Central California Irrigation District
Water Management Plan
2023

Date of first draft: September 2024

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Central California Irrigation District Water Management Plan

Section I – Description of the District

	(Enter Information Below)
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A. History

Organization of the Central California Irrigation District occurred under the provisions of the California Irrigation District Act and was approved by a vote of the people held on October 9, 1951.

The early history of our canal system and its various parent companies dates back to March 7, 1866. Mr. John Bensley became involved in a corporation formed to build an irrigation and barge canal system that would connect Tulare Lake Basin with the San Joaquin River at Mendota Pool. From here he would build a new canal system connecting the Mendota Pool with the Sacramento, San Joaquin Delta, San Francisco Bay, and the Pacific Ocean – all of which was no small undertaking. Construction began on the first leg in Tulare Lake Basin in 1852.

In order for the newly formed corporation to succeed it needed assurances that irrigation water could be sold from the canal system as it traversed the valley floor. By the early 1870's, the Miller & Lux holdings has already established control of much of the land immediately to the north of the Mendota Dam site. Thus, the financial dependency of the fledgling company required it to strike a deal with the Miller & Lux interests.

Under the agreement entered into on May 18, 1871, Miller & Lux subsidized the newly formed canal company. In exchange, the newly formed company agreed to provide Miller & Lux with a discounted price on irrigation and livestock water. This same year also witnessed the construction of the first permanent dam facility at the Mendota Pool. The new structure impounded the entire flow of the San Joaquin River and the Fresno Slough, re-diverting these to the headworks of the newly constructed Main Canal.

Unfortunately for its investors, the canal company never proved to be a financial success. As they became more and more disenchanted, Miller & Lux was ever ready to purchase outstanding stock at a greatly reduced price. These stock acquisitions continued until Miller & Lux finally wrestled control away from investors. As the major stockholder, they immediately embarked on a rapid-fire campaign of canal construction. From the early 1870's through the 1920's, virtually all construction of what is now the Central California Irrigation District occurred.

In 1933, the United States Department of Interior negotiated with the heirs of Miller & Lux for the acquisition of the riparian rights from the area which is now identified as the Grassland Water District. At the same time, they negotiated for an exchange of water between the Central Valley Project and Miller & Lux's riparian water rights on the San Joaquin River. As part of the Central Valley Project (CVP) the United States proposed to construct and operated a new dam on the Sacramento River above Shasta. Transport of water stored behind this facility would be down the Sacramento River to the Delta. It would then be pumped from the Delta into a newly constructed Delta-Mendota Canal terminating at the Mendota Pool. In addition, as part of the project Miller & Lux exchanged water rights to the San Joaquin for water from the CVP. Water from these rights would be impounded behind what is now Friant Dam, where it would be redistributed along the east side of the valley through the Friant Kern canal.

Obviously, a major ingredient of this entire project was the negotiation of an exchange of water between the heirs of Henry Miller and the Federal government. Without such an agreement there would have been no Central Valley Project. The parties finally reached an agreement in 1937. This accord, "The Exchange Contract," remains the backbone of the Central California Irrigation District's water supply to this day.

As mentioned earlier, Central California Irrigation District came into being in 1954 as a result of an election by landowners who were then receiving water from the San Joaquin Canal Company, a former Miller & Lux holding. Shortly after this, landowners held a second election for the purpose of levying a general obligation bond against the properties within the newly formed District. Through the sale of these bonds, they raised enough capital to purchase the assets, including water rights and distribution system, from the San Joaquin Canal Company. In 1954, the newly formed district took over the operation of the Canal Company.

1. Date District Formed: 1954 Date of First Reclamation Contract: July, 1939

Original Size Acres: 143,699 Current Year (last complete calendar year): 2023

2. Current size, population, and irrigated acres

	2023
Size (acres)	143,319
Population Served (For Urban, number of connections)	5,700
Irrigated Acres*	140,208
*All Irrigated Acres in multiple cropping	

3. Water supplies received in current year

Water Source	AF
Federal urban water (Table 1)	0
Federal agricultural water (Table 1)	445,198
State water (Table 1)	0
Other Wholesaler (define) (Table 1)	0
Local surface water (Tbl 1)	0
Upslope drain water (Tbl 1)	0
District groundwater (Tbl 2)	2,306
Banked water (Tbl 1)	0
Transferred water (Tbl 1)	22,161
Recycled water (Tbl 3)	0
Other (define) (Tbl 1) (Drain Re-Use)	46,772
Total	516,437

4. Annual entitlement under each right and/or contract

The Exchange Contract provides for the annual delivery of 532,400 acre-feet under non-critical year hydrologic conditions. Under critical year hydrologic conditions, the delivery is reduced to 399,300 acre-feet. The Exchange Contract also provides for maximum monthly water entitlements.

	AF	Source	Contract #	Availability Period(s)
Reclamation Urban AF/Y	N/A			
Reclamation Agriculture AF/Y	532,400	Exchange Contract	I1r-1144	January - December
Other AF/Y	N/A			

5. Anticipated land-use changes. For Ag contractors, also include changes in irrigated acres

Central California Irrigation District does not anticipate any significant land-use changes over the next 5 years.

6. Cropping patterns (Agricultural only)

List of current crops (crops with 5% or less of total acreage) can be combined in the 'Other' category

Original Plan (1993)		Previous Plan (2016)		Current Plan (2023)	
Crop Name	Acres	Crop Name	Acres	Crop Name	Acres
Cotton	Unknown	Alfalfa	28,909	Alfalfa	17,994
Tomato	Unknown	Bean – Dry	4,541	Almonds	32,349
Corn	Unknown	Broccoli	1,237	Corn	24,240

Crop Name	Acres	Crop Name	Acres	Crop Name	Acres
Alfalfa	Unknown	Corn	13,330	Cotton	14,039
		Cotton	26,606	Oats	8,291
		Melon	4,217	Tomatoes	7,585
		Oats	4,351	Wheat	10,194
		Orchard - Almond	16,406		
		Orchard - Pistachio	4,521		
		Orchard - Miscellaneous	1,014		
		Orchard - Walnut	5,607		
		Pasture	4,945		
		Pre-Irrigation	7,922		
		Rice	1,854		
		Sudan	1,484		
		Tomato	11,833		
		Wheat	7,933		
		Winter Forage	992		
Other (<5%)	Unknown	Other (<5%)	7,763	Other (<5%)	25,516
Total	Unknown	**Total**	155,466	**Total**	140,208

7. Major irrigation methods (by acreage) (Agricultural only)

Original Plan (1993) Previous Plan (2016) Current Plan (2023)

Irrigation Method	Acres	Irrigation Method	Acres	Irrigation Method	Acres
Level basin	Unknown	Drip	8,647	Drip	24,263
Furrow	Unknown	Flood/Conventional	1,941	Flood/Conventional	2,098
Sprinkler	Unknown	Furrow	52,504	Furrow	33,874
Low-volume	Unknown	Furrow/Border Strip	47,001	Furrow/Border Strip	45,162
Multiple	Unknown	Micro-spray/Sprinkler	15,333	Micro-spray/Sprinkler	18,433
Other	Unknown	Sprinkler	1,601	Sprinkler	258
		Tape	23,938	Tape	15,261
		Other	4,501	Other	859
Total	Unknown	**Total**	155,466	**Total**	140,208

B. Location and Facilities

See Attachment A-1 and A-2 for maps containing the following: incoming flow locations, turnouts (internal flow), conveyance system, storage facilities, operational loss recovery system, district wells and lift pumps.

1. Incoming flow locations and measurement methods

Location Name	Physical Location	Type of Measurement Device	Accuracy
Mendota Dam	Mendota Pool	Rated Canal Section & Doppler Meter	+/- 3%
Main Canal	Mendota Pool	Rated Canal Section & Metered upstream of control weir	+/-3%
Outside Canal	Mendota Pool	Rated Canal Section & Metered upstream of control weir	+/-3%
Helm Ditch	Mendota Pool	Propeller Meter	+/-3%
DMC	Mile Post 58.27	Propeller Meter	+/-3%
DMC	Mile Post 60.65	Propeller Meter	+/-3%
DMC	Mile Post 76.05	Rated Canal Section & Doppler Meter	+/-3%
DMC	Mile Post 83.08	Propeller Meter	+/-3%
DMC	Mile Post 85.05	Propeller Meter	+/-3%
DMC	Mile Post 86.17	Propeller Meter	+/-3%

2. Current year Agricultural Conveyance System

Miles of Unlined – Canal	Miles of Lined – Canals	Miles of Pipe	Miles – Other
251	5.34	0	322 Private

3. Current year Urban Distribution System

N/A

Miles of AC Pipe	Miles of Steel Pipe	Miles of Cast Iron Pipe	Miles – Other

4. Storage facilities (tanks, reservoirs, regulating reservoirs)

Name	Type	Capacity (AF)	Distribution or Spill
Colony Reservoir	Regulating	60	Distribution & Spill
East Ditch	Regulating	107	Distribution & Spill
Laguna Reservoir	Regulating	20	Distribution & Spill
Gustine Reservoir	Regulating	120	Distribution & Spill
Ingomar Reservoir	Regulating	230	Distribution & Spill
Poso Reservoir	Regulating	250	Distribution & Spill

5. Description of the agricultural spill recovery system and outflow points

In addition to the above regulating reservoirs, the District automated the Main and Outside Canals to automatically reduce or recover spills from the system. The headworks of the Poso and Sullivan Canals are automated.

6. Agricultural delivery system operation

CCID employs a Watermaster who monitors the daily needs of the delivery system through coordination with the various canal workers throughout the District. Our farmers contact the canal workers with their water needs and the canal workers relay these requests to the Watermaster during morning calls. The Watermaster then adjusts the canal levels to meet the demand, taking into account current conditions. Modernization allows the District to monitor the canal elevations and flow rate using SCADA technology. This has resulted in significant water conservation as well as improved water service to all users. All system operations are governed under Rule 12, of Rules and Regulations (Attachment C).

Scheduled	Rotation	Other (Describe)
X		

7. Restrictions on water source(s)

Source	Restriction	Cause of Restriction	Effect on Operations
	Water Transfer guidelines (Federal & State)	Public Law I02-575	Transfer out of the area

8. Proposed changes or additions to facilities and operations for the next 5 years

The District employed Cal Poly ITRC to develop a conservation plan. The District is in the process of accomplishing projects prioritized in the plan. The District has budgeted $9.7 million in the next 5 years for District owned facilities improvements as well as $12.2 million for grants and $7.3 million for loans through our Water Conservation Program for on-farm projects.

C. Topography and Soils

1. Topography of the district and its impact on water operations and management

The District has slopes that range from 30 feet per mile in the foothills to 1 foot per mile in the lower bottom lands of the District. Several creeks cross the District, with sloughs and wetlands scattered throughout the area. Production land is generally flat, with deep, loam soils prevalent throughout the agricultural area.

2. District soil association map (Agricultural only)

The general soils maps showing soil associations, map showing soil mapping units, and the descriptions of NRCS soil series soils occurring in Central California Irrigation District are included in Attachment B1–3.

Soil Association	Estimated Acres	Effect on Water Operations and Management
*Balfour Clay Loam	4,100	Partial Damage
-*Dos Palos Clay	5,085	Partial Damage

*See complete soil on Attachment B1-3.

3. Agricultural limitations resulting from soil problems (Agricultural only)

Soil Problem	Estimated Acres	Effect on Water Operations and Management
Salinity	6,000	Salt in soil profiles
High-water table	0	Crop root zone damage
High or low infiltration rates	0	Irrigation uniformity
Other (define)	0	N/A

D. Climate

1. General climate of the district service area

The general climate of the District service area is mild winters with dense fog at times; no snow; hot summers.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Ave Precip	2.46	1.13	1.46	0.44	0.28	0.00	0.00	0.01	0.03	0.16	0.67	2.39	9.04
Ave Temp	49	52	55	62	68	75	81	80	76	67	55	48	64
Max Temp	73	80	86	94	104	108	111	106	113	96	81	71	94
Min Temp	29	30	35	39	43	48	53	55	49	37	32	28	40
ETo	1.46	2.44	3.73	5.89	7.77	8.95	9.34	7.76	5.81	4.22	2.12	1.34	60.82

Weather station ID: NWS Co-op Station: Los Banos Data period: Year 2017 to Year 2023
ET Station ID: CIMIS Station #124: Panoche Average annual frost-free days: 365
Frost Free Days – According to National Oceanic and Atmospheric Administration (NOAA), frost free days are days with temperatures greater than 28 degrees Fahrenheit.

2. Impact of microclimates on water management within the service area

None.

E. Natural and Cultural Resources

1. Natural resource areas within the service area

Name	Estimated Acres	Description
None		

2. Description of district management of these resources in the past or present

N/A

3. Recreational and/or cultural resources areas within the service area

Name	Estimated Acres	Description
Volta NWA	13,235	Wildlife Refuge
China Island	11,001	Wildlife Refuge
Kesterson NWA	7,600	Wildlife Refuge
San Luis NWA	8,200	Wildlife Refuge
West Gallo	5,000	Wildlife Refuge

F. Operating Rules and Regulations

1. Operating rules and regulations

See Attachment C, "Rules and Regulations of Central California Irrigation District Governing the Distribution and Use of Water" were adopted by the CCID Board of Directors June 27, 1956 and last revised January 10, 1990.

Water allocation policy (Agricultural only)

See Attachment C, Rule 13

2. Official and actual lead times necessary for water orders and shut-off

See Attachment C, Rule 12

3. Policies regarding return flows (surface and subsurface drainage from farms) and outflow (Agricultural only)

See Attachment C, Rule 4

4. Policies on water transfers by the district and its customers

See Attachment D, Central California Irrigation District Water Transfers Rules and Regulations See Attachment E, San Joaquin River Exchange Contractors Water Authority Water Transfer Policy

G. Water Measurement, Pricing, and Billing

1. Agricultural Customers – Refer to BMP A.1. Information on water measurement for agricultural contractors is completed under BMP A.1 on page 4-15.

2. Urban Customers

   a. Total number of connections 1

   b. Total number of metered connections 1

   c. Total number of connections not billed by quantity 0

   d. Percentage of water that was measured at delivery point 100%

   e. Percentage of delivered water that was billed by quantity 100%

   f. Measurement device table

Meter Size and Type	Number	Accuracy* (+/- Percentage)	Reading Frequency (Days)	Calibration Frequency (Months)	Maintenance Frequency (Months)
5/8" - 3/4"					
1"					
1-1/2"					
2"					
3"					
4"					
6"					
8"					
10"	1	+/-2%	Daily	Annually	Annually
Compound					
Turbo					
Other (define)					
Total					

3. Agricultural and Urban Rates

   a. Current year agricultural and /or urban water charges - including rate structures and billing frequency.

CCID sets the water rates annually. Water delivered in January through October is priced by tiers as follows:

Tier 1	0 – 3.2 af/ac	@	$17.00/af
Tier 2	3.2 – 3.7 af/ac	@	$60.00/af
Tier 3	3.7 af/ac and up	@	$100.00/af

The per-acre quantities above represent how much water will be available, if needed, but the amounts are not guaranteed. The actual amount of water available is subject to the Bureau's ability to deliver water to the District, and limitations in the Exchange Contract.

We generally have a good supply of water available in November and December, although availability may be limited depending on the need to perform winter maintenance and construction projects. Water available during this period is sold on a first-come, first-served basis, at $17.00 per af.

Municipal water is available at $75.00 per af.

See Attachment F, Letter from Board of Directors establishing water rates for 2023.

b. Annual charges collected from agricultural customers

Fixed Charges

Charges ($ by unit)	Charge Units ($/AF, etc)	Units Billed During Year (AF, etc)	Total $ Collected ($ times Units)
N/A			

Volumetric Charges

Charges ($ by unit)	Charge Units ($/AF, etc)	Units Billed During Year (AF, etc)	Total $ Collected ($ times Units)
Tier 1	$17.00	346,695	$5,893,815
Tier 2	$60.00	8,742	$524,520
Tier 3	$100.00	3,567	$356,700

Urban Fixed Charges

Charges ($ by unit)	Charge Units ($/AF, etc)	Units Billed During Year (AF, etc)	Total $ Collected ($ times Units)
N/A			

Urban Volumetric Charges

Charges ($ by unit)	Charge Units ($/AF, etc)	Units Billed During Year (AF, etc)	Total $ Collected ($ times Units)
$75	Per acre foot	1,007	$75,525

c. Describe the contractor's record management system

District records agricultural water use on a daily basis. Growers may request that information from the District Office. Monthly billing shows water use by turnout, by farm, for the past 30 days. All delivery records are kept at the District Office and are available to Growers upon request.

H. Water Shortage Allocation Policies

1. Current year water shortage policies or shortage response plan – specifying how reduced water supplies are allocated

See Attachment C, Rule 13

Urban: The City of Dos Palos has a right by contract to receive up to 2,500 af/yr of CCID's Exchange Contract water (untreated Ag water) due to their not having available groundwater.

2. Current year policies that address wasteful use of water and enforcement methods

See Attachment C, Rule 4

I. Evaluate Policies of Regulatory Agencies Affecting the Contractor and Identify Policies that Inhibit Good Water Management

Discuss possible modifications to policies and solutions for improved water management

CCID is one of four Exchange Contractors. The conveyance and storage policies of the Central Valley Project affects us differently than the Bureau's federal contractors because of the Exchange terms. With our very successful Water Conservation Program and continued work with the Bureau on future policies and programs, the Exchange Contractors will work toward future conservation and flexibility for all CVP water users.

Section II – Inventory of Water Resources

A. Surface Water Supply

1. Surface water supplies in acre feet, imported and originating within the service area, by month (Table 1)

See Section V, Water Inventory Tables, Table 1

2. Amount of water delivered to the district by each of the district sources for the last 10 years

See Section V, Water Inventory Tables, Table 8

B. Groundwater Supply

1. Groundwater extracted by the district and delivered, by month (Table 2)

See Section V, Water Inventory Tables, Table 2

2. Groundwater basin(s) that underlies the service area

Name	Size (Square Miles)	Usable Capacity (AF)	Safe Yield (AF/Y)
Delta-Mendota Subbasin	~1,195	4,440,000	308,000 – 375,000

3. Map of district-operated wells and managed groundwater recharge areas

See Attachment A-2, for District Deep Wells and Lift Pumps Map

4. Description of conjunctive use of surface and groundwater

District supplements summer irrigation requirements with groundwater to meet grower demand. Due to water allocation restrictions, full demands cannot be met with Contract water, therefore wells are used to supplement irrigation needs during the summer months.

5. Groundwater Management Plan

See Attachment H, AB3030

6. Groundwater Banking Plan

The District is currently implementing a 10 year Water Resources Plan, a portion of which is analyzing water banking opportunities in and around the CCID service area.

C. Other Water Supplies

1. "Other" water used as part of the water supply – Drain Re-use

See Section V, Water Inventory Tables, Table 8

D. Source Water Quality Monitoring Practices

1. Potable water quality (Urban only)

N/A – CCID does not make potable water deliveries. Over 35 years ago, the City of Dos Palos arranged to have their CCID supply wheeled to themselves through the San Luis Canal, where they take delivery of the water into their own conveyance, treatment and distribution system – which is completely independent of CCID.

2. Agricultural water quality concerns: [ ] No [X] Yes (if yes, describe)

Salinity (measured daily)
Boron (impacts orchards in the north end of the District)
Selenium (not allowed in the system)

3. Description of the agricultural water quality testing program and the role of each participant, including the district, in the program

The District participates through the Exchange Contractors Watermaster in measuring water quality (EC and Boron) on all in-flows monthly to confirm compliance of the Exchange Contract water delivery standards. In addition, the District annually measures Ag suitability constituents for all deep wells that pump into the system. The District utilizes an in-house laboratory to test EC and Boron in key locations within the conveyance system on a weekly basis.

4. Current water quality monitoring programs for surface water by source (Agricultural only)

Analyses Performed	Frequency	Concentration Range	Average
Total Dissolved Solids	Continuous	200 - 500	350
Ag suitability	Monthly - ECw	200 - 1,200	350

5. Current water quality monitoring programs for groundwater by source (Agricultural only)

Analyses Performed	Frequency	Concentration Range	Average
Ag Suitability	Monthly – ECw	300 – 1,400	500

E. Water Uses Within the District

1. Agricultural

See Section V, Water Inventory Tables, Table 5 - Crop Water Needs

2. Types of irrigation systems used for each crop in current year

Crop Name	Total Acres	Drip (Acres)	Flood / Conventional (Acres)	Furrow (Acres)	Furrow / Border Strip (Acres)	Micro-spray / Sprinkler (Acres)	Sprinkler (Acres)	Tape (Acres)	Other (Acres)
Alfalfa	17,994	48		3,569	13,487			643	248
Almonds	32,349	18,246		35	21	13,359		677	12
Corn	24,240			8,596	14,243			1,401	
Cotton	14,039	29		11,474	468			1,985	84
Oats	8,291			623	7,669				

Crop Name	Total Acres	Drip (Acres)	Flood / Conventional (Acres)	Furrow (Acres)	Furrow / Border Strip (Acres)	Micro-spray / Sprinkler (Acres)	Sprinkler (Acres)	Tape (Acres)	Other (Acres)
Tomatoes	7,585	50		581	85		137	6,732	
Wheat	10,194			4,868	3,928			1,368	30
Other (<5%)	25,516	5,890	2,098	4,130	5,261	5,074	121	2,456	486
Total	140,208	24,263	2,098	33,874	45,162	18,433	258	15,261	859

3. Urban use by customer type in current year

Customer Type	Number of Connections	AF
Single-family		
Multi-family		
Commercial		
Industrial		
Institutional		
Landscape irrigation		
Wholesale	1	1,007
Recycled		
Other (specify)		
Other (specify)		
Other (specify)		
Unaccounted for		
Total	1	1,007

4. Urban Wastewater Collection/Treatment Systems serving the service area

Treatment Plant	Treatment Level (1,2,3)	AF	Disposal to/Uses
None in District			
	Total		
Total discharged to ocean and/or saline sink			

5. Groundwater recharge in current year (Table 6)

Recharge Area	Method of Recharge	AF	Method of Retrieval
Stockton Pit	Flood	900*	Well Pump
Orestimba Creek	Flood	911	Well Pump

Recharge Area	Method of Recharge	AF	Method of Retrieval
*Estimated			
	Total	1,811	

6. a. Transfers and exchanges **into** the service area in current year – (Table 1)

From Whom	To Whom	AF	Use
Outside	CCID	22,161	Agricultural
	Total	22,161	

6. b. Transfers and exchanges **out** of the service area in current year – (Table 6)

From Whom	To Whom	AF	Use
CCID	Outside	54,676	Agricultural
	Total	54,676	

7. Wheeling, or other transactions in and out of the district boundaries – (Table 6)

From Whom	To Whom	AF	Use
CCID	Grasslands WD	131,926	Refuge
CCID	Triangle T WD	4,654	Agricultural
	Total	136,580	

8. Other uses of water

Other Uses	AF
None	

F. Outflow from the District (Agricultural only)

Irrigation drainage from the District is not measured. CCID has an internal drainage district (Camp 13 Drainage District) that discharges to the San Luis Drain on a limited basis. Any other discharges are either re-circulated for irrigation or released to the San Joaquin River thru the Salt/Mud Sloughs or other facilities.

1. Surface and subsurface drain/outflow

CCID does not have subsurface drain/outflow.

Outflow Point	Location Description	AF	Type of Measurement	Accuracy (%)	% of Outflow	Acres Drained
SJR	Salt/Mud Slough	1,000	Estimated			5,000

Outflow Point	Where the Outflow Goes (Drain, River, or Other Location)	Type Reuse
SJR	Unmeasured outflow to SJR, seeps into channel	Unknown

2. Description of the Outflow (surface and subsurface) water quality testing program and the role of each participant in the program

All CCID acreage is within the boundaries of the Westside San Joaquin River Watershed Coalition. The Coalition conducts sampling on a monthly basis and storm events throughout the area and also uses the data of the monitoring station at Sand Dam. The major concerns for the Regional Water Control Board are exceedances of chlorpyrifos and diazinon.

3. Outflow (surface drainage & spill) Quality Testing Program

Analyses Performed	Frequency	Concentration Range	Average	Reuse Limitation
EC, Boron, etc.	Monthly			Salt load

Outflow (subsurface drainage) Quality Testing Program

CCID does not have a subsurface drainage testing program.

Analyses Performed	Frequency	Concentration Range	Average	Reuse Limitation
N/A				

4. Provide a brief discussion of the District's involvement in Central Valley Regional Water Quality Control Board programs or requirements for remediating or monitoring any contaminants that would significantly degrade water quality in the receiving surface waters.

Central California Irrigation District is a member of the Westside Regional Water Coalition. All acreage within CCID is enrolled to comply with the agricultural waiver requirements.

Districts included in the drainage problem area, as identified in "A Management Plan for Agricultural Subsurface Drainage and Related Problems on the Westside San Joaquin Valley (September 1990)," should also complete Water Inventory **Table 7 in Section V**.

G. Water Accounting (Inventory)

Tables 1 through 8 are included in Section V.

Section III – Best Management Practices (BMPS) for Agricultural Contractors

A. Critical Agricultural BMPs

1. Measure the volume of water delivered by the district to each turnout with devices that are operated and maintained to a reasonable degree of accuracy, under most conditions, to +/- 6%

The District primarily uses metered gates (whistle pipes), open flow meters, measuring weirs and a few others such as acoustic Doppler meters to measure water deliveries to each water user. The District has been in a program of increasing the accuracy of these measurements using pool stabilization through modernization and automation of the Main and Outside Canals (127 miles), which are the main distribution canals in the District. The automation of the Main and Outside Canals are complete, automation and/or pool stabilization of the south division canals is presently underway and is expected to be complete with the next 10 year timeline. The south division pool stabilization will be accomplished through a combination of installation of long crested weirs, weir automation and installation of regulating reservoirs. The District currently has 6 regulating reservoirs. Over the next 10 years, an additional reservoir will be installed, and an existing reservoir will be expanded.

In addition, in order to comply with the requirements of the SB X7-7, the District has been systematically field checking the physical and hydraulic condition of turnouts, and performing field flow measurements to verify accuracy. The District has been standardizing turnout design and size by installing gates which have been calibrated in accordance with the Cal Poly Irrigation Training and Research Center (ITRC) for laboratory testing and verification under different submergence conditions in 2016 (Attachment J). Accurate discharge tables were developed for all the different types of metered gates used in the District's canals that take into consideration the exact location of the whistle pipes and the conditions of submergence.

a. Number of delivery points (turnouts and connections) 1,249

b. Number of delivery points serving more than one farm 257

When a delivery services more than one farm, the District Canal Workers track water to each farm separately. All water is measured at the outlet from the district owned canal or ditch. In a large percentage of cases where more than one farm is serviced, water is being delivered into a privately owned ditch which the landowners have connected to the district's facilities. Water deliveries to landowners are started separately to each landowner so that each land owner gets all of their water and the ditch is allowed to reach equilibrium which in most cases occurs within a matter of hours. Then the next delivery is made into the ditch and the ditch is operated to insure all the additional water goes to the new delivery. Water is measured at all deliveries on a daily basis. In a normal water year, there are very few disputes over the quantities of water delivered, given the fact that water is charged on a tiered water rate basis this is a further indication that water is measured fairy and accurately especially in community ditches. If a dispute does occur, a landowner notifies their Canal Worker whom attempts to resolve, if the Canal Worker cannot resolve then he notifies the Division Supervisor whom is trained in the use of open flow measurement which is employed as needed.

c. Number of measured delivery points (meters and measurement devices) 1,249

d. Percentage of water delivered to the contractor that was measured at a delivery point Percentage of water that was measured at delivery point 100%

e. Total number of delivery points not billed by quantity 0

f. Delivery point measurement device table

Measurement Type	Number	Accuracy* (+/- %)	Reading Frequency (Days)	Calibration Frequency (Months)	Maintenance Frequency (Months)
Meter gates	703	+/- 5%	Daily	*	*
Open flow meters	189	+/- 5%	Daily	*	*
Measuring weirs	11	+/- 5%	Daily	*	*
Ramp weirs	5	+/- 5%	Daily	*	*
Doppler meters	29	+/- 5%	Daily	*	*
Pitot tubes	2	+/- 5%	Daily	*	*
Saddle meters	310	+/- 5%	Daily	*	*
Total (various)	1,249	+/- 5%		*	*

*The District completely removes, cleans, and calibrates each open flow meter every winter, then reinstalls at each site. Each meter gate is currently being checked for accuracy and needed site adjustments are made each winter. The meter gates and measurement weirs will be rechecked and calibrated on a 3-year frequency.

2. Designate a water conservation coordinator to develop and implement the Plan and develop Annual Updates.

Name Tracey Rosin Title Conservation Coordinator

Address P.O. Box 1231, Los Banos, CA 93635

Telephone 209-826-1421 Email trosin@ccidwater.org

Provide the job description and minimum qualifications

Description: Responsible to develop a drain monitoring program; prepare feasibility analyses and develop preliminary improvement plans for community ditches; assist in the coordination of in-District conservation projects; administer on-farm Water Conservation Loan Program and incentive grant program; identify and work with drainage impacted areas; identify high water use growers and help develop strategies to reduce water use; and assist in evaluating other conservation related projects.

Qualifications: Ability to organize, prioritize and accomplish work with only general guidelines and objectives given and with minimal direct supervision; evaluate irrigation efficiencies; strong interpersonal written and verbal communication skills; organize and lead public meetings and grower workshops; work effectively with other departments and assist in project design and development and inspection functions.

3. Provide or support the availability of water management services to water users

Cal Poly ITRC schedules summer irrigation evaluations throughout the District. This service is by request to Cal Poly and must be scheduled in advance. Grower demand for system evaluations outweighs ITRC's time allowed to accomplish this service. Notification for this free service is through ITRC mailing list and through District email notice. Large amounts of acreage are being converted annually to drip and micro irrigation. These landowners are responsible for follow up irrigation analysis.

4. On farm irrigation and drainage system evaluations using a mobile lab type assessment

A mobile lab type assessment is no longer available. The District provides on-call on farm evaluations to evaluate serviceability and drainage facilities and provide improvement and operation recommendations. The District evaluates an estimated 12-15 farms annually.

	Total in District	# Surveyed Last Year	# Surveyed in Current Year	#Projected for Next Year	# Projected 2nd Year in Future
Irrigated Acres	140,208	N/A	N/A	N/A	N/A
Number of Farms	700	N/A	N/A	N/A	N/A

a. Timely field and crop-specific water delivery information to the water user

Water use by day or by irrigation can be supplied to any water user by request at the District Office or by logging onto their individual account on-line. Irrigation meters are read daily and reported to the District Office. Monthly bills show water use for the past 30 days and growers can track how much water was applied for any specific irrigation event. Canal men are also available to assist the Grower as needed.

b. Real-time and normal irrigation scheduling and crop ET information

The District provides weather station data and promotes the use of CIMIS data. Growers are informed about the availability of the data through annual meetings, quarterly newsletters and through the District's webpage www.ccidwater.org.

The District also promotes the use and assists interested growers by walking them through irrigation scheduling techniques with the ITRC California Crop and Soil Evapotranspiration website at www.itrc.org/reports/californiacrop.htm.

CCID provides technical assistance to all growers on accessing and using the evapotranspiration information from the CIMIS website at www.cimis.water.ca.gov/cimis

Information is also included on the San Joaquin River Exchange Contractor's website at www.sjrecwa.net. In addition to these practices, some growers subscribe to professional irrigation scheduling services.

c. Surface, ground, and drainage water quantity and quality data provided to water users

CCID is very active in the monitoring of all waters within the District. These data are available at the District Office as well as being reported in the District newsletter on an ongoing basis.

d. Agricultural water management educational programs and materials for farmers, staff, and the public

Program	Co-Funders (If Any)	Yearly Targets
CCID Observer Newsletter	N/A	700 farms/public
Water Conservation Program	N/A	700 farms
CCID Scholarship Program	CCID Landowners	All local students
Annual Public Meetings District Tours – 3-5 per year Site Specific Meetings (drainage)	N/A	Consumers/Public All landowners Public 50/tour Govt/State Reps

See Attachment I for samples of provided materials and notices

e. Other

None.

5. Pricing structure – based at least in part on quantity delivered. Adopt a water pricing structure based on the measured quantity delivered

All water is billed by quantity.

6. Evaluate and improve efficiencies of district pumps. Describe the program to evaluate and improve the efficiencies of the contractor's pumps

CCID maintains all pumps used for re-lift or delivery with an annual maintenance program. Normal maintenance, repair and upgrades are scheduled as needed, generally each year after irrigation season or an on-demand basis during the delivery periods. See Attachment A-2.

	Total in District	# Surveyed Last Year	# Surveyed in Current Year	#Projected for Next Year
Wells	66	64	54	64
Lift Pumps	20	20	20	20

B. Exemptible BMPs for Agricultural Contractors

(See Planner, Chapter 2, Addendum B for examples of exemptible conditions)

1. Facilitate alternative land use

None identified at this time. Severe drainage impacted areas are not formable and have no intended use currently.

Drainage Characteristic	Acreage	Potential Alternate Uses
High water table (<5 feet)	N/A	
Poor drainage	N/A	
Groundwater Selenium concentration > 50 ppb	N/A	
Poor productivity	N/A	

Describe how the contractor encourages customers to participate in these programs

2. Facilitate use of available recycled urban wastewater

No urban wastewater is available.

Sources of Recycled Urban Waste Water	AF/Y Available	AF/Y Currently Used in District
N/A	N/A	N/A

3. Facilitate the financing of capital improvements for on-farm irrigation systems

Program	Description
Water Conservation Loan and Grant Program	Annual Water User Loan and Grant Funding

CCID's Water Conservation Program began in 1990 offering low-interest loans for on-farm conservation practices. In 1999, a grant component was made available to cost-share 50% of concrete ditches and pipelines, up to $400/per acre benefited and 25% of other practices that result in water conserved such as micro and drip irrigation or tail water return systems. To date, the program has loaned over $20.6 million and granted nearly $21.5 million as our consumers accomplish their on-farm practices.

4. Incentive pricing
   Describe incentive rate structure or other programs and purpose

Our Board of Directors sets the water rates annually using a tiered pricing structure to ensure beneficial use of District water supply. See Attachment F.

Tier 1	0 – 3.2 af/ac	@	$17.00/af
Tier 2	3.2 – 3.7 af/ac	@	$60.00/af
Tier 3	3.7 af/ac and up	@	$100.00/af

5. a. Line or pipe ditches and canals

CCID does not currently line its delivery canals or ditches. Consumers, through the District's Water Conservation Program, apply for funds to line on-farm ditches and this yearly program is very active and used frequently. An estimated 5 miles of on-farm canals have been concrete lined in the past 5 years.

Canal/Lateral (Reach)	Types of Improvement	Number of Miles in Reach	Estimated Seepage (AF/Y)	Accomplished/Planned Date
N/A				

5. b. Construct/line regulatory reservoirs

Reservoir Name	Location	Describe Improved Operational Flexibility and AF Savings
Riverside Reservoir	**Dos Palos**	**Regulating reservoir to increase delivery efficiency**

6. Increase flexibility in water ordering by, and delivery to, water users

The District allows flexibility in water ordering by its water users if the canal system can handle a requested off-hour change without affecting other deliveries or water levels in the canal system. Canal workers, with the concurrence of the Watermaster, can adjust schedules if requested and the change does not result in delivery or canal impacts.

7. Construct and operate district spill and tailwater recovery systems

Complete – the District's spill recovery system recovers 95% of all spills for re-use.

Distribution System Lateral	Annual Spill (AF/Y)	Quantity Recovered and Reused (AF/Y)
Main and Outside Canals	10,000*	9,500
Total Outflow	500	

Drainage System Lateral	Annual Drainage Outflow (AF/Y)	Quantity Recovered and Reused (AF/Y)
Community Ditch Laterals	5,000*	4,750
Total Outflow	250	

*Estimated amounts as spills are intermittent.

Describe facilities that resulted in reduced spill and tailwater

Consumers have constructed on-farm capture basins and water conservation efforts in drip and sprinkler irrigation have reduced surface tailwater.

8. Plan to measure outflow

The District maintains 6 to 8 portable data recorders that are rotated to different outflow locations on community ditches throughout the District. This practice will continue and enhanced as necessary as indicated by the analysis of the data collected.

9. Optimize conjunctive use of surface and groundwater
   Describe the potential for increasing conjunctive use of surface and groundwater

Surface and groundwater use complement each other in providing irrigation water to all crops as required by consumptive use of the crops. The Exchange Contract dictates amounts of contract water available each month to the water users and if those amounts are not sufficient, groundwater is used to fulfill daily requirements. Goal is to use Contract water when available and supplement in low supply periods or years with local groundwater to maximize crop production.

10. Automate distribution and/or drainage system structures
    Identify locations where automation would increase delivery flexibility and reduce spill and losses. Describe program to achieve these benefits and estimate the annual water savings

The District's Main and Outside Canals are fully automated. The District's canals in our southern portion are in the process of being automated. The upstream gates at the head of Poso and Sullivan canals are also automated.

11. Facilitate or promote water customer pump testing and evaluation

The District continues to encourage its users to maintain their pumps in good working order. Prudent business sense mandates that all pumps be kept in good working order to maximize pumping requirements and reduce power consumption. The District gets this message out to its users through the newsletter and private pump companies remind them of services available through private mailings and advertisements.

12. Mapping

Estimated Cost (in $1,000s)

GIS Maps	Current Year	Year 2	Year 3	Year 4	Year 5
Layer 1 – Distribution system	5	5	5	5	5
Layer 2 – Drainage system	2	2	2	2	2
Suggested layers:					
Layer 3 – Groundwater information	3	3	3	3	3
Layer 4 – Soils map	0	0	0	0	0
Layer 5 – Natural & cultural resources	0	0	0	0	0
Layer 6 – Problem areas	0	0	0	0	0

C. Provide a 5-Year Budget for Implementing BMPs

1. Amount actually spent during current year

Current Year BMP #	BMP Name	Budgeted Expenditure (not including staff time)	Staff Hours
A1	Measurement	$150,000	0
A2	Conservation staff	$130,000	0
A3	On-farm evaluation/water delivery info irrigation Scheduling	$150,000	0

Current Year BMP #	BMP Name	Budgeted Expenditure (not including staff time)	Staff Hours
	Water quality Agricultural Education Program		
A4	Quantity pricing	$5,000	0
A5	Contractor's pumps	$0	0
B1	Alternative land use	$0	0
B2	Urban recycled water use	$0	0
B3	Financing of on-farm improvements	$750,000	0
B4	Incentive pricing	$5,000	0
B5	Line or pipe canals/install reservoirs	$2,000,000	0
B6	Increase delivery flexibility	$50,000	0
B7	District spill/tailwater recovery systems	$300,000	0
B8	Measure outflow	$5,000	0
B9	Optimize conjunctive use	$1,000,000	0
B10	Automate canal structures	$300,000	0
B11	Customer pump testing	$5,000	0
B12	Mapping	$20,000	0
	Total	**$4,870,000**	**0**

2. Projected budget summary for the next year

Year 2 BMP #	BMP Name	Budgeted Expenditure (not including staff time)	Staff Hours
A1	Measurement	$150,000	0
A2	Conservation staff	$140,000	0
A3	On-farm evaluation/water delivery info irrigation Scheduling Water quality Agricultural Education Program	$150,000	0
A4	Quantity pricing	$5,000	0
A5	Contractor's pumps	$0	0
B1	Alternative land use	$0	0
B2	Urban recycled water use	$0	0
B3	Financing of on-farm improvements	$1,500,000	0
B4	Incentive pricing	$5,000	0
B5	Line or pipe canals/install reservoirs	$2,000,000	0
B6	Increase delivery flexibility	$35,000	0
B7	District spill/tailwater recovery systems	$300,000	0
B8	Measure outflow	$5,000	0

Year 2 BMP #	BMP Name	Budgeted Expenditure (not including staff time)	Staff Hours
B9	Optimize conjunctive use	$1,195,000	0
B10	Automate canal structures	$300,000	0
B11	Customer pump testing	$5,000	0
B12	Mapping	$20,000	0
	Total	**$5,810,000**	**0**

3. Projected budget summary for the 3rd year

Year 3 BMP #	BMP Name	Budgeted Expenditure (not including staff time)	Staff Hours
A1	Measurement	$150,000	0
A2	Conservation staff	$145,000	0
A3	On-farm evaluation/water delivery info irrigation Scheduling Water quality Agricultural Education Program	$150,000	0
A4	Quantity pricing	$5,000	0
A5	Contractor’s pumps	$0	0
B1	Alternative land use	$0	0
B2	Urban recycled water use	$0	0
B3	Financing of on-farm improvements	$2,000,000	0
B4	Incentive pricing	$5,000	0
B5	Line or pipe canals/install reservoirs	$2,000,000	0
B6	Increase delivery flexibility	$50,000	0
B7	District spill/tailwater recovery systems	$300,000	0
B8	Measure outflow	$5,000	0
B9	Optimize conjunctive use	$1,000,000	0
B10	Automate canal structures	$300,000	0
B11	Customer pump testing	$5,000	0
B12	Mapping	$20,000	0
	Total	**$6,135,000**	**0**

4. Projected budget summary for the 4th year

Year 4 BMP #	BMP Name	Budgeted Expenditure (not including staff time)	Staff Hours
A1	Measurement	$150,000	0
A2	Conservation staff	$150,000	0
A3	On-farm evaluation/water delivery info	$150,000	0

Year 4 BMP #	BMP Name	Budgeted Expenditure (not including staff time)	Staff Hours
	irrigation Scheduling Water quality Agricultural Education Program		
A4	Quantity pricing	$5,000	0
A5	Contractor's pumps	$0	0
B1	Alternative land use	$0	0
B2	Urban recycled water use	$0	0
B3	Financing of on-farm improvements	$1,500,000	0
B4	Incentive pricing	$5,000	0
B5	Line or pipe canals/install reservoirs	$2,000,000	0
B6	Increase delivery flexibility	$50,000	0
B7	District spill/tailwater recovery systems	$300,000	0
B8	Measure outflow	$5,000	0
B9	Optimize conjunctive use	$1,100,000	0
B10	Automate canal structures	$300,000	0
B11	Customer pump testing	$5,000	0
B12	Mapping	$20,000	0
	Total	**$5,740,000**	**0**

5. Projected budget summary for the 5th year

Year 5 BMP #	BMP Name	Budgeted Expenditure (not including staff time)	Staff Hours
A1	Measurement	$150,000	0
A2	Conservation staff	$155,000	0
A3	On-farm evaluation/water delivery info irrigation Scheduling Water quality Agricultural Education Program	$150,000	0
A4	Quantity pricing	$5,000	0
A5	Contractor's pumps	$0	0
B1	Alternative land use	$0	0
B2	Urban recycled water use	$0	0
B3	Financing of on-farm improvements	$1,500,000	0
B4	Incentive pricing	$5,000	0
B5	Line or pipe canals/install reservoirs	$2,000,000	0
B6	Increase delivery flexibility	$50,000	0
B7	District spill/tailwater recovery systems	$300,000	0
B8	Measure outflow	$5,000	0

Year 5 BMP #	BMP Name	Budgeted Expenditure (not including staff time)	Staff Hours
B9	Optimize conjunctive use	$1,100,000	0
B10	Automate canal structures	$300,000	0
B11	Customer pump testing	$5,000	0
B12	Mapping	$20,000	0
	Total	**$5,745,000**	**0**

Section IV – Best Management Practices for Urban Contractors

OMITTED – Not Applicable

Section V - District Water Inventory Tables

This Section includes the 2023 water inventory tables for Central California Irrigation District as follows:

- Table 1 Surface Water Supply
- Table 2 Groundwater Pumping
- Table 3 Total Water Supply
- Table 4 Agricultural Distribution System
- Table 5 Crop Water Needs
- Table 6 2023 District Water Inventory
- Table 7 Influence on Groundwater and Saline Sink
- Table 8 Annual Water Quantities Delivered Under Each Right or Contract

Year of Data	2023	Enter data year here

Table 1

Surface Water Supply

2023 Month	Federal Ag Water (acre-feet)	Federal non-Ag Water. (acre-feet)	State Water (acre-feet)	Local Water (define) (acre-feet)	Other Water (Drain Re-Use) (acre-feet)	Transfers into District (acre-feet)	Upslope Drain Water (acre-feet)	Total (acre-feet)
Method								
January	1,381	0	0	0	99	0	0	1,480
February	8,683	0	0	0	2,816	0	0	11,500
March	8,526	0	0	0	1,588	0	0	10,114
April	24,297	0	0	0	1,961	2,453	0	28,711
May	51,756	0	0	0	5,407	1,420	0	58,583
June	79,536	0	0	0	7,329	3,557	0	90,422
July	97,926	0	0	0	8,608	4,690	0	111,224
August	86,860	0	0	0	7,714	1,396	0	95,970
September	47,282	0	0	0	4,574	994	0	52,850
October	19,730	0	0	0	3,389	7,651	0	30,770
November	18,003	0	0	0	2,643	0	0	20,646
December	1,218	0	0	0	644	0	0	1,862
TOTAL	445,198	0	0	0	46,772	22,161	0	514,132

Table 2

Ground Water Supply

2023 Month	District Groundwate (acre-feet)	Private Agric *(acre-feet)
Method		
January	31	0
February	15	0
March	15	0
April	30	0
May	50	0
June	193	0
July	682	0
August	410	0
September	505	0
October	332	0
November	26	0
December	17	0
TOTAL	2,306	28,274

*normally estimated

Table 3

Total Water Supply

2023 Month	Surface Water Total (acre-feet)	District Groundwate (acre-feet)	Recycled M&I (acre-feet)	Total District Water (acre-feet)
Method				
January	1,480	31	0	1,511
February	11,500	15	0	11,515
March	10,114	15	0	10,129
April	28,711	30	0	28,741
May	58,583	50	0	58,632
June	90,422	193	0	90,615
July	111,224	682	0	111,906
August	95,970	410	0	96,380
September	52,850	505	0	53,355
October	30,770	332	0	31,102
November	20,646	26	0	20,673
December	1,862	17	0	1,879
TOTAL	514,132	2,306	0	516,438

*Recycled M&I Wastewater is treated urban wastewater that is used for agriculture.

Precipitation Worksheet					Evaporation Worksheet				
2023	inches precip	ft precip	acres	AF/Year	2023	inches evap	ft evap	acres	AF/YEAR
Jan	5.25	0.44			Jan	1.46	0.12		
Feb	1.28	0.11			Feb	2.08	0.17		
Mar	3.13	0.26			Mar	2.96	0.25		
Apr	0.01	0.00			Apr	5.90	0.49		
May	0.87	0.07			May	6.61	0.55		
Jun	0.00	0.00			Jun	7.87	0.66		
Jul	0.00	0.00			Jul	9.25	0.77		
Aug	0.08	0.01			Aug	7.53	0.63		
Sept	0.00	0.00			Sept	5.53	0.46		
Oct	0.00	0.00			Oct	4.15	0.35		
Nov	0.72	0.06			Nov	2.35	0.20		
Dec	2.33	0.19			Dec	1.34	0.11		
TOTAL	**13.67**	**1.14**	**2,175.0**	**2,477.7**	**TOTAL**	**57.03**	**4.75**	**2,175.0**	**10,336.7**

Table 4

Agricultural Distribution System

2023 Canal, Pipeline, Lateral, Reservoir	Length (feet)	Width (feet)	Surface Area (square feet)	Precipitation (acre-feet)	Evaporation (acre-feet)	Spillage (acre-feet)	Seepage (acre-feet)	Total (acre-feet)
All Canals	1,353,475	70	94,743,250	2,477.7	10,336.7	0	60,000	(67,859)
TOTAL				2,477.7	10,336.7	0.0	60,000.0	(67,859.0)

Table 5

Crop Water Needs

2023 Crop Name	Area (crop acres)	Crop ET (AF/Ac)	Leaching Requirement (AF/Ac)	Cultural Practices (AF/Ac)	Effective Precipitation (AF/Ac)	Appl. Crop Water Use (acre-feet)
Alfalfa	17,994	3.64	0.1	0.1	0.0	69,097
Almonds	32,349	3.74	0.1	0.1	0.0	127,595
Corn	24,240	2.75	0.1	0.1	0.0	71,508
Cotton	14,039	2.73	0.1	0.1	0.0	41,134
Oats	8,291	0.26	0.1	0.1	0.0	3,814
Tomatoes	7,585	2.33	0.1	0.1	0.0	19,190
Wheat	10,194	0.26	0.1	0.1	0.0	4,689
Other (<5%)	25,516	2.11	0.1	0.1	0.0	58,942
Crop Acres	140,208					395,969

Total Irrig. Acres 140,208 (If this number is larger than your known total, it may be due to double cropping)

Table 6

2023 District Water Inventory

Type of Water	Location of Information		
Water Supply	Table 3		516,438
Riparian ET	(Distribution and Drain)	minus	0
Groundwater recharge	(intentional - ponds, injection)	minus	1,811
Seepage	Table 4	minus	60,000
Evaporation - Precipitation	Table 4	minus	7,859
Spillage	Table 4	minus	2,657
Transfers out of District		minus	54,676
Water Available for sale to customers			389,434
Actual Agricultural Water Sales 2023	From District Sales Records		359,004
Private Groundwater	Table 2	plus	28,274
Crop Water Needs	Table 5	minus	395,969
Drainwater outflow	(tail and tile, not recycled)	minus	0
Percolation from Agricultural Land	(calculated)		(8,691)
Unaccounted for Water	(calculated)		30,430

Table 7

Influence on Groundwater and Saline Sink

2023	
Agric Land Deep Perc + Seepage + Recharge - Groundwater Pumping = District Influence on	59,505
Estimated actual change in ground water storage, including natural recharge)	0
Irrigated Acres (from Table 5)	140,208
Irrigated acres over a perched water table	0
Irrigated acres draining to a saline sink	0
Portion of percolation from agri seeping to a perched water table	0
Portion of percolation from agri seeping to a saline sink	0
Portion of On-Farm Drain water flowing to a perched water table/saline sink	0
Portion of Dist. Sys. seep/leaks/spills to perched water table/saline sink	0
Total (AF) flowing to a perched water table and saline sink	0

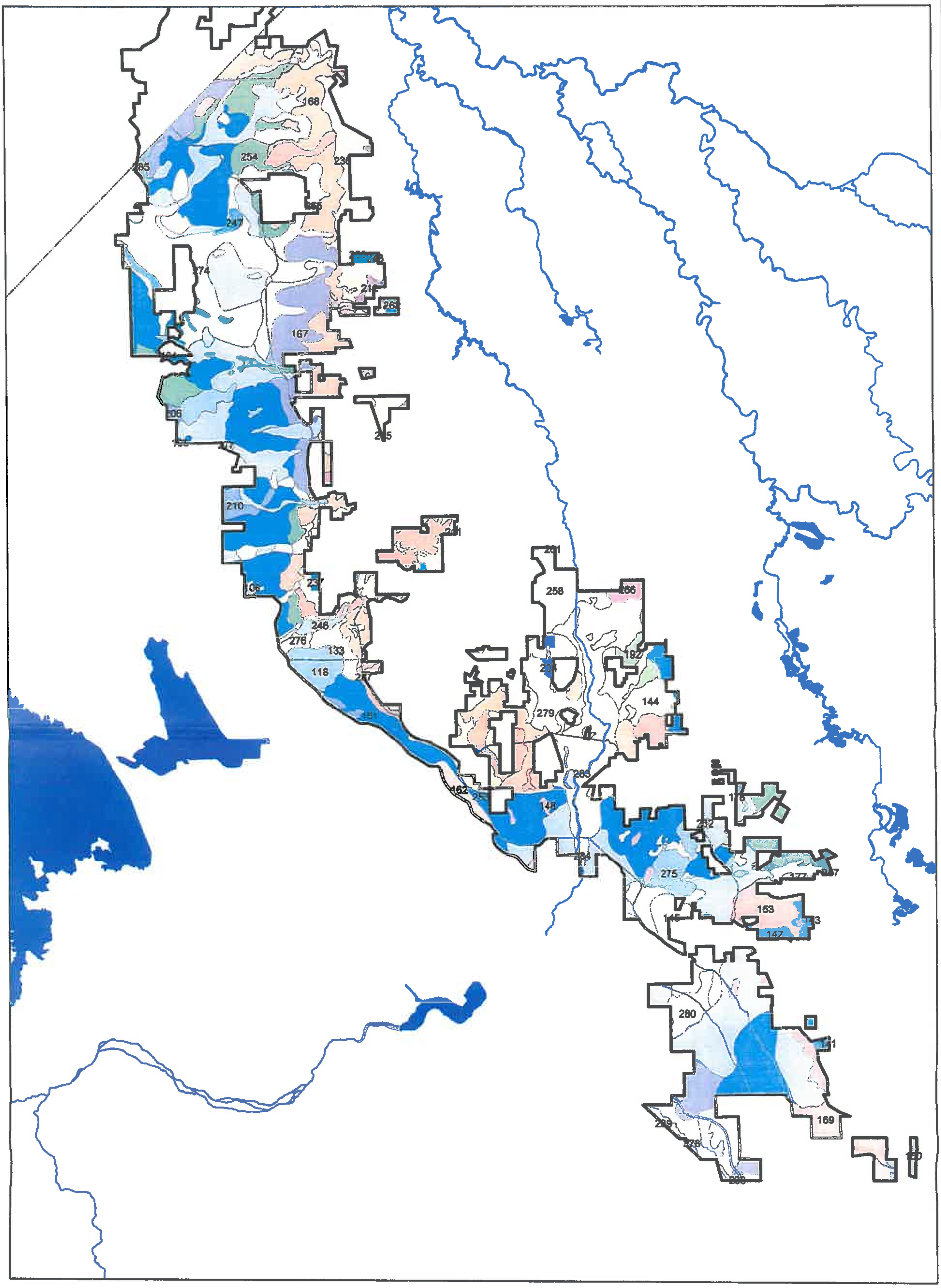
Table 8

Annual Water Quantities Delivered Under Each Right or Contract

Year	Federal Ag Water (acre-feet)	Federal non-Ag Water. (acre-feet)	State Water (acre-feet)	Local Water (define) (acre-feet)	Other Water (Drain Re-Use) (acre-feet)	Transfers into District (acre-feet)	Upslope Drain Water (acre-feet)	Total (acre-feet)
2014	347,981	0	0	0	20,759	2,836	0	371,576
2015	277,520	0	0	0	16,604	3,749	0	297,873
2016	440,799	0	0	0	43,327	10,668	0	494,794
2017	495,966	0	0	0	52,630	16,232	0	564,828
2018	507,639	0	0	0	58,125	46,061	0	611,825
2019	480,153	0	0	0	54,538	26,539	0	561,230
2020	489,330	0	0	0	54,219	30,428	0	573,977
2021	374,869	0	0	0	51,497	5,176	0	431,542
2022	418,808	0	0	0	45,369	20,623	0	484,800
2023	445,198	0	0	0	46,772	22,161	0	514,132
Total	4,278,263	0	0	0	443,840	184,473	0	4,906,577
Average	427,826	0	0	0	44,384	18,447	0	490,658

Newman
Gustine
Los Banos
Dos Palos
Firebaugh
Stanislaus
Merced
Madera
Fresno
MAIN CANAL
OUTSIDE CANAL
Legend
Turnouts
Inflows
CCID Canals
Rivers, Creeks, Other Canals, and Aqueducts
Cities
Counties
Roads
Display, Road_Class
Interstate
State Highway
Local Road
The Central California Irrigation District
DISTRICT TURNOUTS & INFLOWS
1335 West I Street • P.O. Box 1231
Los Banos, CA 93635
(209) 826-1421
Revised Date: 07/2017


Newman
Gustine
Los Banos
Dos Palos
Firebaugh
MAIN CANAL
OUTSIDE CANAL
Miles
Legend
District Boundary
Cities
Counties
CCID Canals
Rivers, Creeks, Other Canals, and Aqueducts
Lift Pump
Deep Wells
The Central California Irrigation District
CCID Deep Wells and Low Lift Pumps
1335 West I Street • P.O. Box 1231
Los Banos, CA 93635
(209) 826-1421



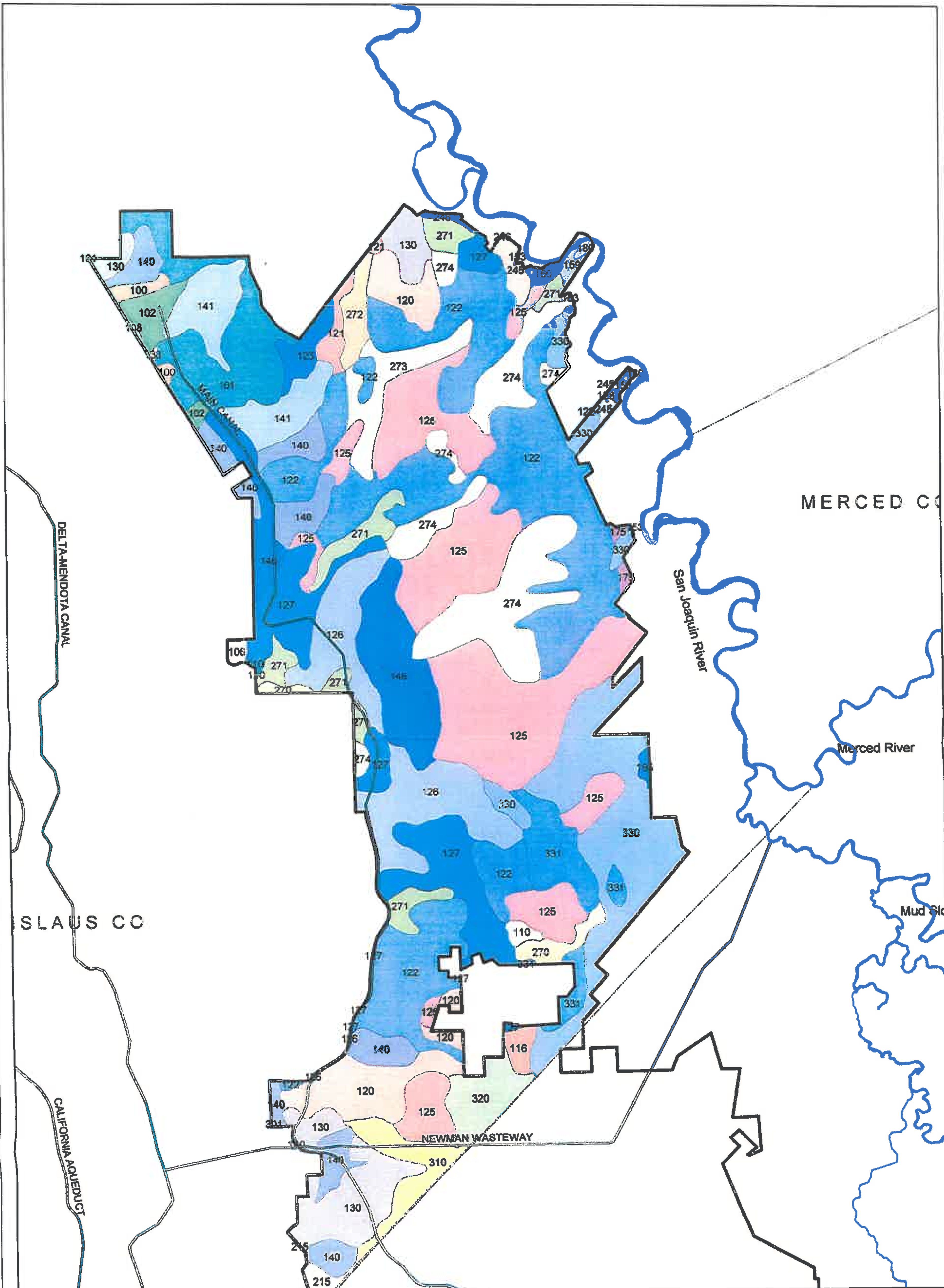
Central California ID Soil Survey for Merced County

* see table for map unit explanation

2/24/04

Central California Irrigation District - Soil Map unit Explanations - Merced County Portion		
Map Unit Symbol	Sum_Acres	Soil type
103	685.99	ALROS CLAY LOAM, PARTIALLY DRAINED
106	81.16	ANELA GRAVELLY LOAM, 0 TO 2 PERCENT SLOPES
116	537.70	ARBUCKLE VARIANT SANDY LOAM
133	33.82	BAPOS SANDY CLAY LOAM, 0 TO 2 PERCENT SLOPES
137	260.55	BISGANI LOAMY SAND, PARTIALLY DRAINED
139	4100.15	BOLFAR CLAY LOAM, PARTIALLY DRAINED
141	21.82	BRITTO CLAY LOAM
142	466.10	BRITTO CLAY LOAM, LEVELED
143	5.04	BRITTO CLAY LOAM, PONDED
144	515.11	CAPAY CLAY LOAM
145	817.33	CAPAY CLAY
148	169.92	CARRANZA-WOO COMPLEX, 0 TO 2 PERCENT SLOPES
150	480.67	CHATEAU CLAY, PARTIALLY DRAINED
151	19.69	CHATEAU CLAY, PONDED
152	13.32	CHECKER LOAM
153	2148.00	CHINVAR LOAM
161	991.61	DAMLUIS CLAY LOAM, 0 TO 2 PERCENT SLOPES
162	242.15	DAMLUIS CLAY LOAM, 2 TO 8 PERCENT SLOPES
164	0.13	DAMLUIS GRAVELLY CLAY LOAM, 2 TO 8 PERCENT SLOPES
165	1.26	DAMLUIS GRAVELLY CLAY LOAM, 8 TO 15 PERCENT SLOPES
167	3038.52	DELDOTA CLAY, PARTIALLY DRAINED
168	4889.48	DOSAMIGOS CLAY LOAM, PARTIALLY DRAINED
169	1724.96	DOSAMIGOS CLAY, PARTIALLY DRAINED
170	2407.12	DOSPALOS CLAY LOAM, PARTIALLY DRAINED
171	5085.30	DOSPALOS CLAY, PARTIALLY DRAINED
172	5.97	DOSPALOS CLAY, HUMMOCKY
174	47.39	DOSPALOS-URBAN LAND COMPLEX, PARTIALLY DRAINED
177	32.76	EDMINSTER VARIANT SAND
178	855.27	ELNIDO SANDY LOAM, PARTIALLY DRAINED
180	1624.23	ELNIDO CLAY LOAM, PARTIALLY DRAINED
181	440.64	ESCANO CLAY LOAM, PARTIALLY DRAINED
186	17.71	FLUVAQUENTS, CHANNELED
192	336.14	HENMEL CLAY LOAM, PARTIALLY DRAINED
206	172.09	LOS BANOS CLAY LOAM, 0 TO 2 PERCENT SLOPES
210	280.64	LOS BANOS VARIANT GRAVELLY SANDY CLAY LOAM
211	10.90	MARCUSE SILTY CLAY
212	106.27	MARCUSE CLAY, LEVELED
228	2731.12	PALAZZO SANDY LOAM, PARTIALLY DRAINED

Central California Irrigation District - Soil Map unit Explanations - Merced County Portion		
Map Unit Symbol	**Sum_Acres**	**Soil type**
234	230.43	PEDCAT LOAM, 0 TO 2 PERCENT SLOPES
236	4892.73	PEDCAT CLAY LOAM, LEVELED, 0 TO 2 PERCENT SLOPES
237	46.46	PEDCAT CLAY, 0 TO 2 PERCENT SLOPES, SEVERELY ERODED
238	1.21	PITS
239	58.32	PLEITO GRAVELLY CLAY LOAM, 8 TO 15 PERCENT SLOPES
246	259.78	SAN EMIGDIO FINE SANDY LOAM
247	306.72	SAN EMIGDIO LOAM
248	16.38	SANTANELA LOAM
253	8763.43	STANISLAUS CLAY LOAM
254	2379.48	STANISLAUS CLAY LOAM, WET
255	25.19	STANISLAUS-DOSAMIGOS-URBAN LAND COMPLEX
256	8.65	TRIANGLE CLAY
257	6.34	TRIANGLE CLAY, ALKALI
258	956.39	TRULAE SILTY CLAY, PARTIALLY DRAINED
261	7.44	TURLOCK LOAM, LEVELED
262	27.18	TURMOUND SANDY LOAM
265	11.63	VOLTA CLAY LOAM
266	280.39	VOLTA CLAY LOAM, PARTIALLY DRAINED
267	2053.78	WEKODA CLAY, PARTIALLY DRAINED
274	8151.46	WOO LOAM, 0 TO 2 PERCENT SLOPES
275	1155.54	WOO LOAM, GRAVELLY SUBSTRATUM, 0 TO 2 PERCENT SLOPES
276	414.45	WOO SANDY CLAY LOAM, 0 TO 2 PERCENT SLOPES
277	9483.75	WOO CLAY LOAM, 0 TO 2 PERCENT SLOPES
278	182.88	WOO CLAY LOAM 2 TO 5 PERCENT SLOPES
279	3297.91	WOO CLAY LOAM, WET, 0 TO 2 PERCENT SLOPES
280	1959.53	WOO CLAY, 0 TO 2 PERCENT SLOPES
282	101.53	WOO-URBAN LAND COMPLEX, 0 TO 2 PERCENT SLOPES
283	179.23	XEROFLUVENTS, CHANNELED
284	53.08	XEROFLUVENTS, EXTREMELY GRAVELLY
285	106.66	YOKUT SANDY LOAM
287	558.07	WATER



* see table for map unit explanation

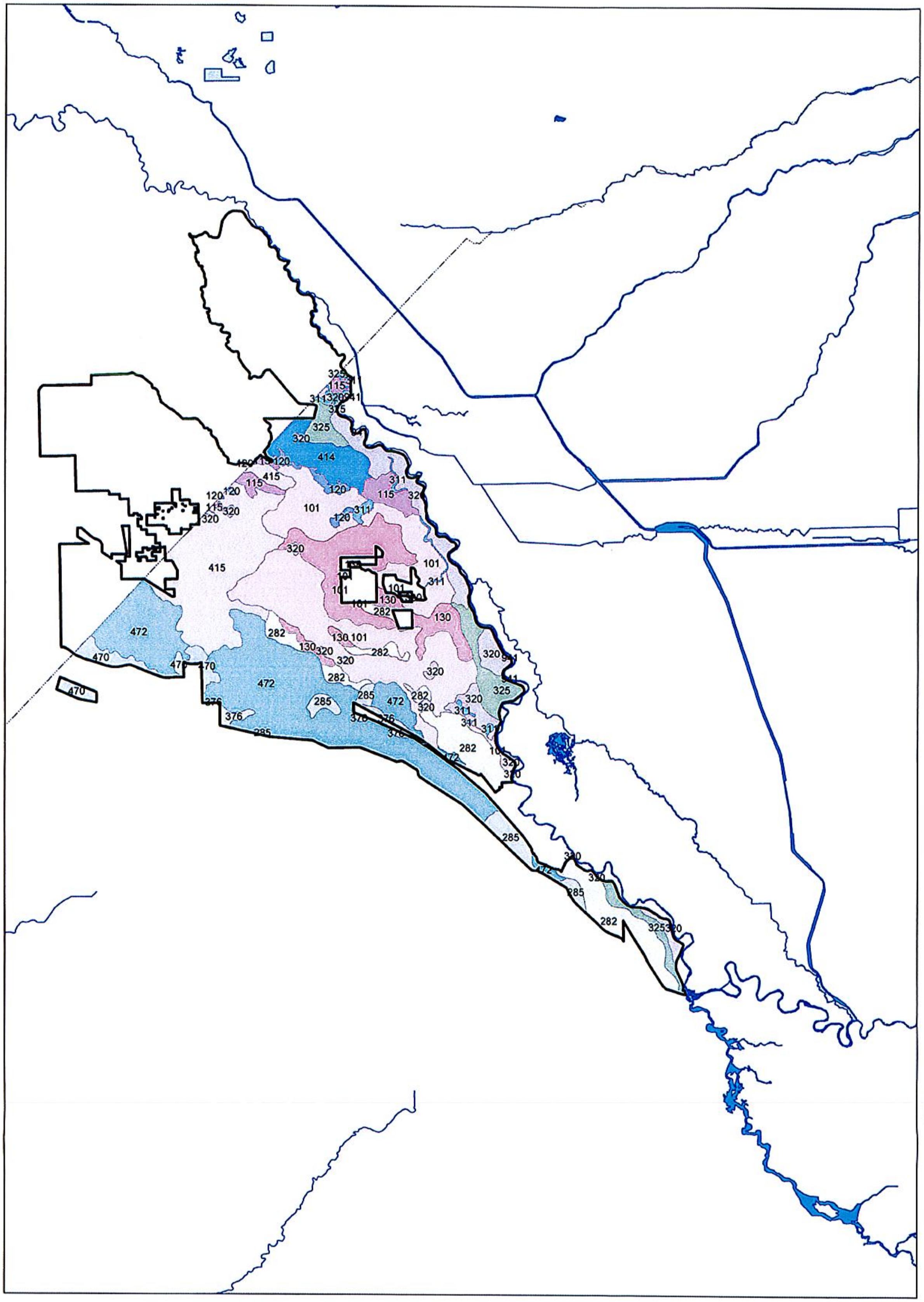
Central California ID Soil Survey for Stanislaus County

2/24/04

0 0.5 1 2 3 4 Miles

Central California Irrigation District -Soil Map Explanation - Stanislaus Co portion		
Map Unit Symbol	Sum_Acres	Min_MUNAME
100	72.65	CAPAY CLAY, 0 TO 2 PERCENT SLOPES
101	828.11	CAPAY CLAY, WET, 0 TO 2 PERCENT SLOPES
102	177.97	CAPAY CLAY, LOAMY SUBSTRATUM, 0 TO 2 PERCENT SLOPES
106	40.45	CAPAY CLAY, 0 TO 2 PERCENT SLOPES, RARELY FLOODED
110	43.97	EL SOLYO SILTY CLAY LOAM, 0 TO 2 PERCENT SLOPES
116	74.88	EL SOLYO SILTY CLAY LOAM, 0 TO 2 PERCENT SLOPES, RARELY FLOODED
120	757.46	VERNALIS-ZACHARIAS COMPLEX, 0 TO 2 PERCENT SLOPES
121	105.55	VERNALIS LOAM, WET, 0 TO 2 PERCENT SLOPES
122	3649.10	VERNALIS LOAM, 0 TO 2 PERCENT SLOPES
123	142.93	VERNALIS CLAY LOAM, WET, 0 TO 2 PERCENT SLOPES
125	3142.86	VERNALIS CLAY LOAM, 0 TO 2 PERCENT SLOPES
126	1146.64	VERNALIS-ZACHARIAS COMPLEX, 0 TO 2 PERCENT SLOPES, RARELY FLOODED
127	1183.11	VERNALIS LOAM, 0 TO 2 PERCENT SLOPES, RARELY FLOODED
128	3.93	WATER
130	859.24	STOMAR CLAY LOAM, 0 TO 2 PERCENT SLOPES
140	890.49	ZACHARIAS CLAY LOAM, 0 TO 2 PERCENT SLOPES
141	601.69	ZACHARIAS CLAY LOAM, WET, 0 TO 2 PERCENT SLOPES
146	930.35	ZACHARIAS CLAY LOAM, 0 TO 2 PERCENT SLOPES, RARELY FLOODED
153	30.10	COLUMBIA FINE SANDY LOAM, CHANNELED, PARTIALLY DRAINED, 0 TO 2 PERCENT SLOPES, FREQUENTLY FLOODED
159	37.37	COLUMBIA COMPLEX, 0 TO 2 PERCENT SLOPES, FREQUENTLY FLOODED
160	38.34	MERRITT SILTY CLAY LOAM, PARTIALLY DRAINED, 0 TO 2 PERCENT SLOPES, OCCASIONALLY FLOODED
175	34.71	DOSPALOS-BOLFAR COMPLEX, 0 TO 2 PERCENT SLOPES, RARELY FLOODED
180	17.35	DELLO FINE SANDY LOAM, CHANNELED, 0 TO 2 PERCENT SLOPES, FREQUENTLY FLOODED
195	23.66	CLEAR LAKE CLAY, 0 TO 2 PERCENT SLOPES, RARELY FLOODED
215	68.62	YOKUT SANDY LOAM, 0 TO 2 PERCENT SLOPES
245	111.59	BOLFAR-COLUMBIA COMPLEX, 0 TO 2 PERCENT SLOPES, RARELY FLOODED
246	27.74	BOLFAR-COLUMBIA COMPLEX, 0 TO 2 PERCENT SLOPES, OCCASIONALLY FLOODED
270	147.58	ELSALADO FINE SANDY LOAM, 0 TO 2 PERCENT SLOPES, RARELY FLOODED
271	518.90	ELSALADO LOAM, 0 TO 2 PERCENT SLOPES, RARELY FLOODED
272	150.93	ELSALADO LOAM, WET, 0 TO 2 PERCENT SLOPES
273	332.83	ELSALADO FINE SANDY LOAM, 0 TO 2 PERCENT SLOPES
274	1369.38	ELSALADO LOAM, 0 TO 2 PERCENT SLOPES
301	2.47	DAMLUIS CLAY LOAM, 2 TO 8 PERCENT SLOPES
310	313.69	DELDOTA CLAY, 0 TO 2 PERCENT SLOPES
320	300.58	DOSAMIGOS CLAY LOAM, 0 TO 2 PERCENT SLOPES
330	1586.53	PEDCAT CLAY LOAM, 0 TO 2 PERCENT SLOPES, RARELY FLOODED
331	473.45	PEDCAT CLAY LOAM, 0 TO 2 PERCENT SLOPES

ATTACHMENT B-3



* see table for map unit explanation

Central California ID Soil Survey for Fresno County

0 1 2 4 6 8 Miles

2/24/04

Central California Irrigation District - Soil Map Unit explanation - Fresno County portion		
MUSYM	Sum_Acres	Soil Type
101	11131.08	ARMONA LOAM, PARTIALLY DRAINED, 0 TO 1 PERCENT SLOPES
115	1182.45	BOLFAR LOAM, DRAINED, 0 TO 1 PERCENT SLOPES
120	433.58	ALTASLOUGH CLAY LOAM, 0 TO 1 PERCENT SLOPES
130	4258.54	GEPFORD CLAY, 0 TO 1 PERCENT SLOPES
282	4483.34	TACHI CLAY, 0 TO 1 PERCENT SLOPES
285	1221.19	TRANQUILLITY-TRANQUILLITY, WET, COMPLEX, SALINE-SODIC, 0 TO 1 PERCENT SLOPES
311	489.61	BISGANI SANDY LOAM, DRAINED, 0 TO 1 PERCENT SLOPES
320	3434.40	ELNIDO SANDY LOAM, DRAINED, 0 TO 1 PERCENT SLOPES
325	2242.95	PALAZZO SANDY LOAM, DRAINED, 0 TO 1 PERCENT SLOPES
376	437.47	AGNAL SILTY CLAY, 0 TO 1 PERCENT SLOPES
414	1739.92	DOSPALOS CLAY LOAM, DRAINED, 0 TO 1 PERCENT SLOPES
415	6127.50	DOSPALOS CLAY, DRAINED, 0 TO 1 PERCENT SLOPES
470	1170.56	CHATEAU CLAY, PARTIALLY DRAINED, 0 TO 1 PERCENT SLOPES
472	11825.46	WEKODA CLAY, PARTIALLY DRAINED, 0 TO 1 PERCENT SLOPES
941	26.37	BISGANI-ELNIDO ASSOCIATION, 0 TO 1 PERCENT SLOPES

RULES AND REGULATIONS

CENTRAL CALIFORNIA IRRIGATION DISTRICT

Los Banos, California
RULES AND REGULATIONS
of
CENTRAL CALIFORNIA IRRIGATION DISTRICT

Governing the Distribution
and Use of Water

ADOPTED JUNE 27, 1956
REVISED MARCH 12, 1969
REVISED JANUARY 10, 1990

The Central California Irrigation District, hereafter called District, is a State agency governed by a Board of Directors elected by the people. It operates under the Water Code of the State of California. It makes no profit and is operated for the sole benefit of the lands and people within its boundaries. The benefits the people can derive from the District will be measured by the extent to which they cooperate to make it a success.

These rules and regulations are adopted pursuant to Section 22257 of the Water Code to effect orderly, efficient and equitable distribution and use of the water supplies by the District.

RULE 1
Management

The operations and maintenance of the irrigation system of the District shall be under the exclusive control of the Manager, acting under policies set by the Board of Directors.

The Manager shall employ such personnel as may be required and authorized by the Board of Directors for the operation, maintenance and improvement of the system.

RULE 2
Control of Works

All diversion works, canals, ditches, headgates, and other structures belonging to the District will be operated and maintained by the District and their control and operation will be under the exclusive control of the authorized agents of the District. Upon application, the District shall construct, or cause to be constructed water service outlets for the purpose of delivering water from a District conduit. The service outlet shall be constructed in such a manner as to conform to standards established by the District, and once constructed, shall become the sole property of the District. All costs for materials and/or labor, including that of an adequate measuring device, shall be paid for by the user or applicant. Maintenance and replacement of such works shall be at the expense of the District, except when such facilities are used to serve lands located outside the District. In such a case, the user or landowner shall be responsible for the needed maintenance and/or replacement, the need of which shall be solely determined by the District. The location and number of gates for the distribution of water from the District's canals and the manner of delivery therefrom, so as to secure safe and efficient operation thereof, shall be determined by the Manager, subject to the approval of the Board of Directors.

RULE 3
Tampering and Damage to District Facilities

Manipulation of District weirs, headgates and other structures is forbidden, unless permission is given by the Section Foreman or other authorized employee of the District. Cutting canal or ditch banks and/or placing dams or other obstructions in District-owned canals or ditched is prohibited.

Removal of dirt from, or other use, of the District-owned property such as, but not limited to, the utilization of the canal bank on which to turn farm equipment, the placing of toe ditches, drainage ditches, fences, tress or other crops, pumping plants, structures or other obstructions upon the District's rights-of-way are also prohibited, unless done with specific permission of the District.

Consumers shall not permit their livestock to feed or trespass up the rights-of-way of District-owned canals, drains or ditches except with specific permission of the District. In cases where it is necessary to cross the right-or-way or to move livestock from one point to another along District rights-or-way, permission to use the rights-of-way for that purpose must be obtained from the Manager in advance. Any damage done to canal or ditch banks in using them for a roadway, whether moving livestock, farm equipment, or other vehicles, shall be the responsibility of those making such use of the property. If it is found necessary for the District to repair such damage, those responsible therefore shall pay all costs of such repairs.

RULE 4
Operation and Maintenance of Private Ditches or Laterals

The term "ditch" as used in this Rule, includes all gates, structures or other diversion works within a private ditch or lateral.

The operation and maintenance of privately owned ditches or laterals shall be the sole responsibility of the individual or individuals who use the private ditch or lateral. "Use" of such ditch or lateral means irrigating from it, draining into it, or allowing the grazing or watering of stock therein, or taking or permitting any action of any nature which is in any way responsible for any impairment of flow of water therein. Such user is liable for his share of the cost of maintenance of the ditch or lateral affected by his conduct.

Privately owned ditches or laterals must be kept in reasonable repair and reasonably free from weeds and other obstructions and be of sufficient capacity at all times to carry an adequate amount of water to irrigate the lands under them.

In the event that water is ordered in excess of the capacity of a privately owned ditch, only amounts up to the capacity of the ditch will be delivered. If the ditch is in such unclean or otherwise unsuitable condition that a usable amount of water cannot be delivered safely, or waste would result, delivery will be refused until such conditions are remedied.

Landowners shall construct and maintain adequate drainage facilities so that adjacent or lower lying lands will not be damaged, and no irrigator shall be delivered a greater amount of water that he can economically and beneficially use without waste, and with due regard to the needs of other irrigators.

The District will not be responsible for any loss or damage resulting from open ditch or drainage cuts, or improperly closed ditch or drainage cuts made by the consumer in any privately owned ditch or lateral, or for the improper functioning of any gate, structure or other diversion works therein.

Agreements may be entered into by the District and the landowners owning a particular ditch or section thereof, for the construction, reconstruction, and/or maintenance thereof under appropriate sections of the Water Code.

The legal provisions of the Water Code governing maintenance of privately owned ditches, and the District's powers with respect thereto, are set forth in Appendix A of these Rules and Regulations.

RULE 5
Liability for Damage

The District will not be liable for any damage caused by the negligence or carelessness of any consumer in the use of water or for failure on his part to maintain any ditch or structure therein for which he is responsible – either wholly or in part.

RULE 6
Trespass on District Property

Any consumer or any other individual entering upon District property does so at his own risk.

RULE 7
Irrigation of Excessively High Ground

The District will not raise water to an excessive height in canals or ditches in order to give service to lands or ditches of unreasonable elevation, as determined by the District.

Upon request made to the Manger, the District will set a reference point or grade which will be maximum elevation of land which can be served by that particular District canal.

RULE 8
Application For Water

At the beginning of each irrigation season the Manager shall obtain from each water user a written application for water on forms to be furnished by the District, specifying the number of acres to be irrigated, the kind of crops, and the number of acres to be devoted to each crop, as nearly as can be determined, and such other information as the Manager may require to enable him to plan properly for distribution of water. The landowner, if different from the water user, must also sign the water application, acknowledging his responsibility for payment of any unpaid charges incurred on his property.

RULE 9
Irrigation Season

The District's annual irrigation season shall commence with the filling of the canal system starting on January 16th of each year and terminate on November 15th of each year. However, the District reserves the right, at its sole discretion, to deviate from these dates, both as to the canal system as a whole, or any portion thereof, based upon irrigation water requirements, climatic conditions, construction and maintenance requirements, or for any other reason.

During the period November 16th to January 15th of the following year, such other non irrigation period as may be determined by the District, irrigation service may be given, at the sole discretion of the District, by the use of available gravity entitlement water supply, or by the usage of District of privately owned wells, where physically and economically feasible, and where such service does not in any manner interfere with maintenance, construction or other activities of the District necessary to properly operate district canals and facilities.

The charges to the water user or users of such service shall include all costs of any necessary, individual user, physical facilities required, and a flat charge per acre foot for all well costs as may be determined and established by the Board of Directors. If gravity entitlement water only is furnished, the District's regular charge per acre foot shall be used.

RULE 10

Charges for Water, Materials and Services

Charges for water, materials and services including the transportation of non-District water, will be fixed, and the date or dates of payment of the same shall be determined by the Board of Directors. Such charges are in addition to any assessments that may be levied by the Board of Directors under the provisions of the Water Code.

RULE 11

Unpaid Charges and Refusal of Service

All invoices for water, work orders, materials, and permanent maintenance agreements are due and payable within 30 days of the date of the invoice. All past due bills shall be subject to a penalty of one percent (1%) per month, compounded monthly.

Any charges that are not paid in full prior to March 1 of the following year will be declared delinquent, and the consumer who is responsible for those charges will be required to pay all new bills for the succeeding year within 30 days, or face termination of service.

Because of the face that landowners are ultimately responsible to the District for all unpaid bills incurred by themselves or tenants, the Manager shall notify all landowners of all outstanding bills against their particular property as soon as practical after December 31st of each year. However, failure to so notify the landowner will not eliminate the ultimate legal responsibility of the landowner for such payment.

The District reserves the right to refuse or discontinue service to any consumer who is in default in the payment of any District assessment or charge of any nature, and also to any land on which any such payment is delinquent, in accordance with Sections 22256 and 22282.1 of the Water Code of the State of California. In addition, the amount of any delinquent charges may be recorded as a lien against the consumer's property, in accordance with Section 25806 of the Water Code.

All claims for overcharges or errors must be made in writing and filed with the District within thirty days from the date the bill is received.

RULE 12

Delivery of Water

During the irrigation season, the hours of 6:00 a.m. to 9:00 p.m. shall be considered normal business hours for the Section Foreman. Telephone calls during that time may be answered by a telephone recorder. Routine calls will be promptly acknowledged, and emergencies will be responded to as quickly as possible.

Water should be ordered 48 hours in advance, and the District will attempt to deliver water to the District's headgate as timely as possible. In order to provide timely service and to minimize waster of water the Section Foreman must be given a one-day shut-off notice. Repeated failure to comply with this shut-off provision may result in the consumer being billed for an additional 24 hours of water use.

Water will be delivered in sequence as ordered within lateral areas as equitably as possible. Any consumer not able to use water at the time requested on any run may receive water upon the completion of the delivery in his lateral, provided no undue loss of water is involved and there is no interference with deliveries to other irrigators. Heads applied for may be altered by the District when necessary. Unless specifically authorized by the Watermaster, consumers will be required to use water continuously day and night until irrigation is completed and without waste at any time.

RULE 13
Basis of Allocation and Shortage of Water

Each consumer shall be entitled to his proportionate share of the quantity of water available in accordance with the provisions of the Water Code of the State of California. Requests for delivery of water should be made at least seven days prior to the date water is wanted. However, water will be delivered on requests made less than seven days before the date water is wanted provided water is available and deliveries can be made without interference with other users and without undue waste of water or undue manipulations of weirs and gates. In the event that during any irrigation season there is an anticipated shortage of water, or an actual shortage of water occurs, the District will pro-rate the available supply among all consumers. In pro-rating the water the District may reduce the length of time of each run of water, and/or the amount of water delivered during each run of water, or the amount of water delivered during the period of shortage. Due notice will be given all consumers of such change of service.

The District reserves the right to suspend service during any period of time when it is necessary to take water out of the canals for cleaning or other maintenance, repair or reconstruction work.

RULE 14
Point of Delivery

All measurements and deliveries of water shall be made at the point where the consumer's lateral or ditch connects with the canal or ditch owned by the District, at which point the District shall install and operate a controlled outlet box or headgate as provided for in Rule 2. The time of delivery will start when the headgates to such laterals or ditches are opened and expire when said headgates are closed. Exceptions to this rule may be made by the District to fit operating conditions in unusual circumstances.

RULE 15
Unauthorized Taking of Water

Persons interfering with the regulation of water in the canals or ditches of the District are liable to criminal prosecution. If any person takes water without permission of the Watermaster or Section Foreman, he shall not only be subject to criminal prosecution, but may also forfeit his right to water.

RULE 16
Transportation of Well and/or Government Water

The Board of Directors reserves the right to adopt such policies and/or rules and regulations on the transportation of well and/or Government owned waters through District owned canals and ditches as may be to the best interest of the District and its consumers.

RULE 17
Ownership of Water

All water in District owned canals, drains or ditches, regardless of source, except water being transported therein by permission of the District, is District water and is subject to diversion and use by the District.

RULE 18
Limitation on Drainage

No drainage waters shall be introduced into District-owned canals, drains or ditches, either directly or indirectly, without the specific written permission of the District.

RULE 19
Access to Land

The authorized agents or employees of the District shall have free access at all times to all lands irrigated from the District system for the purpose of examining any ditches, laterals or drains serving such lands and/or the flow of water therein, for the purpose of ascertaining the acreage of crops on lands irrigated or to be irrigated, or for any other District purpose.

RULE 20
Nuisances

No material or substance of any nature, and particularly those that are or may become offensive to the senses or injurious to health or which do or may injuriously affect the quality of water, obstruct the flow of water, or result in the scattering of seeds or noxious weeds, plants or grasses, shall be placed or left so as to roll, slide, flow, or be washed or blown into any ditch or onto any right-of-way. Any violation of this rule will subject the offender to criminal prosecution. All employees of the District shall promptly report any violation of this rule, and the consumers of the District are especially urged to cooperate in its enforcement.

RULE 21
Complaints of Consumers

Complaints of any kind against the District or any of its personnel should be made in writing to the Manager promptly after the acts complained of have occurred. Consumers shall have the right to refer any complaints in writing or in person to the Board of Directors of the District, which meets at 9:30 a.m. on the second and fourth Wednesdays of each month, at the office of the District, 1335 West “I” Street, Los Banos, California.

RULE 22
Stock Water

The District shall not be required to furnish water for the exclusive purpose of watering stock.

RULE 23
Pumping and Pipelines

All consumers pumping water from the canals or conveying water by means of pipelines or closed conduits shall be governed in all respects by the rules and regulations applicable to consumers under gravity ditch service. Pumping by users of District transported or Government water is done at the user's risk, and the District, its officers and employees, assume no liability for damage to pumping equipment or to pipelines, or other damages as a result of turbulent water, shortage of excess of water, or other causes.

RULE 24
Rights Not Limited

These rules and regulations are not intended to limit any right of either landowners, consumers or the District which may be legally theirs, but which is not herein stated.

RULE 25
Penalty for Non – Compliance

Refusal to comply with the requirement hereof, or transgression of any of the foregoing rules and regulations, or any interference with the discharge of the duties of any employee of the District, shall be sufficient cause for shutting off the water, and water will not again be furnished until full compliance has been made with all requirements hereof.

RULE 26
Changes in Rules and Regulations

The Board of Directors reserves the right to change these Rules and Regulations by majority action of the Board at any regular or special meeting, by adopting an appropriate resolution and spreading such resolution in the minutes of the District, a public record. Publications and disseminations of such changes by the printing of revised Rules and Regulations will be limited to economically feasible intervals as determined by the Board.

There shall be maintained at the office of the District, however, a master copy of these Rules and Regulations, including all changes made by the Board of Directors, which copy will be open to inspection at any time during office hours of the District.

APPENDIX A – SELECTED CODE SECTIONS

Penal Code of the State of California

SECTION 592. Every person who shall, without authority of the owner or managing agent, and with intent to defraud, take water from any canal, ditch, flume or reservoir used for the purpose of holding or conveying water for manufacturing, agriculture, mining, irrigation or generation of power, or domestic use, or who shall without like authority, raise, lower, or otherwise disturb any gate or other apparatus thereof, used for the control or measurement of water, or who shall empty or place, or cause to be emptied or placed, into any such canal, ditch, flume or reservoir, any rubbish, filth, or obstruction to the free flow of the water, is guilty of a misdemeanor.

Water Code of the State of California

SECTION 7000. As used in this chapter "conduit" includes ditch, pipeline, and flume.

SECTION 7001. When two or more persons are associated by agreement in the use of a conduit, well or pumping plant, for the conveyance, obtaining or disposing of water, or are using such conduit, well or pumping plant, or any part thereof, for any lawful purpose, to the construction of which they or their grantors have contributed, each is liable, in the absence of any agreement to the contrary, to the others for the reasonable expenses of maintaining and repairing the same proportionately to the use actually made of such conduit, well or pumping plant, whether used in connection with irrigation or drainage.

SECTION 7002. If any person neglects, after demand in writing, to pay his proportion of the expenses under the next preceding section, he is liable therefor in an action for contribution, and in any judgment obtained against him interest from the time of demand shall be included.

SECTION 7003. The action authorized by this article may be brought by any or all of the parties who have contributed more than his or their just proportion of the expenses, and the plaintiff may recover, as costs, reasonable counsel fees to be fixed by the court.

SECTION 22256. A district may refuse to furnish water to any land to which it holds title by virtue of collector's deeds to the district or to any or all land on which the district has an outstanding unredeemed certificate of sale for the nonpayment of a district assessment.

SECTION 22257. Each district shall establish equitable rules for the distribution and use of water, which shall be printed in convenient form for the distribution in the district. A district may refuse to deliver water through a ditch which is not clean or not in suitable condition to prevent waste of water and may determine through which of two or more available ditches it will deliver water.

A district may close a defective gate in a community water distribution system used for irrigation purposes and may refuse to deliver water through the defective gate if the landowner fails to repair the gate or outlet to the satisfaction of the district within a reasonable time after receipt of notice from the board though its authorized water superintendent, manager, or ditch tender to repair the gate or outlet…

SECTION 22282.1 A district may refuse service to any land if outstanding charges for services already rendered such land have not been paid within a reasonable time.

SECTION 22283. A district may prescribe reasonable rules to carry out the provisions of this article.

SECTION 25806. (a) In case any charges for water and other services or either remain unpaid the amount of the unpaid charges may, in the discretion of the district:

(1) …

(2) Be secured at any time by filing for record in the office of the county recorder of any county, a certificate specifying the amount of such charges and the name and address of the person liable therefore.

From the time of recordation of the certificate, the amount required to be paid together with interest and penalty constitutes a lien upon all real property in the county owned by the person or afterwards, and before the lien expires, acquired by him. The lien has the force, priority, and effect of a judgment lien and shall continue for 10 years from the date of the filing of the certificate unless sooner released or otherwise discharged. The lien may, within 10 years from the filing of the certificate or within 10 years from the date of the last extension of the lien in the manner herein provided, be extended by filing for record a new certificate in the office of the county recorder of any county and from the time of such filing the lien shall be extended to the real property in such county for 10 years unless sooner released or otherwise discharged.

CENTRAL CALIFORNIA IRRIGATION DISTRICT

WATER TRANSFER POLICY

Adopted: October 27, 1993
Last Revised: January 18, 2023

I. Transfers by Landowners within CCID:

The Central California Irrigation District ("District") under its Exchange Contract, with permission of the Bureau of Reclamation, will permit water transfers. Water to be transferred may be from individual allotment or non-allocated District supply.

a. The District will permit transfer of water from a Landowner within the District only to his or her owned land in another Recipient District.

b. "Landowner" shall mean the owner of the right through deeds or contracts of sale to possession of the property for farming purposes which contract must provide the right to control and utilize on the land the surface water provided by CCID upon that land. A lessee, regardless of the term of the lease, is not a Landowner for purposes of this policy, nor is a lessee who holds an option to purchase considered a Landowner for the purposes of this policy. The holder of a life estate entitling the person to possession and use of the land and the surface water provided by CCID upon that land shall be deemed a Landowner. If the land is owned by a corporation, trust, partnership, or other form of business entity, provided all other owners of that business entity consent in writing, a person holding an undivided interest may to the extent of that proportional interest be considered a Landowner of that percentage of the acreage, provided that the proposed land to receive the transfer is the same person or an entity holding title in which that individual holds a similar percentage interest. The parents or spouse or natural or adopted children or grandchildren of a Landowner will be treated as identical with the Landowner for the purposes of transfers because these ownership differences often arise from estate planning, governmental entitlement or similar requirements. A person who does not own that interest in land within CCID, and in addition, the interest in the land to which the water is to be transferred for at least one (1) calendar year prior to January 1 of the year in which the transfer is proposed to occur shall not be permitted to transfer water under the District programs until that ownership period has been complied with. If a Landowner owns the In-District land on January 1 of the year in which the transfer is proposed and the Landowner was the tenant upon the property in the previous full year and held a written option to purchase, the Landowner shall be treated as complying with this requirement. The District will not approve a transfer between entities of the Landowner’s proportion of the surface water otherwise transferable unless all of the other holders of proportional interests of both the transferring land and the recipient land agree to be parties to the contract indemnifying, defending and holding the District harmless from any claims.

c. A "Recipient District" is (i) a district or mutual water company within the geographical area described in the Twenty-Five Year Transfer Approval CEQA/NEPA process conducted by the San Joaquin River Exchange Contractors Water Authority (SJRECWA) and Bureau of Reclamation, (ii) a District or mutual water company overlying the same groundwater basin which is adjacent to CCID and which through direct connection well water can be delivered, and (iii) which district or mutual water company agrees in writing to comply with the terms and conditions of the transfer.

II. Types of Transfers:

CCID transfers conserved water for the benefit of all CCID Landowners. In addition, there are two (2) types of transfers possible involving individual Landowners:

a. CCID District Conservation Transfers: Conservation of irrigation water is a duty of all Landowners. Water conserved is transferred through District programs and the benefits of the transfer are shared by all District Landowners and water users. To the extent that CCID believes that through conservation and other means available the District will have water available that may be transferred from non-allocated supplies, the District may provide for that water to be transferred. The proceeds of those transfers will be utilized by the District in accordance with its policies regarding conservation loans and grants, payments of project costs, and disbursement of portions of the District water charges to growers and Landowners.

b. Transfer of Water Generated from Well Pumping: A Landowner who has a well upon his or her owned land within CCID may transfer by a credit well water pumped into a District owned or controlled facility, up to 3.0 acre-feet per acre for lands owned by that same Landowner in a Recipient District for use on land overlying the same groundwater basin. See “Rules Governing Pumping of Private Wells for Water Credits in Other Districts” for more details and requirements, including means of assuring water pumped will not harm other groundwater or surface water users. The water may be transferred to the Recipient District for use only on the Landowner’s owned lands.

c. Transfer of Water Generated from Land Fallowing: A Landowner who wishes to fallow a specified portion of his or her land within CCID may apply to CCID to provide for the transfer of the amount of water that would be consumptively used upon those fallowed lands to lands owned by the same Landowner located in a Recipient District; provided the Landowner meets the requirements of the District's policy and its program, the water may be transferred to the Recipient District for use only on the Landowner’s owned lands. The Landowner must comply with the District requirements of the program. See “Rules Governing Fallowing of CCID Land for Water Credit in Other Districts.”

III. Conditions of Transfers:

The District shall strive to manage water transfers so that the water supply, operations, and financial condition of the District, the Exchange Contractors, and water users within the Exchange Contract service area are not unreasonably impacted. Before the District will consider a Landowner's written water transfer proposal to be complete, the Landowner will need to demonstrate:

(1) that the transfer does not unreasonably impact:

a. the quantity and quality of the water supply available to the District and its water users;
b. the quantity and quality of groundwater in the District and the Exchange Contract service area, or interrelated surface streams, or other groundwater supplies within the District and Exchange Contract service area;
c. the District's operations, including, but not limited to the ability of the District to meet its delivery obligations, obtain additional water supplies, and undertake conservation measures, exchanges, transfers, groundwater storage, or conjunctive use programs;
d. the District's financial condition and its cost of providing water service to its water users;
e. the appropriate maintenance practices regarding the fallowed land, if the proposal is to fallow lands;
f. the ability of the District or its water users to provide drainage to land including the ability to meet regulatory requirements relating to discharge of agricultural drainage; and
g. other relevant factors that may create an adverse financial, operations, or water supply impact on the District or its water users.

(2) that the Landowner has paid or made acceptable arrangements to pay, all costs associated with developing a complete written water transfer proposal, including District staff and attorney review necessary to process the transfer proposal.

(3) that the Landowner has paid, or made acceptable arrangements to pay, all necessary mitigation costs associated with the transfer including without limitation:

a. Studies to determine safe annual yield of groundwater, if the proposal is to pump groundwater and deliver that groundwater to the District for credit.
b. Monitoring and quantifying groundwater conditions both in terms of quantity and quality.
c. Funds to study and determine the amount of applied water which recharges the groundwater or enters drainage systems.
d. Funds to study and monitor for subsidence impacts.
e. Funds to study and monitor for fallowing impacts and guarantee that fallowing will not impact other growers and Landowners within the District and will not result in permanent abandonment of irrigation upon the fallowed lands.
f. Landowners requesting transfers based on groundwater pumping will be required to pay all costs of monitoring and quantifying groundwater conditions both in terms of quantity and quality. If it is discovered that detrimental quantity or quality conditions require a reduction in pumping amounts, the Landowner will be required to reduce, or curtail, pumpage of groundwater to protect both quality and quantity.

g. A Landowner proposing to fallow shall provide the monies to study and determine the amount of applied water which enters drainage systems which can be used by District or other Exchange Contractors.

(4) that the Landowner has paid, or made acceptable arrangements to pay, District water transfer conservation fees.

IV. <u>Documentation and Quantities of Transfers.</u>

1. All transfers which an individual Landowner wishes to make must be presented to the District for processing and processed only through the District utilizing the device of a written contract between the District and the Landowner (including the signature of all holders of interest in the land and the signature of any deed of trust holders or other secured parties upon the land or improvements, if necessary, which determination will be the Landowner's responsibility). The District will enter into a corresponding agreement with the Recipient District if the conditions of CCID are met regarding the transfer.

2. For fallowed land transfers the total water to be transferred by a Landowner shall not exceed the lesser of: (i) the water generated from fallowing 20% of the Landowner's total ownership within the District, or (ii) that quantity of water which is a Landowner's allocated share of the maximum amount of water which may be transferred through Landowner to the same Landowner fallowing program in a calendar year pursuant to restrictions enacted by the Exchange Contractors, CEQA and NEPA documents, or regulatory requirements such as the Bureau of Reclamation requirements, or (iii) that quantity of water which the District determines can be safely transferred without adversely impacting the quantity and quality of the water supply available to the District and its water users, including the quantity and quality of groundwater, whichever amount is less. The total water to be transferred shall be computed after subtracting from the total delivered water all transportation, evaporation, seepage, metering or measurement error and any amounts necessary to provide for agreements with other Exchange Contractors to relax monthly delivery limitations or similar agreements with other parties such as Grassland Water District, Department of Fish and Game, United States Fish and Wildlife Service, and the Bureau of Reclamation, and the total amount of water applied which is calculated to have historically entered the underground basins directly or indirectly through relaxation of well use.

    a. The District may elect not to apply the 20% limitation or may apply different limitations to a Landowner if the District determines that the land seeking to transfer water creates severe drainage quality conditions. Land with those conditions, proposed to be fallowed, may be provided a priority in participation in transfers.

    b. If District transfers together with Landowner-requested transfers exceed 20% of the water to be applied in the District, or such lesser amount that the District determines can be safely transferred without adverse impacts on the quantity and quality of the water supply available to the District and its water users including the quantity and quality of groundwater or because of the limitations set forth in Paragraph 2 above, District may proportionately reduce, or curtail, the Landowner-requested transfers with consideration of whether drainage impacted lands should be entitled to any priority, to a level at which no more than 20% of the District consumed surface water as described in Paragraph 2 will be transferred.

3. Because the District Landowners conjunctively use groundwater replacing surface water for groundwater and storing groundwater for drought periods, and because the lands from which a fallowing or groundwater transfer is proposed will not participate fully in that conjunctive use program, the amounts of groundwater used by the lands initiating a transfer cannot exceed annually their fair share of the safe yield, assuming all other Landowners used their fair share of the safe yield. This will allow storage for drought periods by all lands overlying the basin or area. If the studies for such determination of safe annual yield do not exist, Landowners initiating transfers will be required to fund those studies by the District upon an equitable basis before a transfer may be processed. The equitable terms may include reimbursement of a portion of the costs of studies by other transferring Landowners who enjoy the use of the studies.

4. The District has adopted a policy entitled "Central California Irrigation District Rules Governing Pumping of Private Wells for Water Credits in Other Districts." A Landowner proposing to pump groundwater for credit in other Districts is directed to that policy for more specific conditions and requirements and that policy is incorporated herein as if set forth in full. The District has adopted a policy entitled "Central California Irrigation District Rules Governing Fallowing of CCID Land for Water Credit in Other Districts." Landowners are directed to that policy for more specific conditions and requirements, and that policy is incorporated herein as if set forth in full.

V. Recipient District Conditions and Requirements.

In order to avoid unreasonable impacts on the water supply, operations, and financial condition of the District and its water users, the District will not approve a water transfer proposal unless:

1. The Recipient District conducts a water conservation program that includes efficient water management practices, or is in compliance with an urban water management plan under Water Code Section 10610 et seq., or an agricultural water management plan adopted pursuant to Water Code Section 10800 et seq.; and

2. The Recipient District conducts a drainage program which assures that the water transfer will not cause a deleterious effect on lands downslope from any lands irrigated as a result of the transfer; and

3. The Landowner receiving the transferred water and the Recipient District demonstrate that the Landowner will not be dependent upon the transferred water supply at the end of the one (1) year term of the proposed transfer.

4. Transfers shall be submitted and approved only on a one-year basis by the District.
5. The District has adopted a technical standard entitled "Maximum Quantity of Water Transferable from CCID Due to Fallowing," a copy of which is attached hereto and incorporated herein as if set forth in full. Fallowing transfers involve complex requirements and interrelationships between the San Joaquin River Exchange Contractors Water Authority, Bureau of Reclamation and CCID policies. Frequent changes in the policy should be anticipated by Landowners. CCID cannot guarantee that requirements will not change during a calendar year, but new requirements will not apply retroactively to fallowing transfers already approved by the Board of Directors of the District for that year.

V. <u>District Hearings and Process.</u>

1. The District staff will review each transfer in order to determine the impact of the proposed transfer on the water supply, groundwater, operations, and financial conditions of the District and its water users. A Landowner requesting a transfer will be required to deposit from time to time the amounts estimated to be expended in that review.

2. The District may conduct a public hearing to determine the impact of the proposed transfer. The Landowner and Recipient District shall attend the hearing if requested to do so by the District in order to respond to questions and comments regarding the impact of proposed water transfers.

3. If land use ordinances, general plan or other zoning conditions require the acquisition of use permits from the County, the landowner must acquire the necessary permits prior to CCID's approval of the Landowner's participation in such a transfer. All CEQA/NEPA requirements imposed by law in connection with that process shall be the responsibility of the Landowner, except that the District shall be the lead agency for CEQA purposes. The District must be consulted as an interested agency in any process in which the District is not the Lead Agency.

4. All NEPA requirements of the Bureau of Reclamation or any other federal agency shall also be complied with before the District processes the Landowner's application. To provide for the most rapid compliance with CEQA/NEPA requirements, the Landowner shall fund a cooperative joint EIR/EIS process with the County (if there are applicable land use permits required) together with the United States lead agency. If the County does not have land use jurisdiction, the District will be the lead agency for CEQA purposes and the Landowner will pay the cost of compliance by the District.

5. District transfers, including Landowner requests, shall be monitored at least annually and will be subject to modification, including restrictions or termination, in response to:

    a. Changes in applicable laws, regulations, contracts and court decisions.

    b. Changed or adverse environmental impacts or other circumstances that cause a transfer to result in impacts on the water supply, groundwater, operations, or financial conditions of the District or its water users, or adjacent areas dependent directly or indirectly on District supply.

c. Restrictions or prohibitions by the USBR or other agencies exercising jurisdiction over any phase of the transfer.

6. The District will adopt a use fee schedule for processing these transfers. If it does so, the District will use fees from water transfers for conservation projects and rehabilitating District facilities for the benefit of its water users. The District will develop a use fee, or schedule of fees, as it determines appropriate, that will be levied by the District on all water transferred. Fees will be in the nature of a water conservation use fee and the District will use its share of the income from such fees for conservation projects within the District and for the rehabilitation of District facilities to reduce conveyance losses. It is the goal of the District, in implementing this policy, to ensure that revenues of the District generated by transfers are used for the improvement of its system and the improved management of its water supplies in order to ensure that the transfer can be sustained without adverse impact on District surface water and/or groundwater supplies. The use fee will be established by evaluating short and long term conservation and water management programs within the District that should be implemented and the cost of such programs. Fees shall be paid prior to the time the transfer is initiated or at such periodic times as is determined appropriate by the District in the case of long-term transfers.

7. The contract between the District and the Landowner shall provide for payment of all costs, expenses, water tolls, assessments, and all additional costs and expenses incurred by the District for consultants, staff, Board operations, and dislocations or reductions in economies of scale arising from the transfer. The Landowner shall be required to continue to pay all PMA and community ditch charges and similar operation, maintenance, repair and reconstruction costs necessary to avoid increased burdens upon neighboring Landowners not participating in transfers. These charges and expenses, including the costs of monitoring and enforcing these conditions of transfers, shall be adjusted and calculated from time to time by the District and if not paid, the Landowner-requested transfer shall not be permitted to continue.

8. The contract will provide, among other terms, for a requirement that any fallowed land be maintained at the cost of the Landowner in a condition that noxious weeds and pests are not permitted to be maintained upon the fallowed land, all air pollution requirements for suppression of dust and blowing objects are complied with, and the land is maintained in a condition in which the land may be returned to irrigated farming in the following water year, including maintenance of any facilities required for that use.

9. Included within the reimbursable costs to be paid by Landowner will be calculated value of power generation lost at the power plants located on the District's system by virtue of any water transferred which is not available for hydroelectric generation. Power costs will be estimated based on reasonable models of scheduled generation applied to then existing published power values.

10. The rules and regulations of the District will include a term that a Landowner-requested transfer which is not processed through the District in accordance with these policies and which is accomplished shall nevertheless be subject to each and every term and condition of these policies. Until the terms and conditions of these policies are substantially complied with, the Landowner shall be in violation of the District rules and regulations and will not be delivered water upon the lands from which the transfer is made or any other lands which the Landowner had an interest in upon the date of the transfer. The Landowner shall be provided a hearing prior to the imposition of the bar upon water service and if the District can set fees and charges which will compensate for the impacts upon the District system and water use within the District system, those fees and charges will be levied annually as a condition of water service rather than the prohibition upon water service.

11. Certain lands within the District are not eligible for fallowing or well water transfer programs. Those include lands which have converted from Second Class to Primary Use status and ten (10) years has not elapsed since that conversion.

Land Fallowing
Technical Standards and Guidelines

2.1. **Maximum Quantity of Transferable Water**

2.1.1. The maximum quantity of water (Max Transferable) that can be transferred by a Landowner fallowing land is the <u>lesser</u> *of the monthly* ***Consumptive Use*** *of the crop being fallowed or the* ***CCID Deliverable Monthly Entitlemen****t.* (Subject to **Adjustments** within paragraph 2.4.)

2.2. **Consumptive Use**

2.2.1. The consumptive use will be calculated using the average of the crops grown on the land for the past three water years.

2.2.2. Consumptive Use (CU) = Evapotranspiration Crop (ETc) + Required Leaching Fraction (LF) – Effective Precipitation (EP).

2.2.2.1. CU = ETc + LF – EP

2.2.3. Etc is calculated on a monthly time step for the calendar year. Data on the baseline three year average ETo and rainfall is collected from the nearest CIMIS station(s). The crop coefficients (Kc) are taken from the SWRCB report # 84-1.

2.2.4. LF is calculated based on the methodology outlined in the Western Fertilizer Handbook.

2.2.5. EP is 50% of the three year average rainfall measured at the nearest CIMIS station(s).

2.2.6 . No crops may be grown on the fallowed lands at any time during the calendar year during which the fallowing transfer will take place. Crops which are normally harvested in the preceding calendar year which are delayed in harvesting by weather or other factors beyond the control of the Landowner until after January l, shall not be excluded from eligibility for a potential transfer but the circumstances shall be brought to the Board of Directors for approval or disapproval on an individual basis prior to eligibility being determined for the fallowing program.

2.3. CCID Deliverable Monthly Entitlement

2.3.1. The deliverable monthly entitlement is that quantity of Exchange Contract Water, on average, (not other water such as well water) that can be delivered to farmed fields within the entity.

2.3.2. The deliverable monthly entitlement is calculated on a per acre basis.

2.3.2.1. The deliverable monthly quantities are the Division of Waters Agreement quantities less system losses and other commitments divided by total entity acreage.

2.4. Adjustments

2.4.1. The deliverable monthly entitlement may be accumulated (bath tubbed) for the 7 month period so long as the bath tub is being provided by Reclamation in accordance with the Refuge Water Transportation Agreement.

2.5. Determination of Acreage of Fallowed Land

2.5.1. Acreage of Fallowed land will be based on farmed acres not assessed acreage. Each field that is fallowed must be contiguous unto itself.

2.5.2. The following are acceptable methods for determining farmed acreage:

2.5.2.1. CCID Field Map acreage;
2.5.2.2. Measurements based on aerial photography;
2.5.2.3. Field measurements; and
2.5.2.4. Equivalent methods approved by the transfer committee.

2.5.3. To the extent possible, whole fields will be fallowed.

2.5.4. If only a portion of a field is to be fallowed then the fallowed portion must be physically separated from the farmed field by levee or drain. (No water of any kind be applied to the fallowed land.)

SAN JOAQUIN RIVER EXCHANGE CONTRACTORS WATER AUTHORITY WATER TRANSFER POLICY & DRAINAGE TRANSFER POLICY

Adopted April 7, 2000
Adopted Revised Policy – November 6, 2020

1. Background.

1.1 The San Joaquin River Exchange Contractors Water Authority (**SJRECWA**) is a joint exercise of powers authority formed and existing under California law. Its member agencies are Central California Irrigation District, San Luis Canal Company, Firebaugh Canal Water District, and Columbia Canal Company. These four entities are traditionally referred to collectively as the **Exchange Contractors**.

1.2 The **Exchange Contractors** hold pre-1914 water rights on the San Joaquin River. In order to facilitate the construction of the Central Valley Project, the **Exchange Contractors** and their predecessors entered into two contracts with the United States Bureau of Reclamation (Reclamation) in 1939. The Purchase Contract conveyed excess San Joaquin River flows—the so called "high flows" -- and reserved the first San Joaquin River flows—sometimes referred to as the "low flows" -- to the **Exchange Contractors**. The Exchange Contract established the terms pursuant to which a substitute supply of water was to be delivered by the Reclamation to the **Exchange Contractors** in lieu of their "low flow" diversions from the San Joaquin River. These agreements established the underpinnings for the Reclamation to construct Friant Dam on the upper San Joaquin River and divert the river's natural flow north to Madera and Chowchilla through the Madera Canal and south into Kern County through the Friant-Kern Canal. The Exchange Contract specifies that so long as the **Exchange Contractors** are provided a quantified substitute supply of water, the **Exchange Contractors** will not exercise their pre-1914 right to divert water from the San Joaquin River. The Exchange Contract at Article 5a contemplates that most, if not all, of this substitute water will be delivered to the **Exchange Contractors** from the Sacramento River watershed, pumped from the South Delta, and conveyed by means of the Delta-Mendota Canal. The current Exchange Contract is the Second Amended Contract for Exchange of Waters, Contract No. Ilr-1144, executed February 14, 1968.

