AGRICULTURAL WATER MANAGEMENT PLAN

Prepared Pursuant to Water Code Section 10826

Prepared for

WHEELER RIDGE-MARICOPA WATER STORAGE DISTRICT

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SUBMITTED TO THE

CALIFORNIA DEPARTMENT OF WATER RESOURCES

IN ACCORDANCE WITH THE

AGRICULTURAL WATER MANAGEMENT PLANNING ACT OF 2009 (SBx7-7) and Executive Order B-29-15

December 2015
Update January 2016

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Acronyms

AF	acre-feet
AWMC	Agricultural Water Management Council
AWCP	Agricultural Water Conservation Plan
AWMP	Agricultural Water Management Plan
Cfs	cubic feet per second
CIMIS	California Irrigation Management Information System
CVP	Central Valley Project
CVRWQCB	Central Valley Regional Water Quality Control Board
DWR	Department of Water Resources
EPA	U.S. Environmental Protection Agency
ET	Evapotranspiration
ET_c	Crop Evapotranspiration
ET_O	Reference Evapotranspiration
EWMP	Efficient Water Management Practice
GHG	Greenhouse Gas
ID	Irrigation District
ILRP	Irrigated Lands Regulatory Program
ITRC	Irrigation Training & Research Center (Cal Poly)
IRWM	Integrated Regional Water Management
GWMP	Groundwater Management Plan
KCWA	Kern County Water Agency
KRWCA	Kern River Watershed Coalition Authority
NWKRCD	North West Kern Resource Conservation District
M&I	Municipal and Industrial
MOU	Memorandum of Understanding
NPDES	National Pollutant Discharge Elimination System (EPA)
OCAP	Operations Criteria and Plan for CVP Deliveries (USBR)
ppm	parts per million
USACE	U.S. Army Corps of Engineers
USBR	U.S. Bureau of Reclamation

SBx7-7	Water Conservation Act of 2009
SCADA	Supervisory Control and Data Acquisition
SWP	State Water Project
SWRCB	State Water Resources Control Board
TDS	Total Dissolved Solids
TOC	Total Organic Carbon
WSD	Water Storage District
WRMWSD	Wheeler Ridge-Maricopa Water Storage District

Introduction

1.1 Overview

The Agricultural Water Management Plan (AWMP) describes district planning and implementation activity of the Wheeler Ridge-Maricopa Water Storage District (WRMWSD or District) for the purpose of providing reliable agricultural water supply for its landowners. The District covers approximately 147,646 acres in the southern end of the San Joaquin Valley in Kern County. The District delivers a combination of imported water from the State Water Project (SWP), previously imported water recovered from several Kern County banking projects, local groundwater to agricultural customers using District facilities, and other water supplies as necessary to mitigate water shortages from the State Water Project. In addition, some agricultural water users in the District provide their own irrigation water through groundwater pumping.

This AWMP document conforms to the framework presented in *A Guidebook to Assist Agricultural Water Suppliers to Prepare a 2015 Agricultural Water Management Plan* (Guidebook) that was issued by the California Department of Water Resources (DWR) in June, 2015 to aid water suppliers in preparing AWMPs in accordance with the requirements of SBx7-7.

Much of this AWMP is based on information contained in the District's *2007 Groundwater Management Plan* (GWMP), the District Engineer-Manager's monthly and annual reports, and information based on a number of studies the District has undertaken over time. The past studies are related to increasing the reliability and quality of the water supply for the benefit of District customers. An example of a past regional study relied upon for this AWMP is the Report on Investigation of Optimization and Enhancement of the Water Supplies of Kern County (Associated Engineering Consultants, 1983).

The past studies, the 2007 GWMP, the previous AWMP adopted in January, 2015, and this AWMP are collectively intended as documentation of the District's efficient water management practices implemented, planned, or expected to occur in five and ten years, the efficient distribution and use of all District water supplies, and as a guide for the development of additional water sources.

The District's location and service area are shown on Figure 1.

Figure 1. Location and Size of District

1.2 Purpose

The purpose of the 2015 AWMP is to describe and document the District's existing and proposed agricultural water management programs and activities. In particular, the 2015 AWMP complies with the requirements of the Governor's Executive Order B-29-15, which was issued on April 1, 2015 in response to the 2013-2015 drought conditions. The Executive Order B-29-15 requires detailed drought management plans, quantification of water supplies and demands for 2013, 2014, and 2015, and additional information regarding the implementation of Efficient Water Management Practices (EWMP).

The AWMP maintains compliance with the requirements of the SBx7-7, the Agricultural Water Management Planning Act (Section I, Part 2.8, Division 6 (commencing at Section 10800) of the Water Code), and the subsequent Agricultural Water Measurement Regulation requirements (described in Title 23 California Code of regulations), notwithstanding such regulations go beyond that required by the statute and in many instances are not applicable to areas such as this District. The requirements of SBx7-7 include discussion of EWMPs and of the potential impacts of climate change on District operations.

Included in *Section 7* of this plan is a description of the efficient water management practices implemented or planned to be implemented, estimates of water use efficiency improvements that have been implemented since the District completed their last AWMP, and estimates of water use efficiency improvements expected to occur five and ten years in the future. The EWMPs are grouped into the following categories: *Critical Efficient Water Management Practices* and *Conditional Efficient Water Management Practices.*

1.3 Description of Previous Water Management Activities

The District and growers within the District have continually improved on-farm water management practices since formation of the district in 1959. Improvements have been driven by technology improvements, increased crop values, and increasing scarcity and costs of State Water Project supplies. The District's water management has also improved over time with the advancement of technology, conjunctive use facilities and practices, and Grower's on-farm irrigation application method improvements. In 2007, the District prepared a groundwater management plan to better manage their various water sources.

This AWMP identifies several previously implemented and ongoing water management activities, which include:

- Acquire surface water supplies from the State Water Project, and construct irrigation distribution system facilities to lands which previously relied exclusively on pumped groundwater for the purpose of District delivery of surface water.
- Secure additional dry year water supplies from groundwater banking and recovery projects (Kern Water Bank, 2800 Acres, Pioneer Project, and Berrenda Mesa Project) and local groundwater supplies (District wells and private wells).
- Secure additional water supplies to mitigate water shortages from the State Water Project.
- Manage imported water and groundwater conjunctively to increase water supply reliability.
- Promote water use efficiency through:
- Metered and tiered water pricing, and
- Financial support of the North West Kern Resource Conservation District's (NWKRCD) Mobile Laboratory and encouraging landowners to take advantage of this resource by requesting field irrigation evaluations.
- Actively participate in local water resource management forums, including the Water Association of Kern County, Kern County Integrated Regional Water Management Plan (Kern IRWM Plan), the Kern River Watershed Coalition Authority (KRWCA), and the Kern Groundwater Management Committee (now Kern Groundwater Authority).
- Require installation of flow meters on private landowner wells that pump into the District facilities.

1.4 Coordination Activities

The District notified public entities of the AWMP preparation and adoption as shown in Table 1. Public participation requirements associated with preparation of an AWMP are identified in SBx7-7; however it does not specify how much advance notice is required to cities and counties regarding 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.

Table 1. Summary of Plan Coordination, Adoption, and Submittal Activities

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
California Dept. of Water Resources	X			X		X
Kern County Water Agency	X			X		X
Arvin Edison Water Storage District	X			X		
Kern Delta Water District	X			X		
Henry Miller Water District	X			X		
California State Library						X
GEI Consultants, Inc.	X	X	X	X	X	X

1.5 Plan Adoption and Submittal

The AWMP, once adopted by the District following a public hearing, will be submitted to DWR within 30 days of adoption by the District. In addition, the District will send a copy of the AWMP to the Kern County Water Agency (KCWA or Agency) and the California State Library. A copy of the AWMP will also be available from the District by request.

Appendices to the AWMP include: 1) proof of publication documenting notice of a public hearing, 2) a signed resolution of AWMP Adoption by the District's Board of Directors, 3) notification letters indicating a copy of the AWMP was sent to the three interested parties indicated in Table 1, 4) WRMWSD Rules and Regulations for Distribution of Water, and 5) the DWR AWMP Checklist.

Description of the Wheeler Ridge-Maricopa Water Storage District and Service Area

2.1 Physical Characteristics

2.1.1 Size of Service Area

The District was formed on August 11, 1959 under California Water Storage District law for the purpose of securing a surface water supply for agricultural purposes from the Feather River Project (presently known as the State Water Project). The District's Project, including authority to execute a water supply contract for SWP supplies, and construct a water distribution system, was approved by the District's landowners at an election on November 14, 1967.

The location and size of the District is shown on Figure 1. The District's distribution system and service areas are shown on Figure 2. The District is governed by an elected nine-member Board of Directors, and operated by a staff of approximately 40 employees.

The District receives SWP through a contractual agreement with the KCWA. KCWA was formed to contract with the State of California for delivery of SWP to 13 water districts in Kern County. Delivery to the District from the SWP began in 1971. The District receives and delivers untreated surface water from the SWP to landowners within the District.

Since the 1990's the District's SWP supply has become increasingly unreliable. To compensate for this loss of reliability, the District acquires and delivers several sources of water through the California Aqueduct in addition to their SWP Table A contract amount. Since the 1990's the District has secured additional dry year water supplies for its landowners from the Kern Water Bank, 2800 Acres, Pioneer Project, Berrenda Mesa Project, new District wells, and its Blanca Rosa Improvement District. Additional water supply reliability and cost reliability were also secured through the Monterey Amendments to the SWP contracts.

Figure 2. District's Distribution System and Service Areas

The District's water supplies are comprised of the SWP (197,088 acre-feet of Table A allocation), groundwater banking projects, local groundwater and other imported supplies. The District delivers on average 169,000 acre-feet annually, totalling 7.5 million acre feet delivered from 1971 to 2015. Current Grower demands vary from 175,000 to 185,000 acre-feet per year of supply to farm lands within the District's Surface Water Service Area (SWSA) (under the terms of recorded long-term agricultural water service contracts). In 2015, about 85,973 acres of farm land within the District were irrigated. Approximately 60,512 acres were irrigated acres within the SWSA and 24,686 acres were irrigated acres outside of the SWSA, but within the District's boundaries. Approximately 28,000 acres are undeveloped and used primarily for grazing. Except for a few locations along Interstate 5, the District is exclusively rural. There are no cities or towns within the District's boundaries. Table 2 provides an overview of the District history and size.

Table 2. Water Supplier History and Size

Date of Formation	1959
Sources of Water	State (DWR) Regulated Water, Local Surface Water[3], Local Groundwater
Gross Acreage (at Formation[1])	134,190
Total Acreage (Current[2])	147,347
Irrigated Acreage (Current[2])	60,512 SWSA; 26,910 Groundwater Area; 87,422 Total.

[1] Kern County Water Agency Report 1969-1971, by KCWA.
[2] WRMWSD Crop and Land Use Survey, by WRMWSD, shown in Table 22A.
[3] Occasional surface water supplies and runoff from the Southern Stream Group, local creeks (e.g. El Paso, Tunis, and Pastoria) and Tejon Reservoir releases that occur during wet hydrologic years and some normal hydrologic years.

2.1.2 Location of the Service Area and Water Management Facilities

The District is located at the southern end of the San Joaquin Valley approximately 30 miles south of Bakersfield. The San Joaquin Valley is the southern half of the larger Great Valley, an elongated trough extending about 400 miles through the heart of the state. The San Joaquin River and its tributaries drain the northern two-thirds of the San Joaquin Valley northward toward San Francisco Bay. The southern third of the valley drains to several terminal lakebeds, and has done since the Pleistocene Epoch. Two of these lake beds, Buena Vista Lake and Kern Lake, lie adjacent to the northern boundary of the District and are the terminus of surface water drainage in the southernmost portion of the valley. Ephemeral streams from uplands south, east and west of the District flow across District lands toward these lake beds.

Neighboring districts include West Kern Water District to the west, Henry Miller Water District and portions of Buena Vista Water Storage District and Kern Delta Water District to the north, Arvin-Edison Water Storage District to the north and east, and Tejon-Castac Water District to the south, which partially overlaps a portion of the District. The southern boundary of district abuts the foothills of the Tehachapi Mountains. The California Aqueduct traverses the District west to east for about 34 miles, beginning about midway between the District's northern and southern boundaries and exiting the south eastern boundary. Most of the land within the District slopes to the north. Elevations range from 295 feet above sea level at its northwesterly boundary to 1,865 feet at its eastern boundary. Access is obtained via State Route 99 and Interstate 5 highways in the north-south direction, and State Route 166 (Maricopa Highway) in the east-west direction.

Farm lands in the District are approximately 30 miles or more from any urban areas, such as the City of Bakersfield, and there is limited interest to convert these lands to urban uses. However, some urbanization is occurring in other areas of Kern County resulting in the conversion of agriculture lands to urban use. The current irrigated land area within the District is expected to remain relatively stable for the foreseeable future, as indicated in Table 3. While there is a minor potential for some increase in the amount of irrigated acreage since there are undeveloped or un-irrigated lands within the District, the District expects the more likely change would be a decrease in irrigated acreage due to the decreasing reliability of imported supplies from the SWP.

Table 3. Expected Changes to Services Area

Change to Service Area	Estimated Magnitude of Change	Cause(s) of Change	Estimated Effect on Water Supplier
Reduced Service Area	Negligible	Change in District Contract Acres	No substantial impact
Increased Service Area	Negligible	Change in District Contract Acres	None
Reduction in Irrigated Acreage	Negligible	Potential reduction in available water supply.	None
Increase in Irrigated Acreage	Negligible	Limited water supply may limit potential increase in Irrigated Acreage.	None

The District has constructed extensive facilities for the purpose of conveyance and distribution of imported surface water supplies to lands within the District, including canals, pipelines and pumping plants. The District owns and operates a distribution system of 294 miles of pipelines, 137 booster pumps, 16 wells and over 7 miles of concrete-lined canal. Depending on land leasing patterns in a given year, the District serves between 50 and 60 customers. A summary of the existing irrigation distribution facilities located within the District is identified in Table 4.

Table 4. Water Conveyance and Delivery System

System Type	Number of Miles[2]	Percentage of System
Unlined Canals	None	0%
Lined Canals[1]	7.05 miles	2.2%
Pipelines	294 miles	97.8%
Drains	None	0%
Total	301.05 miles	100%

[1] Specifications No. WRM 620 for constructing 850 Canal, 1971.
[2] Based on Wheeler Ridge GIS data and the District Engineer-Manager's Inventory Binder.

The District delivers the SWP water through 15 turnouts within Reaches 14, 15 and 16 of the California Aqueduct. Water is transported through District owned lined canals and pipelines to farm turnouts.

The District's delivery system is automated with pressurized pipelines delivering to 746 farm turnouts, basically eliminating operational spills. Pumps are monitored and controlled remotely through the District's Supervisory Control and Data Acquisition (SCADA) system. Each turnout is equipped with a totalizing and indicating flow meter. Since surface water is delivered from the California Aqueduct into pressurized pipeline delivery systems regulating reservoirs are not necessary for the system to operate efficiently.

Table 5. Water Supplier Reservoirs

Reservoir	Capacity (AF)	Storage Rights (AF)
None	n/a	n/a

The majority of land within the District's service area is well drained which reduces surface runoff. Also, as shown in Table 22A, virtually all on-farm irrigation in the District's service area is made with high-efficiency irrigation systems (micro drip, micro sprinkler, and sprinkler). Therefore, the need for on-farm surface tail-water recovery systems is low. A few vegetable growers use surface tail-water recovery systems to capture and reuse runoff from sprinkler systems.

The District owns one 12 acre Spill Basin (reservoir) to capture operational spills at the end of its 7 mile 850 Canal system. However, as described in Table 49, real-time SCADA control systems on the 850 Canal result in virtually no spill, and operation of the pumps at the Spill Basin for recovery of any spilled water has not been necessary for many years.

Table 6 summarizes the existence of tail-water recovery systems.

Table 6. Tail-Water Recovery System

System Type	Yes/No
District Operated Tail-water Recovery	Yes
Landowner Operated Tail-water Recovery	Yes

As previously stated in Section 1, and described further in Section 7, the District is continually improving water management practices. District Programs are focused on the goal of providing an annual surface water supply to the landowners within the surface water service area to extend the sustainability of local groundwater resources underlying the District.

Due to the extensive plantings of permanent crops within the District, growers have converted on-farm distribution systems to sprinkler, drip and fan-jet systems, which provide highly efficient irrigation operations. The District also provides funds annually to the NWKRCD to support the evaluation of the efficiency of on-farm irrigation systems. In addition, the District maintains and operates its own weather data station that allows water users to base irrigation decisions on locally provided information.

2.1.3 Terrain and Soils

Most of the land within the District covers the valley floor and the gently sloping foothills at the valley's southern edge, where the Coast Ranges and Tehachapi Mountains meet. Elevations within the District range from 295 feet above mean sea level (msl) at the northwesterly boundary to 1,865 feet msl at its eastern boundary. The land surface within the District generally slopes from the foothills along its southern and eastern boundaries to the lower elevation along its northern boundary near historical dry lake beds in the west-central portion of the valley. Grades are generally less than 4 percent and the topography can generally be characterized as flat. The California Aqueduct crosses the District from west to east along an approximate ground surface elevation of 500 feet msl, rising to 1,250 feet msl as it extends over the District and eventually exits the basin to the southeast (Figure 2). The Tehachapi Mountains and San Emigdio Mountains rise up from the valley floor to the south of the District, while the Temblor Range of the Coast Ranges and the Sierra Nevada Foothills rise up to the west and east of the District, respectively. Ground surface elevations within the contributing watershed of the District rise to above 7,000 feet msl in the San Emigdio Mountains south of the District boundary.

Table 7. Landscape Characteristics

Topography Characteristic	Approx. % of District	Effect on Water Operations and Drainage
Flat Land	95%	Land is adaptable to sprinkler and micro irrigation systems.
Rolling Land	5%	Land is adaptable to sprinkler and micro irrigation systems.

The primary land use within the District is agriculture. About 97% of the land within the District is irrigable, with 90% of the soils within the Surface Water Service Area classified as having wide crop adaptability with no limitations. A wide variety of crops are grown. Crops with a total acreage of over 1,000 acres within the District are cotton, safflower, wheat, alfalfa, carrots, lettuce, melons, onions, peppers, potatoes, tomatoes, wine and table grapes, almonds, pistachios, lemons, and oranges. Among other crops grown are asparagus, walnuts, plums, and grapefruit.

The soil types in Kern County vary in structure, texture, and chemistry with geographical location. Valley floor soils are derived mostly from mixed granitic and sedimentary rocks and are characterized as saline-alkaline. The generalized soils map units or soil associations underlying the area, shown in Figure 3, are described in the soil surveys for Kern County, prepared by the U.S. Natural Resources Conservation Service.

A general soil map unit consists of one or more major soil types and some minor soils that occur together in a recognizable pattern. Soils within the District do not have any identifiable impacts upon water operations and management in the service area.

2.1.4 Climate

The District experiences a semi-arid climate. The growing season is among the longest in the San Joaquin Valley, averaging about 300 days above 32 degrees Fahrenheit (°F) and almost 365 days above 28°F. Temperatures exceed 90 degrees Fahrenheit about 110 days per year. The average precipitation of about 7 inches per year falls almost entirely in the winter and spring.

Given the District's location at the southern end of the San Joaquin Valley in a portion of the valley that is partially surrounded by a horseshoe-shaped ring of mountains, the Sierra Nevada Mountains to the east shut out most of the cold air that flows southward over the continent in the winter. Summers in the southern portion of the valley are typically hot and dry. Winters are typically cooler and are characterized by frequent fog or low clouds which occur mostly at night. These conditions prevail when cold, moist air is trapped in the valley by high pressure systems. The depth of fog or clouds is usually less than 3,000 feet above ground level. There are usually clear skies and mild temperatures in the surrounding foothill and mountain areas.

Table 8 summarizes climate conditions as measured by the District. Annual precipitation typically ranges between five to seven inches, with most of the rainfall occurring during the “Wet Season” of November through March. The order of magnitude of the annual rainfall that falls on the San Joaquin Valley floor area where irrigation occurs is comparable low even between dry, typical, and wet year types. The precipitation over the District area is based on a Thiessen average of six weather stations maintained by the District. The irrigated area has received an average annual precipitation of less than 7.11 inches per year. However, the west side of the district is consistently drier than the east. Climate characteristics for the District service area are presented in Table 9.

