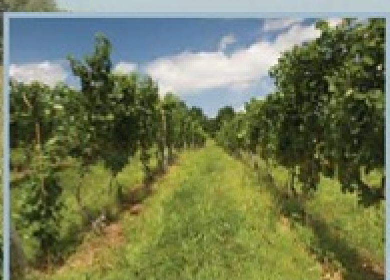
Modesto Irrigation District

Water and Power

Modesto Irrigation District

Agricultural Water Management Plan for 2012

December 2012



AGRICULTURAL WATER MANAGEMENT PLAN for 2012

FOR THE

MODESTO IRRIGATION DISTRICT

December, 2012

Completed In Accordance With the

WATER CONSERVATION BILL OF 2009
(SBx7-7)

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List of Acronyms

AF	acre-feet
AWMC	Agricultural Water Management Council
AWMP	Agricultural Water Management Plan
CCSF	City and County of San Francisco
cfs	cubic feet per second
CIMIS	California Irrigation Management Information System
CVRWQCB	Central Valley Regional Water Quality Control Board
DWR	Department of Water Resources
DSS	Decision Support System
EC	Electrical Conductivity
ET	Evapotranspiration
ET_c	Crop evapotranspiration
ET_o	Reference evapotranspiration
EWMP	Efficient Water Management Practice
FERC	Federal Energy Regulatory Commission
IRGWMP	Integrated Regional Groundwater Management Plan
LGA	Local Groundwater Assistance
M&I	Municipal and Industrial
MID	Modesto Irrigation District
MOU	Memorandum of Understanding
MRWTP	Modesto Regional Water Treatment Plant
OID	Oakdale Irrigation District
ppm	parts per million
UWMP	Urban Water Management Plan
SBx7-7	Water Conservation Act of 2009
SCADA	Supervisory Control and Data Acquisition
SFPUC	San Francisco Public Utility Commission
SSJID	South San Joaquin Irrigation District
STRGBA	Stanislaus and Tuolumne Rivers Groundwater Basin Association
TDS	Total Dissolved Solids
TID	Turlock Irrigation District
USACE	U.S. Army Corps of Engineers
USGS	United States Geological Survey
VAMP	Vernalis Adaptive Management Plan
WSID	West Stanislaus Irrigation District

AGRICULTURAL WATER MANAGEMENT PLAN

Section I. Plan Preparation and Adoption

The Modesto Irrigation District (MID or District) Agricultural Water Management Plan (AWMP) has been prepared in accordance with the requirements of the Water Conservation Bill of 2009 (SBx7-7). Figure 1 is a map showing the location of the District.

This document conforms to the framework presented in *A Guidebook to Assist Agricultural Water Suppliers to Prepare a 2012 Agricultural Water Management Plan* that was issued by the California Department of Water Resources (DWR) on September 10, 2012 to aid water suppliers in preparing Agricultural Water Management Plans in accordance with the requirements of SBx7-7.

The requirements introduced by SBx7-7 are intended to encourage agricultural water suppliers to assess current efficient water management practices, to evaluate additional practices that may conserve water, and to require accurate measurement of water. The AWMP process also presents an opportunity for water suppliers to demonstrate existing accomplishments in water use efficiency.

Included in Section VII of this plan is an analysis of each of the EWMPS presented in *A Guidebook to Assist Agricultural Water Suppliers to Prepare a 2012 Agricultural Water Management Plan.* The EWMPs are grouped into the following categories:

- Critical Efficient Water Management Practices

  1. Measure the volume of water delivered to customers with sufficient accuracy to comply with subdivision (a) of Section 531.10 and to implement paragraph (2) of the legislation.

  2. Adopt a pricing structure for water customers based at least in part on quantity delivered.

- Conditional Efficient Water Management Practices

  1. Facilitation of alternative land use for lands with exceptionally high water duties or whose irrigation contributes to significant problems, including problem drainage.

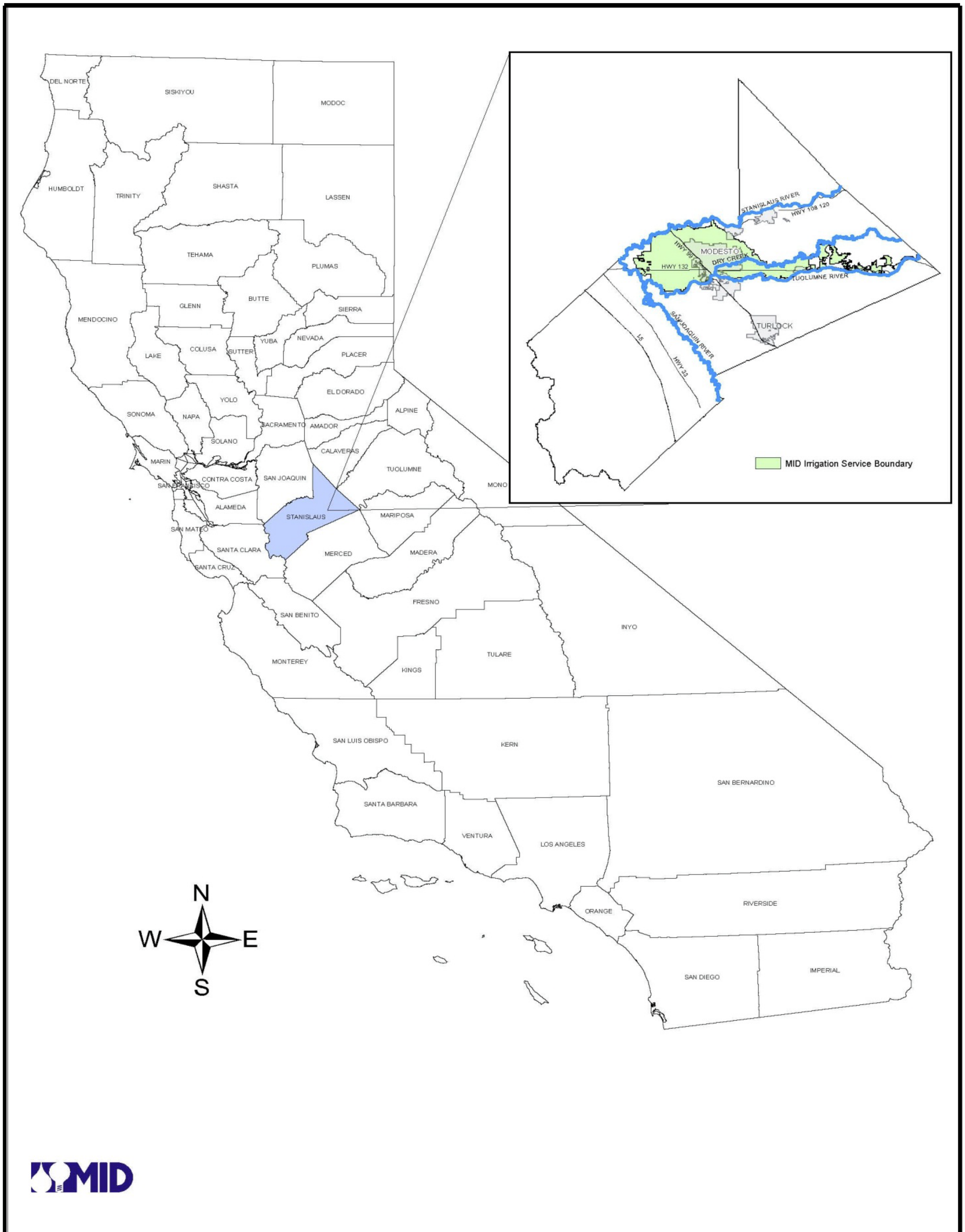

Figure 1. Location Map of MID and Stanislaus County

2. Facilitation of use of available recycled water that otherwise would not be used beneficially, meets health and safety criteria, and does not harm crops or soils. The use of recycled urban wastewater can be an important element in overall water management.

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

4. Implement an incentive pricing structure that promotes one or more of the following goals:

   A. More efficient water use at the farm level such that it reduces waste;
   B. Conjunctive use of groundwater;
   C. Appropriate increase of groundwater recharge;
   D. Reduction in problem drainage;
   E. Improved management of environmental resources, and
   F. Effective management of all water sources throughout the year by adjusting seasonal pricing structures based on current conditions.

5. Expand lined or piped distribution systems, construct regulatory reservoirs to increase distribution system flexibility and capacity, decrease maintenance, and reduce seepage.

6. Increase flexibility in water ordering by, and delivered to, water customers within operational limits.

7. Construct and operate supplier operational outflow and tailwater systems.

8. Increase planned conjunctive use of surface water and groundwater within the supplier service area.

9. Automate canal control devices.

10. Facilitate or promote customer pump testing and evaluation.

11. Designate a water conservation coordinator who will develop and implement the water management plan and prepare progress reports.

12. Provide for the availability of water management services to water users. These services may include, but are not limited to, all of the following:

A. On-farm irrigation and drainage system evaluations;
B. Normal year and real-time irrigation scheduling and crop evapotranspiration information;
C. Surface water, groundwater, and drainage water quantity and quality data, and
D. Agricultural water management educational programs and materials for irrigators.

13. Evaluate the policies of agencies that provide the supplier with water to identify the potential for institutional change to allow more flexible water deliveries and storage.

14. Evaluate and improve the efficiencies of the suppliers' pumps.

A. Description of Previous Water Management Activities

MID and its water users have implemented many of the EWMPs described in the District's original AWMP. In addition, numerous water conservation measures beyond those identified in the original AWMP have been installed.

A central consideration in the District's determination of how best to implement a program of EWMPs is the District's goal of providing flexible, reliable service to its customers. Irrigators in MID are transitioning from producing field crops such as alfalfa and grains to permanent crops such as trees and vines. As irrigators transition from field crops to permanent crops and shift toward low-pressure, low-volume drip and micro-sprinkler systems, the requirements of customer service have changed.

In addition, regardless of crop mix and on-farm irrigation practices, the District remains committed to maintaining a balance between surface water and groundwater as sources of supply and has pursued pricing policies and operational practices that support conjunctive management. The effort required to sustain groundwater levels and retain the ability to tap this resource when needed has served the District well and, as discussed later in this document, may serve as an effective mechanism for responding to the effects of climate change.

For the reasons described above, when evaluating EWMPs, MID assesses the value of EWMPs as part of a package of practices that will help the District provide a high level of customer service and support conjunctive management. As a result, the District may implement individual EWMPs that are not cost-effective in a narrow sense. However, providing reliable, responsive customer service is essential for maintaining a stable customer base which is the foundation of the District's financial health.

The following section describes the practices implemented under the original AWMP and as part of other projects consistent with the principles of the AWMP:

- Financial Grants: MID has provided financial support to water users for the replacement of on-farm water supply ditches and concrete cast-in-place pipelines. With state water conservation and efficiency grants, the MID contribution to the on-farm projects increased from up-to 50 percent to up-to 67 percent of the cost of these projects.

- Low Interest Loans: MID finances the cost of water conservation efforts not covered by grant funds. MID offers loans to water users for the replacement of water supply ditches, pipelines, and other irrigation facilities. Therefore, the water users' capital costs for these projects are completely paid or financed by MID.

- Financial Contributions: MID has made financial contributions to a Mobile Irrigation Lab to evaluate the performance and efficiency of on-farm irrigation systems (MID has paid up to 75 percent of the cost of the irrigation system evaluation).

- In-lieu Groundwater Recharge: Prior to 1995, the City of Modesto relied on groundwater for 100 percent of its municipal and industrial (M&I) needs. MID now delivers up to 33,600 acre-feet of treated Tuolumne River water per year to the City of Modesto.

- Automatic SCADA Controls: Automatic Supervisory Control and Data Acquisition (SCADA) systems have been installed at most of the District's water distribution diversion facilities and operational outflows. The automation of water diversion facilities gives the District greater flexibility to manage the water distribution system and increases the reliability of on-farm water deliveries.

- Crop Water Use Information: MID makes available to water users, data from the California Irrigation Management Information System (CIMIS). CIMIS daily and seasonal crop water use information is available through telephone access or though the MID's website at www.mid.org.

- USGS Groundwater Study: MID contracted with the USGS to conduct a basin groundwater study. The study, entitled "Hydrogeologic Characterization of the Modesto Area, San Joaquin Valley, California", has provided the District and the other basin water users and suppliers with information regarding the hydrologic structure of the basin. The USGS is finalizing the development of a three-dimensional groundwater model for the Modesto Groundwater Subbasin with completion of this effort expected in early 2013.

- A Tuolumne River Watershed Hydrologic Model: MID and Turlock Irrigation District (TID) purchased a hydrologic model for the Tuolumne River for analysis of current and future watershed runoff potential. The model optimizes MID's and TID's management of Tuolumne River watershed runoff and Don Pedro Reservoir water storage.

- Water Quality Monitoring and Sampling: MID has expanded its water quality and monitoring program to comply with the statewide general NPDES permit for discharge of aquatic herbicides. MID also participates in a water monitoring and sampling program in compliance with the Irrigated Lands Regulatory Program (ILRP) as adopted by the Central Valley Regional Water Quality Control Board (CVRWQCB) as a member of the East San

Joaquin Water Quality Coalition. MID annually performs monitoring of District groundwater wells.

- Water Allocation and Pricing: Consistent with MID's goals, the MID Board of Directors has been increasing the cost of the irrigation water service charge by approximately10 percent per year. The District water allocation policy includes a tiered pricing system for water use above the established annual allocation, an allocation based on the water year type index and the carryover supply from the prior year. The water allocation policy includes a volume of water for a base price per acre plus a per acre-foot water charge for usage above the base allocation.

- 2010 Urban Water Management Plan (UWMP): MID and the City of Modesto jointly prepared and adopted the 2010 UWMP in compliance with the Urban Water Management Planning Act.

- Integrated Regional Groundwater Management Plan for the Modesto Groundwater Subbasin (IRGWMP): MID was the lead agency in the development of the IRGWMP by the Stanislaus and Tuolumne Rivers Groundwater Basin Association (STRGBA) in 2005. STRGBA members include MID, the Cities of Modesto, Riverbank, and Oakdale, Stanislaus County, and the Oakdale Irrigation District (OID).

- Recharge Characterization of the Modesto Groundwater Subbasin. This project assessed recharge areas within the District and recharge mechanisms within those areas. The project identified both where recharge is occurring currently and where it has occurred in the past.

- Well Field Optimization Project: This project by MID and OID in cooperation with STRGBA was developed using a DWR-funded grant. The project involved the design and implementation of a computer-aided Decision Support System (DSS) to operate irrigation wells. The DSS was developed as a management tool for implementing the District’s conjunctive use program.

- Comprehensive Water Resources Management Plan: MID, with the assistance of the Irrigation Training and Research Center (ITRC) at California Polytechnic University – San Luis Obispo, is consolidating its various water management plans into a single comprehensive plan. This plan, which is being refined to be used as the basic framework for implementation of water management improvements throughout the District, is described in Section VII of this AWMP.

B. Coordination Activities

1. Notification of AWMP Preparation

SBx7-7 does not specify how much advance time is required for notification of cities and counties of plan preparation, does not require notification to any other agency(s) and does not require that comments from any city, county or other agency must be solicited and considered. In complying with these provisions, MID notified the entities shown in Table 1. **Appendix A** presents the public notice of plan preparation.

2. Public Participation

Public participation activities associated with preparation of the AWMP are presented in Table 1.

C. Plan Adoption and Submittal

The purposes of this AWMP are to assess MID's current water management operations and to respond to the provisions of SBx7-7. The plan describes the District's status in implementation of two new mandatory EWMPs and includes a discussion of issues such as climate change that have not been required in previous plans or plan updates.

With respect to the two new EWMPs, the plan includes a program for bringing the District into compliance with the legislation's requirements regarding 1) delivery measurement, and 2) volumetric pricing. The two new mandatory EWMPs required by SBx7-7 are:

- Measure the volume of water delivered to customers with sufficient accuracy to comply with subdivision (a) of Section 531.10 and to implement paragraph (2) of the legislation.
- Adopt a pricing structure for water customers based at least in part on quantity delivered.

1. Plan Adoption

Appendix B of this document includes a Resolution of Plan Adoption.

2. Plan Submittal

The steps followed in a submittal of the AWMP are described in *A Guidebook to Assist Agricultural Water Suppliers to Prepare a 2012 Agricultural Water Management Plan* and are outlined in Table 1.

3. Plan Availability

The requirements for availability of the District's AWMP are presented in *A Guidebook to Assist Agricultural Water Suppliers to Prepare a 2012 Agricultural Water Management Plan.* The District's compliance with these requirements is shown in Table 1.

In preparing this plan, MID solicited public input by holding a public hearing and inviting oral and written comments prior to adoption of the plan at a Board of Director's meeting on December 18, 2012. Table 1 shows the state and local interested parties who were notified of and/or provided input to this AWMP.

Table 1. Summary of Coordination, Adoption and Submittal Activities

Potential Interested Parties	Notified of Plan Preparation	Assisted in Preparation	Received Draft Plan	Notified of Public Meetings	Notified of Intention to Adopt	Sent Copy of Adopted Plan
Department of Water Resources	X			X	X	Date
City of Riverbank	X			X	X	
Turlock Irrigation District	X		X	X		Date
City of Modesto	X			X		Date
Stanislaus County	X			X		Date
City of Waterford	X			X		
Local Newspaper				Date		
Website						Date posted or sent to DWR for posting

D. Plan Implementation

MID continues to implement EWMPs based upon the implementation plan presented in its original AWMP and refined in later plan updates. In addition to implementing EWMPs described in previous plans, the District will implement the water measurement and volumetric pricing EWMPs mandated by SBx7-7 as described later in this document.

Section II. Description of the Modesto Irrigation District and Service Area

A. Physical Characteristics

The Modesto Irrigation District is a public agency which supplies surface water from the Tuolumne River, groundwater, and electrical service to agricultural, residential, and municipal customers. MID is a 162 square mile (103,733 acre) area in the Tuolumne River watershed. The 1,880 square mile watershed extends to the high Sierra Nevada Mountains and the river flows to its confluence with the San Joaquin River approximately ten miles west of Modesto. Most of the water in the Tuolumne River comes from snowmelt with peak runoff flows occurring from April through July during which time over 60 percent of the annual flow takes place. The river's annual median year runoff is approximately 1,900,000 acre-feet varying between a low of 382,680 acre-feet in 1977 to a high of 4,632,000 acre-feet in 1983. This variability in runoff drives many of MID's policies and practices. Figure 2 shows the footprint of the District and of the City of Modesto.

1. Size of the Service Area

MID was formed on July 9, 1887 as the second irrigation district to be established in California under the California Irrigation Districts Act (Wright Act). During its early years, MID acquired numerous water rights including pre-1914 rights and constructed facilities to deliver water to irrigate farmland and to generate electricity. As shown in Table 2, MID currently delivers water to approximately 57,000 acres of land. In addition, MID can also serve approximately 9,000 acres of additional lands based on customer demand.

Table 2. Water Supplier History and Size

Date of Formation	1887
Source of Water	
Local Surface Water	X
Local Groundwater	X
Gross Acreage - at Time of Formation	108,000
Gross Acreage – Current Service Area (2012)	103,733
Current Irrigated Acreage (2012)	66,517

MID is governed by a five-member Board of Directors. Each board member represents a geographical area within MID known as a division. Board members must live within the division they represent and are elected by the registered voters living within that division.

Land use within the MID is primarily agricultural. Prior to the construction of district irrigation facilities, dry land crops (primarily wheat and pasture) were grown in the service area.

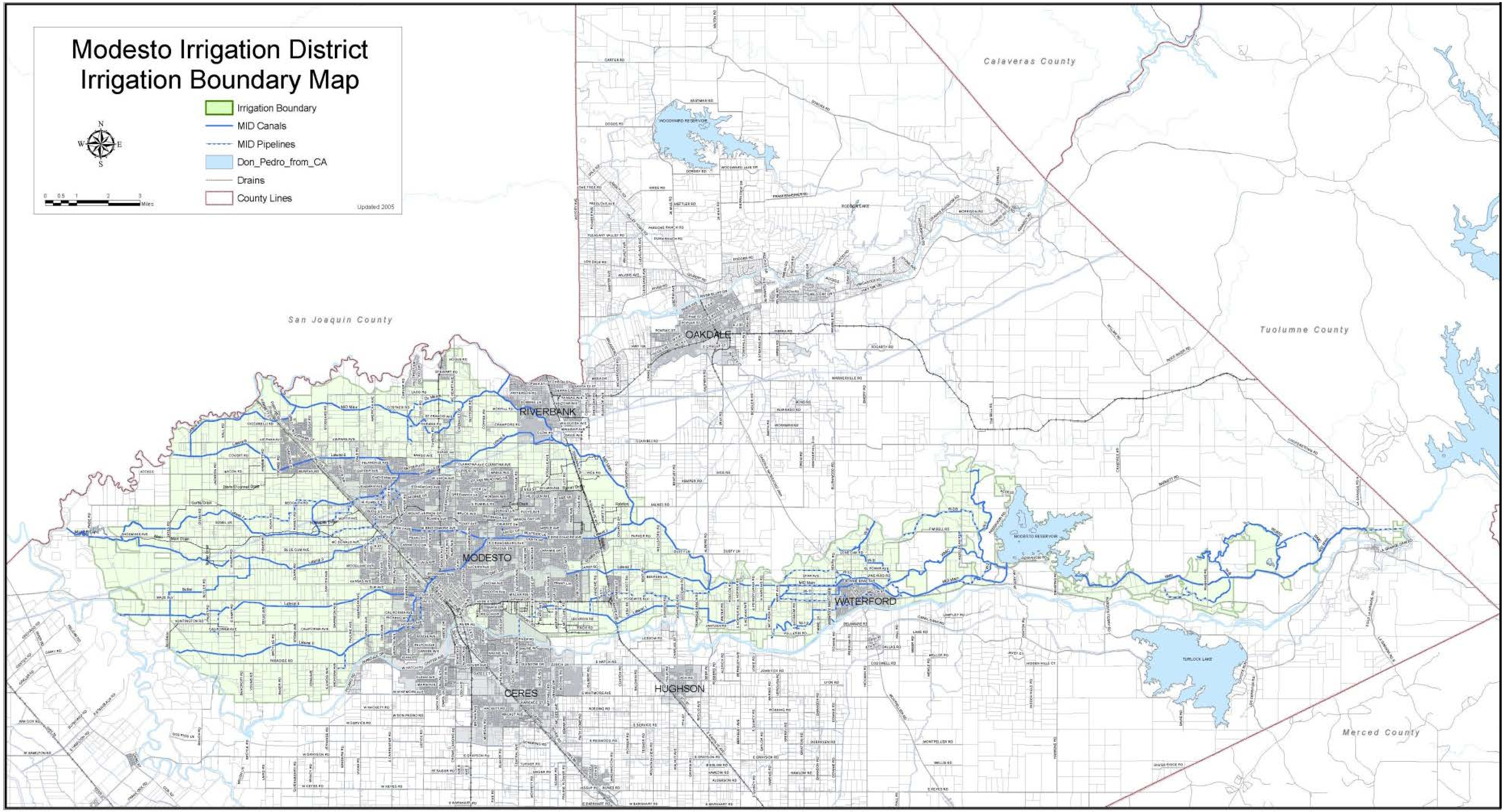

Figure 2. MID Boundary with Footprint of the City of Modesto and Other Small Communities in MID Service Area

The City of Modesto with a population of over 200,000 people divides the District into two parts. In addition, the City of Waterford, with a population of over 10,000, is located on the District's eastern end. Of the 103,733 acres within the district boundary, over 30,000 acres have been developed into residential, commercial and industrial centers.

The irrigated acreage within the District has varied over time principally due to minor annexations and deletions, plus a merger with the Waterford Irrigation District in 1978 and changes in land use driven by urbanization. The trend toward greater urbanization within the District's boundaries is expected to continue at the rate of about 600 acres per year. The anticipated magnitude of this change in land use is shown in Table 3.

Table 3. Expected Changes to Service Area

Change to Service Area	Estimate of Magnitude	Cause of Change	Effect on Water Supplier
Reduced Service Area	None	NA	NA
Increased Service Area	None	NA	NA
Reduction in Irrigated Area	600 acres per year	Urbanization	Change from ag to M&I supply

2. Location of the Service Area and Water Management Facilities

As shown on Figure 2, the MID is located in eastern Stanislaus County which lies in the northeastern part of the San Joaquin Valley. The MID is bounded on the north by the Stanislaus River, on the south by the Tuolumne River, on the west by the San Joaquin River, and on the east by the Sierra Nevada foothills. Neighboring irrigation districts are TID to the south, OID and South San Joaquin Irrigation District (SSJID) to the north, and West Stanislaus Irrigation District (WSID) and a few smaller water districts to the west. With the exception of the WSID and the other smaller water districts which rely on groundwater, these districts divert irrigation water from the Tuolumne and Stanislaus Rivers which provide high quality runoff from the Sierra Nevada Mountains.

Within the upper Tuolumne River watershed, the City and County of San Francisco (CCSF) operates three reservoirs with a total storage capacity of 656,000 acre-feet; in the lower part of the watershed, MID and TID operate the New Don Pedro Reservoir with a maximum storage capacity of 2,030,000 acre-feet. The Districts are also responsible to maintain regulated fish flows in the Tuolumne River to comply with FERC licensing requirements. MID's median annual diversion is 315,756 acre-ft of water. Of that amount, approximately 35,000 acre-feet is diverted to the MRWTP for treatment and delivery to the City of Modesto.

MID distributes a combination of Tuolumne River water and groundwater via a network of storage facilities, canals, pipelines, pumps, drainage facilities and control structures. MID's first major project was the construction of La Grange Dam completed on December 13, 1893 in conjunction with the TID. This masonry dam is still used to divert water from the Tuolumne River into MID's main irrigation canal. When La Grange Dam was built it was the highest overflow dam in the world. On June 27, 1903 irrigators along the newly completed main canal began receiving water, and by September of that year, water was moving through district laterals. Table 4 provides a summary of existing irrigation facilities in MID.

Table 4. Water Conveyance and Delivery System

System Used	Number of Miles
Unlined Canals	20
Lined Canals	142
Pipelines	42
Drains	39

Storage and regulation of main canal deliveries began in 1911 with the completion of the 28,000 acre-foot Dallas-Warner Reservoir, now known as Modesto Reservoir. This reservoir capacity was too small to allow carryover water from year to year to protect permanent crops from extended droughts. Such storage was not available until the completion of the Old Don Pedro Dam and Reservoir. When completed, in 1923, at a height of 284 feet, Old Don Pedro Dam was the highest gravity dam in the world. Old Don Pedro Reservoir allowed MID and TID to store a maximum of 290,400 acre-feet of water for irrigation and recreation and to generate electrical power.

In 1970, MID again, added to its water storage and power generation facilities, the completion of the 2,030,000 acre-foot New Don Pedro Dam and Reservoir. The New Don Pedro facilities are owned by MID and TID and operated by TID. The Districts also share pre-1914 water rights, water diversion facilities, and water right licenses.

Don Pedro Reservoir is a multiple purpose water storage facility. In addition to storing water for irrigated agriculture and M&I use, water releases generate electricity, and the reservoir is used as a recreation and water sports facility. MID and TID also release water to increase instream flows which enhance the environment downstream of the reservoir.

The CCSF has an obligation to release specific flows from the Hetch Hetchy project into the Don Pedro Reservoir depending on the time of year. In order to assist the CCSF in managing available water while meeting the Districts' prior water rights, the Districts have agreed to allow CCSF to have a water bank of 570,000 acre-feet in Don Pedro Reservoir. This water bank allows the CCSF to prerelease water to the water bank. Whenever there is water in the water bank, the CCSF is relieved of its obligation to meet its flow requirements.

There is also a U.S. Army Corps of Engineers (USACE) flood control storage requirement of 340,000 acre-feet of reservoir space that is maintained from October 7 to April 27 of each year. The minimum dead pool storage is 309,000 acre-feet leaving MID and TID with an average working capacity of 1,721,000 acre-feet of which MID's annual share is 31.54 percent or 542,803 acre-feet.

As Table 5 presents, MID has a maximum annual carryover storage capacity of 570,803 acre-feet when storage in the 28,000 acre-foot Modesto Reservoir is included.

Table 5. Water Supplier Reservoirs

Reservoir	Capacity (AF)	MID's Storage Rights (AF)
Modesto Reservoir	28,000	28,000
Don Pedro Reservoir	2,030,000	542,803
Total Storage	2,058,000	570,803

The MID water conveyance and distribution system was designed to deliver water by gravity flow from La Grange Dam on the east to the San Joaquin River on the west. This gravity conveyance system is energy efficient but occasionally creates operational outflows to downstream rivers and creeks. While these outflows are of relatively high quality and generate no environmental impacts, they are a lost resource to MID. MID is in the process of evaluating facilities to capture and return operational outflows for reuse. The District anticipates that it will be able to conserve thousands of acre-feet per year once middle and end of system reservoirs are constructed to capture and re-circulate operational outflows.

The need for on-farm surface drainage is minimal. The majority of the land within the District's service area is well drained. Much of the land is irrigated with the use of level basins allowing water users to retain all irrigation water applied on-farm within the parcels' boundaries. Table 6 summarizes the existence of tailwater/operational outflow recovery systems. Currently MID has no District-operated recovery system while the number of on-farm operated tailwater/operational outflow recovery systems is minimal.

Table 6. Tailwater/Operational Outflow Recovery System

System	Yes/No
District Operated Operational Outflow Recovery	No
On-Farm Operated Tailwater/Operational Outflow Recovery	Yes

There have been substantial improvements to MID's main and secondary canals since they were built in the early part of the 20th century. These improvements have increased the effectiveness of water deliveries. In addition to the District facilities, irrigators constructed ditches and pipelines necessary to convey water from the District's canals to the irrigated fields. By the early 1920s, despite improvements to canals and other water service facilities, many private community ditches were not being maintained. The lack of maintenance to these private ditches and lack of cooperation among the water users resulted in frequent water shortages and inadequate or inefficient water deliveries.