1.3 The **SJRECWA** was formed in 1993 to represent its four member entities in many water matters including issues related to water transfers.

1.4 In California, the concept of water transfers, also referred to as water marketing or water brokering, is considered by some to be a partial solution to the shortage of water. The underlying assumption is that market forces in a free market will reallocate water. In some circumstances, agricultural water users who manage a conjunctive use water resource area can, to some extent, provide flexibility which may, at times, facilitate transfers of water. The **Exchange Contractors** proactively manage their surface water, groundwater, and conserved water conjunctively to maximize its beneficial use.

2. Objective. The objective of this water transfer policy is to manage water transfers to provide a framework by which the **Exchange Contractors** manage water transfers on a sound scientific basis, and to provide a clear set of standards and guidelines that each transfer proposal must comply with, and to only allow **SJRECWA**, or its member entities, to market and/or transfer water, and not individual landowner(s). The approach is designed to (i) ensure that the quantity of water proposed for transfer is made available through technically sound methods and projects which are scientifically based and verifiable; (ii) provide sound analysis of potential water transfer impacts; (iii) properly develop and implement necessary mitigations; (iv) monitor on-going water transfers and water development projects to ensure that beneficial and conjunctive use objectives are met; (v) provide flexible and efficient use of available water resources; (vi) ensure that the water supply, operations, and financial condition of the **Exchange Contractors** and their water users are not unreasonably impacted, and third party impacts from the transfer are mitigated; and, (vii) establish, maintain and utilize a data bank that will be used to manage the San Joaquin River Exchange Contractors Groundwater Sustainability Agency's Groundwater Sustainability Plan. The Transfer Policy will be reviewed by the Water Transfer Committee and Board of Directors every five (5) years, or as needed.

3. Authority

3.1 A transfer of water is considered a beneficial use under state and federal law. (Water Code Section 1011; CVPIA Section 3405.)

3.2 The **Exchange Contractors** hold pre-1914 rights to appropriate water from the San Joaquin River. The California Legislature has declared that it is established policy of the State to facilitate the voluntary transfer of water and water rights. (Water Code Section 109.) The Costa-Isenberg Water Transfer Act adopted by the legislature in 1986 as Water Code Sections 470 and 475-484 provides that voluntary water transfers between water users can result in a more efficient use of water, alleviate water shortages and finds and declares that it is in the public interest to conserve all available water resources. Water transfers do not undermine the rights that are the basis of the transfer. Water Code Sections 1010, 1011, 1011.5, 1244, 1440, 1731, 1737 and 1745.07 were specifically added to provide protection to water right holders who transfer water.

3.3 Reclamation utilizes the water transfer authority provided for in CVPIA to facilitate Exchange Contract water transfers. Water transfers implemented in accordance with CVPIA Section 3405(a) are deemed by federal law to be a beneficial use of water.

4. Applicability. Proposals to transfer any water from the **Exchange Contractors**' service area are subject to the requirements of this policy.

5. Definitions. For purposes of this policy, "water district" shall mean any water district, irrigation district, municipality, federal water agency, state water agency, or similar entity that exists pursuant to federal or state law.

6. Criteria for Water Transfers

6.1 Basis for all water transfers.

6.1.1 The state water rights, that are the underpinning of the Exchange Contract, are owned by the individual **Exchange Contractors'** members. The federal contract rights pursuant to the Exchange Contract are similarly owned by the individual **Exchange Contractors'** members. Consequently, any transfer of water from the **Exchange Contractors'** service area must first be approved by the **Exchange Contractors'** member entity from which the water will be transferred and then by the **SJRECWA**.

6.1.2 The **Exchange Contractors'** member entities share a water right in common, have a single watermaster who schedules water deliveries to the member entities, and are in the process of completing a Groundwater Sustainability Plan (GSP) as required by the Sustainable Groundwater Management Act (SGMA) of 2014. The **Exchange Contractors** actively manage their surface water, groundwater and conserved water resources conjunctively, and manage water application within their service area to minimize drainage discharges from their service area and to cope with regulatory requirements imposed by law. Thus, all proposals to transfer water must be submitted by an **Exchange Contractors'** member entity and by the **SJRECWA** on behalf of its member entities, and water transfer proposals shall not be accepted from individual landowners. An individual landowner who proposes a water transfer must submit the proposal to the landowner's member entity, and, if approved by the member entity, shall be submitted by the member entity on behalf of the individual landowner.

6.1.3 It is imperative to protect the member entity's water rights and to assure that no water right is assigned; therefore, only annually severable water transfers will be considered.

6.2 Water transfer types.

6.2.1 All water transfers shall be proposed by an **Exchange Contractors'** member entity. Additionally, the individual entities may propose a transfer jointly with any or all of the member entities. A transfer of water proposed jointly by all of the member entities shall be handled as a **SJRECWA** water transfer.

6.2.2 Therefore, transfer proposals are limited to three types:

6.2.2.1 A transfer of water by the **SJRECWA** on behalf of its four member entities.

6.2.2.2 A transfer of water by an **Exchange Contractors'** member entity to another water district.

6.2.2.3 A transfer of water by an **Exchange Contractors'** member entity to a water district that is made on behalf of an **Exchange Contractors'** landowner who is entitled to receive Exchange Contract water.

6.3 Water to be transferred. Water that is subject to transfer may be from an **Exchange Contractors'** member entity's water entitlement allocated pursuant to the Exchange Contract Division of Water Agreement, or from a member entity's non-allocated water supplies.

6.4 Generation of transferable water. Transferable water can be generated by using standard methods of conservation, groundwater substitution, or fallowing depending on the special hydrologic conditions that exist within the service area where the water is being generated as determined in paragraph 6.6.

6.5 Transferees. Water shall only be transferred to a water district.

6.6 Technical standards. All water transfers are subject to the technical standards and criteria adopted by the individual entity that proposes the transfer, and the **SJRECWA.** The technical standards are attached hereto as Appendices.

6.7 Priority of Transfers. All transfers are subject to the following priorities:

6.7.1 First priority shall be given to transfers initiated by the **SJRECWA** on behalf of its four member entities, and/or a transfer by an **Exchange Contractors'** member entity that enables an individual landowner within the member entity's service area to transfer water to a CVP ag service contracting water district for their own use in that water district.

6.7.2 Second priority shall be given to transfers initiated by an **Exchange Contractors'** member entity.

6.7.3 Third priority shall be given to transfers proposed by an **Exchange Contractors'** member entity on behalf of one of its landowners.

6.7.4 For illustrative purposes, the attached Appendix "A" provides an example of how the priority system would be implemented under the following three scenarios: 1) the transfer demands are less than the transfer supply during a normal water year; 2) the transfer demands are greater than the transfer supply during a normal water year; and, 3) a critical water year.

6.8 Limitation on Quantity of Water Transferred. For the years 2019 through 2023, the maximum quantity of transfers in each category is as follows:

Table 6.8

PROGRAM	***ACRE FEET (AF) MAXIMUM***	***NOTES***
Current Conservation	80,000 AF	Divided on Four Entity split *
Additional Conservation	20,000 AF	Divided on Four Entity split*
Drainage	20,000 AF	Under the Drainage Transfer Policy
Fallowing	50,000 AF	Divided on Four Entity split*
Groundwater Exchange.	28,000 AF	Divided on Four Entity split *

* Subject to Section 6.8.1.

The annual amount of transfer water to be offered to M&I purchasers is capped at 10,000 AF. The 10,000 AF is from within the quantities in Table 6.8 and not in addition to those amounts.

Each year, each entity shall declare the quantity of water that will be transferred out of the **Exchange Contractors'** service area. The aggregated amount of the water to be transferred shall not exceed the amounts in Table 6.8 above.

Each year, as soon as practicable, and not later than the **Exchange Contractors**' March board meeting, the transfer quantity for the upcoming water year shall be announced. The announced maximum shall not be changed upward or downward from the announced maximum unless clear and convincing scientific evidence supports the change. Transfers initiated by **SJRECWA** will not be permitted in a critical water year designated under the Exchange Contract.

6.8.1 Internal Allocation of Transferable Water: On an annual basis, any Exchange Contractors' member entity may assign any portion of their maximum percent allocation in any of the transfer classifications to one or more of the Exchange Contractors' member entities and this assignment will increase the recipient Member Entity's share of transfers in the classifications stated below. The baseline for determining the Exchange Contractors' member's maximum percent allocation is the 1978 Division of Water Agreement subject to modifications pursuant to Sections 6.8.2.1 and 6.8.2.2.

6.8.2 Transfers will be classified as: (i) conservation or (ii) groundwater exchange or substitution or (iii) fallowing transfers or (iv) drainage transfers. The income from each classification of transfer will be blended and distributed to the member entities in proportion to the amount of water contributed by each entity.

6.9 <u>Annual Establishment of Transferees and Maximum Quantities of Water to be Transferred to Each Transferee</u>. Each year by no later than March 1st, the **SJRECWA** shall establish the transferees and maximum quantities of water to be transferred to each transferee. The water needed to meet these obligations will be in accordance with the transfer priorities established by Section 6.7.

6.10 <u>Water Transfer Committee</u>.

6.10.1 A **SJRECWA** Water Transfer Committee is established to review all transfer proposals that are submitted consistent with this policy. It will review and analyze the technical data upon which each transfer is based and make a recommendation on each water transfer proposed. The membership of the committee will include the manager of each of the **Exchange Contractors'** member entities, and one board member from each member entity, or a member's alternate, appointed by the President of the board. The committee may retain technical consultants.

6.10.2 The committee shall review each transfer proposal and each approved transfer annually to ensure that it meets the stated objectives, technical standards, and criteria of this policy.

6.10.3 Due to the fact that the **Exchange Contractors** and their landowners conjunctively use surface and groundwater resources where a water transfer is proposed from lands that the committee believes will not participate fully in the conjunctive use program, the committee may limit a water transfer to the amount of groundwater used by the lands initiating the transfer so that those lands do not exceed annually their fair share of the safe yield.

6.10.4 The committee shall review each transfer proposal and each approved transfer annually to consider whether it is likely to cause unreasonable impacts to the overall water supply, water management operations, or financial condition of the transferor entity or its water users, and whether member entity impacts that result from the transfer will likely be mitigated.

6.10.5 The committee shall make a recommendation to the **SJRECWA** Board of Directors on each proposed transfer, and an annual recommendation for the continuation or termination of each approved transfer, based upon analysis of technical criteria developed pursuant to paragraph 6.6.

6.11 Water Transfer Fees, Mitigation Costs, and Water Transfer Proceeds.

6.11.1 Where a transfer is made by a **SJRECWA** member entity, the entity will allocate a portion of the income from the water transfer to conservation projects and/or water distribution and drainage facilities, or other similar projects and actions that benefit its water users.

6.11.2 Any Bureau of Reclamation, or state agency water transfer application and environmental assessment fee shall be the responsibility of the transferring entity.

6.11.3 The processing by **SJRECWA** of a water transfer will require the payment by the transferring entity of all costs associated with the transfer. Such cost shall include but not be limited to management and study costs associated with administration of the Transfer Policy. For example, where a transfer involves groundwater, the transferring entity will be responsible for the cost (i) to determine safe annual yield of groundwater, (ii) for monitoring required to analyze groundwater conditions both in terms of quantity and quality, (iii) the amount of applied water that recharges the groundwater or enters drainage systems, and (iv) to study and monitor for subsidence impacts.

6.11.4 The **SJRECWA** shall be the fiscal agent for all water transfers.

6.12 Environmental Requirements. The environmental review requirements of NEPA and CEQA must be complied with before the **Exchange Contractors** will process a transfer application and all such costs shall be born by the transferring member entity.

6.13 Public Hearing. The **Exchange Contractors** may conduct a public hearing to determine the impact of the proposed transfer. The transferor and transferee must attend the hearing if requested to do so by the **Exchange Contractors** or by the entity from which the transferor is entitled to receive water.

6.14 Action by **SJRECWA** Board of Directors. All water transfers must be approved by unanimous vote of the **SJRECWA** Board of Directors. A water transfer proposal along with the recommendation by the Water Transfer Committee will be considered by the **SJRECWA** Board of Directors, and the transfer approved, disapproved, or returned to the Water Transfer Committee for further action as directed by the Board.

APPENDIX "A"

Illustration of Transfer Policy Priority System

Annually the SJRECWA shall establish:

1. Annual Maximum – The maximum annual amount of water to be transferred from the SJRECWA developed on a sub-basin by sub-basin level. (Section 6.8)

2. Demand – The maximum quantities of water to be transferred to each transferee shall be established by no later than March 1st of each year. (Section 6.9)

3. SJRECWA Supply – The amount of water available under a SJRECWA transfer and/or a transfer by an **Exchange Contractors'** member entity that enables an individual landowner within the member entity's service area to transfer water to a CVP ag service contracting water district for their own use in that water district. First priority. (Section 6.7.1)

4. Individual Entity Supply – The amount of water available under an individual entity transfer. Second priority. (Section 6.7.2)

5. Individual Entity on behalf of landowner supply – The amount of water available for an entity on behalf of a landowner, limited by the maximum demand. Third priority. (Section 6.7.3)

The application of the priority system described in section 6.7 is limited to determining quantities of transfer demand to be met by each of water transfer types. It will be calculated as follows (Section 6.9):

	TOTAL DEMAND
Less	***Amount available through SJRECWA initiated and/or Exchange Contractors' member entity that enables an individual within the member entity's service area to transfer water to a CVP ag service contracting water district for their own use in that water district (priority 1)***
Equals	***Amount available for priority 2 and priority 3***
Then	***Amount available through priority 2 and priority 3***
Less	***The amount of water available under an individual entity transfer (priority 2)***
Equals	***Amount available through priority 3***

Individual landowners will be notified of the amount of transfer demand available to be met by the third priority. They will be required to determine their level of participation (through fallowing as an example) as soon as possible.

To further illustrate the priorities, below are three types of water year scenarios:

NORMAL YEAR

100 % allocation to EC; demand is 95,000 af which exceeds Supply

Priority		Supply	Demand	Amount Transferred
1	SJRECWA/ dist. to dist. initiated	75,000	85,000	75,000
2	Exchange Contractor Entity Initiated	5,000	5,000	5,000
3	Exchange Contractor Entity Initiated on behalf of Individual	5,000	5,000	5,000
		85,000	95,000	85,000
	Total amount transferred **85,000**			

NORMAL YEAR

100 % allocation to EC; demand is 65,000 af and is less than Supply

Priority		Supply	Demand	Amount Transferred
1	SJRECWA/ dist. to dist. initiated	75,000	65,000	65,000
2	Exchange Contractor Entity Initiated	5,000	0	0
3	Exchange Contractor Entity Initiated on behalf of Individual	5,000	0	0
		85,000	65,000	65,000
	Total amount transferred **65,000 af**			

CRITICAL YEAR

75 % allocation to EC; demand is 25,000 af and is greater than Supply

Priority		Supply	Demand	Amount Transferred
1	SJRECWA/ dist. to dist. initiated	0	0	0
2	Exchange Contractor Entity Initiated	0	0	0
3	Exchange Contractor Entity Initiated on behalf of Individual	5,000	25,000	5,000
		5,000	25,000	5,000
	Total amount transferred **5,000 af**			

(Appendix to Subparagraph "6.6," Part 1 of 2)

Maximum Quantity of Water Transferable from the
Exchange Contractors Service Area due to fallowing

Adopted August 5, 2005

Land Fallowing
Technical Standards and Guidelines

1. The requirements of this section will be the responsibility of the Entity from which the fallowing transfer is proposed to provide or implement.
2. **Maximum Quantity of Transferable Water**
   a. The maximum quantity of water (Max Transferable) that can be transferred by a landowner fallowing land is the *lesser of the monthly* ***Consumptive Use*** *of the crop being fallowed or the* ***Exchange Contractor Entity Deliverable Monthly Entitlement****.* (Subject to **Adjustments** within paragraph d, and the limits or reductions within Part 2 of 2 paragraphs 3c., 3d., and 3e. of this Appendix.)
   b. **Consumptive Use**
      i. The consumptive use will be calculated using the average of the crops grown on the land for the past three normal water years.
      ii. Consumptive Use (CU) = Evapotranspiration Crop + Required Leaching Fraction (LF) – Effective Precipitation.
         1. CU = Etc + LF – EP
      iii. Etc is calculated on a monthly time step for the calendar year. Data on the baseline three year average ETo and rainfall is collected from the nearest CIMIS station(s). The crop coefficients (Kc) are taken from the SWRCB report # 84-1.
      iv. LF is calculated based on the methodology outlined in the Western Fertilizer Handbook. The ECe and ECw are shown on the attached example. However, these may be updated by the Exchange Contractors.

v. EP is 50% of the three-year average rainfall measured at the nearest CIMIS station(s).

c. **Exchange Contractor Entity Deliverable Monthly Entitlement**

i. The deliverable monthly entitlement is that quantity of Exchange Contract Water, on average, (not other water such as well water) that can be delivered to farmed fields within the entity.

ii. The deliverable monthly entitlement is calculated on a per acre basis.

1. The deliverable monthly quantities are the Division of Waters Agreement quantities less system losses and other commitments divided by total entity acreage.

d. **Adjustments**

i. The deliverable monthly entitlement may be accumulated (bath tubbed) for the 7-month period so long as the bath tub is being provided by Reclamation in accordance with the Refuge Water Transportation Agreement.

3. Determination of Acreage of Fallowed Land

a. Acreage of Fallowed land will be based on farmed acres not assessed acreage.

i. The following are acceptable methods for determining farmed acreage:

1. FSA data base;
2. Measurements based on aerial photography;
3. Field measurements, and;
4. Equivalent methods approved by the transfer committee.

b. To the extent possible whole fields will be fallowed.

c. If only a portion of a field is to be fallowed then the fallowed portion must be physically separated from the farmed field by levee or drain. (It is important that surface water not be applied to the fallowed land.)

(Appendix to Subparagraph "6.6", Part 2 of 2)

TECHNICAL STANDARDS AND CHECKLIST FOR A COMPLETE WRITTEN PROPOSAL FOR A TRANSFER FROM AN ENTITY ON BEHALF OF LANDOWNERS

Revised October 7, 2020

1. Name and address of Transferring Entity
2. Names, addresses and locations of the landowners for whom the Transferring Entity is Transferring water on behalf of.
3. If all or a portion of the transfer proposal by the Entity is on behalf of a Landowner for his own use in another District, then:
    a. Provide name, address and location of the Receiving District
    b. Provide detailed location maps of the area(s) proposed to receive the transferred water.
    c. Provide documentation (deed or other equivalent proof) showing the same ownership of area(s) proposed both to develop water within the Entity and to receive water consistent with the transferring Entities' Transfer Policy. The ownerships must be identical unless the Entities' Transfer Policy proposing the transfer requires the reduction in the quantity of the transfer based on the percentage of ownership difference between the in-District land developing the transfer water AND the receiving land in another District, then the District shall provide the calculations for the reduced transfer quantities, and such a transfer will be allowed and the reduction shall be applied.
    d. Provide a signed statement by the landowner that they are also the 100% farming entity of the receiving lands, or, if the landowner is not the 100% farming entity, then the landowner shall provide documentation (Reclamation Reform Act form or other equivalent proof) showing the percentage of interest the landowner has in the farming interest on the receiving land. The Entity proposing the transfer on behalf of the landowner shall provide the calculations to show that the transfer has

been reduced based on the percentage. (Example: Landowner has a 50% interest in the farming operation then the transfer will be reduced by 50%).

e. The quantity of the transfer to the Receiving District shall also be limited to the CVP allocation deficit below 3.0 acre-feet per acre for the Receiving District as of April 1 in the year in which the transfer is to occur. (Example: If the declared CVP allocation as of April 1 is 50%, then the transfer will be limited to 1.5 acre-feet per acre on the receiving land.)

4. For Fallowing transfers:
    a. Provide crop maps showing the locations of fields being fallowed.
    b. Provide a tabulation of the acreage of fields being fallowed and the crops grown during the last three normal water years.
    c. State the quantity of water involved within the transfer and identify the proposed use for the transferred water.
    d. For transfers based on fallowing, provide the calculations of the **Maximum Quantity of Transferable Water** based on the Land Fallowing Technical Standards and Guidelines.
    e. State that the entity will be responsible to field verify that fallowing is accomplished as proposed and that an end of the year report on the fallowed lands will be provided.
    f. State that the entity will guarantee that the fallowed lands will be maintained so as to not create a nuisance to neighboring lands.

5. For transfers based on groundwater exchanges or substitution, provide basis for calculation of quantity of groundwater to be exchanged or substituted and transferred.
6. Provide a complete written description of the transfer proposal, including any special water transfer scheduling.

7. Attach statement by the Entity from where the water is being transferred that the transfer will have no unreasonable impact on water supply, operations, or financial condition of the Entity or its water users.

WATER TRANSFER POLICY RELATING TO DRAINAGE PROJECTS

Adopted: September 3, 2004
Adopted Revised Policy: November 5, 2010
Adopted Revised Policy: April 12, 2019

1. Background.

1.1 The San Joaquin River Exchange Contractors Water Authority (**SJRECWA**) is a joint exercise of powers authority formed and existing under California law. Its member agencies are Central California Irrigation District, San Luis Canal Company, Firebaugh Canal Water District, and Columbia Canal Company. These four entities are traditionally referred to collectively as the **Exchange Contractors**.

1.2 The **Exchange Contractors** hold pre-1914 water rights on the San Joaquin River. In order to facilitate the construction of the Central Valley Project, the **Exchange Contractors** and their predecessors entered into two contracts with the United States Bureau of Reclamation in 1939. The Purchase Contract conveyed excess San Joaquin River flows—the so called "high flows" -- and reserved the first San Joaquin River flows—sometimes referred to as the "low flows" – to the **Exchange Contractors**. The Exchange Contract established the terms pursuant to which a substitute supply of water was to be delivered by the Reclamation to the **Exchange Contractors** in lieu of their "low flow" diversions from the San Joaquin River. These agreements established the underpinnings for Reclamation to construct Friant Dam on the upper San Joaquin River and divert the river's natural flow north to Madera and Chowchilla through the Madera Canal and south into Kern County through the Friant-Kern Canal. The Exchange Contract specifies that so long as the **Exchange Contractors** are provided a quantified substitute supply of water, the **Exchange Contractors** will not exercise their pre-1914 right to divert water from the San Joaquin River. Reclamation will be entitled during those periods to exercise the pre-1914 rights of the **Exchange Contractors** for the benefit of the Friant Users. The Exchange Contract at Article 5a contemplates that most, if not all, of this substitute water will be delivered to the **Exchange Contractors** from the Sacramento River watershed, pumped from the South Delta, and conveyed by means of the Delta-Mendota Canal. The current Exchange Contract is the Second Amended Contract for Exchange of Waters, Contract No. Ilr-1144, executed February 14, 1968.

1.3 The **SJRECWA** was formed in 1993 to represent its four member entities in many water matters including issues related to water transfers.

1.4 In California, the concept of water transfers, also referred to as water marketing or water brokering, is considered by some in California to be a partial solution to the shortage of water. The underlying assumption is that market forces in a free market will reallocate water. In some circumstances, agricultural water users who manage a conjunctive use water resource area can, to some extent, provide flexibility which may, at times, facilitate transfers of water. The **Exchange Contractors** proactively manage their surface water, groundwater, and conserved water conjunctively to maximize its beneficial use.

1.5 Two areas within the **Exchange Contractors**, the Firebaugh Canal Water District and the Camp 13 area of Central California Irrigation District (as shown on the map included in Appendix A), are currently directly impacted by the inaction of the Bureau of Reclamation (Reclamation) to provide drainage to the San Luis Unit adjacent areas. San Luis Canal Company and Columbia Canal Company are impacted more indirectly at this time from the lack of drainage of poor-quality water originating from irrigation of the San Luis Unit and the Bureau's inaction. Poor-quality drainage waters from the San Luis Unit join in the drains and channels of Central California Irrigation District which lead to the service area of SLCC and add salinity and other constituents to those waters which SLCC utilizes for irrigation. In addition, poor-quality drainage enters underground aquifers which CCID and its landowners use for well water. The return flow from that well water has also been historically utilized by SLCC and is degraded by the drainage water escaping the San Luis Unit. Columbia Canal Company and its landowners depend upon substantial amounts of well water to supplement surface water supplies. A front of poor-quality water generated by irrigation of the San Luis Unit without the provision of drainage has been moving eastward toward the Columbia Canal wells, and degradation of the quality of well water from these drainage waters is believed to be occurring and will increase in the future. Per federal law, Reclamation was required to install and operate a drainage system to provide drainage for irrigation waters applied to lands within the San Luis Unit, and the Bureau has not provided for those works. For more than 35 years, irrigation water has been applied to the upslope San Luis Unit lands causing poor-quality groundwater to migrate through groundwater aquifers into these areas of the **Exchange Contractors'** service area. The application of irrigation water upslope has also resulted in increased pressures transmitted downslope into the Exchange Contractors' service area. The pressure causes poor-quality water to rise into crop root zones and drainage systems within the **Exchange Contractors'** service area. At the same time, new regulatory requirements are being placed upon the quality of drainage discharged from the **Exchange Contractors'** service area. Unless the quality of drainage water discharges are improved, drainage will be prohibited or curtailed. It would not be possible to continue irrigated farming under the proposed regulatory conditions. Because the activities upon upslope lands are not within the control of the **Exchange Contractors,** and Reclamation has never complied with its legal duties relating to drainage, the districts, on behalf of the areas where drainage impacts are occurring, are forced to undertake expensive mitigation measures to provide for reduction in drainage quantities and treatment of drainage water to improve the quality of drainage discharges (pursuant to the attached Appendix A -- Technical Criteria for Drainage Plan Transfers). Other adjacent areas of the **Exchange Contractors** may be threatened with impacts from upslope activity and may be required to take similar measures in the future.

1.6 A Drainage Plan Transfer will not compete with annually severable transfers.

2. Objective. The objective of this water transfer policy is to provide a framework to manage water transfers that relate to drainage by which the **Exchange Contractors** manage such water transfers. The framework will provide a sound scientific basis and provide a clear set of standards and guidelines that each such transfer proposal must comply with. The approach is designed to (i) ensure that the quantity of water proposed for transfer is made available through technically sound methods and projects which are scientifically based and verifiable; (ii) provide sound analysis of potential water transfer impacts; (iii) properly develop and implement necessary mitigations; (iv) monitor on-going water transfers and water development projects to ensure that beneficial and conjunctive use objectives are met; (v) provide flexible and efficient use of available water resources; (vi) ensure that the water supply, operations, and financial condition of the **Exchange Contractors** and their water users are not unreasonably impacted, and third party impacts from the transfer are mitigated; and, (vii) establish, maintain and utilize a data bank that will be used to manage the San Joaquin River Exchange Contractors Groundwater Sustainability Agency's Groundwater Sustainability Plan.

3. Authority.

3.4 A transfer of water is considered a beneficial use under state and federal law. (California Water Code Section 1011; CVPIA Section 3405.)

3.5 The **Exchange Contractors** hold pre-1914 rights to appropriate water from the San Joaquin River. The California Legislature has declared that it is established policy of the State to facilitate the voluntary transfer of water and water rights. (Water Code Section 109.) The Costa-Isenberg Water Transfer Act adopted by the legislature in 1986 as Water Code Sections 470 and 475-484 provides that voluntary water transfers between water users can result in a more efficient use of water, alleviate water shortages and finds and declares that it is in the public interest to conserve all available water resources. Water transfers do not undermine the rights that are the basis of the transfer. Water Code Sections 1010, 1011, 1011.5, 1244, 1440, 1731, 1737 and 1745.07 were specifically added to provide protection to water right holders who transfer water.

3.6 Reclamation utilizes the water transfer authority provided for in CVPIA to facilitate Exchange Contract water transfers. Water transfers implemented in accordance with CVPIA Section 3405(a) are deemed by federal law to be a beneficial use of water.

4. Applicability. Proposals to transfer any water from the **Exchange Contractors**' service for the purpose of solving drainage problems caused in whole or in part by the failure of Reclamation to provide drainage to the San Luis Unit are subject to the requirements of this policy. Proposals to receive high quality surface water from outside of the **Exchange Contractors'** service area and to provide on a cooperative basis for the exchange of water with those third parties, and to provide for the transfer of an equal amount of **Exchange Contractor** water pursuant to the exchange in the same calendar year in order to remedy drainage and water quality problems within an **Exchange Contractors** service area, shall be subject to the requirements of this policy.

5. Definitions. For purposes of this policy, "water district" shall mean any water district, irrigation district, municipality, federal water agency, state water agency, mutual water company, or similar entity that exists pursuant to federal or state law.

6. Criteria for Water Transfers

6.1 Basis for all water transfers.

6.1.1 The state water rights, that are the underpinning of the Exchange Contract, are owned by the individual **Exchange Contractors'** members. The federal contract rights pursuant to the Exchange Contract are similarly owned by the individual **Exchange Contractors'** members. Consequently, any transfer of water from the **Exchange Contractors'** service area must first be approved by the **Exchange Contractors'** member entity from which the water will be transferred and then by the **SJRECWA**.

6.1.2 The **Exchange Contractors'** member entities share a water right in common, have a single water master who schedules water deliveries to the member entities and have adopted a single groundwater management plan. The **Exchange Contractors** actively manage their surface water, groundwater and conserved water resources conjunctively, and manage water application within their service area to minimize drainage discharges from their service area and to cope with regulatory requirements imposed by law. Thus, all proposals to transfer water must be submitted by an **Exchange Contractors'** member entity and by the **SJRECWA** on behalf of its member entities, and water transfer proposals shall not be accepted from individual landowners. An individual landowner who proposes a water transfer must submit the proposal to the landowner's member entity, and, if approved by the member entity, shall be submitted by the member entity on behalf of the individual landowner.

6.1.3 Under no condition will a long-term transfer under this policy be an assignment of a water right.

6.2 <u>Drainage Plan Transfers.</u> Water transfer proposals which provide for funding for drainage projects from: (1) the Firebaugh Canal Water District service area and from the Camp 13 service area portion of the Central California Irrigation District or (2) Exchanges of surface water with third parties for the purposes of remedying significant drainage water quality conditions by any of the **Exchange Contractors** which involve transfers of **Exchange Contractors'** water in the same quantity received from the third party in the same calendar year, are hereinafter referred to as "Drainage Plan Transfers."

6.2.1 <u>A Drainage Plan Transfer is one in which all of the following requirements are met</u>:

A. The transfer is of water conserved, developed or exchanged within the service areas described as an integral part of a plan to reduce drainage, manage drainage and improve drainage water quality, which transfer is based upon findings made and adopted by the respective member entity that the transfer will reduce drainage discharges and contribute to compliance with water quality regulatory requirements; and,

B. The transfer is found by the respective member entity to be required because of a failure of the United States Department of Interior, Bureau of Reclamation to provide for the construction and operation of a drainage system as required by Section lA of the San Luis Act irrigated lands and as provided under Section 5 of the San Luis Act and for adjoining lands impacted by irrigation of San Luis Unit lands; and,

C. The net proceeds of the transfer or exchange will be utilized for the purposes of implementing the Drainage Plan of the Member Entity and reducing the physical and monetary impacts to landowners and water users within the described areas of the Member Units service area from drainage and water quality impacts; and,

D. The amounts of water made subject to transfer will not reduce the amounts of water or the schedule of water deliveries available to other member units under the Exchange Contract;

E. Except when an exchange of water in the same calendar year and in the same amount is the basis for the transfer, the amounts of water to be transferred shall be shown by a water budget first prepared and approved by the member unit and then approved by the **Exchange Contractors** to be not in excess of the amounts of water made available as a means of reducing drainage impacts within the **Exchange Contractors'** service areas. The water budget shall be prepared utilizing established scientific methods and shall demonstrate that the transfer will allow continued agricultural use of water within the Firebaugh Canal Water District and/or the Camp 13 area of Central California Irrigation District on a long-term basis in accordance with the Drainage Plan; and,

F. The transfer shall be conditioned upon the maintenance and implementation of long-term monitoring and adjustment factors which will further the Drainage Plan; and,

G. The initial consideration of the transfer pursuant to the Drainage Plan shall occur prior to conduct of CEQA/NEPA processes and final approval shall occur only after completion of all regulatory and environmental processes. Final approval shall be granted only if, in the judgment of the **SJRECWA**, the approval of the transfer and its term will further the goals of the **SJRECWA** in preserving the rights to water of the **Exchange Contractors** and providing a long term means of reducing damages from drainage impacts and the regulatory conditions placed upon drainage flows.

6.2.2 A Drainage Plan Transfer shall be proposed only by an **Exchange Contractors** Member Entity.

6.3 <u>Water to be transferred</u>. Water that is subject to transfer may be from an **Exchange Contractors'** Member Entity's water entitlement allocated pursuant to the Exchange Contract Division of Water Agreement, or from a member entity's non-allocated water supplies. Water exchanged with a Member Entity to permit a Drainage Transfer by a Member Entity in the same calendar year must be received only from the surface water rights of a water district.

6.4 Generation of transferable water. Transferable water can be generated by using standard methods of conservation, groundwater substitution, or fallowing depending on the special hydrologic conditions that exist within the service area where the water is being generated as determined in paragraph 6.6. Transferred water pursuant to an exchange with third parties and receipt of an equal amount of water in the same calendar year will not require evidence of the generation mechanism except as set forth in Paragraph 6.3 above.

6.5 Transferees. Water shall only be transferred to a water district, although a Drainage Plan Transfer may provide that the recipient agency will use the water transferred only for a specific development.

6.6 Technical standards. All water transfers are subject to the technical standards and criteria adopted by the individual entity that proposes the transfer, and the **Exchange Contractors.** The technical standards are attached hereto as Appendices.

6.7 Water Transfer Committee.

6.7.1 An **Exchange Contractors'** Water Transfer Committee is established to review all transfer proposals that are submitted consistent with this policy. It will review and analyze the technical data upon which each transfer is based and make a recommendation on each water transfer proposed. The membership of the committee will include the manager of each of the **Exchange Contractors'** member entities, and one board member from each member entity, or a member's alternate, appointed by the President of the board. The committee may retain technical consultants.

6.7.2 The committee shall review each transfer proposal, and receive annual reports to ensure that it continues to comply with the stated objectives, technical standards, and criteria of this policy.

6.7.3 The committee shall make a recommendation to the **Exchange Contractors'** Board of Directors on each proposed Drainage Plan Transfer, and an annual report to the Board based upon analysis of technical criteria developed pursuant to paragraph 6.6.

6.8 Water Transfer Fees, Mitigation Costs, and Water Transfer Proceeds.

6.8.1 Where a Drainage Plan Transfer is made by an **Exchange Contractors'** member entity, the entity will allocate the net income from the water transfer to conservation projects and/or water distribution and drainage facilities, or other similar projects and actions that are part of the implementation of the Drainage Plan.

6.8.2 Any Bureau of Reclamation, or state agency water transfer application and environmental assessment fee shall be the responsibility of the transferring entity.

6.8.3 The processing by the **Exchange Contractors** of a Drainage Plan Transfer will require the payment by the transferring entity of all costs associated with the transfer. Such cost shall include but not be limited to management and study costs associated with administration of the Transfer Policy.

6.8.4 The **Exchange Contractors** shall be the fiscal agent for all water transfers, (1) except that the **Exchange Contractors** may decline that role in favor of the Member Entity, and (2) if bonds are to be issued by the Member Unit, the transfer proceeds may be pledged as security for bond repayment by the Member Entity.

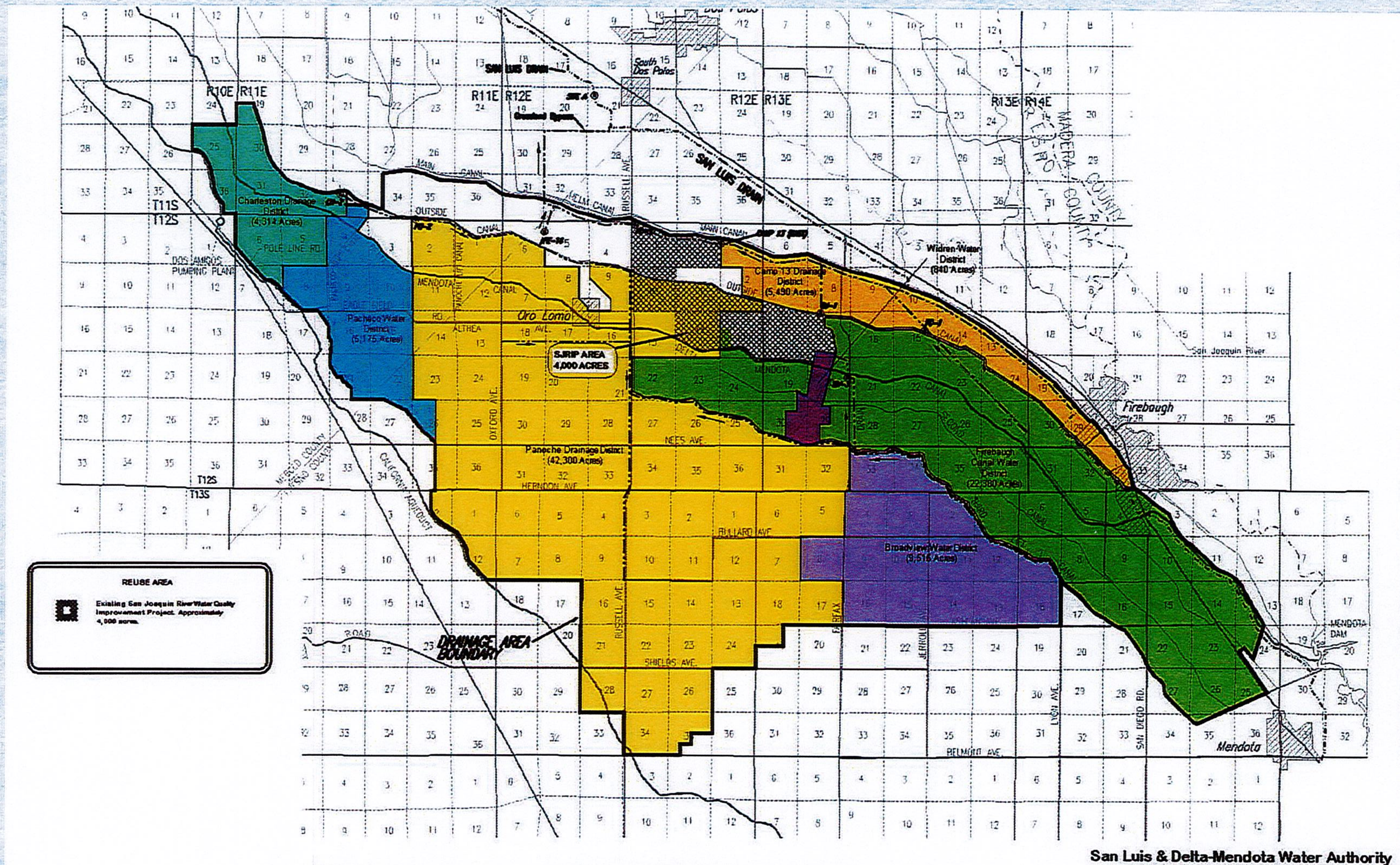
6.9 Environmental Requirements. Any environmental review requirements of NEPA and CEQA must be complied with before the **Exchange Contractors** will process a transfer application and all such costs shall be borne by the transferring member entity.

6.10 Public Hearing. The **Exchange Contractors** may conduct a public hearing to determine the impact of the proposed transfer. The transferor and transferee and/or the third party providing the water to the Member Entity for the exchange must attend the hearing if requested to do so by the **Exchange Contractors** or by the entity from which the transferor is entitled to receive water.

6.11 Action by the **Exchange Contractors'** Board of Directors. All water transfers must be approved by unanimous vote of the **Exchange Contractors'** Board of Directors. A water transfer proposal along with the recommendation by the Water Transfer Committee will be considered by the **Exchange Contractors'** Board of Directors, and the transfer approved, disapproved, or returned to the Water Transfer Committee for further action as directed by the Board.

Appendix A

Insert technical criteria for Drainage Plan transfers not involving exchange of water.



GRASSLAND DRAINAGE AREA
IN-VALLEY TREATMENT SYSTEM

San Luis & Delta-Mendota Water Authority
GRASSLAND DRAINAGE AREA
SUMMERS ENGINEERING, INC.
Consulting Engineers
HANFORD CALIFORNIA
JULY 2002

1335 West "I" Street
PO Box 1231
Los Banos, CA 93635

(209) 826-1421
Fax (209) 826-3184
www.ccidwater.org

Date: February 16, 2023

2023 WATER SUPPLY INFORMATION

The Bureau of Reclamation has made its first official water supply declaration and based on current hydrologic conditions at Shasta, the initial projections show that 2023 will be a non-critical year for CCID and the Exchange Contractors. The District's Board of Directors has adopted a budget and water rate schedule based on a non-critical water supply under the Exchange Contract this year. While our current allocation is non-critical, February has been exceptionally dry. ***Therefore, the quantities and rates shown below for the tiered pricing levels are subject to change if the dry weather continues***. The District will provide updates immediately if conditions change.

IN-DISTRICT WATER SALES

January through October

a. **A 3-tiered rate schedule will apply to all water used from January 1 through October 31**:

   Tier 1 – 0 – 3.20 acre-feet/gross acre – $17.00 /acre-foot

   Tier 2 – 3.21 – 3.70 acre-feet/gross acre (CCID Well Water) – $60.00 /acre-foot

   Tier 3 – Greater than 3.70 acre-feet/gross acre (Purchased Water) – $100.00 /acre-foot

b. The per-acre quantities above represent how much water will be available, if needed, but the amounts are not guaranteed. The actual amount of water available is subject to the Bureau's ability to deliver water to us, and limitations in the Exchange Contract.

November and December

We generally have a good supply of water available in November and December, although availability may be limited depending on the need to perform winter maintenance and construction projects. Water available during this period will be sold on a first-come, first-served basis, at $17.00 per a.f.

DEVELOPED WATER – CLASS II LANDS

Developed water for Class II lands will also be subject to tiered pricing from January 1 through October 31. The first 3.2 a.f. per net acre will be charged $60.00 per a.f. on an "if and when available" basis. All usage in excess of 3.2 a.f. per net acre during this period will be billed at $100.00 per a.f.

Developed water taken in November and December, if available, will cost $60.00 per a.f.

MUNICIPAL AND INDUSTRIAL WATER

Municipal and Industrial (M&I) water will be available to those municipalities contracting with CCID, at $75.00 per a.f.

If you have any questions, please contact the CCID Office at (209) 826-1421.

CUSTOMER BILL

Customer #

Bill #

Bill Date 4/30/2024

CENTRAL CALIFORNIA
IRRIGATION DISTRICT

1335 West I Street
P.O. Box 1231
LOS BANOS, CALIFORNIA 93635

(209) 826-1421

All bills unpaid after 30 days are subject to a 1% per month penalty, compounded monthly.

Newman, CA 95360

Billing Summary

Account Balance	
Previous Balance	$15,654.25
Overpayments/Credits	$0.00
New Charges	$77.40
Total Due	**$15,731.65**

Water Usage	
Billing Period (April)	4/1/2024 To 4/30/2024
Billed Usage	4.30 Af

Detail

Account Number	Grower Field	Description	Qty	Rate	Amount
	Tier 1	Almonds - 0109 - 36.000ac 4/25/2024 To 4/26/2024	4.30 Af	$18.00	$77.40
		Seasonal Water Total	4.30 Af		$77.40
		Total Charges			**$77.40**

Detach and return the bottom remittance portion with your payment.

Customer #

Bill #

Due Date	5/30/2024
Previous Balance	$15,654.25
Overpayments/Credits	$0.00
New Charges	$77.40
Total Due	**$15,731.65**

Amount Enclosed $

Newman, CA 95360

UPDATED AB 3030 GROUNDWATER MANAGEMENT PLAN FOR THE SAN JOAQUIN EXCHANGE CONTRACTORS

Prepared for:
San Joaquin River Exchange Contractors Water Authority
Los Banos, California

by
Kenneth D. Schmidt and Associates
Groundwater Quality Consultants
Fresno, California

May 2014

UPDATED AB 3030 GROUNDWATER MANAGEMENT PLAN FOR THE SAN JOAQUIN EXCHANGE CONTRACTORS

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Fresno, California

May 2014

KENNETH D. SCHMIDT AND ASSOCIATES
GROUNDWATER QUALITY CONSULTANTS
600 WEST SHAW, SUITE 250
FRESNO, CALIFORNIA 93704
TELEPHONE (559) 224-4412

May 14, 2014

Mr. Steve Chedester
Executive Director
San Joaquin River Exchange
Contractors Water Authority
541 H Street
Los Banos, CA 93635

Re: Groundwater Management Plan

Dear Steve:

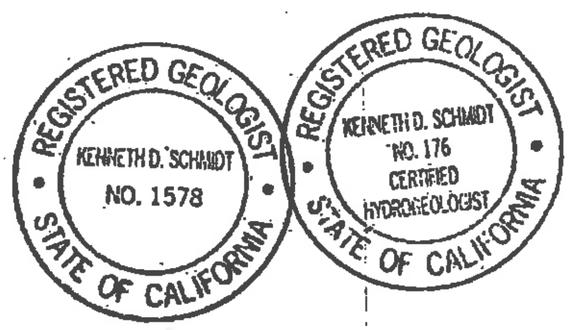
Submitted herewith is our report on the Updated 3030 Groundwater Management Plan within the Exchange Contractors services area.

Sincerely yours,

Kenneth D. Schmidt

Kenneth D. Schmidt
Geologist 1578
Certified Hydrogeologist 176

KDS/td



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UPDATED AB 3030 GROUNDWATER MANAGEMENT PLAN FOR THE SAN JOAQUIN EXCHANGE CONTRACTORS

INTRODUCTION

General

The San Joaquin River Exchange Contractors (SJREC) Water Authority ("Exchange Contractors" or "Authority") is a Joint Powers Authority organized under the Joint Exercise of Power Act. The member agencies are Central California Irrigation District (CCID), Firebaugh Canal Water District (FCWD), Columbia Canal Company (CCC) and San Luis Canal Company (SLCC). Each of the entities is a holder in common of certain priority water rights, which are the subject matter of an agreement executed on February 14, 1968, between the United States of America (Bureau of Reclamation, Department of Interior or USBR) and the Exchange Contractors. The title of the agreement is the "Second Amended Contract for Exchange of Waters" (Contract No. Ilr-1144), commonly known and referred to as the "Exchange Contract". The Exchange Contract confers upon the Exchange Contractors the right to utilize the subject water so long as USBR delivers specified quantities of substitute water at specified locations via the Delta-Mendota Canal.

The Authority

The Authority is empowered to administer and protect the jointly held water rights under the Exchange Contract and power incidental, necessary and convenient thereto, administer operation under the Division of Water Agreement and represent the Exchange Contractors in many water matters, including, but not limited to, operation of the Central Valley Project, conjunctive use of groundwater and surface supplies, water conservation, reclamation, transfers, drainage, management of the San Francisco Bay-Delta Estuary, environmental considerations and related legislation, litigation, and administrative proceedings. The Exchange Contractors Water Authority is committed to managing its ground and surface water resources to replenish and preserve its groundwater.

AB 3030

The State Legislature enacted AB 3030 (Costa), the Groundwater Management Act, in 1992. The act was codified as Part 2.75, commencing with Section 10750 of Division 6 of the Water Code and became effective January 1, 1993.

1. The act applies to all groundwater basins in the state, except any portion of a groundwater basin that is subject to

groundwater management by a local agency or a water master pursuant to other provisions of law, court order, judgment, or decree, unless the local or water master agrees.

2. It provides that any local agency, whose service area includes an applicable groundwater basin, may by ordinance or resolution, adopt and implement a groundwater management plan within a part or all of its service area in accordance with certain procedures.

The Role of Groundwater in the Exchange Contractors Water Operations

The conjunctive use of groundwater within the Exchange Contractors service area is required due to surface water delivery restrictions contained within the Exchange Contract. In addition, peak irrigation demands within certain areas exceed surface water distribution channel capacities. Groundwater is pumped and delivered into the system to make up capacity shortfalls.

1. The Exchange Contract provides both non-critical and critical surface water entitlement maximums on a per month basis, on a five-month basis (January, February, March, November, and December), and on a seven-month basis (April through October). In addition, monthly maximum instantaneous delivery flow rates are

defined. Provisions are made to allow deliveries in excess of these rates if it can be done without detriment to the United States or its other obligations.

2. The Exchange Contract entitlement maximums and the instantaneous flow limits require conjunctive use of surface and groundwater to meet peak crop water demands during June, July, and August. While USBR has historically allowed instantaneous flow deliveries in excess of the limits (except in 1992), the five-month and seven-month entitlement maximums remain in effect. When USBR provides this flexibility, the Contractors must pump groundwater from District owned wells during April, May, and early June to "bank" sufficient Exchange Contract water for use during peak demands in June, July, and August. Groundwater pumpage from District owned wells must continue through June, July, and August, due to the seven-month Exchange Contract maximum for surface water. During the rest of the water year, there are sufficient quantities of surface water to meet crop water demands and provide necessary quantities for storage in the aquifer for use during the critical months.

3. During critical water years the necessity for conjunctive use of water increases. The seven-month surface water entitlement maximums decrease during critical water years. The five

month maximums are not reduced.

4. Private well pumpage within the Exchange Contractors service area also fluctuates in response to the non-critical or critical surface supply. As shown in Table 1, the total groundwater pumpage within the Exchange Contractors service area averaged about 160,000 acre-feet per year from 1996 to 2012. The pumping ranged from about 80,400 acre-feet in 1998 to 212,000 acre-feet in 2004. Tiered water prices are analyzed yearly based on the annual "deep well" study. This mechanism has been effectively utilized to incorporate groundwater pumpage from both private and District owned wells into a conjunctive use program.

5. The groundwater in the FCWD has become unusable for agricultural purposes because of high levels of total dissolved solids (TDS), boron, and selenium. FCWD is able to provide surface water capacity to the other Exchange Contractors in return for their cooperation in utilizing groundwater during periods in which FCWD needs amounts of water in excess of that available from its share of the Exchange Contract supply. As a result, groundwater within CCID, SLCC, and CCC is conjunctively used, not simply with the surface deliveries within the service areas for those specific entities, but also within service areas of

TABLE 1-WELL PUMPAGE INSIDE AND OUTSIDE OF THE EXCHANGE CONTRACTORS SERVICE AREA

2012 — PUMPED WATER — MONTHLY BASIS — (AF)

NO	Canal	JAN.	FEB.	MAR.	APRIL	MAY	JUNE	JULY	AUG.	SEPT	OCT.	NOV.	DEC.	AC FT (meter rdg)	E&D COST /AC. FT.	AVE. KWHr /AC. FT.	SECTION / WELL NO.	
1	Main		46.3	130.8	27.2	163.5	170.4	147.5	128.9	103.4		16.1		934	$35.08	160.0	W/L. Banos	1
2	Main		36.4	48.3	64.1	148.8	118.0	160.8	157.6	169.6		17.6		904	$19.80	169.4	Newman	2
3	Main		73.5	191.2	82.3	303.9	193.7	282.1	216.8	280.6		28.3		1650	$19.33	185.9	Newman	3
4	Main		49.7	105.5	54.9	167.9	64.8	168.2	140.1	28.4		18.0		781	$23.09	181.5	Newman	4
5 A	Main		67.7	122.8	114.9	298.1	148.3	148.3	320.9	130.5	166.6	28.3		1518	$21.40	198.2	Headgate	5
6 B	Colony-Br 4		67.1	5.0	36.9	123.7	160.0	90.1	145.2	39.2	48.8	44.1		761	$12.38	83.8	N/D. Palos	6
7 A	Colony-Main		132.6	123.7	103.3	174.1	91.8	178.2	137.0	117.5	86.1	33.6		1175	$15.21	124.2	S/D. Palos	7
8 A	Outside		167.6	179.5	201.9	277.4	283.1	282.5	170.1	172.3	0.0			1715	$13.98	123.9	S/L. Banos	8
9 A	Colony-Main		77.4		118.3	78.7	70.5	115.7	69.4	66.8	84.5			898	$29.07	245.0	S/D. Palos	9
10 A	Central			81.2	74.9	308.5	242.1	185.5	232.4	136.1	209.3	43.4		1624	$1.80	13.4	Poso	10
11 A	East Ditch		111.0	14.4	65.2	225.5	219.6	201.5	259.3	114.7	0.3	34.8		1269	$14.20	116.8	S/D. Palos	11
12 C	Main		93.1	164.8	91.3	166.8	102.8	90.5	107.8	77.0	37.5			891	$27.78	250.2	Headgate	12
13	Main		49.7	127.9	66.0	169.9	165.0	171.9	140.2			20.1		942	$26.28	211.8	Newman	13
14	Main		112.8	113.6		108.6	207.2	46.3	179.6	88.2		20.2		880	$15.10	82.2	W/L. Banos	14
15 B	Main		99.4	97.2	84.0	144.8	102.7	119.7	139.0	163.2	133.7	15.8		1003	$29.77	264.1	Headgate	15
16 C	Main		106.6	169.0	166.3	280.0	182.1	168.5	229.6	163.9	207.2	28.2		1742	$11.45	109.4	Headgate	16
17 A	Parsons D.		94.0	121.8	41.8	95.1	72.6	150.2	142.8	69.3	130.4	179.3		1071	$20.55	166.8	Parsons	17
18 D	Parsons D.			wire stolen	5.0			225.0	120.1	0.1	1.1			369	$39.88	274.8	Parsons	18
19 B	Parsons D.		92.1	84.2	20.5	146.2	82.1	130.4	134.6	72.3	93.0	36.7		879	$27.19	209.8	Parsons	19
20 A	Parsons D.		193.9	161.2	35.3	306.1	228.7	185.4	322.7	97.2	138.2	83.6		1700	$4.74	44.5	Parsons	20
21 B	Parsons D.		116.8	137.8	36.1	210.0	173.5	164.8	164.2	38.0	44.6			1105	$16.66	155.8	Parsons	21
22 B	Main		89.6	155.5	39.9	237.2	220.7	209.2	201.8	192.8		25.8		1360	$25.82	229.1	Gustine	22
23 B	Main		69.7	159.4	74.1	147.6	118.6	103.6	128.5	61.2	117.7	13.1		1009	$20.58	184.7	Headgate	23
24 A	Main		47.6	189.0	38.8	180.8	268.4	191.0	159.0	130.0		2.8		1184	$24.27	202.8	W/L. Banos	24
25 B	Colony-Main		111.3	119.8	109.7	98.4	170.7	189.0	213.5	138.2	65.2			1204	$17.73	145.4	S/D. Palos	25
26 A	Colony-Main		119.7	69.8	94.9	171.8	46.6	167.0	210.3	37.0	84.2			999	$21.22	167.9	S/D. Palos	26
27 A	Outside		112.3	138.3	28.8	207.8	217.0	187.5	178.8	114.5		0.4		1176	$20.62	166.8	W/L. Banos	27
28 D	Main		84.0	120.1	69.9	182.4	132.4	130.2	170.0	129.1	170.8	20.8		1209	$28.19	202.4	Headgate	28
29	Poso		2.1	28.2	102.6	82.4	60.6	178.1	202.5	178.6	119.6			912	$29.05	229.2	Poso	29
30	Shafter D.				43.2	28.0	107.4	59.0	60.8	18.6	79.7			438	$34.00	119.9	S/D. Palos	30
31 A	Central	new	new		34.0	137.3	77.1	98.2	129.2	78.8	65.8	66.3		703	$22.14	183.5	Poso	31
32 C	Outside		30.2	92.5	0.0	136.8	103.5	67.0	112.2	7.4	69.4			686	$29.60	222.5	Headgate	32
33 B	Parsons D.		122.6	140.4	1.2	208.7	211.8	179.8	180.6	72.1				1128	$11.28	86.2	Parsons	33
34 A	Poso		87.6	88.8	82.1	181.4	194.8	147.0	169.2	113.3	116.8	38.4		1177	$28.34	238.8	Poso	34
35 A	Main		113.4	280.1	200.8	226.0	251.8	258.5	305.4	220.3	227.1	22.7		2063	$15.23	139.2	Headgate	35
36	Main		139.8	162.9	76.1	178.8	180.5	128.2	139.7	179.6		17.0		1192	$23.22	205.0	Newman	36
37 A	Poso		149.8	198.0	73.9	311.3	238.9	204.0	278.9		160.2	66.4		1686	$18.82	161.3	Poso	37
38 A	Helm Ditch		67.0	198.8	28.2	93.8	71.0	95.1	182.0	64.5	34.7			773	$12.08	95.9	Headgate	38
39 A	Central		31.6	44.8	34.3		49.5	52.9	112.1	0.0		0.6		325	$44.71	349.0	Poso	39
40 A	Poso		105.7	111.5	8.5	198.0	140.9	155.7	173.4	128.3	103.6	68.9		1199	$19.98	184.5	Poso	40
41	Poso		63.1	314.9	68.5	482.1	482.1	214.3	221.0	186.1	149.1			2121	$14.59	120.9	Poso	41
42	Main		148.0	108.2	64.6	228.3	150.9	194.6	201.1	212.6		22.2		1417	$12.47	119.6	Newman	42
43 A	Colony-Main				118.7	240.0	188.6	229.4	244.2	164.5	35.0	-0.1		1220	$16.57	159.3	S/D. Palos	43
44 A	Poso		78.1	113.4	60.9	182.4	148.9	134.8	169.9	109.0	158.9	58.6		1182	$17.00	147.3	Poso	44
45 A	Main		44.5	98.2	49.7	209.2	189.9	198.1	198.1	32.5		28.4		1009	$22.25	190.6	Newman	45
46	Colony-Main				49.6	258.2	168.5	190.6	242.9	144.4	160.2	28.2		1239	$19.25	182.9	S/D. Palos	46
47 A	Main			wire stolen	19.3	150.5	198.0	184.6	129.7			18.8		642	$31.98	247.1	Newman	47
48 A	Main		134.7	170.3	39.4	178.5	207.9	197.4	181.5	146.5	202.4	29.9		1490	$20.72	179.9	W/L. Banos	48
49 A	Main		59.4	172.4	178.4	248.5	268.9	218.1	168.4	159.4		27.1		1492	$19.32	177.8	W/L. Banos	49
50 A	Main		35.7	102.2	106.8	192.2	47.2	163.2	138.2	79.8		27.2		882	$23.82	183.8	Newman	50
51	Main		27.4	62.1	69.1	289.0	93.3	286.6	242.8	289.6		25.9		1310	$34.65	201.7	Newman	51
52 A	Main		39.7	104.6	108.8	218.9	67.6	235.4	222.8			27.1		1040	$34.57	289.1	Newman	52
53	Main		190.6	74.3	83.3	298.2	267.4	273.0	224.4	45.1		28.2		1475	$21.44	182.0	Newman	53
54 A	Central		16.1	64.1		90.0	92.2	96.7	87.3	43.2	40.5	39.1		571	$28.69	208.7	Poso	54
55	Central		69.4	82.0	70.3	129.2	138.2	128.9	100.9	35.8	35.0	71.7		860	$18.63	133.0	Poso	55
56	Main		106.6	109.2	82.1	169.0	178.6	173.3	119.5	137.0	130.2			1208	$33.11	285.4	S/L. Banos	56
57	Main		1.9	70.3	35.9	169.9	173.9	182.1	182.4	159.9		19.7		943	$34.00	290.8	Gustine	57
58	Colony-Main		60.3	65.6	0.2	66.1	60.2	69.4	97.1	39.7	48.8	10.4	0.5	595	$22.51	139.0	N/D. Palos	58
59	Shafter D.		129.2	30.6	169.5	91.2	208.9	140.6	120.9	113.1	15.3			1014	$30.85	155.4	S/D. Palos	59
60 A	Colony-Br 5		79.3	22.1	17.8	59.1	61.9	70.3	68.9	28.6	32.8	21.1		491	$11.29	69.2	N/D. Palos	60
61 A	Poso		46.3	0.0	72.0	186.8	146.2	147.7	167.2	148.2	169.0	34.7	44.4	1208	$23.24	190.7	Poso	61
62	Outside		174.3	189.3	189.3	293.1	279.8	293.1	161.7	289.0	219.3			1930	$4.80	39.3	S/L. Banos	62
63	Main		72.6	139.6	121.9	171.8	168.4	170.1	145.5	112.7		2.2		1123	$13.77	114.9	W/L. Banos	63
64	Parsons D.	new	new	new	22.3	38.0	130.5	157.3	167.3	27.7	38.3	19.6		611	$19.08	121.7	Parsons	64
65																		
66	Poso	new	new	13.0	122.6	238.5	177.1	150.6	214.0	134.0	101.6	28.4		1274	$10.57	163.4	Poso	66
cfs flow (avg/day)			84.9	109	76	189	171	175	189	108	75	35						
AF sub-totals			4717	6646	4919	11559	10169	10692	11232	6682	4476	1628	46	72272	$18.92	163.2		65
monthly %	% of total AF year	NA	0.07	6.2%	6.4%	16.0%	14.1%	14.7%	15.6%	9.2%	6.2%	2.1%		acre feet	ave. cost /af	ave. kwh/af		units

TABLE 1-WELL PUMPAGE INSIDE AND OUTSIDE OF THE EXCHANGE CONTRACTORS SERVICE AREA (CONTINUED)

WELL NO. / AF MONTHLY DATA
2012 DATA

WELL CCID/PRIVATE NO.	WELL DESCRIPTION	JAN-12 2012	FEB 2012	MAR 2012	APRIL 2012	MAY 2012	JUNE 2012	JULY 2012	AUG 2013	SEPT 2012	OCT 2012	NOV 2012	DEC-12 2012
#3A	Gustine Gun Club,												
RedBarn	Domestic well @ Red Barn/Hwy 165												
Dom	Domestic well												
5A	US Fish/Wl@Mud												
6A	Freitas Unit;												
654	Bennett												
10	PG&E mtr - 51M088 (8855R3)			102.9	21.0		167.3		184.3			102.9	
34	Santos			283.6	88.0	88.8		46.5		181.4			
45	Woolen												
78	Bennet			74.0	32.1		233.7	184.3	207.3	184.5	187.7		
98	7A ; Pinheiro well												
	Teicheira house well												
102	Sagouspe												
162	Jensen		24.0	7.0		7.5		4.6		28.2	5.7	0.0	
169	Pfitzer Rd												
204	Dompe												
229	Maring												
389	S&J farms												
417	Mell-E/Eastin Rd	41.0	13.0	20.2					may->sept	380.7	60.0		
634	Redfern			88.0									
8	Fagundes, Chris		44.4	-0.0			28.2					-0.0	
115	Fagundes, Chris												
121	Hostetler-W2LB-old well by rd												
950	Hostetler-W1LB-new well by rd												
964	Hostetler-W3LB-new 1/4 mi /rd												
690	Paradiso												
139	Silveria-dom												
125	Oliveria												
145	Afonso												
944	Trinta												
DOM	Silva												
#3	Volcan G. Pit monitoring well-S/dmo												
#5	Volcan G. Pit monitoring well-N/sunse												
		41	81	584	141	78	429	215	392	735	233	103	

the other entities, as the availability of surface water under the Exchange Contract is not sufficient to meet crop water demands.

Entrix, Inc. (2007) reported on the Environmental Assessment/ Initial Study for the Groundwater Pumping/Water Transfer Project for 25 consecutive years. The primary source of the water to be transferred is pumpage of poor quality shallow groundwater in the area west and northwest of Firebaugh. The easterly and northeasterly migration of the poor quality groundwater above the Corcoran Clay has been identified as a major groundwater management concern in Madera County.

6. The Exchange contractors have a need to store groundwater for later use. Three specifics areas are being considered for water storage projects. There are 1) Los Banos Creek, 2) Orestimba Creek, and 3) the Columbia Canal Co. service area. These potential projects are in the process of being evaluated and implemented. Each project is subsequently discussed in the plan.

GENERAL CONDITIONS OF THE EXCHANGE CONTRACTORS GROUNDWATER BASIN

Figure 1 is the AB 3030 base map of the Exchange Contractors service area. The service area is divided into sub-areas of gen-

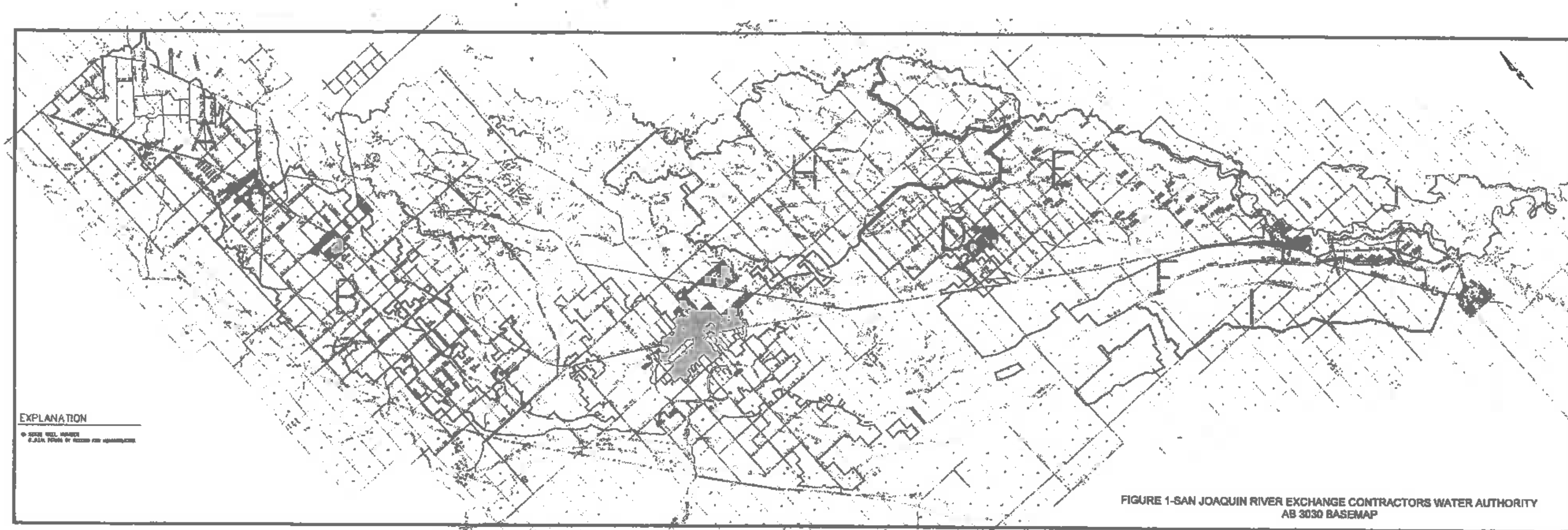

FIGURE 1-SAN JOAQUIN RIVER EXCHANGE CONTRACTORS WATER AUTHORITY
AB 3030 BASEMAP

erally similar aquifer, water supply, and drainage characteristics. Detailed evaluations of the groundwater conditions within the boundaries were performed by Kenneth D. Schmidt and Associates in 1997 ("Groundwater Conditions in and near Central California Irrigation District"), and in 2007 ("Update on Groundwater Conditions in the San Joaquin River Exchange Contractors Service Area"), and in 2013 (another update). The evaluations included: 1) subsurface geologic conditions, 2) depth to water, water-levels elevations, the direction of groundwater flow, and water-level trends, 3) aquifer characteristics, based on numerous pump tests and aquifer tests on about two dozen wells, 4) land surface subsidence, and 5) groundwater quality in both the upper and lower aquifers. The 2013 update also includes more detailed information on land subsidence and on the three proposed water storage project areas.

DEMANDS ON THE GROUNDWATER BASIN

In addition to the yearly demands placed upon groundwater to meet the conjunctive use requirements to supplement the Exchange Contract surface water, other demands are placed upon the basin.

Surface Water Transfers

Each of the four entities comprising the Exchange Contractors have developed and adopted transfer policies.

All water transfers have potential impacts on the aquifer. Three types of transfers are possible based on: 1) groundwater substitution, 2) fallowing of crops, and 3) conservation. Of these, groundwater substitution has the highest potential impact to groundwater. CCID, FCWD, and SLCC allow groundwater substitution type transfers, but the CCC does not allow groundwater substitution. Its policy states that "no transfer of groundwater to areas outside the Company service area will be approved and no transfer of surface water without fallowing the land to which such surface supply would have been delivered will be approved.".

Groundwater Pumping into the Delta-Mendota Canal

The San Luis and Delta-Mendota Water Authority (SL&DMWA) has administered a program to allow groundwater pumping into the Delta-Mendota Canal for drought contingency. Figure 1, (the AB 3030 basemap), shows the groundwater pumping management areas developed by the SL&DMWA groundwater management committee. The potential impacts to the Exchange Contractors are 1) degradation of the surface water quality delivered through the Delta-Mendota Canal, and 2) land surface subsidence along the CCID outside canal and the Delta-Mendota Canal. High salinity and boron concentrations have been problems in many DMC pumper wells. For the most part, the pumped water is generally not suitable for use on crops without blending with the better quality surface water. Land surface subsidence along the Outside Canal was discussed by KDSA (2013). The CCID undertook a five million dollar improvement project on the Outside Canal, to raise banks and replace structures due to subsidence. Subsidence along the Delta-Mendota Canal is shown in Figure 2.

Groundwater Pumping into the Mendota Pool

The Mendota Pool, on the San Joaquin River, is the location were the Exchange Contractors receive most of the substitute water under the Exchange Contract. For two decades, there has been concentrated groundwater pumping in the Mendota Pool area. The magnitude of the pumping depends in large part on the yearly allocations by the USBR to Central Valley Project agricultural contractors. In response to reduced allocations, groundwater pumped near the Mendota Pool is introduced into the Pool and either delivered to adjacent Central Valley Project agricultural contractors directly through pumping facilities or credit is given for the groundwater pumped into the Pool, and in exchange, the USBR provides deliveries to Westlands Water District. The potential impacts of the pumping program are water quality degradation, well interference, and land surface subsidence affecting the Exchange

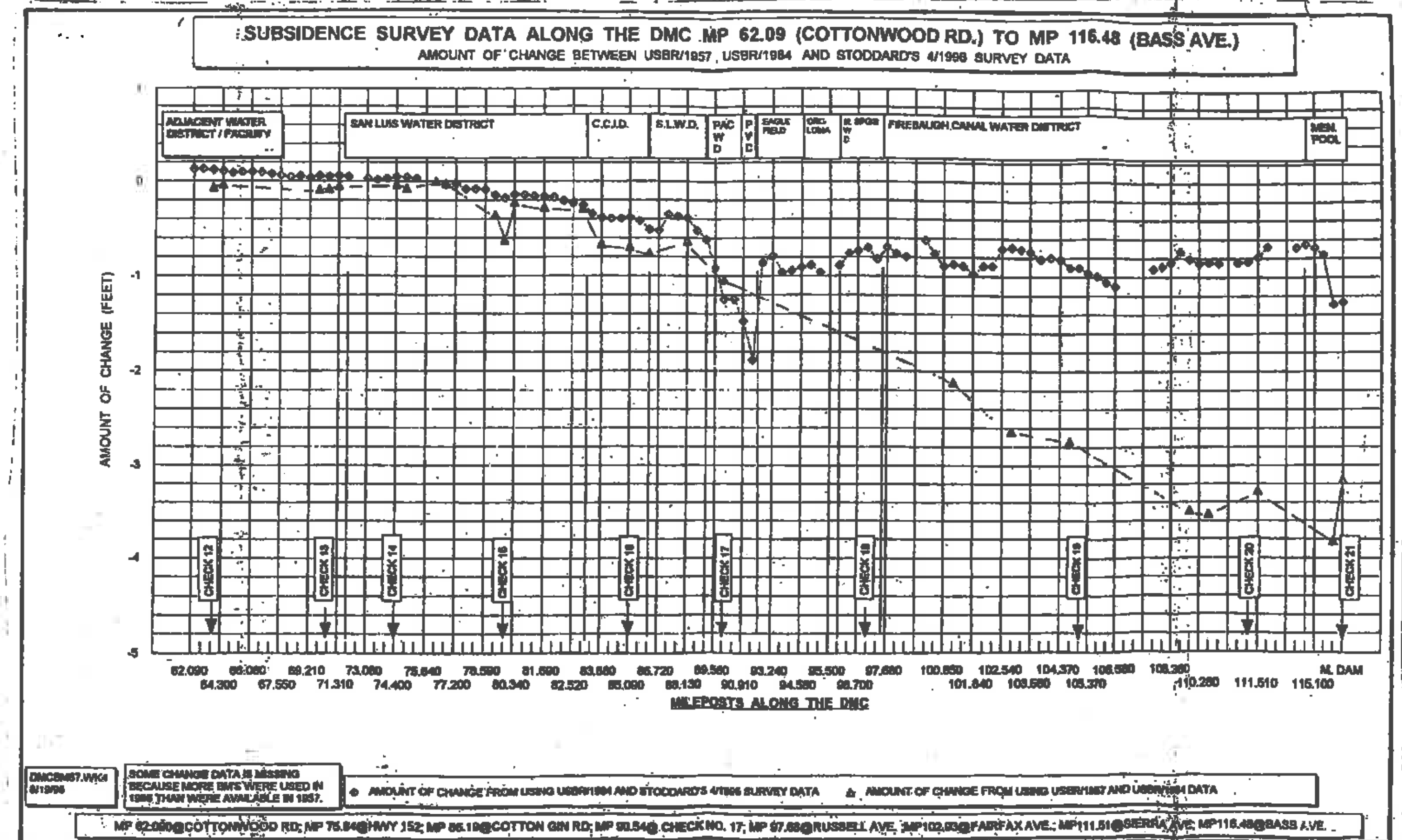

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FIGURE 2-SUBSIDENCE ALONG THE DELTA-MENDOTA CANAL

Contractors gravity canal system headwork's facilities and the Mendota Dam.

The Mendota Pool Group (MPG) transfer pumping began in 1989 to make up for some of the cutbacks in deliveries of Central Valley Project and State Water Project surface water during the drought. The greatest MPG transfer pumping was during 1991-1992 and 1994. There was little MPG transfer pumping between 1995 and 1999, except make up for some of the cutbacks in deliveries of Central Valley for a four-month period in 1997.

A pilot pumping and monitoring program was undertaken in 1999 to determine the impacts of MPG transfer pumping on water users within the SJREC Water Authority and Newhall Land and Farming Company (NLF) service areas. Extensive monitoring of pumpage, water levels, water quality, and compaction was initiated in 1999. This led to a settlement agreement that provided for continued MPG pumping, constrained by the results of monitoring and other factors. The extensive monitoring has continued to the present.

Annual reports are prepared on the results of the monitoring. The results of monitoring have been used to revise the pumping program to mitigate adverse impacts. For example, pumpage from the lower aquifer has been limited, primarily due to drawdowns and land surface subsidence. Presently, studies are underway to evaluate a possible extension of the original 10 year agreement.

Migration of Poor Quality Groundwater

Water-level elevation contours for the upper aquifer (above the Corcoran Clay) were provided by KDSA (1997, 2007, and 2013). These maps indicate that groundwater enters the upper aquifer from upslope areas along virtually all the west and southwest boundaries of the Exchange Contractors service area. Certain areas west and southwest of the Exchange Contractors boundaries contain poor quality groundwater. The areas include 1) areas recharged by creeks south of Los Banos Creek and north of Panoche Creek, 2) the area southwest of the Firebaugh-Mendota Area, and 3) the area south of Orestimba Creek.

Urban Groundwater Pumpage

Urban groundwater issues facing the Cities within the Exchange Contractors service area were summarized by KDSA (2008). In addition, cooperative groundwater studies have been done during the past two decades by the CCID and the Cities of Mendota, Los Banos, Gustine, and Newman. The first Mendota study was completed in February 1999, and a later study was conducted about possibly expanding pumpage from the new City well field. Studies in Los Banos were completed in 1991 and updated in 1998.

A study focusing on the area along Los Banos Creek was completed in 2010. Studies in Gustine and Newman were completed in 1992 and updated in 2001. High manganese concentrations in well water have been a problem in Firebaugh and Mendota. High salinity water was also a problem in Mendota, prior to several years ago. As a result of the Mendota study (KDSA, 1999), the City developed a new well field in the mid-2000's, to mitigate water quality degradation coming from the area west of Mendota. The City of Dos Palos developed a surface water supply because of the poor chemical quality of the groundwater.

In and near Los Banos, Newman, and Gustine, groundwater of suitable quality for public supply has been developed through test hole exploration and enhanced well construction programs. However, a number of potential well sites have been found to be unsuitable. The establishment of a maximum contaminant level (MCL) for hexavalent chromium will have a significant effect on these cities. This is because natural hexavalent chromium concentrations in groundwater tapped by these cities often exceeds this MCL. Thus treatment for hexavalent chromium or development of an alternative water supply may be necessary.

Land Subsidence

Land subsidence along the DMC was previously discussed.

In addition, a serious subsidence problem has been documented in the Red-Top El Nido Area. Figure 3 shows long-term land surface elevations along the Highway 152 transect. Until about five years ago, most of the subsidence was east of the Bypass, but now this subsidence has expanded to the west and accelerated. This is because of the development of numerous new wells tapping the lower aquifer (below the Corcoran Clay). Figure 4 shows land surface elevations along the Arroyo and Poso Canals, and Figure 5 shows recent land subsidence in the Red-Top El Nido Area. The subsidence just during the past few years has exceeded one foot in places and can have enormous undesirable consequences, which are discussed later in this plan.

ELEMENTS OF THE PLAN

The elements of the original plan were divided into two categories. Implementation of each of the elements proceeded concurrently.

Monitoring, Data Acquisition, and Evaluation

This element is subdivided into 1) regional activities, and 2) site specific (done to address specific groundwater issues).

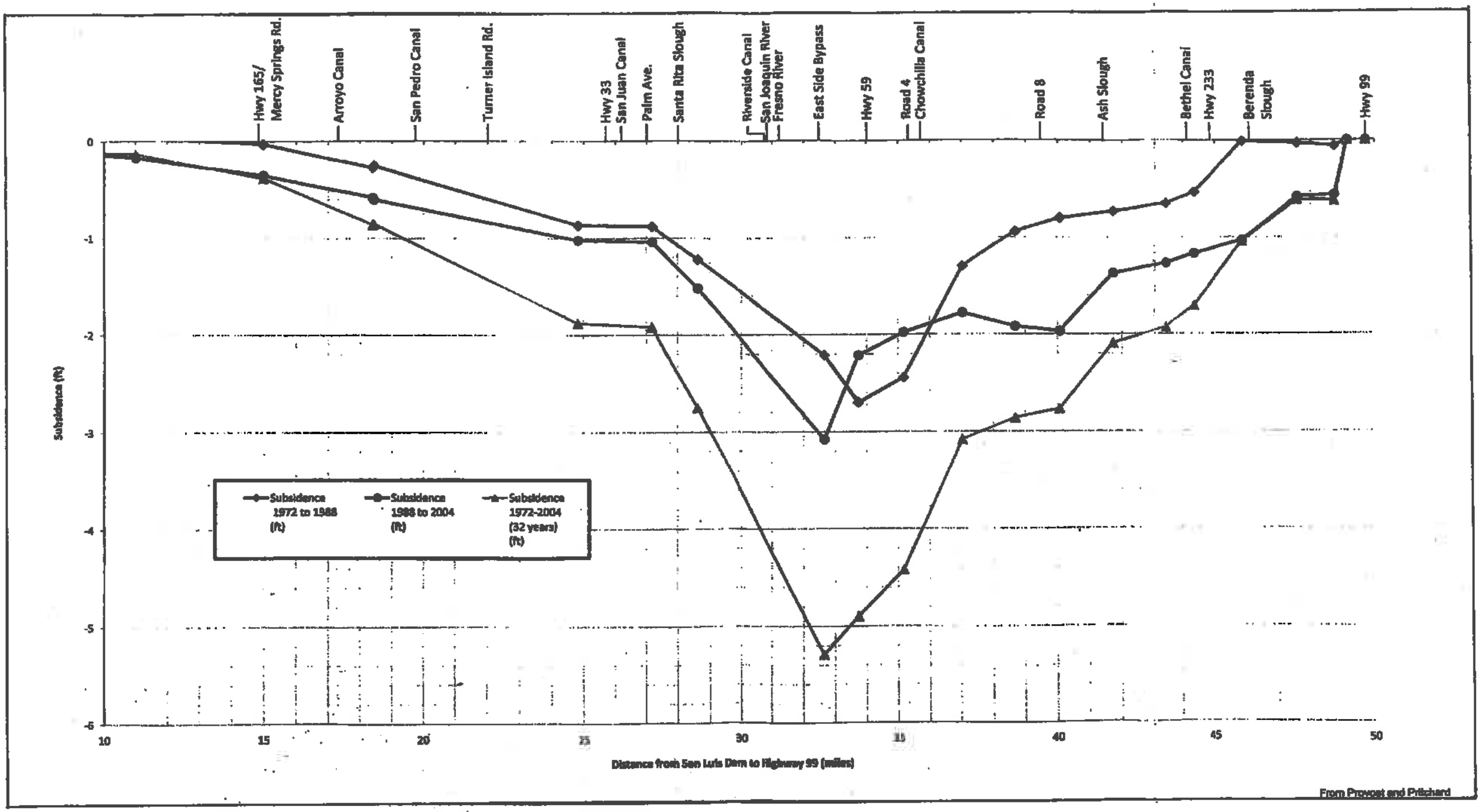


FIGURE 3-LONG-TERM LAND SURFACE ELEVATIONS ALONG THE HIGHWAY 152 TRANSECT

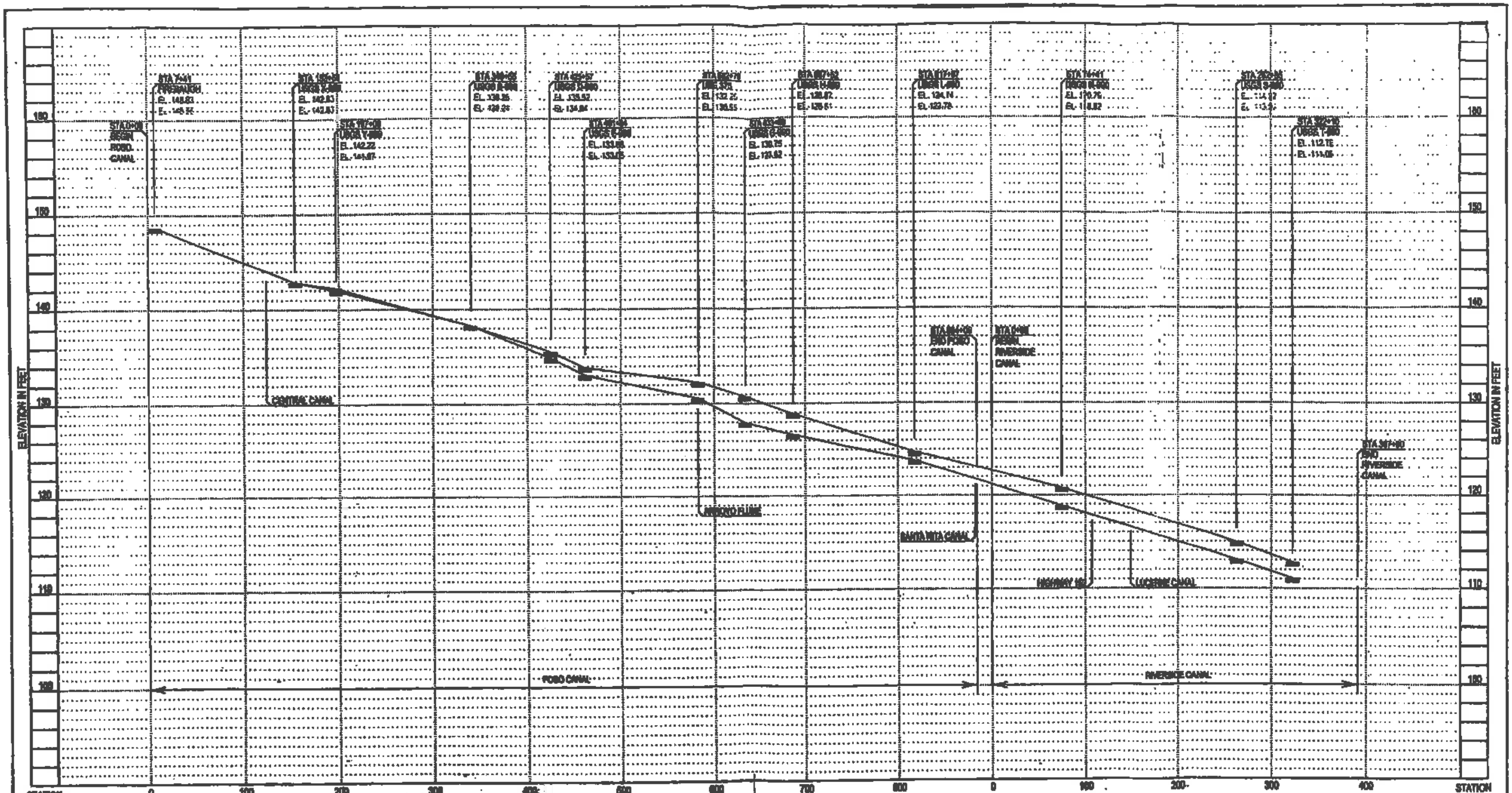


FIGURE 4-LAND SURFACE ELEVATIONS ALONG THE ARROYO AND POSO CANALS

From Central California Irrigation District

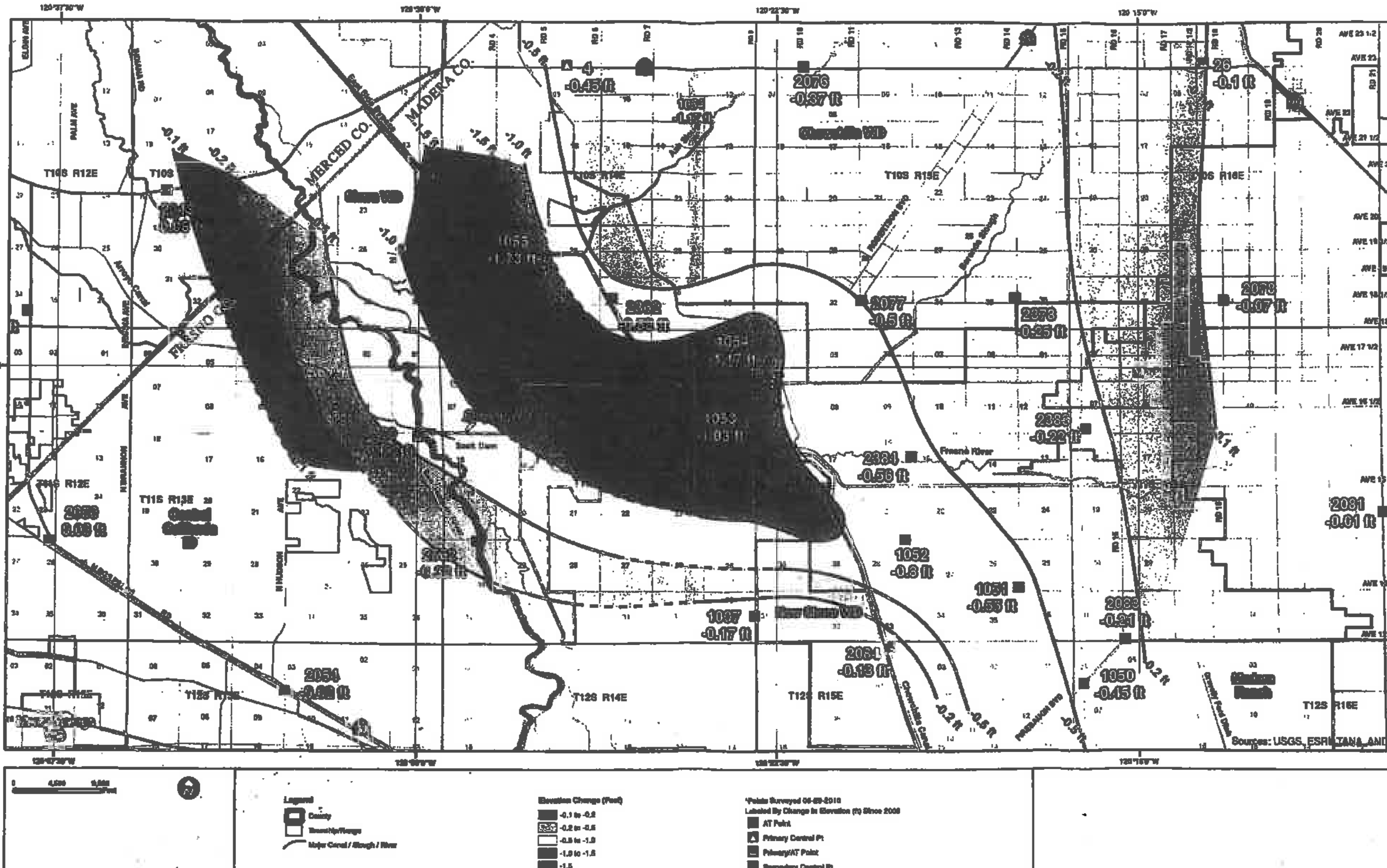


FIGURE 5-RECENT LAND SUBSIDENCE IN THE RED TOP-EL NIDO AREA

Regional Activities

Overall or regional activities to be conducted by the Exchange Contractors include the following.

Coordination with Other AB 3030 Groundwater Management Plans and Cooperation. The Central Valley Project agricultural contractors located upslope of the Exchange Contractors service area have developed two regional groundwater management plans through the San Luis and Delta-Mendota Water Authority (Stoddard & Associates, 1996a and b). As part of these plans, Stoddard & Associates (1999a and b) prepared associated groundwater monitoring plans. Both of the management plans were updated in 2007. In order to monitor the larger connected groundwater basin, future regional monitoring would include a coordinated data gathering effort with the upslope areas. Madera County developed an Integrated Regional Water Management Plan in 2008 for the area northeast and downgradient of the Exchange Contractors service area. This plan focused on groundwater overdraft, particularly in non-Districted areas. The Aliso Water District located, just east of the CCC Service area, has recently completed an updated AB 3030 plan. Madera County is also updating its AB 3030 plan, which is to be completed in early 2014.

A program will be pursued such that the necessary studies are accomplished and water-level measurements and water sampling results will be coordinated and gathered by each respective agency and shared.

Water Levels. Monthly water-level measurements are now being made in some areas. In the Red Top Area, transducers are recommended for a number of deep wells to provide continuous water-level records. Water-level elevation maps will be prepared approximately every five years, except in the Red Top area, where they would be prepared at least every two years. Data gaps in the existing monitoring plan were filled in accordance to the recommendations contained in the KDSA 1997 report. As part of the 2008 update by KDSA, a water-level elevation and direction of groundwater flow map was prepared for the upper aquifer for Spring 2006. Sufficient data were not available to prepare an updated map for the lower aquifer for the entire service area for 2006. As part of the 2013 update a map was prepared for the upper aquifer for Spring 2013. Another updated map for the lower aquifer was prepared, utilizing 2013 data where available.

Water-level hydrographs were provided for a number of wells in the KDSA 1997, 2008, and 2013 existing conditions reports. As part of this plan update, the CCID updated many of these hydrographs through early 2013. The KDSA 2013 existing conditions report update contains a detailed discussion by subarea of the water-level trends for 1962-2013.

Aquifer Characteristics. The Exchange Contractors have continued to obtain specific capacity values from pump tests for wells within the Districts. As part of this updated plan, a specific capacity map was prepared by CCID for 2012, and this was presented in the 2013 existing conditions hydrogeologic report update. Updated maps for specific capacities will be prepared about every five years.

Pumpage. Annual measurements and estimates of pumpage have been continued. Pumpage has been determined for each subarea, and divided into the upper aquifer, the lower aquifer, and composite (from both aquifers). Table 1 provided a pumpage update through 2012.

Land Subsidence. Three compaction recorders are now being operated in the area. One is at Yearout Ranch, southeast of Mendota, which is operated by CCID, as part of the MPG monitoring program. A second is the Fordel recorder, adjacent to the Mendota Airport, which is operated by the MPG. The third is along the DMC near Russell Avenue, which is operated by the SL&DMWA. Information on the first two recorders is provided in the annual monitoring reports for the MPG program. These two record subsidence data due to pumping from above the Corcoran Clay.

In addition, the Scripts Institute has established a continuous land surface elevation monitoring station (CORS) at Meyers Farms, about one mile southeast of Mendota. This monitoring has provided additional information on subsidence near Mendota including from pumpage below the Corcoran Clay.

At least one new compaction recorder is recommended in the Red-Top Area.

Groundwater Quality. At least every five years, water samples are obtained from numerous selected wells for irrigation suitability analyses. Maps will be periodically prepared to show the geographic distribution of selected constituents in the upper and lower aquifers. As part of the 2008 and 2013 updates, updated maps of electrical conductivity were prepared. These maps were generally similar to the previous map, and evidence was presented that indicated the northeasterly flow of poor quality groundwater has continued in the Mendota-Firebaugh area. As part of the 2008 and 2013 updates, water quality hydrographs were prepared for electrical conductivity of water from district supply wells and other selected wells. These hydrographs will be updated every several years in the future.

<u>Site Specific Activities</u>

These activities are to be accomplished in response to specific groundwater issues. Many of the activities will be accomplished cooperatively with other entities or made a requirement of pumping program.

<u>Land Subsidence</u>. If land subsidence isn't stopped in the Red Top-El Nido Area, there will be three major impacts:

1) Flooding in western Madera and Merced Counties.
2) Up to 20 percent reductions in water district conveyance capacities (CCID and SCCC).
3) The San Joaquin River Restoration program could be jeopardized.

In addition, collapse of irrigation wells casings would continue. The estimated reduction in reduced canal capacities during the past four years has resulted in an estimated reduced flood flow capacity of about 4,000 cubic feet per second (cfs).

Alternative solutions to the subsidence program are being evaluated. Included are on-site facilities and acquisition of a supplement water supply. A major goal is to reduce pumping from below the Corcoran Clay (from the lower aquifer), which is the cause of the land subsidence. On-site facilities include development of recharge ponds (estimated 720 acres) and the associated turnout facilities, replacement of deep irrigation wells with ones tapping only the upper aquifer (estimated 30 wells), and development of a surface water distribution system to serve about 25,600 acres of farmland.

A pilot recharge test has been conducted at the Triangle T Ranch in a basin north of the Fresno River and west of the Bypass. Infiltration rates of about 0.7 acre-feet per acre per day have been achieved. In addition, soil borings have been done at some other sites and more borings are planned, to further delineate the favorable areas for other recharge basins.

Several shallow new irrigation wells have been developed in the Madera County part of the area that tap only the upper aquifer and are near recharge sources. In addition, a pilot project has been planned to evaluate recharge of well water from the upper aquifer down into the lower aquifer.

Acquisition of about 10,000 acre-feet per year of supplement water supply is being evaluated, through the Madera Water Bank.

<u>Water Storage Projects</u>. Recharge/recovery projects being actively evaluated include: 1) Los Banos Creek, 2) Orestimba Creek, and 3) the Columbia Canal Co. service area.

Los Banos Creek

For the Los Banos Creek project (Figure 6), the total estimated storage capacity ranges from about 15,000 acre-feet in wet years to 35,000 acre-feet in dry years (when water levels are deeper). Project 1 involves conveyance of Los Banos flood releases to the DMC. There would be a gravity diversion of 250 cfs and a pumped diversion of 150 cfs. Project 2 would be built to convey water from an existing pipeline from the California Aqueduct to deliver water to the Los Banos Reservoir for storage. An existing San Luis W. D. pump station would be used. Water from the Los Banos Reservoir would be released in a controlled manner down the Los Banos Creek channel below the Los Banos Dam to infiltrate in the channel, primarily in the reach upstream of the Main Canal. Stream gaging sites would be used at the DMC, the Outside Canal, and Main Canal to determine recharge. Recovery wells would be constructed adjacent to the creek, tapping strata above the Corcoran Clay, for return of stored water to the Outside and/or Main Canals.

Orestimba Creek

For the Orestimba Creek project, Orestimba Creek flows and other imported water supplies would be diverted onto lands near

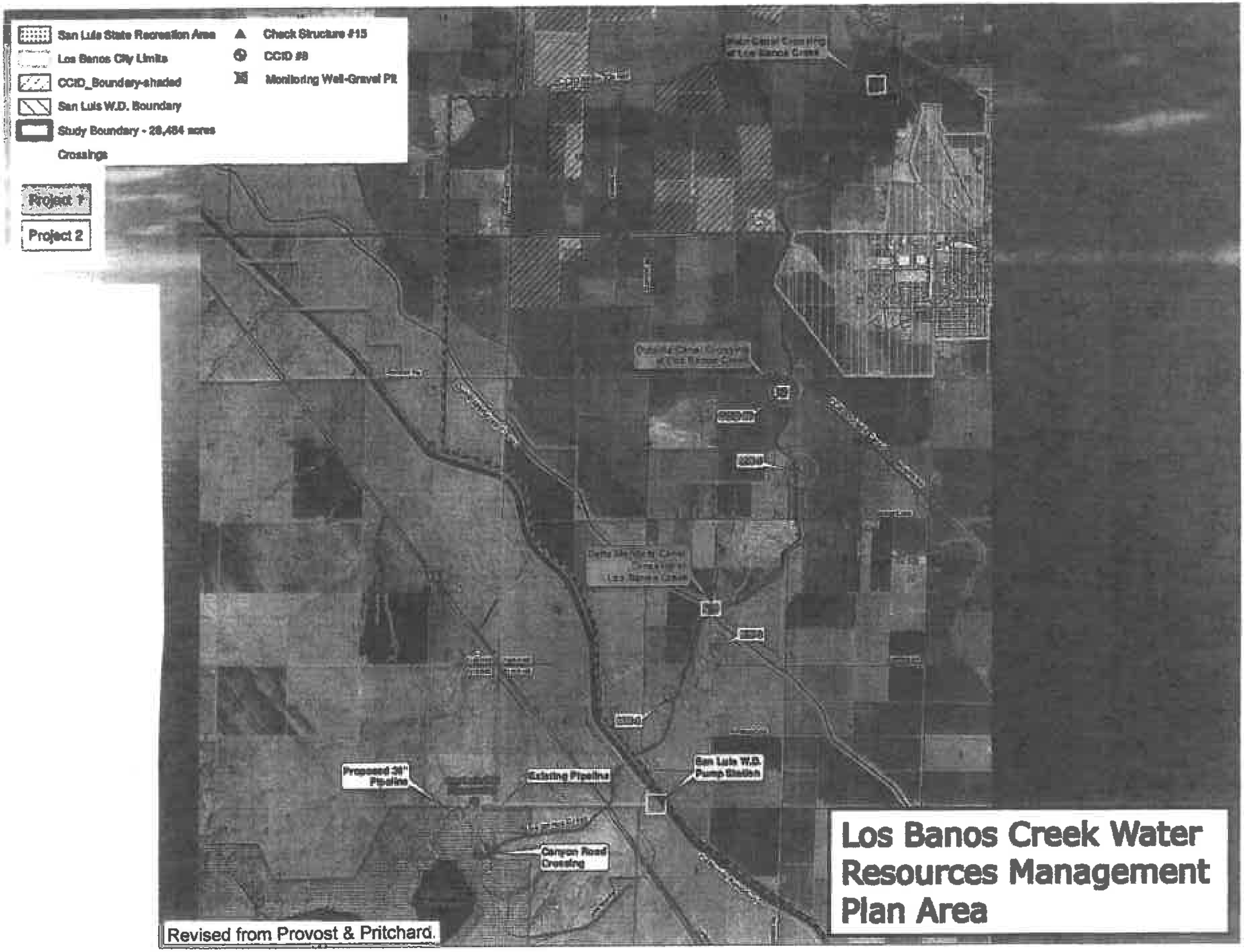


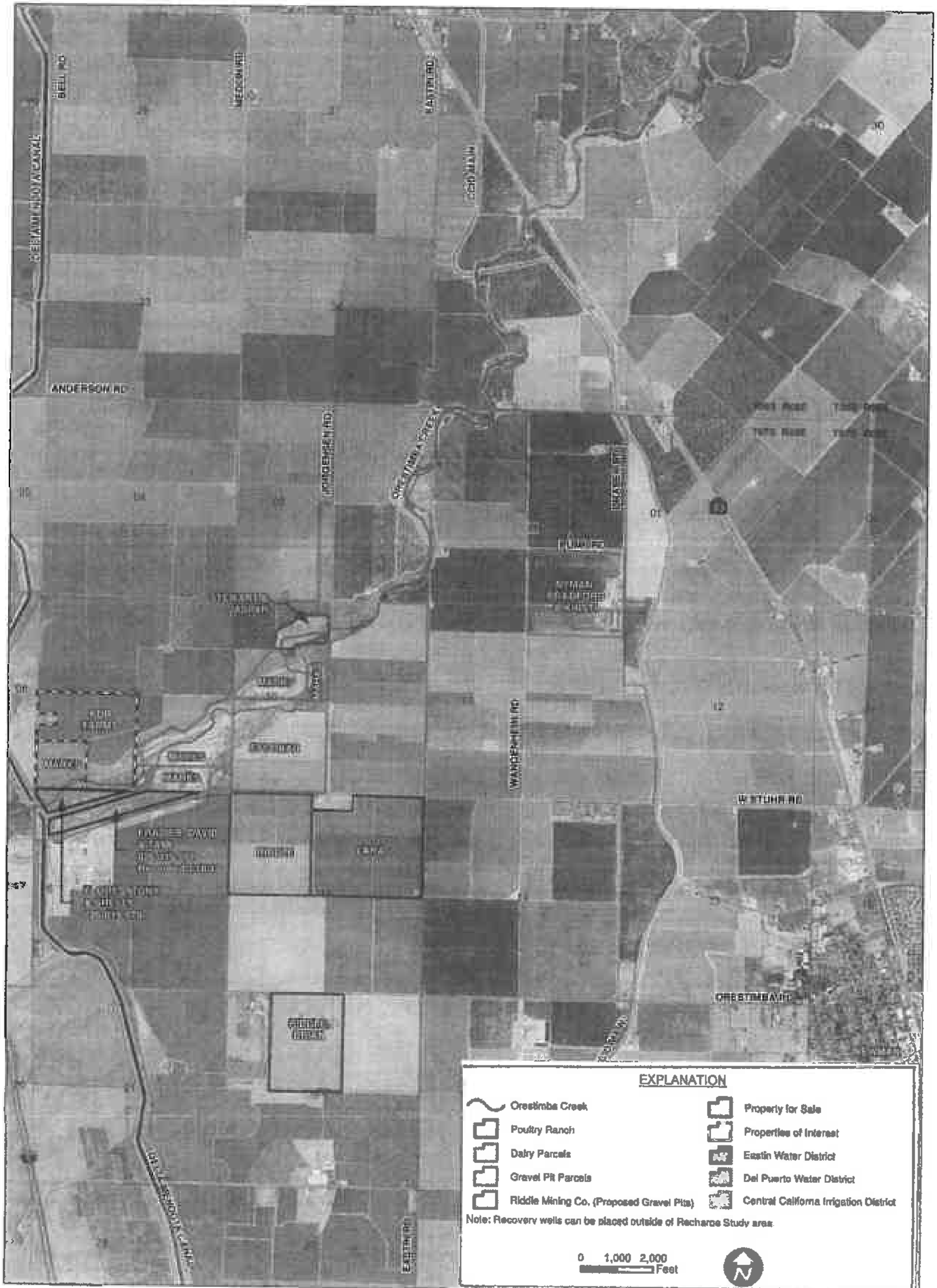
FIGURE 6-LOS BANOS CREEK AREA

Orestimba Creek for recharge and subsequent storage and recovery. The creek channel and the DMC would be used to convey water to and from the storage areas. Water supplies could include surface water from the CCID and Del Puerto Water District and high flows in the Kings River and San Joaquin River. Recovery wells to pump the stored water would be constructed near recharge facilities, as well as along the CCID Main Canal. The City of Newman could participate in this project by recovering stored water in exchange for pumping and delivering groundwater suitable for irrigation to participating districts.

Figure 7 shows the location of Orestimba Creek and potential recharge sites. Included are the creek channel, several existing gravel pits, two proposed gravel pits, and another property south of Orestimba Creek and east of the DMC. The available storage capacity in the area is estimated to range from about 15,000 to 25,000 acre-feet.

Columbia Canal Co. Service Area

Water from high flows in the San Joaquin and Kings Rivers and surface water from the CCID would be delivered for in-lieu recharge and/or direct recharge in the Columbia Canal Co. service area. Diversion works include the Chowchilla Bypass, Lone Willow Slough, Big Bertha pumps, and the Columbia Canal intake



Modified from Provost & Pritchard.

FIGURE 7-ORESTIMBA CREEK AREA

pump. There are four existing recharge basins at the New Columbia Ranch. The 7101 and 7103 basins are in the Columbia Canal Co. Service Area and the 7102 and 7104 basins are to the east in the Aliso W.D. Figure 8 shows the Columbia Canal Co. service area. The estimated recharge capacities of the 7101 and 7103 ponds are about 10 cfs and the recharge capacities of the 7102 and 7104 ponds are about 55 cfs. Phase I involves delivery of 8,000 acre-feet of water to the Columbia Canal Co. service area and subsequent recovery of 6,000 acre-feet of this water in a critical year. Phase II may involve storage of water in the Aliso W.D.

Surface Water Transfers. For well water substitution transfer request the following hydrogeologic items will be required:

1. Locations and types of wells in vicinity, including domestic and stock wells.

2. Subsurface geologic conditions, extent of confinement, and possibly impacted aquifers. Existing sections could be used if they are near the proposed project and representative of conditions at the project site.

3. Depth to water, direction of groundwater flow, and any

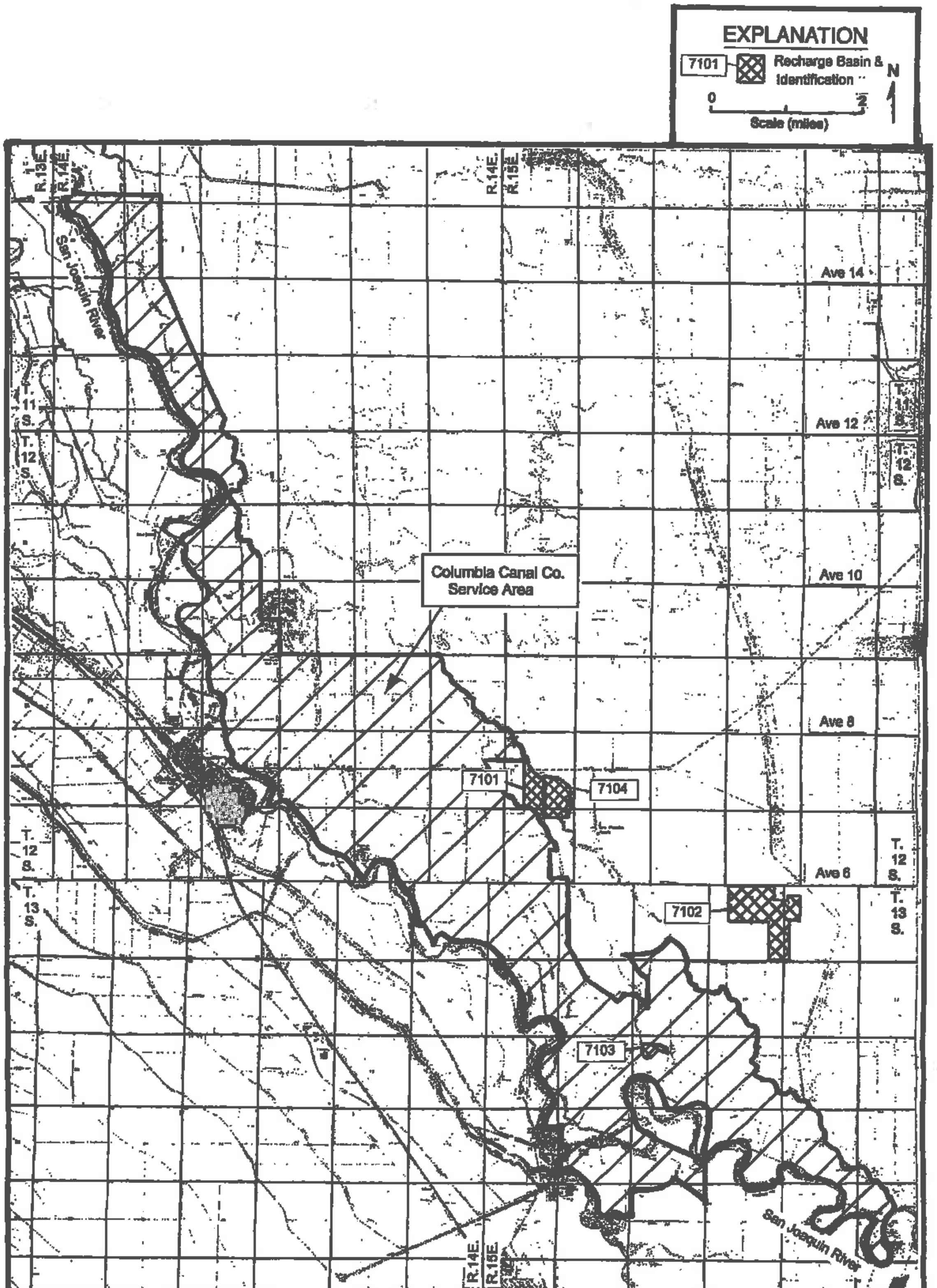


FIGURE 8-COLUMBIA CANAL CO. SERVICE AREA

changes that would occur. Existing water-level maps and hydrographs are expected to be suitable in most cases. However, in areas where data gaps are present water-level measurements and preparation of local maps are expected to be necessary.

4. Long-term water-level trends and the status of groundwater overdraft.

5. Aquifer characteristics.

6. Potential for land surface subsidence, particularly where groundwater is confined.

7. Overall water budgets (consumptive use versus recharge) for the pre-existing situation for the proposed project.

8. Groundwater quality, identification of problem constituents, and the potential migration of poor quality groundwater.

9. Subsurface drainage problems and the possible beneficial impacts of the proposed project.

10. Drawdown projections due to the proposed project.

11. A technical report by a certified hydrogeologist including supporting tables, illustrations, and appendices. The report will document pre-existing conditions and evaluate possible hy-

drogeologic impacts of the proposed transfer.

Pool Pumpers. A process is now in place to monitor the effects of MPG pumping in order to monitor potential impacts from future pumping and in cooperation and participation with other entities. As discussed previously, annual reports on the results of monitoring are prepared.

Delta-Mendota Canal Pumpers. In order to monitor potential impacts from future pumping the following monitoring is needed.

1. Annual water-level maps for each zone being pumped.

2. Continuous water-level recorders.

3. Annual pumpage.

4. Annual reports on the compaction recorder located at Russell Avenue.

5. Water quality maps prepared every five years.

6. Water-level and quality hydrographs.

Cities. Focused groundwater quality studies will be periodically performed. In the case of Mendota, Newman, Gustine, and Los Banos, this will require periodic updates of the joint studies previously accomplished. Firebaugh would benefit from an updated study in about five years. Attachment B contains a copy of the sample MOU to be utilized outlining the scope of work and subdivision of costs.

Migration of Poor Quality Groundwater. As compilation and analyses of regional monitoring activities identify areas or pockets of migration of poor quality groundwater, more focused monitoring in these areas may be needed. Case by case evaluations of risk to the groundwater will be made, and site specific monitoring will be developed as necessary.

Water Banking. There is potential for water banking in the Exchange Contractors service area, exclusive of FCWD and the Camp 13 Drainage District. Water banking could involve direct recharge in basins or stream channels, or in-lieu recharge. In-lieu recharge generally involves delivering water to users who would otherwise have pumped groundwater. When pumping is decreased, water levels tend to recover. Later, groundwater is pumped and delivered to the banking partner(s). The in-lieu type of recharge has been practiced for years in the Semitropic WSD, and is particularly applicable in areas where subsurface geologic conditions aren't favorable for intentional recharge.

Areas considered to have potential for direct recharge include parts of the Columbia Canal Water Co., where depth to the shallow groundwater is generally more than about 30 feet. There are several areas along the west side of the CCID where direct recharge by basins or stream channels may be possible. Included are the fans of Los Banos Creek and Orestimba Creek, where permeable deposits are present, groundwater salinity is relatively low, and depth to water is adequate to allow recharge.

In-lieu recharge normally involves expanding District surface water delivery facilities to areas previously served by groundwater pumpage. The banking partners normally pay for these facilities and in wet years their excess water is delivered to farmers who then decrease their groundwater pumpage. When the banking partners need water returned, it is pumped from wells and delivered to the banking partners, or exchanges of surface water supplies can also be used.

