7.10.2 Bylaws

WCWD's bylaws are provided on the following pages.

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FIRST AMENDED
BYLAWS

WESTERN CANAL WATER DISTRICT

PREAMBLE:

Western Canal Water District is a political subdivision of the State of California formed and existing pursuant to the provisions of Division 13 of the Water Code of the State of California. The District was formed on December 21, 1984, includes comprises approximately 59,000 irrigable acres in Butte and Glenn Counties. The District derives its water supply from direct diversion appropriative rights in the Feather River with a priority date of 1908, and from delivery by PG&E, through the facilities of the State Water Project, at the Thermalito Afterbay, and by direct diversion from Butte Creek.

A five member Board of Directors elected for staggered four year terms, governs the District. The general District election is held in November of odd-numbered years.

I. Definitions:

As used herein, the following words have the following meanings:

"District" means the Western Canal Water District.

"Application" means the annual application for irrigation service from the District and/or the annual application for winter water or waterfowl habitat service from the District during the non-irrigation season.

"Board" means the Board of Directors of Western Canal Water District.

"Irrigation Season" will be the period from April 1 to November 1.

"General Manager" means the General Manager of the District who is appointed by the Board of Directors.

"Works" of the District include all canals, laterals, ditches, drains, pipelines, conduits, crossings, pumps, check gates, weirs, and measuring devices used in connection with such facilities, and all other facilities owned and operated by the District and used in connection with the performance of its business of distributing water within the District.

"Private Conduits" means ditches, pipelines, standpipes, drains, pumps, and structures within the District owned by private persons.

"Person" means any person, firm, association, organization, partnership, business trust, corporation or company. Person does not include a public agency of the state or a special district.

"Customer" means any landowner or water user ordering and receiving water service from the District.

II. General Information:

1. Western Canal Water District is a landowner-voting District. A voter is a "person" owning land in the District and such persons owning land are eligible to vote at District elections and all lands within the District are eligible to vote at District elections either through the landowner, by proxy, or in the case of landowners composed of corporations or other similar legal entities, through a legal representative. Forms of proxies and of legal representation are available from the District Office.

2. Directors of Western Canal Water District must be persons who are owners of land within the District, or legal representatives thereof. Other officers of the District need not be landowners.

3. Directors of Western Canal Water District will be compensated in accordance with the provision of Section 20200, et seq. of Division 10 of the Water Code of the State of California. Attendance at meetings of the Board, or attendance at meetings on behalf of the Board as directed by the Board of Directors shall be considered as a day of service on behalf of the District. Other service rendered as a member of the Board of Directors at the request of the Board will be compensated in accordance with the determination of the Board as to the reasonable time required for such services to the District.

4. The address of the District Office is 2003 Nelson Rd., Nelson, California. The District may change the location of its office upon resolution of its Board of Directors.

5. The District is governed by the provisions of Division 13 of the Water Code, Rules and Regulations of the District, and Bylaws of Western Canal Water District. The Bylaws are adopted by the Board of Directors subsequent to approval by the Board of Supervisors of the County of Butte, State of California. Amendments to the Bylaws may be made by Resolution of the Board of Directors and are subject to the approval of the Board of Supervisors of the County of Butte. The alternate procedure for amendment of Bylaws is through a direct vote of the landowners.

6. The regular meeting of the Board of Directors shall be held on the third Tuesday of each month, at the hour of 9:00 a.m. at District headquarters. The Board of Directors reserves the right to modify the date and time of the regular meeting as necessary to meet the schedule and availability of Board members and to, by resolution, establish a different time and place for the regular District Board of Directors' meeting. Adjourned meetings and special meetings may be

scheduled as required and in accordance with law.

III. Control of the System:

1. The distribution system and works of the District are under the exclusive management and control of the General Manager, who is appointed by the Board of Directors. No other person shall have any right to interfere with said distribution system and works of the District in any manner whatsoever.

2. The General Manager shall appoint and employ such assistants and other employees as he may deem necessary for the proper operation of the system, subject to the approval of the Board, and at rates of compensation that will be fixed by the Board. The General Manager may delegate his authority with respect to the operations of the works of the system to other employees of the District, at his discretion.

IV. Ownership of Water.

1. All water delivered by the District is the property of the District and is subject to diversion, rediversion, reclamation, reuse, sale and resale, by the District as it sees fit. Landowner shall have a right to service from the District but no landowner or water user acquires any proprietary right to the water delivered to him by the District by reason of such use, nor does such landowner or consumer acquire any right to resell the water purchased or used, or the right to use it on premises or for a purpose other than for which it was applied and as stated in the Application. The District expressly asserts the right to recapture, reuse, and resell all water that passes from the premises described in the application as the place of use, and asserts its rights to all waters within the District.

2. If a person uses water on lands outside of the District that was applied for use within the District, whether by routing through a conduit, first flowing it across land within the District, by recapturing it from drains, or otherwise, the District may refuse service to the land within the District for which the Application was made until all charges for use of the water on the outside land, as fixed by the Board, are paid and the person makes such physical changes in his fields or irrigation systems as the Board deems necessary to assure the District that no future use of District water on the outside land can occur.

3. All persons intercepting, using, or impounding District water will be charged for such water at the rates established by the District, irrespective of whether the water is diverted or pumped from a conduit, taken from or impounded in a natural channel or drain, or whether it is waste, spill, seepage, runoff or other water. In order for water rates to be kept as low as possible, water users should notify the General Manager or canal operator of any waste or unauthorized use of water.

V. Applications for Water Use:

1. Applications for water use for the irrigation season must be filed with the District prior to April 1 of each year or at such later date as may be established by the Board, on forms furnished by the District. In the event of a shortage of water supply, if an application for agricultural water use shall not be received prior to April 1, that land may not be entitled to receive water during the water year without the express permission of the Board. Application for special service or water service during the non-irrigation season shall be required on forms and at times as specified annually by the Board of Directors.

2. In submitting an application for water, customers agree to be bound by the rules and regulations, and the bylaws, of the District, as they may exist, or as they may be modified from time to time. Customers also agree, in submitting said application, that the District, and its employees, will have access to and across the lands of customer for purposes of managing and regulating water and for inspecting the facilities for the distribution of water provided by the District.

3. In the event of a shortage of water, the Board shall establish rules for the proration of water, as necessary, prior to the irrigation season.

VI. Charges for Water Service:

1. The District shall, on or before April 1 of each year, establish appropriate charges for the delivery of water from the District. The charges that may be levied by the District include, but are not limited to, a standby charge and a water charge. Customers shall pay the standby charge for all irrigable acres within the District whether or not water is actually received, or ordered for those lands. The Board of Directors shall determine the irrigable acres based on relevant data, including Farm Service Administration acreage determinations or other appropriate criteria. All customers who are receiving irrigation water shall pay the water charge. The District reserves the right to establish additional rates and charges for purposes of meeting the costs and expenses of operating the District.

2. No water shall be delivered to any land if there is any outstanding or delinquent charge due and owing to the District for services provided by the District, including winter water service. The District has established penalties and delinquency fees to be paid in the event any water or standby charge is not paid when due and becomes delinquent. As an accommodation, the District may provide service to tenants, but the responsibility to pay for services provided to any tenant remains with the landowner.

3. Failure to receive a bill for water service shall not in any way excuse a landowner, or recipient of water, from the obligation to pay the applicable rates and charges for the water delivered.

4. Applicable water charges, including standby charges, shall be due and payable as determined by the Board of Directors. The Board shall establish times at which all applicable rates and charges, including standby charges, shall become delinquent and shall impose penalties, including interest and other penalties, if not paid by the date established by the Board of Directors.

VII. Liability for Delinquent Bills:

Landowners are responsible for the payment of all water charges applicable to their lands. Any delinquent water charges, or standby charges, will be subject to penalties and interest as established by the Board, and will be made a lien upon the land. It shall be the responsibility of the landowner to secure payment of said charges, whether by the tenant or by the landowner directly. In accepting an application for water service from a tenant, the District shall in no way waive its rights to collect all applicable water charges and standby charges from the landowner and to place any delinquent charges as a lien against the landholdings.

VIII. Control of Water:

No person within the District, other than the General Manager, or a delegated representative, shall operate the works of the District nor take any action to modify, control, interrupt, or effect the delivery of water by the District to any lands within the District without the consent of the District's General Manager.

IX. Shortages of Water:

The District shall not be liable for any damage that may result from an interruption or lack of service due to a shortage of water, or to any other cause that is beyond the control of the District. Temporary shutdowns may be made by the District to make improvements and repairs as necessary. Whenever possible and if time permits, landowners effected by such a shutdown shall be notified prior to the shutdown taking place.

X. Credit Deposits:

Prior to providing water service to any landowner or tenant who has, within the three years immediately prior to said application, been delinquent in the payment of any District water charge or standby charge the District may, in the discretion of the Board of Directors, require a deposit for all or a portion of the water charges anticipated to be levied for the coming water year. A deposit may also be required from a tenant if requested by the landowner. Landowners who have availed themselves of the protection of the bankruptcy laws may be required to pay for future service in advance.

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XI. Condition of Private Laterals and Conduits:

All private conduits must be in a condition to receive and transport water without waste and must be kept free from debris and other obstructions which, in the opinion of the General Manager, restrict the capacity of the canal or conduit below that which is necessary for the provision of water service. Customers shall, as soon as receiving notification thereof from the District's General Manager, make such improvements or modifications as are necessary to properly clean and maintain private conduits, or to restore private conduits to a condition where reliable water service can be provided. Failure to comply with an order of the General Manager to maintain or improve the private conduit shall relieve the District of any and all responsibility or liability for not delivering water and the District may, thereafter, refuse to deliver water to said facility.

XII. Quality of Water:

The District transports and delivers raw water for agricultural purposes only, and the water is not fit for human consumption and is not marketed for any domestic use whatsoever. The purpose of District water supply is for the irrigation of crops, straw-decomposition, and waterfowl habitat, and no landowner shall make an additional use of District's water supply without the express consent of the Board of Directors of the District. Customers shall assume full responsibility for and hold the District harmless from all damages resulting from an unauthorized use of District water.

XIII. District Employees:

District vehicles, tools, equipment, or manpower may not be used for the provision of any service to any landowner or water user within or without the District without the express authorization of the Board.

XIV. Recreational Use of Works of the District:

The canals, conduits, and other works of the District are maintained and dedicated to the provision of agricultural irrigation water to the lands within the District. The use of these facilities for recreational purposes, play, or other similar purposes is expressly prohibited.

Customers are urged to prevent use of District works and their banks for swimming or play. Water in many of the conduits is cold, swift and deep, and the conduits cover so many miles of the District that supervision of their use for recreation is impossible.

Any person who shall permit any equipment, livestock, poultry or waterfowl to damage or injure any works of the District, or who shall damage, injure or destroy by burning or otherwise any such works, or who shall dump any rubbish or pollutants therein or thereon, or who will erect signs, fences or structures on the District rights of way, will pay to the District upon demand all expenses incurred in repairing the damage or removing the rubbish, pollutants, signs, fences, or structures, including the reasonable value of staff time and attorney fees expended in enforcing this provision.

XV. Canal Bank Roads:

Use of District canal bank roads is at the sole risk of the user. The use of such roads by vehicles not owned by the District is prohibited where District signs, chains, or other barricades so indicate. Public use of canal bank roads without written permission of the General Manager may also be prohibited during certain periods of the year.

XVI. Water Use:

The District is primarily in existence for the purpose of supplying water to lands for irrigation, straw-decomposition, waterfowl, and other agricultural uses. The District, incidentally, provides water, in a non-irrigation season, for the flooding of duck clubs in the Butte Sink area.

When authorized by the Board of Directors, the District will consider the provision of water, for flooding of duck ponds within the boundaries of the District, but only when such service will not, in the opinion of the General Manager, through seepage or overflow from conduits or the fields flooded, interfere with the agricultural operations of other landowners, or interfere with the District's ability to operate and maintain its canal system.

XVII. Waste of Water:

Any customer, who in the opinion of the General Manager, is wasting water (on roads or vacant land, or land previously irrigated) either willfully, carelessly, negligently, or on account of defective private conduits, or who shall collect any portions of its land to an unreasonable depth, or use an unreasonable amount of water in order to properly irrigate other portions, or whose land has been improperly prepared for the economical use of water, or who allows an unnecessary amount of water to escape from any tail gate, may be refused the use of water until such conditions are remedied, or the District may reduce the inflow into the customer's fields to a flow that would be reasonable if such conditions were remedied.

The District reserves the right to refuse delivery of water when, in the opinion of the General Manager, the proposed use, or method of use, will require such extensive quantities of water as to constitute waste.

XVIII. Nonliability of District:

The District will not be liable for any damage of any kind or nature resulting directly or indirectly from the use of a private conduit or by reason of lack of capacity in any private or District conduit or for negligent, wasteful, careless or other use or handling of water by customers.

The District does not guaranty an uninterrupted supply of water nor is the District responsible for interruption or shortage of distribution capacity or water supply for any reason, including but not limited to excessive demand, drought, canal breaks or scheduled or unscheduled maintenance.

The water supply of the District flows through many miles of river channels and open canals and the District assumes no responsibility for the quality of the water, temperature, or fluctuations in flow.

Customers pumping water do so at their own risk and the District is not responsible for damages to pumping equipment used to lift or reclaim District-supplied water.

XIX. Freedom from Obstruction:

No fences, bridges, ditches, buildings or other obstructions shall be placed by any customer across or upon, or along any canal, ditch, right of way, or property of the District without first obtaining the written permission of the District's General Manager.

XX. Transfers of District Water.

The Board of Directors reserves the right to enter into negotiations and to negotiate appropriate terms and conditions related to the transfer of a portion of the District's water supply. Transfers may be implemented through the reduction in diversions of the District's deliveries from State Water Project facilities; substitution of groundwater for surface water; reduction in diversion as a result of land idling; or reduction and sale of contract quantities as determined reasonable and necessary by the Board of Directors. No individual landowner within the District shall have the right to negotiate for and/or to carry out a transfer of a portion of the water supply available to said landowner unless prior approval is received from the Board of Directors.

XXI. Ownership of Structures:

All structures and meters used for the provision, measurement, or regulation of water service from District works shall be constructed and installed by the District or under its direction and supervision, and in compliance with all applicable District specifications.

XXII. Annexation and Detachment.

The Board of Directors of Western Canal Water District shall have the right, in accordance with the provisions of Division 3 of Title 5 of the Government Code, to undertake proceeding for annexation into and detachment from the boundaries of the District and to establish and modify the Sphere of Influence of the District. The Board of Directors shall require an agreement with landowners prior to seeking annexation. Annexation shall be either "primary," according to the annexee full rights, including a pro rata share of District's water supply, or secondary, according to the annexee as-available water when determined to be surplus to the needs of the primary landowners of the District, or on some other basis as determined to be appropriate by the Board of Directors. Costs and expense of all charges, including Board-authorized annexation and detachment fees, shall be the obligation of the landowner(s) requesting such change.

XXIII. Severability and Breach:

Each article of these Bylaws is separate and distinct and the determination by a court or regulatory agency that any provision hereof is unenforceable shall not in any manner restrict or affect the remaining provisions.

Failure by the District to enforce or restrain the breach of any provision of these Bylaws or its applicable rules, shall not be construed as an estoppel or a waiver of any rights of enforcement the District may possess in the future or as a modification of said Bylaws or rules.

WESTERN CANAL WATER DISTRICT

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7.10.3 Agricultural Water Measurement Compliance Documentation

Documentation of WCWD's compliance with Section 10608.48(b) of the California Water Code (CWC §10608.48(b)) and the resulting California Code of Regulations Title 23 Division 2 Chapter 5.1 Article 2 Section 597 et seq. (CCR 23 §597) is provided on the following pages.

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Western Canal Water District

California Code of Regulations Title 23 §597

Agricultural Water Measurement Compliance Documentation

Executive Summary

Western Canal Water District (WCWD, or District) supplies water from the Feather River to over 50,000 acres of land in agricultural production and is required by law to comply with the measurement requirements of Section 10608.48(b) of the California Water Code (CWC §10608.48(b)) and the resulting California Code of Regulations Title 23 Division 2 Chapter 5.1 Article 2 Section 597 et seq. (CCR 23 §597). CWC §10608.48(b) states that agricultural water suppliers subject to the law, such as WCWD, are mandated to measure the volume of water delivered to customers with sufficient accuracy to:

- Enable reporting of aggregated farm-gate delivery data to the State and
- Adopt a pricing structure based at least in part on the quantity of water delivered.

CCR 23 §597 describes the accuracy requirements for the measurement of farm-gate deliveries, which fall into three different categories with corresponding accuracy requirements, as follows:

- ±12 percent by volume for existing devices certified in the field (i.e. field testing),
- ±10 percent by volume for new devices certified in the field using a non-laboratory certification (i.e. field testing or field inspection), and
- ±5 percent by volume for new devices certified in the laboratory (i.e. laboratory certification).

The regulation mandates that an accuracy certification be performed by either: (1) field testing of a random and statistically representative sample of existing or new farm turnouts, (2) field inspections and analysis of every existing farm turnout, or (3) a laboratory certification. The field testing and field inspection based accuracy certifications must documented in a report approved by a California-registered professional engineer.

From its inception in 1984, WCWD has used propeller meters to measure farm-gate deliveries and has billed customers using a volumetric pricing structure based on the quantity of water delivered. In order to determine whether or not the delivery measurement program was compliant with the requirements of CCR 23 §597, WCWD elected to perform field testing of its existing devices. A California-registered professional engineer performed field testing (i.e. field verification measurements) on a statistically representative sample consisting of 11 percent (n = 34) of the entire population of measurement devices that the District currently uses for measurement (N = 303).

The average percentage difference between delivery volumes reported by the meters and verification measurements was negative seven percent, meaning that the recorded meter measurements tended to be seven percent lower by volume than the verification measurements. Out of the 34 meters tested, 29 (85% of the sample) had a percent difference of less than ±12 percent, while five (15% of the sample) had a percent difference greater than ±12 percent; therefore, the number of meters outside the accuracy requirements was less than one quarter of the devices tested. CCR 23 §597.4(b) states that no more than one quarter of the devices tested can have measurement errors greater than ±12 percent. Thus, existing volumetric delivery measurement by WCWD satisfies the requirements of CCR 23 §597.

The remainder of this document provides a more detailed description of volumetric delivery measurement by WCWD as detailed in CCR §597.4(e) and includes the following subsections:

- 1. Documentation of Compliance (CCR §597.4(e)(1)) - Review of requirements of CWC §10608.48, description of delivery measurement program, volumetric pricing structure, field testing methodology, and field testing results;
- 2. Best Professional Practices (CCR §597.4(e)(2)) - Description of best professional practices for maintaining delivery measurement program including collection of water measurement data, frequency of measurements, method of determining irrigated acres, and quality control and assurance procedures;
- 3. Determination of Volume (CCR §597.4(e)(3)) - Summary of procedure for determination of volume;
- 4. Corrective Action Plan Summary (CCR §597.4(e)(4)) - Explanation that no corrective action plan is required since current measurement program is compliant; and
- 5. References.

1. Documentation of Compliance (CCR §597.4(e)(1))

1.1. Review of §10608.48 Agricultural Water Measurement Requirements

Agricultural volumetric delivery measurement requirements are outlined in the Section 10608.48(b) of the California Water Code (CWC §10608.48(b)). A review of the requirements and associated legislation and regulations are contained in this section.

The Water Conservation Act of 2009 passed by the California State legislature consists of four policy bills and an $11.14 billion water bond. One of the policy bills (Senate Bill x7-7, or SBx7-7) addresses both urban and agricultural water conservation and, with respect to agriculture, includes new mandates regarding the accuracy of customer delivery measurement applicable to agricultural water suppliers serving more than 25,000 acres. WCWD serves water to over 50,000 acres and is therefore subject to the regulation.