Figure 3. Generalized Soil Texture Map

Table 8. Landscape Characteristics

Climate Characteristic (Basis)	Units	Value
Avg. Precipitation (annual)[1]	In	7.11
Max. Precipitation (annual)[1]	In	17.46[(6)]
Min. Precipitation (annual)[1]	In	3.09[(7)]
Avg. Mean Daily Temperature (winter season)[2]	deg-F	48.3
Avg. Daily Min. Temperature (winter season)[3]	deg-F	38.1
Avg. Mean Daily Temperature (summer season)[4]	deg-F	80.3
Avg. Daily Max. Temperature (summer season)[5]	deg-F	94.1

[1] Based on Thiessen average precipitation as computed from observations at six District-operated weather stations over the 30-year period from 1984 to 2013, all measurements made by the District's staff.
[2] Average of mean daily average air temperature during the months of December through February using CIMIS Station #125 (Arvin-Edison) data during the period 2004-2013.
[3] Average of daily minimum air temperature for the months of December through February using CIMIS Station #125 (Arvin-Edison) data for the period 2004-2013.
[4] Average of mean daily average air temperature during the months of June through August using CIMIS Station #125 (Arvin-Edison) data during the period 2004-2013.
[5] Average of daily maximum air temperature for the months of June through August using CIMIS Station #125 (Arvin-Edison) data for the period 2004-2013.
[6] Occurred in 1998.
[7] Occurred in 2008.

Table 9. Detailed Climate Characteristics

Month/ Time	Season	Avg. Precipitation (in)[1]	Avg. Ref ET(in)[2]	Avg. Min Temperature (deg-F)[3]	Avg. Max Temperature (deg-F)[4]
January	Wet	1.29	1.52	37.9	57.1
February		1.39	2.29	40.6	63.4
March		1.10	4.02	45.1	69.0
April	Dry	0.54	5.64	48.2	73.7
May		0.30	7.70	55.1	82.2
June		0.06	8.64	61.2	89.5
July		0.02	9.18	67.3	97.3
August		0.00	8.57	64.4	95.5
September		0.10	6.40	59.2	90.6
October		0.33	3.97	49.7	77.8
November	Wet	0.84	2.11	42.1	66.9
December		1.09	1.43	35.9	58.5
Wet Season Total[5]		5.71	2.27	-	-
Dry Season Total[5]		1.35	7.16	-	-
Annual Total		7.06	61.47	-	-

[1] Based on Thiessen average precipitation as computed from observations at six District-operated weather stations over the 29-year period from 1985 to 2013, all measurements made by the District's staff.
[2] Based on daily ET_0 data at CIMIS Station #125 (Arvin-Edison) during the period 2004 to 2014.
[3] Based on daily minimum air temperature using CIMIS Station #125 (Arvin-Edison) data during the period 2004 to 2014.
[4] Based on daily maximum air temperature using CIMIS Station #125 (Arvin-Edison) data during the period 2004 to 2014.
[5] "Wet" season constitutes total values for November through March; "Dry" season covers April through October.

2.2 Operational Characteristics

2.2.1 Operating Rules and Regulations

The District has adopted Rules and Regulations for Distribution and Use of Water ("Rules and Regulations"; copy included in Appendix A) that serve as the guideline for District operations and delivery of water. The Rules and Regulations cover the procedures which are followed to distribute irrigation water in an orderly, efficient, and equitable manner.

The District's Rules and Regulations are established pursuant to the requirements of the California Water Code by the Board of Directors of the Wheeler Ridge-Maricopa Water Storage District for the distribution and use of water within the District. The District's Rules and Regulations expand upon the contracts between the District and Water Users for water service.

The adopted Rules and Regulations enable the District to perform its functions efficiently, to deliver water to Water Users at the least possible cost, and are the Rules and Regulations mentioned in water service contracts between the District and various landowners within the District. These Rules and Regulations were first adopted July 8, 1970, and have been amended from time to time.

Several of the terms and expressions employed in the Rules and Regulations are defined in the Water Service Contracts executed by the District and its landowners. As defined in the District Rules and Regulations for Distribution of Water, Contract Water Service is provided only to lands in the District's **Surface Water Service Area**. Note that there are rules for addition of land to and exclusion of lands from the Surface Water Service Area. When available, **Unscheduled Water Service** in excess of the Contract Amount is offered to Water Users.

Since the District is a member of the KCWA, which is a State Water Contractor, it receives an annual allocation of SWP water in addition to other contracted water supplies that are delivered via the California Aqueduct. Each year, the District endeavors to provide the contract amount of water on a demand basis as requested by Water Users, but, does not assume any obligation if it is unable to do so. It is recognized that the District's delivery capability is limited in the month or months of maximum demand by the capability of the District's distribution facilities, SWP facilities, and such limitations must be considered in meeting Water Users' requests.

Table 10. Supplier Delivery System

Delivery System Type	Type Used? Yes/No	Approx. Percentage of System
On Demand	No	-
Arranged Demand	Yes	100%
Rotation	No	-

[1] Arranged Demand type based on 24-hour notice given to District for water user activities.

The District's Contracts and Rules and Regulations contain the procedures for allocation of available water supplies and establishing water rates. Such allocations and rates are adopted annually by the Board of Directors. Water Users within the District hold contracts with the District that specifically detail the Contract Acres, Allocation Acres, and Contract Amount of Water (CAW) for each contract. If the total available District supply is greater than 2.0 acre-feet per allocation acre, then the District supply is allocated per CAW. If the total District supply is less than 2.0 acre-feet per allocation acre then the District supply is allocated per allocation acre. The total District Contract Acres, Allocation Acres, and CAW are 72,081 acres, 71,082 acres and 200,818 acre-feet, respectively. The District's SWP contract amount through the KCWA is 197,088 acre-feet of the total 200,818 CAW.

Table 11. Water Allocation System

Basis of Water Allocation[1]	Allocation Type	Normal Year Allocation[2]	Percentage of Water Deliveries
Lands within the Service Area	Volume	200,818 AF[3]	100%
Other[4]	Equitable Allocation by Volume or by Acre	-	-

[1] Water allocation to users is by volume determined in various contract conditions.
[2] District sets an annual water allocation target.
[3] Total water held by all contract users in the District (i.e. contract numbers, not physical water); actual allocation in a given year determined based on actual supply
[4] Equitable allocations by volume or by acre depending on quantity of contract water supplies available.

The District Rules and Regulations provide as follows: *"Daily orders to turn on or to turn off water, or orders to increase or decrease the rate of water delivery, shall be made at the District office through telephone communication, facsimile transmission, e-mail or personal communication from Water User or his designee as provided in these Rules and Regulations. Water orders shall be placed before 8:00 AM for water service for the following day, and water orders placed after 8:00 AM will be for water service the second succeeding day. In the event of an emergency, or when a change is in the delivery point within the service area of the same lateral, or when it may otherwise be practical to do so, changes in deliveries may be approved on lesser notice but the District assumes no obligation to do so. Although the District will make every reasonable effort to comply with the requested water orders, there may be times when, because of system capacity limitations, or limitations in the amount of water available, such compliance may not be possible, and the*

District assumes no obligation therefor. Orders shall normally be made on the basis of continuous use of water during the 24-hour period commencing between 7:00 AM and 9:00 AM. Provided however, that the Board may establish special conditions for short-run deliveries and/or for deliveries at lower flow rates than for normal irrigation practices." Although the Rules provide for continuous 24-hour use, current practice is for Water Users to order water with specific start and stop times, including changes in flows. This flexibility allows Water Users to deliver only that quantity required for crop needs, avoid overwatering because of required 24-hour use, and thereby improve on-farm irrigation efficiency.

Table 12. Actual Lead Times

Operations	Hours/Days
Water Orders	24-hr notice
Water Shut-Off	No notice needed.[1]

[1] Landowners can shut-off incoming water and notify district will little to no lead time needed.

2.2.2 Water Delivery Measurements or Calculations

All farm delivery points, or "turnouts", for water delivered by the District to the landowner are equipped with flowmeters that indicate instantaneous flow and accumulate the quantity delivered with a totalizer. District Staff read the meters every Tuesday and observe each meter for any sign of abnormal reading. Figure 4 is a photograph of a typical farm turnout.

Figure 4. Typical Farm Turnout

Since all propeller meters used by the District are equipped with totalizers, the District can equate the calibrated accuracy of the flow meter to volumetric accuracy. According to the publication SBx7-7 Flow Rate Measurement Compliance for Agricultural Irrigation Districts by the Irrigation Training & Research Center (ITRC) of the California Polytechnic Institute, San Luis Obispo, devices with totalizers provide measurements that are sufficiently precise (in monitoring flow duration) to assume that the flow rate accuracy is equivalent to the calibrated volumetric accuracy. As a result, the devices used by the District to measure delivery rates provide data that enables reliable computation of volumes of water delivered at each turnout.

The DWR maintains flow measurement devices that measure the quantity of water delivered through each of the turnouts from the California Aqueduct. A discussion is provided in Section 8 of this AWMP regarding how the District makes a comparison between the total volume delivered as determined by the DWR measurement off of the California Aqueduct and the total volume delivered to the landowners as determined by the flow meters at farm turnouts read by the District Staff.

Based on the District's operation and maintenance procedures, the District is confident the DWR and District meters provide a very accurate method of measuring both the flow rate and the volume of water delivered into the District and at the District's turnouts. As documented herein, the District's existing water measurement devices perform substantially better than the ±12 percent accuracy standard and new meters perform substantially better than the ±5 percent accuracy standard. District Staff routinely monitor each meter for abnormalities and District policy is to replace a meter if the abnormal reading cannot be rectified in the field (see Section 8 of the plan). The District uses the same manufacturer for all meters to help with consistency in measurement. In addition to District Staff monitoring for any abnormal performance, landowners can request the meter be tested.

Table 13 provides District flow meter information in tabular form, along with the typical levels of accuracy for typical types of measurement devices.

Table 13. Water Delivery Measurements

Measurement Device	Frequency of Measure	Frequency of Calibration	Frequency of Typical Maintenance	Est. Level of Accuracy
Propeller Meters with Totalizers[1]	Read Weekly	Infrequently	As needed	± 2%
Venturi Meters[2]	Continuous	As needed	As needed	± 2%

[1] Propeller Meter manufacturer (MC Model MG900; McCrometer, Hemet, CA) specifies ±2% accuracy reading guaranteed, throughout range of 40 gpm to 8500 gpm depending on nominal pipe size (±1% accuracy over reduced range), and a repeatability 0.25% or better. See specification sheet for Propeller Meter in Appendix F.

[2] Venturi Meters are used for deliveries off the California Aqueduct to the District's conveyance system. These meters are operated and maintained by the DWR.

2.2.3 Water Rate Schedules and Billing

The District Board of Directors annually establishes water rates. The District has several service areas that have different energy charges associated with them resulting in some variation in rate based on the pumping lifts required to deliver water to service areas.

Although the District pricing structure is quite complicated, it is basically split into two areas; fixed charges (typically based upon Contract Acres), and variable charges based upon the quantity of water ordered or delivered. The costs associated with the District infrastructure and personnel are charged through the acreage charge, and the water costs and power costs associated with the delivery are charged on a per acre-foot basis.

Table 14. Water Rate Basis

Type of Billing Rate Basis	Type Used? Yes/No	Approx. % of Water Deliveries	Description
Volume of Water Delivered	Yes	100%	A portion of each water bill is based on volume of water delivered.
Area (acres)	Yes	100%	A portion of each water bill is based on an acreage charge.
Land Assessment	Yes	-	Lands benefitting from the District's Project that are outside the Surface Water Service Area pay a small fixed per acre charge regardless of availability of surface water delivered by the District.
Crop	No	-	-

Under conditions of Contract Water Service, Water Users pay the Water Availability Charge and Water Use Charge as provided in the Water Service Contract. On or before July 1 of each year, the District mails to each Contract Water User a final accounting of water charges for the previous year which corrects the budgeted rates and deliveries to actual values

Table 15. Rate Structure

Type of Billing Rate Structure	Type Used? Yes/No	Description
Declining Block Rate	No	-
Uniform	Yes	Varies from year-to-year based on availability of SWP and other scheduled, contracted water or supplemental water supplies in addition to the contract water supply.
Increasing Block Rate	No	-

On or before December 1 of each year, District will notify each Water User in writing of the estimated total amount of water charges for the year. The total amount shall be paid by Water User in eight equal installments due and payable on the tenth day of the months of February through September of each year, which includes all water allocated for the year. The frequency of billing is shown in Table 16.

Table 16. Frequency of Billing

Billing Frequency
8 Equal Monthly Installments.

2.2.4 Water Shortage Allocation Policies and Drought Management Plan

The District's Water Shortage Allocation Policy is stated in Section 3(l) of the Water Service Contracts and Section 8 Water Shortages of the District's Rules and Regulations. Section 8 provides as follows:

"Pursuant to powers granted by Section 43003 et seq., of the California Water Code, the Board has established the water shortage policy to provide for the sharing of the burden of any shortages in the quantity of water available for distribution to Water Users and the cost of thereof during any year.

Allocation of Water: The water supplies available to the District will be allocated to the District's Agricultural Contract Water Users as follows:

> i. If the District's available water supply in any year is less than the total of Contract Amount of Water for all Water Users, but more than two acre-feet per acre when averaged for all lands in the Surface Water Service Area, the available supply will be apportioned to all Water Users in the proportion that each Water User's Contract Amount of Water for that year bears to the total of Contract Amount of Water for all Water Users.
>
> ii. If the District's available supply in any year, averaged for all lands in the Surface Water Service Area, is less than two acre-feet per acre, the available supply will be apportioned among all Surface Water Service Area lands on an equal acre-feet per acre basis provided that Water User shall not be apportioned more water under this paragraph (ii) than Water User would receive under paragraph (i) above. Notwithstanding the above, in the event of a severe long-term water shortage, the Board reserves the right to make such other allocations as it deems appropriate, taking into consideration the type of crop, critical water needs, and the economic effect of losses which may occur as a result of such allocations and may provide for adjustments of charges as a result of such allocations.

Supplemental Water: The District during years of short supply may obtain water supplies in addition to that available under the KCWA Contract, including District wells and Banking Programs. Such water supplies are allocated first to provide the full Contract Amount of Water provided for in the contracts for Agricultural Water Service under terms as the Board then determines appropriate and the costs thereof borne by the beneficiaries of such supplies. The method of allocation of Supplemental Water is as set forth in the contracts for Agricultural Water Service and recited in paragraph 8(a) above.

Industrial Water: Apportionment of water under an Industrial Water Service Contract is governed by the terms of that Contract.

Conveyance of Ground Water: In any year the District declares a water shortage exists, District facilities may be used to convey ground water for use upon land within the District for agricultural purposes [whether or not the lands to be served are within the common ownership or Farming Operation of the land from which the water is pumped], provided the affected parties enter into an Agreement in a form provided by the District…"

Under its contract with the Kern County Water Agency, the District receives an annual allocation of SWP water which is delivered from the California Aqueduct. The amount of water available from this source varies with the type of year ("dry" versus "wet") and any judicial and administrative constraints on the amount of pumping allowed from the Sacramento-San Joaquin River Delta. Similarly, additional contract water supplies vary from year-to-year, as additional contract supplies are dependent on purchases made by the District.

During years of short supply, the District may supplement available surface water through purchases of surface supply and the operation of District-owned wells. Table 17 lists the measures that the District Board has exercised in responding to water shortages.

Table 17. Decreased Water Supply Allocation

Allocation Method	Method Used? Yes/No
Decrease Allocated Water	Yes
Shorten Irrigation Season	No
Restrict Water to Specific Crops	No

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

Table 18. Enforcement Method of Allocations Policy

Enforcement Method	Method Used? Yes/No
Shut-Off of Water Supplies	Yes
Refuse Service	No
Fines/Penalties	No

This Drought Management Plan section details how the District would prepare for droughts and manage water supplies and allocations during drought conditions. Some components or actions may require review of conditions, policy changes, and long-term capital improvements. Additionally, as conditions change and new technology and knowledge becomes available, opportunities and constraints will change. The drought management plan describes the following components prescribed in the Guidebook:

1) ***What hydraulic levels or conditions (reservoir levels, stream flows, groundwater, snowpack etc.) are monitored and measured to determine the water supply available and level of drought severity.***

   The primary source of surface supply for the District is its allocation to SWP water through the Kern County Water Agency (KCWA), the local contractor with the SWP. Hydrologic conditions affecting supply and operations of the SWP are extensively monitored by DWR and used to forecast allocations to each of the project's contractors. These allocations then determine the quantity of SWP water available to the District. Deliveries from the California Aqueduct into the District's system are measured. In addition, the District participates in several water purchase and transfer programs that acquire water supplies which are typically acquired during wet periods, placed into groundwater storage outside of the District, and recovered for in-district use in dry years. The District also monitors groundwater elevations for compliance with DWR's CASGEM program.

   Determinations of drought severity as it applies to the SWP are developed by DWR. Data on groundwater elevations are used by the District to assess drought severity.

2) ***The district's policy and process for declaring a water shortage and implementing the water shortage allocation and drought management plan.***

   Water supplies available from the SWP are governed by watershed precipitation, snow melt runoff and other hydrologic factors that affect the yield of the SWP. For SWP water, in any year when the District's water supply from the KCWA is less the total of the contract amounts for all water users in the service areas, each water user is allocated a pro-rated share of the District's total water supply in accordance with the shortage policy described for the District. The District may also allocate supplies obtained through active purchase and transfer programs and from surface supplies retrieved from previously stored water in groundwater banks. A portion of the water allocated to water users may be from sources other than the SWP, including water it returns as a delivery into the District from storage in banking projects located outside of the District.

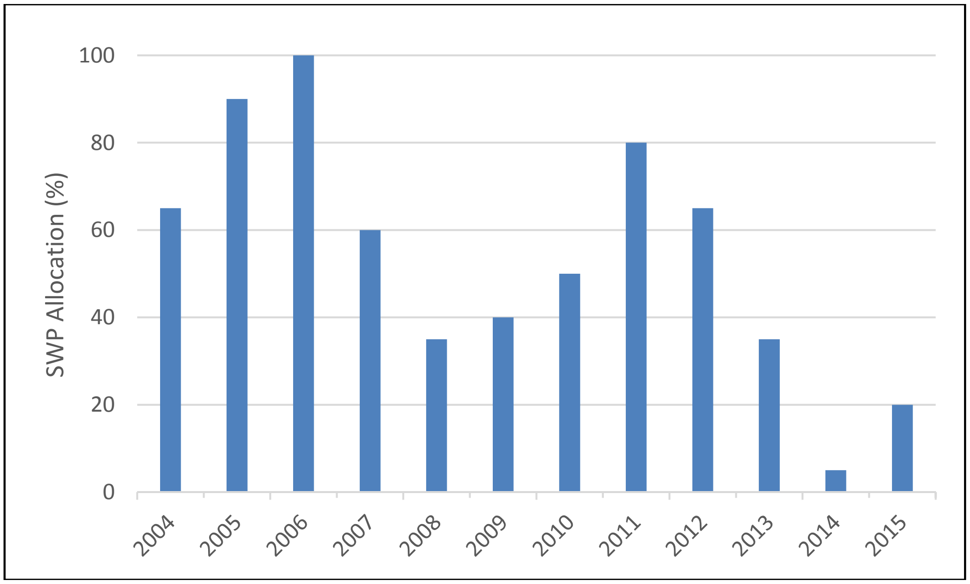
During years when the availability of water from the SWP is limited, the District pumps groundwater from District-owned wells as part of the District's conjunctive management strategy. The District also recovers water from banking facilities that are located outside of the District. These facilities include the Kern Water Bank Authority, the Pioneer Project, and Berrenda Mesa Project.

3) Operational Adjustments – changes in district water management and district operations to respond to drought, including canal and reservoir operations and groundwater management.

Figure 5 shows the annual percent of SWP allocation to the District from 1992-2015. The figure illustrates that in a "dry" year, surface water supplies can be very limited as in 2014. Under these conditions, pumping from both District-owned-and-operated wells and from privately-owned wells increases to meet demands. By contrast, in a recent "wet" year such as 2011, surface water deliveries exceeded 159,000 AF delivered within the District and over 111,117 AF delivered to banking facilities located outside of the District. The "wet" year deliveries are sufficient not only to satisfy irrigation water requirements within the District's Contract Service Area (and thereby minimize the use of groundwater), but to store surface supplies for later delivery into the District for use in dry periods.

During droughts, because surface water supplies available to the District are reduced, measures to improve management of surface water through canal and reservoir operations have limited effectiveness. The District's response to dry conditions has been to exercise conjunctive management by increasing extraction of supplies previously stored in groundwater banks located outside of the District and increasing extraction from District- and privately-owned wells to compensate for reduced deliveries of surface water.

Due to its length and severity, the current drought is causing the District to utilize previously stored surface water that it had put into groundwater storage. In addition to the drought response measures undertaken by the District, individual land-owners within the District service area have been actively managing land, water and other resources to minimize drought-induced impacts on their farming operations.



Source: Engineer-Manager Monthly Report for November 2015.