Development of Drought Contingency Strategies

Drought contingency strategies are necessary during times when multiple critical water years occur, or when the USBR cannot provide delivery capacity flexibility during the seven moth period. An itemized list of drought period procedures will be developed and adopted. Such a list might include:

1. Reducing irrigation demand peaks through water ordering strategies.

2. Purchase of private well water and an associated emergency notification and purchase procedure.

3. Maximum pumping from drainage wells and tailwater return pumps.

4. Borrowing space and or water from other Exchange Contractors.

5. Provide economic incentives for growers to pump wells not plumbed into the canal system.

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CCIDOBSERVER

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Reclamation announces Non-Critical (100%) allocation for CCID Growers

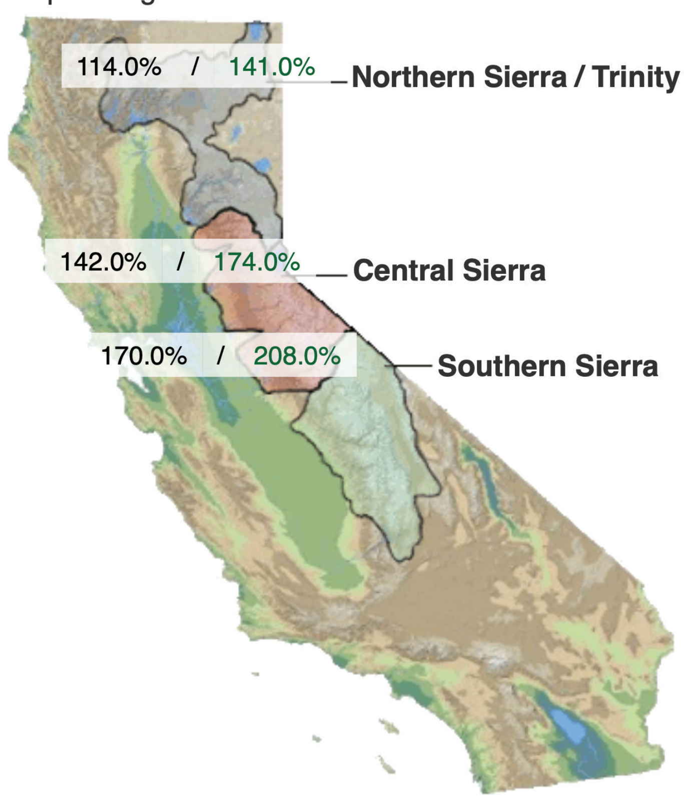
January rain was a welcome sight after a string of critical water years. This year the target inflow to Shasta is 4 million acre-feet. The results of the February snow survey modeled an inflow to Shasta of almost 4.2 million acre-feet under the 90% exceedance forecast. This triggered the Bureau of Reclamation to announce that CCID will receive a Non-Critical Allocation under the Exchange Contract.

February has been categorically dry. The Bureau will continue to provide monthly assessments of the allocation and there is a possibility that the 100 percent allocation could change. However, we are seeing a decent snow pack above Shasta. The current expectation is that we will see that snow generate runoff rather than being absorbed through the volcanic rock like we observed in the previous few years. May we all continue to pray for rain.

Provided by the California Cooperative Snow Surveys

Data For: **22-Feb-2023**

% Apr 1 Avg. / % Normal for this Date



2023 Grower Meeting

Mark your calendar for the upcoming Annual Grower Meeting on March 29th at the Los Banos Fairgrounds in the O'Banion Building. Dinner will be served at 6 p.m. followed by a presentation of important topics for 2023.

- Water Supply Update
- District Operations
- In-Depth Water Quality Discussion
- Preserving the Exchange Contract
- And more

Please call the CCID Main Office at (209) 826-1421 by March 24th to reserve your seat.

CONSERVATION SPOTLIGHT

WATER QUALITY

Where Problems meet Solutions:

For over 7 decades, CCID has been providing irrigation water to farms. “Much of what we have done in California is focus on water supply and water conservation” said General Manager Jarrett Martin. “At CCID, we have broadened our efforts to more holistically manage the resource with a focus on water quality.”

Each time we irrigate, salts are imported to our soils. The problem is exacerbated during droughts as we rely more on our aquifers that have a higher salinity, as well as other harmful constituents. In dry years, we also observe a decline in water quality moving down the Delta-Mendota Canal.

Water quality and soil health are quite literally foundational to the productivity of the farm. While flushing soils with fresh water is best, extra water in California has become increasingly difficult to find. “While each field is unique, one of the biggest deficiencies in soils across the Central Valley is carbon fixation and a reduction in organic matter,” stated Richard Kreps a Certified Crop Advisor (CCA) and Sustainability Specialist (SSp). “We need to use biology to improve our soil health and one simple way is to change the Carbon-Nitrogen relationship. Biology will make our nutrients more efficient while neutralizing some of the more problematic constituents.”

Data is the key to successful management strategies. CCID is taking aggressive actions to enhance our water quality data collection on all wells and drains. Our focus is to develop projects and policies to improve the soil health throughout the District.

2023 Scholarships

The CCID Board of Directors continues to sponsor three scholarship programs, funded by Directors and growers from the District. These scholarships are intended to help students further their education and help offset tuition and book expenses.

2023 CCID Water Awareness Scholarship
Due Date: Wednesday, March 8, 2023
Applicant – High School Seniors

2023 CCID Vocational / Trade School Scholarship in Honor of James O’Banion
Due Date: Wednesday, March 8, 2023
Applicant – High School Seniors pursuing a Vocational / Trade School certification

2023 CCID Redfern Ranch Scholarship for Ag Leadership
Due Date: Friday, April 21, 2023
Applicant – College Students pursuing a career in agriculture

Applicants must submit an application, essay and unofficial transcript to the CCID Main Office by deadlines.
For additional information please contact CCID Main Office at 209-826-1421 or our website at www.ccidwater.org

Apply by

March 10, 2023
or
August 11, 2023

Conservation Program

Step-by-Step

Fill out application on-line or in the office and submit with project design and cost estimate by either deadline

All projects will be reviewed by the Water Conservation Committee for preliminary approval

Once notified of approval, submit construction schedule to CCID

Any changes to submitted design MUST be provided to CCID *prior* to construction

Upon completion of engineering evaluation, notice to construct will be issued

Call CCID for periodic inspections throughout construction

After final inspection, bills are submitted

Completed projects are presented to the Board of Directors and funds are disbursed to Landowner

For Questions or More Information
Please contact:
Tracey Rosin
Conservation Coordinator
Phone: (209) 826-1421
Cell: (209) 777-8060
Fax: (209) 826-3184
trosin@ccidwater.org

Central California Irrigation District

2023 On-Farm Water Conservation Program

The Water Conservation Program **has two sign-up periods for 2023** funding requests: March 10th and August 11th. A project design and cost estimate must be submitted prior to either deadline to be considered for preliminary approval. Water Conservation Program Guidelines are available on-line at www.ccidwater.org. Funding levels may be pro-rated based on the number of applications received.

DEADLINE MARCH 10, 2023 or AUGUST 11, 2023

GRANT PROGRAM

50% cost-share

for all Concrete Lining or Pipelining up to **$600/acre** benefited

25% cost-share

for irrigation enhancements up to **$600/acre** benefited such as:

Tailwater Return Systems, Micro-Irrigation, Drip Systems, Dairy related projects, other irrigation efficiency improvements

LOAN PROGRAM

3% interest loans up to $1,000/acre benefited for farmer's portion after cost-share grant.

One annual payment per year

5 year term for on-farm systems   10 year term for community ditches

Contact your local FSA office for additional funding options

Post Office Box 1231
Los Banos, CA 93635
209-826-1421

Prsrt Std
U.S. Postage
PAID
Fresno, CA
Permit #1242

A look back...

50 Years Ago – Spring 1973

- With 12.21 inches of rain so far this fiscal year and 2.79 inches recorded in the first 14 days of February, compared to a normal total for February of 1.39 inches, no water demand exists at the present time. All local creeks are running intermittently, with 600 CFS being released from the Los Banos Creek Detention Dam, a peak of approximately 2,500 CFS in Orestimba Creek, and an estimated 600 CFS in Garzas Creek. The Bureau of Reclamation commenced with flood releases from Friant Dam on February 12th with a total of 3,500 CFS being released at this time down the San Joaquin River channel.

25 Years Ago – Spring 1998

- It was reported that Friant Dam was releasing 4,000 CFS down the San Joaquin River and that Pine Flat had also began releases and was expected to peak at 3,000 CFS within the next week. The Sierra snowpack was 150% to 165% of normal and it was stated that the Exchange Contractors would be receiving river water through July or August. Shasta inflow to date was 4,700,000 CFS.

10 Years Ago – Spring 2013

- The accumulated full natural inflow to Shasta was 2,007,200 a.f, which was 94% of average, and the latest 90% exceedance forecast by MBK Engineers was for just under 4,000,000 a.f. for the year, which would be enough for a Normal Year allocation for the Exchange Contractors, but with a small carryover. Shasta Dam rainfall was only 49% of average and statewide snowpack was only 78% of normal.

CENTRAL CALIFORNIA IRRIGATION DISTRICT

ON-FARM WATER CONSERVATION LOAN and GRANT PROGRAM POLICY

Adopted: February 14, 1990
Revised: January 18, 2023

1. All projects must be for the benefit of the CCID service area. However, CCID will assist consumers in coordinating with adjoining districts to accomplish mutually beneficial projects. As further assistance, CCID's staff will compile and maintain a list of additional funding sources available for projects.

2. Types of Projects.
    a. Concrete-lined Ditches, Pipeline installations, Tailwater Return Systems, Micro-Irrigation Systems, Drip Tape Irrigation Systems (cost of tape material excluded) and Community Ditch upgrading will be accepted by CCID staff. Installation of deep wells and projects for Urban Development are excluded.
    b. On properties where prior funding has been issued, the life cycle of the project funded must be expended before additional funding can be requested.
    c. All other proposed projects will require consideration by the Water Conservation Committee.

3. The factors considered in order to determine project funding and/or funding priority include but are not limited to:
    a. Quantity and cost per acre-foot of water conserved
    b. Reduction of soil erosion
    c. Reduction of suspended solids in irrigation facilities and drains
    d. Reduction of impacts of drainage discharges
    e. Reduction of leakage from aged facilities
    f. Benefits to drainage impacted areas which reduce quantities or improve quality of drainage discharged
    g. Protection of groundwater

4. As part of the application process, the applicant must meet with District staff to analyze the applicant's conservation project. A design and cost estimate shall be submitted to the District and will be used as the maximum funding allocated for completion of said project. This shall be completed and reviewed before any funds can be committed to a project. Any subsequent alteration in cost or design of the project will not be permitted without additional approval from the Water Conservation Committee.

5. Projects involving community ditches are encouraged to maintain or enter into a Permanent Maintenance Agreement.

6. No work is to be done until the project is approved, and a pre-construction meeting is accomplished identifying applicable Natural Resource Conservation Service (NRCS) construction standards to be utilized. Work must be commenced within six months of approval. The project shall be completed within 18 months of project approval.

7. Ditch and Pipeline projects will be funded at 50% project costs up to $600 per acre benefitted. All other projects will be funded at 25% projects costs up to $600 per acre benefitted. The maximum to be loaned is $1,000.00 per acre benefited, not to exceed a $500,000 loan balance owed per in-District entity. The maximum to be granted is $600.00 per acre benefited, not to exceed $300,000 per year per in-District entity. For Class II entities, loan balances shall not exceed $460,000 and grants shall not exceed $240,000.

8. The term will be 5 years, except under the following conditions, where the term may be extended up to 10 years:

a. The conservation project involves the lining or undergrounding of a community ditch.
b. When the total loan request, combined with the amount owed under any previous water conservation loan, exceeds $500.00 per acre.

9. The loan will be secured as a recorded lien against the county-assessed parcel involved. The Landowner will be required to sign the repayment agreement document.

10. The Landowner is required to sign a Grant Acknowledgment letter to receive grant funding. An Assignment of Benefits letter is available to facilitate payment of grant proceeds directly to the applicant, if so desired.

11. The District will issue payment upon final inspection and completion of the project. Payment will be made to the Landowner. The District's payment will be made after all other funding sources have been awarded. Such payment shall never exceed 100% of the project costs.

12. All loans shall be repaid with single annual payments, due on January 1 each year.
    a. The initial annual installment will be due on the first January 1 that is more than six months after the loan is issued.
    b. The principal amount of the loan shall be repaid in equal amounts over the term of the loan
    c. 3% simple interest on the unpaid principal balance of the loan will be included with each year's billing.
    d. If an annual installment has not been made by March 1, then the entire loan balance will be subject to 1% per month penalties, compounded monthly, for the remainder of the loan period.

RECORDING REQUESTED BY:
Central California Irrigation District

WHEN RECORDED PLEASE MAIL TO:
This recording is for the public benefit pursuant to
the provisions of Government Code
6103. 1(a)(2)(D)
Central California Irrigation District
Post Office Box 1231
Los Banos, CA 93635

CENTRAL CALIFORNIA IRRIGATION DISTRICT
AGREEMENT FOR WATER CONSERVATION LOAN

THIS Agreement is made and entered into this [redacted] day of [redacted], by and between CENTRAL CALIFORNIA IRRIGATION DISTRICT, a political subdivision formed and existing under the California Irrigation District law, hereinafter called "District,"

[redacted]

hereinafter called "Petitioner."

RECITALS

A. Water Code Section 22234 provides that the District may "contract to operate, maintain, or improve ditches and laterals not owned by the District upon petition of at least two-thirds of the owners of land served by such ditches or laterals;" and,

B. Petitioner applies to the District for a low interest water conservation loan the proceeds of which are to improve facilities that provide water and/or drainage service to Petitioner's lands; and,

C. The District has determined that the proposed improvements to the Petitioners' irrigation facilities that are to be funded by the low interest conservation loan will improve water and drainage service, decrease maintenance costs, and promote efficient distribution of District water, and is therefore in the public interest; and

D. The District has allocated money to fund low interest loans to District landowners in order to encourage them to improve facilities that provide water and/or drainage service so as to promote efficient distribution of District water.

NOW, THEREFORE, in consideration of the Recitals set forth above, and the mutual promises and conditions set forth herein, the parties hereto agree as follows:

1. Loan Application. Petitioner hereby applies to the District for a low interest water conservation loan to fund the following improvement(s): Installation of a micro irrigation system for [redacted] acres of [redacted].

2. Total Amount of Loan. The District hereby agrees to advance to Petitioner the costs of the aforesaid improvements in the total amount of [redacted]

3. Terms of Repayment. The costs of the aforesaid improvements shall be fixed by the District and reimbursed by Petitioner as set forth in the schedule attached hereto, the terms and provisions of which are incorporated herein by reference as if set out in full. At the option of Petitioner, the entire charge, or any portion thereof, may be repaid in advance of the scheduled installment dates without penalty and with proportionate reduction in the amount of interest payable hereunder. Interest shall be payable together with and in addition to each annual installment at the simple rate of three percent (3%) per annum on the unpaid balance. If Petitioner sells the real property described herein prior to the full repayment of the charges hereunder, then the entire outstanding balance of charges, plus all accrued interest thereon, shall be immediately due and payable. If an annual installment is not paid when due, or within 60 days of the due date, then the interest rate on the loan will be converted to the District interest rate then in effect for unpaid water bills. At the time of this Agreement, that rate is 1% per month, compounded monthly.

4. Loan is a Service to Petitioner. Petitioner agrees that, in making this loan, the District is providing a service to Petitioner, and Petitioner agrees that any and all monetary charge resulting from Petitioner's agreement hereunder may be added to and become an unpaid charge owed and be

a part of an assessment levied upon the real property of Petitioner that is located within the District boundaries. Furthermore, Petitioner agrees that the amount of any such unpaid charge may be secured by the District by filing for record in the office of the county recorder of any county, a certificate specifying the amount of the charge and the name of the Petitioner; and Petitioner understands and agrees that such notice shall constitute a lien upon all real property in the County owned by the Petitioner. Petitioner agrees on its behalf and on behalf of its successors in ownership or occupancy of the real property that the failure to pay all amounts due under this Loan Agreement will permit the District to refuse water service until all amounts of those charges have been paid in full, including any accelerated loan payments due because of default.

5. Property. The land to which this Agreement pertains is within the County of [redacted], described as follows:

County Assessor's Parcel No. [redacted]
A portion of the [redacted] of Section [redacted], T.[redacted]., R.[redacted]., M.D.B.&M.; containing [redacted] acres, more or less.

6. Petitioner hereby further agrees as follows:

a. Petitioner certifies that all improvements for which this loan application is made are for the express purpose of conserving water and improving Petitioner's agricultural practices on property within the District's service area.

b. All improvements financed hereunder shall remain in place and operational for the purposes described above for a minimum of five years from the date of this Agreement, or the term of the loan, whichever is longer.

c. If, within five years of the date of this Agreement, or the term of the loan if longer than five years, said improvements are removed, or otherwise cease to be used for the purposes expressed above, then the entire loan balance shall be recalculated as if the original loan amount were a regular invoice of the District, at one percent interest (1%) per month, compounded monthly, and the additional amount shall also be immediately due and payable.

7. Petitioner agrees to indemnify, protect, hold harmless and defend the District, its officers, employees, agents, successors and assigns from and against any and all liability, including without limitation, all costs, expenses, attorney fees, and expert witness fees from any claim, action or proceeding brought against the District, its officers, employees, or agents, to attack, set aside, void, or annul, in whole or in part, relating to the loan or improvements to be installed or constructed pursuant to the loan and/or the validity of or money due to the District pursuant to this Agreement. Petitioner agrees that it is not acting as the agent or representative of District in providing for the installation, construction or alteration of irrigation facilities described in Paragraph 1 or the improvements to be installed, and that Petitioner's agreement to indemnify, defend and hold harmless extends to and includes any claims related to those improvements.

8. Binding Agreement. This agreement shall be binding on the heirs, transferees, successors, assigns and personal representatives of Petitioner.

IN WITNESS WHEREOF, the parties hereunto have set their hands the day and year hereinabove written.

CENTRAL CALIFORNIA IRRIGATION DISTRICT

By: ______________________________
Eric Fontana, President

By: ______________________________
Crystal Guintini, Secretary

PETITIONER/OWNER

By: ______________________________
[redacted]

ADDENDUM TO AGREEMENT FOR WATER CONSERVATION LOAN

FOR MICRO-SPRINKLER AND DRIP SYSTEMS

This addendum to CCID Agreement for Water Conservation Loan ("Conservation Loan"), dated [redacted], is entered into this [redacted] day of [redacted], [redacted]. The parties are as described in the Agreement for Water Conservation Loan.

Petitioner's project involves the installation of micro-sprinklers or a drip system. Petitioner is advised and understands that the use of micro-sprinklers or drip systems where the source of irrigation water is a community ditch or pipeline delivery system may result in the concentration of lesser quality water on crops. On community lateral systems, other water users may have discharged irrigation return flow into the ditch, which has blended with irrigation water in the ditch, thereby increasing the load of salts and other constituents in the water supply. Depending on the circumstances that exist that affect the quality of water in the community lateral, use of micro-sprinklers or drip systems may not be compatible with the concentration of salt, and could in some circumstances result in adverse effect on irrigated crops.

Petitioner has made his/her own independent investigation of the benefits and risks of using micro-sprinklers or drip for Petitioner's irrigation application and Petitioner agrees to indemnify, protect, hold harmless and defend the District, its officers, employees, agents, successors and assigns from and against any and all claims and any and all liability, including without limitation, all costs, expenses, attorney fees and expert witness fees in any way connected with Petitioner's irrigation practices and use of CCID irrigation water.

IN WITNESS WHEREOF, the parties hereunto have set their hands the day and year hereinabove written.

CENTRAL CALIFORNIA IRRIGATION DISTRICT

By: ____

Eric Fontana, President

By: ____

Crystal Guintini, Secretary

PETITIONER/OWNER

By: ____

[redacted]

2023 CCID WATER AWARENESS SCHOLARSHIP
Due Date: Wednesday, March 8, 2023

A. The Board of Directors of the Central California Irrigation District (CCID) is sponsoring a scholarship, which will be available to any students who meet either of the following criteria:
   1. A graduating high school student from any of the five school districts within the CCID service area:
      - Newman-Crows Landing Unified School District
      - Gustine Unified School District
      - Los Banos Unified School District
      - Dos Palos-Oro Loma Unified School District
      - Firebaugh-Las Deltas Unified School District
   2. A student graduating from any high school, whose parents or grandparents either farm or own land in CCID or the other member agencies of the San Joaquin River Exchange Contractors (Columbia Canal Company, Firebaugh Canal Water District and San Luis Canal Company).

B. The scholarship will consist of at least $500.00. The Board of Directors has requested donations from the District's landowners and consumers, and there will be one or more additional scholarships offered this year, depending upon how much money is received. The money will be paid in two equal installments to the recipient: one-half after proof of registration at the beginning of the first semester or quarter; and one-half after proof of registration for the second semester or quarter.

C. The scholarship will be available to students seeking education beyond high school in any field at any accredited college or university, community college, or trade or vocational school.

D. Applicants must have a minimum grade point average of 3.0.

E. Applicants must submit an essay of a minimum of 300 words. The essay should include some or all of the following elements
   - The history and current status of the CCID water supply
   - The importance and value of the Exchange Contract to CCID farmers in a drought year
   - The effect of State and Federal regulations on the District's ability to receive its full water supply
   - The importance of local agriculture
   - The applicant's vision as to what part he or she may be playing in local agriculture in the future

   It is suggested that applicants contact Board members, farmers and employees of CCID for information. Some general information about CCID can also be found on the District's website, www.ccidwater.org.

F. The criteria for selection will be:
   1. Essay contents (70%, broken down as follows: 50% contents; 10% organization; and 10% presentation)
   2. Scholastic records (15%)
   3. All activities and service (15%)

G. A committee appointed by the CCID Board of Directors will make the final selection.

I. The application package is to be returned to the CCID Main Office, located at 1335 West "I" Street, Los Banos, or may be mailed to:

   Central California Irrigation District
   Scholarship Committee
   P.O. Box 1231
   Los Banos, CA 93635

J. Applications must be received by the District no later than 5:00 p.m., Wednesday, March 8, 2023, and must include:
   1. A completed application form
   2. An unofficial copy of the transcript
   3. The essay, as described in paragraph F above

2023 CCID WATER AWARENESS SCHOLARSHIP APPLICATION FORM
DUE: Wednesday, March 8, 2023 by 5:00 p.m.

Student's Name: ____________________

Student's Address: ____________________

Phone Number: ____________________ E-mail address: ____________________

Father's Occupation: ____________________ Where Employed: ____________________

Mother's Occupation: ____________________ Where Employed: ____________________

High School Attending: ____________________ Graduation Date: ____________________

Honors and Awards: ____________________

____

____

Offices held in class or school organizations: ____________________

____

____

Record of participation in extracurricular school activities: ____________________

____

____

Community or area services you have performed: ____________________

____

____

Name and relationship of family member who owns or farms in CCID or one of the other Exchange Contractors water agencies (for applicants who are graduating from high school outside the service area):

____

Institution you plan to attend: ____________________

Your major education goal and vocation: ____________________

____

Have you already made your application and been accepted to the school? ____________________

List of sources you contacted for information for the essay: ____________________

____

____

The applicant hereby authorizes high school representatives to release transcripts to the CCID Scholarship Committee if requested. Permission is granted to the Committee to publish and/or duplicate the essay submitted by the applicant, either in whole or in part.

____________________ ____________________

Date Signature of Student

____________________ ____________________

Date Signature of Parent or Legal Guardian

IRRIGATION TRAINING & RESEARCH CENTER
California Polytechnic State University
San Luis Obispo, CA 93407-0730
Phone: (805) 756-2434 FAX: (805) 756-2433 www.itrc.org

Practical Guide for Metergates

by

Dr. Charles Burt and Dr. Daniel Howes

Rev November 14, 2016

Background

This document contains brief instructions on the use of special round canal gates called "metergates" for flow measurement. A metergate differs from a traditional canal gate turnout because it has a hole in the top of the pipe attached to a stilling well downstream of the gate so that the downstream water level can be measured.

Metergates have been used since the early 1900's for flow measurement in addition to on/off control. Recent research conducted by the authors at the Irrigation Training and Research Center has shown that the existing tables for "Armco"-type metergates, published after the 1950's, provide good accuracy for flow measurement (if measurements are made correctly).

Armco-type metergates include round gates from Fresno Valve and Castings (101), Waterman (C-10), and X-CAD (model unknown) gates. In order to properly use these gates, a hole (5/8 to 3/4 inch in diameter) must be drilled in the pipe 12 inches downstream of the back face of the gate (or at the top of a corrugation as close to 12 inches as possible). This hole must be attached to a stilling well at least 6 inches in diameter that protrudes up to the elevation of the top of the gate frame.

Figure 1 shows a common metergate design drawing.

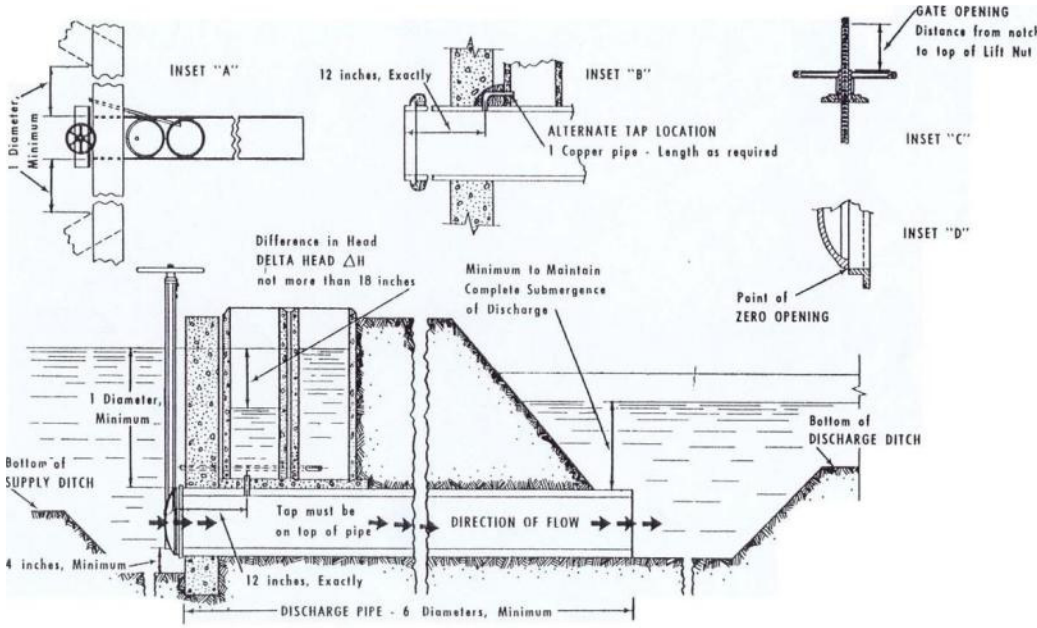


Figure 1. Metergate drawing used by various manufacturers, USBR, etc.

ITRC Research

ITRC evaluated the calibration of a variety of Armco-type round and square gates to determine if published "metergate" calibration tables are accurate. These gates were installed at the ITRC gate calibration facility (**Figure 2**). The gate calibration facility is set up so that the turnout gate is perpendicular to the main supply channel flow, which is typical in field installations.

Figure 2. ITRC gate calibration facility

Summary of ITRC Research Results

1. A high level of accuracy (+/-5%) was found if all of the following conditions are met:
   a. Gate opening range: 20% < Gate opening < 75%
   b. Upstream submergence > 0.5D (where D is the gate diameter)
   c. Stilling well location was 4" to 12" downstream of the face of the gate
2. The distance downstream of the gate at which the stilling well is located (as long as it is within the 4" to 12" range) does not have a significant effect on the flow rate obtained using the tables **unless** the gate is **open** more than 70-75% (percent of fully open).

3. The preliminary evaluation of tangential supply channel flow velocity did not seem to have a significant impact on the flow through the turnout gates. Supply channel velocities up to 1.9 feet per second (fps) were examined in this evaluation.
4. Higher uncertainty (error) occurred at smaller gate openings.
5. Optimum range of operation for the highest accuracy was an opening between 20% and 75% under most conditions. Smaller gate openings seemed to be more problematic than larger gate openings.
6. One issue that is not discussed here but was apparent was the submergence (water level) in the supply canal above the turnout pipeline. Care should be taken to ensure that the water level upstream of the top of the turnout pipe remains above (0.5 × gate diameter). The USBR standard is (1 × gate diameter).

Correction for Stilling Well 4" from Gate

Standard flow tables are based on a stilling well located 12" downstream of the back of the gate. Stilling well measurements were made at multiple locations downstream of the gate to analyze the effects of stilling well location. It was found that, at gate openings less than 70% open, there was **minimal** impact on the change in head from any stilling well closer than 12" to the gate. Once the gate reached an opening of 70% or greater, the ΔH measurement measured at the closer stilling wells (e.g., at 4") began to vary depending on gate size resulting in more significant error.

On average, at gate openings above 75%, the flow rate for a 4" stilling well was 8%-10% greater than the value shown on a 12" stilling well-based table. This adjustment could be applied in the case where gates must be opened more than 75%.

Practical Details

Figure 3 shows one recommended configuration for a metergate. There are some significant differences between **Figures 1** and **3**. With metergates, "the devil is in the details". These are discussed on the next few pages.

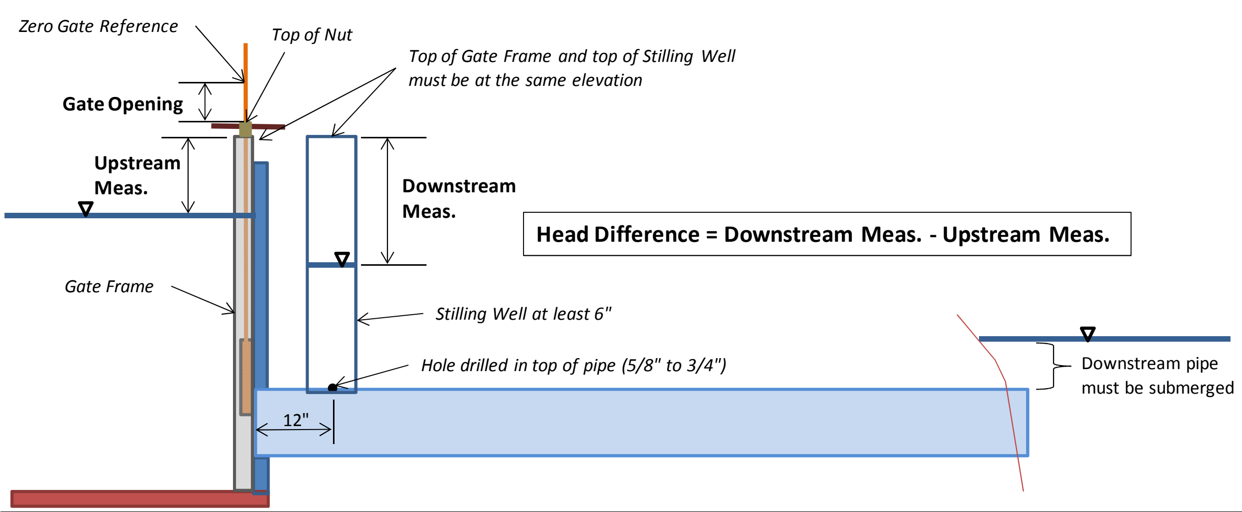


Figure 3. ITRC recommendation for proper metergate installation. These have been improved by Glenn Colusa ID with pre-cast concrete structures.

Practical Detail #1 – The pipe downstream of the metergate needs to be full. The water level needs to rise to some measurable level in the downstream stilling well.

Practical Detail #2 – Sufficient upstream submergence is needed. The required water level in the canal, above the top of the pipe, must be at least ½ of the gate (or pipe) diameter. In other words, if there is a 12" pipe, the water level in the supply canal needs to be at least 6" above the top of the pipe.

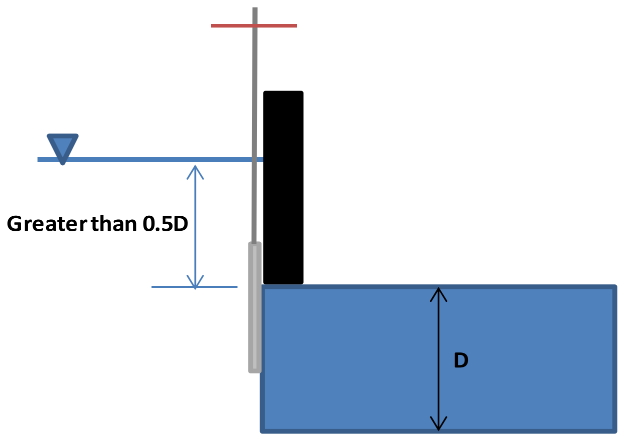


Figure 4. Recommended upstream submergence above the gate to ensure accurate flow measurement

Practical Detail #3 – All of the calibration charts require knowledge of the **gate opening**, as measured by the shaft opening. The "zero" gate opening must be properly determined and marked on the gate shaft. This is not a trivial detail. Specific points are:

1. All measurements of gate opening, as well as the initial marking, must be made after the gate stem has been lifted (opened). This is because there is some "slop" or movement between the shaft and the gate itself.
2. The gate stem will move up some distance before the gate plate itself reaches the bottom of the pipe. The charts depend on knowing the gate opening, not the movement from the gate seating position. The gate must be closed beyond the bottom of the pipe to seal off completely. That sealed position is not the "zero" position.
3. There must be some specific way to measure the shaft position when the bottom of the gate just barely clears the bottom of the pipe – in other words, when there is a "zero opening". This is fairly easy to set and measure if the canal is full. The gate is opened until a narrow strip of paper can be inserted into the crack. **Figure 5** shows photos taken at San Luis Canal Company of a customized tool that is used to detect the actual gate opening, but a similar device can be used to detect the initial "cracking (zero) open" position..

Figure 5. Special tool to detect actual gate opening

4. The shaft needs to be marked in a clear manner so that operators know where the "zero" opening is for the gate when they open the gate. **Figure 6** shows a properly cut notch. It has a sharp bottom edge that was cut with a grinding wheel so that the bottom of the cut is at the same elevation as the top of the bushing. Notice from the color on the shaft that the shaft can be lowered from this position to properly seat the gate.

   The operator will measure from the bottom of cut to the top of the bushing, when the gate is open, to determine the gate opening. This is always measured after an "uplift" action.

Practical Detail #4 – The stilling well needs to have sufficient diameter to dampen the turbulence, and so that operators can see into it. ITRC recommends a stilling well of 6" – 8" diameter, with an access hole of about 5/8" or 3/4" diameter.

Figure 6. Proper cut in shaft to mark the "zero" opening

Figure 7. Stilling well is located the correct distance downstream of the gate, but is so small that there will be tremendous surging (up/down movement), and operators cannot see the water surface

Practical Detail #5 – The stilling well does not need to be centered over the access hole in the top of the discharge pipe. In general, it is good to have the stilling well close to the gate frame/bulkhead, so that it can be supported.

Practical Detail #6 – Make it easy to measure the difference in head (between the water level in the canal, and the water level in the stilling well). In other words, use the same datum (elevation) for both measurements. **Figure 8** shows a stilling well with the top correctly placed at the same elevation as the gate frame, and with a proper diameter. **The top of the stilling well should be at the same elevation as the top of the gate frame (where the bottom of the nut rests), or have the same elevation as another reference point.** Then the upstream measurement should be taken from the top of the gate frame to the water level. The downstream measurement should be taken from the top of the stilling well to the water level. The head difference is the difference between the upstream and downstream water levels.

Figure 8. Stilling well installed on an existing discharge pipe. It is constructed of PVC pipe that is too thin for long life, but it serves as an example of the correct diameter, position, and height.

Figure 9. An old type of dual-stilling well commonly found in Central California irrigation districts. One stilling well was connected to the canal, and the second was directly over the discharge pipe. The idea of measuring down into both stilling wells from the same center point was good, but the top of the stilling well was so close to the ground surface that road maintenance quickly filled these stilling wells with dirt. Also, the side connection between the canal stilling well and the canal itself was too difficult to clean.

Figure 10. This stilling well is properly located, but it has too small a diameter. The operator also needs to know the elevation difference between the top of the stilling well and the gate frame, which requires an extra computation to determine the difference in head across the gate.

Figure 11. Correct height of stilling well to match top of gate frame. However, the diameter is too small. Steel pipe material is good

Figure 12. Large diameter stilling well, with cover to minimize having it fill with dirt from the road. Strong concrete, with the rim of the stilling well at the same elevation as the bulkhead top.

The tables at the end of this report show the key measurements needed to properly use a metergate. The gate opening should be measured from the top of the gate opening nut to a zero gate opening reference. **As mentioned previously, the zero gate opening reference should be marked with a grinder at the gate opening nut on the shaft when the gate is just open enough to breach the bottom of the pipe.**

The Glenn-Colusa ID Configuration

Glenn-Colusa ID (GCID) worked with Briggs (a local pre-cast concrete structure company near Willows, CA) to incorporate the ITRC recommendations into a pre-cast structure. The following photos illustrate their solution, which appears to be excellent. **Table 1** after the photos includes the approximate cost breakdown of the installation.

Figure 13. GCID metergate at Briggs

Figure 14. Pre-cast metergate ready for transport

Figure 15. Installation of GCID metergate

Figure 16. Final concrete for GCID metergate, showing downstream pre-cast outlet box

Table 1. Approximate cost for GCID metergate installation

18" X 6' H-Metergate with precast concrete tailbox						
1). MATERIAL COST	QUANTITY			UNIT	COST/UNIT	COST
STILLING WELL 12" X 6' H W/ LID	1			EA	$340	$340
PRE/FAB 6' H BRIGG'S (metergate box)	1			EA	$470	$470
PLYWOOD				EA	$1	$0
SNAP TIES				YD	$1	$0
PIPE (18"PLASTIC)	25			Ft.	$11	$278
GATE 18" 5' FRAME	1			EA	$1,270	$1,270
CONCRETE	3			YD	$105	$315
METER BOX 5' H (tailbox)	1			EA	$550	$550
					TOTAL COST =	$3,223
2). LABOR COST	QUANTITY	HRS/JOB	COST/HR	UNIT	COST/UNIT	COST
					TOTAL COST =	$650
3). EQUIPMENT COST	QUANTITY	HRS/JOB	COST/HR*	UNIT	COST/UNIT	COST
BACKHOE			$25.00	P/H		$0
EXCAVATOR	1	$1.00	$50.00	P/H		$50
LONG REACH			$50.00	P/H		$0
TRUCK	1	$12.00	$25.00	P/H		$300
TRANSPORT	1	$1.00	$44.00	P/H		$44
CRANE			$50.00	P/H		$0
PICKUPS	1	$4.00	$5.50	P/H		$22
D-6 DOZER			$35.00	P/H		$0
D-4 DOZER			$25.00	P/H		$0
MISC.(WELDERS,PUMPS,GENERATORS)	1	$4.00	$8.00	P/H		$32
					TOTAL COST =	$448
					TOTAL HOURS =	22
					TOTAL =	**$4,321**

Canal Gates in Free-Flow Conditions

ITRC conducted testing of three sizes of round, Armco-type canal gates in non-submerged conditions. In these cases the downstream stilling well does not have measureable water level because the downstream water level is at or below the top of the turnout pipe. The difficulty with this condition is that the downstream water level could still be high enough to submerge the gate opening or it could be fully free flow (downstream water level at or below the bottom of the gate). The testing examined both of these conditions and found that the flow rate could be measured within a reasonable level of accuracy (within +/-8% flow rate uncertainty) if operated within the recommended criteria outlined for meter gates in this report.

For these conditions, the upstream head is measured from the top of the turnout gate pipe to the upstream water surface. This may be difficult to accurately measure depending on the gate configuration. During the off-season, a staff gauge or reference mark could be installed to more accurately measure the head above the top of the turnout pipe. There is no need to measure the downstream water level as long as the downstream water surface is at or below the top of the turnout pipe at the exit. Special tables for the FREE-FLOW condition are included for the 12", 18", and 24" round, Armco-Type gate. Do not use the normal meter gate tables for these conditions.

ITRC Water Measurement Tables for
ROUND (Armco-Type) Gates on Round Pipes
Discharge Values in CFS

ΔH (feet)	ITRC Water Measurement Tables – **12" Armco-Type Gate**, Stilling Well Located 12" d/s of Back of Gate [Blue center represents best accuracy range] Net Gate Opening (feet)																	
	0.042	0.08	0.13	0.17	0.21	0.25	0.29	0.33	0.38	0.42	0.46	0.50	0.58	0.67	0.75	0.83	0.92	1.00
0.08	0.07	0.16	0.25	0.34	0.42	0.48	0.55	0.61	0.67	0.73	0.79	0.85	0.97	1.10	1.20	1.27	1.32	1.34
0.10	0.08	0.18	0.28	0.38	0.47	0.54	0.61	0.68	0.75	0.81	0.89	0.96	1.09	1.23	1.34	1.42	1.47	1.50
0.13	0.09	0.20	0.31	0.42	0.51	0.59	0.67	0.74	0.82	0.89	0.97	1.05	1.19	1.35	1.46	1.56	1.61	1.64
0.15	0.09	0.21	0.33	0.45	0.55	0.64	0.72	0.80	0.88	0.96	1.05	1.13	1.28	1.46	1.58	1.68	1.74	1.77
0.17	0.10	0.23	0.36	0.49	0.59	0.68	0.77	0.86	0.94	1.03	1.12	1.21	1.37	1.56	1.69	1.80	1.86	1.89
0.19	0.10	0.24	0.38	0.52	0.63	0.72	0.82	0.91	1.00	1.09	1.19	1.28	1.46	1.66	1.79	1.91	1.98	2.01
0.21	0.11	0.25	0.40	0.54	0.66	0.76	0.87	0.96	1.06	1.15	1.25	1.35	1.53	1.74	1.89	2.01	2.08	2.12
0.23	0.12	0.26	0.42	0.57	0.69	0.80	0.91	1.00	1.11	1.20	1.31	1.42	1.61	1.83	1.98	2.11	2.19	2.22
0.25	0.12	0.28	0.44	0.60	0.72	0.84	0.95	1.05	1.16	1.26	1.37	1.48	1.68	1.91	2.07	2.21	2.28	2.32
0.27	0.13	0.29	0.45	0.62	0.75	0.87	0.99	1.09	1.20	1.31	1.43	1.54	1.75	1.99	2.16	2.30	2.38	2.41
0.29	0.13	0.30	0.47	0.64	0.78	0.90	1.02	1.13	1.25	1.36	1.48	1.60	1.82	2.06	2.24	2.38	2.47	2.50
0.31	0.14	0.31	0.49	0.67	0.81	0.94	1.06	1.17	1.29	1.41	1.53	1.66	1.88	2.14	2.32	2.47	2.55	2.59
0.33	0.14	0.32	0.50	0.69	0.84	0.97	1.09	1.21	1.34	1.45	1.58	1.71	1.94	2.21	2.39	2.55	2.64	2.68
0.35	0.14	0.33	0.52	0.71	0.86	1.00	1.13	1.25	1.38	1.50	1.63	1.76	2.00	2.27	2.46	2.63	2.72	2.76
0.38	0.15	0.34	0.53	0.73	0.89	1.03	1.16	1.28	1.42	1.54	1.68	1.81	2.06	2.34	2.54	2.70	2.80	2.84
0.40	0.15	0.35	0.55	0.75	0.91	1.05	1.19	1.32	1.46	1.58	1.73	1.86	2.12	2.40	2.61	2.78	2.87	2.92
0.42	0.16	0.36	0.56	0.77	0.93	1.08	1.22	1.35	1.49	1.62	1.77	1.91	2.17	2.47	2.67	2.85	2.95	2.99
0.46	0.16	0.37	0.59	0.81	0.98	1.13	1.28	1.42	1.57	1.70	1.86	2.00	2.28	2.59	2.80	2.99	3.09	3.14
0.50	0.17	0.39	0.62	0.84	1.02	1.18	1.34	1.48	1.64	1.78	1.94	2.09	2.38	2.70	2.93	3.12	3.23	3.28
0.54	0.18	0.41	0.64	0.88	1.06	1.23	1.40	1.54	1.70	1.85	2.02	2.18	2.47	2.81	3.05	3.25	3.36	3.41
0.58	0.19	0.42	0.66	0.91	1.10	1.28	1.45	1.60	1.77	1.92	2.10	2.26	2.57	2.92	3.16	3.37	3.49	3.54
0.63	0.19	0.44	0.69	0.94	1.14	1.32	1.50	1.66	1.83	1.99	2.17	2.34	2.66	3.02	3.27	3.49	3.61	3.67
0.67	0.20	0.45	0.71	0.97	1.18	1.37	1.55	1.71	1.89	2.06	2.24	2.42	2.75	3.12	3.38	3.60	3.73	3.79
0.71	0.20	0.46	0.73	1.00	1.22	1.41	1.60	1.76	1.95	2.12	2.31	2.49	2.83	3.22	3.49	3.71	3.84	3.90
0.75	0.21	0.48	0.75	1.03	1.25	1.45	1.64	1.82	2.00	2.18	2.38	2.56	2.91	3.31	3.59	3.82	3.96	4.02
0.79	0.22	0.49	0.77	1.06	1.29	1.49	1.69	1.87	2.06	2.24	2.44	2.63	2.99	3.40	3.68	3.93	4.06	4.13
0.83	0.22	0.50	0.79	1.09	1.32	1.53	1.73	1.91	2.11	2.30	2.50	2.70	3.07	3.49	3.78	4.03	4.17	4.23
0.92	0.23	0.53	0.83	1.14	1.39	1.60	1.82	2.01	2.22	2.41	2.63	2.83	3.22	3.66	3.97	4.22	4.37	4.44
1.00	0.24	0.55	0.87	1.19	1.45	1.67	1.90	2.10	2.31	2.52	2.74	2.96	3.36	3.82	4.14	4.41	4.57	4.64
1.08	0.25	0.57	0.91	1.24	1.51	1.74	1.97	2.18	2.41	2.62	2.86	3.08	3.50	3.98	4.31	4.59	4.75	4.83
1.17	0.26	0.60	0.94	1.29	1.56	1.81	2.05	2.26	2.50	2.72	2.96	3.20	3.63	4.13	4.47	4.77	4.93	5.01
1.25	0.27	0.62	0.97	1.33	1.62	1.87	2.12	2.34	2.59	2.81	3.07	3.31	3.76	4.27	4.63	4.93	5.11	5.19
1.33	0.28	0.64	1.00	1.37	1.67	1.93	2.19	2.42	2.67	2.91	3.17	3.42	3.88	4.41	4.78	5.09	5.27	5.36
1.42	0.29	0.66	1.04	1.42	1.72	1.99	2.26	2.50	2.75	3.00	3.27	3.52	4.00	4.55	4.93	5.25	5.44	5.52
1.50	0.30	0.68	1.07	1.46	1.77	2.05	2.32	2.57	2.83	3.08	3.36	3.63	4.12	4.68	5.07	5.40	5.59	5.68
1.58	0.30	0.69	1.09	1.50	1.82	2.11	2.39	2.64	2.91	3.17	3.45	3.73	4.23	4.81	5.21	5.55	5.75	5.84
1.67	0.31	0.71	1.12	1.54	1.87	2.16	2.45	2.71	2.99	3.25	3.54	3.82	4.34	4.93	5.35	5.70	5.90	5.99
1.75	0.32	0.73	1.15	1.57	1.91	2.21	2.51	2.77	3.06	3.33	3.63	3.92	4.45	5.06	5.48	5.84	6.04	6.14
1.83	0.33	0.75	1.18	1.61	1.96	2.27	2.57	2.84	3.13	3.41	3.71	4.01	4.55	5.18	5.61	5.97	6.18	6.28
1.92	0.34	0.76	1.20	1.65	2.00	2.32	2.63	2.90	3.20	3.48	3.80	4.10	4.66	5.29	5.73	6.11	6.32	6.42
2.00	0.34	0.78	1.23	1.68	2.05	2.37	2.68	2.96	3.27	3.56	3.88	4.19	4.76	5.41	5.86	6.24	6.46	6.56
2.08	0.35	0.80	1.26	1.72	2.09	2.42	2.74	3.03	3.34	3.63	3.96	4.27	4.85	5.52	5.98	6.37	6.59	6.69
2.17	0.36	0.81	1.28	1.75	2.13	2.46	2.79	3.09	3.41	3.70	4.04	4.36	4.95	5.63	6.10	6.49	6.72	6.83
2.25	0.36	0.83	1.31	1.79	2.17	2.51	2.84	3.14	3.47	3.78	4.11	4.44	5.04	5.73	6.21	6.62	6.85	6.96
2.33	0.37	0.84	1.33	1.82	2.21	2.56	2.90	3.20	3.53	3.84	4.19	4.52	5.14	5.84	6.33	6.74	6.98	7.09
2.42	0.38	0.86	1.35	1.85	2.25	2.60	2.95	3.26	3.60	3.91	4.26	4.60	5.23	5.94	6.44	6.86	7.10	7.21
2.50	0.38	0.87	1.38	1.88	2.29	2.65	3.00	3.31	3.66	3.98	4.34	4.68	5.32	6.04	6.55	6.98	7.22	7.33
2.58	0.39	0.89	1.40	1.91	2.33	2.69	3.05	3.37	3.72	4.05	4.41	4.76	5.40	6.14	6.66	7.09	7.34	7.45
2.67	0.40	0.90	1.42	1.94	2.36	2.73	3.10	3.42	3.78	4.11	4.48	4.84	5.49	6.24	6.76	7.20	7.46	7.57
2.75	0.40	0.91	1.44	1.97	2.40	2.78	3.15	3.48	3.84	4.17	4.55	4.91	5.58	6.34	6.87	7.32	7.57	7.69
2.83	0.41	0.93	1.46	2.00	2.44	2.82	3.19	3.53	3.89	4.24	4.62	4.98	5.66	6.43	6.97	7.43	7.69	7.81

ΔH (feet)	ITRC Water Measurement Tables – 18" Armco-Type Gate, Stilling Well Located 12" d/s of Back of Gate [Blue center represents best accuracy range] Net Gate Opening (feet)																						
	0.042	0.08	0.13	0.17	0.21	0.25	0.29	0.33	0.38	0.42	0.46	0.50	0.58	0.67	0.75	0.83	0.92	1.00	1.08	1.17	1.25	1.33	1.42	1.50
0.04	0.07	0.16	0.25	0.35	0.44	0.52	0.61	0.68	0.75	0.81	0.87	0.93	1.05	1.17	1.29	1.40	1.54	1.67	1.81	1.95	2.05	2.14	2.17	2.17
0.06	0.08	0.20	0.31	0.43	0.54	0.64	0.74	0.84	0.92	1.00	1.07	1.14	1.29	1.43	1.58	1.72	1.88	2.05	2.22	2.39	2.51	2.62	2.66	2.66
0.08	0.	0.23	0.36	0.50	0.62	0.74	0.86	0.96	1.06	1.15	1.24	1.31	1.49	1.65	1.82	1.98	2.18	2.36	2.57	2.76	2.90	3.02	3.07	3.07
0.10	0.11	0.25	0.40	0.56	0.70	0.83	0.96	1.08	1.19	1.29	1.38	1.47	1.67	1.85	2.04	2.22	2.43	2.64	2.87	3.09	3.24	3.38	3.43	3.43
0.13	0.12	0.28	0.44	0.61	0.76	0.91	1.05	1.18	1.30	1.41	1.51	1.61	1.83	2.03	2.23	2.43	2.66	2.89	3.14	3.38	3.55	3.70	3.76	3.76
0.15	0.13	0.30	0.48	0.66	0.82	0.98	1.13	1.28	1.40	1.52	1.63	1.73	1.97	2.19	2.41	2.62	2.88	3.12	3.39	3.65	3.84	4.00	4.06	4.06
0.17	0.14	0.32	0.51	0.70	0.88	1.05	1.21	1.36	1.50	1.63	1.75	1.85	2.11	2.34	2.58	2.80	3.08	3.34	3.63	3.90	4.10	4.27	4.34	4.34
0.19	0.15	0.34	0.54	0.75	0.93	1.11	1.28	1.45	1.59	1.73	1.85	1.97	2.24	2.48	2.74	2.97	3.26	3.54	3.85	4.14	4.35	4.53	4.60	4.61
0.21	0.15	0.36	0.57	0.79	0.98	1.17	1.35	1.52	1.68	1.82	1.95	2.07	2.36	2.62	2.88	3.13	3.44	3.74	4.06	4.36	4.58	4.78	4.85	4.85
0.23	0.16	0.37	0.60	0.82	1.03	1.23	1.42	1.60	1.76	1.91	2.05	2.17	2.47	2.74	3.02	3.29	3.61	3.92	4.25	4.58	4.81	5.01	5.08	5.09
0.25	0.17	0.39	0.62	0.86	1.08	1.28	1.48	1.67	1.84	2.00	2.14	2.27	2.58	2.87	3.16	3.43	3.77	4.09	4.44	4.78	5.02	5.23	5.31	5.32
0.27	0.17	0.41	0.65	0.90	1.12	1.34	1.54	1.74	1.91	2.08	2.23	2.36	2.69	2.98	3.29	3.57	3.92	4.26	4.62	4.98	5.23	5.44	5.53	5.54
0.29	0.18	0.42	0.67	0.93	1.16	1.39	1.60	1.80	1.99	2.16	2.31	2.45	2.79	3.10	3.41	3.71	4.07	4.42	4.80	5.16	5.42	5.65	5.74	5.74
0.31	0.19	0.44	0.70	0.96	1.20	1.44	1.66	1.87	2.06	2.23	2.39	2.54	2.89	3.20	3.53	3.84	4.21	4.57	4.97	5.35	5.62	5.85	5.94	5.95
0.33	0.19	0.45	0.72	0.99	1.24	1.48	1.71	1.93	2.12	2.30	2.47	2.62	2.98	3.31	3.65	3.96	4.35	4.72	5.13	5.52	5.80	6.04	6.13	6.14
0.35	0.	0.46	0.74	1.02	1.28	1.53	1.76	1.99	2.19	2.38	2.55	2.70	3.07	3.41	3.76	4.09	4.48	4.87	5.29	5.69	5.98	6.23	6.32	6.33
0.38	0.21	0.48	0.76	1.05	1.32	1.57	1.82	2.05	2.25	2.44	2.62	2.78	3.16	3.51	3.87	4.20	4.61	5.01	5.44	5.86	6.15	6.41	6.50	6.51
0.40	0.21	0.49	0.78	1.08	1.36	1.62	1.87	2.10	2.31	2.51	2.69	2.86	3.25	3.61	3.98	4.32	4.74	5.15	5.59	6.02	6.32	6.58	6.68	6.69
0.42	0.22	0.50	0.81	1.11	1.39	1.66	1.91	2.16	2.37	2.58	2.76	2.93	3.33	3.70	4.08	4.43	4.86	5.28	5.74	6.17	6.48	6.75	6.86	6.87
0.46	0.23	0.53	0.84	1.17	1.46	1.74	2.01	2.26	2.49	2.70	2.90	3.08	3.50	3.88	4.28	4.65	5.10	5.54	6.02	6.47	6.80	7.08	7.19	7.20
0.50	0.24	0.55	0.88	1.22	1.52	1.82	2.10	2.36	2.60	2.82	3.03	3.21	3.65	4.05	4.47	4.85	5.33	5.79	6.28	6.76	7.10	7.40	7.51	7.52
0.54	0.25	0.57	0.92	1.27	1.59	1.89	2.18	2.46	2.71	2.94	3.15	3.34	3.80	4.22	4.65	5.05	5.55	6.02	6.54	7.04	7.39	7.70	7.82	7.83
0.58	0.26	0.60	0.95	1.31	1.65	1.96	2.26	2.55	2.81	3.05	3.27	3.47	3.94	4.38	4.83	5.24	5.75	6.25	6.79	7.30	7.67	7.99	8.11	8.12
0.63	0.26	0.62	0.99	1.36	1.70	2.03	2.34	2.64	2.91	3.16	3.38	3.59	4.08	4.53	5.00	5.43	5.96	6.47	7.02	7.56	7.94	8.27	8.40	8.41
0.67	0.27	0.64	1.02	1.41	1.76	2.10	2.42	2.73	3.00	3.26	3.49	3.71	4.22	4.68	5.16	5.61	6.15	6.68	7.25	7.81	8.20	8.54	8.67	8.68
0.71	0.28	0.66	1.05	1.45	1.81	2.16	2.50	2.81	3.10	3.36	3.60	3.82	4.35	4.82	5.32	5.78	6.34	6.89	7.48	8.05	8.45	8.81	8.94	8.95
0.75	0.29	0.68	1.08	1.49	1.87	2.23	2.57	2.89	3.19	3.46	3.71	3.93	4.47	4.96	5.47	5.95	6.53	7.09	7.70	8.28	8.70	9.06	9.20	9.21
0.79	0.	0.69	1.11	1.53	1.92	2.29	2.64	2.97	3.27	3.55	3.81	4.04	4.59	5.10	5.62	6.11	6.70	7.28	7.91	8.51	8.94	9.31	9.45	9.46
0.83	0.31	0.71	1.14	1.57	1.97	2.35	2.71	3.05	3.36	3.64	3.91	4.15	4.71	5.23	5.77	6.27	6.88	7.47	8.11	8.73	9.17	9.55	9.70	9.71
0.92	0.32	0.75	1.19	1.65	2.06	2.46	2.84	3.20	3.52	3.82	4.10	4.35	4.94	5.49	6.05	6.57	7.21	7.83	8.51	9.15	9.62	10.02	10.17	10.18
1.00	0.34	0.78	1.25	1.72	2.15	2.57	2.97	3.34	3.68	3.99	4.28	4.54	5.16	5.73	6.32	6.86	7.53	8.18	8.89	9.56	10.04	10.46	10.62	10.64
1.08	0.35	0.81	1.30	1.79	2.24	2.67	3.09	3.48	3.83	4.15	4.45	4.73	5.37	5.96	6.58	7.15	7.84	8.52	9.25	9.95	10.45	10.89	11.05	11.07
1.17	0.36	0.84	1.35	1.86	2.33	2.78	3.20	3.61	3.97	4.31	4.62	4.91	5.58	6.19	6.83	7.41	8.14	8.84	9.60	10.33	10.85	11.30	11.47	11.49
1.25	0.37	0.87	1.39	1.92	2.41	2.87	3.32	3.73	4.11	4.46	4.78	5.08	5.77	6.41	7.06	7.68	8.42	9.15	9.93	10.69	11.23	11.70	11.87	11.89
1.33	0.39	0.90	1.44	1.99	2.49	2.97	3.42	3.86	4.25	4.61	4.94	5.25	5.96	6.62	7.30	7.93	8.70	9.45	10.26	11.04	11.60	12.08	12.26	12.28
1.42	0.	0.93	1.49	2.05	2.56	3.06	3.53	3.98	4.38	4.75	5.09	5.41	6.15	6.82	7.52	8.17	8.97	9.74	10.58	11.38	11.96	12.45	12.64	12.66
1.50	0.41	0.96	1.53	2.11	2.64	3.15	3.63	4.09	4.51	4.89	5.24	5.56	6.32	7.02	7.74	8.41	9.23	10.02	10.88	11.71	12.30	12.81	13.01	13.03
1.58	0.42	0.98	1.57	2.17	2.71	3.23	3.73	4.20	4.63	5.02	5.39	5.72	6.50	7.21	7.95	8.64	9.48	10.30	11.18	12.03	12.64	13.17	13.36	13.38
1.67	0.43	1.01	1.61	2.22	2.78	3.32	3.83	4.31	4.75	5.15	5.53	5.86	6.67	7.40	8.16	8.86	9.73	10.56	11.47	12.34	12.97	13.51	13.71	13.73
1.75	0.44	1.03	1.65	2.28	2.85	3.40	3.92	4.42	4.87	5.28	5.66	6.01	6.83	7.58	8.36	9.08	9.97	10.83	11.75	12.65	13.29	13.84	14.05	14.07
1.83	0.45	1.06	1.69	2.33	2.92	3.48	4.01	4.52	4.98	5.40	5.79	6.15	6.99	7.76	8.56	9.29	10.20	11.08	12.03	12.95	13.60	14.17	14.38	14.40
1.92	0.46	1.08	1.73	2.38	2.98	3.56	4.11	4.62	5.09	5.53	5.93	6.29	7.15	7.93	8.75	9.50	10.43	11.33	12.30	13.24	13.91	14.48	14.70	14.72
2.00	0.47	1.10	1.76	2.43	3.05	3.63	4.19	4.72	5.20	5.64	6.05	6.42	7.30	8.10	8.94	9.71	10.66	11.57	12.57	13.52	14.20	14.80	15.02	15.04
2.08	0.48	1.13	1.80	2.48	3.11	3.71	4.28	4.82	5.31	5.76	6.18	6.56	7.45	8.27	9.12	9.91	10.88	11.81	12.83	13.80	14.50	15.10	15.33	15.35
2.17	0.49	1.15	1.84	2.53	3.17	3.78	4.36	4.92	5.41	5.88	6.30	6.69	7.60	8.44	9.30	10.10	11.09	12.05	13.08	14.07	14.79	15.40	15.63	15.66
2.25	0.	1.17	1.87	2.58	3.23	3.85	4.45	5.01	5.52	5.99	6.42	6.81	7.75	8.60	9.48	10.30	11.30	12.27	13.33	14.34	15.07	15.69	15.93	15.95
2.33	0.51	1.19	1.91	2.63	3.29	3.93	4.53	5.10	5.62	6.10	6.54	6.94	7.89	8.75	9.65	10.49	11.51	12.50	13.57	14.61	15.34	15.98	16.22	16.25
2.42	0.52	1.21	1.94	2.68	3.35	3.99	4.61	5.19	5.72	6.21	6.65	7.06	8.03	8.91	9.82	10.67	11.71	12.72	13.81	14.86	15.61	16.26	16.51	16.53
2.50	0.53	1.23	1.97	2.72	3.41	4.06	4.69	5.28	5.82	6.31	6.77	7.18	8.16	9.06	9.99	10.85	11.91	12.94	14.05	15.12	15.88	16.54	16.79	16.82
2.58	0.54	1.26	2.01	2.77	3.46	4.13	4.77	5.37	5.91	6.42	6.88	7.30	8.30	9.21	10.16	11.03	12.11	13.15	14.28	15.37	16.14	16.82	17.07	17.09
2.67	0.55	1.28	2.04	2.81	3.52	4.20	4.84	5.45	6.01	6.52	6.99	7.42	8.43	9.36	10.32	11.21	12.30	13.36	14.51	15.61	16.40	17.09	17.34	17.37
2.75	0.56	1.30	2.07	2.85	3.57	4.26	4.92	5.54	6.10	6.62	7.10	7.53	8.56	9.50	10.48	11.38	12.50	13.57	14.73	15.86	16.66	17.35	17.61	17.64
2.83	0.56	1.31	2.10	2.90	3.63	4.33	4.99	5.62	6.19	6.72	7.20	7.65	8.69	9.65	10.64	11.56	12.68	13.77	14.96	16.09	16.91	17.61	17.88	17.90

ITRC Water Measurement Tables – **24" Armco-Type Gate**, Stilling Well Located 12" d/s of Back of Gate [Blue center represents best accuracy range]

Net Gate Opening (feet)

ΔH (feet)	0.042	0.08	0.13	0.17	0.21	0.25	0.29	0.33	0.38	0.42	0.46	0.50	0.58	0.67	0.75	0.83	0.92	1.00	1.08	1.17	1.25	1.33	1.42	1.50	1.58	1.67	1.75	1.83	1.92	2.00
0.04	0.10	0.22	0.35	0.49	0.61	0.73	0.84	0.95	1.05	1.14	1.23	1.31	1.49	1.65	1.81	1.96	2.14	2.32	2.45	2.57	2.71	2.85	3.01	3.16	3.30	3.51	3.68	3.71	3.77	3.57
0.06	0.12	0.27	0.43	0.60	0.75	0.89	1.03	1.17	1.29	1.40	1.51	1.61	1.82	2.02	2.22	2.40	2.63	2.84	3.00	3.14	3.32	3.49	3.68	3.87	4.04	4.30	4.51	4.54	4.62	4.37
0.08	0.14	0.31	0.50	0.69	0.86	1.03	1.19	1.35	1.49	1.62	1.74	1.85	2.10	2.33	2.56	2.78	3.03	3.28	3.46	3.63	3.84	4.03	4.25	4.47	4.67	4.97	5.20	5.24	5.34	5.04
0.10	0.15	0.35	0.56	0.77	0.96	1.15	1.33	1.51	1.66	1.81	1.95	2.07	2.35	2.61	2.87	3.10	3.39	3.67	3.87	4.06	4.29	4.51	4.76	4.99	5.22	5.56	5.82	5.86	5.97	5.64
0.13	0.17	0.39	0.61	0.84	1.06	1.26	1.46	1.65	1.82	1.98	2.13	2.27	2.58	2.86	3.14	3.40	3.71	4.02	4.24	4.44	4.70	4.94	5.21	5.47	5.72	6.09	6.37	6.42	6.54	6.18
0.15	0.18	0.42	0.66	0.91	1.14	1.36	1.58	1.78	1.97	2.14	2.30	2.45	2.78	3.09	3.39	3.67	4.01	4.34	4.58	4.80	5.07	5.33	5.63	5.91	6.17	6.57	6.88	6.93	7.06	6.67
0.17	0.19	0.44	0.71	0.97	1.22	1.46	1.69	1.91	2.10	2.29	2.46	2.62	2.98	3.30	3.63	3.93	4.29	4.64	4.90	5.13	5.43	5.70	6.02	6.32	6.60	7.03	7.36	7.41	7.55	7.13
0.19	0.20	0.47	0.75	1.03	1.29	1.55	1.79	2.02	2.23	2.43	2.61	2.78	3.16	3.50	3.85	4.17	4.55	4.92	5.20	5.44	5.75	6.05	6.38	6.70	7.00	7.45	7.81	7.86	8.01	7.56
0.21	0.22	0.50	0.79	1.09	1.36	1.63	1.89	2.13	2.35	2.56	2.75	2.93	3.33	3.69	4.05	4.39	4.80	5.19	5.48	5.74	6.07	6.38	6.73	7.06	7.38	7.86	8.23	8.29	8.44	7.97
0.23	0.23	0.52	0.83	1.14	1.43	1.71	1.98	2.23	2.47	2.68	2.89	3.07	3.49	3.87	4.25	4.61	5.03	5.44	5.74	6.02	6.36	6.69	7.05	7.41	7.74	8.24	8.63	8.69	8.85	8.36
0.25	0.24	0.54	0.87	1.19	1.49	1.78	2.07	2.33	2.58	2.80	3.02	3.21	3.65	4.04	4.44	4.81	5.25	5.68	6.00	6.28	6.64	6.98	7.37	7.74	8.08	8.61	9.01	9.08	9.24	8.74
0.27	0.25	0.57	0.90	1.24	1.55	1.86	2.15	2.43	2.68	2.92	3.14	3.34	3.79	4.21	4.62	5.01	5.47	5.92	6.24	6.54	6.92	7.27	7.67	8.05	8.41	8.96	9.38	9.45	9.62	9.09
0.29	0.26	0.59	0.94	1.29	1.61	1.93	2.23	2.52	2.78	3.03	3.26	3.47	3.94	4.37	4.80	5.20	5.67	6.14	6.48	6.79	7.18	7.54	7.96	8.36	8.73	9.30	9.74	9.80	9.98	9.43
0.31	0.26	0.61	0.97	1.33	1.67	2.00	2.31	2.61	2.88	3.13	3.37	3.59	4.08	4.52	4.96	5.38	5.87	6.36	6.71	7.03	7.43	7.81	8.24	8.65	9.04	9.62	10.08	10.15	10.33	9.77
0.33	0.27	0.63	1.00	1.38	1.72	2.06	2.38	2.69	2.97	3.24	3.48	3.71	4.21	4.67	5.13	5.55	6.07	6.56	6.93	7.26	7.67	8.06	8.51	8.93	9.33	9.94	10.41	10.48	10.67	10.09
0.35	0.28	0.65	1.03	1.42	1.78	2.12	2.46	2.78	3.07	3.34	3.59	3.82	4.34	4.81	5.29	5.72	6.25	6.77	7.14	7.48	7.91	8.31	8.77	9.21	9.62	10.25	10.73	10.80	11.00	10.40
0.38	0.29	0.67	1.06	1.46	1.83	2.19	2.53	2.86	3.16	3.43	3.69	3.93	4.46	4.95	5.44	5.89	6.43	6.96	7.35	7.70	8.14	8.55	9.02	9.47	9.90	10.54	11.04	11.12	11.32	10.70
0.40	0.30	0.69	1.09	1.50	1.88	2.25	2.60	2.94	3.24	3.53	3.79	4.04	4.59	5.09	5.59	6.05	6.61	7.15	7.55	7.91	8.36	8.79	9.27	9.73	10.17	10.83	11.34	11.42	11.63	10.99
0.42	0.31	0.70	1.12	1.54	1.93	2.30	2.67	3.01	3.33	3.62	3.89	4.15	4.71	5.22	5.73	6.21	6.78	7.34	7.75	8.11	8.58	9.02	9.51	9.99	10.44	11.11	11.64	11.72	11.93	11.28
0.46	0.32	0.74	1.17	1.61	2.02	2.42	2.80	3.16	3.49	3.80	4.08	4.35	4.94	5.47	6.01	6.51	7.11	7.70	8.12	8.51	9.00	9.46	9.98	10.47	10.94	11.66	12.20	12.29	12.52	11.83
0.50	0.33	0.77	1.22	1.69	2.11	2.52	2.92	3.30	3.64	3.96	4.26	4.54	5.16	5.72	6.28	6.80	7.43	8.04	8.48	8.89	9.40	9.88	10.42	10.94	11.43	12.17	12.75	12.84	13.07	12.35
0.54	0.35	0.80	1.27	1.75	2.20	2.63	3.04	3.44	3.79	4.13	4.44	4.73	5.37	5.95	6.54	7.08	7.73	8.37	8.83	9.25	9.78	10.28	10.85	11.39	11.90	12.67	13.27	13.36	13.61	12.86
0.58	0.36	0.83	1.32	1.82	2.28	2.73	3.15	3.56	3.94	4.28	4.61	4.91	5.57	6.17	6.78	7.35	8.03	8.68	9.16	9.60	10.15	10.67	11.26	11.82	12.35	13.15	13.77	13.87	14.12	13.34
0.63	0.37	0.86	1.37	1.88	2.36	2.82	3.27	3.69	4.07	4.43	4.77	5.08	5.76	6.39	7.02	7.61	8.31	8.99	9.49	9.94	10.51	11.04	11.65	12.23	12.78	13.61	14.25	14.35	14.62	13.81
0.67	0.39	0.89	1.41	1.95	2.44	2.91	3.37	3.81	4.21	4.58	4.92	5.24	5.95	6.60	7.25	7.85	8.58	9.28	9.80	10.26	10.85	11.41	12.03	12.63	13.20	14.06	14.72	14.82	15.10	14.26
0.71	0.40	0.92	1.46	2.01	2.51	3.00	3.48	3.93	4.34	4.72	5.08	5.41	6.14	6.80	7.47	8.10	8.84	9.57	10.10	10.58	11.18	11.76	12.40	13.02	13.61	14.49	15.17	15.28	15.56	14.70
0.75	0.41	0.94	1.50	2.06	2.59	3.09	3.58	4.04	4.46	4.86	5.22	5.56	6.31	7.00	7.69	8.33	9.10	9.85	10.39	10.89	11.51	12.10	12.76	13.40	14.00	14.91	15.61	15.72	16.01	15.13
0.79	0.42	0.97	1.54	2.12	2.66	3.18	3.67	4.15	4.58	4.99	5.37	5.71	6.49	7.19	7.90	8.56	9.35	10.12	10.68	11.18	11.82	12.43	13.11	13.77	14.38	15.32	16.04	16.15	16.45	15.54
0.83	0.43	0.99	1.58	2.18	2.73	3.26	3.77	4.26	4.70	5.12	5.50	5.86	6.66	7.38	8.11	8.78	9.59	10.38	10.95	11.47	12.13	12.75	13.45	14.12	14.76	15.72	16.46	16.57	16.88	15.95
0.92	0.45	1.04	1.66	2.28	2.86	3.42	3.95	4.47	4.93	5.37	5.77	6.15	6.98	7.74	8.50	9.21	10.06	10.88	11.49	12.03	12.72	13.37	14.11	14.81	15.48	16.48	17.26	17.38	17.70	16.73
1.00	0.47	1.09	1.73	2.38	2.99	3.57	4.13	4.67	5.15	5.61	6.03	6.42	7.29	8.08	8.88	9.62	10.51	11.37	12.00	12.57	13.29	13.97	14.74	15.47	16.17	17.22	18.03	18.15	18.49	17.47
1.08	0.49	1.13	1.80	2.48	3.11	3.72	4.30	4.86	5.36	5.84	6.28	6.69	7.59	8.41	9.24	10.01	10.94	11.83	12.49	13.08	13.83	14.54	15.34	16.10	16.83	17.92	18.76	18.90	19.24	18.18
1.17	0.51	1.18	1.87	2.57	3.23	3.86	4.46	5.04	5.57	6.06	6.51	6.94	7.87	8.73	9.59	10.39	11.35	12.28	12.96	13.58	14.35	15.09	15.92	16.71	17.46	18.60	19.47	19.61	19.97	18.87
1.25	0.53	1.22	1.94	2.66	3.34	3.99	4.62	5.22	5.76	6.27	6.74	7.18	8.15	9.04	9.93	10.76	11.75	12.71	13.41	14.05	14.86	15.62	16.48	17.30	18.07	19.25	20.15	20.30	20.67	19.53
1.33	0.55	1.26	2.00	2.75	3.45	4.12	4.77	5.39	5.95	6.47	6.96	7.42	8.42	9.33	10.26	11.11	12.13	13.13	13.85	14.51	15.34	16.13	17.02	17.87	18.67	19.88	20.81	20.96	21.35	20.17
1.42	0.56	1.30	2.06	2.84	3.56	4.25	4.92	5.56	6.13	6.67	7.18	7.64	8.68	9.62	10.57	11.45	12.51	13.53	14.28	14.96	15.82	16.63	17.54	18.42	19.24	20.49	21.46	21.61	22.00	20.79
1.50	0.58	1.33	2.12	2.92	3.66	4.37	5.06	5.72	6.31	6.87	7.39	7.87	8.93	9.90	10.88	11.78	12.87	13.92	14.70	15.40	16.28	17.11	18.05	18.95	19.80	21.09	22.08	22.24	22.64	21.40
1.58	0.59	1.37	2.18	3.00	3.76	4.49	5.20	5.87	6.48	7.06	7.59	8.08	9.17	10.17	11.18	12.10	13.22	14.31	15.10	15.82	16.72	17.58	18.54	19.47	20.34	21.66	22.68	22.84	23.26	21.98
1.67	0.61	1.41	2.24	3.08	3.86	4.61	5.33	6.03	6.65	7.24	7.79	8.29	9.41	10.44	11.47	12.42	13.56	14.68	15.49	16.23	17.16	18.03	19.03	19.97	20.87	22.23	23.27	23.44	23.87	22.55
1.75	0.63	1.44	2.29	3.15	3.95	4.72	5.46	6.17	6.82	7.42	7.98	8.50	9.64	10.69	11.75	12.73	13.90	15.04	15.87	16.63	17.58	18.48	19.50	20.47	21.39	22.77	23.85	24.02	24.46	23.11
1.83	0.64	1.48	2.35	3.23	4.04	4.83	5.59	6.32	6.98	7.59	8.17	8.70	9.87	10.95	12.03	13.03	14.23	15.39	16.25	17.02	17.99	18.91	19.95	20.95	21.89	23.31	24.41	24.58	25.03	23.65
1.92	0.65	1.51	2.40	3.30	4.14	4.94	5.72	6.46	7.13	7.76	8.35	8.89	10.09	11.19	12.30	13.32	14.55	15.74	16.61	17.40	18.40	19.34	20.40	21.42	22.38	23.83	24.96	25.13	25.60	24.19
2.00	0.67	1.54	2.45	3.37	4.22	5.05	5.84	6.60	7.29	7.93	8.53	9.08	10.31	11.43	12.56	13.60	14.86	16.08	16.97	17.78	18.79	19.75	20.84	21.88	22.86	24.35	25.49	25.67	26.15	24.71
2.08	0.68	1.57	2.50	3.44	4.31	5.15	5.96	6.74	7.44	8.09	8.70	9.27	10.52	11.67	12.82	13.88	15.17	16.41	17.32	18.14	19.18	20.16	21.27	22.33	23.33	24.85	26.02	26.20	26.68	25.22
2.17	0.70	1.60	2.55	3.51	4.40	5.25	6.08	6.87	7.58	8.25	8.88	9.45	10.73	11.90	13.07	14.16	15.47	16.73	17.66	18.50	19.56	20.56	21.69	22.77	23.80	25.34	26.53	26.72	27.21	25.72
2.25	0.71	1.63	2.60	3.58	4.48	5.35	6.20	7.00	7.73	8.41	9.05	9.63	10.94	12.13	13.32	14.43	15.76	17.05	18.00	18.85	19.93	20.95	22.11	23.21	24.25	25.82	27.04	27.23	27.73	26.21
2.33	0.72	1.66	2.65	3.64	4.56	5.45	6.31	7.13	7.87	8.56	9.21	9.81	11.14	12.35	13.57	14.69	16.05	17.37	18.33	19.20	20.30	21.34	22.51	23.63	24.69	26.30	27.54	27.73	28.24	26.69
2.42	0.73	1.69	2.69	3.71	4.64	5.55	6.42	7.26	8.01	8.72	9.37	9.98	11.33	12.57	13.81	14.95	16.33	17.67	18.65	19.54	20.66	21.71	22.91	24.05	25.13	26.76	28.02	28.22	28.74	27.16
2.50	0.75	1.72	2.74	3.77	4.72	5.64	6.53	7.38	8.15	8.87	9.53	10.16	11.53	12.78	14.04	15.21	16.61	17.98	18.97	19.87	21.01	22.09	23.30	24.46	25.56	27.22	28.50	28.71	29.23	27.62
2.58	0.76	1.75	2.78	3.83	4.80	5.74	6.64	7.50	8.28	9.01	9.69	10.32	11.72	12.99	14.28	15.46	16.89	18.27	19.29	20.20	21.36	22.45	23.69	24.87	25.98	27.67	28.97	29.18	29.71	28.08
2.67	0.77	1.78	2.83	3.89	4.88	5.83	6.74	7.62	8.41	9.16	9.85	10.49	11.91	13.20	14.50	15.71	17.16	18.56	19.59	20.53	21.70	22.81	24.07	25.27	26.40	28.11	29.44	29.65	30.19	28.53
2.75	0.78	1.81	2.87	3.95	4.95	5.92	6.85	7.74	8.54	9.30	10.00	10.65	12.09	13.41	14.73	15.95	17.42	18.85	19.90	20.84	22.04	23.16	24.44	25.66	26.81	28.55	29.89	30.11	30.66	28.97
2.83	0.80	1.83	2.92	4.01	5.03	6.01	6.95	7.86	8.67	9.44	10.15	10.81	12.27	13.61	14.95	16.19	17.69	19.14	20.20	21.16	22.37	23.51	24.81	26.04	27.21	28.98	30.34	30.56	31.12	29.41

Preliminary Tables for

Round Gates on Round Pipes

Discharge Values in CFS

These tables are from the original ARMCO Flow Measurement Tables and will be replaced as these gate sizes are tested by ITRC

Armco-Type Metergate Tables - Preliminary

8-inch Round Gate

Head Difference (feet)	Net Gate Opening (feet)												
	0.17	0.21	0.25	0.29	0.33	0.38	0.42	0.46	0.50	0.54	0.58	0.63	0.67
	Discharge (cfs)												
0.08	0.27	0.32	0.38	0.42	0.46	0.51	0.55	0.57	0.59	0.61	0.62	0.63	0.64
0.10	0.30	0.36	0.42	0.46	0.51	0.56	0.60	0.63	0.65	0.68	0.70	0.71	0.71
0.13	0.32	0.39	0.46	0.50	0.56	0.61	0.67	0.69	0.72	0.75	0.77	0.78	0.78
0.15	0.35	0.42	0.49	0.54	0.60	0.66	0.72	0.75	0.78	0.81	0.83	0.84	0.85
0.17	0.37	0.44	0.52	0.58	0.64	0.70	0.76	0.80	0.83	0.86	0.89	0.90	0.91
0.19	0.39	0.46	0.54	0.61	0.67	0.74	0.80	0.84	0.88	0.92	0.94	0.96	0.97
0.21	0.41	0.49	0.57	0.64	0.70	0.77	0.85	0.89	0.93	0.96	1.00	1.01	1.02
0.23	0.42	0.51	0.60	0.66	0.74	0.81	0.88	0.93	0.97	1.01	1.04	1.06	1.07
0.25	0.44	0.53	0.62	0.70	0.76	0.84	0.92	0.97	1.02	1.06	1.09	1.11	1.12
0.27	0.46	0.55	0.64	0.72	0.79	0.87	0.95	1.01	1.06	1.10	1.13	1.15	1.16
0.29	0.47	0.57	0.67	0.74	0.82	0.90	0.99	1.05	1.10	1.14	1.18	1.20	1.21
0.31	0.49	0.59	0.69	0.77	0.85	0.93	1.02	1.08	1.14	1.18	1.22	1.24	1.26
0.33	0.50	0.60	0.71	0.79	0.88	0.96	1.05	1.12	1.18	1.22	1.26	1.28	1.30
0.35	0.52	0.62	0.73	0.82	0.90	0.99	1.08	1.15	1.22	1.26	1.30	1.33	1.34
0.38	0.53	0.64	0.75	0.84	0.92	1.02	1.11	1.19	1.25	1.30	1.34	1.37	1.38
0.40	0.54	0.65	0.76	0.86	0.95	1.04	1.14	1.22	1.29	1.34	1.38	1.41	1.42
0.42	0.56	0.67	0.78	0.88	0.97	1.07	1.17	1.25	1.32	1.37	1.42	1.44	1.46
0.46	0.58	0.70	0.81	0.91	1.01	1.12	1.22	1.31	1.38	1.44	1.49	1.52	1.54
0.50	0.60	0.72	0.84	0.95	1.06	1.17	1.27	1.36	1.44	1.50	1.55	1.58	1.60
0.54	0.62	0.75	0.87	0.99	1.10	1.22	1.32	1.42	1.50	1.56	1.61	1.65	1.67
0.58	0.64	0.77	0.90	1.03	1.15	1.26	1.37	1.47	1.55	1.62	1.67	1.71	1.74
0.63	0.66	0.80	0.94	1.06	1.19	1.31	1.42	1.53	1.61	1.68	1.73	1.77	1.80
0.67	0.68	0.82	0.96	1.10	1.22	1.35	1.47	1.58	1.66	1.73	1.79	1.83	1.86
0.71	0.70	0.85	1.00	1.13	1.26	1.39	1.52	1.62	1.71	1.78	1.84	1.88	1.92
0.75	0.72	0.87	1.02	1.16	1.30	1.43	1.56	1.67	1.76	1.84	1.89	1.94	1.97
0.79	0.74	0.90	1.05	1.19	1.33	1.47	1.60	1.72	1.81	1.89	1.94	1.99	2.02
0.83	0.76	0.92	1.08	1.22	1.37	1.51	1.64	1.76	1.85	1.94	1.99	2.04	2.08
0.92	0.79	0.96	1.13	1.28	1.44	1.58	1.72	1.85	1.94	2.03	2.09	2.14	2.18
1.00	0.83	1.01	1.18	1.34	1.50	1.66	1.80	1.93	2.03	2.12	2.18	2.24	2.27
1.08	0.86	1.05	1.23	1.40	1.56	1.72	1.87	2.01	2.12	2.21	2.29	2.33	2.37
1.17	0.89	1.09	1.28	1.45	1.62	1.79	1.94	2.08	2.20	2.29	2.36	2.42	2.46
1.25	0.92	1.13	1.32	1.50	1.68	1.85	2.01	2.16	2.27	2.37	2.44	2.50	2.54
1.33	0.95	1.16	1.37	1.55	1.73	1.91	2.08	2.23	2.35	2.45	2.52	2.58	2.62
1.42	0.98	1.20	1.41	1.60	1.78	1.97	2.14	2.30	2.42	2.52	2.60	2.66	2.71
1.50	1.01	1.23	1.45	1.64	1.84	2.03	2.20	2.36	2.49	2.60	2.68	2.74	2.79

Armco-Type Metergate Tables - Preliminary

15-inch Round Gate

Head Difference (feet)	Net Gate Opening (feet)																	
	0.17	**0.21**	**0.25**	**0.29**	**0.33**	**0.38**	**0.42**	**0.46**	**0.50**	**0.58**	**0.67**	**0.75**	**0.83**	**0.92**	**1.00**	**1.08**	**1.17**	**1.25**
	Discharge (cfs)																	
0.08	0.46	0.57	0.66	0.75	0.83	0.91	0.98	1.07	1.14	1.30	1.43	1.58	1.71	1.84	1.94	2.04	2.13	2.18
0.10	0.51	0.62	0.73	0.83	0.92	1.02	1.09	1.19	1.27	1.44	1.59	1.75	1.90	2.05	2.17	2.29	2.38	2.43
0.13	0.55	0.67	0.79	0.91	1.00	1.11	1.19	1.30	1.38	1.57	1.74	1.91	2.08	2.24	2.38	2.51	2.62	2.67
0.15	0.59	0.72	0.85	0.98	1.08	1.19	1.28	1.39	1.49	1.68	1.87	2.06	2.24	2.41	2.57	2.72	2.83	2.90
0.17	0.63	0.77	0.90	1.04	1.15	1.27	1.37	1.48	1.59	1.79	1.99	2.20	2.39	2.58	2.75	2.90	3.03	3.09
0.19	0.67	0.81	0.95	1.10	1.22	1.34	1.45	1.57	1.68	1.89	2.11	2.33	2.54	2.73	2.91	3.07	3.22	3.28
0.21	0.70	0.85	1.00	1.15	1.28	1.41	1.53	1.65	1.76	1.99	2.22	2.45	2.68	2.87	3.07	3.24	3.40	3.46
0.23	0.73	0.89	1.05	1.20	1.33	1.48	1.60	1.73	1.84	2.09	2.33	2.57	2.81	3.01	3.21	3.40	3.57	6.64
0.25	0.76	0.93	1.09	1.25	1.38	1.54	1.67	1.80	1.92	2.18	2.43	2.69	2.93	3.14	3.35	3.54	3.73	3.81
0.27	0.79	0.97	1.13	1.29	1.43	1.60	1.73	1.87	2.00	2.27	2.53	2.80	3.05	3.27	3.49	3.68	3.88	3.97
0.29	0.82	1.00	1.17	1.33	1.48	1.65	1.79	1.94	2.08	2.36	2.63	2.90	3.17	3.39	3.62	3.82	4.01	4.11
0.31	0.85	1.03	1.21	1.37	1.53	1.70	1.85	2.01	2.15	2.44	2.72	3.00	3.28	3.51	3.75	3.96	4.14	4.25
0.33	0.88	1.06	1.25	1.41	1.58	1.75	1.91	2.07	2.22	2.52	2.81	3.10	3.39	3.63	3.87	4.09	4.27	4.39
0.35	0.91	1.09	1.29	1.45	1.63	1.80	1.97	2.13	2.29	2.60	2.90	3.20	3.49	3.74	3.99	4.21	4.40	4.53
0.38	0.93	1.12	1.32	1.49	1.68	1.85	2.03	2.19	2.36	2.68	2.98	3.29	3.59	3.85	4.10	4.33	4.53	4.67
0.40	0.95	1.15	1.35	1.53	1.73	1.90	2.09	2.25	2.42	2.75	3.06	3.38	3.69	3.96	4.21	4.45	4.65	4.80
0.42	0.97	1.18	1.38	1.57	1.77	1.95	2.14	2.31	2.48	2.82	3.14	3.47	3.79	4.06	4.32	4.57	4.77	4.92
0.46	1.01	1.23	1.44	1.64	1.85	2.05	2.24	2.43	2.60	2.96	3.30	3.63	3.97	4.26	4.54	4.79	5.00	5.14
0.50	1.05	1.28	1.50	1.71	1.93	2.14	2.34	2.54	2.72	3.09	3.44	3.79	4.15	4.44	4.74	5.00	5.22	5.36
0.54	1.09	1.33	1.56	1.78	2.01	2.23	2.44	2.64	2.83	3.22	3.58	3.95	4.32	4.62	4.93	5.20	5.43	5.58
0.58	1.13	1.38	1.62	1.85	2.09	2.31	2.53	2.74	2.93	3.34	3.72	4.10	4.48	4.79	5.11	5.40	5.64	5.79
0.63	1.17	1.42	1.68	1.92	2.16	2.39	2.62	2.84	3.03	3.46	3.85	4.25	4.64	4.96	5.29	5.59	5.84	5.99
0.67	1.21	1.46	1.73	1.98	2.23	2.47	2.71	2.93	3.13	3.57	3.98	4.39	4.79	5.13	5.47	5.78	6.03	6.19
0.71	1.24	1.50	1.78	2.04	2.30	2.55	2.79	3.02	3.23	3.68	4.10	4.52	4.93	5.29	5.64	5.95	6.22	6.38
0.75	1.27	1.54	1.83	2.10	2.37	2.62	2.87	3.11	3.33	3.79	4.22	4.65	5.07	5.44	5.80	6.12	6.40	6.56
0.79	1.30	1.58	1.88	2.16	2.43	2.69	2.95	3.19	3.42	3.89	4.34	4.78	5.21	5.59	5.96	6.29	6.58	6.74
0.83	1.33	1.62	1.93	2.22	2.49	2.76	3.03	3.27	3.51	3.99	4.45	4.91	5.35	5.73	6.11	6.46	6.75	6.92
0.92	1.39	1.70	2.03	2.32	2.61	2.90	3.17	3.43	3.68	4.18	4.66	5.14	5.61	6.01	6.41	6.77	7.07	7.26
1.00	1.45	1.78	2.12	2.42	2.73	3.03	3.31	3.59	3.84	4.37	4.87	5.37	5.86	6.29	6.70	7.07	7.39	7.59
1.08	1.50	1.85	2.21	2.52	2.84	3.15	3.45	3.73	4.00	4.55	5.07	5.59	6.10	6.54	6.97	7.36	7.69	7.89
1.17	1.55	1.92	2.29	2.62	2.95	3.27	3.58	3.87	4.15	4.72	5.26	5.80	6.34	6.79	7.24	7.64	7.98	8.19
1.25	1.60	1.99	2.37	2.71	3.05	3.38	3.70	4.01	4.30	4.88	5.44	6.00	6.56	7.03	7.49	7.91	8.26	8.47
1.33	1.65	2.05	2.45	2.80	3.15	3.49	3.82	4.14	4.44	5.04	5.62	6.20	6.77	7.26	7.73	8.17	8.53	8.75
1.42	1.70	2.11	2.52	2.89	3.25	3.60	3.94	4.27	4.57	5.20	5.80	6.39	6.98	7.48	7.97	8.42	8.80	9.02
1.50	1.75	2.17	2.59	2.97	3.34	3.70	4.05	4.39	4.70	5.35	5.96	6.58	7.18	7.69	8.20	8.66	9.05	9.28

Armco-Type Metergate Tables - Preliminary

16-inch Round Gate

Head Difference (feet)	Net Gate Opening (feet)																		
	0.17	0.21	0.25	0.29	0.33	0.38	0.42	0.46	0.50	0.58	0.67	0.75	0.83	0.92	1.00	1.08	1.17	1.25	1.33
	Discharge (cfs)																		
0.08	0.49	0.59	0.70	0.79	0.89	0.97	1.05	1.14	1.22	1.37	1.53	1.68	1.83	1.96	2.10	2.24	2.35	2.43	2.47
0.10	0.55	0.66	0.77	0.88	0.98	1.08	1.16	1.27	1.36	1.52	1.70	1.87	2.04	2.19	2.34	2.50	2.63	2.72	2.78
0.13	0.59	0.72	0.84	0.96	1.07	1.18	1.27	1.39	1.48	1.66	1.86	2.04	2.22	2.39	2.56	2.74	2.89	2.98	3.05
0.15	0.63	0.77	0.90	1.03	1.15	1.27	1.37	1.49	1.59	1.79	1.99	2.20	2.40	2.57	2.76	2.96	3.12	3.23	3.31
0.17	0.67	0.82	0.96	1.10	1.23	1.35	1.46	1.59	1.69	1.91	2.12	2.34	2.56	2.74	2.94	3.16	3.31	3.46	3.54
0.19	0.71	0.86	1.02	1.16	1.30	1.43	1.54	1.68	1.79	2.02	2.25	2.48	2.71	2.91	3.11	3.33	3.50	3.66	3.75
0.21	0.75	0.90	1.07	1.21	1.36	1.50	1.62	1.76	1.89	2.13	2.37	2.61	2.85	3.08	3.28	3.50	3.68	3.85	3.95
0.23	0.78	0.94	1.12	1.26	1.42	1.57	1.69	1.84	1.98	2.23	2.49	2.74	2.99	3.23	3.44	3.67	3.86	4.03	4.14
0.25	0.81	0.98	1.16	1.31	1.48	1.64	1.76	1.92	2.06	2.33	2.60	2.86	3.12	3.37	3.59	3.83	4.04	4.20	4.33
0.27	0.84	1.02	1.20	1.36	1.54	1.70	1.84	2.00	2.14	2.43	2.71	2.98	3.25	3.51	3.74	3.99	4.20	4.37	4.51
0.29	0.87	1.06	1.24	1.41	1.59	1.75	1.91	2.08	2.22	2.52	2.81	3.09	3.37	3.64	3.88	4.14	4.36	4.53	4.69
0.31	0.90	1.09	1.28	1.46	1.64	1.81	1.98	2.15	2.30	2.61	2.91	3.20	3.49	3.77	4.02	4.28	4.52	4.69	4.86
0.33	0.93	1.12	1.32	1.51	1.69	1.87	2.05	2.22	2.38	2.69	3.00	3.31	3.61	3.89	4.15	4.42	4.67	4.85	5.02
0.35	0.96	1.15	1.36	1.56	1.74	1.93	2.11	2.29	2.45	2.77	3.09	3.41	3.72	4.01	4.28	4.56	4.81	5.00	5.18
0.38	0.99	1.18	1.40	1.61	1.79	1.99	2.17	2.36	2.52	2.85	3.18	3.51	3.83	4.13	4.40	4.69	4.95	5.15	5.32
0.40	1.02	1.21	1.44	1.65	1.84	2.04	2.23	2.42	2.59	2.93	3.27	3.61	3.94	4.24	4.52	4.82	5.09	5.29	5.46
0.42	1.04	1.24	1.48	1.69	1.89	2.09	2.29	2.48	2.66	3.01	3.36	3.70	4.04	4.35	4.64	4.95	5.22	5.43	5.59
0.46	1.08	1.30	1.55	1.76	1.98	2.19	2.40	2.60	2.79	3.16	3.52	3.88	4.24	4.56	4.87	5.19	5.47	5.69	5.85
0.50	1.12	1.36	1.61	1.83	2.07	2.28	2.50	2.71	2.91	3.30	3.68	4.05	4.42	4.76	5.08	5.42	5.71	5.94	6.10
0.54	1.16	1.41	1.67	1.90	2.15	2.37	2.60	2.82	3.03	3.43	3.83	4.21	4.60	4.96	5.29	5.64	5.95	6.18	6.35
0.58	1.20	1.46	1.73	1.97	2.23	2.46	2.70	2.93	3.14	3.56	3.97	4.37	4.77	5.15	5.49	5.85	6.18	6.41	6.59
0.63	1.24	1.51	1.79	2.04	2.31	2.55	2.80	3.04	3.25	3.69	4.11	4.53	4.94	5.33	5.68	6.06	6.39	6.64	6.82
0.67	1.28	1.56	1.85	2.11	2.39	2.63	2.89	3.14	3.36	3.81	4.25	4.68	5.11	5.50	5.87	6.26	6.60	6.86	7.05
0.71	1.31	1.60	1.90	2.18	2.46	2.71	2.98	3.24	3.46	3.93	4.38	4.82	5.26	5.67	6.05	6.45	6.81	7.07	7.27
0.75	1.34	1.64	1.95	2.24	2.53	2.79	3.07	3.33	3.56	4.04	4.51	4.96	5.41	5.83	6.23	6.64	7.01	7.27	7.48
0.79	1.37	1.68	2.00	2.30	2.60	2.87	3.15	3.42	3.66	4.15	4.63	5.10	5.56	5.99	6.40	6.83	7.20	7.47	7.68
0.83	1.40	1.72	2.05	2.36	2.67	2.95	3.23	3.51	3.75	4.26	4.75	5.23	5.71	6.15	6.56	7.00	7.39	7.67	7.88
0.92	1.46	1.80	2.15	2.48	2.80	3.09	3.39	3.68	3.93	4.46	4.98	5.48	5.98	6.45	6.88	7.34	7.74	8.04	8.26
1.00	1.52	1.88	2.25	2.59	2.92	3.23	3.54	3.84	4.11	4.66	5.20	5.73	6.25	6.74	7.19	7.66	8.09	8.40	8.63
1.08	1.58	1.96	2.34	2.69	3.04	3.36	3.68	4.00	4.28	4.85	5.41	5.96	6.50	7.01	7.48	7.98	8.41	8.74	8.98
1.17	1.64	2.04	2.43	2.79	3.15	3.49	3.82	4.15	4.44	5.03	5.61	6.19	6.75	7.28	7.76	8.27	8.73	9.07	9.32
1.25	1.70	2.11	2.51	2.89	3.26	3.61	3.96	4.29	4.60	5.21	5.81	6.40	6.99	7.54	8.04	8.56	9.04	9.39	9.65
1.33	1.76	2.18	2.59	2.99	3.37	3.73	4.09	4.43	4.75	5.38	6.00	6.61	7.22	7.79	8.30	8.85	9.34	9.70	9.96
1.42	1.81	2.25	2.67	3.08	3.48	3.84	4.22	4.57	4.90	5.55	6.19	6.82	7.44	8.03	8.56	9.13	9.63	10.00	10.27
1.50	1.86	2.31	2.75	3.16	3.58	3.95	4.34	4.70	5.04	5.71	6.37	7.01	7.65	8.25	8.80	9.39	9.90	10.28	10.56

Armco-Type Metergate Tables - Preliminary

20-inch Round Gate

Head Difference (feet)	Net Gate Opening (feet)																						
	0.17	0.21	0.25	0.29	0.33	0.38	0.42	0.46	0.50	0.58	0.67	0.75	0.83	0.92	1.00	1.08	1.17	1.25	1.33	1.42	1.50	1.58	1.67
	Discharge (cfs)																						
0.08	0.58	0.73	0.86	0.96	1.10	1.21	1.32	1.43	1.54	1.75	1.92	2.12	2.29	2.48	2.66	2.84	3.01	3.16	3.31	3.44	3.57	3.68	3.71
0.10	0.66	0.81	0.96	1.09	1.23	1.35	1.42	1.60	1.72	1.95	2.16	2.37	2.56	2.77	2.98	3.18	3.37	3.54	3.71	3.86	4.01	4.14	4.19
0.13	0.72	0.88	1.04	1.18	1.35	1.47	1.61	1.74	1.88	2.12	2.35	2.58	2.79	3.03	3.25	3.47	3.69	3.88	4.06	4.23	4.39	4.52	4.61
0.15	0.77	0.95	1.11	1.27	1.44	1.58	1.72	1.87	2.02	2.27	2.52	2.77	3.00	3.26	3.50	3.73	3.95	4.18	3.36	4.55	4.71	4.86	4.97
0.17	0.82	1.01	1.18	1.36	1.53	1.68	1.83	1.99	2.15	2.42	2.69	2.95	3.21	3.48	3.73	3.97	4.20	4.46	4.66	4.85	5.02	5.20	5.31
0.19	0.87	1.07	1.25	1.44	1.62	1.78	1.94	2.11	2.27	2.56	2.86	3.13	3.42	3.69	3.96	4.21	4.45	4.72	4.95	5.15	5.33	5.53	5.65
0.21	0.91	1.12	1.31	1.51	1.70	1.87	2.04	2.21	2.38	2.70	3.02	3.31	3.62	3.89	4.18	4.45	4.70	4.97	5.21	5.43	5.63	5.83	5.95
0.23	0.95	1.17	1.37	1.58	1.78	1.96	2.13	2.31	2.49	2.84	3.16	3.49	3.80	4.08	4.39	4.66	4.95	5.21	5.46	5.70	5.91	6.13	6.24
0.25	0.99	1.22	1.43	1.65	1.85	2.04	2.22	2.41	2.60	2.96	3.30	3.64	3.96	4.26	4.58	4.86	5.16	5.44	5.70	5.95	6.17	6.41	6.52
0.27	1.03	1.27	1.49	1.71	1.92	2.12	2.31	2.51	2.71	3.08	3.44	3.79	4.12	4.44	4.77	5.06	5.37	5.66	5.94	6.20	6.43	6.68	6.80
0.29	1.07	1.31	1.54	1.77	1.99	2.19	2.40	2.61	2.82	3.20	3.56	3.93	4.28	4.60	4.95	5.25	5.57	5.88	6.16	6.43	6.67	6.92	7.08
0.31	1.10	1.35	1.59	1.83	2.06	2.26	2.49	2.70	2.92	3.31	3.68	4.07	4.43	4.76	5.13	5.44	5.77	6.09	6.38	6.65	6.90	7.15	7.32
0.33	1.13	1.39	1.64	1.88	2.12	2.33	2.57	2.79	3.02	3.42	3.80	4.20	4.57	4.92	5.29	5.62	5.96	6.29	6.58	6.87	7.12	7.38	7.56
0.35	1.16	1.43	1.69	1.93	2.18	2.40	2.65	2.88	3.12	3.52	3.92	4.33	4.71	5.07	5.45	5.79	6.14	6.48	6.78	7.08	7.34	7.61	7.79
0.38	1.19	1.47	1.73	1.98	2.24	2.47	2.73	2.96	3.21	3.62	4.04	4.46	4.85	5.22	5.61	5.96	6.32	6.67	6.98	7.29	7.56	7.84	8.02
0.40	1.22	1.51	1.77	2.03	2.30	2.54	2.80	3.04	3.29	3.72	4.16	4.58	4.99	5.36	5.76	6.13	6.50	6.85	7.18	7.50	7.77	8.05	8.25
0.42	1.25	1.55	1.81	2.08	2.36	2.61	2.87	3.12	3.37	3.82	4.26	4.70	5.12	5.50	5.91	6.29	6.66	7.03	7.36	7.69	7.97	8.26	8.46
0.46	1.31	1.61	1.89	2.18	2.48	2.74	3.02	3.28	3.53	4.01	4.47	4.93	5.36	5.77	6.20	6.59	6.98	7.37	7.72	8.06	8.36	8.66	8.87
0.50	1.37	1.67	1.97	2.28	2.59	2.86	3.15	3.42	3.69	4.19	4.67	5.15	5.60	6.04	6.48	6.89	7.30	7.70	8.06	8.41	8.73	9.05	9.26
0.54	1.42	1.73	2.05	2.38	2.69	2.98	3.28	3.56	3.85	4.36	4.86	5.37	5.84	6.28	6.76	7.17	7.60	8.02	8.40	8.76	9.10	9.44	9.65
0.58	1.47	1.79	2.12	2.47	2.79	3.09	3.40	3.70	3.99	4.53	5.05	5.57	6.06	6.51	7.01	7.45	7.89	8.32	8.72	9.10	9.43	9.78	10.02
0.63	1.52	1.85	2.19	2.56	2.89	3.20	3.52	3.82	4.13	4.68	5.22	5.76	6.26	6.74	7.25	7.70	8.16	8.61	9.02	9.42	9.76	10.12	10.37
0.67	1.57	1.91	2.26	2.65	2.98	3.30	3.63	3.94	4.26	4.83	5.39	5.95	6.46	6.96	7.48	7.95	8.43	8.88	9.31	9.72	10.08	10.44	10.70
0.71	1.61	1.97	2.33	2.73	3.07	3.40	3.74	4.06	4.39	4.98	5.55	6.13	6.66	7.17	7.70	8.19	8.69	9.15	9.60	10.01	10.40	10.76	11.03
0.75	1.65	2.02	2.40	2.80	3.16	3.50	3.85	4.18	4.52	5.13	5.71	6.31	6.86	7.38	7.92	8.43	8.95	9.42	9.88	10.30	10.70	11.08	11.34
0.79	1.69	2.07	2.47	2.87	3.25	3.60	3.96	4.30	4.65	5.27	5.87	6.49	7.06	7.59	8.14	8.67	9.20	9.69	10.15	10.59	11.00	11.40	11.65
0.83	1.73	2.12	2.54	2.94	3.34	3.70	4.07	4.42	4.77	5.41	6.03	6.65	7.25	7.79	8.36	8.90	9.44	9.95	10.41	10.88	11.28	11.69	11.96
0.92	1.81	2.22	2.67	3.08	3.50	3.87	4.28	4.63	5.00	5.67	6.31	6.97	7.60	8.16	8.76	9.32	9.88	10.42	10.91	11.44	11.82	12.24	12.53
1.00	1.88	2.32	2.79	3.22	3.66	4.04	4.47	4.84	5.22	5.92	6.59	7.29	7.93	8.53	9.16	9.74	10.32	10.89	11.41	11.93	12.34	12.79	13.10
1.08	1.95	2.42	2.91	3.36	3.81	4.21	4.64	5.04	5.44	6.17	6.87	7.60	8.26	8.88	9.55	10.13	10.76	11.33	11.88	12.40	12.86	13.32	13.65
1.17	2.02	2.52	3.02	3.49	3.95	4.38	4.81	5.23	5.64	6.40	7.13	7.89	8.57	9.21	9.90	10.52	11.16	11.77	12.32	12.87	13.33	13.82	14.17
1.25	2.08	2.61	3.12	3.61	4.09	4.53	4.97	5.41	5.84	6.62	7.38	8.15	8.86	9.53	10.24	10.88	11.53	12.18	12.74	13.30	13.80	14.30	14.65
1.33	2.14	2.70	3.22	3.73	4.22	4.67	5.13	5.58	6.03	6.84	7.62	8.41	9.15	9.85	10.58	11.23	11.90	12.56	13.16	13.72	14.25	14.78	15.13
1.42	2.20	2.78	3.32	3.84	4.35	4.81	5.29	5.75	6.22	7.05	7.85	8.67	9.43	10.15	10.90	11.58	12.27	12.94	13.58	14.14	14.69	15.24	15.59
1.50	2.26	2.86	3.41	3.95	4.47	4.95	5.45	5.92	6.40	7.25	8.08	8.93	9.70	10.44	11.22	11.92	12.64	13.32	13.98	14.56	15.11	15.68	16.05

Armco-Type Metergate Tables - Preliminary

30-inch Round Gate

Head Difference (feet)	Net Gate Opening (feet)																									
	0.17	0.21	0.25	0.29	0.33	0.38	0.42	0.46	0.50	0.58	0.67	0.75	0.83	0.92	1.00	1.08	1.17	1.25	1.33	1.50	1.67	1.83	2.00	2.17	2.33	2.50
	Discharge (cfs)																									
0.08	0.84	1.05	1.25	1.45	1.63	1.84	2.00	2.20	2.34	2.69	3.03	3.35	3.64	3.92	4.20	4.48	4.75	5.03	5.28	5.84	6.34	6.76	7.10	7.46	7.70	7.86
0.10	0.93	1.17	1.39	1.62	1.82	2.04	2.23	2.45	2.61	2.99	3.36	3.71	4.04	4.36	4.67	4.99	5.30	5.61	5.89	6.49	7.04	7.51	7.90	8.31	8.58	8.77
0.13	1.01	1.27	1.52	1.76	1.97	2.22	2.43	2.66	2.85	3.25	3.63	4.05	4.41	4.75	5.11	5.46	5.80	6.12	6.46	7.08	7.67	8.19	8.65	9.07	9.40	9.59
0.15	1.08	1.37	1.63	1.89	2.12	2.39	2.62	2.87	3.06	3.50	3.88	4.37	4.73	5.11	5.49	5.86	6.22	6.57	6.94	7.60	8.25	8.81	9.29	9.72	10.15	10.32
0.17	1.16	1.46	1.74	2.02	2.27	2.54	2.80	3.05	3.27	3.73	4.13	4.64	5.03	5.45	5.86	6.26	6.63	7.02	7.41	8.11	8.78	9.40	9.91	10.34	10.88	11.04
0.19	1.23	1.55	1.85	2.14	2.40	2.69	2.96	3.22	3.46	3.95	4.38	4.90	5.33	5.78	6.21	6.64	7.04	7.45	7.86	8.61	9.31	9.94	10.48	10.94	11.56	11.74
0.21	1.30	1.63	1.94	2.25	2.52	2.84	3.11	3.38	3.63	4.15	4.63	5.15	5.61	6.09	6.55	7.00	7.41	7.85	8.29	9.07	9.81	10.48	11.03	11.52	12.16	12.40
0.23	1.36	1.70	2.03	2.35	2.64	2.98	3.25	3.53	3.80	4.34	4.86	5.40	5.89	6.39	6.87	7.34	7.78	8.23	8.69	9.51	10.28	10.98	11.56	12.08	12.68	13.00
0.25	1.41	1.77	2.11	2.45	2.75	3.11	3.38	3.67	3.95	4.53	5.08	5.64	6.16	6.68	7.17	7.67	8.13	8.60	9.08	9.94	10.75	11.47	12.07	12.62	13.18	13.55
0.27	1.46	1.84	2.19	2.55	2.86	3.22	3.50	3.81	4.10	4.71	5.29	5.87	6.41	6.95	7.46	7.98	8.46	8.95	9.45	10.34	11.20	11.95	12.57	13.15	13.68	14.05
0.29	1.51	1.90	2.27	2.64	2.96	3.33	3.62	3.94	4.25	4.88	5.49	6.09	6.65	7.21	7.75	8.28	8.78	9.29	9.81	10.74	11.62	12.40	13.06	13.65	14.18	14.52
0.31	1.56	1.96	2.35	2.72	3.06	3.43	3.74	4.07	4.40	5.05	5.68	6.30	6.88	7.47	8.02	8.57	9.09	9.62	10.14	11.12	12.03	12.83	13.50	14.12	14.67	14.98
0.33	1.61	2.02	2.42	2.80	3.15	3.53	3.85	4.20	4.54	5.21	5.86	6.51	7.10	7.71	8.28	8.85	9.38	9.93	10.47	11.48	12.42	13.25	13.94	14.58	15.15	15.44
0.35	1.65	2.08	2.49	2.88	3.24	3.63	3.96	4.33	4.68	5.38	6.04	6.71	7.32	7.95	8.54	9.12	9.67	10.23	10.80	11.83	12.80	13.66	14.37	15.03	15.61	15.90
0.38	1.69	2.14	2.56	2.96	3.33	3.73	4.07	4.45	4.82	5.54	6.22	6.91	7.54	8.18	8.79	9.39	9.95	10.53	11.12	12.17	13.17	14.06	14.80	15.47	16.07	16.36
0.40	1.73	2.20	2.62	3.04	3.42	3.82	4.18	4.57	4.95	5.69	6.39	7.10	7.75	8.40	9.03	9.65	10.23	10.82	11.43	12.51	13.54	14.45	15.20	15.90	16.52	16.82
0.42	1.77	2.25	2.68	3.11	3.50	3.91	4.29	4.69	5.08	5.84	6.56	7.29	7.95	8.62	9.26	9.90	10.50	11.11	11.73	12.84	13.90	14.83	15.60	16.32	16.95	17.26
0.46	1.85	2.35	2.80	3.25	3.66	4.09	4.50	4.92	5.33	6.12	6.88	7.64	8.34	9.05	9.72	10.38	11.02	11.65	12.30	13.47	14.57	15.56	16.36	17.10	17.77	18.10
0.50	1.93	2.45	2.92	3.39	3.82	4.27	4.70	5.14	5.56	6.39	7.19	7.98	8.70	9.45	10.14	10.84	11.50	12.16	12.83	14.06	15.20	16.23	17.08	17.85	18.55	18.90
0.54	2.01	2.55	3.04	3.53	3.97	4.44	4.89	5.35	5.79	6.65	7.48	8.31	9.06	9.84	10.56	11.29	11.96	12.66	13.36	14.63	15.83	16.90	17.77	18.58	19.30	19.65
0.58	2.09	2.64	3.15	3.64	4.13	4.61	5.07	5.55	6.01	6.90	7.76	8.62	9.40	10.20	10.96	11.72	12.42	13.14	13.87	15.19	16.43	17.53	18.45	19.30	20.04	20.40
0.63	2.16	2.72	3.25	3.76	4.27	4.77	5.25	5.75	6.21	7.15	8.03	8.92	9.74	10.56	11.35	12.13	12.85	13.60	14.36	15.72	17.00	18.15	19.10	19.97	20.74	21.12
0.67	2.23	2.80	3.34	3.88	4.41	4.92	5.42	5.94	6.42	7.38	8.30	9.21	10.06	10.90	11.72	12.52	13.27	14.04	14.83	16.23	17.56	18.73	19.72	20.62	21.42	21.82
0.71	2.30	2.88	3.43	3.99	4.54	5.07	5.59	6.12	6.61	7.60	8.55	9.49	10.36	11.23	12.08	12.91	13.68	14.47	15.29	16.73	18.10	19.30	20.32	21.26	22.08	22.52
0.75	2.36	2.96	3.52	4.10	4.67	5.22	5.75	6.30	6.81	7.82	8.80	9.76	10.66	11.56	12.44	13.28	14.07	14.90	15.74	17.21	18.62	19.87	20.91	21.87	22.72	23.17
0.79	2.42	3.04	3.61	4.21	4.80	5.36	5.91	6.47	7.00	8.04	9.04	10.03	10.95	11.89	12.79	13.64	14.46	15.30	16.15	17.68	19.14	20.41	21.49	22.47	23.34	23.80
0.83	2.48	3.12	3.70	4.32	4.93	5.50	6.06	6.64	7.18	8.26	9.28	10.30	11.24	12.20	13.12	14.00	14.85	15.70	16.60	18.15	19.65	20.95	22.06	23.06	23.95	24.40
0.92	2.59	3.27	3.88	4.53	5.17	5.78	6.36	6.96	7.53	8.66	9.73	10.80	11.78	12.79	13.74	14.69	15.57	16.47	17.40	19.03	20.50	21.96	23.13	24.20	25.12	25.58
1.00	2.70	3.40	4.05	4.74	5.40	6.04	6.64	7.27	7.86	9.04	10.16	11.28	12.31	13.36	14.35	15.33	16.26	17.20	18.16	19.88	21.50	22.95	24.15	25.25	26.23	26.72
1.08	2.81	3.52	4.21	4.93	5.62	6.28	6.91	7.57	8.19	9.40	10.57	11.74	12.82	13.90	14.94	15.96	16.93	17.90	18.90	20.70	22.40	23.90	25.15	26.28	27.30	27.80
1.17	2.91	3.64	4.37	5.11	5.84	6.51	7.17	7.86	8.49	9.76	10.97	12.18	13.30	14.43	15.50	16.56	17.56	18.57	19.60	21.48	23.23	24.80	26.10	27.28	28.32	28.85
1.25	3.01	3.76	4.52	5.29	6.04	6.74	7.42	8.13	8.79	10.10	11.37	12.62	13.76	14.93	16.04	17.14	18.18	19.23	20.30	22.23	24.05	25.66	27.00	28.23	29.32	29.86
1.33	3.11	3.88	4.67	5.47	6.24	6.96	7.66	8.40	9.08	10.43	11.74	13.03	14.22	15.42	16.57	17.70	18.77	19.86	20.97	22.95	24.84	26.50	27.87	29.15	30.30	30.84
1.42	3.20	3.99	4.81	5.64	6.43	7.18	7.90	8.66	9.36	10.76	12.10	13.43	14.65	15.90	17.08	18.26	19.36	20.48	21.62	23.66	25.60	27.32	28.73	30.06	31.25	31.80
1.50	3.28	4.10	4.95	5.79	6.61	7.39	8.13	8.91	9.63	11.06	12.43	13.81	15.08	16.36	17.57	18.78	19.90	21.05	22.25	24.34	26.34	28.10	29.56	30.92	32.15	32.70

Armco-Type Metergate Tables - Preliminary

36-inch Round Gate

Head Difference (feet)	Net Gate Opening (feet)																												
	0.17	0.21	0.25	0.29	0.33	0.38	0.42	0.46	0.50	0.58	0.67	0.75	0.83	0.92	1.00	1.08	1.17	1.25	1.33	1.50	1.67	1.83	2.00	2.17	2.33	2.50	2.67	2.83	3.00
	Discharge (cfs)																												
0.08	0.96	1.22	1.47	1.71	1.94	2.16	2.41	2.61	2.82	3.24	3.67	4.05	4.42	4.77	5.10	5.47	5.83	6.13	6.50	7.12	7.86	8.43	8.92	9.37	9.84	10.10	10.35	10.56	10.74
0.10	1.07	1.35	1.62	1.89	2.15	2.41	2.69	2.90	3.12	3.59	4.05	4.50	4.91	5.31	5.67	6.10	6.49	6.82	7.22	7.87	8.67	9.30	9.88	10.38	10.89	11.20	11.50	11.74	11.92
0.13	1.17	1.47	1.77	2.06	2.34	2.63	2.94	3.16	3.40	3.92	4.43	4.93	5.36	5.79	6.20	6.68	7.08	7.44	7.89	8.59	9.44	10.14	10.81	11.33	11.86	12.24	12.57	12.84	13.02
0.15	1.26	1.59	1.92	2.22	2.53	2.84	3.18	3.42	3.67	4.24	4.77	5.32	5.79	6.25	6.70	7.20	7.63	8.04	8.52	9.28	10.17	10.95	11.65	12.25	12.80	13.24	13.60	13.91	14.09
0.17	1.34	1.70	2.05	2.36	2.69	3.04	3.39	3.66	3.92	4.53	5.08	5.68	6.18	6.66	7.17	7.67	8.13	8.60	9.10	9.95	10.87	11.71	12.43	13.09	13.67	14.16	14.54	14.87	15.05
0.19	1.42	1.80	2.17	2.50	2.85	3.21	3.58	3.87	4.14	4.79	5.38	6.00	6.52	7.04	7.61	8.12	8.62	9.12	9.65	10.57	11.52	12.42	13.18	13.86	14.47	15.00	15.39	15.74	15.95
0.21	1.50	1.89	2.28	2.63	3.00	3.37	3.76	4.07	4.35	5.04	5.65	6.30	6.85	7.42	8.02	8.56	9.09	9.61	10.18	11.13	12.16	13.10	13.88	14.60	15.21	15.76	16.17	16.54	16.78
0.23	1.57	1.98	2.39	2.76	3.14	3.52	3.93	4.26	4.55	5.28	5.91	6.60	7.18	7.79	8.42	8.98	9.54	10.07	10.68	11.68	12.76	13.73	14.55	15.31	15.93	16.50	16.94	17.34	17.60
0.25	1.63	2.06	2.49	2.88	3.28	3.67	4.10	4.45	4.75	5.50	6.17	6.89	7.50	8.13	8.79	9.37	9.95	10.52	11.15	12.20	13.31	14.35	15.20	16.00	16.64	17.23	17.68	18.10	18.38
0.27	1.69	2.14	2.59	3.00	3.41	3.82	4.27	4.63	4.95	5.72	6.42	7.17	7.81	8.46	9.15	9.76	10.35	10.96	11.60	12.70	13.86	14.95	15.83	16.66	17.33	17.94	18.40	18.85	19.14
0.29	1.75	2.21	2.68	3.11	3.53	3.95	4.42	4.79	5.13	5.93	6.66	7.44	8.10	8.78	9.49	10.12	10.74	11.37	12.04	13.18	14.37	15.50	16.42	17.28	17.98	18.61	19.08	19.54	19.85
0.31	1.81	2.28	2.76	3.22	3.65	4.08	4.56	4.95	5.31	6.14	6.90	7.70	8.39	9.09	9.82	10.48	11.11	11.77	12.46	13.63	14.89	16.04	16.99	17.89	18.60	19.27	19.74	20.23	20.55
0.33	1.86	2.35	2.84	3.31	3.76	4.20	4.68	5.11	5.49	6.34	7.13	7.95	8.66	9.38	10.14	10.83	11.48	12.15	12.87	14.08	15.37	16.56	17.55	18.46	19.20	19.90	20.40	20.89	21.25
0.35	1.91	2.42	2.92	3.40	3.86	4.32	4.81	5.27	5.66	6.54	7.35	8.20	8.93	9.67	10.45	11.16	11.83	12.52	13.27	14.51	15.84	17.08	18.10	19.03	19.80	20.50	21.05	21.53	21.90
0.38	1.96	2.49	3.00	3.49	3.96	4.44	4.94	5.42	5.82	6.73	7.56	8.44	9.19	9.95	10.76	11.49	12.18	12.89	13.66	14.94	16.31	17.57	18.61	19.60	20.38	21.10	21.65	22.17	22.55
0.40	2.01	2.56	3.08	3.58	4.06	4.56	5.07	5.57	5.98	6.92	7.77	8.67	9.45	10.22	11.06	11.80	12.52	13.25	14.04	15.35	16.76	18.05	19.13	20.15	20.95	21.68	22.25	22.80	23.20
0.42	2.06	2.62	3.16	3.67	4.16	4.68	5.19	5.72	6.14	7.10	7.97	8.89	9.70	10.49	11.34	12.10	12.85	13.60	14.40	15.75	17.20	18.53	19.64	20.65	21.50	22.25	22.80	23.40	23.80
0.46	2.16	2.74	3.31	3.84	4.36	4.90	5.43	6.00	6.43	7.44	8.36	9.33	10.17	11.00	11.90	12.70	13.47	14.25	15.10	16.52	18.03	19.43	20.60	21.65	22.55	23.35	23.90	24.50	24.90
0.50	2.26	2.86	3.45	4.00	4.55	5.11	5.67	6.26	4.71	7.77	8.73	9.73	10.61	11.50	12.42	13.26	14.07	14.88	15.77	17.25	18.82	20.28	21.50	22.62	23.55	24.39	24.95	25.60	26.00
0.54	2.35	2.98	3.59	4.16	4.72	5.32	5.91	6.52	6.99	8.09	9.09	10.13	11.04	11.97	12.93	13.80	14.64	15.50	16.41	17.97	19.60	21.13	22.40	23.65	24.50	26.39	26.00	26.65	27.10
0.58	2.44	3.09	3.72	4.31	4.89	5.52	6.14	6.76	7.25	8.39	9.43	10.51	11.46	12.41	13.42	14.32	15.20	16.09	17.03	18.64	20.35	21.94	23.25	24.44	25.43	26.33	27.00	27.67	28.15
0.63	2.53	3.19	3.85	4.45	5.06	5.72	6.36	7.00	7.51	8.69	9.76	10.89	11.87	12.85	13.90	14.83	15.74	16.67	17.64	19.30	21.08	22.72	24.08	25.30	26.34	27.25	27.95	28.65	19.15
0.67	2.61	3.29	3.97	4.59	5.23	5.91	6.57	7.23	7.76	8.97	10.09	11.24	12.26	13.28	14.35	15.32	16.25	17.20	18.21	19.92	21.75	23.45	24.84	26.13	27.20	28.13	28.85	29.55	30.10
0.71	2.69	3.38	4.08	4.72	5.39	6.09	6.77	7.45	8.00	9.25	10.40	11.59	12.63	13.68	14.79	15.79	16.74	17.72	18.77	20.54	22.42	24.15	25.60	26.95	28.05	29.00	29.75	30.45	31.00
0.75	2.76	3.47	4.19	4.85	5.55	6.27	6.97	7.60	8.23	9.52	10.70	11.93	13.00	14.08	15.21	16.25	17.23	18.23	19.31	21.15	23.07	24.85	26.33	27.73	28.85	29.84	30.62	31.35	31.88
0.79	2.83	3.56	4.30	4.98	5.70	6.44	7.16	7.87	8.45	9.78	11.00	12.26	13.37	14.47	15.63	16.68	17.70	18.73	19.84	21.72	23.70	25.55	27.05	28.47	29.63	30.65	31.45	32.20	32.75
0.83	2.90	3.65	4.41	5.11	5.85	6.61	7.35	8.07	8.67	10.03	11.28	12.58	13.71	14.83	16.03	17.10	18.17	19.21	20.35	22.27	24.30	26.20	27.75	29.20	30.40	31.45	32.25	33.05	33.60
0.92	3.05	3.82	4.60	5.36	6.13	6.92	7.70	8.46	9.10	10.52	11.82	13.18	14.37	15.55	16.81	17.93	19.05	20.14	21.33	23.35	25.47	27.45	29.10	30.60	31.85	32.95	33.80	34.65	35.20
1.00	3.16	3.98	4.79	5.61	6.40	7.23	8.05	8.85	9.51	10.99	12.35	13.78	15.01	16.25	17.58	18.74	19.90	21.05	22.30	24.40	26.62	28.70	30.40	32.00	33.30	34.45	35.35	36.20	36.80
1.08	3.28	4.14	4.98	5.85	6.67	7.52	8.39	9.22	9.89	11.44	12.85	14.35	15.62	16.93	18.30	19.53	20.72	21.92	23.22	25.40	27.75	29.87	31.65	33.32	34.65	35.85	36.80	37.68	38.30
1.17	3.39	4.29	5.16	6.06	6.91	7.81	8.70	9.56	10.26	11.88	13.33	14.88	16.21	17.58	18.99	20.25	21.50	22.75	24.10	26.35	28.80	31.00	32.85	34.60	35.98	37.20	38.18	39.10	39.75
1.25	3.50	4.43	5.34	6.27	7.15	8.08	9.00	9.89	10.62	12.30	13.80	15.40	16.78	18.19	19.64	20.95	22.24	23.54	24.93	27.30	29.80	32.10	34.00	35.80	37.25	38.50	39.50	40.45	41.15
1.33	3.61	4.56	5.51	6.48	7.39	8.34	9.29	10.22	10.98	12.69	14.27	15.90	17.33	18.78	20.29	21.65	22.98	24.30	25.75	28.20	30.75	33.15	35.10	36.95	38.45	39.80	40.80	41.80	42.50
1.42	3.72	4.69	5.68	6.68	7.62	8.60	9.58	10.54	11.32	13.08	14.70	16.39	17.86	19.34	20.92	22.32	23.69	25.05	26.55	29.03	31.70	34.15	36.20	38.10	39.60	41.10	42.05	43.10	43.80
1.50	3.82	4.82	5.85	6.87	7.84	8.85	9.86	10.84	11.64	13.45	15.12	16.88	18.39	19.89	21.54	22.97	24.36	25.78	27.33	29.85	32.63	35.15	37.25	39.20	40.75	42.30	43.25	44.35	45.10

ITRC Water Measurement Tables for **FREE FLOW Armco-Type Gates on Round Pipes**

Discharge Values in CFS

Upstream head is measured from the top of turnout pipe.

