



Quincy-Columbia Basin Irrigation District

Review of West Canal Water Conservation by Spill Recovery Utilizing On-Demand Controls

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SYSTEM OPTIMIZATION REVIEW

Background Data

The Quincy-Columbia Basin Irrigation District (District/QCBID) is located in east central Washington, within Reclamation's Pacific Northwest Region. Reclamation's Columbia Basin Project serves approximately 671,000 acres of farmland. Water is pumped uphill from Lake Roosevelt behind Grand Coulee Dam into Banks Lake Reservoir where it is diverted onward through over 300 miles of project main canals and about 5,500 project miles of laterals, drains, and wasteways. Water is primarily used for irrigation, but in limited circumstances is used for municipal and industrial purposes. Over 90 different crops are grown with apples, wheat, and corn being the largest value crops. Other benefits of the Columbia Basin Project include recreation, habitat creation, flood control, and power generation.

District Headquarters are located in Quincy, Washington approximately 17 miles west of Ephrata, Washington. The District operates and maintains a portion of the Columbia Basin Project, under contract with the Bureau of Reclamation's Ephrata Field Office. The District's main canal is 89 miles long in addition to several thousand miles of laterals, wasteways, and drains. The Quincy-District serves approximately 250,000 acres of farmland.

In an effort to conserve water, the District has entered into a coordinated water conservation plan with the East and South Columbia Basin Irrigation Districts and the Washington State Department of Ecology to allow additional irrigation acreage to be served, while remaining water budget neutral on the Columbia River. Long-term planning is essential to solving future water resource problems such as project water shortages caused by drought. Since 2009, the Districts on the project have conserved over 30,000 acre-feet of water by completing over 150,000 feet of piping and canal lining projects.

The coordinated water conservation plan identified water conservation opportunities exist by reducing the daily 30 cfs spill from the end of the West Canal, via the Goose Lake Wasteway. In



2009 QCBID consulted with CH2M Hill to evaluate potential sites and develop cost estimates for a regulation reservoir that would allow for water conservation. All potential sites were on private ownership. The preferred site has since been converted to orchard. Construction estimates for a regulation reservoir and associated pumping equipment were \$4.8 million dollars. The water conserved from this project was about half of the daily 30 cfs spills via the Goose Lake Wasteway. Due to cost benefit ratio limitations and issues with available site locations, the District abandoned the pursuit of a regulation reservoir.

In 2016, QCBID was approached by Rubicon Water with the idea of controlling the lower section of the West Canal with demand-driven control paradigm utilizing Rubicon's Total Channel Control (TCC). With only in-kind cost incurred by the District, Rubicon Water prepared a scoping study from data provided regarding the canal design and facilities in August 2016.

Technical Project Description

Dynamic Model of West Canal to Validate the Opportunity to Eliminate Operational Spill from the West Canal

A design analysis of the West Canal has established that there is an opportunity to recover large volumes of water lost as operational spill from the Lower West Canal. The existing canal operations have been developed under an upstream level control philosophy which by its nature requires surplus flows to be delivered through the canal network. The District is considering reconfiguring the Lower West Canal control infrastructure to provide a demand-driven control paradigm utilizing Rubicon's Total Channel Control (TCC). The conversion to a demand-driven automated system will precisely match supplied flows to demand and maintain stable supply levels at each check structure. By matching supply to demand, the TCC implementation will reduce spill into Goose Lake and divert this recovered water to Billy Clapp, Evergreen, or Potholes Reservoir. It is estimated that historical annual spills into Goose Lake are on the order of 30cfs over the season, amounting to a volume of 9,000 ac-ft of recoverable water each year that will be made available to Potholes Reservoir resulting in more water availability for further beneficial use. The value of an investment in this Total Channel Control system has been estimated at \$3.75 Million, meaning that the water recovered over the 30-year asset life would be achieved at a price of approximately \$15 per acre-foot per year.



