Reclamation District No. 108

SBx7-7 Water Measurement Compliance Program

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Reclamation District No. 108

SBx7-7 Water Measurement Compliance Program

PURPOSE

This SBx7-7 Water Measurement Compliance Program (Program) has been developed and implemented by Reclamation District No. 108 (RD 108 or District) to comply with the requirements of Water Code Section 10608.48 (WC §10608.48) and the Agricultural Water Measurement Regulation, CCR §597. The Program has become a component of the District’s Agricultural Water Management Plan. Specifically, the Program outlines how the Company has addressed the Efficient Water Management Practices (EWMPs) identified in WC §10608.48.

WC §10608.48(a) states that agricultural water suppliers “shall implement efficient water management practices pursuant to subdivisions (b) and (c).” Subdivision (b) identifies the following two “critical efficient water management practices:

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

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

Subdivision (c) identifies several “additional” EWMPs that are to be implemented by agricultural water suppliers “if the measures are locally cost effective and technically feasible.” Both the Critical and Additional EWMPs are discussed below.

CRITICAL EFFICIENT WATER MANAGEMENT PRACTICES

California Code of Regulations (CCR) §597, approved on July 11, 2012, defines how agriculture suppliers comply with WC § 10608.48(b)(1). The District currently measures its deliveries to all customers and believes it is in compliance with the provisions of Section 10608.48(b)(1) and the measurement accuracy provisions of CCR §597. The District’s water delivery measurements and certification are described below.

A. Water Delivery Measurement

The District invested time and money to perform significant pilot projects to determine how measurement compliance could be achieved in the District. Three measurement methods, an orifice gate, a weir box, and the RemoteTracker (a portable velocity sensor). The results of the studies were clear. The use of a velocity measurement device provided consistently accurate measurements that would meet the State regulation. This RemoteTracker reduced the impacts
from the challenging low head and extreme high flow conditions. As a result, RD 108 proceeded with implementation of turnout measurement using the RemoteTracker system, a wirelessly controlled acoustic Doppler velocity sensor. To fund the measurement program, RD 108 held an election in accordance with Proposition 218 to approve a special assessment under which the landowners paid the costs to implement the measurement program.

In order to implement the measurement program, the District modified all 600 field turnouts and pump discharges to provide turnout measurement that meets the accuracy standards required by the State regulation. This included the addition of a concrete weir box on all field turnouts and either a weir box, or if not possible, installation of a flow meter on each lift pump. In order to accomplish this, the District hired additional staff to help assemble an installation crew. The general box installation included removing any existing end of turnout structure, excavating the location for the new box to be placed, cutting the end of pipe as necessary, removing sediment from pipe, placing base rock foundation for the new box, grouting the box to the end of pipe, placing boards in box up to field elevation and backfilling around the box. Each box was then equipped with a properly located bracket to position the portable measurement device. Approximately $650,000 was spent on the boxes, meters, and equipment. Labor costs associated with the program were an additional $180,000.

District watermen use these portable acoustic Doppler flow meters to take point measurements whenever the flow through the field turnout is changed. This information is then transferred via Bluetooth to a ruggedized tablet PC in the operator’s vehicle and used to calculate the volume of water delivered over time. The information is automatically transferred through wireless technology to a server in the District office where quality control, monthly reporting and billing is performed. Finally, the district has developed a tool that allows all landowners to access this data in real time to help them manage their water usage. The costs for the hardware, software, general engineering, and general legal were approximately $485,000.

The capital improvements and data management processes were completed prior to the 2016 irrigation season as the regulation requires and the measurement program has been fully implemented during the 2016 season. The approximant total cost implement the measurement program is $1,315,000 to date.

B. Accuracy Certification

RD 108 performed field verification of the device with five comparison measurements between the RemoteTracker and an USGS mid-section method measurement performed with a SonTek ADV. The results indicated that the RemoteTracker measurement methodology compared very well with the standard mid-section open channel methodology. In addition, the acoustic doppler sensor was lab tested and certified at the California State University Chico Agricultural Teaching and Research Center (CSUC ATRC) in July of 2012. Seven measurements obtained from the RemoteTracker were compared to measurements taken with a 10” magnetic flow meter manufactured by Water Specialties. The measurements compared very well with the magnetic meter and showed that the RemoteTracker can meet the accuracy requirements of the regulation. As required under CCR §594.4, the results of the certification program are enclosed as Exhibit 1, the RemoteTracker Volumetric Accuracy
Certification further describes the results from the laboratory testing that support compliance with regulations.

C. Pricing Structure

The District worked with landowners and water users through a series of meetings to develop a new rate structure during 2015. During 2015 the District was also able to gather data at all of the completed measurement locations. This data was combined with billing proposals to help the water users and District arrive at a water rate structure proposal for a Prop 218 election that was approved by the voters prior to the 2016 irrigation season. The District’s Board considered and adopted pricing policy based in part on the measured volume delivered to customers in accordance with Water Code Section 10608.48(b)(2). The pricing consists of three equal revenue components: 1) a fixed acreage charge, 2) a crop based estimated volume charge and 3) an actual measured volumetric charge. The District required water deliveries to collect $3,000,000 total in revenue, so each of these components was designed to collect $1,000,000 each. The acreage component is a rate equal to the $1,000,000 divided by the irrigated acreage. The crop based volumetric approach weights each farmed acre by the applied water necessary for that crop and then proportions the $1,000,000 based on that weighted water use, and the last component is a per acre foot rate required to collect $1,000,000 based on the District’s average annual farm turnout deliveries. Attached as Exhibit 2 is the District’s Prop 218 memorandum, Report Detailing the Cost of Service that was distributed to the landowners which describes the rates in greater detail.

ADDITIONAL EFFICIENT WATER MANAGEMENT PRACTICES

In addition to the critical EWMPs discussed above, Water Code § 10608.48(c) identifies additional EWMPs which are to be implemented if the measures are locally cost effective and technically feasible. These additional EWMPs are referred to in DWR’s AWMP Guidebook as Conditional EWMPs.

The District has evaluated many of the Conditional EWMPs as part of the 2007 RWMP and its updates through addressing the targeted benefits (TBs) and quantifiable objective (QOs). The District may further address Conditional EWMPs at a future date.
EXHIBIT 1

REMO TETRACKER VOLUMETRIC ACCURACY CERTIFICATION
Reclamation District No. 108

RemoteTracker Volumetric Accuracy Certification

Colusa and Yolo Counties, California

Prepared by

DAVIDS
ENGINEERING, INC

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Abbreviations

%  Percent
AF  acre-feet
Avg  Average
CCR  California Code of Regulations
cfs  cubic feet per second
DEL  Delivery
DWR  California Department of Water Resources
ft  feet/foot
ft/s  feet per second
gpm  gallons per minute
GT  Gate
Max  Maximum
Min  Minimum
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A-1.0 Introduction and Summary

This document (1) provides an overview of the RemoteTracker system (Section A-2.0), (2) presents results of initial laboratory and field testing (Section A-3.0) and (3) develops a volumetric accuracy analysis to support compliance of RemoteTracker system with California Code of Regulations Title 23 Division 2 Chapter 5.1 Article 2 Section 597 (CCR 23 §597) (Section A-4.0). Based on the analysis in Section A.3, the expected accuracy in volumetric measurements performed with the RemoteTracker system is ±4.6 percent. Because the RemoteTracker system utilizes a laboratory certified acoustic doppler velocimeter manufactured by SonTek to measure water velocity, the ±5 percent by volume laboratory certification option presented in CCR 23 §597.3(a)(2)(B) applies. Thus, the demonstrated accuracy of the RemoteTracker complies with the ±5 percent by laboratory certification standard. Documentation of the protocols associated with the measurement of the cross-section flow area and duration of delivery, as required by §597.4(e)(3)(B), is presented in Section A-4.0.

A-2.0 RemoteTracker System Overview

The RemoteTracker is an integrated turnout flow measurement, data management and volumetric accounting system developed by H2oTech\(^1\) specifically for agricultural water suppliers in response to CCR 23 §597. The RemoteTracker system is comprised of (1) a wirelessly controlled water velocity sensor, (2) a ruggedized tablet PC in the operator's vehicle and (3) a database running on a file server connected to the internet. The user interface on the tablet PC enables operators to view real time flow data from the wirelessly controlled water velocity sensor via a Bluetooth radio connection while adjusting flows at the turnout gate. Data is automatically transferred over a wireless wide area network (WWAN) to a centralized file server at the District headquarters where it is automatically loaded into a custom database application. The database performs quality control and quality assurance procedures on the data and then develops daily volumes for each customer delivery point (turnout or delivery) within the District.