The California Department of Water Resources (DWR) was responsible for developing and adopting regulations pursuant to SBx7-7, resulting in California Code of Regulations Title 23 Division 2 Chapter 5.1 Article 2 Section 597 et seq. (CCR 23 §597). CCR 23 §597, referencing CWC §10608.48(b), states that agricultural water suppliers subject to the law shall measure the volume of water delivered to customers with sufficient accuracy to:

- Enable reporting of aggregated farm-gate delivery data to the State, and
- Adopt a pricing structure based at least in part on the quantity of water delivered.

CCR 23 §597 describes the accuracy requirements for the volumetric measurement of farm turnout[1] deliveries, which fall into three different categories with corresponding accuracy requirements, as follows:

- ±12 percent by volume for existing devices certified in the field (i.e. field testing),
- ±10 percent by volume for new devices certified in the field using a non-laboratory certification (i.e. field testing or field inspection), and
- ±5 percent by volume for new devices certified in the laboratory (i.e. laboratory certification.

The regulation requires that an accuracy certification be performed by either: (1) field testing of a random and statistically representative sample of existing or new farm turnouts, (2) field inspections and analysis of every existing farm turnout, or (3) a laboratory certification. The field testing and field inspection based accuracy certifications must documented in a report approved by a California-registered professional engineer.

[1] The use of "farm turnout" and "turnout" in this document is synonymous with "farm-gate" and "customer delivery point" utilized in CCR 23 §597.

1.2. Delivery Measurement Program

WCWD was formed by a vote of landowners on December 18, 1984, and was previously owned by the Pacific Gas and Electric Company (PG&E). From its inception, propeller meters have been used extensively by the District to measure deliveries to customers. Currently all delivery points are measured as documented below.

Propeller meters are devices that measure both flow rate (cfs) and accumulated volume (af) over time with a totalizer. The District currently uses 303 propeller meters, including 267 (88%) are open channel propeller meters used where gravity deliveries are made and 36 (12%) lift pump propeller meters used where lift pump deliveries are made. The meters are deployed at delivery points across the District wherever control is transferred from the District to the customer(s), as described in CCR 23 §597.2(a)(6).

A typical WCWD farm turnout with gravity delivery is shown in Figure 1. An orifice gate is installed on the upstream side of the turnout for flow control. A concrete headwall is installed on the downstream side, allowing for the installation of an open channel propeller meter mounted in the outfall of the pipe. In locations where differences between the canal water surface elevation and the field elevation are large, a concrete weir box is installed on the downstream side to allow full-pipe flow, which is necessary for accurate delivery measurement. Figure 2 displays a photograph of an open channel propeller meter deployed in a concrete weir box in WCWD.

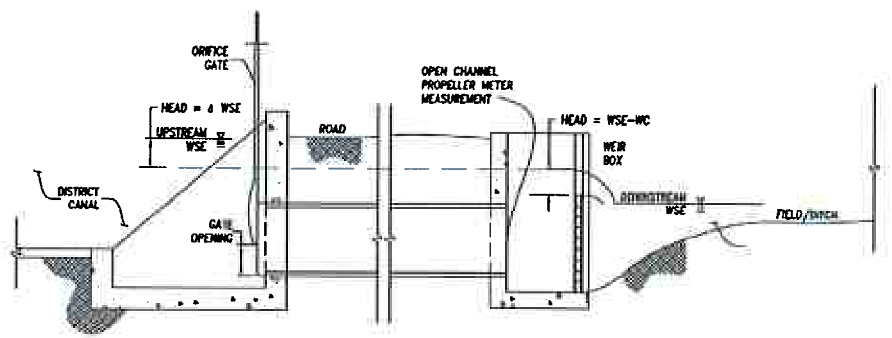

Figure 1. Typical Gravity Delivery Farm Turnout Configuration.

WCWD Agricultural Water Measurement Compliance Documentation

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Figure 2. Open Channel Propeller Meter in WCWD.

Low lift pumps are utilized at locations where gravity deliveries are not possible to deliver water to fields. Lift pump propeller meters are used to measure deliveries in these locations and are inserted directly into the pipeline downstream of the pump. A 45° elbow or other device, as needed, is installed facing upwards in the outfall of the pipe to ensure full-pipe flow (necessary for accurate delivery measurement). Figure 3 displays a photograph of a lift pump propeller meter in WCWD, along with a Prosonics 92T transit-time flow meter used for field testing, which is further described in Section 1.4.

Figure 3. Lift Pump Propeller Meter in WCWD.

Both open channel and lift pump propeller meters are designed to measure flow rate and volume for a specific pipe diameter. The pipe sizes for the 303 meters currently in use at WCWD range from 8 inches to 36 inches. 260 of the meters (approximately 85% of the District's meters) are used in pipes at least 18 inches in diameter. Of the remaining meters, the most common size is 12 inches. The most common pipe and meter size is 24 inches, representing over 90 meters (approximately 30% of the meters used).

Operators visit each meter site at least once daily during the irrigation season to record flow rate and delivered volume and to ensure meters are functioning correctly. Approximately one third of the meters in the District are tested and calibrated annually at WCWD's meter testing facility along Little Dry Creek west of the District's office. The District allocates funds to purchase approximately 10 to 20 meters annually to replace damaged or defective meters. CCR 23 §597 compliance documentation for WCWD's delivery measurement program is provided in Section 1.5.

1.3. Volumetric Billing

Since its formation in 1984, WCWD has billed water users within the District using a wholly volumetric water rate. A minimum charge of one af/ac is billed for service annually, regardless of the volume of water delivered. Any water delivered in excess of one af/ac is billed based on the additional volume delivered. This pricing structure is compliant with the requirements of CWC §10608.48 and CCR 23 §597.

1.4. Field Testing Methodology

CCR 23 §597.4(b)(1) requires testing a minimum sample size of 10% of existing measurement devices. Because the turnout infrastructure and measurement devices being tested predate the regulation, they are required to have an accuracy of ±12 percent by volume. If more than one quarter of the devices fail to meet the accuracy requirements, the measurement program does not meet the requirements of the regulation, and a plan for a second round of field testing and corrective action would need to be developed. The methodology used to test a random and statistically representative sample of existing farm turnouts is described in the remainder of this section. Field testing results are presented in Section 1.5.

There are three alternatives[2] for compliance with the delivery measurement accuracy requirements of CCR 23 §597.3, as described previously in Section 1.1:

- Field testing of a random and statistically representative sample of existing farm turnouts,
- Field inspections and analysis of every existing farm turnout, or
- Referencing a laboratory certification.

In order to determine whether or not the delivery measurement program is compliant with the requirements of CCR 23 §597, WCWD elected to perform field testing. A California-registered professional engineer performed field testing (i.e. field verification measurements) on a statistically representative sample consisting of 11 percent (n = 34) of the entire population of measurement devices currently used for measurement (N = 303).

To obtain a randomized list of meters in WCWD, the District's complete meter list was assembled in a Microsoft Excel spreadsheet. The 'RAND()' function was used to generate a random value between zero and one for each meter. The meter list was then sorted in ascending order by the column containing the random value, creating a randomized list of meters.

Field testing was performed by a California-registered professional engineer over the course of four days on 5/13/2014, 5/14/2014, 5/21/2014, and 5/22/2014. Sites were selected from the randomized meter list from top to bottom; verification measurements were performed for each meter that was currently measuring an irrigation delivery. If the meter selected from the randomized meter list was not measuring an irrigation delivery, the next meter was selected. This process continued until a sample size of at least 10% of the meters had been tested. The resulting dataset was analyzed to ensure that it was statistically representative.

The procedure taken for each field testing (i.e. verification) measurement was:

[2] The first two of the three alternatives are required to be documented by a California-registered professional engineer.

- Upon arrival to the site, a flow reading was taken from the propeller meter by timing the meter for 60 seconds and counting the number of rotations. The meter flow chart, which is shown in Figure 4, was then used to determine the flow rate.
  - For 10" to 18" meters, each revolution is 0.72 cfs.
  - For 21" to 36" meters, each revolution is 7.2 cfs.

Open Flow Meters

	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
0	0.00	0.07	0.14	0.22	0.29	0.36	0.43	0.50	0.58	0.65
1	0.72	0.79	0.86	0.94	1.01	1.08	1.15	1.22	1.30	1.37
2	1.44	1.51	1.58	1.66	1.73	1.80	1.87	1.94	2.02	2.09
3	2.16	2.23	2.30	2.38	2.45	2.52	2.59	2.66	2.74	2.81
4	2.88	2.95	3.02	3.10	3.17	3.24	3.31	3.38	3.46	3.53
5	3.60	3.67	3.74	3.82	3.89	3.96	4.03	4.10	4.18	4.25
6	4.32	4.39	4.46	4.54	4.61	4.68	4.75	4.82	4.90	4.97
7	5.04	5.11	5.18	5.26	5.33	5.40	5.47	5.54	5.62	5.69
8	5.76	5.83	5.90	5.98	6.05	6.12	6.19	6.26	6.34	6.41
9	6.48	6.55	6.62	6.70	6.77	6.84	6.91	6.98	7.06	7.13
10	7.20	7.27	7.34	7.42	7.49	7.56	7.63	7.70	7.78	7.85
11	7.92	7.99	8.06	8.14	8.21	8.28	8.35	8.42	8.50	8.57
12	8.64	8.71	8.78	8.86	8.93	9.00	9.07	9.14	9.22	9.29
13	9.36	9.43	9.50	9.58	9.65	9.72	9.79	9.86	9.94	10.01
14	10.08	10.15	10.22	10.30	10.37	10.44	10.51	10.58	10.66	10.73
15	10.80	10.87	10.94	11.02	11.09	11.16	11.23	11.30	11.38	11.45
16	11.52	11.59	11.66	11.74	11.81	11.88	11.95	12.02	12.10	12.17
17	12.24	12.31	12.38	12.46	12.53	12.60	12.67	12.74	12.82	12.89
18	12.96	13.03	13.10	13.18	13.25	13.32	13.39	13.46	13.54	13.61
19	13.68	13.75	13.82	13.90	13.97	14.04	14.11	14.18	14.26	14.33

Size 10"-to 18" read as shown - Size 21" to 36" move decimal to right one point.

Figure 4. Meter Flow Chart.

- For gravity sites, the following verification measurement was performed:
  - The meter was temporarily removed, since the verification measurement also takes place in the pipe outfall.
  - The recorded pipe diameter and full-pipe flow were verified.
  - A SonTek FlowTracker Acoustic Doppler Velocimeter (ADV) was used to perform a velocity transect in the outfall of the pipe, wherein a distribution of velocity points were measured horizontally and vertically across the pipe as seen in Figure 5.
  - Flow rate was calculated as the product of the average velocity from the measurement transect and the pipe cross-sectional area determined from the inner pipe diameter. The accuracy of this measurement method has been demonstrated by a study comparing this method to the conventional USGS mid-section method (Thiede and Davids 2012).
  - The propeller meter was reinstalled after the verification measurement was complete.

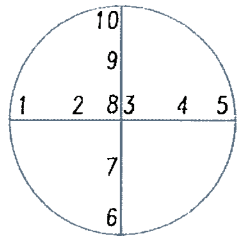

Figure 5. Velocity Transect Measurement Locations.

- For lift pump sites, the following verification measurement was performed:
  - The pipe material, diameter, and thickness were verified.
  - An Endress+Hauser Prosonics 92T Portable Transit-Time Ultrasonic (Prosonics) flow meter was used to perform a verification flow measurement with a two pass (i.e. "V") configuration.
  - A five minute average from the Prosonics flow meter was used as the verification measurement.
- Upon completion of the verification measurement, another flow reading was taken from the propeller meter as described above.
- The average of the two propeller meter readings was compared to the verification measurement to determine measurement device accuracy.

1.5. Field Testing Results

This section describes the results of the field testing effort. Over the course of four days of field testing, a total of 34 existing measurement devices were tested for accuracy as described in Section 1.4. A combination of open channel propeller meters and lift pump propeller meters were tested, with pipe sizes ranging from 12 inches to 36 inches in diameter. The most common meter size tested was 24 inches. The 34 meters (n = 34 or 11%) constitute a randomly selected, and statistically representative sample of the 303 meters (N = 303) in WCWD (as outlined in Section 1.4 in greater detail).

The flow rates measured during the verification measurements ranged from 0.94 cfs to 23.1 cfs with an overall average of 6.85 cfs. The percent difference for each individual meter was calculated using Equation 1, and the average percent difference was then calculated as the arithmetic mean of all 34 verification measurements.

$$\%\,Difference = \left(\frac{Meter\ Reading - Verification\ Measurement}{Verification\ Measurement}\right) \times 100\% \qquad [1]$$

The average percentage difference between the meters and verification measurements was negative seven percent, meaning that the recorded meter measurements tended to be seven percent lower than the verification measurements. Out of the 34 meters tested, 29 (85% of the sample size) had a percent difference of less than ±12 percent, while five (15% of the sample size) had a percent difference greater than ±12 percent; therefore, the number of meters outside the accuracy requirements was less than one quarter of the devices tested. CCR 23 §597.4(b) states that no more than one quarter of the devices tested can have measurement errors greater than ±12 percent. Thus, existing volumetric delivery measurement by WCWD satisfies the requirements of CCR 23 §597.

2. Best Professional Practices (CCR §597.4(e)(2))

The delivery measurement program was verified to be compliant based on field testing during May 2014; however, in order to maintain compliance, current monitoring and maintenance activities related to volumetric delivery measurement need to continue including but not limited to practices to collect data, perform frequent measurements, and accurately determine irrigated acreage, and ensure quality control and quality assurance. This section describes best professional practices to be continued as part of WCWD's delivery measurement program to satisfy the requirements of CCR 23 §597.

2.1. Collection of data

In WCWD, volumetric delivery measurement data is collected using open channel propeller meters for gravity deliveries and lift pump propeller meters for lift pump deliveries. These are devices that measure both instantaneous flow rate (cfs) and volume (af). Flow rate measurements can be taken from meter readings while an operator is on site, using the procedure described above in Section 1.4. Delivered volume is determined on a continuous basis using a totalizer that records accumulated volume over time and can be read from the meter while on site.

2.2. Frequency of Measurements

During the irrigation season, operators visit each meter site at least once daily to record flow rate measurements and volumetric totalizer readings, and ensure meters are functioning correctly. This practice should be continued.

2.3. Method of Determining Irrigated Acreage

Irrigated acreages in the District are provided through the Farm Service Agency (FSA). When customers submit annual applications for water service, they are required to report FSA acreages. Acreages are updated and reviewed annually. This practice should be continued.

2.4. Standards for Quality Control and Quality Assurance

Daily visits to meter sites during the irrigation season are a key component of quality control and quality assurance practices. These visits allow problems with meters to be quickly identified so that steps can be taken to correct any problem in a timely manner. Frequent visits minimize uncertainties in volumetric delivery measurement. Also, maintaining a daily record of both instantaneous flow rate and accumulated volume provides a consistent record over time that can be used for quality control purposes. For example, if the totalizer on a meter malfunctions; this results in a decrease in the rate of accumulated volume. The daily flow rate and volume records can be used to identify the malfunction, and the daily flow record can be used to adjust the volumetric delivery record in place of the faulty totalizer reading. When this occurs, adjustments are summed on a two week basis and added to the difference between the beginning and ending totalizer readings. In the event of a damaged or defective meter, the meter should be replaced as soon as possible.

Approximately one third of the meters in the District are tested and calibrated annually at WCWD's meter testing facility along Little Dry Creek west of the District office, and the District allocates funds to purchase approximately 10 to 20 meters annually to replace damaged or defective meters. These practices should be continued.

3. Determination of Volume (CCR §597.4(e)(3))

CCR 23 §597 states that for water measurement devices that measure flow rate, velocity, or water elevation and do not report the total volume of water delivered, the conversion from the measured value to volume must be documented. There are uncertainties associated with conversions from instantaneous measurement to accumulated volume over time; however, the totalizers on the meters used by WCWD report the total volume of water delivered. For permanently installed devices with totalizers, such as the meters used by WCWD, it can be assumed that flow rate accuracy is equal to volumetric accuracy (Burt and Geer 2012).

4. Corrective Action Plan (CCR §597.4(e)(4))

Because existing volumetric delivery measurement by WCWD satisfies the requirements of CCR 23 §597, no corrective action is necessary.

5. References

Burt, C., E. Geer, 2012, 'SBx7 Flow Rate Measurement Compliance for Agricultural Irrigation Districts,' ITRC Report No. R 12-002, accessed at http://www.itrc.org/reports/pdf/sbx7.pdf.

Thiede, M.T., J.C. Davids, 2012, 'Evaluation of Weir Boxes and Orifice Gates for Farm Gate Delivery Measurement,' U.S. Committee on Irrigation and Drainage, Managing Irrigation Systems in Today's Environment, USCID Water Management Conference, Reno, NV.

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Potential Projects to Enhance WCWD Water Management Capabilities

Overview

A total of three potential projects to enhance water management by Western Canal Water District (WCWD) were evaluated. These range from comprehensive system modernization to localized projects related to boundary outflow and safety spill measurement. Also, a project to bypass the "reservoir" area in the Main Canal at Little Butte Creek was evaluated. For each project, reconnaissance level implementation costs have been estimated. It is anticipated that these projects would be implemented over time subject to the availability of funding and project prioritization. Potential improvements are described in the following sections:

1. System Modernization
2. Boundary Outflow and Primary Spill Measurement
3. Little Butte Creek Reservoir Main Canal Bypass Project

Summary of Cost Estimation Procedure

Reconnaissance level cost estimates were prepared for each improvement project as a basis for prioritization and funding of site improvements. The following summary of the cost estimation procedure applies to all projects described in this attachment.

Site inventories were completed with the help of district staff, and sites were visited as needed to provide sufficient information to develop conceptual designs to estimate material and labor quantities. Detailed site surveys have not been performed, and dimensions of structures and cross sections were gathered only at a sample of locations. Based on field visits, many sites of a specific type (e.g. water level control) were similar, varying primarily in capacity. Accordingly, conceptual designs were developed for each site type across a range of capacities. The typical components for which conceptual designs were developed are listed in Table 1. Costs were developed based on estimates of required site components, quantities, and unit costs.

Table 1. Typical conceptual designs and the variations/configurations developed for purposes of cost estimation.

	Typical Design	Variations/Configurations
A	Acoustic Doppler velocimeter in lined section of channel	
B	Acoustic Doppler velocimeter in unlined section of channel	I. High capacity canal II. Mid-range capacity canal
C	New Precast Spill Box with 36" propeller meter at d/s end	I. 4 ft weir box II. 6 ft weir box
D	Precast headwall with new 36" undershot gate, piping and propeller meter at d/s end	
E	New Precast Spill Box with fixed, sharp-crest weir plate	I. 4 ft weir box II. 6 ft weir box
F	New precast spill box with piping and RemoteTracker bracket at d/s end. RemoteTracker not included.	
G	Locally automated combination weir	450, 250, 150, 75, 50, and 25 cfs capacity
H	Manually Adjusted Undershot Gates	Cost estimated on a per square foot of gate area basis
I	Automated Flow Control Gates	Cost estimated on a per square foot of gate area basis
J	SCADA hardware and related communication components	I. No add'l power source II. No add'l power source, w/ PLC III. W/ solar power system and PLC IV. W/ solar power system, pressure transducer and related components

Unit Costs

Unit costs for the various work items and materials were compiled from a variety of sources including published values, local suppliers, contractors and installers, and projects previously completed by Davids Engineering and others. Standard unit prices were increased by 10% assuming prevailing labor rates will apply. Costs include material and equipment costs, installation labor, shipping, and tax (where applicable).

Cost types fall into three categories: Direct Costs, Indirect Costs, and Contingencies. Direct costs are associated with physical site improvements while indirect costs represent other project costs such as engineering and design, environmental permitting, construction management, administration and legal, and overhead and are included as a percentage of the sum of extended costs plus the contingency. Contingency is applied to the subtotal of direct costs based on uncertainties present at this level of design and cost estimation and to account for unforeseen requirements.