MID could not take on the financial burden of improving the private community ditches without raising taxes to all landowners within the District. As an alternative, the District initiated state legislation allowing for the establishment of local ditch and pipeline "Improvement Districts" within irrigation districts. The legislation to form "Improvement Districts" was sponsored by a local state senator and became state law in 1927.

Improvement districts are small locally controlled districts within a larger irrigation district organized for the purpose of more equitably providing improvements to the land and water conveyance facilities serving that specific area's needs and are, in effect, legal subdivisions of the irrigation district. These improvement districts use the technical and financial expertise of the irrigation district, while leaving the basic decision of whether or not to make the improvements in the hands of those using the community facility. In general, the improvement district landowners make facility improvement decisions that enhance the water delivery efficiency of the local system. Since the Water Code requires that two-thirds of the landowners within an improvement district agree on the expenditures made to improvement district facilities, conflicting interests can be a problem. However, improvement districts are valuable mechanisms for making improvements where most of the landowners have similar interests. Today, MID has approximately 232 active improvement districts.

3. Terrain and Soils

The terrain of the District is relatively flat and is composed primarily of alluvial fans sloping from east to west from the foothills to the San Joaquin River. Elevations range from over 200 feet above sea level on the east to less than 40 feet above sea level on the west. On the east, MID is intersected by Dry Creek which drains over 100 square miles of land from the foothills east of Modesto and runs in a westerly direction before merging with the Tuolumne River near Modesto.

Land within MID consists mainly of sediments that have formed the broad alluvial plains of the Stanislaus and Tuolumne Rivers, two perennial streams which flow in a southwesterly direction and discharge into the San Joaquin River. The topography on the eastern one-third of the District's service area consists mostly of hilly to rolling land sloping in a westerly direction. The western two-thirds of the service area are relatively flat with a mild westerly slope.

The predominant irrigation system in MID continues to be gravity-fed level basins. However, low-pressure sprinkler or drip irrigation systems are now the system of choice for permanent orchard and vineyard crops. For this reason, some land planted to permanent crops irrigated using level basins or impact sprinklers is being converted to low-pressure irrigation systems. The current rate of conversion to low-pressure systems is estimated to be about 400 acres per year.

The soils of the District consist of a broad range of textures from sand to heavy adobe. The soils are distributed according to their position in six distinct physiographic areas: (1) alluvial flood plains; (2) basin lands; (3) young alluvial fans; (4) low alluvial terraces; (5) high alluvial terraces, partially eroded into rolling hills; and (6) uplands of the Sierra Nevada.

The eastern fringe of arable land occurs in the rolling hills of the upland range where the older granitic alluvium supports irrigated trees, mainly almonds. The western fringe consists of mixed alluvium of low relief with some occurrence of heavy adobe and clay containing alkali. Much of the alkali area has been reclaimed, and the soil supports pasture, row and other field crops and some permanent crops. The largest area of land within the basin rim consists of sand to sandy loam, which also supports a wide range of crops and growing conditions. Hardpan occurs mostly in the eastern and western edges of the District.

A portion of the MID service area is underlain by the Corcoran Clay, a formation originating from ancient lake deposits of clayey silt. This formation creates a low permeability boundary of 20 to 120 feet in thickness. Irrigation wells drilled in the areas where the Corcoran Clay is present penetrate aquifers both above and below the clay. However, some deeper wells are perforated exclusively below the Corcoran Clay as that is where the best quality water is found. Generally, wells screened mostly above the clay exhibit better production characteristics than those screened in zones below the clay. Although numerous silt and clay beds occur above and below the Corcoran Clay, they are not correlated over large areas. Therefore, those beds are only of local importance to the confinement of groundwater.

Table 7 summarizes the topographic characteristics of the irrigated lands.

Table 7. Landscape Characteristics

Topography Characteristic	% of the District	Effect on Water Operations and Drainage
Rolling Land	20% of irrigated land	Land is adaptable to sprinkler and micro-irrigation systems.
Flat Land	80% of irrigated land	Land is adaptable to flood and other types of irrigation systems.

4. Climate

The major features of the climate are hot, dry summers and cool, wet winters. Temperature distribution is uniform throughout the area. Average annual rainfall increases from about 10 inches at the San Joaquin River to about 14 inches at the edge of the foothills with 12 inches in the Modesto area. Most of the precipitation occurs from December to March with little to none occurring during the summer months of June through August; the pattern for potential evapotranspiration and evaporation are just the reverse. Summer temperatures commonly are above 85°F and may exceed 100° F, but rarely exceed 105°F. Winter temperatures commonly fall below 32°F, but are rarely lower than 25°F. Table 8 summarizes climatic conditions for Modesto; Table 9 presents more detailed information.

Table 8. Summary Climate Characteristics

Climate Characteristic	Annual Value
Average Precipitation	12.21 inches
Minimum Precipitation	5.70 inches
Maximum Precipitation	27.39 inches
Minimum Temperature (Avg. Winter)	37.6°F
Maximum Temperature (Avg. Summer)	94.3°F

Table 9. Detailed Climate Characteristics

Month/Time	Average Precipitation (inches)	Average Reference ET_o (inches)	Average Minimum Temperature, °F	Average Maximum Temperature, °F
January	2.44	0.87	37.6	53.8
February	2.07	1.71	40.8	60.9
March	1.93	3.43	43.5	66.9
April	1.03	5.24	46.8	73.3
May	0.46	6.70	51.8	81.2
June	0.13	7.40	56.6	88.3
July	0.02	7.85	60.0	94.3
August	0.04	6.75	58.8	92.3
September	0.17	4.93	55.9	87.7
October	0.63	3.37	49.6	77.9
November	1.24	1.66	41.7	64.6
December	2.05	0.87	37.7	54.4
Wet Season*	11.39	13.78		
Dry Season	0.82	37.00		

* Wet season is typically October through April

B. Operational Characteristics

1. Operating rules and regulations

The Rules and Regulations Governing the Distribution of Water within the Modesto Irrigation District (2000 revision) is the guideline for the operation and delivery of water and is presented in **Appendix C**. The rules cover the procedures followed to distribute irrigation water in an orderly, efficient, and equitable manner.

The MID on-farm water delivery system was originally designed to deliver irrigation water by gravity with very large flows (10-20 cfs) on a predetermined rotation (typically every 10-20 days). Water delivery on rotation can be an effective method to deliver water to flood irrigated level basins because the entire crop root zone is saturated with water. The time between irrigations is dependent on the water holding capacity of the soil and climatic conditions which drive the rate of evapotranspiration. However, as irrigators convert their on-farm application practices from flood to pressurized systems, the requests for irrigation water have shifted from rotation to arranged-demand.

Most of the on-farm gravity water delivery systems were designed and built with cast-in-place pipelines and ditches capable of delivering large flows for flood irrigation on a rotation schedule. These pipelines and ditches typically hold water for only a few days as the rotation moves to other facilities downstream. On-farm arranged-demand delivery requires that water be available most of the time and be delivered at a constant low flow rate, a practice which creates an incompatibility between the delivery requirements of flood and low-volume on-farm systems.

Facing a deteriorating system of ditches and pipelines that was not capable of delivering water to the range of on-farm irrigation systems present within the District, the MID Board of Directors approved funding to upgrade the District's water delivery system and to help landowners modernize their on-farm application systems. These upgrades and replacements enhanced water delivery flexibility and increased reliability. With District, improvement district and private upgrades, MID is now capable of delivering irrigation water to most of its customers on an arranged demand schedule as summarized in Table 10.

Table 10. Supplier Delivery System

Type	Check if Used	Percentage of System Supplied
On Demand	X	25
Arranged Demand	X	50
Rotation	X	25

MID has an irrigation water allocation policy, which establishes the allocation and cost of water to landowners. It is adopted by the Board of Directors annually. The allocation is based on factors including the volume of water carried over in storage in Don Pedro Reservoir and the projected runoff from the watershed. The allocation is not finalized and adopted until after the rainy season when runoff information has been made available by the California Department of Water Resources.

Table 11 illustrates factors used to allocate water at MID. These factors are considered in setting the annual water allocation that is applied uniformly across the District and which, in a normal year, is approximately 42 inches/year.

Table 11. Water Allocation Policy

	(Check if applicable)			Allocation	
Basis of Water Allocation	Flow	Volume	Seasonal Allocations	Normal Year	Percent of Water Deliveries (%)
Land within the service area		X		42 in/year	100 %
Reservoir storage		X		42 in/year	100 %
Riparian rights					
Water Year Type		X		42 in/year	100 %
Amount of land owned					
Predicted runoff		X		42 in/year	100 %

MID operates a decentralized water ordering and delivery system. The ditchtenders take water orders from irrigators and coordinate deliveries based on demand and the flow capacity of the distribution system. As MID moves away from rotation to the more flexible arranged demand water delivery system, the ditchtenders' functions have become less routine and more customer-oriented.

Water users with flood irrigated lands may continue to irrigate on a fairly constant rotation while the water users with pressurized irrigation systems may request irrigation water on an arranged demand basis. Therefore, water order lead times vary depending on the time of year, system capacity, and where water is being routed. For example, a water user close to Modesto Reservoir with land near a large canal may have a greater probability of receiving water on short notice than a user who is more distant from the reservoir and from delivery facilities. The District's goal is to supply water to the irrigator when the water is needed and to maintain that delivery for the duration necessary to refill the soil profile or to satisfy the crop water requirement. Table 12 describes lead times for water orders and shut-offs now typical of MID operations.

Table 12. Actual Lead Times

Operations	Hours/Days
Water orders	0-72 hours
Water shut-off	0 hours

Water Delivery Measurements or Calculations

MID uses a variety of devices and methods to measure water within its delivery system. Diversions from the river into the Main Canal are measured continuously by the USGS gage number 11289000 (Modesto Canal near LaGrange). MID uses a Supervisory Control and Data Acquisition (SCADA) system to monitor and control diversions from the Modesto Reservoir and the various canal branches. Most deliveries to irrigators are measured using submerged sidegate orifices that use the pressure differential between the canal and the downstream channel to measure water flow. When properly calibrated, the submerged orifice can be a reasonably accurate method of water measurement. Table 13 shows typical levels of accuracy for various types of measurement devices.

The main disadvantage of calculating delivered water volumes based on an instantaneous measurement is that the measurement does not directly record the volume of delivered water. This can be problematic for two reasons. First, an accurate record of the duration of the delivery must be maintained to convert the instantaneous measurement of flow rate into a volume. Secondly, if there are fluctuations in canal water surface elevation during the course of a delivery, these fluctuations will affect the rate of discharge, and hence, the volume of water delivered. In the case of MID, because the water level at nearly every check structure is controlled by a long-crested weir, there is little variation in canal water levels regardless of the flow in the canals. Therefore, fluctuating water levels have minimal impact on computation of volumes of water delivered from MID canals.

Ditchtenders calculate the volume of a delivery by measuring the differences in water elevations and the sidegate opening, using calibrated tables to compute the flow rate which corresponds to these parameters, and multiplying that flow rate by the recorded duration of delivery. The calculated water delivery is immediately input into the District’s TruePoint water management system which tracks cumulative water delivered to each water user during the irrigation season. These data are used to bill the water user. If there is any use in excess of the allocated amount, the water user will be billed for the additional water in accordance with the District’s tiered pricing structure.

Section VIII of this report discusses steps the District is taking to comply with the water measurement requirements of SBx7-7 by verifying the accuracies of metering devices and of computed seasonal water deliveries.

Table 13. Water Delivery Measurements

Type of Measurement	Frequency of Measure (Days)	Frequency of Calibration (Months)	Frequency of Maintenance (Months)	Est. Level of Accuracy (%)
Orifices	As required	Infrequently	As needed	10
Propeller meters	"	"	"	5
Weirs	Continuous (hourly)	Occasionally	"	10
Flumes	As required	Infrequently	"	7
Venturi meters	"	"	"	5
Pump, runtime	"	"	"	10
Pump, kwh	"	"	"	10

2. Water Rate Schedules and Billing

The MID Board of Directors annually establishes a water rate based on budget requirements and board policy. Factors such as land assessments and cropping do not play a role in the board's determination of water rates.

Table 14. Water Rate Basis

Type of Billing	Check if Used	Percent of Water Deliveries (%)	Description
Volume of Water Delivered	X	100%	Block rate applied to all lands receiving water above the basic allocation
Area (acres)	X	100%	Allocation applied to all lands receiving water
Crop			NA
Land Assessment			NA

As noted earlier, within the allocation policy is an increasing block rate (tiered) pricing structure for water users who exceed the base amount of allocated water. The block rate structure is established annually but typically contains two to three blocks of water with increasing price rates. As a result, MID has a pricing structure that combines a uniform water allocation to all lands with a tiered block rate structure applied to lands whose water use exceeds the annual allocation. Table 15 provides this information in tabular form; **Appendix D** provides detailed information on water allocations and rates.

Table 15. Rate Structure

Type of Billing	Check if Used	Description
Declining Block Rate		
Uniform	X	Based on annual allocation and rate
Increasing Block Rate	X	Based on annually defined block structure and associated rates

Currently MID bills its irrigation water users annually at the end of the irrigation season, as shown on Table 16. This bill is payable in two equal installments due on December 20 of the same year and June 20 of the following year. If the water user exceeds the base water allocation, another bill for the increasing block rate charges will also be mailed to the water user.

Table 16. Frequency of Billing

Frequency	Check if Used
Annually	X

3. Water Shortage Allocation Policies

Water supplies on the Tuolumne River vary depending on watershed precipitation, snow melt runoff, and the prior year's carryover storage in Don Pedro Reservoir. As such, water supply planning must take into consideration the amount of water that will be available when the irrigation season starts, the current year water requirements, and the expected carryover for the following season.

During dry years, the MID Board of Directors decreases the water allocation and may shorten the irrigation season. MID will also conjunctively use ground water pumps to supplement surface water diversions during years of short supply, and water users may turn on their private irrigation wells to supplement District-supplied water. Table 17 lists the measures that the MID Board may exercise to respond to water shortages.

Table 17. Decreased Water Supplies Allocation

Allocation Method	Check if used
Decrease Allocated Water	X
Shorten Irrigation Season	X
Restrict Water to Certain Crops	NA

Section 4.2 of the *MID Rules and Regulations Governing the Distribution of Water within the Modesto Irrigation District* specifically addresses consequences to water users who waste water. Section 4.2.3 states the following:

> *The District may refuse to deliver water to irrigators who waste water on roads or vacant land, or land previously irrigated, either willfully, carelessly, or on account of defective ditches or pipelines. The District may also refuse to deliver water to inadequately prepared land or to users who flood certain portions of the land to an unreasonable depth or amount in order to properly irrigate other portions. Water service may be resumed when these conditions have been remedied.*

Table 18 summarizes enforcement methods available to curtail wasteful water uses.

Table 18. Enforcement Methods of Allocation Policies

Enforcement Method	Check if used
Shut-off of Water	X
Refuse service	X
Fines/Penalties	X

Basis for Reporting Water Quantities

Given water year types which have ranged from critical to wet in the recent past, MID chose 2009, a below normal type year which was preceded by two critical years and followed by an above normal year and a wet year, as the representative year to serve as the basis for reporting water use and water supply data listed in subsequent tables.

Figure 3 displays a time series of key hydrologic parameters extending from 1972 (the year New Don Pedro Dam was commissioned) through 2011. This figure illustrates the great range of computed natural flow (CNF), Tuolumne River flows below LaGrange Dam, and Don Pedro maximum storage which characterize the system. Figure 3 also illustrates that in spite of great fluctuations in CNF, MID diversions have remained relatively stable.

The selection of calendar year 2009 as the representative year is presented in Table 19.

Table 19. Representative Year

	Description
Representative Year based upon	2009
First month of representative year	January
Last month of representative year	December

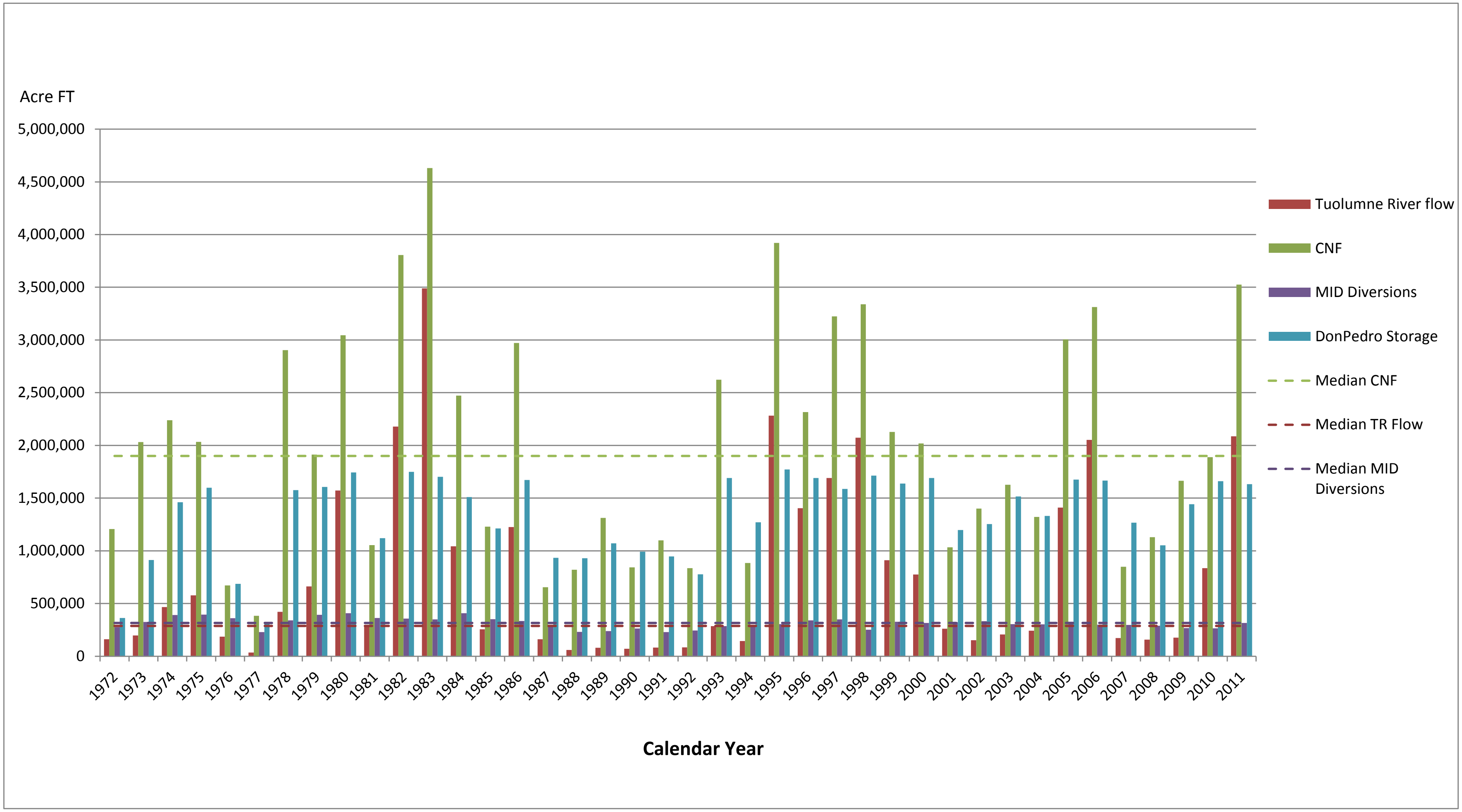

Figure 3. Annual Tuolumne River Computed Natural Flow, River Releases, MID Diversions and Don Pedro Storage

Section III. Description of Quantity of the Water Uses of the Agricultural Water Supplier

Tuolumne River water is diverted to storage in the Don Pedro Reservoir and re-diverted downstream at La Grange Dam into the District's canal system under water right licenses issued by the State Water Resources Control Board. The District also diverts water according to a series of pre-1914 appropriative and storage rights recognized by the State of California. In addition, MID also maintains approximately 90 water wells that are used to supplement the surface water supply particularly during dry years.

A. Agricultural Water Use

The primary crops grown within the MID service area are deciduous trees (mostly almonds), grape vines, grains, row crops, and pasture for livestock. The District serves approximately 3,000 irrigation accounts with an average of 20 acres per account. Improvements in irrigation water delivery systems and changing economic conditions have brought many changes to the crop mix within the District. Nut trees including almonds and walnuts have been the crops with the most rapidly expanding acreages. During the last several years, thousands of acres of pasture and annual crop land have been converted to high value permanent crops.

As the cropping pattern changes, low-volume irrigation systems such as drip and micro-sprinkler are replacing flood irrigation resulting in improvements in on-farm irrigation water use efficiency. Despite these changes the total water requirement for the MID service area has remained about the same over the years. Table 20 summarizes the agricultural water use within the District. Table 21 describes water needs for specific crops grown within MID.

Table 20. Agricultural Water Use for 2009 (AF)

Source	2009
Agricultural Water Supplier Delivered	
Surface and groundwater	152,980
Other (City of Modesto M&I use)	30,034
Other Water Supplies	
Surface Water	NA
Groundwater (Private Pumping)	NA
Other	NA

Table 21.Agricultural Crop Data for 2009

Crop	Total Acres	Estimated ETc (ft)	Crop Water Requirement (AF)	Estimated* Leaching Requirement (AF)	Total Crop Water Requirement (AF)
Alfalfa Hay	3,417	3.67	12,540	1,254	13,794
Almonds	20,006	2.91	58,217	5,822	64,039
Apples	53	2.91	154	55	169
Apricots	34	3.08	105	11	116
Berries – Bush	44	3.26	143	14	157
Cherries	407	3.42	1,392	139	1,531
Garden – Other	38	2.28	87	9	96
Grain – Barley	58	1.59	92	9	101
Grain – Corn	431	2.20	948	95	1,043
Grain – Hay	4,675	1.45	6,779	678	7,457
Grain – Oats	866	1.59	1,377	138	1,515
Grain – Other	12	1.59	19	20	21
Grain – Wheat	119	1.59	189	19	208
Grapes – Table	34	2.50	85	9	94
Grapes – Wine	1,306	2.50	3,265	327	3,592
Lawn – Garden	369	3.42	1,262	126	1,388
Melons	3	1.69	5	1	6
Miscellaneous	31	2.40	74	7	81
Nursery Stock	87	1.94	169	17	186
Open Land	542	0	0	0	0
Other Fruit & Nut Crops	204	2.97	606	61	667
Pasture – Irrigated	8,970	4.07	36,508	3,651	40,159
Peaches	3,013	2.84	8,557	856	9,413
Rice	366	3.30	1,208	121	1,329
Silage – Corn	4,622	2.04	9,429	943	10,372
Strawberries	22	1.70	37	4	41
Sudan	293	1.86	545	55	600
Trees – Christmas	47	4.36	205	21	226
Vegetables – Misc	967	1.89	1,828	183	2,011
Walnuts	8,117	3.37	27,354	2,735	30,089
TOTAL	59,153		173,179	17,380	190,501

* Leaching requirements vary by crop type, soil type and other factors. For the purposes of this table, a leaching requirement of 10 percent of the crop water requirement was assumed district-wide.

The District's gross service area now encompasses approximately 103,733 acres. As shown on Table 22, in 2009 approximately 59,153 acres were irrigated with surface water and MID groundwater. Crop water demand is estimated to be 173,179 acre-feet.

The majority of the non-irrigated land in the service area is within the City of Modesto's sphere of influence.

Table 22. Irrigated Acres for 2009 (acres)

Service Area	103,733
Surface and Ground Water Irrigated Area	59,153

For the purposes of this report, cropped acres are the same as irrigated acres. The amount of irrigated land that is not cropped at any time during the year is shown on Table 21 as Open Land. Over 50 percent of the cropped acres are planted with permanent crops with almonds being the predominant permanent crop with 20,006 acres. All but about 1,500 acres of the land not planted to permanent crops is devoted to pasture and grain crops used primarily for dairy cattle feed. Land planted to grain crops is typically double cropped during the winter and spring months with winter forage also used primarily for dairy cattle. As shown in Table 23, inter-cropping is not a common practice within the MID service area.

Table 23. Multiple Crop Information for 2009 (acres)

Cropped	59,153*
Inter-cropping	Negligible
Double Cropping	8,855

* Includes crops irrigated with surface water and with MID ground water

B. Environmental Water Use

MID and TID own Don Pedro Dam and Reservoir and operate these facilities under a license from the Federal Energy Regulatory Commission (FERC). The FERC license requires minimum releases of between 94,000 and 301,000 acre-feet per year downstream of the dam to protect fisheries, specifically salmon. As a result of an agreement signed in 1995, the minimum flows below La Grange Dam are based on a 10-step water year classification as used by the California Department of Water Resources. During wet years the mandated minimum flows are as high as 300 cfs and in dry years as low as 50 cfs. In addition to the minimum flows, MID and TID release pulse flows in the spring and fall to encourage juvenile salmon to migrate downstream through the Delta and into the open ocean. The actual pre-release flood flows can be several thousand cfs during wet winters.

Required minimum flows have an impact on the amount of water available for beneficial uses. Storage limitations imposed by the State Water Resources Control Board, the minimum in-stream flow requirements imposed by the FERC and flood control rules issued by the USACE all are factors that govern storage and releases from Don Pedro Reservoir. The value of in-stream flow releases shown in Table 24 is based on the 2009 FERC minimum flow requirement of 252,328 of which MID's share was 79,584.

Table 24. Environmental Water Uses for 2009

Environmental Resources	Volume (AF)
In-stream flow releases	79,584*
Streams	0
Lakes or reservoirs	0
Riparian vegetation	0
Total	79,584

* The boundary for the MID water balance presented in the AWMP begins at LaGrange Dam, the point where MID diverts water from the Tuolumne River. Since, instream flow releases from Don Pedro Reservoir are not diverted at LaGrange Dam, these releases are an element of MID operations, but are not included in the accounting of water diverted into the irrigation system that is presented in the AWMP water budget.

C. Recreational Water Use

Don Pedro Reservoir, also known as Don Pedro Lake, has a capacity of 2,030,000 acre-feet. Recreational activities at Don Pedro Lake include swimming, camping, fishing, and boating. MID, TID, and the CCSF are partners in the operation of the Don Pedro Recreation Agency (DPRA) which administers the recreational activities at the lake.

Modesto Reservoir is also a popular recreational facility offering activities similar to those available at Don Pedro Lake. MID is the sole owner of Modesto Reservoir. Through an agreement, MID leases the recreational facilities at the reservoir to the County of Stanislaus.

Table 25 summarizes the facilities' non-consumptive recreational water uses. As seepage and evaporation from Don Pedro Reservoir occur outside of the boundary of the AWMP water balance and as seepage and evaporation from Modesto Reservoir are accounted for as losses which would occur with or without recreational activity, there are no consumptive uses attributable to recreation that apply to the AWMP water balance.

Table 25. Recreational Water Uses for 2009

Recreational Facility	Volume (AF)***
Don Pedro Reservoir*	1,773,000
Modesto Reservoir**	20,400
Total	1,793,400

* USGS Water Data Report for 2009
** MID water data
*** There is no water consumption assigned to recreational water uses

D. Municipal and Industrial Water Use

Prior to 1995 all M&I water use in the MID service area was from groundwater pumping. The City of Modesto, other local communities, rural residences and businesses have all pumped groundwater from the Modesto Groundwater Subbasin for domestic and commercial uses. Beginning in the 1940's, drought conditions and the communities' growth demands contributed to a reduction in groundwater levels and created a cone of depression under the City. This cone of depression, combined with increasingly stringent federal and state water quality requirements, prompted a 1983 study of the groundwater supply that recommended a conjunctive water use program that would supplement the M&I groundwater supply with water from the Tuolumne River.

Following the recommendations of the 1983 study, in 1986 MID and the City of Modesto signed an agreement to allow MID to pursue the construction of a plant to supply treated water from the Tuolumne River to the City of Modesto. In 1994, MID completed Phase One of the Modesto Regional Water Treatment Plant (MRWTP), a 30-million gallon per day (33,000 acre-foot/year) domestic water project. Since its completion, the plant has been operated by MID to treat Tuolumne River water which is then wholesaled to the City. As intended, the delivery of Tuolumne River water to supply the area's urban needs has contributed to stabilization of groundwater levels.

Table 26. Municipal/Industrial Water Uses for 2009 (AF)

Municipal/Industrial Entity	2009
Municipal Entity	
City of Modesto	30,034
Industrial Entity	
NA	
Total	30,034

E. Groundwater Recharge Use

Most of the groundwater recharge in the Modesto Groundwater Subbasin is the result of deep percolation of applied surface water to agricultural lands, seepage from canals and natural streams, and precipitation and urban storm runoff. Seepage from Modesto Reservoir is estimated to be approximately 24,000 acre-feet per year. Approximately 86 percent of MID canals are concrete lined; thus, the amount of canal seepage is relatively small.

It is estimated that the City of Modesto recharges an estimated additional 20,000 acre-feet annually through its approximately 11,000 dry wells. This poor quality runoff water becomes part of the groundwater supply. The 30,034 acre-feet of treated water delivered to the City of Modesto in 2009 for M&I use constitute a major contributor to in-lieu water recharge. Table 27 lists the acres of land where groundwater recharge occurs and the method of recharge.

