FEBRUARY 2016

BUENA VISTA WATER STORAGE DISTRICT

2015 Agricultural Water Management Plan

2015 AGRICULTURAL WATER MANAGEMENT PLAN

FOR THE

Buena Vista Water Storage District

February 2016

Completed In Accordance With the

WATER CONSERVATION BILL OF 2009
(SBx7-7)

and

EXECUTIVE ORDER B-29-15

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List of Acronyms

AF	acre-feet
AWMC	Agricultural Water Management Council
AWMP	Agricultural Water Management Plan
BVWSD	Buena Vista Water Storage District
BWSD	Belridge Water Storage District
cfs	cubic feet per second
CIMIS	California Irrigation Management Information System
CLWA	Castaic Lake Water Agency
CVC	Cross Valley Canal
CVP	Central Valley Project
CVRWQCB	Central Valley Regional Water Quality Control Board
DWR	Department of Water Resources
EC	Electrical Conductivity
ET	Evapotranspiration
ET_c	Crop evapotranspiration
ET_o	Reference evapotranspiration
EWMP	Efficient Water Management Practice
GHG	Greenhouse Gas
GWMP	Groundwater Management Plan
ID	Irrigation District
ITRC	Irrigation Training & Research Center
KCWA	Kern County Water Agency
KDWD	Kern Delta Water District
KRWCA	Kern River Watershed Coalition Authority
LGA	Local Groundwater Assistance
M&I	Municipal and Industrial
Mg/L	Milligrams per Liter
MUD	Municipal Utility District
ppm	parts per million
RRBWSD	Rosedale-Rio Bravo Water Storage District
SBx7-7	Water Conservation Act of 2009
SCADA	Supervisory Control and Data Acquisition
SSJVWQC	Southern San Joaquin Valley Water Quality Coalition
SWP	State Water Project
SWSD	Semitropic Water Storage District
TDS	Total Dissolved Solids
TOC	Total Organic Carbon
USACE	U.S. Army Corps of Engineers
UWMP	Urban Water Management Plan
WKWD	West Kern Water District
WSD	Water Storage District

DWR AWMP PLAN CHECKLIST

The following tables are a DWR checklist for all Agricultural Water Management Plans, set forth in Section 2.1 of the *DWR Guidebook to Assist Agricultural Water Suppliers to Prepare a 2015 Agricultural Water Management Plan.*

AWMP Location	Guidebook Location	Description	Water Code Section (or other, as identified)
I-A	1.4	AWMP Required?	10820, 10608.12
II-A	1.4	At least 25,000 irrigated acres At least 10,000 irrigated acres	10853 Executive Order B-29-15
N/A	1.4	10,000 to 25,000 irrigated acres and funding provided.	10853
I	1.4	December 31, 2015 Update July 1, 2016 AWMP for agricultural water suppliers to 10,000 to 25,000 irrigated acres	10820(a) Executive Order B-29-15
I	1.4	5-year cycle update.	10820(a)
I	1.4	New agricultural water supplier after December 31, 2012 – AWMP prepared and adopted within 1 year.	10820(b)
I-A	1.5, 5	USBR water management/conservation plan:	10828(a) Executive Order B-29-15
I-A	1.5, 5.1	Adopted and submitted to USBR within the previous four years, AND	10828(a)(1)
I-A	1.5, 5.1	The USBR has accepted the water management/conservation plan as adequate.	10828(a)(2)
N/A	1.4	UWMP or participation in area wide, regional, watershed, or basin wide water management planning: does the plan meet requirements of SBx7-7 2.8 **(use checklist)**	10829
I-B	3.1 A	Description of previous water management activities.	10826(d)
I-C	3.1 B.1	Was each city or county within which supplier provides water supplies notified that the agricultural water supplier will be preparing or amending a plan?	10821(a)
I-D	3.2 B.2	Was the proposed plan available for public inspection prior to plan adoption?	10841
APP. A	3.1 B.2	Publically-owned supplier: Prior to the hearing, was the notice of the time and place of hearing published within the jurisdiction of the publicly owned agricultural water supplier in accordance with Government Code 6066?	10841
APP. A	3.1 B.2	14 days notification for public hearing?	GC 6066
APP. B	3.1 B.2	Two publications in newspaper within those 14 days?	GC 6066
APP. B	3.1 B.2	At least 5 days between publications? (not including publication date)	GC 6066
APP. A	3.1 B.2	Privately-owned supplier: was equivalent notice within its service area and reasonably equivalent opportunity that would otherwise be afforded through a public hearing process provided?	10841

AWMP Location	Guidebook Location	Description	Water Code Section (or other, as identified)
I-D	3.1 C.1	After hearing/equivalent notice, was the plan adopted as prepared or as modified during or after the hearing?	10841
I-C	3.1 C.2	Was a copy of the AWMP, amendments, or changes, submitted to the entities below, no later than 30 days after the adoption?	10843(a)
I-C	3.1 C.2	The department.	10843(b)(1)
I-C	3.1 C.2	Any city, county, or city and county within which the agricultural water supplier provides water supplies.	10843(b)(2)
I-C	3.1 C.2	Any groundwater management entity within which jurisdiction the agricultural water supplier extracts or provides water supplies.	10843(b)(3)
I-C	3.1 C.2	Any urban water supplier within which jurisdiction the agricultural water supplier provides water supplies.	10843(b)(4)
I-C	3.1 C.2	Any city or county library within which jurisdiction the agricultural water supplier provides water supplies.	10843(b)(5)
I-C	3.1 C.2	The California State Library.	10843(b)(6)
I-C	3.1 C.2	Any local agency formation commission serving a county within which the agricultural water supplier provides water supplies.	10843(b)(7)
I-D	3.1 C.3	Adopted AWMP availability.	10844
N/A	3.1 C.3	Was the AWMP available for public review on the agricultural water supplier’s Internet Web site within 30 days of adoption?	10844(a)
I-D	3.1 C.3	If no Internet Web site, was an electronic copy of the AWMP submitted to DWR within 30 days of adoption?	10844(b)
	3.1 D.1	Implement the AWMP in accordance with the schedule set forth in its plan, as determined by the governing body of the agricultural water supplier.	10842
II	3.2	Description of the agricultural water supplier and service area including:	10826(a)
II-A	3.2 A.1	Size of the service area.	10826(a)(1)
II-B	3.2 A.2	Location of the service area and its water management facilities.	10826(a)(2)
II-D	3.2 A.3	Terrain and soils.	10826(a)(3)
II-E	3.2 A.4	Climate.	10826(a)(4)
II-F	3.2 B.1	Operating rules and regulations.	10826(a)(5)
II-G	3.2 B.2	Water delivery measurements or calculations.	10826(a)(6)
II-G	3.2 B.3	Water rate schedules and billing.	10826(a)(7)
II-G	3.2 B.4	Water shortage allocation policies. Drought Management Plan	10826(a)(8) Executive Order B-29-15
III	3.3	Water uses within the service area, including all of the following:	10826(b)(5)
III-A	3.3 A	Agricultural.	10826(b)(5)(A)
III-B	3.3 B	Environmental.	10826(b)(5)(B)
III-C	3.3 C	Recreational.	10826(b)(5)(C)

AWMP Location	Guidebook Location	Description	Water Code Section (or other, as identified)
III-D	3.3 D	Municipal and industrial.	10826(b)(5)(D)
III-E	3.3 E	Groundwater recharge.	10826(b)(5)(E)
III-F	3.3 F	Transfers and exchanges.	10826(b)(5)(F)
III-G	3.3 G	Other water uses.	10826(b)(5)(G)
IV	3.4 A	Description of the quantity of agricultural water supplier's supplies as:	10826(b)
IV-A	3.4 A.1	Surface water supply.	10826(b)(1)
IV-B	3.4 A.2	Groundwater supply.	10826(b)(2)
IV-C	3.4 A.3	Other water supplies.	10826(b)(3)
IV-D	3.4 A.4	Drainage from the water supplier's service area.	10826(b)(6)
IV	3.4 B	Description of the quality of agricultural waters suppliers supplies as:	10826(b)
IV-E	3.4 B.1	Surface water supply.	10826(b)(1)
IV-E	3.4 B.2	Groundwater supply.	10826(b)(2)
IV-E	3.4 B.3	Other water supplies.	10826(b)(3)
IV-F	3.4 C	Source water quality monitoring practices.	10826(b)(4)
IV-F	3.4 B.4	Drainage from the water supplier's service area.	10826(b)(6)
V	3.5	Description of water accounting, including all of the following:	10826(b)(7)
V-A	3.5 A	Quantifying the water supplier's water supplies.	10826(b)(7)(A)
V-C	3.5 B	Tabulating water uses.	10826(b)(7)(B)
V-D	3.5 C	Overall water budget.	10826(b)(7)(C)
V-E	3.5 D	Description of water supply reliability.	10826(b)(8)
VI-A / VI-B	3.6	Analysis of climate change effect on future water supplies analysis.	10826(c)
I	3.7	Water use efficiency information required pursuant to Section 10608.48.	10826(e)
VII-A	3.7A	Implement efficient water management practices (EWMPs).	10608.48(a)
VII-A	3.7 A.1	Implement Critical EWMP: 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).	10608.48(b)
VII-A	3.7 A.1	Implement Critical EWMP: Adopt a pricing structure for water customers based at least in part on quantity delivered.	10608.48(c)
VII-A	3.7 A.2	Implement additional locally cost-effective and technically feasible EWMPs.	10608.48(c)
VII-B	3.7 B	If applicable, document (in the report) the determination that EWMPs are not locally cost-effective or technically feasible.	10608.48(d)
VII-A	3.7 A	Include a report on which EWMPs have been implemented and planned to be implemented.	10608.48(d)

AWMP Location	Guidebook Location	Description	Water Code Section (or other, as identified)
VII-A	3.7 A	Include (in the report) an estimate of the water use efficiency improvements that have occurred since the last report, and an estimate of the water use efficiency improvements estimated to occur five and 10 years in the future.	10608.48(d)
	5	USBR water management/conservation plan may meet requirements for EWMPs.	10608.48(f)
VIII-D	6 A	Lack of legal access certification (if water measuring not at farm gate or delivery point).	CCR §597.3(b)(2)(A)
N/A	6 B	Lack of technical feasibility (if water measuring not at farm gate or delivery point).	CCR §597.3(b)(1)(B), §597.3(b)(2)(B)
N/A	6 A, 6 B	Delivery apportioning methodology (if water measuring not at farm gate or delivery point).	CCR §597.3.b(2)(C)
VIII-A	6 C	Description of water measurement BPP.	CCR §597.4(e)(2)
VIII-F	6 D	Conversion of measurement to volume.	CCR §597.4(e)(3)
VIII	6 E	Existing water measurement device corrective action plan? (if applicable, including schedule, budget and finance plan)	CCR §597.4(e)(4)

AGRICULTURAL WATER MANAGEMENT PLAN

Section I. Plan Preparation and Adoption

The Buena Vista Water Storage District (Buena Vista, District) Agricultural Water Management Plan (AWMP) has been prepared in accordance with the requirements of the Water Conservation Bill of 2009 (SBx7-7, Water Code §10820) and Executive Order B-29-15 (E.O. B-29-15). The requirements presented in SBx7-7 are intended to encourage agricultural water suppliers to assess current efficient water management practices, evaluate additional practices that may conserve water and protect water quality and provide for accurate measurement and pricing of water. E.O. B-29-15 was issued on April 1, 2015 in response to the 2013-15 drought and requires detailed drought management plans, as well as the quantification of water supplies and demands for 2013, 2014, and 2015. The purpose of the Buena Vista AWMP is to describe existing water management activities of the District as well introducing proposed programs and initiatives. The AWMP also documents implemented, or proposed, monitoring and management programs designed to improve water use efficiency.

This document conforms to the framework presented in *A Guidebook to Assist Agricultural Water Suppliers to Prepare a 2015 Agricultural Water Management Plan* (2015 Guidebook) that was issued by the California Department of Water Resources (DWR) in June 2015 to aid water suppliers in preparing Agricultural Water Management Plans in accordance with the requirements of SBx7-7 and E.O. B-29-15.

A. SBx7-7 Efficient Water Management Practices (EWMPs)

Included in Section VII of this plan is an analysis of the 16 Efficient Water Management Practices (EWMPs) presented in the Guidebook. Each of the EWMPs is defined below:

Critical Efficient Water Management Practices

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

Conditional Efficient Water Management Practices

1. Facilitation of alternative land use for lands with exceptionally high water duties or whose irrigation contributes to significant problems, including problem drainage.
2. Facilitation of use of available recycled water that otherwise would not be used beneficially, meets health and safety criteria, and does not harm crops or soils. The use of recycled urban wastewater can be an important element in overall water management.
3. Facilitate the financing of capital improvements for on-farm irrigation systems.

4. Implement an incentive pricing structure that promotes one or more of the following goals:
    A. More efficient water use at the farm level such that it reduces waste;
    B. Conjunctive use of groundwater;
    C. Appropriate increase of groundwater recharge;
    D. Reduction in problem drainage;
    E. Improved management of environmental resources, and
    F. Effective management of all water sources throughout the year by adjusting seasonal pricing structures based on current conditions.
5. Expand lined or piped distribution systems, construct regulatory reservoirs to increase distribution system flexibility and capacity, decrease maintenance, and reduce seepage.
6. Increase flexibility in water ordering by, and delivered to, water customers within operational limits.
7. Construct and operate supplier operational outflow and tailwater systems.
8. Increase planned conjunctive use of surface water and groundwater within the supplier service area.
9. Automate canal control devices.
10. Facilitate or promote customer pump testing and evaluation.
11. Designate a water conservation coordinator who will develop and implement the water management plan and prepare progress reports.
12. Provide for the availability of water management services to water users. These services may include, but are not limited to, all of the following:
    A. On-farm irrigation and drainage system evaluations;
    B. Normal year and real-time irrigation scheduling and crop evapotranspiration information;
    C. Surface water, groundwater, and drainage water quantity and quality data, and
    D. Agricultural water management educational programs and materials for irrigators.
13. Evaluate the policies of agencies that provide the supplier with water to identify the potential for institutional change to allow more flexible water deliveries and storage.
14. Evaluate and improve the efficiencies of the suppliers' pumps.

B. Description of Previous Water Management Activities

The mission of Buena Vista WSD is to provide its landowners and water users with a reliable, affordable water supply, while facilitating programs that protect and benefit the groundwater basin and better utilize water resources. The District recognizes that its water supply, drainage system, groundwater aquifer, and soils are all resources which must be actively managed to preserve a productive agricultural environment. The District has implemented, and is currently in the process of developing and implementing, various programs, projects, and policies to meet this objective.

Because a decline in groundwater levels would reduce groundwater reserves, increase pumping lifts, and could require deepening or abandonment of wells, preserving the sustainability of groundwater as a source of supply is essential for the economic wellbeing of the District and its growers, particularly in light of the hardening of demand driven by the conversion from annual crops to orchards and vineyards. In response to these concerns, the District has implemented an extensive water conservation and conjunctive management program, the Buena Vista Water Management Program (Program). Important components of the Program are projects implemented within the District to manage tailwater and to encourage groundwater pumping from privately-owned wells to benefit growers and support district water management objectives. In addition, BVWSD actively participates with neighboring districts having complementary goals and objectives in groundwater banking and water exchange projects. A central objective of the Buena Vista Water Management Program is to enable the District to maintain a positive water balance for at least the next forty years.

Key entities with whom the District frequently engages to advance water management projects are described below:

Kern County Water Agency

The Kern County Water Agency (KCWA, Agency) was created in 1961 by a special act of the California State Legislature and serves as the local contracting entity for the State Water Project (SWP) for the Agency's 13 member units. The Agency participates in a wide scope of water management activities, including water quality, flood control and groundwater operations.

County of Kern

Buena Vista participates in periodic meetings with Kern County staff and with the Board of Supervisors. Kern County has the authority to prepare and enforce county ordinances that protect groundwater quality, such as the Water Well Ordinance (Section 14.08) which presents requirements for well construction and closure. The District has provided comments on the well ordinance amendments and is contacted by the County when wells are found to be abandoned. BVWSD has also reviewed land use change requests that could affect water use and quality within the District.

Kern Integrated Regional Water Management Group

The Kern Integrated Regional Water Management (IRWM) Group is a collaboration of water suppliers, community and government representatives, environmental groups, businesses and a variety of other interested regional and state-wide parties. The IRWM Plan (IRWMP) was developed by a group of over 80 participants in an effort to preserve the economic and environmental health of Kern County communities through comprehensive and efficient management of water resources. The group also shares information on regional water issues and seeks funding for region-wide water programs, projects, and policies.

Regional Groundwater Monitoring Committees

Buena Vista serves on the Kern Fan Monitoring Committee, the Semitropic Groundwater Monitoring Committee, and the Kern Groundwater Monitoring Committee all of which perform regional groundwater monitoring in and around the District.

Water management activities previously implemented or now being implemented by the District include:

- Deliver surface water in lieu of groundwater pumping when practicable; use water pricing, water exchanges, and water banking, as appropriate, to encourage such deliveries.
- Build the Northern Area Pipeline. This project is being aided in part by grants from the DWR and WaterSmart2014.
- Actively seek locations within the District to abandon existing unlined canals, and replace them with pipelines.
- Encourage USACE to expedite “fixes” to Isabella Dam, repairing deficiencies and removing the storage restriction that has been in place since 2006.
- Recharge the aquifer with high quality surface water.
- Actively participate in local water resource management forums including the Semitropic Water Storage District’s Groundwater Monitoring Committee, the Kern Regional Water Management Group, the Kern River Watershed Water Quality Coalition, the Kern Fan Monitoring Committee, and the Kern Groundwater Management Committee.
- The District was awarded a $1 million grant from the USBR’s Water SMART 2011 Program for improving irrigation delivery systems and on-farm efficiency. As part of the program, and in cooperation with the USDA Natural Resources Conservation Service (NRCS), eligible growers were awarded up to a 50 percent cost share for on-farm projects that improve water use efficiency.
- The District was awarded a $2 million grant from Prop 84 monies for construction of the Brackish Groundwater Recovery Program.
- The District has been noticed of a possible $800 thousand grant to help build The Palms, a District owned and operated recharge and recovery facility.

C. Coordination Activities

Notification of AWMP Preparation

SBx7-7 does not specify how much advance time is required for notification of cities and counties of plan preparation, does not require notification of any other agency(s) and does not require that comments from any city, county or other agency must be solicited and considered. In complying with these provisions, Buena Vista notified the entities shown in Table 1. *Appendix A* presents the public notice of plan preparation, and *Appendix B* presents public hearing notification letter. Because there are no incorporated cities lying within or adjacent to Buena Vista's service area, and because no municipalities rely on the District for water, no municipalities have been notified of plan preparation other than by publication in a local newspaper.

In preparing this plan, Buena Vista solicited input by holding a public hearing and inviting oral and written comments prior to adoption of the plan at a Board of Director's meeting on June 18, 2014.

Table 1.Summary of Coordination, Adoption and Submittal Activities

Potential Interested Parties	Notified of Plan Preparation	Assisted in Preparation	Received Draft Plan	Notified of Public Meetings	Notified of Intention to Adopt	Sent Copy of Adopted Plan
County of Kern	X			X	X	X
Dept. of Water Resources	X			X	X	X
Kern County Water Agency	X			X	X	X
California State Library						X

Source: BVWSD

Public Participation

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

D. Plan Adoption and Submittal

The purposes of this AWMP are to assess Buena Vista's current and planned water management operations and to respond to the provisions of SBx7-7 and E.O B-29-15. The AWMP describes the District's status with regard to implementation of two new mandatory EWMPs (Critical EWMPs 1 and 2, defined above) and includes a discussion of the potential impacts of climate change on District operations. EWMPs discussed in this plan are intended to improve district operations, promote water conservation, water measurement and volumetric pricing.

The AWMP, as adopted by the District following a public hearing, will be available from the District by request. A copy of the plan will be submitted to the DWR within 30 days of adoption.

E. Plan Implementation

Buena Vista is implementing EWMPs based upon the program described in Section VII of this AWMP. These EWMPs include improvements to District operations that enhance water management and promote water conservation as well as EWMPs mandated by SBx7-7 that promote water measurement and volumetric pricing.

Section II. Description of the Buena Vista Water Storage District and Service Area

A. Regional History and District Background

The land within the District's boundaries was originally developed by two former meat supply merchants from San Francisco, Henry Miller and Charles Lux. In the early 1870's, these men set out to build a cattle and sheep empire in the Southern San Joaquin Valley and acquired extensive land holdings through the "Swamp and Overflow Act" (1850) with the most productive Kern County portions of these holdings now lying within the District's boundaries. Surface water diverted from the adjoining Kern River and from surface storage within Buena Vista Lake was used to develop lands north of and surrounding the lake.

Kern River water began being used for irrigation in the late 1850's when small private ditches diverted water for the irrigation of grains. As the upstream diversions increased, controversies arose resulting in lengthy litigation between upper and lower river users. Much of today's California water law resulted from the California Supreme Court's decision in the historic case of Lux v. Haggin (69 Cal. 255; 10 P. 674; 1886). The ruling created what is now known as the "California Doctrine" which recognizes both riparian and appropriative water rights. Despite the court's decision, the dispute continued and was finally settled in the historic Miller-Haggin Agreement of July 1888. This agreement was amended by the State Water Resources Control Board (SWRCB) in 1955 and again in 1964 and continues to serve as the basis by which the flow of the Kern River is allocated among "First and Second Point" interests.

Under the Miller-Haggin Agreement, the Second Point interests, namely Miller and Lux, were granted an apportionment of approximately one-third of the Kern River flows from March through August. A subsequent amendment also granted Second Point interests some of the Kern River flows resulting from winter runoff. The Second Point water right amounted to an average entitlement of about 158,000 acre-feet per year (AF/yr), delivered by First Point interests to the Second Point of measurement, undiminished by delivery losses (Krieger & Stewart, 2009). At the time, the SWRCB found that no additional water in the Kern River system remained available for appropriation although a recent court ruling has determined that a forfeiture of water rights has occurred. This ruling should not affect BVWSD's water rights, and the District was not a party to the litigation.

After the death of Henry Miller in 1916, the Miller and Lux Land Company began selling much of its land to its tenant farmers who were largely emigrants from Italy. The new landowners soon realized that an entity would be needed to succeed the company in representing the many interests vested in the water right and to provide irrigation service. The District was organized in 1924 to fulfill this need and began operations following issuance of its 1927 Project Report. Upon its formation, the District became the owner and operator of the irrigation and drainage facilities developed by the Miller and Lux Land Company and, as the successor to the Second Point interests under the Miller-Haggin Agreement, became entitled to provide for the distribution of the Second Point water rights that were tied to the Company's lands. The Project Report also provided for construction of new facilities to enable further development of district lands for agriculture.

Land use within Buena Vista is primarily agricultural. At the time of the District's formation, the service area was devoted almost exclusively to irrigated grains and other annual crops. Now, approximately 45,000 acres have been developed, and approximately 35,000 acres are farmed primarily to field and row crops (Krieger & Stewart, 2009). Cotton is the predominant crop with other major crops including alfalfa, sugar beets, grain, pistachios, vineyards and pomegranates. With cotton, alfalfa and grains continuing to be the primary crops, typical irrigation cycles occur during the winter months of January and February (pre-irrigation season) and the summer period of late May through August (irrigation season). As with neighboring districts, there has been a shift in recent years from row crops to permanent crops. For example, between 2008 and 2015 the percentage of land planted in permanent crops grew from 9 percent to 42 percent, a conversion which increases winter water demands and reduces the ability of growers to reduce demand in droughts.

Buena Vista operates a conjunctive use program in which surface water is recharged to and stored in the aquifer in years of excess surface water supply for recovery by pumping in years when the surface water supply is insufficient to meet the full crop demand. Over the last thirty years, the District has created a net positive water balance relative to the aquifer by recharging an annual average of approximately 46,000 AF/yr of surface water into the underlying aquifers (Buena Vista WSD Water Balance – 1970-2011). A significant volume of that recharged water reaches the aquifer through seepage from canals and laterals. Although most of the stored water resides in aquifers underlying the District, some resides in nearby groundwater banking projects, and a small amount resides for brief periods in surface reservoirs.

The District's ability to maintain a positive long-term water balance is due to delivery of surface water from seasonally regulated flows in the Kern River, schedulable deliveries from the State Water Project (SWP) through the California Aqueduct, and occasional purchases or exchanges for water from the Central Valley Project (CVP) delivered to the Kern River Channel via the Friant-Kern Canal. These surface water sources generate an average annual supply sufficient to meet District-wide demands. However, due to operational limitations, water is not always available when it is needed. Therefore, the remaining demands are filled using groundwater pumped from District- and privately-owned wells. Table 2 provides an overview of the District's history, size and key sources of water supply.

Table 2.Water Supplier History and Size

Date of Formation	1924
Source of water	
Local surface water	Kern River
Imported surface water	SWP/ CVP
Local groundwater	District/ Private
Gross acreage at time of formation	49,461
Gross acreage - current service area (2015)	48,810
Current irrigated acreage (2015)	32,437

Source: BVWSD

B. Location of the Service Area

Buena Vista is located in Kern County, approximately sixteen miles west of the City of Bakersfield in the trough of California's southern San Joaquin Valley. The District is bordered by several water agencies including Belridge Water Storage District (BWSD), Semitropic Water Storage District (SWSD), Rosedale-Rio Bravo Water Storage District (RRBWSD), and the Kern Delta Water District (KDWD). The Kern Water Bank also lies near Buena Vista being separated from the District by the Tule Elk State Natural Reserve. In some areas the District borders lands that have not been organized into a district but which fall within the jurisdiction of the County of Kern and the KCWA.

Buena Vista is made up largely of reclaimed swamp lands located in and along the pre-development course of the lower Kern River which, after exiting the Southern Sierra Nevada mountains near Bakersfield and flowing south and then southwest across the southern San Joaquin Valley, runs through the topographic axis of the valley toward its ultimate terminus at a drainage basin which was once Tulare Lake. The water conveyance systems in and around the District consist of a network of levees and diversions to control the high flows of the Kern River, as well as a system of canals and drains that deliver surface water to, and collect runoff from, the lands within the District.

The District is divided into two distinct areas, as shown in Figure 1: the Buttonwillow Service Area (BSA) comprising 43,460 acres and the Maples Service Area (MSA) comprising 4,350 acres. These two areas are separated by about 15 miles. The BSA and the MSA both lie within the lower Kern River watershed, where historic runoff created heavy clay soils from former swamp and overflow lands along the northern fringe of Buena Vista Lake.