Figure 5. Percent of Annual State Water Project Allocations

4) ***Demand Management – policies and incentives in addition to the water shortage allocation plan to lower on-farm water use.***

The District's programs for demand management includes operating a pressurized delivery system that delivers water to the on-farm, drip irrigation systems and the District has conjunctively managed available supplies to meet demands. The District has purchased surface water supplies available during wet periods, placed the supplies into groundwater storage, and supplemented limited surface supplies during times of drought with the extraction and return of previously stored water. However, for the most part, rather than instituting district-governed policies and incentives to lower on-farm water use, the District's approach to demand management has been largely to provide the high degree of flexibility and responsiveness in deliveries necessary to enable growers to manage water efficiently under all conditions. These practices include use of district-owned conveyance facilities to deliver water transferred to land holdings within the service area.

The District also provides clear estimates of water allocations so that growers can make well-informed farming decisions. The level of operational responsiveness provided by the District together with early projections of water allocations are particularly crucial during droughts when farmers must make challenging decisions on how best to manage their farmland including decisions on planting and on allocation of water among established crops.

5) ***Alternative Water Supplies – discuss the potential if possible for the district to obtain or utilize additional water supplies. These supplies could include transfers from another water agency or district, the use of recycled water and desalination of brackish groundwater or drainage water.***

As previously mentioned, the District's principal source of surface water is its allocation of SWP water. In addition, the District can gain access to supplemental supplies of water through purchases and transfers. Throughout the drought, the District has adhered to its fundamental strategy of returning previously stored water from groundwater banks and on additional purchases and transfers to satisfy demands within the District's service areas.

6) ***Stages of Actions – includes the stages of action and corresponding levels of drought severity that district will implement in response to the drought.***

Drought response in the District is a responsibility shared by the District and its growers. The District's drought response policies are intended to allocate available surface water, augmented by delivery of previously stored water in groundwater banks located outside of the District and from groundwater pumped from district- owned wells, in a manner that is equitable and consistent with the District's operational policies while maintaining the District's financial viability. An important objective of this approach is to provide growers with an accurate assessment of the volume and cost of water that will become available to them so they can utilize this water in a manner that is best suited to the requirements of their farming operations.

Because the quantity of SWP water available to the District in any given year is beyond the District's control, the District's drought response measures center on managing water previously stored in groundwater banks and opportunities to purchase or transfer water during the dry periods. Reduced allocations of District-supplied water have placed the responsibility of managing these reduced supplies on growers to determine how best to utilize limited water supplies through deficit irrigation, fallowing of annual crops and other water conservation measures.

7) ***Coordination and Collaboration – include a description of how coordination and collaboration with other local districts and water agencies or regional groups will be used in drought response.***

The District has participated in drought programs through coordination and collaboration with the KCWA and the Westside 5 (a group of five water districts comprised of Belridge Water Storage District, Berrenda Mesa Water District, Dudley Ridge Water District, Lost Hills Water District and the District) to enhance water supplies available to growers. Implementation of the Sustainable Groundwater Management Act (SGMA) will provide yet another mechanism for regional collaboration and coordination. Regional efforts to implement this legislation will provide a firm, cooperative basis for management of groundwater during all conditions, but will be particularly important as a tool for drought response.

8) ***Revenues and Expenditures – describes how the drought and lower water allocations will affect the district's revenues and expenditures.***

The District's Board of Directors annually establishes a water allocation of available supplies and establishes water rates. Water and the cost for the water is applied on a per-acre basis and is based on budget requirements and Board policy.

Since SWP water is delivered into the District's distribution system and distributed using pressurized laterals, the cost of distributing surface water in the pressurized distribution system is attributable to the fixed costs of operating and maintaining the canal and pipeline distribution system.

The District's Service Charge is based on the volume of surface water projected to be available to the District during the coming irrigation season, and uncertainties in these projections can result in unexpected expenditures to both the District and to its water users.

2.2.5 Basis for Reporting Water Quantities

The District annually receives an allocation of its contract amount of SWP water via the California Aqueduct that is referred to as the SWP "Table A" allocation, which is expressed as a percentage of the District's contract amount. Accordingly, this allocation becomes an indicator of the hydrologic year type. The annual allocation is a function of hydrology and any regulatory constraints on the amount of pumping allowed from the Sacramento-San Joaquin River Delta. Since the degree of variability in the District's surface water supplies is heavily based on the reliability of water deliveries from the SWP, recent years representing each of three year types (wet, intermediate/in-between, and dry) were selected to illustrate the District's operations for annual SWP Table A allocations ranging from 40 to 80 percent. The selection of multiple years illustrates the variability in District operations from year to year. Since the selected years are recent years, they also reflect the "current" level of development, modernization, and delivery capability.

In particular, 2014 represents an extremely dry year with 5 percent Final Table A Allocation with monthly precipitation levels below normal. Moreover, there was a significant amount of additional water supplies purchased or previously banked water recovered by the District due to limited SWP surface water supplies. Conversely, 2011 was a wet year with 80 percent Final Table A Allocation and above average precipitation levels. To illustrate operations in between these two years, 2012 was selected, with a Final Table A Allocation of 65 percent and since weather patterns and surface water supplies were in between the wet- and dry-year scenarios. The District's cropping pattern evidenced some minimal changes between these years, as shown later in Tables 21A through 21D. These years illustrate recent District operations in consecutive years leading into the significant drought year of 2014, and the critically dry year of 2015. The years are identified in Table 19.

Table 19. Presented Years

Calendar Years	2011	2012	2013	2014	2015
Water Year Type	Wet	Typical	Dry	Extremely Dry	Critically Dry
SWP Allocation Percentage	80%	65%	35%	5%	20%

Description of Quantity of the Water Uses of the Agricultural Water Supplier

The total demand for District water use from year to year is fairly consistent; however, it varies a little for industrial uses and for agricultural water use depending on the irrigated acres, types of crops, and the local climate. Regarding agricultural water use, "Applied water" refers to the amount of water that must be applied in addition to rainfall to meet crop water requirements. The applied water requirement which is not met with supplies delivered into the District is met with pumped groundwater.

3.1 Agricultural Water Use

The primary land use within the District is agriculture. Historically, the District's agricultural development expanded significantly in the 1940's, peaked in total acres by the mid-1970's, and since the 1990's shifted from field crops to more permanent crops. Permanent crops, primarily nut trees, citrus, and grapes, account for around 70 percent of the total area of the crops planted in the District's service area. The crop makeup of the District is largely the result of the conversion of annual crops to high value permanent crops over time, which has led to a "hardening" of the total water requirement.

Table 20 summarizes the surface water deliveries (not identified as transfers or exchanges) to agricultural water use within the SWSA of the District for each of the year types. Surface water delivered as a transfer or exchanges to the District are included in Table 28 of this AWMP to maintain separate accounting of these deliveries in the water accounting tables. An estimate of overall agricultural demand is tabulated in Tables 21A, 21B, 21C, 21D, and 21E; and the estimate of the difference between the total water uses (water demand) and the District-delivered water supplies for each of the selected years is identified as the water balance closure term in the Water Budget, shown in Table 48. Regarding the Water Budget calculation, it is recognized as an estimated water balance closure term, calculated to meet the requirements of the DWR's AWMP Guidelines, and does not represent all the components necessary for determining the long term water balance for the District. For instance, the DWR's water balance closure term does not capture all components of the change in groundwater storage over time nor does it include all groundwater sustainability components, such as, an annual contribution or allocation of groundwater based on the safe yield of the basin.

Table 20. Agricultural Water Use for Presented Years

Water Source	SWSA Water Deliveries, per Year (AF)[1]				
	2011	2012	2013	2014	2015
Surface Water[2]	161,805	144,062	114,361	76,704	95,941
Groundwater (District)[3]	1,037	14,579	16,474	16,020	13,857
Groundwater (Private)[4]	1,230	5,853	14,177	40,347	45,669
Total	164,072	164,494	145,012	133,071	155,467

[1]From Engineer-Manager's Monthly Reports.
[2]Includes SWP, delivered banked water, and common landowner transfers. Individual values are refined by the Engineer-Manager.
[3]From User Input-District Wells entry of Monthly Engineer-Manager's Reports.
[4]From User Input-Private Wells entry of Monthly Engineer-Manager's Reports.

Tables 21A through 21E represent the water requirement for specific crops grown on the irrigated lands within the service area of the District during each of the five years. Total crop acreage is based on the District's annual crop survey for the each of the years. The District has an overlap area with neighboring AEWSD that appears as a checkerboard pattern as shown in Figure 2. Accordingly, the District's crop survey acres necessarily include some AEWSD acres in the overlap area. Water requirements are calculated for all of the WRMWSD acres, although AEWSD could potentially "double count" some of these crop water needs when it prepares its Agricultural Water Management Plan. Moreover, the overlap area includes roughly 1,666 acres of AEWSD surface water service area; this report did not attempt to account for AEWSD surface water deliveries to the overlap.

ET_c values are estimates based on *Report on Investigation of Optimization and Enhancement Water Supplies of Kern County*, Table 2, by Associated Engineering Consultants, dated 1983. This set of values, representing long-term average crop consumptive use, is also utilized in the Kern Fan Operations and Monitoring Report, which is prepared annually by the Kern Fan Monitoring Committee. Actual consumptive use of irrigation water will vary from year to year depending on rainfall and temperatures. Regarding the leaching requirement utilized for the crop water requirement calculation, it can vary by crop type, soil type, and other cultural farming practices. For the purpose of this report, the leaching requirement was based on a low, obtainable leaching requirement of five percent of the crop water requirement. The KCWA *Water Supply Report: 2011* stated a range of 5 to 10 percent and it is recognized this District can obtain a high level of district-wide efficiency since most applied water that percolates beneath the root zone is available for later reuse as a component of the groundwater supply. Furthermore, the District delivers water using pressurized delivery systems originating from the California Aqueduct to the farm delivery points; irrigated lands within the District do not require sub-surface drainage to remove salts and maintain salt balance; and applied irrigation water does not leave the SWSA as surface runoff. Although individual leaching requirements for each crop type can vary, given that water leached through the root zone is not lost to the overall District supply in this District, it is appropriate to represent the total crop water requirement calculation for the District by use of a low leaching factor.

Table 21. A. Agricultural Crop Data for the Year 2011

Crop	Total Crop Acres[1]	% of Total	Est ETc (ft)[2]	Water Req. (AF)	Est. Leaching (AF)[3]	Total Req. (AF)
Alfalfa Hay and Clover	1,622	1.9%	3.50	5,678	284	5,962
Almonds[4]	11,473	13.5%	2.50	28,683	1,434	30,117
Apple, Pear, Cherry, Plum, and Prune[4]	1,433	1.7%	3.20	4,585	229	4,814
Carrots	3,755	4.4%	1.60	6,008	300	6,308
Citrus[4]	20,043	23.5%	2.60	52,111	2,606	54,717
Corn and Grain Sorghum	305	0.4%	1.80	550	27	577
Cotton	4,843	5.7%	2.60	12,591	630	13,220
Flowers and Nursery	40	<0.1%	2.00	81	4	85
Grain and Grain Hay	1,988	2.3%	2.00	3,975	199	4,174
Grapes[4]	23,759	27.9%	2.30	54,645	2,732	57,378
Melons, Squash, and Cucumbers	1,633	1.9%	1.60	2,612	131	2,743
Misc. Subtropical Trees[4]	1,027	1.2%	3.20	3,287	164	3,451
Misc. Deciduous[4]	281	0.3%	3.20	899	45	944
Misc. Field Crops	139	0.2%	2.00	277	14	291
Onions and Garlic	1,812	2.1%	1.70	3,081	154	3,235
Pasture and Misc. Grasses	198	0.2%	3.70	733	37	770
Peach, Nectarine, and Apricots[4]	717	0.8%	3.20	2,294	115	2,408
Pistachio[4]	1,753	2.1%	3.20	5,609	280	5,889
Potatoes	2,172	2.6%	2.00	4,345	217	4,562
Safflower and Sunflower	376	0.4%	1.80	676	34	710
Small Vegetables	3,816	4.5%	1.60	6,106	305	6,411
Tomatoes and Peppers	1,969	2.3%	1.60	3,150	157	3,307
Totals[5]	85,153	100.0%		201,975	10,099	212,074

[1] Total acres including double cropped acres, District's *Crop and Land Use Surveys*.
[2] From *Report on Investigation of Optimization and Enhancement Water Supplies of Kern County*, (1983), Table 2, by Associated Engineering Consultants.
[3] Leaching requirements vary by crop type, soil type and other factors. For the purposes of this table, a leaching requirement of 5 percent of the crop water requirement was assigned, not been verified, however it is considered representative for District-wide efficiency.
[4] Considered Permanent Crop, 71 percent of total acres in 2011.
[5] Idle acres of 66,663 acres not included in the total for crop acres for 2011

Table 21. B. Agricultural Crop Data for the Year 2012

Crop	Total Crop Acres[1]	% of Total	Est ET_C (ft)[2]	Water Req. (AF)	Est. Leaching (AF)[3]	Total Req. (AF)
Alfalfa Hay and Clover	2,462	2.7%	3.50	8,616	431	9,047
Almonds[4]	11,976	13.3%	2.50	29,939	1,497	31,436
Apple, Pear, Cherry, Plum, and Prune[4]	1,430	1.6%	3.20	4,577	229	4,805
Beans	104	0.1%	1.40	146	7	153
Carrots	2,974	3.3%	1.60	4,758	238	4,996
Citrus[4]	21,171	23.5%	2.60	55,044	2,752	57,797
Corn and Grain Sorghum	607	0.7%	1.80	1,093	55	1,147
Cotton	3,419	3.8%	2.60	8,889	444	9,333
Flowers and Nursery	75	0.1%	2.00	151	8	158
Grain and Grain Hay	4,192	4.7%	2.00	8,384	419	8,804
Grapes[4]	24,397	27.1%	2.30	56,112	2,806	58,918
Melons, Squash, and Cucumbers	1,702	1.9%	1.60	2,723	136	2,859
Misc. Subtropical Trees[4]	1,118	1.2%	3.20	3,578	179	3,757
Misc. Deciduous[4]	281	0.3%	3.20	899	45	944
Misc. Field Crops	2,518	2.8%	2.00	5,036	252	5,288
Onions and Garlic	1,740	1.9%	1.70	2,958	148	3,106
Pasture and Misc. Grasses	198	0.2%	3.70	733	37	770
Peach, Nectarine, and Apricots[4]	601	0.7%	3.20	1,924	96	2,020
Pistachio[4]	1,753	1.9%	3.20	5,609	280	5,889
Potatoes	2,001	2.2%	2.00	4,002	200	4,202
Safflower and Sunflower	180	0.2%	1.80	324	16	340
Small Vegetables	2,648	2.9%	1.60	4,237	212	4,449
Tomatoes and Peppers	2,498	2.8%	1.60	3,996	200	4,196
Turnips and Misc. Vegetables	37	<0.1%	2.00	75	4	78
Totals[5]	90,082	100.0%		213,803	10,690	224,494

[1] Total acres including double cropped acres, District's *Crop and Land Use Surveys*.
[2] From *Report on Investigation of Optimization and Enhancement Water Supplies of Kern County*, (1983), Table 2, by Associated Engineering Consultants.
[3] Leaching requirements vary by crop type, soil type and other factors. For the purposes of this table, a leaching requirement of 5 percent of the crop water requirement was as assigned, not been verified, however it is considered representative for District-wide efficiency.
[4] Considered Permanent Crop, 69.6 percent of total acres in 2012,
[5] Idle acres of 63,142 acres not included in the total for crop acres for 2012

Table 21. C. Agricultural Crop Data for the Year 2013

Crop	Total Crop Acres[1]	% of Total	Est ETc (ft)[2]	Water Req. (AF)	Est. Leaching (AF)[3]	Total Req. (AF)
Alfalfa Hay and Clover	1,821	2.1%	3.50	6,374	319	6,692
Almonds[4]	12,686	14.5%	2.50	31,716	1,586	33,302
Apple, Pear, Cherry, Plum, and Prune[4]	1,623	1.9%	3.20	5,192	260	5,452
Beans	154	0.2%	1.40	216	11	227
Carrots	2,828	3.2%	1.60	4,524	226	4,751
Citrus[4]	21,285	24.3%	2.60	55,341	2,767	58,108
Corn and Grain Sorghum	987	1.1%	1.80	1,777	89	1,865
Cotton	1,974	2.3%	2.60	5,132	257	5,389
Grain and Grain Hay	4,036	4.6%	2.00	8,072	404	8,475
Grapes[4]	25,123	28.7%	2.30	57,784	2,889	60,673
Melons, Squash, and Cucumbers	1,512	1.7%	1.60	2,419	121	2,540
Misc. Subtropical Trees[4]	1,122	1.3%	3.20	3,592	180	3,771
Misc. Deciduous[4]	468	0.5%	3.20	1,498	75	1,573
Misc. Field Crops	690	0.8%	2.00	1,379	69	1,448
Onions and Garlic	1,728	2.0%	1.70	2,937	147	3,084
Pasture and Misc. Grasses	160	0.2%	3.70	593	30	622
Peach, Nectarine, and Apricots[4]	351	0.4%	3.20	1,123	56	1,179
Pistachio[4]	2,583	3.0%	3.20	8,264	413	8,678
Potatoes	1,762	2.0%	2.00	3,524	176	3,700
Safflower and Sunflower	32	<0.1%	1.80	57	3	60
Small Vegetables	1,528	1.7%	1.60	2,445	122	2,567
Tomatoes and Peppers	2,931	3.4%	1.60	4,689	234	4,924
Turnips and Misc. Vegetables	38	<0.1%	2.00	75	4	79
Totals[5]	87,422	100.0%		208,723	10,436	219,160

[1] Total acres including double cropped acres, District's *Crop and Land Use Survey*s.
[2] From Report on Investigation of Optimization and Enhancement Water Supplies of Kern County, (1983), Table 2, by Associated Engineering Consultants.
[3] Leaching requirements vary by crop type, soil type and other factors. For the purposes of this table, a leaching requirement of 5 percent of the crop water requirement was assigned, not been verified, however it is considered representative for District-wide efficiency.
[4] Considered Permanent Crop, 74.6 percent of total acres in 2013.
[5] Idle acres of 64,774 acres not included in the total for crop acres for 2013.

Table 21. D. Agricultural Crop Data for the Year 2014

Crop	Total Crop Acres[1]	% of Total	Est ET_C (ft)[2]	Water Req. (AF)	Est. Leaching (AF)[3]	Total Req. (AF)
Alfalfa Hay and Clover	2,153	2.49	3.50	7,537	377	7,914
Almonds[4]	14,259	16.47	2.50	35,648	1,782	37,431
Apple, Pear, Cherry, Plum, and Prune[4]	1,218	1.41	3.20	3,897	195	4,092
Beans	94	0.11	1.40	131	7	138
Carrots	3,205	3.70	1.60	5,128	256	5,385
Citrus[4]	20,858	24.09	2.60	54,231	2,712	56,943
Corn and Grain Sorghum	225	0.26	1.80	405	20	426
Cotton	1,627	1.88	2.60	4,230	211	4,441
Flowers, Nursery and Christmas Tree	76	0.09	3.20	242	12	254
Grain and Grain Hay	2,036	2.35	2.00	4,072	204	4,275
Grapes[4]	26,197	30.25	2.30	60,252	3,013	63,265
Melons, Squash, and Cucumbers	951	1.10	1.60	1,521	76	1,597
Misc. Subtropical Trees[4]	824	0.95	3.20	2,636	132	2,768
Misc. Deciduous[4]	660	0.76	3.20	2,112	106	2,217
Misc. Field Crops	392	0.45	2.00	784	39	823
Onions and Garlic	1,236	1.43	1.70	2,101	105	2,206
Pasture and Misc. Grasses	198	0.23	3.70	733	37	770
Peach, Nectarine, and Apricots[4]	402	0.46	3.20	1,288	64	1,352
Pistachio[4]	4,162	4.81	3.20	13,317	666	13,983
Potatoes	1,740	2.01	2.00	3,480	174	3,654
Safflower and Sunflower	32	0.04	1.80	57	3	60
Small Vegetables	1,273	1.47	1.60	2,036	102	2,138
Tomatoes and Peppers	2,738	3.16	1.60	4,381	219	4,600
Turnips and Misc. Vegetables	38	0.04	2.00	75	4	79
Totals[5]	86,593	100		210,296	10,515	220,811

[1] Total acres including double cropped acres, District's *Crop and Land Use Surveys*.
[2] From Report on Investigation of Optimization and Enhancement Water Supplies of Kern County, (1983), Table 2, by Associated Engineering Consultants.
[3] Leaching requirements vary by crop type, soil type and other factors. For the purposes of this table, a leaching requirement of 5 percent of the crop water requirement was assigned, not been verified, however it is considered representative for District-wide efficiency.
[4] Considered Permanent Crop, 79.2 percent of total acres in 2014.
[5] Idle acres of 65,657 acres not included in the total for crop acres for 2014.