The wireless water velocity sensor (WWVS) is held in place at a precise location at the pipe outlet by an aluminum or stainless steel mounting bracket. The user interface, shown in Figure A-1, was designed with simplicity and ease of use in mind. If ‘Auto Locate’ is selected, the program automatically populates the three site identification pull-downs at the top of the screen. If the operator needs to select a different site, the pull-downs can be manually changed. The site selection hierarchy is a three digit abbreviation of ‘Operator Route’ (i.e. ride, beat or division) on the left, a three digit abbreviation of ‘Canal’ in the middle and site name on the right. The most recently measured flow, and any pending orders are shown on the ‘Home’ tab. Many useful reports, including (1) Delivery History, (2) Pending Orders, (3) Fulfilled Orders and (4) Canal Management are available on the ‘Reports’ tab. These reports can be sorted at any spatial or temporal scale. The data sharing and management framework allows water order and delivery data collected by any operator to be automatically available for viewing by other operators or management staff in a matter of minutes.

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\(^1\) H2oTech is a company based in Chico, California that focuses on the development of innovative technologies to solve water management challenges.
The basic components of the RemoteTracker system are illustrated in Figure A-2. Water velocity is collected by a portable acoustic Doppler velocimeter deployed during measurement by hanging it on brackets permanently installed at each turnout. The brackets are precisely positioned such that the sample volume is at the center of the pipe. Data is transmitted via a class 1 Bluetooth radio to a ruggedized tablet PC where it is processed, displayed and stored. Data is then transferred via a WWAN to a file server at the District headquarters. Data from each operator is aggregated with an automated database procedure and then returned to each operator via WWAN, thereby ensuring that delivery and order data is shared and accessible throughout the entire District.
RemoteTracker® Principles of Operation Diagram

Class I (330 foot range minimum) Bluetooth wireless communication between computer and water velocity sensor.

Ruggedized computer mounted in operator vehicle acts as windows platform for user interface, sensor hub and safe storage for logged measurement data.

Global Positioning System (GPS) for self-location and site selection

Automated transfer of data from remotes via WWAN to District data server. Combined data transferred back to remotes.

Operator deploys wirelessly controlled water velocity sensor in preinstalled mounting bracket at delivery outfall.

District data server stores farm-gate delivery measurement data (either custom developed or off-the-shelf database application).

* Patent Pending

Figure A-2. RemoteTracker Principles of Operation Overview
The key to pipe flow measurement using the RemoteTracker is the consistent relationship between a single velocity measurement at the center of the pipe and the average pipe flow velocity shown in Figure A-3 derived from 146 measurements of center and mean pipe velocity. Based on this relationship, with the pipe diameter and cross sectional area known, the single point velocity can be accurately and reliably correlated with mean pipe velocity (flow rate).

![Figure A-3. Relationship between Average and Center Point Pipe Flow Velocity](image)

As with weir and orifice gate measurement, full pipe flow is required for the RemoteTracker to measure correctly. Therefore, a weir box is needed at each turnout to ensure full pipe flow as well as to accommodate the mounting bracket to hold the wireless water velocity sensor so that the sample volume is at the center of the pipe.

The RemoteTracker system can also be integrated with existing or new data management systems at the District office for report generation, accounting and billing. This capability can be added later to provide additional efficiencies in water billing and accounting procedures.
A-3.0 Initial Testing Results

A-3.1 Laboratory Testing

Additional testing was performed at the California State University Chico Agricultural Teaching and Research Center (CSUC ATRC) in July of 2012. Flow data obtained from the RemoteTracker was compared to measurements taken with a 10-inch diameter magnetic flow meter manufactured by Water Specialties. Figure A-4 shows the Water Specialties Magnetic meter with an Endress & Hauser Transit-Time Meter installed just upstream as an additional check. The 3 foot wide by 3 foot deep concrete flume was modified to simulate a typical delivery configuration by forcing all the flow through a 20 foot length of 18 inch HDPE smooth interior wall pipe submerged in the concrete flume. The RemoteTracker wireless water velocity sensor was installed at the pipe outfall using a temporarily constructed headwall with a mounting bracket as shown in Figure A-5.

![Figure A-4. Water Specialties Magnetic Flow Meter at CSUC ATRC](image-url)
Seven comparison measurements were made between the RemoteTracker and magnetic meter ranging from 0.5 cfs to just over 3.0 cfs (the maximum pump capacity). The percent difference between the two measurements averaged roughly -2.6 percent with a range of -10.2 to 2.8 percent indicating that the RemoteTracker measurement methodology compares very well with the magnetic meter. Note that the -10.2 percent difference occurred at the lowest flow rate of approximately 0.5 cfs and represents an absolute flow rate difference of just 0.05 cfs between the two measurement methods. The results of the comparison measurements are presented in Figure A-6 where the blue bars represent flow rates obtained with a magnetic meter, the red bars represent flow rates obtained with the RemoteTracker and the green triangles represent the percent difference between the two (secondary vertical axis).
Figure A-6. RemoteTracker and CSUC ATRC Magmeter Comparisons

Note:
Flow measurement comparison data obtained at the CSU Chico ATRC flume facility on 7/9/12.
A-3.2 Field Testing

Five comparison measurements between the RemoteTracker and USGS mid-section method measurements with a SonTek ADV were performed at two turnouts in two irrigation districts (one turnout in each District) in Northern California during the 2011 irrigation season. The turnouts were selected because the delivery spilled into a field ditch (or head ditch) rather than a field, so both a RemoteTracker and a USGS mid-section method measurement (Rantz 1982) could be taken and compared. Figure A-7 shows the cross section report for one of the measurements in a typical earthen head ditch, in this case with a maximum depth of 2.5 feet, top width of 14 feet and bottom width of 5 feet. Typically, velocity measurements were performed at 0.5 foot intervals with velocities averaged over a 40 second period.

![Figure A-7. SonTek ADV Cross Section for Canal Verification Measurement](image)

The percent difference between the RemoteTracker and the USGS mid-section method averaged roughly 0.9 percent with a range of -0.8 to 3.4 percent, indicating that the RemoteTracker measurement methodology compares very well with the standard mid-section open channel methodology. The results of the comparison measurements are presented below in Figure A-8 where the blue bars represent flow rates obtained with a SonTek ADV in an open channel downstream of the turnout, the red bars represent flow rates obtained with the RemoteTracker and the green triangles represent the percent difference between the two (secondary vertical axis).
Figure A-8. RemoteTracker and Mid-Section method Comparisons

Note:
Flow measurement comparison data obtained on 7/19/11 and 8/5/11 at BWGWD and RD respectively.

Average Percent Difference: 0.9%
A-4.0 Volumetric Conversion (CCR 23 §597.4 (e) (3))

Accuracy requirements established by CCR 23 §597 apply to delivery volume and not instantaneous flow rate or velocity. CCR 23 §597.4(e)(3)(B) states, “For devices that measure velocity only, the documentation shall describe protocols associated with the measurement of the cross-sectional area of flow and duration of water delivery...”. This document provides descriptions of the protocols associated with the measurement of (1) average velocity, (2) cross-sectional area of flow and (3) duration of delivery, in addition to the corresponding accuracies associated with each measurement.

Because the RemoteTracker WWVS measures water velocity only, Equation A-1 suggested in CCR 23 597.4(e)(3)(B) is used to calculate volume.

\[ \forall = V \times A \times \Delta t \]  
(Equation A-1)

Where the variables are defined as:

- \( \forall \): Volume
- \( V \): Average Velocity
- \( A \): Cross-Section Flow Area
- \( \Delta t \): Duration of Delivery

This relative accuracy analysis assumes:

- 3 cubic foot per second (cfs) maintenance delivery
- A 24 inch inner diameter delivery pipe
- Normal distribution of measurement errors

A 3 cfs delivery was selected because it represents the lower range of agricultural water delivery rates and accuracy is harder to achieve at low flows. A 24 inch pipe is the average turnout pipe size within most agricultural districts. These assumptions lead to the listed variables having the values presented below.