<u>Buttonwillow Service Area (BSA)</u>

The BSA is a 26-mile long, three- to five-mile wide strip of land that occupies the overflow lands within the Buttonwillow Syncline, a geological feature described later in this document. As shown in Figure 1, the service area lies west of the Kern River alluvial fan between the Elk Hills and Buttonwillow Ridge, where the pre-development course of the lower Kern River followed the valley's topographic axis from the Buena Vista Lake Bed northward toward the Tulare Lake Bed. Because of the asymmetry of the San Joaquin Valley's topography, the axial trough where the BSA lies borders the western edge of the valley. Land surface elevations in the BSA range from 320 feet above sea level on the eastern flank to lower than 300 feet above sea level in the west.

The BSA shares parts of its northern, eastern, and southern boundaries with the Semitropic and Rosedale-Rio Bravo water storage districts and the Kern Water Bank and shares its western boundary with lands not organized into districts which separate the service area from the Belridge Water Storage District and oilfield properties farther to the west. The service area is situated northwest of the Buena Vista Lake Bed which consists of agricultural land that receives water from the Henry Miller Water District (HMWD) which is part of Buena Vista, but is not served district water.

The northern half of the Buttonwillow Service Area differs in several respects from the rest of the District. The soils are dense, heavy, and poorly-drained and are underlain by a shallow, perched water table

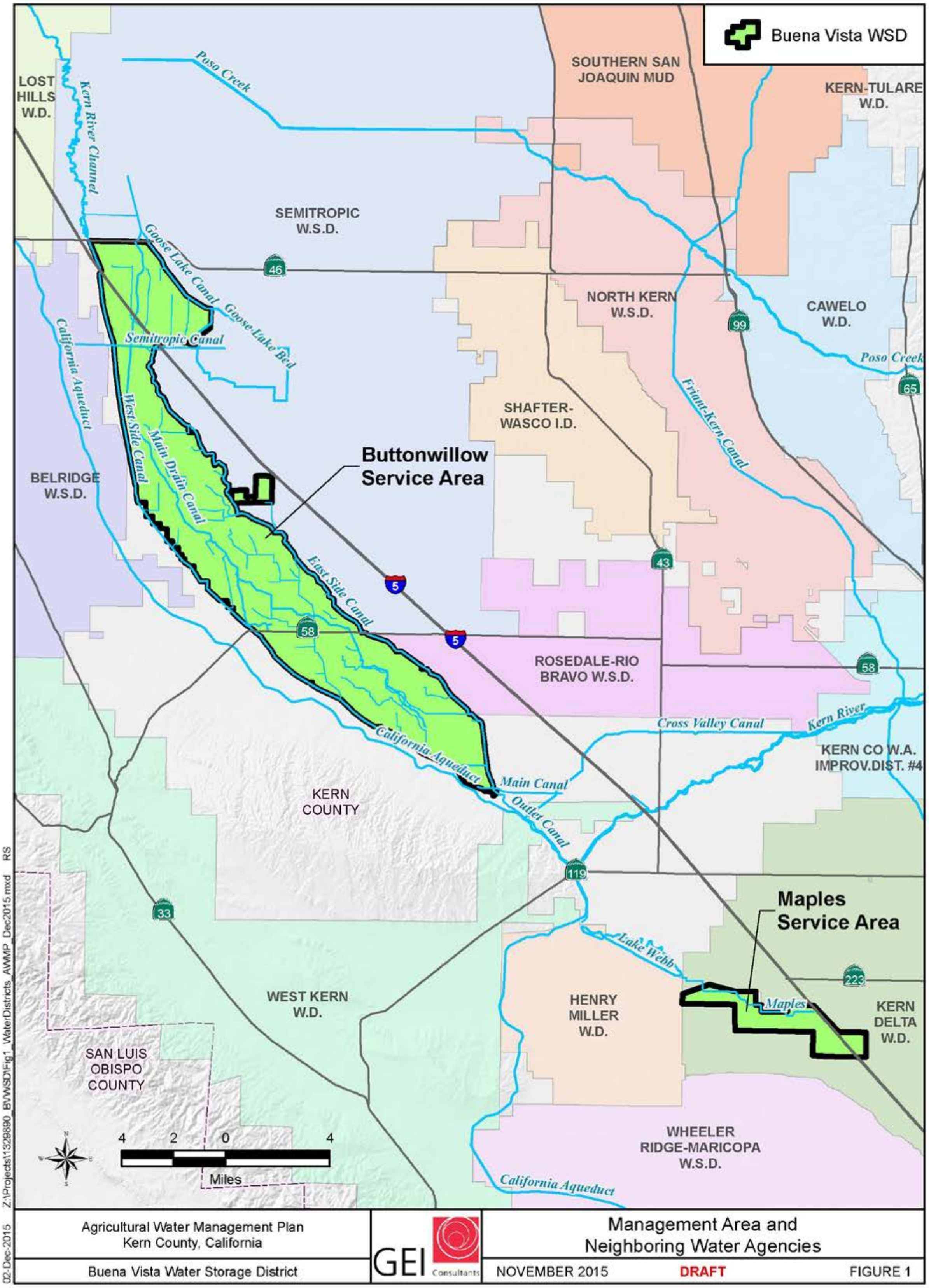

Figure 1. Management Area and Neighboring Water Agencies.

containing groundwater with salinity in excess of 2,000 mg/L. These conditions result in poor infiltration, water encroaching into the root zone, and moderately saline soils. For these reasons, only salt-tolerant crops are grown, and yields are lower than in other parts of the District.

The District is currently constructing the Northern Area Pipeline, which will convert the existing open channel delivery system in the Buttonwillow Service Area north of Seventh Standard Road to a pressurized pipeline system. This Northern Area Pipeline Project is intended to reduce seepage to the perched aquifer that underlies lands being converted from row crops to permanent crops. The Project will bring additional surface water to areas where groundwater is not a reliable alternative source of supply and will enable year-round deliveries to areas where water is now typically delivered from the end of May to August or September except in wet years when there is also a winter pre-irrigation run. The Northern Area Project is especially timely because the on-going conversion to permanent crops increases winter water demands and reduces the ability of growers to fallow land to reduce demand during droughts.

Maples Service Area (MSA)

The (MSA) is about seven miles long and one mile wide and occupies the overflow lands between the Kern Lake Bed to the east and the Buena Vista Lake Bed to its west along the southern toe of the Kern River alluvial fan. The MSA is entirely surrounded by the Kern Delta Water District which overlies the groundwater basin south of the river.

Expected Changes to Land Use

As noted earlier, land use within both the BSA and the MSA is predominately agricultural. As neither service area encompasses or borders an urban or municipal area, there is little pressure to convert irrigated lands to urban uses. For this reason, long-term changes in farmed acreage are likely to result from implementation of programs such as the Conservation Easement Water Acquisition and Management Project (CEWAMP). Under this program, Buena Vista is investigating acquiring and managing water service rights in the "Northern Area Lands" (i.e., BSA lands generally north of Lerdo Highway) that have already entered into, or that will soon enter into, conservation easement programs and that have transitioned away from full agricultural production.

The conservation easements typically require that 40 percent of the surface water applied to the land remain available for conservation purposes. The remaining 60 percent of the water can be used on other lands within the District. Water intended for inclusion in the CEWAMP does not include water that has already been designated for use in habitat restoration by conservation easements. Implementation of the CEWAMP may include one or more of the following:

- Leasing or otherwise acquiring an interest in agricultural land that would be allowed to lie fallow, enabling water that would have been used for irrigation to be applied elsewhere;
- Acquiring water service rights from owners within the Northern Area Lands, such as buying back water use allocations from current users;
- In-District re-marketing, including marketing water obtained through the above methods for use or sale within the District, and
- Other methods that may be developed during the environmental review and planning process.

The District anticipates that approximately 3,000 acres have been or will be encumbered by conservation easements and that the resulting reduction in irrigation demand will make approximately 4,000 AF/yr available for use in other locations.

Information on expected changes to land use within the District is summarized in Table 3.

Table 3.Expected Changes to Service Area

Change to Service Area	Estimate of Magnitude	Cause of Change	Effect on Water Supplier
Reduced Service Area	None		
Increased Service Area	None		
Reduction in Irrigated Area*	2,815 acres	Implementation of CEWAMP Project	Reduction in demand for irrigation water.

* As of 2015
Source: BVWSD

C. Regional and District Water Management Facilities

To understand the District's operations it is useful to first understand the District's relationship to regional water conveyance facilities. More than a dozen major canal systems deliver water to Kern County from three principal sources inside and outside the county: the Kern River, the SWP's California Aqueduct, and the CVP's Friant-Kern Canal. Buena Vista is favorably located to receive waters by gravity flow from each of these sources, as described below.

Regional Conveyance Facilities

Regional conveyance facilities: California Aqueduct.

In the mid-1960's, the SWP completed the construction of canals, reservoirs, and pumping plants to convey water from Northern California to urban and agricultural areas in central and southern California. The two main arteries for delivery of SWP water are the California Aqueduct and the Cross Valley Canal, described below. The SWP has a contractual obligation to deliver 983,000 AF/yr firm and 94,000 AF/yr surplus water to the KCWA. Based on a 1973 agreement with KCWA, Buena Vista holds a long-term contract for 21,300 AF/yr firm and 3,750 AF/yr surplus water supply (Kriger & Stewart, 2009). BVWSD now has access to SWP water from four turnouts along the California Aqueduct, together providing approximately 750 cfs of capacity feeding directly into the District's distribution system.

Regional conveyance facilities: Friant-Kern Canal.

In 1951, construction was completed on the Friant-Kern Canal, a CVP facility which connects Sierra Nevada water supplies near Fresno to federal-project participants along the eastern side of the San Joaquin Valley through Bakersfield and as far south as the Arvin area. Although Buena Vista is not a long-term CVP contractor and has no direct connection with this system, the District can receive Friant-Kern water on a temporary basis by purchase or exchange through the Cross Valley Canal (described below), the Kern River Channel (described below), and the Kern River Canal, which connect the canal systems on the east side of the southern San Joaquin Valley to those on the west side in the immediate area of the District.

Regional conveyance facilities: Cross Valley Canal (CVC).

The bi-directional CVC connects the conveyance systems of the Bakersfield area on the east side of the San Joaquin Valley to the California Aqueduct on the west side of the valley. Westerly flow in the 21.5-mile-long CVC is entirely by gravity, whereas easterly flow is assisted by pumping lifts on seven successive reaches situated between the California Aqueduct and Bakersfield. The canal was constructed with a 900 cfs capacity in 1975 that was increased to 1,422 cfs in 2012.

Since Buena Vista has turnouts on the California Aqueduct, the District does not need to wheel water through the KCWA's conveyance system. However, when the District purchases Friant-Kern water, delivers water to banking projects on the Kern River, or fulfills a water transaction with another district, some or all of this water may be conveyed through the CVC.

Regional conveyance facilities: Kern River Channel.

The North and South forks of the Kern River rise from the Southern Sierra Nevada Mountains and pass through Inyo and Sequoia National Forests and the Golden Trout Wilderness draining a 2,074-square mile watershed before joining at Lake Isabella and then flowing west-southwest through the deeply- incised Kern River Canyon to Bakersfield.

The river meanders for about twelve miles from the mouth of the Kern River Canyon before emerging in the vicinity of Bakersfield at the apex of its modern depositional area known as the Kern Fan. From apex to toe, the Kern Fan extends about 19 miles west and 16 miles south with a constant slope of about seven feet per mile. Over time, the river channel has occupied different locations on the fan and many of the current irrigation canals that divert water to lands south of the river occupy former river channels. The current river channel runs about 18 miles on a fairly straight course from the fan apex to the California Aqueduct Intertie just south of the small town of Tupman. The entire length of the river is underlain by a persistent, elongated recharge mound which is the main location of basin recharge.

Since the completion of the Lake Isabella Dam in 1954, the USACE has regulated releases from the dam for flood control. The USACE also provides releases as determined by the Kern River Watermaster, who represents downstream water rights holders and has the authority to request irrigation releases from the USACE. Flow in the Kern River below the dam varies because of the timing of snowmelt in the watershed and because of the regulated releases from the lake. In most years, essentially all of the water flowing in the Kern River is diverted for irrigation purposes along a 10-mile reach from just above the Gordon's Ferry crossing to the Bellevue Weir at River Walk Park located near where the Stockdale Highway crosses the Kern River. Downstream from the Bellevue Weir, the river is usually dry except in very wet years when the unregulated flows released by the USACE exceed the diversion capacity of all of the upstream takeouts.

Because of the riparian use of lower-river water by landowners prior to the formation of the District and because of the terms of the out-of-court settlement of the Lux-Haggin lawsuits of the 1880s, Buena Vista now holds a water right to approximately one-third of the six-month Spring and Summer river flow during the months of March through August less 300 cfs (as measured at the First Point gauging station) that are delivered to Kern Island. The First Point water rights holders must deliver this water undiminished by seepage losses to Buena Vista's place of delivery near the Enos Lane (Hwy 43) crossing of the Kern River channel which is known as "Second Point". Water is delivered to Second Point through lined canals including the Carrier Canal and the Kern River Canal that are owned and operated by the City of Bakersfield. Historically, the District has received an average 158,000 AF/yr at Second Point with this volume being reduced by Isabella Reservoir hydrologic losses which average approximately 12,000 AF/yr.

District Conveyance Facilities

The District receives surface water from the Kern River, the California Aqueduct and the Friant-Kern Canal. Kern River and Friant-Kern Canal flows are delivered via the Kern River Channel, the City's Kern River Canal, and the District's Main, Outlet, and Alejandro canals. California Aqueduct inflow points include BV-1B, BV-2, BV-6 and BV-8 which provide adequate capacity to meet almost the entire peak-period demands within the service area. The District is able to deliver water to the northern portion of the BSA through turnout BV-1B which facilitates management of water in the Northern Area. In addition to the turnouts listed above, Turnout BV-3 provides water to the Henry Miller WD. Altogether, there are approximately 240 miles of pipelines, lined and unlined canals and drainage ditches within the District with seepage from the unlined canals recharging groundwater. The District operates all of the water conveyance and control facilities within its service area and maintains flow records for each reach of District canal.

<u>District Conveyance Facilities: Buttonwillow Service Area</u>

The design and operation of the conveyance system within the BSA is controlled by the area's unique topography with the backbone of the irrigation and drainage system formed by canals originally developed by Miller and Lux. Irrigation water is conveyed from south to north by the East Side Canal and the West Side Canal that define the BSA's eastern and western boundaries. Water is diverted from these canals to irrigated fields via a system of smaller lateral canals and private ditches which are interconnected by manually-operated weirs and turnouts operated by district staff. Average annual seepage from BSA conveyance facilities is approximately 37,000 AF (Sierra Scientific, 2013).

The topography of the BSA allows drainage to flow to the center of the service area as the land surface falls to the north toward Tulare Lake via the historic low point slough which is now the Main Drain Canal, shown in Figure 1. The Main Drain Canal is over 20 miles long and flows at a gradient of about two feet per mile from the southeast portion of the BSA before leaving the District at Highway 46 where it merges with the Goose Lake Canal which conveys water to and beyond the Kern National Wildlife Refuge, approximately eight miles downstream from Highway 46.

Tailwater and storm runoff from the community of Buttonwillow are collected by drainage ditches which flow to the Main Drain Canal. The District is trying to get the County to stop this non-conforming practice. Most of the water conveyed in the canal is reclaimed and re-used by District landowners; the remainder is either delivered by the Goose Lake Canal to non-District landowners to the north or pumped to Semitropic WSD (SWSD) to the east. The District has an interconnection with SWSD used to transfer water into Buena Vista's system and to transport reclaimed tailwater collected by the Main Drain Canal to SWSD's system. Annual deliveries to SWSD have varied from 1,000 to 10,000 AF (Buena Vista Water Storage District, 2014). Agricultural runoff typically enters the Main Drain Canal during the January and February pre-irrigation season and the May through August irrigation season, but the canal can also carry significant flows during other months due to additional agricultural operations or storm runoff.

The BSA can receive gravity inflow from turnouts on the California Aqueduct, from deliveries to Second Point through the Main Canal, or from the Buena Vista Aquatic Recreation Area (BVARA) through the Outlet Canal. The BSA can also receive Kern River water directly from the lower Kern River channel although this stretch of river is dry during most years due to complete upstream diversion.

District Conveyance Facilities: Maples Service Area

The MSA receives most of its irrigation water from the fully-lined Alejandro Canal which flows by gravity from a turnout on the Kern River Canal to BVARA from which the Maples Canal carries water into the MSA. The MSA can also receive SWP deliveries from turnouts that deliver water directly into the western edge of BVARA. Average annual seepage from MSA conveyance facilities is approximately 1,650 AF (Sierra Scientific, 2013).

The District's distribution system and service areas are shown on Figure 2. Figure 3 shows a typical turnout from the California Aqueduct.

Table 4 provides a summary of irrigation distribution facilities located within Buena Vista's two service areas.

Table 4.Water Conveyance and Delivery System

System Used	Number of Miles
Unlined Canals	144
Lined Canals	5
Pipelines	6
Drains	83

Source: BVWSD

Seepage and evaporation account for approximately 30 to 35 percent of the water diverted into the system for the short pre-irrigation run and approximately 28 percent for an average summer run. The District estimates that recharge from canal seepage in the Buttonwillow and Maples service areas accounts for an average of 0.79 AF/yr for every acre of District's 48,810 acre total area with this recharge ranging between 0.4 and 1.5 feet/yr depending on the location within the District. This widely distributed seepage spreads the recharge over a large area and creates only small, localized impacts. Some seepage flows to shallow saline groundwater and is not suitable for reuse without treatment or blending with higher quality water.

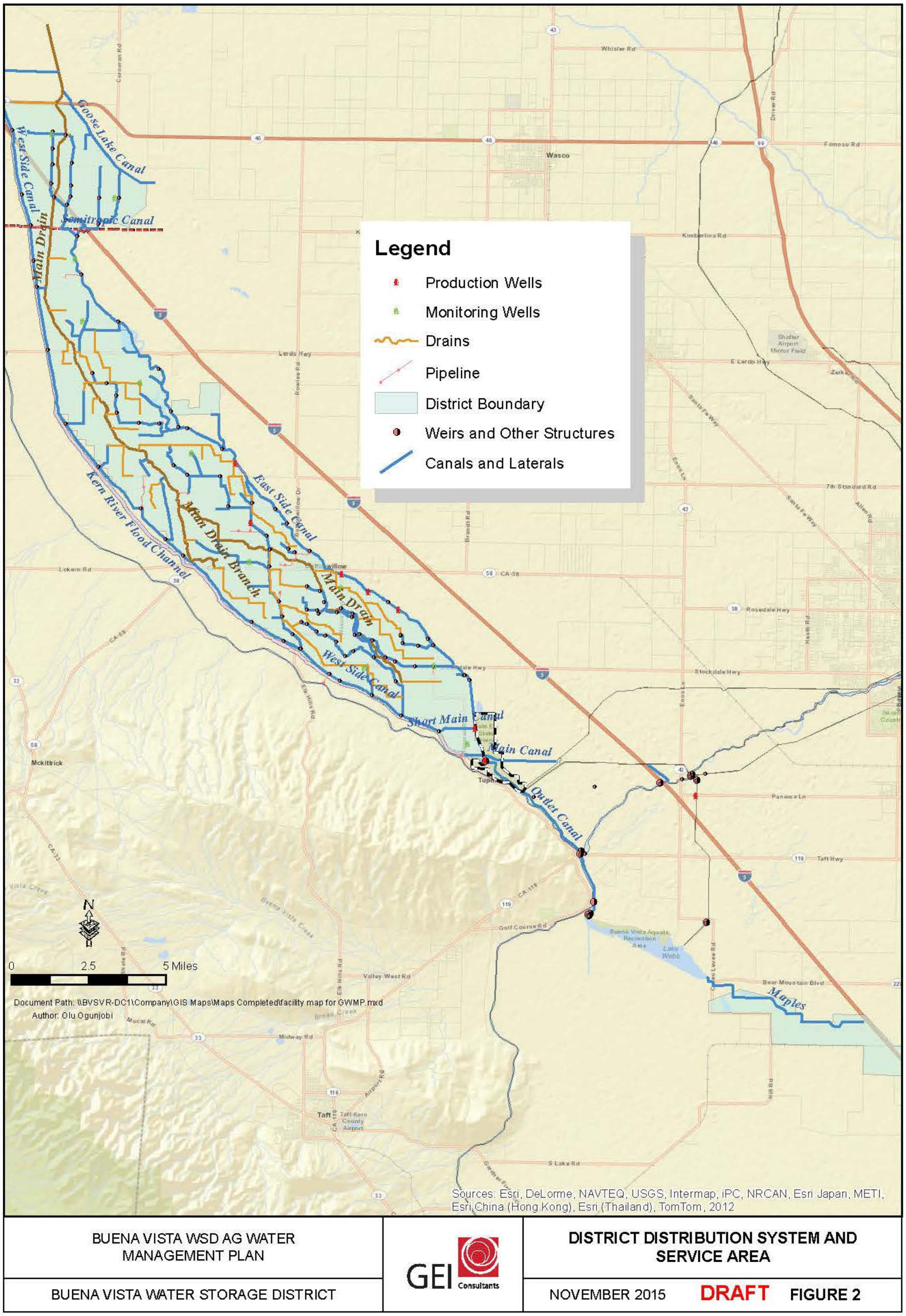

Figure 2. District Distribution System and Service Area.

Figure 3. Turnout BV-8 from California Aqueduct.

Figure 4. Measurement Flume on Main Drain Canal.

Reservoir Facilities

Isabella Reservoir

Isabella Reservoir (Lake Isabella), with a total storage capacity of 568,500 AF, is located well to the east of the District in the southern Sierra Nevada Mountains. The USACE constructed Isabella Dam in the 1950s and is responsible for day-to-day operations. In the 1960s, BVWSD and North Kern WSD contracted for 535,000 AF of conservation storage in Lake Isabella, which they use to store and regulate their deliveries of river water. Since 2006, the capacity of the reservoir has been restricted to a maximum volume 360,000 AF because of concerns over the physical integrity of Isabella Dam.

Isabella Reservoir is a multiple purpose facility with the primary purpose being flood control and other functions including water storage, releases for hydropower, and recreation. Operating criteria require that total reservoir storage be no more than 170,000 AF by November 1 of each year, unless otherwise approved by the USACE. Buena Vista's share of this carryover storage capacity is 44,800 AF or approximately 26 percent. Historically, the maximum carryover storage approved by the USACE has been 245,000 AF with a minimum pool of 30,000 AF. Under this condition, the District has been entitled to store 68,800 AF.

Buena Vista's share of the available maximum conservation space in the reservoir is 105,600 AF or approximately 29 percent of the current maximum storage volume. Based on the reservoir's capacity at the spillway crest, the District is entitled to store 172,000 AF or 30 percent of the total storage capacity of 568,500 AF. Buena Vista is not responsible for reservoir maintenance but does pay a share of maintenance costs based on a contract with the USACE.

Buena Vista Aquatic Recreation Area (BVARA)

BVARA was built in the early 1970s as part of the State Water Project and is owned by the County of Kern. The District holds a perpetual right-of-use easement entitling Buena Vista to the top two feet of storage capacity in the reservoir which corresponds to approximately 1,800 AF. The District is responsible for scheduling and regulating water stored in this pool, while the County of Kern is responsible for all losses.

Buena Vista can deliver water to BVARA from two sources. Water released from Lake Isabella can be conveyed down the Kern River into the concrete-lined Kern River Canal which feeds the Alejandro Canal that discharges to BVARA. The District can also divert water into BVARA from the California Aqueduct through turnout BV-3. All inlets to and outlets from BVARA are metered.

During Buena Vista's pre-irrigation and summer runs, the District aims to hold lake levels in the middle of the operating range to maintain consistent outflows. Targeting the mid-point provides the District the flexibility to increase or reduce flows into BVARA without restricting when deliveries can be made from the lake. In addition, operating from the mid-point enables the District to adjust to changes in the availability of water from either the Kern River or the State Water Project.

Table 5. Water Supplier Reservoirs

Reservoir	Capacity (AF)	Storage Rights (AF)	BVWSD Storage (AF)
BVARA	6,800	1,800	1,800
Lake Isabella:			
At Spillway Crest	568,500	172,000	165,964
With USACE Storage Restriction	360,000	105,600	101,400
Carryover Storage	170,000	44,800	43,027
Carryover Storage + 75K	245,000	68,800	66,078

Source: BVWSD

Operational Outflow/Tailwater Recovery Systems

The District encourages growers to employ on-farm tailwater collection systems as the most efficient mechanisms for reuse of tailwater. Drainage of tailwater into District supply canals is prohibited, however upon prior approval, growers may deliver tailwater to District drainage facilities. Therefore, all District irrigated lands have either on-farm tailwater recovery systems or release tailwater to District drains.

To meet increasing demands for reclaimed water, Buena Vista has implemented programs to recycle tailwater collected by the District's drainage system. The District currently has nine reclamation pumps that lift water from the tailwater recovery system into delivery canals for re-use. These pumps are capable of re-circulating up to 100 cubic feet per second or 200 AF/day and have reclaimed an average of 8,780 AF/yr over the period from 1992 through 2011, a volume equivalent to about 0.18 AF/acre if the water were applied to the District's entire area. Buena Vista also has the ability to sell reclaimed water to other districts.

In 1985 the District instituted a program allowing landowners to install reclamation pumps for use on their farms. This program provides landowners a choice between paying a set rate to the District for access to reclaimed water through the program described above or to trade one acre-foot of surface allocation for each two acre-feet of supply reclaimed using their own pumps. These grower-owned reclamation pumps have re-circulated an additional average of 4,130 AF/yr over the period from 1992 through 2011.

As noted earlier, tailwater not reclaimed by the above programs is conveyed by the Main Drain Canal until entering the Goose Lake Canal and flowing north of Highway 46. By separate agreement, this water is captured for farming operations in a portion of the Semitropic Water Storage District, and BVWSD is paid for delivery of this water. Table 6 summarizes the status of tailwater/operational outflow recovery systems. No tailwater has left the District in the Goose Lake Slough since May 2013.

Table 6.Tailwater/Operational Outflow Recovery System

System	Yes/No
District Operated Tailwater Recovery	Yes
Landowner Operated Tailwater Recovery	Yes

Source: BVWSD

D. Terrain and Soils

Buena Vista is located on the floor of the southern portion of the San Joaquin Valley, a physiographic trough characterized by low alluvial plains and fans and by overflow lands and old lakebeds. The valley is closely bounded by the Temblor Range and Coast Range to the west, the Tehachapi Mountains to the south, and the Sierra Nevada Range to the east.