Figure 1 - Quincy Columbia Basin Irrigation District's Lower West Canal

An implementation of Rubicon's Total Channel Control will transform the operation of this canal from a traditional supply-driven operating mode to a demand-driven operating mode, in which water is precisely delivered at precise times and volumes to exactly match the aggregate water demand of all users on the Lower West Canal and thereby eliminate surplus deliveries and operational spill.

In order for this Total Channel Control implementation to be successful, there must be available buffering storage upstream to provide an on-demand source of water to supply the precise flow requirements of the Lower West Canal. To verify this on-demand water supply is available, a dynamic theoretical model of the West Canal hydraulics will be developed and this model will be used to assess the fluctuation in pool supply levels along the West Canal as the demand in the Lower West Canal changes in response to the Total Channel Control's precision time-varying flow deliveries.

The West Canal dynamics will be modeled from the 40 Mile Check down to the Frenchman Hills Tunnel and Wasteway, which is defined as the start of the Lower West Canal. This stretch of canal is supplied with relatively slowly varying flow set points from the Billy Clapp Lake diversion. This relatively slowly varying inflow supplies a potentially rapidly varying supply to the Frenchman Hills Tunnel, below which the supplied flows are precisely matched to aggregate demand by the Total Channel Control management system.

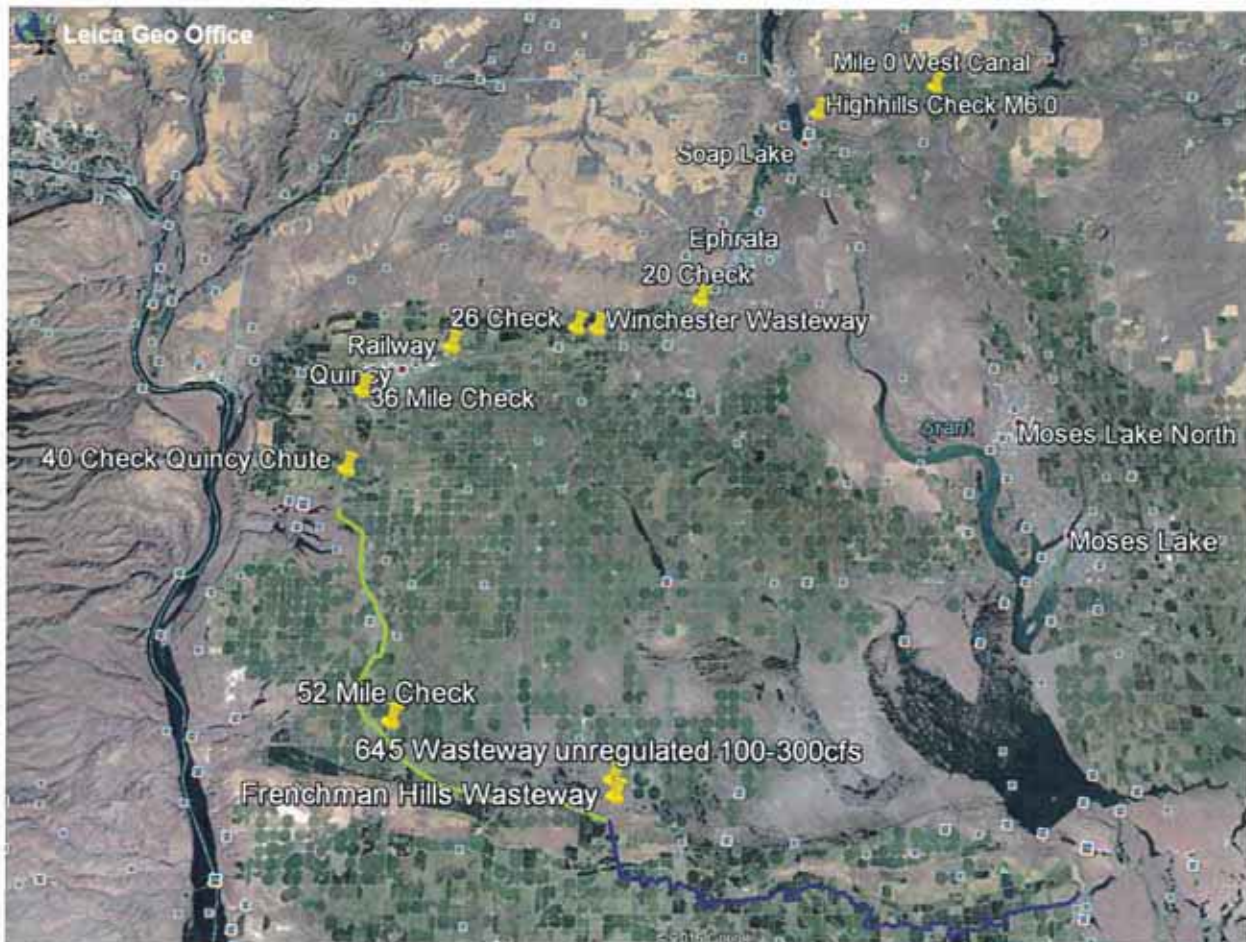


Figure 2 - The Lower West Canal (Blue) and the West Canal (Green) to be analyzed in this study

This imbalance between real-time flows into the 40 Mile Check and the real-time flows into the Frenchman Hills Tunnel requires a balancing volume to buffer the differing inflows and outflows. This research task will develop a mathematical dynamic model to analyze the length of

the West Canal between 40 Mile Check and the Frenchman Hills Tunnel (indicated by the green canal trace in Figure 2 above). The canal will be treated a 25-mile-long distributed reservoir. A dynamic model will be developed to define the Time Constant and Time Delay of the two pools spanning this 25-mile stretch of canal, and the Time Constant and Time Delay of the conveyance pools supplying water from Billy Clapp Reservoir. This dynamic model will be used to simulate the water level fluctuations that will occur in the two pools between 40 Mile Check and Frenchman Hills Tunnel that will result from a range of demand profiles and a range of diversion strategies from the Billy Clap Diversion.