- \( V_{RT} \) = RemoteTracker Velocity Measurement = 1.00 ft/s
- \( V_{Avg} \) = Average Velocity of the pipe at the time of the RemoteTracker spot measurement = 0.95 ft/s (determined by correlation with measured velocity; see Figure A-3)
- \( D \) = Pipe Diameter = 2.00 ft
- \( A \) = Cross-Section Flow Area = 3.14 ft^2

Based on the following analysis, the expected accuracy in volumetric measurements performed with the RemoteTracker system is ±4.6 percent.
**A-4.1 Volumetric Accuracy Analysis Overview**

Volumetric accuracy of water deliveries consists of the accuracies in each of the following three components:

- Average Velocity ($V_{Avg}$)
- Cross-Section Flow Area ($A$)
- Duration of Delivery ($\Delta t$)

The total absolute accuracy is found using the following equation;

$$
\sigma_V = \pm \sqrt{\left(\frac{\partial V}{\partial V_{Avg}} \sigma_{V_{Avg}}\right)^2 + \left(\frac{\partial V}{\partial A} \sigma_A\right)^2 + \left(\frac{\partial V}{\partial \Delta t} \sigma_{\Delta t}\right)^2}
$$  \hspace{2cm} (Equation A-2)

Where the variables are defined as:

- $V$: Volume
- $V_{Avg}$: Average Velocity
- $\Delta t$: Duration of Delivery
- $\sigma$: Absolute Accuracy (expressed in the units of the term in question)
- $U$: Relative Accuracy (expressed as a percentage)

The total relative accuracy is:

$$
U_V = \frac{\sigma_V}{V} = \pm \frac{1}{V} \sqrt{\left(\frac{\partial V}{\partial V_{Avg}} \sigma_{V_{Avg}}\right)^2 + \left(\frac{\partial V}{\partial A} \sigma_A\right)^2 + \left(\frac{\partial V}{\partial \Delta t} \sigma_{\Delta t}\right)^2}
$$  \hspace{2cm} (Equation A-3)

Where the partial derivatives are:

$$
\frac{\partial V}{\partial V_{Avg}} = A \Delta t, \quad \frac{\partial V}{\partial A} = V_{Avg} \Delta t, \quad \frac{\partial V}{\partial \Delta t} = V_{Avg} A
$$

Substituting in the solutions to the partial derivatives:

$$
U_V = \pm \frac{1}{\sqrt{V}} \left(\frac{\Delta t \sigma_{V_{Avg}}}{V_{Avg}} + (V_{Avg} \Delta t \sigma_A)^2 + (V_{Avg} A \sigma_{\Delta t})^2\right)
$$
\[
U_v = \pm \sqrt{\left(\frac{A \Delta t \sigma_{V \text{Avg}}}{V}\right)^2 + \left(\frac{V_{\text{Avg}} A \sigma_{\Delta A}}{V}\right)^2 + \left(\frac{V_{\text{Avg}} A \sigma_{\Delta t}}{V}\right)^2}
\]

\[
U_v = \pm \sqrt{\left(\frac{\sigma_{V \text{Avg}}}{V_{\text{Avg}}}\right)^2 + \left(\frac{\sigma_{\Delta A}}{A}\right)^2 + \left(\frac{\sigma_{\Delta t}}{\Delta t}\right)^2}
\]

This becomes:

\[
U_v = \pm \sqrt{\left(U_{V \text{Avg}}\right)^2 + (U_{\Delta A})^2 + (U_{\Delta t})^2}
\]

(Equation A-4)

Based on Equation A-4, the relative accuracies of Average Velocity, Cross-Section Flow Area, and Duration of Delivery are required. The following sections detail their determination.

### A-4.2 Relative Accuracy in Velocity

The following bullet points provide protocols for the collection of water velocity data.

- The RemoteTracker WWVS will be deployed in the delivery pipe outfall so that the sample volume is located in the center of the delivery pipe.
- Water velocities will be collected with the RemoteTracker WWVS at:
  - The start of all delivery events
  - After any changes in delivery events
- Shutoffs will be recorded on the RemoteTracker user interface with the “Record Shutoff” button at the time the gate is closed.

The accuracies in average velocity consist of three parts:

1. \(\sigma_{V_{RT}}\): Accuracy of RemoteTracker velocity measurements
2. \(\sigma_{V_{\text{Avg}}}\): Accuracy due to the process of correlating RemoteTracker velocity measured at the pipe center and the average velocity of the pipe at the time of the RemoteTracker spot measurement \(^2\)
3. \(\sigma_{\Delta V_{\text{RT}}}\): Accuracy due to the difference between the average velocity at the time of the RemoteTracker spot measurement and the actual average velocity for the duration of the delivery (i.e. change in velocity over time)

The average velocity relative accuracy is:

\(^2\) Average velocity at the time of the RemoteTracker spot measurement represents a snapshot of the average water velocity in a delivery pipe at the time of the RemoteTracker measurement.
\[ U_{V_{\text{Avg}}} = \pm \frac{\sigma_{V_{\text{Avg}}}}{V_{\text{Avg}}} \]  

(Equation A-5)

Where the variables are defined as:

- \( V_{\text{Avg}} \): Average Velocity
- \( U_{V_{\text{Avg}}} \): Relative Velocity Accuracy
- \( \sigma_{V_{\text{Avg}}} \): Absolute Velocity Accuracy

The average velocity of the entire irrigation event is the summation of the average velocity at the time of observation and the average change in velocity throughout the remainder of the event due to water level fluctuations.

\[ V_{\text{Avg}} = V_{\text{Avg}*} + \Delta V_T \]  

(Equation A-6)

Where the variables are defined as:

- \( V_{\text{Avg}} \): Average Velocity
- \( V_{\text{Avg}*} \): Average Velocity at the time of the RemoteTracker spot measurement
- \( \Delta V_T \): Average Change in Velocity over time

Therefore:

\[ \sigma_{V_{\text{Avg}}} = \pm \sqrt{\left( \frac{\partial V_{\text{Avg}}}{\partial V_{\text{Avg}*}} \sigma_{V_{\text{Avg}*}} \right)^2 + \left( \frac{\partial V_{\text{Avg}}}{\partial \Delta V_T} \sigma_{\Delta V_T} \right)^2} \]  

(Equation A-7)

Where the partial derivatives are:

\[ \frac{\partial V_{\text{Avg}}}{\partial V_{\text{Avg}*}} = 1, \quad \frac{\partial V_{\text{Avg}}}{\partial \Delta V_T} = 1 \]

Substituting in the solutions to the partial derivatives:

\[ \sigma_{V_{\text{Avg}}} = \pm \sqrt{\left( \sigma_{V_{\text{Avg}*}} \right)^2 + \left( \sigma_{\Delta V_T} \right)^2} \]  

(Equation A-8)

The following subsections present (1) the accuracy of the RemoteTracker velocity measurements, (2) the accuracy of the average velocity at the time of the RemoteTracker spot measurements (\( \sigma_{V_{\text{Avg}*}} \)) and (3) the accuracy in the change in average velocity over time (\( \sigma_{\Delta V_T} \)).
A-4.2.1 Accuracy of RemoteTracker Velocity Measurement

The RemoteTracker system uses a SonTek ADV for water velocity measurements. The SonTek ADV technical specifications sheet lists a velocity measurement error of 0.01 or 1.0% (SonTek 2006). Therefore, $\sigma_{V_{RT}}$ is equal to 0.010 ft/s, or 1.0% of 1.00 ft/s ($V_D$).

A-4.2.2 Accuracy of the Average Velocity at the Time of the RemoteTracker Spot Measurement

The average velocity is computed as the product of the velocity measured by the RemoteTracker and the coefficient correlating the RemoteTracker velocity measurement to the average velocity at the time of the RemoteTracker spot measurement.

$$V_{Avg}^* = CV_{RT}$$

(Equation A-9)

Where the variables are defined as:

- $V_{Avg}^*$: Average velocity at the time of the RemoteTracker spot measurement
- $C$: Coefficient correlating the RemoteTracker velocity measurement to the average velocity at the time of the RemoteTracker spot measurement, which is equal to 0.95 (see Figure A-3)
- $V_{RT}$: RemoteTracker velocity measurement

Therefore:

$$\sigma_{V_{Avg}^*} = \pm \sqrt{(\frac{\partial V_{Avg}^*}{\partial C} \sigma_C)^2 + (\frac{\partial V_{Avg}^*}{\partial V_{RT}} \sigma_{V_{RT}})^2}$$

(Equation A-10)

Where the partial derivatives are:

$$\frac{\partial V_{Avg}^*}{\partial C} = V_{RT}, \frac{\partial V_{Avg}^*}{\partial V_{RT}} = C$$

Substituting in the solutions to the partial derivatives:

$$\sigma_{V_{Avg}^*} = \pm \sqrt{(V_{RT} \sigma_C)^2 + (C \sigma_{V_{RT}})^2}$$

(Equation A-11)

Based on water velocity data collected, the average error introduced by converting the RemoteTracker velocity measurement to the average velocity at the time of the RemoteTracker spot measurement ($\sigma_C$) is 0.014 or 1.4%.
Inserting the determined values into Equation A-11:

\[ \sigma_{V_{Avg}^*} = \pm \sqrt{(1.0 \times 0.014)^2 + (0.95 \times 0.010)^2} = \pm 0.017 \text{ ft/s} \]

### A-4.2.3 Accuracy of the Change in Velocity over Time

A Microsoft Access database was developed to assess the accuracy in the change in velocity over time. Based on the orifice equation, the change in velocity through an orifice is solely a function of changes in head (or difference between upstream and downstream water level). Only water level data from the typical irrigation season (i.e. May through August) was used. It was assumed that measurements of velocity were performed every three days.