The overall efficiency of on-farm irrigation application in MID is assumed to be approximately 62 percent when the efficiencies of both level-basin and low volume application systems are combined. Because on-farm runoff from MID fields is negligible, the remaining 32 percent of the applied water is assumed to be destined to groundwater recharge with a portion of this recharge satisfying leaching requirements. Total groundwater recharge contributed by application of MID irrigation water (152,980 acre-feet of surface water and groundwater as shown in Table 20) is estimated to be approximately 58,132 acre-feet in 2009. This value for groundwater recharge exceeds the requirement for crop leaching shown in Table 21 and, therefore, satisfies that requirement.

Table 27. Groundwater Recharge Water Uses for 2009 (AF)

Location/Groundwater Basin	Method of Recharge	2009
MID Service Area	On-farm Irrigation	58,132*
MID Service Area	Canal Seepage	8,000**
Modesto Reservoir	Reservoir Seepage	24,000***
Total		80,954

* shown as groundwater recharge in Table 44 – Quantify Water Uses for 2009
** shown as canal seepage in Table 44 – Quantify Water Uses for 2009
*** shown as reservoir seepage in Table 44 – Quantify Water Uses for 2009

F. Transfer and Exchange Use

During the 1987 through 1992 drought, MID transferred several thousand acre-feet of water to the CCSF. The water was released into the San Joaquin River and was pumped to the CCSF service area through a cooperative agreement between the CCSF and the Santa Clara Valley Water District. MID has also participated in the transfer of water through a U. S. Bureau of Reclamation program for river and fishery enhancement known as the Vernalis Adaptive Management Program (VAMP). Under VAMP, between 1999 and 2010 pulse water flows required during critical stages of salmon growth were released from various San Joaquin River tributary reservoirs in the spring to entice young salmon to leave the spawning areas and swim to the Delta. Table 28 summarizes MID activity in water transfers in 2009. Although the District had participated in the VAMP program in prior years, in 2009 MID provided no water for VAMP flows.

Table 28. Transfers and Exchanges Water Uses for 2009

From What Agency	To What Agency	Type of Transfer or Exchange (Ag to M&I, M&I to Ag, or Ag to Ag)	Volume (AF)
Modesto ID	USBR (VAMP)	Agricultural to Environmental	0

G. Other Water Use

All water uses of any significance have been described previously in this section. Negligible volumes of water are used within the District for livestock watering, mixing with agricultural chemicals before spraying and dust abatement. Table 29 notes that the cumulative water use for these purposes is insignificant.

Table 29. Other Water Uses for 2009 (AF)

Water Use	2009
No other uses of significance	NA

H. Projected Water Use

As the developed areas of the City of Modesto and other communities within the MID service area expand, irrigated land is being replaced by urban land uses. This continuing shift in land use drives projected changes in water use.

As noted earlier, in 2009 the MRWTP delivered 30,034 acre-feet of treated surface water from MID to the City of Modesto. The UWMP produced jointly by the City of Modesto and MID projects that by 2015 the capacity of the treatment plant will increase to 67,200 acre-feet/yr. Upon completion of this expansion, this supply source will become the City's primary water supply, with groundwater supplementing the available surface water supplies to meet demands. The UWMP projects that the capacity of the MRWTP will remain constant throughout the time horizon of the plan which extends until 2035.

Future changes in agricultural water use will be driven by changes in cropping, irrigation practices, climate change, and fluctuations in the hydrology of the Tuolumne River watershed. Although the irrigated area within the MID is expected to remain relatively stable, even considering the impacts of urban expansion, changes in the availability of surface water will continue to influence the annual allocation of water.

Given the unknown nature of the impacts of climate change, it appears likely that surface water supplies will become less dependable which will lead to an increasing reliance on groundwater and on the conjunctive management practices needed to sustain groundwater elevations. Among the consequences of any future increases in groundwater pumping needed as a substitute for surface water delivered by gravity will be an increase in the energy required for groundwater pumping as well as the air quality impacts of increased energy use.

Section IV. Description of Quantity and Quality of the Water Resources of the Agriculture Water Supplier

A. Water Supply Quantity

1.Surface Water Supply

Water that flows from Don Pedro Reservoir and is re-diverted at La Grange Dam flows through the MID Upper Main Canal and into the Modesto Reservoir. Some water is supplied to water users directly from the Upper Main Canal before it arrives at Modesto Reservoir. From Modesto Reservoir water is diverted into the lower lying downstream irrigation canals for delivery to agricultural lands. Water is diverted directly from the Modesto Reservoir to the MRWTP. Table 30 shows MID's water diversions from the Tuolumne River for the years 2007-2011 in acre-feet per year. Table 31 lists restrictions or imposed limitations on sources of MID water supply.

Table 30. Surface Water Supplies (AF)

Source	Diversion Restriction	2007*	2008*	2009*	2010**	2011**
MID Water Diverted from the Tuolumne River at La Grange	Water year type, conveyance capacity and licenses	296,000	288,000	267,300	264,633	315,912

* USGS Provisional Data
**District data

Table 31. Restrictions on Water Sources

Source	Restrictions or Imposed Limitations	Name of Agency Imposing Restrictions	Operational Constraints
Tuolumne River	Pre-1914 Water Rights Pre-1914 Storage Rights	Prior appropriation and use	Limited to unimpaired flow
Tuolumne River	Storage Rights	SWRCB	SWRCB license limits
Tuolumne River	Minimum In-Stream Flow Requirements	FERC	In-stream water volume and rate of change in river flow, water year type, FERC license requirements
Tuolumne River	Flood Control	USACE	USACE flood control rule curve

2. Groundwater Supply

Groundwater is pumped in the MID service area to supplement the surface water supply and to control high water tables on the west side of the District. The combined pumping capacity of the approximately 90 groundwater wells owned by the District is approximately 250 cfs. However, based on MID's experience during prolonged droughts, pumping at this rate by MID, combined with pumping by other users within the Modesto Groundwater Subbasin, would not be sustainable over extended periods of time.

To better understand MID's and other local agencies' groundwater supplies, the Stanislaus and Tuolumne Rivers Groundwater Basin Association (STRGBA) was formed in 1994 and an Integrated Regional Groundwater Management Plan (IRGWMP) was adopted in 2005 for the Modesto

Groundwater Subbasin. In addition to MID, the other STRGBA members include OID, the City of Modesto, Stanislaus County, the City of Oakdale, and the City of Riverbank.

The depth to groundwater in the District ranges from approximately ten feet on the west side of the District near the San Joaquin River to over 100 feet east of the City of Modesto. The hydraulic gradient of the unconfined groundwater is generally southwesterly from the mountains toward the valley parallel to the slope of the river channels. In areas influenced by the rivers, by urban pumping centers or by agricultural pumping, the direction of the local groundwater flow gradient is altered significantly.

Long term water-level data in selected wells representing the unconfined to semiconfined aquifer east of Modesto, adjacent to Modesto, and west of Modesto suggest that water levels generally decreased in the eastern and central Modesto area until the early 1990s . A series of wet years, as well as the completion of a surface-water treatment plant in 1994 that provided an additional source of municipal and industrial water supply, resulted in recent recovery of water levels under the City of Modesto. By contrast, water levels in the unconfined aquifer in the northwestern part of the study area have remained relatively constant during this same period.

Deep percolation of applied surface water to agricultural areas comprises the major source of groundwater recharge for the groundwater basins. Other significant sources of recharge include stream-aquifer interactions and precipitation. Table 32 summarizes information on the size and capacity of the Modesto Groundwater Subbasin; Table 33 lists the firm responsible for preparation of the plan. The executive summary of this plan is presented as **Appendix E**.

Table 32. Groundwater Basins

Basin Name	Size (Sq. Mi.)	Estimated Capacity (AF)	Safe Yield (AFY)
Modesto Groundwater Subbasin	385	6,500,000	Unknown

DWR San Joaquin District Modesto Groundwater Basin Information:
http://www.water.ca.gov/pubs/groundwater/bulletin_118/basindescriptions/5-22.02.pdf

Table 33. Groundwater Management Plan

Prepared By:	GEI Consultants
Year:	2005
Is Appendix Attached?	Yes

Irrigation Wells

Because of the availability of high quality surface water, groundwater pumping by the District as a source of supply has generally been used only to supplement reduced availability of water from the Tuolumne River during dry years and to serve areas where it is more difficult to deliver adequate amounts of surface water.

Groundwater pumping becomes crucial in areas adjacent to downstream laterals where flow fluctuations in canals occur most frequently. In gravity water delivery systems, flow fluctuations towards the ends of canals are common due to various factors including farm delivery mismatches, evaporation losses, water being turned on and off, and flow restrictions. In some cases, to avoid the need to divert additional surface water to minimize delivery shortages, groundwater pumping is used to balance differences between water orders and water deliveries. By using the pumps to minimize these fluctuations, the overall system efficiency is improved. One of the functions of the District's Decision Support System (DSS) is to aid in determining which wells to use to most efficiently minimize mismatches between demands and the availability of water for delivery.

Beginning in the late 1940's, irrigator reliance on District surface water began to change as some field crop land was converted to permanent crops such as orchards and vineyards. Since the mid-1970's, this conversion has accelerated as additional irrigators converted from flood irrigation to low-volume irrigation technologies for convenience and to maximize crop yields. Because low-volume irrigation requires more frequent irrigations and water free from debris, water users began converting to groundwater to supply their pressurized irrigation systems rather than continuing to receive surface water and installing filtration required for operation of low-volume systems. Surface water continues to be used for salinity control, so most irrigators maintain access to District water.

To encourage water users to remain on canal water and to support conjunctive management, the District is providing incentives and developing management strategies that include:

- Increasing use of automated control structures and deep wells;
- Using the District's DSS to aid in selecting wells to be used for augmenting surface water supplies;
- Using canals as short-term reservoir systems;
- Enhancing and encouraging groundwater recharge during wet years;
- Reducing the length of the water delivery system between the canal and water user;
- Providing loans and other incentives for water delivery system improvements, and
- When possible, making water available on demand or arranged demand rather than rotation.

The ability to use groundwater to augment surface water supplies to more efficiently deliver water through the conveyance system is one important benefit of the conjunctive water management approach implemented by the District. If groundwater levels decline to the extent that the operational flexibility afforded by conjunctive management is compromised, additional groundwater management measures will be exercised by the District to protect the availability of groundwater. Without these measures, increases in private pumping could have far-reaching effects on the area's water supply reliability.

The volume of groundwater pumped within the boundaries of MID in 2009 is shown in Table 34. Although privately-owned wells are also pumped within the District, the District does not have a reliable estimate of the volume of private pumping. This situation will be rectified in the coming years as SmartMeters come on line which will enable MID to track energy usage by privately-owned wells and to apply this usage as a factor in estimating pumpage.

Table 34. Groundwater Supplies for 2009

Groundwater Basin	2009 Total (AF)
MID Direct Pumping[a]	20,057
City of Modesto Pumping[b]	35,722
Total	55,779

a. MID pumping includes deep well irrigation pumping as well as drainage pumping on the western part of the District
b. City of Modesto M&I pumping based on city records

3. Other Water Supplies

During the irrigation season, approximately 17,000 acre-feet of operational outflow from OID enters MID canals. The OID operational outflows entering the MID system are not scheduled; therefore, MID cannot fully utilize this inflow and a significant amount is discharged to the Stanislaus River.

4. Drainage from the Water Supplier's Surface Area

Drainage Wells

Drainage wells have been employed by the District to control shallow groundwater in the western part of the District since 1918. Drainage wells are relatively shallow (usually less than 100 feet deep) and are perforated throughout their depth. They are generally pumped during the irrigation season to maintain groundwater levels below the crop root zone, which controls root zone salinity and allows for healthy root development and growth.

In some areas, drainage wells are used as irrigation water supply wells to supplement surface water. In these areas, the groundwater levels are below the root zone and are not damaging to the crops. Although drainage well water is generally of poorer quality than surface water, it is suitable for agriculture and in most cases meets drinking water standards. As Table 35 summarizes, there are no flows to saline sinks and flows to a perched water table are minimal.

Table 35. Drainage Discharge for 2009

Surface/Subsurface Drainage Path	AF
Flows to saline sink	N/A
Flows to perched water table	Minimal

B. Water Supply Quality

MID's groundwater and surface water quality is generally good to excellent. Surface water diverted from the Tuolumne River originates from snowmelt in the high Sierras. The water is of excellent quality with a total dissolved solids (TDS) content of less than 40 ppm. Groundwater is also of relatively high quality with a TDS generally less than 500 ppm.

MID performs water quality monitoring consistent with the CVRWQCB Irrigated Land Regulatory Program (Ag Waiver) through participation in the East San Joaquin Water Quality Coalition. MID conducts real-time water quality analyses on several operational outflows. Water quality sensors collect data for temperature, conductivity and pH which can be monitored through SCADA.

1. Surface Water Supply

The Tuolumne River watershed covers approximately 1,500 square miles of the western slopes of the central Sierra Nevada Mountains including portions of the Yosemite National Park. Snowmelt from the central Sierra Nevada is of excellent quality. For example, surface water diverted from the Tuolumne River at La Grange has a TDS of approximately 36 milligrams per liter (mg/l). Other water quality constituents that impact agricultural and domestic water use are also very low or negligible. The quality of the river water is fairly consistent from year to year. As runoff from agricultural and developed land is introduced into the lower part of the river, the overall water quality degrades but remains good.

Table 36. Modesto Reservoir Water Supply Quality - 2009

Parameter	Units	2009
Al	mg/l	0.24
As	µg/l*	ND
Ba	mg/l	ND
Ca	mg/l	3.3
Cu	µg/l	ND
Fe	mg/l	0.19
Mg	mg/l	1.5
Se	µg/l	ND
Na	mg/l	1.7
TDS	mg/l	36

*micrograms per liter (µg/l)

2. Groundwater Supply

Groundwater quality in the District ranges from mostly good in the unconfined aquifer to poor in some areas of the confined aquifer. Total TDS in groundwater in the eastern two-thirds of the District is generally less than 500 mg/L with a range from 90 mg/L to 700 mg/L. High TDS (2,000 mg/L) groundwater is present beneath the District at a depth from about 400 feet in the west to about 800 feet in the east. This degraded water originates in marine sediments underlying the San Joaquin

Valley. The shallowest high TDS groundwater (TDS greater than 1,000 mg/L) occurs around 120 feet below land surface within a 5- to 6-mile-wide zone parallel to the San Joaquin River.

3. Other Water Uses

There are no additional uses other than those described in this plant.

4. Drainage from the Water Supplier's Surface Area

Subsurface drainage for lands served by MID is controlled with drainage wells. Therefore, there is currently no need for on-farm subsurface drainage systems. Because the shallow groundwater is of good quality (less than 500 ppm of dissolved solids) and is suitable for most irrigation purposes, during the irrigation season, some drainage well water is used to supplement the District's irrigation water supply. The use of drainage wells to supplement surface water serves as a source of supply during dry years and improves the overall efficiency of the water delivery system by making water available where and when it is needed.

On-farm tailwater drainage within the District's service area is minimal due to the prevalence of low-volume and level-basin irrigation systems. In cases where on-farm tailwater is generated, the water users typically contain it within their property. In some instances, surface drainage water is recycled by downstream water users.

As presented in Table 36, the quality of water which enters the system from Modesto Reservoir is high. As a result, water quality throughout the system remains adequate to prevent water quality from limiting reuse of drainage water as shown in Table 37.

Table 37. Drainage Reuse Effects

Analyte	**Drainage Reuse Limitations**				
	Increased Leaching	Blending Supplies	Restricted Area of Use	Restricted Crops	Other
TDS	No limitation	No limitation	No limitation	No limitation	NA

C. Water Quality Monitoring Practices

1. Source Water

MID monitors the quality of water diverted from the Modesto Reservoir and pumped from groundwater in compliance with several water quality monitoring programs. Table 38 provides general information on monitoring of source water quality in the District.

Table 38. Water Quality Monitoring Practices

Water Source	Monitoring Location	Monitoring Practice	Frequency of Analysis
Surface water	Various canal locations	Agricultural Suitability, state-wide aquatic herbicide general permit	Periodically and in compliance with permit requirements
Surface water	Real-time monitoring locations on Lateral 3, Lateral 4, and Lateral 6	Agricultural Suitability	Continuous
Surface water	Modesto Reservoir	Domestic Water Quality Standards	Daily
Groundwater	Irrigation water wells	Agricultural Suitability	Annually

2. Drainage Water

As noted on Table 39, MID conducts periodic monitoring and analyses of surface drainage and groundwater to confirm the suitability of this water for reuse.

Table 39. Water Quality Monitoring Programs for Surface/Sub-Surface Drainage

Monitoring Program	Analyses Performed	Frequency of Analysis
Surface Water	Ag-Suitability Lab	Periodically
Groundwater	Ag-Suitability Lab	Annually
Surface Water	EC, Temp, pH	Continuously
Aquatic Herbicide general permit	Permit Requirements	Permit Requirements

Section V. Water Accounting and Water Supply Reliability

A.Quantifying the Water Supplier's Water Supplies

1. Agricultural Water Supplier Water Quantities

Tuolumne River water diversions at La Grange Dam vary from year to year depending on the weather, the amount of runoff, and operational considerations. For purposes of the AWMP, 2009 is the reference year. Water year 2009 was classified as a below normal year on the Tuolumne River watershed but was a typical water delivery year. The irrigation season started on March 23 (March 15 is the typical start) and ended on October 30, the typical end being October 31. Table 40 summarizes monthly diversions from the Tuolumne River to the MID water delivery system in 2009.

Table 40. Surface and other Water Supplies for 2009 (AF)

Source	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Tuolumne River	1,920	1,580	13,470	28,220	35,200	42,590	48,620	44,350	28,190	16,380	6,670	94	267,284
Transfers & Exchanges	0	0	0	0	0	0	0	0	0	0	0	0	0
Recycled Water	0	0	0	0	0	0	0	0	0	0	0	0	0
OID operational outflow*													17,000
Total													284,280

* OID operational outflow is estimated to average 17,000 acre-feet/year. There are no measurements of the monthly distribution of this flow.

In addition to water diverted from the Tuolumne River, MID, the City of Modesto, other local communities and irrigators pump groundwater. MID reporting of groundwater pumping includes drainage water pumped to lower the shallow water table in the western part of the District. Most of the water pumped by MID was used to supplement surface water when the local demand was greater than the available surface water supply, a practice that eliminates ordering make-up water from a reservoir several miles away.

Table 41 summarizes the quantity of groundwater pumped by MID and the City of Modesto in 2009. As discussed in the description of Table 34, the quantity of water discharged from privately-owned wells within the District boundaries is not included in this plan's accounting of groundwater pumping because there are now no reliable estimates of the extent of private pumping.

Table 41.Groundwater Supplies Summary for 2009

Month	MID Total[a] (AF)	City of Modesto[b] (AF)	Total (AF)
January	0	2,331	2,331
February	0	1,485	1,485
March	817	2,538	3,355
April	5,436	2,927	8,363
May	4,255	3,928	8,183
June	1,835	4,205	6,040
July	2,230	5,010	7,240
August	1,876	4,927	6,803
September	2,644	3,691	6,335
October	867	2,062	2,929
November	67	1,226	1,293
December	0	1,402	1,402
Total	20,057	35,722	55,779

a. MID pumping includes deep well irrigation pumping and drainage pumping on the western part of the District
b. City of Modesto M&I pumping based on city records

2. Other Water Sources Quantities

Surface water diverted from the Tuolumne River and groundwater are the two sources of water actively managed by MID. The third, and most variable, source of water available to District lands is effective precipitation. The United Nations Food and Agricultural Organization (FAO) method for computing effective precipitation was applied to monthly 2009 precipitation data to generate the values shown in Table 42.

Table 42. Effective Precipitation Summary for 2009 (AF)

Month	2009
January	5,270
February	4,128
March	3,776
April	1,142
May	-
June	-
July	-
August	-
September	-
October	-
November	1,669
January	4,128
Total	20,112

B. Quantification of Water Uses

Table 43 shows the volume of surface water delivered to MID irrigation customers in 2009. The volume of water delivered is based on measurements to customers used as the basis for computing water charges.

Table 43. Applied Water for 2009

	Volume (AF)
Delivered surface water charged to landowners	152,980

Table 44 summarizes water uses within the MID service area for 2009. The calculated crop ETc was used in developing the District's water balance (Table 44). During this year, there were estimated to be 59,153 acres irrigated by either groundwater or surface water within the District and crop evapotranspiration during that year was estimated to be 162,788 acre-feet as described in Table 21 and the text which accompanies this table.

Seepage losses from the canal system are based on canal loss calculations performed by the Kings River Water Conservation District on canals of similar characteristics as those at MID and preliminary canal seepage tests conducted by MID. Modesto Reservoir seepage losses are based on preliminary water seepage calculations performed at the end of each irrigation season. The 30,034 acre-feet for M&I usage were based on the actual 2009 water deliveries to the City of Modesto in accordance with the treatment and delivery agreement.

The value for "conveyance operational outflows" presented in Table 44 is based on recorded MID outflows to the Tuolumne, Stanislaus and San Joaquin rivers in 2009.

Table 44. Quantify Water Use for 2009 (AF)

Estimated Water Use	2009
Crop Water Use	
1 Crop evapotranspiration	173,179
2 Leaching (included in item 16 – Groundwater recharge)	NA
3 Cultural practices	NA
Conveyance and Storage System	
4 Conveyance seepage	8,000
5 Conveyance evaporation	2,100
6 Conveyance operational outflows	29,768
7 Reservoir evaporation (Modesto Reservoir)	7,200
8 Reservoir seepage	24,000
Environmental Use	
9 Environmental use – wetlands	0
10 Environmental use – other	0
11 Riparian vegetation	0
12 Recreational use	0
Municipal and Industrial	
13 Municipal (from Table 26)	30,034
14 Industrial (from Table 26)	0
Outside the District	
15 Transfers or Exchanges out of the service area (from Table 28)	0
Conjunctive Use	
16 Groundwater recharge (from Table 27)	58,132
Other (from Table 29)	0
Subtotal	332,413

Table 45 summarizes the amount of on-farm surface and subsurface drainage water leaving the service area. As discussed earlier, the amount of on-farm drainage water leaving the service area is minimal.

Table 45. Quantify Water Leaving the District for 2009 (AF)

Drain Water	2009
Surface drain water leaving district	Minimal
Subsurface drain water leaving district	Minimal
Subtotal	Minimal

Table 46 shows that there are no irrecoverable losses from the District.

Table 46. Irrecoverable Water Losses for 2009 (AF)

Drain Water	2009
Flows to saline sink	None
Flows to perched water table	None
Subtotal	None

C. Overall Water Budget

Table 47 summarizes the total water supplies available in 2009 to the MID service area. Surface water is the volume of water diverted from the Tuolumne River to the MID water system plus operational outflows from OID that enter the MID system. The groundwater volume includes MID pumping from deep wells and drainage pumping on the western part of the District. The total rainfall in Modesto for the period of January 2009 to December 2009 was 12.21 inches. Annual effective rainfall precipitation was determined using the FAO formula for calculating effective precipitation. The effective precipitation based on annual rainfall over 59,153 acres of irrigated land was 0.34 feet per acre or 22,750 acre-feet total.

Table 47. Quantify Water Supplies for 2009 (AF)

Water Supplies	2009
1 Surface Water (summary total from Table 40)	284,284
2 Groundwater (MID summary total from Table 41)	20,057
3 Annual Effective Precipitation (summary total from Table 42)	20,112
4 Water purchases	0
5 Transfers or exchanges into District	0
Subtotal	324,453

Table 48 summarizes the water budget for the service area. As noted earlier in this document, although private wells are known to be used within the MID service area to provide irrigation water, there is no accurate accounting for the extent of private pumping. Because of the great uncertainty regarding this element of the MID water budget, the closure term of the budget represents an approximation of the level of private pumping that occurred in 2009.

Table 48. Budget Summary for 2009 (AF)

Water Accounting	2009
1 Subtotal of Water Supplies (Table 47)	324,453
2 Subtotal of Water Uses (Table 44)	332,413
3 On-farm Drainage Water Leaving Service Area (Table 45)	Minimal
Closure term attributed to private pumping within the MID service area	7,960

D. Water Supply Reliability

The average calculated median annual unimpaired runoff from the Tuolumne River basin at La Grange is approximately 1,900,000 acre-feet (California Department of Water Resources: 2000 to 2010). However, the annual runoff is highly variable with no predictable year-to-year correlation. Historic annual runoff values have ranged from 377,000 acre-feet in 1977 to 4,400,000 acre-feet in 1983. Therefore, water storage facilities and conjunctive management practices that carry over water from years of abundance to dry years are critical for the well-being of the communities who depend on the river. The importance of water storage and conjunctive management became particularly apparent during the prolonged drought of 1987-1992.

Excluding dry years, sufficient natural precipitation and watershed runoff occurs to satisfy the local agricultural and domestic needs as well as those of the CCSF. During dry years, the Districts rely on carryover storage and irrigation wells to supplement river water diversions. However, in recent years new demands on MID's water supplies, such as additional fish flows and domestic water needs, are creating greater uncertainty. As a result, MID is continuously developing new technologies and adopting conservation techniques to manage its water supply. For example, MID has expanded its Supervisory Control and Data Acquisition (SCADA) system to better monitor and manage the water flows in the water distribution system, and has implemented a DSS to increase the efficiency of groundwater use. MID also works with agricultural customers to improve on-farm water application to both increase crop productivity and to improve on-farm water use efficiency.

E. Future Water Supply

MID derives all of its surface water from diversions from the Tuolumne River; therefore, future changes in the MID water supply will be driven by changes in hydrology and particularly by the volume, nature and timing of precipitation in the watershed of Don Pedro Reservoir. The discussion presented in Section VI of this plan describes how climate change may affect the hydrology of the Tuolumne River watershed.

The secondary source of water supply for the District is groundwater. Although not immediately affected by changes in surface water hydrology, local groundwater is a derivative of surface water hydrology in that groundwater recharge is driven by percolation of applied irrigation water and precipitation. While MID has no way to control the volume of water flowing into Don Pedro Reservoir, the District's conjunctive management program provides mechanisms for generating deep percolation needed to maintain groundwater levels. Therefore, while changes in watershed hydrology may reduce the reliability of surface water from the Tuolumne River watershed in ways the District cannot control, the District is committed to adapting its water management practices, particularly its exercise of conjunctive management, to respond to these changes as best it can.

Section VI. Analysis of Effect of Climate Change

A. Effects of Climate Change on Water Supply

The future availability of the MID water supply will be driven by changes in hydrology and particularly by the volume, nature and timing of precipitation in the Tuolumne River watershed. In addition to direct impacts on surface water supplies, climate change may indirectly affect groundwater resources. This section describes analyses of how climate change may affect the hydrology of the Tuolumne River watershed.

A study of the possible effects of climate change on the Tuolumne River watershed was conducted by the San Francisco Public Utility Commission (SFPUC) as part of an assessment of the Hetch Hetchy Reservoir and other reservoirs in the basin. As part of this study, a literature review of recent assessments of climate change was conducted to identify the current status of available information and to determine potential impacts of climate change on SFPUC water resources in the watershed. Based on the review, climate change could result in the following types of water resources impacts:

- Reduction in the average annual snowpack due to a rise in the snowline and thinner snowpack in low- and medium-elevation zones
- Changes in the timing, intensity, location, amount, and variability of precipitation, including a shift in snowmelt runoff to earlier in the year and an increased amount of precipitation falling as rain instead of as snow
- Long-term changes in watershed vegetation and increased incidence of wildfires that could affect water quality
- Increased water temperatures with accompanying adverse effects on some fisheries
- Increase in evaporation and concomitant increased demand by water users

The implications of climate change noted by the SFPUC researchers are similar to those identified by other researchers modeling water resource impacts in the Sierra Nevada due to warming trends associated with climate change and are believed to be representative of the types of impacts that may affect MID operations.

Following their qualitative assessment of the potential impacts of climate change, SFPUC staff performed an initial evaluation of the effect on the regional water system of a 1.5 degree Celsius (°C) temperature rise between 2000 and 2025 (SFPUC, 2006a). The temperature rise of 1.5°C is based on a consensus among many climatologists that current global climate modeling suggests a 3°C rise will occur between 2000 and 2050 and a rise of 6°C will occur by 2100. The evaluation predicts that an increase in temperature of 1.5°C will raise the snowline approximately 500 feet every 25 years. Therefore, the SFPUC evaluation indicates that a rise in temperature of 1.5°C between 2000 and 2025 will result in less or no snowpack below 6,500 feet and faster melting of the snowpack above 6,500 feet. Similarly, the snowline will have risen to 7,000 feet in 2050 and to 8,000 feet in 2100. The snow-free portion of the basin will rise from 13 percent in 2000 to 57 percent by 2100. This shift in snowline implies that more of the basin will receive rain during a storm and less will receive snow. This change will produce a shift in runoff timing: more runoff during the early winter and less snowmelt at the end of the winter.

The SFPUC evaluated the shift in the timing of runoff with their current runoff forecasting model. By raising daily maximum and minimum temperatures to simulate climate change, the results indicated that about 7 percent of the runoff currently draining into Hetch Hetchy Reservoir will shift from the spring and summer to the fall and winter by 2025. This percentage is within the current interannual variation in runoff and is within the range accounted for during normal runoff forecasting and existing reservoir management practices. As the warming process continues and if even larger shifts occur, reservoir operational strategy will have to be changed in response.

The findings of SFPUC staff for the Hetch Hetchy Watershed provide a useful indication of the nature and extent of the impacts of climate change on inflow to New Don Pedro Reservoir. Trends observed in the SFPUC report are supported by observations presented in the DWR study *Progress on Incorporating Climate Change into Management of California's Water Resources*. Based on analysis of flows of four rivers in the San Joaquin River watershed (Stanislaus, Tuolumne, Merced, and San Joaquin), the report notes April through July runoff has declined by approximately 7 percent relative to total water year runoff over the past 100 years. Therefore, while total runoff in these watersheds has decreased, April through July runoff has decreased at a greater rate. The DWR paper states that, "It is reasonable to conclude that that this trend (toward reduced runoff) is the likely result of climate change and warming and an attendant decline in Sierra snowpack. A portion of the trend may also be attributable to progressively earlier melting of Sierra snowpack due to warming."

