments
Areas Under Indian Reservation
Other irrigated Areas
Areas Irrigated by Dr Morrison Ditch
Counties
Salinity Affected Irrigated Areas (Tons/Acre)
0.00 - 1.07
1.08 - 2.51
2.52 - 4.71
4.72 - 8.30
8.31 - 13.04
Pilot Study Area
MONTROSE
SAN MIGUEL
OURAY
HINSDALE
DOLORES
SAN JUAN
RIO GRANDE
MINERAL
MONTEZUMA
CONEJOS
LA PLATA
ARCHULETA
Mancos River
Dolores River
Animas River
Florida River
Piedra River
Navajo River
10 0 10 20
Miles

2012

MWH Global

[PILOT STUDY: CANDIDATE SYSTEM SELECTION]

Division 6 (Yampa River Basin): Ekhart Ditch

Structure Name: EKHART DITCH

Source: Elk River

Q10 Q40 Q160 Section Twnshp Range PM
SE NE 28 9N 85W S

Water District: 58 Structure ID Number: 623

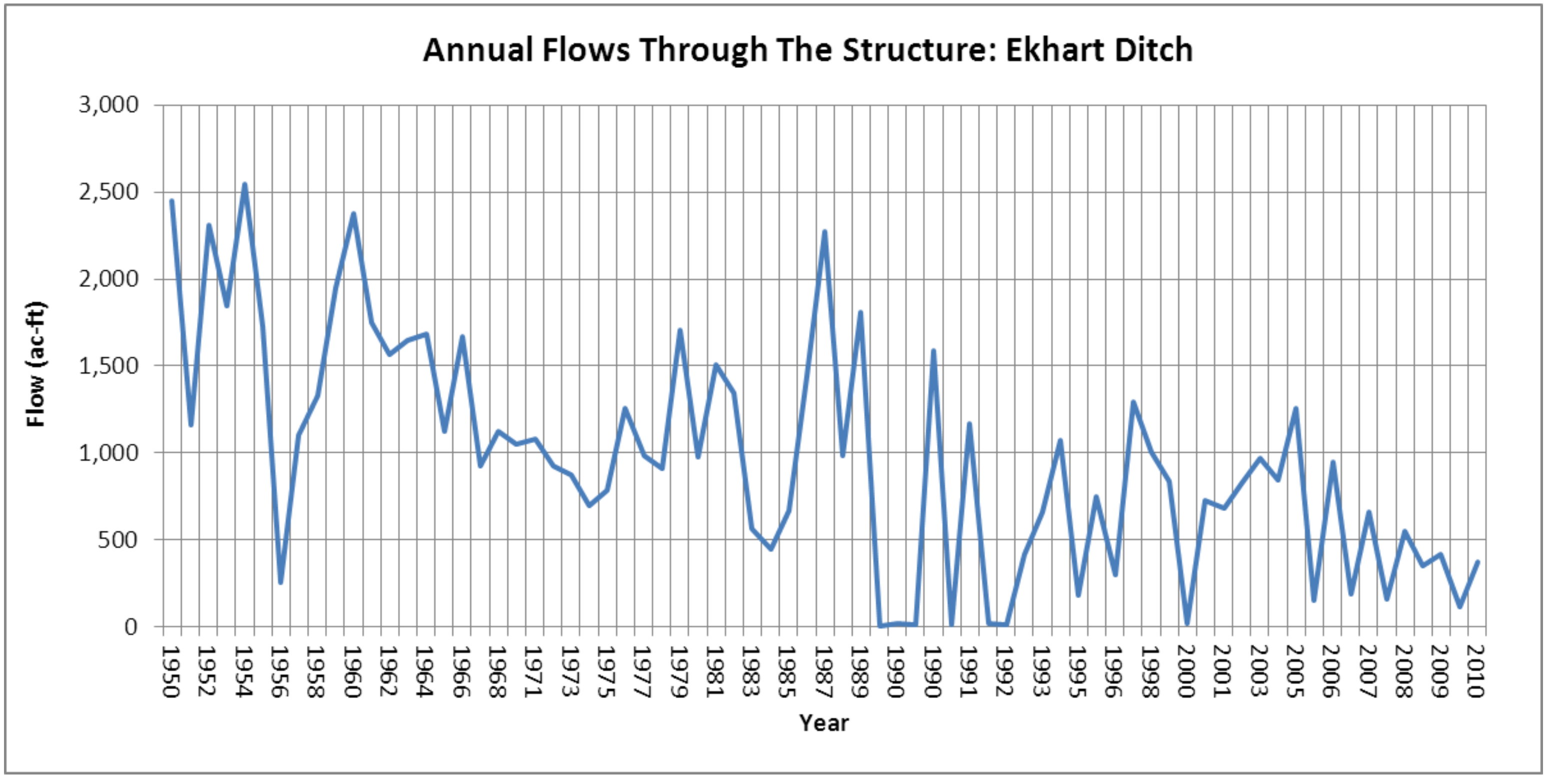
UTM Coordinates (NAD 83): Northing (UTM y): 4508542 Easting (UTM x): 337636
Spotted from PLSS distances from section lines

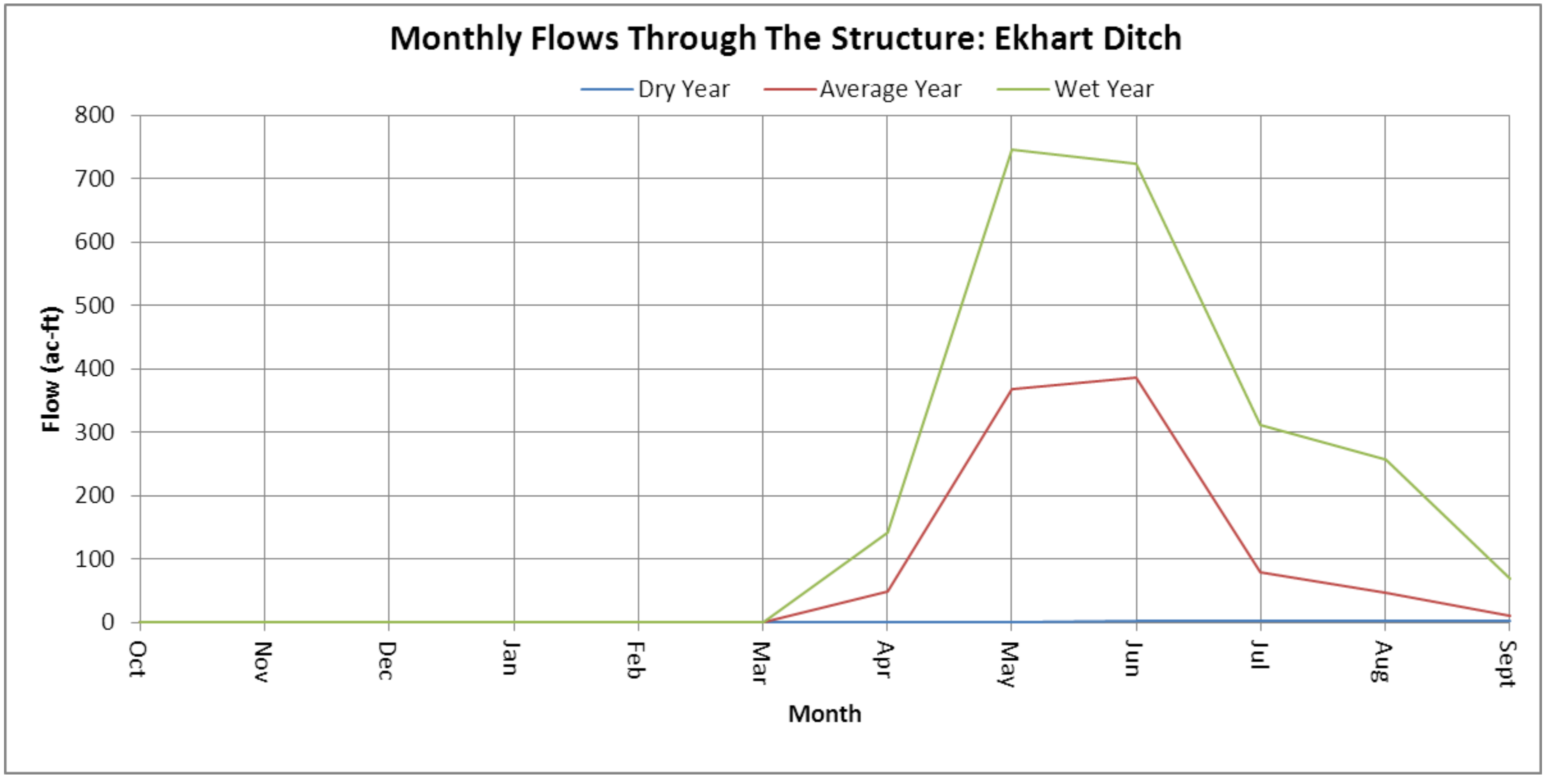
Water Rights Summary			
Parameter	Absolute	conditional	AP/EX
Total Decreed Rate(s) (CFS)	18.57	0.00	0.00
Total Decreed Volume(s) (AF)	0.00	0.00	0.00

	Pre Compact
	Post compact

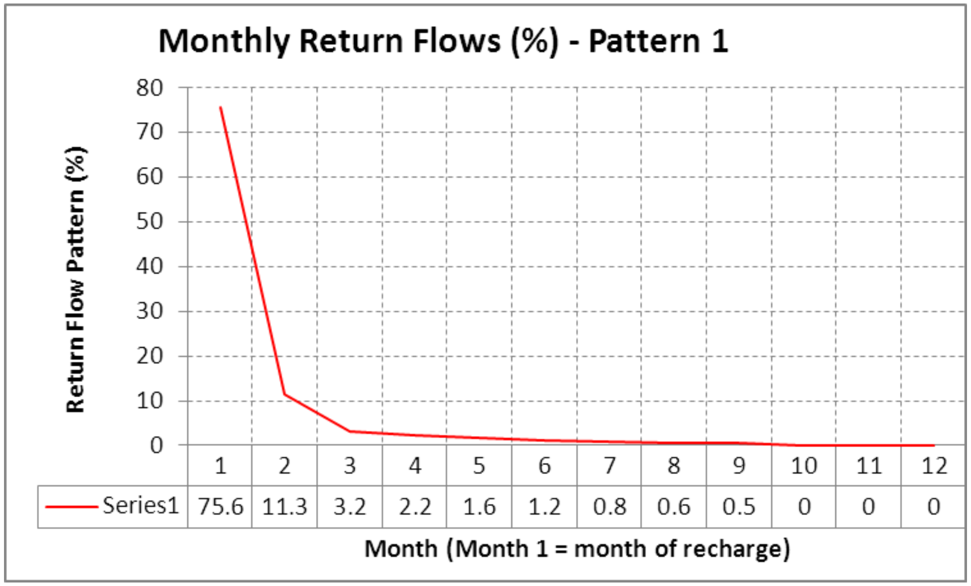
Water Rights - Transactions											
Case Number	Adj-Date	App-Date	Admin. No.	Order No.	Priority No.	Decreed Amt	Adj Type	Status Type	Transfer Type	Use	Action Comment
W0550-73	12/31/1973	12/31/1973	44925.43	0		2	S	A		IRRSTK	
W1056-76	9/22/1892	9/22/1892	13284.00	0	21	2	O	A	TT	STOIRRMUNCOMINDRECFISDOMWLD	CHANGE OF USE FOR 2CFS
09/22/1892	9/22/1892	9/22/1892	13284.00	0	21	4.7	O	A		IRR	SIX AP FOR 2.0 CFS UP TO 47 AF; SEE AUG . W 1056
W1056-76	9/22/1892	9/22/1892	13284.00	0	21	2	O	A	TF	IRR	CHANGE OF USE FOR 2CFS
CA0756	7/1/1912	7/1/1912	22544.23	0	212	0.66	S	A		IRR	
CA2475	9/14/1946	9/14/1946	33782.30	0	335	4.7	S	A		IRR	
CA3538	3/30/1964	3/30/1964	39254.36	0	24	1.21	S	A		IRRDOMSTK	
09/22/1892	9/22/1892	9/22/1892	14138.00	0	56	1.3	O	A		IRR	

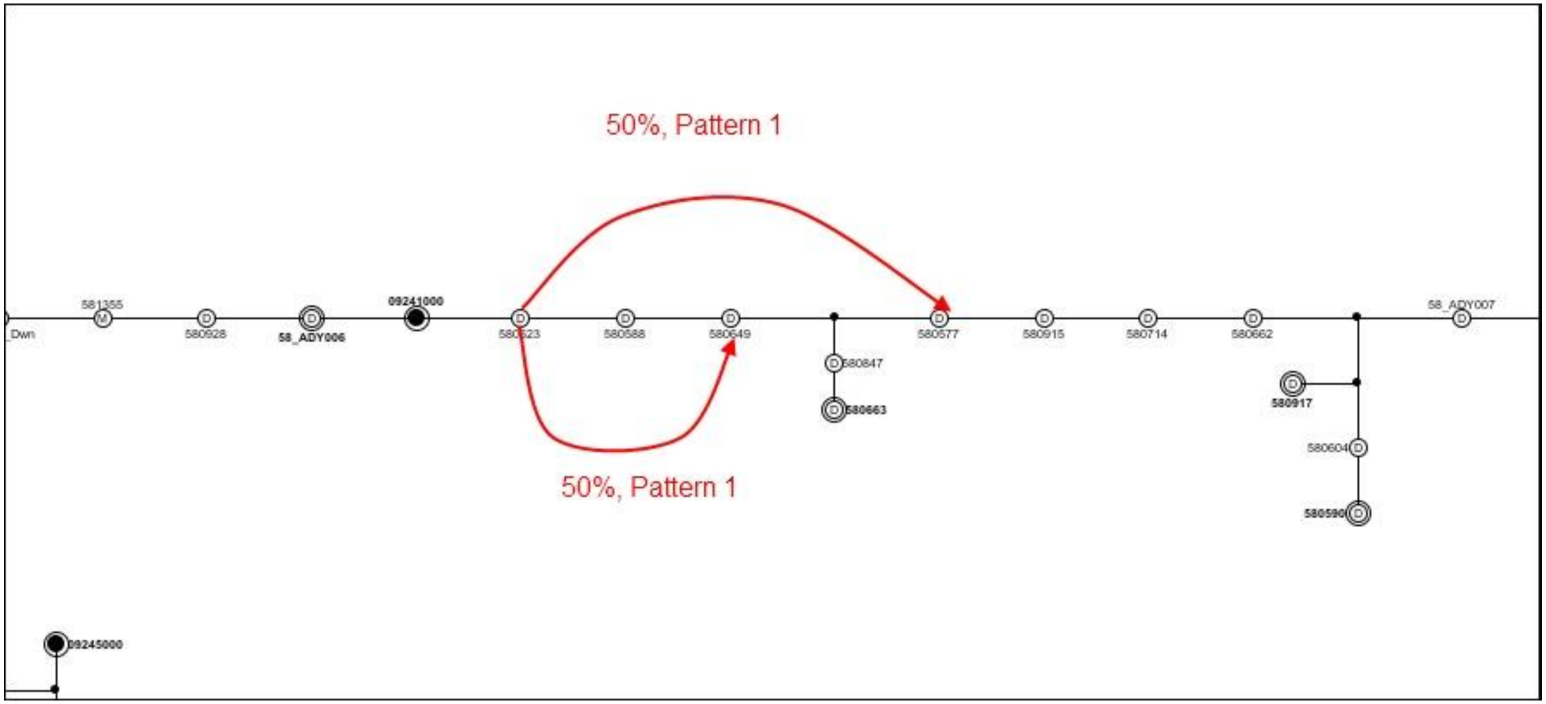
Water Rights - Net Amounts										
				Priority/Case	Rate (CFS)			Volume (Ac-Ft)		
Adj-Date	App-Date	Admin. No.	Order No.	Number	Absolute	Conditional	AP/EX	Absolute	Conditional	AP/EX
12/31/1973	6/1/1967	12/30/2022	1/0/1900	W0550-73	2.00	0.00	0.00	0.00	0.00	0.00
9/22/1892	5/15/1886	5/14/1936	1/0/1900	21	4.70	0.00	0.00	0.00	0.00	0.00
9/22/1892	9/15/1888	9/15/1938	1/0/1900	56	1.30	0.00	0.00	0.00	0.00	0.00
7/1/1912	8/26/1911	9/20/1961	1/0/1900	212	0.66	0.00	0.00	0.00	0.00	0.00
3/30/1964	6/15/1949	6/21/2007	1/0/1900	24	1.21	0.00	0.00	0.00	0.00	0.00
9/14/1946	6/1/1933	6/27/1992	1/0/1900	335	4.70	0.00	0.00	0.00	0.00	0.00


Annual Flows Through The Structure: Ekhart Ditch
3,000
2,500
2,000
1,500
1,000
500
0
Flow (ac-ft)
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1990
1990
1991
1992
1993
1995
1996
1998
2000
2001
2003
2005
2006
2007
2008
2009
2010
Year



Note: Based on the available monthly flow dataset for the structure annual values were computed and the top and bottom 10% values in terms of magnitude were used to select the wet and the dry years while the rest of years were considered as representatives of average years. Monthly averages were computed based on those years and were used to generate the monthly plots.

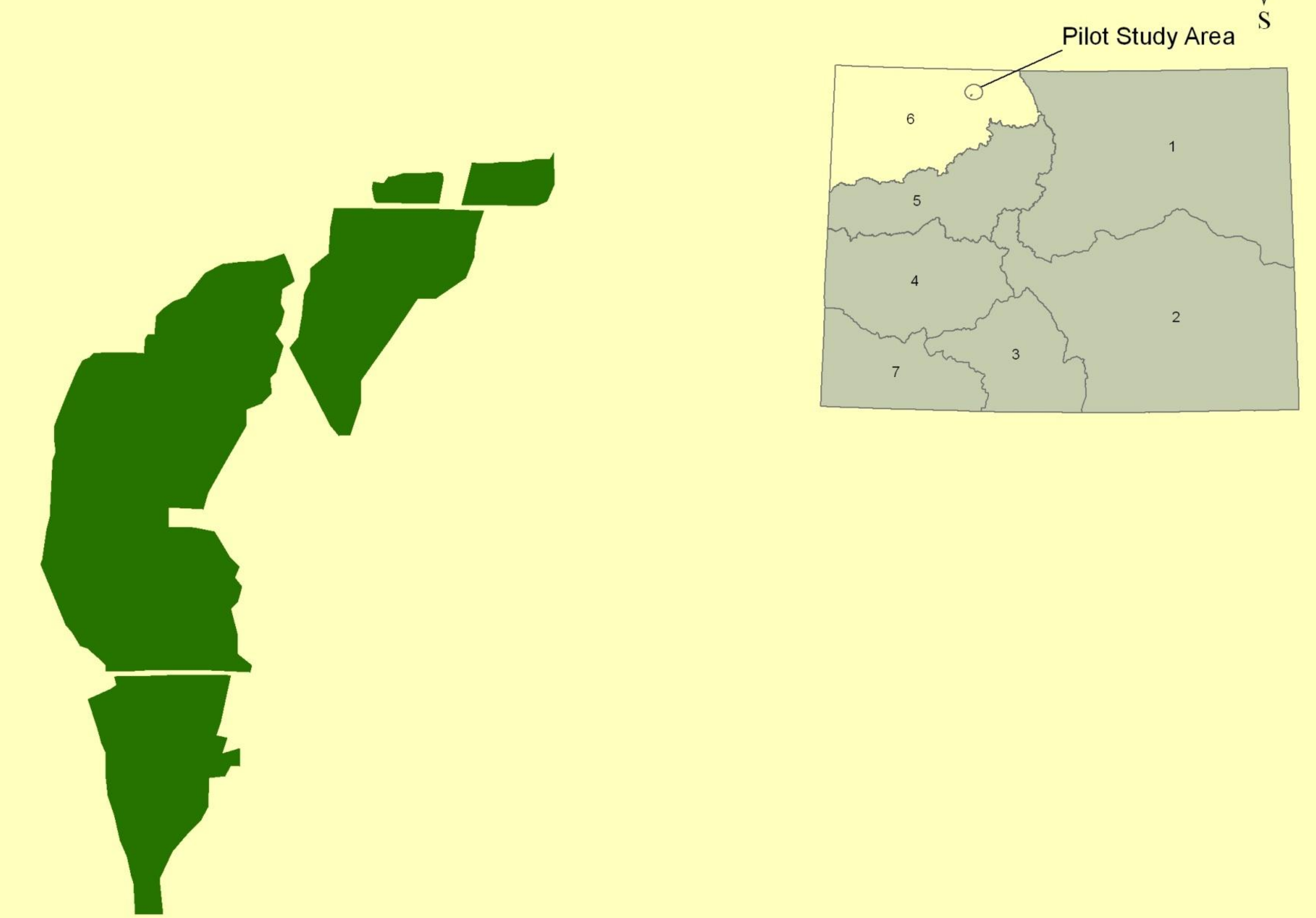

Monthly Return Flows (%) - Pattern 1
Return Flow Pattern (%)
80
70
60
50
40
30
20
10
0
1 2 3 4 5 6 7 8 9 10 11 12
Series1 75.6 11.3 3.2 2.2 1.6 1.2 0.8 0.6 0.5 0 0 0
Month (Month 1 = month of recharge)