The difference between the head observed every three days and the actual average of the 15 minute data during the three day period was computed for each 15 minute record and then averaged over the observation period. Equation A-14 was then used to calculate the change in velocity over time \( \Delta V_T \) for each three day period. The initial head \( h_i \) was assumed to be 0.5 feet to simulate a low head delivery. A low head was chosen because water level fluctuations impact the velocity of low head deliveries more significantly than high head deliveries.

Rearranging Equation A-6:

\[ \Delta V_T = V_{Avg} - V_{Avg}^* \]

From the orifice equation:

\[ V = C(2gh)^{0.5} \quad \text{(Equation A-12)} \]

Where the variables are defined as:

- \( V \): Velocity
- \( C \): Discharge Coefficient
- \( g \): gravitational constant
- \( h \): Head

Orifice gates in most agricultural water districts operate under submerged conditions (i.e. not free flow conditions). As upstream canal water levels fluctuate, the flow through the orifice would theoretically vary as a function of the changes in canal water level to the one-half power. However, since the orifice gates are submerged, the hydraulically connected downstream water level also varies together with the upstream canal water level. This provides a damping effect on the overall change in velocity due to upstream water level fluctuations. The California Polytechnic State University at San Luis Obispo Irrigation
Training and Research Center (ITRC) suggest using a power of 0.38 in the orifice equation to simulate the damping effect of submergence for a range of downstream channel conditions (Burt and Geer 2012).

\[ V = C (2gh)^{0.38} \]  

(Equation A-13)

Substituting values:

\[ \Delta V_T = C (2gh_{avg})^{0.38} - C (2gh_O)^{0.38} \]

Where the variables are defined as:

- \( h_{avg} \): Average Head
- \( h_O \): Observed Head

Factoring:

\[ \Delta V_T = C (2g)^{0.38} \left( (h_{avg})^{0.38} - (h_O)^{0.38} \right) \]

Substituting values:

\[ \Delta V_T = C (2g)^{0.38} \left( (h_i + \Delta h_{avg})^{0.38} - (h_i)^{0.38} \right) \]  

(Equation A-14)

Where the variables are defined as:

- \( h_i \): Initial head at time of observation
- \( \Delta h_{avg} \): average change in head

Since the volumetric reporting requirements apply to a monthly or bi-monthly basis (California Water Code §531.10(a)), the change in velocity over time was then averaged on a monthly time step. The average of the absolute values of each of the average monthly changes in velocity over time was taken across all nine sites. Largely due to the fact that water level fluctuations are normally distributed, the results of the hydraulic database model suggest that the average change in velocity over time due to water level fluctuation is:

\[ \sigma_{\Delta V_T} = \pm 0.033 \text{ ft/s} \]

Based on the evaluation of continuous upstream and downstream water level data from 14 irrigation events in RD 108 with an average duration of five days, the average change in velocity over time was determined to be ±1.0 percent. In the context of this analysis, the accuracy in the change in velocity over time would be:
\[ \sigma_{\Delta V_T} = \pm 1.0\% \text{ or } \pm 0.010 \text{ ft/s} \]

Therefore, utilizing the value of \( \pm 0.033 \text{ ft/s} \) for the volumetric accuracy analysis is a conservative assumption.

Inserting the calculated values into Equation A-8, the average velocity accuracy is:

\[ \sigma_{V_{\text{Avg}}} = \pm \sqrt{(0.017)^2 + (0.033)^2} = 0.037 \text{ ft/s} \]

The relative accuracy of the average velocity is:

\[
U_{V_{\text{Avg}}} = \pm \frac{\sigma_{V_{\text{Avg}}}}{V_{\text{Avg}}} = \pm \frac{0.037 \text{ ft/s}}{0.95 \text{ ft/s}} = \pm 0.039 \text{ or } 3.9\% 
\]

**A-4.3 Relative Accuracy in Cross-Section Flow Area**

The following bullet points provide protocols for the collection of cross-section flow area data.

- The cross-section flow area will be calculated by measuring the inner diameter of the delivery pipe at the location of the water velocity measurement and using Equation A-16 to calculated area from inner diameter
- Inner pipe diameters will be measured with best professional practices when the pipe is dry

The accuracy in the inner pipe diameter measurement is assumed to be 0.02 feet (or 1/4 inch). The relative accuracy due to area is:

\[ U_A = \pm \frac{\sigma_A}{A} \quad \text{(Equation A-15)} \]

The correlation between diameter and area is:

\[ A = \frac{\pi D^2}{4} \quad \text{(Equation A-16)} \]

Where the variables are defined as:

- \( A \): Cross-Section Flow Area
- \( \pi \): Pi
- \( D \): Inner Diameter

The accuracy is:
\[ \sigma_A = \pm \sqrt{\frac{\partial A}{\partial D} \sigma_D} \]  \quad \text{(Equation A-17)}

Where the partial derivative is equal to:

\[ \frac{\partial A}{\partial D} = \frac{2\pi D}{4} = \frac{\pi D}{2} \]

The assumed pipe is 2.00 feet (24 inch) in diameter, giving an area of 3.142 ft\(^2\)

\[ \sigma_A = \pm \sqrt{\left(\frac{\partial A}{\partial D} \sigma_D\right)^2} = \sqrt{\left(\frac{\pi D}{2} \times 0.02\right)^2} = \pm 0.063 \text{ ft} \]

The relative accuracy in the cross-section flow area is:

\[ U_A = \pm \frac{\sigma_A}{A} = \pm \frac{0.063}{3.142} = \pm 0.020 \text{ or } 2.0\% \]

**A-4.4 Relative Accuracy in Duration of Delivery**

The following bullet points provide protocols for the collection of duration of delivery data.

- The start time for delivery will be the date and time recorded in the RemoteTracker system when a velocity measurement is taken at the start of a delivery.
- The stop time for delivery will be the date and time recorded in the RemoteTracker system when either:
  - “Record Shutoff” is pressed after a gate is closed at the end of a delivery or
  - A new velocity measurement is taken after a change in delivery flow rate is made.

A conservative value for the duration of an irrigation event is assumed to be a period of 24 hours. The possible accuracy in duration measurement is considered to be 15 minutes for the startup and 15 minutes for the shutoff (or 0.25 hours for both). Realistically, the actual accuracy in duration is much smaller when using the RemoteTracker system since the operator is recording water velocity data on site when gate position changes are made. The relative accuracy due to duration of delivery is:

\[ U_{\Delta t} = \pm \frac{\sigma_{\Delta t}}{\Delta t} \]  \quad \text{(Equation A-18)}

Where:

\[ \Delta t = Et - St \]  \quad \text{(Equation A-19)}

Where the variables are defined as:
• \( \Delta t \): Duration of Delivery
• St: Start Time
• Et: End Time

The accuracy of the Duration of Delivery is:

\[
\sigma_{\Delta t} = \pm \sqrt{\left( \frac{\partial \Delta t}{\partial St} \sigma_{St} \right)^2 + \left( \frac{\partial \Delta t}{\partial Et} \sigma_{Et} \right)^2}
\]

(Equation A-20)

Where the partial derivatives are equal to:

\[
\frac{\partial \Delta t}{\partial St} = 1, \quad \frac{\partial \Delta t}{\partial Et} = 1
\]

\[
\sigma_{\Delta t} = \pm \sqrt{(\sigma_{St})^2 + (\sigma_{Et})^2} = \sqrt{(0.25)^2 + (0.25)^2} = 0.35 \text{ hrs}
\]

The relative accuracy in the duration of delivery is:

\[
U_{\Delta t} = \pm \frac{\sigma_{\Delta t}}{\Delta t} = \pm \frac{0.35}{24} = \pm 0.015\ or\ 1.5\%
\]

A-4.5 Relative Accuracy in Volume

As previously stated this relative accuracy assumes a 3 cfs maintenance delivery in a 24” pipe. Inserting the calculated accuracy value for each component, the relative accuracy is as follows:

\[
U_\forall = \pm \sqrt{\left( U_{\forall,Avg} \right)^2 + (U_A)^2 + (U_{\Delta t})^2}
\]

(Equation A-21)

Inserting all calculated accuracy values the relative accuracy in volumetric measurements is:

\[
U_\forall = \pm \sqrt{(.039)^2 + (.020)^2 + (.015)^2}
\]

\[
U_\forall = \pm 0.046\ or\ \pm 4.6\%
\]

Based on the foregoing analysis and the resulting \(\pm 4.6\%\) accuracy in delivery volume determined for the RemoteTracker, the RemoteTracker complies with the \(\pm 5.0\%\) accuracy standard in CCR 23 §597 for laboratory testing.
EXHIBIT 2

REPORT DETAILING THE COST OF SERVICE
RECLAMATION DISTRICT NO. 108

REPORT DETAILING THE COST OF SERVICE

BACKGROUND

Reclamation District No. 108 (RD108) was formed in 1870 under the general Reclamation District Law of 1868 for the purpose of constructing levees to provide flood protection to over 100,000 acres of farmland along the west side of the Sacramento River from north of Colusa to Knights Landing. In the early 1900s, RD108 was consolidated to approximately 58,000 acres to provide irrigation water service, flood control, and drainage for lands within its service area. In 1917, RD108 began construction of major irrigation distribution system facilities for delivery of water from the Sacramento River to approximately 48,000 acres.