Alluvial deposits in Kern County generally consist of sand, silt, and clay laid down in a complex sequence principally by the Kern River, Poso Creek, Deer Creek, the White River, small drainages along the Sierra Nevada Mountains, and streams along the Coast Range. The terminus for these flows in the geologic past was Tulare Lake, located to the north of Kern County on the west side of the San Joaquin Valley near where the District lies.

Soils within Buena Vista 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 are described in the published soil survey for northwestern Kern County and are presented in Figure 5. Soils within the District do not have any identifiable impacts upon water operations and management in the service area.

According to the Soil Survey of Kern County, California, Northwestern Part (NRCS, September 1988), soils in the Buttonwillow Service Area consist primarily of the Buttonwillow and Lokern series. Table 7 summarizes the topographic characteristics of the irrigated lands.

Table 7.Landscape Characteristics

Topography Characteristic	Percent of the District	Effect on Water Operations and Drainage
Flat Land	100	Slope is sufficient to enable gravity operation of canals and drains

Source: BVWSD

E. Regional Climate

Buena Vista lies at the southern end of the San Joaquin Valley, 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 winter and catch snow, which provides irrigation water for use during the dry summer months.

Summers are hot and dry. The average length of the growing season is 265 days, typically lasting from March to November. December and January 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. In extreme cases, fogginess or cloudiness may occur continuously for two to three weeks. The depth of the fog or clouds is usually less than 3,000 feet. Under these conditions, there usually are clear skies and mild temperatures in the surrounding foothills and mountains. Most precipitation occurs in the winter with little occurring during the summer months of June through August. By contrast, rates of evaporation and transpiration are low in the cooler, wetter months and peak during the hot, dry summer growing season.

Table 8 summarizes climate conditions for the community of Buttonwillow, recorded at Western Regional Climate Center NOAA Cooperative Station 041244. Temperatures in the summer typically range in the upper 90s and nights are fairly warm. Throughout the year, the mean temperatures vary from 35°F in December to 98°F in July. Annual precipitation typically ranges from five to seven inches. More detailed climatic data from the Western Regional Climate Center website are presented in Table 9.

Table 8.Summary Climate Characteristics

Climate Characteristic	Value
Average Annual Precipitation	5.64 inches
Minimum Monthly Precipitation (Avg. July Minimum)	0.02 inches
Maximum Monthly Precipitation (Avg. February Maximum)	1.07 inches
Minimum Temperature (Avg. December Minimum)	34.5° F
Maximum Temperature (Avg. July Maximum)	98.4° F

Source: Western Regional Climate Center Station 041244 over the period from January 1, 1940 through January 1, 2015.

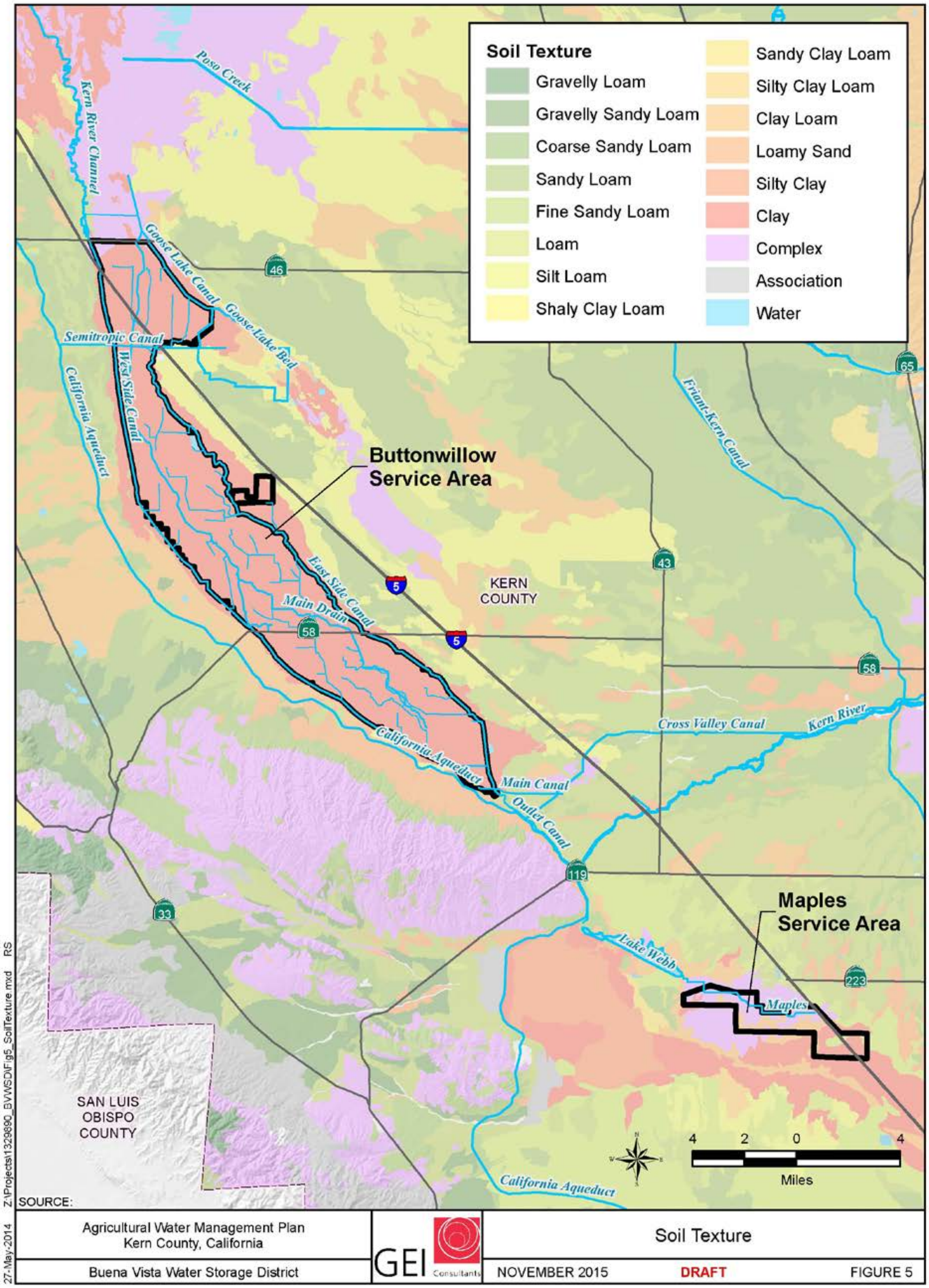

Figure 5. Generalized Soil Texture Map.

Table 9. Detailed Climate Characteristics

Month/Time	Average Precipitation (inches)	Average Reference ET (inches)[1]	Average Minimum Temperature, ºF	Average Maximum Temperature, ºF
January	1.06	1.59	35.2	56.4
February	1.07	2.20	39.0	63.2
March	0.97	3.66	43.0	69.1
April	0.55	5.08	47.2	76.0
May	0.21	6.83	54.1	84.7
June	0.05	7.80	60.1	92.4
July	0.02	8.67	65.3	98.4
August	0.02	7.81	63.3	96.7
September	0.12	5.67	57.9	91.7
October	0.27	4.03	48.8	81.4
November	0.55	2.13	39.2	67.4
December	0.75	1.59	34.5	57.2
Wet Season[2]	0.88[4]	2.23[4]	38.2[4]	62.7[4]
Dry Season[2]	0.18[4]	6.56[4]	56.7[4]	88.8[4]
Annual	5.64[3]	57.06[3]	49.0[4]	77.9[4]

[1] Obtained from DWR CIMIS data for Belridge Station #146.
[2] "Wet Season" constitutes months of November through March; "Dry Season" covers remaining months (April through October).
[3] Total seasonal and annual values
[4] Average of seasonal and annual monthly values

F. Operational Characteristics

Buena Vista is governed by a five-member Board of Directors who serve staggered terms. Each member represents a geographical area within the District known as a division. Board members must be landowners (or a representative of a landowner) within the District and be elected by the landowners owning lands within their division. Board elections are held on odd years on a one-vote per acre basis.

Buena Vista's adopted *Rules and Regulations of the Buena Vista Water Storage District* (Rules and Regulations as amended on March 13, 2012) is the guideline for District operations and delivery of water (included as Appendix D**).** The *Rules and Regulations* cover the procedures which are followed to distribute irrigation water in an orderly, efficient, and equitable manner.

Per district guidelines, new water orders or increases to existing water orders are to be placed by growers a minimum of 48 hours prior to the time that the delivery is to commence. Water users are to give notice at least 24 hours in advance of a request for a shut-off order or for a decrease in an existing water order. Water users are to give at least 24-hour notice of a "move". Moves may be requested if the place of delivery of the original and the "moved" order are within the same canal reach. If the request is for delivery within a different canal reach or a different canal, then the request will be considered to be a new order and a 48-hour notification will be required.

Water orders can be placed by calling the District or by ordering online through the Buena Vista website before 2 pm. Any water order placed after 2 pm is treated as a next day order. If a farmer has a water emergency shut-off, the District will accommodate the order on the same day, but if they lose deliveries from a well, the District will attempt to provide water adequate to compensate for the loss of the well water on the following day.

The District places water orders with the City of Bakersfield dispatcher for releases of Kern River Water from Lake Isabella. Orders are placed 24 hours in advance, and water ordered before 2 pm is released the next day. From the time of release, there is typically a lag of between 24 and 48 hours before water from Lake Isabella arrives at BVARA with the travel time depending on the volume of water in the river. Orders for Kern River water are often placed in advance with delivered water then stored in BVARA until needed.

Water orders for deliveries from the California Aqueduct are also placed 24 hours in advance. However, these orders are placed with the KCWA and must be placed before 10 am for next day delivery. Since SWP water goes directly from the points of diversion to District facilities, there is no appreciable lag between the time the water is released and the time it is received by the District. If water emergencies arise, the District typically responds by making adjustments in flows from BVARA and from the California Aqueduct because of the short lag times and because DWR has historically accommodated emergency requests quickly.

In the event of capacity restrictions, the District will endeavor to prorate deliveries or delay new deliveries or changes until capacity issues have subsided. Prorations and delays among water users consider the following factors:

- a water user's total assessed acres within a service area or a specific system;
- timing of water orders;
- nature of restriction, and
- any other equitable factors deemed appropriate by the District.

Although the *Rules and Regulations* describe Buena Vista's obligations for water delivery, in practice, the District strives to accommodate growers' water orders, regardless of notice, so long as the orders can be delivered without disrupting other scheduled orders. Therefore, Buena Vista routinely operates as a scheduled on-demand system. On the day a water order is put into effect, one of the district's canal tenders turns the delivery gate on or off, in accordance with the scheduled delivery, at the time a canal tender passes the gate on his regular run. Generally, turn ons, turn offs and adjustments are made in the mornings. As described above, whenever possible, service is provided as requested; however, at times, the District may require the rescheduling of service due to capacity limitations within the District's distribution system or necessary shutdowns for emergencies beyond the District's control. Table 10 shows that Buena Vista operates on an arranged demand delivery system.

Table 10. Supplier Delivery System

Type	Check if Used	Percentage of System Supplied
On Demand		
Arranged Demand	X (48 hr notice)	100
Rotation		

Source: BVWSD

Table 11 illustrates that all District water is allocated to land within the service area.

Table 11. Water Allocation Policy

Basis of Water Allocation	(Check if applicable)			Allocation	
	Flow	Volume	Seasonal Allocations	Normal Year	Percent of Water Deliveries (%)
Land within the Service Area		X	X	X	100
Riparian Rights – none allocated	X		X		
Amount of Land Owned		X	X		
Predicted runoff – see Riparian Rights	X		X		
Other (USBR*, Duck Club, emergency and miscellaneous deliveries)	X		X	X	100

*Annual USBR deliveries average approximately 17,000 AF
Source: BVWSD

Table 12 illustrates the lead times for requested service, as part of the arranged-demand operation, as described above.

Table 12. Actual Lead Times

Operations	Hours/Days
Water orders	48 hrs/ 2 days
Water shut-offs	24 hrs/ 1 day
Water increases	48 hrs/ 2 days
Water decreases	24 hrs/ 1 day
Water moves*	24 hrs/ 1 day

Source: BVWSD
*Water moves are only allowed if they are in the same canal reach. Otherwise, a new water order must be placed.

F1. Water Delivery Measurements or Calculations

The District's Hydrography Department maintains detailed records that show how District water is utilized and provides quantitative data on irrigation deliveries, canal losses, intentional recharge, reservoir losses, third party sales, and banking programs. When combined with estimates of crop water use, these data also enable estimation of pumping from privately-owned wells and net groundwater recharge.

All deliveries of surface water and groundwater within the District are made through turnouts managed by the District. Readings at each turnout are taken each day that a turnout is running. Most turnouts have 18- to 24-inch diameter Waterman C-10 or C-20 gates with up to 30 feet of discharge pipe to control and measure flow to landowners' ditches. C-10 gates are installed at locations where flow is always in one direction, and C-20 gates are used for bi-directional flow. All gates are installed on concrete headwalls with a stilling well behind the headwall to indicate the downstream level, and all gate stems are marked to ensure that District staff know the correct opening at all times and are stamped so that operators know the gate diameter. District staff measure flow through all gates that are in operation each morning. For gates where water deliveries are begun in the morning of a given day, flows are measured later that day after the farmer has started irrigating. This delay enables water levels in farm ditches to stabilize which improves the accuracy of the measurements.

Measurements at gates are taken by District staff using the following procedure:

1. Measure the upstream and downstream water levels to determine the difference in head across the gate;
2. Measure the gate opening, and
3. Use the discharge table in the Waterman Data Book to determine the flow through the gate based on the measured head difference, gate opening, and gate size.

Buena Vista is in the process of installing meters at all turnouts from the Northern Area Pipeline. All District booster pumps now have meters and, in addition to turnouts which are already metered, Buena Vista staff is installing meters at every farmer-owned deep well this year. In the future, the District will continue to install meters which will enable staff to monitor sites remotely with SCADA to ensure the most efficient operations possible. Figures 6A and 6B are photographs of typical metered and gated farm turnouts, respectively.

Figure 6A. Metered farm turnout

Figure 6B. Typical gated farm turnout.

All meters and gates are periodically checked as part of the District's maintenance program. When properly calibrated, both metered and gated turnouts provide accurate measurement of deliveries. Table 13 shows typical levels of accuracy for typical types of measurement devices.

Table 13.Water Delivery Measurements

Type of Measurement	Frequency of Measure (Days)	Frequency of Calibration (Months)	Frequency of Maintenance (Months)	Est. Level of Accuracy
Waterman gates[1]	1	N/A	As needed	+/- 5%
Propeller meters[2]	1	As needed	6-12	+/-5%
Weirs	1	As needed	As needed	+/-5%
Flumes	1	1	1-3	+/- 2% to 5%
Magnetic flowmeters[3]	1	As-needed	As-needed	+/- 2%

[1] Deliveries at 296 turnouts are measured using Waterman gates (66 percent).
[2] Deliveries at 154 turnouts are measured using propeller meters (34 percent).
[3] Magnetic flow meters are installed on wells and will be installed on turnouts serving the Northern Area Project and other locations where canals are being replaced by pipelines.
Source: BVWSD

All propeller meters and magnetic flow meters used by the District are equipped with totalizers, which accumulate the volume of flow at each turnout. According to the manual *SBx7 Flow Rate Measurement Compliance for Agricultural Irrigation Districts* by the Irrigation Training & Research Center of the California Polytechnic Institute, San Luis Obispo, (included as Appendix E) devices with totalizers provide measurements that are sufficiently precise to assume that the accuracy of the volumetric total is equivalent to the calibrated accuracy of the flow rate measurement. As a result, the meters used by the District to measure delivery rates should provide data that enables reliable computation of volumes of water delivered through Buena Vista turnouts. All new meters on farmer-owned wells are electromagnetic meters which measure instantaneous flow as well as a total flow volume.

Section VIII of this report discusses steps the District is taking to comply with the water measurement requirements of SBx7-7 by verifying the accuracies of measurement devices in determining volumes of water delivered during the irrigation season.

F2. Water Rate Schedules and Billing

The Buena Vista Board of Directors allocates supplies to lands within the District based on assessed acreage. The allocation amount, timing and duration of water service is based upon a number of factors, including but not limited to water supply forecasts, available surface and groundwater storage, contract supplies, demand patterns, special project commitments, available or anticipated surplus supplies, system maintenance requirements, operational efficiencies, weather conditions and any other factors deemed appropriate by the Board of Directors.

A land assessment is levied on each assessed acre with this charge being established by the District's Board on an annual basis. In addition, the District bills water users on a volumetric basis. Land assessments and water tolls for 2013 through 2016 are summarized in Table 14.

Table 14.Water Rate Basis

Type of Billing	Check if Used	Percent of Water Deliveries (%)	Description
Volume of Water Delivered Water Toll Charge ($/AF)	X	100	2013 - $17.50; 2014 - $17.50, 2015 - $22.50; 2016 - $22.50 Variable water toll charge
Land Assessment ($ per assessed acre)	X	100	2013 - $35.00; 2014 - $29.00; 2015 - $38.00; 2016 - $38.00

Source: BVWSD

Federal CVP water supplies are available from time to time from the Friant-Kern Canal. Rate structures for delivery of excess CVP water are assessed upon availability, and capability of delivery to the District's service area. All water use tolls are applied uniformly across the District. Table 15 provides this information in tabular form.

Table 15. Rate Structure

Type of Billing	Check If Used	Description
Uniform (contract water)	X	Assessment
Other (non-essential seasonal)	X	Reclamation water

Source: BVWSD

In 2013, the first year Buena Vista billed its irrigation water users for a water toll charge, it billed once at the end of the irrigation season. Beginning in 2014, the District has billed users at the end of each month, or on the first day of the following month, depending on the volume and timing of water deliveries to users. The frequency of billing is shown in Table 16.

Table 16. Frequency of Billing

Frequency	Check If Used
Monthly	X

Source: BVWSD

F3. Water Shortage Allocation Policies

Surface water supplies available to Buena Vista are highly variable, depending largely on watershed precipitation, runoff and snow melt, as well as regulatory constraints or court-ordered actions. In the case of Kern River supply, the District's share is determined from the prior year's carryover storage in Isabella Reservoir. As such, water supply planning must take into consideration the amount of water that will be available during the irrigation season, the current year's water requirements, and the target carryover storage for the following season.

During years of short surface water supply, Buena Vista conjunctively uses groundwater, through the operation of District-owned wells, and water users increase their use of groundwater through the operation of private wells. Table 17 lists the measures that the Buena Vista Board may exercise to respond to water shortages. In 2014, the District operated a fallow land program where it paid growers to fallow land.

Table 17. Decreased Water Supplies Allocation

Allocation Method	Check If Used
Decrease Allocated Water	
Area in District	X
Restrict Water to Certain Crops	

Source: BVWSD

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

Table 18. Enforcement Methods of Allocation Policies

Enforcement Method	Check If Used
Shut-off of Water	X
Liens on Property	X
Fines/ Penalties	X

Source: BVWSD

<u>F3a. Drought Management Plan</u>

The Drought Management Plan details how Buena Vista 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.***

   Buena Vista receives surface water from two sources. The primary source is the Kern River, however, the District also has an entitlement to SWP water through the KCWA, the local contractor for SWP water. Hydrologic conditions affecting supply and operations of the SWP are extensively monitored and used to forecast allocations to each of the Project's contractors. These allocations then determine the quantity of SWP water available to Buena Vista. Hydrologic conditions in the Kern River watershed, including snowpack and precipitation, are measured by snow surveys and rain gauges. The data gathered assists in forecasting inflow to Isabella Reservoir. Estimates of reservoir storage and projected inflows are, in turn, used to determine the volume of Kern River water available to the District. Releases from storage for delivery to Buena Vista are measured as are inflows to the Buena Vista system. In addition to extensive observations of surface water to enable prediction of supplies and measurement of deliveries, groundwater elevations are monitored both for compliance with DWR's CASGEM program and for operational purposes.

   Data on snowpack, precipitation, storage in Lake Isabella and groundwater elevations are also used to assess the severity of drought in the Kern River watershed. Determinations of drought severity as it applies to the SWP are developed by DWR.

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

   Water supplies in the Kern River vary depending on watershed precipitation, snow melt runoff, and Buena Vistas' share of the prior year's carryover storage in Isabella Reservoir. Similar factors affect water supplies available from the SWP. Buena Vista applies water supply projections from both Isabella Reservoir and the SWP, groundwater storage estimates, demand patterns, special project commitments, available or anticipated surplus supplies, system maintenance requirements, operational efficiencies, weather conditions and other factors deemed appropriate by the Board when determining the annual water allocation and the timing and duration of water service to provide to growers during the irrigation season.

   During years when the availability of water from the Kern River and the SWP is limited, Buena Vista pumps groundwater from District-owned wells and manages a "Landowner Well Use Program" that enables the District to incentivize use of surplus capacity in privately-owned wells by reimbursing participating well owners for energy charges in addition to capital replacement and maintenance costs. The District also supports reclamation of tailwater using privately-owned pumps through a range of district-run programs. As a result, although 2013, 2014, and 2015 were three of the driest years in over 100 years of flow records on the Kern River, as shown in Figure 7, Buena Vista was able to respond effectively to the drought through heavy reliance on groundwater. The effectiveness of the District's long-term conjunctive management efforts is demonstrated by the fact that growers were able to continue irrigation operations even in 2014 and

2015, years when no surface water from either the Kern River or the SWP was delivered by the District.

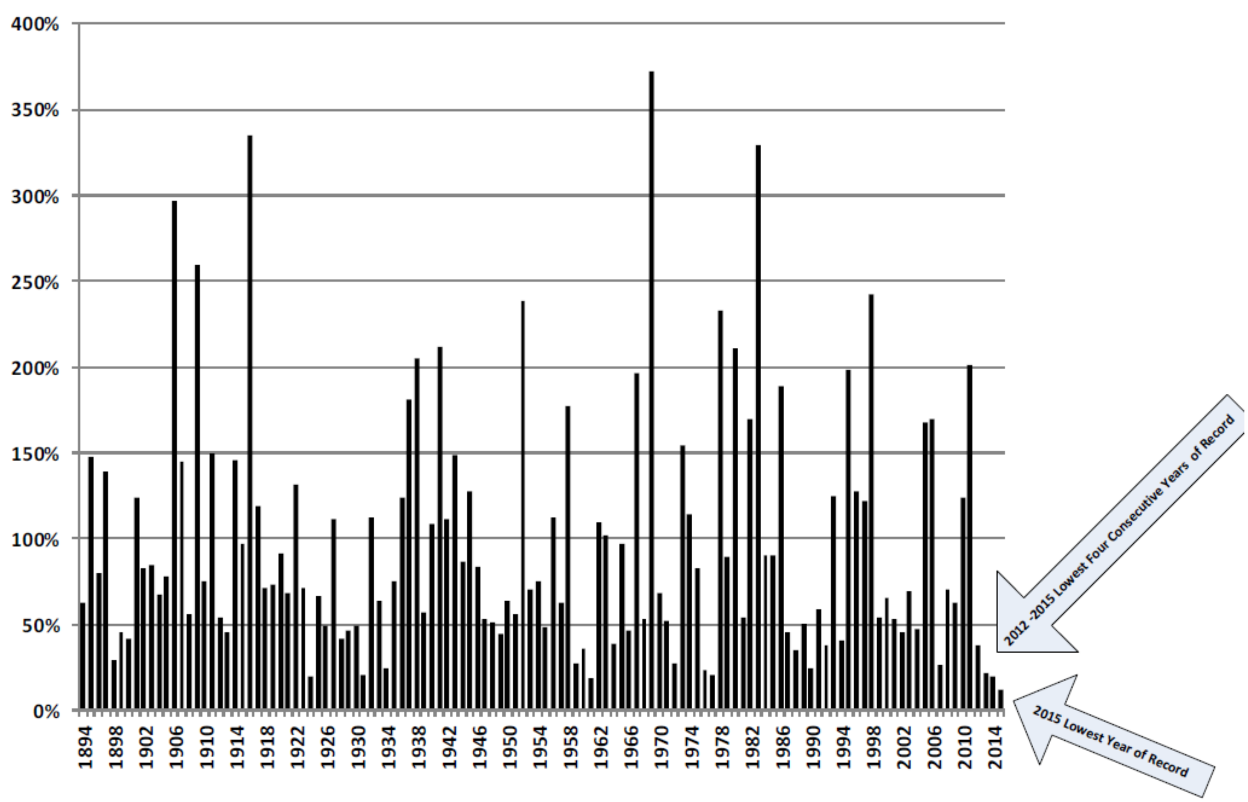

Figure 7: April-July Kern River Runoff (1984-2015)

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

As Figure 7 highlights, there is significant year-to-year variability in the volume of Kern River runoff. Even when combined with SWP deliveries, in "dry" years no surface water may be delivered to growers, as was the case in 2014 and 2015. By contrast, in a "wet" year, surface water supplies are sufficient not only to satisfy irrigation water requirements (and thereby minimize the use of groundwater), but to recharge aquifers largely through deep percolation from irrigated lands and seepage from unlined canals and recharge facilities.

During dry periods, because surface water supplies are minimal, measures to improve management of surface water through canal and reservoir operations have limited effectiveness. Buena Vista's response to dry conditions has been to exercise conjunctive management by increasing extraction of groundwater from District- and privately-owned wells to compensate for reduced deliveries of surface water.

In addition to the drought response measures undertaken by the District, individual land-owners within the Buena Vista service area have been actively managing land, water and other resources to minimize drought induced impacts on their farming operations. These activities are described in greater detail below.

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

Rather than instituting district-governed policies and incentives to lower on-farm water use, Buena Vista's approach to demand management has been to provide the high degree of flexibility and responsiveness in deliveries necessary to enable growers to manage water efficiently under all conditions. This includes programs that encourage:

- use of surplus capacity in privately-owned wells to augment water supplies available from District sources;
- recovery and reuse of tailwater, and
- use of district-owned conveyance facilities to transfer water within the service area.

The District also informs water users of the annual water allocation so that growers can make well-informed farming decisions. The level of operational responsiveness provided by Buena Vista 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.***

Buena Vista's principal source of surface water is the Kern River, with its entitlement to SWP serving as a second source of supply. In addition, the District can gain access to supplemental supplies, including CVP water, through exchanges and water purchases. Due to its long-term stewardship of groundwater, Buena Vista has not relied on transfers of supplemental water into the District as a drought response measure, but rather has transferred surface water to other agencies. Therefore, throughout the drought, Buena Vista has adhered to its fundamental strategy of relying on groundwater recharged during wet years to serve as a reservoir that could be relied upon during droughts to satisfy irrigation requirements.