Upstream Head (feet)	ITRC Water Measurement Tables – 12" Armco-Type Gate, FREE FLOW [Blue center represents best accuracy range] (Flows in CFS) Net Gate Opening (feet)																	
	0.042	0.08	0.13	0.17	0.21	0.25	0.29	0.33	0.38	0.42	0.46	0.50	0.58	0.67	0.75	0.83	0.92	1.00
1.00	0.24	0.55	0.87	1.17	1.47	1.75	2.04	2.31	2.53	2.74	2.89	3.01	3.31	3.58	3.79	3.99	4.11	4.16
1.04	0.	0.57	0.88	1.20	1.50	1.79	2.08	2.36	2.59	2.79	2.95	3.08	3.38	3.65	3.87	4.07	4.19	4.25
1.08	0.25	0.58	0.90	1.22	1.53	1.82	2.12	2.41	2.64	2.85	3.00	3.14	3.44	3.72	3.94	4.15	4.28	4.33
1.13	0.26	0.59	0.92	1.25	1.56	1.86	2.16	2.45	2.69	2.90	3.06	3.20	3.51	3.79	4.02	4.23	4.36	4.41
1.17	0.26	0.60	0.94	1.27	1.59	1.89	2.20	2.50	2.74	2.95	3.12	3.25	3.57	3.86	4.09	4.31	4.44	4.49
1.21	0.27	0.61	0.95	1.29	1.61	1.92	2.24	2.54	2.79	3.01	3.17	3.31	3.64	3.93	4.17	4.39	4.52	4.57
1.25	0.27	0.62	0.97	1.31	1.64	1.96	2.28	2.59	2.83	3.06	3.23	3.37	3.70	4.00	4.24	4.46	4.59	4.65
1.29	0.28	0.63	0.98	1.33	1.67	1.99	2.31	2.63	2.88	3.11	3.28	3.42	3.76	4.06	4.31	4.54	4.67	4.73
1.33	0.28	0.64	1.00	1.36	1.70	2.02	2.35	2.67	2.93	3.16	3.33	3.48	3.82	4.13	4.38	4.61	4.74	4.80
1.38	0.29	0.65	1.02	1.38	1.72	2.05	2.39	2.71	2.97	3.21	3.39	3.53	3.88	4.19	4.44	4.68	4.82	4.88
1.42	0.29	0.66	1.03	1.40	1.75	2.08	2.42	2.75	3.02	3.26	3.44	3.59	3.94	4.26	4.51	4.75	4.89	4.95
1.46	0.29	0.67	1.05	1.42	1.77	2.11	2.46	2.79	3.06	3.30	3.49	3.64	4.00	4.32	4.58	4.82	4.96	5.02
1.50	0.	0.68	1.06	1.44	1.80	2.14	2.49	2.83	3.10	3.35	3.54	3.69	4.05	4.38	4.64	4.89	5.03	5.09
1.54	0.30	0.69	1.08	1.46	1.82	2.17	2.53	2.87	3.15	3.40	3.58	3.74	4.11	4.44	4.71	4.96	5.10	5.16
1.58	0.31	0.70	1.09	1.48	1.85	2.20	2.56	2.91	3.19	3.44	3.63	3.79	4.16	4.50	4.77	5.02	5.17	5.23
1.63	0.31	0.71	1.10	1.50	1.87	2.23	2.60	2.95	3.23	3.49	3.68	3.84	4.22	4.56	4.83	5.09	5.24	5.30
1.67	0.31	0.71	1.12	1.52	1.90	2.26	2.63	2.99	3.27	3.53	3.73	3.89	4.27	4.62	4.89	5.15	5.30	5.37
1.71	0.32	0.72	1.13	1.53	1.92	2.29	2.66	3.02	3.31	3.58	3.77	3.94	4.32	4.67	4.95	5.22	5.37	5.44
1.75	0.32	0.73	1.15	1.55	1.94	2.32	2.69	3.06	3.35	3.62	3.82	3.99	4.38	4.73	5.01	5.28	5.44	5.50
1.79	0.33	0.74	1.16	1.57	1.97	2.34	2.73	3.10	3.39	3.66	3.86	4.03	4.43	4.79	5.07	5.34	5.50	5.57
1.83	0.33	0.75	1.17	1.59	1.99	2.37	2.76	3.13	3.43	3.70	3.91	4.08	4.48	4.84	5.13	5.40	5.56	5.63
1.88	0.33	0.76	1.19	1.61	2.01	2.40	2.79	3.17	3.47	3.75	3.95	4.13	4.53	4.90	5.19	5.46	5.63	5.70
1.92	0.34	0.77	1.20	1.63	2.03	2.42	2.82	3.20	3.51	3.79	4.00	4.17	4.58	4.95	5.25	5.53	5.69	5.76
1.96	0.34	0.77	1.21	1.64	2.05	2.45	2.85	3.24	3.55	3.83	4.04	4.22	4.63	5.01	5.30	5.59	5.75	5.82
2.00	0.34	0.78	1.22	1.66	2.08	2.48	2.88	3.27	3.58	3.87	4.08	4.26	4.68	5.06	5.36	5.64	5.81	5.88
2.04	0.	0.79	1.24	1.68	2.10	2.50	2.91	3.30	3.62	3.91	4.13	4.31	4.73	5.11	5.41	5.70	5.87	5.94
2.08	0.35	0.80	1.25	1.69	2.12	2.53	2.94	3.34	3.66	3.95	4.17	4.35	4.78	5.16	5.47	5.76	5.93	6.00
2.13	0.35	0.81	1.26	1.71	2.14	2.55	2.97	3.37	3.69	3.99	4.21	4.39	4.82	5.21	5.52	5.82	5.99	6.06
2.17	0.36	0.81	1.27	1.73	2.16	2.58	3.00	3.40	3.73	4.03	4.25	4.44	4.87	5.26	5.58	5.87	6.05	6.12
2.21	0.36	0.82	1.29	1.74	2.18	2.60	3.03	3.44	3.77	4.07	4.29	4.48	4.92	5.32	5.63	5.93	6.11	6.18
2.25	0.36	0.83	1.30	1.76	2.20	2.63	3.05	3.47	3.80	4.10	4.33	4.52	4.96	5.37	5.68	5.99	6.16	6.24
2.33	0.37	0.85	1.32	1.79	2.24	2.67	3.11	3.53	3.87	4.18	4.41	4.60	5.05	5.46	5.79	6.10	6.28	6.35
2.42	0.38	0.86	1.35	1.83	2.28	2.72	3.16	3.60	3.94	4.25	4.49	4.68	5.14	5.56	5.89	6.20	6.39	6.47
2.50	0.38	0.88	1.37	1.86	2.32	2.77	3.22	3.66	4.01	4.33	4.56	4.76	5.23	5.66	5.99	6.31	6.50	6.58
2.58	0.39	0.89	1.39	1.89	2.36	2.81	3.27	3.72	4.07	4.40	4.64	4.84	5.32	5.75	6.09	6.41	6.60	6.69
2.67	0.	0.90	1.41	1.92	2.40	2.86	3.32	3.78	4.14	4.47	4.71	4.92	5.40	5.84	6.19	6.52	6.71	6.79
2.75	0.40	0.92	1.44	1.95	2.43	2.90	3.38	3.84	4.20	4.54	4.79	5.00	5.49	5.93	6.28	6.62	6.81	6.90
2.83	0.41	0.93	1.46	1.98	2.47	2.95	3.43	3.89	4.27	4.60	4.86	5.07	5.57	6.02	6.38	6.72	6.92	7.00
2.92	0.42	0.95	1.48	2.01	2.51	2.99	3.48	3.95	4.33	4.67	4.93	5.15	5.65	6.11	6.47	6.82	7.02	7.10
3.00	0.42	0.96	1.50	2.03	2.54	3.03	3.53	4.01	4.39	4.74	5.00	5.22	5.73	6.20	6.56	6.91	7.12	7.20
3.08	0.43	0.97	1.52	2.06	2.58	3.07	3.57	4.06	4.45	4.80	5.07	5.29	5.81	6.28	6.65	7.01	7.21	7.30
3.17	0.43	0.99	1.54	2.09	2.61	3.12	3.62	4.12	4.51	4.87	5.14	5.36	5.89	6.36	6.74	7.10	7.31	7.40
3.25	0.44	1.00	1.56	2.12	2.65	3.16	3.67	4.17	4.57	4.93	5.20	5.43	5.97	6.45	6.83	7.19	7.41	7.50
3.33	0.44	1.01	1.58	2.14	2.68	3.20	3.72	4.22	4.63	4.99	5.27	5.50	6.04	6.53	6.92	7.29	7.50	7.59
3.42	0.	1.02	1.60	2.17	2.71	3.24	3.76	4.28	4.68	5.06	5.34	5.57	6.12	6.61	7.00	7.38	7.59	7.69
3.50	0.46	1.04	1.62	2.20	2.75	3.28	3.81	4.33	4.74	5.12	5.40	5.64	6.19	6.69	7.09	7.47	7.69	7.78
3.58	0.46	1.05	1.64	2.22	2.78	3.31	3.85	4.38	4.80	5.18	5.47	5.70	6.26	6.77	7.17	7.55	7.78	7.87
3.67	0.47	1.06	1.66	2.25	2.81	3.35	3.90	4.43	4.85	5.24	5.53	5.77	6.34	6.85	7.26	7.64	7.87	7.96
3.75	0.47	1.07	1.68	2.27	2.84	3.39	3.94	4.48	4.91	5.30	5.59	5.83	6.41	6.93	7.34	7.73	7.96	8.05
3.83	0.48	1.08	1.70	2.30	2.87	3.43	3.99	4.53	4.96	5.36	5.65	5.90	6.48	7.00	7.42	7.81	8.04	8.14
3.92	0.48	1.10	1.71	2.32	2.91	3.46	4.03	4.58	5.01	5.41	5.71	5.96	6.55	7.08	7.50	7.90	8.13	8.23
4.00	0.49	1.11	1.73	2.35	2.94	3.50	4.07	4.63	5.07	5.47	5.77	6.03	6.62	7.15	7.58	7.98	8.22	8.32

Upstream Head (feet)	ITRC Water Measurement Tables – 18” Armco-Type Gate, FREE FLOW [Blue center represents best accuracy range] (Flows in CFS) Net Gate Opening (feet)																							
	0.042	0.08	0.13	0.17	0.21	0.25	0.29	0.33	0.38	0.42	0.46	0.50	0.58	0.67	0.75	0.83	0.92	1.00	1.08	1.17	1.25	1.33	1.42	1.50
1.50	0.42	0.99	1.58	2.18	2.78	3.39	3.99	4.59	5.03	5.43	5.79	6.11	6.89	7.59	8.30	8.95	9.50	9.97	10.44	10.85	11.15	11.36	11.55	11.59
1.54	0.43	1.00	1.60	2.21	2.82	3.44	4.05	4.65	5.10	5.51	5.87	6.20	6.99	7.69	8.42	9.08	9.63	10.11	10.59	11.00	11.30	11.52	11.71	11.75
1.58	0.44	1.02	1.62	2.24	2.86	3.48	4.10	4.72	5.17	5.58	5.95	6.28	7.08	7.79	8.53	9.20	9.76	10.24	10.73	11.14	11.46	11.67	11.87	11.91
1.63	0.44	1.03	1.65	2.27	2.90	3.53	4.15	4.78	5.24	5.65	6.03	6.36	7.17	7.90	8.64	9.32	9.89	10.38	10.87	11.29	11.61	11.83	12.03	12.06
1.67	0.	1.04	1.67	2.30	2.94	3.57	4.21	4.84	5.30	5.72	6.10	6.44	7.26	8.00	8.75	9.44	10.01	10.51	11.01	11.43	11.75	11.98	12.18	12.22
1.71	0.45	1.06	1.69	2.33	2.97	3.62	4.26	4.90	5.37	5.80	6.18	6.52	7.36	8.10	8.86	9.55	10.14	10.64	11.15	11.57	11.90	12.13	12.33	12.37
1.75	0.46	1.07	1.71	2.36	3.01	3.66	4.31	4.96	5.43	5.87	6.25	6.60	7.44	8.19	8.97	9.67	10.26	10.77	11.28	11.72	12.04	12.27	12.48	12.52
1.79	0.46	1.08	1.73	2.38	3.04	3.70	4.36	5.02	5.50	5.94	6.33	6.68	7.53	8.29	9.07	9.78	10.38	10.89	11.42	11.85	12.19	12.42	12.63	12.67
1.83	0.47	1.09	1.75	2.41	3.08	3.75	4.41	5.07	5.56	6.00	6.40	6.76	7.62	8.39	9.18	9.90	10.50	11.02	11.55	11.99	12.33	12.56	12.77	12.81
1.88	0.47	1.11	1.77	2.44	3.11	3.79	4.46	5.13	5.62	6.07	6.47	6.83	7.71	8.48	9.28	10.01	10.62	11.14	11.68	12.13	12.47	12.70	12.92	12.96
1.92	0.48	1.12	1.79	2.47	3.15	3.83	4.51	5.19	5.69	6.14	6.55	6.91	7.79	8.57	9.39	10.12	10.74	11.27	11.81	12.26	12.60	12.84	13.06	13.10
1.96	0.49	1.13	1.81	2.49	3.18	3.87	4.56	5.24	5.75	6.21	6.62	6.98	7.88	8.67	9.49	10.23	10.85	11.39	11.93	12.39	12.74	12.98	13.20	13.24
2.00	0.49	1.14	1.83	2.52	3.22	3.91	4.61	5.30	5.81	6.27	6.69	7.06	7.96	8.76	9.59	10.34	10.97	11.51	12.06	12.52	12.88	13.12	13.34	13.38
2.04	0.	1.15	1.84	2.55	3.25	3.95	4.66	5.36	5.87	6.34	6.76	7.13	8.04	8.85	9.69	10.44	11.08	11.63	12.19	12.65	13.01	13.26	13.48	13.52
2.08	0.50	1.17	1.86	2.57	3.28	3.99	4.70	5.41	5.93	6.40	6.82	7.20	8.12	8.94	9.79	10.55	11.20	11.75	12.31	12.78	13.14	13.39	13.62	13.66
2.13	0.51	1.18	1.88	2.60	3.31	4.03	4.75	5.46	5.99	6.46	6.89	7.27	8.20	9.03	9.88	10.65	11.31	11.86	12.43	12.91	13.27	13.52	13.75	13.79
2.17	0.51	1.19	1.90	2.62	3.35	4.07	4.80	5.52	6.05	6.53	6.96	7.34	8.28	9.12	9.98	10.76	11.42	11.98	12.55	13.04	13.40	13.66	13.89	13.93
2.21	0.52	1.20	1.92	2.65	3.38	4.11	4.84	5.57	6.10	6.59	7.03	7.41	8.36	9.20	10.07	10.86	11.53	12.10	12.67	13.16	13.53	13.79	14.02	14.06
2.25	0.52	1.21	1.94	2.67	3.41	4.15	4.89	5.62	6.16	6.65	7.09	7.48	8.44	9.29	10.17	10.96	11.63	12.21	12.79	13.28	13.66	13.92	14.15	14.19
2.33	0.53	1.23	1.97	2.72	3.47	4.23	4.98	5.73	6.27	6.77	7.22	7.62	8.60	9.46	10.36	11.17	11.85	12.43	13.03	13.53	13.91	14.17	14.41	14.45
2.42	0.54	1.26	2.01	2.77	3.53	4.30	5.07	5.83	6.38	6.89	7.35	7.76	8.75	9.63	10.54	11.36	12.06	12.65	13.26	13.77	14.15	14.42	14.67	14.71
2.50	0.	1.28	2.04	2.82	3.60	4.37	5.15	5.93	6.49	7.01	7.48	7.89	8.90	9.79	10.72	11.56	12.26	12.87	13.48	14.00	14.40	14.67	14.92	14.96
2.58	0.56	1.30	2.08	2.86	3.65	4.45	5.24	6.02	6.60	7.13	7.60	8.02	9.04	9.95	10.90	11.75	12.47	13.08	13.71	14.23	14.63	14.91	15.16	15.21
2.67	0.57	1.32	2.11	2.91	3.71	4.52	5.32	6.12	6.71	7.24	7.72	8.15	9.19	10.11	11.07	11.94	12.67	13.29	13.93	14.46	14.87	15.15	15.41	15.45
2.75	0.57	1.34	2.14	2.95	3.77	4.59	5.40	6.22	6.81	7.35	7.84	8.27	9.33	10.27	11.24	12.12	12.86	13.50	14.14	14.69	15.10	15.39	15.64	15.69
2.83	0.58	1.36	2.17	3.00	3.83	4.66	5.48	6.31	6.91	7.46	7.96	8.40	9.47	10.43	11.41	12.30	13.06	13.70	14.36	14.91	15.33	15.62	15.88	15.93
2.92	0.59	1.38	2.20	3.04	3.88	4.72	5.56	6.40	7.01	7.57	8.07	8.52	9.61	10.58	11.58	12.48	13.25	13.90	14.56	15.12	15.55	15.84	16.11	16.16
3.00	0.	1.40	2.24	3.09	3.94	4.79	5.64	6.49	7.11	7.68	8.19	8.64	9.75	10.73	11.74	12.66	13.43	14.10	14.77	15.34	15.77	16.07	16.34	16.39
3.08	0.61	1.42	2.27	3.13	3.99	4.86	5.72	6.58	7.21	7.79	8.30	8.76	9.88	10.88	11.90	12.83	13.62	14.29	14.98	15.55	15.99	16.29	16.57	16.62
3.17	0.62	1.44	2.30	3.17	4.05	4.92	5.80	6.67	7.31	7.89	8.41	8.88	10.01	11.02	12.06	13.01	13.80	14.48	15.18	15.76	16.20	16.51	16.79	16.84
3.25	0.63	1.46	2.33	3.21	4.10	4.99	5.87	6.76	7.40	7.99	8.52	8.99	10.14	11.17	12.22	13.18	13.98	14.67	15.37	15.97	16.41	16.73	17.01	17.06
3.33	0.63	1.48	2.36	3.25	4.15	5.05	5.95	6.84	7.50	8.10	8.63	9.11	10.27	11.31	12.38	13.34	14.16	14.86	15.57	16.17	16.62	16.94	17.22	17.28
3.42	0.64	1.49	2.39	3.29	4.20	5.11	6.02	6.93	7.59	8.20	8.74	9.22	10.40	11.45	12.53	13.51	14.34	15.04	15.76	16.37	16.83	17.15	17.44	17.49
3.50	0.	1.51	2.42	3.33	4.25	5.18	6.10	7.01	7.68	8.30	8.85	9.33	10.53	11.59	12.68	13.67	14.51	15.23	15.95	16.57	17.03	17.36	17.65	17.70
3.58	0.66	1.53	2.44	3.37	4.30	5.24	6.17	7.09	7.77	8.39	8.95	9.44	10.65	11.72	12.83	13.84	14.68	15.41	16.14	16.76	17.23	17.56	17.86	17.91
3.67	0.66	1.55	2.47	3.41	4.35	5.30	6.24	7.18	7.86	8.49	9.05	9.55	10.78	11.86	12.98	14.00	14.85	15.59	16.33	16.96	17.43	17.77	18.06	18.12
3.75	0.67	1.56	2.50	3.45	4.40	5.36	6.31	7.26	7.95	8.59	9.16	9.66	10.90	11.99	13.13	14.15	15.02	15.76	16.51	17.15	17.63	17.97	18.27	18.33
3.83	0.68	1.58	2.53	3.49	4.45	5.42	6.38	7.34	8.04	8.68	9.26	9.77	11.02	12.13	13.27	14.31	15.19	15.94	16.70	17.34	17.83	18.17	18.47	18.53
3.92	0.69	1.60	2.56	3.53	4.50	5.48	6.45	7.42	8.13	8.78	9.36	9.87	11.14	12.26	13.42	14.47	15.35	16.11	16.88	17.53	18.02	18.36	18.67	18.73
4.00	0.69	1.62	2.58	3.56	4.55	5.53	6.52	7.50	8.21	8.87	9.46	9.98	11.25	12.39	13.56	14.62	15.51	16.28	17.06	17.71	18.21	18.56	18.87	18.93
4.08	0.	1.63	2.61	3.60	4.59	5.59	6.58	7.57	8.30	8.96	9.55	10.08	11.37	12.52	13.70	14.77	15.67	16.45	17.23	17.90	18.40	18.75	19.06	19.12
4.17	0.71	1.65	2.64	3.64	4.64	5.65	6.65	7.65	8.38	9.05	9.65	10.18	11.49	12.64	13.84	14.92	15.83	16.61	17.41	18.08	18.58	18.94	19.26	19.32
4.25	0.71	1.67	2.66	3.67	4.69	5.70	6.72	7.73	8.47	9.14	9.75	10.29	11.60	12.77	13.98	15.07	15.99	16.78	17.58	18.26	18.77	19.13	19.45	19.51
4.33	0.72	1.68	2.69	3.71	4.73	5.76	6.78	7.80	8.55	9.23	9.84	10.39	11.71	12.89	14.11	15.22	16.15	16.94	17.75	18.43	18.95	19.31	19.64	19.70
4.42	0.73	1.70	2.71	3.74	4.78	5.81	6.85	7.88	8.63	9.32	9.94	10.49	11.83	13.02	14.25	15.36	16.30	17.11	17.92	18.61	19.13	19.50	19.83	19.89
4.50	0.74	1.71	2.74	3.78	4.82	5.87	6.91	7.95	8.71	9.41	10.03	10.58	11.94	13.14	14.38	15.51	16.45	17.27	18.09	18.79	19.31	19.68	20.01	20.07
4.58	0.74	1.73	2.76	3.81	4.87	5.92	6.98	8.02	8.79	9.49	10.12	10.68	12.05	13.26	14.51	15.65	16.61	17.42	18.26	18.96	19.49	19.86	20.20	20.26
4.67	0.	1.75	2.79	3.85	4.91	5.98	7.04	8.10	8.87	9.58	10.21	10.78	12.16	13.38	14.64	15.79	16.76	17.58	18.42	19.13	19.67	20.04	20.38	20.44
4.75	0.76	1.76	2.81	3.88	4.96	6.03	7.10	8.17	8.95	9.66	10.30	10.87	12.26	13.50	14.78	15.93	16.90	17.74	18.59	19.30	19.84	20.22	20.56	20.62
4.83	0.76	1.78	2.84	3.92	5.00	6.08	7.16	8.24	9.03	9.75	10.39	10.97	12.37	13.62	14.90	16.07	17.05	17.89	18.75	19.47	20.02	20.40	20.74	20.80
4.92	0.77	1.79	2.86	3.95	5.04	6.13	7.22	8.31	9.11	9.83	10.48	11.06	12.48	13.73	15.03	16.21	17.20	18.05	18.91	19.64	20.19	20.57	20.92	20.98
5.00	0.78	1.81	2.89	3.98	5.08	6.19	7.29	8.38	9.18	9.91	10.57	11.16	12.58	13.85	15.16	16.34	17.34	18.20	19.07	19.80	20.36	20.75	21.09	21.16

Upstream Head (feet)	ITRC Water Measurement Tables – 24” Armco-Type Gate, FREE FLOW [Blue center represents best accuracy range] (Flows in CFS) Net Gate Opening (feet)																												
	0.042	0.08	0.13	0.17	0.21	0.25	0.29	0.33	0.38	0.42	0.46	0.50	0.58	0.67	0.75	0.83	0.92	1.00	1.08	1.17	1.25	1.33	1.42	1.50	1.58	1.67	1.75	1.83	1.92	2.00
2.00	0.67	1.54	2.45	3.37	4.29	5.20	6.11	7.01	7.82	8.60	9.35	10.1	11.6	13.0	14.2	15.2	16.5	17.8	18.8	19.7	20.5	21.2	21.9	22.6	23.1	23.5	23.8	24.2	24.4	24.5
2.04	0.68	1.56	2.48	3.41	4.33	5.25	6.17	7.09	7.90	8.69	9.45	10.2	11.7	13.2	14.3	15.3	16.7	18.0	19.0	19.9	20.7	21.4	22.2	22.8	23.4	23.8	24.1	24.5	24.6	24.8
2.08	0.68	1.57	2.50	3.44	4.38	5.31	6.24	7.16	7.98	8.78	9.54	10.3	11.8	13.3	14.5	15.5	16.9	18.2	19.2	20.1	20.9	21.7	22.4	23.0	23.6	24.0	24.3	24.7	24.9	25.0
2.13	0.69	1.59	2.53	3.47	4.42	5.36	6.30	7.23	8.06	8.87	9.64	10.4	11.9	13.4	14.6	15.6	17.0	18.4	19.4	20.3	21.1	21.9	22.6	23.3	23.8	24.2	24.6	25.0	25.1	25.3
2.17	0.70	1.60	2.55	3.51	4.46	5.41	6.36	7.30	8.14	8.95	9.73	10.5	12.1	13.6	14.7	15.8	17.2	18.5	19.6	20.5	21.4	22.1	22.8	23.5	24.1	24.5	24.8	25.2	25.4	25.5
2.21	0.70	1.62	2.57	3.54	4.50	5.47	6.42	7.37	8.22	9.04	9.83	10.6	12.2	13.7	14.9	15.9	17.4	18.7	19.8	20.7	21.6	22.3	23.1	23.7	24.3	24.7	25.0	25.5	25.6	25.8
2.25	0.71	1.63	2.60	3.58	4.55	5.52	6.48	7.44	8.30	9.12	9.92	10.7	12.3	13.8	15.0	16.1	17.5	18.9	20.0	20.9	21.8	22.5	23.3	23.9	24.5	25.0	25.3	25.7	25.9	26.0
2.29	0.72	1.65	2.62	3.61	4.59	5.57	6.54	7.51	8.37	9.21	10.01	10.8	12.4	13.9	15.2	16.2	17.7	19.1	20.1	21.1	22.0	22.7	23.5	24.2	24.7	25.2	25.5	25.9	26.1	26.3
2.33	0.72	1.66	2.65	3.64	4.63	5.62	6.60	7.58	8.45	9.29	10.10	10.9	12.5	14.1	15.3	16.4	17.8	19.2	20.3	21.3	22.2	22.9	23.7	24.4	25.0	25.4	25.7	26.2	26.3	26.5
2.38	0.73	1.68	2.67	3.67	4.67	5.67	6.66	7.64	8.52	9.37	10.19	11.0	12.6	14.2	15.4	16.5	18.0	19.4	20.5	21.5	22.4	23.1	23.9	24.6	25.2	25.6	26.0	26.4	26.6	26.7
2.42	0.73	1.69	2.69	3.71	4.71	5.72	6.72	7.71	8.60	9.45	10.28	11.1	12.7	14.3	15.6	16.7	18.2	19.6	20.7	21.7	22.5	23.3	24.1	24.8	25.4	25.9	26.2	26.6	26.8	27.0
2.46	0.74	1.71	2.72	3.74	4.75	5.77	6.77	7.78	8.67	9.54	10.37	11.2	12.8	14.4	15.7	16.8	18.3	19.8	20.9	21.8	22.7	23.5	24.3	25.0	25.6	26.1	26.4	26.9	27.0	27.2
2.50	0.75	1.72	2.74	3.77	4.79	5.81	6.83	7.84	8.74	9.62	10.45	11.3	13.0	14.6	15.8	17.0	18.5	19.9	21.0	22.0	22.9	23.7	24.5	25.2	25.8	26.3	26.6	27.1	27.3	27.4
2.54	0.75	1.74	2.76	3.80	4.83	5.86	6.89	7.91	8.82	9.70	10.54	11.4	13.1	14.7	16.0	17.1	18.6	20.1	21.2	22.2	23.1	23.9	24.7	25.5	26.1	26.5	26.9	27.3	27.5	27.7
2.58	0.76	1.75	2.78	3.83	4.87	5.91	6.94	7.97	8.89	9.77	10.63	11.4	13.2	14.8	16.1	17.2	18.8	20.3	21.4	22.4	23.3	24.1	24.9	25.7	26.3	26.7	27.1	27.5	27.7	27.9
2.63	0.77	1.77	2.81	3.86	4.91	5.96	7.00	8.04	8.96	9.85	10.71	11.5	13.3	14.9	16.2	17.4	18.9	20.4	21.5	22.6	23.5	24.3	25.1	25.9	26.5	27.0	27.3	27.8	27.9	28.1
2.67	0.77	1.78	2.83	3.89	4.95	6.01	7.06	8.10	9.03	9.93	10.80	11.6	13.4	15.0	16.4	17.5	19.1	20.6	21.7	22.8	23.7	24.5	25.3	26.1	26.7	27.2	27.5	28.0	28.2	28.3
2.71	0.78	1.79	2.85	3.92	4.99	6.05	7.11	8.16	9.10	10.01	10.88	11.7	13.5	15.2	16.5	17.6	19.2	20.7	21.9	22.9	23.9	24.7	25.5	26.3	26.9	27.4	27.7	28.2	28.4	28.5
2.75	0.78	1.81	2.87	3.95	5.03	6.10	7.17	8.23	9.17	10.09	10.97	11.8	13.6	15.3	16.6	17.8	19.4	20.9	22.1	23.1	24.1	24.9	25.7	26.5	27.1	27.6	27.9	28.4	28.6	28.8
2.79	0.79	1.82	2.89	3.98	5.06	6.14	7.22	8.29	9.24	10.16	11.05	11.9	13.7	15.4	16.7	17.9	19.5	21.1	22.2	23.3	24.2	25.1	25.9	26.7	27.3	27.8	28.2	28.6	28.8	29.0
2.83	0.80	1.83	2.92	4.01	5.10	6.19	7.27	8.35	9.31	10.24	11.13	12.0	13.8	15.5	16.9	18.0	19.7	21.2	22.4	23.5	24.4	25.3	26.1	26.9	27.5	28.0	28.4	28.8	29.0	29.2
2.88	0.80	1.85	2.94	4.04	5.14	6.24	7.33	8.41	9.38	10.31	11.21	12.1	13.9	15.6	17.0	18.2	19.8	21.4	22.6	23.6	24.6	25.4	26.3	27.1	27.7	28.2	28.6	29.1	29.2	29.4
2.92	0.81	1.86	2.96	4.07	5.18	6.28	7.38	8.47	9.45	10.39	11.29	12.2	14.0	15.7	17.1	18.3	19.9	21.5	22.7	23.8	24.8	25.6	26.5	27.3	27.9	28.4	28.8	29.3	29.4	29.6
2.96	0.81	1.87	2.98	4.10	5.21	6.33	7.43	8.53	9.51	10.46	11.37	12.3	14.1	15.8	17.2	18.4	20.1	21.7	22.9	24.0	24.9	25.8	26.7	27.5	28.1	28.6	29.0	29.5	29.7	29.8
3.00	0.82	1.89	3.00	4.13	5.25	6.37	7.48	8.59	9.58	10.53	11.45	12.3	14.2	16.0	17.3	18.6	20.2	21.8	23.0	24.1	25.1	26.0	26.9	27.7	28.3	28.8	29.2	29.7	29.9	30.0
3.04	0.82	1.90	3.02	4.16	5.29	6.41	7.54	8.65	9.65	10.61	11.53	12.4	14.3	16.1	17.5	18.7	20.4	22.0	23.2	24.3	25.3	26.2	27.1	27.8	28.5	29.0	29.4	29.9	30.1	30.2
3.08	0.83	1.91	3.04	4.19	5.32	6.46	7.59	8.71	9.71	10.68	11.61	12.5	14.4	16.2	17.6	18.8	20.5	22.1	23.4	24.5	25.5	26.3	27.2	28.0	28.7	29.2	29.6	30.1	30.3	30.5
3.13	0.84	1.93	3.06	4.21	5.36	6.50	7.64	8.77	9.78	10.75	11.69	12.6	14.5	16.3	17.7	19.0	20.6	22.3	23.5	24.6	25.6	26.5	27.4	28.2	28.9	29.4	29.8	30.3	30.5	30.7
3.17	0.84	1.94	3.08	4.24	5.39	6.54	7.69	8.83	9.84	10.82	11.77	12.7	14.6	16.4	17.8	19.1	20.8	22.4	23.7	24.8	25.8	26.7	27.6	28.4	29.1	29.6	30.0	30.5	30.7	30.9
3.21	0.85	1.95	3.10	4.27	5.43	6.59	7.74	8.88	9.91	10.89	11.84	12.8	14.7	16.5	17.9	19.2	20.9	22.6	23.8	25.0	26.0	26.9	27.8	28.6	29.3	29.8	30.2	30.7	30.9	31.1
3.25	0.85	1.96	3.12	4.30	5.46	6.63	7.79	8.94	9.97	10.96	11.92	12.8	14.8	16.6	18.1	19.3	21.1	22.7	24.0	25.1	26.1	27.1	28.0	28.8	29.5	30.0	30.4	30.9	31.1	31.3
3.29	0.86	1.98	3.14	4.32	5.50	6.67	7.84	9.00	10.03	11.03	12.00	12.9	14.9	16.7	18.2	19.5	21.2	22.9	24.1	25.3	26.3	27.2	28.2	29.0	29.7	30.2	30.6	31.1	31.3	31.5
3.33	0.86	1.99	3.16	4.35	5.53	6.71	7.89	9.06	10.10	11.10	12.07	13.0	15.0	16.8	18.3	19.6	21.3	23.0	24.3	25.4	26.5	27.4	28.3	29.2	29.8	30.4	30.8	31.3	31.5	31.7
3.38	0.87	2.00	3.18	4.38	5.57	6.76	7.94	9.11	10.16	11.17	12.15	13.1	15.1	16.9	18.4	19.7	21.5	23.1	24.4	25.6	26.6	27.6	28.5	29.3	30.0	30.6	31.0	31.5	31.7	31.9
3.42	0.87	2.01	3.20	4.41	5.60	6.80	7.99	9.17	10.22	11.24	12.22	13.2	15.1	17.0	18.5	19.8	21.6	23.3	24.6	25.8	26.8	27.7	28.7	29.5	30.2	30.7	31.2	31.7	31.9	32.1
3.50	0.88	2.04	3.24	4.46	5.67	6.88	8.08	9.28	10.35	11.38	12.37	13.3	15.3	17.2	18.7	20.1	21.8	23.6	24.9	26.1	27.1	28.1	29.0	29.9	30.6	31.1	31.5	32.1	32.3	32.4
3.58	0.89	2.06	3.28	4.51	5.74	6.96	8.18	9.39	10.47	11.51	12.52	13.5	15.5	17.4	19.0	20.3	22.1	23.9	25.2	26.4	27.5	28.4	29.4	30.2	30.9	31.5	31.9	32.4	32.6	32.8
3.67	0.91	2.09	3.32	4.56	5.80	7.04	8.27	9.50	10.59	11.65	12.66	13.6	15.7	17.6	19.2	20.5	22.4	24.1	25.5	26.7	27.8	28.7	29.7	30.6	31.3	31.9	32.3	32.8	33.0	33.2
3.75	0.92	2.11	3.35	4.62	5.87	7.12	8.37	9.61	10.71	11.78	12.80	13.8	15.9	17.8	19.4	20.8	22.6	24.4	25.8	27.0	28.1	29.1	30.1	30.9	31.7	32.2	32.6	33.2	33.4	33.6
3.83	0.93	2.13	3.39	4.67	5.94	7.20	8.46	9.71	10.83	11.91	12.95	13.9	16.0	18.0	19.6	21.0	22.9	24.7	26.0	27.3	28.4	29.4	30.4	31.3	32.0	32.6	33.0	33.5	33.8	34.0
3.92	0.94	2.16	3.43	4.72	6.00	7.28	8.55	9.82	10.95	12.04	13.09	14.1	16.2	18.2	19.8	21.2	23.1	24.9	26.3	27.6	28.7	29.7	30.7	31.6	32.3	32.9	33.4	33.9	34.1	34.3
4.00	0.95	2.18	3.46	4.77	6.06	7.36	8.64	9.92	11.06	12.16	13.22	14.2	16.4	18.4	20.0	21.4	23.4	25.2	26.6	27.9	29.0	30.0	31.0	31.9	32.7	33.3	33.7	34.3	34.5	34.7
4.08	0.96	2.20	3.50	4.82	6.13	7.43	8.73	10.02	11.18	12.29	13.36	14.4	16.6	18.6	20.2	21.7	23.6	25.5	26.9	28.2	29.3	30.3	31.4	32.3	33.0	33.6	34.1	34.6	34.8	35.0
4.17	0.96	2.22	3.54	4.87	6.19	7.51	8.82	10.12	11.29	12.41	13.50	14.5	16.7	18.8	20.4	21.9	23.8	25.7	27.1	28.4	29.6	30.6	31.7	32.6	33.4	34.0	34.4	35.0	35.2	35.4
4.25	0.97	2.25	3.57	4.91	6.25	7.58	8.91	10.23	11.40	12.54	13.63	14.7	16.9	19.0	20.6	22.1	24.1	26.0	27.4	28.7	29.9	30.9	32.0	32.9	33.7	34.3	34.7	35.3	35.5	35.8
4.33	0.98	2.27	3.61	4.96	6.31	7.66	8.99	10.33	11.51	12.66	13.76	14.8	17.1	19.2	20.8	22.3	24.3	26.2	27.7	29.0	30.2	31.2	32.3	33.2	34.0	34.6	35.1	35.7	35.9	36.1
4.42	0.99	2.29	3.64	5.01	6.37	7.73	9.08	10.42	11.62	12.78	13.90	15.0	17.2	19.4	21.0	22.5	24.5	26.5	28.0	29.3	30.5	31.5	32.6	33.6	34.4	35.0	35.4	36.0	36.2	36.5
4.50	1.00	2.31	3.67	5.06	6.43	7.80	9.17	10.52	11.73	12.90	14.03	15.1	17.4	19.5	21.2	22.7	24.8	26.7	28.2	29.6	30.8	31.8	32.9	33.9	34.7	35.3	35.7	36.3	36.6	36.8
4.58	1.01	2.33	3.71	5.10	6.49	7.87	9.25	10.62	11.84	13.02	14.16	15.2	17.5	19.7	21.4	23.0	25.0	27.0	28.5	29.8	31.1	32.1	33.2	34.2	35.0	35.6	36.1	36.7	36.9	37.1
4.67	1.02	2.35	3.74	5.15	6.55	7.94	9.33	10.72	11.95	13.14	14.28	15.4	17.7	19.9	21.6	23.2	25.2	27.2	28.7	30.1	31.3	32.4	33.5	34.5	35.3	35.9	36.4	37.0	37.2	37.5
4.75	1.03	2.38	3.78	5.19	6.61	8.02	9.42	10.81	12.05	13.25	14.41	15.5	17.9	20.1	21.8	23.4	25.5	27.5	29.0	30.4	31.6	32.7	33.8	34.8	35.6	36.3	36.7	37.3	37.6	37.8
4.83	1.04	2.40	3.81	5.24	6.66	8.09	9.50	10.90	12.16	13.37	14.54	15.7	18.0	20.3	22.0	23.6	25.7	27.7	29.2	30.6	31.9	33.0	34.1	35.1	35.9	36.6	37.1	37.7	37.9	38.1
4.92	1.05	2.42	3.84	5.28	6.72	8.15	9.58	11.00	12.26	13.48	14.66	15.8	18.2	20.4	22.2	23.8	25.9	27.9	29.5	30.9	32.2	33.3	34.4	35.4	36.2	36.9	37.4	38.0	38.2	38.5
5.00	1.06	2.44	3.87	5.33	6.78	8.22	9.66	11.09	12.37	13.60	14.79	15.9	18.3	20.6	22.4	24.0	26.1	28.2	29.7	31.2	32.4	33.6	34.7	35.7	36.6	37.2	37.7	38.3	38.6	38.8

ITRC Water Measurement Tables for **RECTANGULAR Gates on Round Pipes**

Discharge Values in CFS

ITRC Water Measurement Tables – 18” Rectangular Gate, Stilling Well Located 12” d/s of Back of Gate [Blue center represents best accuracy range]

ΔH (feet)	Net Gate Opening (feet)																							
	0.042	0.08	0.13	0.17	0.21	0.25	0.29	0.33	0.38	0.42	0.46	0.50	0.58	0.67	0.75	0.83	0.92	1.00	1.08	1.17	1.25	1.33	1.42	1.50
	Discharge (cfs)																							
0.04	0.02	0.	0.09	0.13	0.18	0.23	0.28	0.34	0.40	0.46	0.52	0.58	0.72	0.86	1.01	1.17	1.34	1.51	1.71	1.92	2.07	2.21	2.26	2.28
0.06	0.02	0.06	0.11	0.16	0.22	0.28	0.35	0.42	0.49	0.56	0.64	0.71	0.88	1.05	1.24	1.43	1.64	1.85	2.10	2.36	2.54	2.70	2.77	2.79
0.08	0.02	0.07	0.12	0.19	0.25	0.33	0.40	0.48	0.56	0.65	0.73	0.82	1.01	1.21	1.43	1.65	1.89	2.13	2.43	2.72	2.93	3.12	3.20	3.22
0.10	0.03	0.08	0.14	0.21	0.28	0.37	0.45	0.54	0.63	0.72	0.82	0.92	1.13	1.36	1.60	1.85	2.11	2.39	2.71	3.04	3.28	3.49	3.58	3.60
0.13	0.03	0.08	0.15	0.23	0.31	0.40	0.49	0.59	0.69	0.79	0.90	1.01	1.24	1.49	1.75	2.02	2.32	2.61	2.97	3.33	3.59	3.82	3.92	3.95
0.15	0.03	0.09	0.16	0.25	0.34	0.43	0.53	0.63	0.74	0.86	0.97	1.09	1.34	1.61	1.89	2.19	2.50	2.82	3.21	3.60	3.88	4.13	4.24	4.26
0.17	0.03	0.09	0.17	0.26	0.36	0.46	0.57	0.68	0.80	0.92	1.04	1.16	1.44	1.72	2.02	2.34	2.67	3.02	3.43	3.85	4.15	4.42	4.53	4.56
0.19	0.04	0.	0.18	0.28	0.38	0.49	0.60	0.72	0.84	0.97	1.10	1.23	1.52	1.82	2.15	2.48	2.84	3.20	3.64	4.08	4.40	4.68	4.80	4.84
0.21	0.04	0.11	0.19	0.29	0.40	0.52	0.64	0.76	0.89	1.02	1.16	1.30	1.60	1.92	2.26	2.61	2.99	3.37	3.83	4.30	4.63	4.94	5.06	5.10
0.23	0.04	0.11	0.20	0.31	0.42	0.54	0.67	0.79	0.93	1.07	1.22	1.36	1.68	2.01	2.37	2.74	3.14	3.54	4.02	4.51	4.86	5.18	5.31	5.35
0.25	0.04	0.12	0.21	0.32	0.44	0.57	0.70	0.83	0.97	1.12	1.27	1.42	1.76	2.10	2.48	2.86	3.28	3.70	4.20	4.71	5.08	5.41	5.55	5.58
0.27	0.04	0.12	0.22	0.34	0.46	0.59	0.72	0.86	1.01	1.17	1.32	1.48	1.83	2.19	2.58	2.98	3.41	3.85	4.37	4.90	5.28	5.63	5.77	5.81
0.29	0.04	0.13	0.23	0.35	0.48	0.61	0.75	0.90	1.05	1.21	1.37	1.54	1.90	2.27	2.68	3.09	3.54	3.99	4.54	5.09	5.48	5.84	5.99	6.03
0.31	0.05	0.13	0.24	0.36	0.49	0.63	0.78	0.93	1.09	1.25	1.42	1.59	1.97	2.35	2.77	3.20	3.66	4.13	4.70	5.27	5.68	6.05	6.20	6.24
0.33	0.05	0.13	0.24	0.37	0.51	0.65	0.80	0.96	1.12	1.30	1.47	1.64	2.03	2.43	2.86	3.30	3.78	4.27	4.85	5.44	5.86	6.24	6.41	6.45
0.35	0.05	0.14	0.25	0.38	0.52	0.67	0.83	0.99	1.16	1.33	1.51	1.69	2.09	2.50	2.95	3.41	3.90	4.40	5.00	5.61	6.04	6.44	6.60	6.65
0.38	0.05	0.14	0.26	0.40	0.54	0.69	0.85	1.02	1.19	1.37	1.56	1.74	2.15	2.57	3.03	3.50	4.01	4.53	5.14	5.77	6.22	6.62	6.79	6.84
0.40	0.05	0.	0.27	0.41	0.55	0.71	0.88	1.04	1.23	1.41	1.60	1.79	2.21	2.65	3.12	3.60	4.12	4.65	5.29	5.93	6.39	6.81	6.98	7.03
0.42	0.05	0.15	0.27	0.42	0.57	0.73	0.90	1.07	1.26	1.45	1.64	1.84	2.27	2.71	3.20	3.69	4.23	4.77	5.42	6.08	6.55	6.98	7.16	7.21
0.46	0.06	0.16	0.29	0.44	0.60	0.77	0.94	1.12	1.32	1.52	1.72	1.93	2.38	2.85	3.35	3.87	4.44	5.00	5.69	6.38	6.87	7.32	7.51	7.56
0.50	0.06	0.16	0.30	0.46	0.62	0.80	0.98	1.17	1.38	1.59	1.80	2.01	2.49	2.97	3.50	4.05	4.63	5.23	5.94	6.66	7.18	7.65	7.84	7.90
0.54	0.06	0.17	0.31	0.48	0.65	0.83	1.03	1.22	1.43	1.65	1.87	2.10	2.59	3.09	3.65	4.21	4.82	5.44	6.18	6.93	7.47	7.96	8.16	8.22
0.58	0.06	0.18	0.32	0.49	0.67	0.86	1.06	1.27	1.49	1.71	1.94	2.17	2.69	3.21	3.78	4.37	5.00	5.65	6.42	7.20	7.75	8.26	8.47	8.53
0.63	0.07	0.18	0.33	0.51	0.70	0.90	1.10	1.31	1.54	1.77	2.01	2.25	2.78	3.32	3.92	4.52	5.18	5.84	6.64	7.45	8.03	8.55	8.77	8.83
0.67	0.07	0.19	0.35	0.53	0.72	0.92	1.14	1.36	1.59	1.83	2.08	2.32	2.87	3.43	4.05	4.67	5.35	6.04	6.86	7.69	8.29	8.83	9.06	9.12
0.71	0.07	0.	0.36	0.54	0.74	0.95	1.17	1.40	1.64	1.89	2.14	2.40	2.96	3.54	4.17	4.82	5.51	6.22	7.07	7.93	8.55	9.10	9.34	9.40
0.75	0.07	0.20	0.37	0.56	0.76	0.98	1.21	1.44	1.69	1.94	2.20	2.47	3.04	3.64	4.29	4.96	5.67	6.40	7.28	8.16	8.79	9.37	9.61	9.67
0.79	0.07	0.21	0.38	0.57	0.78	1.01	1.24	1.48	1.73	2.00	2.26	2.53	3.13	3.74	4.41	5.09	5.83	6.58	7.47	8.38	9.03	9.62	9.87	9.94
0.83	0.08	0.21	0.39	0.59	0.81	1.03	1.27	1.52	1.78	2.05	2.32	2.60	3.21	3.84	4.52	5.22	5.98	6.75	7.67	8.60	9.27	9.87	10.13	10.20
0.92	0.08	0.22	0.41	0.62	0.84	1.08	1.33	1.59	1.87	2.15	2.43	2.73	3.37	4.03	4.74	5.48	6.27	7.08	8.04	9.02	9.72	10.36	10.62	10.69
1.00	0.08	0.23	0.42	0.65	0.88	1.13	1.39	1.66	1.95	2.24	2.54	2.85	3.52	4.20	4.96	5.72	6.55	7.39	8.40	9.42	10.15	10.82	11.09	11.17
1.08	0.09	0.24	0.44	0.67	0.92	1.18	1.45	1.73	2.03	2.33	2.65	2.96	3.66	4.38	5.16	5.96	6.82	7.69	8.74	9.81	10.57	11.26	11.55	11.62
1.17	0.09	0.	0.46	0.70	0.95	1.22	1.50	1.79	2.10	2.42	2.75	3.08	3.80	4.54	5.35	6.18	7.08	7.98	9.07	10.18	10.97	11.68	11.98	12.06
1.25	0.09	0.26	0.47	0.72	0.99	1.27	1.56	1.86	2.18	2.51	2.84	3.18	3.93	4.70	5.54	6.40	7.33	8.26	9.39	10.53	11.35	12.09	12.40	12.49
1.33	0.10	0.27	0.49	0.75	1.02	1.31	1.61	1.92	2.25	2.59	2.94	3.29	4.06	4.86	5.72	6.61	7.57	8.53	9.70	10.88	11.72	12.49	12.81	12.90
1.42	0.10	0.28	0.50	0.77	1.05	1.35	1.66	1.98	2.32	2.67	3.03	3.39	4.18	5.00	5.90	6.81	7.80	8.80	10.00	11.21	12.09	12.87	13.20	13.29
1.50	0.10	0.28	0.52	0.79	1.08	1.39	1.71	2.03	2.39	2.75	3.11	3.49	4.31	5.15	6.07	7.01	8.02	9.05	10.29	11.54	12.44	13.25	13.59	13.68
1.58	0.10	0.29	0.53	0.81	1.11	1.42	1.75	2.09	2.45	2.82	3.20	3.58	4.42	5.29	6.24	7.20	8.24	9.30	10.57	11.86	12.78	13.61	13.96	14.05
1.67	0.11	0.	0.55	0.83	1.14	1.46	1.80	2.14	2.52	2.90	3.28	3.68	4.54	5.43	6.40	7.39	8.46	9.54	10.85	12.16	13.11	13.96	14.32	14.42
1.75	0.11	0.31	0.56	0.85	1.17	1.50	1.84	2.20	2.58	2.97	3.36	3.77	4.65	5.56	6.56	7.57	8.67	9.78	11.11	12.46	13.43	14.31	14.68	14.77
1.83	0.11	0.31	0.57	0.87	1.19	1.53	1.89	2.25	2.64	3.04	3.44	3.85	4.76	5.69	6.71	7.75	8.87	10.01	11.37	12.76	13.75	14.65	15.02	15.12
1.92	0.11	0.32	0.59	0.89	1.22	1.57	1.93	2.30	2.70	3.11	3.52	3.94	4.87	5.82	6.86	7.92	9.07	10.23	11.63	13.04	14.06	14.97	15.36	15.46
2.00	0.12	0.33	0.60	0.91	1.25	1.60	1.97	2.35	2.76	3.17	3.60	4.03	4.97	5.95	7.01	8.09	9.27	10.45	11.88	13.32	14.36	15.30	15.69	15.79
2.08	0.12	0.34	0.61	0.93	1.27	1.63	2.01	2.40	2.81	3.24	3.67	4.11	5.07	6.07	7.15	8.26	9.46	10.67	12.13	13.60	14.66	15.61	16.01	16.12
2.17	0.12	0.34	0.62	0.95	1.30	1.67	2.05	2.44	2.87	3.30	3.74	4.19	5.18	6.19	7.29	8.42	9.64	10.88	12.37	13.87	14.95	15.92	16.33	16.44
2.25	0.12	0.	0.64	0.97	1.32	1.70	2.09	2.49	2.92	3.36	3.81	4.27	5.27	6.31	7.43	8.58	9.83	11.09	12.60	14.13	15.23	16.22	16.64	16.75
2.33	0.13	0.36	0.65	0.99	1.35	1.73	2.13	2.54	2.98	3.43	3.88	4.35	5.37	6.42	7.57	8.74	10.01	11.29	12.83	14.39	15.51	16.52	16.95	17.06
2.42	0.13	0.36	0.66	1.00	1.37	1.76	2.17	2.58	3.03	3.49	3.95	4.43	5.47	6.54	7.70	8.90	10.19	11.49	13.06	14.65	15.78	16.81	17.25	17.36
2.50	0.13	0.37	0.67	1.02	1.39	1.79	2.20	2.63	3.08	3.55	4.02	4.50	5.56	6.65	7.84	9.05	10.36	11.69	13.28	14.90	16.05	17.10	17.54	17.66
2.58	0.13	0.37	0.68	1.04	1.42	1.82	2.24	2.67	3.13	3.61	4.09	4.58	5.65	6.76	7.96	9.20	10.53	11.88	13.50	15.14	16.32	17.38	17.83	17.95
2.67	0.14	0.38	0.69	1.05	1.44	1.85	2.27	2.71	3.18	3.66	4.15	4.65	5.74	6.87	8.09	9.34	10.70	12.07	13.72	15.39	16.58	17.66	18.12	18.24
2.75	0.14	0.39	0.70	1.07	1.46	1.88	2.31	2.75	3.23	3.72	4.22	4.72	5.83	6.97	8.22	9.49	10.87	12.26	13.93	15.62	16.84	17.94	18.40	18.52
2.83	0.14	0.39	0.71	1.09	1.48	1.91	2.34	2.80	3.28	3.78	4.28	4.79	5.92	7.08	8.34	9.63	11.03	12.44	14.14	15.86	17.09	18.21	18.67	18.80

ITRC Water Measurement Tables – <u>24" Rectangular Gate</u>, Stilling Well Located 12" d/s of Back of Gate [Blue center represents best accuracy range]

ΔH (feet)	Net Gate Opening (feet)																													
	0.042	0.08	0.13	0.17	0.21	0.25	0.29	0.33	0.38	0.42	0.46	0.50	0.58	0.67	0.75	0.83	0.92	1.00	1.08	1.17	1.25	1.33	1.42	1.50	1.58	1.67	1.75	1.83	1.92	2.00
	Discharge (cfs)																													
0.04	0.04	0.07	0.12	0.18	0.25	0.31	0.38	0.44	0.52	0.60	0.68	0.76	0.93	1.11	1.30	1.49	1.68	1.86	2.06	2.25	2.45	2.65	2.87	3.08	3.28	3.70	3.89	4.05	4.06	4.07
0.06	0.04	0.08	0.15	0.23	0.30	0.38	0.46	0.54	0.64	0.73	0.83	0.93	1.14	1.36	1.60	1.83	2.06	2.28	2.52	2.75	3.00	3.25	3.51	3.77	4.02	4.54	4.76	4.96	4.97	4.98
0.08	0.05	0.09	0.17	0.26	0.35	0.44	0.54	0.63	0.74	0.85	0.96	1.07	1.32	1.57	1.84	2.11	2.38	2.64	2.91	3.18	3.47	3.75	4.06	4.36	4.64	5.24	5.50	5.73	5.74	5.75
0.10	0.06	0.10	0.19	0.29	0.39	0.50	0.60	0.70	0.82	0.95	1.07	1.20	1.48	1.76	2.06	2.36	2.66	2.95	3.25	3.55	3.88	4.20	4.54	4.87	5.19	5.85	6.15	6.41	6.42	6.43
0.13	0.06	0.11	0.21	0.32	0.43	0.54	0.66	0.77	0.90	1.04	1.18	1.32	1.62	1.93	2.26	2.59	2.91	3.23	3.56	3.89	4.25	4.60	4.97	5.33	5.69	6.41	6.73	7.02	7.03	7.04
0.15	0.07	0.12	0.23	0.34	0.46	0.59	0.71	0.83	0.97	1.12	1.27	1.42	1.75	2.08	2.44	2.80	3.14	3.49	3.85	4.20	4.59	4.96	5.37	5.76	6.14	6.93	7.27	7.58	7.59	7.61
0.17	0.07	0.13	0.24	0.37	0.50	0.63	0.76	0.89	1.04	1.20	1.36	1.52	1.87	2.23	2.60	2.99	3.36	3.73	4.11	4.49	4.90	5.31	5.74	6.16	6.57	7.41	7.77	8.10	8.12	8.13
0.19	0.08	0.14	0.26	0.39	0.53	0.66	0.80	0.94	1.10	1.27	1.44	1.61	1.98	2.36	2.76	3.17	3.56	3.96	4.36	4.77	5.20	5.63	6.09	6.53	6.97	7.86	8.24	8.59	8.61	8.62
0.21	0.08	0.15	0.27	0.41	0.55	0.70	0.85	0.99	1.16	1.34	1.52	1.70	2.09	2.49	2.91	3.34	3.76	4.17	4.60	5.02	5.48	5.93	6.41	6.89	7.34	8.28	8.69	9.06	9.07	9.09
0.23	0.08	0.15	0.28	0.43	0.58	0.73	0.89	1.04	1.22	1.41	1.59	1.78	2.19	2.61	3.05	3.50	3.94	4.37	4.82	5.27	5.75	6.22	6.73	7.22	7.70	8.68	9.11	9.50	9.52	9.53
0.25	0.09	0.16	0.30	0.45	0.61	0.77	0.93	1.09	1.28	1.47	1.66	1.86	2.29	2.73	3.19	3.66	4.12	4.57	5.04	5.50	6.00	6.50	7.03	7.54	8.05	9.07	9.52	9.92	9.94	9.96
0.27	0.09	0.17	0.31	0.47	0.63	0.80	0.97	1.13	1.33	1.53	1.73	1.94	2.38	2.84	3.32	3.81	4.28	4.75	5.24	5.73	6.25	6.77	7.31	7.85	8.37	9.44	9.91	10.33	10.35	10.37
0.29	0.10	0.17	0.32	0.49	0.66	0.83	1.00	1.18	1.38	1.59	1.80	2.01	2.47	2.95	3.45	3.95	4.45	4.93	5.44	5.94	6.49	7.02	7.59	8.15	8.69	9.80	10.28	10.72	10.74	10.76
0.31	0.10	0.18	0.33	0.50	0.68	0.86	1.04	1.22	1.43	1.64	1.86	2.08	2.56	3.05	3.57	4.09	4.60	5.11	5.63	6.15	6.71	7.27	7.86	8.43	8.99	10.14	10.64	11.09	11.11	11.13
0.33	0.10	0.19	0.34	0.52	0.70	0.89	1.07	1.26	1.47	1.70	1.92	2.15	2.64	3.15	3.68	4.23	4.75	5.27	5.82	6.35	6.93	7.51	8.11	8.71	9.29	10.47	10.99	11.46	11.48	11.50
0.35	0.11	0.19	0.35	0.54	0.72	0.91	1.11	1.29	1.52	1.75	1.98	2.22	2.72	3.25	3.80	4.36	4.90	5.44	6.00	6.55	7.15	7.74	8.36	8.98	9.58	10.80	11.33	11.81	11.83	11.85
0.38	0.11	0.20	0.36	0.55	0.74	0.94	1.14	1.33	1.56	1.80	2.04	2.28	2.80	3.34	3.91	4.48	5.04	5.59	6.17	6.74	7.35	7.96	8.61	9.24	9.85	11.11	11.66	12.15	12.17	12.20
0.40	0.11	0.20	0.37	0.57	0.76	0.97	1.17	1.37	1.61	1.85	2.09	2.34	2.88	3.43	4.01	4.61	5.18	5.75	6.34	6.92	7.55	8.18	8.84	9.49	10.12	11.41	11.98	12.49	12.51	12.53
0.42	0.11	0.21	0.38	0.58	0.78	0.99	1.20	1.40	1.65	1.90	2.15	2.40	2.96	3.52	4.12	4.73	5.31	5.90	6.50	7.10	7.75	8.39	9.07	9.74	10.39	11.71	12.29	12.81	12.83	12.86
0.46	0.12	0.22	0.40	0.61	0.82	1.04	1.26	1.47	1.73	1.99	2.25	2.52	3.10	3.69	4.32	4.96	5.57	6.18	6.82	7.45	8.13	8.80	9.51	10.21	10.89	12.28	12.89	13.44	13.46	13.48
0.50	0.13	0.23	0.42	0.64	0.86	1.09	1.31	1.54	1.80	2.08	2.35	2.63	3.24	3.86	4.51	5.18	5.82	6.46	7.12	7.78	8.49	9.19	9.94	10.67	11.38	12.83	13.46	14.03	14.06	14.08
0.54	0.13	0.24	0.43	0.66	0.89	1.13	1.37	1.60	1.88	2.16	2.45	2.74	3.37	4.01	4.70	5.39	6.06	6.72	7.42	8.10	8.84	9.57	10.34	11.10	11.84	13.35	14.01	14.61	14.63	14.66
0.58	0.14	0.25	0.45	0.69	0.93	1.17	1.42	1.66	1.95	2.24	2.54	2.84	3.50	4.17	4.87	5.59	6.29	6.98	7.70	8.40	9.17	9.93	10.73	11.52	12.29	13.85	14.54	15.16	15.18	15.21
0.63	0.14	0.26	0.47	0.71	0.96	1.21	1.47	1.72	2.02	2.32	2.63	2.94	3.62	4.31	5.04	5.79	6.51	7.22	7.97	8.70	9.49	10.28	11.11	11.93	12.72	14.34	15.05	15.69	15.72	15.75
0.67	0.14	0.26	0.48	0.74	0.99	1.25	1.52	1.78	2.08	2.40	2.72	3.04	3.74	4.45	5.21	5.98	6.72	7.46	8.23	8.98	9.80	10.61	11.47	12.32	13.14	14.81	15.55	16.20	16.23	16.26
0.71	0.15	0.27	0.50	0.76	1.02	1.29	1.56	1.83	2.15	2.47	2.80	3.13	3.85	4.59	5.37	6.16	6.93	7.69	8.48	9.26	10.11	10.94	11.83	12.70	13.54	15.27	16.02	16.70	16.73	16.76
0.75	0.15	0.28	0.51	0.78	1.05	1.33	1.61	1.88	2.21	2.54	2.88	3.22	3.97	4.72	5.53	6.34	7.13	7.91	8.73	9.53	10.40	11.26	12.17	13.07	13.93	15.71	16.49	17.19	17.22	17.25
0.79	0.16	0.29	0.53	0.80	1.08	1.37	1.65	1.94	2.27	2.61	2.96	3.31	4.07	4.85	5.68	6.51	7.32	8.13	8.97	9.79	10.68	11.57	12.50	13.42	14.32	16.14	16.94	17.66	17.69	17.72
0.83	0.16	0.30	0.54	0.82	1.11	1.40	1.70	1.99	2.33	2.68	3.04	3.40	4.18	4.98	5.82	6.68	7.52	8.34	9.20	10.05	10.96	11.87	12.83	13.77	14.69	16.56	17.38	18.12	18.15	18.18
0.92	0.17	0.31	0.57	0.86	1.16	1.47	1.78	2.08	2.44	2.81	3.19	3.57	4.38	5.22	6.11	7.01	7.88	8.75	9.65	10.54	11.50	12.45	13.45	14.44	15.41	17.37	18.23	19.00	19.03	19.07
1.00	0.18	0.32	0.59	0.90	1.21	1.53	1.86	2.18	2.55	2.94	3.33	3.72	4.58	5.45	6.38	7.32	8.23	9.14	10.08	11.00	12.01	13.00	14.05	15.09	16.09	18.14	19.04	19.85	19.88	19.92
1.08	0.18	0.34	0.61	0.94	1.26	1.60	1.93	2.26	2.66	3.06	3.46	3.88	4.77	5.68	6.64	7.62	8.57	9.51	10.49	11.45	12.50	13.53	14.63	15.70	16.75	18.88	19.82	20.66	20.69	20.73
1.17	0.19	0.35	0.64	0.98	1.31	1.66	2.01	2.35	2.76	3.17	3.59	4.02	4.95	5.89	6.89	7.91	8.89	9.87	10.88	11.89	12.97	14.04	15.18	16.30	17.38	19.59	20.57	21.44	21.47	21.51
1.25	0.20	0.36	0.66	1.01	1.36	1.72	2.08	2.43	2.85	3.28	3.72	4.16	5.12	6.10	7.13	8.18	9.20	10.21	11.27	12.30	13.43	14.53	15.71	16.87	17.99	20.28	21.29	22.19	22.23	22.27
1.33	0.20	0.37	0.68	1.04	1.40	1.77	2.14	2.51	2.95	3.39	3.84	4.30	5.29	6.30	7.37	8.45	9.51	10.55	11.63	12.71	13.87	15.01	16.23	17.42	18.58	20.95	21.99	22.92	22.95	23.00
1.42	0.21	0.39	0.70	1.07	1.45	1.83	2.21	2.59	3.04	3.49	3.96	4.43	5.45	6.49	7.59	8.71	9.80	10.87	11.99	13.10	14.29	15.47	16.73	17.96	19.15	21.59	22.66	23.62	23.66	23.71
1.50	0.22	0.40	0.72	1.11	1.49	1.88	2.27	2.66	3.13	3.60	4.08	4.56	5.61	6.68	7.81	8.97	10.08	11.19	12.34	13.48	14.71	15.92	17.21	18.48	19.71	22.22	23.32	24.31	24.35	24.39
1.58	0.22	0.41	0.74	1.14	1.53	1.93	2.34	2.74	3.21	3.69	4.19	4.69	5.76	6.86	8.03	9.21	10.36	11.50	12.68	13.85	15.11	16.36	17.68	18.98	20.25	22.83	23.96	24.97	25.01	25.06
1.67	0.23	0.42	0.76	1.17	1.57	1.98	2.40	2.81	3.29	3.79	4.30	4.81	5.91	7.04	8.24	9.45	10.63	11.79	13.01	14.21	15.50	16.78	18.14	19.48	20.77	23.42	24.58	25.62	25.66	25.71
1.75	0.23	0.43	0.78	1.19	1.61	2.03	2.46	2.88	3.38	3.88	4.40	4.93	6.06	7.22	8.44	9.68	10.89	12.08	13.33	14.56	15.89	17.20	18.59	19.96	21.29	24.00	25.19	26.25	26.30	26.35
1.83	0.24	0.44	0.80	1.22	1.64	2.08	2.51	2.95	3.45	3.98	4.51	5.04	6.20	7.38	8.64	9.91	11.15	12.37	13.64	14.90	16.26	17.60	19.03	20.43	21.79	24.56	25.78	26.87	26.92	26.97
1.92	0.24	0.45	0.82	1.25	1.68	2.13	2.57	3.01	3.53	4.07	4.61	5.16	6.34	7.55	8.83	10.14	11.40	12.65	13.95	15.23	16.62	18.00	19.46	20.89	22.28	25.11	26.36	27.48	27.52	27.57
2.00	0.25	0.46	0.84	1.28	1.72	2.17	2.63	3.08	3.61	4.15	4.71	5.27	6.47	7.71	9.02	10.35	11.64	12.92	14.25	15.56	16.98	18.39	19.87	21.34	22.76	25.65	26.93	28.07	28.11	28.17
2.08	0.26	0.47	0.85	1.30	1.75	2.22	2.68	3.14	3.68	4.24	4.80	5.37	6.61	7.87	9.21	10.57	11.88	13.19	14.54	15.88	17.33	18.76	20.28	21.78	23.22	26.18	27.48	28.65	28.69	28.75
2.17	0.26	0.48	0.87	1.33	1.79	2.26	2.73	3.20	3.76	4.32	4.90	5.48	6.74	8.03	9.39	10.78	12.12	13.45	14.83	16.20	17.68	19.14	20.69	22.21	23.68	26.70	28.03	29.21	29.26	29.32
2.25	0.27	0.49	0.89	1.35	1.82	2.30	2.79	3.26	3.83	4.40	4.99	5.59	6.87	8.18	9.57	10.98	12.35	13.70	15.11	16.51	18.01	19.50	21.08	22.63	24.14	27.21	28.56	29.77	29.82	29.88
2.33	0.27	0.49	0.90	1.38	1.86	2.34	2.84	3.32	3.90	4.49	5.08	5.69	6.99	8.33	9.75	11.18	12.58	13.95	15.39	16.81	18.34	19.86	21.47	23.05	24.58	27.71	29.08	30.32	30.37	30.42
2.42	0.27	0.50	0.92	1.40	1.89	2.39	2.89	3.38	3.97	4.56	5.17	5.79	7.12	8.48	9.92	11.38	12.80	14.20	15.66	17.11	18.67	20.21	21.85	23.45	25.01	28.20	29.60	30.85	30.90	30.96
2.50	0.28	0.51	0.93	1.43	1.92	2.43	2.94	3.44	4.03	4.64	5.26	5.89	7.24	8.62	10.09	11.58	13.02	14.44	15.93	17.40	18.99	20.56	22.22	23.85	25.44	28.68	30.11	31.38	31.43	31.49
2.58	0.28	0.52	0.95	1.45	1.95	2.47	2.99	3.50	4.10	4.72	5.35	5.99	7.36	8.77	10.25	11.77	13.23	14.68	16.19	17.69	19.30	20.90	22.59	24.25	25.86	29.16	30.60	31.90	31.95	32.01
2.67	0.29	0.53	0.96	1.47	1.98	2.51	3.03	3.55	4.17	4.80	5.43	6.08	7.48	8.91	10.42	11.95	13.44	14.92	16.45	17.97	19.61	21.23	22.95	24.64	26.28	29.62	31.09	32.41	32.46	32.52
2.75	0.29	0.54	0.98	1.50	2.01	2.55	3.08	3.61	4.23	4.87	5.52	6.18	7.59	9.04	10.58	12.14	13.65	15.15	16.71	18.25	19.91	21.56	23.30	25.02	26.68	30.08	31.57	32.91	32.97	33.03
2.83	0.30	0.54	0.99	1.52	2.04	2.58	3.13	3.66	4.29	4.94	5.60	6.27	7.71	9.18	10.74	12.32	13.86	15.38	16.96	18.52	20.21	21.88	23.65	25.39	27.08	30.53	32.05	33.41	33.46	33.52

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Rating Rectangular Farm Delivery Meter Gates for Flow Measurement

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Abstract: Traditional meter gates for farm delivery flow measurement from an open channel conveyance have traditionally incorporated round canal gates (Armco type) for control. In recent years, some irrigation water agencies (i.e., irrigation districts) have replaced deteriorating round gates with lower-cost rectangular gates that cover round holes. Similar to the situation described in a companion paper, where round gates were examined, there have been no investigations into flow measurement uncertainty using the existing rating tables for these gates. In this study, two commonly used rectangular gate sizes, 0.46 m (18-in.) and 0.61 m (24-in.), were tested under scenarios of various gate openings, upstream heads, and head differences. Coefficient of discharge (C_d) values were computed based on actual gate open areas. These improved C_d values were used to generate new discharge rating tables for 0.46 m (18-in.) and 0.61 m (24-in.) rectangular meter gates. Limitations for these rectangular gates are discussed. If guidelines presented in this paper and in the companion paper are followed, the average instantaneous flow measurement uncertainty that could be expected is better than ±5%. However, uncertainty is higher (up to approximately 9.5%) at the lower end of the recommended gate openings [0.10 m (4 in.)] for these rectangular gates.

Introduction

Flow measurement of water delivered to farms is important for water management both on-farm and within the water agency/district conveying the water. Water is often measured by volume or flow rate at a turnout structure, which is a device that moves water from the main conveyance either to a lateral or on-farm conveyance. There are many common devices used to measure flow rate through farm turnout structures, which vary widely in cost (in terms of both fixed costs and maintenance), accuracy, and strengths/limitations. For example, propeller meters are commonly used in districts that have clean water and turnout configurations that fit the specific installation requirements of propeller meters. The fixed cost is generally reasonable, but these devices must be removed and recalibrated every several years, which increases the maintenance costs. Most districts must deal with moss, algae, and aquatic weeds, which plug up the meters and render them ineffective. The installation of necessary debris screens upstream of the devices also significantly increases the initial cost of these devices.

In this paper, as well as a companion paper, a device termed a *meter gate* was evaluated. Meter gates have been installed throughout much of California and can be found in regions all over the world. The traditional meter gate consists of a round gate on the upstream end of a round culvert pipe with a tap hole for a stilling well approximately 0.305 m (12 in.) downstream from the back face of the gate to measure the downstream head. The difference in head between the water levels upstream of the gate and in the downstream stilling well, in combination with the net vertical gate opening, is used with a rating table to determine the flow rate. In a companion paper, the round gate configuration (termed an Armco-type meter gate) was examined. However, irrigation districts have been replacing the round gate with square/rectangular manufactured gates because of the lower cost.

Formal testing to develop flow rate rating tables for square-flat-leaf gates was conducted for 0.46 m (18-in.) and 0.61 m (24-in.) gates by the U.S. Bureau of Reclamation (USBR) in the 1950s and published in Ball (1961). This study found consistent coefficient of discharge values (based on an area computed based on pipe diameter rather than on actual gate opening area) for both gate sizes if the downstream tap hole was placed at one-third of the full pipe diameter ($D_p/3$), downstream from the face of the gate. The chart of full pipe coefficient of discharge (C_d) values related to net gate opening percent for the square gates with a measuring tap well at $D_p/3$ can be found in the USBR Water Measurement Manual (Chapter 9. Section 14. Meter Gates) (USBR 1997).

As with the Armco-type (round) gates discussed in the companion paper, the USBR testing of these rectangular gates was conducted with supply flow entering parallel to the turnout pipe (straight into the pipe). This differs from most installations in distribution canals where the supply channel flow is perpendicular to the turnout pipe. Since the 1950s when the USBR work was completed, no independent evaluations of the results for rectangular meter gates has been conducted. In addition, the USBR Flow Measurement Manual states that the methodology presented in the meter gate section can result in uncertainty of computed flow within ±2.5% (USBR 1997). However, given the coarse resolution for full pipe C_d in both USBR (1997) and Ball (1961), this level of accuracy is most likely unattainable.

One goal of this study was to assess the uncertainty related to using these gates for flow measurement. Another was to investigate if improved discharge equations could be developed. Finally, either

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with an improved discharge equation or improved coefficient of discharge (C_d) values, a goal was to develop gate discharge tables for use with these rectangular meter gates.

Procedures

Procedures applicable to the testing of rectangular gates, which differ from those of the Armco-type gates, will be discussed in this section. For measurement procedures that were the same under both gate types, readers should refer to the companion paper, which describes these in detail. There may be overlap in some areas for general information. The standard discharge equation for a submerged orifice is

$$Q = C_d A_o \sqrt{2\ g\Delta H} \tag{1}$$

where Q = flow rate [cubic meters per second (CMS)]; C_d = coefficient of discharge; A_o = net gate opening area (m^2); g = gravitational acceleration (9.81 m/s^2); and ΔH = head difference across the gate (m). The coefficient of velocity (C_v) has been neglected since the velocity of approach is close to zero because these gates are typically installed perpendicular to the supply channel velocity streamlines.

If the flow rate is measured independently, the C_d value can be computed from Eq. (2) as

$$C_d = \frac{Q}{A_o\sqrt{2\ g\Delta H}} \tag{2}$$

A new meter gate testing facility was constructed at the Cal Poly Irrigation Training and Research Center (ITRC) and is described in the companion paper.

Three calibrated magnetic (mag) meters were used to measure Q downstream of the meter gate. In order to test a variety of flow rates, three different mag meter sizes were used: 0.25 m (10-in.), 0.46 m (18-in.), and 0.61 m (24-in.). The calibration and layout of these mag meters is discussed in the companion paper.

The head difference (ΔH) is taken as the difference in the head upstream of the gate and downstream of the gate. The downstream head measurement was taken at various locations, but this paper will focus primarily on the standard pressure tap location 0.305 m (12 in.) downstream of the back face of the gate. Potential errors related to using pressure tap locations at the 0.15 m (6-in.) and 0.20 m (8-in.) locations will be discussed in the "Results" section. A more detailed evaluation of the influences due to pressure tap location will be presented in future work. The measurement procedure and setup is discussed in detail in the companion paper.

Net Gate Opening Area (A_o)

In this study, the actual gate opening area (A_o) was used to compute the C_d from Eq. (2). The actual gate opening area is smaller than the full pipe area (A_p) for all gate openings less than fully open.

The following is the relationship between net gate open area (A_o), pipe radius (R_p), and net gate opening (y) from Skogerboe and Merkley (1996):

$$A_o = \frac{R_p^2}{2} \times \left\{ 2 \times \cos^{-1}\left(1 - \frac{2 \times y}{R_p}\right) - \sin\left[2 \times \cos^{-1}\left(1 - \frac{2 \times y}{R_p}\right)\right]\right\} \tag{3}$$

where y = net gate opening; and R_p = pipe inside radius shown in Fig. 1. Since the ratings are based on net gate opening (also referred to as the stem height), correct measurement is critical. The correct procedure for this measurement is from the bottom of the inside diameter of the pipe to the bottom of the gate. The gate stem (above the frame) must be marked to indicate the correct zero opening, which occurs just as the gate breaches the bottom of the pipe, while the gate is being opened (not closed). The distinction between measurement during the action of opening or closing the gate is necessary because the stem-gate connection almost always has free movement.

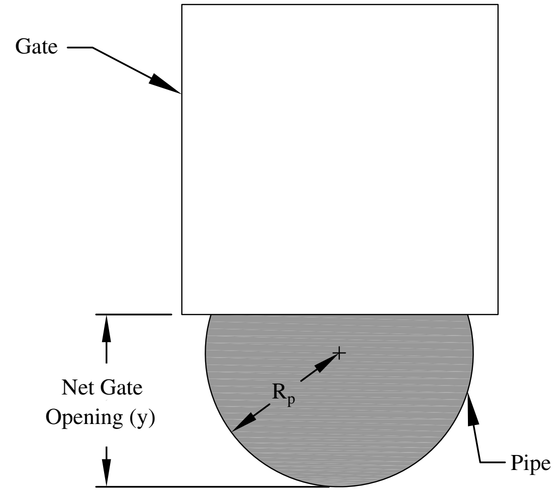

Fig. 1. Rectangular meter gate dimensions needed for correct opening area calculation; the gray region is the net gate opening area (A_o)

Meter Gate Testing Scenarios

A variety of conditions were tested for each gate to examine their effects on C_d and their relationship to discharge. Upstream water level in the supply channel, water level in the downstream sump, gate opening, supply channel velocity, and gate size were variables investigated during the testing. The results presented here will not include effects of supply channel velocity and will focus on ΔH taken at the 0.305 m (12-in.) head measurement location.

Two commonly used rectangular canal gate sizes [0.46 m (18-in.) and 0.61 m (24-in.)] were examined under various conditions. These rectangular gates were manufactured by Mechanical Associates (Visalia, California) and provided by San Luis Canal Company (Dos Palos, California) for the testing.

Table 1 shows the different tests and testing ranges conducted as part of the rectangular meter gate evaluation under low supply channel velocity. Since the gates were set perpendicular to the supply channel flow direction, tests were conducted under various supply channel flow velocities to determine if there was any influence. The lowest supply channel velocity occurred when 0.02–0.06 cm remained in the supply channel after flow was diverted into the meter gate. Only results from these testing scenarios will be shown in this paper. For each scenario in Table 1, a range of values for each variable was targeted. The results will be presented for the actual measured variable.

The upstream head (H_1, measured from the top of the pipe to the water surface) varied from approximately 0.4 times the turnout pipe diameter to 2 times the pipe diameter (except for the 0.61 m gate). For the 0.61 m gate, the *Very High Upstream Head* was the maximum upstream water level that could be safely passed through the flume without overtopping.

Net gate openings were measured in 0.05 m increments from 0.05 m to fully open. The net gate openings were measured using

Table 1. Tests Conducted under Low Supply Channel Velocity for the Rectangular Meter Gate Testing

Gate type	Nominal gate size (m)	Relative upstream head	Relative head loss	Upstream head (H_1) range (m)	ΔH range (m)
Rectangular	0.46	Very low	Small	0.246–0.232	0.059–0.027
Rectangular	0.46	Low	Small	0.416–0.322	0.151–0.062
Rectangular	0.46	Standard	Small	0.73–0.457	0.191–0.143
Rectangular	0.46	Standard	Large	0.73–0.457	0.262–0.19
Rectangular	0.46	High	Small	0.66–0.584	0.319–0.184
Rectangular	0.46	High	Large	0.66–0.584	0.353–0.266
Rectangular	0.46	Very high	Small	0.819–0.775	0.323–0.22
Rectangular	0.46	Very high	Large	0.819–0.775	0.573–0.305
Rectangular	0.61	Very low	Small	0.449–0.249	0.054–0.038
Rectangular	0.61	Very low	Medium	0.449–0.249	0.263–0.151
Rectangular	0.61	Low	Medium	0.529–0.379	0.263–0.151
Rectangular	0.61	Low	Large	0.529–0.379	0.382–0.309
Rectangular	0.61	Standard	Small	0.7–0.667	0.051–0.03
Rectangular	0.61	Standard	Medium	0.7–0.667	0.221–0.171
Rectangular	0.61	Standard	Large	0.7–0.667	0.407–0.305
Rectangular	0.61	High	Small	0.798–0.745	0.049–0.032
Rectangular	0.61	High	Medium	0.798–0.745	0.215–0.167
Rectangular	0.61	High	Large	0.798–0.745	0.438–0.329

a gauge with 1 mm resolution from the gate zero opening identified on the gate stem, to the reference location on the lift nut. Net gate opening area was computed using the gate opening and pipe inside diameter using Eq. (3).

Flow Measurement Errors and Uncertainty

Volumetric uncertainties are discussed in detail in the companion paper. Similar statistical procedures are used in this evaluation. Coefficient of discharge (C_d) values were computed for each net gate opening under each scenario in Table 1.

The percent error between the computed flow rate and the measured flow rate through the mag meters is computed based as

$$E_{Qi} = \frac{Q_i - Q}{Q} \times 100 \tag{4}$$

where E_{Qi} = percent error between the estimated flow (Q_i) and the actual flow measured by the mag meter (Q). The estimated flow (Q_i) was based on the new C_d values developed from this work (Q_{improved}). The relative expanded uncertainty (95% confidence level) was developed based on multiple independent tests with the same gate at each gate opening for the flow rate using the new C_d values from this study. Standard uncertainty of the meter gate flow rate (U_Q) was computed as the standard deviation of the error (Q_i-Q) at each gate opening. A coverage factor of $k = 2$ (i.e., ± 2 standard deviations) was applied for the expanded uncertainty to the 95% confidence level (U_{Q_95}). The relative expanded uncertainty (RU_{95}) was computed as the relative expanded uncertainty (U_{Q_95}) divided by the main flow rate for the tests for that gate opening. More discussion on the methods used can be found in the companion paper as well as other references (Taylor and Kuyatt 1994; USBR 1997; Lozano et al. 2009).

Results and Discussion

The C_d values computed from Eq. (2), for each testing scenario, are shown at different fractions of net open areas (A_o/A_p) for the 0.46 and 0.61 m rectangular gates in Figs. 2(a and c), respectively. These C_d values are based on a head difference measurement using the downstream water level at the 0.305 m (12-in.) tap location. The net gate open area (A_o) is computed from Eq. (3) and the pipe inside diameter area was computed using the pipe inside radius (R_p) and the formula for area of a circle.

Figs. 2(a and c) indicate significant variability at the lowest gate opening of 0.05 m (2 in.), which for these rectangular gates resulted in an A_o/A_p of less than 0.10. There are several reasonable explanations for this variability. Gate leakage through areas other than the pipe open area resulting as a higher percentage of the total flow could be one cause for the variability. This could depend on the head difference (ΔH) either causing increased or decreased leakage. Both the rectangular and Armco-type (round) gates use a wedge-type seating mechanism that forces the gate to seal when completely closed. When it is opened, however, water can leak between the gate and the seal around the perimeter of the pipe. Summers (1951) also found inconsistent C_d values at low gate openings with the Armco-type gates.

Another potential cause is the hydraulics downstream of the gate at the stilling well tap location. The water jets through the bottom of the gate creating a roller structure (where velocities are circulating in a reverse direction) in the water between the jet and the top of the pipe. While this roller structure would occur in most gate openings, it is most pronounced at the smallest openings. This could be the cause of inconsistent downstream head readings as is indicated in A_o/A_p less than 0.10 in Figs. 2(a and c). Therefore, it is recommended that A_o/A_p should be greater than 0.10 for rectangular gates, which is equivalent to a net gate opening of 0.10 m (4 in.) or more for the 0.46 m and 0.61 m gates. The smallest net gate opening was removed from the analysis and the remaining C_d values are shown in Figs. 2(b and d).

The C_d values in Fig. 2 are higher at smaller A_o/A_p, tend to level out, and then increase again at larger A_o/A_p. For the 0.61 m gate, the C_d values are relatively consistent at A_o/A_p greater than 0.20 and less than 0.80. Ball (1961) found similar results at the larger gate openings, where the C_d values increase and then drop down at full opening ($A_o/A_p = 1$). He attributed this variation to the tap location where the downstream water level is measured. This will be discussed in more detail later in this section. The gate structure seems to play a role since the increase in C_d at the higher gate openings is not as significant for the Armco-type gates described in the companion paper.

Similar to the statistical analysis in the companion paper, a multiple regression analysis was examined on the non-excluded

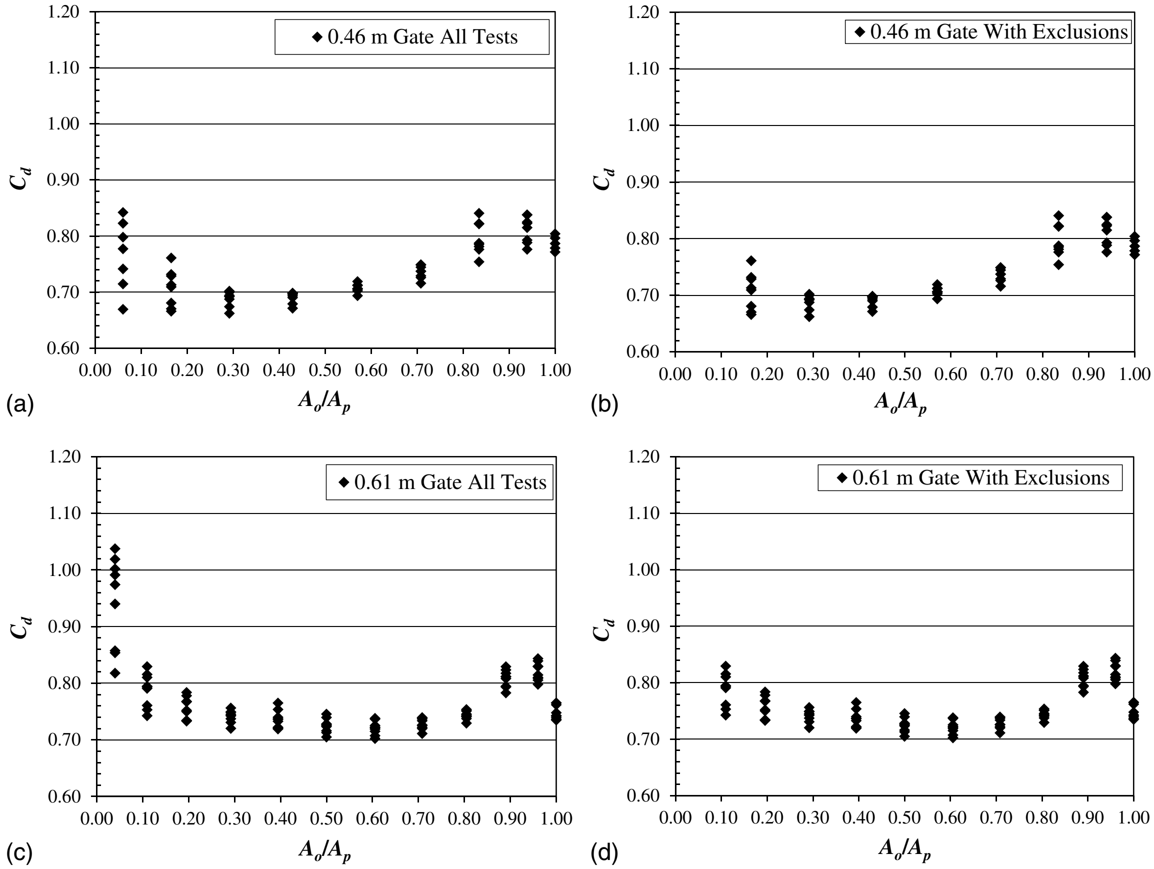

Fig. 2. Coefficient of discharge for all rectangular testing scenarios (a and c) and excluding fractions of net gate openings less than 0.2 and tests with upstream head tests less than 0.5 times the pipe diameter (b and d) related to the fraction of gate open area (A_o/A_p) for the rectangular 0.46 and 0.61 m gates measuring the downstream water level at the 0.305 m pressure tap

data relating A_o/A_p, H_1/D and $\Delta H/H_1$ to C_d using the model

$$\hat{C}_d = \beta_5 \left(\frac{A_o}{A_p}\right)^3 + \beta_4 \left(\frac{A_o}{A_p}\right)^2 + \beta_3 \left(\frac{A_o}{A_p}\right) + \beta_2 \left(\frac{H_1}{D}\right) + \beta_1 \left(\frac{\Delta H}{H_1}\right) + \beta_0 \tag{5}$$

where $\hat{C}_d$ = predicted discharge coefficient; β_0 through β_5 = regression coefficients; and other variables have been previously defined. Residual analysis was used to confirm the assumptions (normality, homoscedasticity, and independence of the errors) required for the multiple regression. The multiple regression coefficients and corresponding P-values for each gate size tested are shown in Table 2. It can be concluded that A_o/A_p have some influence on C_d, (P-value less than 0.01) while statistically, H_1/D and $\Delta H/H_1$ do not affect C_d. Additionally, since the β_5 P-value for the 0.61 m gate is greater than 0.01, the null hypothesis that β_5 is zero cannot be rejected (at an α-level of 0.01). The low R^2 value for the 0.61 m gate is due to the relatively constant C_d between A_o/A_p of 0.2–0.8. Multiple regression is not recommended to compute the C_d. Alternative recommendations for determining C_d values will be discussed.

Fig. 3 shows the C_d related to the relative upstream head (H_1/D). Different fractions of net opening areas (A_o/A_p) are shown for each rectangular gate size. The regression analysis results in Table 2 indicate that H_1/D does not affect C_d statistically. Additionally, performance does not seem to be impacted for H_1/D greater than 0.5. This indicates that upstream head (H_1) can be lower than the current recommendation of 1 pipe diameter but should remain at or above 0.5 times the pipe diameter. Having an H_1 that is too low may lead to vortexing in the supply canal (which introduces air), and also limits the ΔH because the downstream water level becomes too low and the difference also cannot be accurately measured.

Relationships between C_d and relative head difference ($\Delta H/H_1$) and Reynolds number in the turnout pipe (R_{pipe}) are shown in Figs. 4(a–d). The C_d at the 0.305 m tap location is not affected by relative head difference at an α-level of 0.1 (Table 2).

Table 2. Results of a Multiple Regression Analysis Showing the Test Variables Influencing C_d Values for Each Rectangular Gate Tested. P-Values > 0.01 Indicate the Variable does not Affect C_d at an α-Level $= 0.01$

		0.46 m rectangular[a]		0.61 m rectangular[b]	
Predictor	Coefficient	Coefficient	P-value	Coefficient	P-value
Constant	β_0	0.815	0.000	0.868	0.000
$(A_o/A_p)^3$	β_5	−0.823	0.000	−0.373	0.020
$(A_o/A_p)^2$	β_4	1.673	0.000	0.936	0.001
(A_o/A_p)	β_3	−0.859	0.000	−0.622	0.000
H_1/D	β_2	0.005	0.553	−0.006	0.652
$\Delta H/H_1$	β_1	−0.023	0.390	−0.037	0.018

[a] $R^2 = 0.83$.
[b] $R^2 = 0.51$.

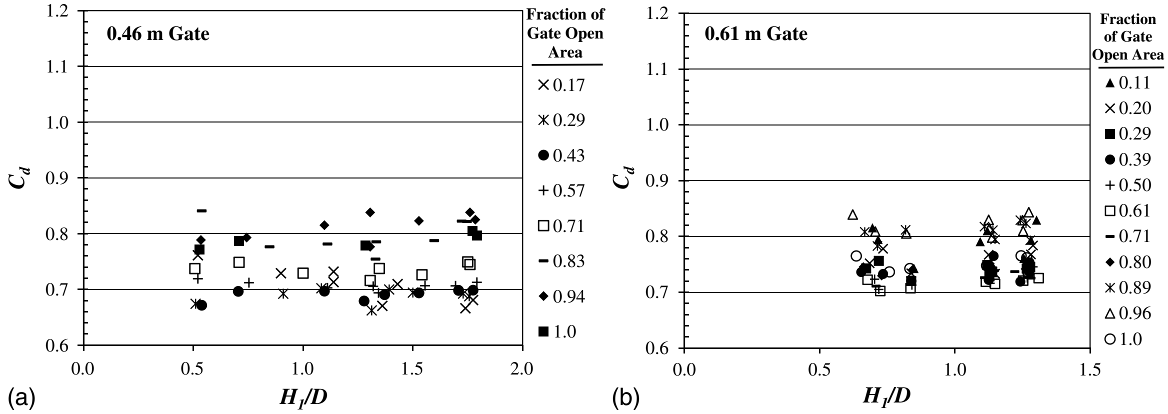

Fig. 3. Coefficient of discharge variation (0.305 m pressure tap location) at different relative upstream head (H_1/D) for the fraction of gate openings greater than 0.10: (a) rectangular 0.46 m gate; (b) rectangular 0.61 m gate

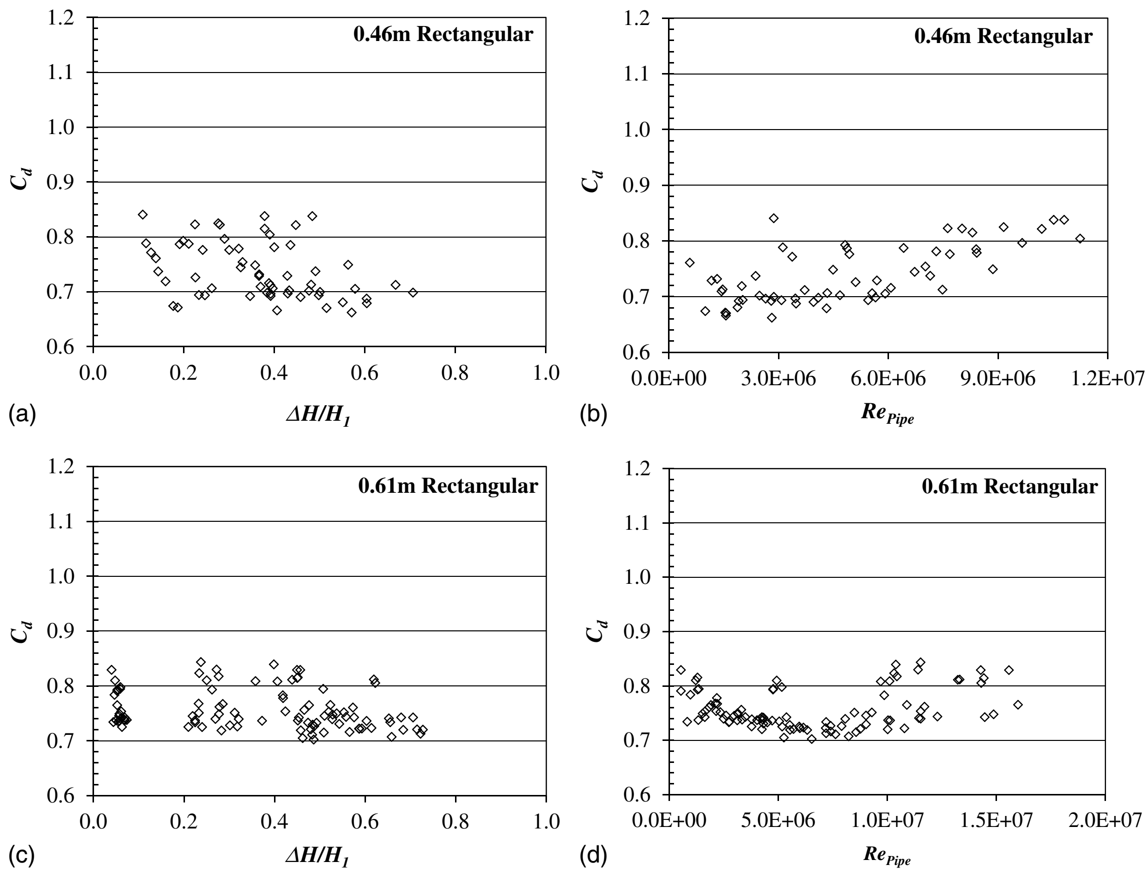

Fig. 4. Coefficient of discharge relationship to relative head difference ($\Delta H/H_1$) and Reynolds number in the turnout pipe (R_{pipe}) for the two rectangular gate sizes

The *P*-value was low for the 0.61 m rectangular gate β_1 (but still above the selected α-level of 0.01). While this could be interpreted as being worthy of further investigation, the small coefficient (β_1) indicates that any potential effect $\Delta H/H_1$ has on C_d is very small. As discussed in the companion paper, $\Delta H/H_1$ above 0.75 was attempted but the water level was too low in the stilling well attached to the 0.305 m tap to make an accurate reading. In application, care should be taken to ensure that the upstream head above the pipe (H_1) is high enough so that the downstream water level can be measured.

Figs. 4(b and d) indicate that C_d increases at higher R_{pipe}. This is likely driven by gate opening (Fig. 2) since higher R_{pipe} coincides with the larger gate openings in general. Because of this correlation R_{pipe} was not included in the multiple regression analysis.

The average C_d values based on a 0.305 m (12-in.) downstream tap location by A_o/A_p for the two rectangular gate sizes are shown in Fig. 5(a). At A_o/A_p less than 0.6, the larger 0.61 m (24-in.) gate C_d is higher than the 0.46 m rectangular gate. The C_d values are similar at A_o/A_p greater than 0.6 and less than 1.0. These results

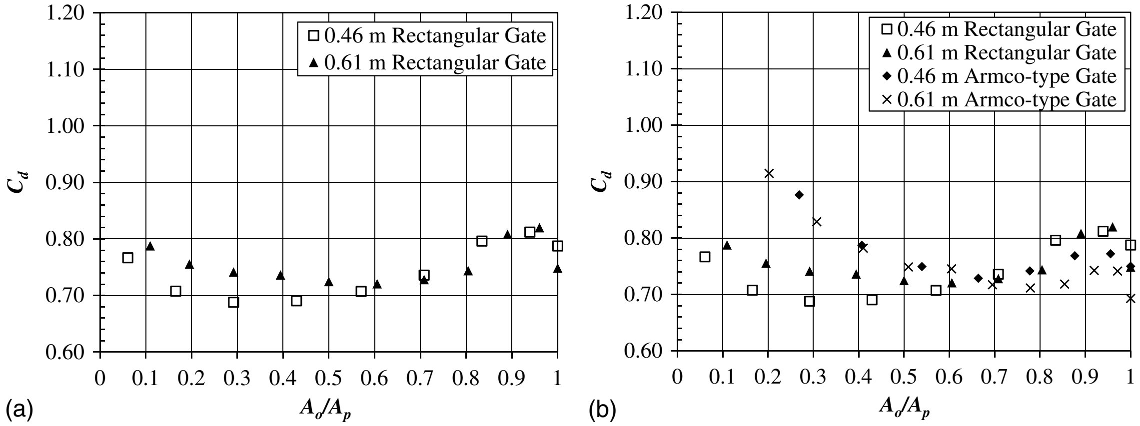

Fig. 5. Average C_d computed in this study for the rectangular gates tested (a) and rectangular compared with Armco-type (round) gates of the same size from a companion paper (b) by fraction of net gate opening area

differ from those found for the Armco-type (round) gate presented in the companion paper as shown in Fig. 5(b). The Armco-type C_d values are similar between the two gate sizes for A_o/A_p less than 0.7 and deviate at the larger gate opening areas.

It is clear from Fig. 5(b) that the gate shape plays a role in C_d. This is likely due to the influence of the bottom of the gate on the water entering the pipeline related to the location of the stilling well tap. A higher C_d value for the Armco-type gates at A_o/A_p less than 0.7 indicates that there is less head difference measured at the 0.305 m (12-in.) pressure tap compared with the rectangular gates for the same flow rate.

The difference in C_d values when the gate is fully open (bottom of the gate is at the top of the pipe) where A_o/A_p is equal to 1. The C_d values should be similar for the same size pipes; however, the Armco-type gates have C_d values lower than their rectangular counterparts. Again this indicates that gate shape, even though the gate is not protruding into the pipe area, is influencing the water movement into the pipe. A more detailed examination of tap location influence on C_d with different gate sizes and types will be conducted in future work.