RD108 obtains its water supply from the Sacramento River under its riparian water rights and licenses for appropriation of surface waters. This water supply is supplemented when necessary from groundwater, using the District’s wells and privately owned wells and by diversion of water from the Colusa Basin Drain under the District’s appropriative license. RD108’s appropriative water rights for diversion from the Sacramento River have priority dates of 1917 and 1919. RD108’s appropriative water right for diversion from the Colusa Basin Drain has a priority date of 1947.

In 1964, RD108 entered into a negotiated settlement agreement with the U.S. Bureau of Reclamation (USBR), quantifying the amount of water RD108 could divert from the Sacramento River. The resulting negotiated agreement recognized RD108’s annual entitlement of Base Supply of 199,000 acre-feet per year (ac-ft/yr) of flows from the Sacramento River and also provided for a 54,500 ac-ft/yr allocation of Central Valley Project supply (Project Supply). In 1974, the District reduced its Project Supply allocation to 33,000 ac-ft/yr with the expectation that conservation efforts including canal lining and recirculation of drainage water would reduce diversion requirements. The subsequent contract entitlement was thus for a total of 232,000 ac-ft/yr. The contract stipulated maximum diversions of Base and Project Supply for the months of April through October and remained in effect until March 31, 2006, at which time it was extended for an additional 40 years.

Rice is the predominant crop grown within RD 108’s service area. Other key crops include tomatoes, alfalfa, vineseed, wheat, and corn.

ACCOUNTING BASIS

RD108 irrigation services are accounted for within a single irrigation fund. RD108 uses the accrual basis of accounting and, as such, revenues are recognized when earned and expenses are recorded when the liability is incurred, regardless of the timing of cash flows. Capital assets are depreciated over the useful life of the asset.

COST OF WATER SERVICE

For purposes of complying with the mandates of Article XIII D of the California Constitution, it is imperative that the amount of a charge (such as the water rates) not exceed the cost of service. The cost of service
is determined by preparing a budget with all revenues and expenses necessary to operate RD108 (including a budget reserve), but without including the revenues generated from annual water rates. Then, using an estimate of the number of acres that will be irrigated, associated water duties, and volumes of water delivered, water rates necessary to balance the budget can be calculated.

As shown on the attached Table 1 the Irrigation Budget for 2016 is projected to result in a net loss. RD108’s 2016 Irrigation Budget demonstrates that its water rates will not exceed the cost of service and, in fact, every property in RD108 receiving water will be charged slightly less than the cost of service.

**Avoided Cost of Service for Lift Pumps**

Some RD108 customers receive water via lift pumps that are operated by the Water User to lift water from the RD108 conveyance channel to the field to be irrigated. As a result, RD108 avoids additional costs that would otherwise be required to construct and operate District pumping facilities to lift the water from the canal for each Water User. In order to account for this avoided cost of service that would otherwise be incurred, RD108 reduces the charge for water delivered by the estimated avoided pumping costs. This cost is estimated to be approximately $0.30 per acre-foot per foot of lift.

**PROPORTIONALITY OF WATER RATES TO SERVICE PROVIDED**

Charges subject to Article XIII D must also be proportional to the service provided. Historically, RD108 has charged its landowners who receive water for rice irrigation a per-acre water rate. For other crops, a per-acre water rate is charged for the first irrigation, followed by a lesser per-acre water rate for each subsequent irrigation. For non-rice crops, this approach results in higher rates on fields with crops using more irrigation applications, which results in rates reasonably proportional to the amount of water applied. As described previously, Water Users who pump water using lift pumps are charged lesser rates in proportion to the avoided cost to RD108 of pumping the water. For non-rice crops, all charges are calculated based on the number of irrigations provided. Due to the fact that RD108’s field turnouts have not historically been metered, this method is reasonable for estimating Water User’s water use.

In 2015, RD108 authorized Davids Engineering to evaluate potential rate structures and estimated applied water duties for irrigation by crop\(^1\) with the goal of developing a water rate based in part on the actual volume of water delivered to individual field turnouts, as required under California Senate Bill x7-7 (SBx7-7), also known as the Water Measurement Program, and the Water Conservation Act of 2009. The evaluation included evaluation of a three-part rate structure that includes two fixed (per acre) components of the water rate and a volumetric (per acre-foot) component of the water rate.

**PROPOSED WATER RATES**

**Three-Part Rate Structure**

For 2016, it is proposed that the three-part rate structure evaluated be implemented, including two fixed rate components and a volumetric rate component, as described above. The first fixed component of the rate includes an equal charge per acre irrigated applicable to all crops. The second fixed component of the rate includes a per-acre charge that varies based on the estimated applied water duty for each crop.

\(^1\) A table of estimated applied water duties by crop is provided as Exhibit 1.

Davids Engineering, Inc.  
January 15, 2016
The volumetric component of the rate includes a charge based on the actual quantity of water delivered, as measured by RD108.

A large part of RD108’s annual expenses are related to the fixed costs of operating and maintaining the water system infrastructure and are not directly dependent upon the amount of water actually delivered to irrigated parcels within RD108. As such, it is desirable for RD108 to implement the proposed rate structure, including the volumetric component of the rate, in 2016. The proposed rate structure provides benefits to RD108, as compared to a wholly fixed or wholly volumetric rate structure. A portion of charges based on the number of acres irrigated using RD108 water, promotes revenue stability to RD108 across years and allows RD108 to proceed with delivery measurement at field turnouts and to implement associated volumetric charges as required by SBx7-7 without solely charging based on the amount delivered. Basing a portion of charges based on the actual volume of water delivered to field turnouts encourages conservation of limited water supplies and provides equitability among Water Users growing a particular crop with different amounts of applied water per acre.

For the proposed rate update, RD108 has determined that, on average, one third of the cost of service is to be recovered through each of the three components of the rate, with adjustments based on lift pump costs incurred by RD108 Water Users, applied to the second fixed rate component (per-acre charge based on crop grown and corresponding estimated applied water duty) and the volumetric rate component (per acre-foot charge based on actual measured delivery volume) as appropriate. This division of fixed and volumetric rate components is expected to result in a desirable blend of the benefits described above.

2016 Water Rates
It is proposed that for 2016 and subsequent years, unless otherwise modified by the RD108 Trustees, the three-part rate structure will be applied. All rates represent proposed maximum water rates that could be charged and may be reduced at any time at the discretion of the RD108 Board of Trustees.

Proposed rates have been calculated based on the projected cost of service for 2016, minus any revenues from other sources. Estimated irrigation water rate changes for 2016 by crop are summarized in Exhibit 2. Increased water rates reflect a combination of increased cost of service and changes resulting from transition for RD108’s current rate structure to the proposed three-part rate structure, which includes a rate component based on the volume of water delivered. Due to the change in rate structure, the rate of increase for individual crops varies. In general water rates for crops with the least number of irrigations increase by the greatest percentage due to the inclusion of the fixed component applied to all crops based on the acreage irrigated. Conversely, water rates for crops with the greatest number of irrigations tend to decrease.

A sample rate sheet describing water rate components by crop for 2016 is provided in Exhibit 3. Example rate calculations for individual fields are provided in Exhibit 4.

Payment Collection Schedule
Under the three-part rate structure, payment will be due in three installments, with the exception of deliveries for rice straw decomposition, as described below. The acreage-based fixed rate component will be due prior to delivering water to the field at the beginning of the irrigation season. The crop-based estimated applied water fixed rate component will be due by August 1 of the year during which the crop is grown. The volumetric rate component based on the actual volume of water delivered will be due by December 1 of the year during which the crop is grown.