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 Buena Vista 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 groundwater pumped from district-owned and privately-owned wells and reclaimed tailwater, 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 water in a manner that is best suited to their farming operations.

Because the quantity of Kern River and SWP water available to Buena Vista in any given year is beyond the District's control, Buena Vista's drought response measures center on managing groundwater and reclaimed tailwater. Reduced allocations of District-supplied water elevate the responsibility of growers to determine how best to allocate 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 Kern Regional Water Management Group (RWMG) has proven itself to be an effective organization for operational coordination and for collaboration on development of water conveyance and groundwater management projects. These projects have enabled the District to improve management of brackish groundwater underlying the northern portion of the District and to expand its capacity to recharge the local aquifer. From a regional perspective, the projects have improved the ability to distribute water within the region and increased the capability of the RWMG's members to exchange and transfer water for irrigation applications and for recharge. In addition to developing projects, the RWMG has been successful in obtaining state and federal funding for implementation of projects that have improved regional resiliency to drought.

The implementation of the Sustainable Groundwater Management Act (SGMA) will provide 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 Buena Vista Board of Directors annually establishes a water allocation which is applied on a per-acre basis. The allocation amount and the timing and duration of water service are based upon a number of factors including, but not limited to, water supply forecasts, available surface and groundwater storage, contract supplies, demand patterns, special project commitments, available or anticipated surplus supplies, system maintenance requirements, operational efficiencies, weather conditions and other factors deemed appropriate by the Board. Water tolls are applied on a per-acre-foot basis and are based on budget requirements and Board policy.

Because Kern River and SWP water are delivered by gravity, the cost of distributing surface water is attributable largely to the fixed costs of operating and maintaining the canal system. By contrast, the costs to the District, as well as to private well owners, of increased groundwater pumping during dry years are substantial due to both the greater volumes of groundwater pumped during droughts and increases in the unit cost of pumping caused by declining groundwater elevations. However, because Buena Vista was able to rely entirely on groundwater in 2014 and 2015 and transfer its limited supplies of surface water, these transfers generated sufficient revenue to enable the District to maintain a firm financial standing.

G. Basis for Reporting Water Quantities

The nature of Buena Vista's surface water supplies results in considerable year-to-year variability. In a "dry" year, surface water supplies are limited and pumping from District- and privately-owned wells is significant. In a "wet" year, surface water supplies are sufficient to satisfy all irrigation water requirements and to contribute substantially to groundwater recharge.

Buena Vista receives a contracted annual allocation of SWP water delivered through the California Aqueduct that is referred to as a Table A allocation. SWP allocations are based on factors including the hydrologic year type and any court ordered constraints on the amount of pumping allowed from the Sacramento-San Joaquin River Delta.

E.O. B-29-15 requires that water supplies and demands for 2013, 2014, and 2015 be reported. These years have been among the driest on record in California and represent extreme drought conditions and operations for the District. Table 19 summarizes the annual allocations for both the SWP Table A water as well as the Kern River for the representative years. Allocations for 2014 were the lowest of the three years at 5 percent, but all three are considered "dry".

Significantly, with completion of turnout BV-8 from the California Aqueduct in 2013, Buena Vista was able to receive all surface water deliveries from the California Aqueduct while the District exchanged water from its Kern River entitlement with other entities for SWP water. Because of its proximity to the aqueduct and its ability to store SWP water in BVARA, receiving water from the aqueduct simplifies operations both for the BVWSD and for other entities more distant from the aqueduct able to benefit from access to Kern River water stored in Lake Isabella.

Table 19. Representative Years

	2013	2014	2015
Representative year based upon	Dry Year (New Facilities)	Dry	Dry
First month of representative year	January	January	January
Last month of representative year	December	December	December
Final Table A Allocation (Percent)	35%	5%	20%
Kern River Runoff Allocation (Percent of Average)*	9%	4%	<1%

* Average Kern River Allocations are 158,000 AF/yr

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

A. Agricultural Water Use

Total water requirements have varied with changes in the cropping pattern and variation in the hydrologic year type as shown in Table 20.

Table 20.Agricultural Water Use (AF)

Source	2013	2014	2015
Agricultural Water Supplier Delivered			
Surface and groundwater	33,106	0	0
Other Water Supplies			
Surface Water	0	0	0
Groundwater (Land-owner well use agreement*)	0	0	0
Other – Reclaimed Water	5,176	0	0
Total	**38,282**	**0**	**0**

Source: BVWSD
* Land-owner well use agreement – Groundwater pumped by growers for distribution through the District's canal system under these agreements is included in the "Surface and groundwater" row of this table.

Tables 21.A through 21.C present the water needs for specific crops grown within the Buena Vista service area for the three representative years. The efficiency of on-farm applications and crop water demands vary by crop, soil type, irrigation method and other factors; however, for the purposes of this water balance, a uniform adjustment of 5 percent of estimated crop consumptive use was applied to all crops.

Table 21.A Agricultural Crop Data for 2013

Crop	Total Acres	Estimated ET_c[a] (ft)	Total ET_c Requirement (AF)	Crop Water Demand in Excess of ET_c (AF)	Total Crop Water Demand (AF)
Alfalfa Hay	7,658	3.96	30,319	1,516	31,835
Grain – Corn	745	2.45	1,823	91	1,914
Grain – Wheat	1,674	1.36	2,272	114	2,386
Grapes – Table[b]	972	2.36	2,292	115	2,407
Pomegranates[c]	1,684	2.93	4,934	247	5,181
Cotton	12,624	2.80	35,284	1,764	37,048
Pistachios - mature[b]	3,446	2.97	10,223	511	10,734
Pistachios - young[b]	2,782	2.03	5,643	282	5,925
Cherries[b]	41	3.39	139	7	146
Olives[b]	80	2.97	237	12	249
Vegetables[d]	2,084	2.07	4,319	216	4,535
Others[e]	3,122	2.19	6,832	342	7,174
TOTAL	**36,912**	--	**104,317**	**5,216**	**109,534**

[a] Data obtained from ITRC. ET_c values based on 1999 Dry Year
[b] Drip irrigated crops
[c] ET_c estimated by District Staff
[d] Primarily onions and tomatoes
[e] Includes Sudan grass and milo

Table 21.B Agricultural Crop Data for 2014

Crop	Total Acres	Estimated ET_c[a] (ft)	Total ET_c Requirement (AF)	Crop Water Demand in Excess of ET_c (AF)	Total Crop Water Demand (AF)
Alfalfa Hay	7,749	3.96	30,680	1,534	32,214
Grain – Corn	172	2.45	421	21	442
Grain – Wheat	1,444	1.36	1,960	98	2,058
Grapes – Table[b]	2,273	2.36	5,360	268	5,629
Pomegranates[c]	1,725	2.93	5,054	253	5,307
Cotton	9,455	2.80	26,427	1,321	27,748
Pistachios - mature[b]	3,679	2.97	10,914	546	11,460
Pistachios - young[b]	3,559	2.03	7,219	361	7,580
Cherries[b]	105	3.39	356	18	373
Olives[b]	80	2.97	237	12	249
Vegetables[d]	1,784	2.07	3,697	185	3,882
Others[e]	437	2.19	956	48	1,004
TOTAL	**32,462**		**93,282**	**4,664**	**97,946**

[a] Data obtained from ITRC. ET_c values based on 1999 Dry Year
[b] Drip irrigated crops
[c] ET_c estimated by District Staff
[d] Primarily onions and tomatoes
[e] Includes Sudan grass and milo

Table 21.C Agricultural Crop Data for 2015

Crop	Total Acres	Estimated ET_c[a] (ft)	Total ET_c Requirement (AF)	Crop Water Demand in Excess of ET_c (AF)	Total Crop Water Demand (AF)
Alfalfa Hay	6,652	3.96	26,336	1,317	27,653
Grain – Corn	646	2.45	1,581	79	1,660
Grain – Wheat	1,135	1.36	1,541	77	1,618
Grapes – Table[b]	2,575	2.36	6,073	304	6,376
Pomegranates[c]	1,725	2.93	5,054	253	5,307
Cotton	8,182	2.80	22,869	1,143	24,012
Pistachios - mature[b]	4,470	2.97	13,261	663	13,924
Pistachios - young[b]	4,119	2.03	8,355	418	8,772
Walnuts - young[b]	596	3.60	2,146	107	2,253
Cherries[b]	105	3.39	356	18	373
Olives[b]	80	2.97	237	12	249
Vegetables[d]	2,107	2.07	4,367	218	4,585
Others[e]	45	2.19	98	5	103
TOTAL	**32,437**		**92,273**	**4,614**	**96,886**

[a] Data obtained from ITRC. ET_c values based on 1999 Dry Year
[b] Drip irrigated crops
[c] ET_c estimated by District Staff
[d] Primarily onions and tomatoes
[e] Includes Sudan grass and milo

The District's gross service area encompasses approximately 48,810 acres and has not changed in recent years. As shown in Table 22, the acres irrigated from surface water and groundwater sources reported in Tables 21.A through 21.C varied slightly among the three representative years.

Table 22. Irrigated Acres (acres)

	2013	2014	2015
Service Area	48,810	48,810	48,810
Surface Water and Groundwater Irrigated Area	36,912	32,462	32,437

Source: BVWSD

For the purposes of this report, cropped acres are the same as irrigated acres. The majority of cropped acres are planted with annual crops with cotton being the predominant crop. Land planted to grain crops is typically double cropped during the winter and spring months with winter forage used primarily for dairy cattle. Inter-cropping is not a common practice within the Buena Vista service area.

Table 23. Multiple Crop Information (acres)

	2013	2014	2015
Cropped	36,912	32,462	32,437
Inter-cropping	0	0	0
Double cropping	2,445	0	0

Source: BVWSD

B. Environmental Water Use

Periodically, Buena Vista makes deliveries for environmental purposes. The deliveries include local duck clubs or occasionally the Kern National Wildlife Refuge (KNWR) on behalf of the Bureau of Reclamation. However, during the three drought years of 2013-2015, there were no environmental water uses as shown in Table 24. The U.S. Army Corps of Engineers is responsible for Isabella Reservoir operations and any environmental use of water stored in Isabella Reservoir is incidental to that operation.

Table 24. Environmental Water Uses for Representative Years (AF)

Environmental Resources	2013	2014	2015
Vernal pools	0	0	0
Streams	0	0	0
Lakes or reservoirs	0	0	0
Riparian vegetation	0	0	0
Duck clubs[1]	0	0	0
Refuge water[2]	0	0	0
Total	**0**	**0**	**0**

Source: BVWSD

[1] Water sale to duck clubs

[2] Buena Vista periodically wheels Reclamation water to the Kern Wildlife Refuge through the Main Drain Canal.

C. Recreational Water Use

Recreational activities at Lake Isabella include camping, fishing, and boating. The Army Corps of Engineers is responsible for day-to-day reservoir operations, while the Kern County Parks and Recreation Department administers the recreational activities at the lake. Buena Vista is not responsible for any recreational activities at Lake Isabella. Recreational use of District water supplies is incidental to the District's storage of water in the reservoir. Accordingly, no consumptive use has been assigned to water stored in Lake Isabella. Similarly, although water stored in BVARA is available for recreational use, none of the losses associated with this facility are credited to the District, so none are included in the District water balance.

Table 25. Recreational Water Uses for Representative Years (AF)

Recreational Facility	2013	2014	2015
Buena Vista Aquatic Recreation Area (BVAR A)[1]	0	0	0
Lake Isabella Recreation[2]	0	0	0
Total	**0**	**0**	**0**

Source: BVWSD

[1] Consumption of water for recreational purposes is not a District responsibility and is not accounted for in the District water balance.

[2] No recreational consumption of water is included in the District water balance.

D. Municipal and Industrial Water Use

All M&I water use in the vicinity of the Buena Vista service area is from groundwater pumping. Although the community of Buttonwillow lies within the District's Buttonwillow Service Area, the community receives all of its water from deep wells operated by the community that extract water from the Buttonwillow Subbasin. The District's access to surface water reduces reliance on the underlying groundwater, thereby supporting all users of groundwater.

Table 26 summarizes the District's municipal and industrial water uses.

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

Municipal/Industrial Entity	2013	2014	2015
Municipal Entity	0	0	0
Industrial Entity	1,167	1,704	876[1]
Total	**1,167**	**1,704**	**876**

Through August, 2015

Source: BVWSD

E. Groundwater Recharge Use

The District has long realized the value of aquifer storage and recovery programs operated within the District and with third parties and has participated in such programs to maximize the usage of surface water supplies.

Groundwater Recharge and Recovery Project (GRRP)

The Groundwater Recharge and Recovery Project (GRRP) entails groundwater recharge conducted through a combination of direct and in-lieu techniques. The GRRP also includes the construction of up to seventeen additional District-owned groundwater recovery wells. Groundwater may be recovered through the use of:

- District wells,
- Privately-owned wells,
- Agreements with individual well owners to recover recharged groundwater, and
- Use of other wells within the District's service area.

The ultimate annual volume of recovered water generated by the GRRP could be up to 20,000 AF, and the District will manage these supplies through programs within the District and with entities outside of the District. Although the District has recharged the groundwater basin for over 90 years using its unlined canals, it has expanded its recharge program within the District with the addition of The Palms. The Palms is a staged recharge and recovery program covering 1,160 acres.

The GRRP is an ongoing program with the District now having seven recovery wells functioning within its boundaries. In addition, Buena Vista has developed a Landowner Well Use Program which allows the District to use privately-owned wells for recovery. The number of participating landowner wells fluctuates but averages about five wells for a total of 12 District and landowner wells active in the project. The District is investigating up to 17 additional deep wells for recovery.

The District also has operated an "In-Lieu Water Banking Program" since 1983, which has allowed the West Kern Water District to store "surplus" water in the District and to recover their water when needed. In 2002, the District entered into a similar program with another neighboring district, the Rosedale-Rio Bravo Water Storage District. In addition to these programs, the District has operated various small district storage and recovery programs.

Other external conjunctive use projects that Buena Vista participates in include:

- Second priority rights to recharge water in the Kern Water Bank;
- Pioneer Recharge Project. The District recharges water and performs exchanges for the recharged water in the California Aqueduct, and
- Rosedale Rio Bravo WSD banking project with Irvine Ranch. The District and Rosedale Rio Bravo are also jointly developing the James Groundwater Bank at the McAllister Ranch. This project will include lands available for direct recharge. Rosedale Rio Bravo is the lead agency in development of this project which is still in the conceptual phase.

Table 27 lists volumes of groundwater recharged by various mechanisms in each of the three representative years.

Table 27. Groundwater Recharge Water Uses for Representative Years (AF)

Location/Groundwater Basin	Method of Recharge	2013	2014	2015
District Spreading Ponds	Percolation from ponds	0	0	0
District Canal Seepage	Infiltration from canals	16,595	0	0
Deep percolation from applied water[1]	Infiltration from applied water	5,216	4,664	4,614
Total		**21,811**	**4,664**	**4,614**

[1] Tables 21a through 21c – Crop Water Demand in Excess of ETc.
Source: BVWSD

F. Transfer and Exchange Use

Because of the District's water rights on the Kern River, Buena Vista has access to large quantities of Kern River water in wet years. Under the Water Exchange Project (WEP), the District delivers a portion of its surplus wet-year supplies to another entity with the other entity later returning a predetermined or negotiated quantity of its regulated water to the District, with or without an additional financial consideration. Current and potential participants in the WEP include Cawelo WD, Kern Delta WD, West Kern Water District (WKWD), North Kern WSD, Rosedale-Rio Bravo WSD, Semitropic WSD, Castaic Lake Water Agency (CLWA), Poso Creek Water Company, Lost Hills WD, Belridge WSD, Berrenda Mesa WD, Wheeler Ridge-Maricopa WSD, and Improvement District No. 4 of the Kern County Water Agency.

In addition to transfers with other entities, Buena Vista facilitates certain types of transfers within the District provided that these transfers do not injure other landowners or impair District operations. Categories of intra-district transfers that the District allows include the following:

- Transfer within a farming unit;
- Transfer of water generated by intentional fallowing;
- Transfer of reclaimed water, and
- Minor transfers.

In addition to these general categories, for the duration of an emergency, the District will make every reasonable and prudent effort to provide needed additional water service to any water user to prevent crop loss or other damages. Table 28 summarizes Buena Vista activity in long-term water exchanges in the three representative years. The total shown represents the sum of water transferred to and from the District.

Table 28.Transfers and Exchanges Water Uses for Representative Years (AF)

From What Agency	To What Agency	Type of Transfer or Exchange (Ag to M&I, M&I to Ag, or Ag to Ag)	2013	2014	2015
KDWD	BVWSD	State/ Kern River	5,312	0	5,100
WKWD	BVWSD	State/ Kern River	8,750	0	0
CWA	BVWSD	State/ Kern River	6,720	0	0
WKWD	BVWSD	State – WD/ Kern River	5,080	0	0
Total			**25,862**	**0**	**5,100**

Source: BVWSD

G. Other Water Uses

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

Table 29. Other Water Uses for Representative Years (AF)

Water Use	2013	2014	2015
None	NA	NA	NA

Source: BVWSD

H. Projected Water Use

There is the potential that Buena Vista's Kern River and SWP supplies will be reduced in the future; however, the amount and timing of the reduction is uncertain. In addition, while Buena Vista has purchased "surplus" water which has been available from time to time from the Friant-Kern Canal, it is projected that there will be less of this water available to non-contractors, such as Buena Vista, as the San Joaquin River Restoration Program is implemented.

A consequence of the constraints noted above is that reductions in the availability of surface water during a given year will be offset by corresponding increases in pumping of groundwater to meet irrigation water requirements. In addition, future demand patterns are expected to change as a response to modifications in cropping patterns and irrigation practices.

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

A. Surface Water Supply

Buena Vista lies entirely within Kern County, which arguably has the best inter-connected surface water conveyance system in the Central Valley. As a result, several Kern County water districts are able to obtain significant water supplies from three sources; the SWP via the California Aqueduct, the CVP via the Friant-Kern Canal, and the Southern Sierra Nevada watershed of the Kern River. Besides augmenting the volume of water available from local sources such as the Kern River and groundwater, access to SWP and CVP water provides a distributed water supply that buffers the impacts of a regional drought or a catastrophic failure of water conveyance infrastructure.

Buena Vista controls an average entitlement of approximately 158,000 AF/yr of surface water from the Kern River, based on the Miller-Haggin Agreement of 1888. In 1973, the District contracted with the KCWA for an additional surface water supply from the SWP delivered via the California Aqueduct. The contract provided for an annual firm supply of 21,300 AF and a surplus supply of 3,750 AF. The District's geographic location, with respect to the California Aqueduct and other KCWA member units, provides the opportunity for exchanges of the District's Kern River water for east side member units' SWP water. The District has also been a historic user of surplus Friant-Kern Canal flows to serve irrigation demands and for groundwater recharge programs. Table 30 details surface water supplies used by the District over the period from 2007 through 2013.

In some years, scheduling conflicts have prevented the District from meeting its entire water demand with surface water, even when the total supply of surface water has been adequate. In these years, groundwater has been pumped during the growing season and surface water recharged to the subbasin at times and locations when surplus surface water was available. In drought years, when the surface water supply must be augmented to meet demand, groundwater is pumped from the subbasin and this pumped water is accounted for as District water which has previously been stored. So long as the long-term District water balance remains positive, then the water levels beneath the District will not experience a long-term decline unless water is lost from the subbasin due to other causes.

Table 30. Surface Water Supplies (AF)

Source	Diversion Restriction	2007	2008	2009	2010	2011	2012	2013	2014	2015
Kern River and exchanges		82,860	74,842	58,358	122,573	160,593	89,450	42,557	0	0

Source: BVWSD

Table 31 lists restrictions or imposed limitations on sources of Buena Vista's water supply, in particular, the District's supply of SWP water via the California Aqueduct and the storage of water in Isabella Reservoir. Restrictions on SWP supply generally result from regulatory actions of wildlife agencies related to endangered species and actions of the SWRCB that restrict pumping from the Delta.

Table 31. Restrictions on Water Sources

Source	Restrictions or Imposed Limitations	Name of Agency Imposing Restrictions	Operational Constraints
State Water Project (SWP)	Delivery Schedule and Volume	DWR/ SWRCB	Reduced reliability of SWP deliveries south of the Sacramento-San Joaquin River Delta due to court-ordered restrictions on pumping.
Kern River	Storage	USACE	Dam safety considerations caused USACE to impose a maximum storage restriction of 360,000 AF, which is about 200,000 AF less than the reservoir's capacity at spillway crest. This restriction will be in place until the dam safety concerns have been addressed.

Source: BVWSD

B. Groundwater Supply

BVWSD overlies the Kern County Subbasin (DWR Basin No. 5-22.14) which comprises the entire southern end of the San Joaquin Valley Groundwater Basin. The subbasin covers about 3,040 square miles and is bounded on the east, south and west by the topographic slope break between the valley fill and the surrounding dissected foothills. To the north, the basin is delineated by the boundary between Kern, Kings, and Tulare counties, a political boundary which does not define a change in geological or flow conditions.

The District is shown in relation to the groundwater basin boundary in Figure 8, and the size of the basin is indicated in Table 32.

Table 32.Groundwater Basins

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

Source: DWR San Joaquin District Kern County Groundwater Basin Information: http://www.water.ca.gov/pubs/groundwater/bulletin_118/basindescriptions/5-22.14.pdf

The Subbasin has been divided into additional hydrological subbasins based on geophysical analysis and seismic mapping of undulating bedrock structures formed due to folding or faulting (KCWA, 1991). One such subbasin is a structural entity named the Buttonwillow Subbasin which underlies the entire Buttonwillow Service Area. This subbasin exhibits some isolation from the larger main subbasin to the east and exhibits groundwater behavior which is consistent with the interpreted shape and structural controls of the Buttonwillow Subbasin (Sierra Scientific, 2013).

The aquifer beneath the BSA consists of a sequence of interbedded, laterally discontinuous, sandy and silty sediments. Down to a depth of about 200 feet, silty sediments tend to predominate, but from 200 to 600 feet, sandy and silty sediments occur in approximately equal proportions. The Corcoran Clay, or another stratigraphically-equivalent clay, has been mapped or inferred to exist under the BSA and MSA. The clay layer lies from 450 to 600 feet below the ground surface under the central portion of the BSA, but rises to about 100 feet below the surface under the south end and 250 feet below the surface under the north end. The clay layer is about 500 feet deep under the MSA.

The portion of the BSA north of 7th Standard Road where the Northern Area Project is being constructed, includes fine-grained soils near the surface resulting in a shallow perched aquifer ranging from approximately two to twelve feet below ground surface that underlies approximately 12,000 to 15,000 acres (Krieger & Stewart, 2009). Water quality in the perched aquifer is poor with a TDS of 2,000 ppm or higher which limits the types of crops that can be grown and reduces crop yields. The perched aquifer is monitored with an extensive network of shallow piezometers. No intentional recharge or banking is performed within the northern portion of the District due to subsoil conditions.

The depth to groundwater below ground surface in the main aquifer varies from about 30 feet to 140 feet, generally increasing in a southerly direction. Groundwater elevations vary from about 230 feet to 130 feet above MSL and generally decrease in a southerly direction. The gradient evidenced by the groundwater elevations indicates that groundwater may flow from north to south within the District (Buena Vista Water Storage District, 2014). Generally groundwater levels observed over the past 20 years appear to be stable in the north while declining in the south which suggests that the north-to-south gradient has been increasing. However, the operation of groundwater banks in areas neighboring the District generate fluctuations in gradients that can temporarily alter the direction of subsurface flow.

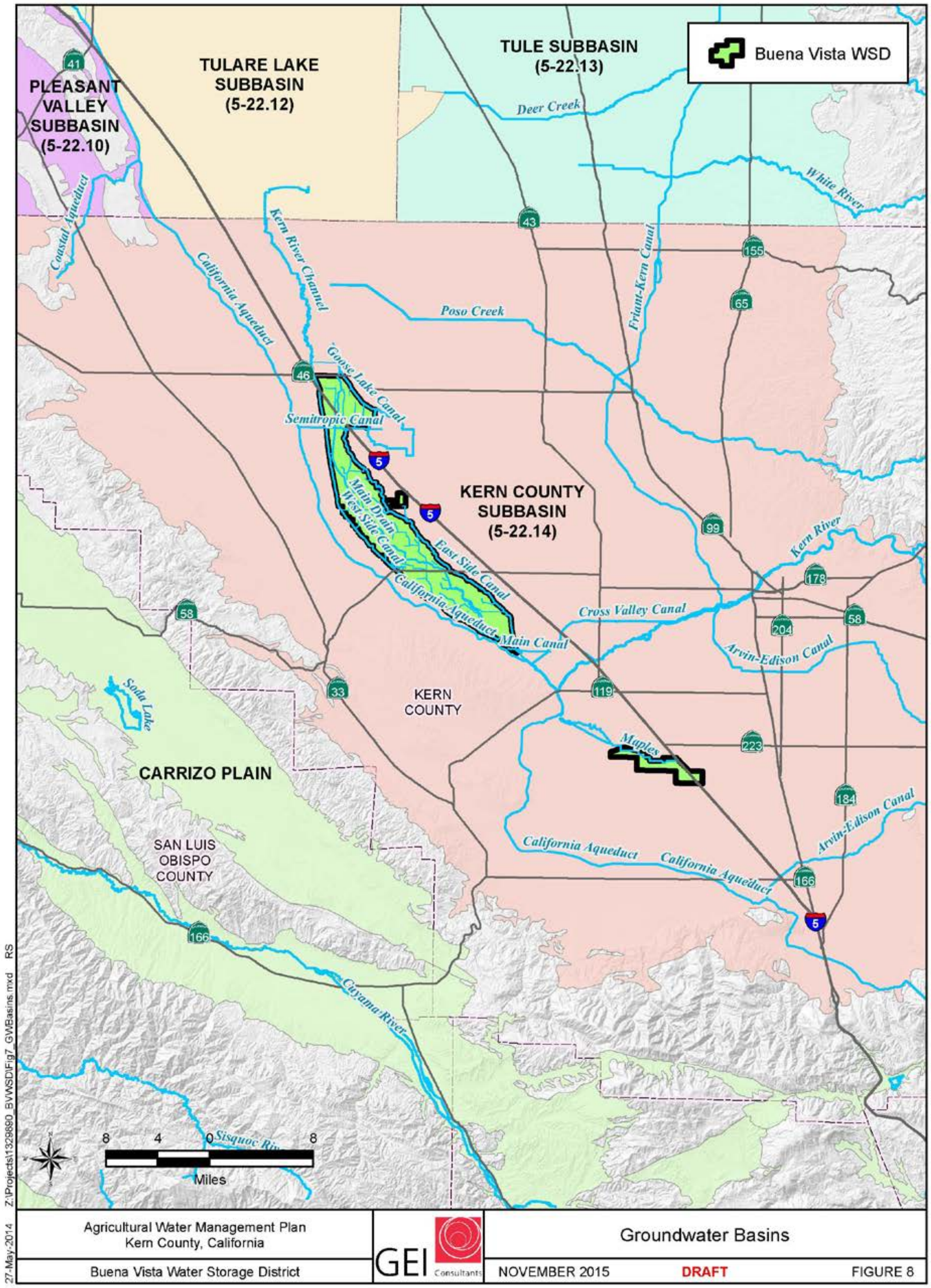

Figure 8. Map of District in Relation to Groundwater Basin(s).