Total indirect costs plus contingency vary by site type to account for differences in site complexities, construction effort, engineering and design requirements, the source of the unit cost information, and professional judgment. Mark-ups are summarized in Table 2. All projects were assumed to be designed and constructed using competitive bidding processes. It is likely that several of the site improvements could be implemented under a design-build scenario, or even by district forces, both of which might result in costs less than those presented herein.

Table 2. Summary of range of percentage multipliers applied to cost estimate to account for indirect costs and contingencies.

Range of Percentages Applied to Total Direct Costs			
Engineering & Construction Management	10%	to	20%
Legal, Environmental and Administration	0%	to	20%
Total =	10%	to	40%
Percentage Applied to Total Site Cost			
Contingency	10%	to	20%

Quantities

Canal capacities were determined through consultation with district operators or estimated using Manning's equation for open channel flow using a combination of measured and assumed cross section dimensions. For each canal the top water width was measured at several locations using the point-to-point utility in Google Earth. Canal water depths were estimated based on field observations. Average slopes along the canal lengths were estimated from Google Earth and USGS topographic maps. A Manning's roughness coefficient of 0.033 was used assuming excavated earthen canals, winding and sluggish with grass and some weeds, as defined in Te Chow (1959)[1]. Where available, calculated capacities were validated with measured capacities or typical peak diversions and globally adjusted as appropriate.

Quantities for larger structures were independently calculated and compared with conceptual structures designed for the Sutter Butte Regional Conveyance Study[2], conceptual structures in the WCWD Draft 20-Year Capital Improvements Plan, and 60% design cost estimates[3] for the BWGWD Gray Lodge Wildlife Area Supply Project.

Site Specific Improvement Costs

For each site, applicable designs and base cost estimates for typical sites were either used without modification, adjusted to reflect actual site conditions, or combined with components for other sites to create site specific improvement capital and annualized costs, as appropriate.

Annual Costs

Annual capital repayment was estimated for each item using an amortization rate of 5 percent and capital recovery factors calculated using the estimated expected life of each cost item. Total annual costs also include annual operations and maintenance (O&M) costs associated with the improvement. O&M costs were estimates as a percentage of the total extended cost of the item. The percentage ranged from 0 percent for items not requiring annual maintenance to 5 percent for electrical or mechanical components where more frequent O&M is necessary to ensure reliable operation and system longevity.

[1] Te Chow, Ven. 1959. Open Channel Hydraulics. The Blackburn Press, Caldwell, New Jersey, U.S.A.
[2] GEI Consultants, 2006. Regional Conveyance System Improvement Project – Final Report, May 2006. Completed for Sutter Extension Water District by Bookman-Edmonston, a division of GEI Consultants, Inc.
[3] Engineer's Opinion of Probable Construction Cost, 60% Design. October 2011. Prepared by Provost and Pritchard Consulting Engineers.

Project 1: System Modernization

Project Description

The proposed system modernization project aligns with WCWD's proactive stance on the replacement and improvement of existing infrastructure, the development of data to evaluate existing operations and potential future water management improvements, and the development and implementation of management strategies and tools to meet water management objectives including water conservation at the district scale and improved delivery service to customers.

System modernization is generally implemented to achieve one or more of the following goals:

1. Increase the efficiency of the distribution system to conserve water at the district scale,
2. Increase the efficiency of the distribution system to irrigate additional land,
3. Increase the level of service provided to growers and respond to changes in cropping or irrigation method,
4. Reduce risks to the safety of operations staff, and
5. Improve the overall operability and management of the District.

A comprehensive modernization plan provides a road map for a phased implementation that allows for improvements to occur over time at a pace that considers available funds and prioritization of improvements to meet objectives in the most beneficial manner possible. Sites within each phase may be completed all at once, or on a prioritized basis, but would generally begin at the head of the system and proceed downstream to maximize benefits relative to implementation costs. The system modernization strategy developed for WCWD involves four phases with flow measurement being an overarching improvement. It is anticipated that the actual sequence of improvements to individual sites may differ from those described herein as informed by evaluation of opportunities, costs, and other considerations over time.

The system modernization program generally includes improvements to three site categories: heading structures, upstream water level control structures, and spill structures. The objectives for each of these site categories is described in Table 3.

Table 3. System Modernization Objectives by Site Category.

Site Category	General Modernization Objective
Heading	• Replace old, aging and/or deteriorated structures and equipment, as needed. • Provide increased accuracy, repeatability, and consistency in downstream deliveries to district customers to reduce farm runoff and tail end spills. • Improve the ability to make flow adjustments to prevent spill and enhance delivery service. • Increase safety of site for operators.
Upstream Water Level Control	• Replace old, aging and/or deteriorated structures and equipment, as needed. • Maintain steady upstream deliveries by reducing fluctuation in upstream water levels over a range of canal flow rates. • Simplify operations by reducing the need to add or remove flashboards to maintain water levels across a range of flows. • Facilitate the ability to make frequent flow changes through the system, as needed. • Consolidate safety spills by eliminating intermediate safety spills, where practical. • Increase safety of site for operators.
Spills	• Provide accurate and accessible measurement of spillage flow rate from the lateral as feedback on heading operation, general lateral operation, and District water accounting. • Increase safety of site for operators.

The specific improvements completed under each of the four phases of modernization are described in additional detail below.

Phase I System Modernization

The first phase would concentrate on primary inflow and operational outflow locations. These are generally the primary diversion locations or headings (heading gates from the afterbay, etc.) and primary outflow points. The type and sophistication of improvements required to meet objectives varies by site, but the general objective is to provide improved control over the water that enters the district, as informed by improved information describing the timing and amount of water leaving the district. Readily accessible measurement of inflows and outflows has several benefits, including information to inform operational adjustments, data for water accounting and billing, and information to support prioritization of additional improvements by quantifying potential benefits.

For WCWD, the primary inflow point is the Western Canal at Thermalito Afterbay which has an approximate capacity of 1,200 cfs. Currently, WCWD contacts the California Department of Water Resources (DWR) operations staff for daily changes in inflow. Flows into the Western Canal are measured by DWR in the WCWD canal downstream of the heading with no secondary measurement to verify released flows. Fluctuations in afterbay water levels can cause fluctuations in delivered flows. Accurate flow measurement at primary inflow locations is important to achieve water management objectives because it allows for more accurate and precise management of inflows to the distribution system. Recommended improvements at the heading include installation of new flow measurement that would be remotely monitored by the district operations manager and operators for improved operations and accounting. In addition to physical improvements, it is anticipated that protocols would be developed in consultation with DWR to allow more precise and potentially more frequent adjustments to releases to better match demands and increase operational efficiency.

501 Main Drain Outflow to Butte Creek

The primary operational outflow locations in WCWD are the ends of the Ward Canal at the 501 Main Drain and the 1656l spill site at the end of the Main Canal. Being at the bottom end of the system, these two outflow locations include the majority of the operational spillage from the system downstream of the "reservoir". Following rerouting of spills in later modernization phases, these sites will see greater concentration of remaining spills. Additionally, operational spills at the Butte Creek Spill and return flows from the Pratt Lateral (Fenn Drain) would benefit from measurement and remote monitoring and help inform operations as well as future phases of modernization.

Phase II System Modernization

The second phase of modernization would improve key control points along the main supply canal between the headings and outflows to increase conveyance efficiency. This would include main canal water level control structures and lateral headings. Existing control structures may be abandoned in some cases, re-configured, retrofitted, downsized, or retained. WCWD has initiated modernization in this regard and replaced three existing check structures (535 Check, 875 Check, and 1190 Check) with locally automated Langemann Gates and is currently planning to replace the Nelson check structure[4]. The addition of Phase II improvements to Phase I improvements would generally provide steadier delivery of water from the main canal to laterals and turnouts, simplify operations by adding automation to increase the ability to make flow changes, and concentrate primary routing of flow fluctuations along the main canal.

In WCWD (as in most open canal systems) the remaining structures are flashboard check structures that require adjustment whenever there is a flow change to avoid impacts to deliveries to upstream laterals and turnouts. Without adjustment, water level fluctuations can reduce the steadiness of these flows. In addition to impacting service, these fluctuations present challenges to water accounting and may result in operators storing "extra water" in certain canal reaches as a buffer for when deficiencies occur. This water may ultimately spill if not needed.

The modernization strategy for WCWD is to provide new check structures that can pass flow fluctuations downstream while maintaining upstream water levels across a range of flows with limited fluctuation. In order to function over a wide range of flows, new check structures would incorporate locally

[4] It is anticipated that the structure will be replaced in January 2015.

875 Check Structure on Main Canal

automated overshot gates. For purposes of the reconnaissance level cost estimates presented herein, several capacities of check structures were conceptually designed ranging from 1,200 cfs (634 and 702 Checks) to 600 cfs at the 1152 Check. The use of adjustable overshot gates provides a more flexible range if flows with better performance than fixed crest structures and would allow the upstream water depth to be minimized to reduce seepage during rice field dry-down periods (i.e., August and September) but when deliveries for waterfowl habitat are desired.

A key focus of the modernization process is to select how and where flow fluctuations in excess of demands should be routed through the system. Consolidation and routing of fluctuations along one primary route increases the likelihood that they can be used to meet downstream demand, and allows for simplified monitoring of system operations to inform adjustments to diversions and upstream structures to reduce spillage. The ability to route flow fluctuations effectively is currently limited in some cases because many canal structures are unable to quickly pass fluctuations. As a result, the use of intermediate safety spills (such as Butte Creek Spill) that provide temporary relief is required until flashboard adjustments can be made in the Western Canal. The Butte Creek Spill site is currently a point of reregulation when used in conjunction with the downstream radial gate used for flow control. Following improvement, the radial gate would operate in upstream water level control and reduce the need for the spill to be a reregulation point.

In addition to passing flow fluctuations downstream, new overshot-style water level control structures would enable steadier deliveries to laterals and turnouts supplied by the main canal by essentially fixing the upstream water level; however, upstream water level control is only part of the solution to maintain constant delivery rates. Improvement of lateral headings (including private headings) along the Western Canal is additionally recommended. These improvements would include new adjustable undershot gates and flow measurement. The recommended measurement approach for lateral headings depends on the frequency of use and lateral size. In general, smaller, less frequently used laterals are measured using propeller meters. Acoustic Doppler flow meters with continuous measurement capability are recommended for larger laterals.

The improvement of check structures and lateral headings along the Western Canal as described herein would establish the canal as the primary spill route. Figure 1 provides an overview of all proposed improvement sites.

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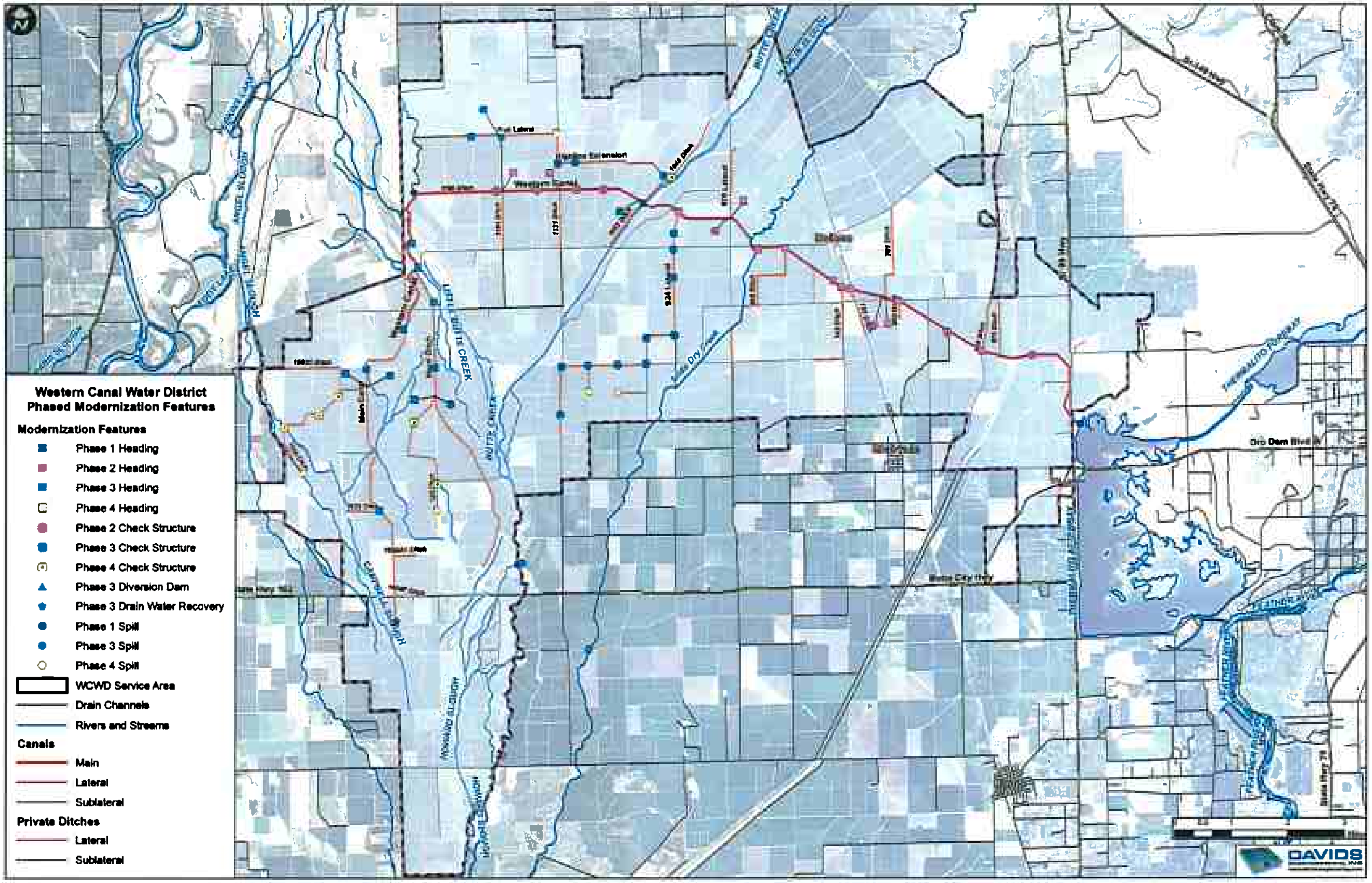

Figure 1. WCWD System Modernization Phasing and Improvement Sites.

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Phase III System Modernization

To extend benefits to deliveries from the laterals, Phase III would improve primary lateral control structures and end spills to further improve controllability. Additionally, improved routing of flow fluctuation to the Main Canal and Ward Ditch would be accomplished, consolidating spills to the 1656I spill and the 501 Main Drain. The Main Canal and Ward Ditch heading structures both receive water from the tail end of the Western Canal via an area referred to as the "reservoir." The reservoir is an impounded section of Little Butte Creek that receives inflows from Western Canal on the east and conveys water to the Main and Ward Laterals to the west. This site poses several challenges, including:

1. Operation of the Front and Back slide gates to impound the creek and provide conveyance through pond storage requires the use of 59 individual 5 ft by 5 ft metal gates. Gates must all be raised/removed following the irrigation season to accommodate storm flows.
2. The relatively flat topography requires a significant incoming volume to increase water depth and conveyance capacity.
3. Normal upstream inflows in Little Butte Creek can cause unexpected fluctuations in inflows to the Main and Ward laterals.
4. Measurement of inflows to the Main and Ward canal headings requiring significant judgment by operators.

The modernization project would replace the existing Main and Ward canal headings with automated flow control gates and new concrete structures to enable constant flow to meet downstream demand, regardless of the upstream water level fluctuations. To improve operational efficiency and operator safety during the seasonal opening and closing of the Front Slide Gates, existing gates would be fitted with gear operated cable hoists and gate slides refurbished to minimize friction. The Front Slide Gates would be operated to function solely as a diversion dam during the irrigation season. The Back Slide Gates would provide upstream water level control for the upstream diversion. Replacement of several of the existing rectangular slide gates with locally automated radial gates would increase upstream delivery steadiness and reduce operational effort while enabling free, unimpaired flow during the off-season.

Spill routing within primary laterals would also be completed under Phase III. Replacing existing check structures along these routes with long crested weirs would provide steady upstream water levels with no adjustment required. Because of the long weir length, a large change in flow would result in only a small change in head enabling more rapid transfer of flow fluctuations down the system because the change in upstream pond storage to pass the change would be minimized. Laterals that would be improved under Phase III include the Main Canal, Ward Ditch, 1500 Ditch, 1625 Ditch, W120 924 Ditch, Highline Extension, and Pratt Lateral.

Phase IV System Modernization

The fourth modernization phase would build upon lateral heading flow control completed under Phases II and III and lateral water level control completed under Phase III by improving secondary control structures along laterals and sublaterals to inform and improve operations. Additionally, minor or secondary safety spills are prioritized for improvement although some intermediate safety spills would likely not be needed and could be abandoned as check structures are improved to allow routing of flow fluctuations without causing substantial water level fluctuations, capacities are increased, and the controllability of flows at heading structures is increased. Objectives are to increase flexibility, consistency, and adequacy of supply to sublaterals; increase delivery steadiness and consistency; and concentrate routing of flow fluctuations to a designated location with measurement to provide operators with feedback to help determine the need for a changes at lateral headings to improve operations. The final phase would include additional improvements to the 1500 ditch, W120 ditch, Skinner Dam, and several minor spills.

Inventory of Existing Conditions

Existing conditions were characterized through consultation with District staff and digitally inventoried in tabular form and in an interactive mapping format. For each site type, representative sites were selected for field inspection to obtain dimensions, coordinates, photos and operational features typical of the site type to aid in strategy development and cost estimation. These sites included primary control points. Table 4 provides the site name, the site type, latitude, longitude, and a description of existing conditions for each site to be improved under the System Modernization project. Sites were assigned to one of the following categories: Inflow, Heading, Water Level Control, or Safety Spill. The system modernization plan described herein focuses on primary and secondary control points and other system components and may not be exhaustive.

Table 4. Inventory of Existing Conditions.

Site Name	Site Type	Latitude	Longitude	Description of Existing Conditions
Western Canal Heading	Inflow	39.51	-121.69	Remotely controlled gates for inflow to Main Canal from Thermalito Afterbay. Gates controlled by California DWR operators.
Butte Creek Spill	Spill	39.56	-121.83	Concrete overpour structure spills water as levels rise above crest. Designed to pass 200 cfs. Two undershot gates used for delivery to Butte Sink during Fall. Manual measurement of spill over pour three times per day.
501 Main Drain Outflow to Butte Creek	Spill	39.47	-121.87	Structure holds water level for upstream deliveries. Concrete abutments with several manually adjusted flashboard bays. Steel catwalk spans structure. Approximately 2ft of drop through structure.
1656I Spill	Spill	39.46	-121.91	Precast weir box with adjustable boards and short section of pipe on downstream end. Structure holds a level pond for several upstream pumped deliveries. Excesses spill northeast-ward to slough.
Pratt Lateral Return Flow (Fenn Drain)	Inflow	39.57	-121.91	Return flows to the Western Canal from Pratt Lateral spill points, and also spills from Fenn deliveries. Meandering earthen cross section of various widths. Culvert road crossing just upstream from return flow to Western Canal.
535 Check Structure	Water Level Control	39.52	-121.7	Concrete structure with two 18' wide Langemann Gates that operate under locally automated upstream water level control.
634 Check Structure	Water Level Control	39.53	-121.73	Concrete structure with ten manually adjusted flashboard bays

Site Name	Site Type	Latitude	Longitude	Description of Existing Conditions
702 Check Structure	Water Level Control	39.54	-121.75	Concrete structure with ten manually adjusted flashboard bays
Nelson Check Structure	Water Level Control	39.54	-121.77	Concrete structure with two 16' wide Langemann Gates that operate under locally automated upstream water level control.[5]
Dry Creek Sidegates	Heading	39.55	-121.79	Concrete headwall with undershot gate just upstream from Dry Creek siphon. WCWD makes deliveries here for extraction downstream at Harris Dam and Dry Creek Dam.
870 Headgates	Heading	39.56	-121.8	Concrete headwall structure with three 36" diameter undershot gates.
875 Check Structure	Water Level Control	39.56	-121.8	Concrete structure with two 15' wide Langemann Gates that operate under locally automated upstream water level control.
924 Headgates	Heading	39.56	-121.82	Concrete headwall structure with 2 48" undershot gates. Total capacity is approximately 200 cfs.
1090 Check Structure	Water Level Control	39.57	-121.84	Concrete structure with eight manually adjusted flashboard bays
1115 Check Structure	Water Level Control	39.57	-121.85	Concrete structure with eight manually adjusted flashboard bays
1152 Check Structure	Water Level Control	39.57	-121.86	Concrete structure with eight manually adjusted flashboard bays
1190 Check Structure	Water Level Control	39.57	-121.88	Concrete structure with one 15' wide Langemann Gate that operate under locally automated upstream water level control.
599 Headgates (Private)	Heading	39.52	-121.72	Concrete headwall with undershot gate. Short section of pipe downstream of gate before discharging to ditch. Differential head calculations used for measurement
690 Headgates (Private)	Heading	39.54	-121.75	
701 Headgates (Private)	Heading	39.54	-121.75	Concrete headwall structure with two 36" undershot gates and one 30" undershot gate.
735 Headgates (Private)	Heading	39.54	-121.76	Concrete headwall with undershot gate. Short section of pipe downstream of gate before discharging to ditch. Differential head calculations used for measurement
743 Headgates (Private)	Heading	39.54	-121.76	Concrete headwall with three undershot gates.