Davids Engineering, Inc.  
January 15, 2016
For rice straw decomposition (decomp) and the second crop for double-cropped fields, the acreage-based fixed rate component will be waived, as it will have been paid for the preceding crop. The estimated applied water fixed rate component will be due prior to reflood for decomp or prior to the first irrigation of the second crop for double-cropped fields. The volumetric rate component based on the actual volume of water delivered for decomp and second crops will be due prior to the first irrigation of the field in the following year or by April 1, whichever comes first.

CONCLUSION
The proposed three-part rate structure ensures that RD108’s water rates do not exceed the cost of service, are reasonably proportional to the service provided, equitably distributed among Water Users, and compliant with the requirements of the California Water Code established with the adoption of SBx7-7.
Table 1. RD108 2016 Irrigation Budget.

**INCOME**

<table>
<thead>
<tr>
<th>Description</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Sales/Irrigation</td>
<td>$3,000,000.00</td>
</tr>
<tr>
<td>Water Sales/Fair Ranch</td>
<td>$29,800.00</td>
</tr>
<tr>
<td>Water Sales/Rice Straw Decomposition</td>
<td>$200,000.00</td>
</tr>
<tr>
<td>Water Transfer</td>
<td>$-</td>
</tr>
<tr>
<td>Earned Interest</td>
<td>$4,500.00</td>
</tr>
<tr>
<td>Outside Drainage Charge</td>
<td>$2,779.00</td>
</tr>
<tr>
<td>Miscellaneous Operating</td>
<td>$-</td>
</tr>
<tr>
<td><strong>TOTAL INCOME</strong></td>
<td><strong>$3,237,079.00</strong></td>
</tr>
</tbody>
</table>

**EXPENSES**

<table>
<thead>
<tr>
<th>Description</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>USBR Water Charges</td>
<td>$922,615.00</td>
</tr>
<tr>
<td>Office Supplies</td>
<td>$80.00</td>
</tr>
<tr>
<td>Power &amp; Energy</td>
<td>$850,000.00</td>
</tr>
<tr>
<td>System Facilities</td>
<td>$1,644,402.00</td>
</tr>
<tr>
<td>Water Transfer</td>
<td>$-</td>
</tr>
<tr>
<td>Water Conservation Program</td>
<td>$-</td>
</tr>
<tr>
<td>Miscellaneous Non-Operating</td>
<td>$-</td>
</tr>
<tr>
<td><strong>TOTAL EXPENSES</strong></td>
<td><strong>$3,417,097.00</strong></td>
</tr>
</tbody>
</table>

**NET INCOME/LOSS**

<table>
<thead>
<tr>
<th>Description</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NET INCOME/LOSS</strong></td>
<td><strong>$(-180,018.00)</strong></td>
</tr>
</tbody>
</table>
EXHIBIT 1. ESTIMATED APPLIED WATER DUTIES (DELIVERIES) BY IRRIGATED LAND USE².

<table>
<thead>
<tr>
<th>Crop</th>
<th>Estimated Water Duty per acre</th>
<th>Applied Water Duty (acre-feet)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa</td>
<td>4.50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beans</td>
<td>2.50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Canola</td>
<td>2.20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carrots</td>
<td>2.50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clover</td>
<td>4.50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conservation</td>
<td>2.50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cotton</td>
<td>3.30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corn</td>
<td>2.50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Garlic</td>
<td>1.50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grain</td>
<td>2.00</td>
<td></td>
<td>Barley, Buckwheat, Milo, Oats, Wheat</td>
</tr>
<tr>
<td>Market Veg</td>
<td>2.50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Melons</td>
<td>1.60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Onions</td>
<td>1.50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Orchard, Young</td>
<td>1.60</td>
<td>3 years or younger</td>
<td></td>
</tr>
<tr>
<td>Orchard, Mature</td>
<td>3.00</td>
<td>4 years or older</td>
<td></td>
</tr>
<tr>
<td>Pasture</td>
<td>3.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pumpkins</td>
<td>1.60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rice</td>
<td>5.50</td>
<td></td>
<td>Medium, Short, Sweet</td>
</tr>
<tr>
<td>Rice - Wild</td>
<td>5.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safflower</td>
<td>2.20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soybeans</td>
<td>2.50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sudan Grass</td>
<td>3.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sugar Beets</td>
<td>3.50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sunflowers</td>
<td>2.20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tomatoes</td>
<td>2.30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vetch</td>
<td>2.50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vine Seeds</td>
<td>1.60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Idle Lands</td>
<td>0.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decomp, 1 Flood</td>
<td>1.00</td>
<td></td>
<td>Rice straw decomposition with one-time flood</td>
</tr>
<tr>
<td>Decomp, Maint.</td>
<td>2.00</td>
<td></td>
<td>Rice straw decomposition with maintenance flow</td>
</tr>
<tr>
<td>Fall Only, 1 Flood</td>
<td>1.00</td>
<td></td>
<td>One-time fall flood (no summer crop)</td>
</tr>
<tr>
<td>Fall Only, Maint.</td>
<td>2.00</td>
<td></td>
<td>Fall flood with maintenance (no summer crop)</td>
</tr>
</tbody>
</table>

² For double-cropping, duties will be estimated as the sum of duties for individual crops grown.
EXHIBIT 2. ESTIMATED WATER RATE CHANGES FOR 2016 BY CROP.3,4

<table>
<thead>
<tr>
<th>Crop</th>
<th>Budgeted Acres</th>
<th>Estimated Average Irrigations</th>
<th>Estimated Applied Water Duty (ac-ft/ac)</th>
<th>Average Historical Water Rate ($/ac)</th>
<th>Proposed Water Rate ($/ac)</th>
<th>Total Change ($/ac)</th>
<th>Percent Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa</td>
<td>1,850</td>
<td>4.9</td>
<td>4.5</td>
<td>$54.86</td>
<td>$65.86</td>
<td>$11.00</td>
<td>20%</td>
</tr>
<tr>
<td>Beans</td>
<td>300</td>
<td>5.6</td>
<td>2.5</td>
<td>$61.58</td>
<td>$46.66</td>
<td>$14.92</td>
<td>-24%</td>
</tr>
<tr>
<td>Corn</td>
<td>500</td>
<td>5.0</td>
<td>2.5</td>
<td>$55.70</td>
<td>$46.66</td>
<td>-$9.04</td>
<td>-16%</td>
</tr>
<tr>
<td>Grain</td>
<td>2,400</td>
<td>1.2</td>
<td>2.0</td>
<td>$18.53</td>
<td>$41.86</td>
<td>$23.33</td>
<td>126%</td>
</tr>
<tr>
<td>Melons</td>
<td>260</td>
<td>4.4</td>
<td>1.6</td>
<td>$49.93</td>
<td>$38.02</td>
<td>-$11.91</td>
<td>-24%</td>
</tr>
<tr>
<td>Orchard, Young</td>
<td>670</td>
<td>3.8</td>
<td>1.6</td>
<td>$44.27</td>
<td>$38.02</td>
<td>-$6.25</td>
<td>-14%</td>
</tr>
<tr>
<td>Orchard, Mature</td>
<td>1,700</td>
<td>3.8</td>
<td>3.0</td>
<td>$44.27</td>
<td>$51.46</td>
<td>$7.19</td>
<td>16%</td>
</tr>
<tr>
<td>Pasture</td>
<td>160</td>
<td>4.3</td>
<td>3.0</td>
<td>$48.16</td>
<td>$51.46</td>
<td>$3.30</td>
<td>7%</td>
</tr>
<tr>
<td>Rice</td>
<td>31,830</td>
<td>NA</td>
<td>5.5</td>
<td>$68.20</td>
<td>$75.46</td>
<td>$7.26</td>
<td>11%</td>
</tr>
<tr>
<td>Safflower</td>
<td>840</td>
<td>1.3</td>
<td>2.2</td>
<td>$20.02</td>
<td>$43.78</td>
<td>$23.76</td>
<td>119%</td>
</tr>
<tr>
<td>Sudan Grass</td>
<td>40</td>
<td>2.4</td>
<td>3.0</td>
<td>$30.07</td>
<td>$51.46</td>
<td>$21.39</td>
<td>71%</td>
</tr>
<tr>
<td>Sunflowers</td>
<td>1,410</td>
<td>1.6</td>
<td>2.2</td>
<td>$22.88</td>
<td>$43.78</td>
<td>$20.90</td>
<td>91%</td>
</tr>
<tr>
<td>Tomatoes</td>
<td>3,930</td>
<td>6.7</td>
<td>2.3</td>
<td>$71.44</td>
<td>$44.74</td>
<td>-$26.70</td>
<td>-37%</td>
</tr>
<tr>
<td>Vine Seeds</td>
<td>870</td>
<td>4.4</td>
<td>1.6</td>
<td>$49.93</td>
<td>$38.02</td>
<td>-$11.91</td>
<td>-24%</td>
</tr>
<tr>
<td>Decomp, 1 Flood</td>
<td>7,000</td>
<td>NA</td>
<td>1.0</td>
<td>$17.57</td>
<td>$9.60</td>
<td>-$7.97</td>
<td>-45%</td>
</tr>
<tr>
<td>Decomp, Maint.</td>
<td>4,500</td>
<td>NA</td>
<td>2.0</td>
<td>$23.93</td>
<td>$19.20</td>
<td>-$4.73</td>
<td>-20%</td>
</tr>
<tr>
<td>Fall Only, 1 Flood</td>
<td>200</td>
<td>NA</td>
<td>1.0</td>
<td>$17.57</td>
<td>$32.26</td>
<td>$14.69</td>
<td>84%</td>
</tr>
<tr>
<td>Fall Only, Maint.</td>
<td>110</td>
<td>NA</td>
<td>2.0</td>
<td>$23.93</td>
<td>$41.86</td>
<td>$17.93</td>
<td>75%</td>
</tr>
</tbody>
</table>