Based on groundwater level data, little groundwater appears to flow across the boundaries of the northern half of the BSA. This is especially evident along the eastern boundary shared with Semitropic WSD. While the water elevation averages 10 feet above MSL in Semitropic, an average elevation of 180 feet above MSL is observed in Buena Vista. This large difference in elevation across a distance of two miles is thought to be the consequence of the Buttonwillow Anticline, a subsurface structure which forms Buttonwillow Ridge and is believed to separate the main groundwater basin to the east from the Buttonwillow Subbasin (Buena Vista Water Storage District, 2014). In the southern portion of the BSA, there is some evidence of groundwater flowing out of the District into the Rosedale-Rio Bravo WSD and into the District from Belridge Water District to the west. However, there is insufficient data to draw firm conclusions, and more dedicated monitoring wells are needed on the western border of the District to evaluate the groundwater conditions.

The Kern County Subbasin has been classified by DWR as a critically overdrafted groundwater basin (Bulletin 118). However, as described above, data on local geology and groundwater conditions within Buena Vista suggest that the District is substantially isolated from much of the Kern County Subbasin and that this isolation, coupled with the District's access to surface water, leads to groundwater supply conditions within the District's boundaries that differ from those characteristic of many other locations within Kern County.

California Energy Commission Report

In January, 2013, the California Energy Commission released a report which evaluated the long term change in water levels under the BSA. Based on 19 water level hydrographs spread throughout the service area, the CEC concluded that the BSA-wide average water level has risen by 6.8 feet since 1974. Using an estimated specific yield of 0.15, the CEC concluded that this represented a long-term average rate of increase in groundwater storage of 4,600 AF/yr.

The rate at which aquifer storage within the BSA is increasing reported in the CEC study, (4,600 AF/yr) differs significantly from the rate at which the District's long-term water balance estimates that water is being recharged through infiltration of precipitation, system seepage and deep percolation of applied water (36,964 AF/yr). Since there is no significant inflow across the service area boundaries, the difference between the estimated rate of recharge and the estimated increase in storage suggests that there is an average annual outflow from the BSA of approximately 32,000 AF/yr. This rate of outflow is equivalent to the volume of groundwater extracted by 18 irrigation wells, each pumping at a constant rate of five cfs for six months each year, a reasonable scenario for the subbasin areas outside the BSA for which no surface water delivery system exists. Therefore, it is possible that much of the groundwater recharge originating within in the BSA is being extracted by privately-owned wells located outside the District boundary but inside the Buttonwillow Subbasin. The discrepancy between the estimated rate of recharge and the observed change in aquifer storage may also be due to lateral outflux from the southern BSA. An outward flux of 89 AF/day through a 400-ft-thick aquifer across a four-mile boundary would account for the loss of 32,000 AF/yr from the aquifer underlying the BSA. Figure 9 illustrates the boundaries of subbasins identified in the vicinity of the District.

The District currently has insufficient data to determine what mechanisms are causing the observed change in aquifer storage to account for only 12 percent of the water estimated to be recharged by the District. However, both groundwater pumping within the Buttonwillow Subbasin and movement of groundwater across the southern boundary of the BSA are plausible and are consistent with pumping activities and groundwater flow behaviors in the area. Therefore, both mechanisms may be factors in the outflow of groundwater from the subbasin.

Groundwater Management Plan

The District prepared a Groundwater Management Plan (GWMP) in 1997 and updated it in 2002. A more recent update to the plan was approved by the BVWSD Board of Directors in 2014 to satisfy the requirements for GWMPs created by the September 2002 California State Senate Bill No. 1938 and 2011 Senate Bill 359, which amended Sections 10753 and 10795 of the California Water Code. Table 33 names the firm responsible for preparation of the groundwater management plan. This plan is available upon request.

Table 33.Groundwater Management Plan

Prepared By:	Provost & Prichard
Year:	2014
Is Appendix Attached?	No, but is available upon request

Source: BVWSD

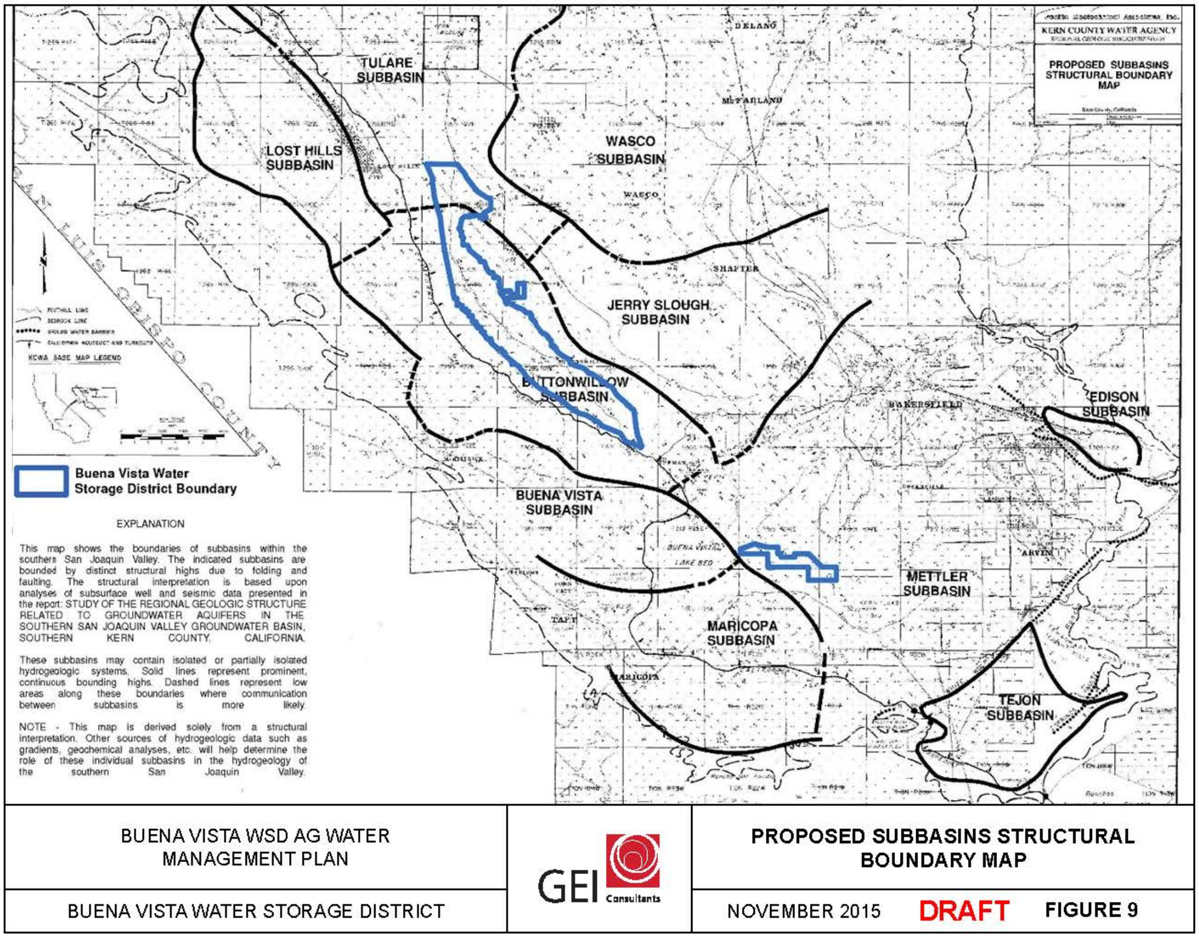

Figure 9. Proposed Subbasins Structural Boundary Map

District Irrigation Wells

While most of the groundwater pumping within the District is attributable to on-farm pumping from approximately 200 privately-owned wells, the District maintains and operates 7 production wells within the District with an eighth well lying outside the District's boundaries along the Alejandro Canal near the Kern River Channel (reference Figure 2 for the locations of these wells). The majority of irrigation wells in the District are completed to depths between 200 and 600 feet with perforated intervals around 150 feet to the bottom, in a 21-inch (minimum) diameter bore hole. Pumping lifts vary with hydrology and location; however, the average lift has been approximately 100 feet in recent years. A typical District-owned deep well is shown in Figure 10.

The District has established a "Landowner Well Use Program", which is a voluntary program to assist the District in satisfying water demands during dry years by making unused well capacity available in return for reimbursement to participating well owners for energy charges in addition to capital replacement and maintenance costs. As noted earlier, this program is part of the District's drought response effort.

Figure 10. Typical District Deep Well.

The quantities of groundwater pumped within the boundaries of Buena Vista for discharge into the district's distribution system are shown in Table 34. Although additional water is pumped from privately-owned wells within the District for direct application onto farmland, the volume of this pumping is not reported to the District.

Table 34. Groundwater Supplies for Representative Years (AF)

Groundwater Basin	2013	2014	2015
District Deep Wells	2,905	0	72
Non-District Deep Wells	NA	NA	NA
2800 Olcese Wells*	0	0	0
Total	**2,905**	**0**	**72**

Source: BVWSD
* Withdrawal from banking project. Accounted in Table 30 as a surface water delivery to District.

C. Other Sources of Supply

There are no uncontrolled inflows into the District so all water available to the District has been discussed in the preceding sections.

D. Drainage from Water Supplier's Surface Area

As described throughout this document, Buena Vista maintains a system of drainage canals which feed tailwater and storm runoff into the Main Drain Canal for conveyance and reuse both within the District and in neighboring areas. In some areas, groundwater recharge72from deep percolation is recovered for use by programs such as the Brackish Groundwater Remediation Program (BGRP), described later. As Table 35 summarizes, there are no flows to saline sinks, and flows to a perched water table are only of concern in the northern portion of the District. Such flows are not measured or estimated by the District. Figure 11 is a photograph of reclaimed water being pumped from the Main Drain Canal for irrigation.

Table 35. Drainage Discharge for Representative Years (AF)

Surface/Subsurface Drainage Path	2013	2014	2015
Flows to saline sink	0	0	0
Flows to perched water table	N/A	N/A	N/A

Source: BVWSD

Figure 11. Grower Pump Reclaiming Water from Main Drain Canal.

E. Water Supply Quality

Buena Vista's groundwater and surface water quality is generally good to excellent. Surface water diverted from the Kern River originates from snowpack in the Sierra Nevada Mountains and contains low amounts of total dissolved solids (TDS) and negligible amounts of other water quality constituents that impact agricultural water use. The source of water for the Friant Unit of the CVP is also snowpack from the Sierra Nevada and is of very high quality. Although the quality of water delivered from the SWP is also suitable for irrigated agriculture, the TDS of these deliveries is higher because this water, while also largely originating from snowpack, is exported from the Delta. The quality of the groundwater underlying Buena Vista varies with depth and location.

Surface Water Quality

Based on data from the KCWA, the average TDS concentrations reported for the District's sources of surface water are:

- SWP: 350 - 450 mg/L;
- Kern River: 90 - 120 mg/L;
- CVP: 50 mg/L, and
- Tailwater: 200 - 400 mg/L.

Water quality data for other constituents are presented for the Kern River in Table 36 for 2012, the most recent year with complete data.

Table 36. Surface Water Supply Quality - 2012

Parameter	Units	2012
B	mg/L	<0.1
Ca	mg/L	13
Mg	mg/L	2.4
Na	mg/L	15
K	mg/L	0.94
Cl	mg/L	4.4
SO_4	mg/L	17
NO_3	mg/L	<2.0
TDS	mg/L	69

Source: North Kern Water Storage District

Groundwater Quality

As described previously, the District's surface water supplies cannot always meet irrigation demands. For this reason, the District is managed conjunctively so that groundwater is available when needed to support deliveries of surface water. However, as poor quality groundwater is of limited use, protecting groundwater quality is a cardinal consideration for water management in Buena Vista. Groundwater quality can be protected through proper use of pesticides, herbicides and fertilizers, storm water and septic system management, and proper well construction and abandonment procedures. Some of these functions are the responsibility of cities and communities, but the District supports their efforts whenever possible.

Within the BSA, groundwater quality varies with location and depth. In the southern portion of the area, the TDS from production wells varies from 300 to 1,000 mg/L while in the northern portion the TDS varies from 1,000 to 4,500 mg/L. The TDS of the shallow, perched zone ranges from 850-5,500 mg/L based on annual data from shallow piezometers. In the Maples Service Area, the TDS ranges from 200 to 1,600 mg/L. Groundwater quality is generally better in the south, and improves in the interior of the District, possibly due to dilution with surface water from canal seepage and deep percolation from irrigation.

Groundwater salinity levels have generally been increasing over the past 20 years. The sources of the salinity are not fully understood but may include groundwater inflow from the west.

Other Water Uses

There are no uses other than those described in this plan.

Drainage from the Water Supplier's Surface Area

As described previously, the District has a number of programs that support reclamation of drainage water, either with growers using their own facilities or through use of reclaimed water from District drains. Reclaimed water is applied at the growers' discretion, and there are no known limitations on its use resulting from the quality of the reclaimed water.

Table 37. Drainage Reuse Effects

Analyte	Drainage Reuse Limitations				
	Increased Leaching	Blending Supplies	Restricted Area of Use	Restricted Crops	Other
Main Drain Canal	Unknown	Yes	None	None	No limitations

Source: BVWSD

F. Water Quality Monitoring Practices

Surface Water Monitoring

Buena Vista regularly monitors the quality of surface water diverted from the SWP and Kern River (and CVP, as applicable). In particular, samples of SWP water are collected monthly at the Tupman Road Bridge over the California Aqueduct while samples from the Kern River are collected at Gordon's Ferry Bridge. Samples taken at both locations are analyzed by the KCWA's Improvement District 4 Water Quality Laboratory.

Surface water quality monitoring is discussed in a report entitled *"Water Quality Management Plan - Main Drain"* (BVWSD, August 2012). The report describes water quality issues in the Main Drain Canal and proposed measures to correct observed deficiencies. Ultimately, the concerns center on the quality of water leaving the District at Highway 46. A monitoring station at this location is the most downstream sampling point on the canal and will continue to be the focal point for implementation of the Water Quality Management Plan. A second sampling site is located on the Main Drain Canal at Seventh Standard Road. This station was introduced in 2009 to help identify potential sources of poor quality water and is sampled on a monthly basis when there is flow in the canal.

Groundwater Monitoring

Groundwater quality monitoring is an important aspect of groundwater management in Buena Vista and serves the following purposes:

1. Spatially characterizes water quality according to soil type, soil salinity, geology, surface water quality, and land use;
2. Establishes a baseline for future monitoring;
3. Compares constituent levels at a specific well over time (i.e. years and decades);
4. Determines the extent of groundwater quality problems in specific areas;

5. Identifies groundwater quality protection and enhancement needs;
6. Determines water treatment needs;
7. Identifies impacts of recharge and surface water use on water quality;
8. Identifies suitable crop types that are compatible with the water characteristics; and
9. Monitors the migration of contaminant plumes.

The groundwater monitoring program in Buena Vista is performed with grower-owned wells, 14 District-designated monitoring wells, and shallow piezometers. The District monitors 57 of about 200 growers' wells. Each of the dedicated monitoring wells is sampled annually and salinity levels are recorded using a hand-held electroconductivity meter. A survey of all wells within the District is taken every five years. Recorded data includes well location, state of use, depth to water, and information on the pumps, motors and other equipment installed at each of the wells. Table 38 provides general information on monitoring of groundwater and reclaimed water quality in the District.

In addition to the monitoring facilities noted above, in conjunction with DWR, Buena Vista has installed 104 twenty-foot deep piezometers to monitor the shallow perched water within the Northern Area of the BSA. Data on perched water elevations is collected by taking readings from at least 80 of these piezometers four times each year.

Details of the District's monitoring efforts are included in the *Buena Vista Water Storage District Groundwater Monitoring Plan* and the monitoring programs outlined in the District's *Groundwater Status and Management Plan* (GSMP, 2002).

Table 38. Water Quality Monitoring Practices

Water Source	Monitoring Location	Monitoring Practice	Frequency of Analysis
Drain Water	Main Drain (12 locations)	Sampling and analysis by accredited laboratory	Monthly
Groundwater aquifer	14 locations within District boundary	KCWA staff purges wells and collects pumped water samples and reports analyses to Buena Vista	Yearly
Perched water	95 locations in and around District boundary	District staff collects samples and tests each piezometer using a handheld salinity meter	Yearly

Source: BVWSD

Beyond groundwater monitoring within the District, Buena Vista participates in multiple regional monitoring efforts including the California State Groundwater Elevation Monitoring (CASGEM) program, the Kern Fan Monitoring Committee, and the Semitropic Groundwater Monitoring Committee.

CASGEM. The California State Groundwater Elevation Monitoring program was created by the California state legislature in 2009 and is the first statewide program to collect groundwater elevations, facilitate collaboration between local monitoring entities and DWR, and report this information to the public. In 2011, Buena Vista was designated as a CASGEM monitoring entity as part of the Kern River Fan Group. The District now uploads groundwater level data to the CASGEM database quarterly.

Kern Fan Monitoring Committee. The Kern Fan Monitoring Committee was developed to monitor groundwater levels and quality in and around the Kern Water Bank, which is located just east of the southern tip of the Buttonwillow Service Area. The District provides water level measurements, water quality analyses and prepares an annual water balance for inclusion in the committee's annual monitoring reports.

Semitropic Groundwater Monitoring Committee. Buena Vista participates as an adjoining entity in the Semitropic Groundwater Monitoring Committee which is part of an effort by Semitropic to monitor the impacts of groundwater recharge and pumping within its service area. Buena Vista provides groundwater level data from district wells for use in development of regional contour maps.

Drainage Water

Drainage water is actively monitored by the District. As noted in Table 39, Buena Vista conducts monitoring of surface water drainage on a monthly basis and of groundwater on an annual basis to confirm the suitability of these waters for reuse.

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

Monitoring Program	Analyses Performed	Frequency of Analysis
Irrigated Lands Regulatory Program	Metals, organics, toxicity and soil chemistry	Monthly
Groundwater Monitoring Program	Irrigation suitability and metals	Yearly
Perched Groundwater Program	Salinity	Yearly

Source: BVWSD

District landowners have participated in the Southern San Joaquin Valley Water Quality Coalition (SSJVWQC), a group of growers and other agricultural interests formed to address industry issues such as the Irrigated Lands Regulatory Program (ILRP). The coalition encompasses the watersheds of the Kings, Kaweah, Tule and Kern rivers and represents all "dischargers", including Buena Vista, who own or farm irrigated lands in the Southern San Joaquin Valley.

The long-term ILRP monitors discharges from irrigated lands (tailwater, water from underground drains, and stormwater runoff) to waters of the State. Monitoring is divided into five tasks: registered pesticides, toxicity, legacy pesticides, dissolved oxygen/pH and salinity/pathogens (specifically E. coli.).

Due to the unique nature of the hydrogeology, topography and water use of growers in the District, the Buena Vista Coalition, was recently formed to address the long-term ILRP. This coalition includes all of the irrigated lands in Buena Vista, with the exception of the Henry Miller Water District. Additional lands may join the Buena Vista Coalition. To address the long-term ILRP, other areas within the SSJVWQC have split into five other smaller coalitions with boundaries likely to coincide with individual watersheds. The SSJVWQC will continue but will have no duties with any current IRLP coalitions.

Section V.Water Accounting and Water Supply Reliability

A. Agricultural Water Supplier Water Quantities

Diversions of surface water to Buena Vista vary from year to year depending on the weather, the amount of runoff, and operational considerations. Tables 40.A, 40.B and 40.C summarize monthly deliveries to Buena Vista during each of the representative years from the primary surface water sources and transfer/exchange agreements. Note that these values represent the monthly amount of water delivered to the District after subtraction of losses which occur outside of the District.

Table 40.A Surface and other Water Supplies for 2013 (AF)

Source	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Kern River	0	0	0	0	635	44	339	0	0	0	0	0	1,018
KR/ST Exchange	0	1,662	107	97	277	12,283	19,194	7,120	389	345	65	0	41,539
Total	**0**	**1,662**	**107**	**97**	**912**	**12,327**	**19,533**	**7,120**	**389**	**345**	**65**	**0**	**42,557**

Source: BVWSD

Table 40.B Surface and other Water Supplies for 2014 (AF)

Source	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Kern River	0	0	0	0	0	0	0	0	0	0	0	0	0
KR/ST Exchange	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Source: BVWSD

Table 40.C Surface and other Water Supplies for 2015 (AF)

Source	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Kern River	0	0	0	0	0	0	0	0	0	0	0	0	0
KR/ST Exchange	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Source: BVWSD

Tables 41.A through 41.C summarize the quantity of groundwater pumped by Buena Vista in each of the three representative years. These volumes include water pumped from eight district-owned wells, from privately-owned wells that discharge into District canals for conveyance, and from the Olcese wells.

Table 41.A Groundwater Supplies Summary for 2013 (AF)

Month	District Deep Wells	Non-District Deep Wells	Olcese Wells[1]	Total[2]
January	118	0	0	118
February	279	0	0	279
March	40	0	549	40
April	201	0	1,348	201
May	216	0	1,452	216
June	988	208	1,818	1,196
July	959	821	611	1,780
August	5	238	0	243
September	99	0	0	99
October	0	0	0	0
November	0	0	0	0
December	0	0	1,146	0
Total	**2,905**	**1,267**	**6,924**	**4,172**

[1] Water banking project – Water accounted for in Table 30 summary of surface water deliveries to District
[2] To avoid double counting, totals do not include water pumped from Olcese wells
Source: BVWSD

Table 41.B Groundwater Supplies Summary for 2014 (AF)

Month	District Deep Wells	Non-District Deep Wells	Olcese Wells	Total
January	0	NA	0	0
February	0	NA	0	0
March	0	NA	0	0
April	0	NA	0	0
May	0	NA	0	0
June	0	NA	0	0
July	0	NA	0	0
August	0	NA	0	0
September	0	NA	0	0
October	0	NA	0	0
November	0	NA	0	0
December	0	NA	0	0
Total	**0**	**NA**	**0**	**0**

Source: BVWSD

Table 41.C Groundwater Supplies Summary for 2015 (AF)

Month	District Deep Wells	Non-District Deep Wells	Olcese Wells	Total
January	0	NA	0	0
February	0	NA	0	0
March	64	NA	0	64
April	8	NA	0	8
May	0	NA	0	0
June	0	NA	0	0
July	0	NA	0	0
August	0	NA	0	0
September	0	NA	0	0
October	0	NA	0	0
November	0	NA	0	0
December	0	NA	0	0
Total	**72**	**NA**	**0**	**72**

Source: BVWSD

B. Other Water Source Quantities

Surface water diversions and groundwater are the two sources of water actively managed by Buena Vista. Effective precipitation constitutes an uncontrolled source of supply which reduces the requirement for irrigation water. Because rainfall was very limited during 2013, 2014, and 2015, effective precipitation is being discounted in the water balance calculated for these years, and no effective precipitation is entered in Table 42.

Table 42. Effective Precipitation Summary (AF)

Total Annual Effective Precipitation	2013	2014	2015
	0	0	0

Source: KCWA

C. Quantification of Water Uses

Table 43 shows the volume of water delivered through district facilities to Buena Vista irrigation customers in the three representative years. The volumes of delivered water are based on flow measurements at the farm turnouts.

Table 43. Applied Water for Representative Years (AF)

	2013	2014	2015
Delivered surface water charged to landowners	38,282	0	0

Source: BVWSD

Table 44 summarizes water uses within the Buena Vista service area for the three representative years. The calculated crop ET_c was used in developing the District's crop water requirement presented in Tables 21.A, 21.B, and 21.C and described in the text which accompanies these tables.

Table 44. Quantify Water Use (AF)

Estimated Water Use	2013	2014	2015
Crop Water Use			
1 Crop Water Requirement (includes ETc and an allowance for leaching and cultural practices) – Table 21.A through Table 21.C	109,534	97,946	96,886
2 Leaching[1]	N/A	N/A	N/A
3 Cultural Practices[1]	N/A	N/A	N/A
Conveyance and Storage System			
4 Conveyance Seepage - Table 27	16,595	0	0
5 Conveyance Operational Outflows – Table 45[2]	246	0	N/A
6 Conveyance Evaporation[3]	N/A	NA	N/A
7 Reservoir Seepage[3]	N/A	N/A	N/A
Environmental Use (from Table 24)			
8 Environmental Use – Wetlands	0	0	0
9 Environmental Use – Other	0	0	0
10 Riparian Vegetation	0	0	0
11 Recreational Use	0	0	0
Municipal and Industrial (from Table 26)			
12 Municipal	0	0	0
13 Industrial	1,167	1,704	876[4]
Outside the District			
14 Transfers or Exchanges out of the service area - Table 28	0	0	0
Conjunctive Use			
15 Groundwater Recharge - Table 27[5]	0	0	0
Other (from Table 29)	0	0	0
Subtotal	**127,542**	**99,650**	**97,762**

[1] Included in Item 1, see Tables 21.A through 21.C and accompanying text.
[2] All operational outflows for 2014 and 2015 were collected in the District's drainage system for reuse.
[3] Canal evaporation. Lake Isabella and BVARA seepage and evaporation are not credited against the District and are not included in the water balance.
[4] Through August, 2015
[5] This amount reflects direct recharge from District spreading ponds only. Canal seepage is presented in Item 4, and deep percolation of applied water is included in Item 1.

Table 45 summarizes the amount of monitored on-farm surface and subsurface drainage water leaving the service area.