[5] Improvements not yet completed at time of plan preparation. Expected to be completed in January 2015.

Site Name	Site Type	Latitude	Longitude	Description of Existing Conditions
806 Headgates (Private)	Heading	39.55	-121.78	Concrete headwall with undershot gate. Short section of pipe downstream of gate before discharging to ditch. Differential head calculations used for measurement
1052 Headgates (Private)	Heading	39.56	-121.83	
1131 Headgates (Private)	Heading	39.57	-121.86	
1184 Headgates (Private)	Heading	39.57	-121.88	
1190 Headgates (Private)	Heading	39.57	-121.88	
Highline Extension and Pratt Lateral Weirs	Water Level Control	Several Locations		Concrete structures with several flashboard bays that are manually adjusted. Various stages of disrepair.
Butte Creek Radial Gate	Water Level Control	39.56	-121.83	Single 12ft wide radial gate in concrete structure. Typical flow range is 400 to 600 cfs. Currently used for flow control.
Back Slide Gates	Water Level Control	39.55	-121.91	Concrete and steel structure that spans slough. Approximately 200 ft wide made up of 5'x5' vertical steel undershot gates that are manually adjusted.
Front Slide Gates	Water Level Control	39.55	-121.9	Concrete and steel structure that spans slough. Approximately 150ft wide made up of 5'x5' vertical steel undershot gates that are manually adjusted.
Ward Heading	Heading	39.54	-121.9	Concrete headwall with undershot gates for flow control.
Main Heading	Heading	39.53	-121.91	Concrete headwall structure with several undershot gates for flow control. Currently limited to approximately 280 cfs.
Main Weirs	Water Level Control	Several Locations		Concrete structures with several flashboard bays that are manually adjusted. Various stages of disrepair.
1500 Ditch Headgates	Heading	39.52	-121.92	Concrete headwall with manually operated undershot gate. Short section of pipe on discharge side conveys flow under canal levee to ditch.

Site Name	Site Type	Latitude	Longitude	Description of Existing Conditions ·
1625 Ditch Headgates	Heading	39.49	-121.92	Concrete headwall with manually operated undershot gate. Short section of pipe on discharge side conveys flow under canal levee to ditch.
Ward Weirs	Water Level Control	Several Locations		Concrete structures with several flashboard bays that are manually adjusted. Various stages of disrepair.
W120 Headgate	Heading	39.51	-121.9	Concrete headwall with manually operated undershot gate. Short section of pipe on discharge side conveys flow under canal levee to ditch.
924 Weirs	Water Level Control	Several Locations		Concrete structures with several flashboard bays that are manually adjusted. Condition varies.
924L Spill	Spill	39.52	-121.84	Precast weir box with adjustable boards and short section of pipe on downstream end.
924O Spill	Spill	39.52	-121.85	
HL115 Spill	Spill	39.57	-121.86	
Dry Creek at Harris Dam (RID joint site)	Flow Control	39.48	-121.84	Six 48"wide flashboard bays in drain to west. Little Dry creek can either pass through/over structure to west (to Butte Creek) or continue south over shallow road crossing and Watt Canal siphon. Bridge over Little Dry Creek appears to collect debris
Little Dry Creek Spill	Spill	39.47	-121.87	Concrete headwall structure that spans the drain channel and increases the upstream water level. Manually adjustable weir boards dictate spill point.
1500 Ditch weirs	Water level control	Several Locations		Concrete structures with several flashboard bays that are manually adjusted. Various stages of disrepair.
1500L Spill	Spill	39.5	-121.94	Precast weir box with adjustable boards and short section of pipe on downstream end.
W120 Weirs	Water Level Control	Several Locations		Concrete structures with several flashboard bays that are manually adjusted. Various stages of disrepair.
W120GSpill	Spill	39.49	-121.9	Precast weir box with adjustable boards and short section of pipe on downstream end.
Pratt Headgates	Heading	39.58	-121.86	Two 48" undershot gates
Skinner Dam	Water Level Control	39.57	-121.82	Weir structure with adjustable weir crest that enables diversion of water from the Highline Extension canal for delivery to irrigators upstream along Butte Creek. Check structure creates level-top pool that can be pumped from.
P52 Spill	Spill	39.58	-121.88	Precast weir box with adjustable boards and short section of pipe on downstream end.

System Modernization Physical and Operational Improvements

Level 1 and 2 Improvements

For each site, improvement is split into two levels, Level 1 and Level 2. Level 1 improvements typically include fundamental infrastructure and measurement enhancements that are manually operated or read, or locally automated, and designed as SCADA-Ready[6]. These improvements include, but are not limited to new, manually adjustable heading gates; long crested weirs; locally automated overshot gates; and measurement devices such as weirs, acoustic Doppler flow meters, and propeller meters. Level 2 improvements build upon Level 1 improvements by automating certain additional features, adding electronic sensors, installing on-site digital display of flow rate or other parameters, or adding remote monitoring or control through a Supervisory Control and Data Acquisition System (SCADA). Level 1 improvements are stand-alone, while Level 2 improvements generally require Level 1 to be completed prior to or at the same time. The progression from level 1 to level 2 improvements provides the flexibility to complete Level 1 (which has significant benefits on its own) while assessing the benefits of SCADA, further prioritizing sites, establishing a SCADA base station, and gradually implementing potentially more complex and technically intricate remote control sites. In some cases, there could be capital cost savings by completing Level 1 and Level 2 improvements at the same time.

Although Level 2 is not universally required to substantially achieve water management objectives, several sites would benefit. Two examples of this are:

1. Remotely located end spill sites not frequently visited by operators. Remote monitoring would reduce travel time potentially enabling additional flow changes, as needed.
2. Automated flow control gates at headings with substantial upstream water level fluctuations; however, assuming water level control structures are installed, the flow control device could have little additional benefit.

Table 5 provides a description of the improvements proposed for each site, the objective of the improvements and estimated Level 1 and Level 2 improvement costs. For each site and level of improvements, upfront capital costs and annualized capital, operations, and maintenance costs are provided. All costs are subject to refinement as informed by more detailed review and design.

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[6] "SCADA-Ready" describes a package of hardware and/or software that communicates and operates locally but has been specifically designed and installed to readily accept a data transmission and receiving device (e.g. radio, cellular modem, etc.) and to provide remote communication with an established base station and SCADA human machine interface (HMI).

Table 5. Site Improvement Matrix.

Site Name	Site Type	Description of Operational Objective with Improvements	Level 1 Modernization and Enhancement	Capital Cost ($)	Annual Cost ($/yr)	Level 2 Modernization and Enhancement	Capital Cost ($)	Annual Cost ($/yr)
SCADA Office Base Station		Allows remote monitoring of measured parameters at SCADA equipped sites. Also allows remote control and adjustment of set points at automated water level or flow control sites. Provides for storage of data and interface for developing comprehensive status reports, usage statistics, and monitoring information for improved water management, accounting and reporting.	Level 1 Modernization and Enhancement does not include SCADA at sites; therefore, base station is not required.	$0	$0	Furnish and install one desktop personal computer, including: processor, monitor, keyboard, mouse, drivers, USB, RS232, Ethernet, communication ports, cables, adapters, modems, printer, operating system software and HMI software. Base station spread spectrum radio, mast, and antenna for communication with remote sites. Five hardened laptops and vehicle mounts for operator/in-field use. Vehicle-mounted radios and antennas for remote communications and monitoring of sites.	$138,063	$17,039
Spare Equipment		Minimize down time associated with simple equipment maintenance or malfunctions and/or procurement of site or system specific hardware.	Small inventory of site and system specific equipment that is critical for proper operation of improvements.	$23,692	$2,913	None	$0	$0
Phase 1 Modernization - Improvement of Primary Inflow Locations and Primary Operational Outflow Locations								
Western Canal Heading	Inflow	Provide WCWD managers and WCWD canal operators with accurate inflow to the Western Main for improved water allocation, accounting and general management. Enable frequent adjustments to respond to changes in downstream demand.	Construct control section d/s from heading gates and install ADVM. Perform velocity index calibration. Install digital display at canal bank. Site will be SCADA-Ready. Enter into negotiations with afterbay operators to increase the frequency of adjustments allowable.	$55,400	$5,300	Add communication hardware to measurement site and integrate with SCADA system to provide real-time monitoring of flow rate and water level	$5,900	$600
Butte Creek Spill	Spill	Provide accurate and accessible measurement of spillage flow rate from the Western Canal as feedback on heading operation, general lateral operation, and for improved District water accounting. Spillage records will help inform the modernization process. Spill at this site is expected to decline with modernization and automation of the Western Canal.	Install pressure transducer in new stilling well upstream of weir crest to measure head on weir. Perform calibration of weir, install solar power system, data logger and digital display of water level.	$1,543	$116		$13,678	$955
501 Main Drain Outflow to Butte Creek	Spill			$1,543	$116		$13,678	$955
1656I Spill	Spill			$6,905	$378		$7,400	$700
Pratt Lateral Return Flow (Fenn Drain)	Inflow		Construct stable and uniform cross section in existing canal cross section and install ADVM. Install solar power system, digital flow display, and related components. Perform velocity index calibration of measurement site. Site will be SCADA-Ready.	$19,900	$1,090		$5,900	$600
Phase 2 Modernization - Improvement of Main Canal (Western Canal) Primary Control Points								
535 Check Structure	Water Level Control	Maintain constant upstream deliveries by maintaining the desired upstream water level in the supply canal over a range of canal flow rates.	This site has recently been improved. No Level 1 improvements recommended.	$0	$0	Add communication hardware to site and integrate with SCADA system to allow real-time monitoring of water levels, sensor parameters, and allow remote manual adjustment of gate set points.	$0	$0
634 Check Structure	Water Level Control	Maintain constant upstream deliveries by maintaining the desired upstream water level in the supply canal over a range of canal flow rates. Simplify operations by reducing the need to add or remove flashboards, and increase the rate at which flow changes can be passed through the system	Replace existing weir structure in Western Canal with combination water level control structure with locally automated overshot gate set to maintain upstream water level.	$1,267,317	$69,419		$7,400	$700
702 Check Structure	Water Level Control			$1,152,106	$63,109		$7,400	$700

Site Name	Site Type	Description of Operational Objective with Improvements	Level 1 Modernization and Enhancement	Capital Cost ($)	Annual Cost ($/yr)	Level 2 Modernization and Enhancement	Capital Cost ($)	Annual Cost ($/yr)
Nelson Check Structure	Water Level Control	Maintain constant upstream deliveries by maintaining the desired upstream water level in the supply canal over a range of canal flow rates.	This site will be improved in January 2015 to include two automated Langemann Gates. No Level 1 Improvements recommended.	$0	$0	Add communication hardware to site and integrate with SCADA system to allow real-time monitoring of water levels, sensor parameters, and allow remote manual adjustment of gate set points.	$0	$0
Dry Creek Sidegates	Heading	Provide accurate, repeatable and consistent flow to supply deliveries downstream in Butte Creek.	Install weir box on downstream end of existing pipe and install open channel propeller meter. Install trash rack at inlet. Replace heading gate as necessary to provide adjustable and reliable control. Site will be SCADA-Ready.	$26,400	$2,400	Install communication hardware and integrate with SCADA system to allow remote monitoring.	$11,800	$1,200
870 Headgates	Heading	Provide accurate, repeatable and consistent flow to supply downstream deliveries in the lateral ditch.	Construct stable and uniform cross section in existing canal cross section and install ADVM. Install solar power system, digital flow display, and related components. Perform velocity index calibration of measurement site. Site will be SCADA-Ready.	$26,400	$2,900	Add communication hardware to site and integrate with SCADA system to allow real-time monitoring of flow rates, water depths and sensor parameters.	$5,900	$600
875 Check Structure	Water Level Control	Maintain constant upstream deliveries by maintaining the desired upstream water level in the supply canal over a range of canal flow rates.	This site has recently been improved. No Level 1 Improvements recommended.	$0	$0	Add communication hardware to site and integrate with SCADA system to allow real-time monitoring of water levels, sensor parameters, and allow remote manual adjustment of gate set points.	$0	$0
924 Headgates	Heading	Provide accurate, repeatable and consistent flow to supply downstream deliveries in the lateral ditch.	Construct stable and uniform cross section in existing canal cross section and install ADVM. Install solar power system, digital flow display, and related components. Perform velocity index calibration of measurement site. Site will be SCADA-Ready.	$26,400	$2,900	Add communication hardware to site and integrate with SCADA system to allow real-time monitoring of flow rates, water depths and sensor parameters.	$5,900	$600
1090 Check Structure	Water Level Control	Maintain constant upstream deliveries by maintaining the desired upstream water level in the supply canal over a range of canal flow rates. Simplify operations by reducing the need to add or remove flashboards, and increase the rate at which flow changes can be passed through the system	Replace existing weir structure in Western Canal with combination water level control structure with locally automated overshot gate set to maintain upstream water level.	$806,474	$44,176	Add communication hardware to site and integrate with SCADA system to allow real-time monitoring of water levels, sensor parameters, and allow remote manual adjustment of gate set points.	$7,400	$700
1115 Check Structure	Water Level Control			$748,869	$41,021		$7,400	$700
1152 Check Structure	Water Level Control			$691,264	$37,865		$7,400	$700
Butte Creek Radial Gate	Water Level Control	Reconfigure structure to maintain upstream water level control and pass fluctuations down to the Back and Front Slide Gates.	Install upstream water level sensor, drive motor, gear box, gate actuator and controls and related components to provide locally automated upstream water level control.	$79,214	$4,339	Add communication hardware to site and integrate with SCADA system to allow real-time monitoring of water levels, sensor parameters, and allow remote manual adjustment of gate set points.	$7,400	$700
1190 Check Structure	Water Level Control	Maintain constant upstream deliveries by maintaining the desired upstream water level in the supply canal over a range of canal flow rates.	This site has recently been improved. No Level 1 Improvements recommended.	$0	$0		$0	$0
599 Headgates (Private)	Heading	Provide accurate, repeatable and consistent flow to supply downstream deliveries in the private ditch.	Install weir box on downstream end of existing pipe and install open channel propeller meter. Install trash rack at inlet.	$26,400	$2,400	Install communication hardware and integrate with SCADA system to allow remote monitoring.	$11,800	$1,200

Site Name	Site Type	Description of Operational Objective with Improvements	Level 1 Modernization and Enhancement	Capital Cost ($)	Annual Cost ($/yr)	Level 2 Modernization and Enhancement	Capital Cost ($)	Annual Cost ($/yr)
690 Headgates (Private)	Heading		Replace heading gate as necessary to provide adjustable and reliable control. Site will be SCADA-Ready.	$26,400	$2,400		$11,800	$1,200
701 Headgates (Private)	Heading		Construct stable and uniform cross section in existing canal cross section and install ADVM. Install solar power system, digital flow display, and related components. Perform velocity index calibration of measurement site. Site will be SCADA-Ready.	$26,400	$2,900	Add communication hardware to site and integrate with SCADA system to allow real-time monitoring of flow rates, water depths and sensor parameters.	$5,900	$600
735 Headgates (Private)	Heading		Install weir box on downstream end of existing pipe and install open channel propeller meter. Install trash rack at inlet. Replace heading gate as necessary to provide adjustable and reliable control. Site will be SCADA-Ready.	$26,400	$2,400	Install communication hardware and integrate with SCADA system to allow remote monitoring.	$11,800	$1,200
743 Headgates (Private)	Heading		Construct stable and uniform cross section in existing canal cross section and install ADVM. Install solar power system, digital flow display, and related components. Perform velocity index calibration of measurement site. Site will be SCADA-Ready.	$26,400	$2,900	Add communication hardware to site and integrate with SCADA system to allow real-time monitoring of flow rates, water depths and sensor parameters.	$5,900	$600
806 Headgates (Private)	Heading			$26,400	$2,400		$11,800	$1,200
1052 Headgates (Private)	Heading			$26,400	$2,400		$11,800	$1,200
1131 Headgates (Private)	Heading		Install weir box on downstream end of existing pipe and install open channel propeller meter. Install trash rack at inlet. Replace heading gate as necessary to provide adjustable and reliable control. Site will be SCADA-Ready.	$26,400	$2,400	Install communication hardware and integrate with SCADA system to allow remote monitoring.	$11,800	$1,200
1184 Headgates (Private)	Heading			$26,400	$2,400		$11,800	$1,200
1190 Headgates (Private)	Heading			$26,400	$2,400		$11,800	$1,200
Phase 3 Modernization - Improvement of Lateral Primary Control Points and Spill Routing								
Highline Extension and Pratt Lateral Weirs	Water Level Control	Maintain constant upstream deliveries by maintaining the desired upstream water level in the supply canal over a range of canal flow rates. Simplify operations by reducing the need to add or remove flashboards.	Replace four existing check structures with LCWs. Gradually phase out use of intermediate spills and concentrate spills at end spill. LCWs allow spills to travel to end spill without impacting simultaneous deliveries.	$212,400	$13,600	None	$0	$0
Back Slide Gates	Water Level Control	The function of this structure will remain the same as current, but will be reconstructed to increase operator safety, provide flexibility in the adjustment of upstream water level, and also minimize flow restriction during off-season/winter stream flows.	Retrofit gates with gear reduction boxes and hand cranks to simplify seasonal opening and closing and improve operator safety.	$28,600	$1,567	None	$5,900	$600