The watershed of Don Pedro Reservoir includes lands lying at lower elevations than the watershed of Hetch Hetchy Reservoir. Therefore, while both studies predict a substantial reduction in percentage of their respective watersheds covered in snow, the DWR report predicts that a 5°C rise in temperature will result in 35 percent of the Don Pedro Reservoir watershed being covered by snow, while the SFPUC report predicts that a 6°C rise in temperature will reduce the percentage of the Hetch Hetchy Reservoir watershed to be covered by snow to 43 percent.

One of the potential impacts of the shift from snowfall to rain and the increased variability in annual precipitation expected to result from climate change is the prospect of greater risk of flooding. Should anticipated changes in regional hydrology take place, there is the likelihood that the USACE will exercise its jurisdiction by modifying the flood management rules that apply to Don Pedro Dam. By law MID will be required to adhere to any changes in flood management criteria that may be established by the Corps.

B. Effects of Climate Change on Agriculture's Water Demand

Climate change is expected to increase temperatures in the Central Valley resulting in changes to growing season and higher daytime and nighttime temperatures. The general increase in temperatures coupled with greater variability in precipitation in the valley is expected to lead to increases in evapotranspiration resulting from warmer seasons; thereby creating a general increase in agricultural water demand for irrigation water and an increase in the year-to-year variability of demand.

The effects of increased temperatures are expected to be particularly pronounced on fruit crops such as apples, cherries and pears, due, in part, to the reduction of winter chill hours likely to result from warmer temperatures. By the end of the century, the safe winter chill needed for these orchard crops is predicted to disappear. Today, the number of hours of winter chill in the San Joaquin Valley has sunk from about 1,500 a few decades ago, to approximately 1,000 to 1,200 hours. Some farmers are beginning to overcome this change by planting trees closer together and using new varieties.

Studies are now underway to breed varieties of fruit trees which can withstand the decreased winter chill hours. However, replanting orchards to varieties of these crops better suited to warming temperatures may not be feasible for many irrigators.

C. MID Response to Effects of Climate Change

While changes in watershed hydrology and in temperature-driven crop water demand may result from climate change, there is little consensus about the rate at which climate change will occur or the magnitude of the impacts. Given the general agreement that climate change is taking place and the general uncertainty regarding the rate of change, the District is committed to monitoring key indicators of climate change that affect the hydrology of the Tuolumne River watershed and growing conditions in the District's service area and to adapting its water management practices to respond to changes as they become evident.

In addition to adaptive management, implementation of the water conservation initiatives now underway at MID is intended to help the District and its customers prepare for the impacts of climate change both by increasing the efficiency of water use and by improving operational control within the District. Improving operational control will enable the District to exercise adaptive management measures should they become necessary. In particular, should climate change reduce the reliability of surface water from the Tuolumne River, the exercise of pricing and other incentives to encourage conjunctive management may grow in importance.

Section VII. Water Use Efficiency Information

A. EWMP Implementation and Reporting

Table 49 summarizes the status of implementation of EWMPs at MID. As the table indicates, each of the EWMPs listed in the DWR publication *A Guidebook to Assist Agricultural Water Suppliers to Prepare a 2012 Agricultural Water Management Plan* is now being implemented.

The District has chosen to implement some EWMPs that, when viewed in isolation, are not locally cost effective water conservation measures. These measures are being implemented because MID's goal is to provide the flexibility and reliability of water service necessary to maintain the District's system as the water source of choice by all irrigators within the District's service area. Maintaining irrigators' preference to receive water from gravity deliveries is fundamental to MID's ability to manage water conjunctively, to conserve energy, and to maintain the District's financial viability. Therefore, when viewed as an overall strategy for serving irrigators, the benefits of implementing the full program of EWMPs are clear.

MID's integrated program for implementation of EWMPs is apparent in the District's *Irrigation Infrastructure Plan*. This plan includes a comprehensive program of new and rehabilitated facilities and improved controls to improve the efficiency and effectiveness of water management throughout the District.

Table 49. Report of EWMPs

Water Code Reference	EWMP	Current Status	Status of EWMP
10608.48.b(1)	Measure the volume of water delivered to customers with sufficient accuracy to comply with subdivision (a) of Section 531.10 and to implement paragraph (2) of the legislation.	Proceeding with implementation	MID currently measures, monitors, and controls flows throughout its water delivery system. The District also measures deliveries in order to bill water users accurately under the District's tiered water pricing system. As water users convert their on-farm systems from flood to low volume irrigation systems, cumulative water measuring devices such as meters are being installed. MID is financially supporting the upgrading of water users' water delivery facilities which include water measuring devices by contributing up to 50% of the installation cost of water measuring devices including water meters. The District is committed to comply with the requirements of SBx7-7 by verifying the accuracy of seasonal measurement of irrigation water deliveries using the methodology described in Section VIII of this report.
10608.48.b(2)	Adopt a pricing structure for water customers based at least in part on quantity delivered	Proceeding with implementation	MID will continue to move forward in implementing volumetric pricing, as appropriate. As it moves forward, the District will pay careful attention to the implications of volumetric pricing on water use efficiency, irrigation service, conjunctive management and other aspects of the District's mission to ensure that water pricing strategies serve their intended purpose.
10608.48.c(1)	Facilitate alternative land use for lands with exceptionally high water duties or whose irrigation contributes to significant problems, including drainage	Currently Implemented	MID facilitates and considers requests for alternative land uses, including assistance with drainage problems.
10608.48.c(2)	Facilitate use of available recycled water that otherwise would not be used beneficially, meets all health and safety criteria, and does not harm crops or soils	Currently Implemented	MID facilitates and considers requests for use of recycled water. Currently, one MID water user has a contract with the community of Salida to use reclaimed water on his property.
10608.48.c(3)	Facilitate financing of capital improvements for on-farm irrigation systems	Currently Implemented	For many years, MID has financially assisted its water users and has contributed up to 50% of the cost of projects to replace private ditches and pipelines. The District has also provided low interest loans for the other 50% of the projects' costs. When state grants are available, MID has contributed up to 67% of the projects' cost.
10608.48.c(4)	Implement an incentive pricing structure the promotes one or more of the following goals: (A) more efficient water use at the farm level; (B) conjunctive use of groundwater: (C) appropriate increase of groundwater recharge, (D) reduction in problem drainage; (E) improve management of environmental resources; (F) effective management of all water sources throughout the year by adjusting seasonal pricing structures based on current conditions.	Currently Implemented	MID's Board of Directors annually establishes a water allocation and pricing structure, which includes a tiered component. In instances, when water users exceed their normal allocation, a higher cost per unit of water is applied. In addition, over the last few years, the water pricing structure has increased the cost of water at a rate of 10% per year. Water rate increases may become another of the factors that lead water users to opt to convert from flood irrigation to low volume irrigation systems. One of the District's goals is to provide incentives to water users to induce them to stay with surface water rather groundwater. A shift in water supply preference could create a ground/surface water imbalance.
10608.48.c(5)	Expand line or pipe distribution system, and construct regulatory reservoirs to increase distribution system flexibility and capacity, decrease maintenance and reduce seepage.	Currently Implemented	MID has concrete lined approximately 86% of its canals. The remaining 14% lie in soils with low permeability and in areas where groundwater recharge is beneficial. The B/C ratio for this EWMP is low due to the small amount of water that can be conserved by lining 20 miles of canal when compared with the estimated cost of $2,500,000. The District accepted this EWMP because, in addition to water conservation, there could be reasons such as improving water supply reliability by reducing the threat of canal bank failures that could decrease the potential for liability.

Figure 49. Report of EWMPs, Continued

Water Code Reference	EWMP	Current Status	Status of EWMP
10608.48.c(6)	Increase flexibility in water ordering by, and delivery to, water customers within operational limits.	Currently Implemented	MID strives to add flexibility to water ordering and delivery. Most water orders and deliveries are based on an arranged demand system where the frequency and duration is flexible. The rate of flow is flexible to the extent that capacity of the delivery system allows. As water users convert from flood to low volume irrigation systems, the District's ability to provide greater water delivery flexibility increases. In addition, MID policy allows water transfers between water users within the boundaries of the District. The policy allows water users to transfer water to parcels owned or rented by the water user. Implementation of the EWMP has been supported by District programs that have replaced some of its own pipelines and contributed to funding to the replacement of private pipelines. These projects were financed by the District to improve service and are timely elements of the District program to improve flexibility and reliability of deliveries as the District replaces its old cast-in-place pipelines. The District is attempting to minimize the number of water users who leave surface water in favor of groundwater for 100% of their irrigation water needs.
10608.48.c(7)	Construct and operate supplier operational outflows and tailwater recovery systems	Currently Implemented	An operational outflow recovery system could recycle an estimated 32,000 acre-feet of water annually. The cost to build a return water system is estimated at over $115,000,000. This water currently flows to local rivers and streams and is lost to the District.
10608.48.c(8)	Increase planned conjunctive use of surface water and groundwater within the supplier service area	Currently Implemented	Conjunctive use of water has been practiced by the District for many years. The District uses groundwater supplies to supplement the water supply during dry years and as needed to minimize operational outflows by using wells to supply nearby water user needs rather than diverting water from several miles away. The District's water treatment and supply agreement with the City of Modesto specifies that in dry years the District may have access to the City's wells to supplement irrigation water in exchange for river water being diverted for domestic purposes. In dry years, the District can pump up to 45,000 acre-feet of groundwater to supplement river diversions. MID also delivers up to 35,000 acre-feet of surface water annually to the City of Modesto in-lieu of using city pumps. A large number of surface water users have also installed private groundwater pumps which can be used for irrigation during dry years.
10608.48.c(9)	Automate canal control structures	Currently Implemented	MID has automated approximately 45 monitoring and flow control stations at Modesto Reservoir and water diversion points and installed monitoring stations along some reaches of its canals. The District has identified another 30 locations that could be automated for greater water management flexibility. The District has added, and will continue to add, canal automation to its in-house SCADA system in order to enhance water delivery flexibility to water users. The District has also installed controls to automate some irrigation water wells. With this automation, the wells can be turned on and off remotely when the water level in the canal drops below a preset point. As with other district initiatives, MID has proceeded with implementation of this EWMP as a vehicle to improve customer service by increasing the flexibility of deliveries to support the increasing number of conversions from annual to permanent crops and from flood to low volume irrigation systems.
10608.48.c(10)	Facilitate or promote customer pump testing and evaluation	Currently Implemented	Upon request by the customer, MID tests private water supply pumps. MID has installed water flow meters on approximately 70% of its pumps and has developed a well field Decision Support System to efficiently operate the pumps.

Figure 49. Report of EWMPs, Continued

Water Code Reference	EWMP	Current Status	Status of EWMP
10608.48.c(11)	Designate a water conservation coordinator who will develop and implement the water management plan and prepare progress reports	Currently Implemented	The MID Board of Directors has appointed a Water Conservation Coordinator.
10608.48.c(12)	Provide for the availability of water management services to water users.	Currently Implemented	MID financially supports the following: 1) CIMIS telephone and website water use information; 2) water flow and measurement information; 3) publishes a periodic newsletter; 4) dissemination of co-op extension and other data; 5) water well pump testing.
10608.48.c(13)	Evaluate the policies of agencies that provide the supplier with water to identify the potential for institutional changes to allow more flexible water deliveries and storage.	Currently Implemented	MID owns pre- and post-1914 water rights on the Tuolumne River. The MID Board of Directors has the legal authority to directly set and implement policies that affect the distribution of water. Given MID's total reliance on water to which the District holds the rights and on local groundwater, there is no need to identify policies of agencies or other institutional changes with agencies that will result in increased water supply flexibility for MID.
10608.48.c(14)	Evaluate and improve the efficiencies of the supplier's pumps	Currently Implemented	The District's well operation decision support system was instituted specifically to improve the efficiency and effectiveness of the District groundwater pumping program. In addition, MID has a program for regular inspection and maintenance of pumps and wells to keep them in good working order.

The 2012 MID Water Operations budget contain $859,841 for capital expenditures, which include the following projects: irrigation well rehabilitation, pump automation, canal SCADA, new pipelines, and operational outflow recorders. Table 50 presents the schedule for implementing EWMPs

Table 50. Schedule to Implement EWMPs

EWMP	Implementation Schedule	Staffing Requirements	Budget Allotment	AWMC MOU Demand Measures
Critical				
1 - Water Measurement	On-going	1 FTE	$100,000	C-1
2 - Volume-based Pricing	On-going	1 FTE	$100,000	
Conditional				
1 - Alternate Land Use				B-1
2 - Recycled Water Use				B-2
3 - On-Farm Irrigation Capital Improvements				B-3
4 – Incentive Pricing Structure				C-2
5 – Infrastructure Improvements				B-5
6 – Order/Delivery Flexibility				B-6
7 – Supplier Operational Outflow and Tailwater Systems				B-7
8 – Conjunctive Use				B-8
9 – Automated Canal Controls				B-9
10 – Customer Pump Test/Evaluation				
11 – Water Conservation Coordinator				A-2
12 – Water Management Services to Customers				A-3
13- Identify Institutional Changes				A-5
14 – Supplier Pump Improved Efficiency				A-6
Grand Total all EWMPs				

B. Documentation for Non-Implemented EWMPs

MID has chosen to implement each of the recommended EWMPs. Although certain of these measures are not locally cost-effective as individual water conservation measures, the District views them as elements of a broad program that enables MID to provide a high level of service to its agricultural customers and to responsibly manage surface water and groundwater resources in the District’s service area. This position is summarized below in Table 51.

Table 51. Non-Implemented EWMP Documentation

EWMP #	Description	(check one of both)		Justification/Documentation
		Technically Infeasible	**Not Locally Cost-Effective**	
NA				All EWMPs are being implemented as they support MID's long-term water management objectives

Section VIII.Supporting Documentation Agricultural Water Measurement Regulation Documentation

A. Description of Water Measurement Best Professional Practices

MID uses the "TruePoint" database which is an established program for tracking and monitoring agricultural water use and deliveries. The database allows input of various measurement methods including meters, metergates and other rated measurement devices. The ditchtender enters this information into a laptop computer in the field. This information is uploaded and downloaded every day at the beginning and end of their shift. The daily measurements are reviewed by a highly trained supervisor, well experienced in water measurement methods and historical usage patterns. The irrigated acreage is determined based upon a crop forecast report that is prepared each winter for the upcoming season. These crop reports include information directly obtained from the irrigator and identify the crop type, irrigation method and acreage. The irrigated acreage values are verified by checking the acreage identified in the Stanislaus County Assessor's Parcel Number database and are further ground truthed by MID field staff and surveyors using GIS/aerial imagery.

The water delivery data are made available to the irrigator whenever it is requested throughout the season. This allows each irrigator to monitor their water usage. The information uploaded to the TruePoint database for billing purposes is reviewed at the conclusion of the irrigation season. The billing system uses the pricing structure adopted by the MID Board of Directors to determine the actual bill amount. The final bill calculation takes into account the amount of water measured and delivered to the grower.

B. Engineer Certification and Apportionment Required for Water Measurement

The methodology used to determine the individual device accuracy values found in Section 597.3(a) will be verified by a Professional Engineer using industry accepted standards. These methods will take into account the differential in water levels and/or fluctuations in the flow rate or velocity during the delivery event and the type, size and characteristics of the measuring device being verified.

Many of the MID irrigators receive water through a common pipeline. Most often, only one irrigator at a time draws water from the pipeline when typically using the flood irrigation method. MID measures the water flowing into the pipeline upstream of the actual turnout to the irrigator's place of use. The flowrate into the pipeline is based upon a rated metergate. The most important factor to control is the source canal water level that is maintained by the hundreds of long-crested weirs that MID has installed throughout its distribution system. The amount of water delivered to each irrigator off of such a pipeline is based upon the flowrate and duration of the irrigation event. This method of apportionment is well documented by historical practice and use patterns based upon crop type, soil conditions and irrigation methodology and has been approved by the MID Board of Directors.

When an irrigator takes water from the pipeline into an on-farm pressurized delivery system such as solid set sprinkler or micro-irrigation systems (drip/micro-spray) the volume of water delivered is known by the design rate of the pumping system or directly measured by a flowmeter. If multiple users are taking water from the pipeline at the same time, the ditchtender takes into account that amount of water that is being delivered to the pressure system by subtracting that amount from the total flow. The balance of that pipeline flow is adjusted to account for the actual amount of water being delivered to the flood irrigated turnout. These methods of apportionment have been verified over many decades of practice and have been found to be more than sufficient for establishing the basis for how each irrigator is charged for the amount of water delivered during each irrigation event and the total amount over the irrigation season.

The allocation of water for each irrigation season is established by the MID Board of Directors based upon water supply conditions. The pricing structure based upon such established allocation takes into account the volume of water delivered to each irrigator.

C. Documentation of Water Measurement Conversion to Volume

SBx7-7 requires an annual volumetric accuracy of within 12 percent on existing devices. Since flow measurement devices at MID typically do not include totalizers, the devices' accuracy in measuring flow rates must be adjusted to estimate their accuracy in measuring volumes. To comply with the requirements presented in the legislation, MID has adopted an approach developed by the Irrigation and Training Research Center (ITRC) at Cal Poly - San Luis Obispo and described in the August 2012 paper *SBx7 Compliance for Agricultural Districts.* As presented in this paper, the annual volumetric accuracy of an individual turnout depends on errors due to:

- IFR – Instantaneous flow rate error
- CWLF – Canal water level fluctuations
- CBP – Changes in backpressure
- ARD – Accuracy in recording duration of deliveries

At MID, because almost every check structure includes a long-crested weir, the seasonal impact of fluctuating canal water levels on deliveries is negligible and the duration of deliveries is accurately recorded. Therefore, the CWLF and ARD factors listed above do not factor in adjusting measured flow rates to seasonal flow volumes.

Based on the formulas presented in the ITRC study, MID flow measurement devices selected for testing under Step 3, above, must measure flow rates within an accuracy of 11.6 percent to obtain the equivalent of 12 percent accuracy of seasonal volumetric measurement.

D. Legal Certification and Apportionment Required for Water Measurement – Lack of Legal Access to the Farm-gate

Whereas MID staff does have legal access to install, measure, maintain, operate and monitor measurement devices at all farm-gates within the District, measurement at turnouts is not always practical. This is because the smooth, laminar flow necessary for accurate measurements is not achievable due to the high Reynold's numbers in pipelines at turnouts. Accurate measurement at turnouts would require additional flow control devices that will be are expensive to install and maintain given that the average irrigated account acreage within the MID water service area is 20 acres.

E. Device Corrective Action Plan Required for Water Measurement

MID has approved $30,000 per year in its Water Operations Capital Budget program for this activity. MID will monitor this activity on an ongoing basis to determine whether or not this level of effort is sufficient and effective, and will make adjustments, as needed, in order to meet the compliance schedule. The three year time frame for compliance allowed in the regulation will be difficult to meet given the available staff resources and funding needed to complete other programs and projects that MID is engaged in that are considered to be higher priority such as distribution system maintenance and other capital improvements that have been planned.

F. Farm Gate Measurement and Device Accuracy Compliance

SBx7-7 requires that agricultural water suppliers measure the volume of water delivered to customers with sufficient accuracy to comply with certain standards described in the legislation. These standards are described below.

1. Measurement Options at the Delivery Point or Farm-gate of a Single Customer

An agricultural water supplier shall measure the volume of water delivered at the delivery point or farm-gate of a single customer. If a device measures a value other than volume, for example, flow rate, velocity or water elevation, the accuracy certification must incorporate the measurements or calculations required to convert the measured value to volume. An existing measurement device shall be certified to be accurate to within ±12 percent by volume.

2. Initial Certification of Device Accuracy

For existing measurement devices, the device accuracy shall be initially certified and documented by either:

- Field-testing that is completed on a random and statistically representative sample of the existing measurement devices. Field-testing shall be performed by individuals trained in the use of field-testing equipment and documented in a report approved by an engineer.

- Field-inspections and analysis completed for every existing measurement device. Field-inspections and analysis shall be performed by trained individuals in the use of field inspection and analysis, and documented in a report approved by an engineer.

3. Protocols for Field Testing

Field-testing shall be performed for a sample of existing measurement devices according to manufacturer's recommendations or design specifications and following best professional practices. It is recommended that the sample size be no less than 10 percent of existing devices, with a minimum of 5, and not to exceed 100 individual devices for any particular device type. Alternatively, the supplier may develop its own sampling plan using an accepted statistical methodology.

If during the field-testing of existing measurement devices, more than one quarter of the samples for any particular device type do not meet the relevant accuracy criteria, the agricultural water supplier shall provide in its Agricultural Water Management Plan a plan to test an additional 10 percent of its existing devices, with a minimum of 5, but not to exceed an additional 100 individual devices for the particular device type. This second round of field-testing and corrective actions shall be completed within three years of the initial field-testing.

Field-inspections and analysis protocols shall be performed and the results shall be approved by an engineer for every existing measurement device to demonstrate that the design and installation standards used for the installation of existing measurement devices meet the relevant accuracy standards and that operation and maintenance protocols meet best professional practices.

4. MID Program for Compliance with Water Measurement Requirements

SBx7-7 offers the water supplier the opportunity to "develop its own sampling plan using an accepted statistical methodology". As referenced above, MID has adopted an approach described in the paper *SBx7 Compliance for Agricultural Districts.* This approach responds to the condition at MID, and at many other irrigation districts, where there is a wide range in the acreage served and the water delivered among the population of turnouts with the population skewed toward turnouts serving small fields. The skewed distribution among field sizes served by a type of turnout leads to the result that a simple random selection of measurement devices is likely to generate a sample for testing that includes a disproportionately large number of turnouts making small deliveries. The likely outcome of random selection of 10 percent of the turnouts from this population would be to identify a sample that served substantially less than 10 percent of the irrigated acreage and delivered less than 10 percent of the water.

To develop a methodology where the selected sample of measuring devices is based not upon a percentage of the number of turnouts but upon a percentage of the acreage served and water delivered, the ITRC study recommends application of a probability proportional to size (PPS) sampling method designed to generate a randomly selected sample of measurement devices that serves at least 10 percent of the irrigated acreage.

The sequence of steps proposed to identify a representative population of turnouts for verification of flow measurement is as follows:

Step 1: Formulate a list of turnouts together with the acreage served by each turnout.

Step 2: Assign a number range to each turnout based on the acreage served by the device. For example, a turnout serving two acres would be assigned two numbers in sequence and a turnout serving 120 acres would be assigned 120 numbers. In this way, each device is weighted in the selection pool by acreage and, hence, by volume of water delivered. This weighting process structures the randomly selected sample so that it will be statistically representative of the overall accuracy of flow measurement within the District.

Step 3: Apply a random number generator to create a sample turnout population that serves at least 10 percent of the total acreage. When numbers in a range representing a particular device are selected, that device would be designated for testing and the numbers associated with that device will be withdrawn from the pool available for future selection. This procedure will be followed until devices delivering water to 10 percent of the MID service area have been identified for testing.

This procedure improves upon the example given in §597.4(b)(1) of the legislation, in that devices providing at least 10 percent of the MID acreage will be selected for sampling rather than a simple random sample of devices that would have been likely to have represented less than 10 percent of the acreage served or water delivered.

Step 4: Evaluate Selected Turnouts and Record Data. Flow measurement devices at turnouts selected for testing in Step 3 will be evaluated by MID for accuracy and measured accuracy will be retained for ten years or two AWMP cycles as per §597.4(c).

Step 5: Determination of Compliance. MID will use the methodology developed by the ITRC to estimate the annual volumetric accuracy of measurement of the selected sample of flow measurement devices. The complete ITRC measurement procedure is presented in **Appendix F**.

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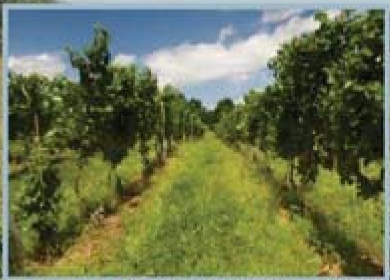


Appendices

Modesto Irrigation District

Agricultural Water Management Plan for 2012

December 2012

Appendices

Appendix A. Public Notice of Plan Preparation

Appendix B. Resolution of Plan Adoption

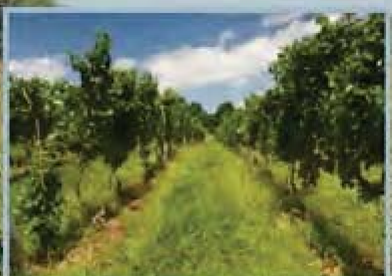
Appendix C. Rules Governing the Distribution of Water in the Modesto Irrigation District

Appendix D. Detailed Information on Water Allocation and Rates

Appendix E. Groundwater Management Plan: Executive Summary

Appendix F. SBx7 Compliance for Agricultural Irrigation Districts

Appendix G. Public Hearing Notification Letters



Appendix A

Public Notice of Plan Preparation

A

PUBLIC HEARING NOTICE

Notice is hereby given that the Modesto Irrigation District (MID) will hold a public hearing on:

Tuesday, November 27, 2012 at 9:00 AM

Regarding:

2012 Agricultural Water Management Plan

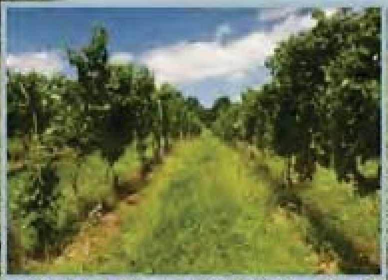
Agricultural water agencies in California are required to prepare Agricultural Water Management Plans (AWMP) in 2012. To meet the new requirements, MID is considering revisions to its existing AWMP. The AWMP includes a discussion of MID and its irrigation facilities, water supply and demand, and various programs, policies and efficient water management practices being implemented now or planned in the coming years. The MID Board of Directors will hold a hearing to consider public comments on the proposed revisions to the AWMP.

A copy of the AWMP may be reviewed at the MID Water Operations Division office (Third Floor, 1231 11th Street, Modesto) or on the MID website (www.mid.org. Written comments, submitted prior to the hearing, should be directed to:

Carrie Loschke
Modesto Irrigation District
P.O. Box 4060
Modesto, CA 95352

Comments may also be provided at the hearing.

If you have questions regarding the AWMP, please contact Carrie Loschke at (209) 526-7570.



Appendix B

Resolution of Plan Adoption

RESOLUTION NO. 2012-84
ADOPTING MODESTO IRRIGATION DISTRICT'S
AGRICULTURAL WATER MANAGEMENT PLAN

WHEREAS, Modesto Irrigation District was originally an active participant in the California Department of Water Resources Advisory Committee which negotiated the Memorandum of Understanding (MOU) regarding Efficient Water Management Practices by Agricultural Water Suppliers in California as directed by the Agricultural Water Suppliers Efficient Water Management Practices Act of 1990, AB 3616; and

WHEREAS, Modesto Irrigation District adopted its first Agricultural Water Management Plan on July 13, 1999 in accordance with the MOU regarding the Agricultural Water Suppliers Efficient Water Management Practices Act of 1990, AB 3616; and

WHEREAS, with the passage of the 2009 Water Conservation Act and SBx7-7, this requirement became mandatory and the requirements introduced were intended to encourage agricultural water suppliers to assess current efficient water management practices, to evaluate additional practices that may conserve water, and to require accurate measurement of water; and

WHEREAS, the District has prepared an Agricultural Water Management Plan pursuant to the guidelines of *A Guidebook to Assist Agricultural Water Suppliers to prepare a 2012 Agricultural Water Management Plan* that was issued by the California Department of Water Resources (DWR) on September 10, 2012 to aid water suppliers in preparing Agricultural Water Management Plans in accordance with the requirements of SBx7-7.

WHEREAS, the District posted the Plan for a two-week review period and subsequently held a hearing on November 27, 2012 to hear and consider comments from the public on the Plan; and

WHEREAS, at the public hearing, there were no verbal objections to the Plan.

NOW, therefore, BE IT RESOLVED, That the Board of Directors of the Modesto Irrigation District does hereby approve and adopt the MID's Agricultural Water Management Plan as presented and prepared in accordance with SBx7-7, California's 2009 Water Conservation Act regarding Efficient Water Management Practices.

Moved by Director Byrd, seconded by Director Warda, that the foregoing resolution be adopted.

The following vote was had:
Ayes: Directors Blom, Byrd, Van Groningen, Warda and Wild
Noes: Directors None
Absent: Directors None
The President declared the resolution adopted.

o0o

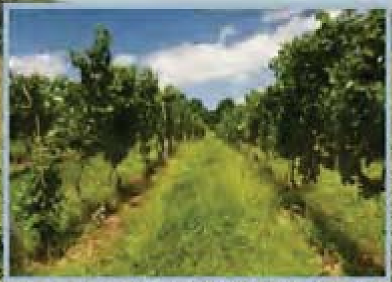
I, Pat Mills, Secretary of the Board of Directors of the MODESTO IRRIGATION DISTRICT, do hereby CERTIFY that the foregoing is a full, true and correct copy of a resolution duly adopted at a special meeting of said Board of Directors held the 18th day of December 2012.