The response behavior of the supply levels will be analyzed and management methodologies will be proposed to coordinate the real-time measurements of these water levels with the diversions from Billy Clapp Reservoir and with operations of Evergreen Reservoir to buffer surplus flows being delivered from the West Canal.

The simulation of water level fluctuations resulting from use of the two pools between 40 Mile Check and Frenchman Hills Tunnel will evaluate whether Evergreen Reservoir will be required to buffer surplus flows in-route from Billy Clapp Reservoir, and whether there is a requirement for a lift station to supply additional flow from the 645 Wasteway to supplement available flows at the Frenchman Hills Tunnel inlet.

Table 1. Project milestone schedule.

Task	Jun 2017	Aug 2017	Oct 2017	Dec 2017	Feb 2018	Apr 2018
Identify members of WCP team	X					
Research existing canal plans	X					
Research historical water order demand schedules and forecast future water order patterns	X	X				
Undertake mathematical model of West Canal		X	X			
Run simulations of historical water demand schedules and assess canal performance			X	X		
Run simulations of future water demand schedules and assess canal performance			X	X		
Run simulations including 645 Wasteway lift pump and assess system performance				X	X	X

Task 2- Research Existing Canal Plans: This task involves gathering data from the as-built system drawings to describe the geometry, flow capacity and bed slopes of the canals and each of the existing check structure regulating gates, and then defining this data in the format required to build the analytical model of the system. The as-built drawings will be verified against present-day canal characteristics by performing a field-survey of the existing canal infrastructure.

Task 3- Research historical water order demand schedules and forecast future water order patterns: This task will involve analyzing the historical water ordering data for the West Canal and aggregating these historical water orders into an aggregated demand profile which shows typical rates of change of demand on the canal, and extreme case rates of change of flow demand in the canal to allow the required controller speed of response to be quantified, and to determine whether any 'demand smoothing' would have been required on this historical data by rescheduling orders to comply with rate of change constraints that might be required.