3 Average historical and proposed water rates by crop are based on gravity deliveries and do not reflect reductions in water rates to be applied based on RD108 avoided costs for pump deliveries. Proposed water rates are based on the estimated applied water duty and will vary somewhat from field to field based on actual usage. Total acres includes 47,070 summer and 12,120 fall irrigated acres. Other totals are calculated as area-weighted averages based on budgeted acreages.

4 Historically, fields have been billed for water purely on a volumetric basis in some cases. For these fields, the average historical water rate and change in water rate will vary from the values shown depending on the amount of water applied.
EXHIBIT 3. SAMPLE 2016 RATE SHEET.

RECLAMATION DISTRICT NO. 108 - 2016 RATE STRUCTURE

This sheet shows how water rates are distributed between a Crop Specific Rate Component ($/Acre), which is comprised of an Acreage Rate Component and an Est. AW Rate Component (see Exhibit X), and a Lift Specific Volumetric Rate Component ($/AF) (see Exhibit Y).

### Exhibit X - 2016 CROP SPECIFIC FIXED RATE COMPONENT

<table>
<thead>
<tr>
<th>Crop</th>
<th>Acreage Rate Component ($/Acre)</th>
<th>Est AW Duty (AF/Acre)</th>
<th>Est. AW Volumetric Component ($/AF)</th>
<th>Est. AW Rate Component ($/Acre)</th>
<th>Total Fixed Rate Component * ($/Acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALFALFA</td>
<td>$22.66</td>
<td>4.50</td>
<td>$4.80</td>
<td>$21.60</td>
<td>$44.26</td>
</tr>
<tr>
<td>BEANS</td>
<td>$22.66</td>
<td>2.50</td>
<td>$4.80</td>
<td>$12.00</td>
<td>$34.66</td>
</tr>
<tr>
<td>CANOLA</td>
<td>$22.66</td>
<td>2.20</td>
<td>$4.80</td>
<td>$10.56</td>
<td>$33.22</td>
</tr>
<tr>
<td>CARROTS</td>
<td>$22.66</td>
<td>2.50</td>
<td>$4.80</td>
<td>$12.00</td>
<td>$34.66</td>
</tr>
<tr>
<td>CLOVER</td>
<td>$22.66</td>
<td>4.50</td>
<td>$4.80</td>
<td>$21.60</td>
<td>$44.26</td>
</tr>
<tr>
<td>CONSERVATION</td>
<td>$22.66</td>
<td>2.50</td>
<td>$4.80</td>
<td>$12.00</td>
<td>$34.66</td>
</tr>
<tr>
<td>COTTON</td>
<td>$22.66</td>
<td>3.30</td>
<td>$4.80</td>
<td>$15.84</td>
<td>$38.50</td>
</tr>
<tr>
<td>CORN</td>
<td>$22.66</td>
<td>2.50</td>
<td>$4.80</td>
<td>$12.00</td>
<td>$34.66</td>
</tr>
<tr>
<td>GARLIC</td>
<td>$22.66</td>
<td>1.50</td>
<td>$4.80</td>
<td>$7.20</td>
<td>$29.86</td>
</tr>
<tr>
<td>GRAIN</td>
<td>$22.66</td>
<td>2.00</td>
<td>$4.80</td>
<td>$9.60</td>
<td>$32.26</td>
</tr>
<tr>
<td>MARKET VEG</td>
<td>$22.66</td>
<td>2.50</td>
<td>$4.80</td>
<td>$12.00</td>
<td>$34.66</td>
</tr>
<tr>
<td>MELONS</td>
<td>$22.66</td>
<td>1.60</td>
<td>$4.80</td>
<td>$7.68</td>
<td>$30.34</td>
</tr>
<tr>
<td>ONIONS</td>
<td>$22.66</td>
<td>1.50</td>
<td>$4.80</td>
<td>$7.20</td>
<td>$29.86</td>
</tr>
<tr>
<td>ORCHARD, YOUNG</td>
<td>$22.66</td>
<td>1.60</td>
<td>$4.80</td>
<td>$7.68</td>
<td>$30.34</td>
</tr>
<tr>
<td>ORCHARD, MATURE</td>
<td>$22.66</td>
<td>3.00</td>
<td>$4.80</td>
<td>$14.40</td>
<td>$37.06</td>
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<tr>
<td>PASTURE</td>
<td>$22.66</td>
<td>3.00</td>
<td>$4.80</td>
<td>$14.40</td>
<td>$37.06</td>
</tr>
<tr>
<td>PUMPKINS</td>
<td>$22.66</td>
<td>1.60</td>
<td>$4.80</td>
<td>$7.68</td>
<td>$30.34</td>
</tr>
<tr>
<td>RICE</td>
<td>$22.66</td>
<td>5.00</td>
<td>$4.80</td>
<td>$24.00</td>
<td>$46.66</td>
</tr>
<tr>
<td>RICE - WILD</td>
<td>$22.66</td>
<td>5.00</td>
<td>$4.80</td>
<td>$24.00</td>
<td>$46.66</td>
</tr>
<tr>
<td>SAFFFLOWER</td>
<td>$22.66</td>
<td>2.20</td>
<td>$4.80</td>
<td>$10.56</td>
<td>$33.22</td>
</tr>
<tr>
<td>SOYBEANS</td>
<td>$22.66</td>
<td>2.50</td>
<td>$4.80</td>
<td>$12.00</td>
<td>$34.66</td>
</tr>
<tr>
<td>SUDAN GRASS</td>
<td>$22.66</td>
<td>4.90</td>
<td>$4.80</td>
<td>$23.52</td>
<td>$46.18</td>
</tr>
<tr>
<td>SUGAR BEETS</td>
<td>$22.66</td>
<td>3.50</td>
<td>$4.80</td>
<td>$16.80</td>
<td>$39.46</td>
</tr>
<tr>
<td>SUNFLOWERS</td>
<td>$22.66</td>
<td>2.20</td>
<td>$4.80</td>
<td>$10.56</td>
<td>$33.22</td>
</tr>
<tr>
<td>TOMATOES</td>
<td>$22.66</td>
<td>2.30</td>
<td>$4.80</td>
<td>$11.04</td>
<td>$33.70</td>
</tr>
<tr>
<td>VETCH</td>
<td>$22.66</td>
<td>2.50</td>
<td>$4.80</td>
<td>$12.00</td>
<td>$34.66</td>
</tr>
<tr>
<td>VINE SEEDS</td>
<td>$22.66</td>
<td>1.60</td>
<td>$4.80</td>
<td>$7.68</td>
<td>$30.34</td>
</tr>
<tr>
<td>DECOMP, 1 FLOOD</td>
<td>$0.00</td>
<td>1.00</td>
<td>$4.80</td>
<td>$4.80</td>
<td>$8.00</td>
</tr>
<tr>
<td>DECOMP, MAINT.</td>
<td>$0.00</td>
<td>2.00</td>
<td>$4.80</td>
<td>$9.60</td>
<td>$13.00</td>
</tr>
<tr>
<td>FALL ONLY, 1 FLOOD</td>
<td>$22.66</td>
<td>1.00</td>
<td>$4.80</td>
<td>$4.80</td>
<td>$27.46</td>
</tr>
<tr>
<td>FALL ONLY, MAINT.</td>
<td>$22.66</td>
<td>2.00</td>
<td>$4.80</td>
<td>$9.60</td>
<td>$32.26</td>
</tr>
</tbody>
</table>