Pat Mills

Secretary of the Board of Directors
of the Modesto Irrigation District

Modesto Irrigation District

Water and Power



Appendix C

Rules Governing the Distribution of Water in the Modesto Irrigation District

RULES AND REGULATIONS GOVERNING THE DISTRIBUTION OF IRRIGATION WATER WITHIN THE MODESTO IRRIGATION DISTRICT

TELEPHONE NUMBERS

Your Ditchtender
MID Irrigation Services 526-7639
MID Irrigation Operations 526-7571

FACILITIES

Don Pedro Lake and Powerhouse
- Completed: 1971
- Construction cost: $105 million
- Primary purpose: Storage and energy
- Maximum storage: 2,030,000 acre feet
- Dam crest elevation: 830 ft. MSL
- Output: 200 MV
- MID owns 31.54%

Modesto Reservoir
- Completed: 1911
- Construction cost: $269,550
- Primary purpose: Regulation of canal flow and storage
- Storage capacity: 28,000 acre feet

LaGrange Dam
- Completed: 1893
- Construction cost: $543,164
- Purpose: Diversion of water for MID and TID

RULES AND REGULATIONS GOVERNING THE DISTRIBUTION OF IRRIGATION WATER WITHIN THE MODESTO IRRIGATION DISTRICT

PREAMBLE

These Rules and Regulations Governing the Distribution of Irrigation Water Within the Modesto Irrigation District are established pursuant to Water Code Section 22257 to ensure the orderly. efficient and equitable distribution, use and conservation of the water resources of the District. The District will endeavor to deliver irrigation water in a flexible, timely manner consistent with the physical and operational limits of the delivery system facilities.

In addition to these Irrigation Rules, the District may enter into agreements and develop policies and programs to enhance service to our customers. Appendix "A" lists the forms and policies that are currently in use. Numbered addenda to these Irrigation Rules will become available as District rules, agreements, policies and programs are updated. To receive further information contact:

Modesto Irrigation District
Water Operations Division
P.O. Box 4060
Modesto, CA 95352
(209) 526-7571

This rules booklet supersedes
"Rules Governing the Distribution of Water in the Modesto Irrigation District"
(Revised to April 1986)

MODESTO IRRIGATION DISTRICT MISSION STATEMENT

To deliver superior value to our irrigation, electric and domestic water customers through teamwork, technology and innovation.

WATER OPERATIONS DIVISION MISSION STATEMENT

To responsibly manage the water resources of the District to provide a safe, reliable and sustainable supply for our agricultural and urban community.

HISTORICAL NOTES

Signing of the Wright Act in March of 1887 allowed for the formation of irrigation districts in California and gave them the power to conduct elections, issue bonds and acquire property. The Modesto Irrigation District was the second irrigation district formed under the new law. The Wright Act was named for C.C. Wright, the Modesto assemblyman who introduced the law.

The District first delivered irrigation water in 1904; the availability of such water changed the nature of the farming in the area within a few years. Large tracts of wheat were replaced with orchards and vineyards. Today Stanislaus County ranks among the top 10 agricultural counties in the nation.

KEY DATES

Established	July 23, 1887
Irrigation service started	1904
Electrical service started	1923
Waterford Irrigation District-merger	January 1, 1978
Domestic water treatment started	1994

IRRIGATION FACTS

No. of acres in the District	101,683
Irrigated acres	64,000
No. of accounts	3,400
Miles of canals	208 (including pipelines)
Water source	Tuolumne River
Annual Modesto Rainfall	12 inches

TABLE OF CONTENTS

SECTION 1: DEFINITIONS

1.1. "Agreement" includes any license agreement or agreement of any nature, application, request for permission, permit, petition or contractual obligation entered into by and/or between a Landowner or Irrigator and the District.

1.2. "Assistant General Manager" or "AGM" is the Assistant General Manager, Water Operations of the District or the AGM's authorized representative.

1.3. "Authorized agent / authorized representative" means a subordinate or other individual granted the authority to act on behalf of the District.

1.4. "Board" means the duly elected Board of Directors of the District.

1.5. "Canals" include canals, laterals, ditches, drains, flumes, pipelines, and all related water conveyance facilities.

1.6. "Canal Road" means the area within District Rights-of-Way maintained for the purpose of permitting the passage of District vehicles.

1.7. "District" means the MODESTO IRRIGATION DISTRICT functioning under the Irrigation District Law of the California Water Code.

1.8. "District Canals" means Canals owned, operated and maintained by the District, but excluding Improvement District Facilities.

1.9. "District Facilities" means Facilities owned, operated and maintained by the District, but excluding Improvement District Facilities.

1.10. "District Rights-of-Way" includes all rights-of-way held by the District, in fee or by easement.

1.11. "Ditchtender" means the District employee, under the general direction of the Irrigation Manager, responsible for making direct irrigation deliveries to Landowners from the District's irrigation system.

1.12. "Facilities" include dams, structures, wells, Canals, pumps, reservoirs, and all other facilities and appurtenances thereto used for or in connection with the delivery or receipt of water.

1.13. "Gravity Water" means water delivered to the end-user by means of gravitational flow.

1.14. "General Manager" or "GM" is the General Manager of the District or the GM's authorized representative.

1.15. "Improvement District" is any sub-district involving two or more landowners within the District formed under the California Water Code and for the purpose of providing for the operation and maintenance of, and capital improvements to, Facilities not owned by the District.

1.16. "Improvement District Facilities" include all Facilities owned by an Improvement District.

1.17. "Irrigable" means all parcels with or without on-farm irrigation facilities that could be irrigated either by District or private water.

1.18. "Irrigation Manager" is the District employee, under general direction from the AGM, who is delegated the authority and responsibility to direct irrigation water deliveries and construction/maintenance of the District's irrigation system.

1.19. "Irrigation Rules" means these Rules and Regulations Governing the Distribution of Irrigation Water Within the Modesto Irrigation District, as duly adopted by the Board, and all regulations, policies, notices and procedures promulgated in accordance therewith.

1.20. "Irrigation Season" means that portion of the calendar year where surface irrigation water is generally made available to District Landowners. The Irrigation Season typically extends from March 1 to October 31, but may be modified each year as directed by the Board.

1.21. "Irrigator" means the Landowner or Renter of a parcel of land who has the primary responsibility for irrigating the parcel. The term includes the Irrigator's officers, employees, contractors and agents.

1.22. "Landowner" means holder of title or evidence of title to land.

1.23. "Laws" includes all federal, state and local statutes and ordinances, and all rules and regulations promulgated, and all orders and decrees issued, in connection therewith.

1.24. "Policy" means Agreements, rules, regulations, guidelines, and Procedures that authorize District staff to act on behalf of the District.

1.25. "Pollutant" means any foreign or deleterious substance or material, including but not limited to garbage, rubbish, refuse, animal carcasses, matter from any barnyard, stable, dairy or hog pen, herbicides, pesticides, fertilizers or any other material which is offensive to the senses or injurious to health, or which pollutes or degrades the quality of the receiving water or any flammable, explosive, or radio active material, toxic substance, hazardous waste, hazardous material, hazardous substance, or the equivalent, as those terms may now or in the future be defined by common practice or by Law.

1.26. "Practice" is a customary activity or generally accepted method.

1.27. "Private Facilities" include all facilities owned by a person or entity other than the District or an Improvement District.

1.28. "Procedure" is an ordered series of steps developed by the District to guide interaction between District staff and the public.

1.29. "Program" is a plan or Procedure through which a Landowner may secure services, such as design, funding and/or financing, for irrigation system improvements.

1.30. "Renter" means a person or entity that leases, rents, or sharecrops land from a Landowner.

1.31. "Vehicle" means any motorized or self propelled vehicle, for air, water or land, including but not limited to boats, cars, motorcycles, bicycles, and all terrain vehicles.

1.32. "Water Allocation" means the quantity of water that is allocated annually by the Board for irrigation distribution to each acre of land within the District.

SECTION 2: FACILITIES

2.1. CONTROL OF FACILITIES:

2.1.1. District Facilities are under the exclusive direction, management and control of authorized District personnel. No persons other than authorized District personnel shall have any right to operate or interfere with said Facilities in any manner.

2.1.1.1. Each Irrigable parcel will be within an area assigned to a designated Ditchtender.

2.1.2. For assistance with Facilities, contact the Irrigation Manager at (209) 526-7637.

2.1.3. For emergency use of Facilities, contact the Irrigation Manager at (209) 526-7637.

2.2. ACCESS TO LANDS:

2.2.1. Every District director, officer, employee, and authorized agent or representative shall have the right, at all times, to enter any land irrigated with water from the District for any of the following purposes:

2.2.1.1. Inspecting District Facilities; the flow of water within and through such Facilities (including measurement thereof); and the use of water on the land;

2.2.1.2. Determining the acreage of crops irrigated or to be irrigated;

2.2.1.3. Maintaining or operating District Facilities;

2.2.1.4. Investigating any incident or report involving District Facilities, or water originating from any District Facility;

2.2.1.5. Responding to an emergency upon notification from law enforcement or other person; and

2.2.1.6. Performing any work contemplated under these Irrigation Rules.

2.3. ENCROACHMENTS:

2.3.1. No trees, vines, crops or other vegetation shall be planted and no encroachments shall be installed, constructed or placed in, on, over, under, along or across any District Facility or Right-of-Way unless such encroachment is consistent with District Policy and the District has given specific written approval for such encroachment. In granting such approval, the District may impose such conditions (including reasonable fees) and/or restrictions as District deems appropriate.

2.3.2. Upon written notification from the District to the Landowner owning the land adjacent to any unauthorized encroachment, said Landowner shall immediately remove such encroachment. If such encroachment is not promptly removed, the District may take all reasonable action to remove the encroachment at the sole expense of the Landowner.

2.3.3. Encroachments in, on, over, under, along or across any District Facility or District Right-of-Way that interfere with the operation or maintenance of that Facility may be removed by the District without notice, at the sole expense of the encroacher or adjacent Landowner.

2.4. CONSTRUCTION OF IRRIGATION FACILITIES:

2.4.1. No irrigation system improvements, including diverting gates, weirs, pump intakes, mechanical screens or structures of a similar nature, shall be planted, installed, constructed or placed in, on, over, under, along or across any District Facility or Right-of-Way unless written permission has first been granted therefore by the District. No person or entity receiving such Permission (a "Permittee") shall acquire any rights in District's Facilities or Rights-of-Way other than those set forth in District's written permission. Permittees shall, at their own expense, promptly upon receipt of notice from District, relocate or remove any improvement. In the event Permittee fails to do so, the District may perform such relocation or removal at Permittee's sole expense.

2.4.2. Unless otherwise specified by Agreement, all improvements shall be at the Permittee's sole expense, built to current District construction and engineering design standards, and shall become the property of the District upon completion.

2.5. CONSTRUCTION OF NON-IRRIGATION FACILITIES: **Reference: Landowner New Bridge Policy, Landowner Replacement Bridge Policy, Rights-Of-Way Policy, Landowner Roadway Gate Policy**

2.5.1. No improvements, including buildings, bridges, gates, cross canal pipes, or structures of a similar nature, shall be planted, installed, constructed or placed in, on, over, under, along or across any District Facility or Right-of-Way unless written permission has first been granted therefore by the District. No Permittee shall acquire any rights in District's Facilities or District Rights-of-Way other than those set forth in District's written permission. Permittees shall, at their own expense, promptly upon receipt of notice from District, relocate or remove any improvement. In the event, Permittee fails to do so, the District may perform such relocation or removal at Permittee's sole expense.

2.5.2. Unless otherwise specified by Agreement, all improvements shall be at the Permittee's sole expense, built to current District construction and engineering design standards, and shall become the property of the District upon completion.

2.6. DESIGN OF PRIVATE OR IMPROVEMENT DISTRICT FACILITIES: **REF: District Construction and Engineering Design Standards, Sidegate Application, Sprinkler Drip Application**

2.6.1. All new Private or Improvement District Facilities used for flood irrigation purposes shall provide for a minimum gravity flow of fifteen (15) cubic feet per second. A variance from this minimum flow size shall be evaluated by the District on a case-by-case basis based on the impact on the operation of the District's water delivery system.

2.6.2. All new Private or Improvement District Facilities used for delivering water to pressure irrigation systems shall be designed to meet the flow requirements of the land served by the Facility without impacting the irrigation operations of the District or other landowners served by the Facility.

2.6.3. The Irrigator will be required to install, operate, and maintain lift pumps, at Irrigator's expense, to receive water where the District is unable to deliver gravity water.

2.6.4. The location and tie-in of gravity or pump Facilities to District Facilities must meet District construction and engineering design standards and be approved in writing by the District prior to construction.

2.6.5. All plans for the installation, construction and placement of Private and Improvement District Facilities shall be submitted to the District for review. No installation, construction, or placement shall commence until the District accepts the plans. The District's rights hereunder to review and accept the plans shall not impose any duties or obligations on the District, nor shall such rights relieve the Irrigator of the sole responsibility for the Facilities plans, schedules and installation, construction and placement work.

SECTION 3: OPERATION OF DISTRICT FACILITIES

3.1. LIMITS OF LIABILITY:

3.1.1. The District's responsibility for the water shall absolutely cease when the water is diverted into any Private or Improvement District Facility or property.

3.1.2. The District shall not be liable for any nuisance or negligent, wasteful or other use or handling of water by any recipient or user thereof.

3.1.3. The District shall not be responsible for any trash, debris or other matter that may flow or accumulate in the water. The District shall not be responsible for any interference with, decrease in the operation or capacity of, or damage to Facilities as a result of such trash, debris or other matter.

3.1.4. The District is not a guarantor of service and shall not be liable for any damage any person may suffer as a result of water not being delivered.

3.2. CONTROL OF SIDEGATES:

3.2.1. The District has sole right and responsibility to operate diversion gates and valves within District Canals. The Ditchtender may authorize an Irrigator to operate a diversion gate or valve during the period when the Irrigator is scheduled to receive water. In such event the authorized Irrigator shall follow any instructions issued by the Ditchtender and shall operate the designated Facilities in a safe and prudent manner. The Irrigator shall be liable for any and all damage resulting directly or indirectly from the Irrigator's operation of District's Facilities.

3.2.2. The District may take any action it deems appropriate to secure District gates, valves and other Facilities, including the use of locks and chains. Irrigators or groups of Irrigators may install locks on District Facilities only with the prior consent of the District. No lock installed by any Irrigator shall interfere with District's use or operation of the Facility.

3.2.3. The District may seal or remove, or require a Landowner to seal or remove, at Landowner's sole expense, any diversion gate or valve where service from that Facility is no longer required by the Landowner.

3.2.4. All turnouts from District Facilities shall be gated or shall have another positive shut-off system easily accessible to the Ditchtender within the District Rights-of-Way.

3.3. PUMPING OF IRRIGATION WATER:

3.3.1. Water pumped from District Canals shall be subject to all rules and regulations governing the use of Gravity Water.

3.3.2. Water pumped from District wells shall be subject to all rules and regulations governing the use of Gravity Water.

3.4. DISTRICT PUMPS: **REF: [Pump Rental Agreement]**

3.4.1. The District, within its sole discretion, shall determine when to run District owned irrigation and drainage pumps. The times of operation may depend upon a variety of circumstances, including the groundwater level near the pump, available supply, peak power load, and the quality of the water being pumped.

3.4.2. District drainage pumping Facilities will not be installed to serve individual acreage. Perched water table control on individual parcels is the responsibility of the Landowner.

3.4.3. District pumps shall be operated during the non-irrigation season, only at the District's discretion.

3.4.4. Irrigators may rent District pumps, as available, in accordance with the terms and conditions of District's pump rental agreement process. The Irrigator will be responsible for the total cost of operating said pump including but not limited to turn-on/turn-off, power, operation, maintenance and capital investments.

3.5. INTERFERENCE WITH DISTRICT FACILITIES: **REF: Rights-Of-Way Policy, Procedure for Pick Up and Disposal of Debris**

3.5.1. Any use of, interference with or damage to any District Facility, including Canals or Canal Roads, is, unless specifically permitted by these Irrigation Rules, prohibited.

3.5.2. No persons other than authorized District employees and agents, and persons permitted in accordance with these Irrigation Rules, shall:

3.5.2.1. Operate any District Facility.

3.5.2.2. Enter onto or into any District Facility

3.5.2.3. Attach, place or remove any boards, chains, ropes, or any other object to, on, in, or upon any District Facility or Canal Road.

3.5.2.4. Attach, place or remove any sign, board, post, fence, or gate to, on, in, or upon any District Facility or Canal Road.

3.5.2.5. Install, place, construct, operate or use any obstruction on, in, or upon any District Facility or Canal Road.

3.5.2.6. Operate, park, abandon or dispose of any Vehicle on, in, or upon any District Facility or Canal Road.

3.5.2.7. Use District property or Facilities for water sports or other recreational purposes, including without limitation surfing, skiing, boating, hunting or camping.

3.6. USE OF CANAL ROADS AND RIGHTS OF WAY: **REF: Rights-Of-Way Policy**

3.6.1. Except as otherwise specifically permitted by the District in writing, no person shall cross any District Canal, including without limitation any weir, bridge or other crossing, except those clearly marked for public use.

3.6.2. No unauthorized vehicle shall be on or within District Canal Roads or Rights-of-Way. District Canal Roads and Rights-of-Way are for the exclusive use of authorized District employees and agents, and other authorized persons permitted in accordance with these Irrigation Rules. Persons requiring a specific use of a Canal Road or Right-of-Way may apply to the District for written permission prior to such use. Notwithstanding any permission granted by the District, use of District Canal Roads and Rights-of-Way is at the sole risk of the user.

3.6.3. The following persons have permission to operate a vehicle upon a District Canal Road or Right-of-Way consistent with District Rights-of-Way Policy 94-01.

3.6.3.1. Any District Director, officer, employee, or authorized agent in the performance of their duties.

3.6.3.2. Persons actively involved in farming a parcel of land adjacent to the specific District Canal Road or Right-of-Way.

3.6.3.3. Persons actively involved in farming who use the specific District Canal Road or Right-of-Way for access to irrigation facilities serving their parcel of land.

3.6.3.4. Persons whose property is directly adjacent to a District Canal and to whom permission for ingress and egress to the property has been granted by the District.

3.6.3.5. Private parties who have made temporary ingress-egress arrangements in writing with the District for property maintenance or construction purposes.

3.6.3.6. Any sheriff, police, fire, or public safety personnel on official business.

3.6.3.7. Any District contractor who needs to use a specific District Canal Road or Right-of-Way to perform work under its contract with the District.

3.6.4. All vehicles using District Canal Banks or Rights-of-Way shall be operated in a safe and lawful manner at all times.

3.7. USE OF FACILITIES FOR WASTEWATER

3.7.1. No Pollutant, shall be, or permitted to be, placed, drained. spilled or otherwise discharged into or onto any District Facility or Canal Road.

3.7.2. No District Facilities shall be used for transportation of manure or other livestock waste of any kind, except with the prior written approval of the District which shall not be granted except under special circumstance, consistent with the District's Water Quality Policy.

3.7.2.1. Any person who violates this rule may be subject to criminal prosecution and civil liability.

3.8. USE OF FACILITIES FOR OTHER WATERS

3.8.1. Nothing other than District water, shall be transported through District Facilities at any time, except with the prior written approval of the District. All water transported through District Facilities shall be of a quality and quantity acceptable to the District.

3.8.2. Permission to use District Facilities as set forth in this Section 3.8 is at the sole discretion of the District and the District may impose reasonable conditions on such permission, including but not limited to the right of the District to approve and monitor the transporter's water measurement facilities. Any permission granted shall be revocable by the District at any time.

3.8.3. A service charge will be made by the District for transporting the water of others through District Facilities. The amount of this service charge will be fixed from time to time by the Board. All costs of transporting the water of others through District Facilities shall be borne by the person whose water is being transported.

3.9. MAINTENANCE OF IMPROVEMENT DISTRICT FACILITIES: **REF: [Work Authorization Forms]**

3.9.1. Each active Improvement District shall appoint at least two Improvement District Committee members who shall be authorized to approve all required maintenance and repair work.

3.9.1.1. Facilities maintenance and repair work for an Improvement District is the responsibility of the Improvement District.

3.9.1.2. Improvement District Landowners shall procure and pay for all materials and labor related to such maintenance and repair work. Said costs shall be prorated on a per acre basis unless otherwise agreed by the Landowners.

3.9.1.3. The District may at its discretion, if requested by the Improvement District Committee, provide maintenance and repair services for Improvement District Facilities.

3.9.2. Improvement District Facilities may be cleaned or repaired by the District at the Improvement District's expense when the District determines such action is necessary for the District's operations.

3.9.3. Maintenance and repair of irrigation valve structures on District or Improvement District Facilities are the responsibility of the Landowner of the property being served by those Facilities.

3.10. FLOW THROUGH FACILITIES:

3.10.1. All Private and Improvement District Facilities must be free from weeds and other obstructions, and properly maintained, to permit sufficient capacity to carry the flow of water requested by any Irrigator, without the danger of levee breaks, overflow, or undue seepage.

3.10.2. The District may curtail or terminate the delivery of water to any Private or Improvement District Facility not meeting the above requirements and require the Facility to be cleaned, repaired, or reconstructed before water delivery is restored.

3.10.3. When an Irrigator proposes to convert from one method of irrigation to another, and the change will result in a modified rate of flow, the Irrigator shall first submit the proposed change to the District for approval. The District may impose reasonable conditions in granting its approval.

SECTION 4: DUTIES OF IRRIGATOR

4.1. IRRIGATOR RESPONSIBILITIES:

4.1.1. All land to be irrigated must be properly prepared to efficiently receive the water.

4.1.2. Landowners and Renter shall ensure that there is an Irrigator on the land at all times that water is made available to the land by the District.

4.1.3. The Irrigator shall be responsible for and shall attend and control the water at all times after it leaves District Facilities.

4.1.4. The Irrigator shall use the water continuously, day and night, from the commencement of water delivery until the completion of irrigation.

4.1.5. The Irrigator shall ensure that all irrigation Facilities are in working condition and ready to receive water at the irrigation start time, including but not limited to the opening and closing of valves and gates as needed.

4.1.6. The Irrigator is responsible for priming the pipeline prior to use.

4.1.7. The Irrigator shall close all gates and valves on the Irrigator's Private Facilities at the end of each irrigation.

4.1.8. The Irrigator shall call the Ditchtender immediately after each irrigation to report the irrigation start and stop times. If the Irrigator does not call promptly, irrigation time may be estimated by the District.

4.1.9. As directed by the Ditchtender, the Irrigator shall, at the end of the irrigation, call and notify the next Irrigator receiving water.

4.2. USE OF WATER:

4.2.1. All water must be applied efficiently and used reasonably and beneficially.

4.2.2. Except as otherwise expressly permitted by these Irrigation Rules, all water shall be used solely for irrigation purposes; provided, however, that an Irrigator may use District water for crops related to cultural practices through the normal irrigation schedule.

4.2.3. The District may refuse to deliver District water to any Irrigator who misuses or wastes water either willfully or carelessly, in any way, including but not limited to the following:

4.2.3.1. Flooding of roads, vacant land, or land previously irrigated.

4.2.3.2. Defective or inadequate non-District Canals or Facilities.

4.2.3.3. Inadequately prepared land.

4.2.3.4. Flooding any part of any land to an unreasonable depth or amount, including for the purpose of irrigating other portions of the land.

4.2.3.5. Flooding across one parcel to irrigate another parcel.

4.2.4. Any person, through acts or omissions, allowing water to discharge upon a public road or highway is liable for any resulting damages and may be subject to fines and/or penalties.

4.3. LIABILITY FOR DAMAGE:

4.3.1. The Irrigator is responsible and liable for any damage caused by the Irrigator's failure to fulfill each of the obligations set forth in these Irrigation Rules, by the Irrigator's negligent or careless use or control of water, or by the Irrigator's improper operation or maintenance of any Facility for which the Irrigator is wholly or partially responsible.

SECTION 5: DELIVERY OF IRRIGATION WATER

5.1. WATER ALLOTMENT AND CHARGES: **REF: Irrigation Water Sign-Off Policy, Irrigation Water Activation and Reactivation Policy**

5.1.1. Each year the Board of Directors shall establish the beginning and ending dates for the irrigation season, the quantities of water available for each type and acre of service, the charges for water, the terms for the transfer of water, and the facilities maintenance charge and other charges for service.

5.1.2. All water charges, Improvement District charges and assessments, and other irrigation or drainage related charges shall be due and payable as stated by Board Resolution and notices in billing statements.

5.2. FAILURE TO PAY CHARGES:

5.2.1. The District may refuse to furnish water to any parcel of land if outstanding charges for water or services already furnished or rendered to such land (including any accrued interest and penalties) have not been paid in full by the District's prescribed payment date.

5.2.2. All charges placed on an individual parcel of land are the responsibility of the Landowner. In accordance with the provisions of Section 25806 of the Water Code, delinquent water service charges and/or assessments, together with all imposed penalties, for a parcel of land will be made a lien on the subject real property.

5.3. WATER USER INFORMATION:

5.3.1. Prior to June 1 of each year, each Landowner or designee shall provide to the District a signed statement, on the District's form, of the kinds of crops, and number of acres of each crop that will be irrigated on each parcel of land, and such other relevant information as the District may reasonably require on the same statement.

5.4. IRRIGATION SERVICE:

5.4.1. To schedule an irrigation, the Irrigator must place an order with the Ditchtender. The Ditchtender will generally schedule the delivery within 72 hours, subject to system limitations. In the event that an Irrigator is not ready to receive the water at the scheduled time, the Irrigator will be required to wait until the Ditchtender can reschedule water to the parcel.

5.4.2. Where possible, irrigation water will be provided to the Irrigator based on an arranged demand delivery, under which the delivery rate is fixed, but the frequency and duration of use are requested by the Irrigator.

5.4.3. Where the capacity of the system is limited, rotation delivery may be used by the Ditchtender. The Ditchtender may, at the Ditchtender's discretion, alter the rotation or cause water to be delivered upon request. Advance notice for rotation deliveries will be made with an appropriate amount of warning time to take into consideration the preparation needed to commence irrigation.

5.4.4. The Ditchtender will inform each Irrigator of the anticipated date and time of water delivery to each of the Irrigator's parcel(s) of land. The Ditchtender will provide information on flows, gate and valve operation, and any special instructions related to the delivery sequence.

5.4.5. The Ditchtender will endeavor to meet the scheduled time of delivery within the capacity limitations of the District's Facilities while maintaining efficient and equitable water distribution among Irrigators.

5.4.6. The District shall not be required to raise water in its Canals to any height in order to deliver irrigation water to lands or ditches deemed by the District to be of unusually high elevation.

5.5. MEASUREMENT OF WATER:

5.5.1. All measurements of water delivered by the District to an Irrigator shall be made by the District at the diverting gate or valve in District's Canal, or at such other appropriate location as the District may determine. The District shall maintain records of the names of each Irrigator, the parcel(s) of land that each Irrigator has irrigated, the number of acre feet of water delivered to each parcel, and other information deemed appropriate by the District.

5.5.2. The District has the authority to install or require the installation of irrigation flow measurement devices or structures at all District turnouts.

5.6. REFUSAL OF WATER BY IRRIGATOR:

5.6.1. If an Irrigator fails or refuses to continuously use the full head of water delivered to a parcel of land or scheduled for delivery, then the following shall apply:

5.6.1.1. The full amount of water normally delivered will be charged to the Irrigator;

5.6.1.2. The Irrigator shall not be entitled to use the unused portion of water at any other time;

5.6.1.3. The Irrigator will be required to reschedule for delivery of water.

5.7. INTERRUPTIONS OF SERVICE:

5.7.1. When a break occurs in any water distribution facility requiring an interruption of irrigation service, the Irrigator whose irrigation was interrupted, shall be allowed to finish irrigating when service is restored and shall not claim another irrigation during the affected irrigation cycle or rotation.

5.7.2. Upon completion of the repair, and provided there is no conflict with current usage, the Ditchtender will endeavor to re-establish service based on the original schedule. Where use conflict occurs, service will be restored at the discretion of the Ditchtender.

5.8. SERVICE TO PRIVATE OR IMPROVEMENT DISTRICT SYSTEMS:

5.8.1. Water deliveries to Irrigators who use Private or Improvement District Facilities shall be delivered to the head of these Facilities by the Ditchtender.

5.8.2. Caution is required when priming, operating and closing canal gates in order to avoid damage to Facilities and the disruption of service caused by such damage.

5.8.3. Landowners shall be responsible for the actions of their Irrigators when taking water through and from Private or Improvement District Facilities.

5.9. IRRIGATION OF GARDEN SERVICE PARCELS:

5.9.1. Garden service parcels, which are typically less than five acres in size and separate or distinct from farm service parcels, will be irrigated as a group, where possible, with a standardized rotation irrigation flow consistent with the capacity of the garden service parcel irrigation Facilities. The irrigation rotation is normally established by the Ditchtender, and is subject to modifications by the Ditchtender.

5.9.2. Deliveries of water for irrigation of garden service parcels will be scheduled by the Ditchtender and may be subject to interruption when water is in short supply or otherwise when it is necessary for the proper irrigation of farm service areas.

5.9.3. Unless the District specifically approves a different arrangement in advance, irrigation water for garden service areas will be furnished during one day of each two-week period. Such service to garden service areas shall not interfere unreasonably with the regular irrigation of farm service areas

5.10. UNAUTHORIZED USE OF WATER:

5.10.1. Any person who uses District water without the District's permission may become subject to criminal prosecution and/or civil liability.

5.10.2. Use of District water without the District's permission may result in a forfeiture of the Irrigator's right to receive water on the next scheduled cycle or rotation.

SECTION 6: DRAINAGE TO DISTRICT FACILITIES

6.1. DRAINAGE: REF: **Water Quality Policy, Storm Drainage License Agreement**

6.1.1. Notwithstanding any other provisions of these Irrigation Rules. no surplus irrigation water, storm water, wastewater, tile drainage, or any other water or substance shall be drained, dumped, pumped, siphoned or otherwise discharged into any District Facility without the prior written agreement of the District. In granting permission to discharge, the District may impose reasonable conditions, including, without limitation, the right of the District to approve and monitor the discharger's measurement facilities. Permission to discharge shall be revocable by the District at any time and for any reason.