The uncertainty evaluation was conducted using the C_d values developed in this study [Fig. 5(a)] to compute the flow rate from the testing scenarios compared with the flow rate measured through the mag meters. Since the C_d values were developed using the same data, the average percent error is zero as shown in Figs. 6(a and b). Of importance is the uncertainty due to the variability in C_d values under various A_o/A_p. As indicated in Fig. 2, the larger spread in C_d values at the lower and higher gate openings results in greater relative expanded uncertainty under these conditions. However, with A_o/A_p greater than 0.1 (equivalent to gate openings of 4 in. or greater for rectangular gates), the relative expanded uncertainty is less than $\pm 10\%$. For the majority of A_o/A_p, the expanded relative uncertainty is within $\pm 5\%$.

A comparison of the flow rate computed from USBR Water Measurement Manual (Chapter 9. Section 14. Meter Gates) C_d values based on full pipe area and on the pressure tap location of $D/3$ (where D is the pipe diameter) was conducted and is shown in Figs. 6(c and d). The USBR C_d method performed relatively well for the 0.46 m (18-in.) rectangular gate at openings less than 0.41 m (16 in.) with a slight underestimation of discharge (average percent flow rate error was -3%). However, the USBR C_d showed significant underestimation of flow rates through the meter gate with an average percent flow rate error of -10% with gate openings less than 0.508 m (20-in. opening).

Downstream Pressure Tap Location Influence

While a more in-depth evaluation of pressure tap locations is planned in the future using data collected in this study, existing meter gates may have tap locations other than 0.305 m. It is the author's experience that the tap location is often less than the recommended 0.305 m. Fig. 7 shows the variation in C_d for different tap locations for the two rectangular gates. The relationship between tap location and C_d was similar for the equivalent Armco-type (round) gates shown in the companion paper. The 0.46 m (18-in.) gate shows close agreement for C_d values at lower gate openings (A_o/A_p less than 0.5). At larger openings the C_d values tend to deviate. However, the 0.20 m (8-in.) tap location has similar C_d values to the 0.305 m location at A_o/A_p less than 0.8. In contrast, as with the similar sized Armco-type gate, the 0.61 m (24-in.) gate indicated little influence between tap location and C_d at A_o/A_p less than 0.75.

At higher gate openings, the influence of tap location on C_d is evident. This indicates that the water jetting under the bottom of the gate, and the jet connecting back up to the pipe downstream, is influencing the downstream water level at different locations. The point where this jet connects with the top of the pipe depends on gate opening. At smaller gate openings the water would connect further downstream than at larger gate openings.

The recommendation by Ball (1961) that the preferred tap location be a distance of $D/3$ cannot be validated in this work. The $D/3$ location is equivalent to the 0.15 and 0.20 m tap locations for the 0.46 and 0.61 m gate, respectively. While there is something to be said about the behavior of the C_d at the closer tap location, it can be difficult in field applications to access the pipe a close distance from the back face of the gate due to the thickness of the concrete bulkhead commonly used.

If a 0.46 m (18-in.) rectangular gate is used with a stilling well location less than 0.20 m (8 in.), the tap location should be moved closer to the 0.305 m (12-in.) location. This will help ensure accurate discharge is recorded using the C_d values presented in this study that are based on the 0.305 m tap location. For both gate sizes with tap locations less than 0.305 m downstream from the back face of the gate, A_o/A_p should be limited to less than 0.80 (less than 14-in. opening for the 18-in. gate and 18-in. opening for the 24-in. gate).

Application

The companion paper provides a set of detailed guidelines for the use of meter gates to attain accurate discharge measurements.

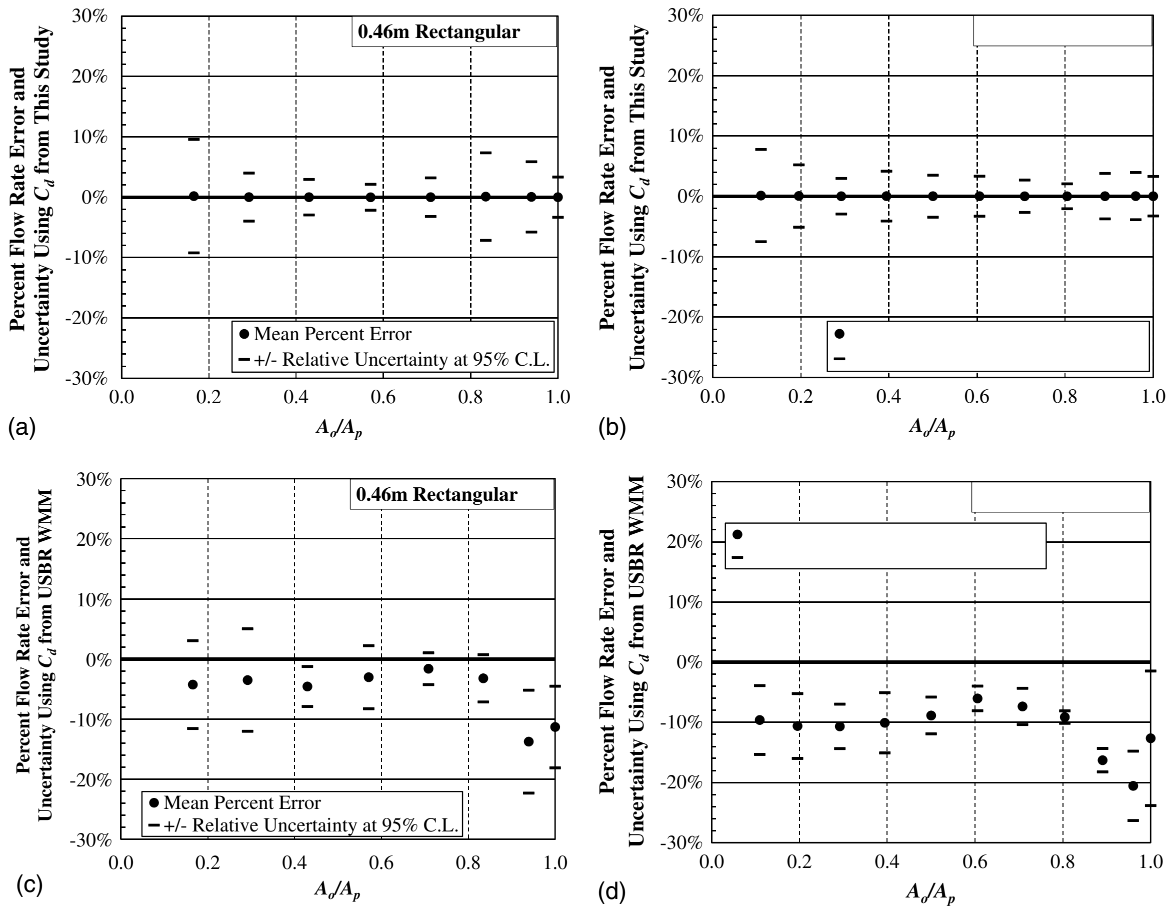

Fig. 6. Average relative error for the two rectangular gates tested based on the new C_d values from this study; relative expanded uncertainty (95% confidence level) is shown as error bars to indicate the accuracy of the instantaneous flow measurement at different gate opening areas

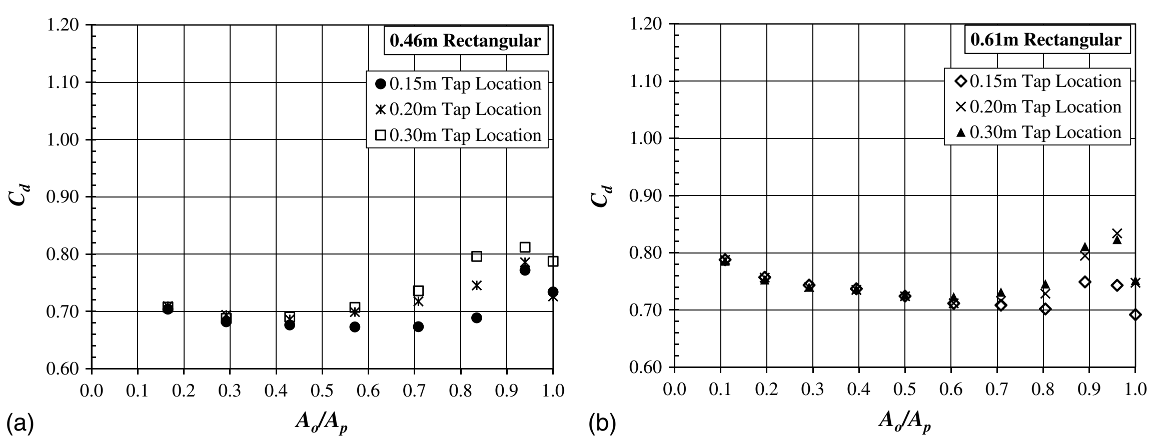

Fig. 7. Effects of downstream tap location on C_d for the two rectangular gates at different net gate opening fractions

That section will not be repeated since those recommendations and limitations are the same for the rectangular gates presented here and the Armco-type (round) gates presented in the companion paper. Proper identification of the *zero* gate opening is critical for obtaining accurate discharge measurement. If the guidelines in the companion paper are followed, users of rectangular gate discharge rating tables based on the C_d values shown in Table 3 should expected uncertainties less than $\pm 10\%$ at all A_o/A_p greater than 0.10 and better than $\pm 5\%$ at more at A_o/A_p greater than 0.20 and less than 0.80. The relationship between A_o/A_p and actual gate opening in meters and inches is shown in Table 3. It is reasonable to assume that most gates would be opened to a variety of gate openings over the course of a season, so an average uncertainty over all gate openings of $\pm 5\%$ can be expected. However, this should be examined on a case-by-case basis.

Table 3 shows the new C_d values for the two rectangular gates in this study by gate opening, fraction of net gate opening (y/y_p, where y_p is the pipe inside diameter) and A_o/A_p. It is

Table 3. New C_d Values from This Study by Net Gate Opening (y), Fraction of Net Gate Opening (y/y_p), and Fraction of Net Opening Area (A_o/A_p)

Gate size	y (m)	y (in.)	y/y_p	A_o/A_p	C_d
0.46 m (18-in.)	0.102	4	0.222	0.165	0.708
	0.152	6	0.333	0.292	0.688
	0.203	8	0.444	0.429	0.690
	0.254	10	0.556	0.571	0.707
	0.305	12	0.667	0.708	0.736
	0.356	14	0.778	0.835	0.796
	0.406	16	0.889	0.939	0.812
	0.457	18	1.000	1.000	0.788
0.61 m (24-in.)	0.102	4	0.167	0.110	0.788
	0.152	6	0.250	0.196	0.756
	0.203	8	0.333	0.292	0.741
	0.254	10	0.417	0.394	0.736
	0.305	12	0.500	0.500	0.725
	0.356	14	0.583	0.606	0.721
	0.406	16	0.667	0.708	0.728
	0.457	18	0.750	0.804	0.744
	0.508	20	0.833	0.890	0.808
	0.559	22	0.917	0.960	0.820
	0.610	24	1.000	1.000	0.748

recommended that these be used for creating new rating tables for these gates. While a best-fit polynomial can be created for each gate, it is more appropriate to interpolate between these values to estimate C_d values for other gate openings. A best-fit regression may have a high R^2 value but the C_d values will not match between the regression equation and the tabular values below at all gate openings, leading to increased uncertainty. In addition, it can perform very poorly at gate openings less than 0.05 m. Linear interpolation or a more advanced interpolation method can be used. If an advanced interpolation is used, the values should be plotted with those reported in this table to ensure that the results conform.

Conclusion

In this study, new coefficient of discharge values based on actual net gate open area for 0.46 m (18-in.) and 0.61 m (24-in.) rectangular meter gates were developed based on a 0.305 m (12-in.) downstream pressure tap location. The gates were tested under a variety of conditions at different gate openings. The C_d values varied most significantly at the lowest net gate opening, increasing the uncertainty at A_o/A_p less than 0.20. Higher gate openings for the 0.46 m gate also showed increased variability; however, the increase in uncertainty was still within $\pm 7\%$ or better. Average overall uncertainty (average of all gate openings) was within $\pm 5\%$.

The C_d values differed significantly between the 0.46 m and the 0.61 m rectangular gates for most openings. This is in contrast to what Ball (1961) found in earlier work. Even though Ball recommended different downstream pressure tap locations, Fig. 7 indicates a significant departure between the C_d values for the different gate sizes. The USBR Water Measurement Manual meter gate C_d figure should not be used for estimating C_d values for rectangular meter gates of various sizes. The authors recommend using the C_d values from this study for 0.46 m and 0.61 m rectangular gates to compute the flow rates if using these as meter gates.

Based on other data collected in this study, an evaluation of the impacts on supply channel velocity perpendicular to the gate will be conducted. Future work is needed to evaluate the effects of different entrance conditions on gate discharge ratings with the supply channel perpendicular to the meter gate turnout. In addition, further testing of different gate sizes is needed to either determine the appropriate discharge rating or examine if a relationship between gate size and coefficient of discharge can be developed.

Acknowledgments

This work was funded by a grant (13-01-005) from the California State University Agricultural Research Institute (CSU ARI). The authors would also like to acknowledge the support provided by San Luis Canal Company, including the donation of the rectangular gates. This work could not have been completed without the hours of work provided by Cal Poly water engineering and irrigation graduate students and construction efforts by ITRC student employees from the BioResource and Agricultural Engineering Department.

Notation

The following symbols are used in this paper:

A_o = net gate opening area;
A_p = full pipe area;
C_d = coefficient of discharge;
C_v = coefficient of velocity;
D = pipe diameter;
E_{Qi} = percent error between the estimated flow and the actual flow;
g = gravitational acceleration;
H_1 = upstream head;
ΔH = head difference across the gate;
Q = flow rate;
Q_i = estimated flow rate;
Q_{improved} = flow rate estimated from new C_d values developed from this work;
R_{pipe} = Reynolds number in the turnout pipe;
R_p = inside radius of the pipe;
RU_{95} = relative expanded uncertainty;
U = uncertainty;
U_Q = instantaneous flow measurement accuracy;
U_{Q_95} = expanded uncertainty to the 95% confidence level; and
y = net gate opening.

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Central California Irrigation District

Modernization Recommendations for the Sullivan Extension Canal Area

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Prepared for
CCID

May 2021

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Issues and Goals

Discussions with CCID management and operations staff identified several issues with the current infrastructure around the Sullivan Extension, Garzas Creek, and the Gustine Reservoir.

Existing Challenges

Operational challenges are outlined below and shown in Figure 1 (starting at the downstream end and working upstream):

- There is a need for supplemental flows in the Lower Main via the Sullivan Extension, but current infrastructure limits the supplemental flows to a maximum of 10 CFS, due restrictive hydraulic control structures at the end of the Sullivan Extension.
- Daily adjustments to the supplemental flows into the Lower Main Canal require frequent operator visits to adjust the flashboard structures at Linville Weir and the flashboard checks downstream of the Linville Weir.
- The Lineville Weir flashboards are inadequate devices for flow control.
- A turnout in Garzas Creek is difficult to service because:
    - Flow control into Garzas Creek is conducted indirectly by forcing an additional flow about equal to the turnout demand into the Outside Canal. The automatic upstream level control algorithm controls how the Garzas Outside gates reacts and diverts.
    - The large gates are designed for storm water control, which make it difficult to maintain small flows.
- The Gustine Reservoir is underutilized. Because the initial inlet pump has been removed, the Gustine Reservoir can only be used to buffer DMC deliveries, but the reservoir is incapable of buffering excess Outside Canal flows, which are instead automatically diverted to Garzas Creek.
- There is limited flow capacity at the DMC 60.65 turnout. There are times when increased flow rate from the DMC would be beneficial for both parties:
    - During peak demand, increased supplemental flows from the DMC would be helpful to CCID operators along the Sullivan extension and Lower Main Canal.
    - Additional flow from the DMC 60.65 turnout would provide water quality benefits to downstream users.
    - Increased delivery flow at the 60.65 turnout would benefit the DMC by alleviating demand upstream of DMC flow capacity bottlenecks caused by subsidence.

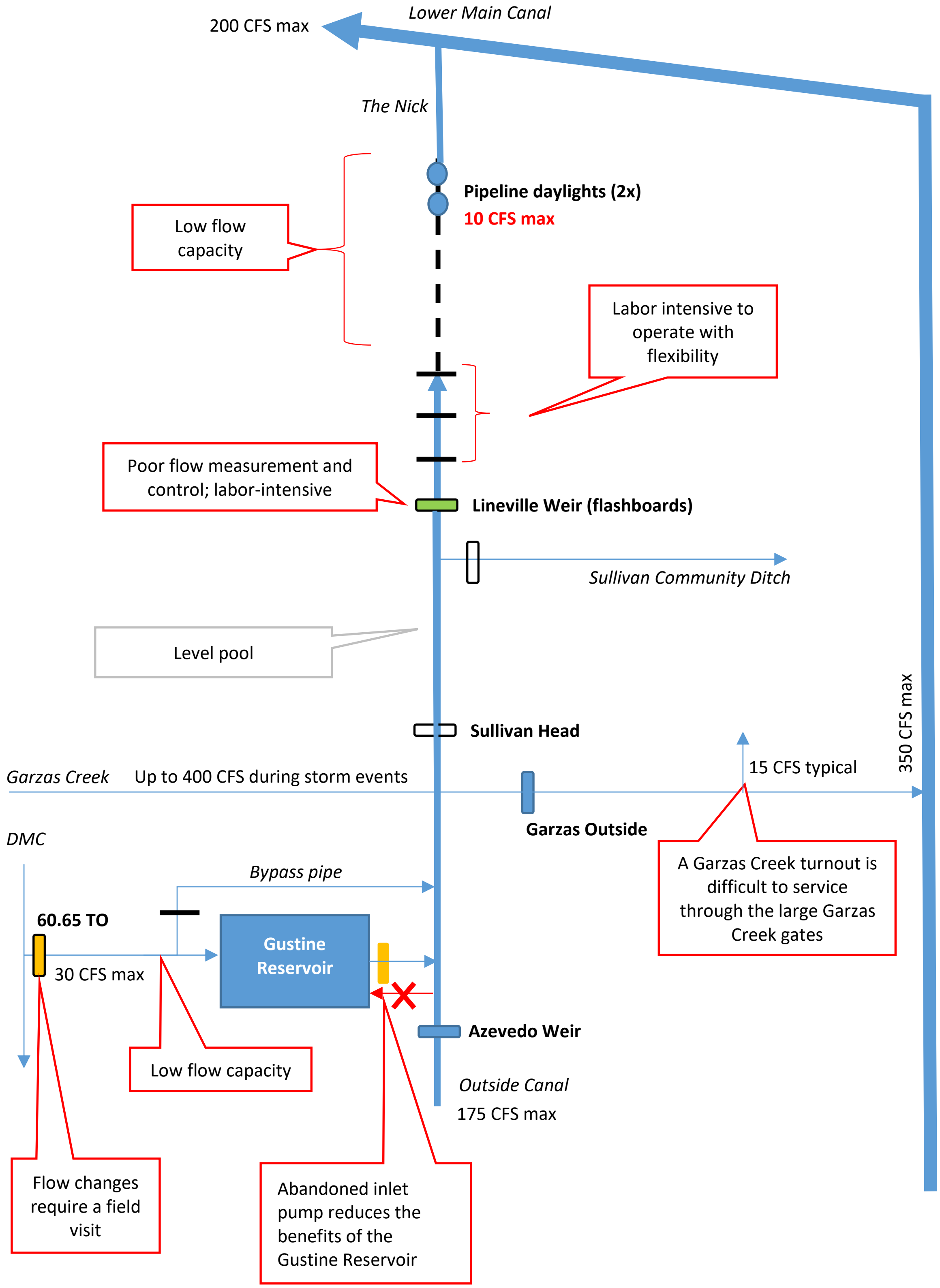


Figure 1. Conceptual schematic of the Sullivan Extension area showing current challenges

The Outside and Sullivan Canal profiles under existing conditions are shown in Figure 2.

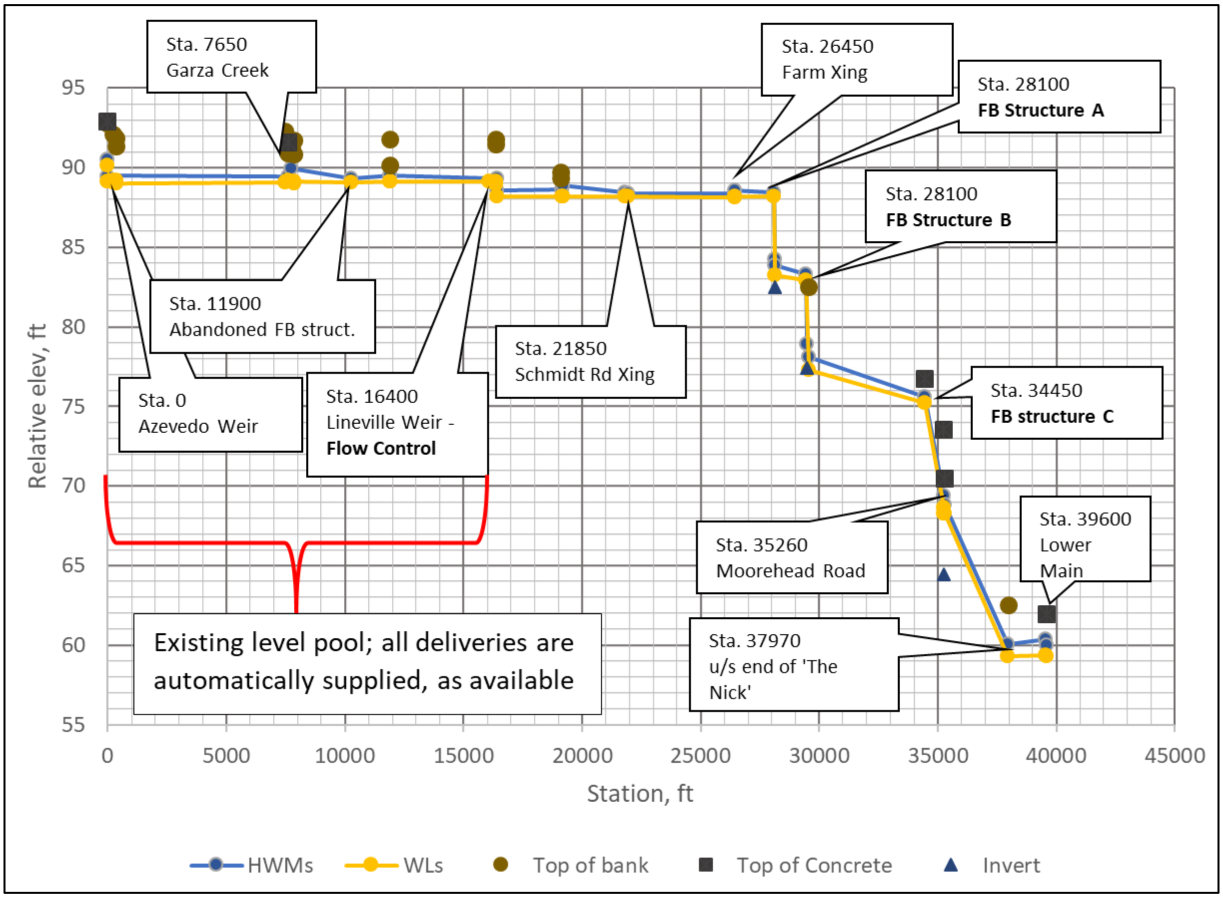


Figure 2. Outside Canal and Sullivan Extension Canal profile under existing conditions

Recommendation Overview

The following recommendations are grouped by anticipated benefits. Additional explanation and justifications are provided in later sections.

1. Increase the supplemental flow capacity and simplify operations between the Lower Main and Sullivan Extension.
    a. Demo existing structures and install a new weir box standpipe at Moorehead Road to increase the capacity for supplemental flows to the Lower Main Canal to about 35 CFS from an existing capacity of about 10 CFS.
    b. Replace Flashboard (FB) structures B and C (labeled in Figure 2) with new long-crested weirs.
    c. Install a new, automated flow control structure with accompanying flume downstream, to replace the FB structure A. The design flow capacity of the new flow control structure will be 60 CFS to accommodate about 35 CFS of supplemental flow to the Lower Main Canal, plus additional capacity to simultaneously meet some irrigation demand.
    d. Demo the existing Linville Weir structure and another abandoned flashboard structure just downstream of the Sullivan Head to maximize flow capacity to downstream parts of the Sullivan Extension.

   e. Over-excavate the Sullivan Extension to lower the invert about 2 feet between the Gustine Reservoir and the proposed new flow control gate (about 28,000').
   f. Raise both banks of the Sullivan Extension Canal between the Linville Weir and the proposed new flow control structure.
2. Simplify irrigation season operations at Garzas Creek:
   a. Install a new, small turnout structure for the Garzas Creek irrigation delivery.
   b. Add additional capabilities, such as automatic flow control to the already-planned replacement Garzas Creek RTU.
3. Simplify operations and increase the functionality of the Gustine Reservoir:
   a. Install a gate at the downstream end of the pipeline supplying Gustine Reservoir. The gate will be automated for level control in the reservoir. Essentially the concept provides automatic filling of the reservoir up to an adjustable set point elevation.
   b. Install a pump to lift water from the Outside Canal to the Gustine Reservoir to provide complete buffering capabilities and avoid unwanted diversions to Garzas Creek.
4. Replace existing RTUs at the Gustine Reservoir and Garzas Creek with upgraded versions instead of replacing in-kind.

Increasing DMC deliveries to the lower Main Canal was also briefly examined, as follows:
1. Increasing the flow capacity of the 60.65 DMC turnout is not possible without an additional or larger pipe – which essentially requires constructing a new turnout. This idea was discarded.
2. A new pump station to lift water from the Newman spillway to the Lower Main Canal. Estimated construction cost is about $2.2 million. Annual utility bills are expected to be between $30-50k annually.
3. A new gravity turnout just upstream of the Gustine Reservoir is estimated to cost about $1.7 million, with negligible operating costs.

Level Pool Discussion

The authors define a level pool as a special canal reach with controlled outflows and an automatically controlled, relatively constant water surface – typically featuring a buffer reservoir. Controlled outflows from the level pool are automatically supplied by a combination of water sources: variable inflow into the level pool, and flow changes into/out of the reservoir.

There is already a level pool in the Outside Canal between the Azevedo Weir and Garzas Creek, which might lead one to ask several questions:
1. Why extend the level pool?

   With an extended level pool, most Sullivan Extension turnouts will be supplied without needing any operator adjustment of check structures or the Lineville Weir, because those turnouts will be directly and automatically fed by the level pool.

2. Why are over-excavation and raised banks needed?

   At very low flows, the water surface in the level pool will be horizontal, but there is about a 1-foot head drop across Linville Weir. Therefore, the banks need to be raised on the downstream end. Enlarging the flow area (by over-excavating the invert) is required to reduce canal "friction" at high flows, so the water level at the far downstream end does not fluctuate so much between high and low flows.

Overviews of the Sullivan Extension recommendations are provided in Figure 3 and Figure 4.

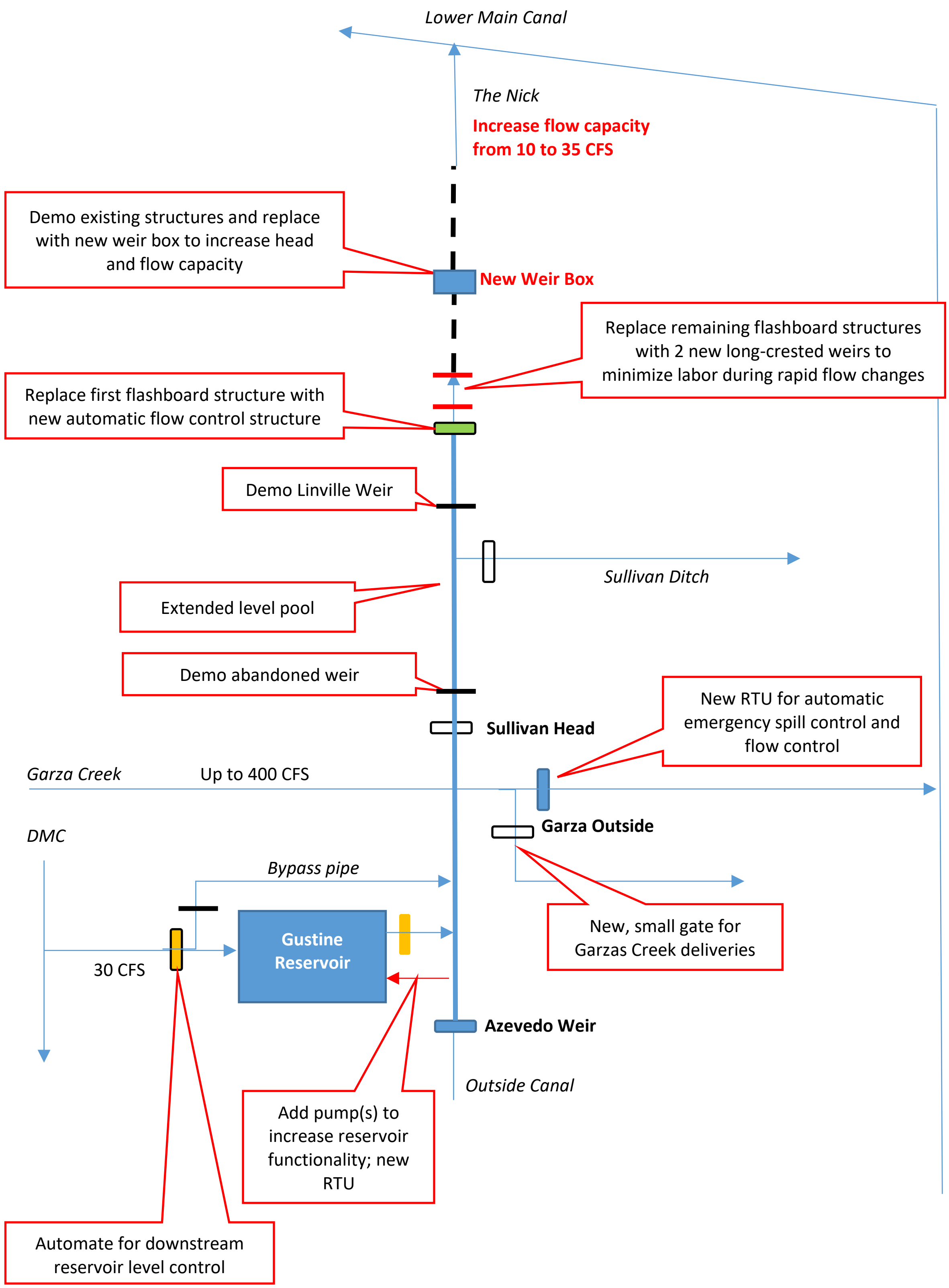


Figure 3. Recommendation overview for the Sullivan Extension area

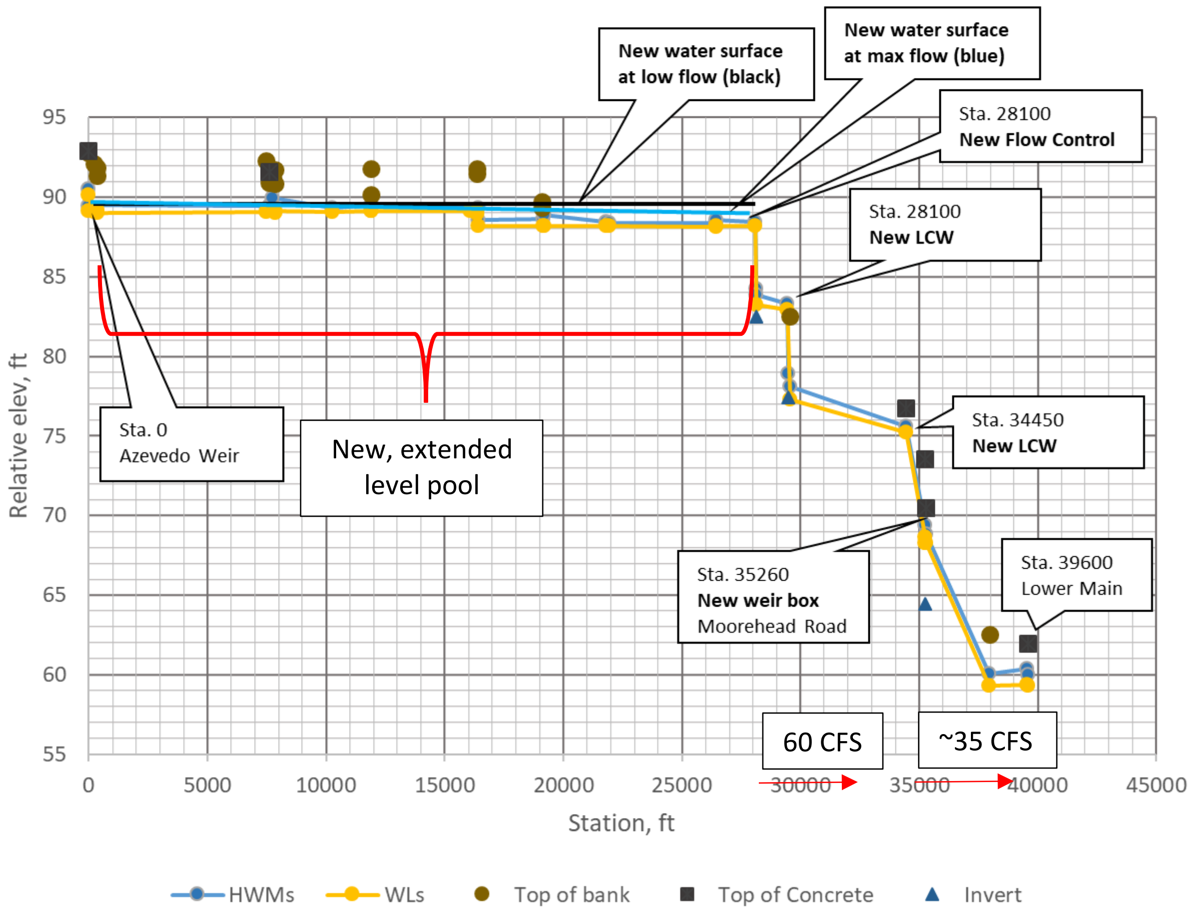


Figure 4. Key recommendations and extended level pool resulting water surfaces laid over the existing canal profile

Reference Elevations

All elevations listed in this document are relative and referenced a monument located adjacent to the Gustine Reservoir outlet gate. A relative elevation of 100' was assigned to the monument (Figure 5).

Figure 5. Monument found adjacent to the reservoir outlet gate; assigned an elevation of 100'

Sullivan Extension and the Nick Improvements

The major cumulative benefits of the recommended improvements are:

- Increase the supplemental flow capacity between the Sullivan Extension and the Lower Main Canal from 10 CFS to about 35 CFS.
- Reduce field labor requirements for rapid flow changes along the Sullivan Extension.
- Simplify Sullivan Extension operations by extending the "level pool" controlled by the reservoir by about 11,000 feet.
- Improve flow measurement and control through a new flow control structure downstream of Linville Weir.
- Increase operational flexibility by enabling rapid supplementation of the Main Canal from either the Garzas Outside gates, or the tail end of the Sullivan Extension.

A visual overview of the recommendations is provided in Figure 6. Site-specific recommendations are provided in the following sections.

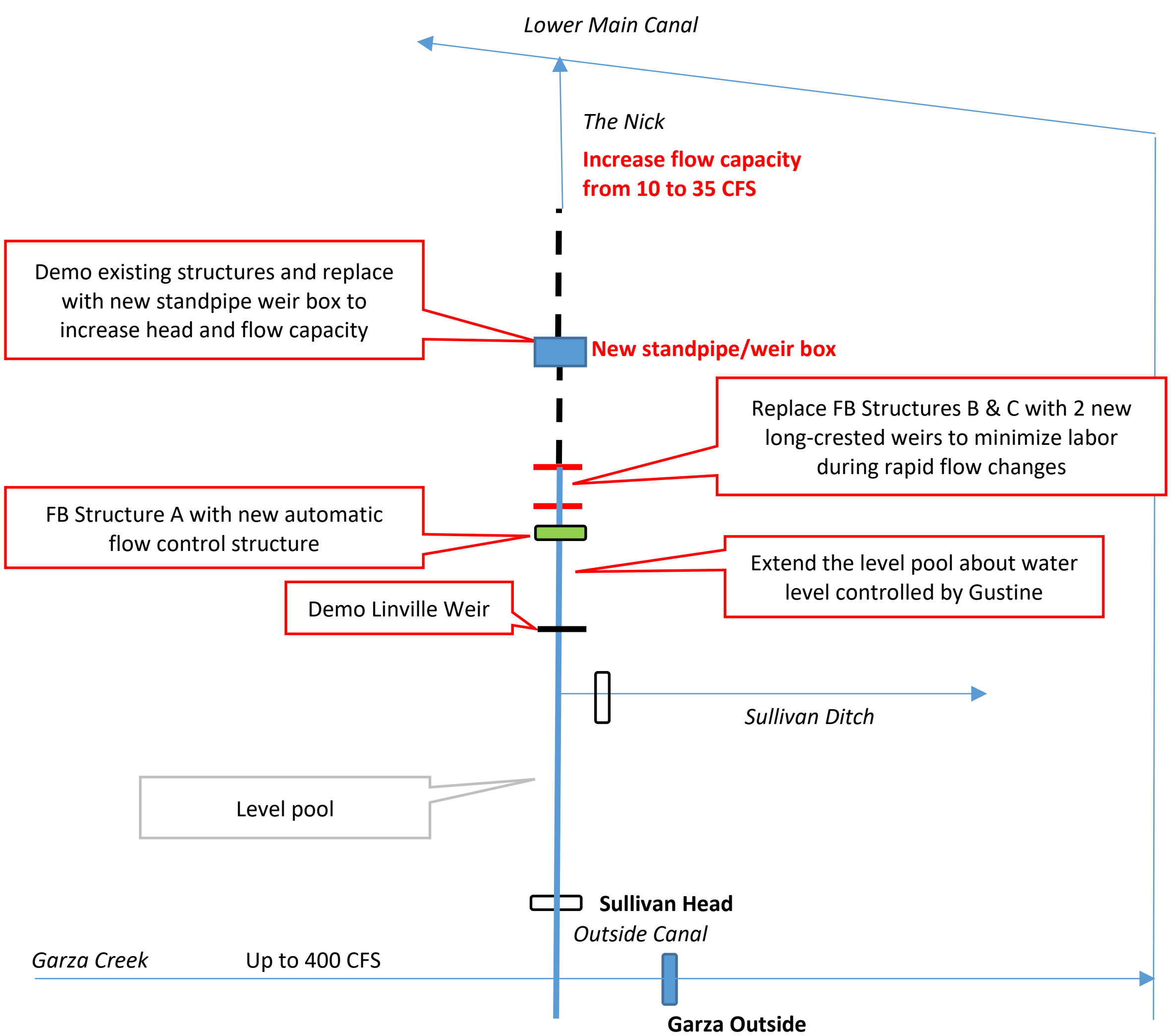


Figure 6. Recommended improvements for the Sullivan Extension

Sullivan Extension at Moorehead Road

Existing conditions at crossing of the Sullivan Extension and Moorehead Road are complicated, as shown in Figure 7. The combination of weir boxes is a primary source of the current capacity constraint of 10 CFS. Both existing weir boxes are fitted with flashboards for adjustment.

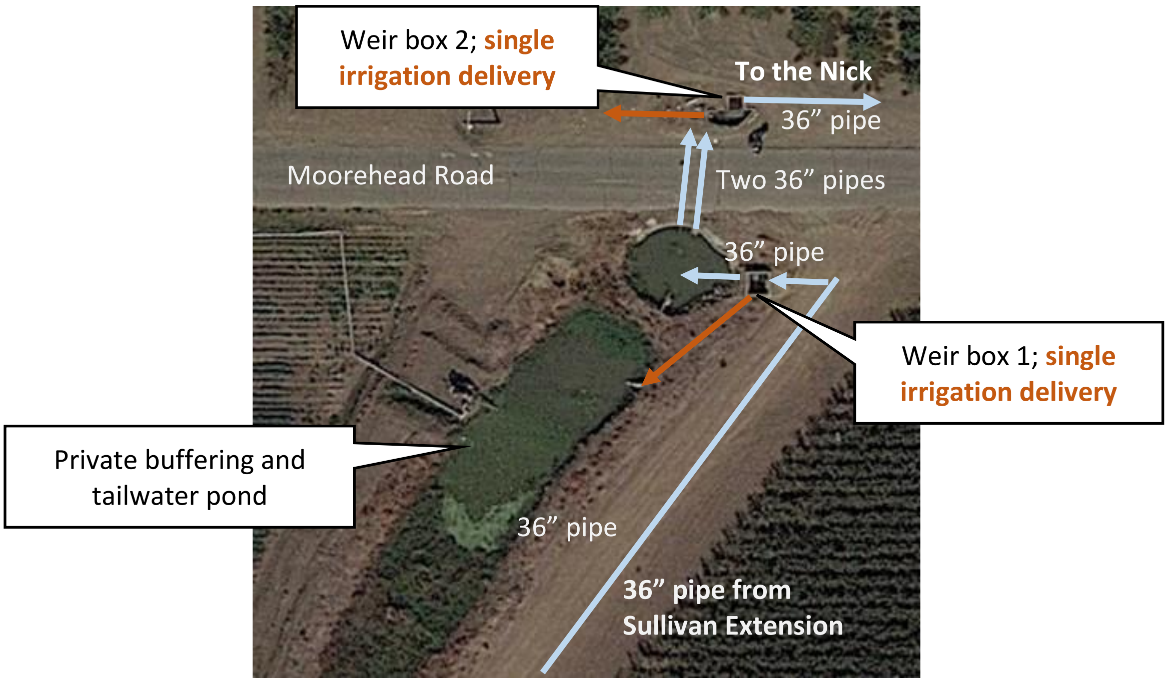


Figure 7. Existing conditions near the convergence of Moorehead Road and the Sullivan Extension pipeline

Sullivan Extension at Moorehead Road Recommendations

It is recommended to:

1. Demolish the existing two weir boxes.
2. Construct a new and taller weir box to the north of Moorehead Road. The new weir box will provide the necessary head in the pipeline to facilitate gravity deliveries at Moorehead Road.
3. Construct new pipeline turnouts upstream of the new weir box.

A plan view of the recommendations is provided in Figure 8.

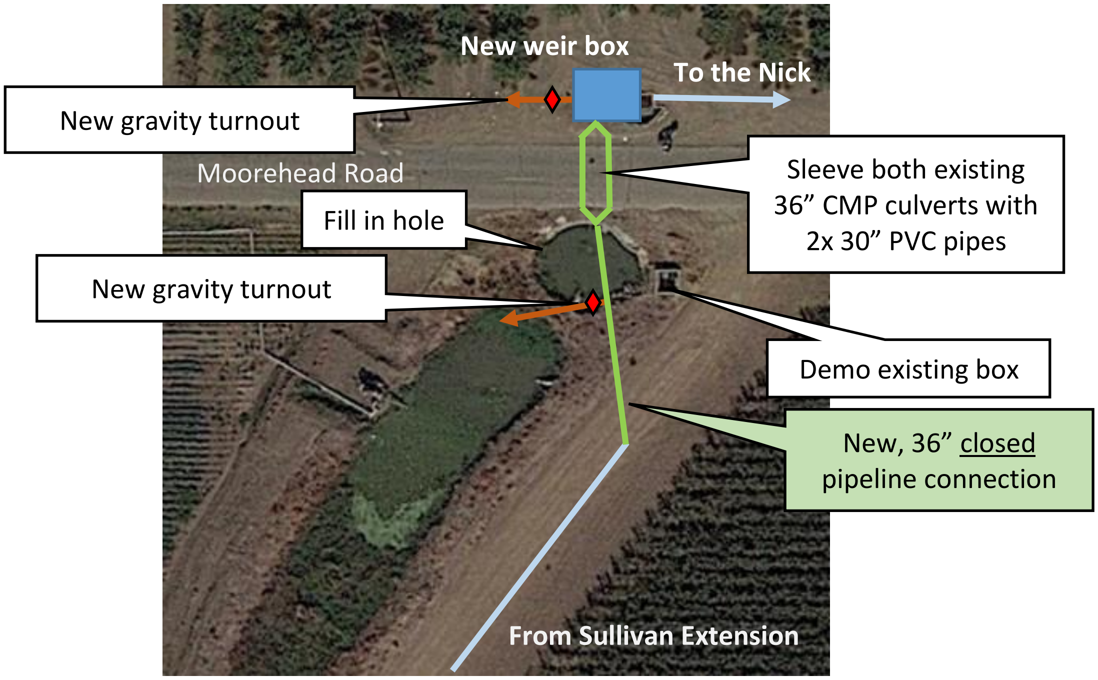
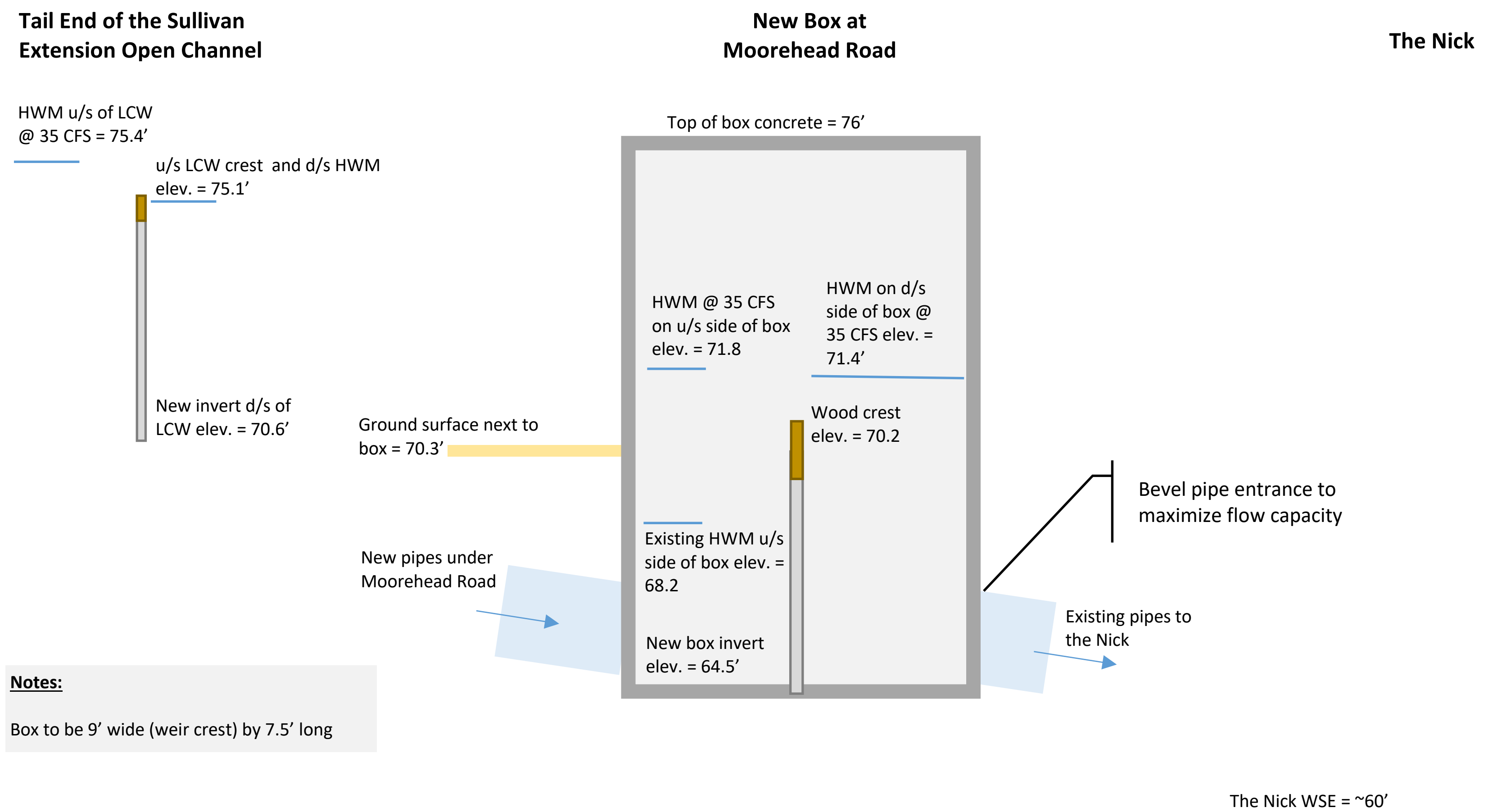


Figure 8. Infrastructure modifications near the convergence of Moorehead Road and the Sullivan Extension pipeline

New Weir Box

The new weir box will be constructed as shown in Figure 9.



Notes:

Box to be 9' wide (weir crest) by 7.5' long

Figure 9. Conceptual profile of the proposed new submerged weir box at Moorehead Road

New Long-Crested Weirs (LCW)

There are two existing flashboard check structures downstream of the proposed new flow control structure. Both are currently used to maintain an appropriate water depth immediately upstream of themselves.

The flashboards require an in-field presence for operation. As such, the flashboards are incompatible with the intended operation of the canal, which is the ability for CCID operators to deliver supplemental flows remotely and rapidly to the Lower Main Canal. As such, it is recommended that the two farthest downstream flashboard structures be replaced with LCWs.

LCW at FB Structure B

The upstream structure is shown in Figure 10 and Figure 11.

Figure 10. Satellite image of the existing, upstream flashboard structure. Note turnouts on both banks.

Figure 11. Existing conditions at the first flashboard check, looking upstream (see left image) and the flashboard structure (right)

The structure will be replaced with a LCW as shown in Figure 12. An upstream facing "duck-billed" weir design was selected because turnouts are located on both banks.

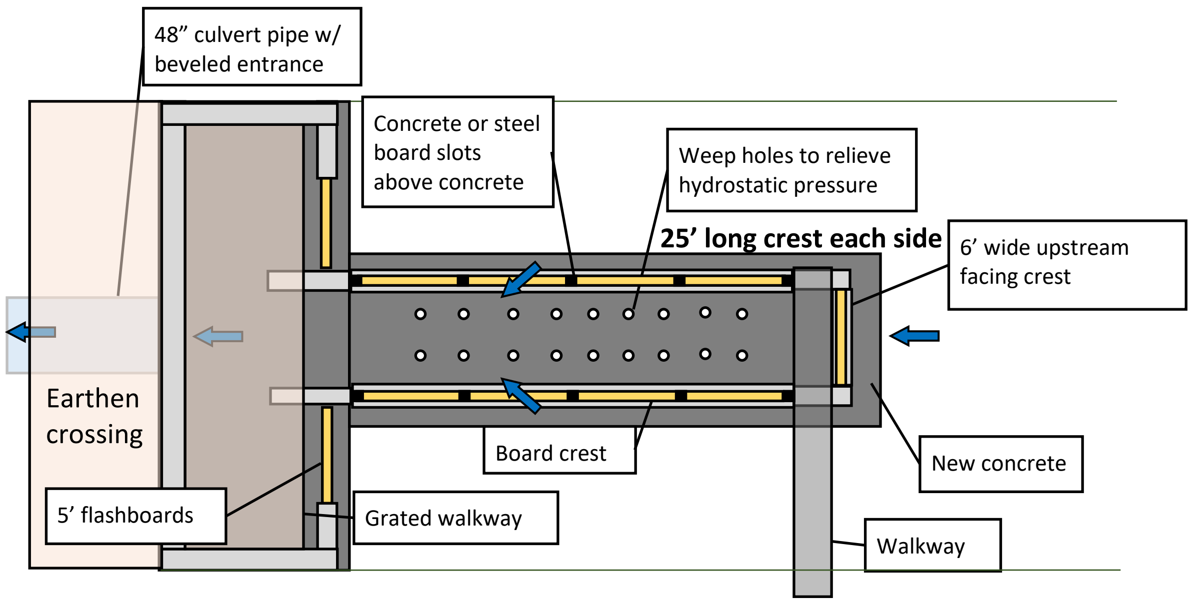


Figure 12. Conceptual plan view of example LCW structure to be constructed to replace the existing flashboards just downstream of the new flow control structure (not to scale)

Additional construction details are provided in Table 1.

Table 1. Upstream LCW construction details

Description	Value (ft)
Total weir crest length, including side flashboards (min.)	60
Board crest elevation	82.8
Height of concrete walls	4
Height of board (LCW crest) above concrete	0.5
Invert elevation	78.3

LCW at FB Structure C

The existing downstream flashboard structure is shown in Figure 13. This structure will also be replaced with a new LCW.

Figure 13. Existing flashboard structure located at the tail end of the Sullivan Extension open channel

To simplify construction, it is recommended that the upstream LCW design be repeated at a lower elevation for the downstream LCW, except for discharge pipe details.

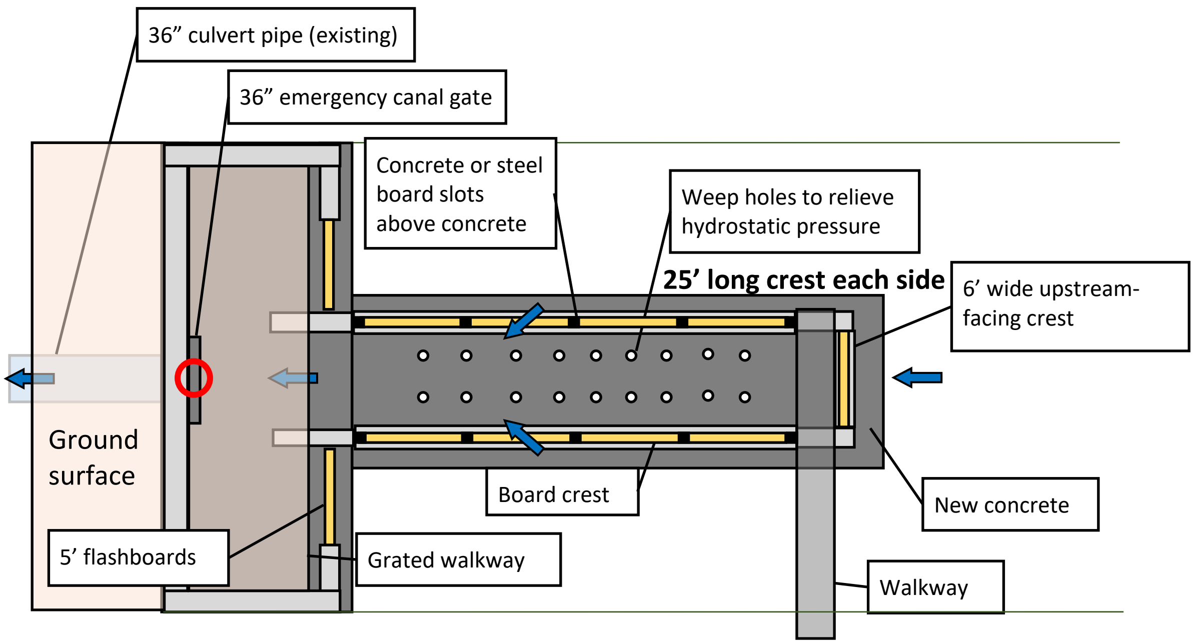


Figure 14. Conceptual plan view of example LCW structure to be constructed to replace the existing flashboards just downstream of the new flow control structure (not to scale)

Site-specific details are provided in Table 2.

Table 2. Downstream LCW construction details

Description	Value (ft)
Minimum weir crest length, including side flashboards	60
Board crest elevation	75.1
Height of concrete walls	4
Height of board (LCW crest) above concrete	0.5
Invert elevation	70.6

New Automated Flow Control Structure at FB Structure A

A new, automated flow control structure will be constructed at Station 280+00 to replace the existing flashboard check structure shown in Figure 15.

Figure 15. Existing flashboard check at Flashboard Structure A (FB A).

Placing a new flow control structure at this location extends the "level pool" by about 11,400 feet. The operational depth of the level pool is maintained automatically by the Gustine Reservoir, with emergency spill diversion via the Garzas Outside gates.

The primary benefit of extending the level pool is a decrease in operational labor. For example, initiating a delivery downstream of the Linville Weir currently requires a field operator to adjust board settings at multiple flashboard structures.

Conceptual Design

A conceptual design of the proposed flow control structure is provided in Figure 16 and Figure 17. Key design components are:

- A new 4' wide by 3' tall slide gate with electronic actuator will be installed upstream of the existing road crossing.
- A new RTU will provide automatic flow control, including remote manual gate controls and pre-scheduled flow target changes.
- A new 48" culvert pipe (HDPE or concrete) will replace the existing culvert pipe.
- A new Replogle flume, with an offline RCP stilling well upstream will be installed just downstream of the new culvert for flow measurement. See Figure 16 for details.

Flume details:

- The flume will be rectangular with an internal width of six feet between vertical side walls.
- The offline stilling well port will be installed 10 feet upstream of the start of the flume sill.
- The rectangular, six-foot wide approach section will be 20 feet long.

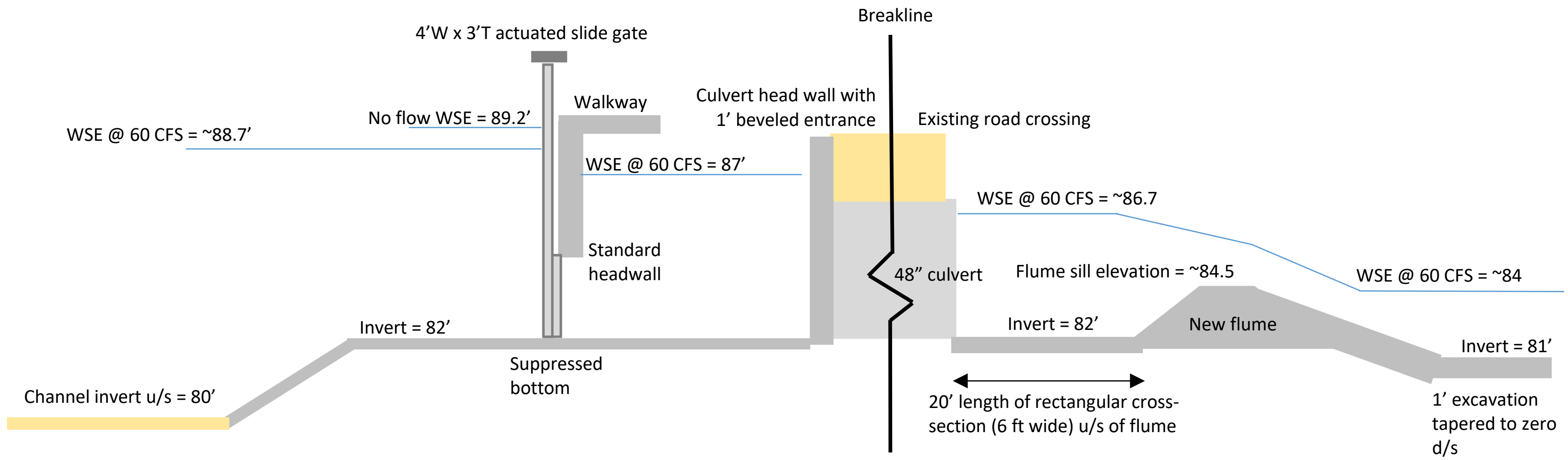


Figure 16. Conceptual profile of the proposed flow control structure

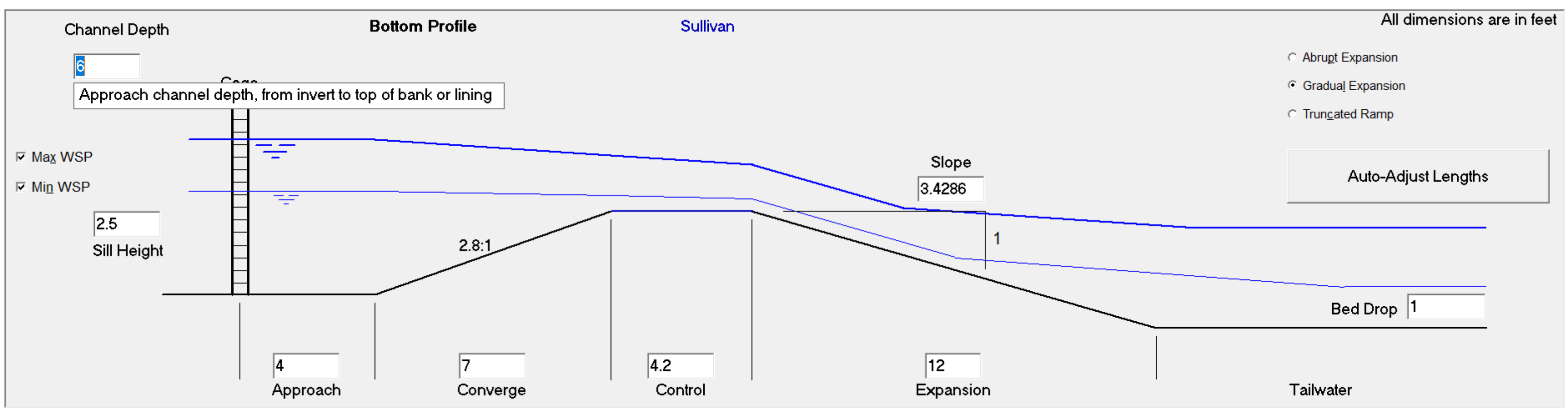


Figure 17. Profile of the proposed flume downstream of the flow control structure

Other Sullivan Extension Modifications

Additional Sullivan Extension recommendations are:

1. Demolish two existing flashboard check structures.
2. Lower the channel invert and raise the banks between Linville Weir and the new flow control structure, as shown in Figure 20.
3. Upgrade the RTUs and programming at:
    a. Garzas Creek/Sullivan Head
    b. Gustine Reservoir

Structure Demolition

Two structures will be demolished to facilitate increased flows down the Sullivan Extension canal while also minimizing the head loss at the tail end during high flow events.

Figure 18. Abandoned flashboard structure just downstream of Garzas Creek – to be demolished

Figure 19. Linville Weir – to be demolished

Excavation and Bank Raising

ITRC staff measured canal depths in four locations along the Outside Canal and Sullivan Extension. Those data are shown in Figure 20 as the “existing invert.” Because it is proposed to increase the channel flow capacity through excavation, more measurements of the existing channel are not necessary, unless CCID needs a good estimate of grading volumes.

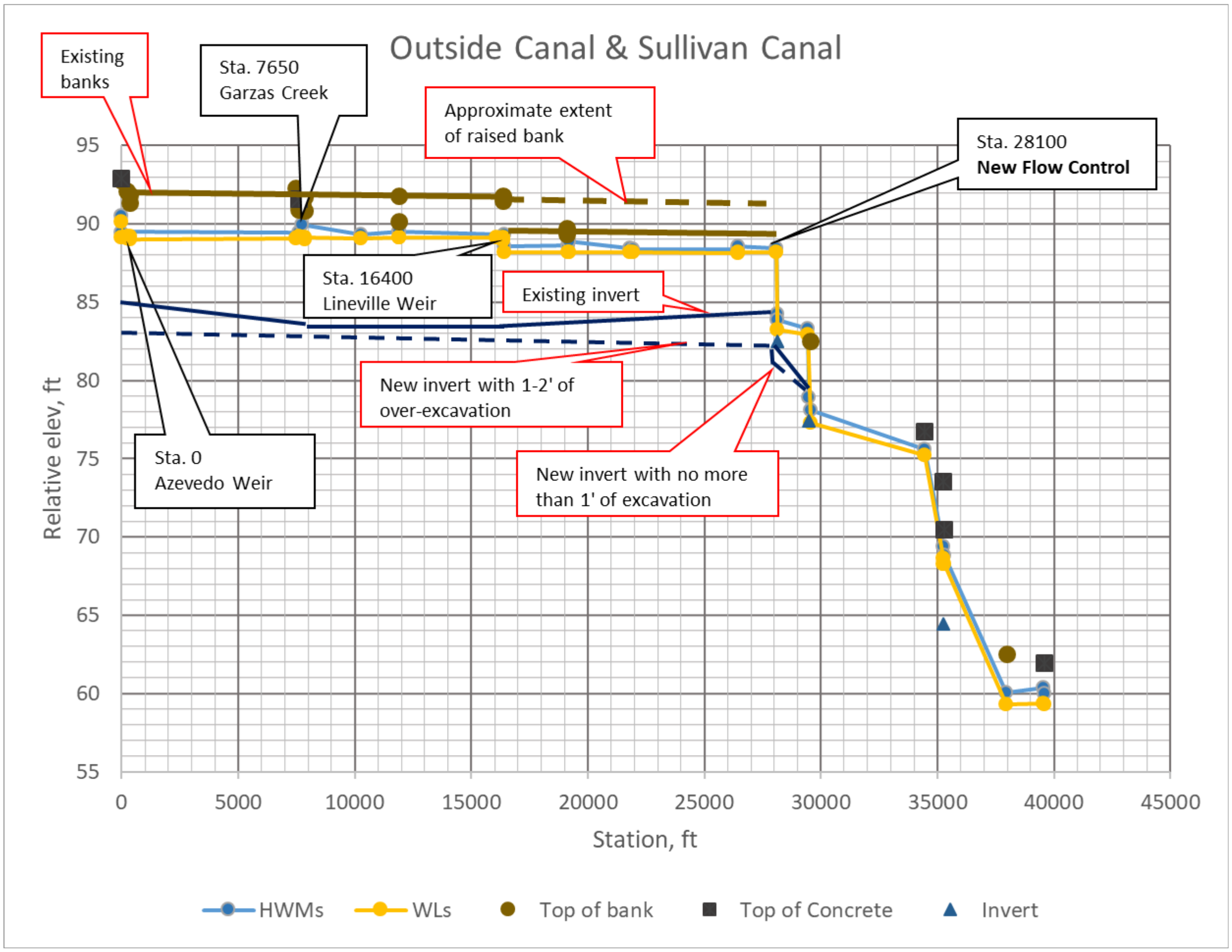


Figure 20. Excavation and bank raising extents, overlain with the existing canal water surface and invert profiles

SCADA/RTU Upgrades

There are currently three Remote Terminal Units (RTU) installed in the Sullivan Extension area:

- Gustine Reservoir, with automatic control of the reservoir's outflow gate and monitoring reservoir/canal levels
- Garzas Outside, with automatic control of the two creek overshot gates to maintain a relatively constant upstream level (higher than the level controlled by the Gustine Reservoir outlet) in case of large level pool inflows.
- Sullivan Head, currently used under storm water control only. Otherwise, the gates remain fully open throughout the irrigation season.

CCID has already planned to replace all three RTUs due to hardware obsolescence, so that will be the best time to add or remove RTU capabilities.

Recommendations

There will be a total of three new RTUs at:

- Gustine Reservoir
- Garzas Outside
- The new flow control structure

New Gustine Reservoir RTU

The new Gustine Reservoir RTU will provide the following capabilities:

- Automatic downstream level control of the extended level pool. This will be accomplished by adjusting the existing outlet gate position and the speed/status of the new inlet pump(s).
- Automatic reservoir level control. This will be accomplished by adjusting the position of a new butterfly valve or gate at the discharge end of the 60.65 turnout pipeline.
- Typical remote manual control of gates/valves/pumps
- Monitoring of:
    - Canal and reservoir levels
    - All flows into/out of the reservoir

New Garzas Outside RTU

The new Garzas Outside RTU will provide the following capabilities:

- Remote manual control of the Sullivan Head gate and both Garzas Creek gates for stormwater management. The two RTUs will be merged because:
    - Hardware and software obsolescence over time is inescapable, meaning it is likely that CCID will continue to need RTU replacements about every 15 years.
    - By combining two adjacent RTUs into one new RTU, CCID will be replacing only one slightly larger RTU about every 15 years, instead of two.
- For Garzas Creek Gate 1: Automatic flow control for one of the two large Garzas Creek overshot gates. This will enable CCID operators to set a relatively constant and relatively large (over 15 CFS) supplemental flow from the Outside Canal to the Main Canal, via Garzas Creek. The automatic flow control will have an automatic upstream spill level control override to divert excess flows automatically and safely from the Outside Canal to Garzas Creek.
- For Garzas Creek Gate 2: Automatic upstream spill level control only.
- Monitoring of all local levels and the flow rate into Garzas Creek from the large gates using a gate rating curve.

New Flow Control Structure

The flow control structure RTU will provide automatic flow control to the downstream reaches of the Sullivan Extension.

Additional SCADA/RTU Improvements

Table 3 summarizes additional SCADA/RTU improvement recommendations.

Table 3. Additional recommended SCADA/RTU improvements

Location of RTU	SCADA/RTU Improvements	Notes
Gustine Reservoir	• Upgrade stilling wells and level sensor installations • Construct a new block building for security and to house the new pump VFD(s) • Add redundant sensors if not already existing • Verify existing sensor calibrations	• Consider installing buried stilling wells for more security
Garzas Outside	• Add demolished Sullivan Head RTU inputs/outputs to the new Garzas Outside RTU • Add redundant sensors if not already existing • Verify existing sensor calibrations	• Consider installing buried stilling wells

New RTU Conceptual Schematic

A conceptual schematic of the area with new RTUs is provided in Figure 21.

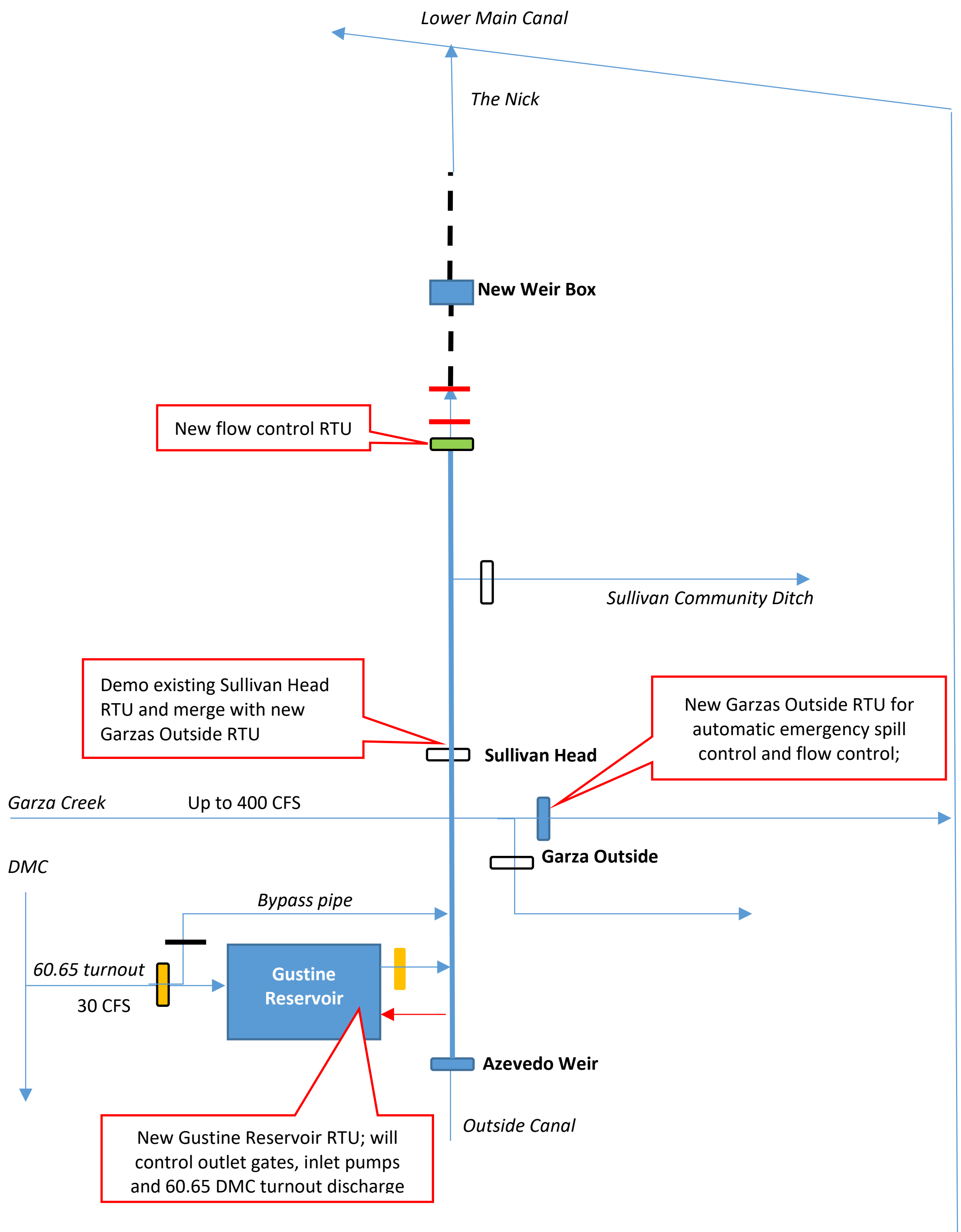


Figure 21. Major SCADA/RTU recommendations shown with a conceptual schematic of post-project conditions

Garzas Creek Turnout

Currently, CCID delivers irrigation water to a turnout in Garzas Creek, about 0.5 miles downstream of the Outside Canal. The required delivery flow ranges from 3-15 CFS with delivery durations of up to a week or more.

There are several issues with the existing Garzas Creek turnout operations:

- The method operators use to work around the existing automation to deliver water to the turnout is complicated. Currently, operators manually add the target turnout flow into the Outside Canal from the Gustine Reservoir.
- The Garzas Creek gates are too large to effectively maintain a very small (<15 CFS) target flow rate. For example, the smallest measurable gate movement of 0.01' results in a 10% change in flow at around 10 CFS.

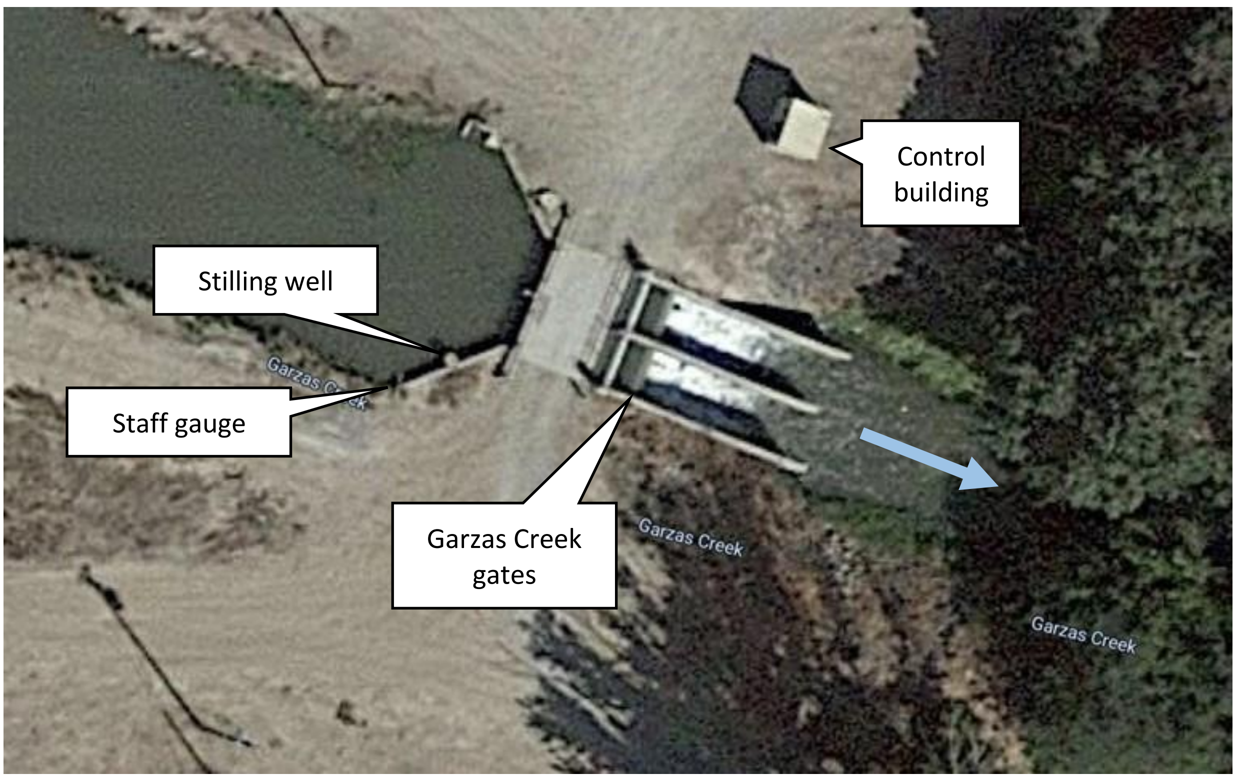


Figure 22. Existing conditions at Garzas Creek

Recommendation Overview

It is recommended to:

1. Install a new turnout gate next to the existing Garzas Outside gates. A Briggs pre-cast metergate that discharges into an open box is recommended for the new turnout gate. A valve on the discharge side of the open box will be adjusted to ensure that the downstream side of the metergate is always submerged. Using a rating table, operators can estimate the discharge flow rate with the following physical measurements:
   a. The net gate opening measured on the gate stem (defined in the ITRC metergate report)
   b. Head differential. Operators measure the difference between the upstream level and downstream new stilling well level (built into the Briggs structure) from a common reference elevation.
   c. Refer to ITRC Report No. R 15-001 (Revised November 2016) for additional metergate details and recommendations.
2. When the Garzas Outside RTU is replaced, the option for automatic flow control will be added to enable CCID staff to remotely set and maintain a relatively constant target flow rate down Garzas Creek to supplement the Main Canal. These flows are expected to be greater than 15 CFS or less design flows for the new turnout.

Garzas Creek Turnout Modifications

A conceptual plan view of the new metergate is shown in Figure 23. The metergate will discharge into the side of the existing Garzas Creek structure to avoid permanent bank erosion problems, which are expected if the pipe instead discharged on the banks of the creek. A conceptual profile view is shown in Figure 24.

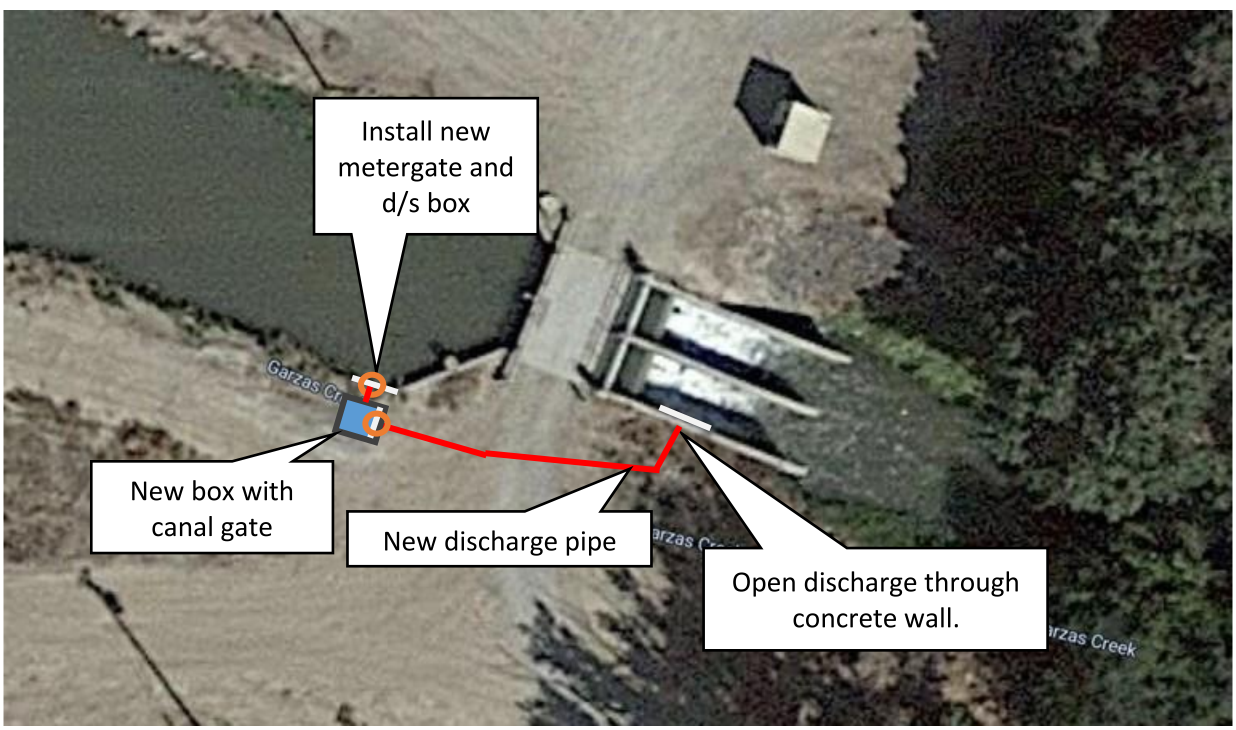


Figure 23. Recommended modifications for a new turnout at Garzas Creek

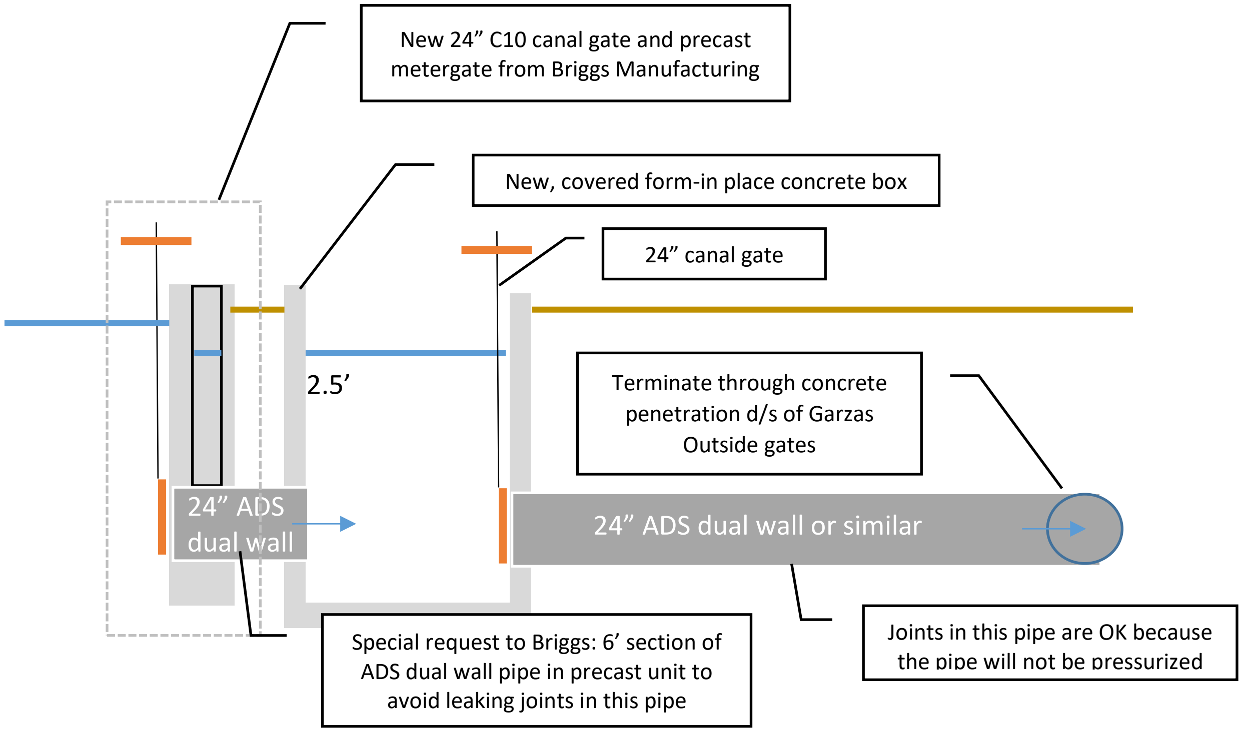


Figure 24. Conceptual cross section view of the proposed new metergate discharging into Garzas Creek

Operations

The turnout would be operated in conjunction with a rating table (see Table 4) as outlined below.

1. Operators will locate a cell that lists a value roughly equal to the target delivery flow within the blue area of Table 4 (also available here: www.itrc.org/reports/pdf/metergate.pdf).

   To illustrate, a hypothetical turnout delivery flow rate of 15.3 CFS is selected on the table.

2. Operators will adjust the position of the upstream gate to the net opening listed in the top row, directly above the cell identified in Step 1.

   Operators would move the upstream gate to 1.25 feet of net gate opening.

3. Operators will adjust the downstream gate until the head differential equals the value shown in the left-most column, in the same row as the cell identified in Step 1.

   Operators would adjust the downstream gate opening until the head differential across the upstream gate is equal to 1.33 feet.

4. When the irrigation event is done, operators will fully close the upstream gate.

Table 4. Rating table to be used with the proposed new Garzas Creek turnout gate. Also available online.

ΔH (feet)	ITRC Water Measurement Tables – **24" Armco-Type Gate**, Stilling Well Located 12" d/s of Back of Gate [Blue center represents best accuracy range] Net Gate Opening (feet)																												
	0.042	0.08	0.13	0.17	0.21	0.25	0.29	0.33	0.38	0.42	0.46	0.50	0.58	0.67	0.75	0.83	0.92	1.00	1.08	1.17	1.25	1.33	1.42	1.50	1.58	1.67	1.75	1.83	1.92	2.00
0.04	0.10	0.22	0.35	0.49	0.61	0.73	0.84	0.95	1.05	1.14	1.23	1.31	1.49	1.65	1.81	1.96	2.14	2.32	2.45	2.57	2.71	2.85	3.01	3.16	3.30	3.51	3.68	3.71	3.77	3.57
0.06	0.12	0.27	0.43	0.60	0.75	0.89	1.03	1.17	1.29	1.40	1.51	1.61	1.82	2.02	2.22	2.40	2.63	2.84	3.00	3.14	3.32	3.49	3.68	3.87	4.04	4.30	4.51	4.54	4.62	4.37
0.08	0.14	0.31	0.50	0.69	0.86	1.03	1.19	1.35	1.49	1.62	1.74	1.85	2.10	2.33	2.56	2.78	3.03	3.28	3.46	3.63	3.84	4.03	4.25	4.47	4.67	4.97	5.20	5.24	5.34	5.04
0.10	0.15	0.35	0.56	0.77	0.96	1.15	1.33	1.51	1.66	1.81	1.95	2.07	2.35	2.61	2.87	3.10	3.39	3.67	3.87	4.06	4.29	4.51	4.76	4.99	5.22	5.56	5.82	5.86	5.97	5.64
0.13	0.17	0.39	0.61	0.84	1.06	1.26	1.46	1.65	1.82	1.98	2.13	2.27	2.58	2.86	3.14	3.40	3.71	4.02	4.24	4.44	4.70	4.94	5.21	5.47	5.72	6.09	6.37	6.42	6.54	6.18
0.15	0.18	0.42	0.66	0.91	1.14	1.36	1.58	1.78	1.97	2.14	2.30	2.45	2.78	3.09	3.39	3.67	4.01	4.34	4.58	4.80	5.07	5.33	5.63	5.91	6.17	6.57	6.88	6.93	7.06	6.67
0.17	0.19	0.44	0.71	0.97	1.22	1.46	1.69	1.91	2.10	2.29	2.46	2.62	2.98	3.30	3.63	3.93	4.29	4.64	4.90	5.13	5.43	5.70	6.02	6.32	6.60	7.03	7.36	7.41	7.55	7.13
0.19	0.20	0.47	0.75	1.03	1.29	1.55	1.79	2.02	2.23	2.43	2.61	2.78	3.16	3.50	3.85	4.17	4.55	4.92	5.20	5.44	5.75	6.05	6.38	6.70	7.00	7.45	7.81	7.86	8.01	7.56
0.21	0.22	0.50	0.79	1.09	1.36	1.63	1.89	2.13	2.35	2.56	2.75	2.93	3.33	3.69	4.05	4.39	4.80	5.19	5.48	5.74	6.07	6.38	6.73	7.06	7.38	7.86	8.23	8.29	8.44	7.97
0.23	0.23	0.52	0.83	1.14	1.43	1.71	1.98	2.23	2.47	2.68	2.89	3.07	3.49	3.87	4.25	4.61	5.03	5.44	5.74	6.02	6.36	6.69	7.05	7.41	7.74	8.24	8.63	8.69	8.85	8.36
0.25	0.24	0.54	0.87	1.19	1.49	1.78	2.07	2.33	2.58	2.80	3.02	3.21	3.65	4.04	4.44	4.81	5.25	5.68	6.00	6.28	6.64	6.98	7.37	7.74	8.08	8.61	9.01	9.08	9.24	8.74
0.27	0.25	0.57	0.90	1.24	1.55	1.86	2.15	2.43	2.68	2.92	3.14	3.34	3.79	4.21	4.62	5.01	5.47	5.92	6.24	6.54	6.92	7.27	7.67	8.05	8.41	8.96	9.38	9.45	9.62	9.09
0.29	0.26	0.59	0.94	1.29	1.61	1.93	2.23	2.52	2.78	3.03	3.26	3.47	3.94	4.37	4.80	5.20	5.67	6.14	6.48	6.79	7.18	7.54	7.96	8.36	8.73	9.30	9.74	9.80	9.98	9.43
0.31	0.26	0.61	0.97	1.33	1.67	2.00	2.31	2.61	2.88	3.13	3.37	3.59	4.08	4.52	4.96	5.38	5.87	6.36	6.71	7.03	7.43	7.81	8.24	8.65	9.04	9.62	10.08	10.15	10.33	9.77
0.33	0.27	0.63	1.00	1.38	1.72	2.06	2.38	2.69	2.97	3.24	3.48	3.71	4.21	4.67	5.13	5.55	6.07	6.56	6.93	7.26	7.67	8.06	8.51	8.93	9.33	9.94	10.41	10.48	10.67	10.09
0.35	0.28	0.65	1.03	1.42	1.78	2.12	2.46	2.78	3.07	3.34	3.59	3.82	4.34	4.81	5.29	5.72	6.25	6.77	7.14	7.48	7.91	8.31	8.77	9.21	9.62	10.25	10.73	10.80	11.00	10.40
0.38	0.29	0.67	1.06	1.46	1.83	2.19	2.53	2.86	3.16	3.43	3.69	3.93	4.46	4.95	5.44	5.89	6.43	6.96	7.35	7.70	8.14	8.55	9.02	9.47	9.90	10.54	11.04	11.12	11.32	10.70
0.40	0.30	0.69	1.09	1.50	1.88	2.25	2.60	2.94	3.24	3.53	3.79	4.04	4.59	5.09	5.59	6.05	6.61	7.15	7.55	7.91	8.36	8.79	9.27	9.73	10.17	10.83	11.34	11.42	11.63	10.99
0.42	0.31	0.70	1.12	1.54	1.93	2.30	2.67	3.01	3.33	3.62	3.89	4.15	4.71	5.22	5.73	6.21	6.78	7.34	7.75	8.11	8.58	9.02	9.51	9.99	10.44	11.11	11.64	11.72	11.93	11.28
0.46	0.32	0.74	1.17	1.61	2.02	2.42	2.80	3.16	3.49	3.80	4.08	4.35	4.94	5.47	6.01	6.51	7.11	7.70	8.12	8.51	9.00	9.46	9.98	10.47	10.94	11.66	12.20	12.29	12.52	11.83
0.50	0.33	0.77	1.22	1.69	2.11	2.52	2.92	3.30	3.64	3.96	4.26	4.54	5.16	5.72	6.28	6.80	7.43	8.04	8.48	8.89	9.40	9.88	10.42	10.94	11.43	12.17	12.75	12.84	13.07	12.35
0.54	0.35	0.80	1.27	1.75	2.20	2.63	3.04	3.44	3.79	4.13	4.44	4.73	5.37	5.95	6.54	7.08	7.73	8.37	8.83	9.25	9.78	10.28	10.85	11.39	11.90	12.67	13.27	13.36	13.61	12.86
0.58	0.36	0.83	1.32	1.82	2.28	2.73	3.15	3.56	3.94	4.28	4.61	4.91	5.57	6.17	6.78	7.35	8.03	8.68	9.16	9.60	10.15	10.67	11.26	11.82	12.35	13.15	13.77	13.87	14.12	13.34
0.63	0.37	0.86	1.37	1.88	2.36	2.82	3.27	3.69	4.07	4.43	4.77	5.08	5.76	6.39	7.02	7.61	8.31	8.99	9.49	9.94	10.51	11.04	11.65	12.23	12.78	13.61	14.25	14.35	14.62	13.81
0.67	0.39	0.89	1.41	1.95	2.44	2.91	3.37	3.81	4.21	4.58	4.92	5.24	5.95	6.60	7.25	7.85	8.58	9.28	9.80	10.26	10.85	11.41	12.03	12.63	13.20	14.06	14.72	14.82	15.10	14.26
0.71	0.40	0.92	1.46	2.01	2.51	3.00	3.48	3.93	4.34	4.72	5.08	5.41	6.14	6.80	7.47	8.10	8.84	9.57	10.10	10.58	11.18	11.76	12.40	13.02	13.61	14.49	15.17	15.28	15.56	14.70
0.75	0.41	0.94	1.50	2.06	2.59	3.09	3.58	4.04	4.46	4.86	5.22	5.56	6.31	7.00	7.69	8.33	9.10	9.85	10.39	10.89	11.51	12.10	12.76	13.40	14.00	14.91	15.61	15.72	16.01	15.13
0.79	0.42	0.97	1.54	2.12	2.66	3.18	3.67	4.15	4.58	4.99	5.37	5.71	6.49	7.19	7.90	8.56	9.35	10.12	10.68	11.18	11.82	12.43	13.11	13.77	14.38	15.32	16.04	16.15	16.45	15.54
0.83	0.43	0.99	1.58	2.18	2.73	3.26	3.77	4.26	4.70	5.12	5.50	5.86	6.66	7.38	8.11	8.78	9.59	10.38	10.95	11.47	12.13	12.75	13.45	14.12	14.76	15.72	16.46	16.57	16.88	15.95
0.92	0.45	1.04	1.66	2.28	2.86	3.42	3.95	4.47	4.93	5.37	5.77	6.15	6.98	7.74	8.50	9.21	10.06	10.88	11.49	12.03	12.72	13.37	14.11	14.81	15.48	16.48	17.26	17.38	17.70	16.73
1.00	0.47	1.09	1.73	2.38	2.99	3.57	4.13	4.67	5.15	5.61	6.03	6.42	7.29	8.08	8.88	9.62	10.51	11.37	12.00	12.57	13.29	13.97	14.74	15.47	16.17	17.22	18.03	18.15	18.49	17.47
1.08	0.49	1.13	1.80	2.48	3.11	3.72	4.30	4.86	5.36	5.84	6.28	6.69	7.59	8.41	9.24	10.01	10.94	11.83	12.49	13.08	13.83	14.54	15.34	16.10	16.83	17.92	18.76	18.90	19.24	18.18
1.17	0.51	1.18	1.87	2.57	3.23	3.86	4.46	5.04	5.57	6.06	6.51	6.94	7.87	8.73	9.59	10.39	11.35	12.28	12.96	13.58	14.35	15.09	15.92	16.71	17.46	18.60	19.47	19.61	19.97	18.87
1.25	0.53	1.22	1.94	2.66	3.34	3.99	4.62	5.22	5.76	6.27	6.74	7.18	8.15	9.04	9.93	10.76	11.75	12.71	13.41	14.05	14.86	15.62	16.48	17.30	18.07	19.25	20.15	20.30	20.67	19.53
1.33	0.55	1.26	2.00	2.75	3.45	4.12	4.77	5.39	5.95	6.47	6.96	7.42	8.42	9.33	10.26	11.11	12.13	13.13	13.85	14.51	15.34	16.13	17.02	17.87	18.67	19.88	20.81	20.96	21.35	20.17
1.42	0.56	1.30	2.06	2.84	3.56	4.25	4.92	5.56	6.13	6.67	7.18	7.64	8.68	9.62	10.57	11.45	12.51	13.53	14.28	14.96	15.82	16.63	17.54	18.42	19.24	20.49	21.46	21.61	22.00	20.79
1.50	0.58	1.33	2.12	2.92	3.66	4.37	5.06	5.72	6.31	6.87	7.39	7.87	8.93	9.90	10.88	11.78	12.87	13.92	14.70	15.40	16.28	17.11	18.05	18.95	19.80	21.09	22.08	22.24	22.64	21.40
1.58	0.59	1.37	2.18	3.00	3.76	4.49	5.20	5.87	6.48	7.06	7.59	8.08	9.17	10.17	11.18	12.10	13.22	14.31	15.10	15.82	16.72	17.58	18.54	19.47	20.34	21.66	22.68	22.84	23.26	21.98
1.67	0.61	1.41	2.24	3.08	3.86	4.61	5.33	6.03	6.65	7.24	7.79	8.29	9.41	10.44	11.47	12.42	13.56	14.68	15.49	16.23	17.16	18.03	19.03	19.97	20.87	22.23	23.27	23.44	23.87	22.55
1.75	0.63	1.44	2.29	3.15	3.95	4.72	5.46	6.17	6.82	7.42	7.98	8.50	9.64	10.69	11.75	12.73	13.90	15.04	15.87	16.63	17.58	18.48	19.50	20.47	21.39	22.77	23.85	24.02	24.46	23.11
1.83	0.64	1.48	2.35	3.23	4.04	4.83	5.59	6.32	6.98	7.59	8.17	8.70	9.87	10.95	12.03	13.03	14.23	15.39	16.25	17.02	17.99	18.91	19.95	20.95	21.89	23.31	24.41	24.58	25.03	23.65
1.92	0.65	1.51	2.40	3.30	4.14	4.94	5.72	6.46	7.13	7.76	8.35	8.89	10.09	11.19	12.30	13.32	14.55	15.74	16.61	17.40	18.40	19.34	20.40	21.42	22.38	23.83	24.96	25.13	25.60	24.19
2.00	0.67	1.54	2.45	3.37	4.22	5.05	5.84	6.60	7.29	7.93	8.53	9.08	10.31	11.43	12.56	13.60	14.86	16.08	16.97	17.78	18.79	19.75	20.84	21.88	22.86	24.35	25.49	25.67	26.15	24.71
2.08	0.68	1.57	2.50	3.44	4.31	5.15	5.96	6.74	7.44	8.09	8.70	9.27	10.52	11.67	12.82	13.88	15.17	16.41	17.32	18.14	19.18	20.16	21.27	22.33	23.33	24.85	26.02	26.20	26.68	25.22
2.17	0.70	1.60	2.55	3.51	4.40	5.25	6.08	6.87	7.58	8.25	8.88	9.45	10.73	11.90	13.07	14.16	15.47	16.73	17.66	18.50	19.56	20.56	21.69	22.77	23.80	25.34	26.53	26.72	27.21	25.72
2.25	0.71	1.63	2.60	3.58	4.48	5.35	6.20	7.00	7.73	8.41	9.05	9.63	10.94	12.13	13.32	14.43	15.76	17.05	18.00	18.85	19.93	20.95	22.11	23.21	24.25	25.82	27.04	27.23	27.73	26.21
2.33	0.72	1.66	2.65	3.64	4.56	5.45	6.31	7.13	7.87	8.56	9.21	9.81	11.14	12.35	13.57	14.69	16.05	17.37	18.33	19.20	20.30	21.34	22.51	23.63	24.69	26.30	27.54	27.73	28.24	26.69
2.42	0.73	1.69	2.69	3.71	4.64	5.55	6.42	7.26	8.01	8.72	9.37	9.98	11.33	12.57	13.81	14.95	16.33	17.67	18.65	19.54	20.66	21.71	22.91	24.05	25.13	26.76	28.02	28.22	28.74	27.16
2.50	0.75	1.72	2.74	3.77	4.72	5.64	6.53	7.38	8.15	8.87	9.53	10.16	11.53	12.78	14.04	15.21	16.61	17.98	18.97	19.87	21.01	22.09	23.30	24.46	25.56	27.22	28.50	28.71	29.23	27.62
2.58	0.76	1.75	2.78	3.83	4.80	5.74	6.64	7.50	8.28	9.01	9.69	10.32	11.72	12.99	14.28	15.46	16.89	18.27	19.29	20.20	21.36	22.45	23.69	24.87	25.98	27.67	28.97	29.18	29.71	28.08
2.67	0.77	1.78	2.83	3.89	4.88	5.83	6.74	7.62	8.41	9.16	9.85	10.49	11.91	13.20	14.50	15.71	17.16	18.56	19.59	20.53	21.70	22.81	24.07	25.27	26.40	28.11	29.44	29.65	30.19	28.53
2.75	0.78	1.81	2.87	3.95	4.95	5.92	6.85	7.74	8.54	9.30	10.00	10.65	12.09	13.41	14.73	15.95	17.42	18.85	19.90	20.84	22.04	23.16	24.44	25.66	26.81	28.55	29.89	30.11	30.66	28.97
2.83	0.80	1.83	2.92	4.01	5.03	6.01	6.95	7.86	8.67	9.44	10.15	10.81	12.27	13.61	14.95	16.19	17.69	19.14	20.20	21.16	22.37	23.51	24.81	26.04	27.21	28.98	30.34	30.56	31.12	29.41

60.65 DMC Turnout

The 60.65 DMC turnout provides supplemental irrigation water to the lower end of the CCID irrigation delivery network and is currently the sole water supply for the Gustine Reservoir. Current operations are as follows:

- Operators open the 60.65 DMC to fill the Gustine Reservoir. Once the reservoir is about full, the 60.65 turnout is shut off. Because the maximum 60.65 turnout capacity (about 30 CFS) is small relative to the flows in the DMC, deliveries to CCID do not need to be scheduled.
- The stored water (about 100 acre-feet) is held in Gustine Reservoir to supplement deficit Outside Canal flows downstream of Azevedo Weir.
- Stored water in the Gustine Reservoir is used to automatically supply deficits in Outside Canal flows.
- Once the Gustine Reservoir is mostly empty, the cycle repeats.

The process is relatively labor-intensive:

- The Water Department needs to make ongoing decisions regarding when to fill the reservoir.
- Implementing the change requires operators to visit the site to manually effect the change.
- Staff attention is required to monitor the reservoir level, decide if known deficits will occur, make the next decision to add, wait or decrease flow into the reservoir, etc.

The recommendations provided in this section are anticipated to decrease the labor required to supervise and operate this part of the CCID water delivery system. Furthermore, compounding benefits are possible if this recommendation is implemented in conjunction with new reservoir inlet pumps.

Existing Conditions

A 36” manual canal gate is left open at the DMC at all times, as shown in Figure 25. The canal gate supplies water to CCID and adjacent irrigators.

Figure 25. DMC 60.65 36” canal gate; left open most of the time

The gate discharges into a distribution box as shown in Figure 26, via a short 36" pipeline. Two of the outlet gates are direct turnouts to adjacent fields. A ~30" canal gate (shown below) is currently used to manually adjust the flow to the Gustine Reservoir. The pipeline between the distribution box and reservoir is 27" PVC.

Figure 26. DMC 60.65 distribution box; the gate supplying CCID is in the foreground

Water from the 60.65 distribution box enters the Gustine Reservoir inlet box, shown in Figure 27. From that point, the water can be diverted in one of two directions:

1. Through a 30" canal gate and directly into the reservoir
2. A ~17' long weir in the box automatically diverts excess inflows directly into the Outside Canal when the reservoir is full or when the 30" canal gate is closed.

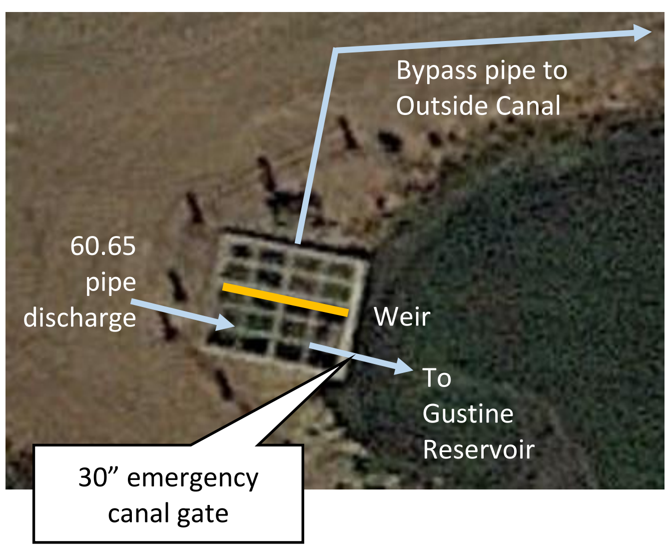


Figure 27. Plan view of the Gustine Reservoir inlet box; located at the northwestern corner of the reservoir

Recommendations

It is recommended that CCID install an automated gate or valve that will control the flow rate of the 60.65 turnout. The gate or valve will be automated to maintain a relatively constant target water level in the reservoir. There are only two possible locations for the new, automated gate/valve:

> **Option 1**. At the 60.65 distribution box, where CCID operators currently adjust the turnout flow, or
> **Option 2.** At the Gustine Reservoir inlet box

Option 1 was considered and then discarded in favor of Option 2 for the following reasons:
1. The 60.65 distribution box area is presumed to be within the DMC right-of-way, making construction there more difficult and expensive.
2. The 60.65 box area is adjacent to a public road, which may increase vandalism.
3. Grid power availability near at the 60.65 distribution box is unknown.

Gustine Reservoir Inlet Box Modifications

The automatic control algorithm will adjust the opening of an electrically actuated butterfly valve just upstream of the existing Gustine Reservoir inlet box, as shown in Figure 28. A magnetic flow meter will provide flow measurement. A propeller meter would not be practical for this application due to the potential for aquatic debris from the DMC getting caught on the propeller.

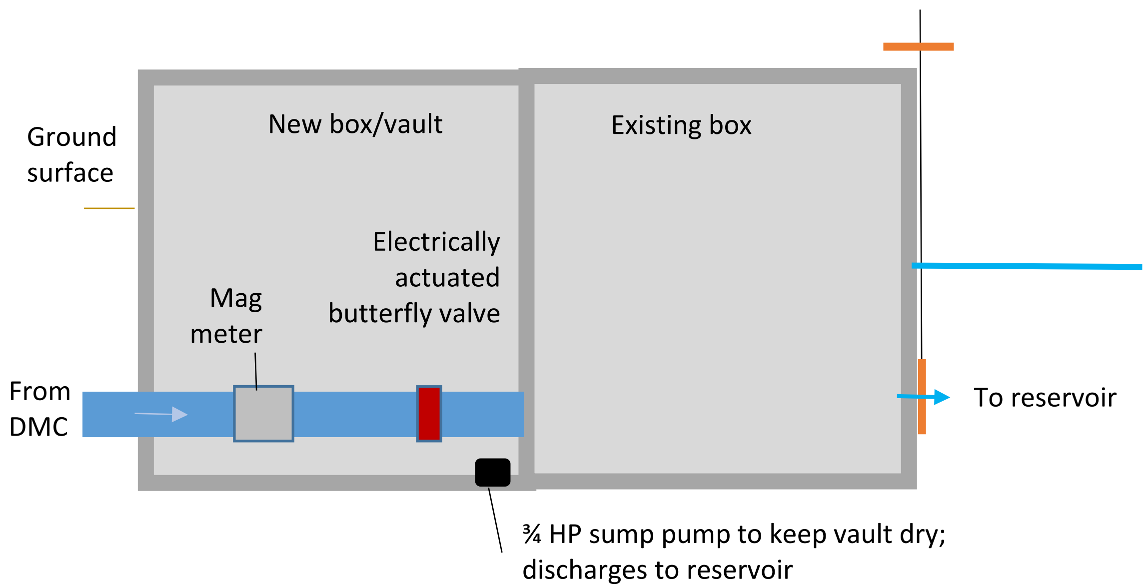


Figure 28. Profile view of the conceptual design for an automated butterfly valve with a magnetic meter for flow measurement

The sizes and configuration recommendations will change if CCID decides to increase the 60.65 turnout capacity. Power, signal and control circuits and conduits will be run from the existing reservoir RTU location.

Gustine Reservoir

The Gustine Reservoir is operated as a holding pond for supplemental DMC water from the 60.65 turnout. This configuration has worked well historically, but the reservoir is under-utilized during drought years when the DMC 60.65 turnout is unavailable – which is when a true buffer reservoir (one that accepts surpluses and supplies deficits) provides the most benefits.

Background

The primary question is this: What does CCID want to do with excess inflows from the Outside Canal? Currently, there is only one destination: Garzas Creek, which eventually makes it to the Main Canal. If, in water-short years, the excess inflow from the Outside Canal would be better utilized in the Outside/Sullivan Extension Canals, then an inflow pump into the reservoir is recommended.

So how much excess water has historically been diverted to Garzas Creek or the Main Canal? It is difficult to assign a precise volume because:

- John Relvas mentioned that one of the gate position sensors needs to be re-calibrated so the flow numbers could be off a bit. By how much? It is unclear.
- Currently the same Garzas Outside gates are used to deliver water to the single turnout along Garzas Creek. CCID staff explained that the delivery pattern to this water user is at most 15 CFS for 1-2 months at a time.

To roughly estimate the volume passed to Garzas Creek, the authors exported Garzas Outside gate flow data from ClearSCADA for 2016 (a dry year) and 2020 (a relatively “wet” year). See the following figures.

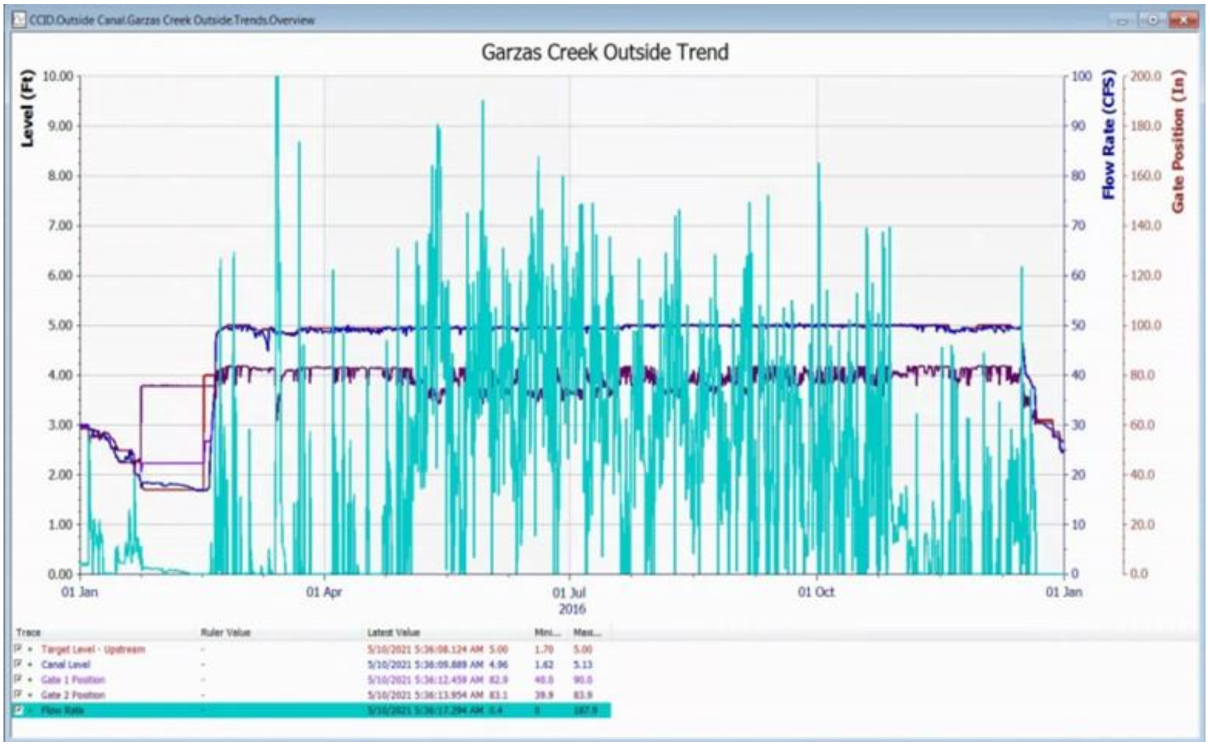


Figure 29. Garzas Outside gate flows for 2016; Note that the estimated flow rates exceeded the y-axis flow scale of 100 CFS at times.