Table 21. E. Agricultural Crop Data for the Year 2015

Crop	Total Crop Acres[1]	% of Total	Est ETc (ft)[2]	Water Req. (AF)	Est. Leaching (AF)[3]	Total Req. (AF)
Alfalfa Hay and Clover	2,544	2.96	3.50	8,902	445	9,348
Almonds[4]	14,502	16.87	2.50	36,256	1,813	38,069
Apple, Pear, Cherry, Plum, and Prune[4]	1,118	1.30	3.20	3,577	179	3,756
Beans	-	-	1.40	-	-	-
Carrots	3,331	3.87	1.60	5,329	266	5,596
Citrus[4]	21,778	25.33	2.60	56,623	2,831	59,454
Corn and Grain Sorghum	-	-	1.80	-	-	-
Cotton	-	-	2.60	-	-	-
Flowers, Nursery and Christmas Tree	75	0.09	3.20	241	12	253
Grain and Grain Hay	701	0.82	2.00	1,402	70	1,472
Grapes[4]	25,654	29.84	2.30	59,003	2,950	61,953
Melons, Squash, and Cucumbers	840	0.98	1.60	1,344	67	1,411
Misc. Subtropical Trees[4]	831	0.97	3.20	2,659	133	2,792
Misc. Deciduous[4]	879	1.02	3.20	2,814	141	2,955
Misc. Field Crops	267	0.31	2.00	534	27	561
Onions and Garlic	1,697	1.97	1.70	2,885	144	3,029
Pasture and Misc. Grasses	198	0.23	3.70	733	37	770
Peach, Nectarine, and Apricots[4]	323	0.38	3.20	1,034	52	1,086
Pistachio[4]	4,485	5.22	3.20	14,350	718	15,068
Potatoes	1,226	1.43	2.00	2,452	123	2,574
Safflower and Sunflower	32	0.04	1.80	57	3	60
Small Vegetables	1,745	2.03	1.60	2,791	140	2,931
Tomatoes and Peppers	3,365	3.91	1.60	5,384	269	5,653
Turnips and Misc. Vegetables	383	0.45	2.00	767	38	805
Totals[5]	85,973	100		209,138	10,457	219,595

[1] Total acres including double cropped acres, District's *Crop and Land Use Surveys*.
[2] From Report on Investigation of Optimization and Enhancement Water Supplies of Kern County, (1983), Table 2, by Associated Engineering Consultants.
[3] Leaching requirements vary by crop type, soil type and other factors. For the purposes of this table, a leaching requirement of 5 percent of the crop water requirement was assigned, not been verified, however it is considered representative for District-wide efficiency.
[4] Considered Permanent Crop, 80.9 percent of total acres in 2015
[5] Idle acres of 65,867 acres not included in the total for crop acres for 2015.

Tables 22A and 22B, located on the following pages, show the acres within the Total Area of the District categorized by the irrigated and non-irrigated land areas within or outside of the District's Surface Water Service Area. The method of irrigation is also categorized, indicating the majority of lands are irrigated with micro-drip systems. The contract service area acreage has changed little over time, while the irrigated acreage has varied due to many factors.

Table 22. A. District Irrigated Acreage for Presented Years

Acreage Basis	Total Acreage, per Year				
	2011	2012	2013	2014	2015
Surface Water Service Area					
Irrigated Lands[1]					
Furrow	151	38	38	151	176
Center Pivot	59	59	59	59	59
Micro drip	54,267	54,396	54,345	56,473	56,771
Micro sprinkler	345	345	345	345	345
Sprinkler	4,972	5,846	4,628	2,111	2,132
Subtotal Spring Net Irrigated	**59,794**	**60,684**	**59,415**	**59,139**	**59,483**
Fall Net Irrigated	450	83	435	349	210
Double Cropped	1,213	1,131	662	426	270
Subtotal SWSA Irrigated/Cultivated[2]	**61,458**	**61,898**	**60,512**	**59,913**	**59,962**
Non-Irrigated Lands					
Miscellaneous Lands	3,649	3,757	4,972	3,615	3,636
Undeveloped/Native Vegetation/Grazing Land	403	397	397	397	397
Fallow/Other/Dry Farm Lands	8,235	7,243	7,297	8,930	8,565
Subtotal SWSA Non-irrigated	**12,287**	**11,397**	**12,666**	**12,942**	**12,598**
Subtotal Within Surface Water Service Area	**72,081**	**72,081**	**72,081**	**72,081**	**72,081**
Lands Outside Surface Water Service Area (GWA)					
Irrigated Lands[1]					
Furrow	394	455	455	301	250
Center Pivot	1,073	1,073	1,073	1,073	1,073
Micro drip	10,560	11,402	11,091	14,425	16,426
Micro sprinkler	91	91	91	91	91
Sprinkler	8,772	10,499	10,449	6,661	4,157
Subtotal Spring Net Irrigated	**20,891**	**23,521**	**23,160**	**22,551**	**21,997**
Fall Net Irrigated	1,183	1,395	1,804	1,333	1,336
Double Cropped	1,622	3,268	1,947	1,575	1,352
Subtotal GWA Irrigated/Cultivated[2]	**23,695**	**28,184**	**26,910**	**25,459**	**24,686**

Acreage Basis	Total Acreage, per Year				
	2011	2012	2013	2014	2015
Non-Irrigated Lands					
Miscellaneous Lands	1,177	1,404	1,387	1,471	1,455
Undeveloped/Native Vegetation/Grazing Land	28,154	28,134	28,124	28,124	28,124
Fallow/Other/Dry Farm Lands	25,044	22,207	22,595	23,120	23,690
Subtotal GWA Non-Irrigated	**54,375**	**51,745**	**52,106**	**52,715**	**53,269**
Subtotal Outside Surface Water Service Area	**75,266**	**75,266**	**75,266**	**75,266**	**75,266**
Total District					
Irrigated Lands[1]					
Furrow	545	493	493	451	426
Center Pivot	1,133	1,133	1,133	1,133	1,133
Micro drip	64,827	65,798	65,436	70,898	73,196
Micro sprinkler	436	436	436	436	436
Sprinkler	13,744	16,345	15,077	8,772	6,289
Subtotal Spring Net Irrigated	**80,685**	**84,205**	**82,575**	**81,690**	**81,480**
Fall Net Irrigated	1,633	1,478	2,239	1,682	1,545
Subtotal Net Spring Plus Net Fall Irrigated/Single Cropped[4]	**82,318**	**85,683**	**84,814**	**83,372**	**83,025**
Double Cropped[4]	2,835	4,399	2,608	2,000	1,622
Total Irrigated/Cultivated[3]	**85,153**	**90,082**	**87,422**	**85,372**	**84,647**
Non-Irrigated Lands					
Miscellaneous Lands	4,826	5,161	6,359	1,471	1,455
Undeveloped/Native Vegetation/Grazing Land	28,557	28,531	28,521	28,521	28,521
Fallow/Other/Dry Farm Lands	33,279	29,450	29,892	32,050	32,255
Total Non-Irrigated/Idle[4]	**66,662**	**63,142**	**64,772**	**65,657**	**65,867**
Total Area Within District	**147,347**	**147,347**	**147,347**	**147,347**	**147,347**

Table 22. B. District Irrigated Acreage for Presented Years

Acreage Basis	Total Acreage, per Year				
	2011	2012	2013	2014	2015
Surface Water Irrigated Area[1]	61,458	61,898	60,512	59,641	59,885
Groundwater Irrigated Area[1]	23,695	28,184	26,910	26,929	26,140
Total Irrigated Area[2]	85,153	90,082	87,422	86,570	86,026

[1] Total acres including double cropped and Fall Net Irrigated acreage, from District *Crop and Land Use Surveys.*
[2] Total acres of irrigated acreage in District (i.e. surface water service area plus groundwater irrigated area).

Cropped acres as shown in Tables 21A, 21B, 21C, 21D, and 21E contain all the District Service irrigated acres, including double cropped acres and the Fall Net Irrigated acres. The amount of irrigated land not cropped at any time during the year is indicated as Idle land in Tables 21A, 21B, 21C, 21D, and 21E footnotes. Inter-cropping is not a common practice within the District service area. District crop surveys were used to assess cropping acreage for the selected years and the surveys indicated some acres as being double cropped. Accordingly, the multiple crop information is reported in Table 23.

Table 23. Multiple Crop Information for Presented Years

Cropping Pattern	Total Acreage, per Year				
	2011	**2012**	**2013**	**2014**	**2015**
Single Cropped[1]	82,318	85,683	84,814	84,570	84,404
Inter-Cropping	Negligible	Negligible	Negligible	Negligible	Negligible
Double Cropped[2]	2,835	4,399	2,608	2,000	1,622
Idle[3]	66,662	63,142	64,772	64,459	64,489
Total	151,816	153,225	152,195	151,029	150,515

[1] Acres NOT including double crop acres, from WRMWSD *Crop and Land Use Surveys.*
[2] Acres, from WRMWSD *Crop and Land Use Surveys.*
[3] Gross acres, from WRMWSD *Crop and Land Use Surveys.*

3.2 Environmental Water Use

While the District does not make direct delivery of water specifically for environmental purposes within the District Service Area, a portion of the District's contract water is contributed to environmental needs outside of the District's Contract Service Area. In particular, to the extent that the District's SWP contract water supply is reduced in reliability to meet the environmental and water quality needs of the Delta, a portion of the contract water intended for delivery to the District Service Area goes to meet environmental water uses outside of the District Service Area, supposedly benefiting fish and wildlife outside of the District.

To the extent water is in the District's 850 Canal that is incidental to operations, a negligible benefit to local wildlife may occur. Since this is an incidental environmental use, it is not a consumptive environmental water use applicable to the AWMP water balance; Table 24 is completed accordingly. Additionally the District is a 24% participant in the Kern Water Bank Authority, which provides significant environmental benefits, including for uplands terrestrial species and water fowl.

Table 24. Environmental Water Uses for Presented Years

Environmental Water Use	Total Deliveries, per Year (AF)		
	2011-2015		
In-Stream Flow Releases	None[1]		
Streams			
Lakes or Reservoirs			
Riparian Vegetation			
Other			
Total	0	0	0

[1] Any environmental uses of District water supplies are incidental to the District's use and conveyance of water.

3.3 Recreational Water Use

The District does not supply water to recreational facilities within the service area.

Table 25. Recreational Water Uses for Presented Years

Recreational Facility Water Uses	Total Deliveries, per Year (AF)
	2011-2015
None	-
Total	-

3.4 Municipal and Industrial Water Use

The District delivers only raw (non-potable) water to industrial water use within the District.

Table 26. Municipal and Industrial Water Uses for Presented Years

Municipal/Industrial Water Uses	Total Deliveries, per Year (AF)				
	2011	2012	2013	2014	2015
Municipal Entities	0	0	0	0	0
Industrial Entities[1]	2,157	3,127	3,577	3,619	3,247
Total	2,157	3,127	3,577	3,619	3,247

[1] Specific industrial entities receiving water supplies are generally listed in the District's monthly and annual water use reports.

Additionally it is noted that a portion of the District overlaps the Tejon-Castaic Water District (TCWDS) which provides primarily industrial water to the Tejon Industrial Complex along the I-5 corridor in the southern most portion of the District. The District does not provide water service to TCWD which has its own surface water supplies and groundwater banking assets for its area.

3.5 Groundwater Recharge Use

Some indirect recharge occurs within the District to the extent that the District delivers surface water in lieu of pumped groundwater to satisfy irrigation water requirements. In addition, surface water supplies which are surplus to immediate irrigation requirements within the District are available for direct groundwater recharge to locations outside of the District. In this regard, the District participates in the Kern Water Bank, 2800 Acres, the Pioneer Project, and the Berrenda Mesa banking projects; all of these banking projects rely on direct recharge, are located outside of the District on the Kern River alluvial fan, and provide a source of supply in "dry" periods. Table 27 shows the volume of water recharged for the years selected, which indicates the District recharge occurs optimistically during particularly wet years when recharge through the use of spreading ponds outside of the District within banking facilities is significant.

Table 27. Groundwater Recharge Uses for Presented Years

Groundwater Recharge Water Uses (Locations)	Delivery or Recovery from Out-of-District Banking Facilities, per Year (AF)[1,2]				
	2011[3]	2012	2013	2014[4]	2015
Kern Water Bank	85,869	(12,000)	(35,434)	(43,403)	(36,509)
Pioneer Project	17,342	(4,300)	(10,083)	(16,925)	(12,465)
Berrenda Mesa Project	5,658	0	0	(2,979)	(3,697)
2800 Acres	14,041	0	0	0	0
ID-4 Wells	0	0	0	(1,342)	(852)
In-District Recharge Ponds	273	0	0	0	0
Total	123,183	(16,300)	(45,517)	(64,649)	(53,523)

[1]From District Engineer-Manager's Monthly Reports.
[2]Represents net water deliveries: banked water minus recovered water.
[3]Includes water delivered or recovered between December 23, 2010 and December 31, 2011.
[4]Includes water delivered or recovered between November 1, 2013 and December 31, 2014.

The District participates in four long-term "Water Banking" programs, which are located out-of-district, allowing the District to store then current "surplus" water and to recover their water when needed. Water banking involves the regulation of surplus surface water supplies, by placing the water into groundwater storage for subsequent recovery. The storage is achieved through either indirect or direct recharge. Indirect recharge is based on the delivery of surface water in-lieu of pumping groundwater. Direct recharge is based on the surface spreading and percolation of water supplies in basins or ponds, which is the method used in the Banking Projects.

The advantage of in-lieu recharge is that the recharge is essentially immediate, as the delivery of one acre-foot of water on the surface immediately displaces one acre-foot of groundwater pumping and does not depend upon percolation and the movement of water in the aquifer. One disadvantage is the fact that the surface water supply must be available on an irrigation demand schedule, with irrigation demands being relatively low during winter months. In contrast, direct recharge through use of the banking project facilities can be accomplished during any time of the year, which increases the likelihood of being able to capture unregulated supplies that become available from time to time.

3.6 Transfer and Exchange Use

Recall that District's primary source of surface water is from the SWP and this water is delivered via the California Aqueduct into the District. When practicable, the District relies on transfers to supplement its annual water supply. Table 28 lists the amount of water transferred from various entities into the District in 2011, 2012, 2013, 2014, and 2015. Also shown in Table 28 is Article 21 water delivered from the KCWA that is not transfer or exchange water; it is wet period, surplus water delivered via the California Aqueduct.

Note that the District views these transfers and exchanges with non-district entities as separate from those made as wheeling of water within District for common landowners. The in-district wheeling of water actions do not alter the total agricultural water uses within the District and are not shown in Table 28.

Table 28. A. Transfer and Exchanges to District for Presented Years

From Agency	Type of Transfer[1]	Total Deliveries, per Year (AF)				
		2011	2012	2013	2014	2015
Buena Vista WSD	Ag to Ag	0	0	0	5,710	0
Butte Water District	M&I to Ag	0	2,599	1,367	37	0
Castaic Lake Water Agency	M&I to Ag	0	4,450	1,626	0	0
Central Coast Water Agency	M&I to Ag	1,340	0	0	0	0
Central Valley Communities	Ag to Ag	0	0	0	446	0
Dry Year Transfer Program	Ag to Ag	0	0	0	0	1,157
Feather River Contractors	Ag to Ag	0	0	21,140	0	0
Fresno Irrigation District	Ag to Ag	0	1,349	889	0	0
Friant-Kern Recirculation	Ag to Ag	4,752	3,086	0	1,024	0
Grimmway Well Production	Ag to Ag	0	0	0	0	1,207
KCWA	Article 21	11,257	1,630	0	0	0
KCWA Lease Water	Ag to Ag	0	0	0	0	240
KCWA Table A	Ag to Ag	0	0	0	81	0
Kern Water Bank	Ag to M&I	448	2,311	2,642	2,555	0
Muly Year Market Pool	Ag to Ag	0	0	0	146	0
North Kern WSD	Ag to Ag	0	0	0	3,816	0
North of Delta Dry Year Transfer Program	Ag to Ag	0	0	0	10,080	0
Rosedale Rio Bravo Wells	Ag to Ag	0	0	0	429	0
San Luis Reservoir[2]	“Carry-over”	(8,512)	(4,300)	(889)	2,546	(3,638)
Semitropic WSD	Ag to Ag	0	0	0	2,000	0
SWP Multi Year Market Pool	M&I to Ag	0	0	9,788	0	0
Tehachapi-Cummings Community Water District	Ag to Ag	0	1,375	809	0	0

From Agency	Type of Transfer[1]	Total Deliveries, per Year (AF)				
		2011	2012	2013	2014	2015
Western Hills Water District	M&I to Ag	0	999	443	0	0
Westlands WD Mitigation	Ag to Ag	0	0	0	212	0
Yuba Category 2, 3 & 4	Ag to Ag	0	0	0	0	728
Yuba County Water Agency	Ag to Ag	0	1,330	6,778	0	0
Yuba Water Program	Ag to Ag	0	0	0	1,117	0
Total (to District)[3]		9,285	14,829	44,593	30,199	(306)

[1] Typical transfer and exchange types include Ag (Agricultural) to M&I (Municipal/Industrial), M&I to Ag, or Ag to Ag.
[2] Water supplies from transfers and exchanges held-over in the California Aqueduct at the San Luis Reservoir or sent directly to banking entities (i.e. water supplies which were not physically sent to the District). Used as identified quantity to balance incoming water supplies to District.
[3] Represents total water transferred or exchanged into District's conveyance system.

Table 28. B. Transfer and Exchanges from District for Presented Years

To Agency	Type of Transfer[1]	Total Deliveries, per Year (AF)				
		2011	2012	2013	2014	2015
Central Coast Water Agency	Ag to M&I	0	0	880	0	0
Western Hills WD	Ag to M&I	0	0	0	108	0
Total (from District)		0	0	880	108	0

[1] Typical transfer and exchange types include Ag (Agricultural) to M&I (Municipal/Industrial), M&I to Ag, or Ag to Ag.

3.7 Other Water Use

All water uses of any significance have been described previously in this section. Minor volumes of water are used within the District for dust abatement and mixing with agricultural chemicals before spraying. Table 29 notes that the cumulative miscellaneous water use reported by the District for other water use purposes is fairly insignificant.

Table 29. Other Water Uses for Presented Years

Other Water Uses	Total Deliveries, per Year (AF)				
	2011	2012	2013	2014	2015
Dust Abatement and Mixing	14	11	38	173	155
Total	14	11	38	173	155

3.8 Projected Water Use

The District receives surface water from the SWP, which is delivered to the District via the California Aqueduct. Historically, Article 21 and Turnback water available for purchase were used to supplement the District's contract water supply. Recently, SWP supplies, including Article 21, have been significantly reduced and there is the potential for additional reductions in the future; however the amount and timing of the reduction is somewhat uncertain. In most years, the District purchases supplemental water supplies from KCWA and other sources.

The District's contracted SWP water supply is constrained by the following management and regulatory factors:

- The conservation facilities to be constructed as part of the SWP have not been completed, which has the effect of reducing the yield of the District's contract supply;
- Federal and State regulatory agencies have, particularly since the mid-1990s, placed additional constraints on pumping from the SWP's Banks Pumping Plant, which were not contemplated, and have resulted in reductions in reliability and yield; and
- The annual allocation of water from the SWP during a given year is a moving target until as late as August in a given year; accordingly, District growers must make decisions regarding annual plantings before knowing their water allocation.

Permanent crops dominate the District's irrigated lands, most of which rely on low-volume, drip irrigation methods. Without any foreseeable pressure to urbanize, the landscape is not expected to change in the near term. Permanent crops represent a "hard" demand for water that must be met each and every year. To the extent that surface water supplies are reduced, there is an offsetting increase in groundwater pumping to meet irrigation water requirements. In this regard, it is noted that groundwater levels were declining prior to importation of SWP supplies and were considered to be in a state of overdraft. The District's importation of SWP water corrected this overdraft and resulted in improvement in (shallower) groundwater levels. Accordingly, recent reductions in the availability of surface water supplies threaten to induce a long-term decline in groundwater levels.

Quantification and Quality Assessment of District Water Resources

4.1 Surface Water Supply

As previously discussed, surface water deliveries to the District began in 1971. All water delivered is in a raw untreated condition, suitable for irrigation, and is not suitable for human consumption without treatment. The primary source of surface water is SWP water delivered through the California Aqueduct. Besides SWP supplies, the District supplements deliveries with water originating from other sources, as noted in Table 28.