6.1.2. Water and other substances discharged into District Facilities shall meet all applicable federal, state and local water quality standards.

6.1.3. The rate and quantity of discharge into any District Facility may be subject to limitations based on the capacity of the Facility and the quality of the water or other substance being discharged.

6.1.4. All discharge Facilities shall be constructed at the discharger's sole expense to and must meet the District's construction and engineering design standards.

6.1.5. All existing field drainage Facilities not currently covered by an agreement shall be subject to the District's current terms and conditions.

6.2. TRANSPORTATION: REF: **Rights-Of-Way Policy, Water Quality Policy, Water Transfers to Areas Outside the District**

6.2.1. No person shall transport any water or other substance through District Facilities without the prior written agreement of the District. In granting permission to transport water or other substances, the District may impose reasonable conditions, including, without limitation, the right of the District to approve and monitor the transporter's measurement facilities. Permission to transport shall be revocable by the District at any time and for any reason.

6.2.2. Water and other substances transported through District Facilities shall meet all applicable federal, state and local water quality standards.

6.2.3. The rate and quantity of water and other substances transported through any District Facility may be subject to limitations based on the capacity of the Facility and the quality of the water and other substances being transported.

6.2.4. All transport Facilities shall be constructed at the transporter's sole expense and must meet the District's construction and engineering design standards.

6.2.5. All existing transportation Facilities not currently covered by an agreement shall be subject to the District's current rate, quantity, quality and other terms and conditions.

6.3. DRAINAGE AND TRANSPORTATION CHARGES

6.3.1. All costs of discharging into or transporting through District Facilities, as well as costs of associated carriage loss, shall be borne and paid by the discharger or transporter. A service charge will be assessed by the District for discharging or transporting through District Facilities. The amount of this service charge will be set from time to time by the Board of Directors.

SECTION 7: POLLUTION ABATEMENT

7.1. POLLUTION: **REF: Water Quality Policy, Rights-Of-Way Policy, Procedure for Pick Up and Disposal of Debris**

7.1.1. No Pollutant shall be placed, carried, transported, drained, dumped, pumped, siphoned, discharged, or otherwise allowed to enter into, onto, over, under, along or across any District Facility or associated Right-of-Way without the consent of the District.

7.1.2. Any person who violates this Rule may be subject to criminal prosecution and/or civil liability.

7.2. CLEANUP:

7.2.1. Any person who willfully or negligently causes or permits any Pollutant to be placed, carried, transported, drained, dumped, pumped, siphoned, discharged, or otherwise allowed into, onto, over, under, along or across any District Facility or associated Right-of-Way without the prior written consent of the District shall immediately notify the District and take all action to mitigate the effects of such Pollutant. Such person shall, at that person's sole expense, unless otherwise directed by the District, perform or cause to be performed all necessary remediation to the District's satisfaction and in compliance with all applicable laws. Such person shall cooperate with the District to complete the remediation and shall reimburse the District for all costs and expenses incurred in connection with the remediation, including but not limited to administrative, investigative, and legal costs, fines and penalties.

7.2.2. No water shall be delivered to any parcel of land from which the pollutant originated or to any other parcel of land owned, rented, leased or irrigated by the person who caused or permitted any Pollutant into, onto, over, under, along or across any District Facility or associated Right-of-Way, until the remediation required in Section 7.2.1 is complete, all damages, costs and expenses, arising out of such event have been paid, and action satisfactory to the District has been taken to ensure that such event will not be repeated.

SECTION 8: ENFORCEMENT OF IRRIGATION RULES AND REGULATIONS

8.1. FAILURE TO COMPLY WITH RULES OR REGULATIONS:

8.1.1. Failure or refusal of any Landowner, Renter or Irrigator to comply with any of these Irrigation Rules or applicable regulations, or any part thereof, may be sufficient cause for curtailment or termination of delivery of District water to the lands of such Landowner, Renter or Irrigator.

8.1.2. Interference by any Landowner, Renter or Irrigator with a District employee, agent or official in the discharge of their duties may be sufficient cause for curtailing or terminating delivery of District water to the lands of such Landowner, Renter or Irrigator.

8.1.3. The District may immediately terminate the delivery of District water supplied to any parcel of land if the condition of the land or irrigation Facility present an immediate danger to any person, to the general public, or to any property, including but not limited to the flooding of property.

8.2. RESTORATION OF SERVICE:

8.2.1. Water delivery shall not be restored until full compliance with requirements established by these Irrigation Rules and Regulations is established.

8.3. APPEAL OF A DECISION TO TERMINATE DELIVERY

8.3.1. From a decision of the Ditchtender, an appeal may be made to the Irrigation Manager. From any decision of the Irrigation Manager, an appeal may be made to the AGM. From any decision of the AGM, an appeal may be made to the GM. From any decision of the GM, an appeal may be made to the Board. If an appeal from any decision is not made within fourteen (14) days of the date of the decision, the decision will be deemed final and the failure to appeal a decision in the manner and within the time period set forth above shall constitute a waiver of all rights to further protect, judicial or otherwise.

APPENDIX "A"

FORMS:

AGREEMENTS	TYPE OF DOCUMENT/ PROCESS	CONTACT
Abandon Use of Ditch	Agreement	Irrigation Engineering
Consent to Common Use	Agreement	Irrigation Engineering
Dust Control	Request for Permission	Irrigation Services
Crossing Agreement	Agreement	Irrigation Engineering
Pump Rental	Agreement	Irrigation Services
Sidegate	Application Agreement	Irrigation Engineering
Storm Drainage	Agreement	Irrigation Engineering
Supplementary Pump Water	Application Agreement	Irrigation Services
Owner-Water Transfer	Agreement	Irrigation Services
Sprinkler/Drip	Application and Petition	Irrigation Engineering
Improvement Dist. Work Auth.	Application and Petition	Irrigation Services
POLICIES		
Landowner New Bridge	Review of Plans and Specifications, Approval and Inspection	Irrigation Engineering
Landowner Replacement Bridge	Review of Plans and Specifications, Approval and Inspection	Irrigation Engineering
Irrigation Facility Sign Off	Agreement	Irrigation Engineering
Drainage Facility Sign Off	Waiver	Irrigation Engineering
Irrigation Water Activation and Reactivation	Application Agreement	Irrigation Engineering
Irrigation Rights-of-Way	Agreement and/or Staff Approval for Encroachment Issues	Irrigation Engineering
Landowner Roadway Gate	Application Agreement	Irrigation Engineering
Procedure for Pick-up and Disposal of Debris	Vehicle Tow Request	Irrigation Services
Water Quality Policy:		
X Use of ID Facilities to Transport Manure	Request to Transport Petition to Transport Agreement to Receive Revocable License Agreement	Irrigation Engineering
X Water Transfers to Areas Outside MID	Board Approval, Environmental Documentation and Permit	Irrigation Engineering
Water Transfers (between landowners/properties)	Transfer Agreement	Irrigation Services

PROGRAMS	TYPE OF DOCUMENT PROCESS	CONTACT
Water Conservation Loan	Petition and Contract	Irrigation Engineering
Irrigation Incentive Program		
• Pipeline Conservation Funding	Application Request	Irrigation Engineering
• Sprinkler/Drip	Application and Petition	Irrigation Engineering

	Phone	Address
Irrigation Engineering Office	(209) 526-7571	1231 11th Street Modesto, CA 95354
Irrigation Services Office	(209) 526-7639	929 Woodland Avenue Modesto, CA95351

APPENDIX "B"

Pertinent Provisions of law:

Water Code Section 22257 provides in part as follows:

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

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

Water Code Section 22282.1 provides that:

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

Penal Code Section 592 provides that:

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

PROCEDURES TO ORDER WATER:

A. Prepare your field to receive water.

B. Contact your Ditchtender to place an order.

C. Your Ditchtender will inform you of the time sequence, and other details regarding water delivery.

IRRIGATION EQUATIONS

$$\text{inches of water} = \frac{(\text{cfs flow}) \times (\text{hours irrigated})}{\text{acres served}}$$

$$\text{hours irrigated} = \frac{(\text{inches of water}) \times (\text{acres served})}{\text{cfs flow}}$$

$$\text{cfs flow} = \frac{(\text{inches of water}) \times (\text{acres served})}{\text{hours irrigated}}$$

$$\text{acre feet} = \text{cfs } (\text{hours irrigated } /24)\ (1.983)$$

$$\text{number of acres} = \frac{(\text{cfs flow}) \times (\text{hours irrigated})}{\text{inches of water}}$$

For example, a 20 acre parcel with a standard cfs irrigation flow will receive 6 inches of water in an 8 hour period.

$$6 \text{ inches} = \frac{(15 \text{ cfs flow}) \times (8 \text{ hours})}{20 \text{ acres}}$$

COMMON CONVERSIONS

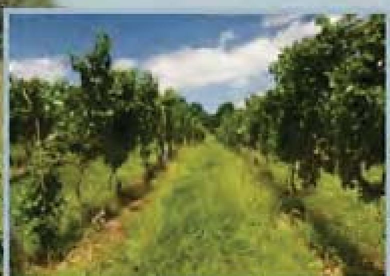
1 cubic foot per second (cfs) = 449 gallons per minute

1 cubic foot per second for 12 hours = 1 acre foot

1 acre foot = 325,900 gallons

1 acre foot = 43,560 cubic feet

An acre foot is the amount of water needed to cover 1 acre with 12 inches of water.



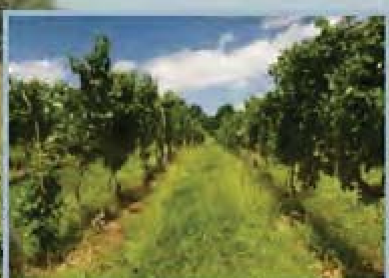
Appendix D

Detailed Information on Water Allocation and Rates

MID/TID Rate Comparison

Year	Base Allotment Tier #1			Base Water Charge Tier #1		Supplemental Water Tier #2		Supp. Water $/AF Tier #2		Supplemental Water Tier #3		Supp. Water $/AF Tier #3	
	MID	Grndwater	TID	MID	TID	MID	TID	MID	TID	MID	TID	MID	TID
1988	Unlimited		12"	$6.00	$4.75	----	18"	----	$10/AF			—	
1989	42"		28"	$6.50	$4.75	Over 42"	6"	$14.00/AF	$10/AF				
1990	42"		30"	$7.00	$4.75	18"	12"	$3.50/AF	$10/AF				
1991	33"		24"	$7.50	$4.75	12"	12"	$7.50/AF	$10/AF				
1992	33"		32"	$7.75	$8.00	12"	12"	$7.80/AF	$10/AF				
1993	42"		48"	$8.00	$10.00	12"	12"	$4.00/AF	$10/AF				
1994	36"		33"	$8.50	$12.50	12"	12"	$4.25/AF	$10/AF				
1995	42"		48"	$9.00	$13.25	18"	12"	$6.50/AF	$10/AF				
1996	42"	0"	48"	$9.50	$14.00	24"	12"	$8.25/AF	$10/AF				
1997	42"	6"	48"	$10.10	$14.00	24"	12"	$8.75/AF	$10/AF				
1998	36"	6"	48"	$11.10	$14.00	30"	12"	$9.00/AF	$10/AF				
1999	42"	12"	48"	$12.20	$14.00	18"	12"	$10.10/AF	$10/AF		12"		$15.00
2000	42"	6"	48"	$13.40	$14.00	24"	12"	$6.70/AF	$10/AF	72" & up	12"		$15.00
2001	42"	0"	42"	$18.00	$14.00	30"	12"	$7.75/AF	$10/AF	72" & up	12"	$20.00	$15.00
2002	42"	0"	36"	$13.90	$14.00	30"	12"	$7.35/AF	$10/AF	72" & up	12" & up	$20.00	$15/AF
2003	36"	6"	42"	$15.30	$14.00	30"	12"	$7.65/AF	$10/AF	66" & up	12" & up	$20.00	$15/AF
2004	42"	0"	45"	$17.00	$17.00	30"	12"	$8.50/AF	$10/AF	72" & up	12" & up	$20.00	$16/AF
2005	42"	6"		$18.70	$20.00	24"	12"	$8.35/AF	$10/AF	72" & up	60" and up	$20.00	$16/AF
2006	42"	6"		$20.50		24"		$10.25/AF		72" & up		$20.00	
2007	36"	6"		$21.50		36"		$10.75/AF		72" & up		$20.00	
2008	36"	0"		$23.50		36"		$11.75/AF		72" & up		$20.00	
2009	36"	0"		$25.50		6"		$12.75/AF		42" & up		$20.00	
2010	42"	6"		$27.00		12"		$13.50/AF		60" & up		$20.00	

Modesto Irrigation District



Appendix E

Groundwater Management Plan: Executive Summary

Executive Summary

Introduction

The Modesto Groundwater Subbasin lies between the Stanislaus River on the north and the Tuolumne River on the south and between the San Joaquin River on the west and crystalline basement rock of the Sierra Nevada foothills on the east. The surface area of the subbasin is 247,000 acres.

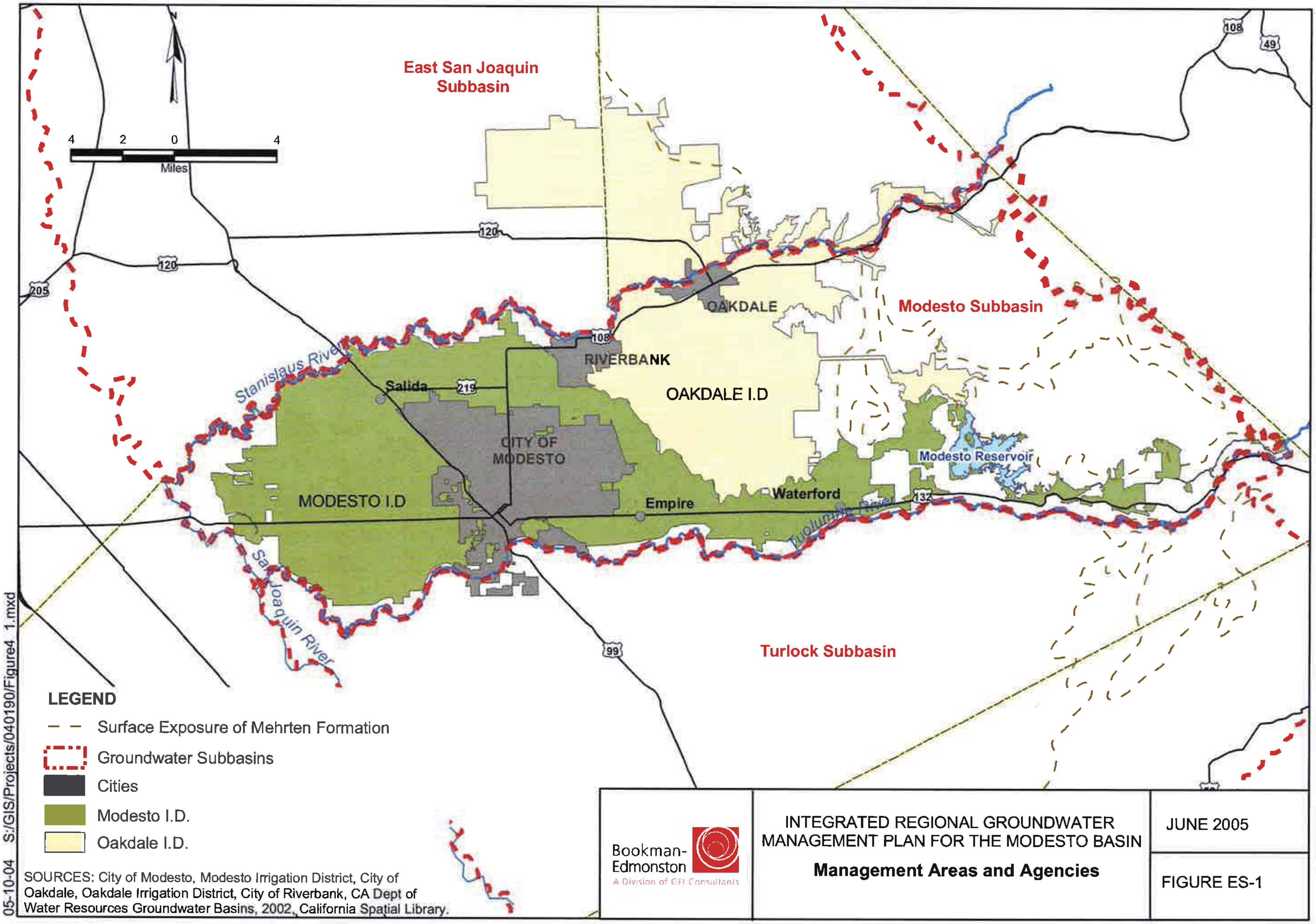
The northern, western, and southern boundaries are shared with the Eastern San Joaquin, Delta-Mendota, and Turlock Groundwater Subbasins, respectively. The major water purveyors in the planning area include the Modesto Irrigation District (MID), the Oakdale Irrigation District (OID), and the Cities of Modesto, Riverbank, and Oakdale.

In April 1994, the five water purveyors were joined by a sixth agency, Stanislaus County, to form the Stanislaus and Tuolumne Rivers Groundwater Basin Association (Association). The Association provides a forum for the coordinated planning and management of the Modesto Groundwater Subbasin and encourages the development of projects and programs that will improve water supply reliability and water quality within the subbasin. Figure ES-1, a map of the subbasin, shows the boundaries of the six agencies.

Since its formation, the Association has been actively engaged in the management of the subbasin. The Association provides its members a vehicle for coordinated planning to make the best use of groundwater and to satisfy the mutual interests of the member agencies. Specific purposes of the Association are to:

- Determine and evaluate the subbasin's groundwater supply
- Promote the coordination of groundwater management planning
- Develop a hydrologic groundwater model of the groundwater basin
- Determine the subbasin's need for additional or improved water extraction, storage, delivery, conservation, and recharge facilities
- Provide information and guidance for the management, preservation, protection, and enhancement of groundwater quality and quantity in the subbasin

In late 2003, the Association began developing an Integrated Regional Groundwater Management Plan (IRGMP) in compliance with the Groundwater Management Planning Act of 2002 (SB 1938) and the Integrated Regional Water Management Planning Act of 2002



Bookman-Edmonston
A Division of GEI Consultants

INTEGRATED REGIONAL GROUNDWATER MANAGEMENT PLAN FOR THE MODESTO BASIN

Management Areas and Agencies

JUNE 2005

FIGURE ES-1

(SB 1672). Throughout the planning process, other interested parties within the subbasin as well as state agencies have been encouraged to participate in the plan's development.

Planning Area

Developed land uses within the Modesto Groundwater Subbasin are concentrated in two major categories: irrigated agricultural and urban land uses. The largest jurisdiction within the subbasin is MID with a service area of 101,700 acres and an irrigated area of approximately 62,000 acres. Nested within MID are the communities of Waterford, Empire, and Salida and parts of Del Rio and Riverbank. Also lying largely within MID is the city of Modesto, which occupies approximately 40 square miles or 25,600 acres. Modesto is in the southwestern portion of the subbasin, and a portion of the city is located south of the Tuolumne River in the Turlock Groundwater Subbasin.

The cities of Oakdale and Riverbank lie in the north-central portion of the subbasin. The southern 60 percent of OID is in the Modesto Groundwater Subbasin and the remaining 40 percent is in the Eastern San Joaquin Groundwater Subbasin.

The Modesto Groundwater Subbasin underlies all of MID, the City of Oakdale, and the City of Riverbank. However, a portion of OID overlies the Eastern San Joaquin Groundwater Subbasin, and a portion of the City of Modesto service area overlies the Turlock Groundwater Subbasin.

Because OID's jurisdictional boundaries reach beyond the boundaries of the Modesto Groundwater Subbasin, the study area has been extended to include OID's complete jurisdiction. A similar water planning effort is under way in the Turlock Groundwater Subbasin, and the portion of the City of Modesto service area within the Turlock Subbasin is covered in the Turlock groundwater planning process.

The entire subbasin and planning area lies within Stanislaus County.

Description of the IRGMP

This IRGMP has been prepared in accordance with requirements of SB 1672 (California Water Code Section 10540 *et seq.*) and SB 1938 (California Water Code Section 10750 *et seq.*). As such, the plan includes components of AB 3030, SB 1938, and SB 1672.

The purpose of this IRGMP is to provide a framework for coordinating groundwater and surface water management activities into a cohesive set of management objectives and for implementing the actions necessary to meet those objectives.

The goal of the IRGMP is to integrate the use of groundwater and surface water within the Modesto subbasin to ensure the reliability of a long-term water supply that will meet current and future beneficial uses including agricultural, industrial, and municipal water requirements while protecting the environment. Attaining this goal requires measures that enable the efficient use of groundwater and surface water and measures that protect water quality.

The overriding objective of the IRGMP is to improve the regional and local management of water resources through the formulation and implementation of Basin Management Objectives (BMOs).

Regional Priorities

The IRGMP recognizes that the most effective approach to managing a basin's water resources is enlisting the cooperation of the agencies whose political boundaries match the basin's physical boundaries. For this reason, the IRWMP frames specific water management projects in the context of an integrated regional strategy. Although the plan emphasizes groundwater management, elements of the plan address the use of surface water supplies, water conservation, and water recycling and blending to meet demands that have previously been met with groundwater. This integration of surface water and groundwater resources leads to a more comprehensive management of water supplies and provides a lucid framework for complying with state and federal water quality standards. The primary regional objective is the preservation and protection of the basin's water resources for the benefit of inhabitants of the region. Specific regional objectives include:

- Improve local water supply reliability
- Protect the groundwater resources of the region
- Improve water quality
- Foster prudent stewardship of water resources
- Facilitate compliance with local, state, and federal water quality and public health regulations.

Local Priorities

In addition to the statewide and regional priorities, the IRGMP addresses local issues by presenting BMOs that have been developed to meet the particular management needs of each of the participating agencies. Local BMOs are specific approaches to water management goals including groundwater supply, groundwater quality, and protection against inelastic land surface subsidence. Because they are presented within the context of a basin-wide plan, the local BMOs illustrate the degree to which many BMOs are common to more than one of the participating agencies. This suggests that in certain instances, implementation of local BMOs may best be achieved through cooperation among participating agencies. The most prominent of the local priorities is protection of groundwater quality through monitoring and control of contaminant plumes.

Statewide Priorities

Implementing the IRGMP will enable the Association and its member agencies to respond to a range of statewide water management initiatives. Key among these is the increasing emphasis placed on developing integrated regional solutions to water management problems and coordinating the conjunctive management of surface water and groundwater to improve water supply reliability and water quality.

In particular, by promoting effective water use in the Modesto Groundwater Subbasin, the implementation of the IRGMP will:

- Increase California's water supply reliability
- Reduce conflicts among water users
- Contribute to meeting Delta water quality objectives
- Assist in the implementation of Regional Water Quality Control Board Watershed Management Initiatives chapters, plans, and policies

Regional BMOs

Specific water management strategies developed during the formulation of the IRGMP are expressed by the regional BMOs agreed upon by all of the participating agencies. The following specific regional BMOs are presented in the IRGMP:

- **Identification of Natural Recharge Areas:** Groundwater recharge has diminished because the expansion of urban areas and trends in agricultural irrigation practices have reduced the deep percolation of applied water. These trends underscore the need to identify and protect remaining natural recharge areas.
- **Development of a Basin-Wide Water Budget:** A basin-wide water budget will describe the pathways by which water enters and leaves the basin. This budget will offer a tool for comparing inflows, outflows, and changes in storage under historical and present conditions with flows and changes in storage that may exist after the implementation of specific BMOs.
- **Feasibility Evaluation of Artificial Recharge Projects:** The basin-wide water balance will reveal whether the basin is in overdraft and will illustrate trends in groundwater recharge and groundwater use. If the water balance demonstrates either that the basin is in overdraft or is likely to fall into overdraft in the near future, artificial recharge basins may be needed to supplement recharge from natural recharge areas.

- **Management and Optimization of Well Field Operation:** A component of improved groundwater management is the optimization of well operations to accomplish specified management objectives. For example, each well in a well field can be instrumented and controlled so that a group of wells can be operated to meet single- or multiple-objective functions.

  In addition, well field optimization can support water quality objectives by reducing agricultural outflows to streams and by blending groundwater with surface deliveries. For example, agencies within the basin could evaluate an expansion of the blending program in order to control shallow groundwater and improve downstream water quality.

- **Identification and Feasibility Study of Conjunctive Use Projects:** Many of the management actions described above can be viewed as components of a broader conjunctive management program whose goal is an integrated approach that balances surface water and groundwater use. Implementation of a conjunctive management strategy may involve reduced groundwater pumping in some parts of the basin and broad controls on pumping to meet target groundwater levels. An important regional conjunctive use initiative is the Modesto Regional Water Treatment Plan, which has reduced demand for groundwater by storing and treating surface water. Because of its success, this project is being expanded.

- **Support of Public Health Programs:** Well construction and demolition standards are designed specifically to protect groundwater quality. Management actions to assist local agencies in complying with public health standards include the following components:

  - Installation of sanitary well seals on all new wells in accordance with the California Well Standards

  - Abandonment of wells in accordance with the California Well Standards

  These actions will be particularly valuable in unincorporated areas not served by a water purveyor.

- **Water Quality Management:** The protection of groundwater quality is of increasing concern because the basin's population is growing. This management action would include a detailed geologic assessment of the basin that would focus on the areas with poor water quality and identify the sources of the contaminants. This assessment would result in coverage on a GIS system for mapping recharge areas and would be used to develop strategies to control the migration and movement of poor quality water into and throughout the basin.

- **Groundwater Monitoring and Subsidence Monitoring Program:** Groundwater monitoring and analysis and the archiving of collected data will be needed to implement several of the recommended management actions (e.g., conjunctive management and optimized operation of well fields) and to meet the reporting requirements of the plan. The Association is developing a database to facilitate the storage, retrieval, and archiving of groundwater data. Monitoring data will be important in the development and calibration of the basin-wide groundwater model that will be used to evaluate the effects of proposed projects and management actions.

  The Association plans to monitor and measure the rate of inelastic land surface subsidence within the basin. Given the ongoing efforts by Association members to prevent groundwater overdraft and conditions that might lead to subsidence, it appears unlikely that the insignificant subsidence that has occurred historically within the basin will be accelerated. However, the Association plans to monitor and document any future changes in land surface elevations and, if inelastic subsidence is observed, may recommend necessary actions.

- **Policy Assessment:** Several of the technical management actions introduced above have clear policy requirements and implications. For example, effective protection of natural recharge areas will require coordination and communication with entities responsible for land use policies. Similarly, annexations to expand agencies' service areas as part of an in-lieu recharge program presume clear policies regarding annexation and a process to evaluate the impacts of annexation on groundwater levels and groundwater quality.

  The development of consistent policies would be assisted by a regional groundwater forum such as the Association. The Association could promote interagency relationships that would foster coordination and cooperation among participating agencies to manage the Modesto Groundwater Subbasin and would provide a framework for the formulation of regional projects and programs for the protection and use of the subbasin's water resources.

  For example, given the mutual concern of agencies within the basin regarding preserving natural recharge areas and protecting these areas from pollutants, local agencies could work together to inform one another about land use practices that may contribute to groundwater degradation and the importance of reducing the occurrence of these land use practices.

- **Promoting Cooperation and Coordination Between Water Entities:** The Association will continue to coordinate water management activities within the basin and to work cooperatively for the implementation of agreed-upon BMOs. It will also develop an outreach and educational program to engage other water interests in the management of the basin. One example of such outreach will be working cooperatively with industrial water users to improve water levels and water quality in the basin and to reduce localized well interference.

Water Management Strategies

The regional BMOs described above have been developed to support a comprehensive approach to managing water resources in the Modesto Groundwater Basin. In particular, these BMOs provide a framework for developing projects that will advance the following water management strategies:

- **Increase Local and Regional Water Supply Reliability and Water Use Efficiency:** BMOs supporting conjunctive management, policy assessment, and development of a basin-wide water budget will be key to the implementation of this strategy.

- **Promote Groundwater Recharge and Management:** BMOs encouraging the identification of natural recharge areas and the evaluation of artificial recharge areas will be used to implement this strategy.

- **Support Water Conservation:** Development of a basin-wide water budget will be used to identify water conservation opportunities, and the management and optimization of well field operations will be used to reduce spillage from irrigation distribution systems.

- **Implement Watershed Management Programs:** This strategy will be implemented through policy assessment, identification of natural recharge areas and evaluation of artificial recharge projects.

- **Promote Water Recycling:** Management and optimization of well field operations, groundwater monitoring, and development of artificial recharge projects offer opportunities for the management and use of recycled water generated by municipalities and industries in the planning area.

- **Foster Conjunctive Use:** The BMO dedicated to the identification and study of conjunctive use projects focuses on developing conjunctive management in the Modesto Groundwater Subbasin. Other BMOs addressing natural and artificial recharge, groundwater monitoring, well field optimization, and policy assessment will also contribute to planning and implementation of conjunctive use.

- **Improve Water Quality:** The water quality management BMO, groundwater monitoring, and the management and optimization of well field operations will all be important BMOs for improving water quality.

- **Improve Storm Water Capture and Management:** BMOs that support public health programs and that call for capturing storm water in dry wells and in natural and artificial recharge facilities will reduce storm water discharges.

Other regional water management elements such as provisions for recreation and environmental and habitat protection are addressed in other planning documents prepared by the participating agencies.