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

Drain Water	2013	2014	2015
Surface drain water leaving District in Goose Lake Canal	246	0	N/A
Subsurface drain water leaving District	0	0	N/A
Subtotal	**246**	**0**	**N/A**

Source: BVWSD

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

Table 46. Irrecoverable Water Losses for Representative Years (AF)

Drain Water	2013	2014	2015
Flows to saline sink (Table 35)	0	0	0
Flows to perched water table (Table 35)	0	0	0
Subtotal	**0**	**0**	**0**

Source: BVWSD

D. Overall Water Budget

Table 47 summarizes the total water supplies available in the representative years to the Buena Vista service area. Surface water is the volume of water delivered from the Kern River, the SWP and the Friant-Kern Canal (CVP) to Buena Vista facilities during each of the three representative years. The groundwater volume includes pumping from District-owned wells and privately-owned wells participating in land owner well use agreements. Groundwater withdrawn from the Olcese groundwater banking project is accounted as surface water as it is conveyed into the District as surface supply.

Table 47. Quantify Water Supplies (AF)

Water Supplies	2013	2014	2015
1 Surface Water - Table 40	42,557	0	0
2 Groundwater - Table 41	4,172	0	72
3 Annual Effective Precipitation - Table 42	0	0	0
4 Transfers or exchanges into District -Table 28[1]	25,862	0	5,100
Subtotal	**72,591**	**0**	**5,172**

[1] Summation of transfers and exchanges into District from KDWD, WKWD and CWD.

Table 48 summarizes the water balance for the service area. Because of the uncertainty regarding the extent of private pumping used to supply water directly to irrigated lands within the District, the closure term of the balance represents an approximation of the level of private pumping. As Table 48 demonstrates, while private pumping supplements District supplied water in all years, when the component of District-supplied water infiltrating to groundwater is removed from the balance:

- During a representative normal year, District-supplied water satisfies nearly all demands
- During a representative wet year, District-supplied water substantially exceeds all demands
- During a representative dry year, District-supplied water must be supplemented by private pumping to satisfy demands.

This summary demonstrates the degree to which Buena Vista's conjunctive management activities affect the balance between groundwater and surface water usage, and why these practices have sustained groundwater levels within the District's service area. As expected during a drought, the closure term indicates that pumping from private wells was necessary to meet crop water demands during 2013, 2014 and 2015. However, growers reduced their demand for water by 21% (27,892 AF) between 2013 and 2014 and by 23% (29,780 AF) between 2013 and 2015.

Table 48. Budget Summary (AF)

Water Accounting	2013	2014	2015
1 Subtotal of Water Supplies (Table 47)	72,591	0	5,172
2 Subtotal of Water Uses (Table 44)	127,542	99,650	97,762
Closure term attributed to private pumping within the District	**54,951**	**99,650**	**92,590**
Closure term minus combined sources of groundwater recharge[1]	**33,140**	**94,986**	**87,976**

[1] Sources include deep percolation of applied water, canal seepage and recharge from percolation basins

E. Future Water Supply Reliability

Buena Vista derives its surface water from diversions from the Kern River, exports from the Sacramento-San Joaquin River Delta and water from the CV P's Friant Unit. Therefore, future changes in the Buena Vista water supply will be driven by changes in hydrology and particularly by the volume, nature and timing of precipitation in the watersheds that feed these water sources. While changes in watershed hydrology may reduce the reliability of surface water supplies in ways the District cannot control, the District, as shown by the programs it is now implementing, is committed to adapting its water management practices to respond to changing conditions.

The secondary source of water supply for the District is groundwater. Although not immediately affected by changes in surface water hydrology, local groundwater is connected to surface water supplies in that groundwater recharge is driven primarily by seepage of surface water conveyed in District facilities and percolation of applied irrigation water.

The information presented in this AWMP shows that Buena Vista is in positive long-term balance within a critically over-drafted groundwater basin. The problem areas described above, such as the perched water area in the District's Northern Area, will require innovative management practices to maintain farming over the long term. Groundwater quality has been closely monitored so that constituents detrimental to crop production do not migrate into neighboring areas. There is also concern that groundwater pumping adjacent to District lands has negatively impacted groundwater elevations especially in the southern part of the District.

In addition to the Water Exchange Program (WEP) and the Conservation Easement and Water Acquisition and Management Project (CEWAMP) described earlier in this document, current and planned programs to sustain the long-term water balance and protect groundwater quality include the following:

Additional Surface Water Imports

During wet years the District authorizes the sale of surplus water to reduce or avoid groundwater pumping and generate revenue to offset operating costs. Surplus water is offered to landowners within the District (for use above their surface water allocation) and to landowners adjacent to the District who rely primarily on groundwater. Such "in lieu" deliveries are beneficial since they prevent overdraft, raise pumping levels, and generate revenue.

Limitations on Pumping

The California Water Code gives water and irrigation districts the power to limit or suspend groundwater extractions if the District determines that groundwater replenishment programs, or other alternative sources of water supply, have proved insufficient to lessen impacts to groundwater. BVWSD has no intention of categorically limiting groundwater pumping or interfering with private landowners' rights to pump groundwater. However, if groundwater overdraft becomes severe, the District may pursue a voluntary program for reducing groundwater pumping, which would include incentives to compensate users for reducing their groundwater use.

Brackish Groundwater Remediation Project

Shallow perched groundwater with elevated TDS concentrations has adversely impacted plant growth and crop yields in affected areas of the District. The Brackish Groundwater Remediation Project (BGRP) is designed to remediate brackish groundwater within the BSA by recovering groundwater from strategic locations.

The target water exists in two zones. There is a shallow, perched water of high TDS which exists from 0 to 12 feet below the ground surface. This perched water interferes with root zone plant growth. There are several ways the District is looking to deal with this high TDS perched water. The BGRP includes constructing and operating strategically-located shallow- and medium-depth brackish groundwater recovery wells and collection and conveyance pipelines that transport the water to participants either inside or outside District boundaries.

The intent of the BGRP is to improve these lands for agricultural use by physically lowering the level of the shallow brackish groundwater. The second zone of high TDS water is at depths ranging between 60 and 400 feet below ground surface where normal agricultural wells draw water. This water has caused farmers to abandon wells in this area.

The long-term goal for the BGRP is to extract up to 12,000 AF/yr of brackish groundwater from the two different target areas.

The District will continue to monitor its activities as they relate to the groundwater subbasin and to search for new technologies which are practical and cost-effective. Cooperative programs involving such entities as the DWR and neighboring agricultural districts, neighboring municipalities and rural communities may provide opportunities for attaining long-term solutions to difficult water management problems.

Section VI.Analysis of Effect of Climate Change

A. Effects of Climate Change on Agriculture's 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 (GHG) emission. 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 3.7°F to 6.3°F under a low carbon and high carbon emission scenario, respectively. The Kern River and CVP are directly affected by the quantities of runoff and recharge in the Sierras. If these predictions materialize, the volume and reliability of runoff from the Sierra Nevada Mountains is expected to decline over time.

Based on these projections, climate change could result in increased demands for irrigation water with reduced surface water deliveries that would be met by increasing groundwater pumpage. This in turn, would likely lead to the following impacts:

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

The combination of groundwater use in dry years and recharge in wet years has provided a balance in water supply. Should climate change result in a reduction in water available from the Kern River and the SWP, this may prompt Buena Vista to increase the frequency of groundwater pumping which would lead to a corresponding decline in groundwater storage. According to another CAWSC study (Proceedings of the Eighth International Symposium on Land Subsidence, 2010), Kern County may experience substantial land subsidence due to the increased demand on groundwater that may 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 23 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 26 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.

Temperate fruit and nut trees such as almonds, pistachios, and apples require adequate winter chill to produce economically viable yields. As explained above, the number of warm nights will increase, and therefore the number of winter chill hours will decrease, causing adverse effects on the yield of these orchard crops, which account for nearly 42 percent of the total irrigated area in the District (BVWSD, 2015). 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 safe winter chill needed for these crops is predicted to disappear.

B. Effects of Climate Change on Water Supply

Buena Vista's surface water supply is currently dictated by changes in the volume, nature, and timing of precipitation in the Sierra Nevada Mountains for Kern River supplies, and into the Sacramento-San Joaquin Delta as the receiving watershed is the source of supply for the SWP. 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 reliability issues facing the SWP and the CVP, and, by extension, Kern River supplies, due to climate change. The 12 scenarios represent projections from six Global Climate Models for higher and lower greenhouse gas 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 Table 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). These decreases in annual Delta exports would reduce water deliveries south of the Delta, which directly affects the water volume supplied to the District. These effects would be magnified by similar changes to other potential surface water supplies, which have been used in the past by the District when water is available (e.g. Kern River, Poso Creek, etc.).

This assumption of reduced reliability can be extended to Kern River water supplies as the reliability of the Kern River will be principally affected by the amount and timing of precipitation and snowfall. Snowpack in the Sierra Nevada Mountains, which serve as the source of runoff to the Kern River, is projected to decrease, as predicted by Cal-Adapt. This results from a shift toward more rain and less snow, causing snow to melt earlier in the year which reduces the availability of water during the summer.

Currently, Buena Vista recharges groundwater during wet years in spreading ponds and unlined canals operated within the District and with third parties. The combination of groundwater use in dry years and recharge in wet years has provided a balance in water supply. Should climate change result in a reduction in water available from the Kern River and SWP, this may prompt the District to increase the frequency of groundwater pumping which would lead to a decrease in groundwater storage without the necessary means of replenishing the depleted storage, impacting all groundwater users.

C. Regional Vulnerability Assessment

The Modified IRWMP Climate Change Vulnerability Assessments 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 previously mentioned, Buena Vista Water Storage District 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 RWMP, gearing answers more specifically to Buena Vista. The checklist 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. A significant amount 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 Buena Vista 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 Kern River and 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 Buena Vista, 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. The Kern River is fed by annual snowmelt from the Southern Sierra Nevada, including Mount Whitney.
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. Portions of the District have groundwater with salinity at rates which prohibit its use for agriculture. This high salinity groundwater entering the aquifer appears to be a natural occurrence. If less freshwater recharges in the area, then salt intrusion may increase.

[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 (cont.)		
II.D	Would your region have difficulty in storing carryover surpluses from year to year?	There is limited carryover available for SWP water in San Luis Reservoir. Carryover of Kern River water in Isabella Reservoir is limited by the Reservoir's flood control purpose and US Army Corps of Engineers 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. 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?	Yes. The Kern River, the primary native surface supply to the District, 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?	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?	The Regional Board has determined that all groundwater beneath the District is suitable for agriculture. However, TDS in certain areas can exceed 5,000 ppm. Growers cannot use this water without treatment by blending.
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?	Buena Vista Water Storage 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. 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. The Buttonwillow lakebed lies within the 100-year floodplain. 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. While Isabella Reservoir does not present a flood control issue for the District, it is a water supply issue, inasmuch as it regulates the delivery of Kern River water to Buena Vista. The District has actively encouraged USACE to expedite the “fix” for Isabella Dam deficiencies.

Modified IRWMP Climate Change Vulnerability Assessments Matrix

List No.	Checklist Item	Regional Conditions
V. Flooding Assessment (cont.)		
V.D	Have flood control facilities (such as impoundment structures) been insufficient in the past?	Yes. The primary flood control facility to the District 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 District with its surface water supplies.
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. Though aquatic pests, including invasive plants have been fought on the Kern River for decades, District lands are flat and not subject to erosion or sedimentation issues.
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. 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?	Recreational use of District water supplies is incidental to the District's storage of water in the reservoir. Inflows to the District from the Kern River can flow through Lake Webb and Lake Evans at the Buena Vista Aquatic Recreation Area (managed by Kern County Parks and Recreation). These bodies of water directly serve the Maples Canal and the Maples Service Area of the District. The District has access to the top two feet of storage capacity in these lakes.
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?	There are several wildlife refuges within the Kern Region including the Kern National Wildlife Refuge that manages some wetlands. Coastal storms are not possible in Buena Vista, due to its location in the southern San Joaquin Valley.

Modified IRWMP Climate Change Vulnerability Assessments Matrix

List No.	Checklist Item	Regional Conditions
VI. Ecosystem and Habitat Vulnerability Assessment (cont.)		
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 Buena Vista that are known to preclude species movement.
VII. Hydropower Reliance Assessment		
VII.A	Is hydropower a source of electricity in your region?	Yes. 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. Additionally, Semitropic has a power plant within Buena Vista on its inlet canal for their private energy use.
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 will increase in the future as a result of several factors, which include changes in land use from agricultural uses to urban uses, increasing population and increases in groundwater pumping. 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. Water Quality
5. Ecosystem and Habitat
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 in Buena Vista. 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.

D. Response to Effects of Climate Change

Buena Vista is committed to monitoring indicators of climate change that affect the hydrology of key surface water sources (e.g. Kern River watershed and Sacramento-San Joaquin River Delta) 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' include the following:

- Expand water storage and conjunctive management of surface and groundwater resources.
- Reduce reliance on imported SWP and CVP 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. 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.

Section VII. Water Use Efficiency Information

A. EWMP Implementation and Reporting

The California Water Code sets forth specific Efficient Water Management Practices (EWMPs) for agriculture; two of which are identified as “critical” and 14 of which are to be implemented if they are “locally cost effective and technically feasible”. The latter are referred to as “conditionally required” in DWR’s *2015 Guidebook*. Each of the 16 EWMPs is listed in the *2015 Guidebook* and in Section 1.2 of this plan. Table 49 summarizes the status of implementation of EWMPs at Buena Vista. The two “critical” EWMPs are listed first, followed by the 14 “conditionally required” EWMPs. Each of the EWMPs is listed in the sequence shown in the *2015 Guidebook* and is referenced following the numbering system used in the *Guidebook.*

As described throughout this report, Buena Vista takes a programmatic approach to water management and has implemented a number of initiatives to conserve water, protect water quality and maintain groundwater elevations throughout its service area that combine features of individual EWMPs.

Table 50 provides an estimate of the improvements in efficiency that have been achieved in Buena Vista since the issuance of the District’s last AgWMP. Table 51 identifies an implementation schedule, finance plan and budget allocation for EWMPs implemented by the District. Buena Vista’s 2016 capital improvements budget of $21.9 million for direct capital expenditures including projects that are partially funded by grant revenues. The description of implemented EWMPs presented here includes projects described in Section 1.A. of this plan. It should be noted that Buena Vista has chosen to implement some EWMPs that, when viewed in isolation, are not locally cost effective but that contribute to the District’s overall water management strategy.

Table 52 describes EWMPs that are not planned for implementation because they are either not technically feasible or are not locally cost effective.

Table 49.Report of EWMPs

Water Code Reference	EWMP	Current Status	Status of EWMP
10608.48.b(1)	Measure the volume of water delivered to customers with sufficient accuracy to comply with subdivision (a) of Section 531.10 and to implement paragraph (2) of the legislation.	Proceeding with implementation	All deliveries to growers are measured either through metered or gated turnouts. The District is in the process for replacing all gated turnouts with either propeller meters or magnetic flow meters. Magnetic flow meters are installed on all district wells. Buena Vista is committed to complying with the requirements of SBx 7-7 and will implement the methodology described in *Section VII* of this report to verify the accuracy of both metered and gated turnouts.
10608.48.b(2)	Adopt a pricing structure for water customers based at least in part on quantity delivered.	Currently implemented	Beginning in 2013 Buena Vista has been charging water users based on the volume of water delivered.
10608.48.c(1)	Facilitate alternative land use for lands with exceptionally high water duties or whose irrigation contributes to significant problems, including drainage.	Currently implemented	Buena Vista considers requests for alternative land uses. Although conversion of land from agricultural to urban uses within the service area is unlikely, the District supports implementation of conservation easements to reduce water usage on lands with problematic drainage conditions.
10608.48.c(2)	Facilitate use of available recycled water that otherwise would not be used beneficially, meets all health and safety criteria, and does not harm crops or soils.	Currently implemented	As described throughout this report, Buena Vista has an extensive program for collection and reuse of tailwater and is initiating programs for reclamation of groundwater. As an example, planning is proceeding on the Brackish Groundwater Recovery Project which will extract perched brackish groundwater in the northern part of the District to improve agronomic conditions for crops grown in that area. The extracted groundwater will be recycled after blending with higher quality surface water.
10608.48.c(3)	Facilitate financing of capital improvements for on-farm irrigation systems.	Currently implemented	The District was awarded a $1,000,000 grant from USBR's Water SMART 2011 Program for improving irrigation delivery systems and on-farm efficiency. As part of this program, eligible grower were awarded up to a 50% cost share for on-farm projects that improve water use efficiency.
10608.48.c(4)	Implement an incentive pricing structure the promotes one or more of the following goals: (A) more efficient water use at the farm level; (B) conjunctive use of groundwater; (C) appropriate increase of groundwater recharge; (D) reduction in problem drainage; (E) improve management of environmental resources; (F) effective management of all water sources throughout the year by adjusting seasonal pricing structures based on current conditions.	Currently implemented	The District Board establishes a water price each year with the objective of using the cost of water to encourage prudent use given the conditions anticipated for the coming year. In particular, the price of surface water is used to promote a reasonable balance of surface water and groundwater usage. As described in this plan, the District has other programs which directly address concerns such as management of drainage and availability of water for environmental uses such as refuges.
10608.48.c(5)	Expand line or pipe distribution system, and construct regulatory reservoirs to increase distribution system flexibility and capacity, decrease maintenance and reduce seepage.	Planned for implementation	Most of the District's irrigation water is distributed in a system of open ditches with seepage from these ditches contributing to groundwater recharge in the service area. However, the District is proceeding to implement piped conveyance projects, such as the Northern Area Project, which are intended to reduce seepage in areas with high groundwater tables. Construction is now underway on the Northern Area Project. The District's use of the Buena Vista Lake Recreational Area (BVARA) as a regulating reservoir, the District's proximity to the California Aqueduct and access to groundwater provide a high degree of operational flexibility and responsiveness.
10608.48.c(6)	Increase flexibility in water ordering by, and delivery to, water customers within operational limits.	Currently implemented	As noted for the previous EWMP, Buena Vista's use of BVARA to regulate deliveries of Kern River Water, the proximity of turnouts from the California Aqueduct to the Buttonwillow Service Area and the use of District- and privately-owned wells provide a high degree of responsiveness and flexibility to the District's water supply. For this reason, the District is able to make deliveries on an arranged demand basis.

Table 49. Report of EWMPs (Continued)

Water Code Reference	EWMP	Current Status	Status of EWMP
10608.48.c(7)	Construct and operate supplier operational outflows and tailwater recovery systems.	Currently implemented	As described in this report, Buena Vista has three programs to encourage growers to reclaim tailwater either through use of District facilities or through use of grower-owned, on-farm facilities. As a result, the District is effective in capturing and recycling tailwater for use either within the District or in neighboring areas. As a result, there is no unmanaged outflow from the District.
10608.48.c(8)	Increase planned conjunctive use of surface water and groundwater within the supplier service area.	Currently implemented	As described in the body of this report, conjunctive management is fundamental to Buena Vista's approach to operation. Conjunctive management has been successful because long-term access to surface water has been adequate to allow the District to meet demands during most years while relying on groundwater as a supplemental supply during years when surface water supplies are inadequate or during periods when constraints in the District's distribution system prevent timely deliveries of surface water.
10608.48.c(9)	Automate canal control structures.	Currently implemented	Buena Vista is implementing a program to replace all gated turnouts with flow meters which will streamline delivery and measurement of irrigation supplies. The District is also in the course of planning and implementing a series of water conservation projects that will replace canals with pipelines. As well as greatly reducing seepage losses in areas underlain by saline groundwater, these projects will replace manually operated canals with automated pipelines.
10608.48.c(10)	Facilitate or promote customer pump testing and evaluation.	Currently implemented	The District has installed water flow meters on all District-owned pumps, but does not test privately-owned pumps and wells. This District does provide funding for operation and maintenance of private wells participating in the Landowner Well Use Program.
10608.48.c(11)	Designate a water conservation coordinator who will develop and implement the water management plan and prepare progress reports.	Currently implemented	The District has appointed Tim Ashlock, the District Engineer, as Water Conservation Coordinator.
10608.48.c(12)	Provide for the availability of water management services to water users.	Currently implemented	District staff responds to water users' routine inquiries and requests for water orders and moves. In addition, District staff work closely with growers interested in participating in particular water management programs established by the District such as the Landowner Well Use Program and the Conservation Easement Water Acquisition and Management Project. The District is also implementing an on-line water ordering system.
10608.48.c(13)	Evaluate the policies of agencies that provide the supplier with water to identify the potential for institutional changes to allow more flexible water deliveries and storage.	Currently implemented	The District receives surface water from the Kern River and from the SWP. In addition, Buena Vista occasionally receives "215 water" from Reclamation; however, the Friant SJR Settlement Agreement has affected the availability of this supply. The main opportunity to improve District operations through engagement with agencies lies in working with the U.S. Army Corps of Engineers to improve conditions at Lake Isabella so that the use of the reservoir's full capacity can be reinstated and working with the County of Kern to improve operation of the Buena Vista Aquatic Recreation Area.
10608.48.c(14)	Evaluate and improve the efficiencies of the supplier's pumps.	Currently implemented	The District has an on-going program of routine maintenance on all District-owned pumps. In addition, the District contributes to maintenance of privately-owned pumps that participate in the Landowner Well Use Program.

The 2016 Buena Vista budget for capital improvement and operations includes funds for operation of existing EWMPS and for continued implementation of the EWMPs described in Table 49. Table 50 presents the schedule for implementing EWMPs.

Table 50. Schedule to Implement EWMPs

EWMP[1]	Activities Scheduled for 2016	Staffing Requirements	Budget Allotment	AWMC MOU Demand Measures
Critical				
1 - Water Measurement	Currently implemented	Routine activity with no dedicated staffing requirement	Not applicable	C-1
2 - Volume-based Pricing	Currently implemented	Routine activity with no dedicated staffing requirement	Not applicable	
Conditional				
1 - Alternate Land Use	On-going	Implementation of CEWAMP program: one-eight full-time equivalent	Operations	B-1
2 - Recycled Water Use	On-going	Routine activity with no dedicated staffing requirement	Not applicable	B-2
3 - On-Farm Irrigation Capital Improvements	On-going	District and NRCS staff	NRCS funded	B-3
4 – Incentive Pricing Structure	On-going	Routine management activity with no dedicated staffing requirement	Not applicable	C-2
5 – Infrastructure Improvements	On-going implementation, planning and financing activity	Staffing requirement for grant and program management: two-thirds full-time equivalent	Capital Improvement	B-5
6 – Order/Delivery Flexibility	On-going	Routine activity with no dedicated staffing requirement	Not applicable	B-6
7 – Supplier Operational Outflow and Tailwater Systems	On-going	Routine activity with no dedicated staffing requirement	Not applicable	B-7
8 – Conjunctive Use	On-going	Routine activity with no dedicated staffing requirement	Not applicable	B-8
9 – Automated Canal Controls	On-going	Routine operational duty with no dedicated staffing requirement	Not applicable	B-9
10 – Customer Pump Test/Evaluation	On-going for district wells and pumps	Contracted activity	Operations	
11 – Water Conservation Coordinator	On-going	Staffing requirement of one quarter full-time equivalent	Operations	A-2
12 – Water Management Services to Customers	On-going	On-going activity with no dedicated staffing requirement	Not applicable	A-3
13 - Identify Institutional Changes	On-going	Routine management duty with no dedicated staffing requirement	Not applicable	A-5
14 – Supplier Pump Improved Efficiency	On-going	Routine operational function with no dedicated staffing commitment	Not applicable	A-6

Table 51 includes a description of key EWMPs in place at the time of submission of the previous Ag Water Management Plan or scheduled for implementation in the near future. Where estimates of quantifiable volumes of conserved water are available, these are presented in this table.

Table 51.Report of EWMPs Efficiency Improvements

EWMP	Estimate of Water Use Efficiency That Occurred Since Last Report[1]	Estimated Water Use Efficiency 5 and 10 years in Future
Critical		
1 – Improved water measurement: Replacement of gates with magnetic flow meters at turnouts from canal reaches being converted to pipelines.	No estimated water conserved but will result in more accurate measurement of delivered water.	
2 – Volumetric pricing: Replacement of gates with magnetic flow meters on turnouts from canal reaches being converted to pipelines.	Increased accuracy of measurement will enable more accurate billing of deliveries.	
Conditional		
1 – Alternate Land Use: attainment of CEWAMP Project Targets	8,000 AF (4,000 AF/yr over two years)	Estimated annual reduction in water use of 4,000 AF Water conserved over: 5 years: 20,000 AF 10 years: 40,000 AF
5 – Expanded lined or piped distribution system: Northern Area Pipeline, Spicer Extension Project	Under construction	Estimated annual reduction in canal seepage of 15,000 AF Water conserved over: 5 years: 75,000 AF 10 years: 150,000 AF
7 – Tailwater Recovery: Installed additional reclamation pumps and turnouts. Eliminated supplier outflow.	25,820 AF (12,910 AF/yr over two years for full tailwater recovery program)	Estimated annual volume of tailwater recovered and recirculated within the District's service area of 12,910 AF Water conserved over: 5 years: 64,550 AF 10 years: 129,100 AF
9 – Automate canal control structures: Addition of two Rubicon gates and multiple SCADA points	No estimate of water conserved but will result in more accurate measurement and control of delivered water.	

B. Documentation for Non-Implemented EWMPs

Buena Vista has implemented, or is in the process of implementing, each of the recommended EWMPs and has extensive programs in place or under development to conserve water, to protect water quality and to maintain groundwater elevations throughout the District. This position is reflected in Table 52, below.

Table 52. Non-Implemented EWMP Documentation

EWMP #	Description	(check one of both)		Justification/Documentation
		Technically Infeasible	**Not Locally Cost-Effective**	
				No EWMPs have been determined to be either technically infeasible or not locally cost-effective.

Section VIII. Supporting Documentation Agricultural Water Measurement Regulation Documentation

A. Description of Water Measurement Best Professional Practices

Section 10608.48(b) of the California Water Code requires that agricultural water suppliers governed by this section, "Measure the volume of water delivered to customers with sufficient accuracy to comply with subdivision (a) of Section 531.10" of the legislation which 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."

Buena Vista makes deliveries of surface water and groundwater to farm delivery points, or "turnouts", which are owned by the District as explained in Section II.F (shown in Figures 6A and 6B). All turnouts are equipped with Waterman gates or piped turnouts, with the diameters of the pipes ranging between 18 and 24 inches. There are also a small number of turnouts to pump stands or to risers with overpours. Flows to pump stands are measured at the pump discharge; flows to risers are measured using weir boards. Deliveries from piped turnouts are measured with propeller flow meters mounted within the turnout piping that also totalize the amount of water delivered. Gated turnout flows are calculated based on the geometry of the gate opening and the duration of flow as described in Section II.F. All turnout measurements follow accepted engineering practices.