<u>State Water Project</u>

The District imports SWP water under a contract with the KCWA for 197,088 acre-feet per year. The contract with the KCWA was signed in 1967. Under its contract with the KCWA, the District receives an annual allocation of SWP water which is delivered from the California Aqueduct. The amount of water available from this source varies with the type of year ("dry" versus "wet") and constraints on the amount of pumping allowed from the Sacramento-San Joaquin River Delta. Similarly, additional contract water supplies vary from year-to-year, as additional contract supplies are dependent on purchases made by the District.

Over the last 12 years, this source of supply has averaged about 117,432 acre-feet annually. Going forward, the average yield of District's contract amount is expected to be around 61 percent of the 197,088 acre-feet or about 120,223 acre-feet annually (based on the *2011 SWP Water Supply Reliability Report*). Shortages in SWP supplies are occurring more frequently and are larger than originally envisioned, mainly due to the regulatory restrictions on exports from the Sacramento-San Joaquin River Delta.

From time to time, additional SWP supplies, referred to as "Article 21" water, are made available. Historically, the District has been able to receive Article 21 water; however, due to the aforementioned restrictions on pumping water from the Delta, Article 21 water is becoming less available to the District and other districts over time.

Tables 30A and 30B contain the surface water supplies delivered to the District that consist of various SWP sources plus water delivered that was recovered as previously banked supply from one of the water banks located outside of the District.

Table 30. A. Surface Water Supplies for Presented Years

Source of Water Supply	Type of Supply	Total Deliveries, per Year (AF)				
		2011	2012	2013	2014	2015
Berrenda Mesa Project	Bank Return	0	0	0	3,268	3,641
Kern Water Bank	Bank Return	2,137	12,000	35,434	44,800	35,928
Kern Water Bank/Pastoria	Bank Return	588	3,044	3,477	3,610	3,128
Pioneer Project	Bank Return	0	4,300	10,083	17,252	13,225
SWP Surface Water Supplies[1]	Surface	159,080	124,218	65,367	33,290	40,863
Common Landowner Transfers		0	500	0	6,701	3,000
Total		**161,805**	**144,062**	**114,361**	**108,921**	**99,785**

[1] Represents all water supplies from the SWP, including District Table A Allocation, Annual Carryover, DWR Pool A and B, Article 21 water supplies, and other water-purchase programs, see Table 30B.

Table 30. B. Surface Water Supplies from SWP Sources for Presented Years

SWP Program	Total Deliveries, per Year (AF)				
	2011	2012	2013	2014	2015
Annual Carryover	2,420	1,493	5,700	23,958	18,810
Article 21	16,239	0	0	0	0
District Table A Allocation[1]	140,421	122,282	59,430	9,332	22,053
DWR Turnback Pools	0	443	237	0	0
Total	**159,080**	**124,218**	**65,367**	**33,290**	**40,863**

[1] Water supply received as part of KCWA's allocation.

Table 31 lists restrictions or imposed limitations on sources of the District's surface water supply, including the largest component of the District's supply, SWP water via the California Aqueduct. Restrictions on this supply generally result from regulatory actions of wildlife agencies related to endangered species actions and actions of the SWRCB that restrict the pumping operations managed by the DWR, and related judicial proceedings. Pumping restrictions have adversely affected the reliability of SWP supply, caused groundwater levels to decline and generally result in application of lower quality groundwater to grow crops. The quantity of transfer water that can be delivered into the District or into banking programs outside of the District has also been restricted due to the imposed limitations shown in Table 31. Additionally these restrictions result in significant financial burdens to the District and its water users because (i) the fixed costs of DWR and the District have to be paid even with reduced quantities to be delivered, and (ii) banked supplies and programs to buy limited additional supplies can only be secured at much greater expense.

Table 31. Potential Restrictions on Water Sources

Impacted Source	Restrictions or Imposed Limitations	Name of Agency Imposing Restrictions	Operational Constraints
State Water Project (SWP)	Delivery Schedule and Volume	USFWS, NMFS, Federal Courts, and SWRCB	Reduced reliability of SWP deliveries south of the Sacramento-San Joaquin River Delta due to constraints on pumping.
Transfers	Conveyance through Sacramento-San Joaquin River Delta	USFWS, NMFS, Federal Courts, and SWRCB	Reduced amount of time during the year for which conveyance through the Delta is allowed.

4.2 Groundwater Supply

The District overlies the southern portion of the Kern County Subbasin within the larger San Joaquin Valley Groundwater Basin, which is a portion of the Central Valley aquifer system. *DWR Bulletin 118* (2003 Update) identifies the Kern County Subbasin as No. 5-22.14. The Kern County Subbasin is shown in relation to the District's service area on Figure 6, and the size of the basin (as published by DWR) is indicated in Table 32.

Table 32. Local Groundwater Basins

Basin Name	Size (Sq. Mi.)	Est. Capacity (AF)	Safe Yield (AFY)
Kern County Groundwater Subbasin[1]	3,040	40,000,000	Unknown

[1] DWR San Joaquin District Kern County Groundwater Subbasin information available at following address: http://www.water.ca.gov/pubs/groundwater/bulletin_118/basindescriptions/5-22.14.pdf

Information on groundwater management in the District, as well as the geology of the aquifer underlying the District's service area, is presented in the WRMWSD's 2007 Groundwater Management Plan. Table 33 indicates the date of the Plan and lists the firm responsible for its preparation.

Table 33. Groundwater Management Plan Information

Prepared By	Todd Engineers w/Kennedy-Jenks Consultants
Year Completed/Approved	2007
Attached in Appendix[1] Yes/No	No

[1] Available upon request.

The District, DWR, KCWA, and Arvin-Edison WSD conduct groundwater monitoring within the District boundaries. Water level monitoring has been conducted in the District since the 1950's.

As stated in the WRMWSD's Groundwater Management Plan, prior to 1967, the only source of water supply in the basin was groundwater. Since that time, the District has secured additional water sources including water from the SWP. Within the portions of the District collectively known as the Surface Water Service Area (SWSA), the District delivers water via a network of distribution lines and turnouts. This water supply consists of SWP water diverted from the California Aqueduct, water obtained from Kern County banking projects, local surface water, and groundwater pumped from the District's 16 groundwater wells. The District records the volume of water drawn from each source and delivered to customers.

Figure 6. Map of District in Relation to Groundwater Basin(s)

Although the water supply provided by the District meets most of the water demand, there remains some water users within the SWSA who supplement surface deliveries with groundwater pumped from private wells. In addition, there are water users outside of the SWSA but within the District boundary whose entire water supply is drawn from private wells. The total volume of groundwater extraction within the District is the combination of water pumped from these private wells and pumping at the 17 District wells. While the District maintains records of the volume of water pumped from its own wells, data are not available on the number of private wells in operation nor the volume of groundwater pumped from these wells. The District's GWMP contains an estimated volume of annual groundwater pumping, on average, of approximately 61,461 AFY for the period 1971 to 2001. A typical well is shown in Figure 7.

Figure 7. Typical District-Owned Groundwater Well

Table 34 shows groundwater pumped into the District conveyance system by District and private wells for the years 2011, 2012, 2013, 2014, and 2015 in acre-feet per year.

Table 34. Groundwater Supplies for Presented Years

Groundwater Supply Source[1]	Total Deliveries, per Year (AF)				
	2011	2012	2013	2014	2015
District-owned Wells	1,037	14,579	16,518	16,020	13,857
Private Wells pumped into District	1,230	5,853	14,134	40,347	45,669
Total	**2,267**	**20,432**	**30,652**	**56,367**	**59,526**

[1] Based on the District's *Summary of Deliveries*.

4.3 Other Water Supplies

The District actively imports surface water from the sources listed in Table 30. In general, there are little uncontrolled inflows to the District, with the exception of small creeks, which are frequently dry but which, at times, provide a source of unregulated inflow that does not, however, exit the District. Flows from the creeks are intermittent and not measured since the flows are very infrequent and do not produce large volumes.

4.4 Drainage from the Surface Area

Drainage wells and surface drainage systems are not employed by the District. In some areas, groundwater below the root zone from excessive deep percolation is recoverable and can be used to supplement surface water. In these areas, the recovered water is generally of poorer quality than surface water and is not suitable for irrigation unless blended with better quality surface water. As Table 35 summarizes, there are some minimal flows to saline sinks or perched water tables based on estimates provided by the District Engineer.

Table 35. Drainage Discharges

Surface/Subsurface Drainage Path	Water Uses, per Year (AF)				
	2011	2012	2013	2014	2015
Flows to Saline Sinks[1]	1,200	1,300	1,500	1,400	1,300
Flows to Perched Water Table	1,300	1,300	1,400	1,200	1,200
Sub-Total	**2,500**	**2,600**	**2,900**	**2,600**	**2,500**

[1] Based on deliveries to certain WRM2, WRM4, and WRM5 System turnouts outside usable GW basin, assuming 5% of deliveries go to return flows.
[2] Assuming 15% of these turnouts deliver to perched water lands and 5% of deliveries go to return flows

4.5 Water Supply Quality

4.5.1 Surface Water Quality

Recall that the District's principal source of surface water is SWP water delivered by the California Aqueduct. Other sources are delivered using the same conveyance facility. Regarding the quality of the water delivered to the District from the California Aqueduct, few water quality problems have been noted that limit the use of the water for irrigation in the District; the water is relatively good quality and suitable for irrigation. Water quality measurements are collected at Check 29 of the California Aqueduct which is located upstream of the turnouts used for deliveries to the District. Water quality data collected from Check 29 during winter and summer conditions are presented in Tables 36A, 36B, 36C, 36D, and 36E for 2011, 2012, 2013, 2014, and 2015.

Table 36. A. Surface Water Supply Quality Assessment for 2011

Parameter/ Constituent	Symbol	Concentration, per Season (mg/l)[1]	
		Winter[2]	Summer[3]
Boron	B	0.1	0.1
Calcium	Ca	14	13
Magnesium	Mg	8	6
Sodium	Na	24	22
Potassium	K	--	--
Chloride	Cl	27	24
Sulfate	SO_4	25	26
Nitrate	NO_3	3	1.5
Total Dissolved Solids	**TDS**	**144**	**184**

[1] Based on data taken from Check 29 of the California Aqueduct, available at following address: http://www.water.ca.gov/waterdatalibrary/waterquality/station_county/gst_report.cfm
[2] Corresponds with readings from December through February, specific date of 1/9/2011.
[3] Corresponds with readings from June through August, specific date of 6/14/2011.

Table 36. B. Surface Water Supply Quality Assessment for 2012

Parameter/ Constituent	Symbol	Concentration, per Season (mg/l)[1]	
		Winter[2]	Summer[3]
Boron	B	0.2	0.2
Calcium	Ca	21	--
Magnesium	Mg	14	--
Sodium	Na	67	--
Potassium	K	--	--
Chloride	Cl	104	57
Sulfate	SO_4	43	37
Nitrate	NO_3	3.2	2.3
Total Dissolved Solids	**TDS**	**322**	**229**

[1] Based on data taken from Check 29 of the California Aqueduct, available at following address: http://www.water.ca.gov/waterdatalibrary/waterquality/station_county/gst_report.cfm
[2] Corresponds with readings from December through February, specific date of 1/8/2012.
[3] Corresponds with readings from June through August, specific date of 6/18/2012.

Table 36. C. Surface Water Supply Quality Assessment for 2013

Parameter/ Constituent	Symbol	Concentration, per Season (mg/l)[1]	
		Winter[2]	Summer[3]
Boron	B	0.2	0.2
Calcium	Ca	24	23
Magnesium	Mg	14	13
Sodium	Na	65	56
Potassium	K	--	--
Chloride	Cl	94	77
Sulfate	SO_4	45	40
Nitrate	NO_3	4.8	1.8
Total Dissolved Solids	**TDS**	**297**	**288**

[1] Based on data taken from Check 29 of the California Aqueduct, available at following address: http://www.water.ca.gov/waterdatalibrary/waterquality/station_county/gst_report.cfm
[2] Corresponds with readings from December through February, specific date of 1/16/2013.
[3] Corresponds with readings from June through August, specific date of 6/18/2013.

Table 36. D. Surface Water Supply Quality Assessment for 2014

Parameter/ Constituent	Symbol	Concentration, per Season (mg/l)[1]	
		Winter[2]	Summer[3]
Boron	B	0.2	0.2
Calcium	Ca	33	29
Magnesium	Mg	6	11
Sodium	Na	70	71
Potassium	K	--	--
Chloride	Cl	89	85
Sulfate	SO_4	66	57
Nitrate	NO_3	5.4	2.4
Total Dissolved Solids	**TDS**	**331**	**365**

[1] Based on data taken from Check 29 of the California Aqueduct, available at following address: http://www.water.ca.gov/waterdatalibrary/waterquality/station_county/gst_report.cfm
[2] Corresponds with readings from December through February, specific date of 1/21/2014.
[3] Corresponds with readings from June through August, specific date of 6/17/2014.

Table 36. E. Surface Water Supply Quality Assessment for 2015

Parameter/ Constituent	Symbol	Concentration, per Season (mg/l)[1]	
		Winter[2]	Summer[3]
Boron	B	0.2	0.2
Calcium	Ca	31	27
Magnesium	Mg	--	14
Sodium	Na	58	69
Potassium	K	--	--
Chloride	Cl	52	92
Sulfate	SO_4	49	49
Nitrate	NO_3	6.5	2.6
Total Dissolved Solids	**TDS**	**278**	**315**

[1] Based on data taken from Check 29 of the California Aqueduct, available at following address: http://www.water.ca.gov/waterdatalibrary/waterquality/station_county/gst_report.cfm
[2] Corresponds with readings from December through February, specific date of 1/20/2015.
[3] Corresponds with readings from June through August, specific date of 6/16/2015.

4.5.2 Groundwater Quality

Groundwater quality is generally not suitable for irrigation use in the western 6 miles of the District due to higher levels of salts and boron. However, east of this area, such quality is generally suitable for irrigation use, although significant water quality changes are noted from one subarea to another. Ambient groundwater quality and spatial variability across the study area were examined using water quality data provided by the District and geochemical plots constructed by Todd Engineers for the previously mentioned GWMP.

4.5.3 Other Water Supplies

Water transferred into the District or returned from banking projects is conveyed in the California Aqueduct; therefore, its water quality is represented by the sampling already occurring for the California Aqueduct.

4.5.4 Drainage from the Water Supplier's Service Area

The District is a member of the Kern River Watershed Coalition Authority (KRWCA), which is in turn a member of the Southern San Joaquin Valley Water Quality Coalition (SSJVWQC) and in that capacity, participates in, and contributes financially to, a Regional Water Quality Control Board program to monitor and improve surface water and groundwater quality associated with agricultural activities. The Regional Board has promulgated a broader Irrigated Lands Regulatory Program (ILRP) to address both surface water and groundwater quality. As a service to its landowners, the District does participate in and help facilitate the ILRP in cooperation with the KRWCA.

Since the District does not provide drainage facilities or assessment of on-farm subsurface drainage systems, the limitations associated with drainage reuse are not applicable to District operations, as noted in Table 37.

Table 37. Drainage Reuse Effects

Drainage Reuse Limitations	Parameter/Constituent
Increased Leaching	None
Blending Supplies	None
Restricted Area of Use	None
Restricted Crops	None
Other (e.g. Landowner)	Reuse system practiced by one landowner.

4.6 Water Quality Monitoring Practices

The District conducts some water quality monitoring in key wells across their service area. Much of the water quality information the District obtains is from private wells that is provided under condition of confidentiality and is not public information. Currently 14 active agriculture wells are included in the program with several alternate locations in the event that a program well cannot be sampled. Water samples are collected from these wells in June or July of each year and analyzed for general minerals, boron, SAR and Langlier indices, a program designed to evaluate the suitability of water quality for irrigation.

The District maintains these data in an Access database. In addition to data from their ongoing monitoring program, the District has also compiled and entered historical water quality data into their database. These data generally date back to the 1960s but contain data from one well sampled in 1910 and five wells sampled in the 1950s.

Included in the database are 133 different water quality parameters including metals, volatile organic compounds (VOC) and fuel oxygenates, major and minor anions and cations, total hardness, conductivity, total alkalinity, pH and TDS. The number of constituents analyzed varies from well to well. Many of the wells in the database contain at least one complete analysis for the major anions and cations, with the exception of potassium, which is absent from many of the cation analyses. Almost all of the wells have at least one value for TDS, total hardness, and pH. Table 38 provides general information on monitoring of source water quality in the District.

Table 38. Water Quality Monitoring Practices

Source	Monitoring Location	Monitoring Practice	Frequency of Analysis
SWP Surface Water	Check 29	Automated Station Data Grab Sample Data	Monthly[1]
Groundwater[2]	Various Wells	Agricultural Suitability	Annually

[1] Monitored by other entities and the DWR, on behalf of the District.
[2] Primarily by District-owned wells, but periodically includes some privately-owned wells. Sample at start-up if discharge goes into district delivery system; if discharge in California Aqueduct, then Title 22 level of testing every three years.

As noted in Table 39, the District does not need to conduct monitoring of surface drainage.

Table 39. Water Quality Monitoring Programs for Surface/Subsurface Drainage

Monitoring Program	Analyses Performed	Frequency of Analysis
Surface Water and Groundwater	EC and NO_3	Not needed.

Water Accounting and Water Supply Reliability

5.1 Quantification of Water Supplies

The District distribution system is composed mostly of pipeline laterals, some concrete-lined canals, and small pumps (5, 10, or 20 cfs) as described in Section 2.2. For the purposes of the AWMP, 2011, 2012, 2013, 2014, and 2015 were chosen to illustrate water delivery operations in the District and to meet the requirements of the executive order that is in response to the drought. Table 40 includes a monthly accounting of the amounts of water arriving within District boundaries from the California Aqueduct, which is the delivery route for each source of supply.

Table 40. Surface Water Supplies for Presented Years

Monthly Surface Water Deliveries[1]	Total Deliveries, per Year (AF)					
	2011	**2012**	**2013**	**2014**	**2015**	**Avg.**
January	1,613	6,100	2,066	1,963	(937)	2,161
February	5,333	8,012	5,485	2,875	245	4,390
March	7,660	9,557	9,141	4,630	4,929	7,184
April	13,618	8,171	13,144	8,671	11,433	11,008
May	20,717	19,923	21,060	17,197	14,987	18,777
June	27,055	25,903	25,540	19,334	18,684	23,303
July	29,353	25,719	24,287	17,583	15,712	22,531
August	24,461	22,416	21,162	11,899	12,658	18,519
September	17,923	14,671	14,916	10,306	9,518	13,467
October	12,343	11,278	11,790	8,563	5,993	9,993
November	4,699	3,843	4,740	1,073	927	3,056
December	6,314	3,298	4,743	596	(903)	2,810
Total	**171,090**	**158,891**	**158,074**	**104,692**	**93,247**	**137,199**
Transfer Deliveries[2]	9,285	14,829	43,713[(3)]	30,091[(3)]	(306)	19,522
Sub-Total[4]	**161,805**	**144,062**	**114,361**	**74,601**	**93,553**	**117,676**

[1] Monthly surface water deliveries equals the total volume of delivered water minus delivered groundwater supplies (Table 41). It includes total of surface water from the SWP and banking projects, as well as, transfer and exchange supplies entering the District. Values are from the monthly Engineer-Manager's Reports.
[2] Transfer Deliveries references the total Transfer and Exchange supplies 'To District' from Table 28A.
[3] Transfer Deliveries for 2013 and 2014 references difference between total transfer supplies (i.e. 'To District' value from Table 28.A minus 'From District' value from Table 28.B). Only 2013 and 2014 had supplies being transferred from the District to another agency.
[4] Sub-Totals represent surface water supplies delivered to district, matching incoming surface water Totals.

The District, along with many other districts and local communities, pump groundwater from the Kern County Subbasin. The District measures and records groundwater pumping from district-owned wells; however, pumping from privately-owned wells is not reported to the District unless the water is pumped into the District's system for conveyance and delivery. Table 41 presents a monthly summary of the quantity of groundwater, from both District-owned and privately-owned wells, that were pumped and delivered through the District conveyance system in 2011, 2012, 2013, 2014, and 2015.

Table 41. Groundwater Supplies for Presented Years (Delivered within District Conveyance System)

Monthly Groundwater Deliveries[1]	Total Deliveries, per Year (AF)					
	2011	**2012**	**2013**	**2014**	**2015**	**Avg.**
January	0	8	147	1,404	3,147	941
February	0	116	902	3,504	4,421	1,789
March	278	1,139	1,554	4,996	5,228	2,639
April	317	2,351	3,855	5,323	5,669	3,503
May	828	3,397	4,694	6,120	5,949	4,198
June	478	3,358	4,354	5,794	5,856	3,968
July	366	2,540	4,312	5,894	5,689	3,760
August	0	2,611	3,392	5,591	5,562	3,431
September	0	2,007	2,174	4,935	5,390	2,901
October	0	1,797	1,650	4,832	4,722	2,600
November	0	1,052	1,745	4,339	3,935	2,214
December	0	56	1,872	3,634	3,957	1,904
Total[2]	**2,267**	**20,432**	**30,651**	**56,367**	**59,526**	**33,848**

[1] Monthly delivery includes total of groundwater supplies from district and private wells entering the District's conveyance system. Private pumping that is not pumped into the District's delivery system is not included in the Table, as those volumes are not reported to the District.