Public Involvement

The six agencies forming the Association share groundwater and surface water resources and worked together to formulate this management plan. Throughout this planning process, other interested agencies and entities within the subbasin were encouraged to participate. The Association will work with its member agencies and other entities to implement the components of this plan. The County of Stanislaus, as a member of the Association, represented other self-supplied groundwater producers. An extensive public involvement process was also followed during the IRGMP's development to enable stakeholder participation in the planning process.

In addition to public stakeholders, key local, state, and federal government agencies have contributed to the IRGMP. In mid-2004, the Association engaged in discussions with the Department of Water Resources to initiate a cooperative relationship for the conjunctive management of the basin. As a result of these discussions, the Association and the Department of Water Resources signed a Memorandum of Understanding to work together to develop conjunctive use projects.

For the last several years, the Association has been working cooperatively with the U.S. Geological Survey to study the geology and aquifers of the Modesto Groundwater Subbasin. The Association and the U.S. Geological Survey have entered into an agreement, under the National Water-Quality Assessment Program, to map the subsurface geology of the basin and to develop a data network and three-dimensional model of the basin.

The Association's member cities are also working with the Department of Health Services on issues related to compliance with Title 22, Drinking Water Quality Standards.

Plan Implementation

A key feature of the IRGMP implementation is the establishment of linkages among program actions. These linkages transform individual implementation activities into a coherent program where the whole is greater than the sum of the parts with respect to achieving regional water management objectives.

Implementation of the actions recommended in the IRGMP is scheduled in three phases:

- **Phase I—Near Term Projects**: These projects are intended to be implemented within the next three years and include:
  - Management of the well fields: A decision support system to assist the districts to optimize groundwater production from their well fields, based on a set of established objectives
  - Additional water blending projects: To help agencies meet their water quality objectives while increasing the beneficial use of groundwater
  - Water conservation projects, including agricultural and urban water conservation projects
  - Identification of conjunctive use project concepts
  - Increase treatment capacity for the City of Modesto
  - Development of a three-dimensional groundwater model
- **Phase II—Mid-Term Projects:** These projects are planned for implementation in four to seven years:
  - Identification of groundwater recharge areas
  - Rock well monitoring
  - Development of conjunctive use projects
  - Development of the in-lieu recharge projects, including evaluation of annexation options to reduce groundwater pumping
  - Development of a basin-wide database
- **Phase III—Long-Term Projects:** These projects are scheduled for implementation beyond seven years in the future and include:
  - Installation of subsidence monitoring station if needed
  - Water exchange program
  - Update water budget
  - Feasibility evaluation of artificial recharge projects

Other water management actions may continue throughout the planning horizon, including:

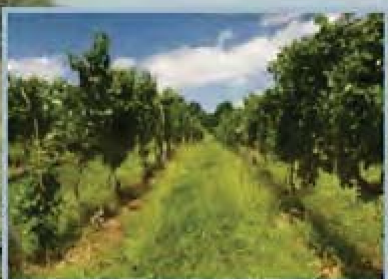
- Monthly Association meetings
- Preparation of annual progress reports
- Groundwater monitoring and data sharing
- Coordination and cooperation with water entities, neighboring basins, and state and federal agencies
- Periodic review of groundwater monitoring and groundwater management

Progress toward the implementation of the IRGMP is contingent upon securing funding to complete the program. Two available avenues are grant funding and funds generated internally by the Association members.

Modesto Irrigation District
Water and Power

Appendix F

SBx7 Compliance for Agricultural Irrigation Districts



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IRRIGATION TRAINING & RESEARCH CENTER

SBx7 Flow Rate Measurement Compliance for Agricultural Irrigation Districts

SBx7 Compliance

Aug 26, 2012

IRRIGATION TRAINING & RESEARCH CENTER

Prepared by
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Irrigation Training & Research Center
Updated October 2012

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GROUPED DELIVERIES

Senate Bill x7-7 (SBx7-7) requires documented volumetric accounting to individual turnouts for water deliveries. Section 597.3 of the bill lists two very different requirements for devices (***bold, underlined, italics*** have been added for emphasis):

- Section 597.3(a) discusses measurement devices that must be used at points where there is a reasonable degree of flow rate control.
- Section 597.3(b) states that "An agricultural water supplier may measure water delivered at a location upstream of the delivery points or farm-gates of multiple customers using one of the measurement options described in §597.3(a) if the downstream individual customer's delivery points meet ***either*** of the following conditions:

    A. The agricultural water supplier does not have legal access to the delivery points of individual customers or group of customers to install, measure, maintain, operate, and monitor a measurement device.

    Or,

    B. An engineer determines that due to small differentials in water level ***or*** large fluctuations in flow rate or velocity that occur during the delivery ***season*** at a single farm-gate, accuracy standards of the measurement options in §597.3(a) cannot be met by installing a measurement device or devices (manufactured or on site built or in-house built devices) with or without additional components (such as gauging rod, water level control structure at the farm-gate, etc.).

This last section (B) in essence defines the most downstream point of measurement to be located at the "hand-off point".

The "hand-off point" can be defined as the location, moving downstream in the branching hydraulic network, below which the irrigation district no longer has good control over the flow rates that go to individual farm-gates.

For example, one might consider using a ditch or pipeline with a rotation delivery schedule, with one "head" or delivery at a time. That single "head" or flow rate is rotated among users, one at a time. There is no control over flow rates at individual turnouts (along that ditch or pipeline); the flow rate is controlled at the head of the ditch or pipeline.

This is also true of ditches or pipelines with a rotation delivery schedule, with two or three "heads" or deliveries. These systems typically have little or no precise flow control downstream of the heading. In some districts, the delivery points are not even to a field; the distribution pipelines have alfalfa valves for each border strip that is irrigated. When there is an internal splitting of two "heads", it is done without the benefit of the structures that provide good water level or pressure control.

While it may be possible in many cases to install flow measurement devices within these pipelines or canals, the measurement would be of uncontrolled flows unless the pipelines or canals were substantially modified. In other words, "additional components" besides the flow measurement devices would be required.

Rice systems are a special category, as good water management of rice irrigation is premised on maintaining a target water level in the fields, rather than on delivering a specific volume to a specific field.

That said, with traditional rice laterals, or with traditional rotation laterals, it is entirely reasonable to require farmers with new pressurized systems on such ditches/pipelines to install magnetic meters or propeller meters on their systems. Such flow measurement installations are rather typical and do not represent technical or fiscal challenges for implementation.

Conclusions

1. The wording of SBx7 appears to clearly indicate that the proper, most downstream flow measurement location would be at the head of any "community ditches". "Community ditches" (sometimes called "improvement districts") are defined as privately owned distribution systems that receive water from the irrigation district. The distribution, partitioning, and scheduling of water deliveries within the "community ditch" is not done by irrigation district personnel.
2. Irrigation district ditches and pipelines that are operated on a rotation schedule need an accurate flow measurement device at the head of the ditch or pipeline, but not at individual delivery points within/along the ditch or pipeline that receives water on a rotation schedule. This pertains to ditches and pipelines that are owned either by improvement districts or by irrigation districts.
3. Individual delivery points with pressurized irrigation systems that receive water from an irrigation district ditch or pipeline that is primarily a "rotation" system must be individually metered.

Note: The phrase "irrigation district" encompasses a wide range of district types including reclamation districts (e.g., RD108), water districts (e.g., Coachella WD), irrigation districts (e.g., Modesto ID), and Water Storage Districts (e.g., Buena Vista WSD).

FLOW RATE VS. VOLUMETRIC ACCURACY

SBx7 requires the verification of the accuracy of annual volumes provided at delivery points.

- For devices **with** totalizers, it can be assumed that:

  Flow rate accuracy = Volumetric accuracy

- For devices such as meter gates and orifice plates that do **not** have totalizers, the flow rate accuracy may only be part of the total desired 12% volumetric accuracy. The annual volumetric accuracy of any such single turnout depends upon errors due to:
  - IFR – Instantaneous flow rate error
  - CWLF – Canal water level fluctuations, or pipeline pressure fluctuations over time. The impact of these fluctuations are mostly self-canceling over the course of an irrigation season. This is discussed later in this report.
  - CBP – Changes in "backpressure". Backpressure is the pressure on the downstream side of the flow measurement device.
  - ARD – Accuracy of the recording of durations. For example, if an actual delivery lasts for a total of 25 hours but it is recorded and billed as a 24-hour delivery, this would be an error of one hour, or 4.2%

These inaccuracies must be mathematically combined to determine the total volumetric accuracy.

$$Volumetric\ accuracy = 100\ \times \left[1 - \sqrt{(IFR)^2 + (CWLF)^2 + (CBP)^2 + (ARD)^2}\right]$$

For example, assume the following errors expressed as decimals rather than as percentages. These are plus/minus errors ("within 5%" means "within +/- 5%"):

IFR is within 5% (IFR =.05)   CBP = .03
CWLF = .02   ARD = .04

Then,

$$Volumetric\ accuracy\ (VA) = 100\ \times \left[1 - \sqrt{(.05)^2 + (.02)^2 + (.03)^2 + (.04)^2}\right]$$

VA = 92.7 = 93%

The errors are independent of each other. Therefore, the total error does ***not*** equal the sum of the errors (14%), which would incorrectly indicate an 86% accuracy.

The maximum acceptable flow rate measurement error (expressed as a decimal) equals:

$$\text{Max. acceptable device flow rate error} = \sqrt{(1 - \frac{VA}{100})^2\ -\ ARD^2 - CBP^2 - CWLF^2}$$

For example, if the required volumetric accuracy (VA) = 88% (88) (i.e., within 12%) and:
ARD = .04   CBP = .03   CWLF = .02

Then, the maximum acceptable device flow rate accuracy error = 0.107 = 10.7%

That is, this specific device, when tested at a specific representative flow rate, must be within 89.3% accuracy.

IMPACT OF CANAL WATER LEVEL CHANGES ON ANNUAL VOLUMETRIC ACCURACY

Background

The volume delivered through flow measurement devices without totalizers is computed as:

$$\text{Volume} = (\text{Flow Rate}) \times \text{Time}$$

The flow rate is typically checked once per day, and a new flow rate is either noted on the records, or the flow rate control device is re-adjusted to provide the target flow rate.

During any 24-hour period, the canal water levels will fluctuate, resulting in a delivery of more or less flow rate than was originally set.

The question addressed in this section is: Over the course of an irrigation season with ten, twenty, or thirty 24-hour irrigation events, do these minute-to-minute fluctuations cancel out? If they do, this will remove the "CWLF" (discussed in the previous section) from consideration.

To examine this, ITRC obtained water level data from multiple locations throughout San Luis Canal Company, over a time period from June 8 to July 11, 2012. Canal levels were recorded automatically on an hourly basis. The total change in water level across the turnout [(water surface in the canal) - (water surface in the downstream ditch)] was also recorded at the start of each datalogging session. The irrigation district has typical flashboard check structures to maintain water levels in the majority of its locations.

A series of 22 sites were analyzed for 48-72 hours. It is believed that these sites are representative of the range of conditions throughout the district. No special management of the check structures was involved; the canal operators were unaware that the levels were being recorded.

Error Analysis

Water Level Error Model

In order to assess the error of volumetric flow rate measurement in the canal system, first the fluctuations in water level must be computed. A model was constructed to measure the percent error of the water level over a 24-hour period from a given starting point in the sample set.

The raw data was normalized so that canal fluctuations would be represented as a percentage of the head difference. In this way, all the data points could be accumulated to create a contiguous set of hourly fluctuations for the model data set. The resulting model contains a total of 5500 hourly data points.

Sample Set

A sample set was generated from the model. The sample set contained three different blocks. Each block had 30 different seasons with varying numbers of irrigations events per season. Block 1 had 30 seasons of ten 24-hour irrigations, Block 2 had 30 seasons of twenty 24-hour irrigations, and block 3 had 30 seasons of thirty 24-hour irrigations.

The starting points for the irrigation events in each season were selected by a random number generator. The error was recorded for each hour from the starting point for a total 24 hours. Thus, each irrigation event consisted of 24 data points, resulting in a total of 21,600 data points sampled for all of the seasons in all 3 blocks.

Results

If the present water level for a moment during an irrigation event in the model is equal to the starting water level for that event, then the percent error at that moment is zero. The percent error at each recorded time during an irrigation is calculated by the following equation:

$$\%\ Error\ at\ a\ moment = \frac{Present\ Water\ Level - Initial\ Water\ Level}{Initial\ Change\ in\ Head} \times 100$$

Where "Initial Water Level" is the water level when the 24-hour irrigation began.

The characteristics of the population of "errors" in water level are shown in the figure below.

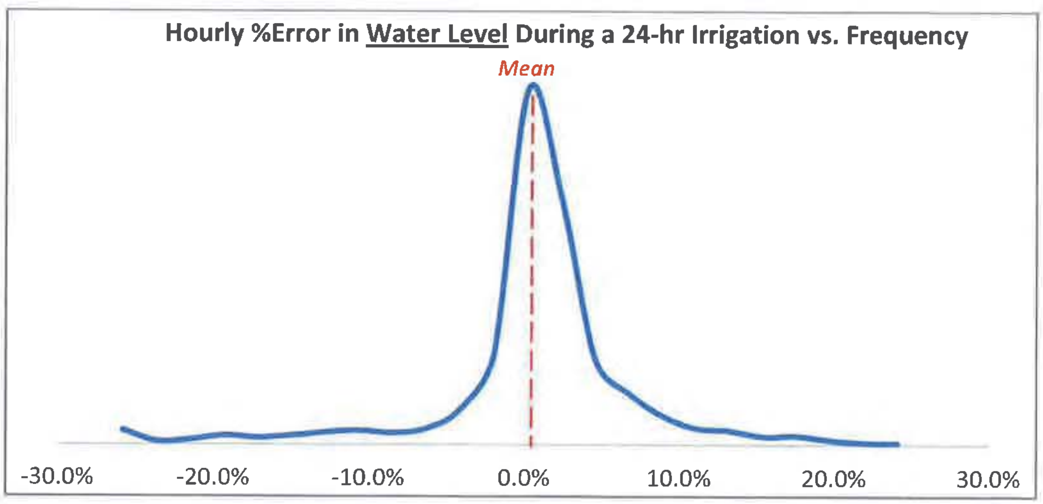


Figure 1. Sample distribution for hourly % error in water level vs. frequency

The variation in relative water levels over time is interesting, but of more interest is the impact on turnout flow rates. There are two possible situations, described below:

1. The flow measurement device is operated under "free flow". That is, the water jets out from it, and the flow rate through the orifice device is not affected by changing downstream water levels. The variation in flow rate over time can be computed, based solely on the upstream water level change. In this case, the sensitivity of the turnout flows to canal water levels is computed as:

$$Free\ Flow\ Error = (1 + Level\ Error)^{0.5} - 1$$

2. The flow measurement device operates under a "submerged" condition. In this case, what happens is that if the canal water level changes, the flow through the measurement device increases. But that also results in a rise in the downstream water level. This provides a "pressure compensating" effect. The total head change is less than the change in the canal water level. ITRC has examined a number of possible downstream channel conditions, and uses the following equation to estimate the effect of a change in canal water level:

$$Submerged\ Flow\ Error = (1 + Level\ Error)^{0.38} - 1$$

For each block (group of 30 randomly selected seasonal irrigation cycles), the mean and standard deviation of the error were computed. **Figure 2** shows the results of the analysis. The mean error is plotted for each block along with the standard deviations. The red bars are 1 standard deviation above the mean, and the green bars are 1 standard deviation below the mean.

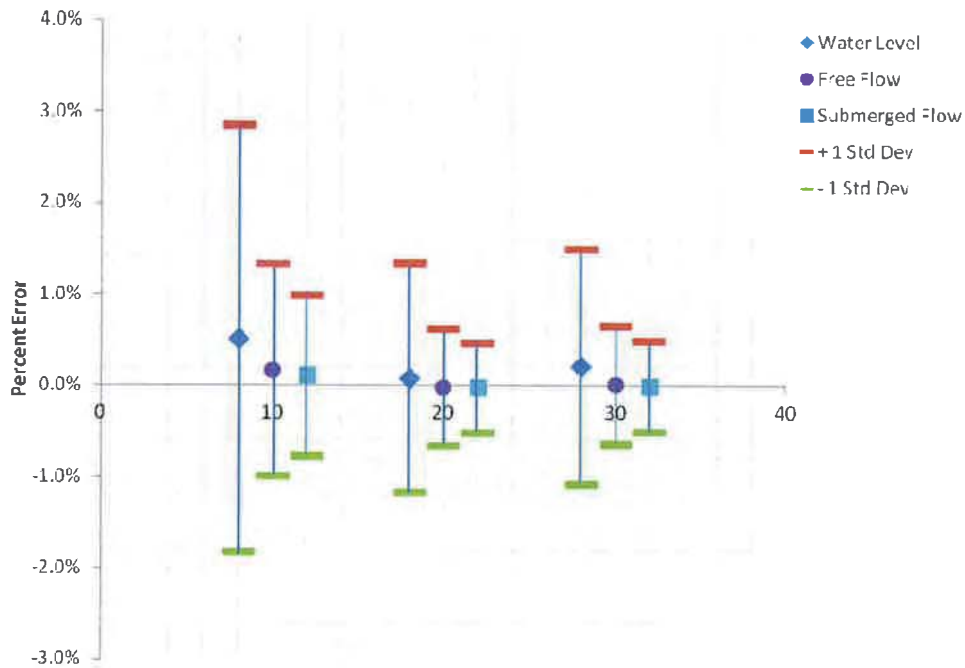


Figure 2. Means and standard deviations for each block

Conclusion

For the condition of 10 irrigations per season, the seasonal flow rate error due to fluctuating canal water levels averages less than 0.2%, regardless of whether the turnout is free flow or submerged flow. The average seasonal error for 20-30 irrigations per season is almost 0.0%.

Because most irrigation districts deliver more than 10 irrigations per season, it appears that a reasonable estimate of the annual volumetric error due to a fluctuating canal water level is about +/- 0.5%, when one considers one standard deviation from the mean.

While this data originated in a single district, ITRC believes that the conditions are representative of "typical" canal districts, based on experiences in about 150 irrigation districts in the western U.S. The exception would be the few irrigation districts that have a very extensive distribution of long-crested weirs or ITRC flap gates throughout the canals. An extreme example would be Modesto ID, in which case almost every check structure is a long-crested weir. In that case, the seasonal impact of fluctuating canal water levels is likely 0.0%, for all practical purposes.

SELECTION OF A REPRESENTATIVE SAMPLE FOR VERIFICATION OF ACCURACY

California Legislature SBx7 requires flow measurement devices to be within a required level of accuracy. For existing flow measurement devices, the acceptable error for volumetric flow measurement is ±12% as stated in §597.3(a)(1). Initial certification of existing devices requires a random and statistically representative sample set or an accepted statistical methodology as described in §597.4(a)(1) and §597.4(b)(1). This document defines a statistical methodology that can be used to provide good information that meets both the intent of SBx7 and the needs of the irrigation districts.

Background

Representative Sample

Irrigation districts have turnouts with flow measurement devices that supply water to areas with correspondingly varying annual delivered volumes. The selection process defined below is intended to define how to select a representative sample set of flow measurement devices for verification of volumetric measurement quality in the district as whole.

In an irrigation district with a wide range of acreages downstream of flow measurement devices, a simple random selection of measurement devices would statistically over-emphasize the importance of small delivery points. The sampling may only represent a very small percentage of all the water delivered in the district. The volume delivered through a turnout is related to the size of the area irrigated. Therefore, it is better to weigh the importance of each measurement device according to the area it services, rather than weighing all turnouts equally. Thus, the sample of flow measurement devices to be tested will be constructed using a ***probability-proportional-to-size (PPS)*** sampling method so that the likelihood of inspection for a given flow measurement device will be proportional to the acreage served by that device.

Considerations for Availability

Ideally, all the devices would be randomly selected by the PPS sampling process mentioned above, and then the selected devices would be evaluated for accuracy. However, only some percentage of the turnouts will be operating at a given time. Therefore, if a turnout is selected in a purely random manner, the customer served by that turnout may not be ready to irrigate, prohibiting evaluation of the flow measurement device at that turnout. It is also clear that even if farmers are scheduled to receive water from a turnout on a specific date/time, they do not always irrigate on that schedule; this makes advance and careful scheduling of field evaluations problematic.

A solution to this is to use ***opportunity sampling*** in combination with ***sampling quotas***. An opportunity sample is composed of samples taken as they are available or convenient. Since device availability will be an issue, devices should be inspected when they are available.

Point #1: To ensure that the data set is representative of the district's overall volumetric flow measurement, a minimum of 10% of the district's service area (or volume) should be represented by the combined service acreage for the turnouts in the sample set.

Point #2: To meet the SBx7 requirements, the minimum sample size of 5 and maximum of 100 for a particular device type should be evaluated.

Point #3: Two scenarios for sampling are described in this document:
- Advance Probability-Proportional-To-Size (PPS) Sampling
- Opportunity Sampling with a consideration of PPS

Scenario 1: Acreage-Based Sampling Using Probability-Proportional-to-Size (PPS)

Scenario 1 is the ideal situation, where at any given time all turnouts will be available for inspection.

Background

Representative Sample Selection

Flow measurement devices in a district will be assigned a number ***range*** based on the acreage (or known annual volume) that the devices serve (e.g., a turnout servicing 10 acres may be assigned 10 numbers such as 61-70). This numbering will have a logical sequencing that is appropriate for the given district. A random number generator will then be used to select a device from the developed sequence. In this way each device will be weighted in selection by the acreage it serves. Specifically, the sample will be skewed favoring devices that measure greater volumes of water. This will ensure that the random sample will be statistically representative of the overall accuracy of flow measurement within the district.

Random Selection Process

A random number generator will be used to select a device to be tested. If the number produced by the random number generator is within the range assigned to a device, then that device will be tested. Once a device has been tested, its range will no longer be considered in the selection process, and numbers randomly generated in its range will be ignored. This procedure will be improved from the example given in §597.4(b)(1), in that devices providing at least 10% of the district volume or acreage (rather 10% of the devices) will be tested, with a minimum of 5 devices, and not to exceed 100 individual devices of a certain type.

Device Types

It is important to take note of device types for this legislation. If 25% of existing devices (as estimated from the properly selected sample) of a particular type are not in compliance with ±12% accuracy requirements, the district must develop a plan to test another sample of measurement devices of this type as stated in §597.4(b)(2). This document interprets the intent of the legislation as applying to 25% of water delivered, rather than 25% of existing devices. For illustration, in the extreme case of a district with the following:

- 100 garden plots of 0.25 acres each, each with a measurement device (25 acres total)
- 50 larger fields of 80 acres each, each with a measurement device (4000 acres total)

Certainly, careful irrigation water management would not focus on the large number of very small plots that represent less than 1% of the total acreage. This document therefore assumes that the proper interpretation is to focus on reasonable measurement of at least 25% of sample water volume, rather than 25% of the sample devices.

Step 1: Assign Sequence Range Numbers to Each Turnout

Table 1 describes a sample scenario and shows a sequence range of number assignments for each turnout. The district in the sample scenario has one lateral with 10 turnouts serving a varying array of acreage.

Table 1. Example of assigning sequence range numbers

Turnout #	Acreage Served	Sequence Range From	Sequence Range To
1	10	**1**	**10**
2	10	**11**	**20**
3	15	**21**	**35**
4	15	**36**	**50**
5	2	**51**	**52**
6	2	**53**	**54**
7	5	**55**	**59**
8	5	**60**	**64**
9	50	**65**	**114**
10	50	**115**	**164**
Total	**164**		

Note that the final sequence number should be equal to the total acreage

Each turnout is assigned sequence range numbers based on their acreage. Turnout 1 is assigned the sequence range from 1 to 10 because it has 10 acres, and Turnout 2 is similarly assigned 11 to 20. Turnout 3 is assigned a longer sequence range, from 21 to 35, because it has 15 acres. Turnouts are continued to be assigned sequence range numbers in this fashion. As a result of this sequence range numbering, each turnout will represent a portion of the total 164 acres.

Step 2: Use a Random Number Generator to Select Turnouts

Use a random number generator to choose a number between 1 and the total acreage of the district. A random number generator can be a software program or simply pulling numbers out of a hat. In the example above the random number generator would pick a number between 1 and 164. If the number produced by the random number generator is between the sequence range numbers assigned to a device, then that device will be tested.

> Repeat this process until devices representing 10% of the acreage served (or volume delivered) have been selected with a minimum of 5 and a maximum of 100 per device type.

Continuing with the example data set above, assume that the first numbers selected by the random number generator were: 17, 24, 157, 156, 53, 42, 41, 36, 2, 12, and 52.

Eliminate duplicate turnouts, starting from the first random number.

With this random selection of numbers, the following turnouts are selected:

2 (selected by number 17; 12 is a duplicate)
3 (selected by number 24)
10 (selected by number 157; 156 is a duplicate)
6 (selected by number 53)
4 (selected by number 41; 41 and 36 are duplicates)

This provides the minimum number of 5 turnouts. Now, the acreage must be checked to verify that the selection represents more than 10% of the acreage (or volume).

Table 2. Example of randomly <u>selected</u> sample set

Green rows indicate the selected devices for the sample set

Turnout	Acreage Served		Sequence Range	
#	Acres	% of Total	From	To
1	10	6%	1	10
2	10	6%	11	20
3	15	9%	21	35
4	15	9%	36	50
5	2	1%	51	52
6	2	1%	53	54
7	5	3%	55	59
8	5	3%	60	64
9	50	30%	65	114
10	50	30%	115	164
Total	**164**	**100%**		

The five turnout samples represent 55% of the total acreage.

Therefore, this sample set meets the criteria of:
- greater than or equal to 10% of the acreage, and
- a minimum of 5 turnouts of a particular type - assuming all are the same device.

Note: If there is more than one device, this process would be repeated ***by device***. The final criteria to be met are:

- Including all device sample sets, at least 10% of the district acreage (or volume) must be accounted for.
- A minimum of 5 turnouts of a particular device, for each device.
- No more than 100 of any particular device.

Step 3: Evaluate Selected Turnouts and Record Data

Once the turnouts have been selected, evaluate each flow measurement device for accuracy. Record gate type, total acreage serviced by the device, and measured accuracy. This data will need to be retained for ten years or two Agricultural Water Management Plan Cycles as per 597.4(c).

To continue the example, **Table 3** shows how data should be recorded for the example district. For simplicity, it is assumed that all devices are meter gates.

Table 3. Sample data collection for selected turnouts

Red rows indicate devices that do not meet the required standard

Turnout #	Device Type	Acreage Served	Flow Accuracy Error, %
2	Meter Gate	10	15%
3	Meter Gate	15	9%
4	Meter Gate	15	6%
6	Meter Gate	2	8%
10	Meter Gate	50	4%
	Total acreage sampled:	***92***	

Step 4: Determination of Compliance

SBx7 requires an annual volumetric accuracy of within 12% on existing devices. Table 3 addresses flow rate accuracy, not volumetric accuracy.

If 25% or more of the sampled area for a particular device type exceeds the 12% annual volumetric allowable error, then a second round of testing must be conducted. This second round of testing should be conducted in the same manner as the first, but only for the device type(s) that did not meet the required accuracy standard.

Compliance of this particular example. Table 3 is repeated below for illustration.

Table 3. Sample data collection for selected turnouts

Red rows indicate devices that do not meet the required standard

Turnout #	Device Type	Acreage Served	Flow Accuracy error, %
2	Meter Gate	10	15%
3	Meter Gate	15	9%
4	Meter Gate	15	6%
6	Meter Gate	2	8%
10	Meter Gate	50	4%
	Total acreage sampled:	***92***	

Assuming that the minimum required flow rate accuracy is 10.7% (using the example), then only one turnout measurement device does not meet the requirement. No re-testing is needed, because:

1. Ninety-two acres were tested out of the total 164 acres. This is much greater than the 10% sample size required.
2. Five devices were sampled, which meets the minimum because all devices are of the same basic design.
3. The one device with greater than 10.7% error only represents 10 acres, which is 11% of the acreage sampled. This is below the allowable 25%.

Scenario 2: Limited Availability of Turnouts and Opportunity Sampling

Turnouts may not be available for inspection due to fluctuations in irrigation scheduling. Therefore, opportunity sample can be used to select devices to be evaluated. As opposed to the PPS random sample set, this sample will be based on availability and service size rather than a weighted random sampling.

Background

Representative Sample Selection

To ensure the sample is representative of the district as a whole, evaluators need to ensure that the area serviced by the devices evaluated is at least 10% of the district's entire area. Furthermore, when given a choice between devices of equal convenience, devices servicing a larger acreage should be given priority for inspection. Additionally, a minimum of 5 devices must be inspected. In this way each device will be weighted in selection by the acreage it serves. Specifically, the sample will be skewed favoring devices that measure greater volumes of water. This will ensure that the opportunity sample will be statistically representative of the overall accuracy of flow measurement within the district.

Selection Process

Devices will be selected as they are available to be tested. Priority for evaluation will be given to devices that service greater acreage. Once a device has been tested, it will no longer be considered in the selection process. A minimum of 5 devices will be tested, and all evaluated devices (summation of all types) will service a combined 10% of the district's total area (or delivered volume), not to exceed 100 individual devices of a certain type.

Step 1: Choose a Currently Available Turnout

Select a turnout that is available for testing based on the size of the turnout, giving priority to turnouts that serve greater acreage. Do not test the same device more than once. **Table 4** shows an example of the selection process for two days. On the first day Turnout 10 serves the largest acreage out of the available turnouts. On day two, Turnout 5 is chosen because it serves the largest area and has not yet been tested. The district in this example has one canal lateral with 10 turnouts, and the turnouts have limited availability for testing.

Table 4. Device selection on two separate days

Green rows indicate the selected turnout. Grey rows indicate a turnout that has been tested.