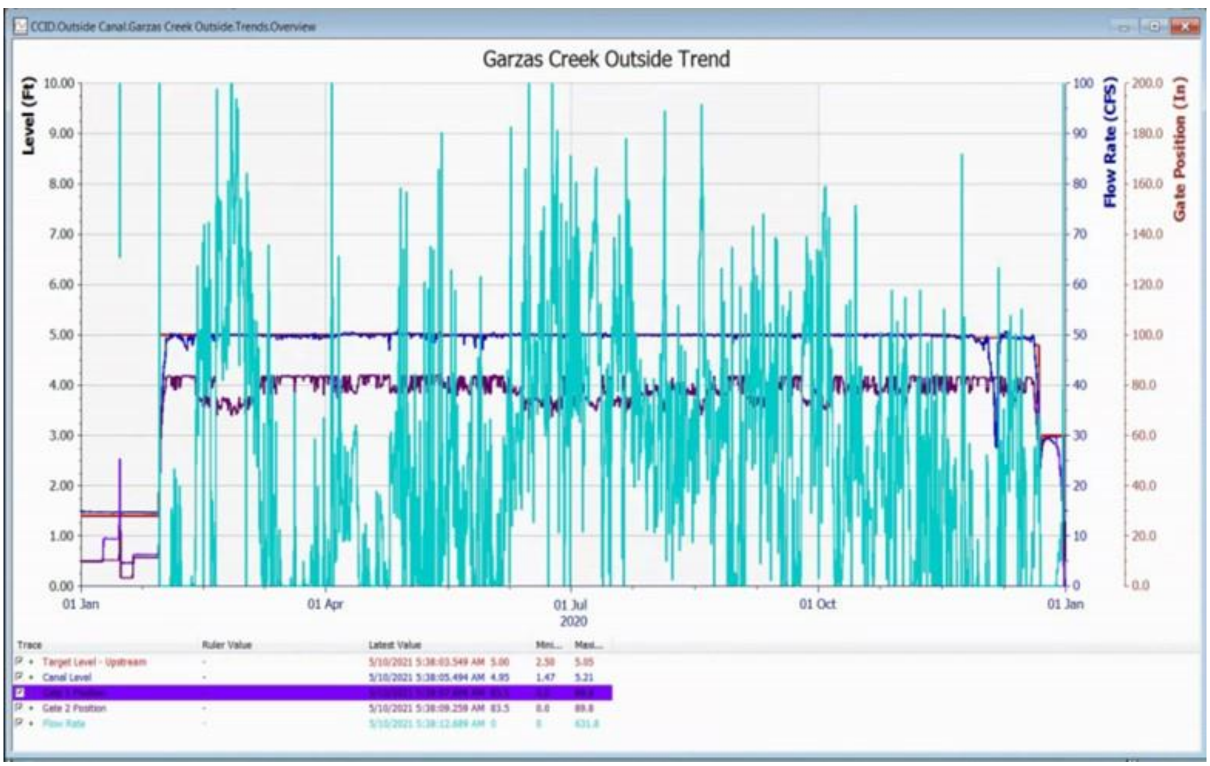


Figure 30. Garzas Outside gate flow for 2020; Note that the estimated gate flow exceeded 100 CFS for much of January

Estimated Volumes Historically Diverted to Garzas Creek

About 3-4 flow rates per day were used to compute a daily flow average. The daily flow averages were converted to acre-feet/day using a multiplier of 1.9. It is then possible to estimate the volume diverted to Garzas Creek due to excess inflows from the Outside Canal as follows:

Volume Diverted to Garzas Creek Due to Excess Outside Canal Inflows =
Total volume diverted to Garzas Creek – Irrigation Deliveries to Garzas Creek

A rough guess for Garzas Creek irrigation deliveries was computed assuming a 15 CFS sustained delivery over 100 days per year (about 2,850 acre-feet/year). The computation results are shown in Table 5.

Table 5. Estimates of water volumes diverted to Garzas Creek and the Main Canal from the Garzas Outside gates

Description	Year and Annual Values	
	"Dry year" 2016	"Wet year" 2020
Total estimated flow diverted to Garzas Creek	12,030	15,800
Estimated delivery to Garzas Creek turnout	(2,850)	(2,850)
Estimated diversion to Garzas Creek due to excess inflows from the Outside Canal	9,180	12,950

The results indicate the following:

- Based on the two sample years (2016 and 2020), about 10,000 AF/year are diverted from the Outside Canal to the Main Canal via Garzas Creek due to excess inflows from the Outside Canal.
- This volume could instead be collected in the Gustine Reservoir and re-used when needed instead of diverted down Garzas Creek. That volume is equivalent to about 100 empty/fill cycles of the Gustine Reservoir with a total storage capacity of about 100 AF.

Recommendations

It is recommended that CCID install VFD-controlled pumps at a new pump station along the banks of the reservoir. The total inflow capacity should be about 60 CFS across at least two pumps. Two potential locations for the pump station are provided in Figure 31. Selecting between the two locations is a matter of preference and constructability. Utility power lines for a new service drop appear to be close to both locations. The pumps will be selected later once a 90% design of the pump station, discharge piping, etc. has been developed.

Figure 31**. Plan view of two potential locations for the recommended new pump station at the Gustine Reservoir**

Increasing Flows from the DMC

Three different conceptual ideas for increasing the flow capacity of DMC deliveries in the Sullivan Extension area:

- Increasing the existing 60.65 turnout capacity
- Constructing a new gravity turnout
- Constructing a new pump station in the Newman Spill way

100 CFS was used as an initial total flow target. Considering the existing 60.65 turnout is capable of about 30 CFS, the required increase in flow (design flow for the improvement project) is about 70 CFS. Note: Cost estimate values were derived from recent CCID construction projects, with the exception of the HDPE pipe, which was sourced from a 2020 engineer's report (Kern Fan Groundwater Storage Project).

60.65 Turnout Upgrades

A brief hydraulic analysis of the existing 60.65 turnout resulted in discarding the idea of a "quick" modification to the 60.65 turnout to increase the existing capacity. Essentially, almost all the 25 ft of available gravity head is consumed in pipe friction.

In other words, the only answer to substantially increasing the 60.65 turnout is a larger pipe and gate – which means essentially constructing a new turnout. As such, this concept was ruled out.

New Pump Station

A new pump station could be constructed where the DMC spillway crosses CCID's Lower Main Canal, as shown in Figure 32. Rough estimates were made to get a sense of the scale and costs of a new pump station.

Figure 32. Potential location of a new pump station to lift DMC delivery water to the Lower Main Canal

Rough engineering estimate data describing the hypothetical new pump station is shown in Table 6. A rough engineering estimate is provided in Table 7.

Table 6. Hypothetical design values for a new pump station at the Newman Spillway

Description	Value	Units	Notes
Design flow	70	CFS	
Static lift	13	ft	From field measurements
Placeholder for minor losses and friction	5	ft	
Friction safety factor	5	Ft	
Hypothetical design TDH	23	Ft	
Water horsepower	182	HP	
Typical bowl efficiency	0.8	n/a	
Brake horsepower	228	HP	
Typical motor efficiency	0.92	n/a	
Total input power	250	HP	
Total input power	185	kW	

Table 7. Estimated costs for hypothetical new pump station

Item	Description	Qty	Unit	Unit price	Extended Cost
1	Demo		LS		4000
2	Excavation	500	CY	$ 6	$ 3,000
3	Furnish and install (F&I) structural backfill		LS		$ 4,000
4	F&I reinforced concrete for sumps, building and bump in spillway	600	CY	$ 1,450	$ 870,000
5	F&I stilling wells	4	Each	$ 4,200	$ 16,800
6	F&I sensor guide tube installation	2	Each	$ 250	$ 500
7	F&I discharge pipes with air vents	2	Each	$ 25,000	$ 50,000
8	F&I concrete outlet structure in Main Canal	1	Each	$ 8,000	$ 8,000
9	F&I flow meters	2	Each	$ 5,000	$ 10,000
10	F&I Wire fence	150	LF	$ 5	$ 750
11	F&I electrical work (new service drop, transformer, pad, underground, etc.)		LS	$ 400,000	$ 400,000
12	F&I control building, electrical, etc.		LS	$ 35,000	$ 35,000
13	Prepare and implement storm water plan, notices, reports		LS	$ 15,000	$ 15,000
14	DMC permitting/coordination		LS	$ 25,000	$ 25,000
15	RTU and integration		LS	$ 50,000	$ 50,000
16	Control programming		LS	$ 25,000	$ 25,000
17	F&I vertical turbine pumps	2	Each	$ 75,000	$ 150,000
18	F&I automatic trash screens	2	Each	$ 60,000	$ 120,000
				Subtotal	**$ 1,787,050**
18	Structural/civil engineering		LS	$ 100,000	
19	Contingency (15%)		LS	$ 268,058	
				Total	**$ 2,155,108**

In addition, there will also be the estimated utility expenses for power to run the pumps, which is estimated at $30,000 to $50,000 annually.

New Gravity Turnout

Another idea is constructing a new gravity turnout between the DMC and the Outside Canal, ideally upstream of the Garzas Creek crossing for more flexibility. The design flow would also be 70 CFS. A hypothetical pipe alignment is shown in Figure 33, and a rough engineering cost estimate was developed and is provided in Table 8.

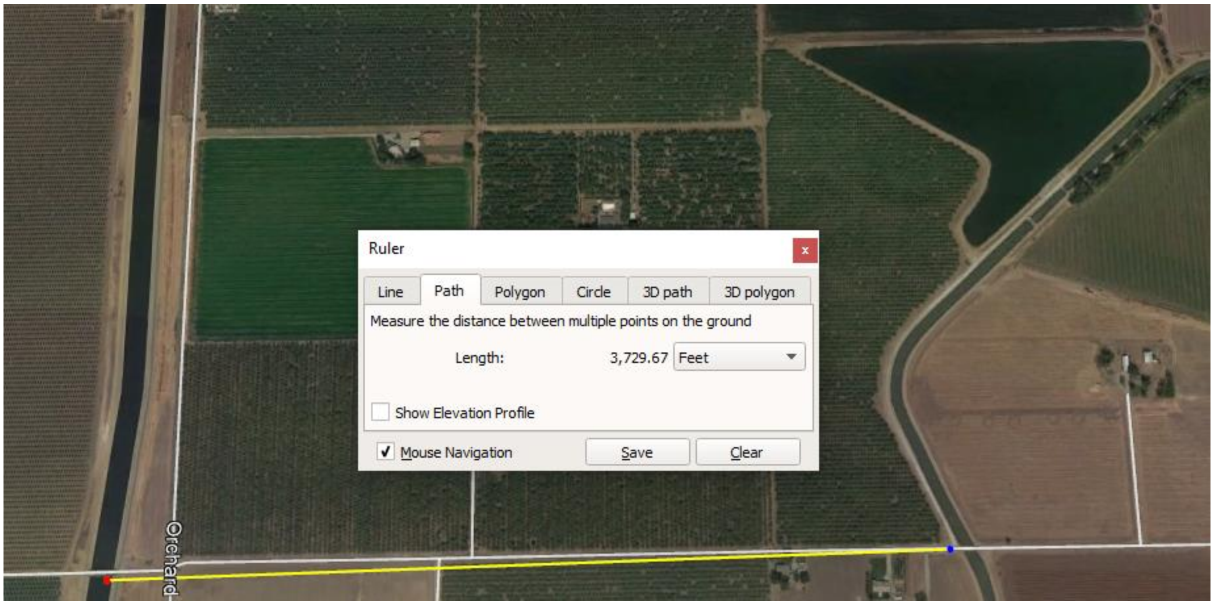


Figure 33. Approximate pipeline route between 60.65 and the Gustine Reservoir that would need upgrading if more flow is needed

Table 8. Estimated costs for a hypothetical new gravity turnout upstream of the Gustine Reservoir

Item	Description	Qty	Unit	Unit price	Extended Cost
1	Demo		LS		4000
2	Trenching	9593	CY	$4	$38,370
3	Furnish and install (F&I) pipe bedding		LS		$100,000
4	F&I concrete inlet and outlet structures	2	Each	$15,000	$30,000
9	F&I flow meter	1	Each	$5,000	$5,000
10	F&I Wire fence	50	LF	$5	$250
11	F&I 48” HDPE pipe	3750	LF	$275	$1,031,250
12	F&I control building, electrical, etc.		LS	$35,000	$35,000
13	F&I 48" slide gate		Each	$11,000	$11,000
14	F&I actuator		Each	$12,000	$12,000
15	F&I electrical service, load center, etc.		Each	$50,000	$50,000
15	F&I electrical service, load center, etc.		Each	$50,000	$50,000
16	Prepare and implement storm water plan, notices, reports		LS	$15,000	$15,000
17	DMC permitting/coordination		LS	$25,000	$25,000
18	RTU and integration		LS	$50,000	$50,000
19	Control programming		LS	$25,000	$25,000
				Subtotal	**$ 1,431,870**
18	Structural/civil engineering		LS	$ 100,000	
19	Contingency (15%)		LS	$ 214,781	
				Total	**1,746,651**

Central California Irrigation District

Modernization of the Colony and Poso Areas

Prepared by
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Signed 5/13/22

Signed 3/5/2021

Prepared for
Central California Irrigation District (CCID)

May 2022

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Central California Irrigation District
Modernization for the Colony and Poso Areas

Executive Summary

ITRC evaluated the "Colony Area" (i.e., Laguna, Colony, Parsons Ditch and Central Canals) and developed modernization recommendations. The "Poso Area" (i.e., Poso, Riverside, Lucerne and Santa Rita canals) were also evaluated, but that evaluation was limited to determining the feasibility of new automatic downstream water level control.

The focus of the recommendations mirrors the goals initially described by CCID staff:
1. Reduce unrecoverable losses of irrigation water, such as spill water leaving the district.
2. Minimize operational complexity and labor requirements.
3. Improve operational flexibility to better match supply with the variable demand from increasing micro-irrigated acreage while reducing stress on operators.

Some recommendations are grouped into "packages," where several improvements are interdependent, and should be implemented together to provide the desired benefit. The remaining recommendations can be implemented individually.

Colony Area Recommendations

High level modernization recommendations for the Colony Area are summarized in Table 1. Subsequent sections of the report provide additional descriptions, conceptual designs, and other recommendations.

Table 1. Major Colony Area modernization recommendations; see individual canal sections for more details

Canal	Item #	Description	Priority	Modernization Group (implement together)
Laguna	1	Install a new RTU at the Laguna Canal headworks along with other improvements. The new RTU will maintain a relatively constant discharge flow rate.	Low	1
	2	Improve upstream water level control structures along the Laguna Canal	Low	1
	3	Modify the spill and pump structure at Shain Drain; remove existing flashboard check	Medium	None
	4	Expand the Laguna Reservoir from 17 AF to 100 AF. Increase the capacities to 60 CFS inflow and 50 CFS outflow	High	2
	5	Increase the capacity of the Laguna Canal and control structures between the Reservoir and Branch 4 to between 30-50 CFS depending on location.	High	2
	6	Remove structure at existing Laguna Canal tail end; convert to level pool downstream (see Branch 4 section for details)	High	2
	7	Consider adding a pump in Rice Drain near Santa Fe Grade and Merrill Ave	Low	None
Colony	8	Install a new RTU at the Colony Main Canal headworks along with other improvements. The new RTU will maintain a relatively constant discharge flow rate.	High	3 (or standalone)
	9	Lower Colony Main Canal headworks weir, along with other improvements	Medium	4
	10	Construct a new 300+ AF reservoir to provide buffering for the Main Canal	High (the need for this will become evident once Colony Main Canal superhighway is functional)	4
	11	Replace the existing 11 Colony Main Canal flashboard check structures with LCWs for improved level control	High	3
	12	Install a new single speed pump to deliver excess East Ditch Reservoir water to the pool upstream of Branch 3 Canal	High	None
	13	Raise and extend the existing Colony Reservoir level pool and banks, along with other improvements	High	5
	14	Convert the Branch 5 and tail end of Colony Main Canal to automatic downstream control	High	5
Branch 3	15	Construct a new automatic flow control structure at the headworks; install a new RTU	High	6
	16	Replace both existing check structures with LCWs	High	6
Branch 4	17	Raise banks and two road crossings to expand level pool	High	7
	18	Convert the remaining existing flashboard check structures to automatic downstream water level control	High	7
Branch 5	19	Construct new automatic downstream level control structures to replace existing headworks and check structures with new higher Colony Main Canal level	High	8
	20	Raise banks and two road crossings	High	8

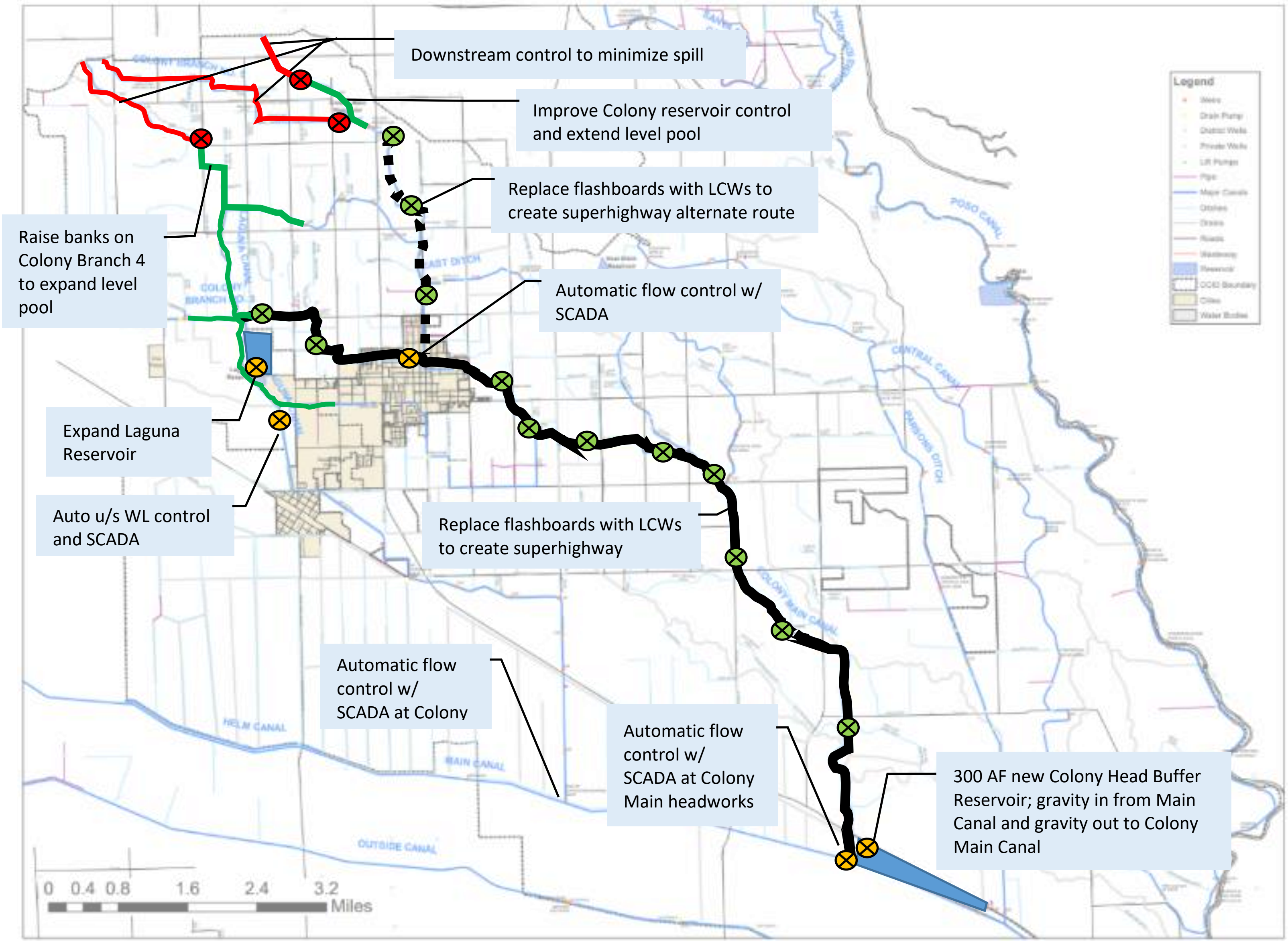

Figure 1. Top Priority Infrastructure recommendation overview for the Colony Main, Colony Branch 2-5 canals and Laguna Canal

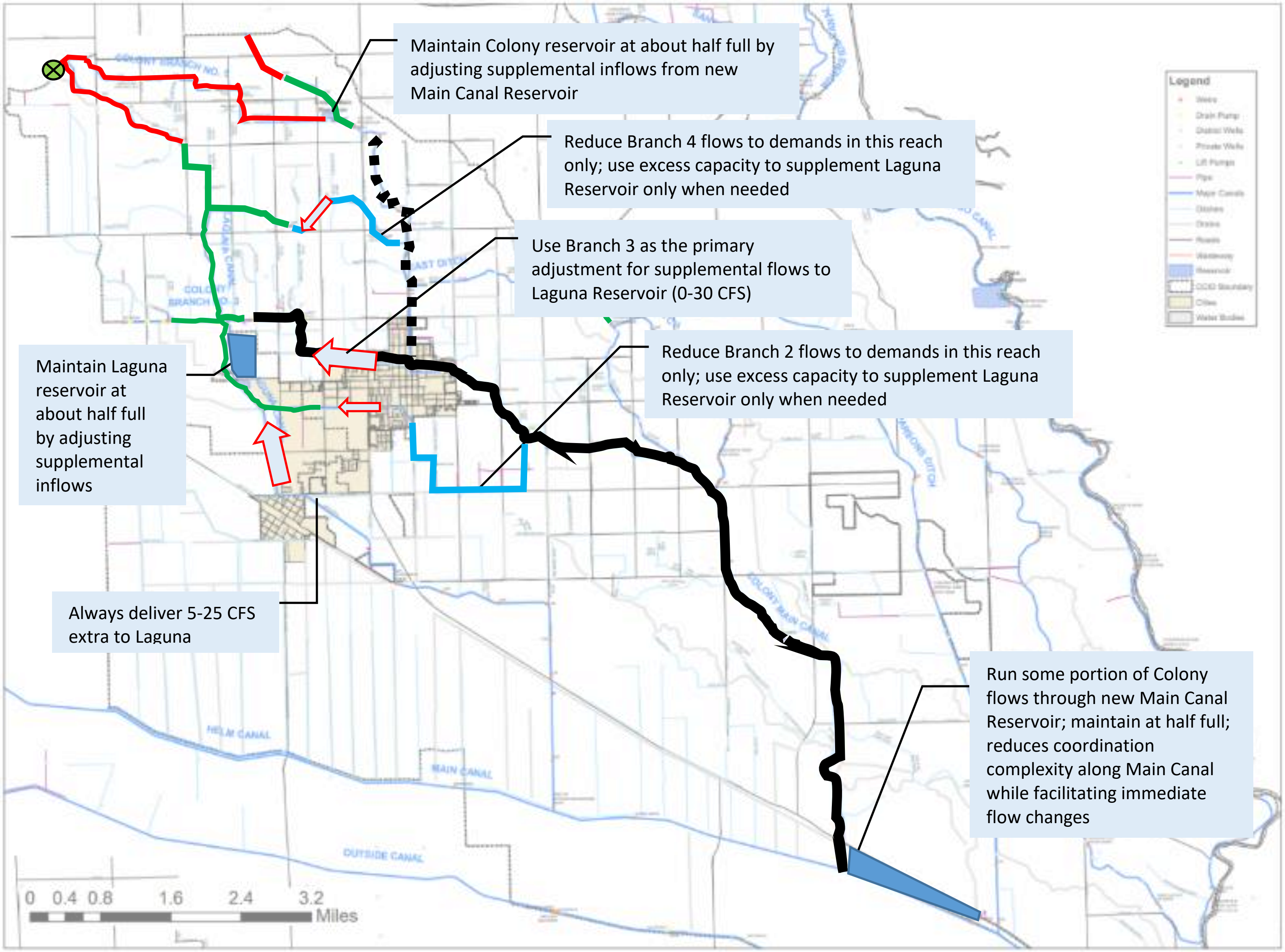

Figure 2. Proposed operations for the Colony and lower-end Laguna Canal systems after recommended modifications

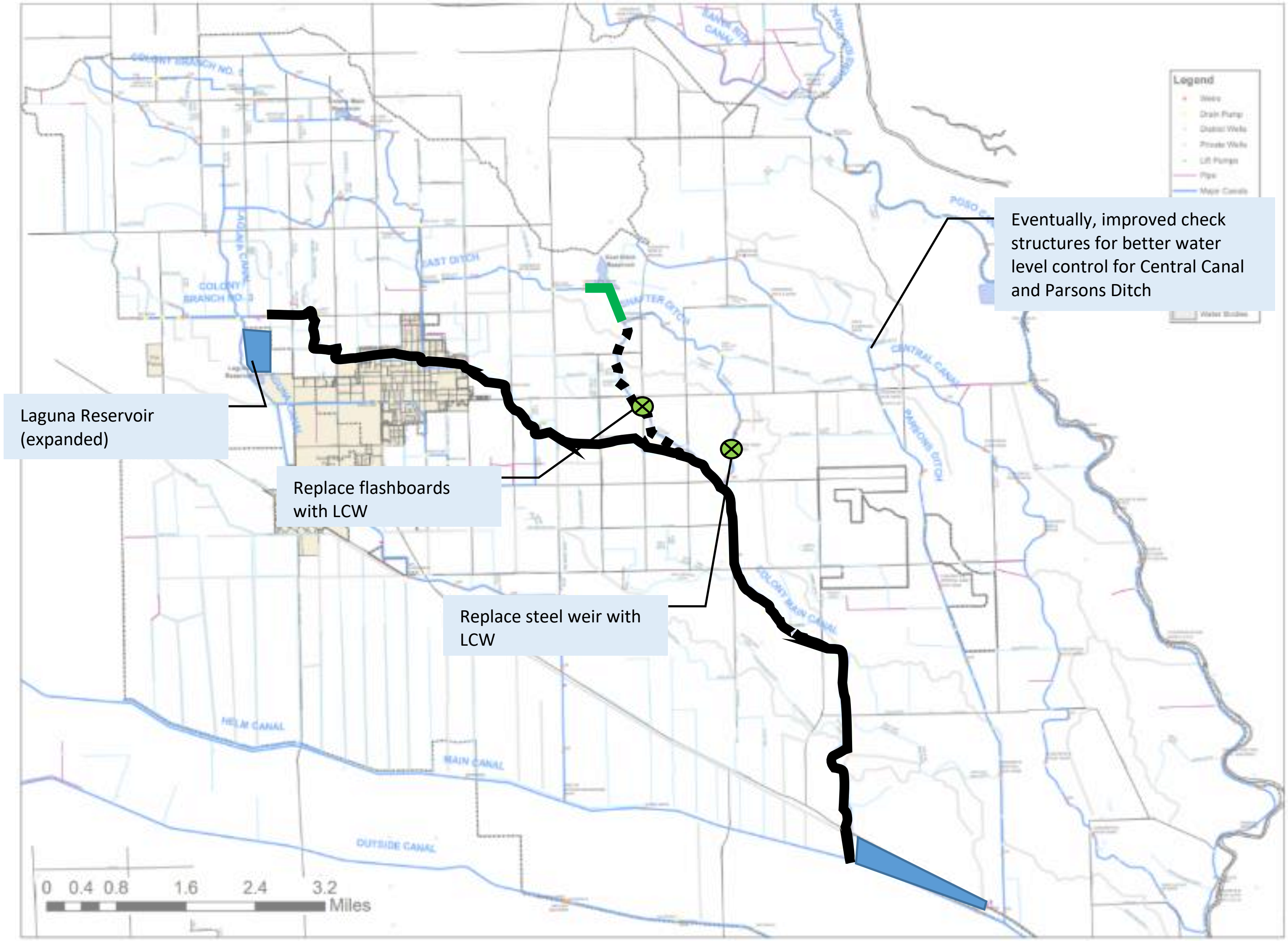

Figure 3. Recommended <u>infrastructure</u> modifications to the East Ditch, Shafter Ditch and Central Canals

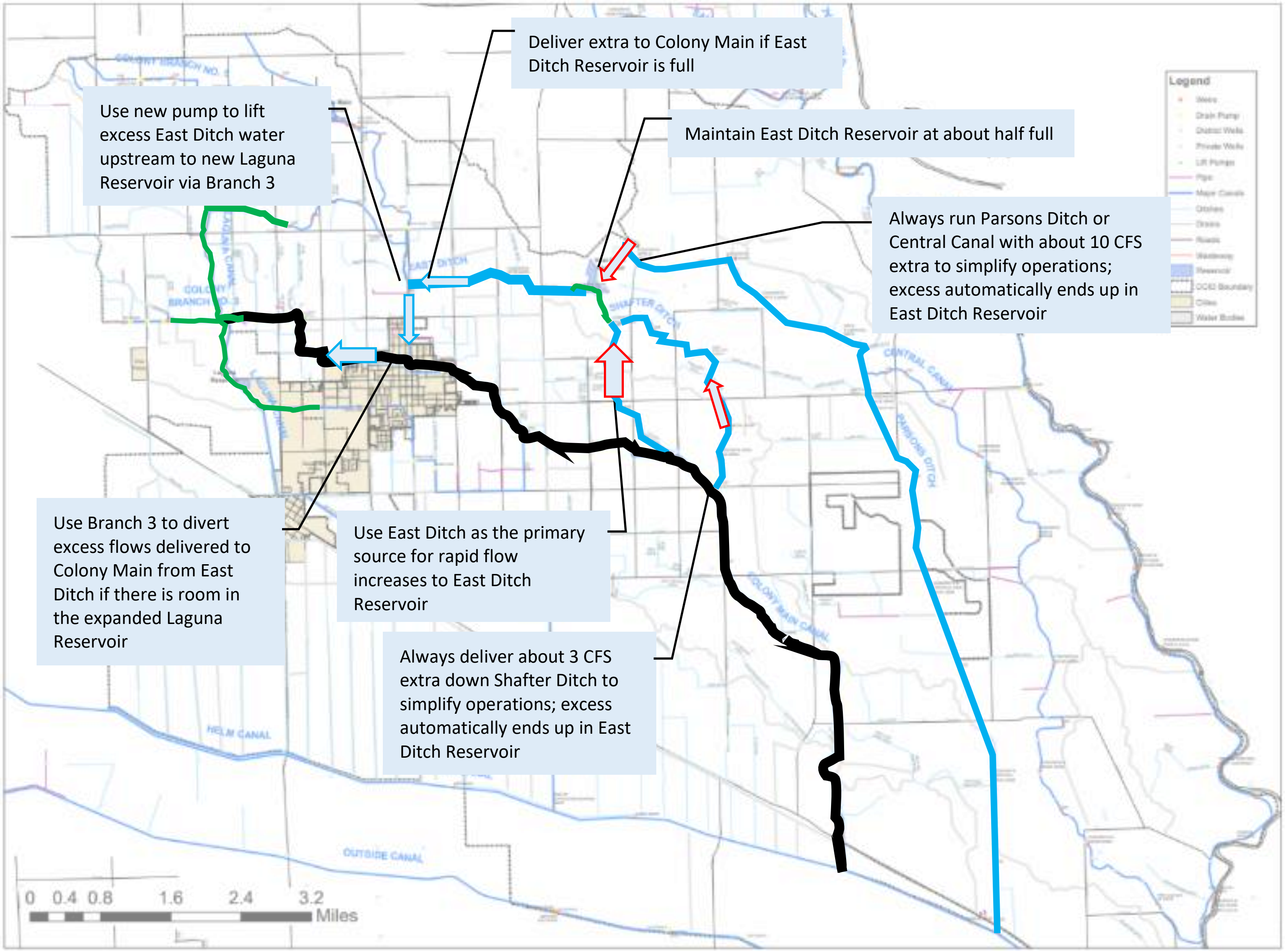

Figure 4. Proposed operations for the East Ditch, Shafter Ditch and Central canals

Poso Area Recommendations

High-level modernization recommendations for the Poso Area are summarized in Table 2. Subsequent sections of the report provide additional descriptions, conceptual designs, and other recommendations.

Table 2. Major Poso Area modernization recommendations; see individual canal sections for more details

Canal	Item #	Description	Modernization Group (implement together)
Riverside	1	Construct a new, small (~10 acre) buffer reservoir adjacent to the Poso Canal around Station 260+00 (between the head of the Santa Rita Ditch and Hwy 152); Double check performance once available parcels are identified, if outside the specified canal reach.	9
Poso	2	Reprogram the Mitchell Weir RTU to automatically maintain the water level in the new, small reservoir	9
Poso	3	Maintain some check structures and replace some others. Raise banks and grade/re-shape canal cross sections as noted	9
All	4	Convert Santa Rita and Lucerne Canals to automatic downstream control; grade/reshape canal cross sections as noted	10

The proposed control scheme after improvement is unique, as shown in Figure 5 and described below:

1. A new small (~10 acre) buffer reservoir will be constructed along the Riverside Canal, between the headworks and Highway 152 (yellow triangle in figure). A new RTU at the reservoir will be installed and programmed to automatically maintain a target water level in the adjacent Riverside Canal pool.
2. The existing Mitchell Weir RTU will be reprogrammed, to be converted to automatically maintain a target water depth in the new, small reservoir.
3. The two existing 150' LCWs will remain as-is. Flow changes from Mitchell Weir will pass automatically downstream over the LCW.
4. Existing check structures downstream of the Highway 152 will be converted to automatic downstream control structures, with new RTUs and associated redundant instrumentation.

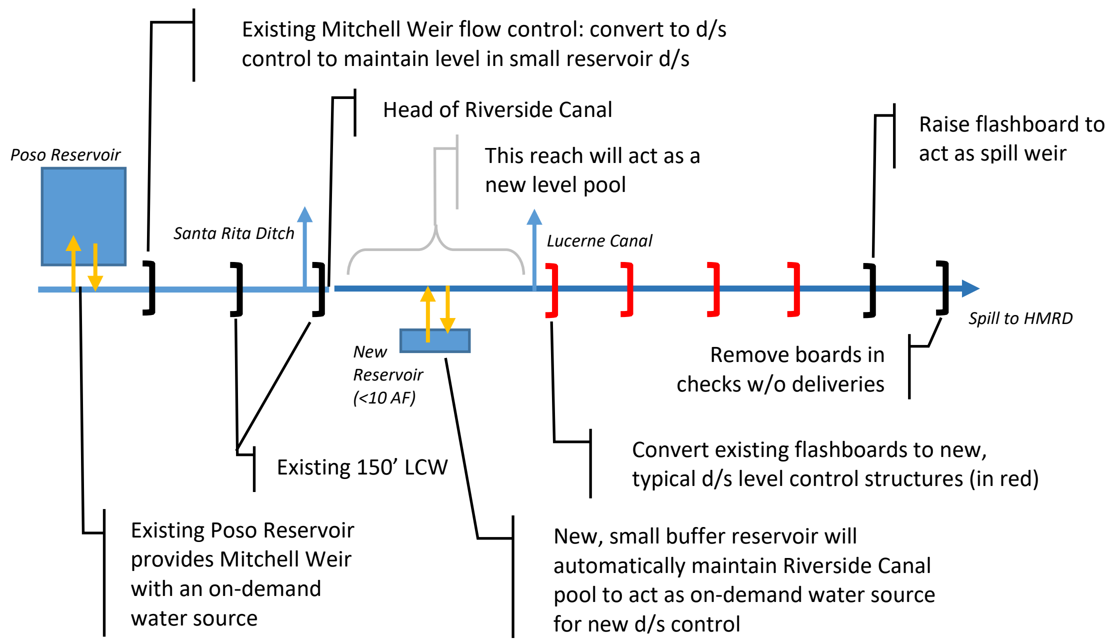

Figure 5. Proposed control scheme after improvements along the Poso/Riverside Canals

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Central California Irrigation District
Modernization of the Colony and Poso Areas

Background

ITRC was contracted by Central California Irrigation District (CCID) to evaluate existing infrastructure and develop modernization recommendations.

Colony Area Analysis

CCID operates irrigation conveyance and distribution infrastructure around Dos Palos, CA. This area is generally referred to as the "Colony Area," which includes the areas serviced by:

- Laguna Canal
- Colony Main Canal
- Parsons Ditch
- Central canals

Three site visits were conducted to the Colony Area. Key sites were visited and a limited RTK survey was conducted to collect elevation data. Elevations collected around the Colony area by ITRC via RTK are NAV88 elevations based on measurements processed through National Geodetic Survey OPUS using Geoid 18 model.

Interviews were conducted with CCID operations and management staff. Several improvement ideas were shared by staff during the interviews and incorporated into this report as appropriate. This report outlines the modernization recommendations developed out of the data collection and evaluation process described above.

Poso Area Analysis

Just to the east of the "Colony Area" is the "Poso Area." It includes the following major canals:

- Poso Canal (downstream end of)
- Riverside Canal
- Santa Rita Ditch
- Lucerne Canal

For the Poso Area, ITRC focused on answering the following question posed by CCID staff: *"Is it possible to convert the tail end of the Poso Area canals to downstream control?"*

CCID contracted with a third-party surveying firm to conduct RTK surveys in the Poso Area. The RTK survey data was used to develop an unsteady canal model using CanalCAD software. After the model was developed, simulations were conducted using proposed control logic. This report details the results of the simulations and other recommendations.

Existing Infrastructure

Existing reservoirs and flow control points in the Colony and Poso Areas are shown in Figure 6**.**

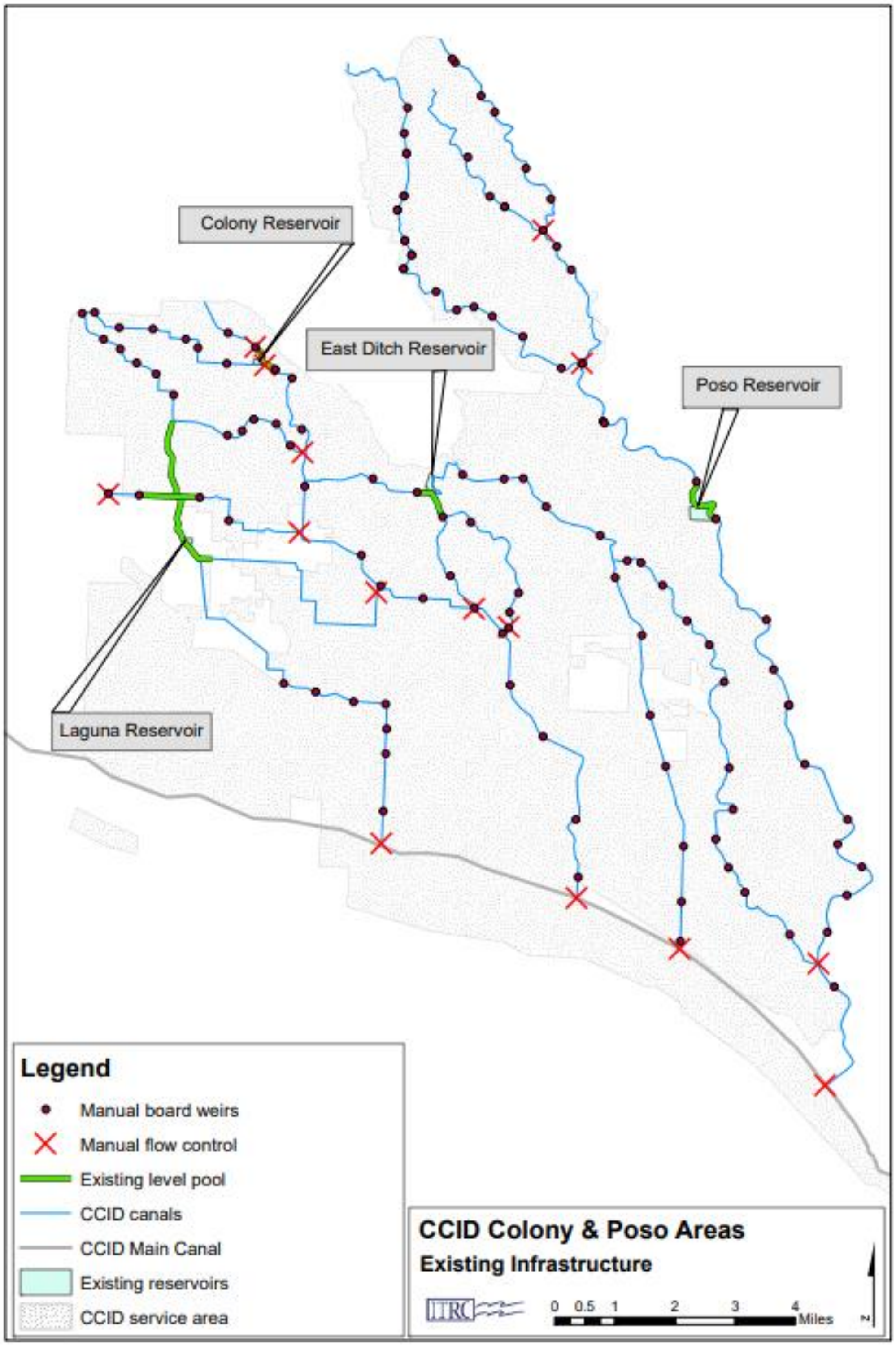


Figure 6. Existing reservoirs and flow control points

Specific Issues

Discussions with CCID staff identified the following major issues in the area:

1. The area is relatively complicated to operate with numerous canal interties lacking flow measurement, plus variable inflows from drain and well pumps.
2. Rapid swings in irrigation demand around weekends (net cuts and adds up to 200 CFS were reported by operators) are difficult to manage.
3. The area is labor-intensive because most control structures are manually operated.
4. Notable volumes of unrecoverable water are lost from CCID due to operational spill along the tail ends of canals. However, spill is difficult to minimize with existing infrastructure.
5. It is unclear how well the Laguna Reservoir is operating because it is not monitored by the existing CCID SCADA system.
6. The East Ditch Reservoir is frequently full, due to a combination of excess inflows and insufficient area downstream to distribute the accumulated water.

The canal system is shown in Figure 7 to highlight the extent of manual operations in the area and key issues.

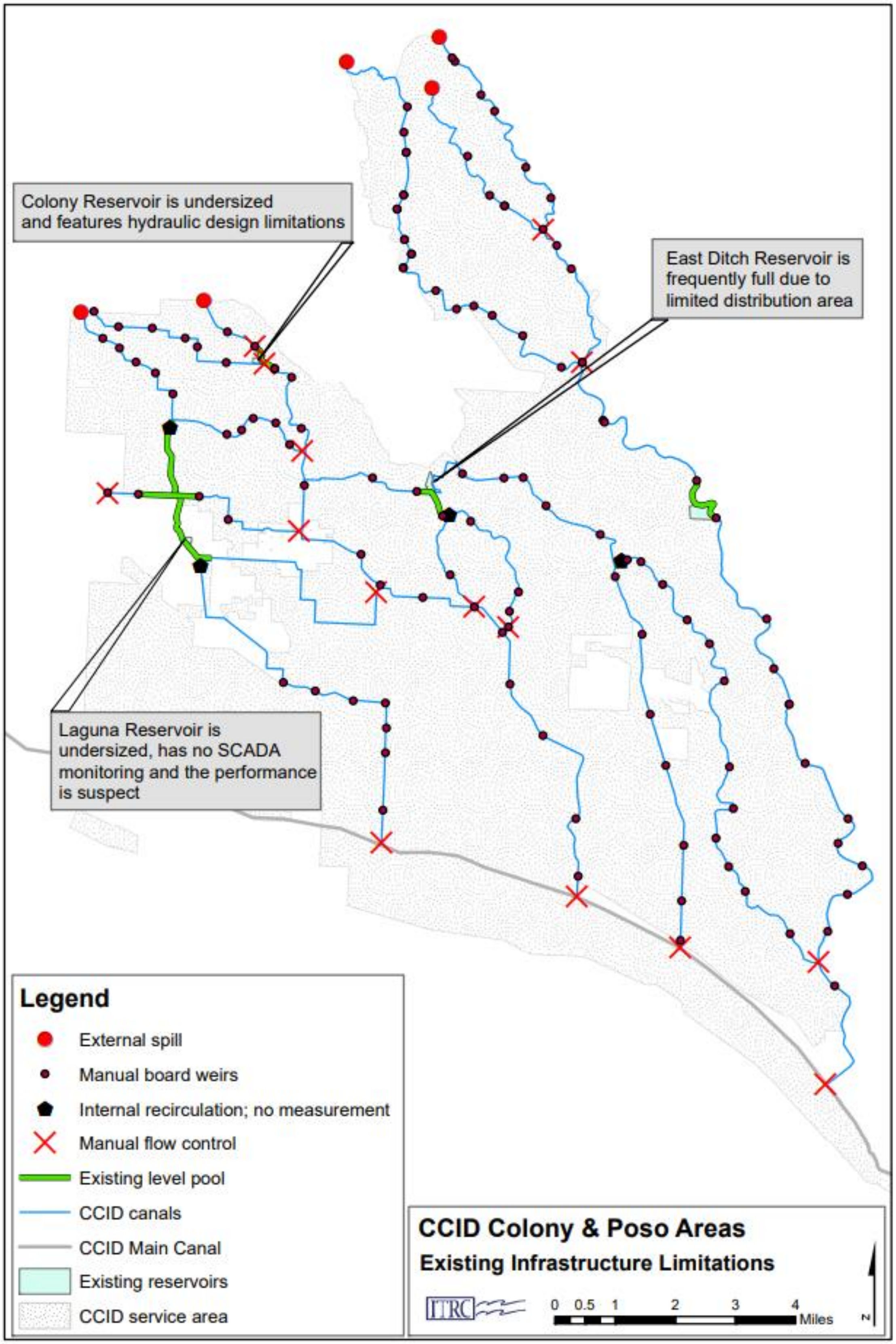


Figure 7. Existing manually controlled infrastructure and other existing limitations

High expectations exacerbate the operational difficulties inherent in complex, manually controlled canal networks:

- Irrigator (called "external") expectations regardless of water year type (wet, dry, etc.):
    - Flexible, scheduled deliveries with 12-24 hours' notice, at any flow rate up to an arranged maximum
    - A wide range of allowable irrigation durations, with flexible of on/off timing
- Staff/management/board (called "internal") expectations for critical water years:
    - Minimal, or preferably no canal spill
    - Maximize supplemental canal inflows from drains and managed well pumping
    - Meet irrigator expectations, outlined above.

These high expectations can be achieved more easily if the right combination of infrastructure improvements is implemented. This report provides recommendations towards that end.

More Modernization?

The Colony Area features several previous modernization projects:
- Three buffer reservoirs
- Some Supervisory Control and Data Acquisition (SCADA) monitoring and automation
- A few long-crested weirs have replaced flashboards for water level control

However, there are still difficulties maintaining flexible deliveries. One might ask: "If so much has been done, why are there still difficulties?" There are several contributors:
- Irrigation demand has become more volatile as more micro-irrigation acreage and other changes to irrigation scheduling practices occur (e.g., shift away from weekend irrigation). Some evidence of increasing volatility is illustrated in Figure 8, in addition to points made by operations staff. Note that the 2020 orange demand line is more frequently at extreme highs and lows (outside of the green colored band), than the blue 2017 line.

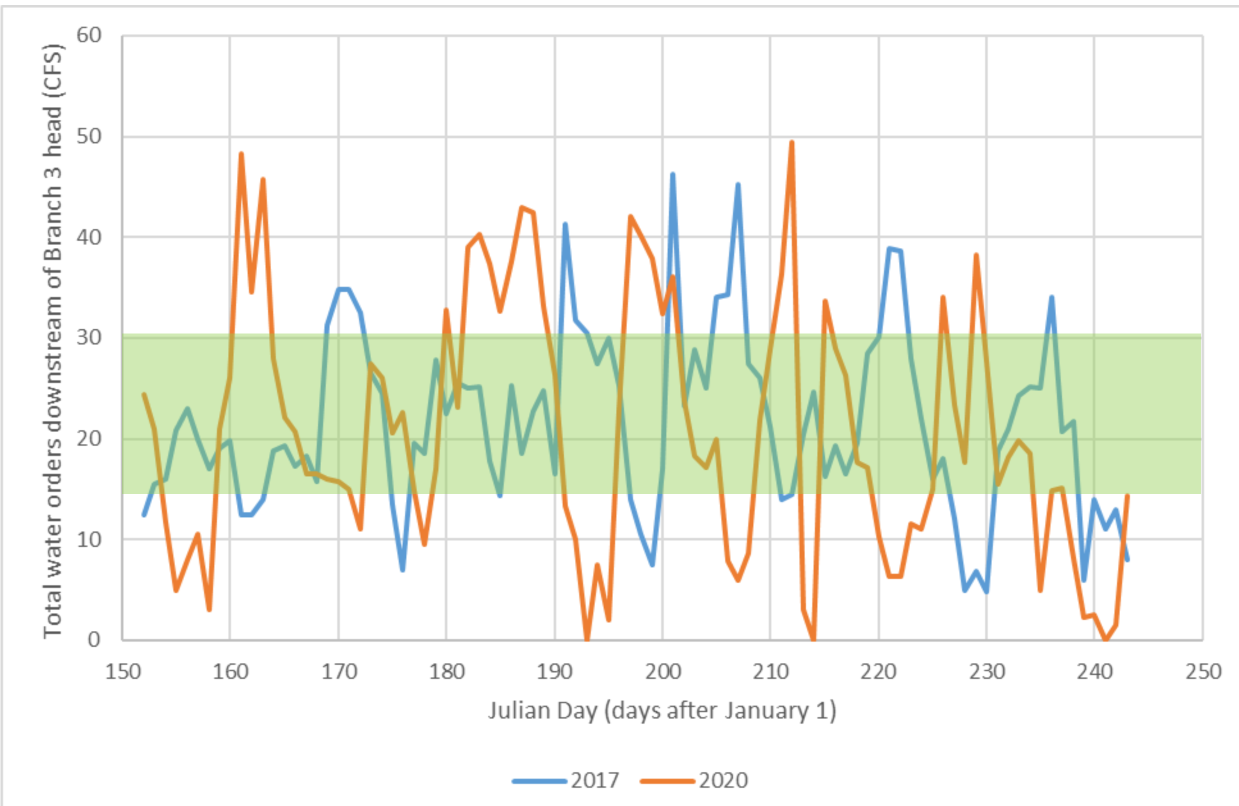


Figure 8. Colony Branch 3 demand volatility comparison between 2017 and 2020 during peak irrigation months; volatility in 2020 was somewhat more extreme.

- The existing buffer reservoir volume is insufficient. This is evidenced by the frequent fill/empty cycles recorded via SCADA. See Figure 9 and Figure 10.

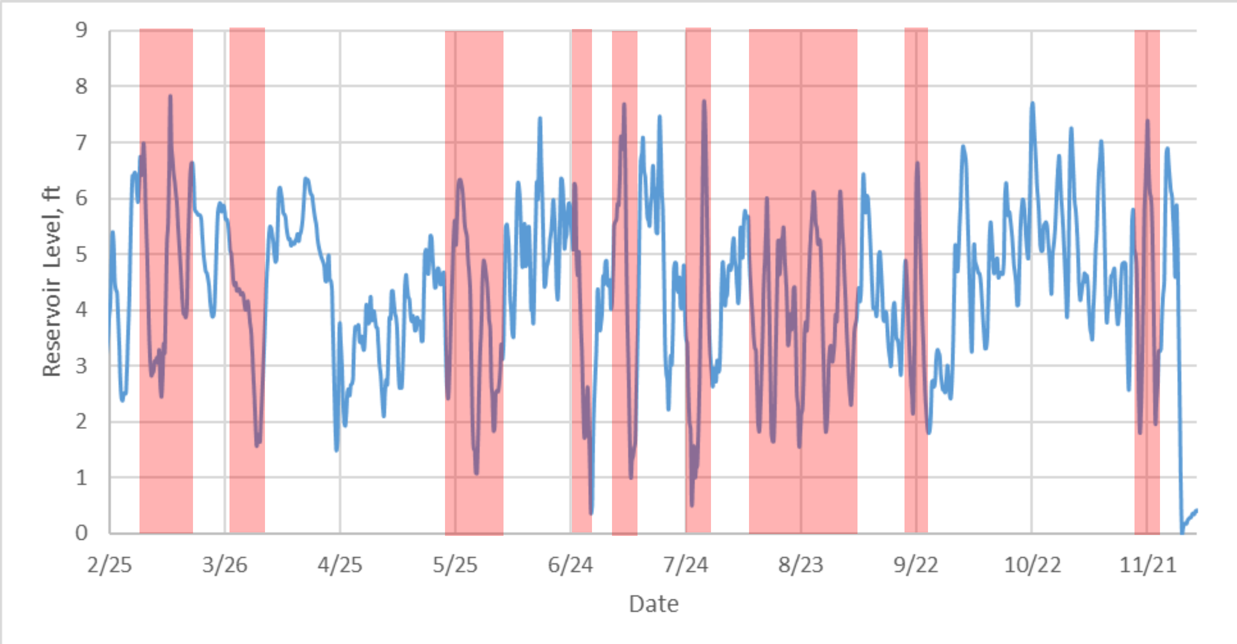


Figure 9. 2020 Colony Reservoir water level trend; red highlighted areas are rapid fill/empty cycles

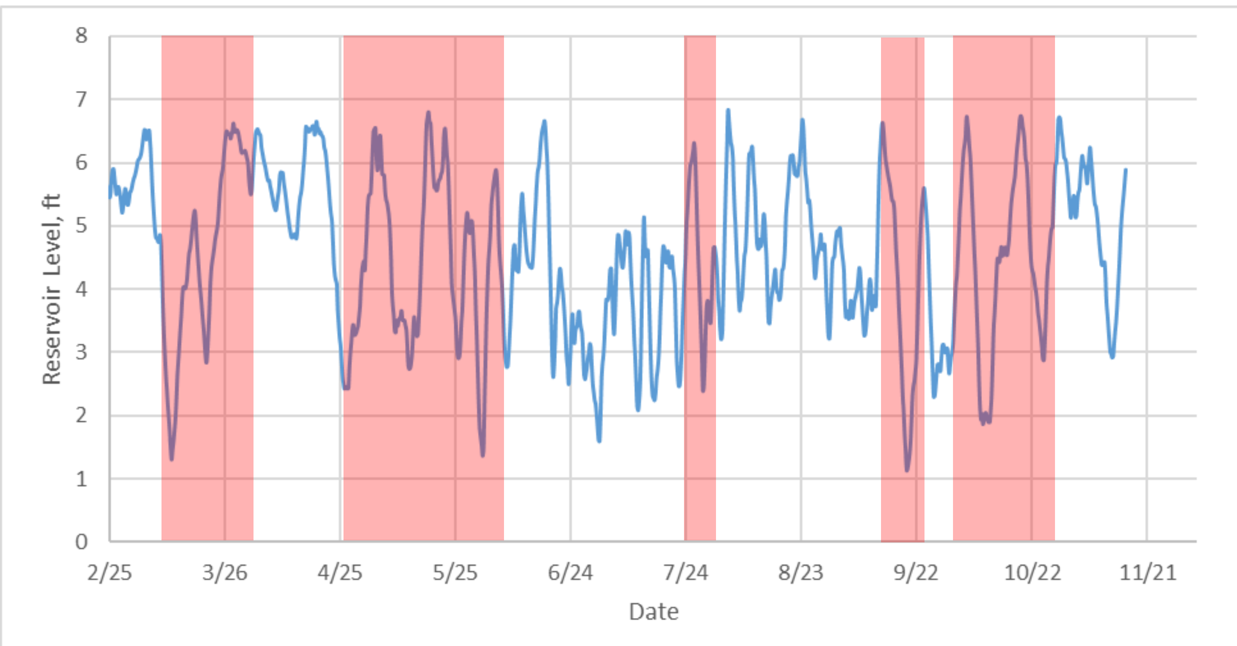


Figure 10. 2020 East Ditch Reservoir water level trend; red highlighted areas are rapid fill/empty cycles

- Operators report difficulties finding downstream demand for excess water accumulated in the East Ditch Reservoir. This point can be confirmed by data presented in Figure 11. Over 30% of the time, the reservoir is nearly full (5.5'-7' depth).

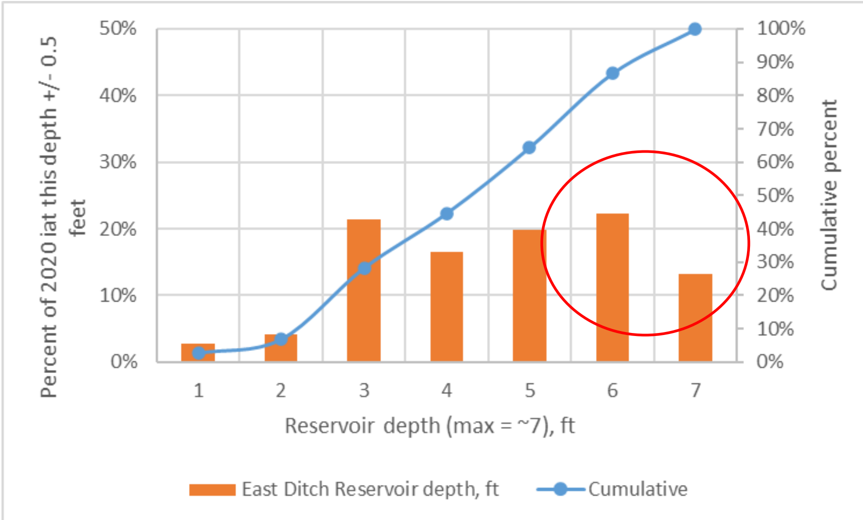


Figure 11. 2020 East Ditch Reservoir depth histogram

- The existing Laguna Reservoir may be underperforming its potential, but it is difficult to confirm due to the lack of SCADA monitoring. During a visit to the reservoir, the outlet pumps were automatically operating at the same time the reservoir was being filled with weir inflow, which at minimum does not inspire confidence.

Existing Buffer Reservoir Inadequacy

Based on the points above, it can be concluded that the existing buffer reservoirs are inadequate to handle current demand patterns without operator difficulty or unmet expectations. Thus, more buffer reservoir storage is recommended in combination with numerous other infrastructure improvements outlined in this report.

If more reservoir storage is recommended, there are several key questions to answer:
1. How much more volume is needed?
2. Is additional inflow/outflow capacity required, or simply more volume
3. Where should the additional volume and flow capacity be?

These questions are answered sequentially in the following sections, under the presumption (and recommendation) that additional storage will be developed through expansion of either the Laguna or Colony Reservoirs, thus avoiding the additional expense of constructing a new reservoir from nothing. Note that expansion of the East Ditch Reservoir was not considered as an option because:
1. It is relatively new, and heavy civil modifications make little sense there if one considers the age and wear on the Laguna and Colony Reservoirs.
2. The East Ditch Reservoir was initially planned to be larger but was downsized in implementation due to the unavailability of land in the area. It is unlikely the situation has changed much.

How Much More Volume?

The additional design volume can be estimated with a first approximation as follows:

Additional design volume (all in acre-feet) = Total design volume with no existing reservoirs – existing volume

Total Design Volume, Assuming No Existing Reservoirs

The total design reservoir volume for the Colony area is dependent on:

- The maximum net flow discrepancy was reported at about 200 CFS.
- The lag time reported between the Main Canal and either of the existing Laguna or Colony Reservoirs (clear options for expansion, rather than a completely new reservoir) was reported as about 15 hours. *Note that the lag time considered only the Laguna/Colony reservoirs, but the flow discrepancy value considers areas buffered by the East Ditch Reservoir.*
- An assumption was that the reservoir will be maintained at about half full, so that there is an equal volume available for storage and supplementation, in most cases.

The total design volume for the Colony Area using the assumptions above, is computed using:

Flow = 200 CFS
Duration = 15 hours
1 CFS × 12 Hours = 1 AF
Double the capacity is needed if it started at half full.

AF = (Flow rate discrepancy) × (Hrs.)/(12 hours) × (2 times because half full at the beginning)

AF = 200 CFS × (15hr/12hr) × 2 = 500 CFS

Additional Required Volume

The additional required buffer reservoir volume can be computed by subtracting the existing reservoir volume from the estimated total required above. The existing reservoirs are characterized in Table 3.

Table 3. Existing Colony area reservoir volumes

Location	Total available capacity when empty, AF
East Ditch	107
Colony	30
Laguna	15
Total	**152**

The additional required buffer reservoir volume = 500 AF – 152 AF = **348 AF**.

The additional volume could be developed by constructing a new reservoir(s) or expanding existing reservoir(s). The following points should be noted:

1. The Laguna Reservoir appears to be the only existing reservoir that can be easily expanded.
2. A new reservoir near Highway 33, plus a “superhighway” of canals with long-crested weirs to the Colony area, should greatly reduce the lag time between the existing Colony area reservoirs and their compensating water supply. Flow changes would not need to travel all the way from Mendota Pool.

Adequacy of Existing Reservoir In/Outflow Capacities

Buffer reservoirs should be capable of accepting and delivering the full discrepancy (200 CFS) flow rate to maximize effectiveness. As in the previous analysis, the additional reservoir in/outflow design capacity will be computed as:

Required additional in/outflow (all in CFS) = Total in/outflow required – existing in/outflow

The existing Colony area reservoir in/out flow capacities are listed in Table 4.

Table 4. Existing Colony area reservoir in/out flow capacities

Location	Existing Flow Capacity, CFS	
	IN	OUT
East Ditch	60	60
Colony	35**	22
Laguna	22	14
Total existing flow capacity in each direction	**117**	**96**

**Assuming the LCW contributes about 5 CFS to inflow (60’ long weir with 0.1’ of head over crest)

The additional reservoir in/outflow design capacity for the area is computed in Table 5.

Table 5. Required additional reservoir in/out flow capacity computation for the area

Location	Flow Capacity, CFS	
	IN	OUT
Design capacity to handle maximum reported flow discrepancy	200	200
Total existing capacity for all reservoirs in Colony area	(117)	(96)
Additional design flow capacity (rounded)	**80**	**100**

Adjustments to Additional Reservoir In/Outflow Capacity Computations

The values computed in Table 5 are subject to the following adjustments due to physical constraints in the field:

- Reservoir outflow: Total reservoir outflow will be limited to no more than the smallest of:
    - 70% of the total irrigation demand downstream of the expanded reservoir. The maximum and 70% downstream demand for each existing reservoir is:
        - Colony: 30 CFS × 0.7 = ~20 CFS
        - Laguna: 70 CFS × 0.7 = ~50 CFS

      These values provide two key conclusions:
        1. The maximum additional reservoir outflow will be limited to 50 CFS.
        2. There is insufficient demand downstream of Colony Reservoir to justify its expansion. **Therefore, an expansion of the Laguna Reservoir volume and in/outflow capacity is recommended**, especially considering the lower level of development of land (and therefore likely availability of land) surrounding the Laguna Reservoir.
    - The maximum canal flow capacity adjacent to and downstream of the Laguna Reservoir is about 50 CFS.
- Reservoir inflow: the total reservoir inflow capacity will be limited to no more than 100% potential excess inflows to the level pool adjacent to the reservoir. This is estimated at 30 CFS from the upstream direction and an additional 30 CFS from the downstream direction. Flows can be directed to the reservoir from upstream and/or downstream. That is a total design inflow of 60 CFS.

A summary of the initial design values and subsequent adjustments are provided in Table 6.

Table 6. Adjustments and final reservoir recommendations

Location	Flow Capacity, CFS	
	IN	OUT
Initial design capacity from previous table	80	100
Design capacities after adjustment for physical field constraints (recommended)	60	50

Both adjustments above are performance inhibitors. However, the disadvantages can be offset by constructing a "superhighway" (discussed in a following section), which provides reduced lag time and operational labor.

Reservoir Recommendation Summary

Major recommendations discussed thus far include:

1. Expand the 15 AF Laguna Reservoir by about 85 acre-feet for a total storage capacity of 100 AF
2. Flow capacities:
    a. 60 CFS inflow
    b. 50 CFS outflow

"Superhighways"

"Superhighways" are irrigation conveyance facilities defined by:

- Purpose: To act as a quick reaction conveyance route (to either increase or decrease flows) for a larger service area downstream
- Key general capabilities/benefits:
    - Rapidly executed flow changes using minimal labor input
    - Excellent water level control throughout, providing reduced lag times
    - Excellent flow measurement

The Colony Main Canal is the recommended "superhighway." The Laguna Canal capacity is simply too small relative to the total area demand and is thus not an option for a superhighway.

CCID Main Canal Buffering

Superhighways benefit downstream operations, but they also shift the burden of supplying flow variations towards the upstream ends of the canals. Furthermore, it is anticipated that irrigation demand volatility will worsen over time with more micro-irrigation acreage, changing labor schedules, etc.

A new, 300 acre-foot buffer reservoir is recommended at the head of the Colony Main Canal to better handle current and future irrigation demand volatility as it shifts to the CCID Main Canal. The anticipated buffering capacity of the proposed new reservoir is illustrated in Figure 12, with the following assumptions:

1. the new 300AF reservoir starts at 50% full
2. No initial reservoir in/outflow
3. The values presented account for 3 hours of travel time between Mendota Pool and the head of the Colony Main Canal (per CCID staff)

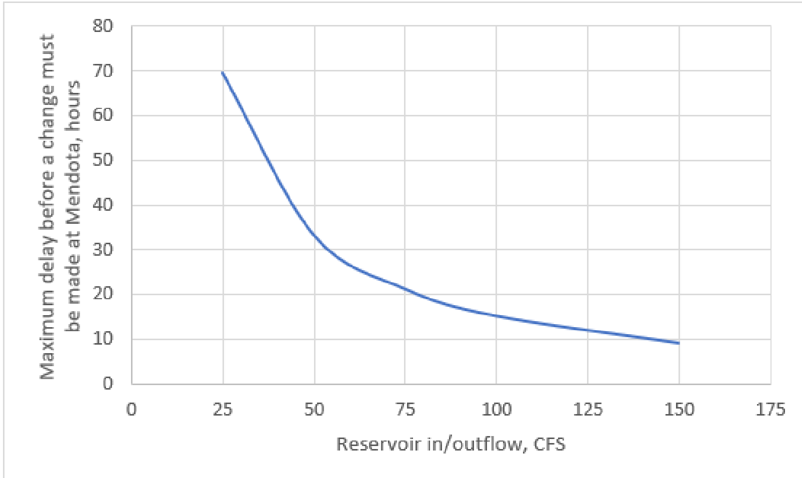


Figure 12. Maximum delay for flow changes from Mendota Pool for various reservoir in/outflows

A hypothetical example is provided below to help interpret the graph and compare operations before and after the reservoir.

Scenario
The 300 AF reservoir is half full with negligible in/outflow. A 50 CFS increase is called for along the Colony Main Canal.

The Authors' Understanding of Current CCID Operations
In general, current Main Canal operations are well-coordinated. A "plus 50 CFS" adjustment would be made at Mendota roughly 3 hours prior to the flow change occurring at the Colony Main Canal. If the scheduling is imperfect, the discrepancy shows up at Ingomar Reservoir.

New Operations with the reservoir
Use the reservoir storage to supply the additional 50 CFS (horizontal axis of graph). CCID staff are provided with up to 32 hours before a corresponding adjustment at Mendota is needed.

Big-Picture Strategy

The reservoir and superhighway recommendations were developed within the context of a larger strategy (illustrated in Figure 13):

- The Colony Main "superhighway" will enable operators to quickly increase or decrease flows into the Colony Area.
- A new automatic flow control structure at the head of Branch 3 will provide operators with the flexibility to:
    - Rapidly add or cut flows to the expanded Laguna Reservoir
    - Move surplus water from East Ditch Reservoir to the Laguna Reservoir
- The level canal pool adjacent to the Laguna Reservoir will be expanded in length to provide "on-demand" deliveries to a larger area. Turnout deliveries in the level pool will be automatically supplied by the reservoir if the water is available.
- Spill from the Colony Main Canal, Branch 4 and Branch 5 will be minimized by implementing automatic downstream control at the tail ends of those canals.

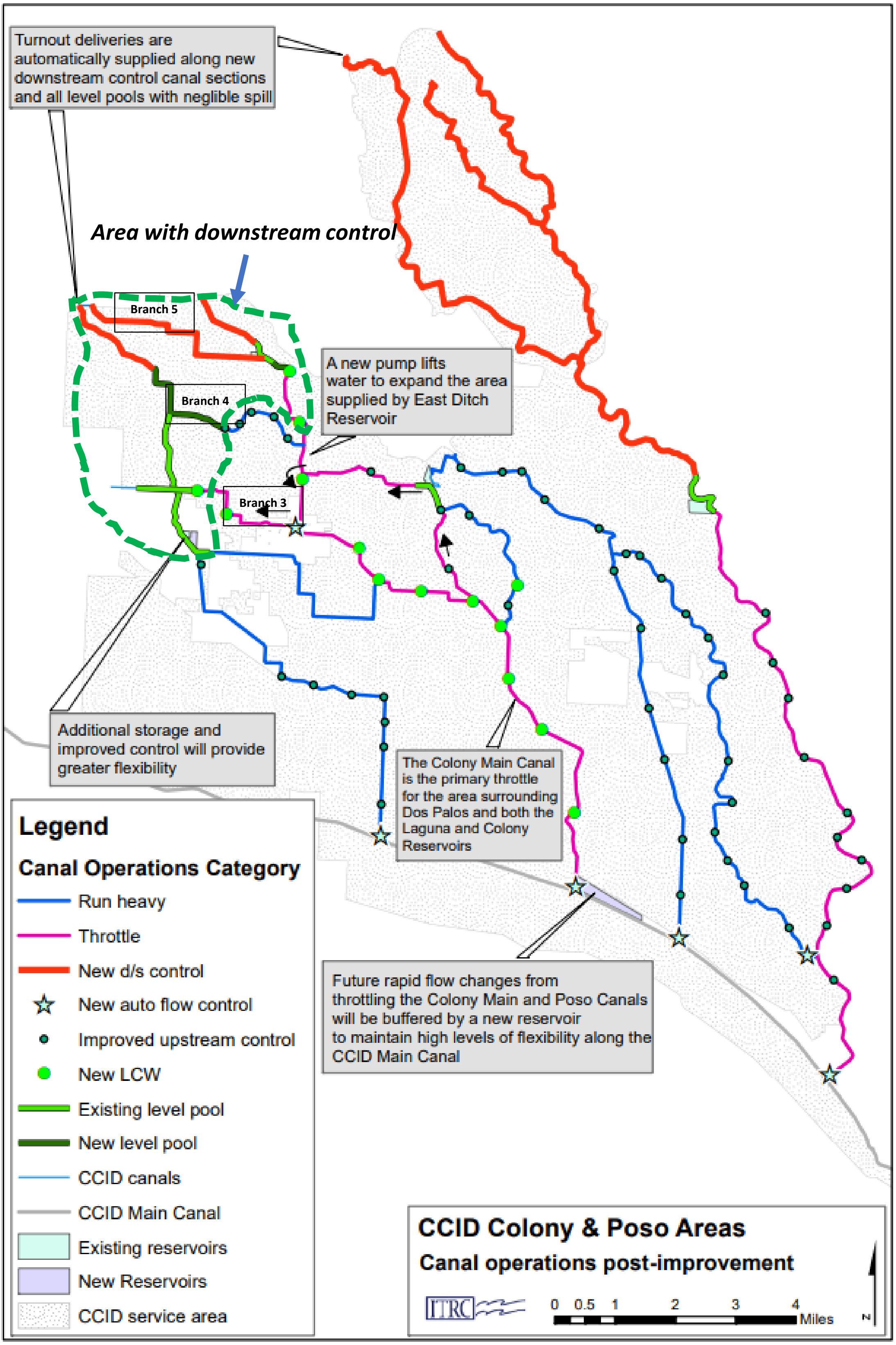


Figure 13. Proposed operational strategy after recommended modifications

Laguna Canal – Existing Conditions

The existing conditions along Laguna Canal are:

1. A target flow rate is set at the Laguna Canal headworks using a manual rating table and manual gate adjustments. Monitoring or adjusting the flow rate requires a 20+ minute drive from the CCID Colony Office.

Figure 14. Laguna Canal headworks gate looking downstream

Figure 15. Laguna Canal headworks weir, looking upstream

2. Flow rate changes at the headworks (at the CCID Main Canal next to Hwy 33) and turnouts require frequent monitoring and adjustment visits to some or all weir check structures.

Figure 16. Laguna Canal 2.913 weir board check structure; similar throughout with a few exceptions

3. The Laguna and Branch 2 canals converge, but the site lacks the ability to measure flow (either individually or combined).

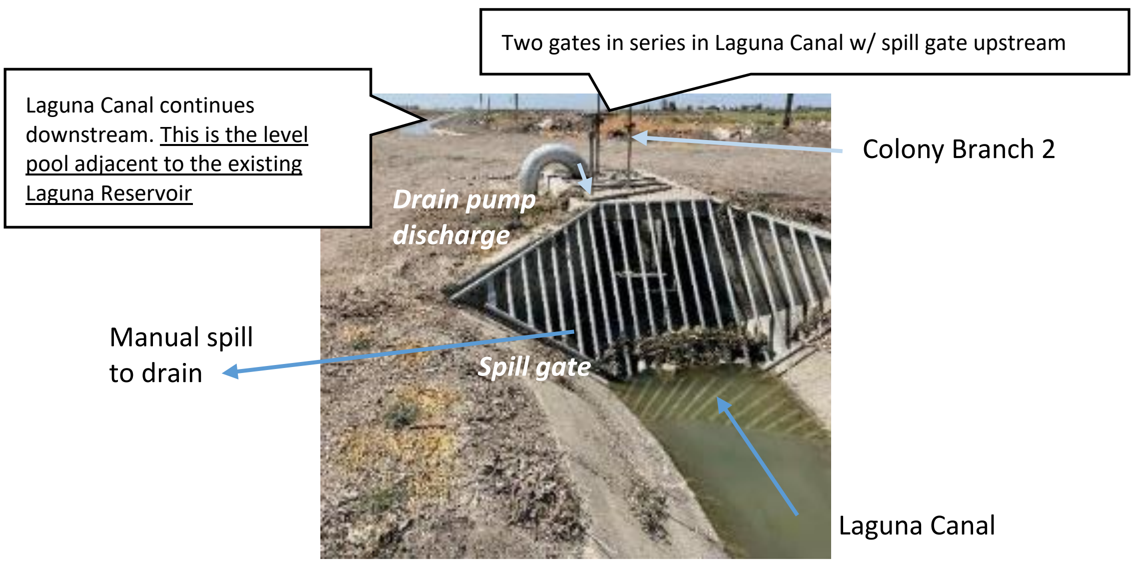


Figure 17. Existing sluice gate structure in the Laguna Canal at station 77+61. Note the side spill gate and drainage pump discharge (located between the existing gates)

4. Intermittent inflows from drain recirculation pumps occur when surface drainage water is available (see above).
5. A buffer reservoir is located just upstream of the convergence of the Laguna Canal and Branch 3 Canal as shown in Figure 18.

Figure 18. Existing Laguna Reservoir inlet weir (left) and outlet pumps (right)

The buffer reservoir is automated to maintain a target range of water surface elevations in the adjacent Laguna Canal pool – extending to and floating with Branch 3 Canal (see Figure 19).

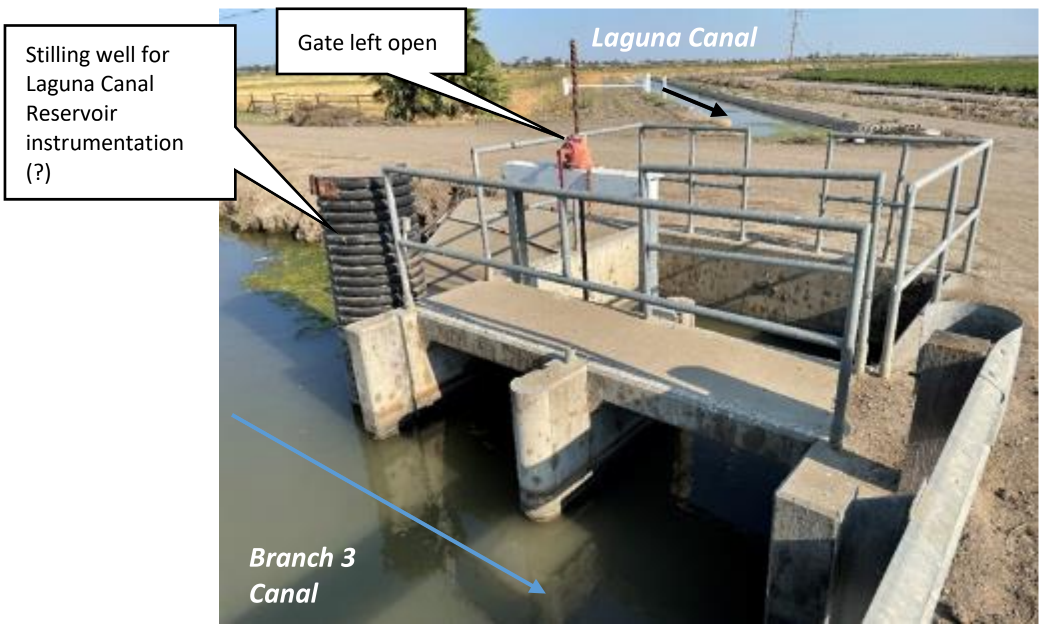


Figure 19. Convergence of Laguna Canal and Branch 3 Canal, looking upstream

The reservoir automatic control performance is unknown because the site is not monitored or recorded by the existing CCID SCADA system. However, a need for automatic control improvement (reported by staff) was confirmed during a site visit by the authors; the outlet pumps were running simultaneously while flow was entering the reservoir via the inlet weir box.

6. The flow rate for the downstream section of the Laguna Canal is adjusted at the Branch 3 Canal intersection, as shown in Figure 20.

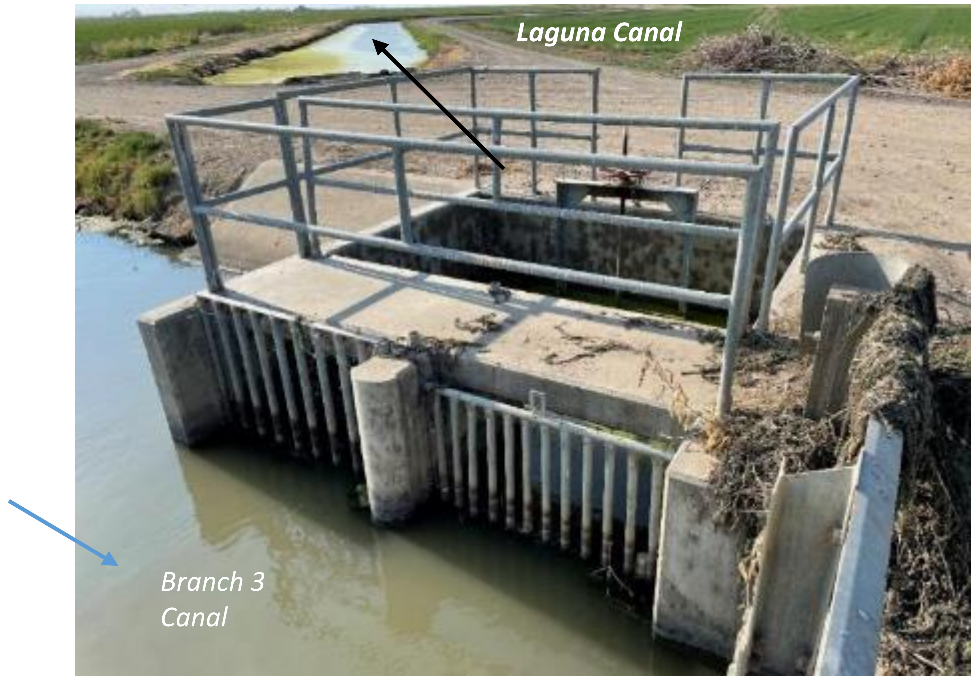


Figure 20. Continuance of the Laguna Canal, looking downstream (north); the gate may be used to set a target flow rate

7. The Laguna Canal spills into Branch 4 Canal, and it appears a gate was installed at the end of the Laguna Canal to deliver a target flow rate to the Branch 4 Canal at that location, as shown in Figure 21.

Figure 21. Laguna Canal tail end, looking upstream. Passive spill continues to Branch 4 Canal

Improvement Strategy

The Laguna Canal operations can be summarized into a few key points:

- Operations are generally labor-intensive, because each change requires manual intervention and constant monitoring visits at check structures, in addition to the turnout operations.
- Operations are imprecise and inflexible in the upstream reaches due to:
  - a lack of flow measurement at key bifurcations
  - no remote monitoring, so operators only "know" the flow rate after visiting and physically measuring something (Such information is neither on their phone nor on a computer accessible to staff in the Colony Office.)
  - inherent lag time, scheduling issues and fluctuating drain pump inflows
  - the allowance for some recoverable spill to Branch 4 Canal
- There is some flexibility in the downstream reaches with minimal spill due to the ability to buffer flows. Discrepancies are buffered using the Laguna Canal Reservoir and the Laguna/Branch 3 Canal pool itself for storage.

Because operations are already flexible, the recommended improvements are focused on:

1. Expanding the flexibility to additional geographical areas. Operational flexibility is currently limited to the Laguna, Branch 2, and Branch 3 canals. Branch 2 and Branch 3 canals are flexible because they can be operated with spill that is internally recirculated and buffered in the Laguna Canal.
2. Reducing complexity
3. Reducing operational labor requirements

Improvement Overview

The recommended improvements for the Laguna Canal are shown in Figure 22.

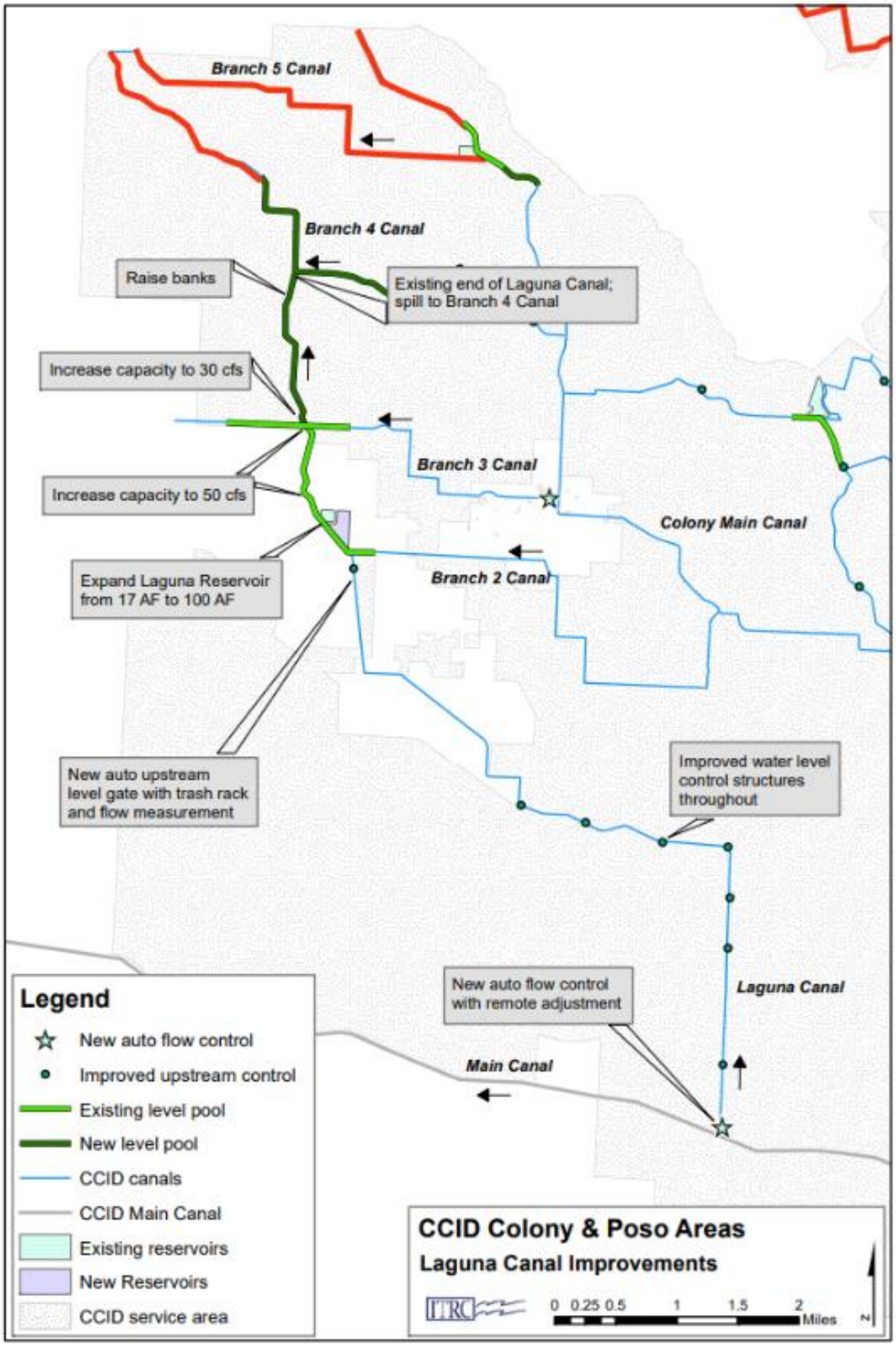


Figure 22. Major Laguna Canal improvement recommendations

Laguna Canal Improvements

Recommended Laguna Canal improvements are listed in Table 7.

Table 7. Major Laguna Canal modernization recommendations

Item #	Modernization components recommended immediately	Priority	Modernization group (to be implemented together)
1	Install a new RTU at the Laguna Canal headworks along with other improvements. The new RTU will maintain a relatively constant discharge flow rate.	Low	1
2	Improve upstream water level control structures along the Laguna Canal	Low	1
3	Modify the spill and pump structure at Shain Drain; remove existing flashboard check	Medium	None
4	Expand the Laguna Reservoir from 17 AF to 100 AF. Increase the capacities to 60 CFS inflow and 50 CFS outflow	High	2
5	Increase the capacity of the Laguna Canal and control structures between the Reservoir and Branch 4 to between 30-50 CFS depending on location.	High	2
6	Remove structure at existing Laguna Canal tail end; convert to level pool downstream (see Branch 4 section for details)	High	2
7	Consider adding a pump in Rice Drain near Santa Fe Grade and Merrill Ave	Low	None

Laguna Canal Headworks

The improvements at the Laguna Canal headworks and check structures are as follows:

1. Evaluate the existing headworks gate for automation. Replace, if necessary, with an equivalent new gate.
2. Install an electric actuator on the existing or new headworks gate and redundant gate position sensors.
3. Install new, offline stilling wells upstream and downstream and redundant water level sensors.
4. Install a new remote terminal unit (RTU) to provide automatic flow control.

These improvements will enable operators to:

- Adjust the flow rate
- Constantly monitor flow rates from authorized mobile phones/tablets
- Be made immediately aware of problems with automatic alarm notifications

The improvements at the Laguna Canal headworks are illustrated in Figure 23.

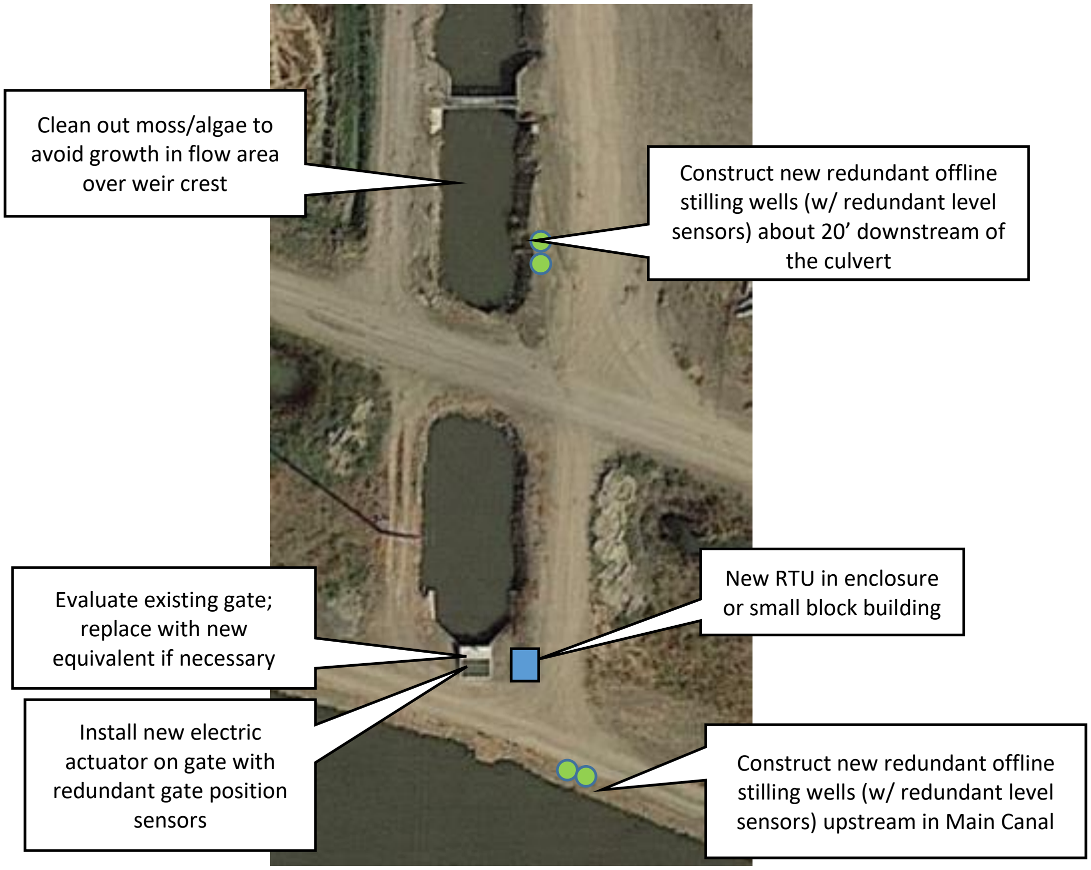


Figure 23. Recommended improvements at Laguna Canal headworks, plan view

Laguna Canal Check Structures

The previous section discussed improvements that are expected to minimize trips to the headworks, but that idea is useless if operators still need to travel down the canal to make flashboard check adjustments for each flow change.

As such, it is recommended that the existing check structures be improved with a long-crested weir (LCW) as shown in Figure 24, with some limited exceptions. The new LCWs will provide automatic upstream level control and the following benefits:

- Flow changes occur without human intervention at the check structures, while the water levels are maintained within +/-0.25 feet, or better if the flush gates are adjusted. By changing the flow through the flush gates, operators can minimize the change in flow (and thus change in water level) over the weir crest.

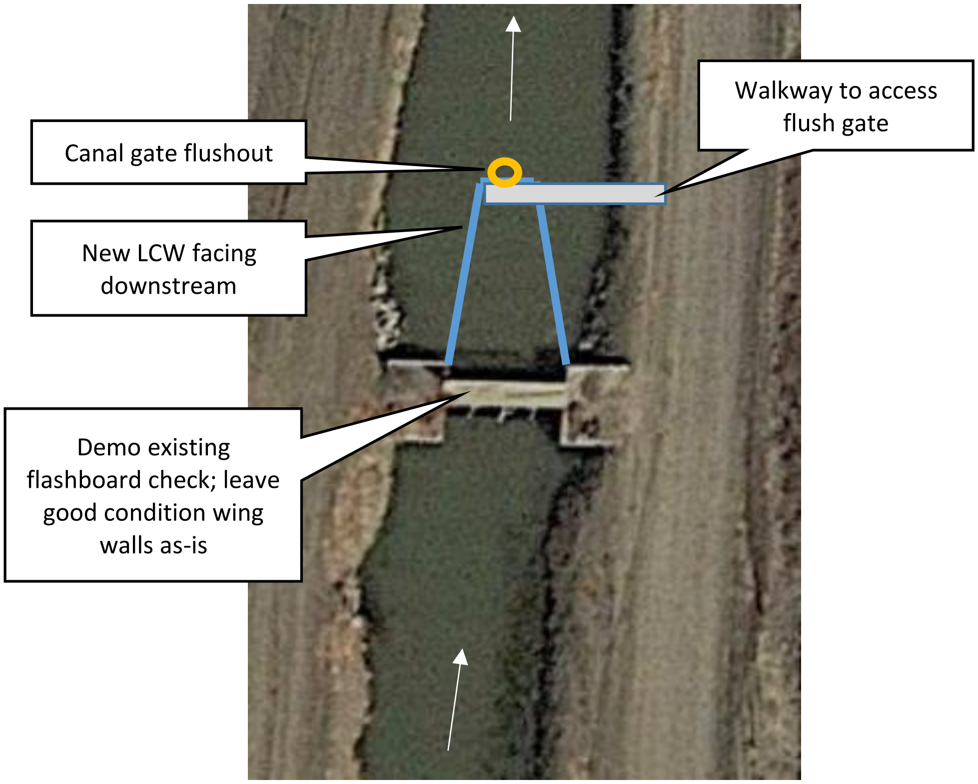


Figure 24. Laguna Canal check structure improvement concept; plan view overlying the first Laguna Canal check

As shown above, the new LCW and flush gate replaces the existing flashboard check. The LCW will be sized to handle all flow changes while some portion of the total flow is passed using the flush gate(s).

Preference is given to downstream-facing weirs because:

- There is no risk of the entire structure floating with a downstream-facing weir; that isn't the case with upstream-facing weirs.
- Downstream-facing weirs require only one flush out gate, but an upstream-facing weir requires two when placed in the center of the channel.

However, there are a few exceptions:

1. A downstream-facing LCW at the second existing Laguna Canal check structure is not feasible without major modifications or losing the road crossing. As such, an upstream-facing weir is conceptualized in Figure 25.
2. An offset design concept is needed at the 9th Laguna Canal check at the corner of Shain Ave and 4th Street South, as shown in Figure 26.

Recommended weir dimensions and relative elevations are provided in the following section.

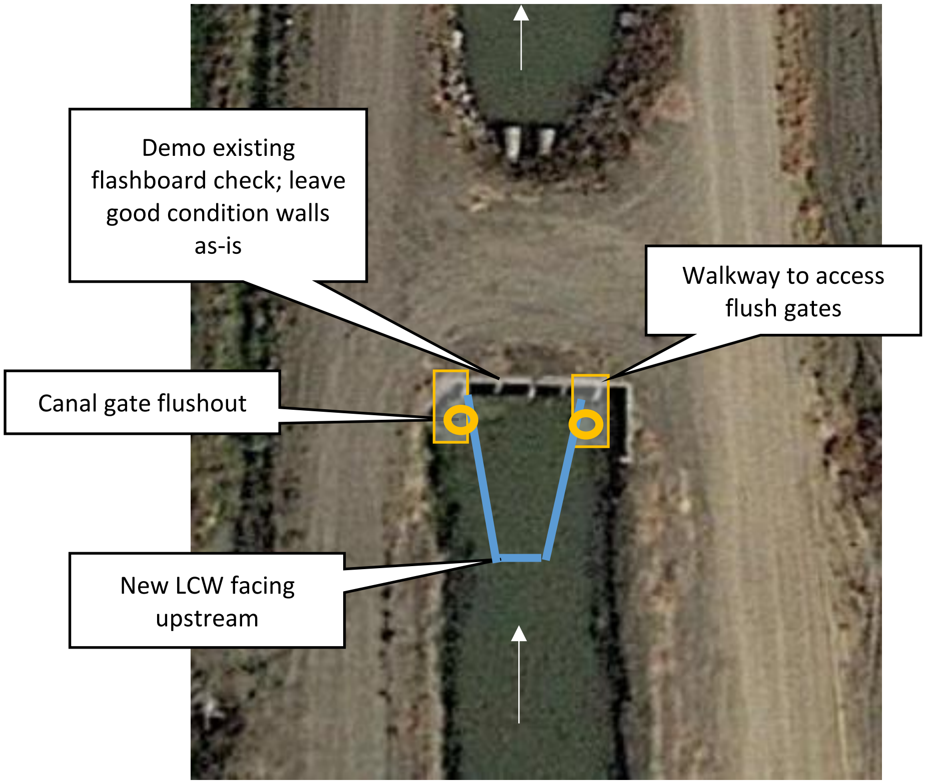


Figure 25. Laguna Canal check structure improvement concept; plan view overlying the second Laguna Canal check

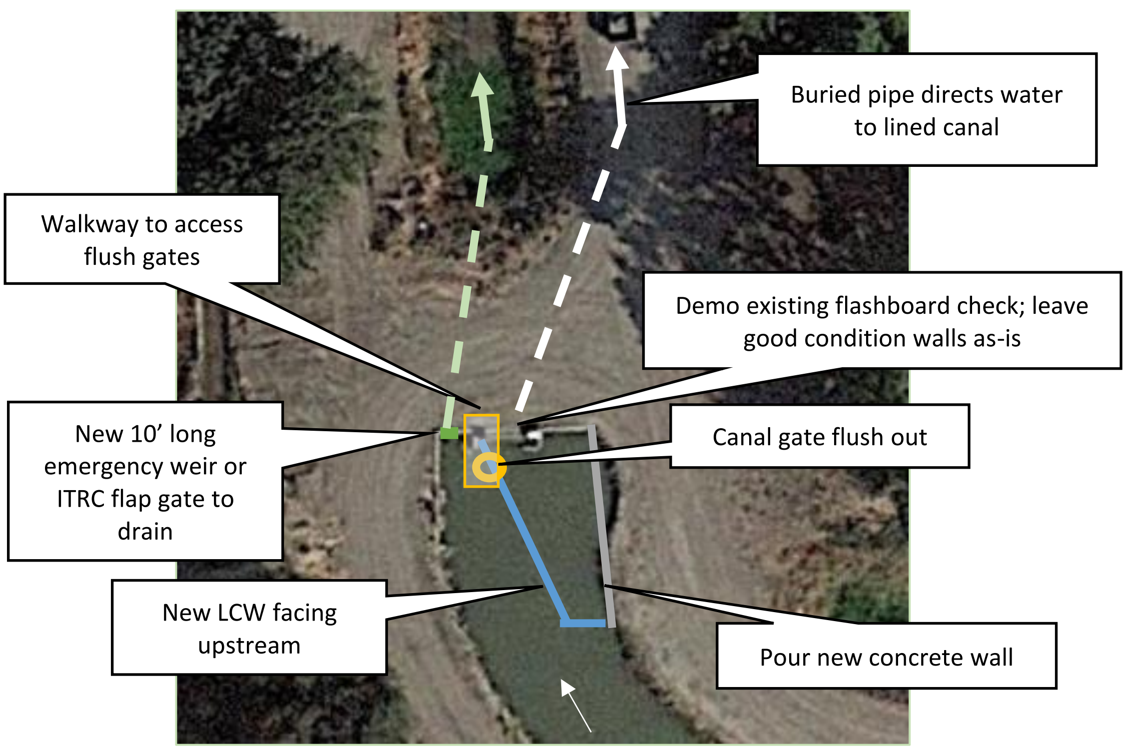


Figure 26. Laguna Canal check structure improvement concept; plan view overlying the 9th Laguna Canal check near Shain Ave and 4th Street South

LCW Assumptions and Design

The following design values were reported by CCID staff, unless noted otherwise:

- Headworks design capacity = 80 CFS
- Typical delivery flow rate at headworks = 60 CFS
- Typical changes at headworks = 15 CFS
- The design capacity of the concrete lined canal just downstream of Shain Ave is estimated to be about 20 CFS (estimated by authors)

Minimum weir crest lengths and gate sizes are provided in Table 8. It is also recommended that CCID determine whether any of the existing checks can be eliminated. That determination will be made after a future survey.

Table 8. Laguna Canal long-crested weir design recommendations, assuming there is a minimum of 0.5' of elevation drop across the existing structure (TBD by future survey). Make the wooden crest at the upstream high water mark elevation minus 0.5'.

Weir number	Minimum total weir crest length, ft	Design capacity over weir with 0.5' over crest and no downstream submergence	Weir facing _______	Flushing canal gate size, inches
1	80	80	Downstream	24
2	80		Upstream	24
3	80		Downstream	24
4	80		Downstream	24
5	60	60	Downstream	18
6	60		Downstream	18
7	60		Downstream	18
8	60		Upstream	18
9	40	35	Downstream	12
10	No LCW here; different recommendation provided in next section			

Laguna Canal at Branch 2 Canal

Two existing structures will be replaced with a single automated overshot gate (or equal) along the Laguna Canal just upstream of the convergence with Colony Branch 2. The new overshot gate will provide automatic upstream level control and flow measurement.

The anticipated benefits are:

- Improved water level control without local human intervention.
- Operator visits will be minimized.
- Operators will be provided with real-time measurement of the Laguna Canal flow rate prior to the convergence with Branch 2 Canal. This information helps better inform flow rate adjustment decisions at the headworks.

The two existing structure locations are shown in Figure 27.

Figure 27. Existing conditions along the Laguna Canal just upstream of the convergence with Colony Branch 2

A canal profile of this section is provided in Figure 28.

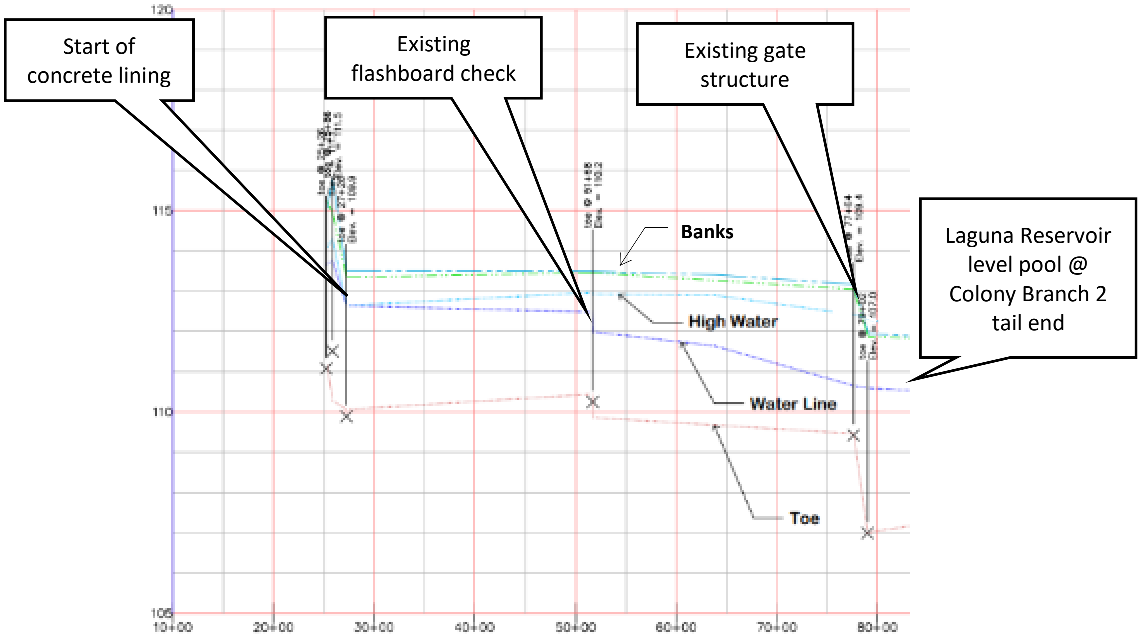


Figure 28. Laguna Canal profile; Station 25+26 is the beginning of the concrete lined section and station 77+98 is the convergence with Colony Branch 2

The flashboard check at station 51+68 is shown in Figure 29.

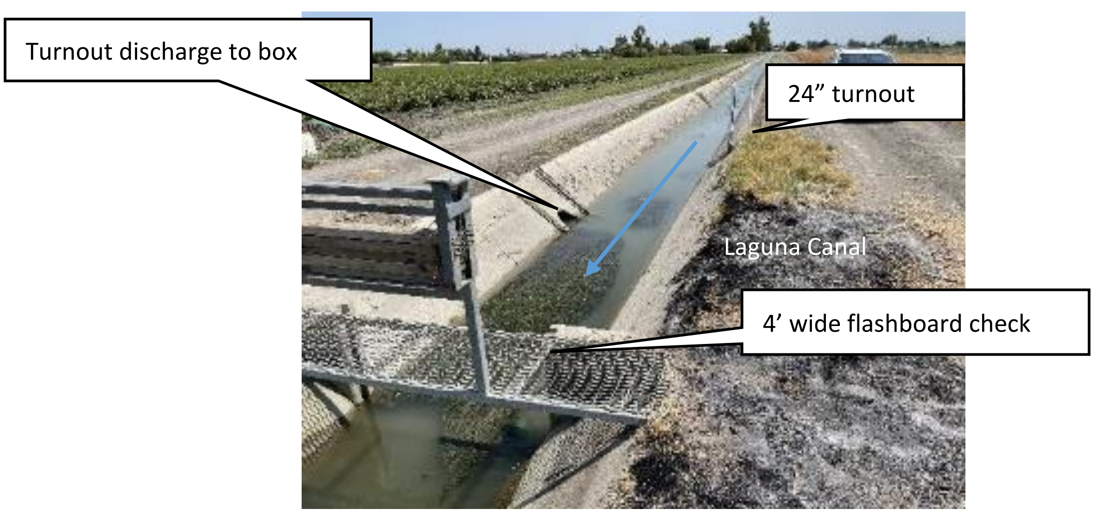


Figure 29. Laguna Canal flashboard check at station 51+68. The delivery water surface elevation upstream of the check is 112.5’. The field elevation to the east (left in photo) is 110.9’.

The gate structure, adjacent to a drain pump is shown in Figure 30.

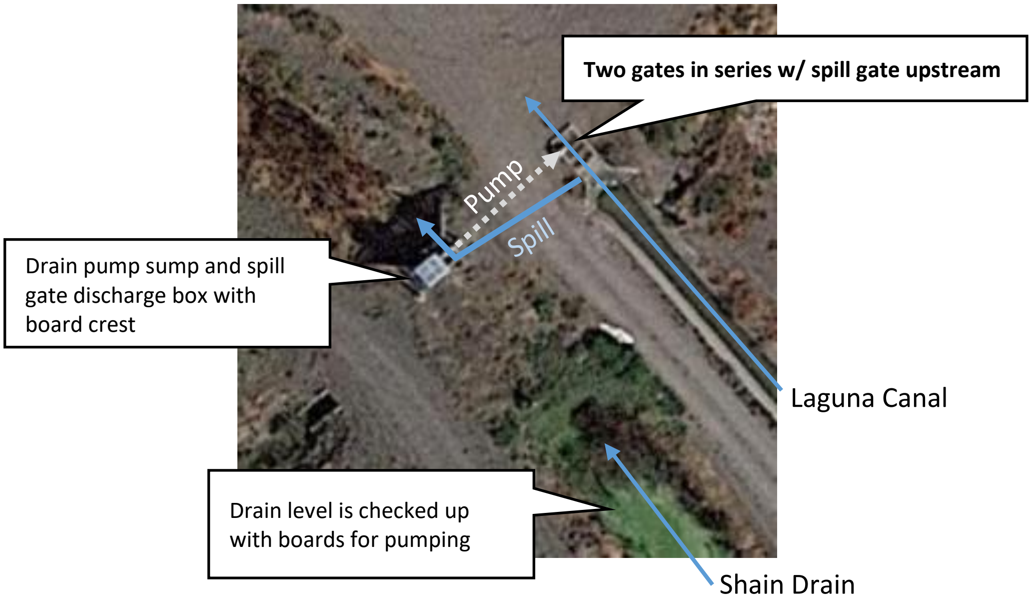


Figure 30. Satellite image of Laguna Canal gate structure and Shain Drain pump at station 77+61, just upstream of convergence with Branch 2 Canal

The sluice gate structure at station 77+61 is shown in Figure 31.

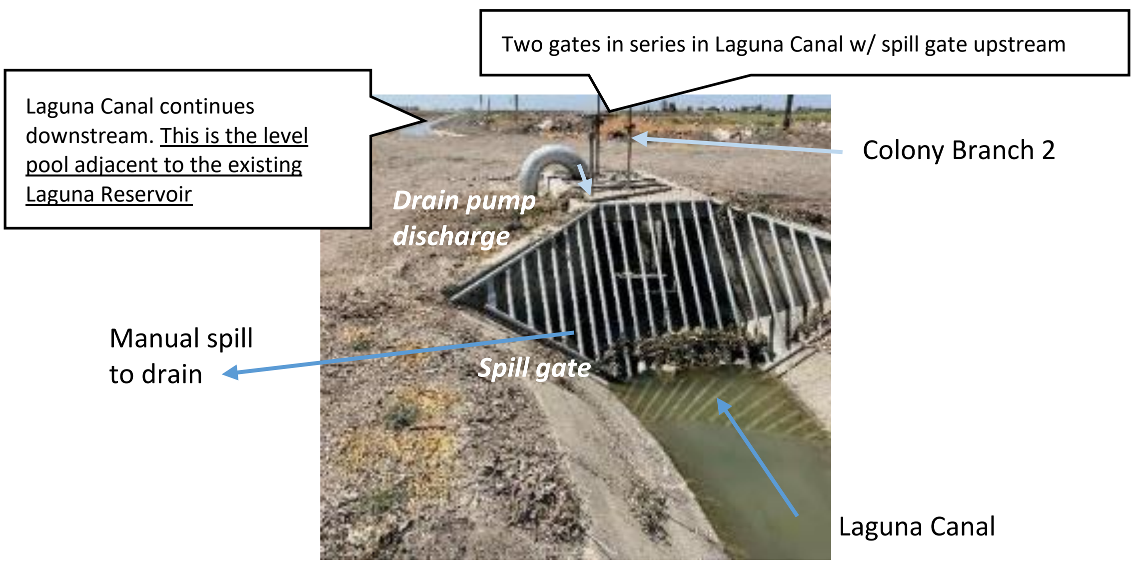


Figure 31. Existing sluice gate structure in the Laguna Canal at station 77+61. Note the side spill gate and drainage pump discharge (located between the existing gates)

Figure 32. Existing Shain Drain pump station and Laguna Canal spill structure at station 77+61

The current infrastructure is inadequate for flexible operations, specifically:

- When flashboards are installed at Station 51+68, frequent visits are required to manually control water levels with variable flows coming from upstream.
- Without flow measurement, there is no way for operators to know the flow past the trash screen into the level pool in real time.
- Operating the drain pump is entirely local and labor intensive. Related manual task examples that can be eliminated:
    - Monitoring drain levels for opportunities at recirculation
    - Turning the pump on/off
    - Accounting for the additional canal inflow
    - Volumetric accounting

Recommendations

The primary intent of the recommendations is to:

- Reduce operational labor requirements.
- Provide more information to operators and supervisors for drain water management. This will be accomplished through SCADA monitoring. Remote monitoring of flows (currently unmeasured) past Station 51+68 is needed to operate the Laguna Canal with some excess for flexibility.

Major recommendations include:

- Remove the flashboard check at station 51+68.
- Modify the sluice gate structure and Shain Drain pump structure at station 77+61 as discussed below. Install a new overshot gate or equivalent.

Upstream Flashboard Check (station 51+68)

Remove the upstream flashboard check. Water level control for the turnouts immediately upstream will be provided by the new, automated overshot or overshot gate installed downstream, adjacent to the Shain Drain pump.

Gate Structure (station 77+61)

Recommended modifications to the gate structure located just upstream of the convergence with Colony Branch 2 are listed below and illustrated in Figure 33:

- Install a single 5-foot wide overshot gate. The new gate will provide automatic upstream level control and flow measurement. An initial upstream water surface elevation target is 112.5 ft. The new RTU will also provide monitoring and control interfaces with the adjacent pump in Shain Drain, as described in the next section.
- Extend the wing walls and concrete pad to install an automated trash rack at the structure inlet.
- Construct new offline stilling wells upstream and downstream of the new trash rack.
- Relocate the drain pump discharge further downstream.
- Keep the spill gate open to enable the spill flow to be controlled by the elevation of the spill weir located on the drain pump structure.

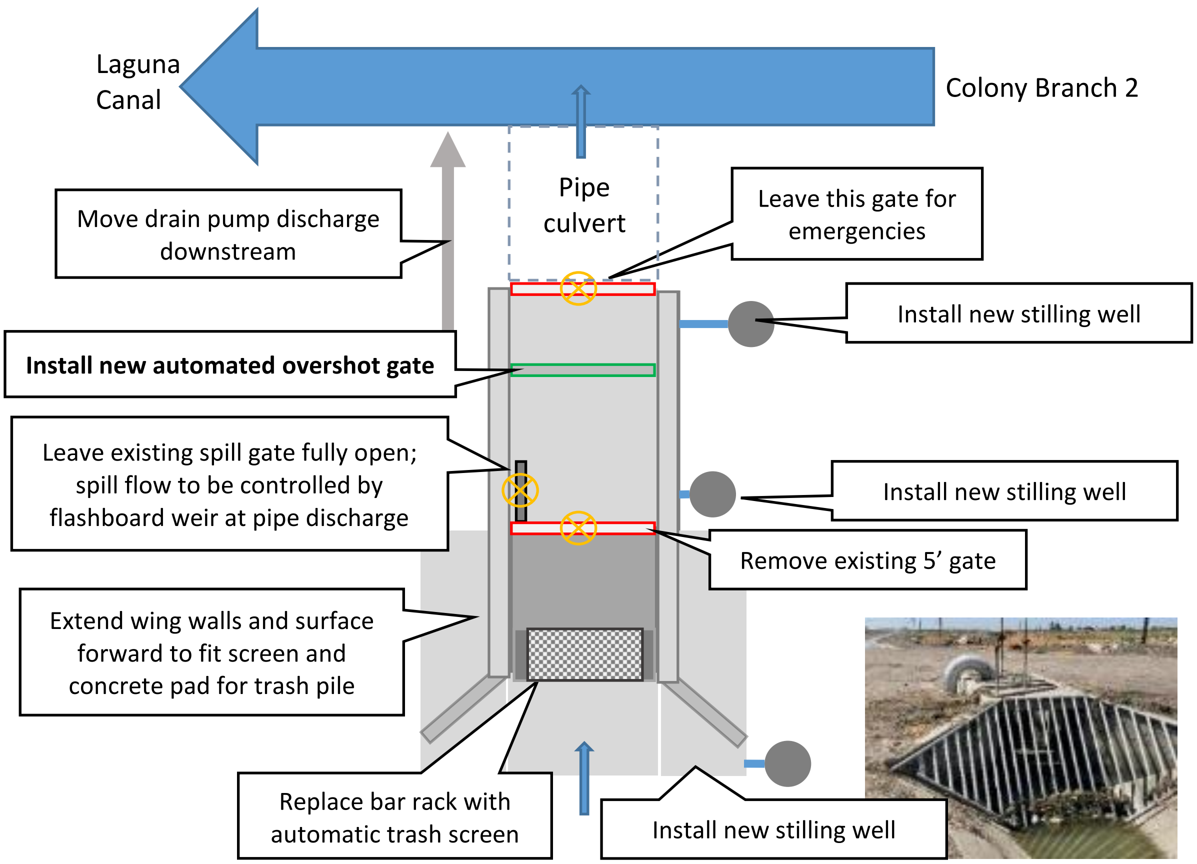


Figure 33. Photo (right) and plan view conceptual drawing showing modifications to the Laguna Canal gate structure just upstream of the convergence with Branch 2 Canal

The existing canal profile is shown in Figure 34 and after modifications in Figure 35.