Task 4 - Undertake Mathematical Model of the West Canal: This task involves modeling of the canal flow dynamics to allow simulation of control system response to varying order demand profiles. The exercise involves using the physical survey data gathered in the initial research task to define system parameters for each pool in the West Canal such as static gain, time delay and time constant. These parameters are used with systems identification controller design methodologies to provide a dynamic model of the canal to simulate the canal response to varying aggregate water order demand scenarios.

Task 5 - Run simulations of historical water demand schedules and assess canal performance: This task involves running simulations of canal response to the historical water order demand schedule data for the West Canal as gathered and defined in the Research Task 3 defined above. The outcome of this task will be graphs showing the water level response in each of the canal pools to the range of order demand scenarios under the proposed operations methodology to be adopted with the Total Channel Control solution.

Task 6 - Run simulations of future water demand schedules and assess canal performance: This task involves running simulations of canal response to a range of potential future water order demand schedules defined in the Research Task 3 defined above. The outcome of this task will be graphs showing the water level response in each of the canal pools to the range of order demand scenarios under the proposed operations methodology to be adopted with the Total Channel Control solution.

Task 7 - Run simulations including 645 Wasteway lift pump and assess system performance: This task involves running simulations of canal response to a range of historical and potential future water order demand schedules defined in the Research Task 3 defined above, including the proposed operational flow inputs contributed by a range of pumped flows from the 645 Wasteway. The outcome of this task will be graphs showing the water level response in each of the canal pools to the range of order demand scenarios under the proposed operations methodology to be adopted with the Total Channel Control solution. These findings will identify whether an investment in a pump lift station at 645 Wasteway will further contribute to system efficiencies.

The benefit outcomes of the proposed activity will be to verify project feasibility and solution compatibility with existing infrastructure to enable adoption of a Total Channel Control solution in the District's Water Conservation Plan. This TCC solution will recover approximately 9,000 ac-ft of operational spill per year. The economics of the water savings opportunity are compelling – they have been estimated at around \$15 per acre foot per year. But first the analysis must be performed. Hence, this initial funding request for \$25,000 if granted, will be an enabler for potential future works to make 9,000 ac-ft of water available each year for further beneficial use.

The project will achieve the benefits by verifying the feasibility of the proposed TCC solution and confirming compatibility with the District's existing infrastructure.

Project Criteria

Sub-criterion No. 1: Association with Reclamation project water supplies (Up to 30 points)

The Quincy-Columbia Basin Irrigation District is located in east central Washington, within Reclamation's Pacific Northwest Region, within Reclamation's Columbia Basin Project. QCBID operates and maintains the West Canal and its associated facilities for Reclamation under contract no. 14-16-100-6418.

Sub-Criterion No. 2: Extent to which SOR is likely to contribute to a more sustainable water supply (Up to 20 points):

- With an on-demand system, it is estimated that the District will recover approximately 9,000 ac-ft of water per year from spill and make this water available to meet demands or to store in Billy Clapp Reservoir, Evergreen Reservoir, or Potholes Reservoir.
- Demonstrate the proposed analysis and outcomes will improve water conservation and promote a sustainable water supply. – This analysis will verify assumptions made in considering the TCC proposal, and thereby confirm whether this future investment is compatible with the existing conveyance system – if it is and the TCC system is subsequently implemented then there will be very significant water conservation outcomes. This study is effectively an enabler for these outcomes.
- Each year the lower section of the West Canal reaches maximum capacity for a couple week period. During periods of peak capacity additional request for demands are met by sharing of water in an informal fashion. The TCC technology will provide a more sustainable water supply during this period of peak capacity.
- On a frequency of about every 5 to 10 years, demands exceed the capacity of the upper section of the West Canal for approximately 10 days. The demands exceed capacity between 50 to 200 cfs. During these periods, demands are formally reduced according to share system capacity. The additional water made available with the TCC technology will provide additional water supply to limit the amount and duration of these shortages.
- During periods when the District uses aquatic herbicides to control aquatic vegetation landowners on the end of the West Canal have interrupted or limited water supply. These interruptions occur on a monthly frequency throughout the irrigation season. The TCC system would control the canal system allowing these demands to be met during periods of aquatic vegetation treatment.