Site Name	Site Type	Description of Operational Objective with Improvements	Level 1 Modernization and Enhancement	Capital Cost ($)	Annual Cost ($/yr)	Level 2 Modernization and Enhancement	Capital Cost ($)	Annual Cost ($/yr)
Front Slide Gates	Water Level Control	Structure function will be reoperated to maintain upstream water level in the 'Reservoir' and pass excesses down Little Butte Creek. A constant water level in the 'Reservoir' will provide more steady deliveries to the Main and Ward Canals. Winter operation of this site	Replace approximately one half of existing rectangular gates with locally automated radial gates set to maintain upstream water levels. Retrofit remaining rectangular undershot gates with gear reduction boxes and hand cranks to simplify seasonal opening and closing and improve	$710,500	$50,575	Install communication hardware and integrate gates with SCADA system to allow remote monitoring of water levels and gate function, and also remote manual adjustment of gate set points.	$7,400	$700
Ward Heading	Heading	Provide accurate, repeatable and consistent flow to supply downstream deliveries. Improve operator safety during operation of the structure and increase abilities to provide flexible delivery service and respond to changes in downstream demand to minimize spillage.	Remove existing structure and construct new concrete heading structure with additional capacity. Install locally automated flow control gates to maintain a set flow downstream to supply deliveries.	$224,000	$16,000	Install communication hardware and integrate gates with SCADA system to allow remote monitoring of flow rate and gate function, and also remote manual adjustment of gate set points.	$7,400	$700
Main Heading	Heading			$268,800	$19,200		$7,400	$700
Main Weirs	Water Level Control	Maintain constant upstream deliveries by maintaining the desired upstream water level in the supply canal over a range of canal flow rates. Simplify operations by reducing the need to add or remove flashboards, and increase the rate at which flow changes can be passed through the system	Replace nine existing check structures with LCWs. Gradually phase out use of intermediate spills and concentrate spills at end spill. LCWs allow spills to travel to end spill without impacting simultaneous deliveries. Replace first 5 structures with combination structures with locally automated overshot gate.	$1,618,100	$119,100	None	$37,000	$3,500
1500 Ditch Headgates	Heading	Provide accurate, repeatable and consistent flow to supply downstream deliveries in the lateral ditch.	Install weir box on downstream end of existing pipe and install open channel propeller meter. Install trash rack at inlet. Replace heading gate as necessary to provide adjustable and reliable control. Site will be SCADA-Ready.	$26,400	$2,400	Install communication hardware and integrate with SCADA system to allow remote monitoring.	$11,800	$1,200
1625 Ditch Headgates	Heading			$26,400	$2,400		$11,800	$1,200
Ward Weirs	Water Level Control	Maintain constant upstream deliveries by maintaining the desired upstream water level in the supply canal over a range of canal flow rates. Simplify operations by reducing the need to add or remove flashboards, and increase the rate at which flow changes can be passed through the system	Replace eight existing check structures with LCWs. Gradually phase out use of intermediate spills and concentrate spills at end spill. LCWs allow spills to travel to end spill without impacting simultaneous deliveries. Replace first 4 structures with combination structures with locally automated overshot gate.	$1,367,800	$100,200	None	$29,600	$2,800
W120 Headgate	Heading	Provide accurate, repeatable and consistent flow to supply downstream deliveries in the lateral ditch.	Install weir box on downstream end of existing pipe and install open channel propeller meter. Install trash rack at inlet. Replace heading gate as necessary to provide adjustable and reliable control. Site will be SCADA-Ready.	$26,400	$2,400	Install communication hardware and integrate with SCADA system to allow remote monitoring.	$11,800	$1,200
924 Weirs	Water Level Control	Maintain constant upstream deliveries by maintaining the desired upstream water level in the supply canal over a range of canal flow rates. Simplify operations by reducing the need to add or remove flashboards, and increase the rate at which flow changes can be passed through the system	Replace ten existing check structures with LCWs. Gradually phase out use of intermediate spills and concentrate spills at end spill. LCWs allow spills to travel to end spill without impacting simultaneous deliveries.	$531,000	$34,000	None	$0	$0
924L Spill	Spill	Provide accurate and accessible measurement of spillage flow rate from the lateral as feedback loop on	Replace weir box with new. Install sharp crested weir plate and mount custom staff	$8,700	$700	Install pressure transducer in new stilling well upstream of spill box to measure head on weir.	$15,400	$1,500
924O Spill	Spill			$8,700	$700		$15,400	$1,500

Site Name	Site Type	Description of Operational Objective with Improvements	Level 1 Modernization and Enhancement	Capital Cost ($)	Annual Cost ($/yr)	Level 2 Modernization and Enhancement	Capital Cost ($)	Annual Cost ($/yr)
HL115 Spill	Spill	heading operation, general lateral operation, and District water accounting.	gage calibrated to report spill flow rate based on the depth of water above the weir crest.	$8,700	$700	Perform calibration of weir. Install communication hardware and integrate with SCADA system to allow remote monitoring.	$15,400	$1,500
Dry Creek at Harris Dam (RID joint site)	Flow Control	Increase control and measurement of flows diverted to serve Western Canal Water District that were delivered to Little Dry Creek u/s. Allow flows in excess of WCWD demand to stay in Little Dry Creek for possible delivery to downstream customers, including Secondary.	Replace three of the six flashboard bays with undershot gates to provide controlled deliveries to WCWD in the amount that they diverted into Little Dry Creek upstream. Remaining bays should be set for emergency spill. Add ADVM downstream for measurement. Increase the weir length in the Little Dry Creek structure to the south and have all excess flow pass over the top of the weir to maintain upstream level	$53,000	$4,526	Install water level sensor upstream of gates for monitoring purposes. Install communication hardware and integrate level sensor and ADVM with SCADA system to allow remote monitoring.	$6,785	$690
Little Dry Creek Dam	Spill	Provide accurate and accessible measurement of spillage to Little Dry Creek as feedback on heading operation, deliveries operations, and for improved District water accounting.	Install sharp crested weir plates and mount custom staff gage calibrated to report spill flow rate based on the depth of water above the weir crest.	$1,543	$116	Install pressure transducer in new stilling well upstream of weir crest to measure head on weir. Perform calibration of weir, install solar power system, data logger and digital display of water level. Install communication hardware and integrate with SCADA system to allow remote monitoring.	$13,678	$955
Phase 4 Modernization - Improvement of Lateral Secondary Points, Sublateral Control Points and Secondary Spill Points								
1500 Ditch weirs	Water level control	Maintain constant upstream deliveries by maintaining the desired upstream water level in the supply canal over a range of canal flow rates. Simplify operations by reducing the need to add or remove flashboards, and increase the rate at which flow changes can be passed through the system	Replace five existing check structures with LCWs. Gradually phase out use of intermediate spills and concentrate spills at end spill. LCWs allow spills to travel to end spill without impacting simultaneous deliveries.	$204,500	$13,000	None	$0	$0
1500L Spill	Spill	Provide accurate and accessible measurement of spillage flow rate from the lateral as feedback loop on heading operation, general lateral operation, and District water accounting.	Replace weir box with new. Install sharp crested weir plate and mount custom staff gage calibrated to report spill flow rate based on the depth of water above the weir crest.	$8,700	$700	Install pressure transducer in new stilling well upstream of spill box to measure head on weir. Perform calibration of weir. Install communication hardware and integrate with SCADA system to allow remote monitoring.	$15,400	$1,500
W120 Weirs	Water Level Control	Maintain constant upstream deliveries by maintaining the desired upstream water level in the supply canal over a range of canal flow rates. Simplify operations by reducing the need to add or remove flashboards, and increase the rate at which flow changes can be passed through the system	Replace four existing check structures with LCWs. Gradually phase out use of intermediate spills and concentrate spills at end spill. LCWs allow spills to travel to end spill without impacting simultaneous deliveries.	$126,200	$8,000	None	$0	$0
W120GSpill	Spill	Provide accurate and accessible measurement of spillage flow rate from the lateral as feedback loop on heading operation, general lateral operation, and District water accounting.	Replace weir box with new. Install sharp crested weir plate and mount custom staff gage calibrated to report spill flow rate based on the depth of water above the weir crest.	$8,700	$700	Install pressure transducer in new stilling well upstream of spill box to measure head on weir. Perform calibration of weir. Install communication hardware and integrate with SCADA system to allow remote monitoring.	$15,400	$1,500
Pratt Headgates	Heading	Provide accurate, repeatable and consistent flow to supply downstream deliveries in the lateral ditch.	Construct stable and uniform cross section in existing canal cross section and install ADVM. Install solar power system, digital flow display, and related components. Perform velocity index calibration of measurement site. Site will be SCADA-Ready.	$26,400	$2,900	Add communication hardware to site and integrate with SCADA system to allow real-time monitoring of flow rates, water depths and sensor parameters.	$5,900	$600

Site Name	Site Type	Description of Operational Objective with Improvements	Level 1 Modernization and Enhancement	Capital Cost ($)	Annual Cost ($/yr)	Level 2 Modernization and Enhancement	Capital Cost ($)	Annual Cost ($/yr)
Skinner Dam	Water Level Control	Provide accurate, repeatable and consistent flow to supply downstream deliveries in the private ditch.	Construct stable and uniform cross section in existing canal cross section just downstream from diversion with Highline Extension and install ADVM. Install solar power system, digital flow display, and related components. Perform velocity index calibration of measurement site. Site will be SCADA-Ready.	$26,400	$2,900		$5,900	$600
P52 Spill	Spill	Provide accurate and accessible measurement of spillage flow rate from the lateral as feedback on heading operation, general lateral operation, and District water accounting.	Replace weir box with new. Install sharp crested weir plate and mount custom staff gage calibrated to report spill flow rate based on the depth of water above the weir crest.	$8,700	$700	Install pressure transducer in new stilling well upstream of spill box to measure head on weir. Perform calibration of weir. Install communication hardware and integrate with SCADA system to allow remote monitoring.	$15,400	$1,500

System Modernization Costs

The total combined cost (all phases, Level 1 and Level 2) of system modernization is estimated to be approximately $11,180,000, with annualized estimated costs of $743,000. Individual costs by modernization phase range from a low of $132,000 to a high of $5,404,000 for Phase I and Phase III, respectively. Costs are further summarized in Table 6. Additionally, the costs of a SCADA base station and mobile operator terminals that would form the backbone of the District SCADA system have been estimated, along with the cost of spare equipment to be kept on hand to repair or replace individual site components due to theft, vandalism, or other failure.

Table 6. Summary of Estimated Capital and Annualized Costs.

	Level 1		Level 2	
Modernization Phase	Capital Cost ($)	Annual Cost ($/yr)	Capital Cost ($)	Annual Cost ($/yr)
Phase I - Improvement of Primary Inflow Locations and Primary Operational Outflow Locations	$85,292	$6,999	$46,555	$3,809
Phase II - Improvement of Main Canal Primary Control Points	$5,009,230	$288,790	$166,800	$16,700
Phase III - Improvement of Lateral Primary Control Points and Spill Routing	$5,200,257	$372,522	$204,163	$19,445
Phase IV - Improvement of Lateral Secondary Points, Sublateral Control Points and Secondary Spill Points	$409,600	$28,900	$58,000	$5,700
Total Cost =	$10,704,379	$697,212	$475,518	$45,654
SCADA Office Base Station	-	-	$138,063	$17,039
Spare Parts	$23,692	$2,913		-

Potential Benefits

The proposed system modernization plan described herein represents comprehensive improvements to the district's distribution system, adding several automated control structures, improved measurement, new heading structures, re-regulation points, and SCADA. Flow paths targeted under the system modernization project are:

- Operational spillage,
- Deliveries to customers,
- Tailwater,
- Diversions, and
- Drainage outflows

Improvements would allow reduced operational spillage and reduced deliveries due to increased delivery efficiency, which would reduce on-farm tailwater and, in some cases, deep percolation. Reduced deliveries result in reduced diversions, which results in corresponding reductions in spillage and drainage outflows. Available water not diverted remains in storage and could potentially be available to meet unmet local demands or to meet regional or statewide objectives. Additionally, water quality benefits may occur through reduced tailwater outflow.

Through implementation of the complete system modernization program (Phases I - IV and Levels 1 and 2), it is estimated that approximately 20 to 50 percent[7] of existing operational spillage could be conserved annually, or between approximately 5,000 and 12,000 af per year.

From a local perspective, this conserved water could be used to increase local water supply reliability and to increase local delivery flexibility. From a regional or statewide perspective, water conserved that would not otherwise be used by downstream water users could be used to increase overall water supply or to meet in-stream flow and/or water quality objectives.

Each phase provides varying levels of anticipated potential benefits with the first two phases likely seeing greater benefit than the third and fourth due to the greater number of sites improved, establishment of primary spill routing, and improvement of control structures that are located higher in the system (i.e. have control over a larger proportion of the total water diverted). The estimated marginal range of percent reduction in spillage and boundary outflow achieved by completing phases is described below:

1. Phase I: 1 to 2 percent reduction; 240 to 480 af of targeted outflows
2. Phase II: 10 to 20 percent reduction; 2,400 af to 4,800 af of targeted outflows
3. Phase III: 8 to 25 percent reduction; 1,920 af to 6,000 af of targeted outflows
4. Phase IV: 1 to 3 percent reduction; 240 af to 720 af of targeted outflows

Net Benefit Analysis

The district is currently implementing associated EWMPs at locally cost-effective levels. WCWD has not used its full allocation in recent years, and thus would not achieve cost savings through additional conservation. The estimated implementation cost per unit of water conserved is presented in Table 7. As a result, further implementation of the system modernization project is not locally cost effective at this time. In the future, it is anticipated that the costs and estimated benefits of this improvement project will be evaluated as additional information becomes available.

[7] Based on estimated percent reductions in spillage for various improvement measured listed in the technical memorandum "Spillage Reduction- Monitoring and Verification" published by the Agricultural Water Management Council, local conditions, experience, and judgment. Limited reductions in tailwater may occur to some degree based on improved delivery steadiness, flow measurement, and control.

Table 7. Estimated Implementation Cost per Unit of Water Conserved.

Modernization Phase	Annual Cost, Levels 1 and 2 ($/yr)	Conserved Water Range (af/yr)			Conservation Cost ($/af)		
Phase I - Improvement of Primary Inflow Locations and Primary Operational Outflow Locations	$11,099	240	to	480	$23	to	$46
Phase II - Improvement of Main Canal Primary Control Points	$313,695	2,400	to	4,800	$65	to	$131
Phase III - Improvement of Lateral Primary Control Points and Spill Routing	$402,495	1,920	to	6,000	$67	to	$210
Phase IV - Improvement of Lateral Secondary Points, Sublateral Control Points and Secondary Spill Points	$35,529	240	to	720	$49	to	$148
Totals	$762,818	4,800	to	12,000	$64	to	$159

Project 2: Boundary Outflow and Primary Spill Measurement

Project Description

The objectives for the Boundary Outflow and Primary Spill Measurement project are described in Table 8.

Table 8. Objectives of Boundary Outflow and Primary Spill Measurement.

Objective	Boundary Flow and Primary Spill Measurement
Improve Water Use Efficiency	Measurement of operational spillage and drainage flows can be used to make better informed system adjustments that can lead to reduced spillage and possibly a reduction in total demands. Reduced spillage and reduced tailwater can lead to reduced diversions.
Develop Water Use Data	Measurement of boundary outflows and primary spillage provides the data necessary to quantify surface water leaving district, better define unmeasured flows (such as deep percolation), determine areas of high loss, characterize operational efficiencies, and aid in prioritization of improvements.
Support Reporting	Measurement of spillage, boundary flows and recovered drainwater provides information relating to water supply, water use, water quality, environmental benefits, etc. Measurement also supports the district in responding to potential inquiries from landowners regarding water supply, water use, and historical trends.
Increase Operational Efficiency	Measurement of spillage enable operators to make corresponding adjustments at lateral headings or at the diversion to reduce spillage or total diversions. Measurement provides early detection of end canal conditions (high or low) that may be impacting delivery service.

The project summaries provided in this attachment include an inventory of existing or potential sites that fall into one of the classifications described in Table 9.

Table 9. Descriptions of Site Type Classifications.

Site Type Classification	Description	Improvement Package
Boundary Inflow	Flows entering the district boundaries and providing the availability of increased supply.	Boundary Flow and Primary Spill Measurement
Boundary Outflow	Flows leaving the district boundaries and representing excess inflows, intentional releases to satisfy obligations to meet out-of-District demands, or water management issues.	Boundary Flow and Primary Spill Measurement
Internal Outflow	Flows intentionally discharged from district canals to drainage channels for downstream delivery or possible recapture (e.g. deliveries to Secondary).	Boundary Flow and Primary Spill Measurement
Internal Inflow	Additional supply entering the district from within its boundaries. (e.g. groundwater wells).	Boundary Flow and Primary Spill Measurement
Internal Spill	Excesses in supply canals that are discharged to drain channels through safety spill structures.	Boundary Flow and Primary Spill Measurement

For each selected site, conceptual designs were developed that improve the site to meet the objectives. A total of two boundary outflow locations, two internal spill/outflow sites, and one drainwater recovery site were identified for improvement under this improvement package. The selected sites (shown in Figure 2) were identified as high priority through consultation with District personnel or identified has likely high use sites based on their position in the distribution system, such as at the end of main canals or primary laterals. Several additional spill sites were identified but not included in this improvement package because of their perceived low volume or infrequent use. Recommended improvement sites are subject to revision following more detailed review and analysis.

Recommended measurement devices for the boundary and spill flows vary by site type, site conditions and existing infrastructure or proposed infrastructure. Additionally, the intensity of use (rate and duration) relative to other sites, and the importance of the site to meeting the objectives also factor into the selection of measurement devices. In total, four measurement strategies were developed based on unique conditions. In general, it is recommended that improvement projects or phased modernization employ the same device, or a limited selection of devices, throughout the District to maintain consistency in reporting, accuracy, and operations. This also simplifies training of new employees, maintenance protocols, and troubleshooting, as well as minimizes the required spare parts. The four measurement strategies are described in Table 10.

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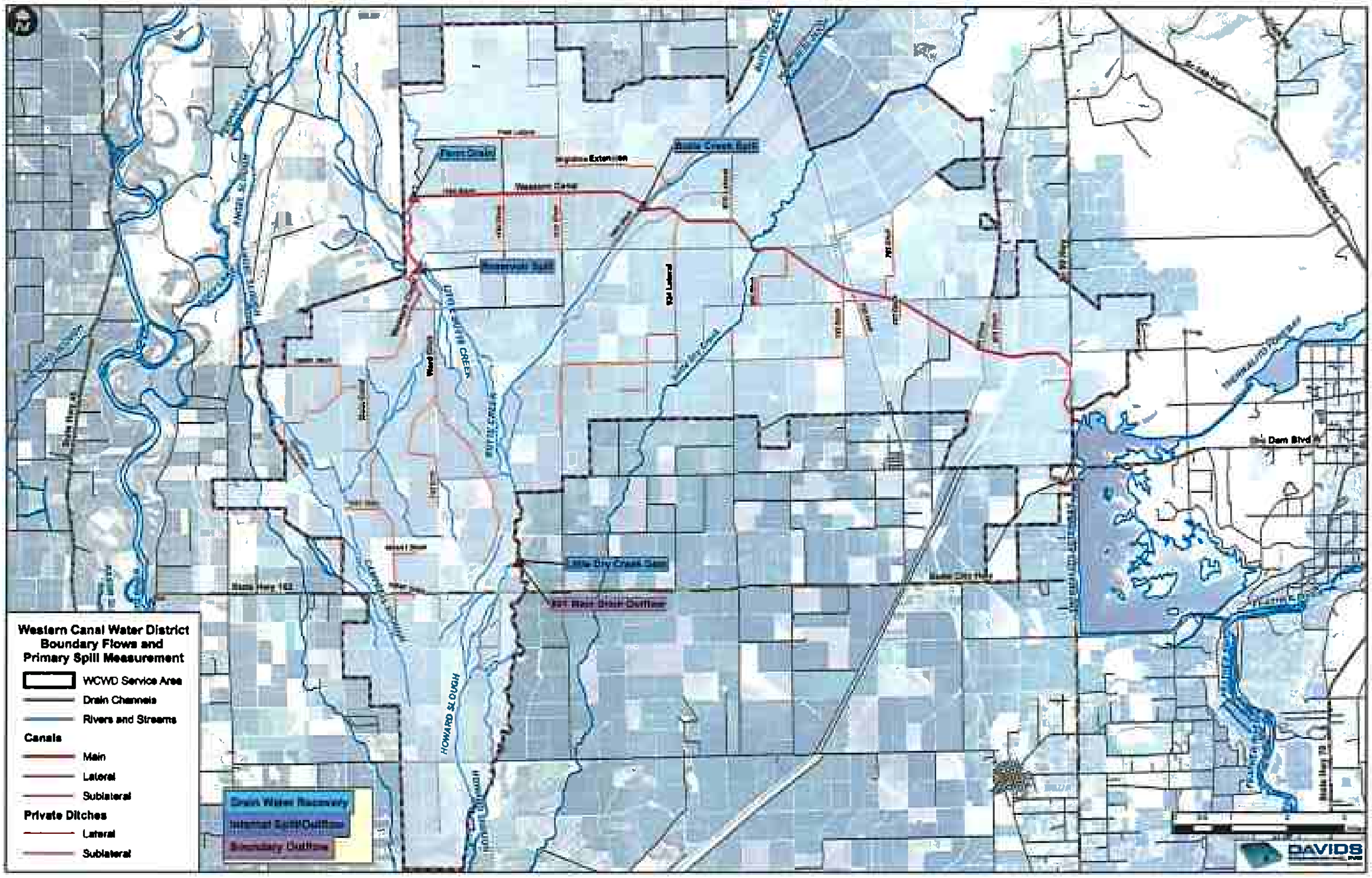

Figure 2. WCWD Boundary Outflow and Primary Spill Sites.