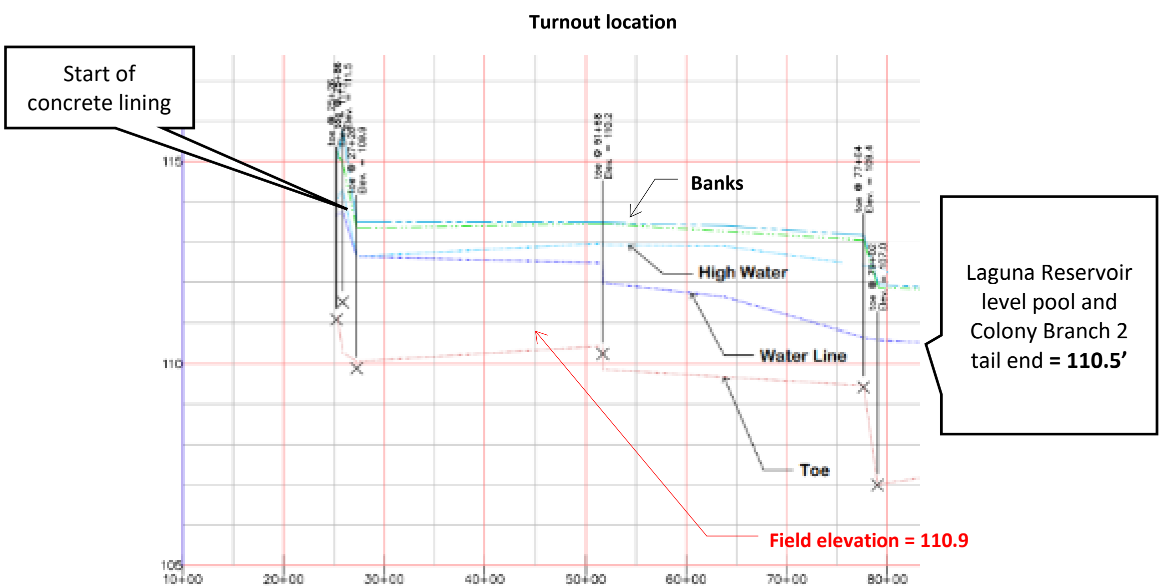


Figure 34. Existing Laguna Canal profile just upstream of the convergence with Branch 2

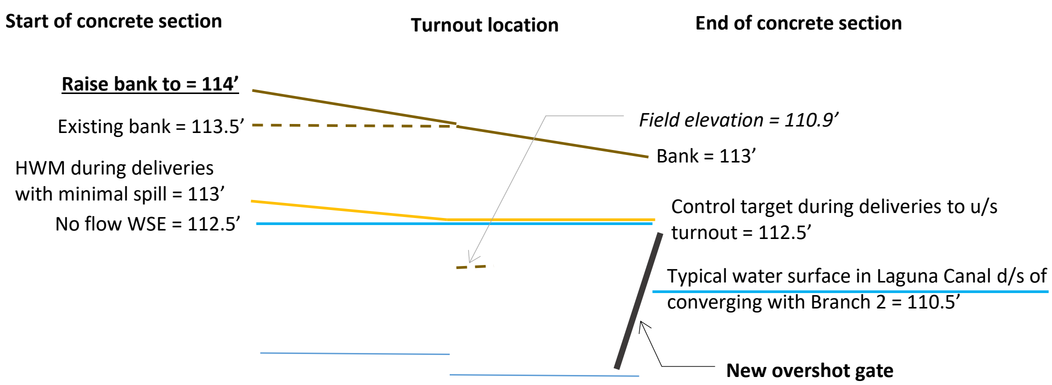


Figure 35. Laguna Canal profile along Laguna Canal after modifications

Pump Structure (station 77+61)

Recommendations for the pump structure at station 77+61 are:

- Incorporate basic remote pump monitoring and controls and integrate into SCADA, via the new gate RTU:
    - Remote manual pump start (with automatic oiler solenoid, if applicable)
    - Automatic pump shut off at low sump levels via contact switch
    - Water level monitoring in Shain Drain with redundant non-contact sensors
    - Flow rate monitoring and volumetric accounting
    - Pump fault and other alarm monitoring
- Maintain the crest of the spill weir at 112.6’ and leave spill gate open.
- Improve the pipeline vertical support near the flow meter; tie in flow meter for monitoring flows and volumes.

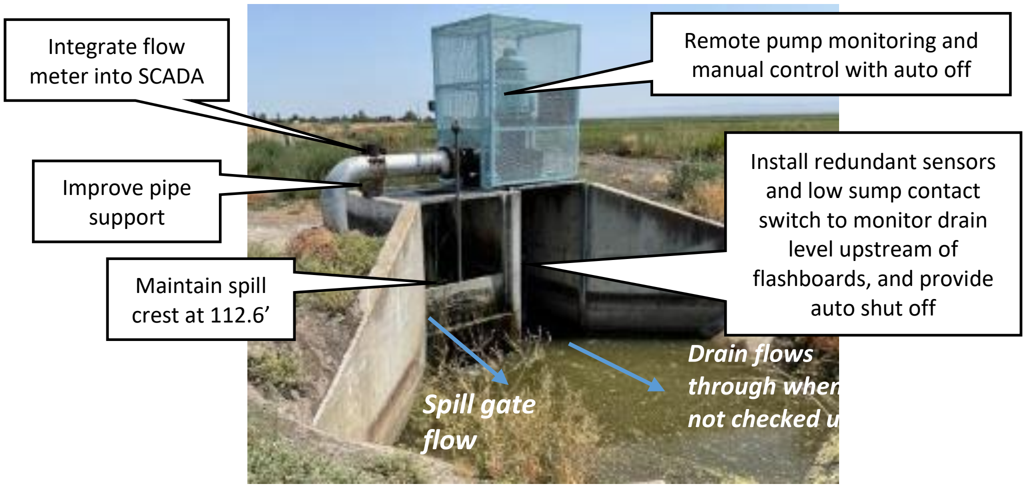


Figure 36. Recommended modifications to the Shain Drain pump station

Laguna Reservoir

The modernization recommendations for the Laguna Reservoir are:

- Expand/replace the Laguna Reservoir to provide a total live storage of 100 acre-feet. The existing live storage is reported as 17 acre-feet.
- Increase the new reservoir flow capacities to:
    - Inflow: 60 CFS
    - Outflow: 50 CFS
- Install a new SCADA remote terminal unit (RTU) to provide improved automatic water level control at a location in the newly expanded Laguna Canal level pool. The exact location and reservoir inflow/outflow control structures will be determined later, after a specific parcel is under contract and a final grading plan has been developed, so that the invert and high water mark elevations are known.
- Increase the capacity of:
    - The portion of the Laguna Canal downstream of the Reservoir. The new design flow is 50 CFS. A potential new cross section is:
        - 12-foot bottom width
        - 1.5 side slope (h:v)
        - ~5-ft water depth

      This might seem large but is necessary to provide excellent water level control performance and flexibility.
    - The Laguna/Branch 3 bifurcation structure. Modify the structure (boxes, culverts, etc.) to limit total head loss (considering friction, minor, entrance and exit losses) to no more than 0.05’ across the structure for each path and respective flow rate indicated in Figure 37.

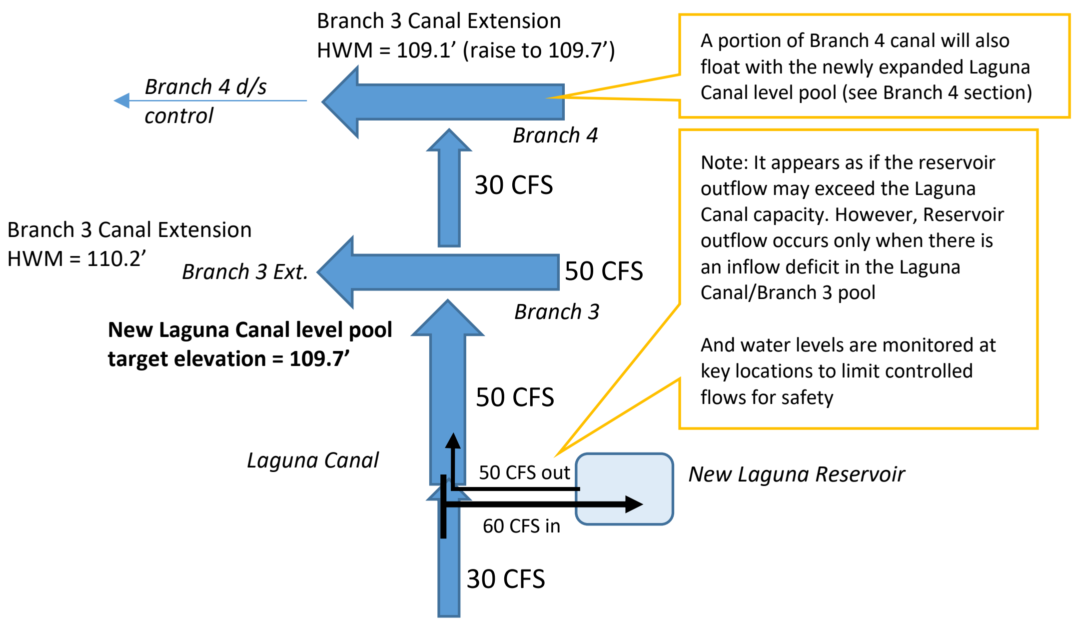


Figure 37. Recommended minimum design flow capacity diagram and water level elevation details, plan view; conceptual

The recommendations are illustrated on a map in Figure 38, presenting alternatives for the expansion area. Option 1 or similar is recommended because it shortens the length of the Laguna Canal, requiring enlargement. Regardless, the question of how or whether to incorporate (or demolish) the existing infrastructure is left unanswered until a specific parcel becomes available.

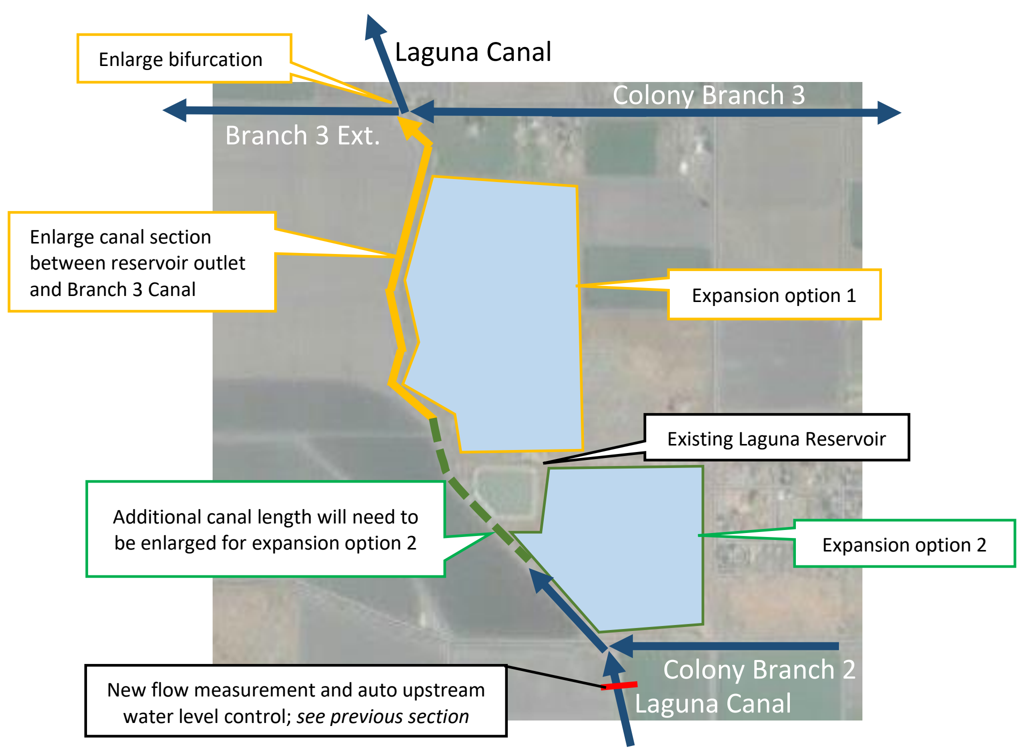


Figure 38. Recommendations for the Laguna Reservoir and Lagune/Branch 3 bifurcation

At minimum, the existing liner will be removed/replaced. Several failures were noted throughout, ranging in size from 1'-3' in the largest dimension. An example is shown in Figure 39.

Figure 39. Puncture failure example (one of many) in existing Laguna Reservoir lining

CCID seems to be successful with lining similar sized buffer reservoirs with compacted native material. As such, it is recommended that the new reservoir reflect a design like the recently constructed Poso Reservoir, as shown in Figure 40.

Figure 40. Poso Reservoir pumps, with compacted native soil and rip-rap lined banks visible in the background

Laguna and Branch 3 Intersection

The recommended modifications to the southern structure located at the intersection of the Laguna and Colony Branch 3 Canals is shown in Figure 41.

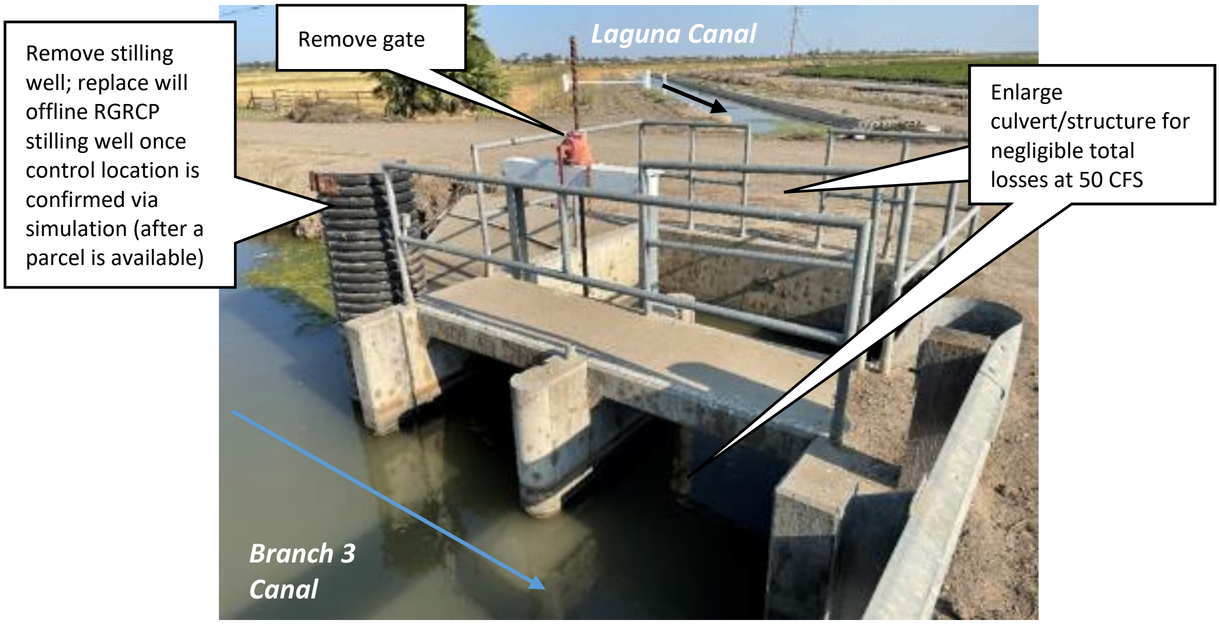


Figure 41. Convergence of Laguna Canal and Branch 3 Canal, looking upstream

The Laguna Canal will float with the Colony Branch 3 Canal (as-is currently), as well as the downstream section of the Laguna Canal. This will require the following modifications to the Laguna Canal downstream of Branch 3 Canal:

- Remove the existing flow control gate and enlargement of the structure to provide negligible head loss at 30 CFS.
- Clean and perform minor reshaping of the channel for a design capacity of 30 CFS.
- Raise the banks between Branch 3 and Branch 4 Canals by 0.5’ to 1’.

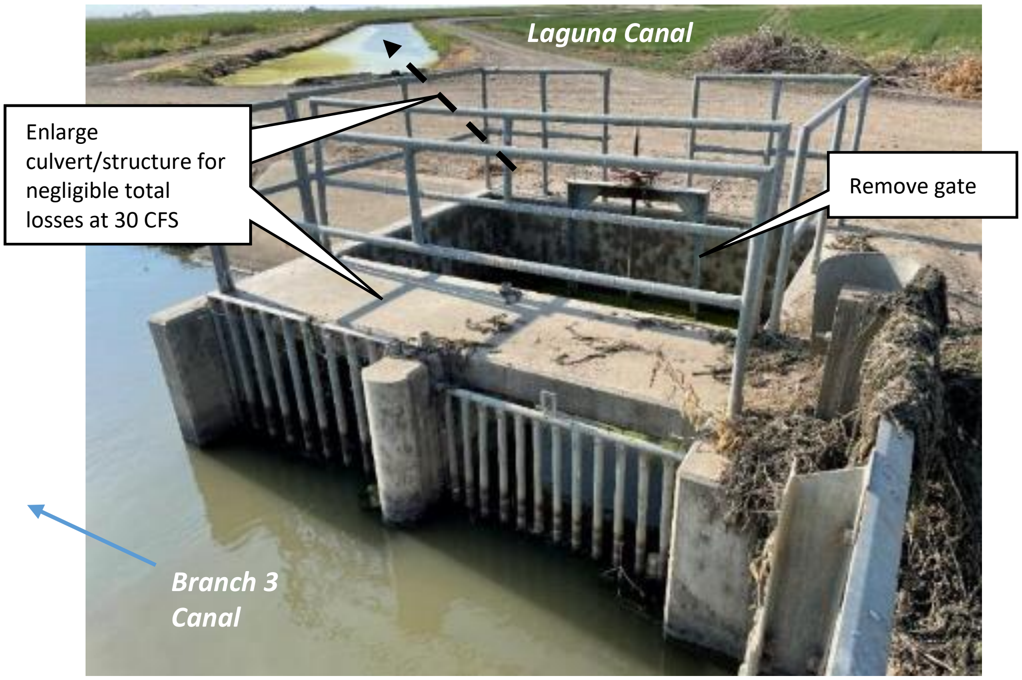


Figure 42. Recommended modifications the northern structure at the confluence of Laguna Canal and Branch 3 Canal

Laguna Canal Spill

The tail end of Laguna Canal will be modified to expand the extent of the Laguna Canal level pool and include a portion of Branch 4 Canal. Specific modifications are listed below and illustrated in Figure 43.

1. The weir insert will be removed to allow the downstream portion of Branch 4 to float with the newly expanded Laguna Canal level pool.
2. The culvert will be enlarged to provide negligible total losses at 30 CFS.

Figure 43. Laguna Canal tail end, looking upstream. Weir to be removed and culvert to be enlarged.

Colony Main Canal – Existing Condition

The Colony Main Canal is supplied from CCID's Main Canal, which is adjacent to Hwy. 33. It flows in a northwesterly direction and ends at the boundary with HMRD. Enroute, it supplies the Shafter Ditch and the East Ditch, as well as the Branch 2, 3, 4 and 5 Canals. It receives tail-end discharges from the Parsons Ditch and Central Canal.

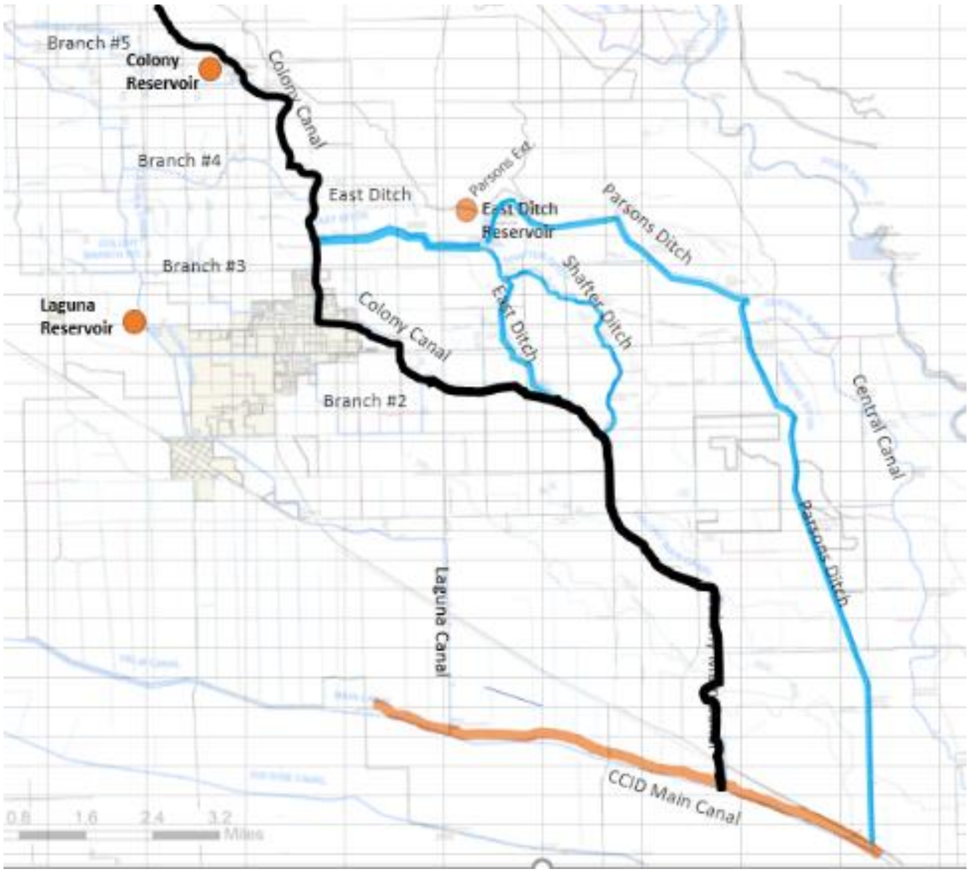


Figure 44. Overview of the existing canals and reservoirs in the Colony Area

The existing conditions are:

1. The Colony Main headworks is shown in Figure 45. One 3' and two 4' wide undershot gates are used manually control the flow into the Colony Main Canal. A flow measurement weir is located about 1,600' downstream of the head gates. Additional photos of the Colony Main Canal diversion are provided in Figure 46, Figure 47, and Figure 48.

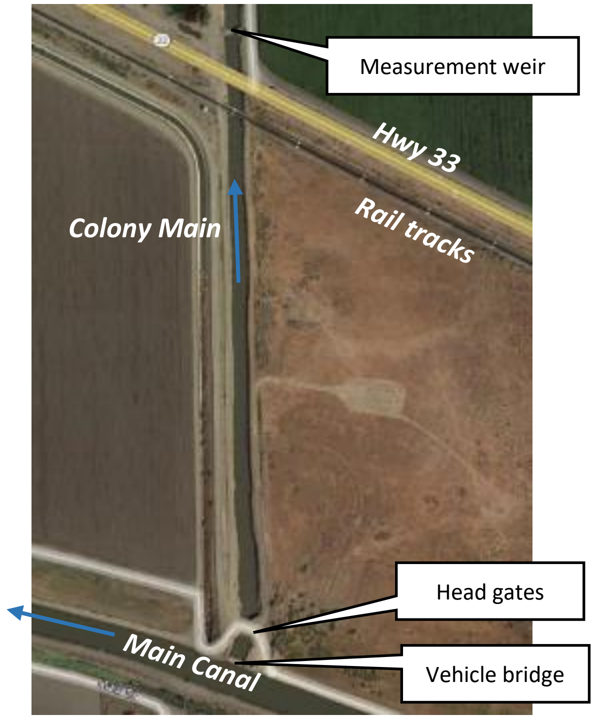


Figure 45. Satellite image of the existing Colony Main headworks

Figure 46. Looking upstream on the CCID Main Canal, with Colony Main Canal headworks on left

Figure 47. Colony Main Canal looking downstream towards the flow control gate just downstream of the headworks structure

Figure 48. Colony Main Canal flow control gates; note the different types of gates and the failing concrete

2. The Colony Main Canal flow rate is measured at a rectangular contracted weir just downstream of the headworks, as shown in Figure 49 and Figure 50.

Figure 49. Colony Main Canal headworks measurement weir, looking downstream

Figure 50. Colony Main Canal headworks measurement weir, looking upstream; not shown is a turnout to the right

3. All the check structures along the Colony Main Canal have flashboards. Most check structures are fitted with multiple ~4.5; wide flashboard bays, as shown in Figure 51. There are, however, some exceptions, as shown in Figure 52. Flow rate changes at the Colony Main Canal headworks and at downstream turnouts require frequent monitoring and adjustment visits to some or all weir check structures. This is a major constraint for flexible management of the Colony Area.

Figure 51. Existing conditions at Custer Check (just upstream of Custer Ave) along the Colony Main Canal

Figure 52. Unique Colony Main Canal 3.265 check structure; a combination of flashboards and a manual radial gate

4. As noted earlier, the Colony Main Canal supplies Shafter Ditch and East Ditch, as well as Branch 2, 3, 4 and 5 Canals. These lateral canal diversions are fitted with a manual canal or sluice gate and an electronic flow meter. The Branch 2 Canal headworks is shown as an example in Figure 53. The other lateral canal headings are generally similar. However, some lack the electronic flow measurement device. At those sites operators use rating tables to estimate the flow rate.

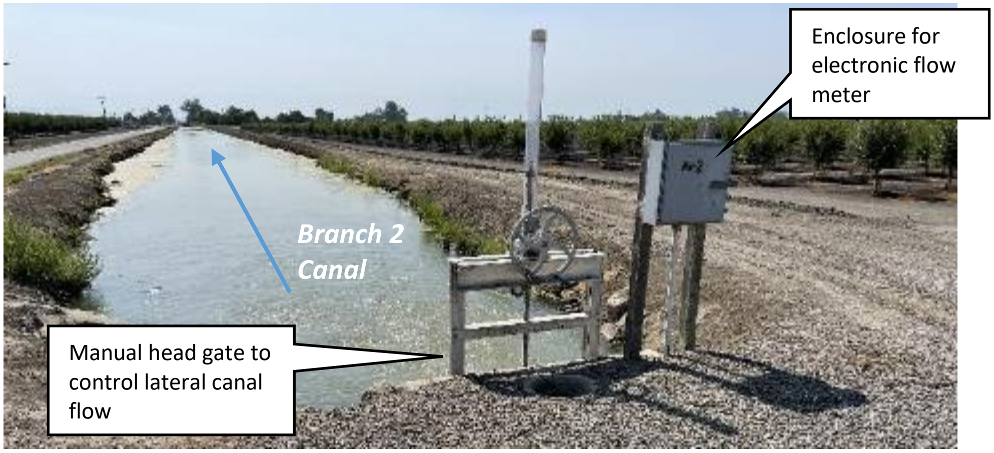


Figure 53. Manual flow control at the head of the Branch 2 Canal.

5. Variable operational spill and/or intentional deliveries enter the Colony Main Canal from the East Ditch.

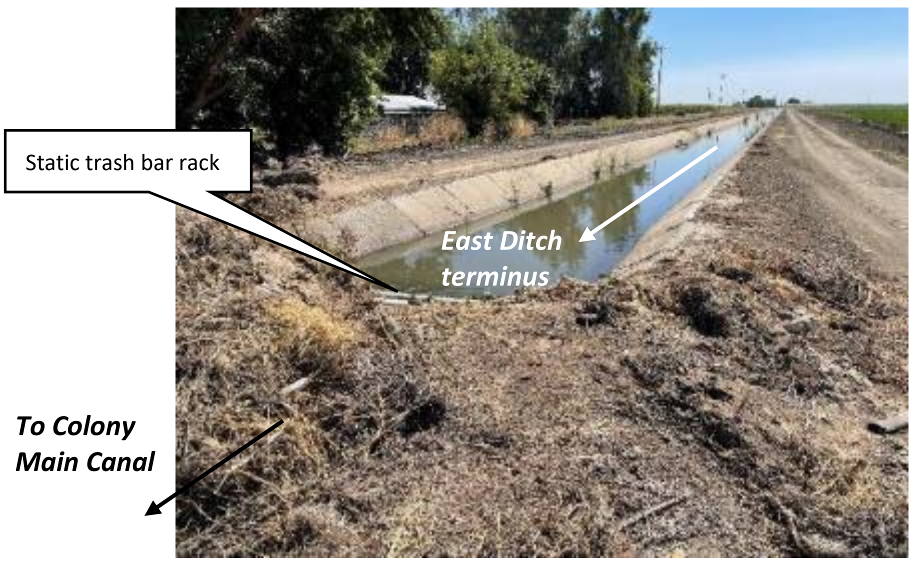


Figure 54. East Ditch terminus looking upstream; excess flow is directed to Colony Main Canal; note the substantial accumulation of aquatic trash, which indicates a need for more automatic trash racks.

6. The existing Colony Main Canal buffer reservoir is located just downstream of the Branch 5 Canal headworks as shown in the map in Figure 55.

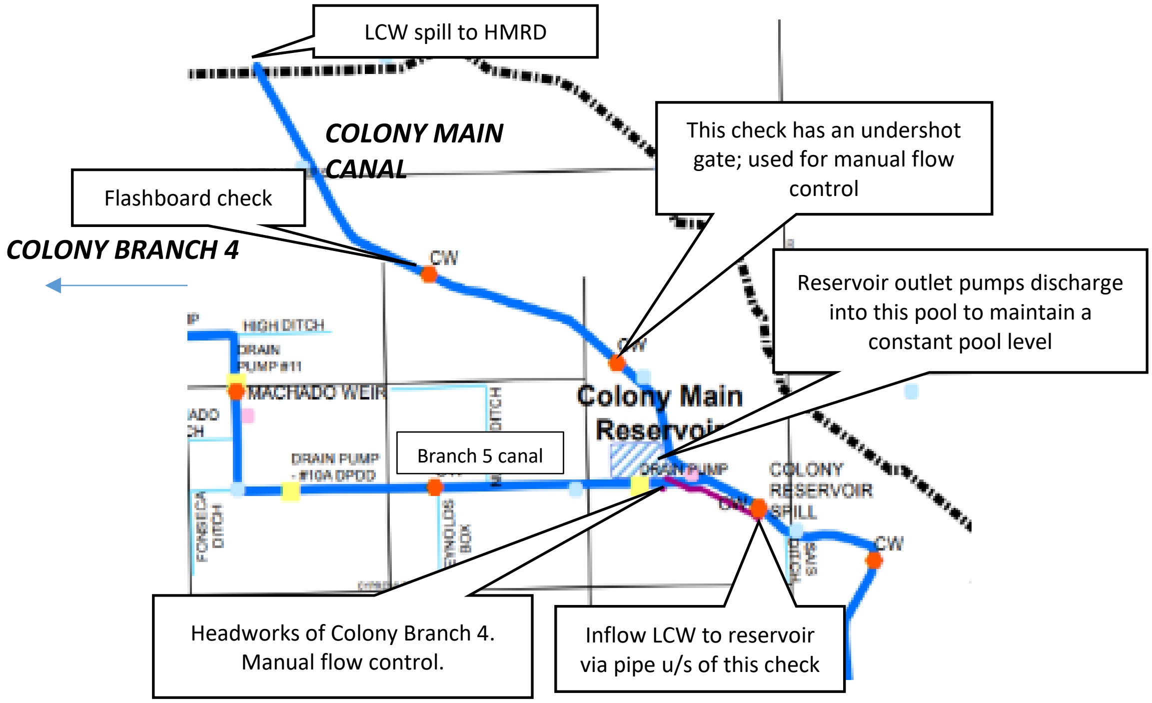


Figure 55. Existing Colony Main Canal Reservoir configuration map

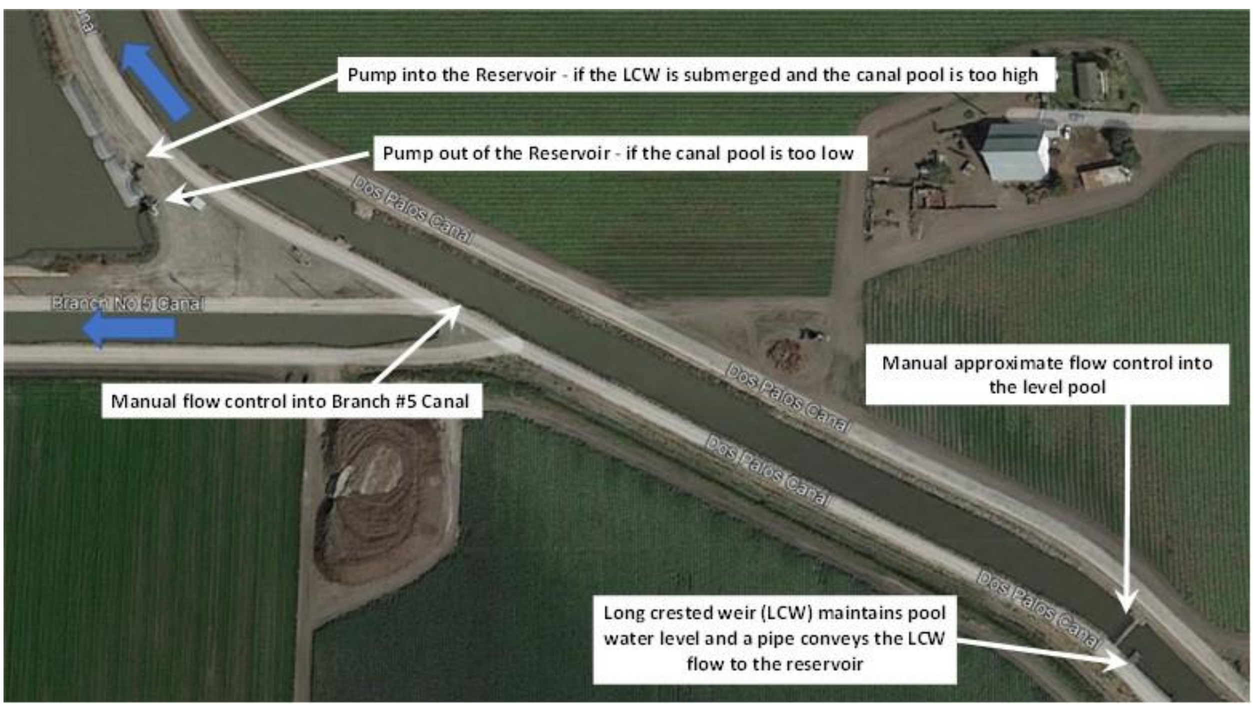


Figure 56. Expanded view of existing control for the Colony Main Canal Reservoir

Photos of the reservoir inlet and outlet structures are shown in Figure 57. The buffer reservoir accepts inflow using two methods:

- Excess flows enter the Reservoir via the LCW located in the pool upstream of the reservoir
- A 30 CFS single speed pump and a flap-check valve were installed previously to increase the operational storage of the reservoir. The pump puts water into the reservoir from the level pool if the reservoir fills so high that the long-crested weir becomes submerged.

The buffer reservoir outflow is controlled by two smaller single speed pumps.

Figure 57. Existing Colony Main Reservoir inlet weir (left) located at an upstream check; Inlet and outlet pumps (right) at reservoir bank

The existing buffer reservoir's automatic control performance is satisfactory but could be improved. On the other hand, the inlet LCW configuration is confusing because the performance of the inlet LCW depends on the placement/adjustment of boards in the adjacent flashboard structure.

7. A flow rate is set at the 13.213 Colony Main Canal structure to meet flow demands downstream of the Colony Main Reservoir.

Figure 58. Colony Main Canal 13.213 structure just downstream of the existing buffer reservoir, looking downstream

8. The tail end of the Colony Main Canal is shown in Figure 59. A LCW controls a safe upstream water level; all excess flows go to HMRD.

Figure 59. Terminus of Colony Main Canal just upstream of HMRD Arroyo Canal

Colony Main Canal – Improvements

Improvement Strategy

The Colony Main Canal operations can be summarized into a few key points:

- Operations are generally labor-intensive because each change requires manual intervention and constant monitoring visits at check structures, in addition to the turnouts.
- Flexibility is becoming difficult to maintain as irrigation scheduling concentrates and then disappears around weekends.
- It is difficult to reduce the flows into the Colony Main Canal when the three downstream reservoirs are filling up; there is a need for more flexibility at the head of the Colony Main Canal.

As such, the recommended improvements are focused on:

1. Increasing flexibility by converting the Colony Main Canal to a superhighway and adding a new regulating reservoir at the head of the Colony Main Canal. Both will allow flow changes (as desired) to reach the Colony Area more quickly.
2. Reducing complexity
3. Reducing operational labor requirements

Improvement Overview

The recommended improvements for the Colony Main Canal are shown in Figure 60.

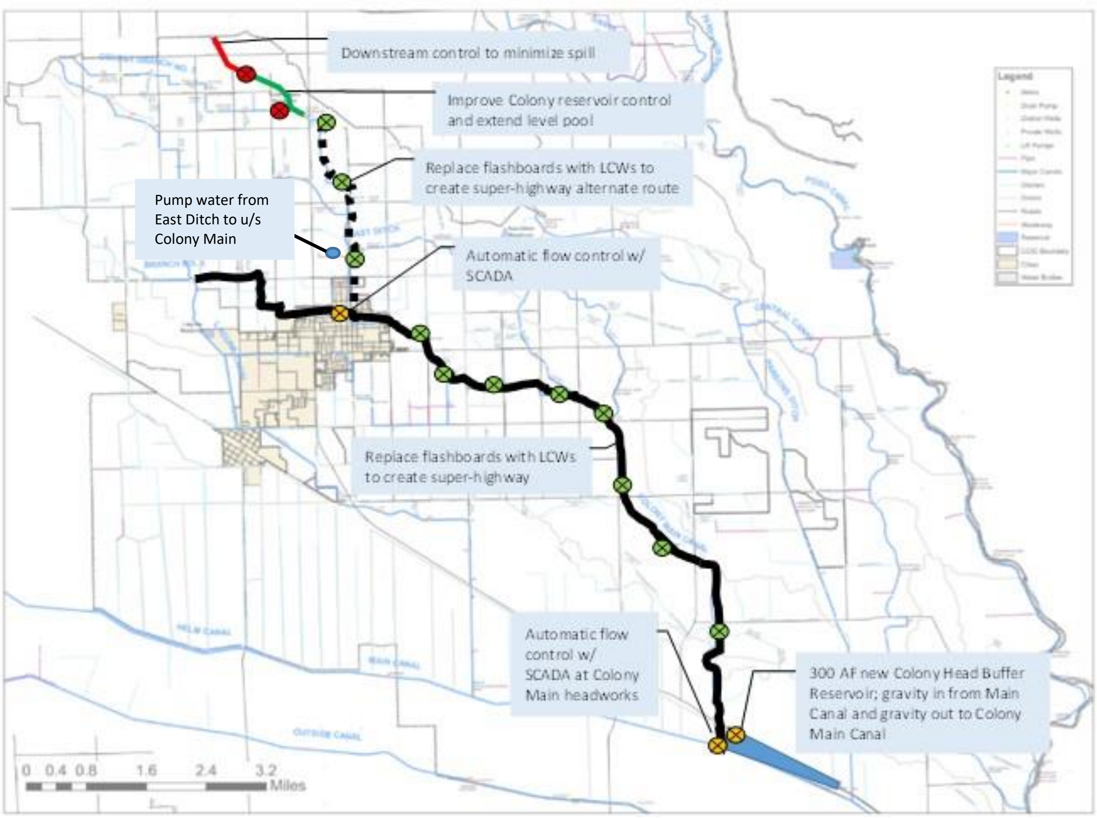


Figure 60. Top Priority Infrastructure recommendation overview for the Colony Main Canal

Overall Details

The Colony Main Canal will be transitioned to a superhighway along with the following recommended major improvements:

Table 9. Major Colony Main Canal modernization recommendations

Item #	Modernization components recommended immediately	Priority	Modernization group (to be implemented together)
1	Install a new RTU at the Colony Main Canal headworks along with other improvements. The new RTU will maintain a relatively constant discharge flow rate.	High	3 (or standalone)
2	Lower the Colony Main Canal headworks measurement weir, along with other improvements	Medium	4
3	Construct a new 300+ AF reservoir to provide buffering for the Main Canal	High (the need for this project will become evident after the proposed Colony Main Canal superhighway is functional)	4
4	Replace the existing 11 Colony Main Canal flashboard check structures with LCWs for improved level control	High	3
5	Install a new single speed pump to lift deliver East Ditch Reservoir excess water to the pool upstream of Branch 3 Canal	High	None
6	Raise and extend the existing Colony Reservoir level pool and banks, along with other improvements	High	5
7	Convert the Branch 5 and tail end of Colony Main Canal to automatic downstream control	High	5

Colony Main Headworks and New Reservoir

Recommendations

Recommendations are:

1. Improve and automate the existing Colony Main Canal headworks for flow control with SCADA monitoring.
2. Construct a new 300 AF buffer reservoir at the Colony Main Canal headworks and lower the existing weir crest.

It appears from an initial survey that there is sufficient head available for gravity flow in and out of the reservoir.

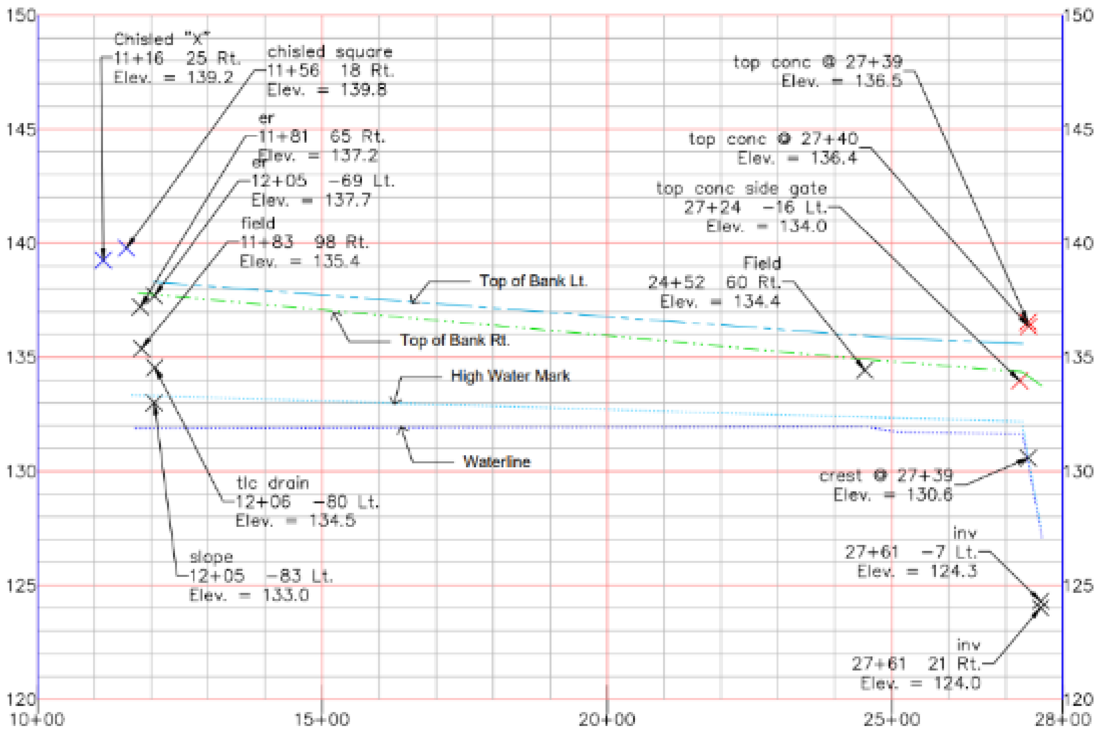


Figure 61. Partial Colony Main Canal profile, starting at the CCID Main Canal (u/s WSE at 137.2' not shown)

Key elevations:

- Main Canal @ Colony Main WSE = 137.2'
- Colony Main:
  - HWM d/s of gates = 133.3'
  - WSE u/s of flow measurement weir = 132'
  - WSE d/s of weir = 127'

Where possible, it is recommended to use gravity (rather than pumps) to control both inflow and outflow to/from the reservoir. It appears there is sufficient head available for gravity flow in both directions, because:

> Main canal water surface elevation = 137.2'
> Elevation downstream of weir = 127'
>
> 137.2' – 127' = 10.2' of total head available between the Main Canal and the Colony Main Canal downstream of the flow measurement weir.

However, the 10.2' of total head available needs to be reduced by 3' to account for:

- Required head over the flow measurement weir at max flow, about 1' max
- The head loss required for each gravity in/outflow structure (there will be two total) for control and flow measurement.

Therefore, practical maximum allowable reservoir stage variation is about 7.2' (10.2'-3'), assuming the existing flow measurement weir crest elevation is lowered to just above the downstream high-water mark.

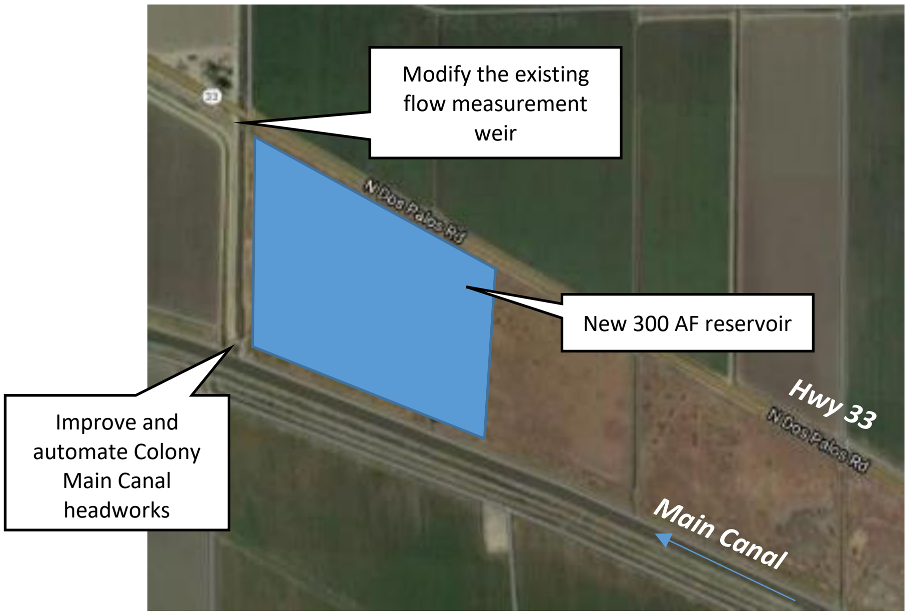


Figure 62. Recommendations for Colony Main Canal headworks

There are several alternative configurations for routing reservoir in/outflows. Each has a unique impact on how the site is operated, as shown in Figure 63.

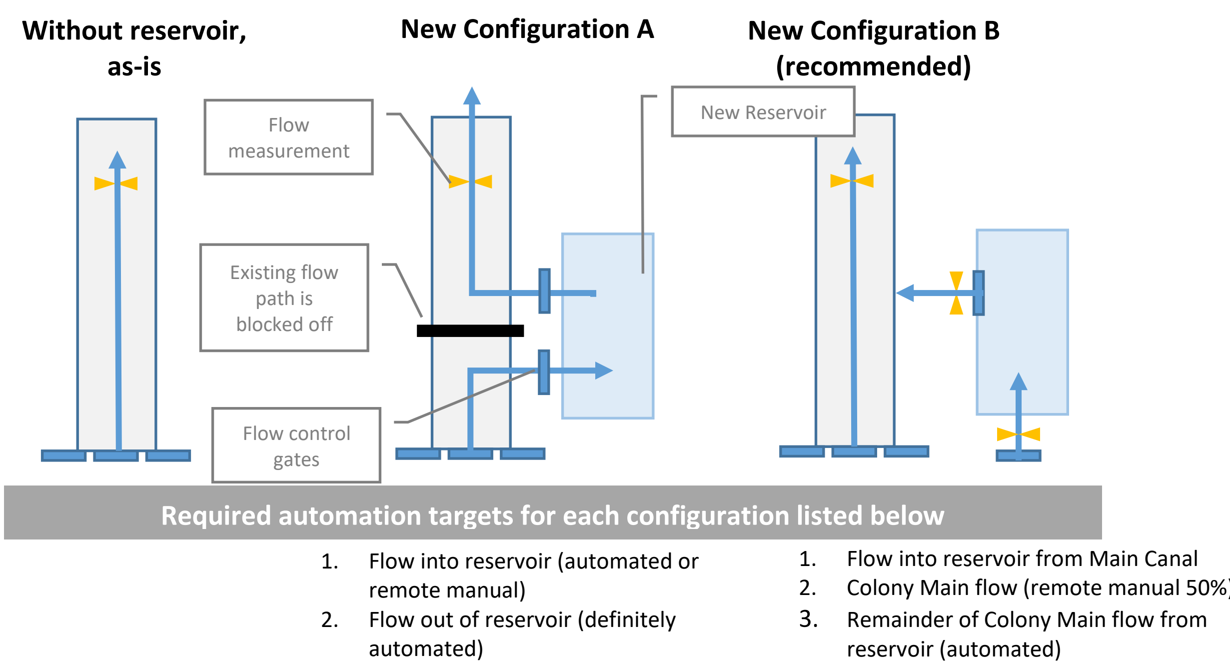


Figure 63. Alternative Main Canal Reservoir configurations

“New Configuration B” is recommended because:

- It enables the reservoir to be cleaned while all the flow is bypassed, as now.
- The inlet/outlet structures for the reservoir can be smaller than Configuration “A.”

Superhighway Water Level Control

The Colony Main Canal will be converted to a superhighway through the following modifications:

- Replace the existing flashboard structures with 12 new LCWs between the Colony Main Canal headworks and the reservoir.
- Implement automatic flow control at the head with remote target set point adjustments (noted previously).

Flow capacities reported by CCID staff for the Colony Main Canal are as follows:

- Max design flow at headworks = 230 CFS
- Typical maximum flow rate at headworks = 140 CFS
- Typical large flow rate change at headworks = 40 CFS

The modifications to the check structures will mirror the recommendations for the Laguna Canal LCW, but with different design capacities, as listed in Table 10.

Table 10. Colony Main Canal long-crested weir design recommendations, assuming there is a minimum of 0.5’ of elevation drop across the existing structure (TBD by future survey). Make the wooden crest at the upstream high water mark elevation, minus 0.5’.

Weir number	Minimum total weir crest length, ft	Design capacity over weir with 0.5’ over crest and no downstream submergence (CFS)	Weir facing ______	Flushing canal gate size, inches
1	200	200		36
2	200	200		36
3	200	150		36
4	200	150		36
5	150	100		30
6	150	100	Downstream	30
7	100	100		24
8	100	100		24
9	80	80		18
10	60	60		18
11	60	60		18
12	Existing flashboard check to be removed and eliminated; downstream pool will be raised			

A conceptual plan view drawing in Figure 64 shows the proposed LCW design.

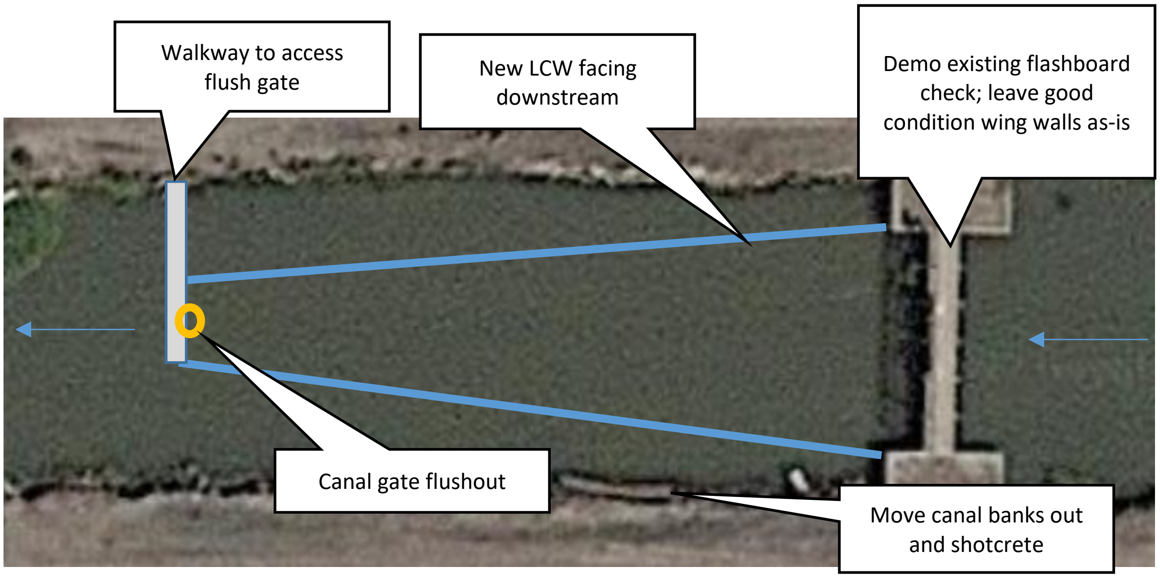


Figure 64. Conceptual LCW design for Colony Main Canal at Custer check, but similar throughout, plan view

Lift Pump

The existing East Ditch Reservoir is frequently full. It is recommended to install a new 15 CFS single speed pump in the location shown in Figure 65. This idea was mentioned by CCID staff. It is complementary to the other modernization recommendations.

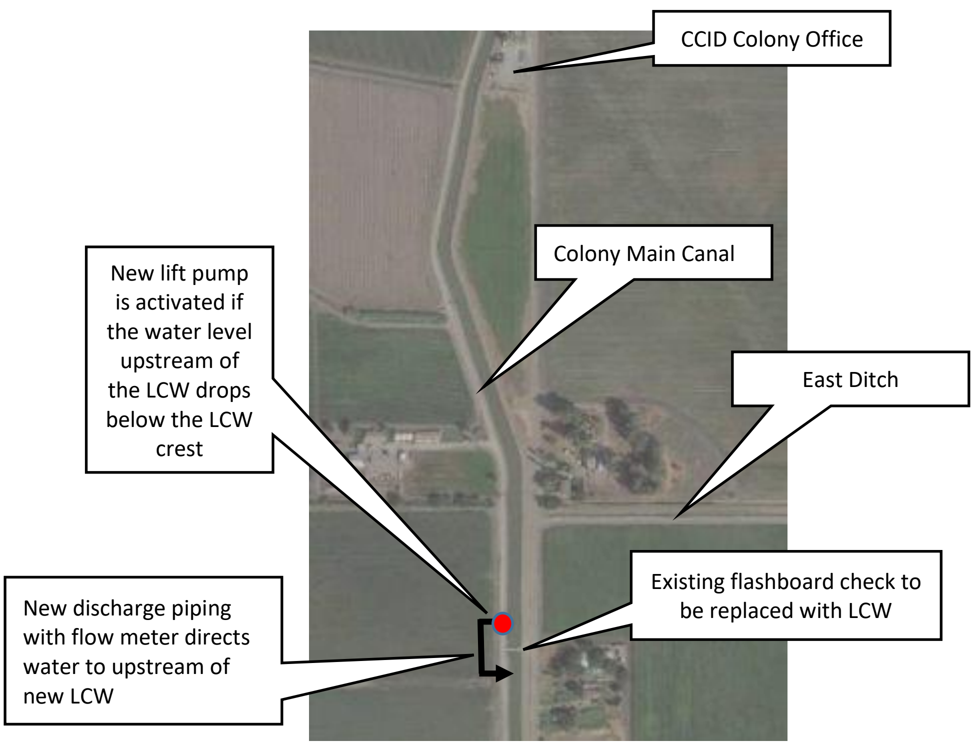


Figure 65. Recommended Colony Main Canal lift pump and discharge locations

Installing the lift pump is expected to increase the available irrigated area that can be supplied by the excess East Ditch water, as shown in Figure 66.

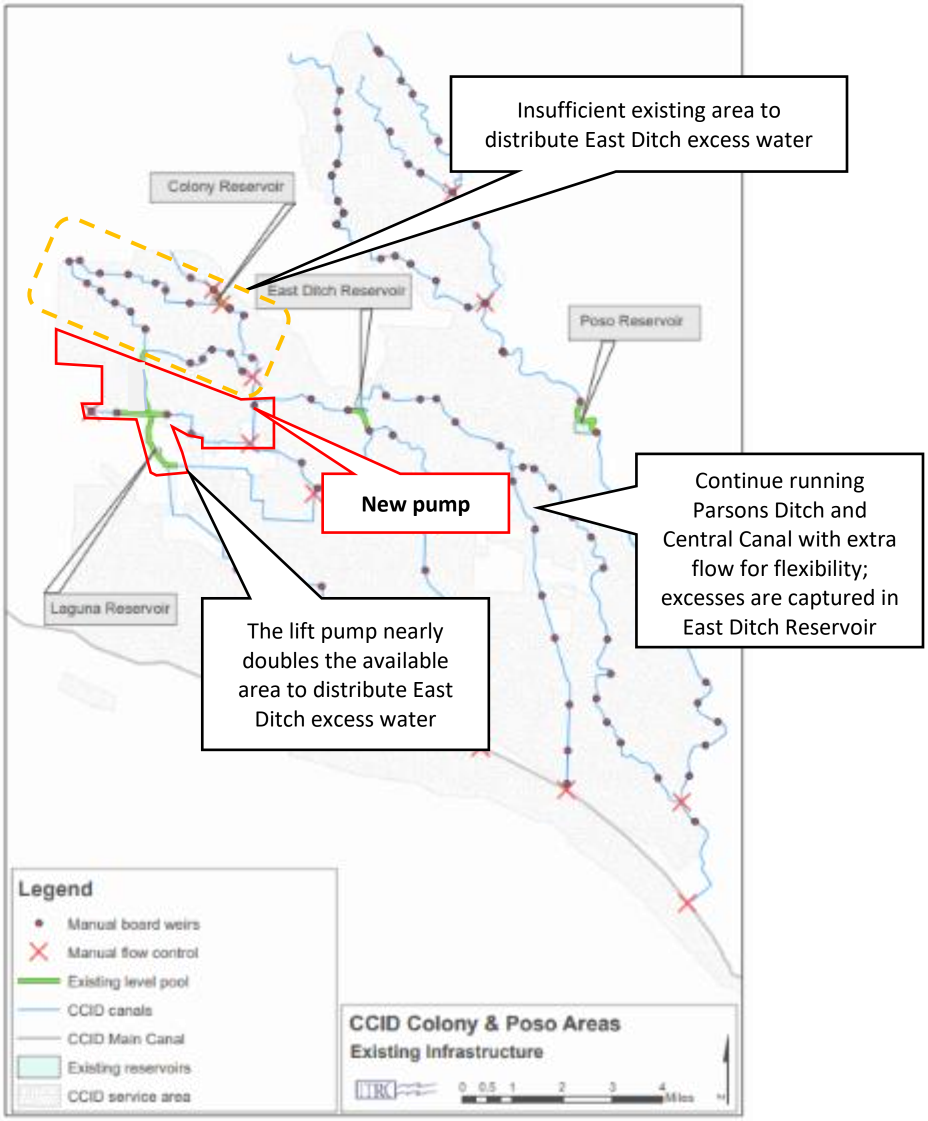


Figure 66. Existing system limitations contrasted with benefits of proposed lift pump in Colony Main Canal

The routing of excess East Ditch water to the Colony and Laguna Canals is illustrated in Figure 67.

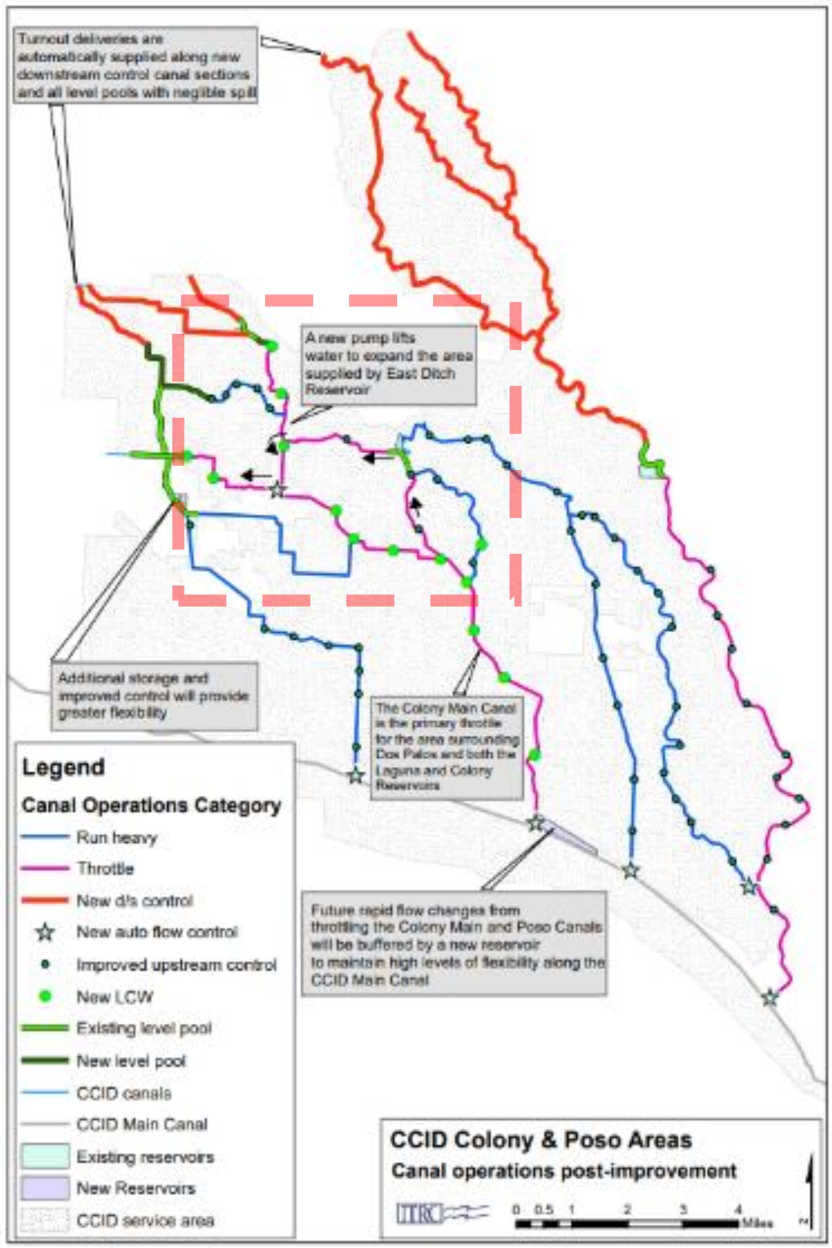


Figure 67. Proposed routing (black arrows) of excess East Ditch reservoir water to Colony Main and Laguna level pool systems

Additional pump recommendations and details:

1. The pump will be a vertical turbine, single speed. The installed design capacity will be 15 CFS, which enables a transfer up to about 30 AF (roughly 30% of the East Ditch Reservoir total storage capacity) from East Ditch Reservoir west, to the Laguna Canal and the new level pool system for deliveries.
2. A new RTU will be installed to provide remote manual pump control. Contact switches will be installed to automatically turn the pump off in the event of a downstream high-water level or low sump level. The new RTU will monitor the pump status, standard single speed pump alarms, as well as an integrated flow meter for monitoring.

Colony Reservoir – Existing Conditions

The existing Colony Main Canal terminates downstream of the Colony Reservoir. The reservoir is intended to automatically maintain the water level in the Colony Main pool adjacent to the reservoir. Descriptions of the operation in/out of the reservoir were presented previously in Figure 55 through Figure 59. Some of the existing infrastructure details are highlighted again in Figure 68.

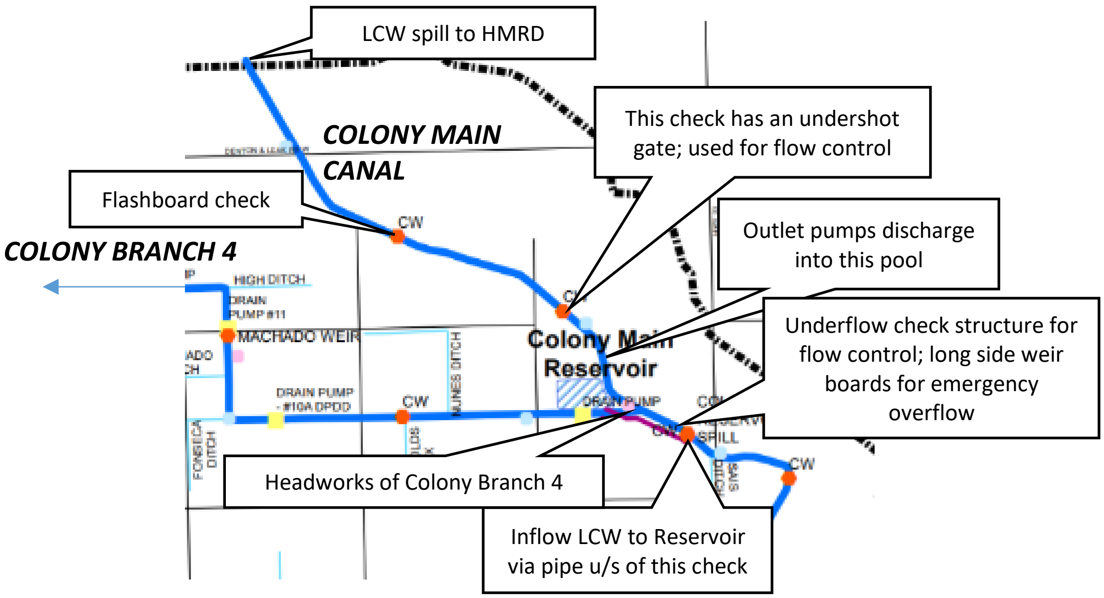


Figure 68. Major existing canal operations along the Colony Main near the Colony Reservoir

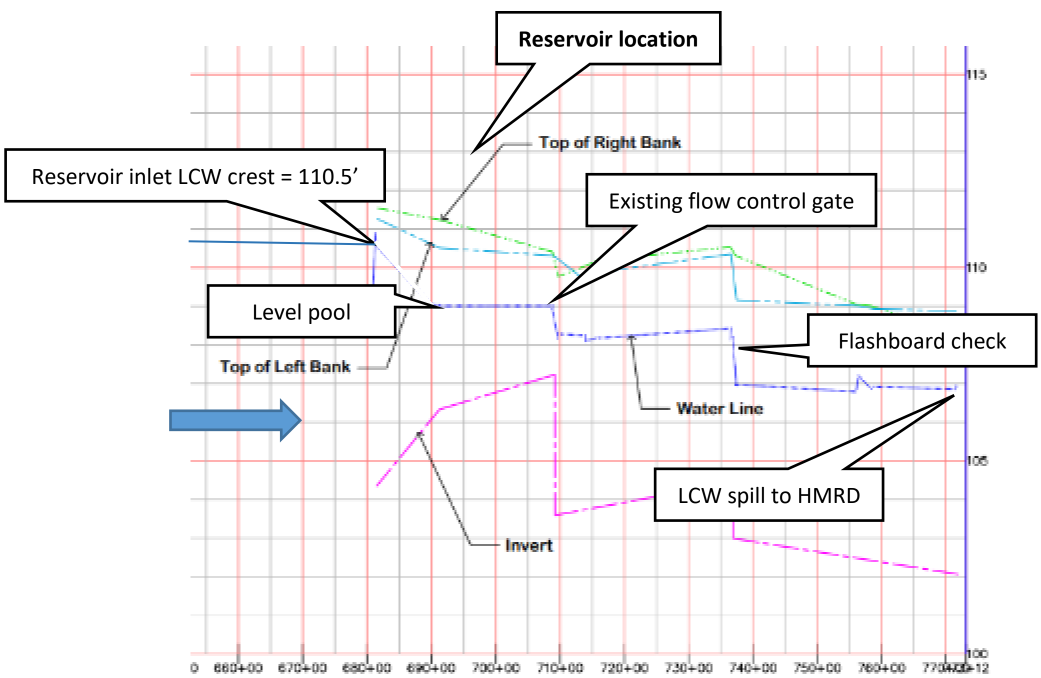


Figure 69. Existing Colony Main canal profile at tail end near Colony Reservoir

Existing Issues

Issues with the existing infrastructure and operations in the area are as follows:

- It is unclear how:
    - flow is measured into the tail-end of the Colony Main Canal, downstream of the reservoir
    - the reservoir inlet LCW is supposed to function in parallel with the adjacent flashboard check structure. Because both are overflow structures, excess flows passively continue in both directions (without constant monitoring and adjustments) despite the typical idea of directing all excesses into the reservoir.
- The area requires frequent visits and attention from operators because the control structures are largely manual, except for the existing reservoir in/out.

Terminal Area of the Colony Main Canal – Recommendations for the Canal Profile

The recommendations for the tail-end of the Colony Main Canal can be seen in the following figure.

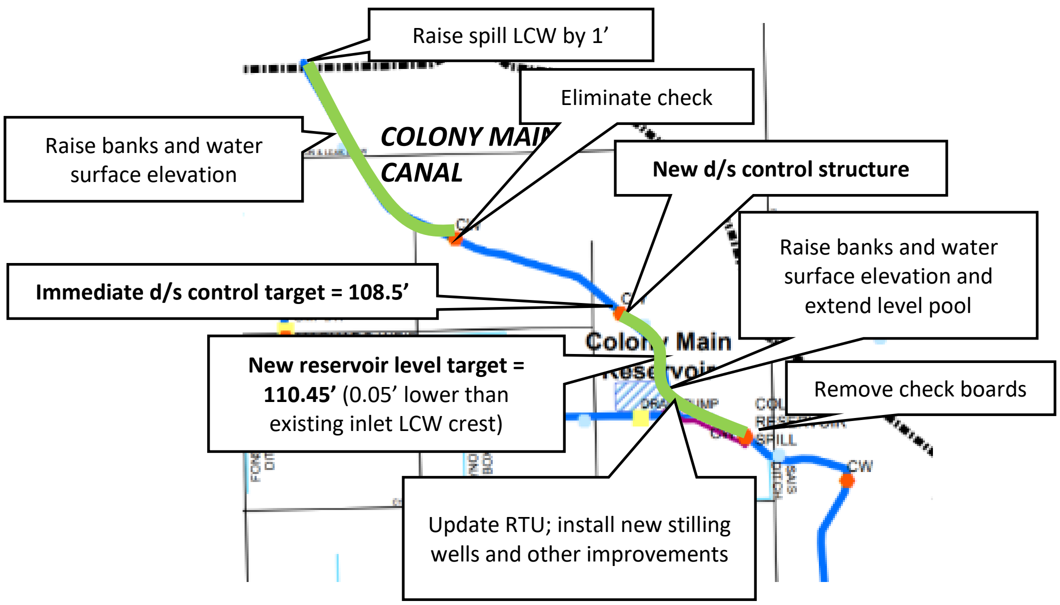


Figure 70. Major recommendations along the Colony Main near the Colony Reservoir

The details are:

1. Raise the canal banks (1.5'-2’) for the pool adjacent to the reservoir to an elevation of around 112’, starting at the existing flow control/emergency overflow structure upstream of the reservoir, down to the existing flow control gate at the downstream end of that pool. This pool is about 2,500’ long.
2. Raise the reservoir’s canal water level target to 110.45’ or 0.05’ below the existing LCW weir crest.
3. Construct a new downstream water level control structure to replace the existing flow control gate downstream of the reservoir (described in more detail later). Install a new RTU to automatically maintain an immediate downstream level target elevation. The downstream target water level = 108.5’.
4. Raise the banks upstream of the LCW spill (to HMRD) to 109’ or higher.
5. Raise the spill LCW structure by about 1’ to accommodate the raised pool upstream.
6. Eliminate the check structure just upstream of the spill LCW (to HMRD).

7. Remove/replace the existing canal lining. Several major failures are visible and are expected to worsen without mitigation.
8. Clean and reshape the modified Colony Main Canal downstream of the reservoir.

The canal profile after implementing the recommendations is provided in Figure 71.

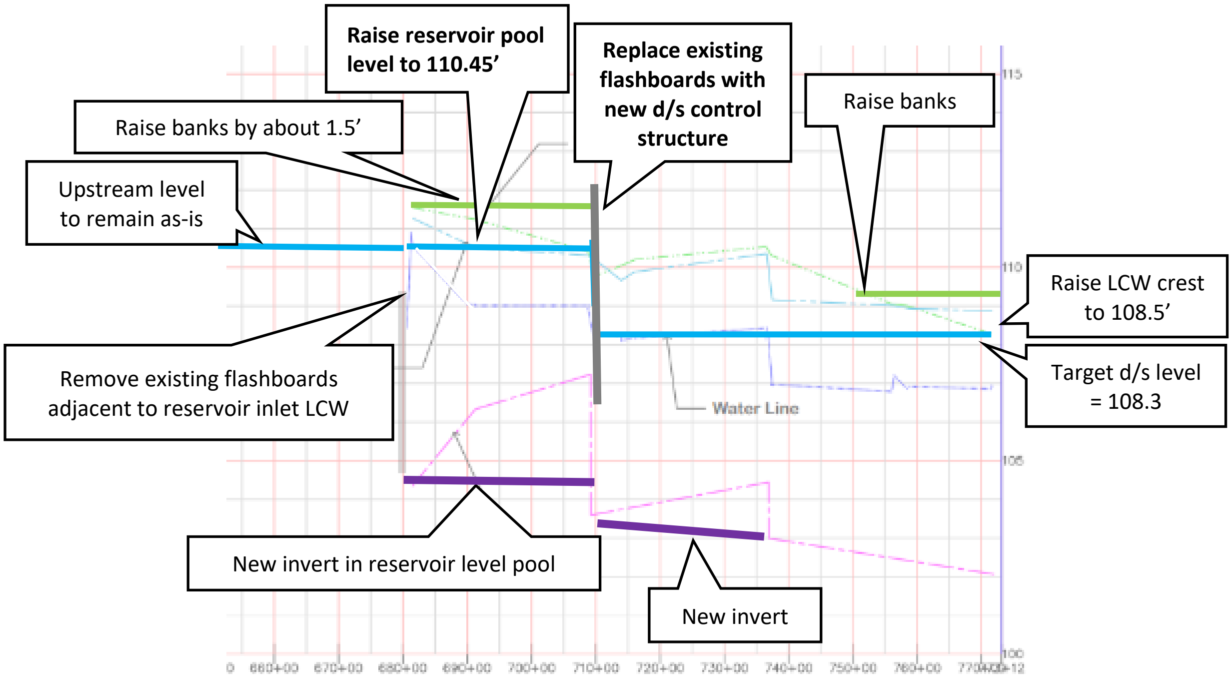


Figure 71. Colony Main Canal profile after modifications

Additional Details for the Colony Reservoir and the Adjacent Colony Main Canal

Colony Reservoir – Recommendations

Recommended modifications in the reservoir and in the adjacent level pool are seen in the following figures.

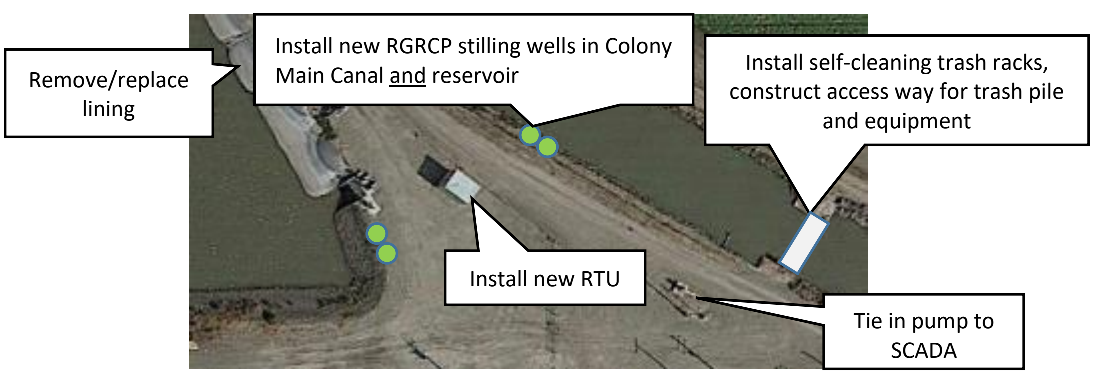


Figure 72. Recommended modifications to the Colony Main Canal pool and Colony Reservoir, plan view

Figure 73. Recommended modifications to the Colony Main Canal pool adjacent to the Colony Reservoir

The Colony Reservoir will receive the following upgrades:

1. Upgrade the existing RTU with new hardware and updated logic for the new, expanded (and raised) level pool. The new level target is 110.45’. Include modern CCID standard inputs/outputs for monitoring/control, including the adjacent pump.
2. Install new 36” RGRCP stilling wells in the Colony Main Canal and reservoir.
3. Construct a new, raised headwall for the inflow pump inlet structure.
4. Raise the flow meters currently installed in the outlet pump discharge pipes.

Downstream Colony Main Canal Control Structure Recommendations

The existing flashboard/sluice gate structure just downstream of the Colony Main Canal Reservoir will be modified for automatic downstream level control. The recommended modifications are listed below and shown in Figure 74.

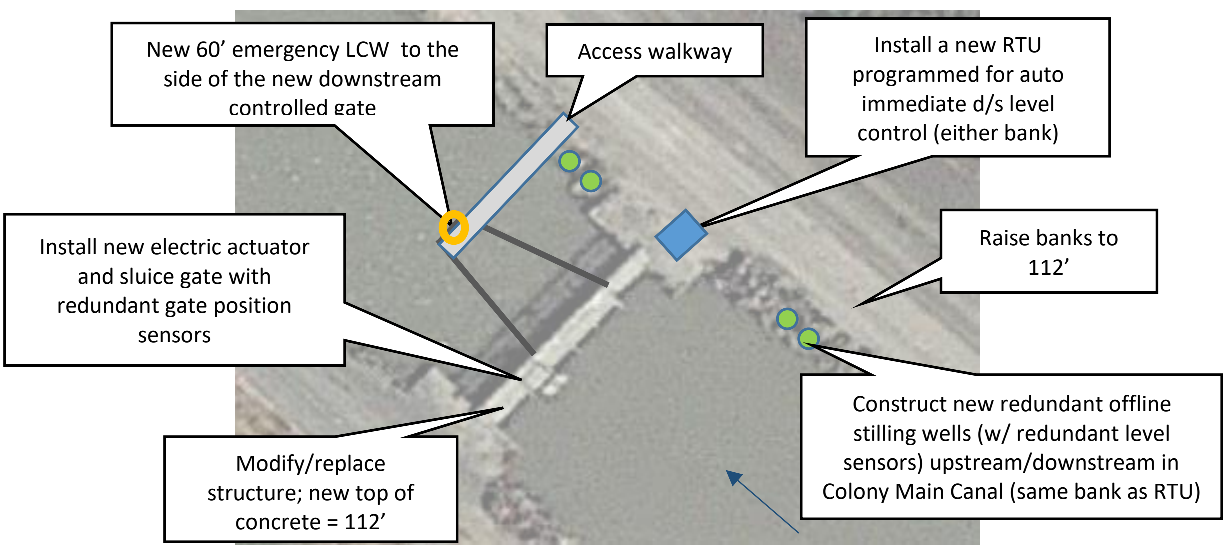


Figure 74. Proposed modifications to the existing flashboard check structure downstream of the Colony Main Canal Reservoir, plan view

1. A new electronic actuator will be installed on the existing ~42” wide gate. This gate may need to be removed and placed into a new structure because the existing structure needs to be raised.

2. A new RTU will be installed and programmed to automatically maintain a relatively constant target water level, immediately downstream of the gates. The preliminary target downstream water surface elevation is 108.3’. Fit the RTU in an enclosure or small block building on either bank.
3. New redundant offline stilling wells will be installed upstream and downstream, each fitted with redundant water level sensors.
4. The concrete structure will:
   a. Be modified, or replaced and raised to 112’ (110.1’ currently) to enable an upstream water level target of 110.45’.
   b. Feature a new additional emergency 60’ LCW with a crest elevation of 110.65’. The LCW is strongly recommended here to provide excellent emergency spill capacity for the Colony Main Canal, through to the spill weir at the tail end. This will be especially beneficial once the Colony Main Canal is operated as a “superhighway” to mitigate risk associated with more frequent and greater in magnitude flow changes. The LCW will be fitted with an 18” flush out gate.

Tail End Spill Modifications

The LCW spill structure at the tail end of the Colony Main Canal will be modified for a higher upstream operating water level, as shown in Figure 75.

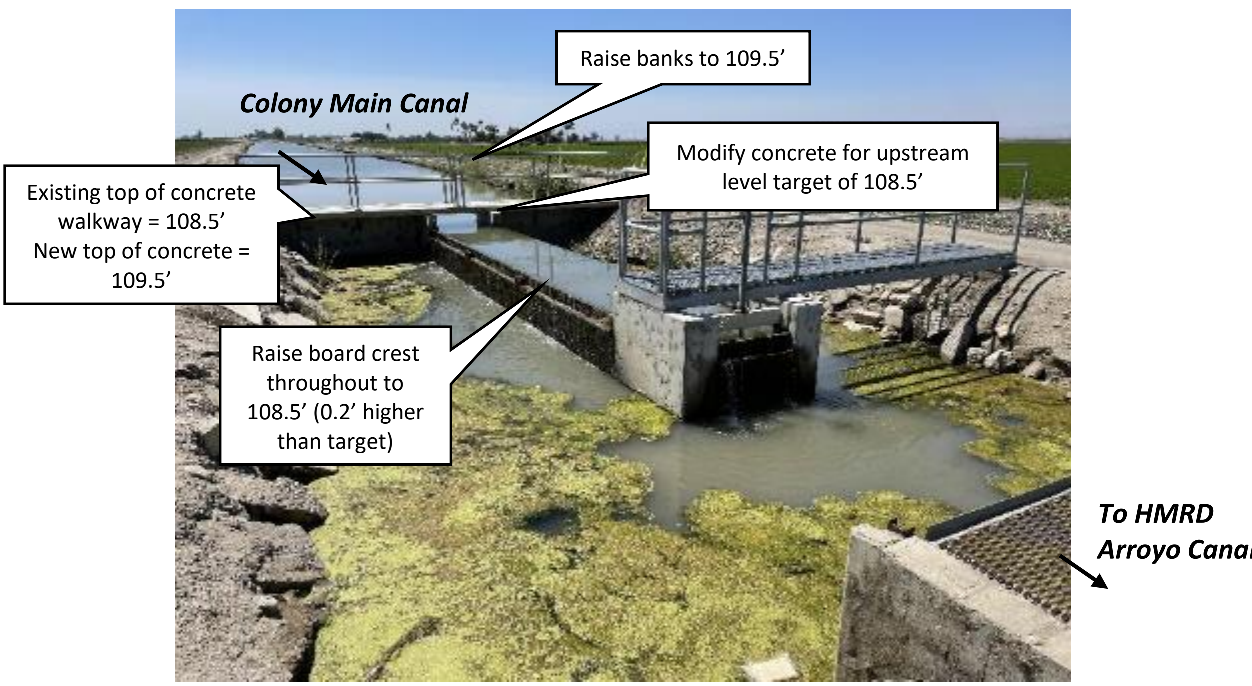


Figure 75. Recommended modifications to the tail end spill structure of Colony Main Canal, just upstream of HMRD Arroyo Canal

Colony Branch 3 – Existing Conditions

An overview of existing conditions along the Colony Branch 3 Canal is shown in Figure 76.

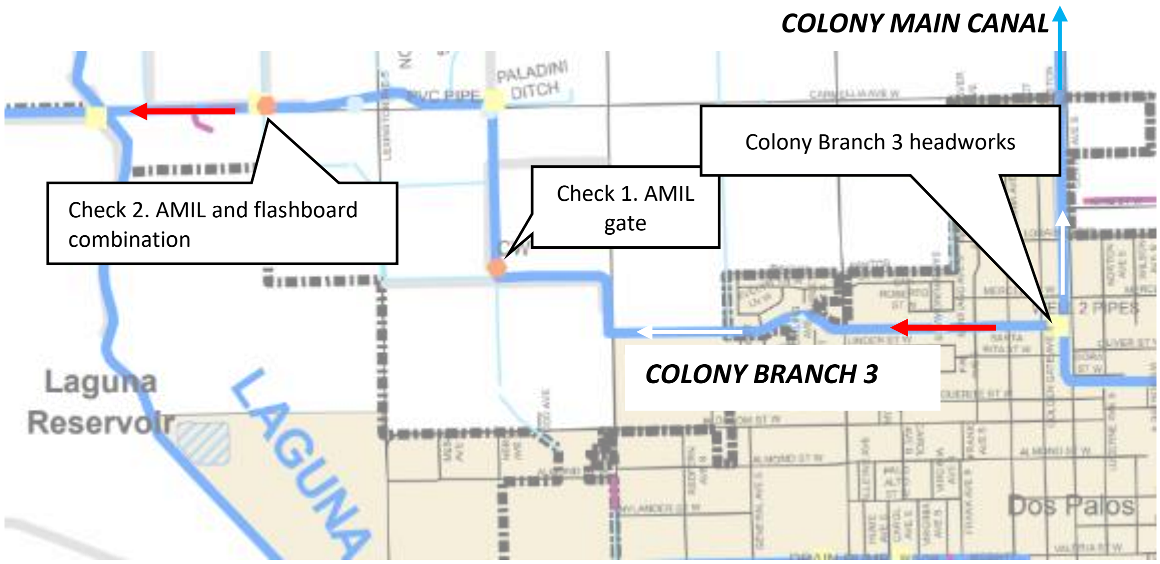


Figure 76. Colony Branch 3 canal plan view

A canal profile for Colony Branch 3 is shown in Figure 77.

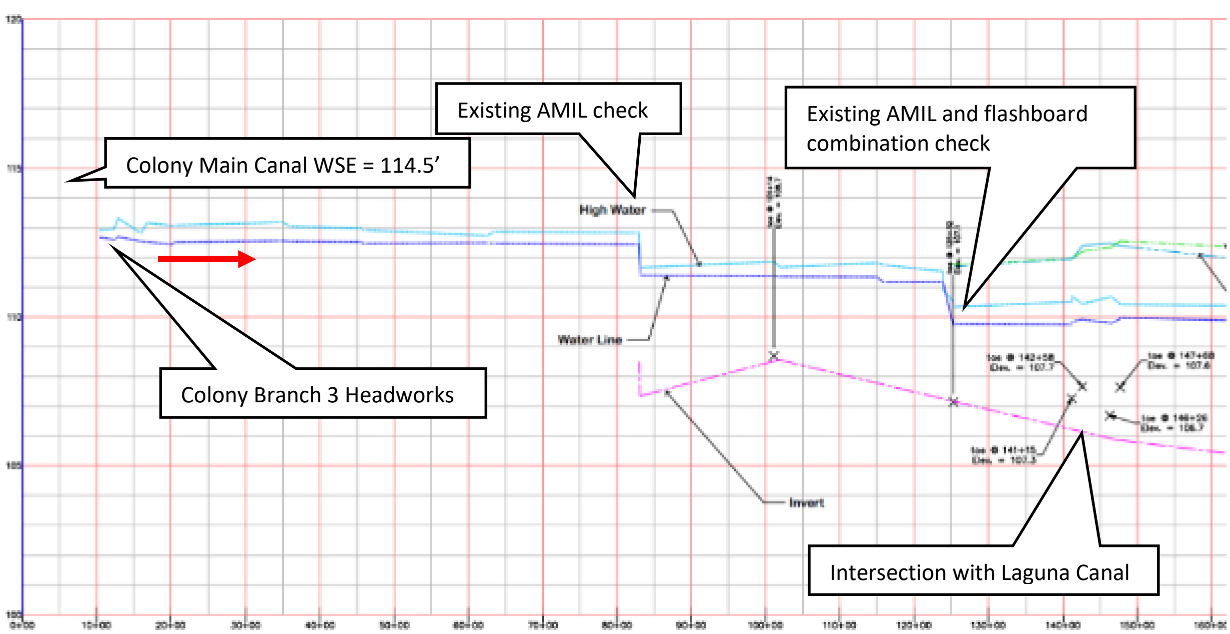


Figure 77. Colony Branch 3 canal profile (flow from left to right)

Branch 3 Headworks

The existing Branch 3 headworks is shown in Figure 78. The site features two 30” manual canal gates. Flow measurement is provided by one or more Doppler meter devices.

Figure 78. Existing Branch 3 Headworks gates, looking downstream

The highwater mark elevations across the structure are as follows:
- Upstream = 114.5’
- Downstream = 113’

The available head loss across the structure is 1.5 feet.

Check 1 AMIL (station 82+50)

The existing 9’4” wide AMIL gate is installed at station 82+50, as shown in Figure 79.

Figure 79. Two views of the existing AMIL gate check along Colony Branch 3 at station 82+50

There is typically about 1 foot of head loss across the gate. The gate was intended to provide automatic upstream water level control. However, operators find it necessary to manually adjust or fix the gate position, which indicates the gate is not balanced correctly. ITRC can help with field balancing. It is a two-step process that must be done when the flow rate is about 10% of maximum or less.

Existing AMIL / Flashboard Combination Check (station 125+00)

The existing 6’9” wide AMIL gate is installed in parallel with a 42-inch-wide flashboard section at station 125+00, as shown in Figure 80.

Figure 80. Two views of the existing AMIL gate check along Colony Branch 3 at station 125+00

There is also about 1 foot of head loss across the structure. Similar to the check further upstream, the AMIL gate has been problematic and is currently disabled from functioning automatically. It may be possible for ITRC to rebalance this gate as well.

Existing Issues

Under the proposed operational strategy, Branch 3 will be used to provide rapid supplementation to the expanded Laguna Reservoir. To provide this, the following are needed:

- Relatively constant target flow rates, that can be maintained and adjusted remotely
- Excellent water level control throughout
- Accurate and robust flow measurement at the headworks

The existing conditions along Branch 3 do not provide those characteristics. Furthermore, the existing AMIL gates are non-functional (manually disabled) reportedly due to poor water level control performance.

Branch 3 Canal Improvements

Table 11 summarizes the major recommendations along Colony Branch 3.

Table 11. Major Branch 3 Canal modernization recommendations

Item #	Modernization components recommended immediately	Priority	Modernization group (to be implemented together)
1	Construct a new automatic flow control structure at the headworks; install a new RTU	High	6
2	Replace both existing check structures with LCWs. *Note: This should only be done after ITRC determines if the gates are merely balanced improperly, which is a common problem.*	High	6

The following points provide additional detail:

1. Complementary changes to Branch 3 Canal operations will be:
    a. The headworks will supply turnouts, so the average delivery flow rate will be lower. Instead, Laguna Canal will be operated with extra flow to supply demand along the newly expanded level pool.
    b. The spare canal capacity will be used to transfer excess water from the East Ditch Reservoir when needed, to areas of demand along the:
        i. Laguna Canal
        ii. section of the Branch 4 Canal downstream of the existing Laguna Canal spill point
        iii. newly expanded Laguna Reservoir
2. The headworks should be automated to maintain a relatively constant target flow rate into the Branch 3 Canal. The recommendation is to construct a new headworks structure with a suppressed sluice gate design that is pre-calibrated for flow measurement; this will eliminate the doppler measurements.
3. Replace both existing check structures with LCWs (Station 85+50 and 125+00).

A map of the recommendations is provided in Figure 81.

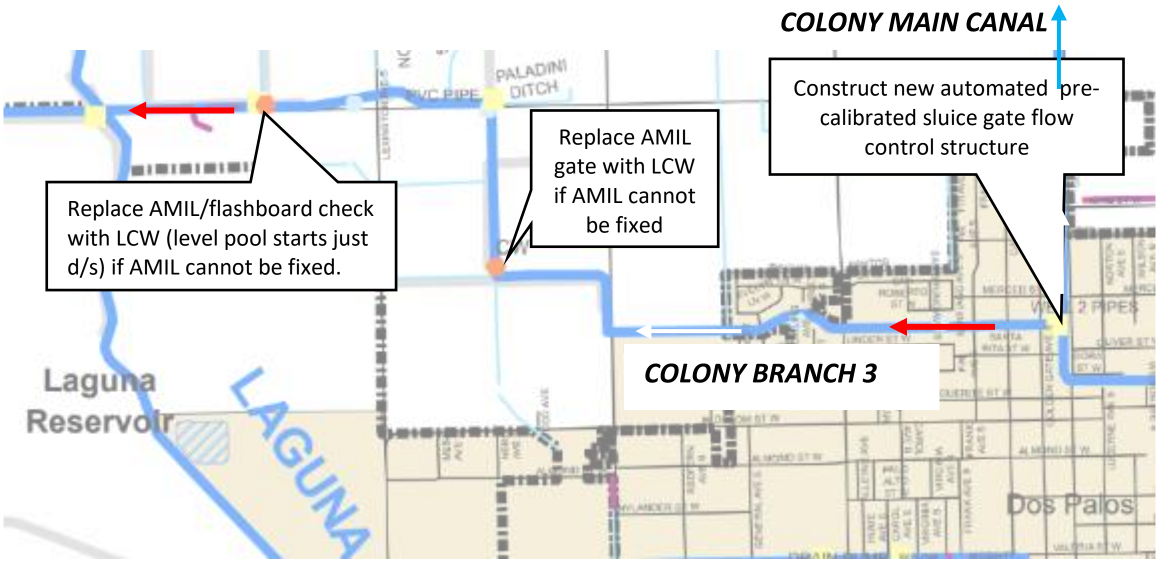


Figure 81. Recommended improvements to Branch 3 Canal

Branch 3 Headworks

The following improvements are recommended at the Branch 3 headworks:

1. A new RTU will be installed to automatically maintain a relatively constant target flow rate.
2. Replace the existing structure with a suppressed sluice gate flow control structure. A conceptual structure example is provided in Figure 82, followed by additional design recommendations. The suppressed sluice gate structure is more robust than the existing configuration of canal gates and flow meters because:
    a. The flow rate is continuously computed based on measurements conducted by redundant commodity-type (gate position and water level) sensors rather than less available and more expensive flow meters.
    b. In the event of electronic failure, the flow rate can still be computed based local on measurements with an engineering tape measure.

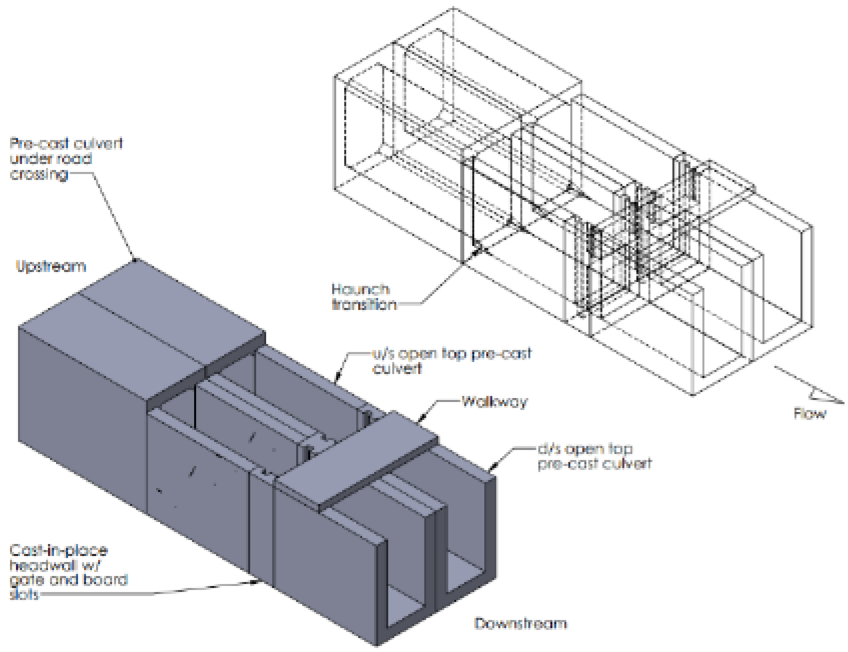


Figure 82. Conceptual isometric view of the recommended Branch 3 headworks flow control structure; angled downstream headwalls not shown for clarity

Additional design recommendations for the Branch 3 flow control structure are:

1. Design capacity = 50 CFS
2. Number of electronically actuated rectangular sluice gates = 2
3. Individual gate open flow area dimensions = 3’ wide × 2’ tall
4. Gate and channel invert elevation = 108.7’
5. Install standard, redundant 36” CCID RCP offline stilling wells to monitor Colony Main Canal and Branch 3 Canal water levels
6. Install a floating boom to deflect debris away from the Branch 3 Canal headworks, so that the trash can remain and be collected in Colony Main Canal by automatic trash screens downstream.
7. Redundant sensor pairs: upstream level, downstream level, gate position 1, and gate position 2

These recommendations are shown in Figure 83.

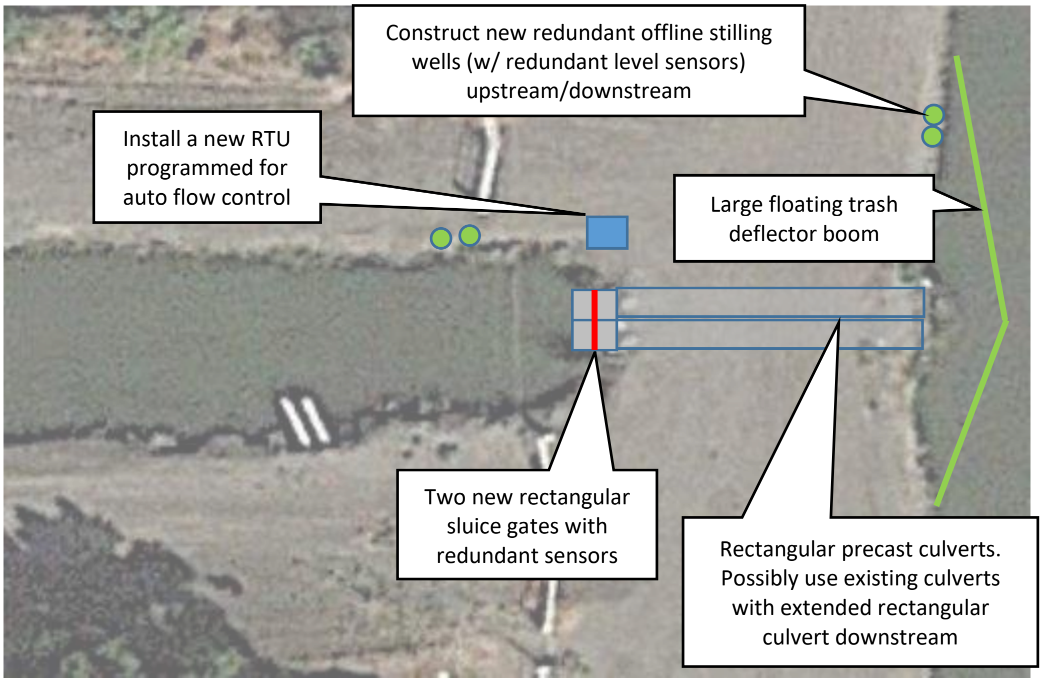


Figure 83. Conceptual design for a new flow control structure at Branch 3 Canal headworks, plan view

Branch 3 Check Structure Replacement

LCW weir design recommendations are provided in Table 12.

Table 12. Branch 3 Canal LCW structure recommendations, to replace existing AMIL gates

Colony Branch 3 Station	Total structure design capacity, CFS	Flush out gate flow capacity, CFS	Remaining design flow over LCW, CFS	LCW crest length, ft	LCW crest elevation, ft	Max u/s WSE with no flow through flush out gate, ft	Flush out canal gate size, inches
85+50	50	15	35	40	112.5	113.1	24
125+00	40	5	35	30	111	111.6	18

Conceptual schematics for the LCWs are shown in Figure 84 and Figure 85.

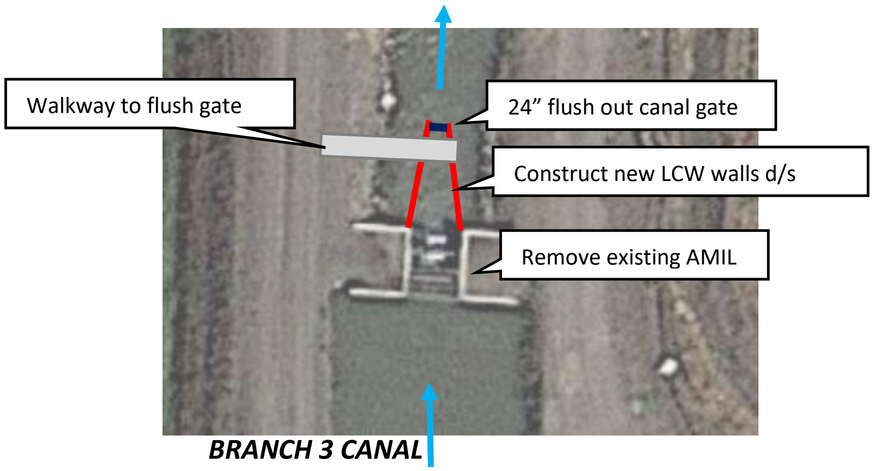


Figure 84. Conceptual LCW design to replace the existing AMIL gate check at Branch 3 Canal station 82+50

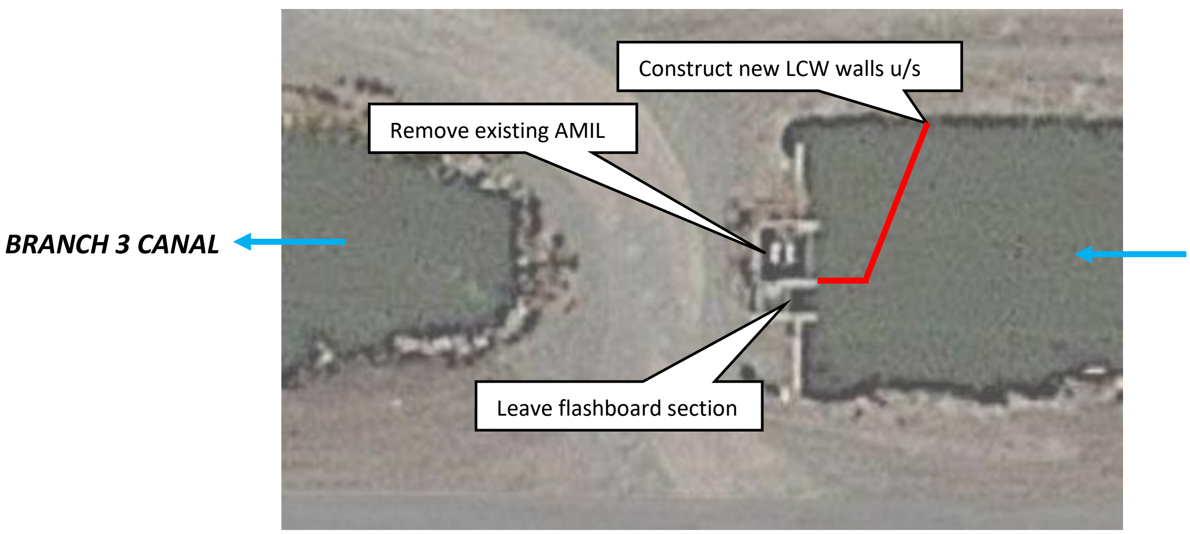


Figure 85. Conceptual LCW design to the existing AMIL gate check at Branch 3 Canal station 125+50

Branch 4 Canal – Existing Conditions

Existing conditions at Branch 4 are shown in Figure 86 and described below.

1. The Colony Branch 4 Canal is currently operated under upstream level control where:
    a. A target flow rate is set at the canal headworks
    b. The water level in each canal pool is maintained by flashboard check structures.
2. Variable spill inflows enter the Colony Branch 4 Canal from the tail end of the Laguna Canal.
3. Excess flows are spilled at the tail end into the HMRD Arroyo Canal.
4. Branch 4 is sometimes used to supply water to tail end turnouts along the tail end of Branch 5.

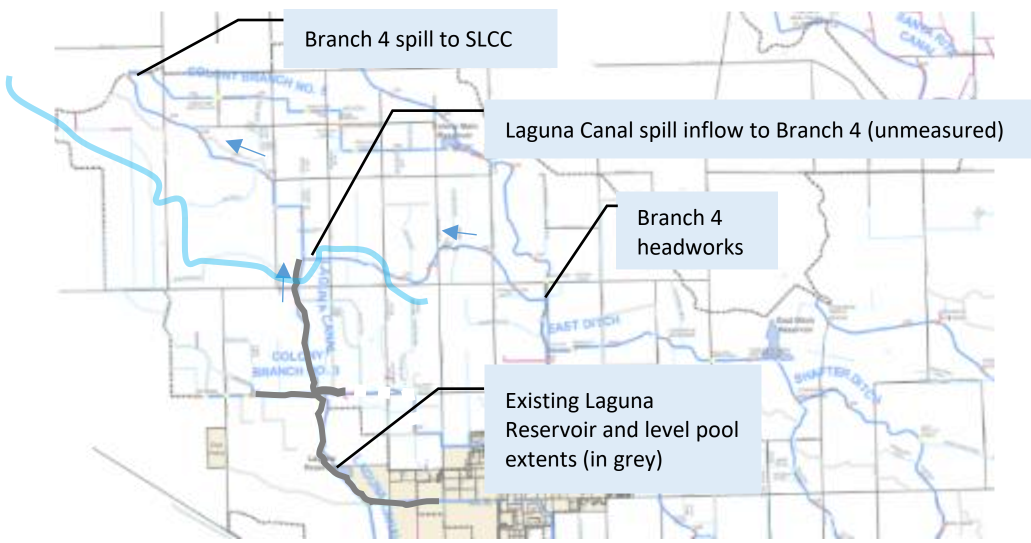


Figure 86. Colony Branch 4 Canal existing conditions

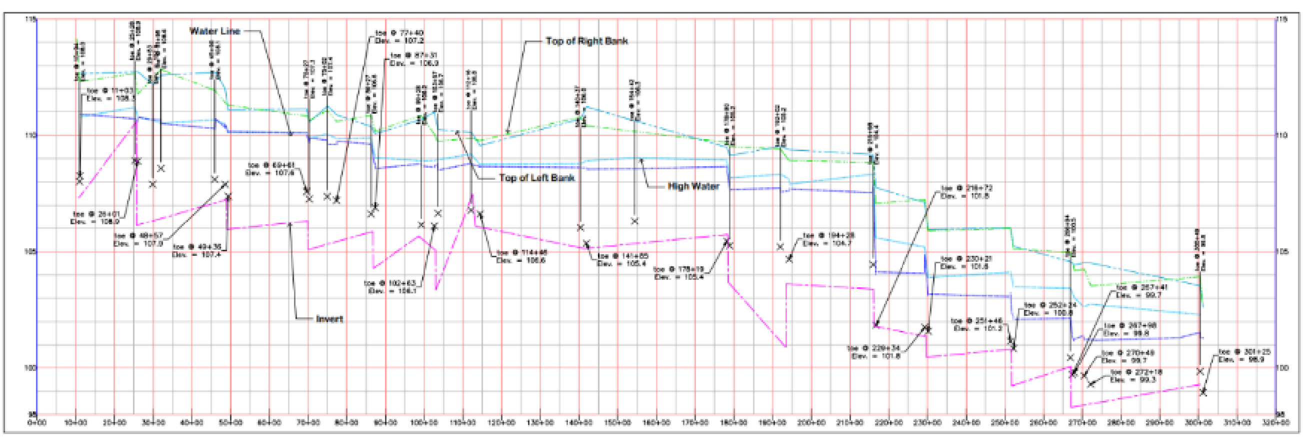


Figure 87. Existing Branch 4 canal profile

The existing headworks structure is shown in Figure 88.

Figure 88. Colony Branch 4 headworks, with 30" two canal gates (on left, looking upstream at the Colony Main Canal) and individual acoustic Doppler flow meters (on right) at the culvert discharge

Branch 4 check structures are generally similar, fitted with multiple flashboard bays as shown in Figure 89.

Figure 89. Branch 4 Canal 1.125 check, an existing flashboard structure, looking downstream; note the failing concrete walkway

The existing spill structure to HMRD is shown in Figure 90.

Figure 90. Existing Colony Branch 4 spill weir structure and downstream convergence with Colony Branch 5. Note that spill flow is lost to HMRD and is unrecoverable.

Figure 91. Newly constructed HMRD spill flow monitoring SCADA site just downstream of the Branch 4 spill structure

The issues and limitations of the existing infrastructure are:

1. All excess Branch 4 Canal flows are lost downstream to SLCC.
2. Inherent spill occurs when Branch 4 is used to deliver water to the tail end of Branch 5.
3. The variable inflows from the tail end of the Laguna Canal are not measured and are thus unknown.
4. All control structures are manual and require staff on-site to make operational changes.

Branch 4 Canal Improvements

The Branch 4 improvements are linked to the changes with the pool adjacent to the Laguna Reservoir. Basically, all the pools downstream of Laguna Reservoir will be consolidated into level top, downstream controlled pools.

1. The first level top pool will be adjacent to the Laguna Reservoir and extend to an expanded length north of the existing pool. It will be "downstream controlled" by the in/out of the reservoir.
2. Figure 92 shows a red line designating a number of new level top pools with downstream control.

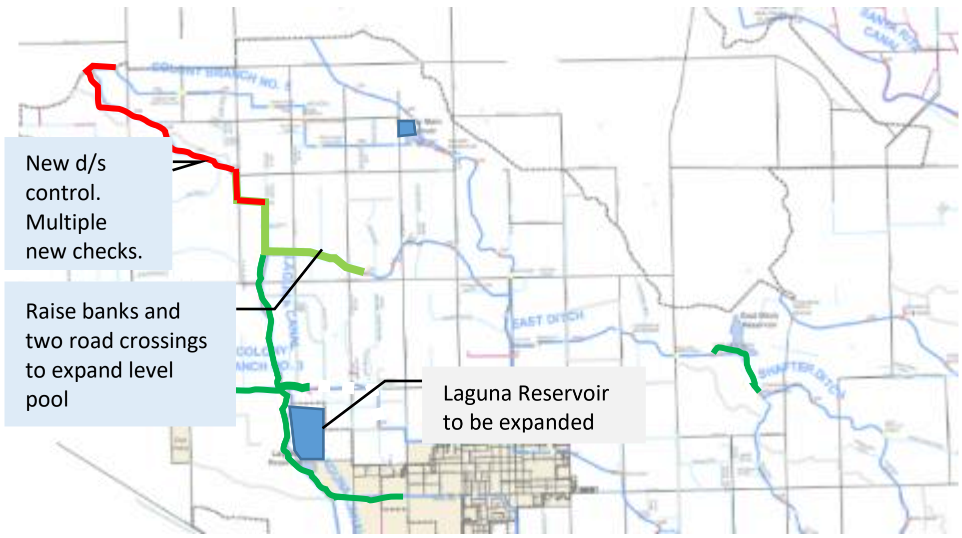


Figure 92. Overview of modernization recommendations for Colony Branch 4

Table 13 summarizes the major recommendations along Colony Branch 4.

Table 13. Major Branch 4 Canal modernization recommendations

Item #	Modernization components recommended immediately	Priority	Modernization group (to be implemented together)
1	Raise banks and two road crossings to expand level pool	High	7
2	Convert the remaining downstream pools to automatic downstream water level control by eliminating some checks and converting others to d/s control.	High	7

The following points provide additional detail:

1. Expand the existing Laguna Canal level pool that will be maintained by the expanded Laguna Reservoir. That way, excess Colony Branch 4 flows are absorbed by the level pool instead of being spilled. The level pool expansion is expected to require:
    a. Raised banks
    b. Raised road crossings at:
        i. Lexington Ave
        ii. Aubrey Ave
    c. Removal of the weir at the tail end of the Laguna Canal

2. Convert the remaining Colony Branch 4 Canal tail end to automatic downstream control, as shown in Figure 92.

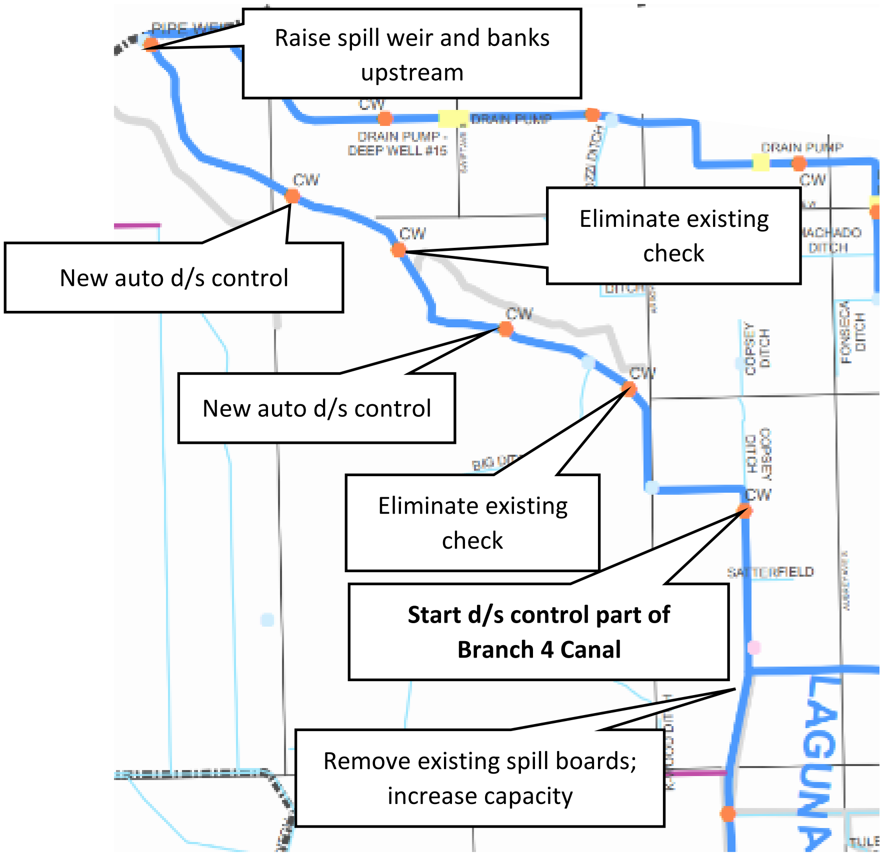


Figure 93. Proposed modifications to the Colony Branch 4 canal tail end structures; existing checks are shown as orange circles

Existing and post-implementation canal profiles for the area are shown in Figure 87 and Figure 94.