Patterns and Locations of Return flow

Division 6 - Yampa River Basin

Pilot Study Area - Ekhart Ditch - Crop Types

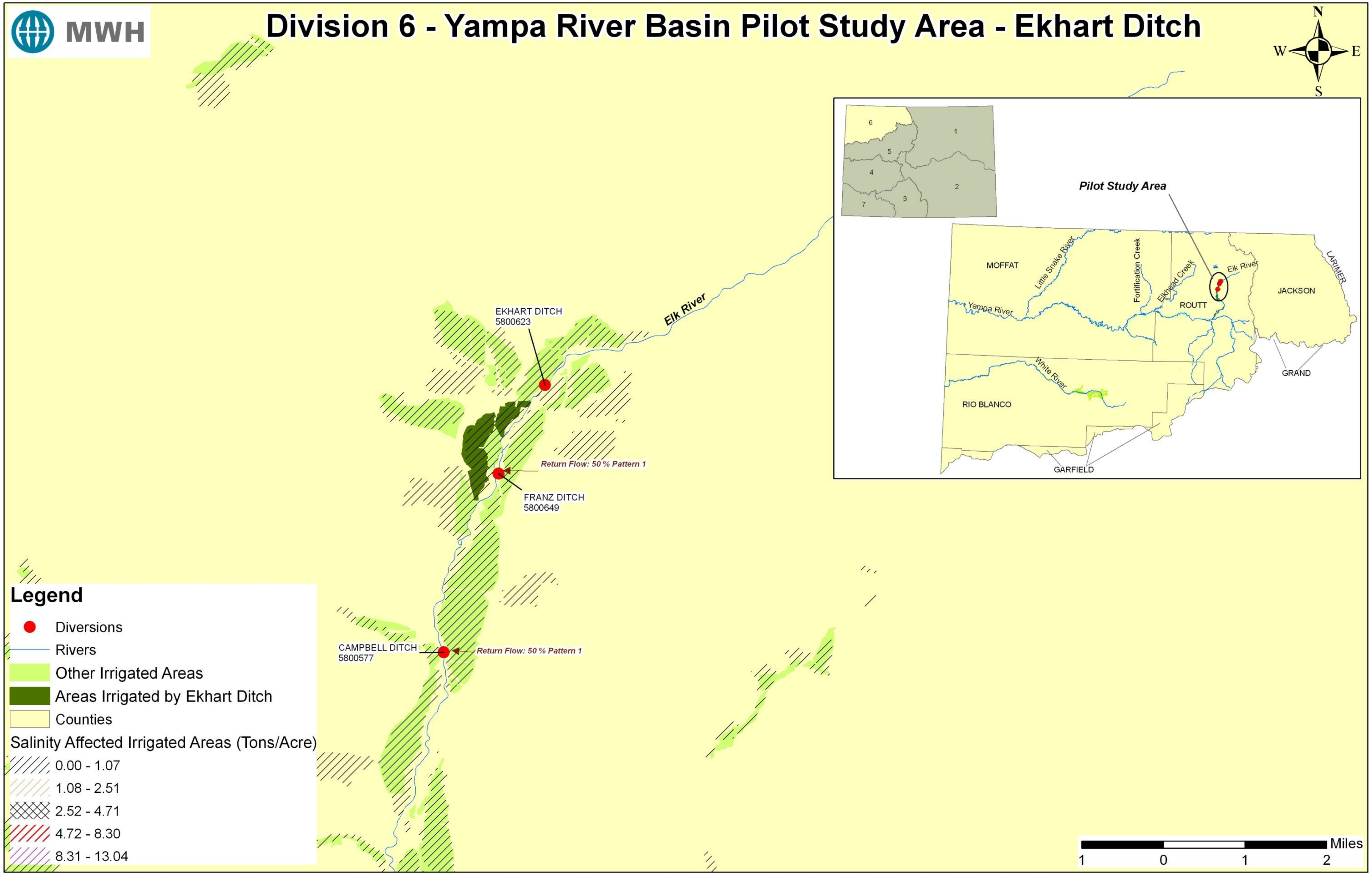


Crop Type	Irrigated Acreage
Alfalfa	-
Grass Pasture	193
Row Crops	-
Others	-
Total	193

Legend

Crop Type

Grass Pasture


Division 6 - Yampa River Basin Pilot Study Area - Ekhart Ditch
MWH
N
S
W
E
EKHART DITCH
5800623
Elk River
Return Flow: 50 % Pattern 1
FRANZ DITCH
5800649
CAMPBELL DITCH
5800577
Return Flow: 50 % Pattern 1
Pilot Study Area
MOFFAT
Little Snake River
Fortification Creek
Elkhead Creek
Elk River
ROUTT
JACKSON
LARIMER
Yampa River
White River
RIO BLANCO
GRAND
GARFIELD
Legend
Diversions
Rivers
Other Irrigated Areas
Areas Irrigated by Ekhart Ditch
Counties
Salinity Affected Irrigated Areas (Tons/Acre)
0.00 - 1.07
1.08 - 2.51
2.52 - 4.71
4.72 - 8.30
8.31 - 13.04
Miles
1
0
1
2

2012

MWH Global

[PILOT STUDY: CANDIDATE SYSTEM SELECTION]

Division 4 (Gunnison River Basin): Colorado Cooperative Ditch

Structure Name: HIGHLINE CANAL
Source: San Miguel River

Q10 Q40 Q160 Section Twnshp Range PM
NE NE SW 30 46N 13W N

Water District: 60 Structure ID Number: 633

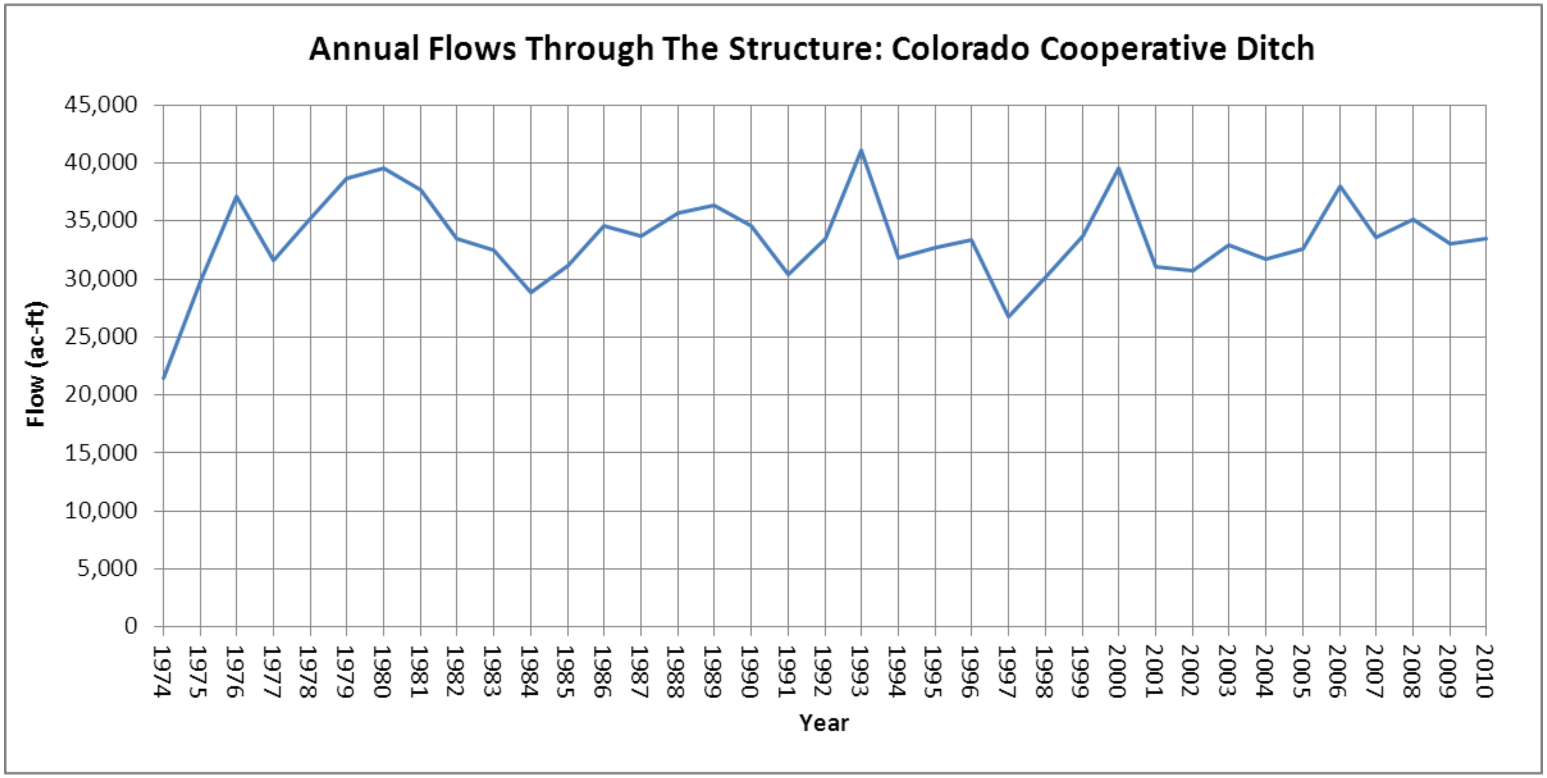
UTM Coordinates (NAD 83): Northing (UTM y): 4234832 Easting (UTM x): 207181.3
Spotted from PLSS distances from section lines

Water Rights Summary			
Parameter	Absolute	conditional	AP/EX
Total Decreed Rate(s) (CFS)	145.00	0.00	0.00
Total Decreed Volume(s) (AF)	0.00	0.00	0.00

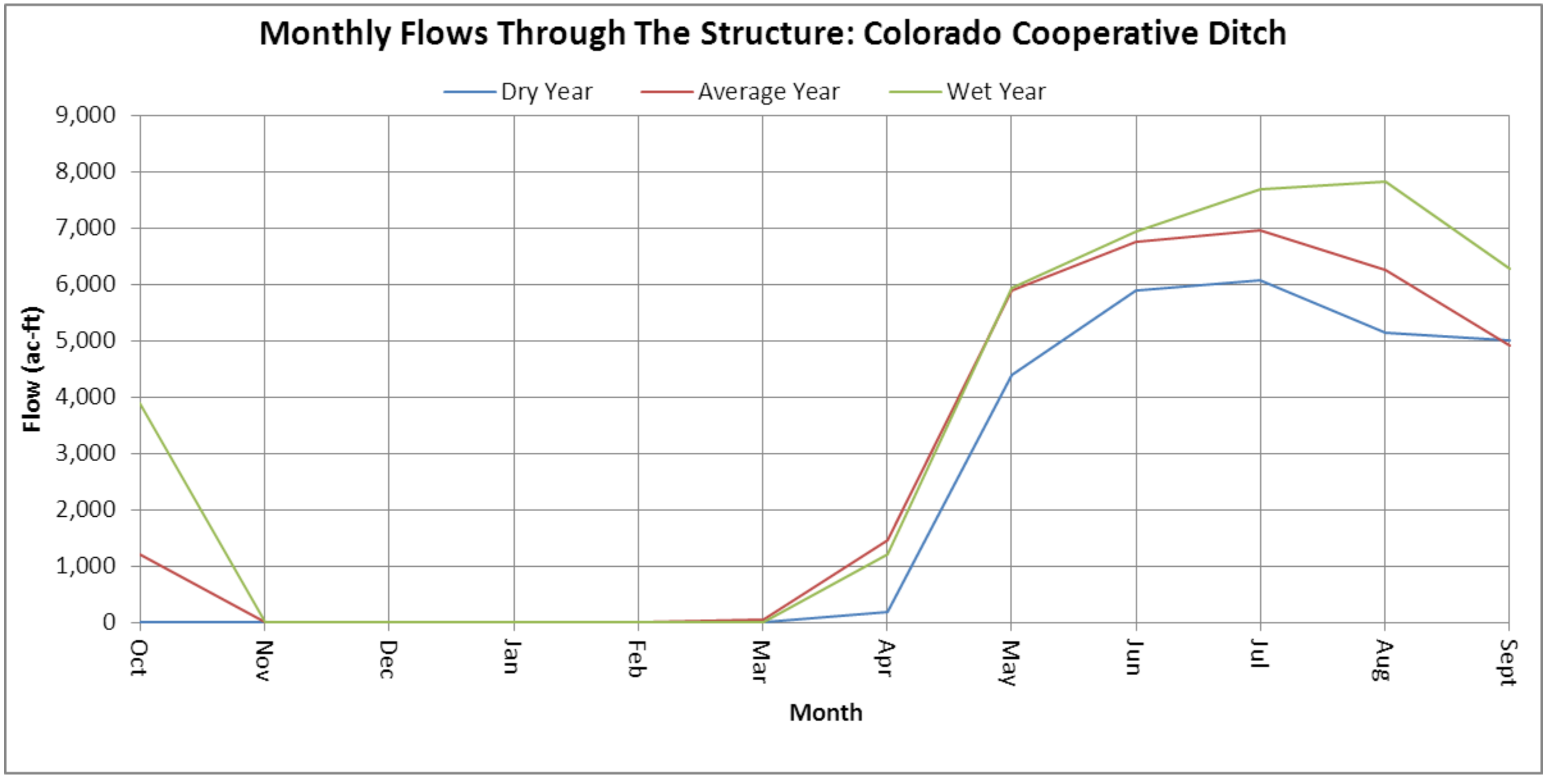
	Pre Compact
	Post compact

Water Rights - Transactions											
Case Number	Adj-Date	App-Date	Admin. No.	Order No.	Priority No.	Decreed Amt	Adj Type	Status Type	Transfer Type	Use	Action Comment
88CW0055	6/3/1911	6/1/1895	16588.00	0.00	74	0.26	O	A	TT	STOIRRMUNINDDOMSTKAUG	AUG, IND, STOR USES ADDED; REPL NUCLA MINE P/A; 97.8AF/YR
88CW0055	6/3/1911	6/1/1895	16588.00	0.00	74	0.26	O	A	TF	IRRMUNDOMSTK	USE ADDED
CA1627	6/3/1911	6/1/1895	16588.00	0.00	74	31.28	O	A		IRR	LOC CORRECTED BY 79CW256 P 90 SEE STIP CIVIL ACTION 6808
CA6808	6/3/1911	6/1/1895	16588.00	0.00	74	0.00	O	A	TF	IRR	USES ADDED TO 31.28CFS SEE STIP CIVIL ACTION 6808
CA6808	6/3/1911	6/1/1895	16588.00	0.00	74	0.00	O	A	TF	IRRMUNDOMSTK	USES ADDED TO 31.28CFS SEE STIP CIVIL ACTION 6808
88CW0055	9/30/1916	12/8/1908	23681.22	0.00	123	0.33	S	A	TF	IRRMUNDOMSTK	USE ADDED
88CW0055	9/30/1916	12/8/1908	23681.22	0.00	123	0.33	S	A	TT	IRRMUNINDDOMSTKAUG	AUG, IND USES ADDED; REPL NUCLA PEABODY P/A
CA2207	9/30/1916	12/8/1908	23681.22	0.00	123	39.62	S	A		IRR	LOC CORRECTED BY 79CW256 HIGHLINE CANAL ENL P 32
CA6808	9/30/1916	12/8/1908	23681.22	0.00	123	0.00	S	A	TF	IRR	USES ADDED TO 39.62CFS SEE STIP
CA6808	9/30/1916	12/8/1908	23681.22	0.00	123	0.00	S	A	TT	IRRMUNDOMSTK	USES ADDED TO 39.62CFS SEE STIP
88CW0055	2/26/1929	10/20/1926	28051.00	0.00	211	0.08	S	A	TT	IRRMUNINDDOMSTKAUG	AUG, IND USES ADDED; REPL NUCLA PEABODY P/A
88CW0055	2/26/1929	10/20/1926	28051.00	0.00	211	0.08	S	A	TF	IRRMUNDOMSTK	USE ADDED
CA3785	2/26/1929	10/20/1926	28051.00	0.00	211	10.00	S	C		IRR	LOC CORRECTED BY 79CW256 HIGHLINE CANAL ENL P 214
CA6808	2/26/1929	10/20/1926	28051.00	0.00	211	0.00	S	C	TT	IRRMUNDOMSTK	USES ADDED FOR 10CFS; SEE STIP IN CA6808
CA6808	2/26/1929	10/20/1926	28051.00	0.00	211	0.00	S	C	TF	IRR	USES ADDED FOR 10CFS; SEE STIP IN CA6808
W0095	2/26/1929	10/20/1926	28051.00	0.00	211	10.00	S	CA		IRRMUNDOMSTK	MADE ABS 11/3/1970 LOC CORRECTION 79CW256 HIGHLINE CANAL ENL NO2
88CW0055	11/1/1939	5/1/1932	30604.30	0.00	323	0.24	S	A	TT	IRRMUNINDDOMSTKAUG	AUG, IND USES ADDED; REPL NUCLA PEABODY P/A
88CW0055	11/1/1939	5/1/1932	30604.30	0.00	323	0.24	S	A	TF	IRRMUNDOMSTK	USE ADDED
CA2207	11/1/1939	5/1/1932	30604.30	0.00	323	14.10	S	A		IRR	LOC CORRECTED BY 79CW256 P 49 SEE STIP CIVIL ACTION 6808
CA2207	11/1/1939	5/1/1932	30604.30	0.00	323	15.00	S	C		IRR	LOC CORRECTED BY 79CW256 P 580 SEE STIP CIVIL ACTION 6808
CA4641	11/1/1939	5/1/1932	30604.30	0.00	323	15.00	S	CA		IRR	COND TO ABSOLUTE 1/27/1942 P 580 SEE STIP CIVIL ACTION 6808
CA6808	11/1/1939	5/1/1932	30604.30	0.00	323	0.00	S	A	TT	IRRMUNDOMSTK	USES ADDED TO 14.1CFS; SEE STIP CIVIL ACTION 6808
CA6808	11/1/1939	5/1/1932	30604.30	0.00	323	0.00	S	A	TF	IRR	USES ADDED TO 14.1CFS; SEE STIP CIVIL ACTION 6808
CA6808	11/1/1939	5/1/1932	30604.30	0.00	323	0.00	S	A	TT	IRRMUNDOMSTK	USES ADDED TO 15CFS; SEE STIP CIVIL ACTION 6808
CA6808	11/1/1939	5/1/1932	30604.30	0.00	323	0.00	S	A	TF	IRR	USES ADDED TO 15CFS; SEE STIP CIVIL ACTION 6808
88CW0055	1/27/1942	2/18/1939	32811.33	0.00	365	0.29	S	A	TT	IRRMUNINDDOMSTKAUG	AUG, IND USES ADDED; REPL NUCLA PEABODY P/A
88CW0055	1/27/1942	2/18/1939	32811.33	0.00	365	0.29	S	A	TF	IRR	USE ADDED
CA4641	1/27/1942	2/18/1939	32811.33	0.00	365	35.00	S	A		IRR	LOC CORRECTED BY 79CW256 P 580 SEE STIP CIVIL ACTION 6808
CA6808	1/27/1942	2/18/1939	32811.33	0.00	365	0.00	S	A	TT	IRRMUNDOMSTK	USES ADDED TO 35CFS; SEE STIP CIVIL ACTION 6808
CA6808	1/27/1942	2/18/1939	32811.33	0.00	365	0.00	S	A	TF	IRR	USES ADDED TO 35CFS; SEE STIP CIVIL ACTION 6808

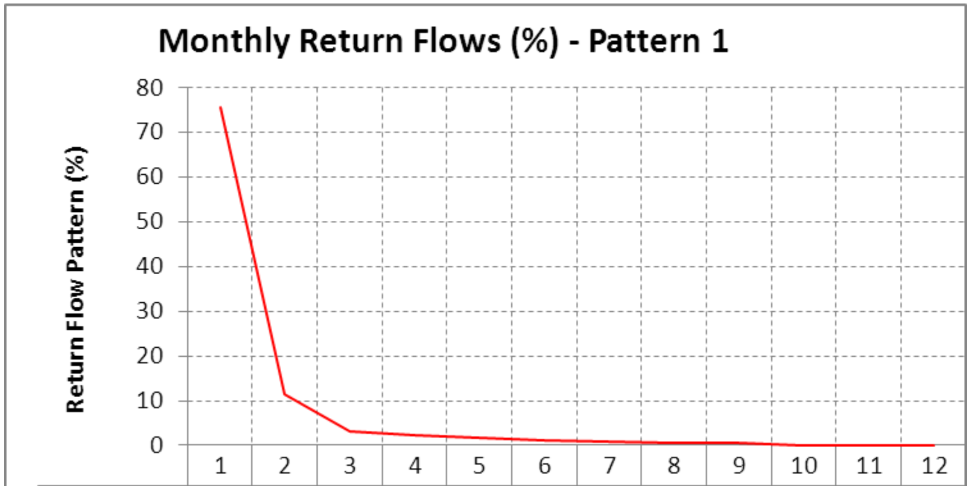
Water Rights - Net Amounts										
				Priority/Case	Rate (CFS)			Volume (Ac-Ft)		
Adj-Date	App-Date	Admin. No.	Order No.	Number	Absolute	Conditional	AP/EX	Absolute	Conditional	AP/EX
6/3/1911	6/1/1895	16588	0	74	31.28	0	0	0	0	0
9/30/1916	12/8/1908	23681.21526	0	123	39.62	0	0	0	0	0
2/26/1929	10/20/1926	28051	0	211	10	0	0	0	0	0
11/1/1939	5/1/1932	30604.30071	0	323	29.1	0	0	0	0	0
1/27/1942	2/18/1939	32811.32555	0	365	35	0	0	0	0	0