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Table 10. Descriptions of Measurement Devices and Associated Advantages and Limitations.

Measurement Device	Measurement Method	Advantages	Limitations
Acoustic Doppler Meter	Doppler technology measures water velocity. Velocity x Area = Flow rate	High accuracy depending on siting. Generally little calibration and are SCADA-Ready. No moving parts.	Requires power source. Requires a stable cross section and uniform flow velocities. Weeds or other obstructions impact accuracy.
Propeller Meter	Flow through pipe rotates propeller. Rotational velocity is related to water velocity. Velocity x Area = Flow rate	Simple and relatively inexpensive device. Can provide good accuracy depending on siting. Effective in submerged situations. District staff is familiar with technology.	Air pockets, turbulence, weeds or other trash may cause inaccuracies. Moving parts require maintenance. Requires full pipe.
Sharp Crested Weir	For a given weir length, flow is determined by depth of flow over weir crest.	Simple and inexpensive device. Easily adaptable to majority of existing spill structures. Good accuracy depending on siting. Minimal maintenance required.	Requires free fall of flow over weir and uniform velocities.

Measurement of drain channels often presents unique challenges not often experienced in distribution canals. These include, but are not limited to: potentially unstable cross sections with heavy vegetative growth, widely fluctuating flows including storm water runoff, are not typically maintained, higher than normal trash loads, below grade, low hydraulic gradients, and may be subject to additional environmental regulations.

Several of the boundary flow and spill sites are also incorporated in the modernization package as measurement of outflows is an important component of water management.

In most cases, selected spill sites are existing sites that require only minimal improvement or slight reconfiguration; however, some require complete reconstruction or new measurement method. Boundary outflow and internal outflow sites are generally new sites, but their locations are defined at the crossing of the District boundary by the conveyance channel. These sites may require the modification of the site for flow measurement accuracy or installation of the measurement device.

Inventory of Existing Sites

Existing sites were identified through consultation with District operations staff and digitally inventoried in tabular form and in an interactive mapping format. For each site type, several sites were selected for field inspection to obtain dimensions, coordinates, photos and operational features typical of the site type to aid in strategy development and costing. For each site proposed for improvement, Table 11 provides the site name, the site type, latitude, longitude, and a description of the existing conditions. As previously discussed, the improvement process described here focuses on primary outflow and spill points and drain water recovery sites and may not include all minor features.

Table 11. Inventory of Existing Sites.

Site Name	Site Type	Latitude	Longitude	Description of Existing Conditions
501 Main Drain Outflow to Butte Creek	Boundary Outflow	39.472	-121.872	Structure holds water level for upstream deliveries. Concrete abutments with several manually adjusted flashboard bays. Steel catwalk spans structure. Approximately 4ft of drop through structure.
Butte Creek Spill	Internal Spill/ Outflow	39.563	-121.830	Concrete overpour structure spills water as levels rise above crest. Designed to pass 200 cfs. Two undershot gates used for delivery to Butte Sink during Fall. Manual measurement of spill three times per day.
Little Dry Creek Dam	Boundary Outflow	39.472	-121.871	Provide accurate and accessible measurement of spillage flow rate from Little Dry Creek as feedback on heading operation, deliveries operations, and for improved District water accounting.
Pratt Lateral Return Flow (Fenn Drain)	Drain Water Return	39.566	-121.905	Return flows to the Western Canal from Pratt Lateral spill and Fenn deliveries. Meandering earthen cross section of various widths. Culvert road crossing just upstream from return flow to Western Canal.
Reservoir Spill	Internal Spill/ Outflow	39.547	-121.903	Flows bypassing back slide gates and continuing downstream in Little Butte Creek. Natural, earthen channel.

Boundary Outflow and Primary Spill Measurement Improvements

For each site, improvement is split into two levels, Level 1 and Level 2. Level 1 improvements often are infrastructure and measurement enhancements that are manually operated or read, but designed as SCADA-Ready[8] sites. Level 2 improvements build on the Level 1 improvements by adding electronic sensors, installing on-site digital display of flow rate or other parameters, or add remote monitoring or control through a Supervisory Control and Data Acquisition System (SCADA). Level 1 improvements are stand-alone, while Level 2 improvements generally require Level 1 to be completed prior or simultaneously. This phased implementation provides the District the flexibility to complete Level 1 (which has significant benefits on its own) while assessing the benefits of SCADA,

Little Dry Creek Dam Outflow to Butte Creek.

[8] "SCADA-Ready" describes a package of hardware and/or software that communicates and operates locally but has been specifically designed and installed to readily accept a data transmission and receiving device (e.g. radio, cellular modem, etc.) and to provide remote communication with an established base station and SCADA human machine interface (HMI).

prioritizing sites, establishing the SCADA base station and gradually implement the more complex or more expensive sites.

Although Level 2 is not universally required to be completed to obtain significant benefits, several sites will greatly benefit from it. For example, remotely located end spill sites or boundary outflow sites are not frequently visited by operators, and if they are visited and spill is noticed, it may not be worth the travel time to the heading to make a change. Remote monitoring would eliminate travel time, but does require the development of a SCADA office base station.

Additionally, in some cases, there is potentially some savings in capital costs by completing level 1 and level 2 at the same time.

Table 12 provides a description of the improvement proposed for each Boundary Flow and Primary Spill sites, the objective of the improvement and a Level 1 and Level 2 cost. All costs are subject to revision following refinement of site improvements following more detailed review and design.

Table 12. Summary of Boundary Outflow and Primary Spill Measurement Improvement Sites.

Site Name	Site Type	Level 1 Modernization and Enhancement	Capital Cost ($)	Annual Cost ($/yr)	Level 2 Modernization and Enhancement	Capital Cost ($)	Annual Cost ($/yr)
501 Main Drain Outflow to Butte Creek	Boundary Outflow	Install sharp crested weir plates and mount custom staff gage calibrated to report spill flow rate based on the depth of water above the weir crest.	$1,543	$116	Install and configure pressure transducer, PLC, solar power site, communication hardware, and digital flow display. Integrate with SCADA system to allow remote monitoring.	$13,678	$955
Butte Creek Spill	Internal Spill	Cut-down top of existing concrete spill wall and install sharp crested weir plates. Mount custom staff gage calibrated to report spill flow rate based on the depth of water above the weir crest.	$1,543	$116		$13,678	$955
Little Dry Creek Dam	Internal Spill	Install sharp crested weir plates and mount custom staff gage calibrated to report spill flow rate based on the depth of water above the weir crest.	$1,543	$116		$13,678	$955
Pratt Lateral Return Flow (Fenn Drain)	Drain Water Return	Install and configure ADVM in existing channel in culvert pipe. Construct solar power site and add digital flow display. Site will be SCADA-ready.	$19,900	$1,090	Install communication hardware and integrate with SCADA system to allow remote monitoring.	$5,900	$600
Reservoir Spill	Internal Spill	Install and configure ADVM in existing channel in stable cross section. Perform velocity index calibration. Construct solar power site and add digital flow display. Site will be SCADA-ready.	$21,293	$1,166	Install communication hardware and integrate with SCADA system to allow remote monitoring.	$5,900	$600

Boundary Outflow and Primary Spill Measurement Costs

Reconnaissance level cost estimates were prepared for the improvement package described in the preceding sections as a basis for prioritization and funding of site improvements. The total combined cost (Level 1 and Level 2) of improvement is approximately $99,000, with annual costs of $7,000. Total costs are further summarized in Table 13.

Table 13. Summary of Costs.

	Level 1		Level 2	
Boundary Flow and Primary Spill Measurement	**Capital Costs ($)**	**Annual Costs ($)**	**Capital Costs ($)**	**Annual Costs ($)**
Boundary Flows Subtotal	$1,543	$116	$13,678	$955
Internal Spills and Return Flows Subtotal	$44,280	$2,487	$39,155	$3,109
Total Cost =	$45,823	$2,603	$52,833	$4,064

The aforementioned costs do not include a SCADA base station (which would be required for Level 2), mobile operator terminals that would form the backbone of the District SCADA system, or costs of spare equipment to be kept on hand to repair or replace individual site components due to theft, vandalism, or other failure. These costs are summarized in Table 14. This cost represents a robust SCADA network that would be capable of monitoring the identified measurement and drain recovery sites as well as existing or future sites, such as detailed in Project 1: System Modernization.

Table 14. Summary of Costs for SCADA Office Base Station and Spare Parts.

Item	Capital Cost ($)	Annual Cost ($)
SCADA Office Base Station	$138,063	$17,039
Spare Parts	$23,692	$2,913

Potential Benefits

Flow paths targeted under the boundary flow and primary spill measurement package are:

- Operational Spillage
- Tailwater
- Drainage Outflows
- Diversions

Measurement of boundary flows and spills would provide operators tools to support reduction of operational losses. Reduction in losses may result in decreased required diversions. Available water not diverted remains in storage and could potentially be available to meet unmet local demands or to meet regional or statewide objectives.

Through implementation of this package, it is estimated that approximately 3 to 10 percent[9] of existing spills could be conserved annually, or between approximately 720 and 2,400 af per year depending on the level of implementation.

Net Benefit Analysis

The district is currently implementing associated EWMPs at locally cost-effective levels. WCWD has not used its full allocation in recent years, and thus would not achieve cost savings through additional conservation. The estimated implementation cost per unit of water conserved ranges from approximately $11 to $37 per acre-foot. As a result, further implementation of the boundary outflow and primary spill measurement project is not locally cost effective at this time. In the future, it is anticipated that the costs and estimated benefits of this improvement project will be evaluated as additional information becomes available.

[9] Based on estimated percent reductions in spillage for various improvement measured listed in the technical memorandum "Spillage Reduction- Monitoring and Verification" published by the Agricultural Water Management Council, local conditions, experience, and judgment.

Project 3: Reservoir Bypass

Project Description

The reservoir is an intentionally impounded section of Little Butte Creek that accepts inflows from the east via the Western Canal and allows for delivery on the west side to the Main and Ward Laterals. This site poses several challenges, including:

1. Operation of the Front and Back slide gates to impound the Creek and provide conveyance through pond storage is a manual process that requires adjustment of 59 individual 5ft x 5ft metal gates. Gates must all be raised following the irrigation season to accommodate storm flows.
2. The relatively flat topography requires a significant incoming volume to increase water depth and increase conveyance capacity.
3. Normal upgradient stream inflows from can cause unexpected fluctuations that transfer to the Main and Ward laterals.
4. No measurement is installed at the Main and Ward Canal gate headings requiring significant judgment by operators.

As an alternative to the current configuration, WCWD has long considered the construction of a bypass canal that would be constructed along the eastern edge of the Creek and extend the Western Canal parallel to the Creek until approximately the location of the Front and Back Slide Gates. At this point, three individual siphons would carry the flow under the Creek to provide unrestricted flow to supply the Main and Ward Canals. To facilitate cost estimation of this alternatives, a conceptual design was developed making the following assumptions:

1. The bypass canal would follow an alignment as identified by WCWD staff as shown in Figure 3.
2. The total length of newly constructed canal would be approximately 6,300 LF with an additional 1,200 LF of inverted siphons. Siphons would range in length from 200 LF to almost 700 LF.
3. Design capacity was estimated at 500 cfs.
4. Limited ground slope (approximately 0.00013 ft/ft) is estimated to exist along the proposed alignment.
5. A trapezoidal canal with a top width of approximately 60 ft was assumed, and two parallel 60" diameter pipes were assumed for each siphon.
6. Siphons would be installed using bore and jack methods to minimize impacts to the Creek.
7. The canal would be unlined and embankments constructed of compacted earth fill sourced from excavation. It was assumed cut and fill quantities would approximately balance requiring no import.
8. Estimated costs do not account for the removal of the Front and Back Slide Gates. An environmental impact/benefit analysis should be completed to evaluate the environmental impact that removal might pose, as opposed to simply removing the gate panels and abandoning the structure.

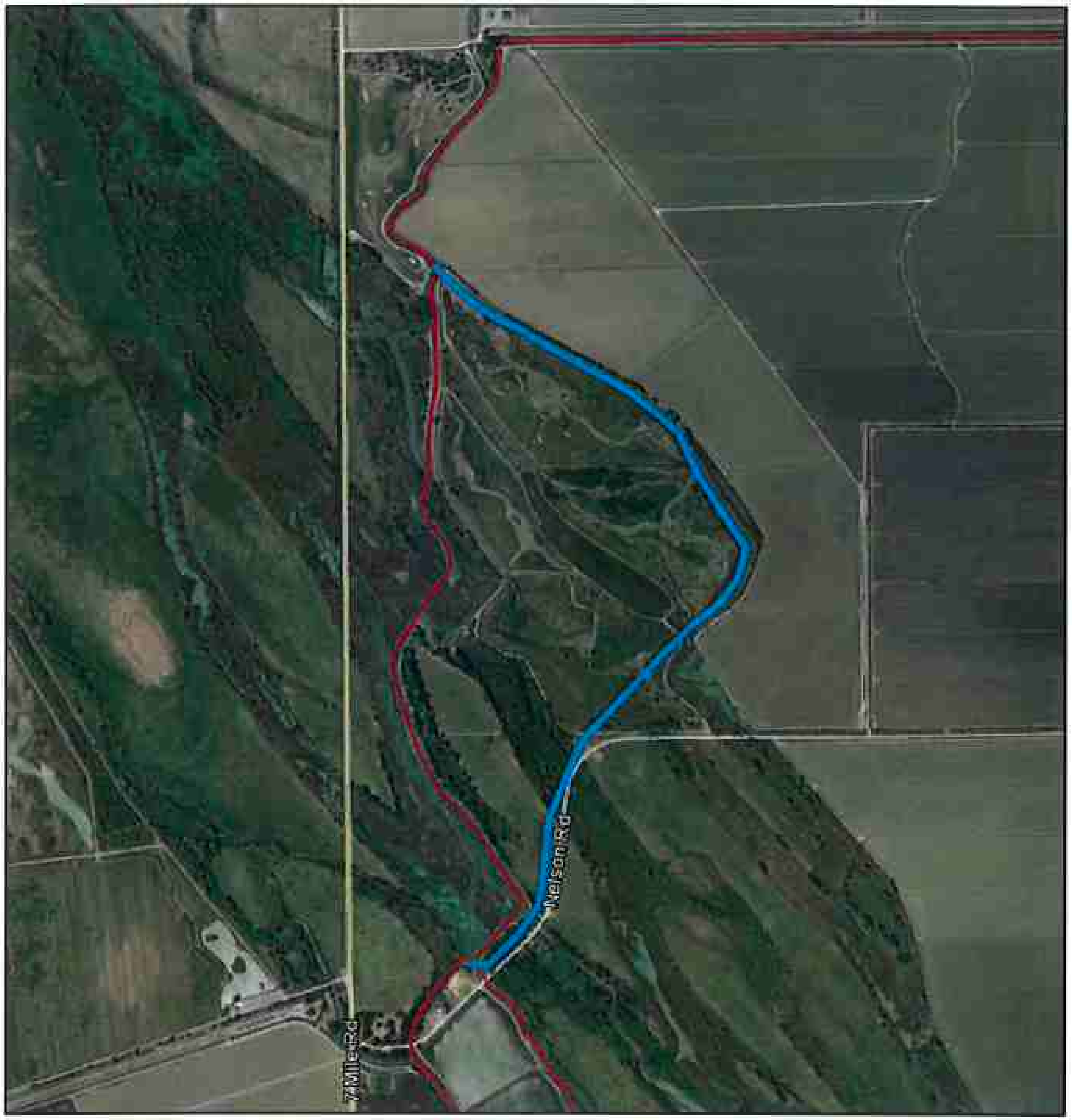

Figure 3. Overview of Existing Canal Alignment (Red) and Conceptual Alignment (Blue) of Reservoir Bypass Canal.

Reservoir Bypass Costs

Reconnaissance level cost estimates were prepared the improvement project described in the preceding sections as a basis for prioritization and funding of site improvements. The total combined cost of improvement is approximately $12,815,000 with estimated annualized costs of $758,000.

Potential Benefits

The construction of a reservoir bypass canal and related components has no water conservation benefits that could be reasonably quantified at this stage of design. However, several qualitative benefits to WCWD include:

- Reduction of labor requirements associated with operations of the reservoir. The alternative provides a direct supply to the Main and Ward Laterals and may improve the operational efficiency of these sites.
- Increased capacity to meet downstream irrigation demand (limited to downstream canal capacity constraints) may enable increased rotational frequency or larger available irrigation heads. This may increase irrigation efficiency.
- Reduced potential for environmental impacts associated with impounding water. An appropriate environmental review would be required for this project.
- Feather River water and Little Butte Creek flows no longer required to be comingled.
- Potential for reduced spillage due to additional control over inflows.
- Increased safety due to elimination of the Front and Back Slide Gates.

Net Benefit Analysis

A net benefit analysis was not performed for this project because the improvements are not aligned with specific EWMPs.

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7.10.5 Drought Management Plan

Introduction

On April 1, 2015 Governor Brown issued Executive Order B-29-15, mandating agricultural water suppliers to include in their 2015 Agricultural Water Management Plan (AWMP) update a detailed Drought Management Plan (DMP) describing actions and measures taken to manage water demand during drought. Three years later Assembly Bill 1668 (AB 1668) was passed on May 31, 2018. AB 1668 amended the California Water Code (CWC) and requirements for AWMPs, providing more detail on the specific requirements for a Drought Plan, or DMP (CWC 10826.2). This DMP builds upon WCWD's existing shortage allocation policies, which were the foundation of the 2015 DMP. The 2020 DMP includes the components required by CWC 10826.2 and recommended by DWR in its 2020 AWMP Guidebook for inclusion (DWR 2020). Additionally, the 2020 DMP provides a reflection on and evaluation of the 2012-2016 drought.

WCWD is well-positioned to respond to drought conditions, with access to a number of reliable water supplies. Since its formation in December 1984, WCWD has had a full surface water supply in all but three years (1991, 1992, and 2015). WCWD holds a surface water right of 145,000 af from storage on the North Fork of the Feather River that is not subject to reduction, a surface water supply of 150,000 af that is available in most years according to its 1986 agreement with the State, and adjudicated water rights on Butte Creek that are subject to surplus availability and dependent on hydrologic conditions. During years in which curtailment is allowed under the agreement, WCWD's water supply of 150,000 af from the State can be reduced by up to 50 percent, as discussed in greater detail below. For purposes of this DMP, drought years are generally considered to be years of reduced surface water supply due to curtailment.

The following sections describe WCWD's (1) drought resiliency planning actions undertaken to prepare for drought, and (2) drought response actions undertaken to manage available water supplies and to meet customer demands to the maximum extent possible during a drought.