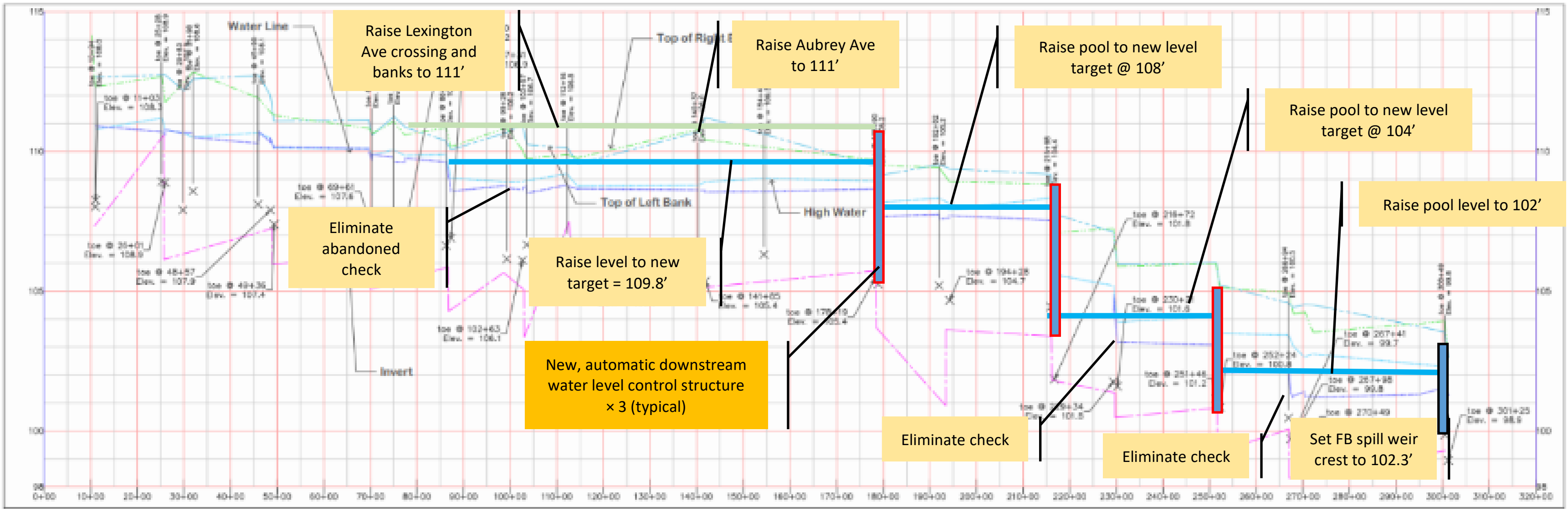


Figure 94. Proposed Branch 4 Canal profile after modifications

Structure Recommendations

The transition to automatic downstream control will require modifications/replacements to remaining canal check structures (some existing checks will be eliminated), as listed below and shown in Figure 95.

1. Each new automatic downstream control structure will be fitted with two 3' wide × 2' tall, fabricated sluice gates. The gates will be grouted into the poured in-place concrete walls, such that both the gate sides and bottom are flush. Redundant sensors will provide gate position measurements.
2. New wing walls on each bank will provide a tapered convergence as well as emergency spill weirs. The total weir length shall be 30 ft. Weir flow will pass under the new walkway on each side of the new gates.
3. New, redundant offline RGRCP stilling wells will be installed upstream and downstream of each structure. The stilling wells will be fitted with instrumentation to provide redundant level measurements upstream and downstream.
4. A new RTU will be installed to provide automatic downstream level control at the control location (the immediate downstream stilling wells)

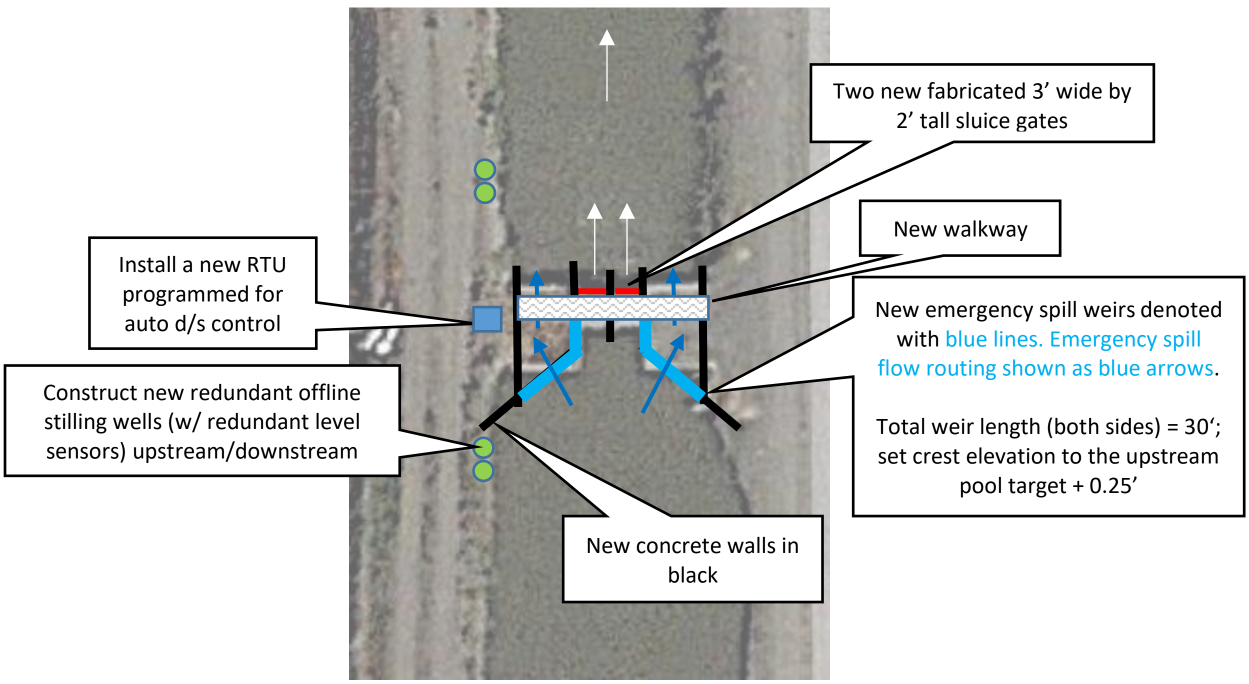


Figure 95. Conceptual drawing showing the new automatic downstream control structure at Branch 4 Canal Station 180+00, plan view

In addition, the tail end spill weir crest elevation will be set to 102.3' to provide emergency spill functions in the event of emergencies.

Figure 96. Branch 4 Canal tail end spill weir structure; set board crest elevation to 102.3' (top of existing concrete at 104.2')

Anticipated Automation Performance

Unsteady canal simulations were completed to verify the feasibility and performance of the proposed automatic downstream control regime along Branch 4 Canal. Model data and simulation results are provided in the *Control Performance* section.

Branch 5 Canal – Existing Conditions

A map of existing Branch 5 Canal infrastructure is shown in Figure 97.

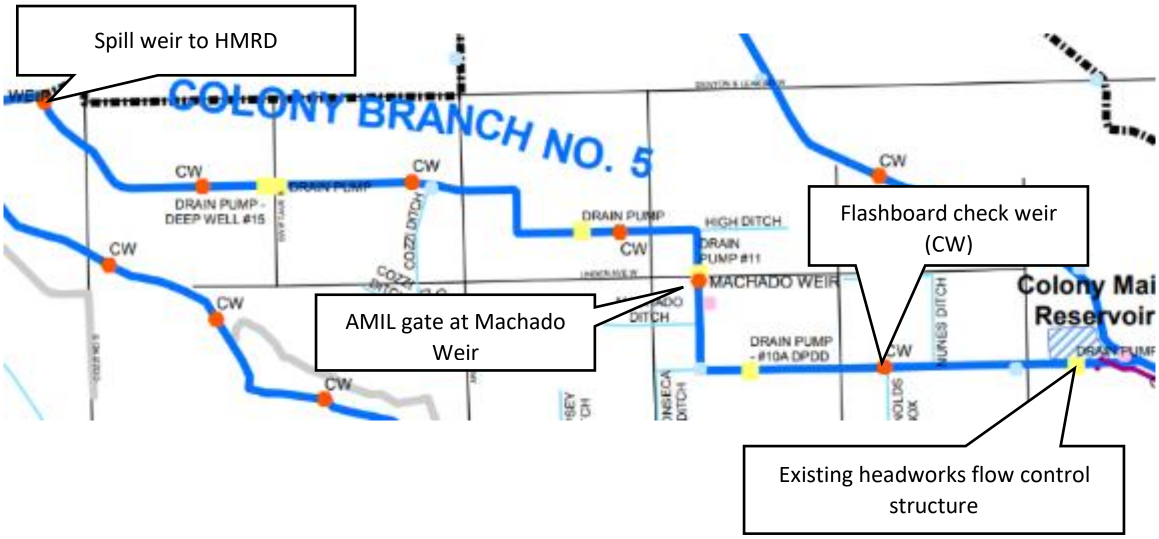


Figure 97. Existing Branch 5 Canal infrastructure map

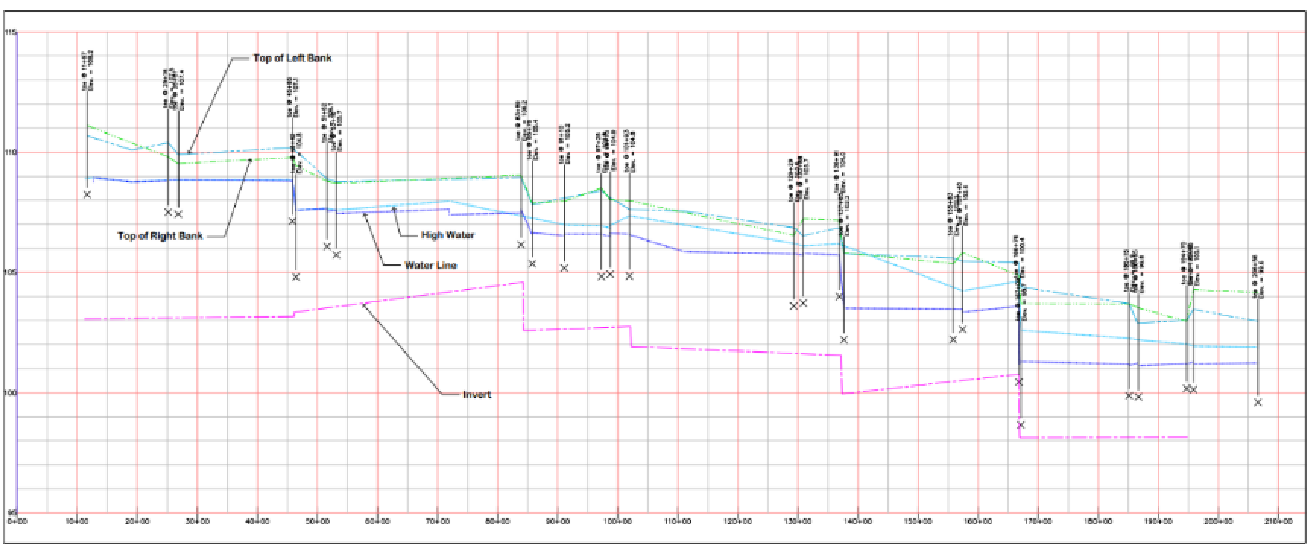


Figure 98. Existing Branch 5 Canal profile

The existing Branch 5 Canal is operated under upstream control, as described and shown in Figure 99.

1. A target flow rate is set at the headworks gates. Flow measurement is provided by two flow meters.

Figure 99. Existing 30” Branch 5 Canal headworks gates, fitted with individual flow meters, looking downstream

2. Changes to turnout and headworks flow rates above a certain minimum threshold typically require repeated visits to flashboard check structures (as in Figure 100) for monitoring and adjustment.

Figure 100. Existing first flashboard check along Branch 5 canal; looking downstream

The Machado Weir is the only non-flashboard check along Branch 5 Canal, as shown in Figure 101.

Figure 101. Existing AMIL gate, installed at the Machado Weir, looking upstream

3. Sometimes operators use the Branch 4 Canal to supply the tail end Branch 5 Canal turnouts, by:
    a. Removing spill weir boards at the tail ends of Branch 4 and Branch 5 Canals (see Figure 102).
    b. Allowing an unknown portion (estimated at 5-15 CFS) of the delivery flow rate to spill to HMRD.

Figure 102. Existing Branch 5 Canal spill structure; the new HMRD spill flow monitoring site is just downstream; existing top of concrete elevation = ~102.5'

Branch 5 Canal Improvements

Table 14 summarizes the major recommendations along Colony Branch 5.

Table 14. Major Branch 4 Canal modernization recommendations

Item #	Modernization components recommended immediately	Priority	Modernization group (to be implemented together)
1	Construct new automatic downstream level control structures to replace existing headworks and check structures with new higher Colony Main Canal level	High	8
2	Raise banks and two road crossings	High	8

The major Branch 5 recommendations are listed below and illustrated in Figure 103.

1. Implement automatic downstream water level control throughout. Specific requirements:
    a. Automate the existing headworks flow control for downstream level control.
    b. Eliminate some of the existing check structures and modify others for automatic downstream level control.
    c. Raise the banks and verify road crossings for:
        i. Linden Rd
        ii. Aubrey Ave.

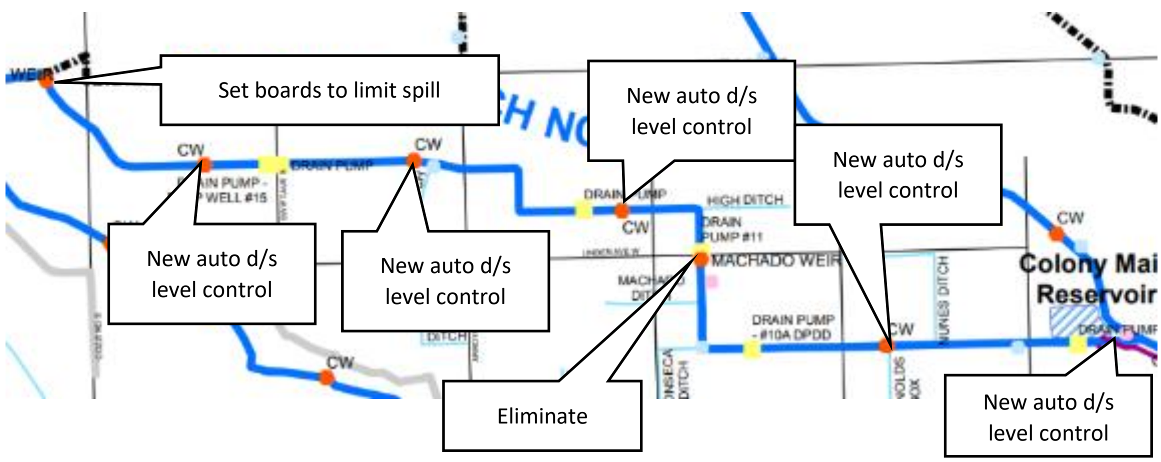


Figure 103. Major Branch 5 recommendations

Branch 5 Headworks

The following improvements are recommended at the Branch 5 headworks:

1. A new RTU will be installed to automatically maintain a relatively constant target flow rate.
2. Replace the existing structure with a suppressed sluice gate flow control structure, as described in the *Branch 4 Improvements – Structure Recommendations* section.

Additional design recommendations for the Branch 5 flow control structure are:

1. Design capacity = 70 CFS (larger than total demand for rapid reactions)
2. Number of electronically actuated rectangular sluice gates = 2 (set flush with concrete flow area, sides and bottom)
3. Individual gate open flow area dimensions = 4’ wide × 2’ tall
4. New upstream water surface elevation (reservoir target) = 110.45’
5. New target downstream water surface elevation = 107.5’
6. New structure u/s top of concrete elevation = 112’
7. Gate and channel invert elevation = 103’
8. Install standard, redundant 36” CCID RCP offline stilling wells to monitor Colony Main Canal and Branch 5 Canal water levels.
9. Install a floating boom to deflect debris away from the Branch 5 Canal headworks, so that it can remain and be collected in Colony Main Canal by automatic trash screens downstream.
10. Install redundant sensor pairs: upstream level, downstream level, gate position 1, and gate position 2.
11. Raise the banks of the Colony Main Canal level pool.
12. Install self-cleaning trash screen(s) in location of the existing, abandoned check structure.

The recommendations are shown in Figure 104.

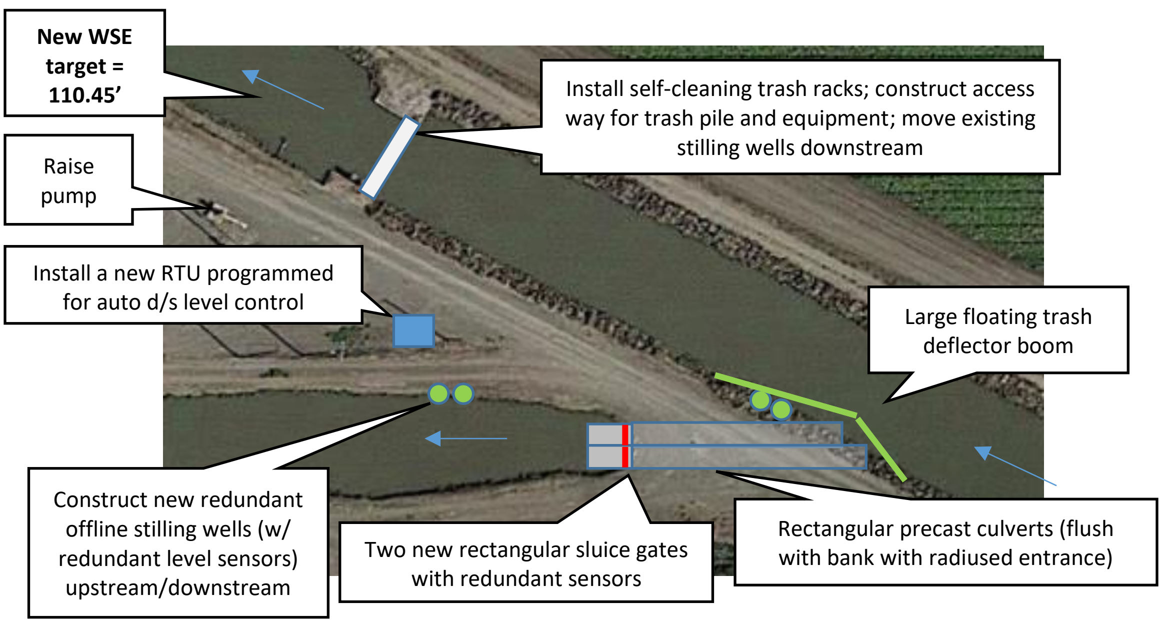


Figure 104. Conceptual Branch 5 Canal headworks recommendations, plan view

Branch 5 Check Structures

Refer to the conceptual *Branch 4 Canal Improvements – Structure Recommendations* section. The same conceptual recommendations apply here. See Figure 98 and Figure 105 for existing and proposed canal profiles.

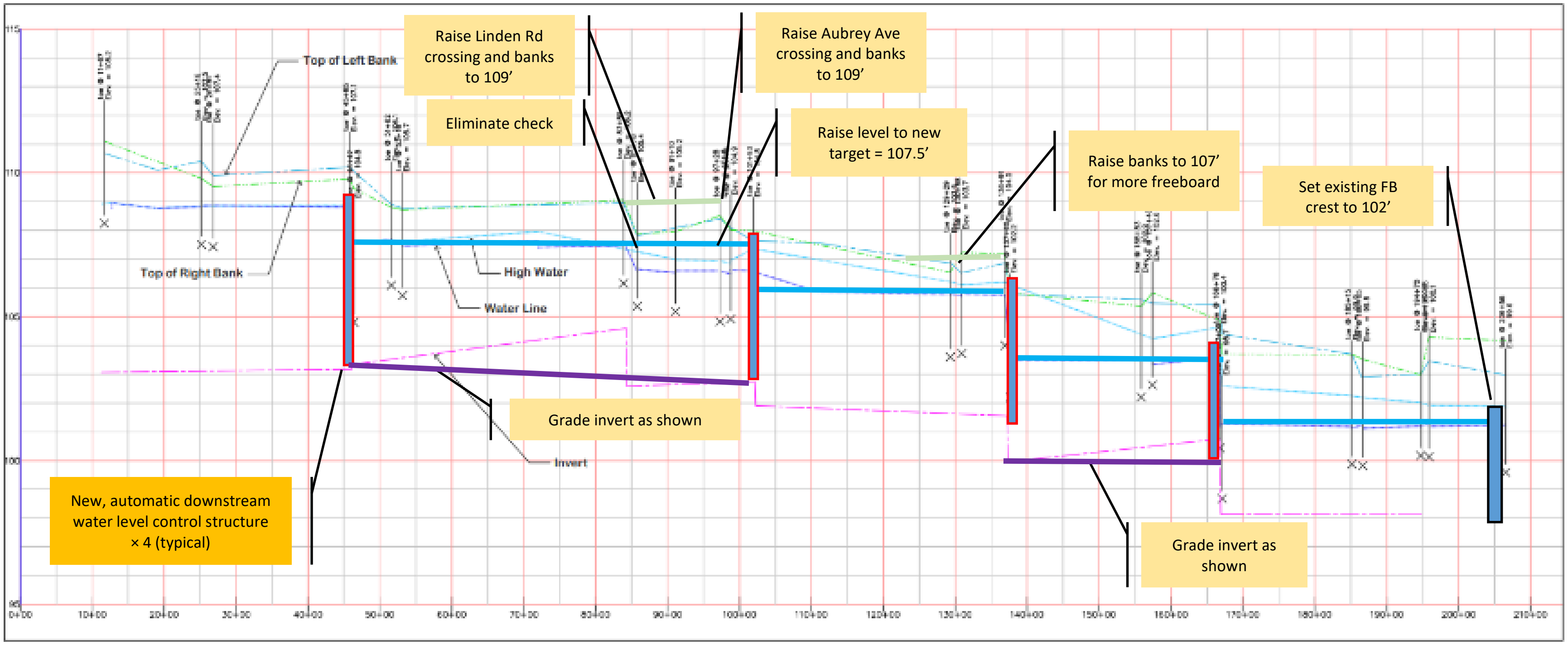


Figure 105. Proposed Branch 5 Canal profile after modifications

Shafter Ditch

The second flashboard weir along Shafter Ditch is failing. The flashboard structure was constructed with coated steel and wood. The structure requires replacement to continue functioning.

Figure 106. Existing wood and steel weir, the second check along Shafter Ditch

The total flashboard width is about 123”. During the site visit, the structure had about 1’ of head drop across it.

Recommendations

It is recommended to install a LCW to replace the failing steel/wood structure. Design assumptions are:

- The structure typically operates with a difference of about 1’ between the upstream HWM and the downstream HWM
- The maximum design capacity of the structure is 40 CFS
- Absolute elevations are unknown

Design details are provided below.

Table 15. Shafter Ditch steel/wood LCW replacement design details

Total structure design capacity, CFS	Flush out gate flow capacity, CFS	Remaining design flow over LCW, CFS	LCW crest length, ft	Flush out canal gate size, inches
40	5	35	40	18

Basic design concepts for the LCW are shown in Figure 107.

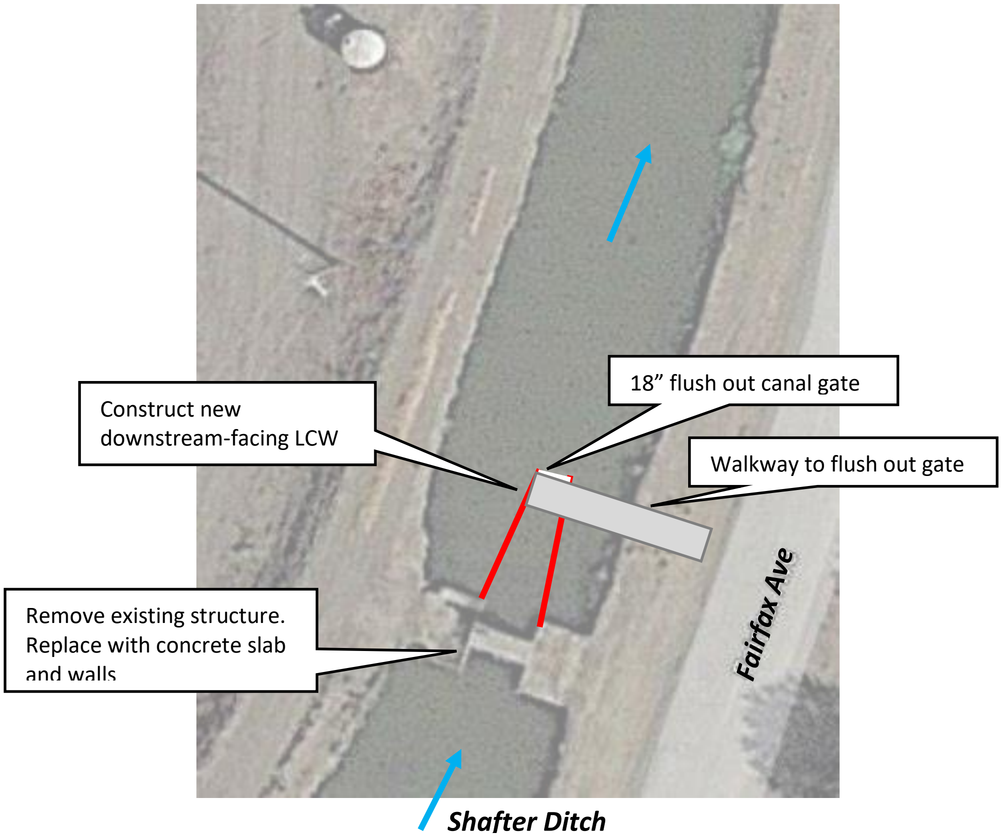


Figure 107. Proposed LCW design, plan view

Key design elevations are presented in Table 16. Because the site has not yet been surveyed, all design elevations are relative to the upstream high water mark.

Table 16. Shafter Ditch Check 2 LCW design elevation details

Design component	Difference in elev. compared to the u/s HWM, feet
Top of LCW wood crest	-0.5
Top of LCW concrete wall	-1
d/s high water mark (est.)	-0.8

Poso Area Canals

A map of the existing Poso/Colony area infrastructure is shown in Figure 108.

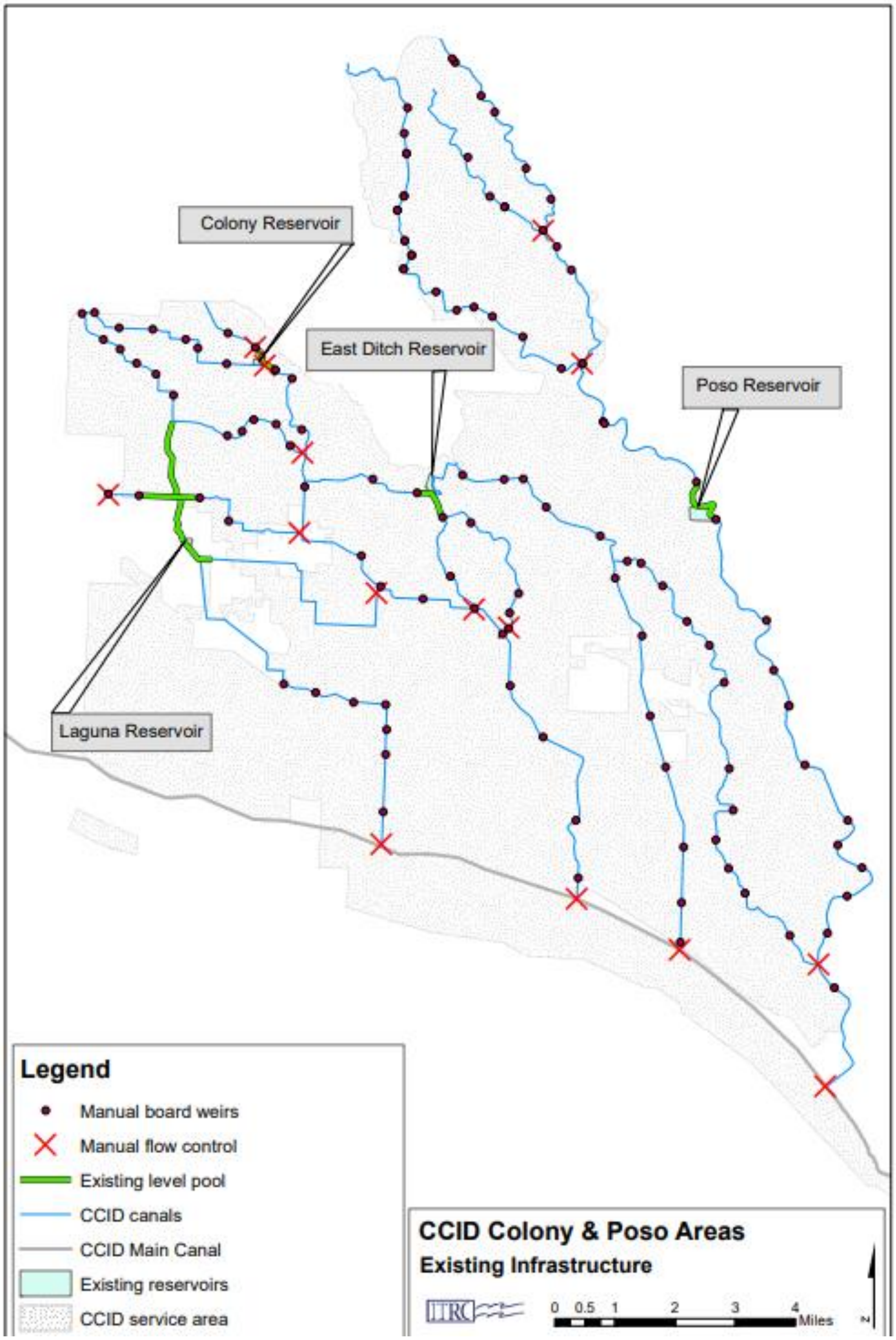


Figure 108. Existing infrastructure map

The existing Poso/Riverside Canal operations are described below and shown in Figure 109.

1. Poso Reservoir buffers variable inflows and provides an on-demand water source for Mitchell Weir. The existing Poso Reservoir RTU is programmed to automatically maintain a relatively constant target water surface elevation in a level pool in the Poso Canal adjacent to the reservoir.
2. Mitchell Weir is equipped with an RTU to automatically maintain a relatively constant target flow rate, remote manually adjusted as needed to meet downstream demand.
3. Two ~150 long crested weirs (LCWs) provide automatic upstream level control for turnouts and the Santa Rita Ditch diversion. The Poso Canal ends at the Santa Rita Ditch headworks LCW. The Riverside Canal continues downstream.
4. Several flashboard check structures are used for manual upstream level control for various turnouts and the Lucerne Canal.

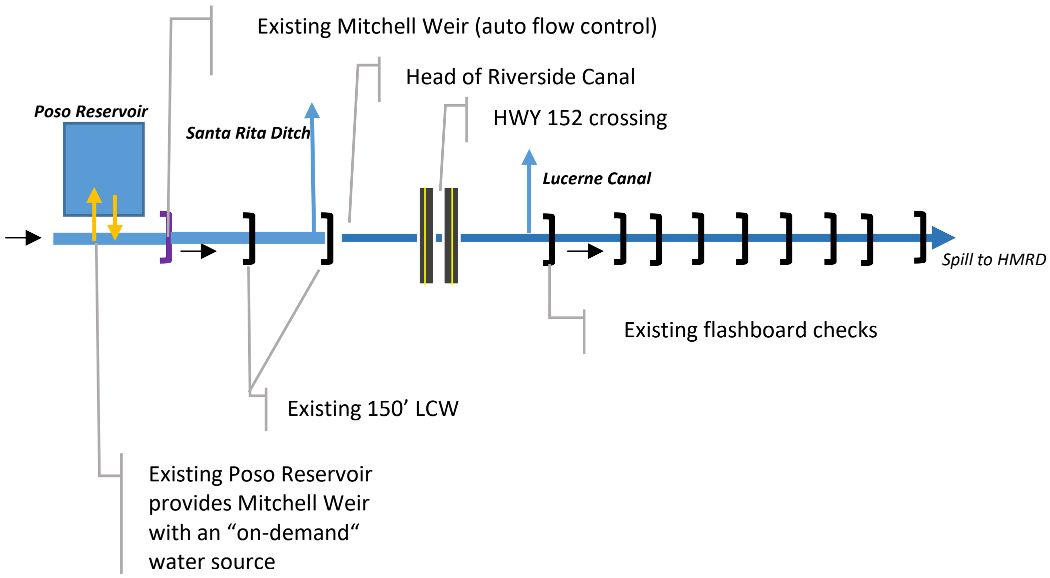


Figure 109. Existing operating conditions along the Poso/Riverside Canal; Santa Rita Ditch and Lucerne canals are also upstream controlled currently (with manual flow control at the heads of each)

Existing Limitations

The construction of the new Poso Reservoir and Mitchell Weir have improved operations along the Poso and Riverside canals. However, it remains difficult to balance irrigation delivery service flexibility while also minimizing spill. This is due to several factors, including the length of the canals, lag time, imperfect timing of flow changes, etc. All these challenges are inherent to upstream controlled canals, especially relatively long canals like these. ITRC evaluated the feasibility of converting the tail ends of the Poso Area canals to downstream control, to help mitigate the limitations described above.

On-Demand Advantages and Disadvantages

Advantages:

- *Reduced operational spill*. The simulations show the potential of eliminating operational spill assuming spill weirs at the tail ends are configured to provide emergency spill for up to 30% of the maximum head inflow but are inoperable (crests above water) under normal conditions.

- *Reduced operating labor*. The automatic controlled gates reduce the frequency for operators to manually adjust check structures – instead, the gate positions are automatically adjusted.

Disadvantages:

- *Increased operational risk*. If one of the automatically controlled sites becomes unavailable, the entire canal downstream of that site must be operated manually (no automation, but perhaps with remote manual control) until the repair is fixed. *Note that ITRC can program the controllers to be able to switch to automatic upstream water level control (manually switched) in case an upstream site is temporarily inoperable under downstream control.*

Objectives

The primary objective of the study was to determine feasibility. Further automatic control performance improvements may be possible to obtain with more thorough modeling, prior to field implementation.

Canal Model

Turnout flow and survey data were provided by CCID and a third-party firm, respectively. Unsteady canal simulations were conducted by ITRC using the data provided.

Design Concepts

The overall automatic downstream water level control concept is shown in Figure 110.

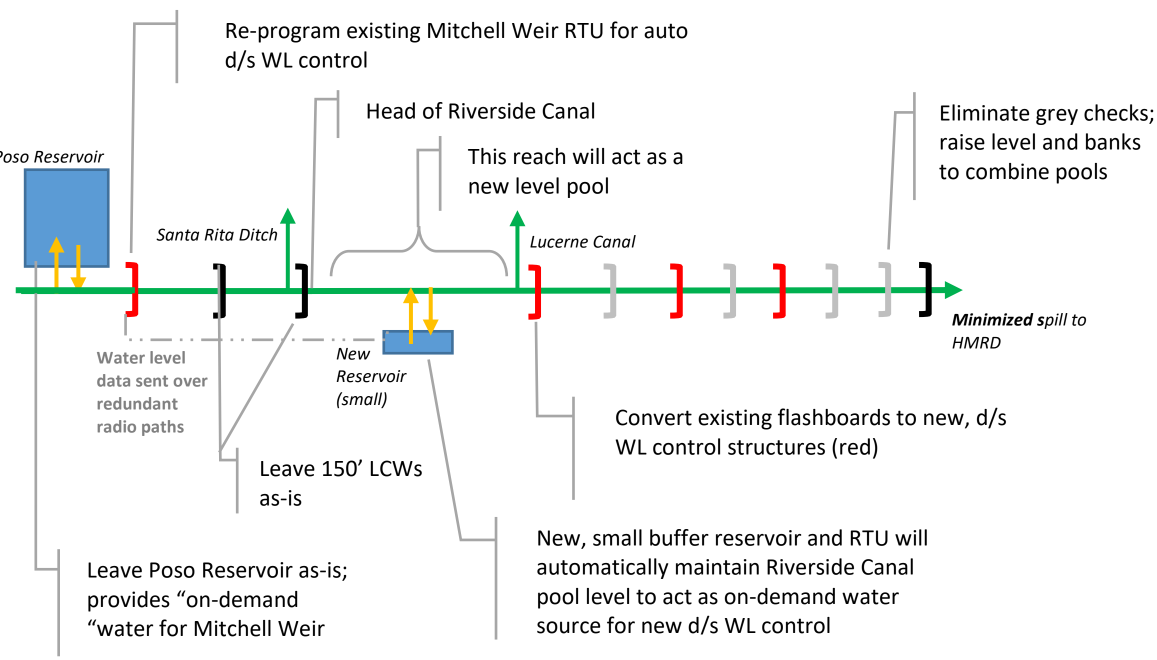


Figure 110. Proposed control scheme after improvements along the Poso/Riverside canals; green colored canals indicate new downstream control service (including all of Santa Rita Ditch and Lucerne Canal); Highway 152 is not shown for clarity.

Several locations for the new, smaller buffer reservoir were attempted to provide a range of simulated reservoir locations, both upstream and downstream of Highway 152. The simulation results indicated:

1. The location upstream of Highway 152 is recommended; see Table 17.
2. A location downstream of Highway 152 is not feasible, due to hydraulic limitations.

Table 17. Small reservoir size and capacity recommendations

Reservoir Location	Approximate Riverside Canal station	Minimum usable reservoir volume (AF)	Minimum small reservoir In/Outflow capacity, CFS
Upstream of HWY 152	20+00	30	30

The following specific design elements were used in the construction of the canal model, and were illustrated in Figure 110:

1. A small ~10-acre (~30 AF) buffer reservoir will be constructed between the head of the Santa Rita Ditch and Highway 152. The new buffer reservoir will be automated to maintain a relatively constant water level in the Riverside Canal at Station 266+00 (referenced from Poso Reservoir as station 0).
2. The existing Mitchell Weir RTU will be reprogrammed to automatically maintain the water level in the new reservoir at about half full. Reservoir water level and sensor status data will be sent over redundant radio paths.
3. Several existing flashboard structures will be eliminated or abandoned, to consolidate pools and minimize the number of automated gate structures.
4. The tail end spill weirs will be modified to provide emergency spill capacity of about 30% of the maximum head inflow.
5. Some existing flashboards will be replaced with new automatic, downstream water level control structures. A conceptual plan view is shown in Figure 111.

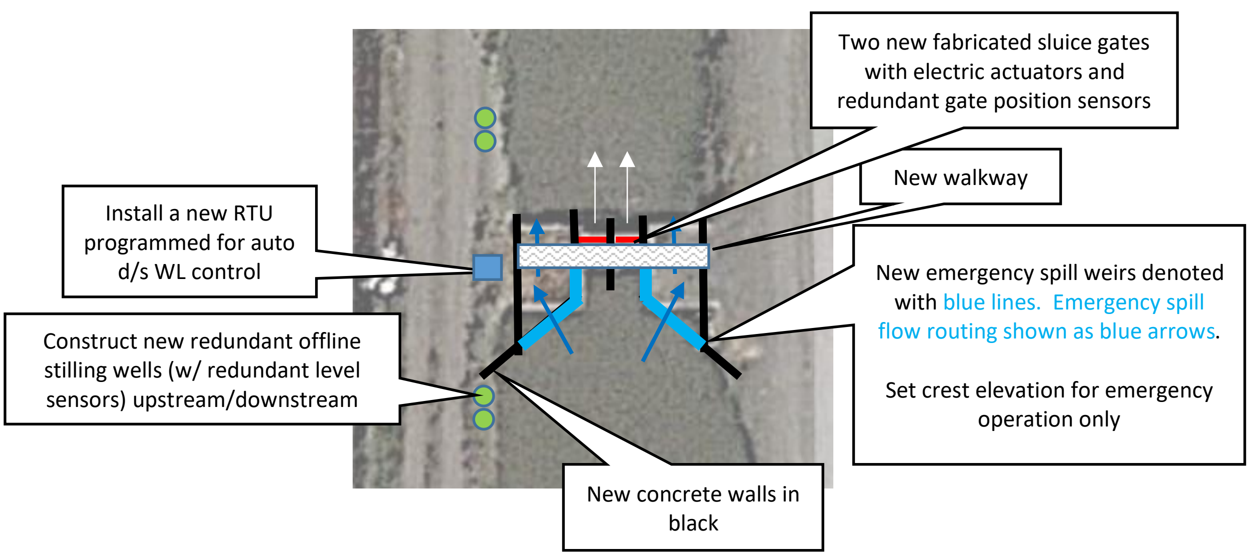


Figure 111. Conceptual drawing showing the new automatic downstream control structure, plan view

6. The new target location is immediately downstream of each gate, with hardwired sensors installed in new redundant, offline stilling wells.
7. **An excellent canal maintenance program will be required to maintain minimum canal friction (roughness) due to aquatic weeds.**
8. Earthwork will be required along certain reaches to:
    a. lower the invert, and
    b. raise canal banks to provide adequate freeboard

Canal Profiles

This section on “canal profiles” shows before and after canal profiles to illustrate:

- Existing check structures that will be converted to automatic downstream control or eliminated – and canal pools will be consolidated.
- The rough magnitude and extent of grading, such as lowering inverts and raising banks. Bank raising extents are not shown specifically for clarity, but it is assumed bank grading will provide sufficient freeboard.

Santa Rita Ditch

The existing Santa Rita Ditch profile is shown in Figure 112. The proposed canal profile, with recommended improvements, is shown in Figure 113.

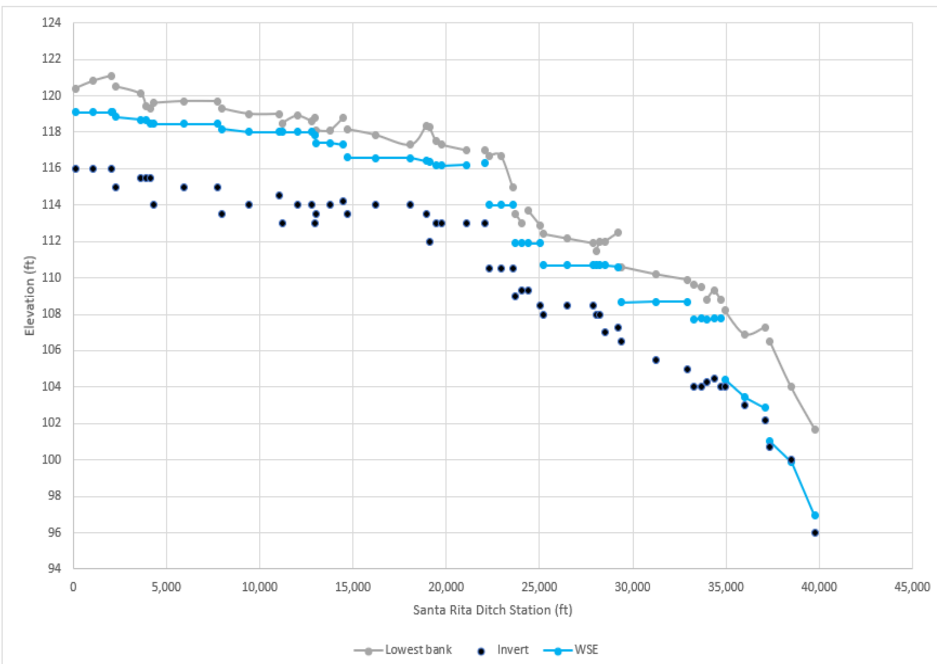


Figure 112. Existing Santa Rita Ditch profile

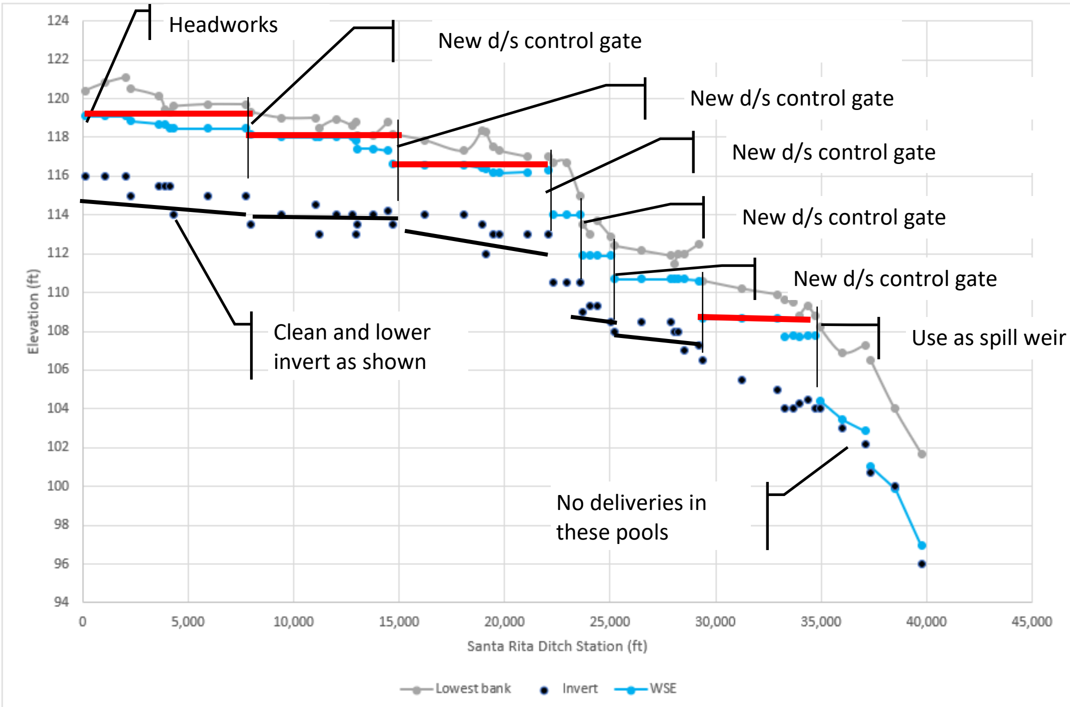


Figure 113. Santa Rita Ditch profile under proposed automatic downstream level control; lower invert as shown; raise banks to provide a minimum of 1' freeboard (not shown for clarity)

Lucerne Canal

The existing Lucerne Canal profile is shown in Figure 114. The proposed canal profile, with recommended improvements, is shown in Figure 115.

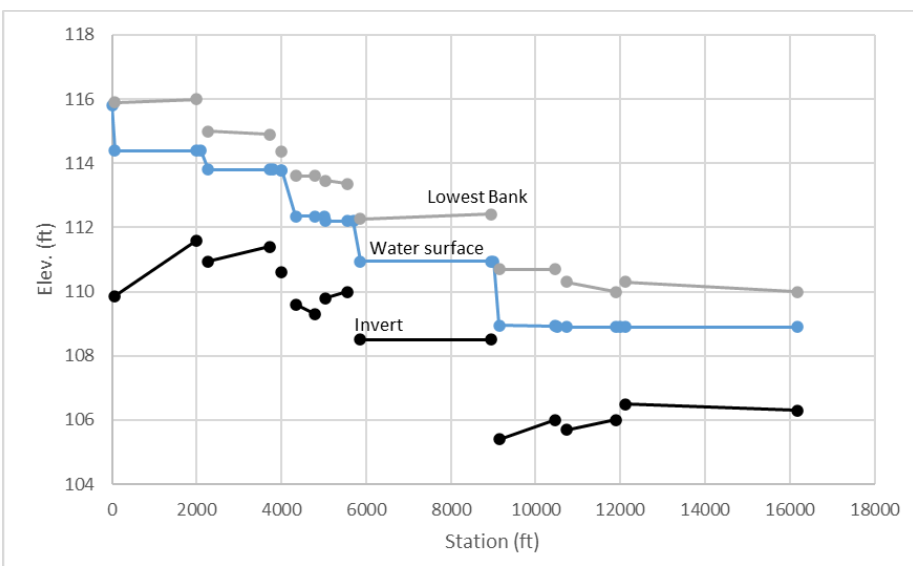


Figure 114. Existing Lucerne Canal cross-section

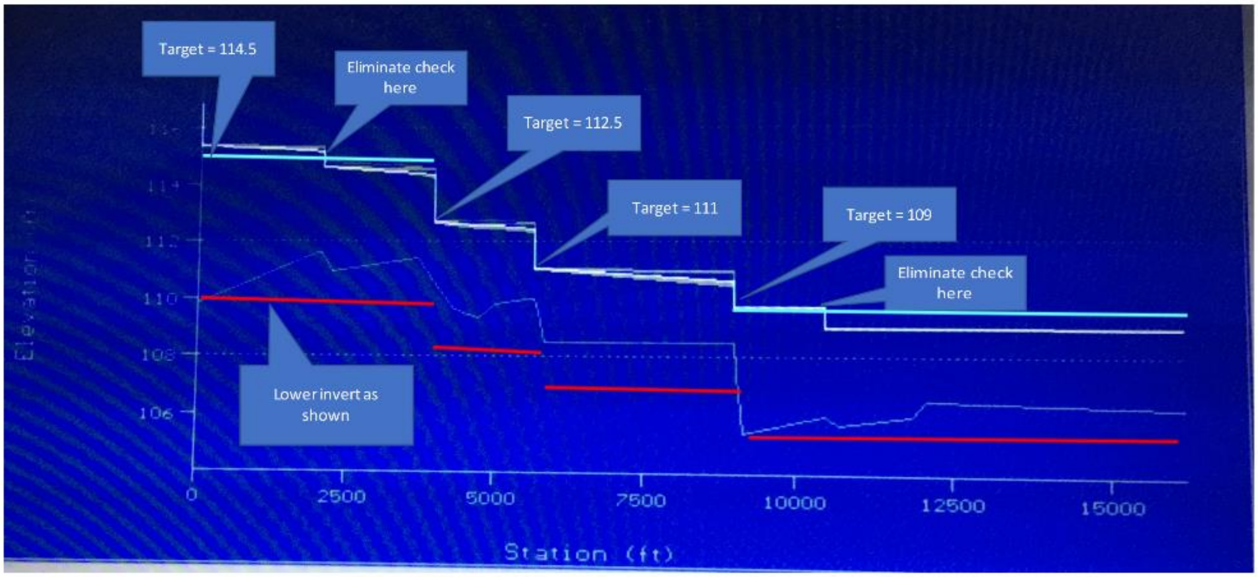


Figure 115. Lucerne Canal profile, including major grading under proposed automatic downstream level control

Poso/Riverside Canals

The existing Poso/Riverside profile is shown in Figure 116. A proposed profile is shown for the Poso/Riverside Canals in Figure 117.

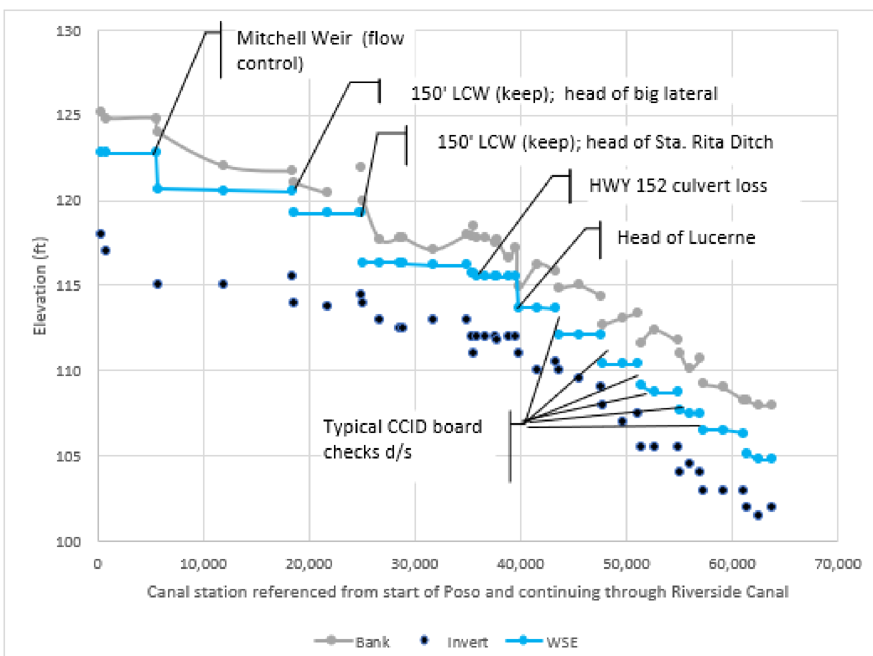


Figure 116. Existing conditions along the Poso/Riverside Canals

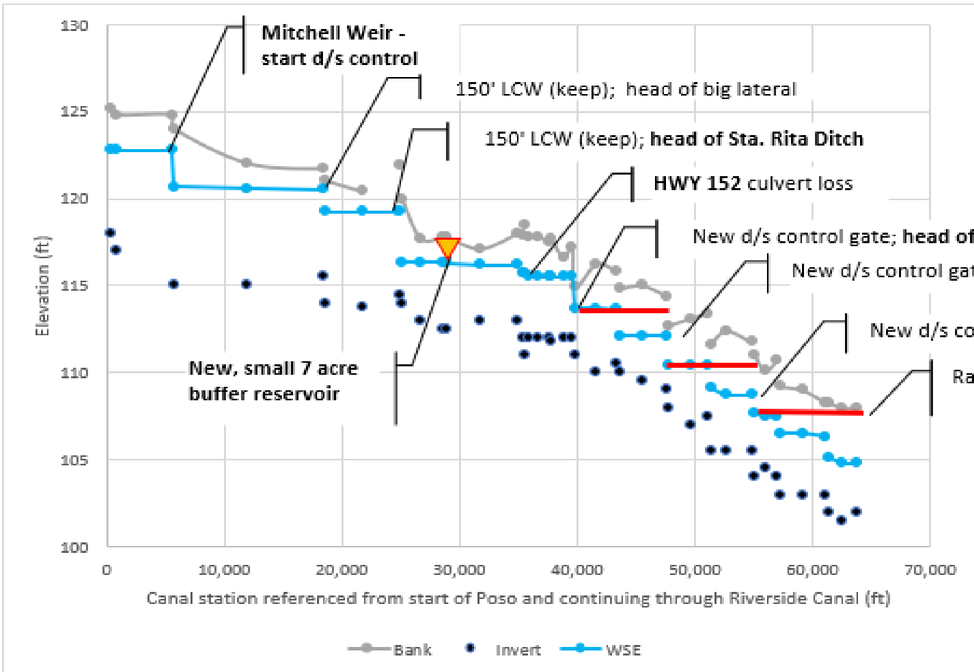


Figure 117. Anticipated profile after improvements along the Poso/Riverside Canals

Control Performance

This section displays the simulated control performance for each canal.

Santa Rita Ditch

The Santa Rita Ditch model profile under simulation is shown below.

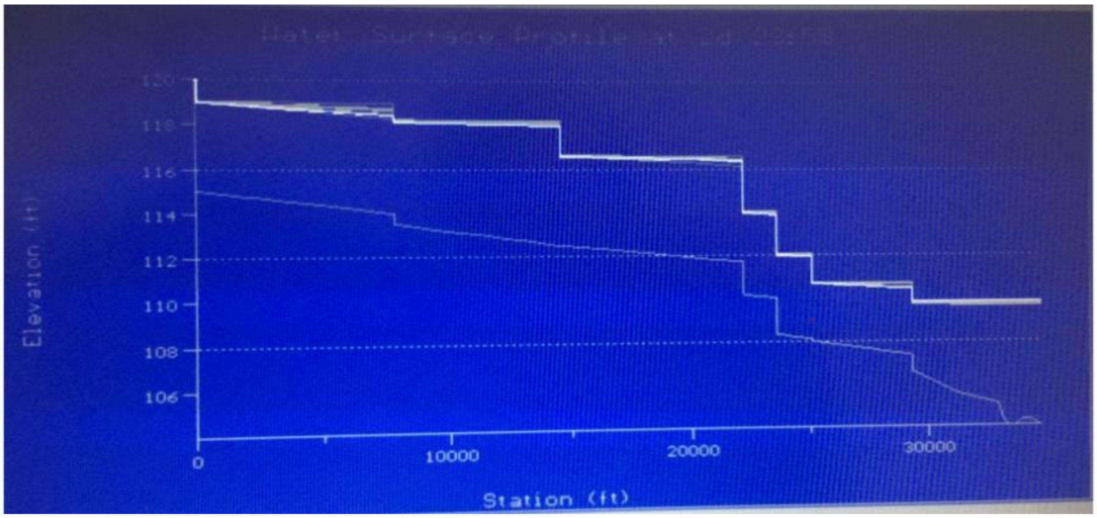


Figure 118. Santa Rita Ditch canal profile simulation results for automatic downstream level control; note that some changes will be made to the first check to increase the head drop across it.

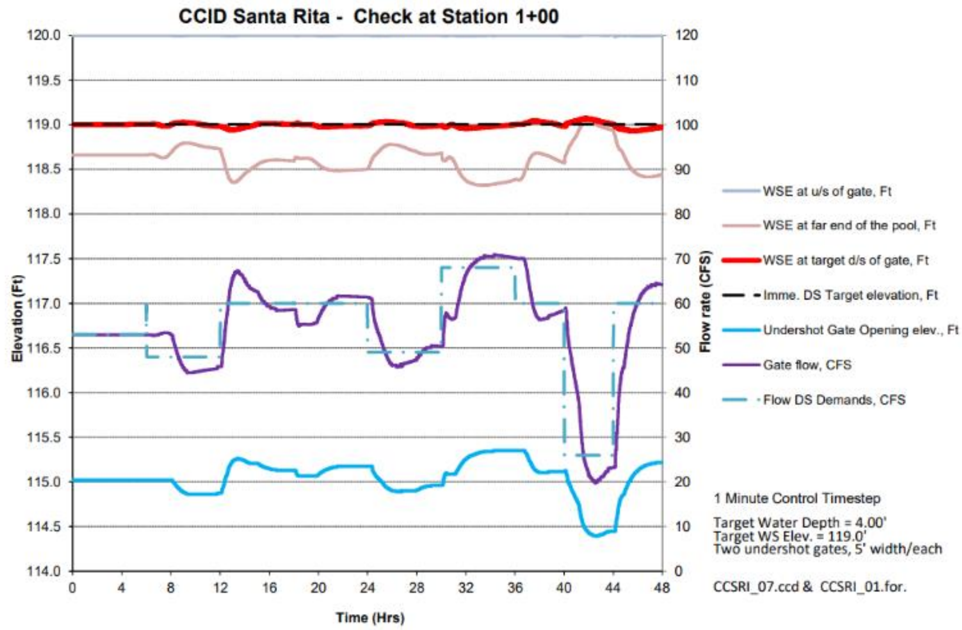
The turnout flow schedule used in the simulation is shown in Table 18.

Table 18. Santa Rita Ditch simulation turnout flow schedule

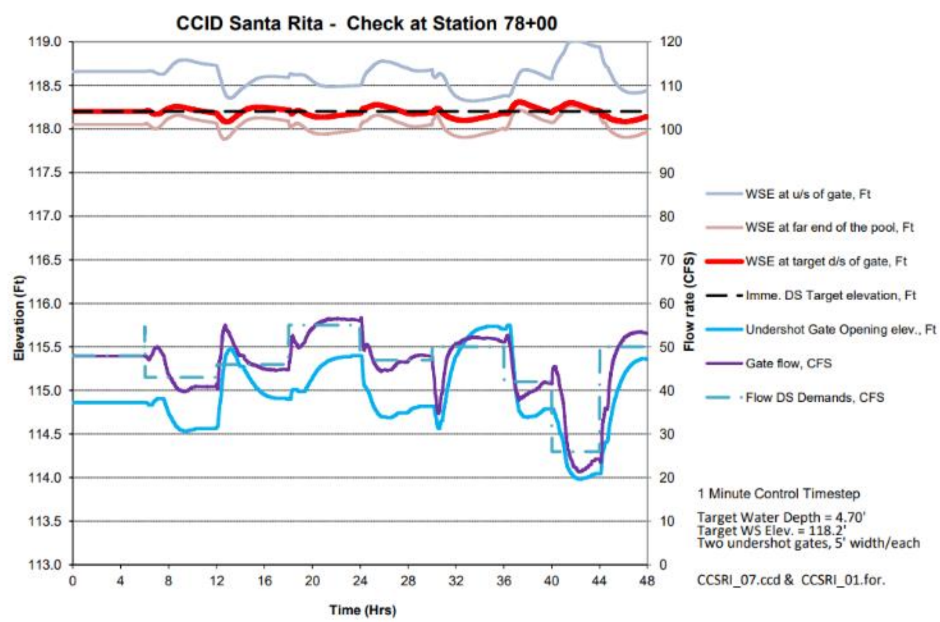
	0 to 7,800	7,801 to 14,019	14,019 to 21,812	21,812 to 23,269	23,269 to 24,690	24,690 to 28,908	28,908 to 34,500	
Pool	1	2	3	4	5	6	7	sum
Max TO flows	21	22	26	7	5	37.9	17	135.9
Hr								
0	5	5	8	0	5	20	10	53
6	5	3	15	5	0	15	5	48
12	14	12	26	3	0	5	0	60
18	5	22	15	0	5	10	3	60
24	2	10	26	0	0	5	6	49
30	18	0	15	7	5	20	3	68
36	18	5	3	3	3	15	13	60
40	0	3	0	3	0	20	0	26
44	10	15	0	0	0	35	0	60

Simulated Control Performance Graphs

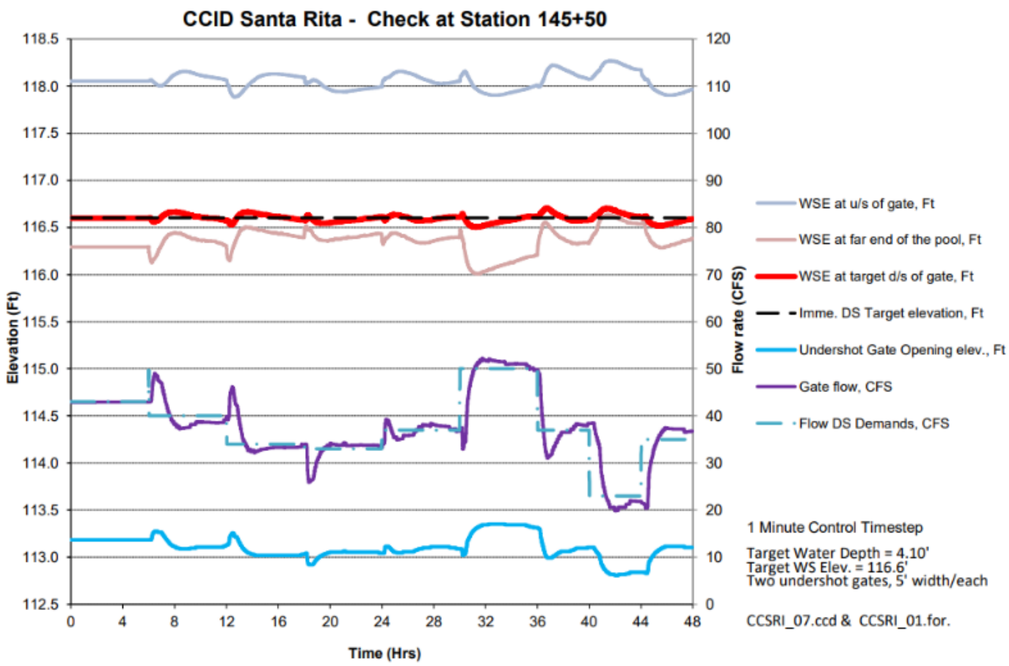
The graphs on the following pages show the anticipated water level control performance at each Santa Rita Ditch check structure.



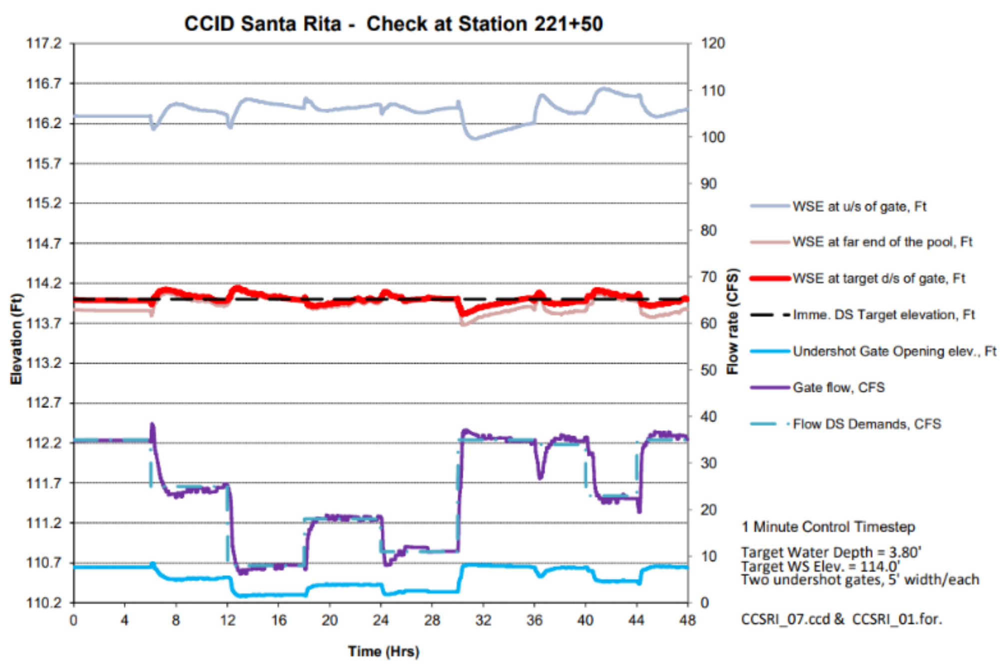
CCSRI_08.xls\Check @ 1+00



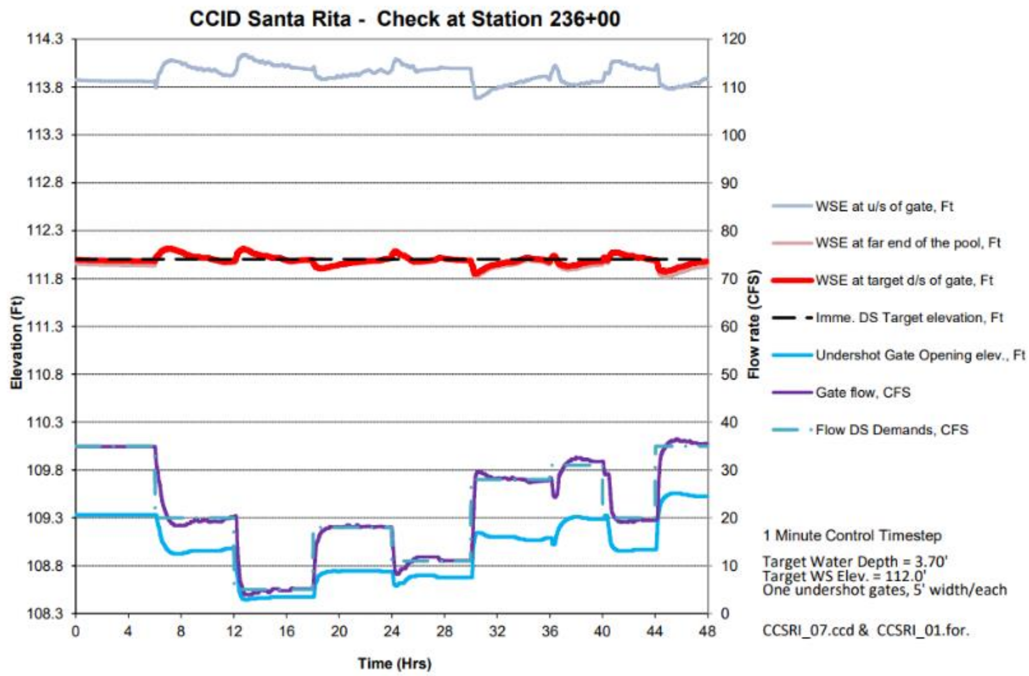
CCSRI_08.xls\Check @ 78+00



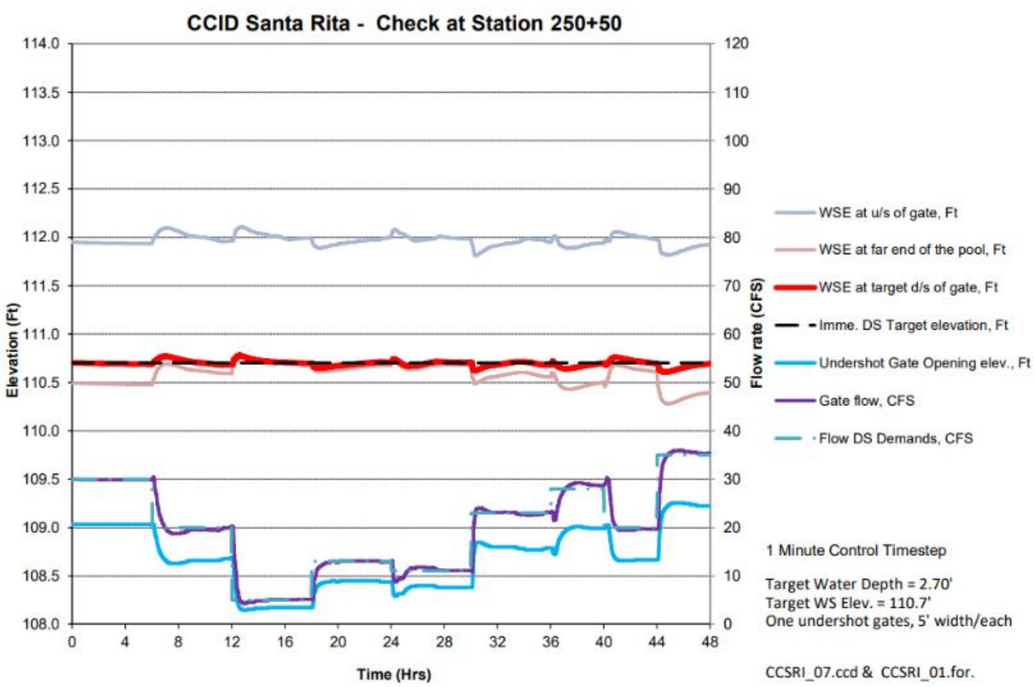
CCSRI_08.xls\Check @ 145+50



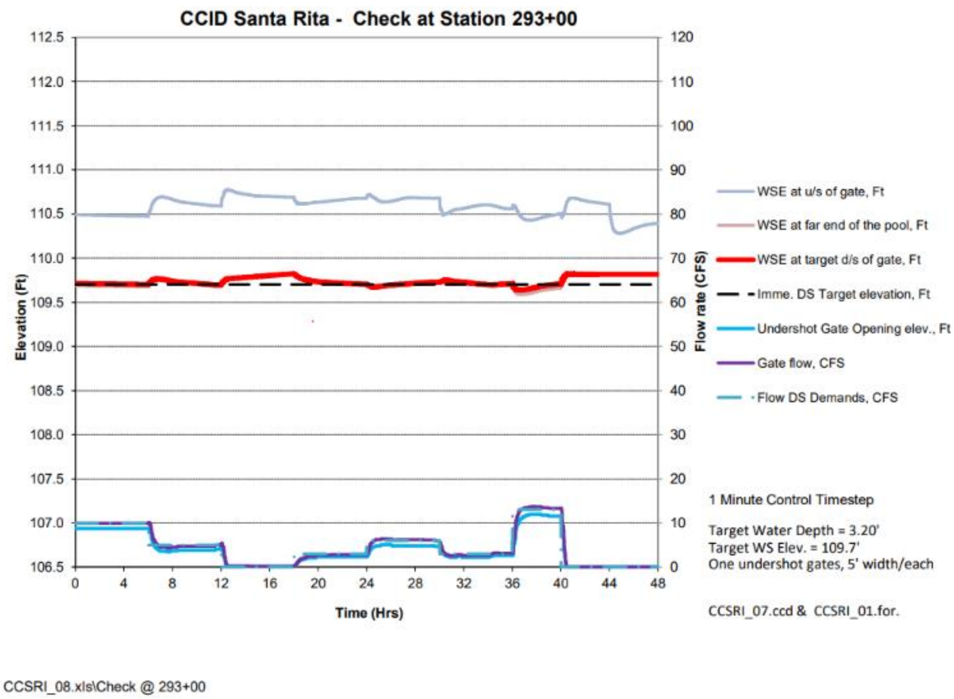
CCSRI_08.xls\Check @ 221+50



CCSRI_08.xls\Check @ 236+00



CCSRI_08.xls\Check @ 250+50



Lucerne Canal

The Lucerne Canal profile after modifications is shown in Figure 119.

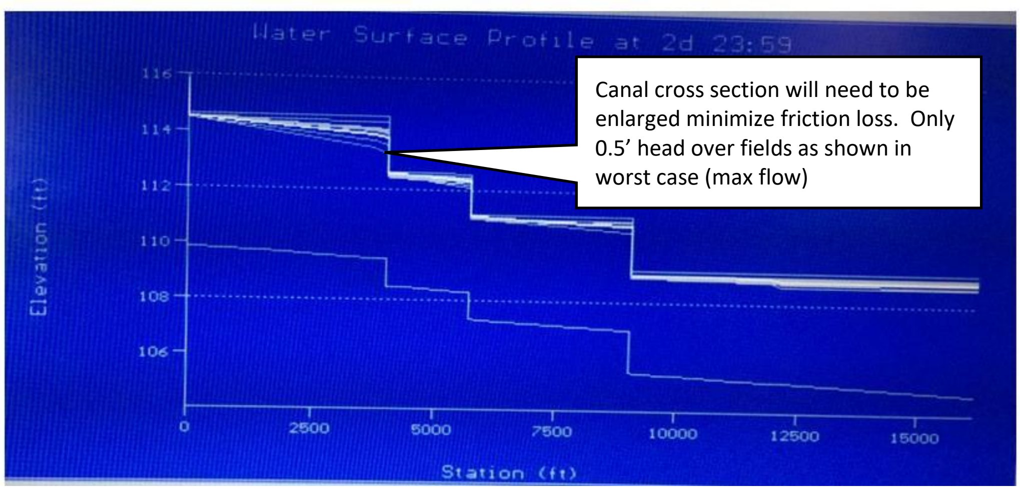


Figure 119. Lucerne Canal profile under simulation

The new cross section in the first pool (Station 0+00 to about 39+89.45) will be enlarged to meet the following minimum design criteria:

- 15 ft bottom width
- Side slope (h:v) = 1.5
- Invert at Station 0+00 = 109.5’
- Invert just upstream of new automatic downstream level control check = 108.75’

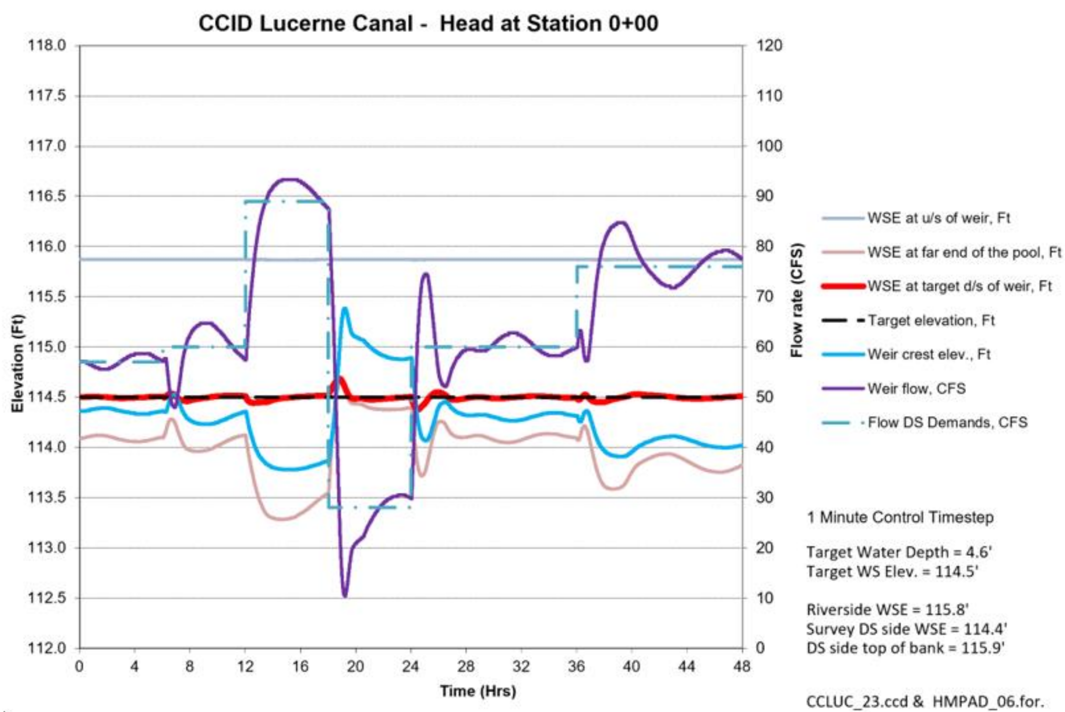
The simulated turnout schedule is provided in Table 19.

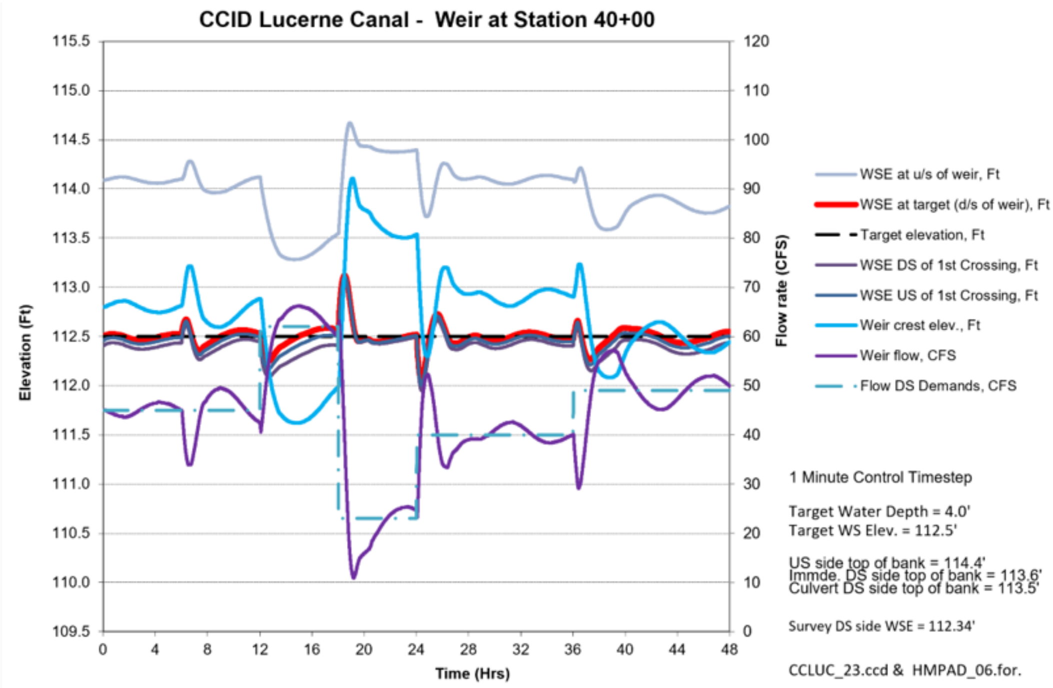
Table 19. Lucerne Canal simulation turnout schedule

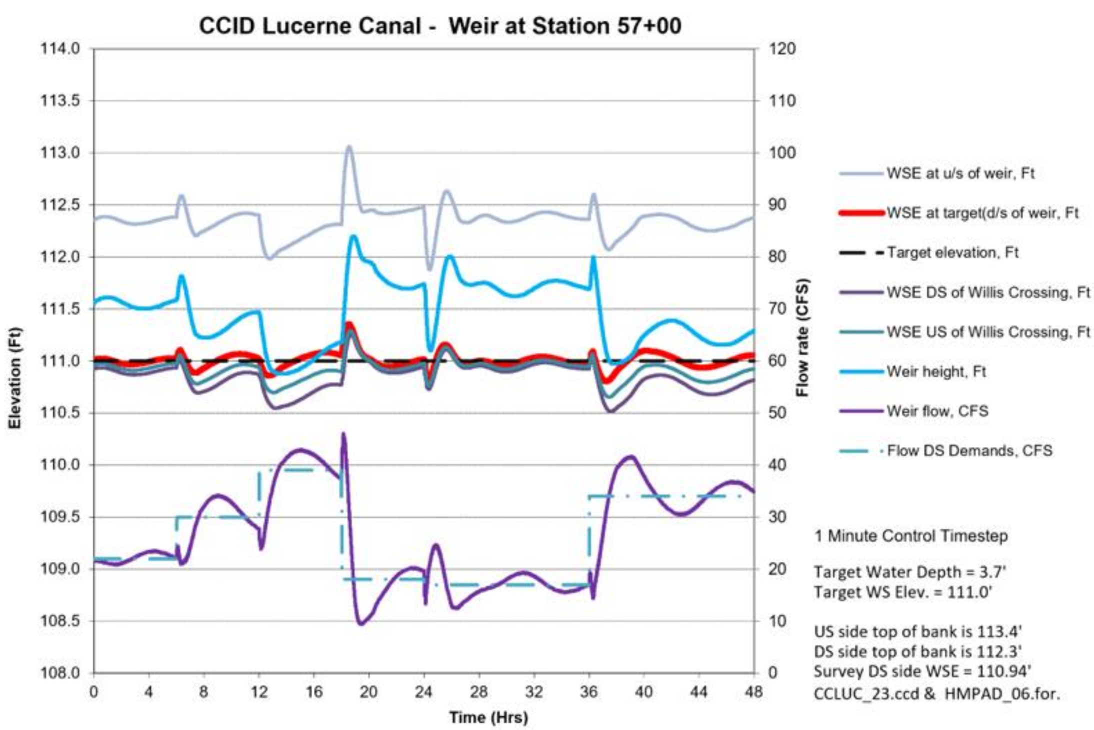
Turnout demand by check station		4000	5700	9000	16000	Total
Max TO flow for 2021, CFS		**12**	**23**	**14**	**13.7**	**62.7**
Historical max flow, CFS		**27**	**23**	**14**	**27**	**91**
Simulation hour	**0**	12	23	14	8	57
	6	15	15	10	20	60
	12	27	23	12	27	89
	18	5	5	5	13	28
	24	20	23	14	3	60
	36	27	15	7	27	76

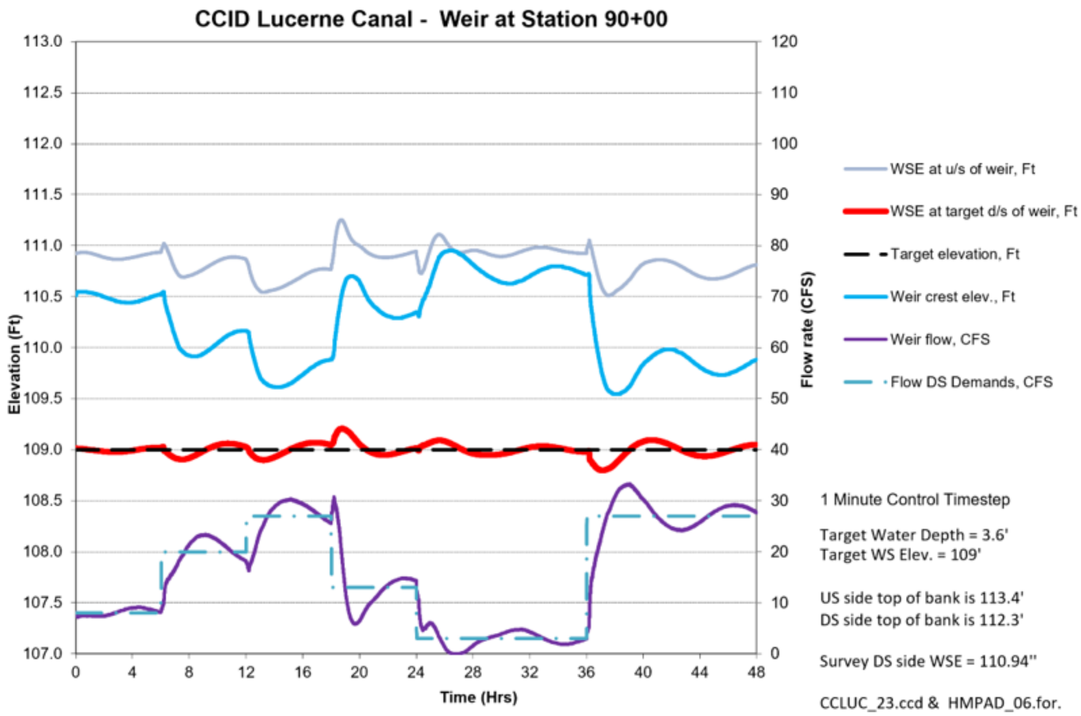
Simulated Control Performance Graphs

The graphs on the following pages show the anticipated water level control performance at each Lucerne Canal check structure.




CCID Lucerne Canal - Weir at Station 40+00
Elevation (Ft)
Flow rate (CFS)
Time (Hrs)
WSE at u/s of weir, Ft
WSE at target (d/s of weir), Ft
Target elevation, Ft
WSE DS of 1st Crossing, Ft
WSE US of 1st Crossing, Ft
Weir crest elev., Ft
Weir flow, CFS
Flow DS Demands, CFS
1 Minute Control Timestep
Target Water Depth = 4.0'
Target WS Elev. = 112.5'
US side top of bank = 114.4'
Immde. DS side top of bank = 113.6'
Culvert DS side top of bank = 113.5'
Survey DS side WSE = 112.34'
CCLUC_23.ccd & HMPAD_06.for.


CCID Lucerne Canal - Weir at Station 57+00
Elevation (Ft)
Flow rate (CFS)
Time (Hrs)
WSE at u/s of weir, Ft
WSE at target(d/s of weir, Ft
Target elevation, Ft
WSE DS of Willis Crossing, Ft
WSE US of Willis Crossing, Ft
Weir height, Ft
Weir flow, CFS
Flow DS Demands, CFS
1 Minute Control Timestep
Target Water Depth = 3.7'
Target WS Elev. = 111.0'
US side top of bank is 113.4'
DS side top of bank is 112.3'
Survey DS side WSE = 110.94'
CCLUC_23.ccd & HMPAD_06.for.



Poso/Riverside Canals (Reservoir location upstream of HWY 152)

Turnout demand schedules for the Poso/Riverside Canals are shown in Table 20.

Table 20. Simulated Poso/Riverside Canal turnout flow schedule

		Purpose	Summarize the canal survey for importation into CanalCAD;													
					TO flow in pool by simulaton hour (CFS)											
ITRC Model Station	Riverside Station	CCID Mile station	Description (as surveyed)	WSE Elev	0	2	8	15	20	22	24	28	30	32	34	36
0	63370.56	12.002	12 mile LCW ms 12.002 (U/S of Poso Res)													
5586.24	68956.8	13.06	Mitchell Weir ms 13.060													
					25	30	40	40	10	10	17	15	10	25	10	15
18469	81840	15.5	Silo LCW ms 15.500													
			Diversions directly from Poso		10	14	19	19	17	3	3	3	10	15	5	10
			Santa Rita Canal Aggregate		60	53	55	73	65	70	40	45	55	40	60	50
25094	88091.03	0	Head of Riverside LCW													
28752	3658		Crossing		16	16	10	20	20	20	20	18	15	15	15	15
35205	10111.2	1.915	weir 1.915													
35674	10580		HWY East crossing													
35869	10775		HWY West crossing													
37824	12730.08	2.411	weir 2.411 Not used													
			Riverside Diversion													
39350	14256	2.7	Lucerne Diversion Aggregate		30	24	24	18	38	30	30	10	10	25	10	15
			Lower Riverside Diversion Aggregate													
39804	14710.08	2.786	Weir @ Head of Lucerne/Lower Riverside ms 2.786													
43611	18516.96	3.507	Weir 3.507													
					3	3	11	11	11	0	0	8	8	3	10	5
47745	22651.2	4.29	Weir 4.29													
51378	26283.84	4.978	Weir 4.978													
					12	10	5	17	15	13	17	14	0	10	5	15
55116	30022.08	5.686	Weir 5.686													
57302	32208	6.1	Weir 6.10													
					5	5	11	11	22	22	22	5	5	15	10	12
61352	36257.76	6.867	Weir 6.867													
64346	39251.52	7.434	SJR River Spill 7.434													
					161	155	175	209	198	168	149	118	113	148	125	137

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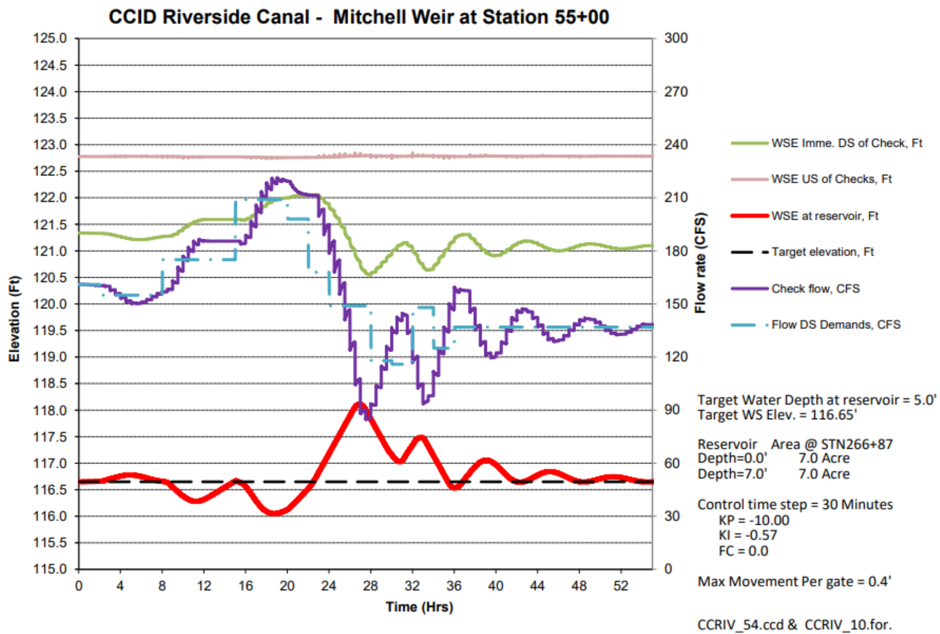
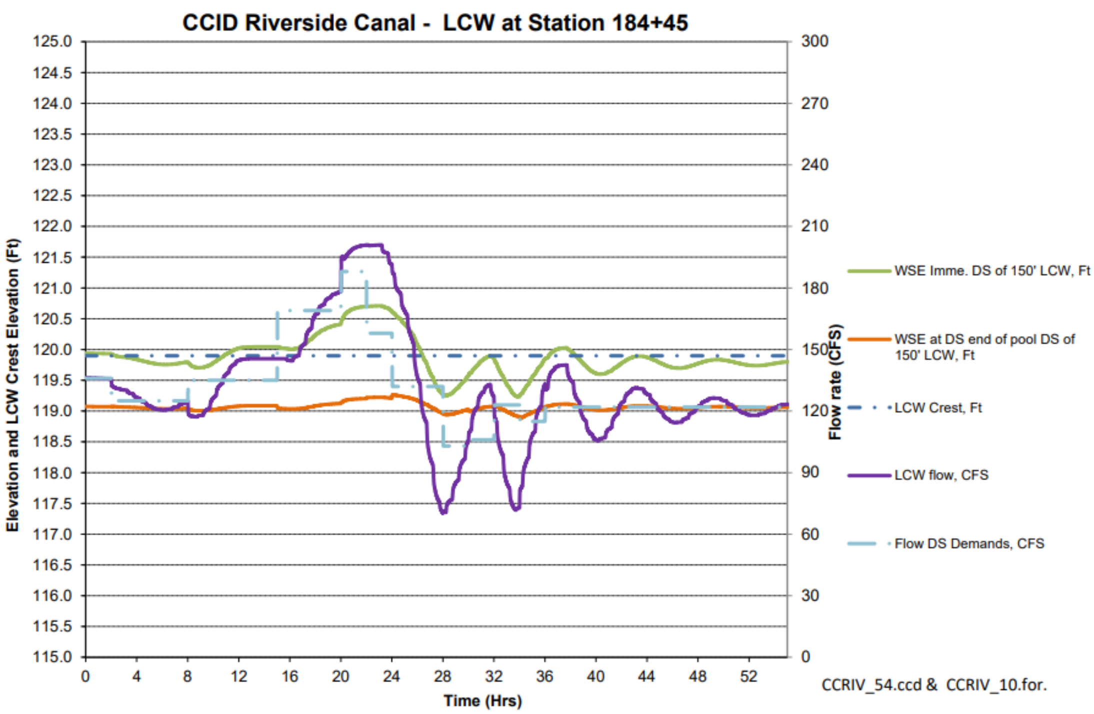
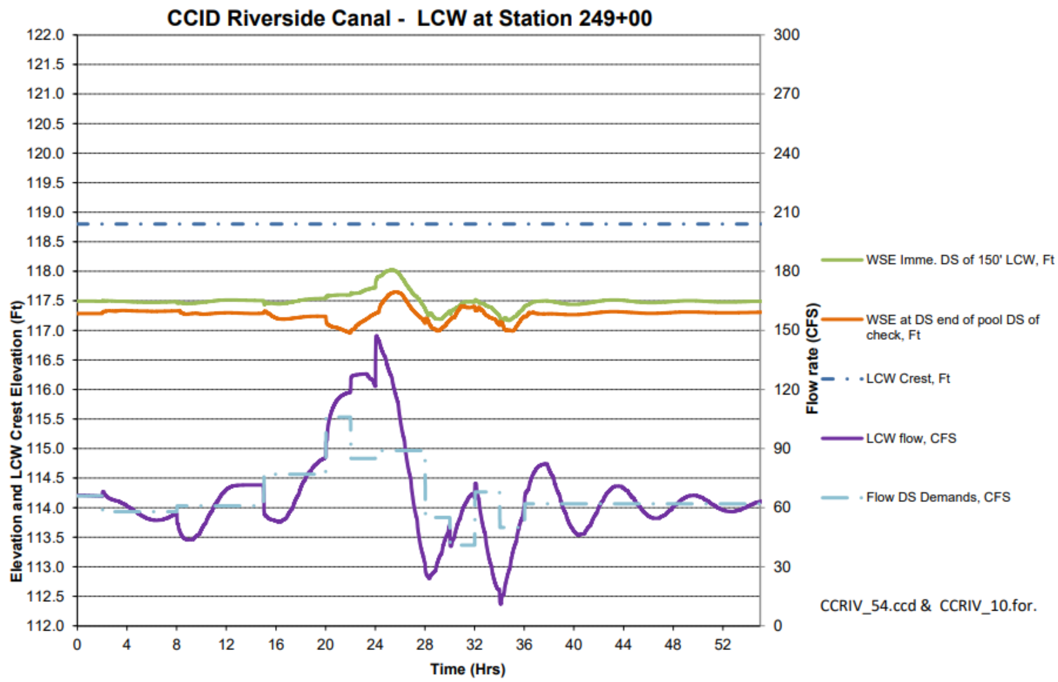
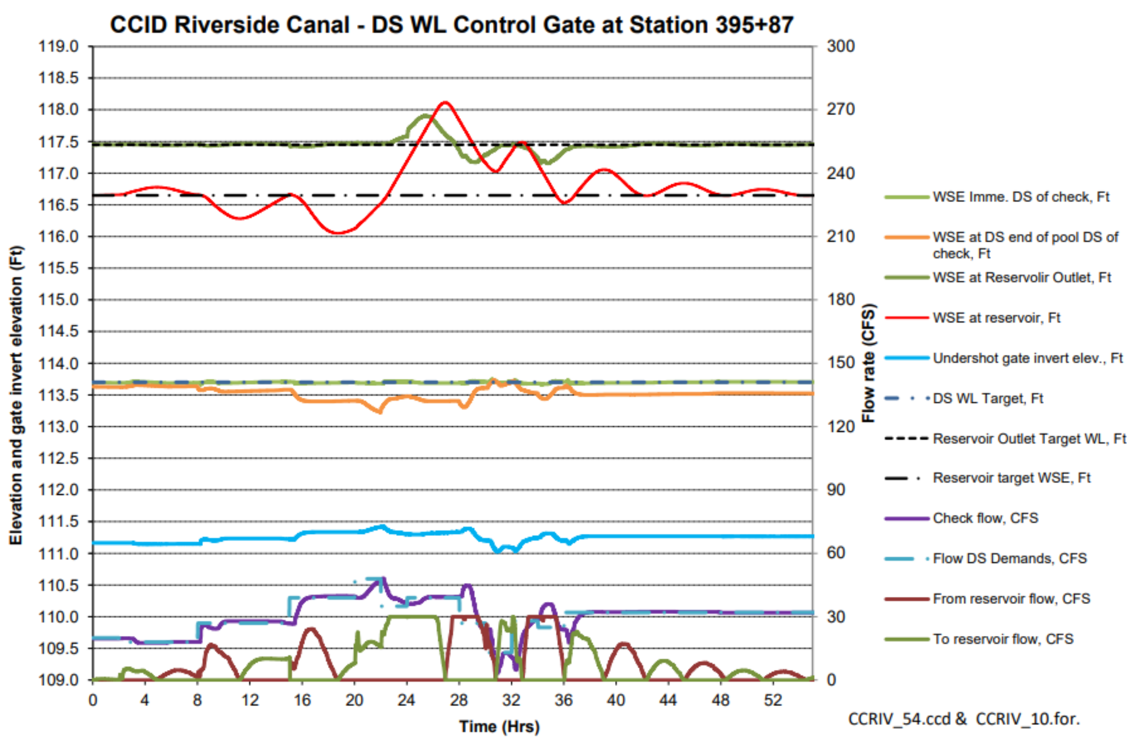
Simulated Control Performance Graphs

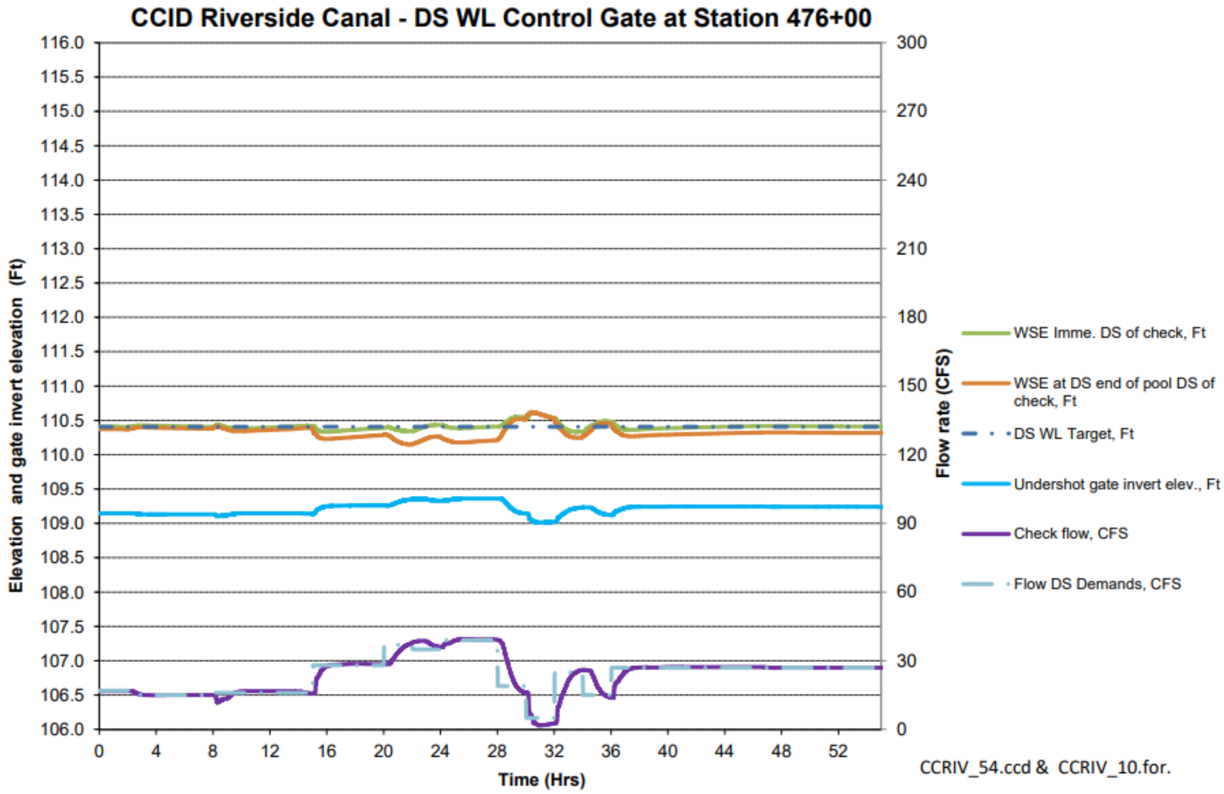
The graphs on the following pages show the simulated control performance at each automated check structure.



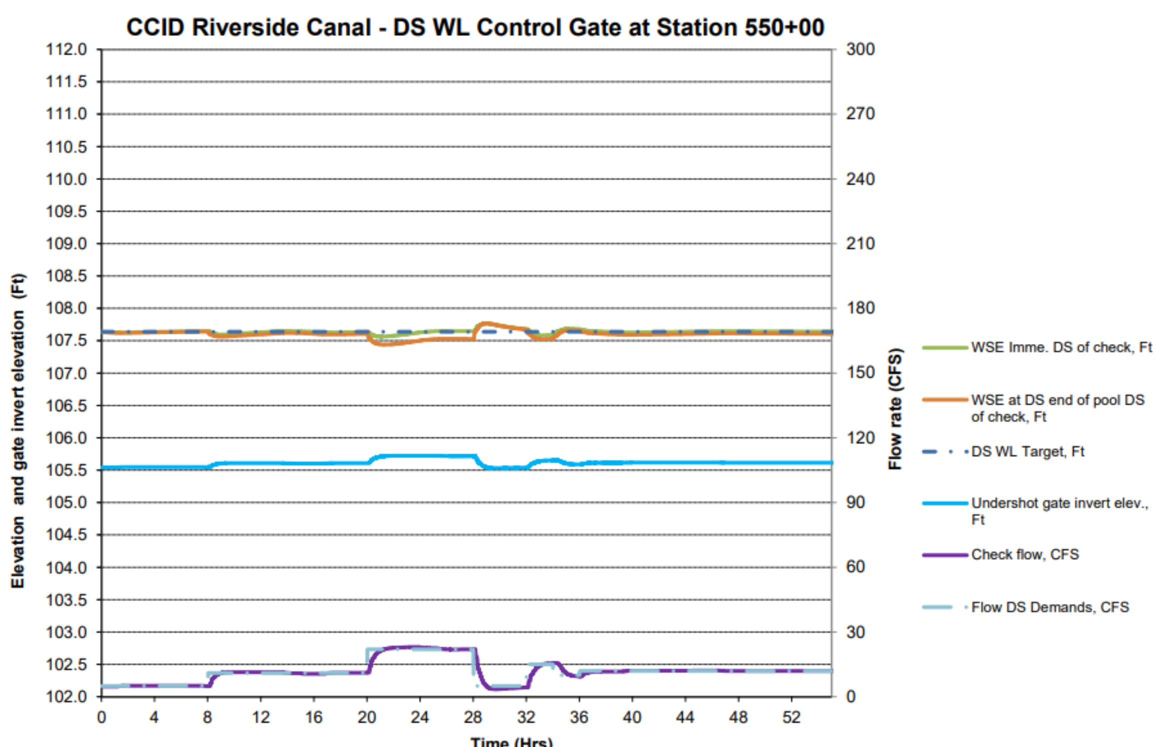



CCID Riverside Canal - LCW at Station 249+00
Elevation and LCW Crest Elevation (Ft)
Flow rate (CFS)
Time (Hrs)
WSE Imme. DS of 150' LCW, Ft
WSE at DS end of pool DS of check, Ft
LCW Crest, Ft
LCW flow, CFS
Flow DS Demands, CFS
CCRIV_54.ccd & CCRIV_10.for.


CCID Riverside Canal - DS WL Control Gate at Station 395+87
Elevation and gate invert elevation (Ft)
Flow rate (CFS)
Time (Hrs)
WSE Imme. DS of check, Ft
WSE at DS end of pool DS of check, Ft
WSE at Reservolir Outlet, Ft
WSE at reservoir, Ft
Undershot gate invert elev., Ft
DS WL Target, Ft
Reservoir Outlet Target WL, Ft
Reservoir target WSE, Ft
Check flow, CFS
Flow DS Demands, CFS
From reservoir flow, CFS
To reservoir flow, CFS
CCRIV_54.ccd & CCRIV_10.for.



CCRIV_54.ccd & CCRIV_10.for.



CCRIV_54.ccd & CCRIV_10.for.

Key Operational Changes

The modernization recommendations discussed in this report function best when coordinated with the following recommended operational changes:

1. The new 300 AF CCID Main Canal buffer reservoir will reduce congestion and coordination along the CCID Main Canal and generally, the entire "Colony Area."
    a. Buffering providing by the reservoir reduces the importance of, and potentially eliminates some need for flow changes at Mendota Pool.
    b. Rapid flow changes can be implemented at the Colony Main Canal with less stress because the changes are buffered.
2. Flexibility and excellent service can be provided along the Laguna Canal, Parsons Ditch, Shafter Ditch and Central Canal simply by running heavy (~105% of perfect) and without requiring substantial investment in modernization. The excess flows will all be internally, and automatically recirculated.
3. The proposed Laguna Reservoir expansion will provide additional buffering storage to reduce the frequency that East Ditch Reservoir is fully drawn down or filled up.
4. Operators will have the ability to rapidly transfer excess water from the East Ditch Reservoir to the Colony Main Canal (via East Ditch) and Branch 3 Canal (via a proposed lift pump), or Branch 4 Canal (via gravity).
5. Improvements at the Colony Reservoir will increase the number of turnouts automatically supplied by a reservoir by extending and raising the level pool.
6. Operational spill that is unrecoverably lost to CCID will be minimized with the implementation of automatic downstream control along the tail ends of the following canals:
    a. Branch 4 Canal
    b. Branch 5 Canal
    c. Colony Main Canal
    d. Poso & Riverside Canals
    e. Santa Rita Ditch
    f. Lucerne Canal

These benefits are illustrated in Figure 120.

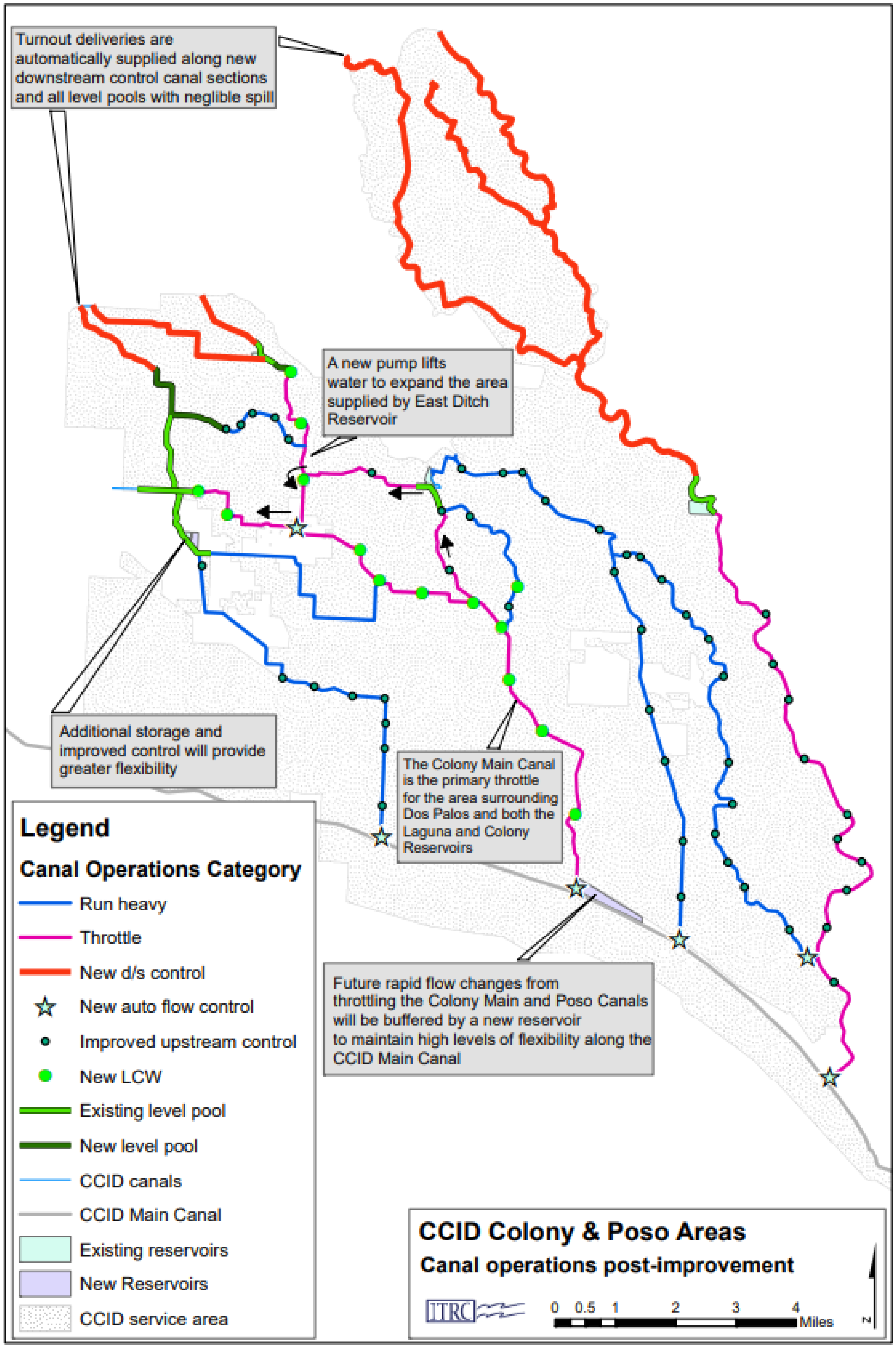


Figure 120. Key operational changes and benefits within the Colony Area

CENTRAL CALIFORNIA IRRIGATION DISTRICT
RESOLUTION NO. 24-09

RESOLUTION TO APPROVE THE WATER MANAGEMENT PLAN UPDATE

WHEREAS, the Central California Irrigation District has previously developed and submitted a Water Management Plan pursuant to the guidelines of the Bureau of Reclamation; and

WHEREAS, the Bureau requires that the Water Management Plan be periodically reviewed and updated; and

WHEREAS, THE CENTRAL CALIFORNIA IRRIGATION DISTRICT has prepared a "Water Management Plan Update" in accordance with the Bureau's current criteria.

NOW, THEREFORE, BE IT RESOLVED that the Board of Directors approves the Water Management Plan Update and directs that a copy of the Plan, along with a certified copy of this Resolution, be forwarded to the Bureau of Reclamation; and

BE IT FURTHER RESOLVED THAT the Manager is hereby authorized to sign and execute on behalf of the District any documents related to the Water Management Plan.

PASSED AND ADOPTED THIS 25th day of September, 2024 by the following vote:

AYES: JENSEN, BLOOM, MEDEIROS, O'BANION, FONTANA

NOES: NONE

ABSENT: NONE

ERIC FONTANA, President

ATTEST:

CRYSTAL GUINTINI, Secretary