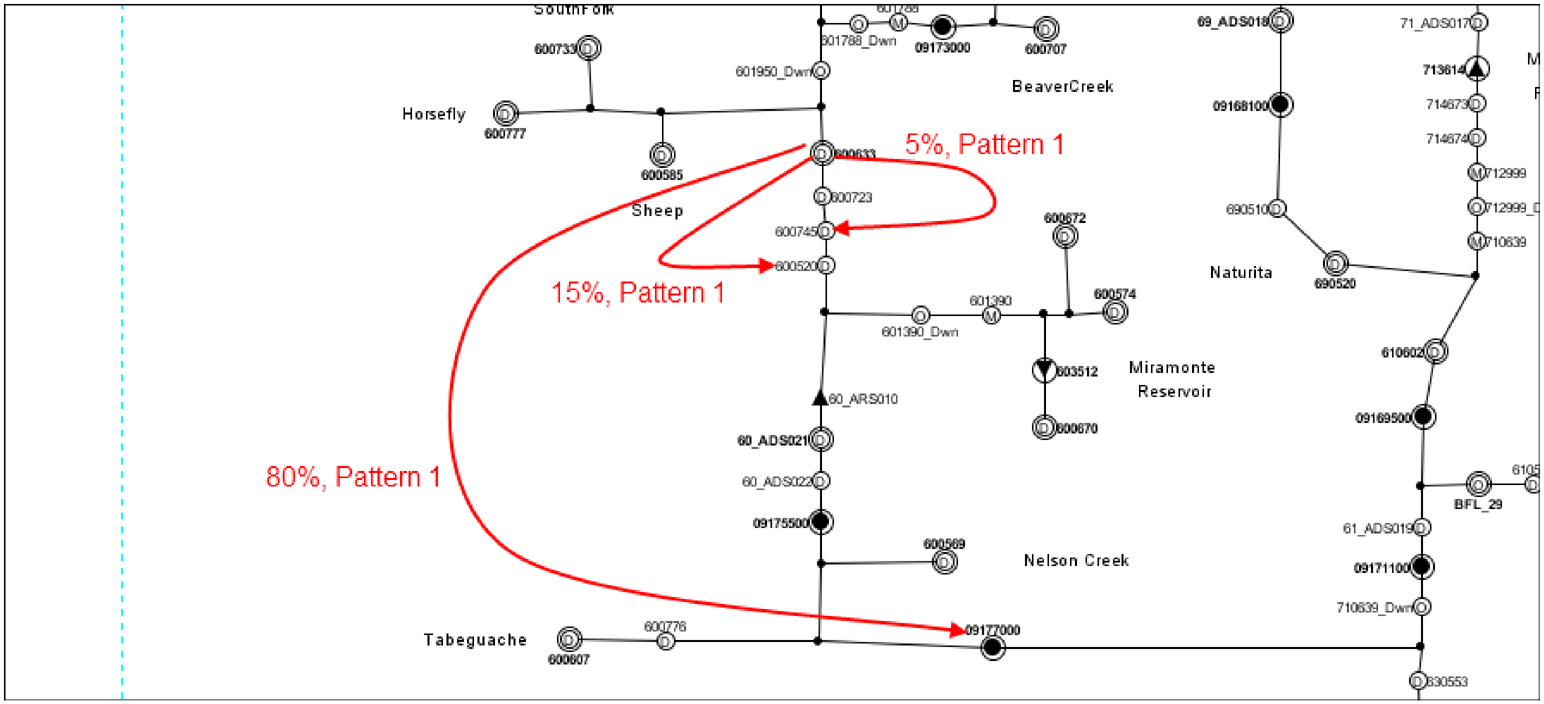
Annual Flows Through The Structure: Colorado Cooperative Ditch
Flow (ac-ft)
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Year



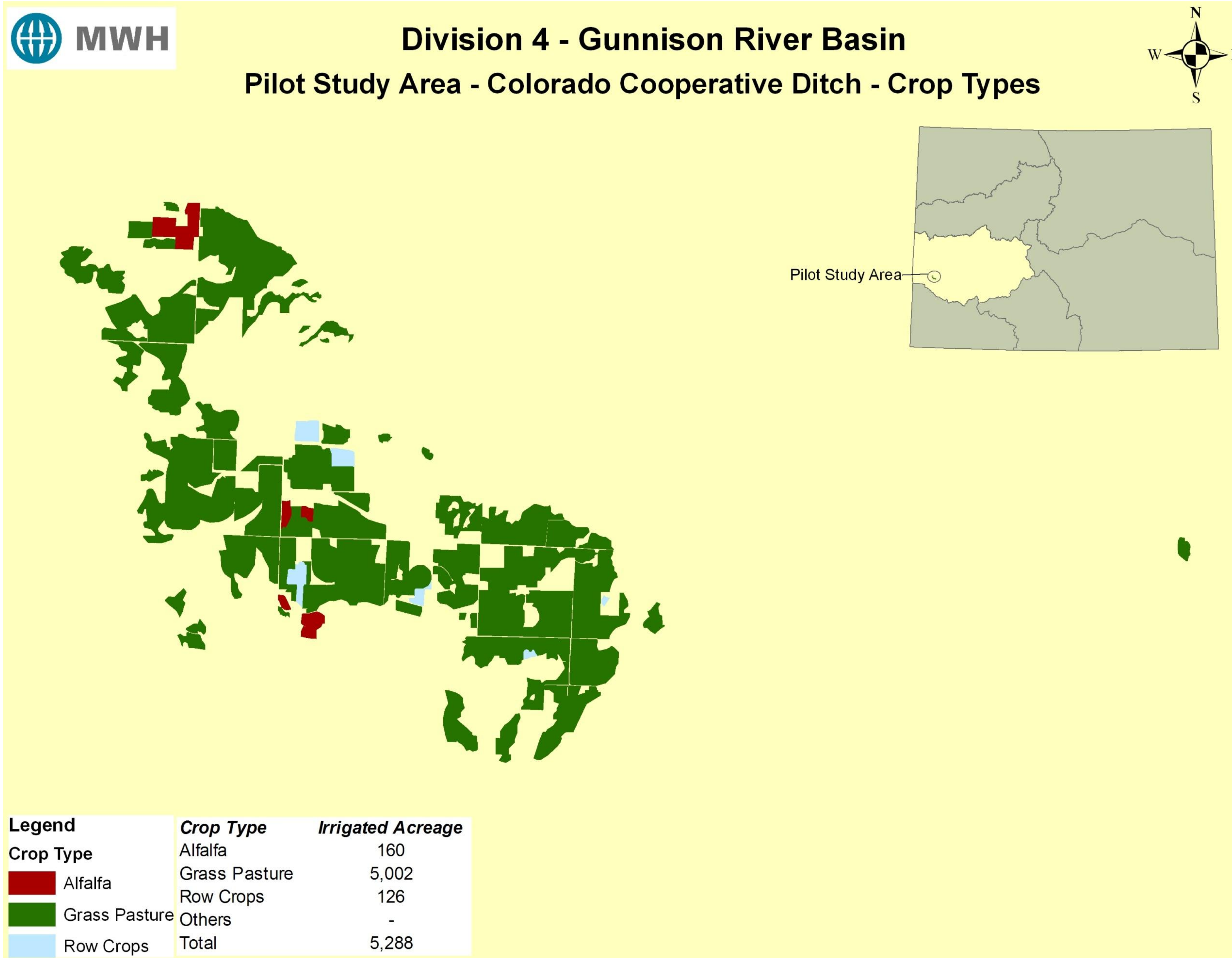
Note: Based on the available monthly flow dataset for the structure annual values were computed and the top and bottom 10% values in terms of magnitude were used to select the wet and the dry years while the rest of years were considered as representatives of average years. Monthly averages were computed based on those years and were used to generate the monthly plots.



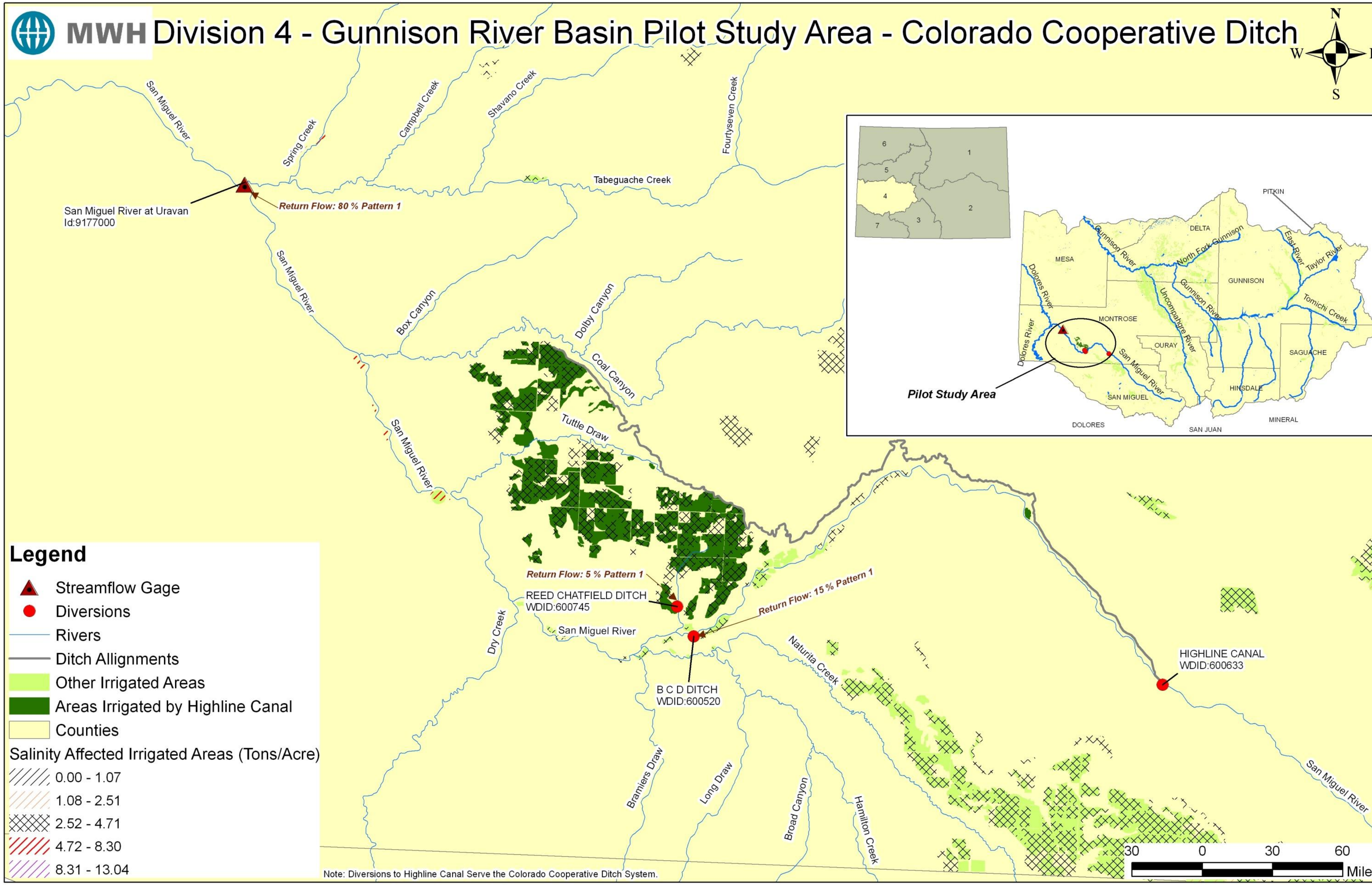
	1	2	3	4	5	6	7	8	9	10	11	12
Series1	75.6	11.3	3.2	2.2	1.6	1.2	0.8	0.6	0.5	0	0	0



Patterns and Locations of Return flow



Crop Type	*Irrigated Acreage*
Alfalfa	160
Grass Pasture	5,002
Row Crops	126
Others	-
Total	5,288



Division 4 - Gunnison River Basin Pilot Study Area - Colorado Cooperative Ditch
N
S
W
E
San Miguel River
Spring Creek
Campbell Creek
Shavano Creek
Fourtyseven Creek
Tabeguache Creek
San Miguel River at Uravan
Id:9177000
Return Flow: 80 % Pattern 1
San Miguel River
Box Canyon
Dolby Canyon
Coal Canyon
Tuttle Draw
San Miguel River
Return Flow: 5 % Pattern 1
REED CHATFIELD DITCH
WDID:600745
Return Flow: 15 % Pattern 1
San Miguel River
B C D DITCH
WDID:600520
Dry Creek
Naturita Creek
Bramiers Draw
Long Draw
Broad Canyon
Hamilton Creek
HIGHLINE CANAL
WDID:600633
San Miguel River
Pilot Study Area
PITKIN
DELTA
MESA
GUNNISON
MONTROSE
OURAY
SAGUACHE
HINSDALE
SAN MIGUEL
DOLORES
SAN JUAN
MINERAL
Gunnison River
North Fork Gunnison
East River
Taylor River
Dolores River
Uncompahgre River
Gunnison River
Tomichi Creek
San Miguel River
Legend
Streamflow Gage
Diversions
Rivers
Ditch Allignments
Other Irrigated Areas
Areas Irrigated by Highline Canal
Counties
Salinity Affected Irrigated Areas (Tons/Acre)
0.00 - 1.07
1.08 - 2.51
2.52 - 4.71
4.72 - 8.30
8.31 - 13.04
Note: Diversions to Highline Canal Serve the Colorado Cooperative Ditch System.
30 0 30 60
Miles

APPENDIX B

Test Case Site Visit Reports

UNCOMPAHGRE VALLEY WATER USERS ASSOCATION SITE VISIT

COLORADO RIVER WATER BANK-PHASE II

Submitted to:

WATER BANK GROUP

Prepared by:

NATURAL RESOURCES CONSULTING ENGINEERS, INC.

Submitted on:

DECEMBER 20, 2012

TABLE OF CONTENTS

1. INTRODUCTION

Steve Harris of the Southwestern Water Conservation District (SWCD), Chip Paulson, Principal Engineer from MWH Americas, Inc. (MWH), Aaron Derwingson, Agricultural Outreach Coordinator of the Nature Conservancy (TNC), and Jordan Lanini, Senior Engineer with NRCE Inc. (NRCE), met with Steve Fletcher, Manager and Ed Suppes from the Uncompahgre Valley Water Users Association (UVWUA) on November 7, 2012. The UVWUA operates and maintains the U.S. Bureau of Reclamation's (USBR) Uncompahgre Project ("Project"), and is located near Montrose, Colorado. This site visit report details the following elements:

1. Location and Operational Description
2. Shortages Experienced During Drought Years
3. Accuracy of State Land Mapping and Diversion Records
4. Physical Potential for Fallowing/Deficit Irrigation
5. Operational Potential for Fallowing/Deficit Irrigation
6. Administrative Potential for Fallowing/Deficit Irrigation
7. Conclusions

2. LOCATION AND OPERATIONAL DESCRIPTION

The Uncompahgre Project consists of several project diversions and structures. The Gunnison Tunnel, which diverts water from the Gunnison River to the Uncompahgre Valley, was one of the first five USBR projects and was completed in 1909 (Clark and Simonds, 1994). The project consists of seven diversion dams, with the USBR-constructed Gunnison Diversion Dam feeding the Gunnison Tunnel. The Bureau of Reclamation purchased the other six diversions and associated canals between 1908 and 1915. The system of diversions and canals distributes water to lands from Montrose 34 miles north to Delta, CO. The project totals 128 miles of main canals, 438 miles of laterals, and 216 miles of drains. Over 76,000 acres are served (USBR, 2012). In addition, the Project contains rights in Taylor Park Reservoir, completed in 1937. The reservoir is located in the upper Gunnison basin on the Taylor River.

Reclamation determines releases from Taylor Park Reservoir for Project water. They have second-fill rights in Taylor Park, so move water from Taylor Park to Blue Mesa Reservoir as soon as possible to get a second fill in Taylor Park. The second fill right is the right to re-fill Taylor Park Reservoir in the amount of 106,230 acre-feet based on an exchange agreement for Taylor Park Reservoir and the Aspinall Unit (Land and Water Fund of the Rockies, 2003). The second fill rights are for use in the Upper Gunnison River Basin, not in the Uncompahgre Valley.

While USBR holds the water rights to the Project, UVWUA manages them. The water rights are unique in that the water can be used to extinction, and drainage water is accordingly reused up to seven times throughout the Project. Water rights are tied to the land, with one share for every acre of irrigated land.

Original USBR land classification determines water rights, with lands classified as arable (1-3), special use (4), and non-arable (5-6). Arable lands are provided Project water, while non-arable lands are not. However, water rotation between parcels and onto non-arable lands is allowed. There are about 76,000 voting shares outstanding, with approximately 3,000 account holders in the Project. Shareholders are allocated water on the basis of soil type, with clay (Adobe) soils receiving four acre-feet per acre and sand (Mesa) soils receiving five acre-feet per acre. These water rights are a combination of instream flow rights in the Uncompahgre River and storage rights from the Gunnison basin.

Photo 1: Corn field in the Uncompahgre Project irrigated by gated pipe.

The UVWUA Board sets the annual allocation of water based on predicted runoff. If the forecast is for less than 100% allocation, all shareholders get a reduced amount on a pro rata basis. Reservoir releases are typically from March through November 1.

Crops are a wide mixture including pasture, alfalfa hay, and grain crops including corn and wheat. Some other crops are grown including onions, potatoes, and fruit. There is also a significant amount of sweet corn grown. Irrigators primarily utilize furrow irrigation but some sprinklers (center pivots and side rolls) and drip irrigation is also used.

Some urbanization of the Project area has occurred, with the City of Montrose accumulating some water rights. Some landowners have turned in water rights during development (water rights owners pay an assessment whether water is used or not) and this water remains in the system to prevent shortages for other users in dry years.

3. SHORTAGES EXPERIENCED DURING DROUGHT YEARS

USBR does produce an annual forecast to UVWUA and farmers can plan ahead, taking marginal lands out of production or planting a crop with lower water requirements. The two more recent drought years, 2002 and 2012, both saw restrictions for water deliveries. zIn 2002, deliveries were restricted to 50% of full allocation. In 2012, deliveries were restricted to 70% of full allocation.

4. ACCURACY OF STATE LAND MAPPING AND DIVERSION RECORDS

4.1 WATER RIGHTS

Water rights were not verified during the interview. The water rights provide for 1,300 cfs through the Gunnison Tunnel, but the maximum capacity is about 1,175 cfs.

Photo 2: Pasture irrigated by side-roll sprinkler.

4.2 IRRIGATED LANDS

UVWUA association uses 80,000 acres irrigated by the Project for planning purposes. The CDSS data describes a total of 68,921 irrigated acres under the Project diversions. Cropped areas and crop types in the Project area appear in Figures 1 and 2 respectively.

4.3 HISTORICAL DIVERSION RECORDS

The historical diversion records were not verified. Some diversions are gaged on a real-time basis.

5. PHYSICAL POTENTIAL FOR FALLOWING

5.1 IMPORTANCE OF GROUNDWATER

Groundwater and subirrigation are not major factors in the Project area. Alluvium fills up by July from irrigation applications, and it seeps back to the river after irrigation stops. However, as soon as irrigation stops, crops stop growing, indicating subirrigation is not an important source of water.

5.2 LOCATION OF RETURN FLOWS

Surface return flows are recaptured by the Project and typically reused, as the Project has the right to use water to extinction. Groundwater returns are to the Uncompahgre River.

5.3 SALINITY AND WATER QUALITY ISSUES

The Project has both salinity and selenium issues. Those croplands underlain by Mancos Shale are typically attributed to contributing salinity loads (USGS 2012). There are multiple salinity reduction efforts within the Uncompahgre Valley, including efforts by USBR and the Natural Resources Conservation Service (NRCS). These improvements include both on-farm (increasing application efficiency through conversion to gated pipe, sprinklers, or drip systems) and off-farm (i.e., canal lining) efforts. Increasing efficiency and reducing canal seepage decreases leaching of salts that subsequently return to the river.

According to the Selenium Task Force (2012), selenium leaching is also associated with Mancos Shale. The eastern side of the Uncompahgre Valley is a key source of selenium to the Colorado River. Selenium toxicity can be a problem, and the U.S. Environmental Protection Agency (EPA) has selenium criteria for protection of aquatic life.

Water saved through efficiency improvements is still used within the Project. The water is conveyed to downstream irrigators. Lower fields have seen considerable improvements in water quality with the salinity control projects.

6. OPERATIONAL POTENTIAL FOR FALLOWING AND DEFICIT IRRIGATION

The lands under the Project provide the operational potential for both fallowing and deficit irrigation. Because fields are hayed three times for alfalfa (twice for grass pasture), the potential exists for deficit irrigation of grass hay and alfalfa fields where water tables are low.

In addition, the changing nature of fields provides the potential for fallowing between crops. Fields might be fallowed for a portion of the year when they might normally be cropped in a rotational pattern.

Because of the reuse of tailwater, fallowing or deficit irrigation would likely need to be examined for damage to downstream irrigators.

7. ADMINISTRATIVE POTENTIAL FOR FALLOWING AND DEFICIT IRRIGATION

7.1 DOCUMENTING SAVED CONSUMPTIVE USE

Return flows are not measured within the Project. As such, direct measurement of avoided consumptive use is not possible.

The Colorado Agricultural Meteorological Network (CoAgMet) has two meteorological stations in the Uncompahgre Valley (Delta and Olathe), with daily estimates of consumptive use by crop type and measurements of precipitation. These can potentially be used to determine foregone consumptive use for fallowed fields.

These data are available from http://ccc.atmos.colostate.edu/cgi-bin/extended_etr_form.pl

7.2 WATER BANK PARTICIPATION

Participation in a water bank would likely be by the landowner. However, cooperation with the UVWUA would be required for shepherding and control of avoided CU, as unused water is typically conveyed to other users. There is the potential for banking of water that is currently unused but paid for (i.e., through development).

One potential issue regarding water bank participation is that there are public acceptance concerns regarding sending additional water to the Front Range.