Drought Resilience Planning (§10826.2(a))

This section describes actions and activities undertaken by WCWD to prepare for drought and effectively manage and mitigate the effects of surface water shortage. It includes the determination of water supply availability and drought severity, identification and analyses of potential vulnerability to drought, and opportunities and constraints for improving drought resiliency planning.

<u>Determination of Water Supply Availability and Drought Severity (§10826.2(a)(1))</u>

As described above, WCWD has access to several surface water supply sources that are available in all, or most, years.

WCWD holds a pre-1914 surface water right for diversion of up to 145,000 af of upstream stored water on the North Fork of the Feather River. This right is not subject to reduction.

WCWD also holds a pre-1914 water right for diversion of up to 150,000 af of natural flow from the Feather River, subject to reduction during drought under terms of its 1986 diversion agreement with the State. As stipulated in its agreement with the State, WCWD's water supply depends on the Lake Oroville inflow. WCWD's surface water supply can be reduced under the following conditions:

- DWR forecast April to July unimpaired runoff into Lake Oroville is less than 600,000 af[12], or
- Total current year predicted and prior year actual deficiencies in unimpaired runoff (as compared to 2,500,000 af) exceed 400,000 af for one or more successive prior water years with less than 2,500,000 af of runoff.

When a reduction is allowed, the WCWD allotment can be reduced by up to 50 percent in any one year, but not by more than 100 percent in any seven consecutive years. Additionally, reductions in any given year cannot exceed the percent reduction experienced for agricultural use by State Water Project (SWP) contractors.

In addition to these supplies, WCWD also has adjudicated water rights on Butte Creek that are subject to surplus availability and are dependent on hydrologic conditions. While the maximum diversion is 9,300 af, average annual diversions have been approximately 7,800 af in recent years. WCWD monitors hydrologic conditions to assess the availability of these supplies from year to year.

Potential Vulnerability to Drought (§10826.2(a)(2))

Generally, WCWD water supplies have been sufficient in all but the driest of years. As described above, under the 1986 agreement with the State WCWD's allotment of natural flow from the Feather River can be reduced by up to 50 percent in any one year, but not by more than 100 percent in any seven consecutive years. This reduces the District's vulnerability to ongoing surface water supply curtailment across consecutive years of drought.

The relative security of these supplies and WCWD's other pre-1914 and adjudicated water rights, even during historic drought conditions, suggests that the District is well-protected against drought vulnerability.

Drought Resilience Opportunities and Constraints: Availability of New Technology or Information (§10826.2(a)(3)(A))

In recent years, WCWD has made substantial improvements to both distribution system infrastructure and operational practices that have improved overall distribution system water management and increased operational efficiency. During periods of surface water shortage, WCWD takes additional, extraordinary measures to further increase operational efficiency and to maximize the beneficial use of available water supplies. Highlights of WCWD activities to increase operational efficiency include the following:

[12] The final, official forecast must be made by April 10 of each year.

- Automation of three primary control structures along the Western Main Canal and automation of the Nelson Check during winter 2015-2016 to reduce spillage, increase operational efficiency, and conserve available water supplies.
- Adoption of the Feather River Regional Agricultural Water Management Plan (FRRAWMP), which included the identification of approximately $12 million in modernization and boundary flow measurement improvements and $13 million in potential improvements to the main canal to bypass Little Butte Creek. These projects have the potential to significantly increase operational efficiency. It is anticipated that these improvements will be implemented over time subject to funding and project prioritization.
- Implementation of a comprehensive water information system (WIS) in 2015 that improves overall system management and incorporates tools for operational staff to support increased operational efficiency (e.g. transitioning from a paper-based tracking system to a digital database system, greatly increasing staff efficiency). The WIS also increases the flexibility with which customers can manage available water supplies, particularly during drought years.
- Operation of the FLOW Portal, an online platform that gives growers access to their delivery flow measurements in real-time in an effort to reduce farm tailwater.
- Increased coordination among operators and with customers to reduce surface outflows resulting from operational spillage and tailwater. These improvements are achieved through a combination of more frequent spill monitoring and more frequent flow adjustments in the system in response to grower demands.
- Submittal of grant applications to the USBR in the summer of 2020 that would fund projects to measure primary boundary outflow sites, providing staff with real-time estimates of water leaving the District. If successfully funded, it is anticipated this work will be completed between 2021-2022.

WCWD plans to continue implementing new technologies to improve drought resiliency and operational efficiency, and is continually exploring new technologies and information to achieve these ends.

Drought Resilience Opportunities and Constraints: Availability of Additional Water Supplies (§10826.2(a)(3)(B))

WCWD's surface water supplies have been generally sufficient during years with a full surface water supply. In years of surface water shortage, growers within WCWD are able to utilize groundwater to augment available water supplies. These groundwater supplies are supported by surface water recharge in years when surface water supplies are sufficient. The conjunctive management of surface water and groundwater supplies over time is a key component of WCWD's drought management strategy.

The District does not own or operate any groundwater wells, although it allows growers to optimize the use of available groundwater during drought through provisions in its shortage allocation policies. These provisions allow growers to convey groundwater pumped using private wells through the District conveyance system, subject to District approval, enhancing the beneficial use of groundwater supplies.

Growers additionally augment water supplies in drought years through the assignment (internal transfer) of water among growers, which is allowed by WCWD. Also, growers increase drainwater recycling by PTO-driven pumps or other means.

Drought Resilience Opportunities and Constraints: Other Planned Actions (§10826.2(a)(3)(C))
The District is actively involved in coordinating and collaborating with adjacent agricultural and urban water suppliers and Groundwater Sustainability Agencies. The Agency is willing to continue supporting conjunctive management to the extent overdraft, land subsidence, and other undesirable results are avoided. Additionally, the District is actively involved in discussions with the State regarding meeting unimpaired flow requirements through voluntary agreements (VA). VAs may require the District to implement certain conservation measures, including land fallowing, to increase in-stream flows during endangered anadromous fish runs.

Drought Response Planning (§10826.2(b))
This section describes actions and activities undertaken by WCWD to address surface water shortage. It includes discussion of the policies and process for declaring a water shortage and implementing water shortage allocation, methods and procedures for the enforcement or appeal of triggered shortage responses, methods and procedures for monitoring and evaluating the drought management plan, communication protocols and procedures, potential financial impacts of drought, and proposed measures to overcome those impacts.

Policies and Processes for Water Shortage Declaration and Water Shortage Allocation and Implementation (§10826.2(b)(1))

Historically during drought, WCWD has apportioned available surface water supplies on a pro-rata basis to irrigable acres for which water applications are received, and informed landowners of the total acre-feet available for irrigation between April 1 and October 31. The total volume of water delivered and remaining for each landowner is then tracked over the course of the irrigation season.

Current shortage policies (Attachment A) include the following, many of which are presented here verbatim:

- When surface water supplies are reduced due to curtailment by the State or other factors as otherwise determined by the Board of Directors, available surface water is allocated on a pro-rata basis to all primary acreage for which a standby fee is paid. Secondary acreage receives no allocation, except as assigned from eligible primary acres.
- An initial allocation will be made by the Board considering system losses and other obligations based on the preliminary DWR forecast as provided on or before February 15. The initial allocation may be revised based on applications for water received, revisions to the forecast, or other factors.
- The initial allocation will be made on March 15 with applications for water due by April 15. No allocation will be made for lands for which applications are not timely received, except upon direction of the Board.

- After receipt of applications, the District will mail out a final water allocation, invoices, and issue notice of rules, rates and policies regarding drought conditions.

The following additional conditions apply:

1. Surface Water
   a. The District will deliver water only to Applicants who have timely and completely filled out an application.
   b. The District reserves the right to increase or decrease the final allocation at any time based on new information or changed circumstances. The District will notify all Applicants concerning any amendments to their allocation.
   c. The District will not supply water in excess of an Applicant's allocation. During the irrigation season, the District will keep track of Applicants' water use and will periodically notify each Applicant of then-current usage and remaining allocation. Failure of the District to provide notice shall not permit Applicant to divert water in excess of their allocation; each Applicant is expected to monitor their diversions to ensure they do not exceed their allocation. The District will cease deliveries once an Applicant's allocation has been delivered.
   d. Assignments of Surface Water
      i. Upon notice to the District, any Applicant may assign all or a portion of their surface water allocation to different fields within the District that are owned or leased by the same Applicant.
      ii. Applicants may assign all or a portion of their surface water allocation to another landowner/grower within the District, provided:
         1. The Applicant and the assignee complete a District assignment form and pay for the water in advance, including a one-time administration/wheeling charge of $200.
         2. Completed assignment forms may be approved by the General Manager at any time. If the General Manager denies a request for assignment or, due to unique circumstances, is unwilling to approve or deny the request, the assigning landowner may seek reconsideration by the Board of Directors. Requests for reconsideration must be received by the District office on or before the Wednesday before the District's regular board meeting (the third Tuesday of each month) so the item may be placed on the agenda for consideration by the Board of Directors.
         3. The District reserves the right to deny assignment requests for any reason, including without limitation inadequate capacity to wheel the water through the District's facilities.
2. Groundwater
   a. The District will not allow the use of its facilities to wheel or accommodate the transfer or assignment of groundwater that may be pumped by landowners. Upon application, a landowner may be allowed to utilize District facilities to convey groundwater to the same landowner's fields. The District reserves the right to grant or deny such request for any reason.

3. Out of District Assignments
    a. Upon request, the Board of Directors of the District will consider assignments of any Applicant's surface water allocation to any Joint District. Prior to making the request, the Applicant must first have obtained the written consent of the applicable Joint District to the possible assignment. Notwithstanding the consent of the applicable Joint District, the District reserves the right to grant or deny any out of district assignment for any reason.
    b. The District will not permit out of District assignments to entities or individuals outside the Joint Districts.

To provide additional flexibility to customers in the use of available surface water supplies, current WCWD policy allows for the assignment of allocations/apportionments among landowners (Attachment B). Under this policy, any landowner may assign a portion of his/her allocation to another landowner in the District, subject to District approval. An administrative fee payable to the District of $200 applies. This policy provides substantial additional flexibility to landowners in maximizing the beneficial use of water within the District during periods of shortage.

<u>Methods and Procedures for Water Shortage Response Actions (§10826.2(b)(2))</u>

During periods of curtailment, the District's Board of Directors determines the course of action to manage available water supplies, including reiteration of the District's current shortage allocation and drought management policies and any revisions that may be required to best serve the landowners. District policies combine measures to reduce operational spillage and to equitably distribute available surface water supplies. Additionally, District policies allow for the conveyance of privately pumped groundwater via the distribution system to meet irrigation demands, subject to approval. These strategies enhance operational efficiency, delivery flexibility, and conjunctive use to maximize the use of available surface water and groundwater supplies to reduce shortage impacts, meet irrigation demands, and maximize the beneficial use of water within WCWD.

WCWD's water shortage response actions are enforced as described in the District's policies or other drought-related materials developed and disseminated by WCWD and the Board of Directors. Failure to comply will typically result in a fine and warning for the first violation; a second violation will typically result in an additional fine and loss of water delivery for the remainder of the irrigation season. Appeals of enforcement actions or for exemption from enforcement are accepted and will be considered by WCWD and the Board of Directors on a case-by-case basis.

<u>Monitoring and Evaluation of Drought Plan (§10826.2(b)(3))</u>

While a portion of the District's water supply is dictated by the 1986 agreement with the State, monitoring of hydrologic conditions to assess available water supply is important to WCWD's water management across the full range of hydrologic conditions experienced. To inform District decisions related to available water supply and to inform growers of supply conditions, the District actively monitors water supply information reported by the Department of Water Resources (DWR), the National Oceanic and Atmospheric Administration (NOAA), and others for Lake Oroville and the Feather River watershed as a whole. Information monitored includes storm activity, accumulated precipitation and snow, water year indices, reservoir storage and releases, and projected and actual reservoir inflow. This valuable information supports the District and its customers in planning for water management and in making cropping decisions in all years. The value of monitoring a broad range of hydrologic information is amplified in years of drought but is also important during wet years due to flood risk in some areas of the District.

In years of curtailment, the District tracks grower applied water using the RemoteTracker delivery measurement system. This allows the District and individual growers to compare applied water estimates to their allotment to ensure the District is on track to reduce surface water diversions.

Communication Protocols and Procedures (§10826.2(b)(4))

WCWD encourages efficient on-farm water management to control demand on an ongoing basis. Because water rates are based on the volume of water delivered, WCWD's water charges implicitly encourage efficient on-farm water use. During curtailment years, on-farm water management efforts are enhanced through several extraordinary actions, which may include the following:

- Additional education and outreach
- Allocation of available water supplies
- Provision of water delivery information in near real time
- Enhanced enforcement of rules and regulations
- Coordination and collaboration with regional and statewide entities

These actions are summarized in the remainder of this section.

Outreach and Incentives

During periods of reduced supply, WCWD increases outreach efforts to encourage on-farm water conservation and to keep growers informed of hydrologic conditions and any changes to WCWD policies and practices to manage limited water supplies.

Allocation of Available Supplies

Under reduced surface water supply conditions, available water is allocated on a pro-rata basis to irrigable acres for which applications are received, as discussed previously. WCWD informs landowners of the total acre-feet available for irrigation between April 1 and October 31. The total volume of water delivered and remaining for each landowner is then tracked over the course of the irrigation season. In the curtailment year of 2015, the implementation of a water information system (WIS) by WCWD allowed the district to transition from a paper-based tracking system to apportion available surface water supplies to a digital database system, greatly increasing the efficiency with which apportionments are managed by staff. The District's policy of apportioning available water by landowner rather than by delivery point or field provides growers substantial flexibility, allowing field-specific planting and irrigation decisions to maximize the beneficial use of available district surface water and private groundwater supplies.

As described previously, WCWD allows the conveyance of privately pumped groundwater via the distribution system to meet irrigation demands, subject to approval. For privately pumped groundwater conveyed through the distribution system, the following steps are taken to ensure equitable distribution of water supplies:

- Flow meters are required on groundwater pumps discharging to the distribution system,
- The amount of groundwater pumped into the system (minus an assumed carriage loss) is added to the landowner's volumetric allocation, and
- Flow meters are monitored regularly over the course of the irrigation season to monitor and record pumped volumes.

Provision of Water Delivery Information in Near Real Time
Over the course of the irrigation season, water delivery information for each grower (including the remaining allocation) is available through District staff. An online interface has additionally been developed and implemented. The interface provides detailed information in near real time describing the timing and amount of water delivered by turnout and by field. This allows growers to access the information at their convenience and easily stay up-to-date on water deliveries and remaining available water.

Enhanced Enforcement of Rules and Regulations
WCWD's Irrigation Rules (AWMP Attachment 7.10.1) allow for the refusal of delivery by the District for wasteful use of water, whether willful, careless, or negligent. Irrigators who waste water may be refused WCWD water until the cause of the condition is remedied at the discretion of the General Manager. During periods of water supply shortage, WCWD may increase enforcement of rules related to the unauthorized use of water and tailwater runoff.

Coordination and Collaboration with Regional and Statewide Entities
WCWD coordinates and collaborates extensively with others regarding local and regional water management in all years. These activities intensify during periods of drought in order to minimize adverse impacts across a range of stakeholders. Examples of longstanding and recent collaboration and coordination activities include the following:

- Bi-weekly coordination calls with the Joint Districts, other Feather River diverters, and the State with regard to Feather River water supplies and demands;
- Reporting of information to the California Department of Water Resources and other governmental entities;
- Participation on the Northern Sacramento Valley Integrated Water Management Plan (NSVIRWMP) board;
- Participation in NCWA's Drought Strike Team;
- Presentations and active social media and other outreach to interested parties including lenders, legislative staff, media representatives, government agency staff, and others regarding surface water and groundwater management, food production and agriculture, and fish restoration and other habitat efforts.

Additionally, WCWD staff serve as members of the water advisory committees for Butte County and Glenn County. These committees address issues including overall water management, surface water and groundwater resources, and public education and outreach. WCWD also works in coordination with Butte County, Glenn County, and DWR to monitor and report groundwater levels within its service area and is actively implementing the Sustainable Groundwater Management Act of 2014 (SGMA).

Potential Financial Impacts of Drought and Proposed District Management Measures (§10826.2(b)(5))

The District's water charges use a volumetric rate dependent on the quantity of water delivered, with a required minimum charge. As a result, revenues are reduced in curtailment years due to reductions in available water for delivery. Revenues also decrease in curtailment years as a result of decreased water sales through out-of-district agreements and water transfers.

In addition to reduced revenues during curtailment years, operating costs increase substantially due to several factors. Increased expenditures include the following:

- Increased staff effort to provide direct customer service;
- Increased outreach to District customers, the general public, and other interested parties; and
- Increased reliance on outside legal and technical support to enhance service and to address reservoir operations, water rights, and other issues.

The District maintains appropriate reserves to cover the cost incurred during drought years, updating water rates in accordance with Proposition 218 to maintain adequate reserve funds, as necessary.

Evaluation of 2012-2016 Drought

The following sections describe the impacts of the 2012-2016 drought on water supply and water demand in WCWD.

As described previously, WCWD has historically experienced very reliable surface water supplies. During the 2012-2016 drought, WCWD had a full surface water supply of 295,000 acre-feet in all years except 2015. To illustrate actions by WCWD and its customers to manage available water supplies during drought years, the water supplies and water demands in 2015 are summarized and compared to other recent years with full supply (1999-2019, excluding 2015). All volumes summarized in this section are from the District water balance, described in Section 7.7 of the AWMP update.

This discussion also examines the effectiveness of WCWD's past drought resilience and drought response efforts, identifies lessons learned from the drought, and provides context for planning future actions.

Impacts on Water Supplies

To illustrate actions by WCWD and its customers to manage available water supplies during drought, water supplies for 2015 are summarized and compared to other years covered in the WCWD water balance (1999-2019, excluding 2015). The years 1999-2019, excluding 2015, represent years where the full surface water supply was available for diversion by WCWD. The year 2015 represents a year in which the 150,000 af water supply based on Feather River natural flow was curtailed by 50%, representing an overall reduction of approximately 25% of WCWD's surface water supply.

Average monthly Feather River diversions to WCWD are shown in Figure 7-11. Total average diversions between April and October were approximately 255,000 af in full supply years (1999-2019, excluding 2015), and 212,000 af in 2015.

Average monthly groundwater pumping within WCWD is shown in Figure 7-12. The total average groundwater pumping between April and October was approximately 6,000 af in full supply years (1999-2019, excluding 2015), but increased to over 35,000 af in 2015. While the District does not own or operate any groundwater wells, growers within WCWD are able to pump from privately-owned groundwater wells to augment available water supplies in years of surface water shortage. As described previously, conjunctive management of surface water and groundwater supplies is a key component of WCWD's drought management strategy. The groundwater supplies that growers used in 2015 are directly supported by surface water recharge in years when surface water supplies are sufficient.

Average monthly total diversions and private groundwater pumping are shown in Figure 7-13. The total combined diversions and private groundwater pumping represent the primary sources of irrigation supply in WCWD. Total average diversions and groundwater pumping between April and October were 262,000 af in full supply years (1999-2019, excluding 2015), and 248,000 af in 2015. While diversions decreased with the curtailment in 2015, the total difference in supply was offset by increased groundwater pumping.