Day 1			Day 2		
Turnout #	Currently Available	Acreage Served	Turnout #	Currently Available	Acreage Served
1	yes	10	1	no	10
2	yes	10	2	yes	10
3	no	9	3	no	9
4	yes	7	4	yes	7
5	no	30	5	yes	30
6	no	1	6	no	1
7	yes	1	7	yes	1
8	yes	2	8	yes	2
9	no	50	9	no	50
10	yes	50	10	yes	50

Continue testing devices until the following criteria have been met:

- *At least 10% of the total district acreage is serviced by the devices tested*
- *At least 5 devices have been tested*
- *Test no more than 100 devices of a particular type*

Steps 2-4 : Follow the Previous Scenario Instructions

FLOW MEASUREMENT DEVICES

Background

This section is intended to provide useful information on several common flow measurement devices that might be considered for traditional, non-pressurized turnouts. Often, the problems with some of the devices (meter gates, orifice plates, and propeller meters) are largely associated with improper measurement, or improper installation or maintenance. If properly designed and maintained, all three of these measurement devices will generally fall well within required SBx7 requirements.

Meter Gates

Meter gates are one of the most common devices used in California irrigation districts to both measure and control flow rates. There is no doubt that many of these devices provide accurate results. However, as with all devices, certain rules must be followed. Typical physical inaccuracies associated with meter gates include:

1. *Incorrect "zero" measurement of gate opening*, as determined by the vertical movement of the threaded shaft.
    a. There are four primary reasons operators might measure the opening from an incorrect "zero" mark on the threaded shaft:
        i. The zero point is affected by "slop" in the connection between the shaft and the gate plate.
        ii. Wedges are used to force the plate against the gate frame during gate closure. These wedges are often adjusted in the field, so there is no standard stopping distance (vertically) for the plate.
        iii. When the plate begins to move, it may overlap the opening (by 0.5 - 2"). Although water may begin to leak as the plate moves out of the wedge constraint, the true zero is the opening at which the bottom of the plate is exactly at the bottom of the frame opening.
        iv. The "zero" point should always be determined while the gate is being raised.
    b. Once the zero point is known, a notch should be scribed into the shaft to note the location of the zero mark. Then the gate opening should always be measured as the gate is being opened, rather than being closed.

2. *Incorrect downstream water level measurement.*
    a. The stilling well must be placed over a full pipe, at a specific distance downstream of the meter gate.
    b. Many existing stilling wells were actually designed to be air vents, and have such a small diameter that there is constant surging. A large diameter stilling well, fed by a relatively small access hole at its bottom (about 1/6th the diameter of the stilling well), is needed to "still" the water surface so it can be measured downstream of the gate. The problem with a small access hole is that it can plug up easily. A good combination is a 2" access hole (connecting the stilling well to the top of the pipe) and a 12" stilling well.
    c. The pipe must be full at all flow rates. This may require the placement of a small obstruction downstream, in the pipe, similar to what is done with well pump discharges to keep propeller meters full. Various entities, including ITRC, have successfully designed side contractions in pipes to create "Replogle flumes" that have very little loss, and that pass bottom loads of silt. Something similar could be used downstream of the meter gates.

Figure 3. Side contractions rather than a traditional "Replogle Flume". Designed by USBR, Yuma. The rocks are not part of the design.

Another technique used in some districts to maintain a submerged condition on a gate is to install "bumps" in the bottom of a canal or ditch downstream of the turnout. These should be permanent "bumps" which, at low flows, will keep the water level high. The rule for building these "bumps" is:

> Build up the restriction from the bottom of the ditch/canal so that at high flow rates, the upstream water surface (relative to the bump) is only raised by about 0.1' or less. In other words, its presence will hardly be noticeable.

If farmers move downstream in their canal, setting siphons at a different place, this "bump" will keep the backpressure on the meter gate almost constant, and minimize the flow rate change that would normally occur.

3. *Incorrect gate opening geometry.* Since the plate has a larger outside diameter than the inside diameter of the pipe, the ratio of the open area between the two openings must be taken into account. Almost everyone uses tables that were developed decades ago. ITRC is not certain if the gate dimensions have changed since then, or if different manufacturers use different gate dimensions. ITRC is planning to verify this in the future.

4. *Non-standard entrance and exit conditions.* The flow rate is associated with a measured opening and head loss. The head loss will be different (at the same flow rate) with different entrance conditions. Various manuals, such as the USBR Flow Measurement Manual, provide recommended dimensions.

Orifice Plates

The following is an explanation of the characteristics of a submerged (on both sides) rectangular orifice plate.

According to the U.S. Bureau of Reclamation *Water Measurement Manual*, conditions for achieving accurate flow measurement of ± 2% for a fully contracted submerged rectangular orifice are:

- The upstream edges of the orifice should be straight, sharp, and smooth.
- The upstream face and the sides of the orifice opening need to be vertical.
- The top and bottom edges of the orifice opening need to be level.
- Any fasteners present on the upstream side of the orifice plate and the bulkhead must be countersunk.
- The face of the orifice plate must be clean of grease and oil.
- The thickness of the orifice plate perimeter should be between 0.03 and 0.08 inches. Thicker plates would need to have the downstream side edge chamfered at an angle of at least 45 degrees.
- Flow edges of the plate require machining or filing perpendicular to the upstream face to remove burrs or scratches and should not be smoothed off with abrasives.
- For submerged flow, the differential in head should be at least 0.2 feet.
- Using the dimensions depicted in **Figure 4** below, P > 2Y, Z > 2Y, and M > 2Y

The equation for determining the flow through a submerged orifice plate is:

$$Q = C_d A\sqrt{2g\Delta h}$$

Where:

Q = Flow Rate, CFS
C_d = Coefficient of Discharge, 0.61
A = Area of the orifice, ft^2
A = W x Y
W = Orifice opening width, ft
Y = Orifice opening height, ft
g = Acceleration due to gravity, 32.2 ft/s^2
Δh = Change in head, ft

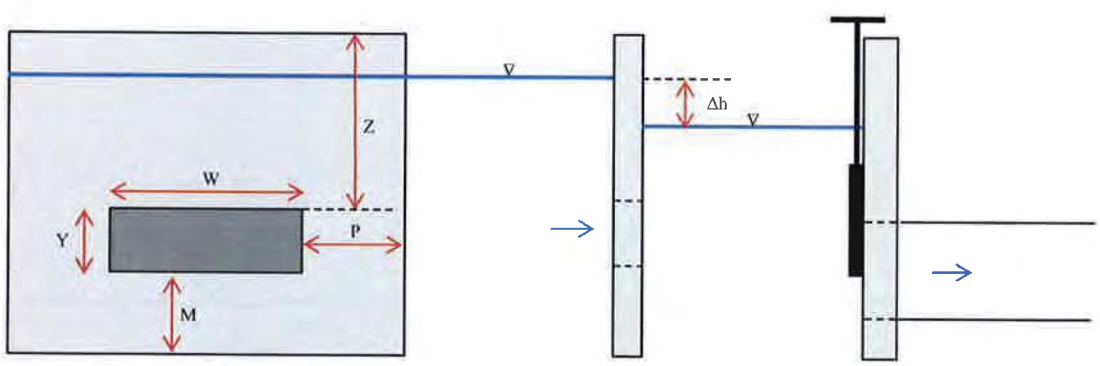


Figure 4. Flow through a submerged orifice plate

For a sharp-edged rectangular orifice where full contraction occurs from every side of the orifice, the coefficient of discharge is 0.61.

It is recommended that "Y" be smaller than "W", so that a good depth "Z" can be maintained. This helps keep the orifice entrance submerged all the time regardless of upstream water level fluctuations, and also provides for the proper entrance conditions.

It is assumed that the flow control gate will be located downstream of the orifice plate. The particular dimensions of that gate would rarely influence the performance of an orifice plate.

Typical problems include:

1. Inaccurate measurement of the difference in head.
   Solution:
   a. Careful relative calibration of pressure transducers, if used. They do not need to read a correct "elevation", but at zero flow rate must read the same "elevation".
   b. Install a horizontal reference steel plate on a bulkhead wall, so operators use the same reference elevation for both measurements if they manually measure the head difference.
2. The distances P, Z, or M are not greater than 2 times the smallest opening dimension (usually "Y"). In reality, it is rare that this "2 times" criteria is met in irrigation districts, except with very small flows.
   Solution:
   a. If only one side is suppressed (typically the bottom entrance, which might have no convergence), adjust the discharge coefficient, C_d as follows:

W/Y	1	2	4
Cd	0.63	0.64	0.65

   b. We do not know exactly how much to adjust the C_d if the distances P, Z, or M are less than two times the smallest opening dimension. Therefore, it is recommended that the orifice be installed in a plate that is wide enough and tall enough to approximately meet those required distances – even if the plate must be extended beyond the inlet to the turnout. See the figure below.

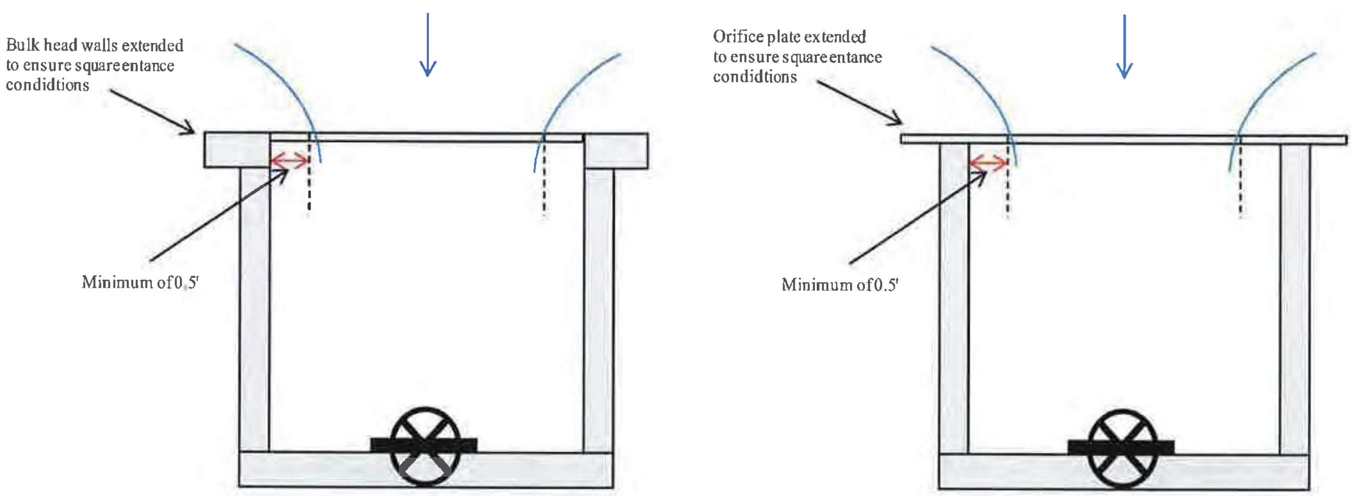


Figure 5. Installation of orifice

3. A single orifice size has a limited flow rate range. This is illustrated in the tables below. At too low a flow rate, the measured head difference is very small, often resulting in major errors in head difference. At too high a flow rate, the measured head difference is excessive, and may well exceed the available head. For this reason, *it is common to have a moveable plate that can be adjusted up and down,* varying the "Y" dimension.

   The addition of the moveable plate (often a rectangular sluice gate) creates the commonly known "CHO" or "constant head orifice". The device certainly does not create a "constant head", but it does provide an adjustable orifice. It provides the flexibility needed for a turnout to supply different flows at different times, with reasonably accurate head measurements. The opening should be adjusted so that the minimum head difference is greater than 0.2'. A 1' head loss across the orifice plate is more than what is attainable in many California irrigation district turnouts.

Table 5. Orifice size values

	Width of Orifice Opening, ft							
	1.0							
	Height of Orifice Opening, ft							
	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
Flow Rate, CFS	Change in Head, ft							
5.0								1.0
4.5							1.0	0.8
4.0						1.0	0.8	0.7
3.5					1.0	0.8	0.6	0.5
3.0				1.0	0.8	0.6	0.5	0.4
2.5			1.0	0.7	0.5	0.4	0.3	0.3
2.0		1.0	0.7	0.5	0.3	0.3	0.2	0.2
1.5	1.0	0.6	0.4	0.3	0.2	0.1	0.1	
1.0	0.5	0.3	0.2	0.1				

	Width of Orifice Opening, ft						
	1.5						
	Height of Orifice Opening, ft						
	0.5	0.6	0.8	1.0	1.2	1.4	1.5
Flow Rate, CFS	Change in Head, ft						
11.0						1.1	1.0
10.0						0.9	0.8
9.0					1.0	0.8	0.7
8.0				1.2	0.8	0.6	0.5
7.0				0.9	0.6	0.5	0.4
6.0			1.0	0.7	0.5	0.3	0.3
5.0			0.7	0.5	0.3	0.2	0.2
4.5		1.0	0.6	0.4	0.3	0.2	0.2
4.0	1.2	0.8	0.5	0.3	0.2	0.2	0.1
3.5	0.9	0.6	0.4	0.2	0.2	0.1	0.1
3.0	0.7	0.5	0.3	0.2	0.1		
2.5	0.5	0.3	0.2	0.1			
2.0	0.3	0.2	0.1				
1.5	0.2	0.1					

Table 5 (continued). Orifice size values

	Width of Orifice Opening, ft								
	2.0								
	Height of Orifice Opening, ft								
	0.5	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0
Flow Rate, CFS	Change in Head, ft								
20.0									1.0
19.0								1.2	0.9
16.0							1.0	0.8	0.7
13.0						0.9	0.7	0.5	0.4
10.0				1.0	0.7	0.5	0.4	0.3	0.3
9.0				0.8	0.6	0.4	0.3	0.3	0.2
8.0			1.0	0.7	0.5	0.3	0.3	0.2	0.2
7.0			0.8	0.5	0.4	0.3	0.2	0.2	0.1
6.0		1.0	0.6	0.4	0.3	0.2	0.1	0.1	
5.0	1.0	0.7	0.4	0.3	0.2	0.1	0.1		
4.5	0.8	0.6	0.3	0.2	0.1	0.1			
4.0	0.7	0.5	0.3	0.2	0.1				
3.5	0.5	0.4	0.2	0.1					
3.0	0.4	0.3	0.1						
2.5	0.3	0.2	0.1						
2.0	0.2	0.1							

	Width of Orifice Opening, ft											
	2.5											
	Height of Orifice Opening, ft											
	0.5	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.5
Flow Rate, CFS	Change in Head, ft											
30.0											1.0	1.0
25.0									1.0	0.9	0.7	0.7
20.0							1.0	0.8	0.7	0.6	0.5	0.4
15.0					1.0	0.8	0.6	0.5	0.4	0.3	0.3	0.2
10.0			1.0	0.7	0.5	0.3	0.3	0.2	0.2	0.1	0.1	0.1
9.0			0.8	0.5	0.4	0.3	0.2	0.2	0.1	0.1		
8.0		1.2	0.7	0.4	0.3	0.2	0.2	0.1	0.1			
7.0		0.9	0.5	0.3	0.2	0.2	0.1	0.1				
6.0	1.0	0.7	0.4	0.2	0.2	0.1						
5.0	0.7	0.5	0.3	0.2	0.1							
4.5	0.5	0.4	0.2	0.1								
4.0	0.4	0.3	0.2	0.1								
3.5	0.3	0.2	0.1									
3.0	0.2	0.2										

	Width of Orifice Opening, ft													
	3.0													
	Height of Orifice Opening, ft													
	0.5	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0
Flow Rate, CFS	Change in Head, ft													
45.0													1.2	1.0
40.0												1.1	0.9	0.8
35.0										1.2	1.0	0.8	0.7	0.6
30.0									1.0	0.9	0.7	0.6	0.5	0.5
25.0							1.1	0.9	0.7	0.6	0.5	0.4	0.4	0.3
20.0						0.9	0.7	0.6	0.5	0.4	0.3	0.3	0.2	0.2
15.0				1.0	0.7	0.5	0.4	0.3	0.3	0.2	0.2	0.2	0.1	0.1
10.0			0.7	0.5	0.3	0.2	0.2	0.1	0.1					
5.0	0.5	0.3	0.2	0.1										

If steel theft is a concern, a marine plywood frame could be used to support a steel orifice opening frame. Fasteners used to connect the steel orifice to the plywood frame would need to be countersunk to minimize debris getting caught on them.

Trash Shedding Propeller Meters

For several decades there has been interest in "trash shedding propeller meters". ITRC examined the "cloggability" of an early design about 20 years ago. Boat propellers are sold with "weed shedding" features, which include specially designed propellers as well as fixed vanes upstream of the propeller that are intended to pass the weeds below or to the side of the boat propeller. McCrometer sells a saddle meter with the trash shedding options.

MC® Propeller

MODEL M0300SW

CONFIGURATION SHEET
REVERSE BOLT-ON SADDLE
SURFACE WATER FLOWMETER

DESCRIPTION

The M0300SW is a bolt-on reverse-helix* propeller meter designed to shed debris often associated with surface water applications. The M0300SW is designed with the meter body turned 180 degrees from normal, a propeller installed nose-first on the bearing shaft, and a reverse flow style bearing assembly. This configuration allows the ell to curve with the flow, allowing grass or other debris to shed off with ease. The assembly design also reduces the ability of sand and silt to accumulate in the bearing.

The M0300SW features a fabricated stainless steel saddle with McCrometer's unique drive and register design. The stainless steel saddle eliminates the fatigue-related breakage common to cast iron and aluminum saddles and provides unsurpassed corrosion protection. Fabricated stainless steel construction offers the additional advantage of being flexible enough to conform to out-of-true pipe. The Model M0300SW is manufactured to comply with applicable provisions of American Water Works Association Standard No. C704-02 for propeller-type flowmeters. As with all McCrometer propeller flowmeters, standard features include a magnetically coupled drive, instantaneous flowrate indicator and straight reading, six-digit totalizer.

The impellers are manufactured of high-impact plastic, capable of retaining their shape and accuracy over the life of the meter. Each impeller is individually calibrated at the factory to accommodate the use of any standard McCrometer register, and since no change gears are used, the M0300SW can be field-serviced without the need for factory recalibration. Factory lubricated, stainless steel bearings are used to support the impeller shaft. The shielded bearing design limits the entry of materials and fluids into the bearing chamber providing maximum bearing protection.

The instantaneous flowrate indicator is standard and available in gallons per minute, cubic feet per second, liters per second and other units. The register is driven by a flexible steel cable encased within a protective vinyl liner. The register housing protects both the register and cable drive system from moisture while allowing clear reading of the flowrate indicator and totalizer.

INSTALLATION

Standard installation is horizontal mount. If the meter is to be mounted in the vertical position, please advise the factory. A straight run of full pipe the length of eight pipe diameters upstream and five diameters downstream of the meter is recommended for meters without straightening vanes. Meters with optional straightening vanes require at least three pipe diameters upstream and two diameters downstream of the meter.

* 4" meters use a forward helix propeller with a reverse register.

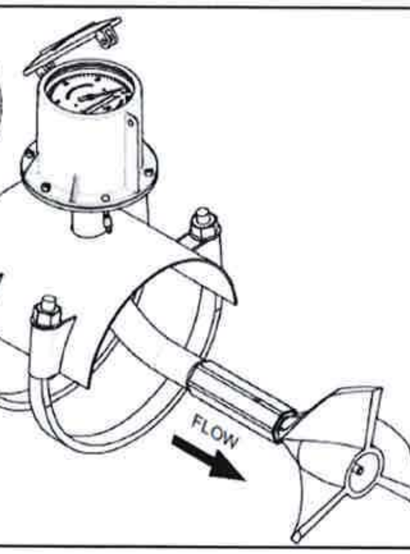
Typical face plate

The McCrometer Propeller flowmeter comes with a standard instantaneous flowrate indicator and straight-reading totalizer. An optional FlowCom register is also available.

Typical face plate

APPLICATIONS

- **Surface Water**
- **Water Containing Trash**
- **Sand Producing Wells**
- **Irrigation District Turnouts**



McCrometer will also mount a reverse-facing propeller on a standard open flow meter, which can be mounted on stands above low pressure pipelines.

MC Propeller

CONFIGURATION SHEET

MODEL M1700 — OPEN FLOWMETER

DESCRIPTION

Model M1700 Open Flowmeters are designed to measure the flow in canal outlets, discharge and inlet pipes, irrigation turnouts and other similar installations. The M1700 series meets or exceeds the American Water Works Association Standard C704-02. Constructed of stainless steel, the meter incorporates bronze mounting brackets that permit simple installation and removal. As with all McCrometer propeller flowmeters, standard features include a magnetically coupled drive, instantaneous flowrate indicator and straight reading, six-digit totalizer.

Impellers are manufactured of high-impact plastic, designed to retain both shape and accuracy over the life of the meter. Each impeller is individually calibrated at the factory to accommodate the use of standard McCrometer registers, and since no change gears are necessary, the M1700 can be field-serviced without the need for factory recalibration. Factory lubricated, stainless steel bearings are used to support the impeller shaft. The sealed bearing design limits the entry of materials and fluids into the bearing chamber providing maximum bearing protection.

An instantaneous flowrate indicator is standard and available in gallons per minute, cubic feet per second, liters per second and other units. The register is driven by a flexible steel cable encased within a protective, self-lubricating vinyl liner. The die-cast aluminum register housing protects both the register and cable drive system from moisture while allowing clear reading of the flowrate indicator and totalizer.

INSTALLATION

The M1700 must be mounted on a headwall, standpipe or other suitable structure so that the propeller is located in the center of the discharge or inlet pipe. A straight run of full pipe the length of ten pipe diameters upstream and two diameters downstream of the meter is recommended for meters without straightening vanes. Meters with optional straightening vanes require at least five pipe diameters upstream of the meter. Please specify the inside diameter of the pipe when ordering.

The McCrometer Propeller flowmeter comes with a standard instantaneous flowrate indicator and straight-reading totalizer. An optional FlowCom register is also available. *Typical face plates.*

APPLICATIONS

The McCrometer propeller meter is the most widely used flowmeter for municipal water and wastewater applications as well as agricultural and turf irrigation measurements.
Typical applications include:

- Water and wastewater management
- Canal laterals
- Gravity turnouts from underground pipelines
- Sprinkler irrigation systems
- Golf course and park water management

A commercially available package that includes a reverse propeller meter and trash-shedding fixed vane, plus flow straighteners, is available from RSA.

Rubicon Transit Time Flow Meter

The Rubicon Sonaray flow meter is an interesting addition for larger turnouts with a canal supply, in that it also has a totalizer. The Rubicon literature cites a flow test in California, but it is unclear if the magmeter used for flow rate verification was recently calibrated. ITRC has found that new magmeters with guaranteed accuracies can be off by several percentage points. The device appears to be new, without substantial field testing in the USA.

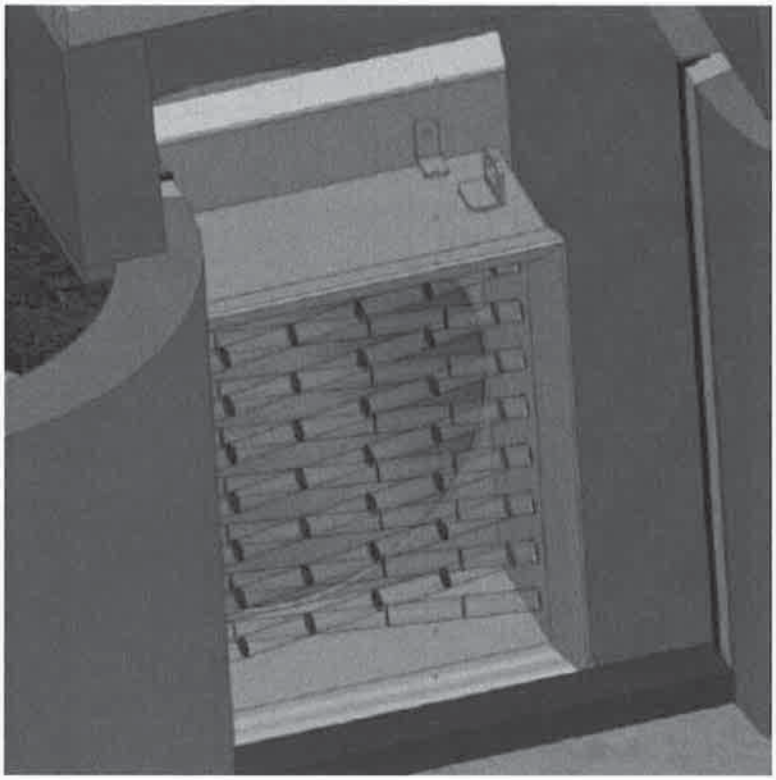
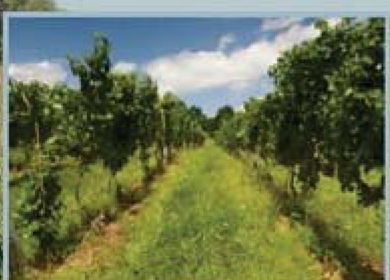


Figure 6. Rubicon Sonaray flow meter



Appendix G

Public Hearing Notification Letters

Modesto Irrigation District
Water and Power

1231 Eleventh St.
P.O. Box 4060
Modesto, CA 95352
(209) 526-7373

November 14, 2012

Agricultural Commissioner's Office
Stanislaus County
3800 Cornucopia Way, Suite B
Modesto, CA 95358

Dear Gentlemen,

RE: Update to the MID Agricultural Water Management Plan – Public Hearing Notice

The Modesto Irrigation District (MID) is scheduled to hold a review and public comment period on the proposed update to the MID Agricultural Water Management Plan (AWMP) from November 16, 2012 through November 30, 2012.

A Public Hearing is scheduled to be held at 9:00AM on November 27, 2012 in the MID Board Room, located at 1231 11th Street, Modesto, CA 95354. At the hearing, the MID Board will receive public comments on the draft AWMP. The MID Board will consider adoption of the AWMP on December 18, 2012. All persons interested in this matter should appear at the public hearing to comment, or submit written comments as described below.

The AWMP includes a discussion of MID and its irrigation facilities, water supply and demand, and various programs, policies and efficient water management practices, being implemented now or planned in the coming years. Copies of the draft plan are available for review at the following locations:

- MID Water Operations Division office located on the Third Floor, 1231 11th Street, Modesto, CA
- Modesto Irrigation District website: www.mid.org

Any comments prior to the hearing should be submitted to:

Carrie Loschke
Modesto Irrigation District
P.O. Box 4060
Modesto, CA 95352

Any questions regarding the draft AWMP or the adoption process should be directed to Carrie Loschke at (209) 526-7570 or carriel@mid.org.

Sincerely,

Walter P. Ward
AGM, Water Operations Division

Modesto Irrigation District
Water and Power

1231 Eleventh St.
P.O. Box 4060
Modesto, CA 95352
(209) 526-7373

November 14, 2012

City Manager's Office
City of Riverbank
6707 Third Street
Riverbank, CA 95367

Dear Gentlemen,

RE: Update to the MID Agricultural Water Management Plan – Public Hearing Notice

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Sincerely,

Walter P. Ward

Walter P. Ward
AGM, Water Operations Division

Modesto Irrigation District
Water and Power

1231 Eleventh St.
P.O. Box 4060
Modesto, CA 95352
(209) 526-7373

November 14, 2012

Jack Bond
City of Modesto
1010 Tenth Street
Modesto, CA 95354

Dear Jack,

RE: Update to the MID Agricultural Water Management Plan – Public Hearing Notice

The Modesto Irrigation District (MID) is scheduled to hold a review and public comment period on the proposed update to the MID Agricultural Water Management Plan (AWMP) from November 16, 2012 through November 30, 2012.

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P.O. Box 4060
Modesto, CA 95352

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Sincerely,

Walter P. Ward
AGM, Water Operations Division

Modesto Irrigation District
Water and Power

1231 Eleventh St.
P.O. Box 4060
Modesto, CA 95352
(209) 526-7373

November 14, 2012

City Manager's Office
City of Waterford
P.O. Box 199
Waterford, CA 95386

Dear Gentlemen,

RE: Update to the MID Agricultural Water Management Plan – Public Hearing Notice

The Modesto Irrigation District (MID) is scheduled to hold a review and public comment period on the proposed update to the MID Agricultural Water Management Plan (AWMP) from November 16, 2012 through November 30, 2012.

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Modesto, CA 95352

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Sincerely,

Walter P. Ward
AGM, Water Operations Division

Modesto Irrigation District
Water and Power

1231 Eleventh St.
P.O. Box 4060
Modesto, CA 95352
(209) 526-7373

November 14, 2012

Wayne Zipser
Stanislaus County Farm Bureau
1201 L Street
Modesto, CA 95354

Dear Wayne,

RE: Update to the MID Agricultural Water Management Plan – Public Hearing Notice

The Modesto Irrigation District (MID) is scheduled to hold a review and public comment period on the proposed update to the MID Agricultural Water Management Plan (AWMP) from November 16, 2012 through November 30, 2012.

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Modesto Irrigation District
P.O. Box 4060
Modesto, CA 95352

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Sincerely,

Walter P. Ward
AGM, Water Operations Division

Modesto Irrigation District
Water and Power

1231 Eleventh St.
P.O. Box 4060
Modesto, CA 95352
(209) 526-7373

November 14, 2012

Steve Boyd
Turlock Irrigation District
333 E. Canal Street
Turlock, CA 95380

Dear Steve,

RE: Update to the MID Agricultural Water Management Plan – Public Hearing Notice

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Modesto Irrigation District
P.O. Box 4060
Modesto, CA 95352

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Sincerely,

Walter P. Ward
AGM, Water Operations Division