8. CONCLUSIONS

Farmers under the Project have variable, rotated cropping practices, and many sell hay and grain crops as a commodity. These facts, in conjunction with the multiple cuttings of hay, provide the opportunity for both fallowing and deficit irrigation for a water bank. Administration of the water bank would require cooperation with the UVWUA, as typically foregone water is passed along within the system.

Calculations of consumptive use, however, are made easier by the CoAgMet stations in the Uncompahgre Valley. These provide daily calculations of consumptive use by crop, and also provide daily precipitation near the fields in question.

While fallowing during a crop rotation provides the potential for water banking, determining consumptive use may cause other issues. Determining the foregone consumptive use requires specifying a crop. This may require bank participants to declare a crop rotation.

Finally, the unique nature of the Uncompahgre water rights may provide some additional opportunity. The water rights contain both direct flow and storage rights. The storage rights may allow for the storage of banked water in Taylor Park Reservoir and the reservoirs of the Aspinall Unit. Also, water can be used to consumption, so there is less concern of damaging other water users.

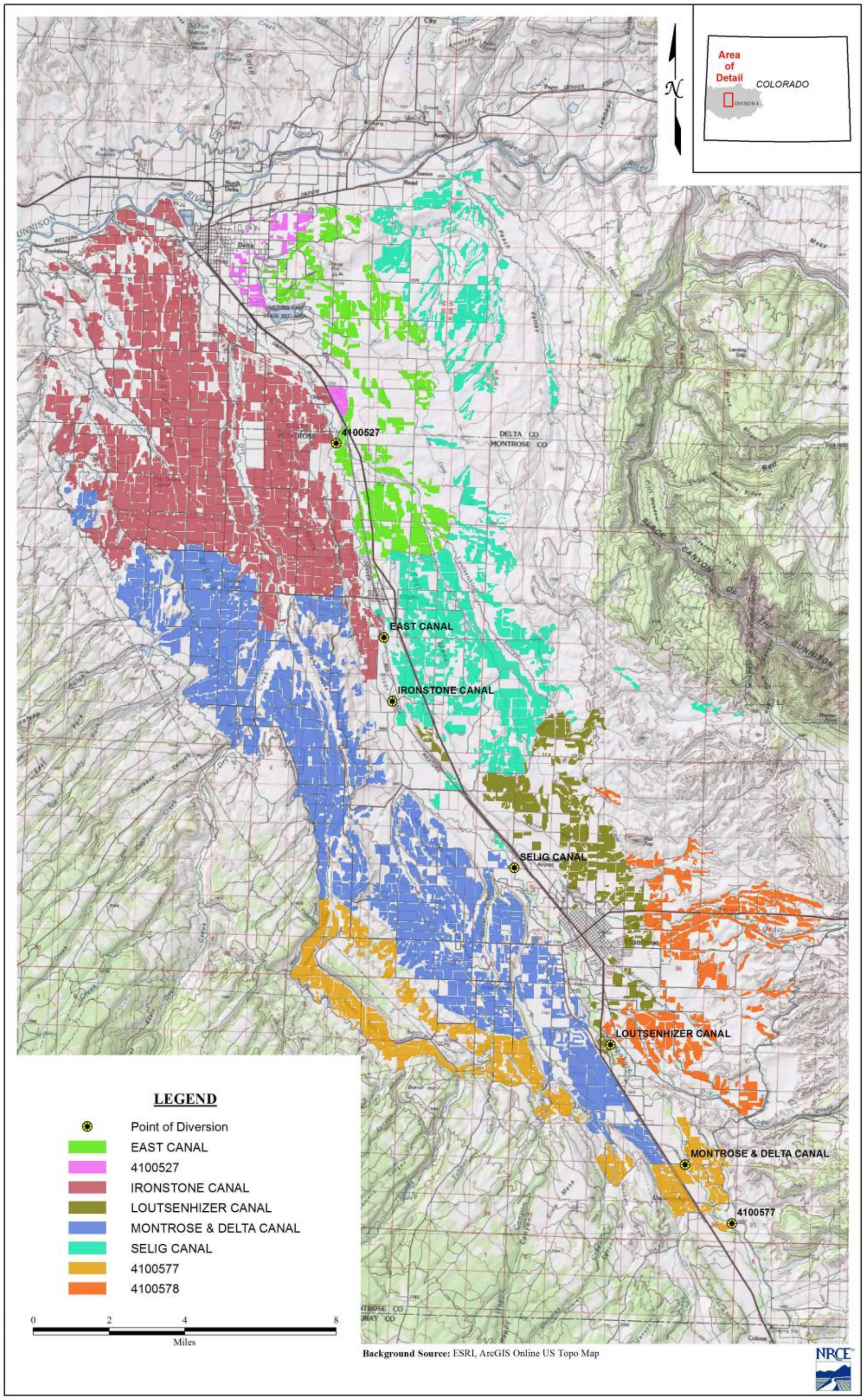


Figure 1: Division 4 - Uncompahgre Irrigated Areas

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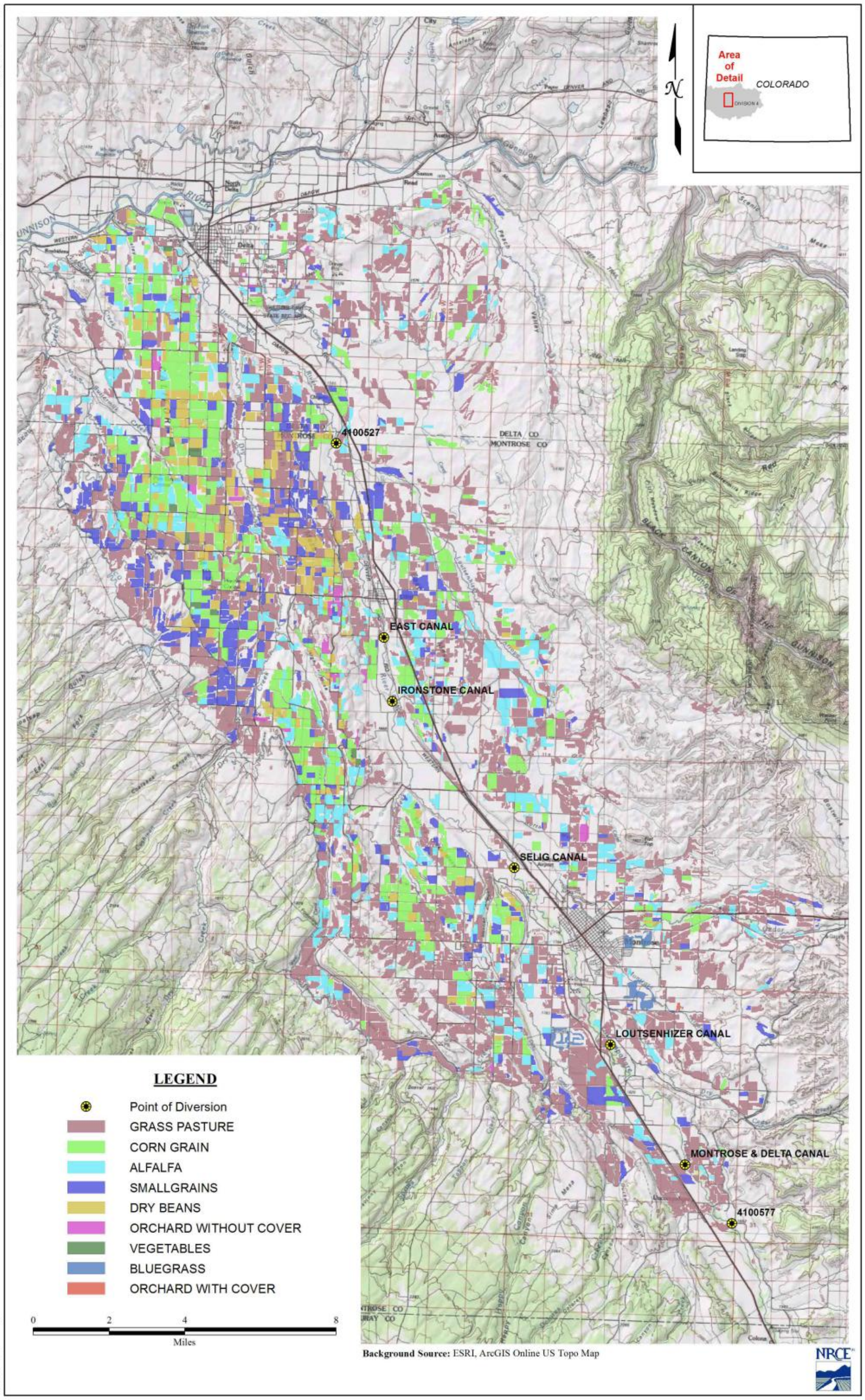

Figure 1: Division 4 - Uncompahgre Irrigated Areas

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TRAMPE RANCH SITE VISIT

COLORADO RIVER WATER BANK-PHASE II

Submitted to:

WATER BANK GROUP

Prepared by:

NATURAL RESOURCES CONSULTING ENGINEERS, INC.

Submitted on:

DECEMBER 20, 2012

TABLE OF CONTENTS

1. INTRODUCTION

Chip Paulson, Principal Engineer from MWH Americas, Inc. (MWH), Dan Birch, Deputy General Manager of the Colorado River Water Conservation District (CRWCD), Jordan Lanini Senior Engineer with NRCE Inc. (NRCE), and Aaron Derwingson of The Nature Conservancy (TNC) met with Bill Trampe of the Trampe Ranch on November 2, 2012. The Trampe Ranch is representative of many high elevation irrigation systems in Colorado which could decide to participate in a Colorado River Water Bank. This site visit report details the following elements:

1. Location and Operational Description
2. Shortages Experienced During Drought Years
3. Accuracy of State Land Mapping and Diversion Records
4. Physical Potential for Fallowing
5. Operational Potential for Fallowing
6. Administrative Potential for Fallowing
7. Conclusions

2. LOCATION AND OPERATIONAL DESCRIPTION

The Trampe Ranch is located about five miles north of Gunnison, CO and sits at approximately 7,800 ft elevation. Trampe Ranch is a cattle operation consisting of approximately 800 cow-calf pairs. The ranch utilizes irrigated hay land for winter feed and grazing, and incorporates other hay and grazing lands near Crested Butte and Jack's Cabin and federal grazing leases for summer range. Many of the cattle winter on the Jack's Cabin lands.

The Gunnison River/Ohio Creek Ditch and the Gunnison River/Ohio Creek Canal supply irrigation water to the ranch. The ditch is the upstream diversion and the canal is the downstream diversion. According to decreed water rights in the State water rights database, the ditch is the larger of the two diversions, consisting of about 170 cfs in water rights, and the canal is around 100 cfs in water rights.[1] Both diversions supply water from the Gunnison River. All irrigated lands are operated by Trampe Ranch.

Fields are irrigated through flood irrigation. The fields are primarily irrigated by raising the water table to the root zone in the spring. The ranch is roughly divided at County Road 8, with fields north of CR 8 irrigated from the ditch and fields south of CR 8 irrigated from the canal. The ranch was pieced together from various original ranches, each with their own irrigation system. Accordingly, water is not applied to the land as efficiently (in terms of labor) as possible.

[1] Mr. Trampe reported that the Ditch water right is 100 cfs and the Canal water right is 170 cfs.

The fields are cut once a year in mid-July for the purposes of winter feed. Mr. Trampe noted that the fields only maintained native grasses due to very thin soils overlaying cobbles. These shallow soils also limit the feasibility of sprinkler irrigation. Mr. Trampe experimented in cooperation with Joe Brummer of the Mountain Meadow Research Station with a travelling big gun sprinkler during a year with limited diversions. They irrigated about 40 acres of an upper field using the gun. However, they found the sprinkler could not keep up with irrigation water requirements. This is likely a result of low soil moisture storage in the topsoil.

Trampe Ranch's herd size is controlled by spring grazing and winter feed, so hay is typically not sold as a commodity. Yields are approximately 1.5 tons per acre. Livestock water was being supplied by the ditch and canal on November 2.

Irrigation continues through the middle of October to keep the water table high. Mr. Trampe noted that wells in the area are likely dependent on the irrigation, with domestic water in the well at his house becoming scarce in March. Homes in a recently constructed subdivision southwest of Trampe Ranch have domestic wells that rely on high groundwater level resulting from application of irrigation water.

Photo 1: Typical irrigation diversion from the canal.

3. SHORTAGES EXPERIENCED DURING DROUGHT YEARS

Trampe Ranch water rights were called out in May 2002. Irrigation diversions were reduced to 20 cfs, and were partially caused by reduced flows within the river. This was the first call since the 1950's.

There were no shortages in 2012. The 2002 shortage impacted fields for two to three years, with reduced yields and a degraded species mix, including introduction of noxious weeds.

4. ACCURACY OF STATE LAND MAPPING AND DIVERSION RECORDS

4.1 WATER RIGHTS

Water rights reported in the State's database appear to be correct. Mr. Trampe noted that Taylor Park Reservoir is operated to reduce frequency of Gunnison River calls, which affects the Trampe system. Second fill rights allow management of early spring releases. Table 1 shows the water rights listed in the State's database for the Trampe Ranch irrigation water sources.

Table 1: Trampe Ranch water rights.

Adjudication Date	Appropriation Date	Rate (CFS)			Volume (Ac-Ft)		
		Absolute	Conditional	AP/EX	Absolute	Conditional	AP/EX
Gunnison River/Ohio Creek Ditch							
9/14/1906	11/10/1902	96.50	0	0	0	0	0
4/29/1941	11/10/1902	35.00	0	0	0	0	0
4/29/1941	7/1/1907	37.66	0	0	0	0	0
Totals		169.2	0	0	0	0	0
Gunnison River/Ohio Creek Canal							
9/14/1906	3/15/1889	9.25	0	0	0	0	0
9/14/1906	6/15/1901	15.25	0	0	0	0	0
10/25/1921	5/17/1920	1.50	0	0	0	0	0
1/7/1924	7/1/1903	0.25	0	0	0	0	0
4/29/1941	5/15/1889	65.79	0	0	0	0	0
4/29/1941	7/1/1903	1.75	0	0	0	0	0
4/29/1941	5/17/1920	4.86	0	0	0	0	0
1/27/1961	7/1/1957	3.00	0	0	0	0	0
Totals		101.7	0	0	0	0	0

4.2 IRRIGATED LANDS

The irrigated lands mapping by the State of Colorado improperly defines the acreage allocated to the various ditches. The State of Colorado field-verified these fields with Mr. Trampe. However, the State allocated fields south of CR 8 to the ditch, when they are actually irrigated from the canal. CDSS lands are shown in Figure 1.

The State's irrigated lands mapping shows a decrease in irrigated acreage from 2,012 acres in 1993 to 1,876 acres in 2005. Mr. Trampe noted that he did not make any changes to his irrigation operations during that period so the difference must be due to differences in the State's data collection methods.

4.3 HISTORICAL DIVERSION RECORDS

The pattern of diversions was roughly correct, but Mr. Trampe expected lower diversions in August and higher diversions in September and October after haying.

Photo 2: Gunnison River/Ohio Ditch headgate.

5. PHYSICAL POTENTIAL FOR FALLOWING

5.1 IMPORTANCE OF GROUNDWATER

Mr. Trampe estimated the depth to groundwater table to be 60-70 feet without irrigation. Trampe Ranch irrigates for two to three weeks in the spring to bring the water table up to within a couple of feet of the surface. Groundwater movement is generally toward the Gunnison River from the upper fields, so groundwater return flows are important for irrigation of lower fields. Mr. Trampe also reported subirrigation in the westernmost fields where irrigation water from the Gunnison River and Ohio Creek meet. On November 2, we observed qualitatively the large quantity of water lost to ditch seepage. Diverted waters from the river to the ditch were more than twice those observed on the fields on the north end of Trampe Ranch.

Groundwater is also quite important for domestic water wells southwest of Trampe Ranch, as well as for water supply to Trampe Ranch. Because of the elevated groundwater table required to irrigate fields, it is likely that fallowing or deficit irrigation would be difficult, especially in the lower elevation fields. Upper elevation fields may be fallowed but ditch seepage would likely contribute to consumptive use.

5.2 LOCATION OF RETURN FLOWS

Return flows from the upper fields (northwest) support fields to the southeast. Neighboring lands irrigated from Ohio Creek may also contribute groundwater to Trampe Ranch fields. Return flows appear somewhat more complex due to the confluence of diversions from the Gunnison River and Ohio Creek. Surface returns are intercepted by lower ditches and re-applied to fields.

5.3 SALINITY AND WATER QUALITY ISSUES

No salinity or other water quality issues were observed or noted.

6. OPERATIONAL POTENTIAL FOR FALLOWING AND DEFICIT IRRIGATION

The ranch's operations are dependent on the hay produced from the irrigated meadows for winter cattle feed. Accordingly, any fallowing or deficit irrigation would require either supplemental hay or herd reduction. Accordingly, Mr. Trampe suggested that a consistent reduction of ranch water use would be preferable to a periodic reduction, as the herd size could be lowered overall. Mr. Trampe also noted the cattle's higher survival rate and cold tolerance (important in the Gunnison Valley) compared to imported cattle. Mr. Trampe also noted issues with non-native hay and weed introduction.

Mr. Trampe pointed out that from an economic perspective, participation in a water bank by several important irrigators could affect the entire Gunnison River Basin. For example, if he were to reduce hay production he would look first to supplemental hay sources in the Uncompahgre Valley. If irrigators in that area were also reducing irrigation for the water bank, supplemental hay supplies would be limited and expensive. If irrigation reductions occurred for several years, the entire agricultural infrastructure and economy in the region could be weakened.

7. ADMINISTRATIVE POTENTIAL FOR FALLOWING AND DEFICIT IRRIGATION

7.1 DOCUMENTING SAVED CONSUMPTIVE USE

Diversion and return flow measurements are not adequate to document foregone consumptive use.

7.2 WATER BANK PARTICIPATION

Fallowing or deficit irrigation would not require decisions or approval other than by the operator. The ranch is not encumbered by a conservation easement.

8. CONCLUSIONS

Trampe Ranch is an example of a high elevation cattle operation in which fallowing or deficit irrigation would be controlled by cattle herd dynamics rather than hay production. The same issues were noted as on the Cold Mountain Ranch and the Fetcher Ranch; namely, that reductions in the cattle herd would take years to recover from.

The soils and irrigation method also make fallowing and deficit irrigation difficult. Because the groundwater table must be raised significantly and subsequent irrigation is used to fill the root zone, it is possible that fallowing or deficit irrigation would be an all-or-nothing situation. If the water table is high to irrigate, it will potentially provide irrigation water to fields selected for deficit irrigation or fallowing. In addition, the low crop yields and high water requirements due to high elevation and poor soil conditions would make it challenging to get substantial CU savings through deficit irrigation without significant impacts on the viability of the cattle operation.

The Trampe Ranch site visit reinforces the conclusion that fallowing or deficit irrigation in high elevation systems used to produce hay for cattle ranching may be difficult. The following issues occur in these systems:

1. Accounting of foregone consumptive use is difficult;
2. Fallowing and deficit irrigation may have long-lasting effects upon cattle herds;
3. Groundwater may supply water to certain fields, especially lower-lying fields;
4. Economics are not the only driver of operational decisions;
5. Groundwater and groundwater returns, as well as irrigated fields, support many other beneficial uses in these areas, including baseflows, wetlands and aesthetics.

Figure 1: Division 4 - Tramp Ranch Irrigated Areas and SSURGO Data

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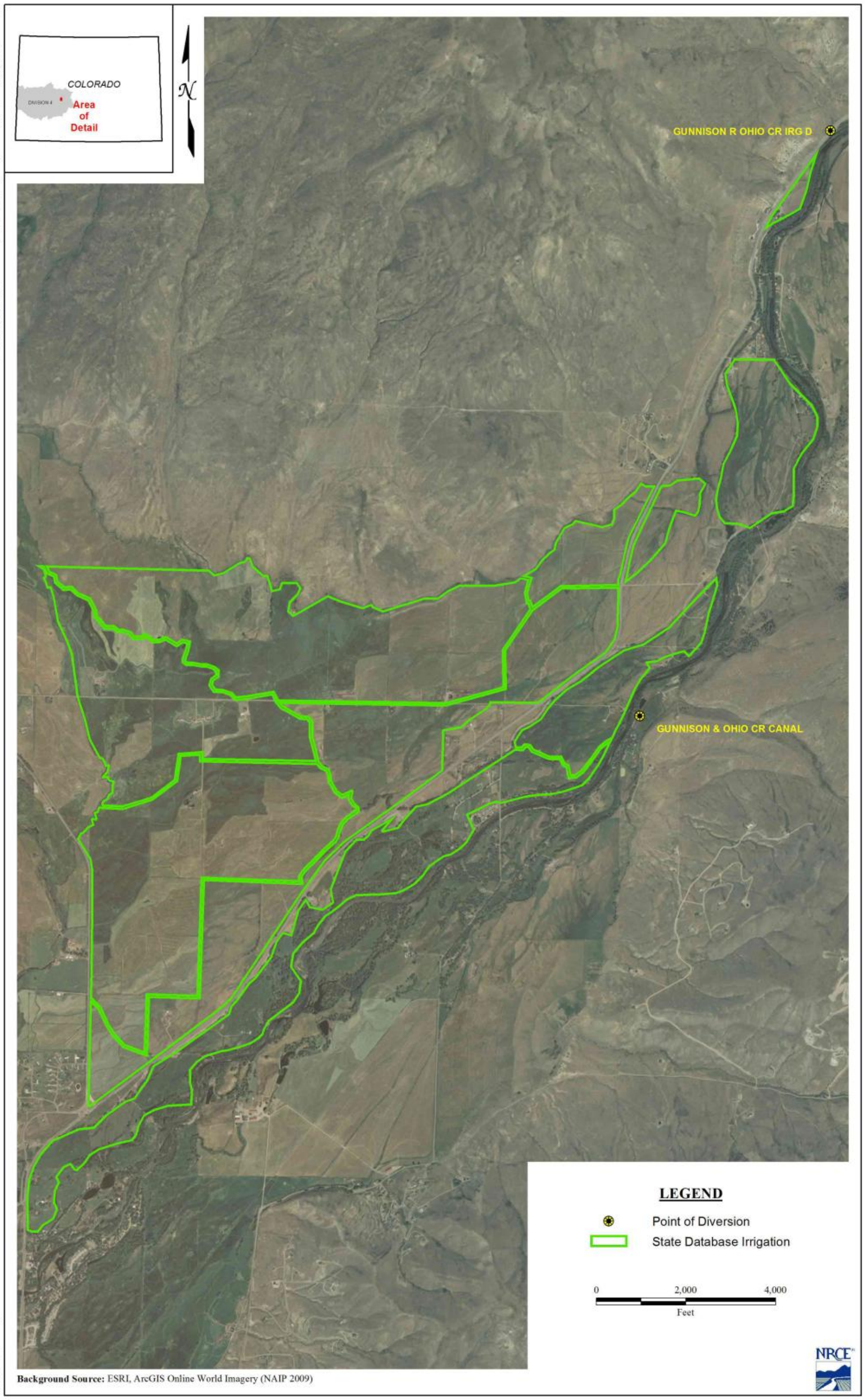

December 2012
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for attorney-client review

COLORADO COOPERATIVE DITCH SITE VISIT

COLORADO RIVER WATER BANK-PHASE II

Submitted to:

WATER BANK GROUP

Prepared by:

NATURAL RESOURCES CONSULTING ENGINEERS, INC.