* Note: Total Fixed Rate Component = Acreage Rate Component + Est. AW Rate Component

### Exhibit Y - 2016 LIFT SPECIFIC NET VOLUMETRIC RATE COMPONENT

<table>
<thead>
<tr>
<th>Crop</th>
<th>Amount of Lift (Ft)</th>
<th>Volumetric Rate Component ($/AF)</th>
<th>Lift Credit ($/AF)</th>
<th>Net Volumetric Rate Component ** ($/AF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALFALFA</td>
<td>0</td>
<td>$4.80</td>
<td>$0.00</td>
<td>$4.80</td>
</tr>
<tr>
<td>BEANS</td>
<td>2</td>
<td>$4.80</td>
<td>$0.60</td>
<td>$4.20</td>
</tr>
<tr>
<td>CANOLA</td>
<td>3</td>
<td>$4.80</td>
<td>$0.90</td>
<td>$3.90</td>
</tr>
<tr>
<td>CARROTS</td>
<td>4</td>
<td>$4.80</td>
<td>$1.20</td>
<td>$3.60</td>
</tr>
<tr>
<td>CLOVER</td>
<td>5</td>
<td>$4.80</td>
<td>$1.50</td>
<td>$3.30</td>
</tr>
<tr>
<td>CONSERVATION</td>
<td>6</td>
<td>$4.80</td>
<td>$1.80</td>
<td>$3.00</td>
</tr>
<tr>
<td>COTTON</td>
<td>7</td>
<td>$4.80</td>
<td>$2.10</td>
<td>$2.70</td>
</tr>
<tr>
<td>CORN</td>
<td>8</td>
<td>$4.80</td>
<td>$2.40</td>
<td>$2.40</td>
</tr>
<tr>
<td>GARLIC</td>
<td>9</td>
<td>$4.80</td>
<td>$2.70</td>
<td>$2.10</td>
</tr>
<tr>
<td>GRAIN</td>
<td>10</td>
<td>$4.80</td>
<td>$3.00</td>
<td>$1.80</td>
</tr>
<tr>
<td>MARKET VEG</td>
<td>11</td>
<td>$4.80</td>
<td>$3.30</td>
<td>$1.50</td>
</tr>
<tr>
<td>MELONS</td>
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<td>$3.60</td>
<td>$1.20</td>
</tr>
<tr>
<td>ONIONS</td>
<td>13</td>
<td>$4.80</td>
<td>$3.90</td>
<td>$0.90</td>
</tr>
<tr>
<td>ORCHARD, YOUNG</td>
<td>14</td>
<td>$4.80</td>
<td>$4.20</td>
<td>$0.60</td>
</tr>
<tr>
<td>ORCHARD, MATURE</td>
<td>15</td>
<td>$4.80</td>
<td>$4.50</td>
<td>$0.30</td>
</tr>
<tr>
<td>PASTURE</td>
<td>16</td>
<td>$4.80</td>
<td>$4.80</td>
<td>$0.00</td>
</tr>
<tr>
<td>PUMPKINS</td>
<td>17</td>
<td>$4.80</td>
<td>$5.10</td>
<td>$-0.30</td>
</tr>
<tr>
<td>RICE</td>
<td>18</td>
<td>$4.80</td>
<td>$5.40</td>
<td>$-0.60</td>
</tr>
</tbody>
</table>

** Note: Net Volumetric Rate Component = Volumetric Rate Component - Lift Credit

** Abbreviations: AF: Acre-foot; FT: Foot; Est. AW: Estimated Applied Water

** Notes:
1. Grain includes Barley, Buckwheat, Milo, Oats, and
2. Rice includes Short, Medium, and Sweet.
the following year will be considered on a field-by-field basis.

For summer crops, payments for water charges will be made in three installments:
- First Installment (Acreage Charge) = Acreage Rate Component * Acres Planted (due Prior to First Delivery)
- Second Installment (Est AW Charge) = Est. AW Rate Component * Acres Planted (due by August 1st)
- Third Installment (Volumetric Charge) = Volumetric Rate Component * Measured AW (due by December 1st)

For rice straw decomposition and second (double) crops, payments for water charges will be made in two installments:
- First Installment (Est AW Charge) = Est. AW Rate Component * Acres Planted (due prior to First Delivery)
- Second Installment (Volumetric Charge) = Volumetric Rate Component * Measured AW (due prior to First Delivery of following year)

Davids Engineering, Inc.
January 15, 2016
EXHIBIT 4. EXAMPLE WATER RATE CALCULATIONS.

RECLAMATION DISTRICT NO. 108 - 2016 RATE STRUCTURE

This sheet shows two sample water rate and water charge calculations. See Exhibits X and Y for Details on Rates.

For summer crops, payments for water charges will be made in three installments:
First Installment (Acreage Charge) = Acreage Rate Component * Acres Planted (due prior to First Delivery)
Second Installment (Est AW Charge) = Est. AW Rate Component * Acres Planted (due by August 1st)
Third Installment (Volumetric Charge) = Volumetric Rate Component * Measured AW (due by December 1st)

For rice straw decomposition and second (double) crops, payments for water charges will be made in two installments:
First Installment (Est AW Charge) = Est. AW Rate Component * Acres Planted (due prior to First Delivery)
Second Installment (Volumetric Charge) = Volumetric Rate Component * Measured AW (due April 1 of following year)

Example Calculations

Given:
Crop: Rice
Acres: 100
Amount of Lift: (FT) 5

<table>
<thead>
<tr>
<th>Installment</th>
<th>Description</th>
<th>Value</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td>Acreage Rate Component ($/AC)</td>
<td>$22.66</td>
<td>Acreage Rate Component for Rice</td>
</tr>
<tr>
<td></td>
<td>Acreage Charge ($)</td>
<td>$2,266.00</td>
<td>$22.66/Acre * 100 acres = $2266</td>
</tr>
<tr>
<td>Second</td>
<td>Est. AW Rate Component ($/AC)</td>
<td>$26.40</td>
<td>Est. AW Rate Component for Rice</td>
</tr>
<tr>
<td></td>
<td>Est. AW Charge ($)</td>
<td>$2,640.00</td>
<td>$26.4/Acre * 100 acres = $2640</td>
</tr>
<tr>
<td>Third</td>
<td>Volume Applied (AF)</td>
<td>620</td>
<td>Volume of water delivered (AF)</td>
</tr>
<tr>
<td></td>
<td>Net Volumetric Rate Component ($/AF)</td>
<td>$3.30</td>
<td>Net Volumetric Rate Component for 5 FT of Lift</td>
</tr>
<tr>
<td></td>
<td>Volumetric Charge ($)</td>
<td>$2,046.00</td>
<td>$3.3/AF * 620 AF = $2046</td>
</tr>
</tbody>
</table>

Total Charge (All Installments) -> $6,952.00
Total Charge Per Acre -> $69.52

Given:
Crop: Tomatoes
Acres: 50
Amount of Lift: (FT) 0

<table>
<thead>
<tr>
<th>Installment</th>
<th>Description</th>
<th>Value</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td>Acreage Rate Component ($/AC)</td>
<td>$22.66</td>
<td>Acreage Rate Component for Tomatoes</td>
</tr>
<tr>
<td></td>
<td>Acreage Charge ($)</td>
<td>$1,133.00</td>
<td>$22.66/Acre * 50 acres = $1133</td>
</tr>
<tr>
<td>Second</td>
<td>Est. AW Rate Component ($/AC)</td>
<td>$11.04</td>
<td>Est. AW Rate Component for Tomatoes</td>
</tr>
<tr>
<td></td>
<td>Est. AW Charge ($)</td>
<td>$552.00</td>
<td>$11.04/Acre * 50 acres = $552</td>
</tr>
<tr>
<td>Third</td>
<td>Volume Applied (AF)</td>
<td>153</td>
<td>Volume of water delivered (AF)</td>
</tr>
<tr>
<td></td>
<td>Net Volumetric Rate Component ($/AF)</td>
<td>$4.80</td>
<td>Net Volumetric Rate Component for 0 FT of Lift</td>
</tr>
<tr>
<td></td>
<td>Volumetric Charge ($)</td>
<td>$734.40</td>
<td>$4.8/AF * 153 AF = $734.4</td>
</tr>
</tbody>
</table>

Total Charge (All Installments) -> $2,419.40
Total Charge Per Acre -> $48.39