Volumes of water delivered through District turnouts are updated on a daily basis. Bar code readings at piped turnouts are used to track the time and location of each measurement and measurement data is automatically downloaded into the District's dispatch office. Calculated readings from gated turnouts are uploaded into the District's water management software. Both are reviewed by a supervisor as a quality control procedure. Irrigated acreage is determined based upon a cropping forecast that is prepared each winter for the upcoming season. These crop reports include information obtained directly from water users that identify the crop type, irrigation method and acreage. The irrigated acreage values are confirmed by checking the acreage identified in the Kern County Assessor's Parcel Number database and are field verified by Buena Vista staff. Although turnouts at Buena Vista deliver water to both single and multiple fields, there is a direct correspondence between the turnout identification number and the area served by that turnout.

Water delivery data are made available to water users whenever it is requested throughout the season, which enables irrigators to monitor their water usage. The District's billing system uses the pricing structure adopted by Buena Vista's Board of Directors and the delivery volumes taken at each farm turnout to determine the water bill associated with deliveries through that turnout.

B. Engineer Certification and Apportionment

Flow meters or gates at each farm turnout measure deliveries to each irrigator's place of use. The proposed methodology to determine whether the accuracy of a representative sample of District flow measurement devices complies with the requirements of Section 597.3(a) is described in the description of the Buena Vista WSD Compliance Methodology presented at the end of this section. Buena Vista plans to adopt this methodology for field testing of flow measurement devices and to present a report approved by a California-Registered Professional Engineer as the basis for ongoing compliance with SBx7-7. This practice conforms with Section 597.3(a) of the California Water Code as stated below:

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

C. Water Measurement Conversion to Volume

SBx7-7 requires an annual volumetric accuracy of within ±12 percent on existing devices. Buena Vista's piped turnouts with propeller meters include totalizers, which directly record cumulative flow volumes. For these metered turnouts, the devices' accuracy in measuring flow rates corresponds to their accuracy in measuring volumetric deliveries. Therefore, with respect to metered deliveries, the discussion presented later in this section that relates to testing the accuracy of measurement of flow rates applies equally to determination of the accuracy of measurement of volumes of delivered water.

For gated turnouts, the devices' accuracy in measuring flow rates must be adjusted to estimate their accuracy in measuring volumes. To comply with the requirements presented in the legislation, Buena Vista has adopted an approach developed by the Irrigation and Training Research Center (ITRC) at Cal Poly - San Luis Obispo and described in the August 2012 paper *SBx7 Compliance for Agricultural Irrigation Districts*. This paper is included as Appendix E. As presented in this paper, the annual volumetric accuracy of an individual turnout depends on errors due to:

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

Because flows entering the Buena Vista system do not fluctuate rapidly and because of the District's internal operating practices, measurement of water deliveries is not affected by fluctuations in canal water levels, so the CWLF factor listed above does not influence the accuracy of measurement of seasonal water deliveries. In addition, because the duration of deliveries is accurately recorded, the impact of the ARD factor is negligible. Therefore, the CWLF and ARD factors need not be applied in adjusting measured flow rates to seasonal flow volumes.

Based on the formulas presented in the ITRC study, the population of District flow measurement devices selected for testing under Step 2 of the proposed compliance methodology will be evaluated to determine the accuracy of their seasonal volumetric measurement following the procedures noted in Step 3 of the proposed methodology and described in detail in Appendix E.

D. Legal Certification and Apportionment (Legal Access to the Farm Gates)

Buena Vista staff has legal access to install, measure, maintain, operate and monitor measurement devices and gates at all farm turnouts from the District's irrigation distribution system. In addition, with few exceptions, turnouts deliver water to single fields. Therefore 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.

E. Device Corrective Action Plan

Historically, Buena Vista has repaired or replaced gates and flow meters only when there was some obvious deficiency in their performance or when a water user questioned the accuracy of a meter. In the case of gated turnouts, the District has only repaired or reconstructed Armco (Waterman) gates if there was a deficiency in their performance due to damage. Buena Vista will continue the practice of repairing or replacing flow measurement devices that are observed to be performing poorly during the course of normal operations. As described above, the District will implement a program of turnout testing specifically designed to meet the requirements of SBx7-7. In addition to these activities, the District will continue its program of replacing all gated turnouts with flow meters.

Devices included in the sample to be tested under the SBx7-7 compliance program that are found to have measurement accuracies that depart by more than ±12 percent from volumes measured by a calibrated device will be repaired either on site (gate adjustments) or in the District's shop (flow meter repairs). If District staff is not able to correct the inaccuracy in flow measurement, the gate or meter will be replaced. As the District is now in the process of replacing gates with meters, gates found to require replacement will be replaced with flow meters. In addition, an aspect of implementation of the Northern Area Project is replacement of turnout gates on the existing canal with magnetic flow meters on the pipeline being installed as a water conservation measure to replace the canal.

After installation in the field, the accuracy of repaired turnouts will be verified using a calibrated device, and an affidavit will be submitted by a California-registered Professional Engineer certifying the accuracy of each repaired meter to be within SBx7-7 compliance. New flow meters will be laboratory certified by their manufacturer prior to installation to have an accuracy of measurement within ±6 percent by volume. Repair of gates or replacement of gates by flow meters and repair or replacement of flow meters will be completed within three years of approval of the SBx7-7 compliant testing program by DWR.

F. Farm Gate Measurement and Device Accuracy Compliance

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

Measurement Options at the Delivery Point or Farm Gate of a Single Customer

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

Initial Certification of Device Accuracy

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

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

Protocols for Field Testing

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

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

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

Buena Vista WSD Compliance Methodology

SBx7-7 offers the water supplier the opportunity to "develop its own sampling plan using an accepted statistical methodology". Buena Vista proposes to implement a five-year testing cycle. As noted above, the District is now implementing a program to replace all gated turnouts with meters so, as gates are phased out and the number of flow meters increases, the population of measuring devices to be tested under the District's program will shift accordingly. The sequence of steps proposed for the Buena Vista compliance methodology is outlined below. Before adopting this testing program, the District will confirm with DWR that the program satisfies the requirements of SBx7-7.

Step 1: *Formulate a list of flow measurement devices* together with the volume of water supplied by each turnout.

Step 2: *Select a sample population based on the methodology presented in the ITRC report* <u>SBx7Flow Rate Measurement Compliance for Agricultural Irrigation Districts</u> *that represents at least 10 percent of the total volume of water delivered through District turnouts*. Buena Vista proposes applying the Probability-Proportionate-to-Size methodology presented in the above-referenced ITRC report to select the population of measurement devices to be sampled. Once a particular device has been selected for inclusion in the sample, that device would be designated for testing and that device will be withdrawn from the pool available for future selection. This procedure will be followed until devices that represent at least10 percent of the volume of water delivered by Buena Vista are identified for testing.

Step 3: *Compare flow measurements taken by each device in the selected sample with measurements taken by calibrated flow meter*. Flow measurement devices at turnouts selected for testing in Step 2 will be evaluated by Buena Vista for accuracy and measured accuracy will be retained for ten years or two AWMP cycles as per §597.4(c).

Step 4: *Determination of compliance.* Buena Vista will estimate the annual volumetric accuracy of measurement of the selected sample of flow measurement devices. The District will expand their number of turnout samples if the accuracy is determined to be outside the limit imposed by SBx7-7 to determine the extent of any measurement issues. Non-compliant measurement devices will be repaired or replaced by the District as described above.

As noted previously, the volumetric accuracy of metered deliveries will correspond directly with accuracy of their measurement of flow rate. Therefore, there will be no need to convert the measurement accuracy of flows measured by flow meters to volumetric accuracy. In the case of gated deliveries included in the sample population, the accuracy of measurement of flow rate when compared with a calibrated flow meter will be converted to an accuracy of seasonal delivery volumes using the methodology presented in the section Flow Rate vs. Volumetric Accuracy of the ITRC paper referenced above and included in Appendix E.

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FEBRUARY 2016

BUENA VISTA WATER STORAGE DISTRICT

Agricultural Water Management Plan

APPENDICES

APPENDIX A Public Hearing Notice

PUBLIC HEARING NOTICE

Notice is hereby given that the Buena Vista Water Storage District (BVWSD) will hold a public hearing on:

December 16, 2015 at 9:30 AM

Regarding:

2015 Agricultural Water Management Plan

The Water Conservation Act of 2009 and the Governor's Executive Order B-29-15 require agricultural water agencies in California to prepare 2015 Agricultural Water Management Plans (2015 AgWMPs). To meet the requirements of this legislation and the Executive Order, BVWSD is preparing a 2015 AgWMP. The 2015 AgWMP includes a discussion of BVWSD and its irrigation facilities, water supply and demand, and various programs, policies and efficient water management practices being implemented now or planned in the coming years. The BVWSD Board of Directors will hold a hearing to consider public comments on the proposed 2015 AgWMP.

A copy of the 2015 AgWMP may be reviewed at the BVWSD office (525 North Main Street, Buttonwillow, CA). Written comments, submitted prior to the hearing, should be directed to:

Tim Ashlock
Buena Vista Water Storage District
P.O. Box 756
Buttonwillow, CA 93206

Comments may also be provided at the hearing.

If you have questions regarding the 2015 AgWMP, please contact Tim Ashlock at (661) 764-5510.

APPENDIX B Public Hearing Notification Letter

November __, 2015

County of Kern
Administrative Office
1115 Truxtun Avenue
5th Floor
Bakersfield, CA 93301 **Example address**

Dear Gentlemen,

RE: Buena Vista WSD Agricultural Water Management Plan – Public Hearing Notice

The Buena Vista Water Storage District (Buena Vista, District) is scheduled to hold a review and public comment period on the District's Agricultural Water Management Plan (AgWMP) from December 4, 2015 through December 16, 2015.

A Public Hearing is scheduled to be held at 9:30 AM on December 16, 2015 in the District's Board Room located at 525 North Main Street, Buttonwillow, CA. At the hearing, District staff will receive public comments on the draft AgWMP. The Buena Vista Board will consider adoption of the AgWMP at a Board meeting to be held at a later time. All persons interested in this matter should appear at the public hearing to comment, or submit written comments as described below.

The AgWMP includes a discussion of Buena Vista WSD and its irrigation facilities, water supply and demand, and various programs, policies and efficient water management practices, being implemented now or planned in the coming years. Copies of the draft plan are available for review at the District's office.

Any comments prior to the hearing should be submitted to:

> Tim Ashlock
> Buena Vista Water Storage District
> P.O. Box 756
> Buttonwillow, CA 93206

Any questions regarding the draft AgWMP or the adoption process should be directed to Tim Ashlock at (661) 764-5510 or tim@bvh2o.com.

Sincerely,

APPENDIX C Resolution of Plan Adoption

RESOLUTION NO. 4292

ADOPTING BUENA VISTA WATER STORAGE DISTRICT'S 2015 AGRICULTURAL WATER MANAGEMENT PLAN

WHEREAS, with the passage of the 2009 Water Conservation Act (Water Code Sections 10800, et seq. also known as SBx7-7 (the "Act")) and the issuance of the Governor's Executive Order B-29-15, certain Agricultural Water Suppliers are to prepare a 2015 Agricultural Management Plan, among other things, intended to encourage agricultural water suppliers to assess current efficient water management practices, to evaluate additional practices that may conserve water, to require accurate measurement of water, and to address drought response; and

WHEREAS, the District has prepared a 2015 Agricultural Water Management Plan pursuant to the guidelines that were issued by the California Department of Water Resources in June, 2015 to aid water suppliers in preparing 2015 Agricultural Water Management Plans in accordance with the requirements of the Act and of E.O. B-29-15.

WHEREAS, the District published notice of the availability of the Plan and of a hearing regarding same, and subsequently held a hearing on December 16, 2015 to hear and consider comments from the public on the Plan; and

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

NOW, THEREFORE, BE IT RESOLVED, that the Board of Directors of the Buena Vista Water Storage District does hereby approve and adopt the District's 2015 Agricultural Water Management Plan as presented and prepared in accordance with the Act and E.O. B-29-15.

Moved by Director Chicca, seconded by Director Wyrick, that the foregoing resolution be adopted.

The following vote was had:

Ayes:	Directors Vidovich, Chicca, Ritchie, Wyrick
Noes:	None
Absent:	Director Cauzza
Abstain:	None

The President declared the resolution adopted.

o0o

I, Jeof Wyrick, Secretary of the Board of Directors of the BUENA VISTA WATER STORAGE DISTRICT, do hereby CERTIFY that the foregoing is a full, true and correct copy of a resolution duly adopted at a meeting of said Board of Directors held the 17th day of February 2016.

Secretary of the Board of Directors
of the Buena Vista Water Storage District

APPENDIX D Rules and Regulations of the Buena Vista Water Storage District

PLEASE COMPLETE THIS INFORMATION

RECORDING REQUESTED BY:

WHEN RECORDED MAIL TO:

Buena Vista Water Storage Dist.
525 N. Main St
Buttonwillow CA 93206

James W. Fitch, Assessor – Recorder
Kern County Official Records

SOFIR
3/16/2012
9:06 AM

Recorded at the request of
Public

DOC#: **0212035531**

Stat Types: 1	Pages: 12
Fees	0.00
Taxes	0.00
Others	0.00
PAID	$0.00

THIS SPACE FOR RECORDER'S USE ONLY

THIS PAGE ADDED TO PROVIDE ADEQUATE SPACE FOR RECORDING INFORMATION
(Additional recording fee applies)

Resolution

RULES AND REGULATIONS
of the
BUENA VISTA WATER STORAGE DISTRICT

Adopted: March 8, 2011
Amended: March 13, 2012

Amended Resolution No. 4174

These Rules and Regulations are established by the Board of Directors pursuant to California Water Code section 43003 which provides, in pertinent part, that the District shall establish rules and regulations for the most economical and efficient distribution and use of water.

1. WATER SERVICE APPLICATIONS

Applications: In order to obtain delivery of water, the owner of lands (or their agent) and the tenant or lessee of lands, (hereinafter referred to as "Water User(s)") must complete, execute and file with the District, an "Application for Water Service" which shall include the name and addresses of the landowner, and tenant or lessee (tenant or lessee, being referred to collectively as “lessee” in these Rules and Regulations), a description of the land to be irrigated, authorization from landowner if a lessee is applying for service, and any other information required by the District. Application forms shall be provided by the District.

Land Transfers: When land is sold, a change of lessee occurs, or title is otherwise transferred to another party, the District shall be under no obligation to deliver water to such lands until a new "Application for Water Service" is properly completed and filed with the District.

Authority of Applicant: The District shall not be obligated to provide water service pursuant to any application for water service, or otherwise, unless and until District is provided, upon request, verification acceptable to the District that applicant has authority to bind the landowner and the lessee for charges associated with water deliveries by District and for any other charges or expenses associated with or authorized by these Rules and Regulations. Any such verification shall be in the form prescribed by District.

2. WATER ALLOCATION

The Board of Directors shall allocate supplies to lands within the District service areas (Buttonwillow and Maples) based on assessed acreage. The allocation amount, timing, and duration of water service shall be based upon a number of factors, including but not limited to water supply forecasts, available surface and groundwater storage, contract supplies, demand patterns, special project commitments, available or anticipated surplus supplies, system maintenance requirements, operational efficiencies, weather conditions, and any other factors deemed appropriate by the Board of Directors.

In any given calendar year, a Water User may, prior or subsequent to the District coordinated run, deliver up to 50% of the 90% Exceedance forecasted summer run allocation as such calculation is determined or approved by the Board of Directors. Said deliveries are not permitted if they will result in unreasonable water waste, and they will only be authorized if actual conveyance losses to the water-users headgate are less than 20% of the ordered amount. Said deliveries will be subject to District water supply restrictions, obligations, maintenance activities, access to facilities, conveyance losses (including actual delivery losses while running outside the coordinated run period plus an additional loss by which for every 85 AF delivered 100 AF will be deducted from the Water-User's allocated amount), any added operational costs, and all other Rules, Regulations, and policies of the District.

3. WATER USE

Any District water delivered to a District landowner or lessee ("Water User") within the District shall be used only within the District boundaries and only for irrigation or other direct land application purposes, unless otherwise permitted by these Rules and Regulations. District waters include, but are not limited to, Kern River Water, State Water Project (SWP) water, Friant-Kern Federal water, well water, storm water runoff, tailwater runoff, exchange water, transferred water, and other 3rd party waters acquired by the District.

Water furnished by the District is unfit for human consumption and may be unfit for purposes other than irrigation, and is not warranted by the District. The District hereby expressly disclaims any and all warranties, including merchantability, either express or implied, as to the fitness or suitability of water for any purpose whatsoever. The District does not represent, express or imply matters as to the integrity, availability, capacity, condition, quantity, quality or suitability of water or the District's facilities at any time for any purpose. Service interruptions, drought conditions and cropping demands are likely to occur whereby the Water User must maintain access to alternative supplies; damages, costs, or inconveniences caused by said interruptions shall be the sole responsibility of the Water User. The District reserves the right to interrupt service at any time and without notice for health and safety concerns or for other reasonable causes.

The District may sell and/or distribute water from its various water sources for any legal purpose, including sales and distributions to storage facilities and/or for special District projects or programs.

4. WATER-USE EFFECIENCY

The Water User shall endeavor to conduct efficient water management practices to eliminate unreasonable water waste and to exercise the beneficial use of water pursuant to

Article X, Section 2, of the California Constitution[1]. The District encourages Water Users to contribute in the development of District, Regional, and State water-use policies, and the cooperation of Water Users in such policies. Water Users shall comply with District, Regional, and State policies, rules, and regulations as may be required by law or these Rules and Regulations. Such policies, rules and regulations may include but are not limited to water use efficiency matters.

5. WATER ORDERS AND ADJUSTMENTS

Requests for irrigation service must be made to the appropriate District personnel (District Agent) at the office of the Buena Vista Water Storage District, 525 N. Main Street, Buttonwillow, Ca., 93206. All requests are taken subject to the following conditions:

a. Water Users shall give notice to the District Agent, at least forty-eight (48) hours in advance of requested date for new "on's" or increases to existing water orders.

b. Water Users shall give notice to the District Agent, at least twenty-four (24) hours in advance of a requested date for "off's" or decreases to existing water orders.

c. Water Users shall give notice to the District Agent, at least twenty-four (24) hours in advance of a requested date for "move's". Move's may be requested if it is within the same reach of the canal where service was originally provided. If the request is within a different reach or canal altogether it will be considered a new request and subject to item 5 (a) above.

d. All changes shall be made no later than 2 p.m. unless an emergency condition exists.

e. Requests for on's, off's and move's will be subject to District operations, capacity, supplies, and availability.

f. After a water delivery has been started, water users are not allowed to make any flow adjustments except as noted above or by notice/approval of the District Agent.

6. CAPACITY RESTRICTIONS

In the event of capacity restrictions, as determined by the District, the District will endeavor to prorate deliveries or delay new on's or changes until capacity issues have subsided. Proration's and delays among Water Users shall consider (1) a Water Users total assessed acres within a service area or specific system as appropriate, (2) timing of water

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[1] In part, Article X, Section 2 provides: "It is hereby declared that because of the conditions prevailing in this State the general welfare requires that the water resources of the State be put to beneficial use to the fullest extent of which they are capable, and that the waste or unreasonable use or unreasonable method of use of water be prevented, and that the conservation of such waters is to be exercised with a view to the reasonable and beneficial use thereof in the interest of the people and for the public welfare."

orders, (3) nature of restriction, and (4) any other equitable factors deemed appropriate by the District.

7. DRAINAGE FACILITIES

The District encourages on-farm tailwater collection systems as the most efficient re-use of tailwater. If this is not practical, landowner may, upon prior approval of District, deliver tailwater to the most practical District drainage system available. Water User's must appropriately manage field drainage and tailwater as to not damage, interfere with, or alter any of the District's facilities or their functions, including the District's drainage system. At no time is any unauthorized person allowed to make any modification to District's facilities. Under emergency conditions that require immediate modifications to District's facilities to prevent flooding or damage to a Water User's crops or facilities, the Water User is required to contact appropriate District personnel as early as possible to notify the District of the circumstances.

Water Users are encouraged to exercise best management practices in the areas of water use efficiency, pesticide and herbicide applications, nutrient management, and other areas that may impact water discharged into the District's drain system or the District's water supply. When required by State regulations, or as the District deems necessary or appropriate, the District will develop new or modify current policies to satisfy State or other regulatory mandates. Discharge policies set forth by the District are intended to help District Landowners and Water Users meet State and other regulatory requirements. As such regulatory requirements may change, District policies regarding the operation and use of drainage facilities may also change.

The District does not permit In-District or Out-of-District Landowners, District Water Users, or any other irrigated lands to drain storm water or tailwater into the District's water supply canals. All District irrigated lands should use a tailwater recovery system or provide facilities that will drain into an appropriate District drain. Filtration flush systems shall not drain filtration flush water into any of the District's water supply canals or right of ways (ROW's). Water from filtration flush systems may, upon appropriate District approval, be directed to District drainage facilities pursuant to the District's Encroachment Permit process.

The District will not typically provide, at District cost, additional drainage facilities in the case of land divisions or as a result of any landowner alterations. New drainage facilities may be considered by the District if the full costs are borne by the requesting landowner.

8. WATER SERVICE HEADGATES

The District will endeavor to provide a reasonable number of headgates and shall generally include an 18-24 inch standard gate (C-10 or District approved equal) and up to 30 feet of discharge pipe to an open landowner ditch. All connections made to headgate facilities are subject to appropriate District's prior approval and subsequent modification.

Any connections requiring unique designs, such as connections to private pipelines shall be the sole responsibility of the Water User. The Water User shall be responsible for any disconnects or re-connects associated with the District maintenance to the full satisfaction of the District. In no case shall the connection create more than 6 inches of back pressure on any District headgate without the appropriate District written approval.

The District will not typically provide, at District cost, additional headgates in the case of land divisions or as a result of any landowner alterations that may restrict delivery capacity or result in the need for another headgate. Additional headgates may be considered by the District if the full costs are borne by the requesting landowner. The District will not raise water to an excessive height in canals in order to provide service.

9. RECLAMATION PROGRAMS

The District operates various facilities and programs that are used for reclamation purposes, including 1) In-District Reclamation Canals and Pumps, 2) In-District Water User Reclamation programs, and 3) Out-of-District Reclamation agreements. In the event that demands for reclaimed water exceed available flows, the in District use demands will be prioritized over Out-of-District use demands. Water Users accessing the Reclamation Programs must recognize that said return flows occur in varying amounts, with varying quality, and at uncertain times.

10. PRIVATE DITCHES AND PIPELINES

The operation and maintenance of private ditches or laterals shall be the responsibility of those Water Users who use them. Such ditches or laterals must be kept in reasonable repair and reasonably free from weeds and other obstructions, and be of sufficient capacity to carry the quantity of water ordered by the Water User to irrigate the lands served by them. In the event that water is ordered in excess of the capacity of a private ditch or pipeline, the District may, but shall not be obligated to limit or terminate such delivery in order to prevent undue waste of water, flooding, or other damages until such conditions are remedied. In the event of breaks in private ditches or any other conditions on non-District owned property where it becomes necessary to cease delivery to the Water User and turn the water back into the District's canals, the District/ditchtender must be notified as soon as possible. The Water User will be responsible for any loss or damage caused by their turning a head of water back into the District's canal without prior notice to the ditchtender or the District Agent or for otherwise failing or refusing to accept ordered water. The Water User will be responsible for any loss or damage caused by their not using the full amount of water ordered by them, without prior notification to the District/ditchtender. Also, the Water User will be charged for the water ordered (or the allocation will be reduced) unless and until such time as the water can be rerouted.

11. TAMPERING OF DISTRICT FACILITIES

Manipulation, interference, or operation of District facilities is strictly forbidden by non-District personnel and may be a violation of California law. No fences, buildings, cuts, plugs, temporary storage, debris, garbage, gates, or any other obstructions shall be placed within District facilities or upon the right-of way of any District facility without prior authorization by the District. If it is necessary for the District to remove or remediate any such manipulation, damage, or obstruction, the Water User will be responsible for the costs of such repairs to the full satisfaction of the District.

12. ENCROACHMENT ON DISTRICT FACILITES

Anyone desiring to modify or encroach upon any District facility or Right of Way shall provide a detailed written request to the District Engineer. The request shall include a plat map indicating the location of the work to be performed, drawings, description of said work, and any additional information deemed necessary by the District. Upon review and approval by the District Engineer, the encroachment permit request and appropriate permits/documents, to allow such facility, will be presented to the Board of Directors for consideration. Any associated permit facilitation and inspection costs shall be recouped by the District from the Permittee, but may be waived in the sole discretion of the District for routine farming practices and where the Permittee owns the underlying fee ownership of the property being encroached upon. All cost of work performed under the provisions of the permit are the responsibilities of the Permittee and such work must be performed to the full satisfaction of the District Engineer and in accordance with any Encroachment Permit that is issued.

13. USE OF DISTRICT FACILITIES

All water conveyance uses of District facilities shall be subject to review and appropriate approval by the District and will be subject to applicable permits, wheeling rates, capacity constraints, losses, maintenance schedules, operational procedures, proper metering requirements, scheduling, water quality, groundwater conditions, and any other factor deemed relevant by the District. District facilities may be used to transport or exchange Water User well water in accordance with the above requirements and limitations, and the place of use is within the District. However, if it is asserted by a neighboring landowner that said practice has caused groundwater impacts, the District will investigate the claim and determine whether mitigation is warranted.

14. ACCESS TO PRIVATE PROPERTY

It is understood that District personnel must from time to time enter upon landowner's property with respect to the operation of the District's facilities and programs and it is understood that all Landowners shall provide such access to water meters, headgates, canals, ditches, and other District facilities.

15. IN-DISTRICT WATER TRANSFERS

Section 15.1. Definitions.

a. "District Lands" as used herein means real property lying within the boundaries of Buena Vista Water Storage District as those boundaries presently exist or as amended from time to time.

b. "District Water" as used herein means (i) water supplies and water rights which are owned, held or controlled by District and which are made available or allocated to District Lands, at any time or from time to time, by action of the Board of Directors; and (ii) return flows therefrom which enter District-owned facilities.

c. "Emergency" as used herein is any sudden, unforeseen event affecting a Water User's ability to meet his or her irrigation demands that cannot, with reasonable diligence, be remedied in time to avoid crop damage or property loss. Facility failure due to lack of normal and proper maintenance is not considered unforeseen and does not constitute an Emergency for purposes hereof.

d. "Water Service Right" as used herein means the right to receive an equitable, proportionate and pro-rata share of water accruing to the water rights owned, held or controlled by the District.

e. "Water User" as used herein means a person, entity or organization (regardless of name, if the principals are the same) irrigating District Lands for agricultural or other overlying purposes and exercising the Water Service Rights of such District Lands for such purposes.

f. "Fallow Lands" as used herein means any District Lands that are typically farmed but will not be planted and/or will not receive water during the given year's growing season or District Lands that are designated as upland habitat and will not receive water during the given calendar year.