Submitted on:

DECEMBER 20, 2012

TABLE OF CONTENTS

1. INTRODUCTION

Chip Paulson, Principal Engineer from MWH Americas, Inc. (MWH), Steve Harris of the Southwestern Water Conservation District (SWCD), Jordan Lanini, Senior Engineer with NRCE Inc. (NRCE), and Aaron Derwingson, Agricultural Outreach Coordinator of the Nature Conservancy (TNC) met with Dean Naslund current Superintendent, Monte Naslund, former Superintendent, and George Glasier, President of the Colorado Cooperative Ditch, on November 7, 2012. The Colorado Cooperative Ditch is a small irrigation system with primarily hay and some grain crops and is representative of many private irrigation companies which could decide to participate in a Colorado River Water Bank. This site visit report details the following elements:

1. Location and Operational Description
2. Shortages Experienced During Drought Years
3. Accuracy of State Land Mapping and Diversion Records
4. Physical Potential for Fallowing
5. Operational Potential for Fallowing
6. Administrative Potential for Fallowing
7. Conclusions

2. LOCATION AND OPERATIONAL DESCRIPTION

The Colorado Cooperative Ditch is located near Nucla, Colorado. The ditch serves about 180 shareholders, with approximately 3,250 shares outstanding. The State of Colorado estimates the acreage irrigated to be 5,288 acres. The Highline Ditch is the only diversion serving the lands under the Colorado Cooperative Ditch Company. The ditch diverts water from the San Miguel River approximately 18 miles upstream from Nucla.

The ditch has a right of 35 cfs for seepage and evaporation losses, and 110 cfs of "usable" water. Approximately 80 cfs of the rights are pre-compact, with 65 cfs post-compact.

Water is delivered to four laterals: the East Lateral, South Lateral, West Lateral, and 2nd Park. They receive, at full capacity, approximately 8 cfs, 30 cfs, 28 cfs, and 20 cfs respectively. Other uses for the ditch include municipal water for the cities of Nucla and Naturita, Colorado, as well as cooling water for the 100 MW coal-fired power plant nearby. The upper ditch loses about 10-15 cfs, with the remaining losses in the approximately 22 miles of laterals. A structure just below the diversion limits diversions to 145 cfs by spilling back into the San Miguel River.

Each share receives 1/3,250th of the ditch's flow. For example, a shareholder with 32 shares might receive 1 percent of the flow of the ditch. If the flow in the ditch on particular day was 100 cfs, that shareholder would receive 1 cfs. Shares are tied to the system but are not tied to the land. The shares can be traded within the system, with the ditch board reviewing all sales. The majority of trading comes previous to the spring cutoff date (March 1), after which the superintendent sets the division boxes that control the water to each user. The division boxes are set to receive a fraction of the total flow. Therefore, no adjustments are needed as flows change within the Highline Canal. Diversions begin around the 15th of April to the 1st of May. Diversions end the first or second week of October. Two water "runs" are made, one around Thanksgiving and the other at the end of March, to fill municipal reservoirs, cisterns for domestic water, and for stockwater purposes. The Colorado Cooperative Ditch operates on a budget of around $100,000 per year, or an assessment of around $31 per share. Assuming 110 cfs delivered from May 1 through October 15, the price of water is approximately $2.75 per acre-foot.

Photo 1: Typical division box used to divert water from the ditch.

Fields are primarily irrigated through a mixture of flood and sprinkler irrigation. Flood irrigation is primarily through gated pipe, with sprinkler irrigation through side rolls and some center pivots. Crops include grass and alfalfa hay and about 200 acres of corn for silage.

Hay and alfalfa fields are cut two to three times a year, with 2.5-3 tons per acre on the grass hay mix and around 5 tons per acre for pure alfalfa. All crops are used in the Nucla area, with crops sold for livestock feed amongst locals.

3. SHORTAGES EXPERIENCED DURING DROUGHT YEARS

In 2002, the diversion was reduced to 35 cfs, and the Colorado Cooperative Ditch called the river in mid-June. Local rainstorms provided enough water to be close to normal yields. In 2012, the diversions were reduced to 75-80 cfs. Production was average to above average in that year.

4. ACCURACY OF STATE LAND MAPPING AND DIVERSION RECORDS

4.1 WATER RIGHTS

Water rights reported in the State's database appear to be correct to those interviewed. CDSS water rights appear below in Table 1.

Table 1: Water rights in the Highline Ditch.

Adjudication Date	Appropriation Date	Rate (CFS)			Volume (Ac-Ft)		
		Absolute	Conditional	AP/EX	Absolute	Conditional	AP/EX
6/3/1911	6/1/1895	31.28	0	0	0	0	0
9/30/1916	12/8/1908	39.62	0	0	0	0	0
2/26/1929	10/20/1926	10	0	0	0	0	0
11/1/1939	5/1/1932	29.1	0	0	0	0	0
1/27/1942	2/18/1939	35	0	0	0	0	0
Totals		145.0	0	0	0	0	0

(grey shading)	Pre Compact
(pink shading)	Post compact

4.2 IRRIGATED LANDS

The irrigated lands mapped by the State of Colorado could not be verified. Row crop acreage was thought to be a little low. CDSS irrigated lands appear in Figure 1.

4.3 HISTORICAL DIVERSION RECORDS

The diversions are gaged, and should therefore be accurate. The seasonal pattern is consistent with experience.

5. PHYSICAL POTENTIAL FOR FALLOWING AND DEFICIT IRRIGATION

5.1 IMPORTANCE OF GROUNDWATER

The groundwater levels are variable. They can be high in some lower lying areas. Water levels in wells are fairly constant throughout the year. Subirrigation can occur in the bottoms of draws where return flows collect.

5.2 LOCATION OF RETURN FLOWS

Return flows collect in five major draws, including Coal Canyon, Tuttle, Calamity, and Smith draws. These draws have water rights filings that rely on the return flows, with an instream flow filing on Calamity Draw. Therefore, altering return flow quantity and patterns has the potential to affect other water rights holders.

5.3 SALINITY AND WATER QUALITY ISSUES

No salinity or other water quality issues were observed or noted.

6. OPERATIONAL POTENTIAL FOR FALLOWING AND DEFICIT IRRIGATION

Because the crops produced (typically pasture, hay or corn silage) are used for local cattle feed, any fallowing or deficit irrigation would likely require reduction in herd sizes. While supplemental hay might be used to maintain herd sizes, the distance from any region producing hay as a commodity would likely make this option undesirable.

7. ADMINISTRATIVE POTENTIAL FOR FALLOWING

7.1 DOCUMENTING SAVED CONSUMPTIVE USE

Diversions on the Highline Canal are gaged, with the data available real-time at http://www.dwr.state.co.us/Surfacewater/data/detail_graph.aspx?ID=HILNCNCO&MTYPE=DISCHRG

Diversion and return flow measurements are not adequate to document foregone consumptive use.

7.2 WATER BANK PARTICIPATION

It is likely that CCD would not have an agreement with a water bank. However, the CCD representatives believe all shareholders would have to agree and the Board would have to approve the concept before any could participate. CCD can't take action that would adversely affect any of its shareholders.

8. CONCLUSIONS

The CCD is an example of a smaller, privately held ditch company. The area is relatively dependent on coal mining and the 100 megawatt coal-fired power plant located at Nucla, and the associated New Horizon coal mine. The New Horizon Mine is also part of the CCD, as it purchases land and water rights in the area. These areas are subsequently mined and then reclaimed by putting them back into irrigated production.

Coal mining and the power plant provide many jobs for local residents. There was some concern that if the power plant is closed due to problems meeting tough new emissions standards, the local economy would be devastated. Similarly, removing a portion of the irrigated acreage may also have substantial local impacts.

The CCD site visit showed many similar issues as the high elevation, single operator ranches. Just as with the higher elevation ranches, the water banking decision would not be purely economic for CCD water users. They described the desire to see the land produce. Fallowing or deficit irrigation in these systems may be difficult. The following issues occur in these systems:

1. Direct accounting of foregone consumptive use is difficult, as only diversions are measured.
2. Fallowing may have long-lasting effects upon regional cattle herds;
3. Economics are not the primary driver of operational decisions;
4. Return flows support other agricultural enterprises.

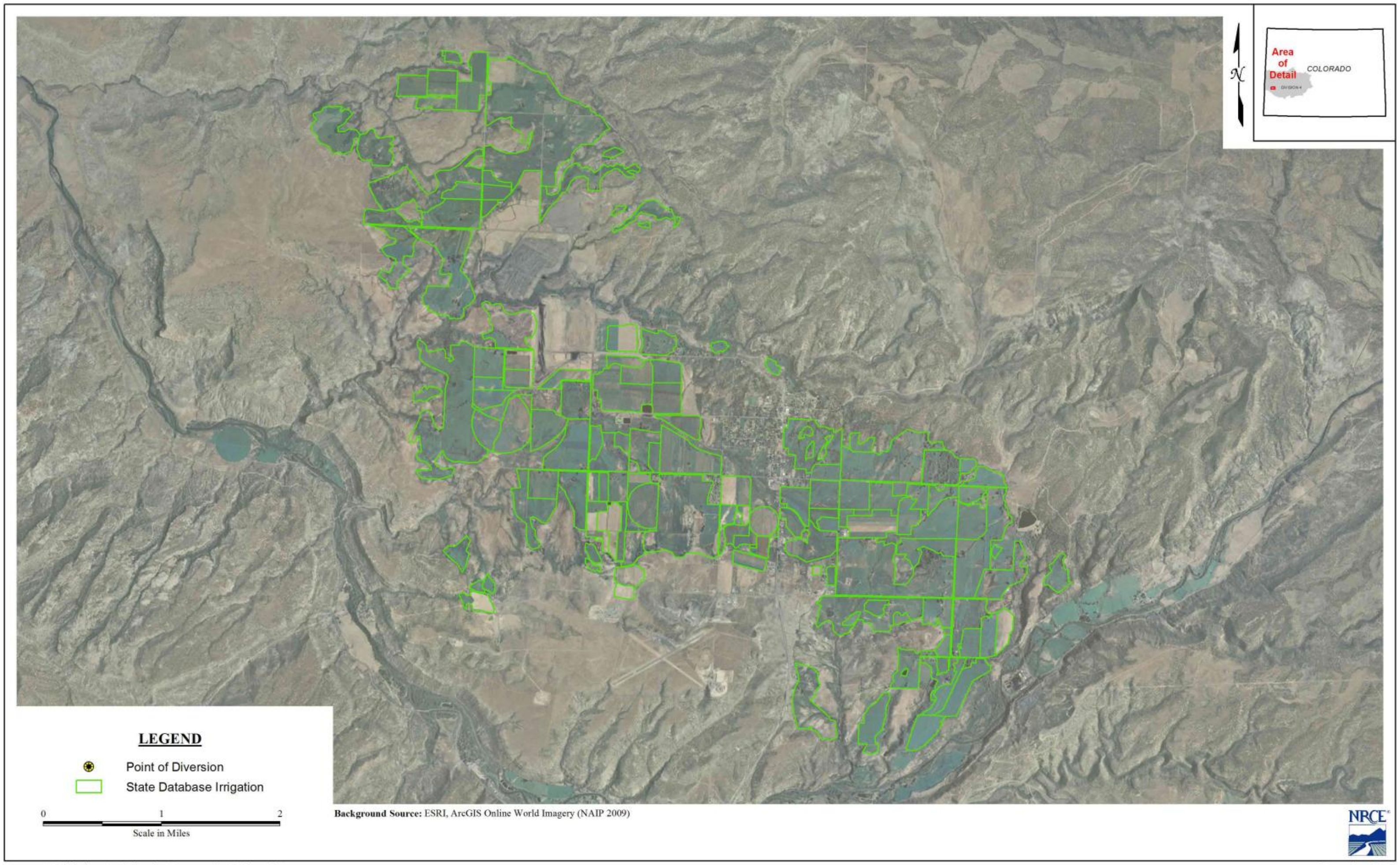

Figure 1: Division 4 - Colorado Cooperative Irrigated Areas

December 2012

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for attorney-client review

GRAND VALLEY IRRIGATION COMPANY SITE VISIT

COLORADO RIVER WATER BANK-PHASE II

Submitted to:

WATER BANK GROUP

Prepared by:

NATURAL RESOURCES CONSULTING ENGINEERS, INC.

Submitted on:

DECEMBER 20, 2012

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1. INTRODUCTION

Dan Birch, Deputy General Manager of the Colorado River Water Conservation District (CRWCD), Chip Paulson, Principal Engineer from MWH Americas, Inc. (MWH), Aaron Derwingson, Agricultural Outreach Coordinator of the Nature Conservancy (TNC), and Jordan Lanini, Senior Engineer with NRCE Inc. (NRCE), met with Phil Bertrand, Superintendant, and Charles Guenther, Assistant Superintendent of the Grand Valley Irrigation Company on November 8, 2012. The Grand Valley Irrigation Company is a large private ditch company diverting from the Colorado River near Grand Junction, Colorado. This site visit report details the following elements:

1. Location and Operational Description
2. Shortages Experienced During Drought Years
3. Accuracy of State Land Mapping and Diversion Records
4. Physical Potential for Fallowing/Deficit Irrigation
5. Operational Potential for Fallowing/Deficit Irrigation
6. Administrative Potential for Fallowing/Deficit Irrigation
7. Conclusions

Photo 1 Typical Residential Irrigation Pumping Station from the Grand Valley Canal.

2. LOCATION AND OPERATIONAL DESCRIPTION

The Grand Valley Canal diverts from the Colorado River near Palisade, CO. The ditch moves water westward toward Grand Junction and Fruita, CO on the north side of the Colorado River.

GVIC owns the water rights. There are 48,000 shares outstanding, with each share bringing the right to 0.4 miner's inches (38.4 Colorado miner's inches is equal to 1 cfs; 0.4 miner's inches is about 4.7 gpm) or 96 shares to the cfs. There are 3,150 accounts served by the ditch, with the shares not tied to the land. Shares can be bought and sold but cannot leave the project area.

GVIC supplies a portion of the City of Clifton's M&I water. Clifton is the GVIC's single largest customer, using 1,200 shares transferred from agricultural users. The GVIC typically irrigates from the 1st of April through the 1st of November, with a water run in December for about five days for domestic and stock use, and to fill cisterns.

GVIC owns and operates the main ditch, with some secondary canals in operation. GVIC has about 100 miles of canals. 4 miles are concrete lined. While there is no storage in system, ditch riders operate the canal system as if it were a long reservoir, maintaining heads at each lateral headgate and delivery point to deliver the correct flow to each part of the system.

Laterals, ditches and drains are privately owned. There are about 1,000 headgates on main canal system, with about 300 headgates for laterals. The largest lateral diversion is 20 cfs.

Users on some of the laterals are organized into associations. They have ditch riders that operate the gates on their systems. Otherwise the individual private landowners operate their individual gates. Many lateral associations were organized to apply for salinity control grants.

GVIC ditch riders have lots of problems with customers adjusting their gates illegally to take more water than allotted. Because much of the system runs through urban area they have lots of problems with trespassing along canal rights-of-way. Many residential area customers are served with landscape irrigation water through their HOAs, which are the GVIC account holders. Some are gravity diversions off canal system, some are pumped.

The GVIC water irrigates a wide range of crops. These crops include row crops such as winter wheat and corn; hay crops including grass and alfalfa; and irrigation of lawns in subdivisions. For hay crops, growers typically get 3-4 cuttings of alfalfa. Types of crops grown can vary year to year based on economics and crop prices. Most cash crops are exported out of the valley. Parcels on west side of valley are larger and dedicated to cash crop agriculture. Those closer to town are more residential HOAs, horse properties, and smaller parcels.

Irrigation of crops is typically flood irrigation, with a small amount of sprinkler irrigation. Conversions of systems are typically to gated pipe rather than sprinklers.

3. SHORTAGES EXPERIENCED DURING DROUGHT YEARS

The GVIC proportions water according to the number of shares for each delivery point. GVIC does not forecast hydrologic conditions to inform shareholders that they may receive less than their full allocation prior to planting.

4. ACCURACY OF STATE LAND MAPPING AND DIVERSION RECORDS

4.1 WATER RIGHTS

Water rights were not verified during the interview. The water rights associated with GVIC appear in Table 1 below.

Table 1: Water rights for the Grand Valley Canal.

Adjudication Date	Appropriation Date	Rate (CFS)			Volume (Ac-Ft)		
		Absolute	Conditional	AP/EX	Absolute	Conditional	AP/EX
7/22/1912	8/22/1882	520.81	0	0	0	0	0
7/25/1941	8/22/1882	300	0	0	0	0	0
7/25/1941	4/26/1914	119.47	0	0	0	0	0
7/21/1959	2/17/1947	0	0	100	0	0	0
7/21/1959	3/17/1947	0	0	4	0	0	0

4.2 IRRIGATED LANDS

GVIC estimates that about 33,000 acres are irrigated, or nearly twice the 18,000 acres shown in the State database. They estimate that about 50,000 acres are under the system. CDSS irrigated lands are shown in Figure 1 and crop types are shown in Figure 2.

4.3 HISTORICAL DIVERSION RECORDS

The historical diversion records were not verified but should be accurate, as they are gaged.

5. PHYSICAL POTENTIAL FOR FALLOWING

5.1 IMPORTANCE OF GROUNDWATER

The importance of groundwater is variable, with some downgradient fields receiving subirrigation from water applications above. Some return flows from the Government Highline Ditch serving the GVWUA (higher in elevation than the majority of the GVIC) are captured by GVIC canals and supply GVIC fields.

5.2 LOCATION OF RETURN FLOWS

Return flows are frequently captured by the Grand Valley Drainage District (GVDD). The GVDD drains return to the Colorado River at various points throughout the Grand Valley. These outfalls are shown in Fig. 1 below.

5.3 SALINITY AND WATER QUALITY ISSUES

The GVIC is underlain by marine shales which cause salinity issues. Salinity does affect productivity of land, and saline soils are visible on fields within the system. GVIC voted to not participate in the Colorado River Basin Salinity Control Project out of concern of Federal involvement in their operations.

6. OPERATIONAL POTENTIAL FOR FALLOWING AND DEFICIT IRRIGATION

The lands under the GVIC provide the operational potential for both fallowing and deficit irrigation. Because fields are hayed three to four times, the potential exists for deficit irrigation of grass hay and alfalfa fields where water tables are low.

In addition, the changing nature of fields provides the potential for fallowing between crops. Fields might be fallowed for a portion of the year when they might normally be cropped in a rotational pattern.

Should diversions be reduced, the main canal might need to be operated differently to provide adequate head for service. Check structures may need to be enhanced or updated.

Deficit irrigation could reduce volume of return flows to drains, which have water quality permits. Changes to the irrigation system might alter the quality and quantity of tailwater collected in drains with water quality permits.

7. ADMINISTRATIVE POTENTIAL FOR FALLOWING AND DEFICIT IRRIGATION

7.1 DOCUMENTING SAVED CONSUMPTIVE USE

Diversions are only measured at the diversion point on the Colorado River. As such, direct measurement of avoided consumptive use is not possible.

The Colorado Agricultural Meteorological Network (CoAgMet) has three meteorological stations in the Grand Valley (Fruita, Grand Junction, and Orchard Mesa), with daily estimates of consumptive use by crop type and measurements of precipitation. These can potentially be used to determine foregone consumptive use for fallowed fields.

These data are available from http://ccc.atmos.colostate.edu/cgi-bin/extended_etr_form.pl

7.2 WATER BANK PARTICIPATION

Because the water is not tied to the land, and deliveries of water are not measured, the potential exists for cheating. GVIC management is skeptical that their customers would abide by the Water Bank agreements; they might try to scam the Water Bank system, getting paid to deficit irrigate while still taking their full water share. Because GVIC only delivers water to the main canals and laterals, they would not be able to enforce deliveries to individual shareholders.

Where they exist, the lateral associations might be able to contract with the Water Bank on behalf of their users.