[2] Total represents groundwater supplies into District's system, matching incoming groundwater Total from Table 34.

The imported surface water, previously banked water, and the pumped groundwater are the primary sources of water for the District. Effective precipitation, however, constitutes an uncontrolled source of supply which reduces the applied irrigation water requirement to some extent. As noted in Section 2.1.4, most of the precipitation occurs in the winter with little to none occurring during the summer months. Accordingly, most of the precipitation that falls within the District's service area provides soil moisture at the beginning of the growing season.

Table 42 shows the estimated volume of effective precipitation for 2011, 2012, 2013, 2014, and 2015, based on the District Engineer's calculation using the local precipitation, local assumptions, and the total irrigated area.

Table 42. Effective Precipitation Summary for Presented Years[1]

Month	Precipitation, per Year (in)									
	2011		2012		2013		2014		2015	
	Total Precip. (in)	Eff. Precip. (AF)	Total Precip. (in)	Eff. Precip. (AF)	Total Precip. (in)	Eff. Precip. (AF)	Total Precip. (in)	Eff. Precip. (AF)	Total Precip. (in)	Eff. Precip. (AF)
Jan	0.47	-	0.58	-	1.26	-	0.03	-	0.80	-
Feb	0.87	-	0.42	-	0.48	-	0.22	-	0.82	-
Mar	2.23	12,015	1.24	3,570	0.72	0	0.33	0	0.90	0
Apr	0.03	0	1.79	10,710	0.01	0	0.54	0	0.15	0
May	0.50	0	0.00	0	0.26	0	0	0	0.52	0
Jun	0.06	0	0.00	0	0.00	0	0	0	0.25	0
Jul	0.00	0	0.00	0	0.00	0	0	0	0.76	1,830
Aug	0.00	0	0.00	0	0.00	0	0	0	0.0	0
Sep	0.15	0	0.00	0	0.00	0	0	0	0.05	0
Oct	0.44	0	0.30	0	0.02	0	0	0	0.15	0
Nov	1.00	-	0.13	-	0.34	-	0.60	-	0.90	-
Dec	0.00	-	1.84	-	0.38	-	1.82	-	-	-
Total	**5.74**	**12,015**	**6.31**	**14,280**	**3.47**	**0**	**3.55**	**0**	**5.30**	**1,830**

[1] Based on Thiessen average precipitation as computed from observations at six District-operated weather stations, all measurements by WRMWSD staff.
[2] Assume effective precipitation occurs during the growing season (roughly March-Oct).
[3] Assume that in any storm, the first 0.5 inches of precipitation evaporates before it makes it to the root zone.
[4] 2011 effective precip. = 1.7 in rainfall x 84,813 cropped acres (Table 23) x 1 ft/12 in = 12,015 AF
[5] 2012 effective precip. = 2.0 in rainfall x 85,684 cropped acres (Table 23) x 1 ft/12 in =17,850 AF
[6] 2015 effective precip = (0.76 - 0.50) in rainfall x 84,404 cropped acres (Table 23) x 1 ft/12 in = 1,830 AF

5.2 Quantification of Water Uses

Table 43 shows the volume of water delivered to District's irrigation customers in 2011, 2012, 2013, 2014, and 2015. The volume of water delivered is based on flow measurements at the farm turnouts.

Table 43. Applied Water for Presented Years

Type	Water Deliveries, per Year (AF)				
	2011	2012	2013	2014	2015
Surface Water and Groundwater Sources[1]	164,072	164,494	145,012	165,288	159,800
Transfer Deliveries[2]	9,285	14,829	43,713[(3)]	30,091[(3)]	(306)
Total[4]	**173,357**	**179,323**	**188,725**	**195,379**	**159,494**

[1] All surface water and groundwater supplies delivered to the District as Total in Table 20.
[2] Transfer Deliveries reference total Transfer and Exchange supplies 'To District' from Table 28A.
[3] Transfer Deliveries for 2013 AND 2014 references difference between total transfer supplies (i.e. 'To District' value from Table 28A. minus 'From District' value from Table 28B.). Only 2013 AND 2014 had supplies being transferred from the District to another agency.
[4] Total deliveries to farm turnouts in District.

Table 44 summarizes water uses within the District service area for 2011, 2012, 2013, 2014, and 2015. The calculated crop ET_c was used in developing the District's crop water requirement as seen in Tables 21A, 21B, 21C, 21D, and 21E and described in the text which accompanies the tables. The estimate of losses in the piped distribution system is minimal, which is based on District observation of measured system inflows and outflows and is recorded as not applicable in Table 44 as "conveyance seepage and evaporation" (item 4). Refer to Section 3 for the description of other agricultural water uses included in Table 44.

Table 44. Quantification of Water Uses for Presented Years

Type	Category	Estimated Water Use, per Year (AF)				
		2011	2012	2013	2014	2015
Crop Water Requirement[1]	Crop Water Use (Tables 21A, 21B, 21C, 21D, and 21E.)	212,074	224,494	219,160	220,811	219,595
Leaching[2]		-	-	-	-	-
Cultural Practices[2]		-	-	-	-	-
Conveyance Seepage and Evaporation[3]	Conveyance and Storage System	-	-	-	-	-
Conveyance Operational Outflows[4]		-	-	-	-	-
Reservoir Evaporation[5]		0	0	0	0	0
Reservoir Seepage[5]		0	0	0	0	0
Environmental Wetlands	Environmental Uses (Table 24)	0	0	0	0	0
Environmental Other		0	0	0	0	0
Riparian Vegetation		0	0	0	0	0
Misc. Recreation	Recreation Uses (Table 25)	0	0	0	0	0
Municipal Entities	Municipal and Industrial Uses (Table 26)	0	0	0	0	0
Industrial Entities		2,157	3,127	3,577	3,506	3,228
Transfers and Exchanges Out of District	Uses Outside of District (Table 28B.)	0	0	880	108	0
Other	Other Uses (Table 29)	14	11	38	173	155
Grand Total of All Uses		**214,245**	**227,632**	**223,655**	**224,598**	**222,978**
Groundwater Recharge[6]	Groundwater Uses (Table 27)	273	0	0	0	0

[1] Includes ETc and an estimated allowance for both leaching and cultural practices.
[2] Included in 'Crop Water Requirement' item.
[3] District canal seepage assumed minimal due to large percentage of pipeline conveyance system without inherent losses, see Table 4 and preceding text.
[4] Operational outflows are directed into the unlined channels for groundwater recharge.
[5] Not applicable to the District, see Table 5 and preceding text.
[6] Amount reflects only direct recharge inside the District, no canal seepage as included in 'Conveyance Seepage' item or deep percolation from applied irrigation water.

Table 45 intended to summarize the amount of monitored on-farm surface and subsurface drainage water leaving the service area; however, as discussed previously, drainage wells and surface drainage systems are not employed by the District.

Table 45. Quantify Water Leaving District for Presented Years

Drain Water Leaving District	Volume, per Year (AF)
	2011-2015
Surface Drain Water Leaving District	Negligible
Subsurface Drain Water Leaving District	Negligible
Sub-Total	**0**

Table 46 identifies the minimal irrecoverable losses within the District.

Table 46. Irrecoverable Water Losses for Presented Years

Drain Water Leaving District	Volume, per Year (AF)				
	2011	**2012**	**2013**	**2014**	**2015**
Flows to Saline Sinks[1]	1,200	1,300	1,500	1,400	1,300
Flows to Perched Water Tables[2]	1,300	1,300	1,400	1,200	1,200
Sub-Total	**2,500**	**2,600**	**2,900**	**2,600**	**2,500**

[1] Based on deliveries to certain WRM2, WRM4, and WRM5 System turnouts outside usable GW basin, assuming 5% of deliveries go to return flows.
[2] Assuming 15% of turnouts deliver to perched water lands and 5% of deliveries go to return flows

5.3 Overall Water Budget

The total water supplies made available by the District to the lands within its service area in 2011, 2012, 2013, 2014, and 2015 are summarized in Table 47. The supply side of the water budget presented in this AWMP identifies the total deliveries by the District, which includes both surface water and groundwater pumped from District-owned and private wells. As described previously, on-farm pumping is not reported to the District except in instances where water from private wells is discharged into District facilities for conveyance. Refer to Section 5.1 for a description and quantities of these sources.

Table 47. Quantify Water Supplies for Presented Years

Water Supplies	Volume, per Year (AF)				
	2011	**2012**	**2013**	**2014**	**2015**
Surface Water Supplies (Table 40)	161,805	144,062	114,361	74,601	117,676
Groundwater Supplies (Table 41)	2,267	20,432	30,651	59,526	33,848
Annual Effective Precipitation (Table 42)	12,015	14,280	0	0	1,830
Water Purchases[1]	-	-	-	-	-
Transfers or Exchanges into District (Table 28A)	9,285	14,829	44,593	30,091	(306)
Grand Total of All Supplies	**185,372**	**193,603**	**189,605**	**164,218**	**153,048**
Grand Total minus Effective Precipitation	173,357	179,323	189,605	164,218	151,218
Transfers or Exchanges from District (Table 28B)	-	-	880	108	-
Accumulated Monthly Deliveries in AF (Annual Total)[2]	**173,358**	**179,322**	**188,726**	**164,110**	**151,218**

[1] Water purchases included as part of surface water supplies from Table 40.
[2] Accumulated Monthly Deliveries in Acre-Feet as reported in Engineer-Manager's Monthly Report for December.

Table 48 summarizes the water budget for the service area for 2011, 2012, 2013, 2014, and 2015. The budget summary identifies the estimated total water uses within the District service area, the water supplies delivered by the District, and any on-farm drainage leaving the service area. The difference of these values is called the Water Balance Closure Term. This computation is not the same as computing the closure term of a long-term water balance since this budget does not account for sub-surface inflow to or outflow to or from the District, nor does it account for minor stream inflow, which would be included in a complete, long-term water balance.

Table 48. Budget Summary for Presented Years

Water Accounting	Volume, per Year (AF)				
	2011	2012	2013	2014	2015
Sub-Total of Water Supplies (Table 47)	185,372	193,603	189,605	164,218	153,048
Sub-Total of Water Uses (Table 44)	(214,245)	(227,632)	(223,655)	(224,317)	(222,283)
On-Farm Drainage Water Leaving Area (Table 45)	0	0	0	0	0
Water Balance Closure Term[1]	(28,873)	(34,029)	(34,050)	(60,099)	(69,235)

[1] The closure term is the difference between estimated total water uses and the district-delivered water supplies.

The "water balance closure term" represents an estimate of the difference between the total water uses (water demand) and the District-delivered water supplies for each of the selected years. Regarding the Water Budget calculation, it is recognized as an estimated water balance closure term, calculated to meet the requirements of the DWR's AWMP Guidelines, and does not represent all the components necessary for determining the long-term water balance for the District. For instance, the DWR's water balance closure term does not capture the change in groundwater storage over time nor does it include all groundwater sustainability components, such as, annual allocations based on the safe yield of the basin.

5.4 Future Water Supply Reliability

Recall that the District contracted with the KCWA for the delivery of SWP water; however, shortages in this source of supply have been more frequent and larger than originally envisioned. This observation is largely due to the incomplete status of SWP facilities and increased regulatory restrictions on exports from the Sacramento-San Joaquin River Delta. In this regard, DWR Bulletin 160-09 (2009) articulated some of the water supply "challenges" facing the Tulare Lake Basin, of which the District is a part. These challenges include the following:

- Water quality and environmental needs for the Delta are reducing the export volume of water pumped and available for delivery. For example, new biological opinions for endangered species and statutory requirements in December 2008 reduced export pumping by around 20-30 percent.

- Changes in the OCAP (Operations Criteria and Plan, USBR) could worsen delivery reliability issues of imported water from the CVP and SWP.
- The San Joaquin River Settlement will reduce CVP water diverted into the Friant-Kern Canal, possibly by as much as 15 percent (on average) as interim flows began October 1, 2009, which also affects the availability of CVP 215 water.

According to the 2011 State Water Project Delivery Reliability Report (DWR 2012), the long-term reliability of surface water supplies to Southern California from the Delta is expected to average 61 percent of the contractual amounts.

Groundwater is pumped to the extent that irrigation water requirements exceed the other supplies available through the District. Accordingly, any reductions in the reliability of these other supplies will result in a commensurate increase in the use of groundwater. Increased use of pumped groundwater will contribute to lower groundwater levels (and higher costs of energy for pumping). While excessive groundwater pumping can result in land surface subsidence, the District does not contain the hydrogeological conditions necessary for such subsidence. The ability of the District to sustainably manage surface and groundwater resources in the long term within the District is dependent on the ability to import surface water supplies that the District has contracted for with DWR through the KCWA from the State Water Project.

Therefore, efficient water management practices and conjunctive management are critical for the well-being of the communities and districts that depend on these sources of water. The District has joined several neighboring water agencies in adopting an Integrated Regional Water Management Plan (Kern IRWMP) which identified "water supply reliability" as one of the Region's principal water resources concerns going forward. The IRWMP identified and prioritized a number of projects to mitigate anticipated reductions in water supply reliability, several of which have been constructed, are under construction, or will be under construction in the near term. A discussion of future changes to the District's water supplies, in particular, from climate change, is presented in Section 6 of the plan.

Analysis of Effects of Climate Change on Water Supply

In accordance with the 2015 Guidebook, WRMWSD has updated the Analysis of the Effects of Climate Change to discuss expanded climate impacts and the vulnerability assessment.

Disclaimer: The District has prepared this Section, *Analysis of the Effects of Climate Change on Water Supply*, in accordance with the requirements of the DWR Guidebook for Preparing AWMPs. The District does not endorse the statements contained in the references regarding the validity or the extent of global warming and/or climate change.

6.1 Effects of Climate Change on Water Demand

Several investigations were conducted by the USGS California Water Science Center (CAWSC) regarding hydrological effects of climate scenarios in the Sierra Nevada Mountain Range (USGS 2009; Water Resources Research, 2012). Each of these investigations predict that California's climate will become warmer (+2° to +4° C) and drier (10-15 percent) during the mid- to late-21st century, relative to historical conditions. These scenarios were based on a commonly accepted projection of 21st century climate from the GFDL CM2.1 (Geophysical Fluid Dynamics Lab Climate Model 2.1) global climate model, responding to assumptions of rapidly increasing greenhouse-gas emissions (GHGs). The California Energy Commission's Cal-Adapt web site predicts temperature differences in the District service area from a baseline historical average (1961 to 1990) to a projected average (2070 to 2090). The projection shows an increase in annual average temperature of about 3.8°F to 6.5°F under a low carbon and high carbon emission scenario, respectively. If these predictions materialize, the level of runoff from the Sierra Nevada Mountains is expected to be much less reliable with quantities presumably declining over time. Reduced surface water deliveries for agriculture in the Central Valley, combined with increased demands for irrigation water due to the increasingly warmer, drier climate, will result in increased use of groundwater, the impacts of which could include the following:

- Reduced base flow in streams;
- Reduced groundwater outflows;
- Increased depths to groundwater, and
- Increased land subsidence.

Should climate change result in a reduction in water available from surface supplies, the increased frequency of groundwater pumping from agricultural water districts and other users will lead to a decrease in groundwater storage without the necessary means of replenishing the depleted storage. According to another CAWSC study (Proceedings of the Eighth International Symposium on Land

Subsidence, 2010), Kern County may expect land subsidence due to the increased demand on groundwater that will result from climate change.

Climate change is also expected to increase both daytime and nighttime temperatures in the Central Valley resulting in lengthening of the growing season. Cal-Adapt predicts that the number of days exceeding the “extreme heat threshold” of 104°F for the District service area will increase from a historical baseline average of 4 extreme heat days (1961-1990) to a projected average of 30 extreme heat days (2070-2090). Using the same baseline and projection years, the number of nights exceeding the “warm night threshold” of 73°F is expected to increase from 4 nights to about 24 nights. This general increase in temperatures coupled with greater variability and unpredictability in precipitation (depicted in decadal average projections by Cal-Adapt) is expected to lead to increases in evapotranspiration resulting from warmer seasons, thereby creating an increase in demand for irrigation water and an increase in the year-to-year variability of demand.

As previously discussed in Section 3.1, permanent crops (e.g. temperate fruit and nut trees) account for over 70 percent of the total irrigated area in the District. Areas with predominately permanent crop acreage may have reduced flexibility for adapting to changing climatic conditions since they require water in all types of water years, therefore “hardening” the demand. In addition, these types of crops generally require adequate winter chill to produce economically viable yield. Increased temperatures in the Central Valley are expected to reduce winter chill hours, thus causing adverse effects on crop yield. Today, the number of hours of winter chill in the San Joaquin Valley has shrunk from about 1,500 a few decades ago, to approximately 1,000 to 1,200 hours (PLoS ONE, 2009). By the end of the century, the winter chill needed for these crops is predicted to disappear.

6.2 Effects of Climate Change on Water Supply

The effects of climate change, particularly changes in the volume, nature, and timing of precipitation on the future of the District’s surface water supply will be driven by changes in hydrology in the Sacramento-San Joaquin Delta, which affects the watershed of Lake Oroville since the District’s main source of surface water is the SWP. In addition, climate change effects may exacerbate pumping restrictions or constraints to convey water south of the Sacramento-San Joaquin River Delta, thus further reducing reliability. This section describes the potential effects of climate change and how it may affect the hydrology for the southern portion of the Central Valley and the statewide changes that could affect the District and its water supplies.

The DWR examined 12 future climate scenarios in a report titled *Using Future Climate Projections to Support Water Resources Decision Making in California* (Chung et al. 2009) to assess future reliability issues with the SWP and the CVP due to climate change. The 12 scenarios represent projections from six Global Climate Models for higher and lower GHG emissions while taking into account potential Delta salinity intrusion due to sea level rise. For all climate projections studied, the reliability, and thus volume of water delivered, by the SWP and CVP water supply systems is expected to be reduced. For instance, average annual SWP exports under future climate scenarios from 2013 to 2033 conditions are projected to decrease 5.6 percent (DWR, 2013). Current long-term reliability predictions of SWP 7Table A deliveries, modeled under historic (1921-2003) precipitation and runoff patterns and accounting for future conditions such as land use and climate change, are expected to decrease 6 percent from the historic average (DWR, 2013).

The District also participates in and receives previously imported water recovered from several Kern County banking projects located outside of the District. Groundwater banking offers the flexibility to respond to climate variability, as water can be stored during "wet" periods for use in "dry" ones. This will become increasingly important as climate change is projected to increase the frequency and intensity of extreme weather events, including floods and droughts. Banking may also become more challenging as it will require additional monitoring and assessment of groundwater levels and quality, especially if the District is limited by constraints on conveyance that reduce reliability of available surface supplies to shift use to groundwater as its reliable water source.

6.3 Regional Vulnerability Assessment

The Matrix below provides an assessment of the regional vulnerability to the potential climate change impacts, using the 'Vulnerability Assessment Checklist' found in the 'Climate Change Handbook for Regional Water Planning' (DWR, 2011) consistent with climate change requirements in the Proposition 84 IRWMP Guidelines (June 2014). As mentioned previously, WRMWSD is a member of the Kern Region Regional Water Management Group (RWMG). This Matrix is a modified version of the checklist provided in the 'Vulnerability to Climate Change Technical Memorandum' (Kennedy/Jenks, 2014) written for the RWMG, gearing answers more specifically to the District. The Matrix provides a further evaluation of the effects on regional water demands and supplies, as well as water quality, flooding events, environmental and ecosystems, and hydropower systems.