Section 15.2 General Rule - Transfers Prohibited. The District owns, holds or controls certain water and water rights, arising by law and contract, which it exercises for the benefit of all District Lands. All District Lands are entitled to a Water Service Right. A Water User is entitled to exercise the Water Service Rights of District Lands solely for agricultural or other overlying purposes. If and to the extent the Water Service Right of certain District Lands is not exercised to the full extent of the water allocation by a Water User, the water not so used remains with the District for subsequent reallocation to all District Lands. Accordingly, it is the General Rule of this District that a Water User may not sell, transfer or convey District Water, within or without the District.

Section 15.3 Exceptions - Non-injurious Transfers. Transfers have the potential to affect or injure other Water Users and are, therefore, only allowed if special circumstances are present warranting a variance from the General Rule. However, certain transfers are allowed at any time and from time to time because the Board of Directors has determined that these operational water management practices are non-injurious to other landowners and provide needed flexibility, namely:

a. Transfer Within Farming Unit: a Water User may transfer Water Service Rights among District Lands within that Water User's farming unit operation. A "farming unit operation" for purposes of this exception means all District Lands which are owned or leased by the Water User making the transfer. The farming unit operation exception is considered a best management practice for Water Users since it allows each Water User to make the most efficient distribution and use of the Water Service Rights available to that Water User. The farming unit operation exception is considered non-injurious because the Water Service Rights of all District Lands within the farming unit are fully exercised by the Water User even though there may be a disproportionate reliance on groundwater supplies from one area to another. However, if it is asserted by a neighboring landowner that said practice has caused groundwater impacts, the District will investigate the claim and determine whether mitigation is warranted.

b. Transfer of Water Generated by Intentional Land Fallowing: a Water User who intentionally fallows District Lands may exercise the Water Service Rights of the fallowed lands for transfer to other Water Users. The land fallowing exception is considered a best management practice for Water Users since it encourages efficiency and avoids waste. The land fallowing exception is considered non-injurious because the Water Service Rights of the fallowed lands would have been exercised for the benefit of the fallowed lands in the absence of the transfer and there is no increased reliance on groundwater supplies. This policy also allows a Water User who fallows District Lands to recoup his or her costs, including District assessments.

c. Transfer of Reclaimed Water: certain Water Users have executed District Reclamation Agreements which allow such Water Users to purchase and use return flows from irrigation of District Lands which have entered District facilities. A Water User may transfer reclaimed water to another Water User or may rely more extensively on reclaimed water and transfer Water Service Rights that would otherwise have been exercised by such Water User. The reclaimed water exception is considered a best management practice for Water Users because it encourages, to the greatest extent practicable, the purchase and use of reclaimed water. The reclaimed water exception is considered non-injurious because the Water Service Rights of the transferor's District Lands would have been exercised for the benefit of such lands in the absence of the reclamation water use and there is no increased reliance on groundwater supplies.

d. Minor Transfers: any Water User may transfer to any other Water User up to 0.15 acre-foot per acre per year of Water Service Right water (i.e., 150 acre feet for each 1000 acres of District Lands). The minor transfer exception is considered a best management practice for Water Users because it provides limited but important flexibility in meeting water needs through groundwater pumping, borrow/payback and similar arrangements. The minor transfer exception is considered non-injurious because the Water Service Rights of the transferor's District Lands would have been exercised for the benefit of such lands in the absence of the transfer and because, even though there may be some increased reliance on groundwater supplies, such increased reliance is *de minimis*. However, if it is asserted by a neighboring landowner that said practice has caused groundwater impacts, the District will investigate the claim and determine whether mitigation is warranted.

Section 15.4 Emergency Transfers. For the duration of an Emergency the District will make every reasonable and prudent effort, including the authorization of Emergency transfers where necessary and appropriate, to provide the needed additional water service to any Water User if the additional water service is for the purpose of preventing crop loss or other damages that are likely to occur but for the additional water service. The District will require full payment of all fees and costs associated with obtaining and providing said additional water service, which payment may be in the form of cash or other consideration (such as future use of a landowner well for the benefit of all landowners) as determined by the Board of Directors.

Section 15.5 Restrictions Applicable to All Transfers. The following restrictions apply to all in-District transfers by and among Water Users:

a. Transfers may be accomplished directly (by direct delivery to the transferee via the District's water distribution system) or indirectly (by exchange delivery of District Water to the transferee). All transfers involving direct delivery are (i) subject to the availability of capacity in District's water distribution system (i.e., the use of the District's water distribution system to accommodate a transfer shall not interfere with the use of such system to meet the delivery demands of non-transferring Water Users); and (ii) subject to assessment of a minimum 10% loss factor or a pro rata share of losses in the conveyance facilities.

b. All transfers between and among Water Users are subject to review and approval by the Engineer-Manager of the District. All transfers that do not fall within the exceptions set forth in Section 3 above (including all Emergency transfers) are subject to review and approval by the Board of Directors of the District. No transfer will be approved, under any circumstances, if it results in waste or unreasonable use of District's water supply. No transfer will be approved if it negatively affects District operations and/or maintenance programs.

c. All transfers shall be not-for-profit, i.e., no money will change hands except reimbursement of the transferor's actual costs (including District assessments relating to the transferred water).

16. BILLINGS

Rates: Water rates, assessments, standby charges, equalization charges, and any other charges permitted by law shall be determined from time to time by the Board of Directors of the District.

Billing Addresses: Invoices for Services shall normally be mailed to the person designated in the application for water. Invoices for, or refunds of Assessments shall be mailed to the Landowner of Record as determined by the Kern County Assessor's Office. Payments to the District should be made at the District office, located at 525 North Main Street (P.O. Box 756), Buttonwillow, CA 93206.

Assessments: Assessment invoices must be paid within 30 days to avoid interest penalty. After expiration of the 30-day period, unpaid Assessments will be charged interest at the rate of 8% per annum pursuant to California Water Code Section 46671. An Assessment Account will be considered delinquent if not paid in full within 60 days of being levied. Delinquent Assessment Accounts will be assessed a 10% penalty on the delinquency date, together with accrued interest at the rate of 8% per annum until paid, pursuant to Section 46710 of the California Water Code.

Other Services: Other District invoices must be paid within 30 days to avoid being considered delinquent. Delinquent accounts will be charged a penalty of 10% of the amount delinquent, plus interest at the rate of 12% per annum until paid, pursuant to section 47182 of the California Water Code.

Delinquent Accounts: No water will be delivered nor will other services be provided to a Water User if their Assessment Account is delinquent or if any other account(s) are delinquent by more than 30 days.

17. ADMINISTRATION OF RULES AND REGULATIONS

Enforcement: The Engineer-Manager of the District shall be responsible for the enforcement of these Rules and Regulations. Nothing in these Rules and Regulations are intended to, nor shall have the effect of limiting any rights granted the District under any laws of the State of California. The failure or refusal to enforce any provision of these Rules and Regulations shall not constitute a waiver of the right to enforce any or all of the provisions contained herein at any subsequent time for the same violation or for any other. In administering these Rules and Regulations, the District will rely upon the Kern County Assessment Roll, last equalized, and upon District records regarding matters of title to land, addresses of landowners, authorizations, appointments, designations and the like filed with the District by a Water User. These records shall be considered continuing representations upon which the District is entitled to rely unless and until the District has received actual written notice of any changes from the Water User, the transferee, or the County of Kern. Refusal to comply with the requirements of any of the foregoing rules and regulations, or any interference with the discharge of the duties of any employee of the District shall be sufficient cause for terminating water service, and water will not be furnished until full compliance has been made with all requirements herein set forth.

Rule Modifications: These rules and regulations may be modified temporarily to meet special conditions at the discretion of the Board of Directors or by the Engineer-Manager who will notify the Board of any necessary or proposed variance from these Rules and Regulations at the next regularly scheduled Board of Directors Meeting. These Rules and

Regulations are also subject to change based upon District policies that may be adopted or amended from time to time.

I HEREBY CERTIFY that the foregoing is a true and correct copy of a resolution duly passed and amended by the Board of Directors of said District at a meeting held on the 13th day of March, 2012, and that said resolution has not be rescinded or modified in any manner.

WITNESS my hand and the official seal of said District the 15th day of March, 2012.

Angela Thompson
Angela Thompson
Assistant Secretary of the Board of Directors
Buena Vista Water Storage District

APPENDIX E SB7x7 Flow Rate Measurement for Agricultural Irrigation Districts

IRRIGATION
TRAINING &
RESEARCH
CENTER

SBx7 Flow Rate Measurement Compliance for Agricultural Irrigation Districts

SBx7 Compliance

Aug 26, 2012

IRRIGATION TRAINING & RESEARCH CENTER

Prepared by
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Disclaimer:

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Irrigation Training & Research Center
Updated October 2012

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GROUPED DELIVERIES

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

- Section 597.3(a) discusses measurement devices that must be used at points where there is a reasonable degree of flow rate control.
- Section 597.3(b) states that "An agricultural water supplier may measure water delivered at a location upstream of the delivery points or farm-gates of multiple customers using one of the measurement options described in §597.3(a) if the downstream individual customer's delivery points meet ***either*** of the following conditions:
  - A. The agricultural water supplier does not have legal access to the delivery points of individual customers or group of customers to install, measure, maintain, operate, and monitor a measurement device.

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

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

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

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

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

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

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

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

Conclusions

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

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

FLOW RATE VS. VOLUMETRIC ACCURACY

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

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

  Flow rate accuracy = Volumetric accuracy

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

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

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

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

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

Then,

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

VA = 92.7 = 93%

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

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

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

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

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

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

IMPACT OF CANAL WATER LEVEL CHANGES ON ANNUAL VOLUMETRIC ACCURACY

Background

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

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

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

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

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

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

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

Error Analysis

Water Level Error Model

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

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

Sample Set

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

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

Results

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

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

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

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

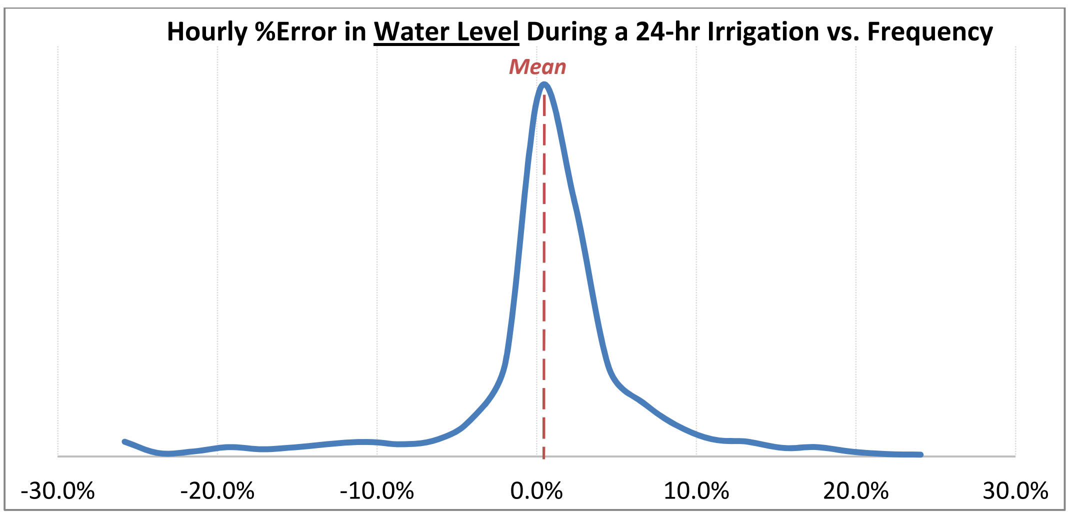


Figure 1. Sample distribution for hourly % error in water level vs. frequency

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

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

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

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

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

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

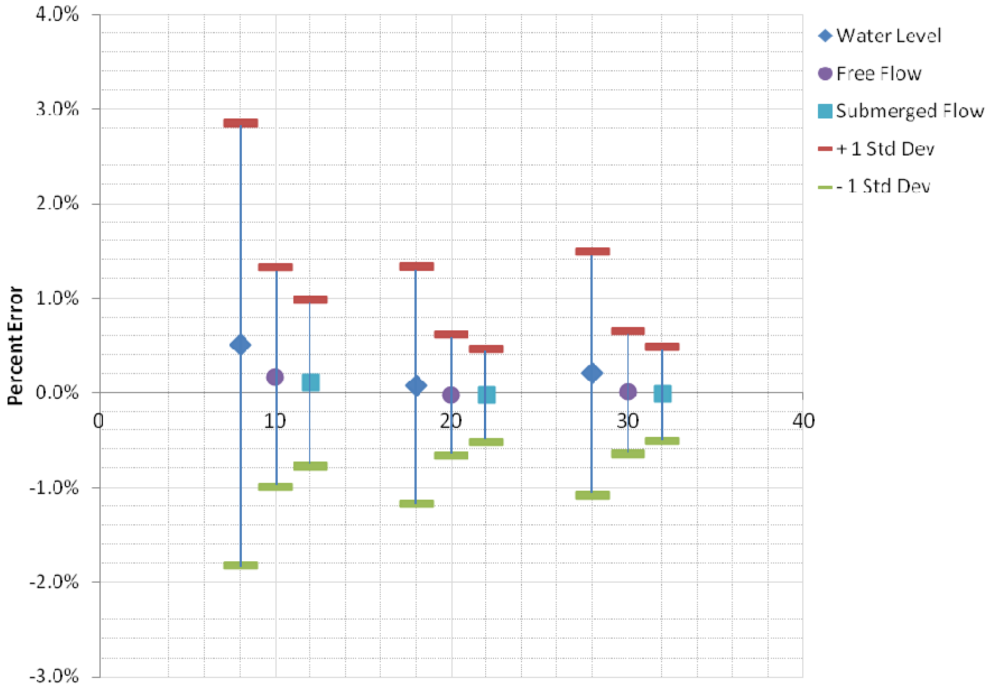


Figure 2. Means and standard deviations for each block

Conclusion

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

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

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

SELECTION OF A REPRESENTATIVE SAMPLE FOR VERIFICATION OF ACCURACY

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

Background

Representative Sample

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

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

Considerations for Availability

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

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

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

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

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

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

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

Background

Representative Sample Selection

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

Random Selection Process

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

Device Types

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

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

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

Step 1: Assign Sequence Range Numbers to Each Turnout

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

Table 1. Example of assigning sequence range numbers

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

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

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

Step 2: Use a Random Number Generator to Select Turnouts

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

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

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

Eliminate duplicate turnouts, starting from the first random number.

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

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

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

Table 2. Example of randomly selected sample set

Green rows indicate the selected devices for the sample set

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

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

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

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

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

Step 3: Evaluate Selected Turnouts and Record Data

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

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

Table 3. Sample data collection for selected turnouts

Red rows indicate devices that do not meet the required standard

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

Step 4: Determination of Compliance

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

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

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

Table 3. Sample data collection for selected turnouts

Red rows indicate devices that do not meet the required standard

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

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

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

Scenario 2: Limited Availability of Turnouts and Opportunity Sampling

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

Background

Representative Sample Selection

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

Selection Process

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

Step 1: Choose a Currently Available Turnout

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

Table 4. Device selection on two separate days

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

Day 1

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

Day 2

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

Continue testing devices until the following criteria have been met:

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

Steps 2-4 : Follow the Previous Scenario Instructions

FLOW MEASUREMENT DEVICES

Background

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

Meter Gates

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

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

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

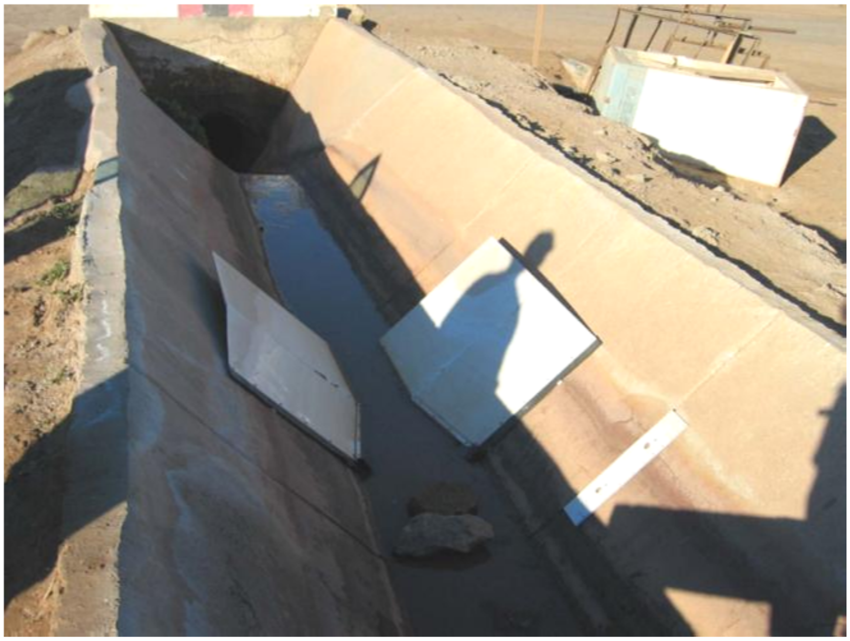


Figure 3. Side contractions rather than a traditional "Replogle Flume". Designed by USBR, Yuma. The rocks are not part of the design.

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

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

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

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

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

Orifice Plates

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

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

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

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

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

Where:

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

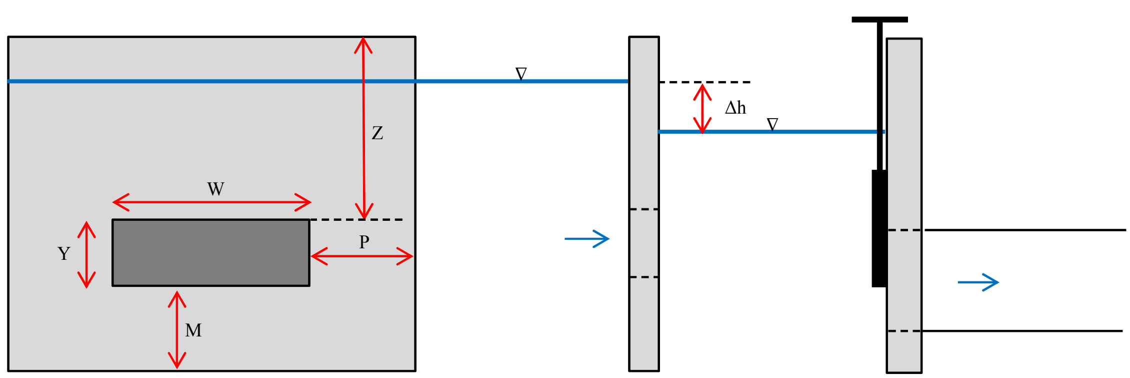


Figure 4. Flow through a submerged orifice plate

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

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

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

Typical problems include:

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

W/Y	1	2	4
Cd	0.63	0.64	0.65

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

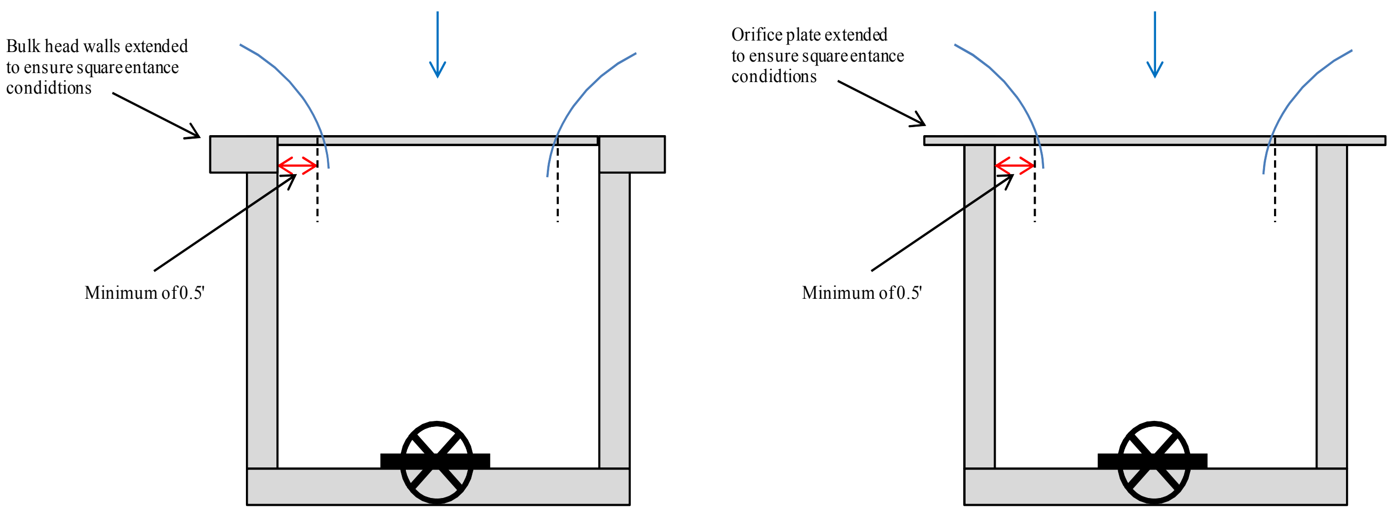


Figure 5. Installation of orifice

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

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

Table 5. Orifice size values

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

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

Table 5 (continued). Orifice size values

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

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

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

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

Trash Shedding Propeller Meters

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

Mc® Propeller

CONFIGURATION SHEET

MODEL M0300SW

REVERSE BOLT-ON SADDLE SURFACE WATER FLOWMETER

DESCRIPTION

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

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

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

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

INSTALLATION

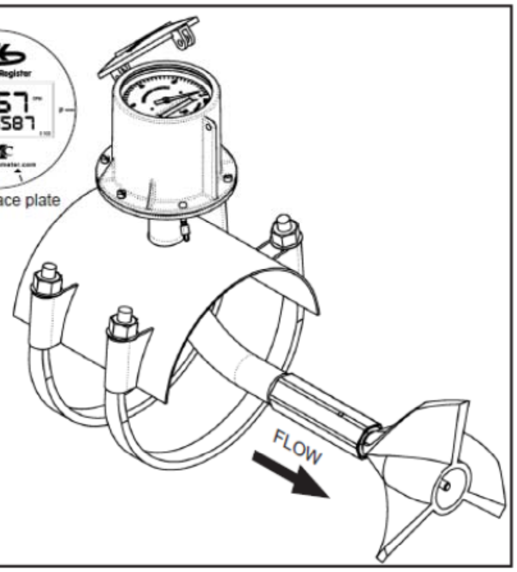
Standard installation is horizontal mount. If the meter is to be mounted in the vertical position, please advise the factory. A straight run of full pipe the length of eight pipe diameters upstream and five diameters downstream of the meter is recommended for meters without straightening vanes. Meters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

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

Typical face plate

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

Typical face plate



APPLICATIONS

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

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

MC Propeller

CONFIGURATION SHEET

MODEL M1700 — OPEN FLOWMETER

DESCRIPTION

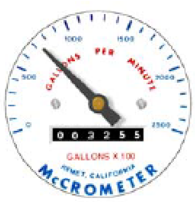
Model M1700 Open Flowmeters are designed to measure the flow in canal outlets, discharge and inlet pipes, irrigation turnouts and other similar installations. The M1700 series meets or exceeds the American Water Works Association Standard C704-02. Constructed of stainless steel, the meter incorporates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

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

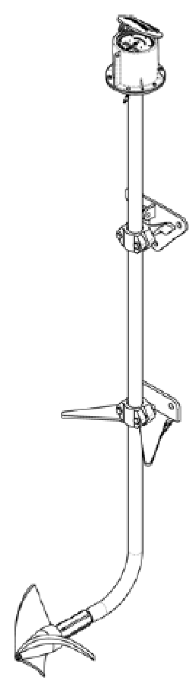
An instantaneous flowrate indicator is standard and available in gallons per minute, cubic feet per second, liters per second and other units. The register is driven by a flexible steel cable encased within a protective, self-lubricating vinyl liner. The die-cast aluminum register housing protects both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

INSTALLATION

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



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



APPLICATIONS

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

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

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

Rubicon Transit Time Flow Meter

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

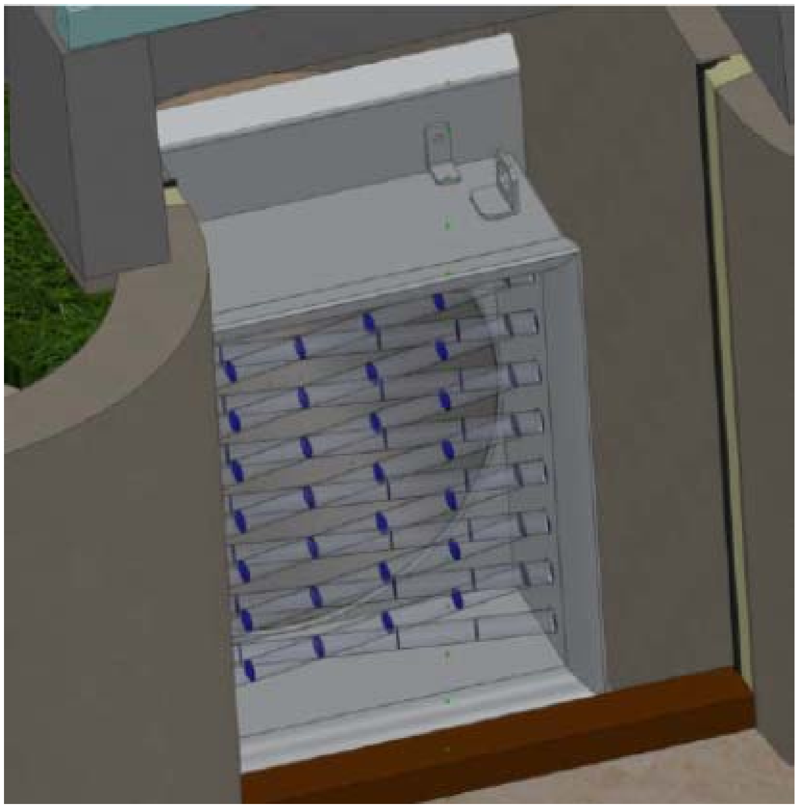


Figure 6. Rubicon Sonaray flow meter

BUENA VISTA WATER

BVWSD

STORAGE DISTRICT