Sub-Criterion No. 3: Extent to which the proposed analysis is expected to result in an action plan that will improve water conservation and water use efficiency (Up to 15 points)

- This analysis is required to validate assumptions that have been made in the scoping study with regard to significant water savings.
- The analysis will verify that the hydraulics of the existing canal network can support the operational changes proposed by the Total Channel Control solution, and hence verify that the proposed TCC solution can generate the anticipated 9,000 ac-ft per year savings.

- Verifying this approach will demonstrate that the proposed TCC Implementation will improve water conservation and promote a sustainable water supply. This verification is a necessary enabler to allow us to adopt the proposed TCC implementation.
- Completing this activity will better position QCBID to implement on-the-ground improvement projects in the future by providing verification that the existing District infrastructure is compatible with the hydraulic requirements of the Total Channel Control solution.
- This analysis will also help determine the required pump capacity for the 645 Wasteway supplemental pump station, providing for an optimized design for the pump specifications for future proposed works.

Sub-Criterion No. 4: Extent to which Federal funding would promote completion of an activity that might otherwise be delayed or postponed (Up to 10 points).

- The mathematical modeling work requires in-depth expert knowledge, which Rubicon have provided pricing for in the accompanying quote.
- District Board has approved funding portion of the required service invoice inclusive of in-kind matching, subject to receipt of this grant.
- Funds to pay for these service must be appropriated from District operating revenues, with competing demands for several other district works undertakings.
- The proposed activity may be accomplished at some point of time in the future, but that would require the ongoing willingness and focus of the District's Board and District farmers to commit funds to investigate this water savings opportunity. The commitment is in place now, and so securing grant funds will allow this study to proceed, and achieve certainty in our water conservation plan for actionable planning in the near future. There is a strong advantage in proceeding while this conservation project has the firm commitment of all stakeholders.
- If the funds are not awarded, we will need to perform the analysis at some point in the future when funds are available. The activity could be postponed for several years.
- Funds awarded under this FOA would allow the System Optimization Review to proceed this year, verifying the water savings capability of the proposed TCC solution.

Sub-Criterion No. 5: Reasonableness of costs (Up to 10 points).

This project is seen as an enabler to pursue an innovative solution to recover approximately 9,000 ac-ft of water per year. The economics of the water savings opportunity are compelling – they have been estimated at around \$15 per acre foot per year. But first the analysis must be performed to verify project feasibility and solution compatibility with existing infrastructure. Hence, this initial funding request for \$25,000 if granted, will be an enabler for potential future works to make 9,000 ac-ft of water available each year for further beneficial use.

Sub-Criterion No. 6: Extent to which applicant's water management plan is complete and updated (Up to 10 points).

QCBID developed a water conservation plan in 2002, which identified additional automation of the lower section of the West Canal as a water management tool. This plan also discussed reduced spill with re-regulation reservoirs as a means to save water.

In 2010, QCBID worked with its sister Districts, East and South, along with the Washington State Department of Ecology, to develop the coordinated water conservation plan for the Columbia Basin Project. This plan also identified reducing spill from the end of the West Canal with a re-regulation reservoir as means to save 6,000 ac-ft per year.

Capturing spill is a component of QCBID's current water management and conservation plans. As discussed, balancing reservoirs have been considered in the past which would only recover approximately 60% water that the proposed TCC solution will save, and so this study is validating a new approach to achieve the water savings opportunity discussed in the district plans.

Sub-Criterion No. 7: Amount and sources of non-Federal funding (i.e. cost-share) (Up to 5 points)

The non-Federal funding by the QCBID is approximately 55% of the project costs. The District proposes to contribute \$30,242, towards the total estimated cost of \$55,242 to perform this evaluation.