Modified IRWMP Climate Change Vulnerability Assessments Matrix

List No.[1]	Checklist Item	Regional Conditions
I. Water Demand Assessment		
I.A	Are there major industries that require cooling/process water in your planning region?	Process water is required in packing plants and other locations for processing crops harvested from the field. However, requirements for cooling/process water are insignificant for the District.
I.B	Does water use vary by more than 50% seasonally in parts of your region?	Yes. The majority of water in the District is used for agricultural purposes, the demand for which fluctuates greatly in the summer compared to the winter.
I.C	Are crops grown in your region climate-sensitive? Would shifts in daily heat patterns, such as long heat lingers before night-time cooling, be prohibitive for some crops?	Yes. All crops grown in the District service area are climate-sensitive and several important crops could be prohibitively affected by shifts in daily heat patterns.
I.D	Do groundwater supplies in your region lack resiliency after drought years?	Groundwater is necessary to maintain a sufficient water supply for the District. The resiliency of the District's groundwater resource is directly related to the reliability of surface water supplies, primarily the availability of water from the SWP since groundwater is used to meet demands that are not fulfilled by surface water supplies. To this extent, "resiliency" has been reduced.
I.E	Are water use curtailment measures effective in your region?	The District may refuse to deliver water to irrigators as a consequence for wasting water, 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 their land to an unreasonable depth in order to properly irrigate other portions. Water service may be resumed when these conditions have been remedied.
I.F	Are some in-stream flow requirements in your region either currently insufficient to support aquatic life, or occasionally unmet?	No. All surface water flows are seasonal with the canals and drains dry most of the year. While there are no in-stream flow requirements within the District, SWP supplies which are available to the District may be affected by such requirements at the sources of these supplies.
II. Water Supply Assessment		
II.A	Does a portion of the water supply in your region come from snowmelt?	Yes. Both the SWP and the Kern River are fed by annual snowmelt from the Sierra Nevada.
II.B	Does part of your region rely on water diverted from the Delta, imported from the Colorado River, or imported from other climate-sensitive systems outside your region?	Yes. The District's primary source of imported surface water is the SWP, delivered through the Delta. As explained above, the SWP is vulnerable to climate change.
II.C	Does part of your region rely on coastal aquifers? Has salt intrusion been a problem in the past?	The District does not rely on coastal aquifers. While salt intrusion from coastal aquifers is not applicable, salt management is still an issue in the region with regard to increasing salinity in groundwater. Salt in imported water supplies such as the SWP is the major source of salt which circulates throughout the groundwater in Kern County.

[1] Numbers based on checklist shown in Section 4.3 of the 'Climate Change Handbook for Regional Water Planning' (DWR, 2011).

Modified IRWMP Climate Change Vulnerability Assessments Matrix

List No.	Checklist Item	Regional Conditions
II. Water Supply Assessment		
II.D	Would your region have difficulty in storing carryover surpluses from year to year?	There is limited carryover available for the District's SWP water in San Luis Reservoir. Within the region, carryover of Kern River water in Isabella Reservoir is limited by the Reservoir's flood control purpose and US Army Corps of Engineer's regulations. However, there are opportunities to expand the Region's[2] groundwater storage capabilities.
II.E	Has your region faced a drought in the past during which it failed to meet local water demands?	No. Water demands have been met through the use of groundwater which, during drought, can result in significant declines in groundwater levels. To the extent that surface water supplies are reduced in the future (as a result of climate change and/or regulatory constraints), recharge will be reduced, which will affect the availability of groundwater for meeting local water demands.
II.F	Does your region have invasive species management issues at your facilities, along conveyance structure, or in habitat areas?	Yes. The District in particular has very little invasive species to manage. Within the region, aquatic pests, including invasive plants have been fought on the Kern River for decades. Prevention and control of invasive species is an ongoing battle by many resource agencies such as the Kern River Preserve Audubon Society, and the Kern River Ranger District.
III. Water Quality Assessment		
III.A	Are increased wildfires a threat in your region? If so, does your region include reservoirs with fire-susceptible vegetation nearby which could pose a water quality concern from increased erosion?	Wildfires are not a threat within the District; however, parts of the Kern Region are prone to wildfires, which impact water quality when rain washes fire debris into waterways.
III.B	Does part of your region rely on surface water bodies with current or recurrent water quality issues related to eutrophication, such as low dissolved oxygen or algal blooms? Are there other water quality constituents potentially exacerbated by climate change?	Not within the District, however, yes within the region. The Kern River, a primary native surface supply to the region, is generally considered a high quality supply. However, Isabella Lake is listed on the 303(D) list for dissolved oxygen and pH. Climate change could exacerbate these water quality conditions from increased temperatures.
III.C	Are seasonal flows decreasing for some water-bodies in your region? If so, are the reduced low flows limiting the water-bodies' assimilative capacity?	Within the region, annual Kern River flows and flows in local ephemeral streams could be decreasing through time.
III.D	Are there beneficial uses designated for some water bodies in your region that cannot always be met due to water quality issues?	No. Water is intended for many beneficial uses including agricultural water supplies, groundwater recharge, water replenishment, recreation, wildlife habitat, rare and endangered species, and wetland ecosystems. Most of these are met within the District; however, outside of the District and within the region, there are two TMDLs for Lake Isabella with regard to DO and pH.
III.E	Does part of your region currently observe water quality shifts during rain events that impact treatment facility operation?	No.

[2] For the entirety of this checklist, "Region" refers to the Kern RWMG Region.

Modified IRWMP Climate Change Vulnerability Assessments Matrix

List No.	Checklist Item	Regional Conditions
IV. Sea Level Rise Assessment		
IV.A	Has coastal erosion already been observed in your region?	The District is located in the Southern San Joaquin Valley, and concerns regarding coastal regions are not applicable.
IV.B	Are there coastal structures, such as levees or breakwaters, in your region?	
IV.C	Is there significant coastal infrastructure, such as residences, recreation, water and wastewater treatment, tourism, and transportation at less than six feet above mean sea level in your region?	
IV.D	Are there climate-sensitive low-lying coastal habitats in your region?	
IV.E	Are there areas in your region that currently flood during high tides or storm surges?	
IV.F	Do tidal gauges along the coastal parts of your region show an increase over the past several decades?	
V. Flooding Assessment		
V.A	Does critical infrastructure in your region lie within the 200-year floodplain?	Yes for the region. The FEMA Flood Insurance Rate Map for the Kern Region designates multiple areas as “High Risk” areas with a 1 percent or greater risk of flooding in any year and a 26 percent chance of flooding over the life of a 30-year mortgage. Some parts of the region lie within these areas. Flooding can result in the inundation of structures, as well as impact damage to structures, roads, bridges, culverts, and other features from high velocity flows and from debris carried by floodwaters.
V.B	Does part of your region lie within the Sacramento-San Joaquin Drainage District?	No.
V.C	Does aging critical flood protection infrastructure exist in your region?	No.
V.D	Have flood control facilities (such as impoundment structures) been insufficient in the past?	Yes for the region. The primary flood control facility to the region is Isabella Dam on the Kern River. Kern River had an unregulated flow until 1954 when the Isabella Dam and Reservoir were constructed by the Army Corps of Engineers. Due to seepage and earthquake concerns, storage restrictions have been in place on Isabella Reservoir since 2006 and will remain in place until dam safety concerns are adequately addressed.
V.E	Are wildfires a concern in parts of your region?	As noted in III.A (above), wildfires are not a concern in the District service area; however, wildfires are a concern in other parts of the Kern Region and the watersheds that provide the region with its surface water supplies.

Modified IRWMP Climate Change Vulnerability Assessments Matrix

List No.	Checklist Item	Regional Conditions
VI. Ecosystem and Habitat Vulnerability Assessment		
VI.A	Does your region include inland or coastal aquatic habitats vulnerable to erosion and sedimentation issues?	Coastal aquatic habitats are not applicable to the District. However, aquatic pests, including invasive plants have been fought on the Kern River for decades.
VI.B	Does your region include estuarine habitats which rely on seasonal freshwater flow patterns?	No.
VI.C	Do climate-sensitive fauna or flora populations live in your region?	No.
VI.D	Do endangered or threatened species exist in your region? Are changes in species distribution already being observed in parts of your region?	Yes for the region. There are many threatened and endangered species in the Kern Region including the bald eagle, burrowing owl, California condor, California red-legged frog, least bell's vireo, and the San Joaquin kit fox. Whether or not changes in species distribution have occurred is unknown.
VI.E	Does the region rely on aquatic or water-dependent habitats for recreation or other economic activities?	Yes. Water-dependent recreation includes a wide variety of outdoor activities that can be divided into two (2) categories. The first category includes fishing, boating, swimming, and rafting, which occur on lakes, reservoirs, and rivers. The second category includes recreation that is enhanced by water features but does not require actual use of the water, such as wildlife viewing, picnicking, camping, and hiking.
VI.F	Are there rivers in your region with quantified environmental flow requirements or known water quality/quantity stressors to aquatic life?	No.
VI.G	Do estuaries, coastal dunes, wetlands, marshes, or exposed beaches exist in your region? If so, are coastal storms possible/frequent in your region?	No.
VI.H	Does your region include one or more of the habitats described in the Endangered Species Coalition's Top 10 habitats vulnerable to climate change?	No. The Central Valley of California, where the District is located, is not listed as one of the 'Top 10' habitats vulnerable to Climate Change according to the 'It's Getting Hot Out There: Top 10 Places to Save for Endangered Species in a Warming World' Report (Endangered Species Coalition, 2010).
VI.I	Are there areas of fragmented estuarine, aquatic, or wetland wildlife habitat within your region? Are there movement corridors for species to naturally migrate? Is there infrastructure projects planned that might preclude species movement?	Yes. There are many wildlife habitats in the Kern Region. However, there are no infrastructure projects planned in the District service area that are known to preclude species movement.

Modified IRWMP Climate Change Vulnerability Assessments Matrix

List No.	Checklist Item	Regional Conditions
VII. Hydropower Reliance Assessment		
VII.A	Is hydropower a source of electricity in your region?	Yes for the region. Within the Kern Region is the Rio Bravo Hydro Project Hydro Power Plant which has a design capacity of 14 megawatts (MWe). However, most of the energy provided in the Kern Region comes from its 37 high-efficiency cogeneration facilities that produce two sources of energy in the form of steam and electricity.
VII.B	Are energy needs in your region expected to increase in the future? If so, are there future plans for hydropower generation facilities or conditions for hydropower generation in your region?	Yes. Energy needs to the District may increase in the future as a result of increasing population and increases in groundwater pumping lifts. However, the Kern Region has a variety of efforts planned to reduce energy use, and to develop local energy supply sources. These efforts include utilization of renewable resources, such as WWTP digester gas recovery, hydropower, and solar power.

The Matrix discusses a list of prioritized vulnerabilities to the District based on presumed level of impact to regional conditions according to climate change considerations given in the checklist. The sector vulnerability prioritization is defined as follows (1 being the sector most prioritized [high risk] and 7 being the sector least prioritized [low risk] with respect to climate change vulnerability):

1. Water Supply
2. Water Demand
3. Flooding
4. Ecosystem and Habitat
5. Water Quality
6. Sea Level Rise
7. Hydropower

Based on the vulnerability assessment, "Water Supply" and "Water Demand" appear to have the highest level of vulnerability to potential Climate Change impacts to the District. This confirms the projected outlook for the District presented in Sections B and A, respectively. The remaining sections assessed in the Matrix, while important, do not pose as much of a projected risk to District water resources operations or management efforts.

6.4 Response to Effects of Climate Change

The District is committed to monitoring indicators of climate change that affect the hydrology of key surface water sources (e.g. Sacramento-San Joaquin River Delta and the Kern River watershed) and growing conditions in the District's service area. The following are ways in which the District, as well as the RWMG, are responding to the above mentioned effects of climate change.

Water Supply

The goal of the District is to utilize the available surface water and groundwater resources as effectively as possible in meeting the requirements of the District's water users. The District will work with the Department of Water Resources and applicable regulatory agencies to ensure that there are adequate surface water supplies available to meet the growing conditions in the District's service area. Regional adaptation strategies to address potential reductions in water supply suggested in the Kern RWMG 'Vulnerability to Climate Change Technical Memorandum' and that may apply to the District include the following:

- Expand water storage and conjunctive management of surface and groundwater resources.

- Reduce reliance on imported SWP water, which depends on the Sierra snowpack for water supply.
- Enhance use of recycled water for appropriate uses as a drought-proof water supply.
- Enhance practices of water exchanges and water banking outside the Region to supplement water supply.
- Encourage local agencies to participate in development of Groundwater Sustainability Plans under the Sustainable Groundwater Management Act.
- Develop plans for local agencies in the Kern Region to monitor the elevation of their groundwater basins.
- Encourage cities and the county agencies in the Kern Region to adopt local ordinances that protect the natural functioning of groundwater recharge areas.

Water Demand

Some farmers are beginning to overcome climate changes, specifically reduced winter chill, by planting trees closer together and using new varieties. Studies are also now underway to prepare farmers for the likely impacts of climate change. These studies include breeding varieties of fruit trees which can withstand the decreased water chill hours, developing tools to aid crops in coping with insufficient chill, and researching the temperature responses of particular orchard crops to better understand potential long-term effects. However, some solutions such as replanting orchards with altered crop varieties may not be feasible for many irrigators.

Regional adaptation strategies to address potential increases in water demand suggested in the Kern RWMG 'Vulnerability to Climate Change Technical Memorandum' and that apply to the District include encouraging agricultural users to adopt efficient water management practices.

The District will work to implement these strategies as applicable. As the District's control over water supplies is limited, management practices used to respond to climate change will need to be adaptive in nature.

Efficiency Improvements and Efficient Water Management Practices

CWC §10826(e) defines the water use efficiency information required of all agricultural water supplies to be included in an AWMP, per §10608.48. As such, this section addresses the water use efficiency improvements that have been implemented by the District and a listing of the Efficient Water Management Practices (EWMPs, CWC §10608.48(a) through §10608.48(f)) which have been implemented or plan to be implemented. Each of the EWMPs is also identified and referenced in the DWR Guidebook.

The District's annual budget contains funding for the personnel and materials necessary to operate, maintain, and improve the District's distribution system. This funding directly and indirectly supports the variety of EWMPs described below. The description of previous water management activities in this section is supplemented by key improvements made to the District's infrastructure and management previously described in this AWMP.

7.1 Water Management Activities and Efficiency Improvements

This AWMP identifies several previously implemented and ongoing water management activities, which include:

Acquire surface water supplies from the State Water Project, and construct irrigation distribution system facilities to lands which previously relied exclusively on pumped groundwater for the purpose of District delivery of surface water.

Secure additional dry year water supplies from groundwater banking and recovery projects (Kern Water Bank, Pioneer Project, and Berrenda Mesa Project) and local groundwater supplies (District wells and private wells).

Secure additional water supplies to mitigate water shortages from the State Water Project.

Manage imported water and groundwater conjunctively to increase water supply reliability.

Promote water use efficiency through:

Metered and tiered water pricing, and

Continued financial support of the North West Kern Resource Conservation District's (NWKRCD) Mobile Laboratory and encouraging landowners to take advantage of this resource by requesting field irrigation evaluations.

Actively participate in local water resource management forums, including the Water Association of Kern County, Kern County Integrated Regional Water Management Plan (Kern IRWM Plan), the Kern River Watershed Coalition Authority (KRWCA), and the Kern Groundwater Management Committee (now Kern Groundwater Authority).

Require installation of flow meters on private landowner wells that pump into the District facilities.

7.2 EWMP Overview

The EWMPs identified in SBx7-7 are grouped in two categories as shown below, from the DWR Guidebook. The numbers supplied for each EWMP are used as reference later in this section.

Critical Efficient Water Management Practices (CR)[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 [CWC §10608.48(b.1), 1999 AWMC MOU C-1].
- Adopt a pricing structure for water customers based at least in part on the quantity delivered [CWC §10608.48(b.2)].

Conditional Efficient Water Management Practices (CO)[2]

- Facilitate alternate land use for lands with exceptionally high water duties or whose irrigation contributes to significant problems, including drainage [CWC §10608.48(c.1), 1999 AWMC MOU B-1].
- 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 [CWC §10608.48(c.2), 1999 AWMC MOU B-2].
- Facilitate financing of capital improvements for on-farm irrigation systems [CWC 10608.48(c.3), 1999 AWMC MOU B-3].

[1] Implementation of Critical EWMPs (CWC Section 10608.48(b)) is required of all agricultural water suppliers.
[2] Other Conditional EWMPs (CWC Section 10608.48(c)) are required only if they are determined to be locally cost-effective or technically feasible by the agricultural water supplier.

- Implement an incentive pricing structure that 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 [CWC 10608.48(c.4), 1999 AWMC MOU C-2].
- Expand line or pipe distribution system, and construct regulatory reservoirs to increase distribution system flexibility and capacity, decrease maintenance and reduce seepage [CWC 10608.48(c.5), 1999 AWMC MOU B-5].
- Increase flexibility in water ordering by, and delivery to, water customers within operational limits [CWC 10608.48(c.6), 1999 AWMC MOU B-6].
- Construct and operate supplier operational outflows and tail-water recovery systems [CWC 10608.48(c.7), 1999 AWMC MOU B-7].
- Increase planned conjunctive use of surface water and groundwater within the supplier service area [CWC 10608.48(c.8), 1999 AWMC MOU B-8].
- Automate canal control structures [CWC 10608.48(c.9), 1999 AWMC MOU B-9].
- Facilitate or promote customer pump testing and evaluation [CWC 10608.48(c.10)].
- Designate a water conservation coordinator who will develop and implement the water management plan and prepare progress reports [CWC 10608.48(c.11), 1999 AWMC MOU A-2].
  - Provide for the availability of water management services to water users [CWC 10608.48(c.12), 1999 AWMC MOU A-3].
  - 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 [CWC 10608.48(c.13), 1999 AWMC MOU A-5].
  - Evaluate and improve the efficiencies of the supplier's pumps [CWC 10608.48(c.14), 1999 AWMC MOU A-6].
  - Improve communication and cooperation among water suppliers, users, and other agencies [1999 AWMC MOU A-4].
  - Facilitate voluntary water transfers [1999 AWMC MOU B-4].

Regarding the two Critical EWMPs and sixteen Conditional EWMPs listed above, the following information is addressed by the District in this AWMP per the DWR Guidebook (pages 70-75):

A list of implemented and planned-to-be-implemented EWMPs.

An estimate of the water use efficiency improvements estimated to occur in five and ten years.

7.3 Implemented and Planned-to-be-Implemented EWMPs

Table 49, located on the following page, summarizes the status of implementation of EWMPs at the District.