GVIC Board approval would not be needed for individual irrigators to participate in Water Bank. But the Board would need to be very well informed so it could promote Water Bank to its customers. The Board would also want to know how water use is changing its system so ditch riders would properly set diversion gates.

Some parcels are in conservation easements to prevent future development. These could affect water use decisions.

8. CONCLUSIONS

Farmers under the GVIC have variable, rotated cropping practices, and typically sell hay and grain crops as a commodity. These facts, in conjunction with the multiple cuttings of hay, provide the opportunity for both fallowing and deficit irrigation for a water bank. Administration of the water bank in the GVIC may be difficult as controlling water delivered to individual fields may be difficult. This likely would require field or satellite verification of foregone consumptive use.

Calculations of consumptive use, however, may be made easier by the CoAgMet stations in the Grand Valley. These provide daily calculations of consumptive use by crop, and also provide daily precipitation near the fields in question.

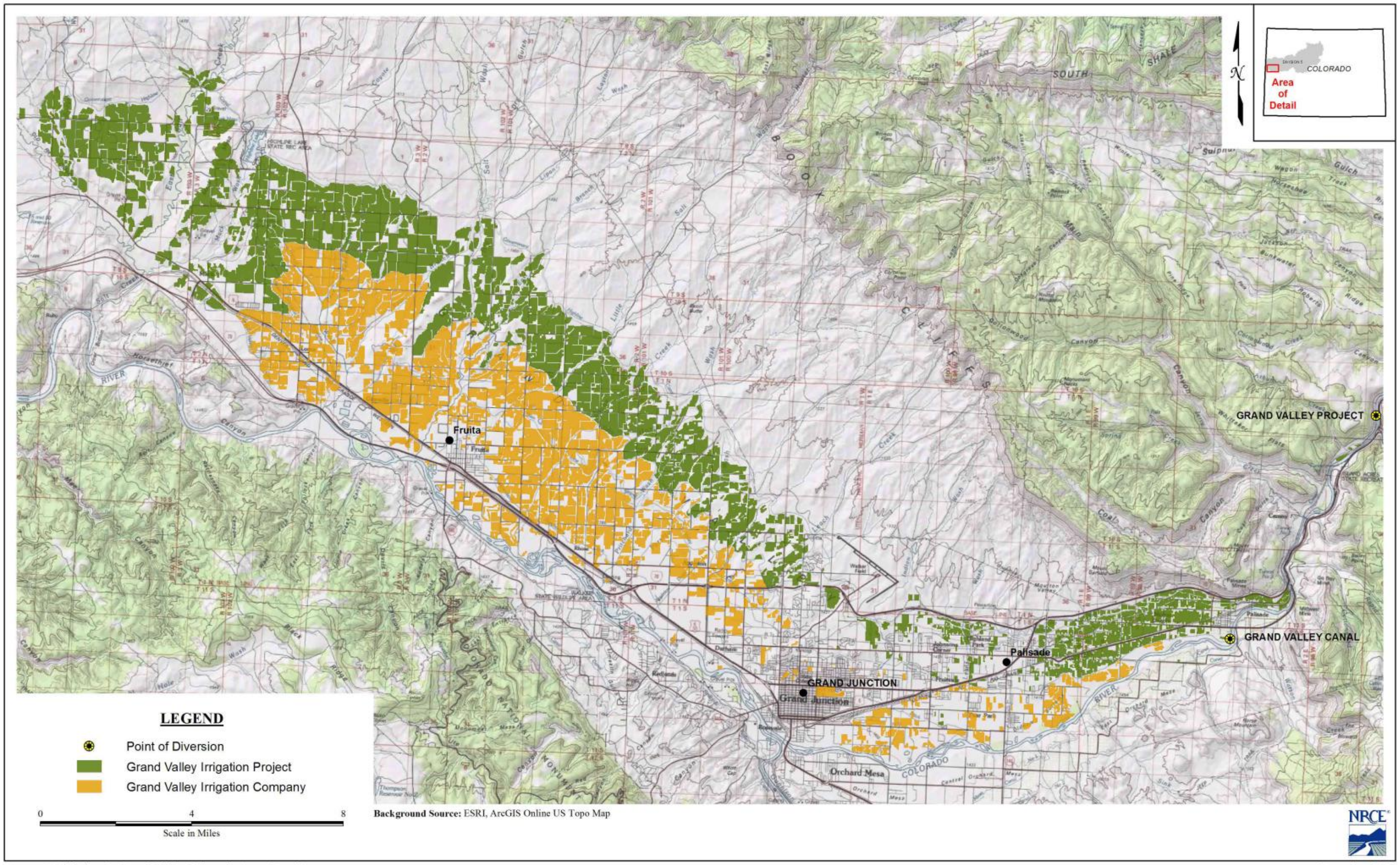

Figure 1: Division 5 - Grand Valley Irrigated Areas Overview

December 2012

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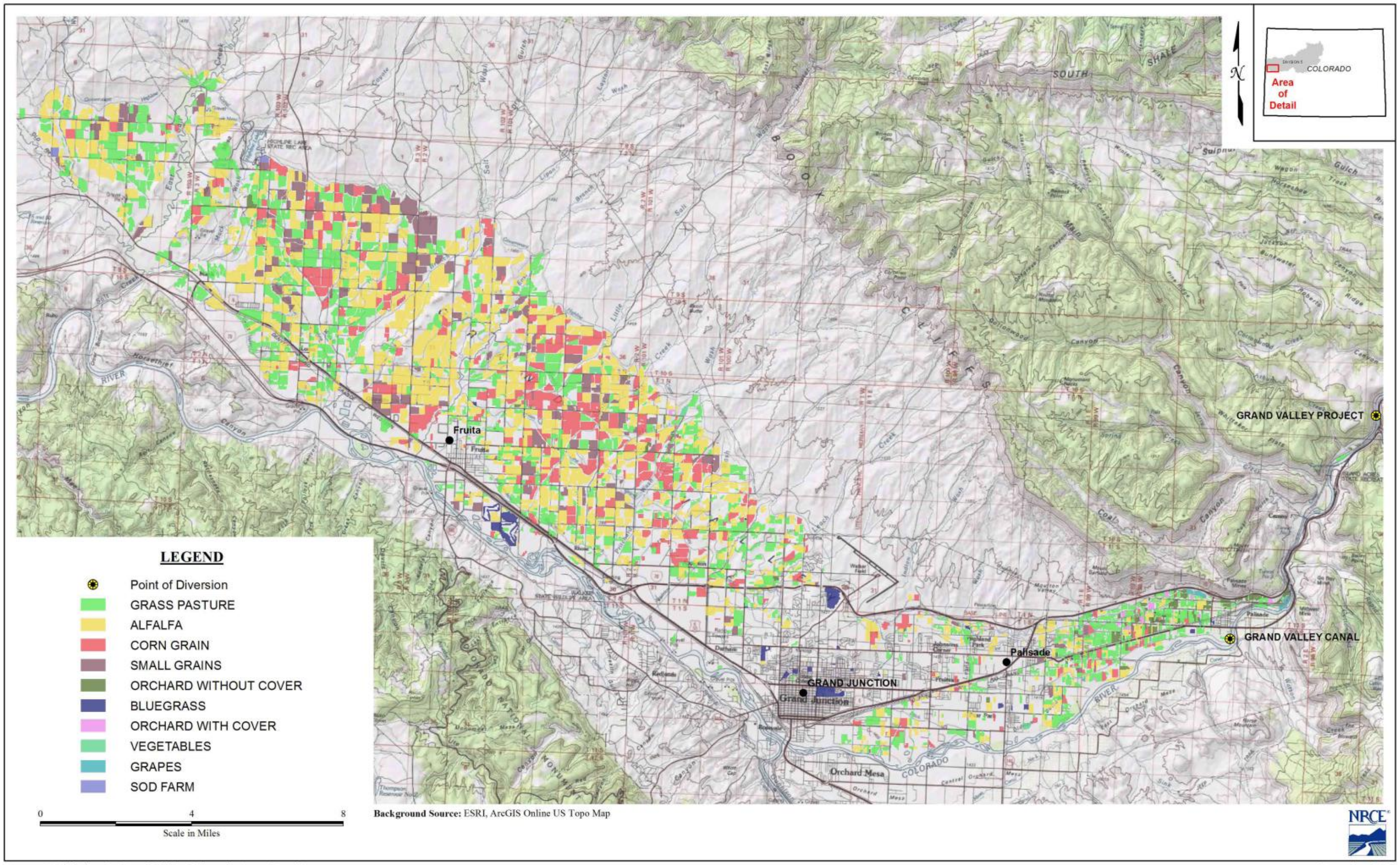

Figure 1: Division 5 - Grand Valley Irrigated Areas Overview

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GRAND VALLEY WATER USERS ASSOCATION SITE VISIT

COLORADO RIVER WATER BANK-PHASE II

Submitted to:

WATER BANK GROUP

Prepared by:

NATURAL RESOURCES CONSULTING ENGINEERS, INC.

Submitted on:

DECEMBER 20, 2012

TABLE OF CONTENTS

1. INTRODUCTION

Dan Birch, Deputy General Manager of the Colorado River Water Conservation District (CRWCD), and Jordan Lanini, Senior Engineer with NRCE Inc. (NRCE), met with Dick Proctor, Manager of the Grand Valley Water Users Association (GVWUA) on November 27, 2012. The GVWUA operates and maintains the U.S. Bureau of Reclamation's (USBR) Grand Valley Project (GVP) and is located near Grand Junction, Colorado. This site visit report details the following elements:

1. Location and Operational Description
2. Shortages Experienced During Drought Years
3. Accuracy of State Land Mapping and Diversion Records
4. Physical Potential for Fallowing/Deficit Irrigation
5. Operational Potential for Fallowing/Deficit Irrigation
6. Administrative Potential for Fallowing/Deficit Irrigation
7. Conclusions

2. LOCATION AND OPERATIONAL DESCRIPTION

The GVP consists of one main diversion dam and canal. The Colorado River is diverted into the Government Highline Canal at the Grand Valley Project Diversion Dam, about eight miles northeast of Palisade, CO. The canal conveys water west parallel to the river. The canal also serves the Orchard Mesa, Palisade, and Mesa County Irrigation Districts. The Government Highline Canal was completed in 1917 and is 55 miles long, with a capacity of 1,675 cfs. The Orchard Mesa Power Canal diverts about 800 cfs from the Government Highline Canal. These districts pay a small amount for conveyance to their systems.

The system consists of about 150 miles of laterals serving 23,340 acres. Class 1 acres are also drained, with around 150 miles of drainage ditches. Some of these ditches have more recently been piped.

While USBR holds the water rights to the Project, GVWUA manages them.

Original USBR land classification determines water rights, with lands classified as arable (1-3), special use (4), and non-arable (5-6). Arable lands are provided Project water, while non-arable lands are not. However, water rotation between parcels and onto non-arable lands (class 6 soils) is allowed. Class 1 soils receive four acre-feet per acre. Water is provided from April 1 through October 31 of each year.

Crops are a wide mixture including pasture, alfalfa hay, and grain crops including corn and wheat. Irrigators primarily utilize flood irrigation, with transition to gated pipe irrigation. There are also a number of large-lot subdivisions served by the GVP.

Some urbanization of the Project area has occurred, although not as much as in the lands served by the Grand Valley Irrigation Company.

3. SHORTAGES EXPERIENCED DURING DROUGHT YEARS

Canal checks have been installed, allowing for reduced diversions. The canal checks raise the water levels, allowing delivery of water during periods of lower demand throughout the system while reducing diversions. These checks are estimated to reduce diversions by about 40,000-50,000 acre-feet per year. In 2002, the checks were installed but were not automated. In 2012, the checks were automated with a SCADA (supervisory control and data acquisition) system.

In 2002, allocations were reduced to 1 ¾ acre-feet. The water for full diversions was not available in the Colorado River. In 2012, the GVWUA placed a call on the river, and allocations were not reduced. More water was available than 2002.

4. ACCURACY OF STATE LAND MAPPING AND DIVERSION RECORDS

4.1 WATER RIGHTS

The water rights were not verified. Water rights from the CDSS database are listed below in Table 1.

Table 1: GVP water rights as listed in the CDSS.

Adjudication Date	Appropriation Date	Rate (CFS)			Volume (Ac-Ft)		
		Absolute	Conditional	AP/EX	Absolute	Conditional	AP/EX
7/22/1912	10/1/1889	80.00	0.00	0.00	0.00	0.00	0.00
7/22/1912	10/1/1900	10.20	0.00	0.00	0.00	0.00	0.00
7/22/1912	7/6/1903	0.00	0.00	40.00	0.00	0.00	0.00
7/22/1912	10/25/1907	450.00	0.00	0.00	0.00	0.00	0.00
7/22/1912	2/27/1908	730.00	0.00	0.00	0.00	0.00	0.00
7/25/1941	2/27/1908	1020.00	0.00	0.00	0.00	0.00	0.00
7/25/1941	6/1/1918	23.50	0.00	0.00	0.00	0.00	0.00
Totals		2313.7	0	40	0	0	0

(shaded)	Pre Compact
(shaded)	Post compact

4.2 IRRIGATED LANDS

GVWUA lists 23,340 acres irrigated. The CDSS data describes a total of 24,562 irrigated acres under the Project diversions. Figure 1 shows Grand Valley irrigated lands and Figure 2 shows CDSS crop types.

4.3 HISTORICAL DIVERSION RECORDS

The historical diversion records were not verified. The diversion is gaged on a real-time basis. The majority of headgates are measured, but drainage is not.

5. PHYSICAL POTENTIAL FOR FALLOWING

5.1 IMPORTANCE OF GROUNDWATER

Water tables are variable throughout the GVP, with locally high tables as evidenced by the need for drainage.

5.2 LOCATION OF RETURN FLOWS

Return flows can be collected by drainage ditches that are part of the GVP. These ditches are subsequently discharged to the Colorado River. In addition, the Grand Valley Irrigation Company (GVIC) captures and reuses some of the irrigation returns from the GVP. Because the lands served by the GVP are typically higher in elevation than the GVIC fields, return flows may affect groundwater levels in the latter fields.

5.3 SALINITY AND WATER QUALITY ISSUES

The Grand Valley Project is underlain by marine shales and has salinity problems. USBR's Colorado River Basin Salinity Control Project's (CRBSCP) Grand Valley Unit was authorized in 1974 and focuses on reducing seepage from conveyance systems in the Grand Valley, including the Project. In addition, the U.S. Department of Agriculture also provides irrigation efficiency improvements on farm through the Colorado River Salinity Control Program. Accordingly, fallowing or deficit irrigation may have water quality benefits as well.

6. OPERATIONAL POTENTIAL FOR FALLOWING AND DEFICIT IRRIGATION

The lands under the Project provide the operational potential for both fallowing and deficit irrigation. Because fields are hayed three times for alfalfa (twice for grass pasture), the potential exists for deficit irrigation of grass hay and alfalfa fields where water tables are low.

In addition, the changing nature of fields provides the potential for fallowing between crops. Fields might be fallowed for a portion of the year when they might normally be cropped in a rotational pattern. For example, a typical crop rotation might be winter wheat followed by alfalfa. The alfalfa crop could be delayed for a year, reducing irrigation in the late fall.

There are some Clean Water Act concerns regarding changes to system operations. Drain outfalls are permitted. Therefore, changes to the drain system (i.e., conveying foregone CU directly to drains) might be contrary to the NPDES permits.

7. ADMINISTRATIVE POTENTIAL FOR FALLOWING AND DEFICIT IRRIGATION

7.1 DOCUMENTING SAVED CONSUMPTIVE USE

While the majority of diversions are measured, return flows are not measured within the Project. As such, direct measurement of averted consumptive use is not possible.

The Colorado Agricultural Meteorological Network (CoAgMet) has three meteorological stations in the Grand Valley (Fruita, Grand Junction, and Orchard Mesa), with daily estimates of consumptive use by crop type and measurements of precipitation. These can potentially be used to determine foregone consumptive use for fallowed fields.

These data are available from http://ccc.atmos.colostate.edu/cgi-bin/extended_etr_form.pl

7.2 WATER BANK PARTICIPATION

Cooperation with the GVWUA would be required for shepherding and control of avoided CU, as unused water is typically conveyed to other users. Mr. Proctor discussed the fact that, with high hay prices, water banking might not currently be attractive to Project farmers.

8. CONCLUSIONS

Similar to the lands under the GVIC, the Grand Valley Project has variable crops. Hay crops produce multiple cuttings, and many crops are sold as commodities. These factors make fallowing or deficit irrigation attractive in the lands under the Project. However, similar to the Uncomphagre Project, water rights are controlled by USBR.

The Project shows a high level of measurement of delivered irrigation which is potentially useful for measuring foregone CU. However, there are no measurements of return flows. The Project also has a drainage system that might be useful for delivering foregone CU to the Colorado River past other Grand Valley diversions, providing enhanced shepherding to the State Line.

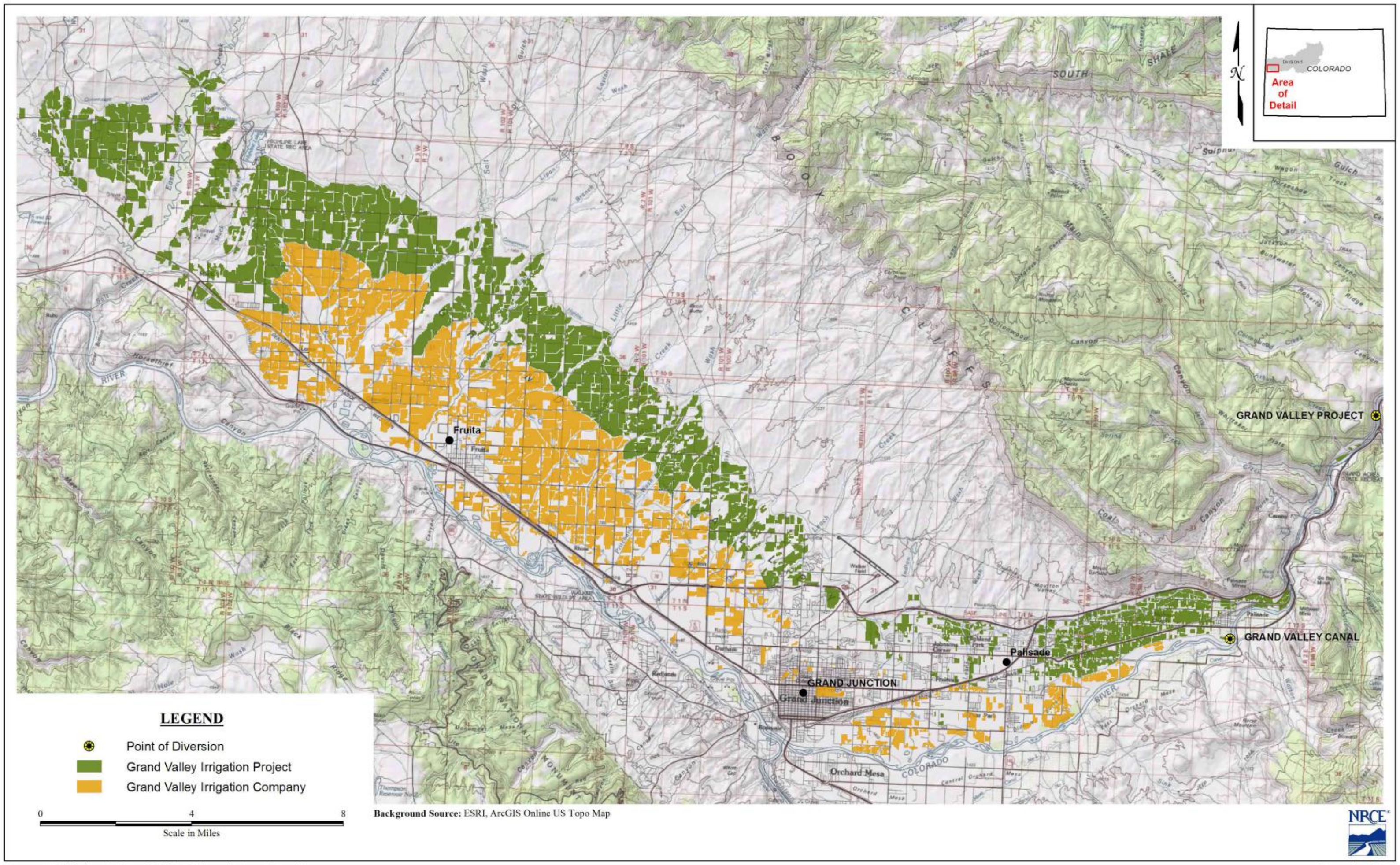

Figure 1: Division 5 - Grand Valley Irrigated Areas Overview

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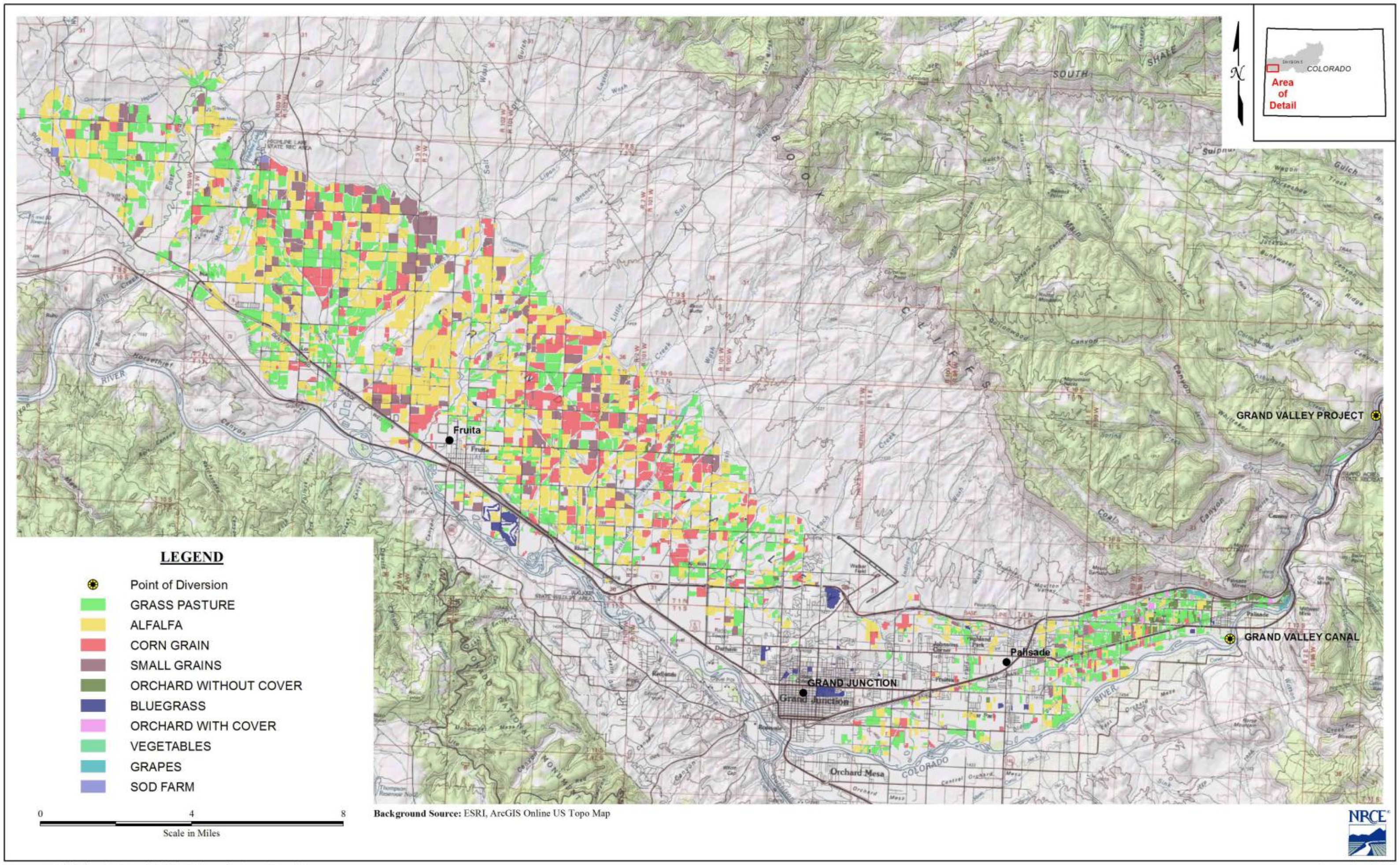

Figure 1: Division 5 - Grand Valley Irrigated Areas Overview

December 2012

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COLD MOUNTAIN RANCH SITE VISIT

COLORADO RIVER WATER BANK-PHASE II

Submitted to:

WATER BANK GROUP

Prepared by:

NATURAL RESOURCES CONSULTING ENGINEERS, INC.