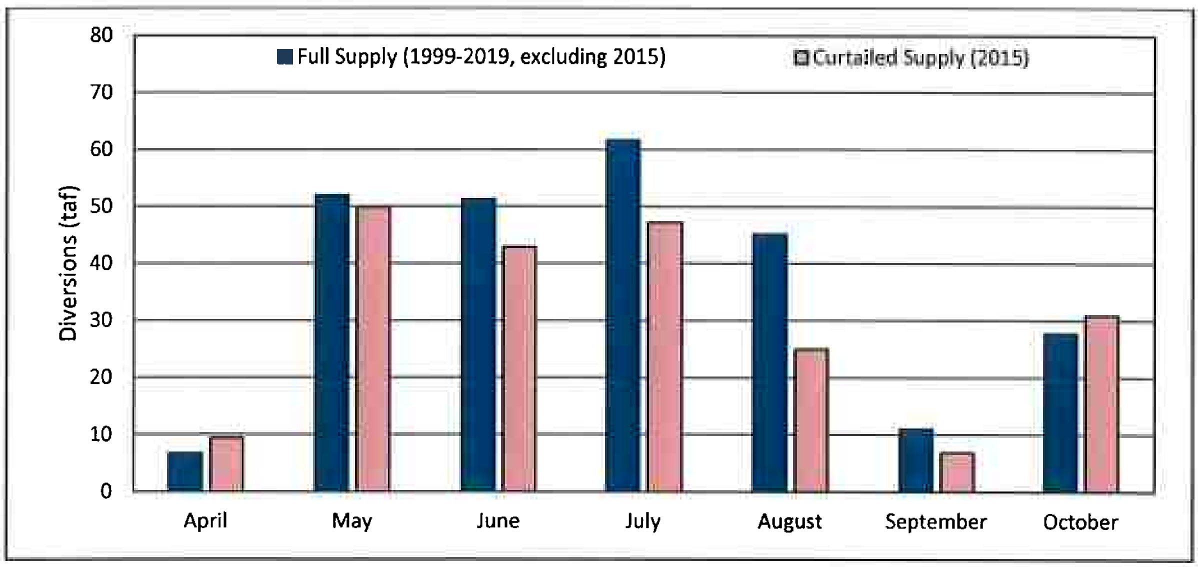

Figure 7-11. WCWD Average Monthly Diversions in April to October, Full Supply (1999-2019, excluding 2015) versus Curtailed Supply (2015) Years.

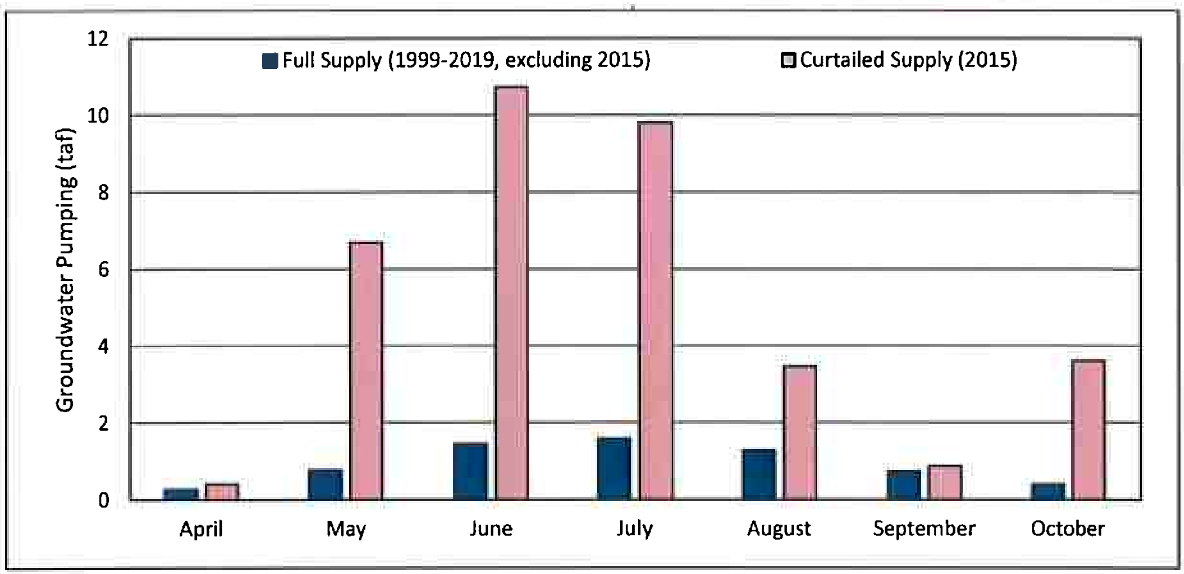

Figure 7-12. WCWD Average Monthly Private Groundwater Pumping in April to October, Full Supply (1999-2019, excluding 2015) versus Curtailed Supply (2015) Years.

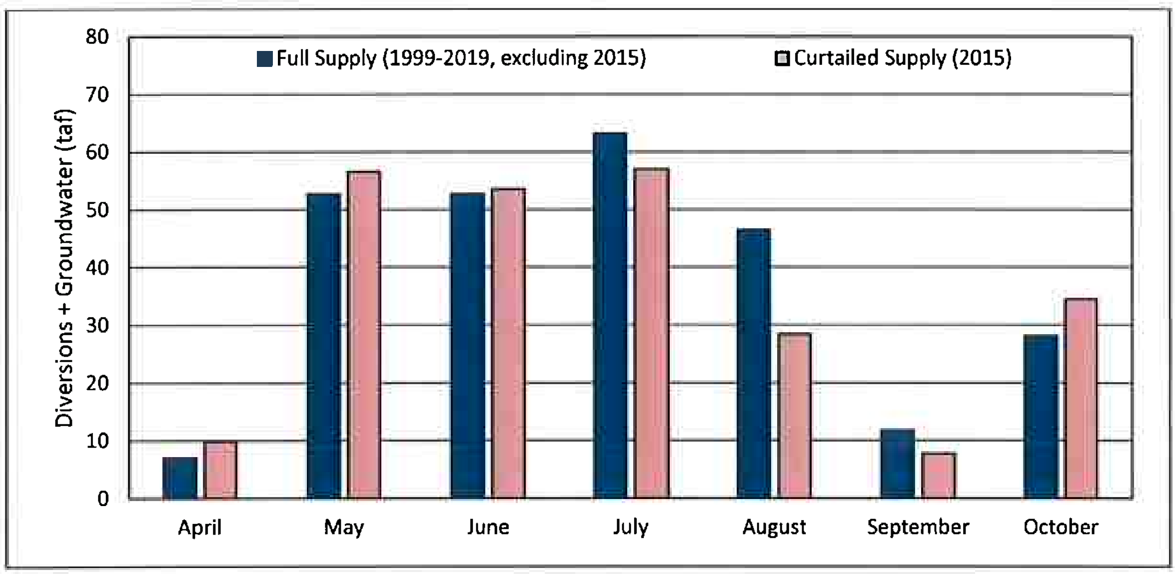

Figure 7-13. WCWD Average Monthly Total Diversions and Private Groundwater Pumping in April to October, Full Supply (1999-2019, excluding 2015) versus Curtailed Supply (2015) Years.

Impacts on Water Demand

To illustrate the impacts of drought on demand in WCWD, applied water demands in 2015 are summarized and compared to demands in other years covered in the WCWD water balance (1999-2019, excluding 2015). The years 1999-2019, excluding 2015, represent years where the full surface water supply was available for diversion by WCWD and demands were fully met. The year

2015 represents a year in which the 150,000 af water supply through the State was curtailed by 50%, representing an overall curtailment of about 25% for WCWD's full surface water supply.

Average monthly deliveries in WCWD are shown in Figure 7-14. In 2015, the deliveries include both surface supplies and comingled private groundwater that is delivered through the District's distribution system. Total average deliveries between April and October were 228,000 af in full supply years (1999-2019, excluding 2015), and 209,000 af in 2015. Deliveries typically represent approximately 80-90 percent of overall diversions, depending on the operational efficiency and drainwater reuse in each year. Deliveries were lower in 2015, corresponding to lower surface water diversions that year. However, as noted in the previous section, the reduction in surface water supplies in 2015 was offset by increased groundwater pumping. Some of this private groundwater pumping comingles with surface water in reaches of the WCWD distribution system where the District has allowed growers to convey groundwater. Including both deliveries and groundwater pumping, the total applied water duty for crops in April to October was similar in 2015 and full supply years, totaling approximately 4.9 af/ac per year. This suggests that WCWD and its growers are resilient to drought conditions. Even in years when surface water supplies are reduced, conjunctive management of surface water and groundwater is effective in sustaining irrigation of cropped land.

Average monthly crop evapotranspiration of applied water (ET_{aw}) in WCWD is shown in Figure 7-15. The total ET_{aw} between April and October was approximately 143,000 af in full supply years (1999-2019, excluding 2015), and 129,000 af in 2015. Dry conditions early in 2015 led to higher applied water demand in the early season, but later in the season ET_{aw} was reduced, particularly in August. This is partly attributable to a reduction in cropped area in 2015, when a total of 47,000 acres were irrigated versus an average of approximately 49,800 acres in full supply years. However, following the curtailment, the cropped area resurged to 51,700 acres in 2016.

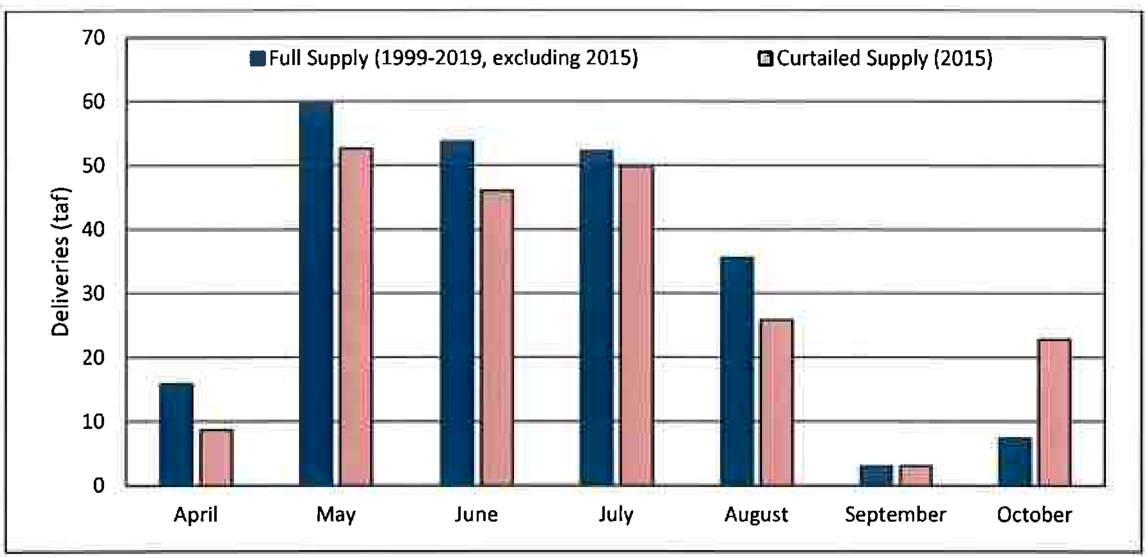

Figure 7-14. WCWD Average Monthly Deliveries in April to October, Full Supply (1999-2019, excluding 2015) versus Curtailed Supply (2015) Years.

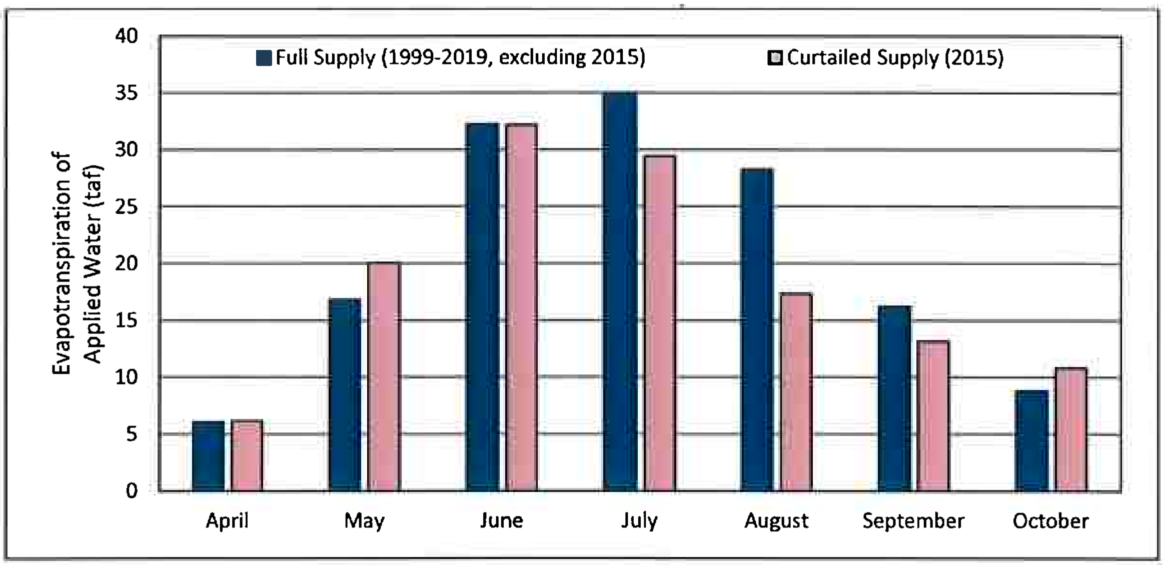

Figure 7-15. WCWD Average Monthly Evapotranspiration of Applied Water in April to October, Full Supply (1999-2019, excluding 2015) versus Curtailed Supply (2015) Years.

Effectiveness of Drought Planning Efforts in 2012-2016

In all, the evaluation of WCWD's water supplies and water demands in 2015 indicate that the District's ongoing drought planning efforts are generally effective in supporting its growers' ability to weather the impacts of drought periods when the District surface water supplies are limited.

As described throughout this plan, WCWD has access to reliable water supplies, totaling at least 295,000 af in full supply years. Since the mid-1990s, the District's supplies were curtailed only in 2015. The District's diversions in 2015 totaled 212,000 af, approximately 17 percent lower than average diversions in full supply years (1999-2019, excluding 2015). When surface water supplies dropped in 2015, growers were able to utilize groundwater supplies available due to ongoing conjunctive management and surface water recharge in WCWD. WCWD's conjunctive management of surface water and groundwater supplies is thus an effective drought resilience and response strategy.

Although groundwater pumping increased during the curtailment in 2015, the total pumping in the following years (2016-2019) returned to levels typical of other, earlier full supply years. Likewise, although the total cropped area and ET_{aw} decreased during the curtailment in 2015, both increased again in 2016 as full supply returned. These temporary shifts suggest that although the severe drought and curtailment in 2015 pushed growers to temporarily pump more groundwater and change their agricultural practices, the availability and affordability of WCWD's surface water supplies strongly incentivize conjunctive management and increased use of surface water when it is available.

These findings indicate that WCWD's ongoing water management and drought planning efforts are effective in sustaining agricultural production even during extended droughts and years when District supplies are curtailed.

References

DWR. 2020. A Guidebook to Assist Agricultural Water Suppliers to Prepare a 2020 Agricultural Water Management Plan. California Department of Water Resources.

Attachments

A. Water Shortage Allocation Policy

B. Surface Water Assignment Form

Attachment A

WESTERN CANAL WATER DISTRICT

WATER SHORTAGE ALLOCATION POLICY

When Western Canal Water District is notified of a water deficiency of 25% pursuant to its contract with the Department of Water Resources (DWR) and/or in the opinion of the Board of Directors of Western Canal Water District there is a water shortage, the water will be apportioned on a pro-rata basis to all primary acreage for which a standby fee is paid. Secondary acreage will not receive any water allocation from the District. Secondary acreage may receive water by assignment pursuant to this policy.

The Board will determine the amount of water to be shared, including water needed to cover system losses and other obligations. The Board will use the preliminary forecast as provided by the DWR on or before February 15 in considering the water allocation. This does not limit the Board in considering other factors, including applications for water, or in amending (increasing or decreasing) the allocation at any time.

The Board's preliminary allocation will be made on March 15. Complete applications for water will be due on or before April 15. Should no application be made at the proper time and in the proper manner, no water will be served, except upon direction of the Board, for that parcel for that irrigation season pursuant to Water Code section 35453.

After receipt of applications, the District will mail out a final water allocation, invoices, and issue notice of rules, rates and policies regarding drought conditions.

1. **Surface Water**
    a. The District will deliver water only to Applicants who have timely and completely filed out an application.
    b. The District reserves the right to increase or decrease the final allocation at any time based on new information or changed circumstances. The District will notify all Applicants concerning any amendments to their allocation.
    c. The District will not supply water in excess of each Applicant's allocation. During the irrigation season, the District will keep track of Applicants' water use and will periodically notify each Applicant of then-current usage and remaining allocation. Failure of the District to provide notice shall not permit Applicant to divert water in excess of their allocation; each Applicant is expected to monitor their diversions to ensure they do not exceed their allocation. The District will cease deliveries once an Applicant's allocation has been met.

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Attachment B

WESTERN CANAL WATER DISTRICT

SURFACE WATER ASSIGNMENT FORM

This Surface Water Assignment Form is made and entered into on the date last shown below, with reference to the following facts:

A. Due to severe reduction of its available water supply in 2014, Western Canal Water District ("District") has authorized, in accordance with Water Code Sections 35420 and 35421, an allocation of water during the irrigation season, from April 1 to September 30, to each applying landowner and has further authorized the assignment of an applying landowner's allocation to another landowner in the District.

B. ______________________________("Assignor") is a landowner entitled to an allocation of water within District and is willing to assign a portion of his/her/its surface water supply to Assignee in 2014.

C. ______________________________("Assignee") is a landowner entitled to an allocation of water within District and is requesting assignment of all or a portion of Assignor's surface water supply in 2014 .

D. Subject to District's approval, Assignor agrees to assign to Assignee ____________ acre-feet for reasonable and beneficial use on Assignee's lands within Western Canal Water District in the 2014 irrigation season.

E. Assignor and Assignee agree that the District, in its sole and absolute discretion, may deny the assignment request. In addition, Assignor and Assignee agree, on the basis of good and valuable consideration, to the following terms and conditions governing the assignment:

1. **Payment to District**. Payment by Assignor for the water to be assigned must be delivered to the District along with a fully completed Assignment Form. District is entitled to full payment for all water assigned, whether or not the assigned water is fully used by Assignee. District's regular rate for water will apply to the water assigned. In addition, a one-time District administrative fee of $200 will also be paid to the District. If the District denies the assignment request, the District will refund payments made under this Article 1.
2. **Payments Between Assignor and Assignee**. Payments, if any, between Assignee and Assignor are the exclusive responsibility of those parties and are not addressed by this Assignment Form. The District will not monitor, ensure payment, or otherwise have any responsibility concerning any parties' compliance with the business terms of the assignment.
3. **Amendments**. Upon completion of the Form and approval of the assignment by the District, the assignment is final and may not be withdrawn, amended, or terminated. No assigned water may be reassigned.
4. **Water Shortage Allocation Policy**. Assignor and Assignee have reviewed and agree to abide by the District's Water Shortage Allocation Policy and any potential amendments thereto. Assignor and Assignee understand and acknowledge that the District may increase or decrease final allocations at any time based on new information or changed circumstances.
5. **Other District Rules**. Assignor and Assignee agree to abide by the District's other rules and regulations concerning the use of water within the District and any amendments thereto.

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6. **Hold Harmless, Indemnity, Defense.** Assignor and Assignee, jointly and severally, agree to defend, indemnify, and hold harmless District, its officers, employees, and consultants from and against any and all claims, liabilities, costs, damages (including attorneys' fees and court costs), lawsuits, or other actions or proceedings (collectively "Claims") arising out of or related to this Assignment Form, its implementation, or the assignment of water between Assignor and Assignee. Without limiting the generality of the foregoing, this Article 6 specifically applies to Claims (1) by or between Assignor and Assignee; (2) initiated by a third-party(ies) objecting to or asserting Claims related to the assignment; and (3) against District for declaratory or injunctive relief, including without limitation, Claims lodged against the District under the California Environmental Quality Act.
7. **Signature Authority.** Assignor and Assignee represent and warrant they are authorized to sign this Form and to act on behalf of any applicable corporation, partnership, trust, or other business or legal entity that may own an interest in either Assignor's or Assignee's real property.

"ASSIGNOR"	"ASSIGNEE"
______________________	______________________
Date:__________________	Date:__________________

Western Canal Water District approves this assignment.

____

Date:__________________

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