Table 49. Report of EWMPs Implemented/Planned

EWMP No.	Description	EWMP Implemented	EWMP Planned
Critical EWMPS			
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.* **Description:** District water delivery points to Farm-gates or turnouts to customers are metered using McCrometer propeller meters (±2% accuracy and ±0.25% repeatability) and are actively monitored by the District Staff. Delivery points into the District are metered by the DWR at turnouts from the California Aqueduct). Compliance with measurement standards (SBx7-7) is further discussed in Section 8.	X	
2	*Adopt a pricing structure for water customers based at least in part on quantity delivered.* **Description:** The District charges water users based on the volume of water delivered as described in Section 3.2.	X	
Conditional EWMPS			
1	*Facilitate alternative land use for lands with exceptionally high water duties or whose irrigation contributes to significant problems, including drainage.* **Description:** The District does not actively facilitate alternate land uses within the District's service area, which is beyond its current jurisdiction. Lands have been taken out of production; however, this was due to the economics of farming and available water supplies.	X	
3	*Facilitate financing of capital improvements for on-farm irrigation systems.* **Description:** The District is a water purveyor, not a provider of on-farm capital. The District does, however, provide funds for irrigation efficiency evaluations (e.g. On-Farm Mobile Lab), which is a free service to landowners. The District will also provide information to landowners regarding grant programs, low interest loans, energy efficiency programs, etc. that may be available from time to time.	X	
4	*Implement an incentive pricing structure that 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.* **Description:** As described in Section 2.2, the District does not apply tiered pricing nor follow a seasonal pricing schedule when charging water users.	X	

EWMP No.	Description	EWMP Implemented	EWMP Planned
5	*Expand line or pipe distribution system, and construct regulatory reservoirs to increase distribution system flexibility and capacity, decrease maintenance and reduce seepage.* **Description:** District conveyance system is predominantly piped network, as described in Section 2.1. Much of the infrastructure improvements facilitated by the District have involved the maintenance and continued operation of the piped network.	X	
6	*Increase flexibility in water ordering by, and delivery to, water customers within operational limits.* **Description:** The District's ability to distribute water supplies and operate on an on-demand basis is covered in the *Rules and Regulations for Distribution of Water* document, and is discussed in Section 2.2. The California Aqueduct acts as a regulating reservoir within the District and allows flexibility in timing and flows of water deliveries to growers.	X	
7	*Construct and operate supplier operational outflows and tail-water recovery systems.* **Description:** Irrigated lands are mostly planted with permanent crops using high-efficiency irrigation methods. Accordingly, there are very few drainage systems in the District and any farm tail-water is handled by individual growers through their own on-farm tail-water recovery systems (minimal use by growers). The California Aqueduct acts as a regulating reservoir to manage mismatches between supply and demand to avoid operational spills.	X	
8	*Increase planned conjunctive use of surface water and groundwater within the supplier service area.* **Description:** As described in Section 2, static groundwater levels in the District are deeper than most parts of Kern County meaning fewer District wells are operated (i.e. high pumping lifts and costs). As such, the District has participated in the Kern Water Bank, Pioneer Project and Berrenda Mesa Project to store and recharge excess surface water supplies, as described in Section 4.3. In addition, the District has practiced conjunctive use water management since 1971, primarily through incidental and in-lieu recharge.	X	
9	*Automate canal control structures.* **Description:** Since the District's conveyance system is predominately a piped network (Table 4) opportunities for additional automation of canal controls is minimal; all structures are presently automated. The piped network infrastructure is already largely automated and heavily monitored by the District. Canal structures for conveying SWP supplies into the District, are already automated and remotely monitored in real time. Canal structures on the District's 850 Canal are remotely controlled in real time and around the clock with a SCADA system to minimize operational spills and ensure sufficient water surfaces for steady on-farm deliveries.	X	
10	*Facilitate or promote customer pump testing and evaluation.* **Description:** Pump efficiency tests (measured kWh/AF) are performed by utilities and pump companies as requested by the landowners.	X	

EWMP No.	Description	EWMP Implemented	EWMP Planned
11	*Designate a water conservation coordinator who will develop and implement the water management plan and prepare progress reports.* **Description:** The District considers the 'Water Conservation Coordinator' title as synonymous with the Manager/Assistant Engineer-Manager position within the staff. As such, the District allows the person holding this position to implement water management plans and progress reports.	X	
12	*Provide for the availability of water management services to water users.* **Description:** The District provides funds for irrigation efficiency evaluations (e.g. On-Farm Mobile Lab) and maintains weather stations around the District's service area. Weather station climate data (evaporation and precipitation) are available on the District's website and are encouraged to be used for irrigation scheduling purposes.	X	
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.* **Description:** The District receives surface water from the SWP, contracted through the KCWA, and is party to turn-in agreements and point-of-delivery agreements with the DWR. Reduced reliability of SWP deliveries south of the Sacramento-San Joaquin River Delta due to administrative and judicial constraints on pumping have limited the District's ability to effectively manage and distribute surface water supplies to water users.	X	
14	*Evaluate and improve the efficiencies of the supplier's pumps.* **Description:** District pump tests are conducted as needed, and pump efficiency is monitored on a continuous basis. The District's Pump/Electrical Department performs routine pump and electrical equipment repairs and maintenance. Non-routine work is contracted. The District provides some funding for District pump testing by services outside of the District staff.	X	
OTHER Optional EWMPs			
1999 AWMC MOU A-4	*Improve communication and cooperation among water suppliers, users, and other agencies.* **Description:** The District cooperates directly with the Kern County Water Agency and is active in the Water Association of Kern County. Communication and cooperation among regional water suppliers are well established. It provides the on-going mechanism to build on established relationships and to enhance cooperation.	X	

EWMP No.	Description	EWMP Implemented	EWMP Planned
1999 AWMC MOU B-4	*Facilitate voluntary water transfers.* **Description:** The District has supported the transfer of a landowner’s SWP water from another district into the District service area; given the landowner operates in both districts (i.e. the water would be moved from the landowner’s land in another district to landowner’s holdings in the District). These transfers have been on a case-by-case and year-by-year basis and also require approval of KCWA. The District has also allowed landowners to move their SWP water around within the District and within common farming units. Water Users with excess supplies can make those supplies available to others via the District Pool (Rule 9. of the Rules and Regulations). The District also allows landowners to use the District's conveyance system to wheel water within the District in the same manner.	X	

Table 50 presents an estimated connection between water use efficiency improvements by the District and the implementation of EWMPs.

Table 50. Report of EWMPs Efficiency Improvements

Corresponding EWMP No.*	EWMP	Efficiency Improvements Since Last Report	Estimated Water Use Efficiency 5 and 10 years in Future
2	Recycled Water Use	Continued Efforts	The District will continue to make use of water with higher concentrations of nitrate and brackish water where applicable.
5	Infrastructure Improvements	Continued Efforts	The District will continue to invest in maintenance and operations improvements to the piped conveyance network.
6	Order/Delivery Flexibility	Continued Efforts	The District will continue exploring enhanced water ordering options (e.g. web-based) to improve operations and delivery flexibility.
8	Conjunctive Use	Continued Efforts	The District will continue exploring groundwater recharge and recovery operations within the service area, and work with neighboring districts to expand banked water supplies.
9	Automated Canal Controls	Continued Efforts	The District has an automated canal and pressurized pipe delivery system in place.
11	Water Conservation Coordinator	Continued Efforts	The District will continue to fund water conservation manager.
12	Water Management Services to Water Users	Continued Efforts	The District will consider additional water purchases with neighboring districts to improve long-term water balance in-district.
13	Identify Institutional Changes	Continued Efforts	The District will consider funding conveyance improvement to the SWP Delta facilities that increase the reliability of SWP contract supplies and support development of better science concerning Delta issues.
14	Supplier Pump Improved Efficiency	Continued District is currently working on pump and meter improvements	The District will continue to fund District pump efficiency improvements and to work with PG&E, the Resource Conservation District (RCD), and neighboring districts to minimize water costs, increase water use efficiency, and reduce power and energy costs.
NA	Improve Communication Among Suppliers	Continued Efforts	The District will maintain and promote communication with landowners and other entities through an active communications system.
NA	Facilitate Voluntary Water Transfers	Continued Efforts	District will continue to support landowner transfers of SWP supplies, on a case-by-case and year-by-year basis.

[1] EWMP numbers correspond to Water Code §10608.48(c).

7.4 Efficiency Improvements and Non-Implemented EWMPs

The District has chosen to implement those EWMPs which were considered 'technically feasible', when considering district water management operations, and/or 'cost-effective' based on the District's typical costs of operations and maintenance. Table 51 shows the implementation schedule of each EWMP. Non-implemented EWMPs are categorized as being "Not Applicable" and are shown in Table 51 and Table 52.

Table 51. Schedule to Implement Efficient Water Management Practices

EWMP No.[1]	Description	Implementation Schedule	Finance Plan[2]	Budget Allotment
Critical EWMPs				
1	Water Measurement	Currently Implemented		Engineering, Operations & Maintenance
2	Volume-Based Pricing	Currently Implemented		Administration, Accounting, Engineering
Conditional EWMPs				
1	Alternate Land Use	Not Applicable		
2	Recycled Water Use	Currently Implemented		Engineering
3	On-Farm Irrigation Capital Improvements	Not Applicable		
4	Incentive Pricing Structure	Not Applicable		
5	Infrastructure Improvements	On-going Service		Administration, Engineering, Consultant Engineers
6	Order/Delivery Flexibility	On-going Service		Administration, Accounting
7	Supplier Operational Outflow and Tail-water Systems	Not Applicable		
8	Conjunctive Use	On-going Service/ Future Imp.		Administration, Engineering, Consultant Engineers
9	Automated Canal Controls	Currently Implemented		Engineering, Operations & Maintenance
10	Customer Pump Test/Evaluation	Not Applicable		
11	Water Conservation Coordinator	Currently Implemented		Administration

12	Water Management Services to Customers	On-going service		Administration, Engineering, Operations & Maintenance
13	Identify Institutional Changes	On-going service		Administration
14	Supplier Pump Improved Efficiency	On-going service		Administration, Engineering, Operations & Maintenance
NA	Improve Communication Among Suppliers	On-going service		Administration, Consultant Engineers
NA	Facilitate Voluntary Water Transfers	On-going service	Operations	Administration, Engineering, Consultant Engineers

[1] EWMP numbers correspond to Water Code §10608.48(c).

[2] The District has long been an efficient water provider since its inception. As such, the finance plan in providing water in an efficient manner is entwined completely within the District budget, which is available upon request.

Table 52. Non-Implemented EWMP Documentation

EWMP No.[1]	EWMP	(check one of both)		Justification/Documentation
		Technically Infeasible	Not Locally Cost-Effective	
1	Alternate Land Uses		x	Land use already follows the economics of farming and available water supplies and beyond the District's jurisdiction. The District does not provide capital for alternate land uses.
3	On-Farm Irrigation Capital Improvements		x	The District is not a provider of on-farm capital. All water conveyance facilities, including farm turnouts, are owned and operated by the District.
4	Incentive Pricing Structure		x	The District does not apply a tiered pricing structure for charging water users. Efficient water use is encouraged by the pricing contracted between the District and water users.
7	Supplier Operational Outflow and Tail-water Systems		x	Irrigated lands are mostly planted with permanent crops using high-efficiency irrigation methods, meaning there are few drainage systems and tail-water issues.
10	Customer Pump Test/Evaluations		x	District policy is to not provide funding for on-farm pump testing for efficiency; testing is conducted by the landowner.

[1] EWMP numbers correspond to Water Code §10608.48(c).

Supporting Agricultural Water Measurement Regulation Documentation

8.1 Description of Water Measurement Best Professional Practices

As stated in CWC Section 10608.48(b), all governed agricultural water suppliers are required to, "Measure the volume of water delivered to customers with sufficient accuracy to comply with subdivision (a) of Section 531.10" of the legislation. Furthermore, Section 531.10(a) requires that, "An agricultural water supplier shall submit an annual report to the department (DWR) that summarizes aggregated farm-gate delivery data, on a monthly or bi-monthly basis, using best professional practices."

The District receives SWP Water deliveries from 15 turnouts off the California Aqueduct (see Figure 2). Each turnout is equipped with a manufactured Venturi device operated and maintained by the DWR capable of directly measuring flow rate and accumulation of the total volume of water delivered. The accuracy of the Venturi-type measurement device is certified by the manufacturer to be accurate for volume measurements within ±2 percent.

All District delivery points for water delivered from the District's distribution system to each of the customers are called a "farm gate" or "turnout". (Figure 4 in Section 2 is a photograph of a typical farm turnout). Each turnout is equipped with a manufactured propeller-based flowmeters capable of directly measuring flow rate and accumulating the volume of water delivered over time with use of a totalizer device. The flowmeters are certified by the manufacturer, McCometer Model 900, to have an accuracy of ±2 percent. [District vertical flowmeters are MW800s and horizontal are MG900s]

District Operations and Maintenance Staff read the meters once a week (Tuesday) and observe each meter for any sign of abnormal reading based on prior experience with a particular meter. The field collected data are reviewed by a supervisor as a quality control procedure. Farm-level water delivery data are assembled by the District and are available to water users upon request throughout the season enabling irrigators to monitor water usage.

Since all measurement flowmeters used by the District are manufactured, certified devices and equipped with totalizers, the District can equate the calibrated accuracy of the flow meter to volumetric accuracy. According to the publication SBx7-7 Flow Rate Measurement Compliance for

Agricultural Irrigation Districts by the Irrigation Training & Research Center (ITRC) of the California Polytechnic Institute, San Luis Obispo, flowmeters with totalizers provide measurements that are sufficiently precise in monitoring flow duration to assume that the flow rate accuracy is equivalent to the calibrated volumetric accuracy. As a result, the flowmeters used by the District to measure delivery of water at the farm gates provide data that enables reliable computation of volumes of water delivered at each turnout.

As stated previously, the DWR maintains devices that measure the quantity of water delivered through each of the turnouts from the California Aqueduct. The District makes a comparison between the total volumes delivered according to the DWR devices at the delivery points off of the California Aqueduct versus recordings of the total volume delivered to the landowners as determined by the District measurement devices at the farm gate delivery points, as shown in Tables 53A, 53B, 53C, 53D, and 53E. The differences are compared within the delivery system by laterals and indicate system accuracy within the limits expected by the water code. This difference is typically less than 2 percent and demonstrates the flowmeters at the turnouts are well within the accuracy range expected by the water code of ±12 percent for existing measurement devices and ±5 percent for new or replacement measurement devices.

Table 53. A. District Meter Measurement Data for 2011

Meter Name	DWR Meas. Inflow (AF)	WRM Meas. Inflow (AF)	Difference (AF)	% Difference
WRM2	3,785	3,798	13	0.34%
WRM3	5,898	6,133	235	3.83%
WRM4	14,448	14,447	-1	-0.01%
WRM5	33,414	34,109	695	2.04%
WRM6	6,515	6,670	155	2.32%
WRM7	21,930	22,927	997	4.35%
WRM8	16,051	16,823	772	4.59%
WRM9	8,779	9,152	373	4.08%
WRM9A	5,367	5,388	21	0.39%
WRM10	36,791	35,854	-937	-2.61%
WRM11	0	10	10	-
WRM12	0	0	0	0.00%
WRM13A	855	868	13	1.50%
WRM13B	1,258	1,374	116	8.44%
WRM14	10,532	10,854	322	2.97%
WRM15	2,765	2,689	-76	-2.83%
Total	168,388	171,096	2,708	1.58%
Average	10,524	10,693	169	1.96%

Table 53. B. District Meter Measurement Data for 2012

Meter Name	DWR Meas. Inflow (AF)	WRM Meas. Inflow (AF)	Difference (AF)	% Difference
WRM2	3,324	3,396	72	2.12%
WRM3	5,892	6,179	287	4.64%
WRM4	16,681	16,839	158	0.94%
WRM5	35,108	35,643	535	1.50%
WRM6	6,679	6,596	-83	-1.26%
WRM7	22,702	23,318	616	2.64%
WRM8	16,008	17,222	1,214	7.05%
WRM9	7,438	7,669	231	3.01%
WRM9A	4,950	4,858	-92	-1.89%
WRM10	22,970	21,697	-1,273	-5.87%
WRM11	0	9	9	-
WRM12	0	0	0	0.00%
WRM13A	873	818	-55	-6.72%
WRM13B	1,342	1,369	27	1.97%
WRM14	10,788	11,339	551	4.86%
WRM15	3,025	2,987	-38	-1.27%
Total	157,780	159,939	2,159	1.35%
Average	9,861	9,996	134	0.78%

Table 53. C. District Meter Measurement Data for 2013

Meter Name	DWR Meas. Inflow (AF)	WRM Meas. Inflow (AF)	Difference (AF)	% Difference
WRM2	3,844	4,059	215	5.30%
WRM3	6,120	6,415	295	4.60%
WRM4	19,450	19,778	328	1.66%
WRM5	34,637	36,634	1,997	5.45%
WRM6	6,892	6,962	70	1.01%
WRM7	20,608	21,600	992	4.59%
WRM8	17,313	18,713	1,400	7.48%
WRM9	7,691	8,112	421	5.19%
WRM9A	5,807	5,706	-101	-1.77%
WRM10	22,340	21,334	-1,006	-4.72%
WRM11	0	14	14	-
WRM12	0	0	0	0.00%
WRM13A	882	873	-9	-1.03%
WRM13B	918	879	-39	-4.44%
WRM14	9,255	9,689	434	4.48%
WRM15	2,687	2,660	-27	-1.02%
Total	158,444	163,428	4,984	3.05%
Average	9,902	10,214	312	1.79%

Table 53. D. District Meter Measurement Data for 2014

Meter Name	DWR Meas. Inflow (AF)	WRM Meas. Inflow (AF)	Difference (AF)	% Difference
WRM2	2,796	2,782	-14	-0.50%
WRM3	6,179	6,567	388	5.91%
WRM4	19,197	19,232	35	0.18%
WRM5	30,228	32,043	1,815	5.66%
WRM6	4,210	4,859	649	13.36%
WRM7	15,899	16,041	142	0.89%
WRM8	15,434	16,670	1,236	7.41%
WRM9	5,558	5,843	285	4.88%
WRM9A	3,550	3,650	100	2.74%
WRM10	7,234	6,656	-578	-8.68%
WRM11	0	9	9	-
WRM12	0	0	0	0.00%
WRM13A	262	235	-27	-11.49%
WRM13B	1,411	1,358	-53	-3.90%
WRM14	9,648	9,670	22	0.23%
WRM15	2,741	2,796	55	1.97%
Total	124,347	128,411	4,064	3.16%
Average	7,772	8,026	254	1.33%

Table 53. E. District Meter Measurement Data for 2015[1]

Meter Name	DWR Meas. Inflow (AF)	WRM Meas. Inflow (AF)	Difference (AF)	% Difference
WRM2	2,190	2,205	15	0.68%
WRM3	5,761	6,114	353	5.77%
WRM4	17,695	17,729	34	0.19%
WRM5	29,404	31,326	1,922	6.14%
WRM6	4,047	4,599	552	12.00%
WRM7	14,666	15,103	437	2.89%
WRM8	13,779	14,688	909	6.19%
WRM9	3,199	3,977	778	19.56%
WRM9A	4,218	4,221	3	0.07%
WRM10	5,914	5,640	-274	-4.86%
WRM11	0	9	9	-
WRM12	0	0	0	0.00%
WRM13A	629	559	-70	-12.52%
WRM13B	1,085	1,093	8	0.73%
WRM14	8,246	8,438	192	2.28%
WRM15	3,141	3,078	-63	-2.05%
Total	113,974	118,779	4,805	4.05%
Average	7,123	7,424	300	2.65%

[1] From January 2015 through November 2015.

The District uses a couple methods to check the field accuracy of the meters. One is they compare the total volume delivered from the whole population of flowmeters used to deliver water at the farm headgate to the total volume delivered by the DWR's devices that are used to meter water volume delivered into the District. This provides a method of comparing the volume of water delivered into the District and at the District's delivery points to the customer. District Staff also routinely monitor each delivery point meter for abnormalities and District policy is to replace a meter if the abnormal reading cannot be rectified in the field.

As evidence of the District meter repair and replacement program, the following number of meters were either repaired or replaced by the field staff in 2011, 2012, 2013, 2014, and 2015.

Year, Number of Meter Repairs or Replacement

- 2011 Repairs-66, Replace-10
- 2012 Repairs-78, Replace-7
- 2013 Repairs-96, Replace-19

In addition to the District Staff monitoring for any abnormal performance, customers can also request the meter be tested. These accurate measurement devices and methods support the District's volumetric pricing structure and compliance with volumetric measurement requirements.

8.2 Legal Certification and Apportionment (Access to Farm-gates)

District staff has access to install, measure, maintain, operate, and monitor flow-measurement devices at all customer water delivery points (Farm-gates and turnouts) from the District's irrigation distribution system. As such, there are no institutional or legal impediments that restrict access to turnouts or measurement of water and, for the purposes of satisfying SBx7-7, there is no need to measure water upstream of points of delivery to individual customers.

8.3 Engineer Certification and Apportionment

An Engineer Certification is not applicable since the District is not relying on measurement options upstream of the delivery points to farm gates. The District measures deliveries at the farm gate using manufactured devices (flow meters) that are equipped with a "totalizer" with certified accuracy of +2 percent of the volume, replaces any malfunctioning measurement devices with manufactured devices with certified accuracy of +2 percent, and implements a methodology for comparison of total volume delivered at the farm gate to total volume delivered off of the California Aqueduct. The methodology used to determine the accuracy of District flow-measurement devices complies with the requirements of Section 597.3(a) and 597.4(a).

8.4 Description of Water Measurement Best Professional Practices

All water suppliers required to implement agricultural water measurement must include a description of Best Professional Practices regarding:

a. The collection of water measurement data – District Staff are trained and supervised by the operations superintendent. District Staff provide field-inspections and analysis for every existing measurement device. A comparison of total water delivered into the District with the total water delivered to all water delivery points to the customer is documented in a report approved by the District Engineer.
b. Frequency of measurements – District Staff collects the "totalizer" value from each meter once a week.
c. Method for determining irrigated acres – District surveys the irrigated acres each year as part of the contract service area.
d. Quality control and quality assurance procedures – Compare the total volume of water metered at all District delivery points with the total water delivered into the District by the DWR. Investigate differences and recommend corrective measures. Replace meters not functioning properly if determined not repairable.

The District maintains records of water delivered from the California Aqueduct into the District and all water delivered to customers at the Delivery Point (Farm-gate or turnout).

8.5 Documentation of Water Measurement Conversion to Volume

SBx7-7 requires an annual volumetric accuracy of within ±12 percent on existing devices and ±5 percent for new and replacement devices. As previously stated, the District's flow measurement devices include totalizers (which directly record cumulative flow volume) with a manufacturer's certified accuracy of ±2 percent. Therefore, the District's measurement devices directly record volumes within accuracy range required by SBx7-7.

8.6 Device Corrective Action Plan

As documented herein, the District's existing water measurement devices perform substantially better than the +12 accuracy standard and new meters perform substantially better than the +5 percent accuracy standard. No correct action is identified or planned. As noted previously, currently the District repairs or replaces flow meters when there is an obvious deficiency in their performance or when a water user questions the accuracy of a meter. The District will continue this practice on an ongoing basis since it also has the ability with the piped delivery system off of the California Aqueduct to compare the total water delivered into the District with the total volume of water delivered at the delivery points (Farm-gates and turnouts) to customers. New replacement meters will be manufactured devices, laboratory certified by their manufacturer prior to installation to have an accuracy of measurement within ±5 percent by volume. The manufacturer presently used by the District has a certified accuracy of +2 percent by volume.

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