Submitted on:

DECEMBER 20, 2012

TABLE OF CONTENTS

1. INTRODUCTION

Chip Paulson, Principal Engineer from MWH Americas, Inc. (MWH), Dan Birch, Deputy General Manager of the Colorado River Water Conservation District (CRWCD), and Jordan Lanini, Senior Engineer with NRCE Inc. (NRCE), met with Bill Fales on November 1, 2012. Mr. Fales is the operator of the Cold Mountain Ranch. The Cold Mountain Ranch is representative of many high elevation irrigation systems in Colorado which could decide to participate in a Colorado River Water Bank. This site visit report details the following elements:

1. Location and Operational Description
2. Shortages Experienced During Drought Years
3. Accuracy of State Land Mapping and Diversion Records
4. Physical Potential for Fallowing/Deficit Irrigation
5. Operational Potential for Fallowing/Deficit Irrigation
6. Administrative Potential for Fallowing/Deficit Irrigation
7. Conclusions

2. LOCATION AND OPERATIONAL DESCRIPTION

The Cold Mountain Ranch is located just south of Carbondale, Colorado and sits at approximately 6,400 ft elevation. Cold Mountain Ranch is a cattle operation consisting of approximately 200 cow-calf pairs. The ranch utilizes irrigated hay land for winter feed and grazing, and incorporates other grazing lands and federal grazing leases for summer range. Many fields on the ranch are growing a grass/alfalfa mix. The ranch also irrigates leased lands from County open space.

Three ditches supply irrigation water to the ranch. The Helms and Lowline Ditches supply water from the Crystal River, and the Pioneer Ditch provides water from Thompson Creek, a tributary to the Crystal River. These ditches also provide irrigation to two downstream water users (Tom Bailey and a subdivision with pond storage and golf course irrigation).

The State of Colorado lists approximately 98 acres irrigated by the Helms Ditch; 351 acres from the Lowline Ditch, and 122 acres from the Pioneer Ditch. Headgates are located within two miles of ranch headquarters.

Fields are irrigated through a combination of flood irrigation and sprinkler irrigation. The ranch operates one side-roll sprinkler system on a lower elevation field, supplied with gravity-fed water from the Lowline Ditch. The highest fields are grass pasture flood irrigated from the Pioneer Ditch, with return flows entering the Lowline Ditch.

Fields below the Lowline Ditch are flood irrigated through corrugated pipe, and are a mixture of native grass and alfalfa. The Bailey lands are irrigated through a center pivot and big gun sprinklers. Bailey combines the flows of the Lowline and Pioneer Ditches at the downstream (north) property line with the ranch. Applied waters are pumped from three submersible pumps with approximately 20 foot deep sumps. When irrigation water is not pumped to the Bailey center pivot, the excess flows from the Pioneer and Lowline Ditches are directed to the Crystal River through a pipe running along the property line.

Photo 1: Lowline Ditch and irrigated hay fields.

The meadows are hayed twice a year for the purposes of winter feed. The meadows are grazed in the fall after cattle are brought down from summer range. Mr. Fale's herd size is controlled by spring grazing and winter feed, so hay is typically not sold as a commodity. The ranch maintains a small hay surplus. In 2011, approximately 150 tons of hay were produced above winter feed requirements and in 2012, about 50 tons remained. Livestock water is supplied by the Lowline Ditch throughout the season.

Yields range from 5 tons/ac for newly seeded fields and average around 3 tons/ac. The ranch's average annual yield is approximately 750-1000 tons per year. Fields are hayed twice annually, with the first cutting in mid-July and the second cutting in early September. Irrigation continues through the middle or end of October for grazing production. Fields are plowed and reseeded at the rate of about 10 ac per year.

3. SHORTAGES EXPERIENCED DURING DROUGHT YEARS

The Pioneer Ditch only produces water in the early season as flows in Thompson Creek are unreliable. The Pioneer Ditch is the senior water right on Thompson Creek. The two ditches on the Crystal River are more reliable, with the Lowline Ditch more reliable than the Helms Ditch.

Mr. Fales discussed three dry years in the observed record. In 1977, the Lowline Ditch was curtailed to the senior right (19 cfs of the total 40.5 cfs). In 2002, the ranch was limited to divert only their water right. The 2012 drought restricted the ranch to their full right.

Production was not limited by lack of diversion. However, lack of precipitation in spring 2012 limited their first cutting to approximately 60% of normal.

Rockford and Town Ditches are downstream and have senior rights to the Lowline and Helms Ditch on the Crystal River, but there has not been a call from these ditches.

Photo 2: Crystal River at the Helms Ditch diversion point. Mt. Sopris is in the background.

4. ACCURACY OF STATE LAND MAPPING AND DIVERSION RECORDS

4.1 WATER RIGHTS

Water rights reported in the State's database were not verified during the site visit. However, the rights were verified as pre-Compact. The junior Lowline and Helms Ditch rights are pre-1929 rights, and account for about half of each of the ditches.

This reach of the Crystal River has a 100 cfs instream flow right. It has a 1970 priority date so it does not affect operation of the water rights for the ranch.

Table 1: Water rights associated with Cold Mountain Ranch.

Adjudication Date	Appropriation Date	Rate (CFS)			Volume (Acre-Feet)		
		Absolute	Conditional	AP/EX	Absolute	Conditional	AP/EX
Lowline Ditch							
5/11/1889	5/1/1881	5.60	0	0	0	0	0
5/11/1889	5/20/1882	4.70	0	0	0	0	0
8/25/1936	9/5/1900	2.21	0	0	0	0	0
Totals		12.5	0	0	0	0	0
Helms Ditch							
12/12/1902	9/25/1890	19	0	0	0	0	0
8/25/1936	10/10/1923	21.5	0	0	0	0	0
Totals		55.2	0	0	0	0	0
Pioneer Ditch							
2/2/1903	11/17/1899	2.9	0	0	0	0	0
8/25/1936	5/1/1924	3.1	0	0	0	0	0
Totals		82.7	0	0	0	0	0

Pre Compact

Post compact

4.2 IRRIGATED LANDS

The irrigated lands mapping by the State of Colorado improperly defines the acreage allocated to the various ditches. The State identifies certain areas above the Lowline Ditch as irrigated by this ditch, rather than the Pioneer Ditch. Similarly, the Pioneer Ditch coverage fails to include a small area in the westernmost field that is irrigated, and this field is wholly attributed to the Pioneer Ditch. However, the Lowline Ditch irrigates half of it. The Helms Ditch is identified as irrigating the southwesternmost field, which is irrigated from the Lowline Ditch. Finally, Tom Bailey fields are irrigated using a mixture of Pioneer and Lowline Ditch water. State-identified irrigated lands appear in Figure 1.

4.3 HISTORICAL DIVERSION RECORDS

The historical diversion records within the State database could not be confirmed by Mr. Fales as he does not track diversion rates. Mr. Fales did expect a larger increase in diversions in October after the second cutting, however.

5. PHYSICAL POTENTIAL FOR FALLOWING

5.1 IMPORTANCE OF GROUNDWATER

Based on Mr. Fales' reports of groundwater, the groundwater table is approximately 60 feet below the surface in the upper fields and 30 feet below the surface in the lower fields. Subirrigation aids only the lower fields east of the highway. Mr. Fales reported that Tom Bailey excavated a ditch 20 feet deep when installing the center pivot system, and no groundwater was observed. In addition, alfalfa roots in this ditch extended only three to five feet in depth. This indicates that it is unlikely alfalfa roots extend to the groundwater table.

Transmission losses through the shared Lowline Ditch may be large, and may contribute to subirrigation of fields east of the Lowline Ditch should irrigation be removed from these fields. Water would need to be diverted in a quantity to ensure adequate delivery to the Bailey and subdivision fields through this ditch.

A small acreage between the Pioneer and Lowline Ditches may be fallowable without any potential subirrigation. There are no return flows above it and these lands do not seem to be as important for the operation. Similarly, downstream water uses could be provided from the Lowline Ditch.

5.2 LOCATION OF RETURN FLOWS

Return flows from the upper fields (west) support fields to the east. Lands irrigated by the Pioneer Ditch are relatively steep and return flows are captured by the Lowline Ditch. In addition, some return flows support irrigated fields to the north. Lowline and Pioneer Ditches combine at the north end of the ranch and are returned to the Crystal River when Bailey does not use the water.

5.3 SALINITY AND WATER QUALITY ISSUES

Excessive sediment in Pioneer Ditch waters was noted. Crystal River diversions also contained sediment in 2012. Sediment is not as much an issue for the ranch as for the sprinkler-irrigated fields to the north. There are no salinity issues.

6. OPERATIONAL POTENTIAL FOR FALLOWING AND DEFICIT IRRIGATION

The ranch's operations are dependent on the hay produced from the irrigated meadows for winter cattle feed. Accordingly, any fallowing or deficit irrigation would require either supplemental hay or herd reduction. However, importing hay potentially would bring in invasive botanicals to the detriment of the fields. Also, the native cattle know the ranch's operations. For example, they avoid potentially harmful weeds, know water sources, and have a generally higher survival rate than imported cattle.

We discussed the potential for deficit irrigation or fallowing through a crop rotation. Because Mr. Fales currently replants his fields every 10 years to alfalfa, the opportunity exists to decrease the rotational time to five years and replant 20 percent of the ranch annually. This could potentially increase yields for all fields while taking some land out of production. Mr. Fales did not feel that this would work for his operation, as the labor of replanting that many acres would be too much. Likewise, he felt that the nutrition of the grass/alfalfa mix hay was well-suited to his herd. Providing richer alfalfa hay might have detrimental effects upon unweaned calves.

Mr. Fales felt that if he were to deficit irrigate, he would do so by cutting deliveries from all three ditches to most or all of his fields rather than completely fallowing selected fields.

7. ADMINISTRATIVE POTENTIAL FOR FALLOWING AND DEFICIT IRRIGATION

7.1 DOCUMENTING SAVED CONSUMPTIVE USE

Detailed diversion records do not exist, nor do return flow records. While some return flows are piped to the Crystal River through the Bailey property, much of the return flows are likely subsurface. The mixing of diversions from the Pioneer and Lowline Ditches is an additional difficulty in estimating saved consumptive use.

The grass hay fields between the Pioneer and Lowline Ditches are the most feasible area for fallowing or deficit irrigation from an administrative sense.

Some of the fields are leased from the county, which may have an interest in maintaining irrigation on the fields. However, lands owned by the Cold Mountain Ranch are not encumbered by a conservation easement.

7.2 WATER BANK PARTICIPATION

Fallowing or deficit irrigation would not require decisions or approval other than by the operator. However, the Lowline and Pioneer Ditches serve other users, who would require deliveries of their water through the Cold Mountain Ranch property.

8. CONCLUSIONS

Cold Mountain Ranch is similar to many high elevation irrigation systems in Colorado. Two factors aid in the flexibility of the ranch to fallowing or deficit irrigate. First, the ranch is able to cut hay twice a season as opposed to just once. This may give the ranch the ability to do partial-season irrigation. Similarly, the ranch's soils and climate allow alfalfa propagation. Because alfalfa is typically planted on some rotation, with replanting and establishment occurring one year of every five, there may be a potential for similar ranches to perform some rotational fallowing or deficit irrigation.

Fallowing/deficit irrigation of the Cold Mountain Ranch runs into the same issues as many other high elevation irrigation systems, however. The ranch's decisions are based upon the size and health of the cattle herd, which is not as flexible as irrigation of the fields. The herd size is based upon available winter feed and any fallowing/deficit irrigation would likely require a corresponding herd reduction or importing of supplemental hay. Reestablishment of the herd would require multiple years.

Likewise, irrigation is not carefully tracked and documenting foregone consumptive use would likely be difficult. Mr. Fales was also opposed to replacing feed from outside sources. This would potentially introduce invasive botanicals to his ranch.

Mr. Fales also made an important point regarding the overall potential for fallowing/deficit irrigation in high elevation irrigation systems. The value of these ranches from a real estate perspective far exceeds the value of agricultural production. Therefore, ranchers using cattle operations as a primary income source are not doing it from a purely financial standpoint, as the opportunity to sell the ranch would be much more lucrative. Those remaining are ranching for the lifestyle and enjoy seeing the land "produce," and any water banking decision may not be purely economical.

Figure 1: Division 5 - Cold Mountain Ranch Irrigated Areas and SSURGO Data

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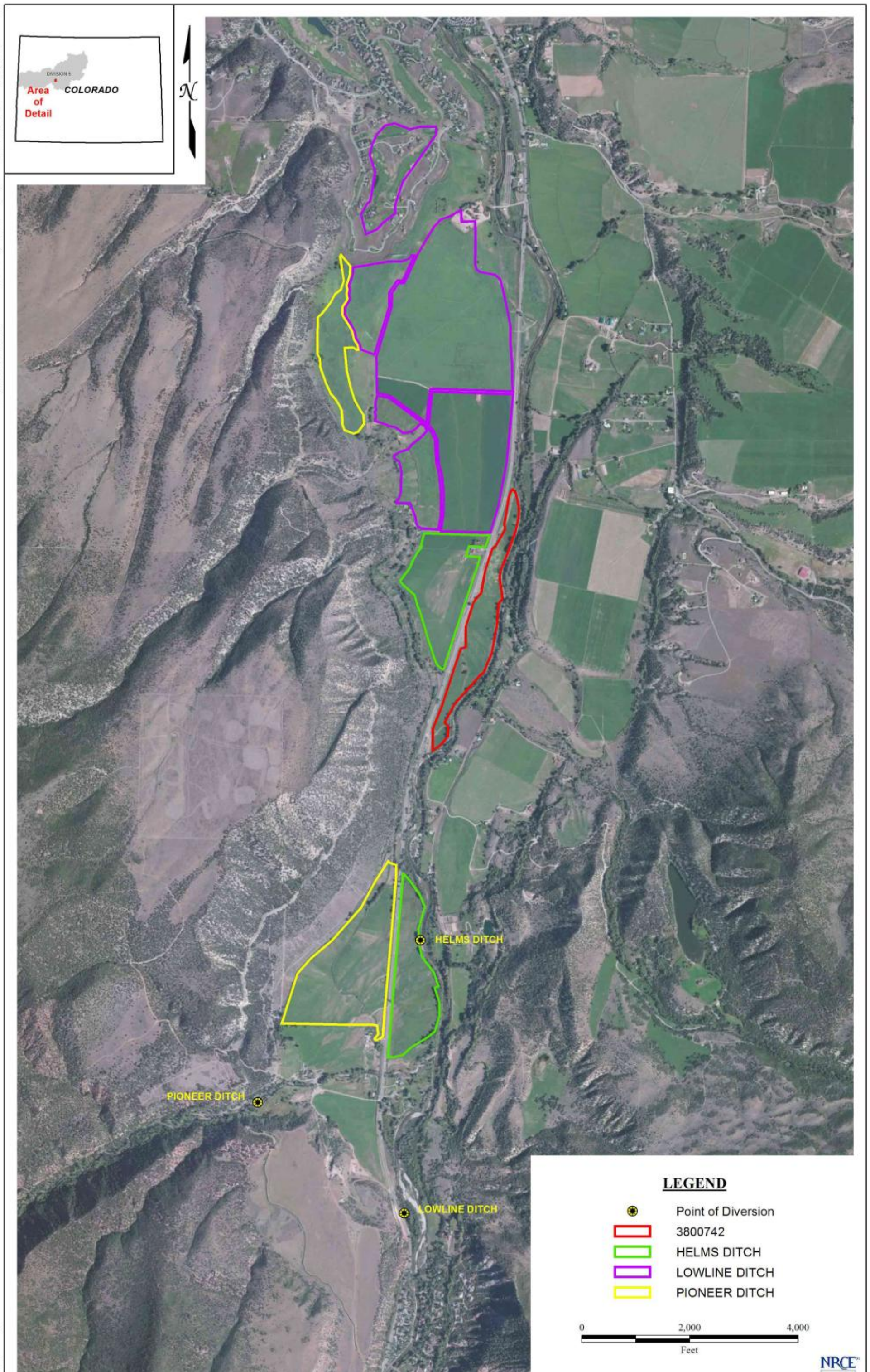

Background Source: ESRI, ArcGIS Online World Imagery (NAIP 2009)

FETCHER RANCH SITE VISIT

COLORADO RIVER WATER BANK-PHASE II

Submitted to:

WATER BANK GROUP

Prepared by:

NATURAL RESOURCES CONSULTING ENGINEERS, INC.

Submitted on:

DECEMBER 20, 2012

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1. INTRODUCTION

Chip Paulson, Principal Engineer from MWH Americas, Inc. (MWH), Dan Birch, Deputy General Manager of the Colorado River Water Conservation District (CRWCD), and Jordan Lanini and Niel Allen, Senior Engineers with NRCE Inc. (NRCE), met with Jay Fetcher of the Fetcher Ranch on October 18, 2012. Mr. Fetcher is the operator of the Ekhart Ditch. This ditch is considered to be representative of many high elevation irrigation systems in Colorado which could participate in a Colorado River Water Bank. This site visit report details the following elements:

1. Location and Operational Description
2. Shortages Experienced During Drought Years
3. Accuracy of State Land Mapping and Diversion Records
4. Physical Potential for Fallowing/Deficit Irrigation
5. Operational Potential for Fallowing/Deficit Irrigation
6. Administrative Potential for Fallowing/Deficit Irrigation
7. Conclusions

2. LOCATION AND OPERATIONAL DESCRIPTION

The Ekhart Ditch diverts from the Elk River, approximately 15 miles north of Steamboat Springs, Colorado, and is at approximately 7,200 ft elevation. The ditch is in the Yampa River Basin (Division 6). The ditch serves approximately 200 acres of grass hay meadows which are flood irrigated. Mr. Fetcher utilizes the meadows for his cattle herd, maintained at approximately 300 head, including mother cows, bulls, and calves. The meadows are hayed once a year for the purposes of winter feed. The meadows are grazed in the fall after cattle are brought down from summer range. Mr. Fetcher's herd size appears to be controlled by winter feed produced by these meadows, and hay is typically not sold as a commodity. Some years a small amount of hay is sold to a nearby guest ranch. The majority of livestock water is supplied by springs and not from the Ditch.

The grass hay meadows are flood-irrigated from water delivered from the Ekhart Ditch. Water is applied until mid-July to all fields. Fields are fertilized with nitrogen but have little maintenance in the form of reseeding or tilling. In mid-July, Mr. Fetcher removes water from half of the fields for haying. After haying is complete on half, irrigation resumes and the other half is dried and hayed. Yields are about 3.5 tons per acre for haying. The ranch's average annual yield is approximately 1,000 1,500 lb round bales.

The Ekhart Ditch continues to irrigate the pastures following the first (and only) cut for storage of groundwater for the next season as well as additional production for fall grazing. Additional production is estimated at around 0.5 tons per acre.

Photo 1: Hay meadow and diversion structure for the Fetcher Ranch. The fields were leveled for increased efficiency.

3. SHORTAGES EXPERIENCED DURING DROUGHT YEARS

Mr. Fetcher reported reliable supplies from the Elk River during drought years of 2002 and 2012. He reported a call within the Elk River for instream flow rights, a junior use to the Ekhart Ditch's pre-1922 rights. These did not affect water delivery to his fields. However, reduced yields occurred in years with lower precipitation, as fields with poor distribution efficiency increase yields with higher precipitation. This is largely due to high spots in fields lacking irrigation water. Mr. Fetcher reported quick recovery of irrigated lands following years of drought, and somewhat slower recovery of non-irrigated areas.

Photo 2: Ekhart Ditch diversion structure on the Elk River.

4. ACCURACY OF STATE LAND MAPPING AND DIVERSION RECORDS

4.1 WATER RIGHTS

Water rights were not verified during the site visit. However, the rights were verified as pre-compact.

4.2 IRRIGATED LANDS

The irrigated lands mapped by the State of Colorado failed to include two fields that are irrigated by the Ekhart Ditch. Accordingly, the irrigated lands database underestimated lands irrigated. CDSS irrigated fields are shown in Figure 1.

4.3 HISTORICAL DIVERSION RECORDS

The diversion records within the State database could not be confirmed by Mr. Fetcher as he does not track diversions. However, the monthly flow distribution represented typical operations, and the flow rates were feasible considering ditch capacities and estimated flows based on the Parshall flume at the diversion. The flume typically runs at a depth of 10 inches in a 3 foot flume, or approximately 9 cfs.

Photo 3: Ekhart Ditch Parshall flume.

5. PHYSICAL POTENTIAL FOR FALLOWING

5.1 IMPORTANCE OF GROUNDWATER

The soil survey for the area reported a shallow water table (21 to 27 inches in depth). However, based on Mr. Fetcher's reports, the fields dry quickly when irrigation water is removed for haying. Groundwater supplements irrigation during spring runoff from the hillsides to the west of the fields. The water table was high during spring of 2011 during a high snowmelt runoff year, but typically the water table is not elevated without supplemental irrigation water. Other than the spring groundwater contributions, subirrigation does not appear to be an important component for these fields. Also, as the ditch only serves one operation, water could be removed from these fields relatively easily.

5.2 LOCATION OF RETURN FLOWS

While return flows are not measured, it appears that all return flows are to the Elk River downstream of the irrigated parcels. Return flows support downstream pastures and wetlands, as well as base flows in the Elk River during late summer and fall periods.

5.3 SALINITY AND WATER QUALITY ISSUES

No salinity issues or other water quality problems were noted.

6. OPERATIONAL POTENTIAL FOR FALLOWING AND DEFICIT IRRIGATION

Mr. Fetcher's operations are dependent on the hay produced from the irrigated meadows for winter cattle feed. As cattle are the major revenue source for the operation, fallowing would require either herd reduction or supplemental purchase of hay for winter feed. Mr. Fetcher described a significant hardship resulting from fallowing and the associated herd reduction, as several years would be required to rebuild.

There would be a small potential for fallowing following the first cut, but this would likely result in a small amount of avoided consumptive use.

Photo 4: Cattle grazing the irrigated meadows.

7. ADMINISTRATIVE POTENTIAL FOR FALLOWING AND DEFICIT IRRIGATION

7.1 DOCUMENTING SAVED CONSUMPTIVE USE

Diversion and return flow measurements are not adequate to document foregone consumptive use. Mr. Fetcher keeps detailed hay yield records which could be used to calculate consumptive use. These could be used to estimate foregone consumptive use.

7.2 WATER BANK PARTICIPATION

Fallowing or deficit irrigation would not require decisions or approval other than by the operator. However, the conservation easement on the lands may complicate participation in a water bank.

8. CONCLUSIONS

The Ekhart Ditch serves as an example of typical high elevation irrigation in Colorado. The site visit revealed that lands served by the ditch could be feasibly fallowed or deficit irrigated from a physical perspective as reductions in irrigation would result in reductions of consumptive use. These savings could be documented through differences in yields.

However, there are considerable operational difficulties in fallowing or deficit irrigating lands served by the Ekhart Ditch. The ditch serves a single cattle operation. The size of the cattle operation is dependent on the irrigated acreage, meaning fallowing would require a corresponding herd reduction. This would result in considerable hardship to the operator as it would require several years to return to a similar herd size. Supplemental purchased hay could be utilized to prevent herd reduction, but may cost more than potential water bank payments.

The Ekhart Ditch site visit provides the following observations when considering high elevation meadow irrigation statewide:

1. Fallowing/deficit irrigation may be feasible for cattle operations not sized based upon winter feed availability (i.e., they are summer range limited or sell extra hay)

2. "Hobby" ranches may provide a potential source of fallowing or deficit irrigation, as these lands may not be operated on the basis of maximizing operational efficiency.

3. While the Fetcher Ranch fields do not appear to be subirrigated, fields would be carefully selected to avoid groundwater influences.

4. Irrigation results in intangible benefits to these areas, including increased baseflow to streams, wildlife, and aesthetic benefits. Fallowing may have an accordingly adverse impact on these resources.

5. Irrigation is not carefully tracked, and determining avoided consumptive use from an accounting perspective may be quite difficult without yield records. Mr. Fetcher's operation appeared very efficient and his records may be more detailed than the typical operation across Colorado. As historical records would be required to determine the baseline, this may be limiting. Also, accounting would be dependent on the operator's report of yields. Operators would have a financial incentive to misreport yields (reporting a lower yield would likely result in higher water bank payments as well as hay revenues).

6. For properties encumbered by a conservation easement that tie the water right of interest to the land, the landowner would need the approval of the organization holding the conservation easement to make any changes to their historic use of the water. The organization would look at the impacts this would have to the property's conservation values they want to protect (wildlife habitat, wetlands, scenic views, etc.). Whether or not it's feasible will depend greatly on the organization and the specific wording of the conservation easement.

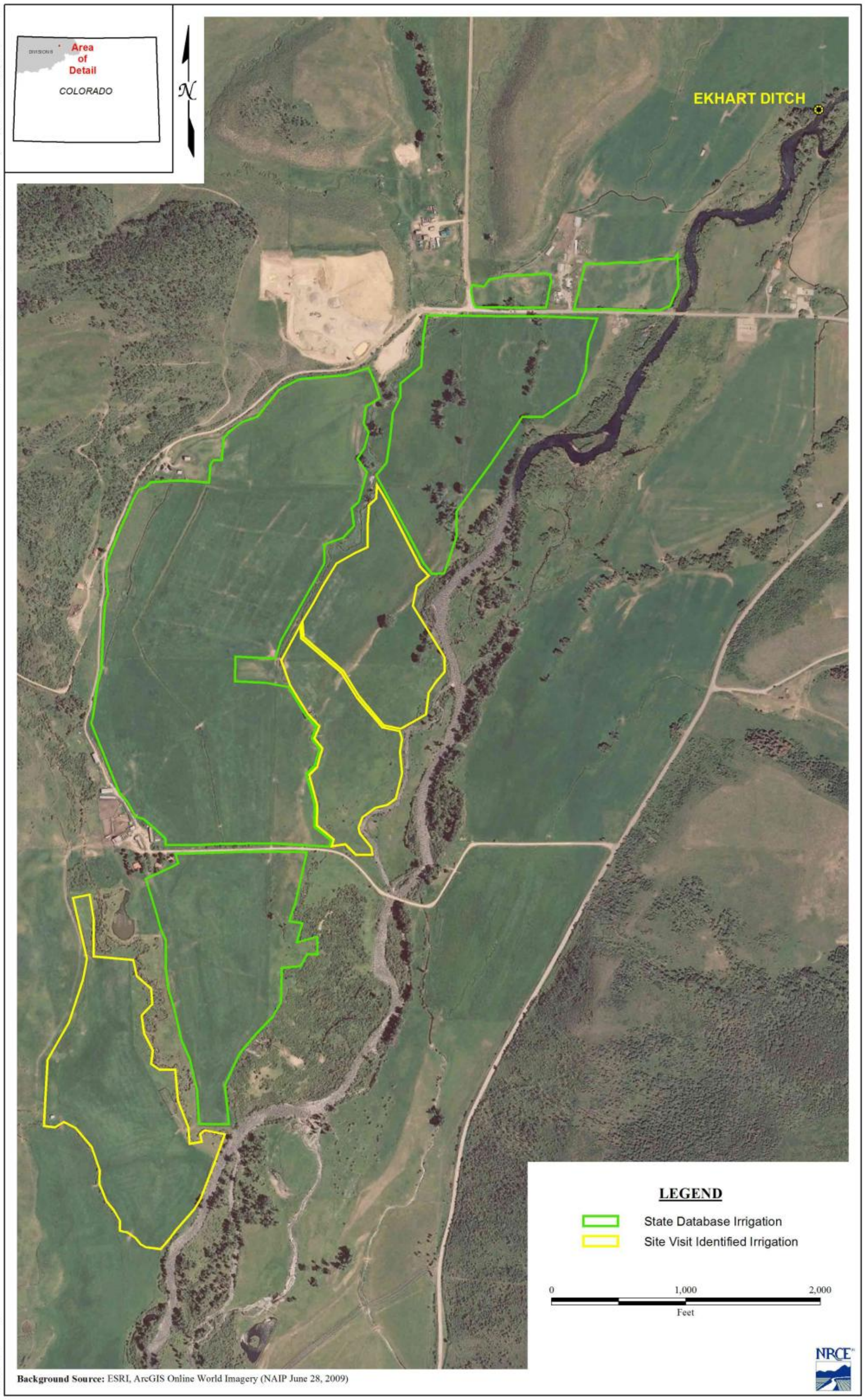

Figure 1: Division 6 - Diversion 5800623 Irrigated Areas and SSURGO Data

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CONFIDENTIAL, PRIVILEGED INFORMATION

December 2012

DRAFT
for attorney-client review

DR. MORRISON DITCH SITE VISIT

COLORADO RIVER WATER BANK-PHASE II

Submitted to:

WATER BANK GROUP

Prepared by:

NATURAL RESOURCES CONSULTING ENGINEERS, INC.

Submitted on:

DECEMBER 20, 2012

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1. INTRODUCTION

Steve Harris, Southwestern Water Conservation District, Dan Birch, Deputy General Manager of the Colorado River Water Conservation District (CRWCD), and Jordan Lanini, Senior Engineer with NRCE Inc. (NRCE), met with the Southern Ute Indian Tribe Water Resources Division ("Tribe") on November 19, 2012. In attendance from the Tribe were Chuck Lawler, Director, and Tami Sheldon and Ryan Huggins. The Dr. Morrison Ditch is a part of the Pine River Indian Irrigation Project (PRIIP), and is a case study of Indian agricultural water in Colorado. This site visit report details the following elements:

1. Location and Operational Description
2. Shortages Experienced During Drought Years
3. Accuracy of State Land Mapping and Diversion Records
4. Physical Potential for Fallowing/Deficit Irrigation
5. Operational Potential for Fallowing/Deficit Irrigation
6. Administrative Potential for Fallowing/Deficit Irrigation
7. Conclusions

2. LOCATION AND OPERATIONAL DESCRIPTION

The Dr. Morrison Ditch is located near Ignacio, Colorado and sits at approximately 6,600 ft elevation. The ditch was constructed as a private ditch and was subsequently purchased by and is operated by the Bureau of Indian Affairs (BIA).

The Dr. Morrison Ditch diverts water from the Los Pinos (also known as the Pine) River. The water rights are both direct-flow rights from the Pine River as well as storage rights in Vallecito Reservoir upstream. Tribal storage rights are one sixth of Vallecito Reservoir's 125,000 acre-feet, but are not exclusive to the Dr. Morrison Ditch. The direct-flow water rights are federally reserved with an appropriation date equal to the 1868 establishment date of the Reservation. Vallecito Reservoir was constructed from 1939-1941 by the Bureau of Reclamation (USBR), and storage rights have a priority date of 1940.

The Dr. Morrison Ditch serves a total of 4,184 assessable acres. Assessable acres are those that were determined by the BIA to be arable under gravity-fed irrigation. The water right was calculated as 1 cfs per 80 acres and water rights are accordingly tied to the land. Acreage is a combination of allotments, fee lands, and Tribal assignments. Allottees and fee lands are directly billed by BIA, and Tribal assignments are directly billed to the Tribe. The Tribe then bills individual Tribal members for water assessments. The Dr. Morrison Ditch parallels the Morrison Ditch, a private ditch serving lands in the same area. The Morrison Ditch and Dr. Morrison Ditch serve both Indian and non-Indian users. The ditches primarily serve grass hay lands under flood irrigation.

Yields range widely, and typically get two cuttings and occasionally three hay cuttings per year. Yields can be as high as 4 tons per acre but typically average around 1.5-2 tons/ac. Yields vary based upon the level of commitment to agriculture by the operator, as some fields are inadequately irrigated.

Hay is typically fed to cattle, but some producers sell hay externally.

Photo 1: Dr. Morrison Ditch.

3. SHORTAGES EXPERIENCED DURING DROUGHT YEARS

The Dr. Morrison Ditch used storage rights in 2002. Typically the Tribe uses approximately 4,000 af of the approximately 20,000 af of storage rights. However, other ditches in the PRIIP may not be able to utilize the storage rights as the conveyance losses and operational difficulties in shared conveyance ditches make it infeasible. The Dr. Morrison Ditch can feasibly utilize storage rights.

The 2012 summer had very limited precipitation and accordingly lower production. Fields were grazed early to sustain cattle herds.

4. ACCURACY OF STATE LAND MAPPING AND DIVERSION RECORDS

4.1 WATER RIGHTS

Water rights reported in the State's database were verified as pre-Compact. The State settlement records these rights with an adjudication priority date of 1930, based on the settlement. However, the federally reserved water rights should have a priority date of 1868. Storage rights are not pre-compact. Water rights appear in Table 1 below.

Table 2: Dr. Morrison Ditch water rights.

Adjudication Date	Appropriation Date	Rate (CFS)			Volume (Ac-Ft)		
		Absolute	Conditional	AP/EX	Absolute	Conditional	AP/EX
10/25/1930	7/25/1868	64.83	13.92	0.00	0.00	0.00	0.00

	Pre Compact
	Post compact

4.2 IRRIGATED LANDS

The State's mapped irrigated lands are 2,133 acres, but 4,184 acres are assessable. The actual area irrigated is somewhere in between these two numbers but is not field-verified by the Tribe. CDSS irrigated lands are shown in Figure 1.

4.3 HISTORICAL DIVERSION RECORDS

The historical diversion records were not verified but seem accurate. The Tribe examined the diversion records and noticed a recent decline in diversions from the full 80 cfs right which may be caused by a newly added pipeline, constricting the flow. Diversions are Tribally gaged but this information is not the basis of the State's diversion records.

Photo 2: Dr. Morrison Ditch diversion.

5. PHYSICAL POTENTIAL FOR FALLOWING

5.1 IMPORTANCE OF GROUNDWATER

Groundwater is locally important in lands served by the Dr. Morrison Ditch. The lands near the Pine River can be subirrigated. Lands served by the ditch also receive water from seepage from area irrigated fields. Low spots in higher fields appeared saturated during the visit, but this is likely from irrigation applications in the field, according to the Tribe. Groundwater may also be important to some created wetland areas.

5.2 LOCATION OF RETURN FLOWS

Flows typically return to the Pine River downstream of the irrigated lands, and within the PRIIP area. There are no downstream irrigators within the State of Colorado dependent on return flows, although there may be some use of return flows within the area irrigated by the Dr. Morrison Ditch.

5.3 SALINITY AND WATER QUALITY ISSUES

There are no salinity issues. Some lands on the western portion of the irrigated areas have some issues with selenium, but it doesn't appear to be a large issue.

6. OPERATIONAL POTENTIAL FOR FALLOWING AND DEFICIT IRRIGATION

There appears to be operational potential for fallowing and/or deficit irrigation. Certain lands are deficit-irrigated through low intensity, inadequate management. These operators may not be interested in the full agricultural production of the land.

7. ADMINISTRATIVE POTENTIAL FOR FALLOWING AND DEFICIT IRRIGATION

7.1 DOCUMENTING SAVED CONSUMPTIVE USE

The Tribe maintains a gage of water diverted to the Dr. Morrison Ditch. However, individual parcels are not measured. Return flows are also not measured, meaning foregone consumptive use cannot be directly measured.

7.2 WATER BANK PARTICIPATION

Water bank participation would require a decision by Tribal Council. The Tribe is interested in examining the possibilities for water banking. We briefly discussed how forbearance might work. It likely would be an agreement with the Tribe. The Tribe would subsequently administer the program and interact with Tribal assignments. However, the Tribe would not administer any agreements with allottees.

Because BIA and USBR operate the Dr. Morrison Ditch and Vallecito Reservoir, respectively, they would need to be consulted on water banking administration.

8. CONCLUSIONS

The Dr. Morrison Ditch is similar to many high elevation irrigation systems in Colorado in terms of irrigation practices. However, the PRIIP has added layers of complexity due to the involvement of both BIA and USBR, as well as three different land classifications within the Project. However, the Tribal Federally reserved water rights cannot be relinquished due to lack of use, meaning there is the potential for longer-term water banking.

In addition, the Tribe does not use its full consumptive water right. Because their storage account resets annually, and not all the assessable acres are irrigated (and some of those that are irrigated are already deficit-irrigated), the potential exists for banking. Similarly, shepherding to the State Line would be somewhat easier, as there are no diversions in Colorado downstream from the Dr. Morrison Ditch.

Figure 1: Division 7 - Dr Morrison Irrigated Areas and SSURGO Data

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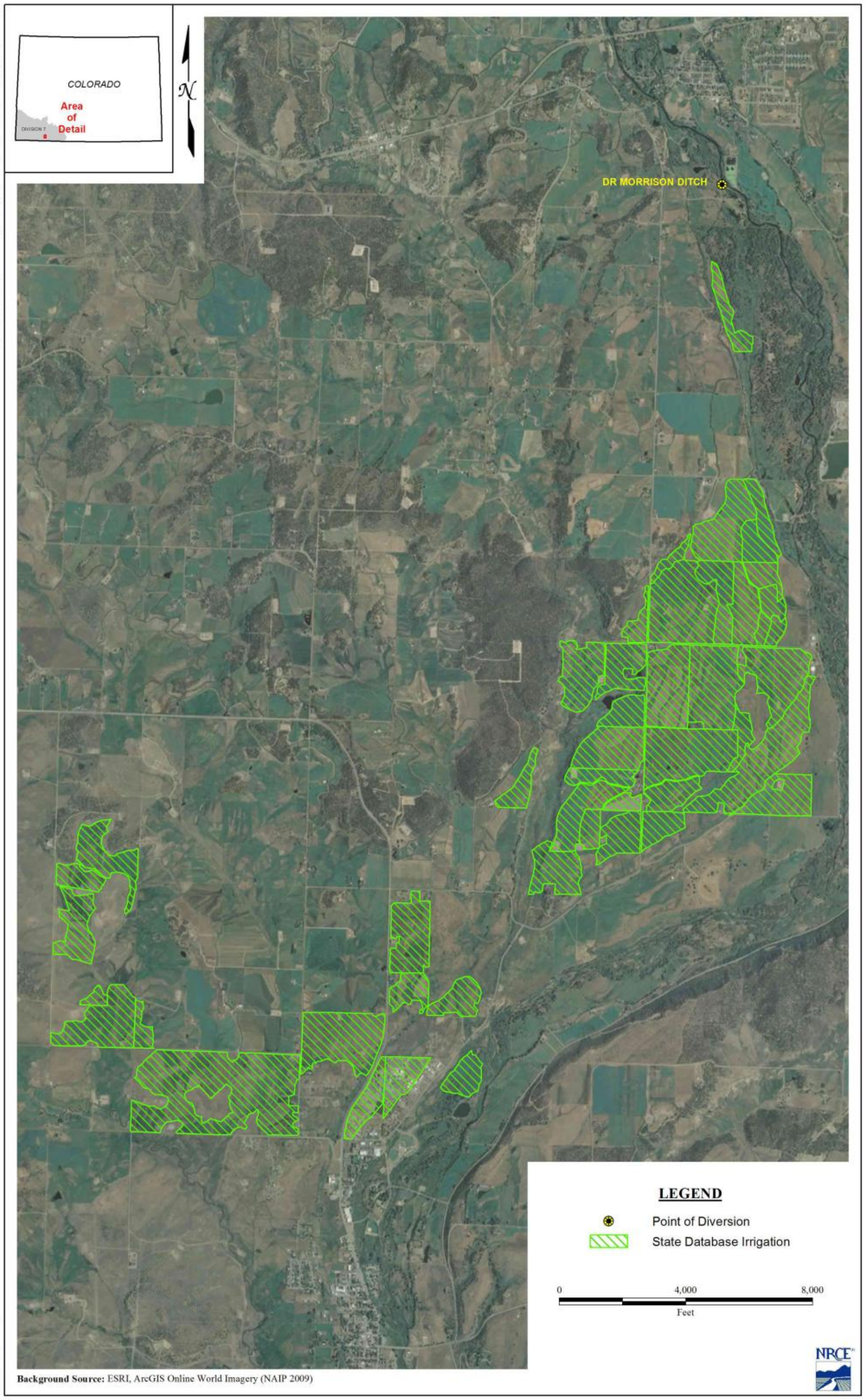

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