Project Budget

Funding Plan

The District's contribution to the cost share requirement will be approximate 55% monetary and 45% in-kind. Source funds will come from 2017 assessments. The District will not seek to include in-kind costs incurred before the anticipated project start date. Project expenses that have already occurred, but which will not be included in the project include administrative and engineering work to provide existing facility designs and review of initial proposal information regarding design concepts for the project.

Funding Sources	Funding Amount
Non-Federal Entities (Quincy-Columbia Basin Irrigation District)	
QCBID Participation and Project Management	\$ 13,700
QCBID Share of Contract	\$ 16,542
Non-Federal Entities Subtotal (QCBID)	\$ 30,242
Other Federal Entities Subtotal	\$ -
Requested Reclamation Funding Subtotal	\$ 25,000
Total Project Funding	\$ 55,242

Budget Proposal

The District's contribution to the cost share requirement will be approximate 55% monetary and 45% in-kind. The District proposes to contribute \$30,242 and is seeking \$25,000 in Federal funds. Source funds will come from 2017 assessments. The District will not seek to include in-kind costs incurred before the anticipated project start date. Project expenses that have already occurred, but which will not be included in the project include administrative and engineering work.

Funding Sources	Percent of Total Project Cost	Total Cost by Source \$
Recipient Funding	55 %	\$ 30,242
Reclamation Funding	45 %	\$ 25,000
Other Federal Funding	0 %	\$ -
Totals	100 %	\$ 55,242

Budget Item & Description	\$/Unit		Quantity	Total Cost
Salaries & Wages				
District Manager, Darvin Fales	\$ 72	hr	20	\$ 1,440
Technical Services Assistant Manager, Roger Sonnichsen	\$ 56	hr	80	\$ 4,480
O&M Assistant Manager, Troy Freeman	\$ 48	hr	40	\$ 1,920
Royal Watermaster, Chris Joslin	\$ 31	hr	40	\$ 1,240
Blythe Watermaster, Dennis Smith	\$ 33	hr	40	\$ 1,320
Fringe Benefits				
	\$ 15	hr	220	\$ 3,300
Contractual				
Rubicon Water with tax				\$ 41,542
Other				
Indirect Costs				
Total				\$ 54,522

Salaries and Wages

Project oversight and system operating criteria will be provided by the District's Manager, Technical Service Assistant Manager, and Operation and Maintenance Assistant Manager to Rubicon Water.

Fringe Benefits

Fringe benefits are estimated to be approximately \$15 per hour. Costs were reported by the District's Human Resource Program Manager and are based on a 2014 survey of all employees.

Travel

Travel expense is not expected for the proposed project.

Equipment

The District does not expect to purchase new equipment for the proposed project.

Contractual

The District will enter into an agreement with Rubicon Water to perform the hydraulic modeling and demand response analysis of QCBID's West Canal.

Environmental and Regulatory Compliance Costs

There are no expected environmental permits required for the completion of the proposed project. A line item has been included in the budget to cover cost incurred to determine the level of environmental compliance required for the project.

Reporting

Reporting expense has been included on the budget to cover costs associated with reporting requirements. All reporting will be performed by District staff

Indirect Costs

No indirect costs are included.

Total Costs

Total project total cost is expected to be \$55,242.

Attachments

- A. Payroll Information on Salary
- B. QCBID - Fringe Benefits calculation
- C. Resolution 2017-11 – Water Conservation Field Services Program – Grant BOR PN-17-F001
- D. Rubicon Water – Quotation – Modeling and Analysis of West Canal Operating Scenarios

Payroll hourly rate



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Name	Hourly Rate (Current Revision)
Smith Dennis G	33.18
Freeman Troy L	47.57
Joslin Christopher J	31.00
Fales Darwin	71.92
Sonnichsen Roger	55.96

Fringe Benefits - QCBID

Holidays	11*8= 88	*20.41= 1796.08	/2080=	\$0.86
Annual Leave	19.5*8= 156	*20.41= 3183.96	/2080=	\$1.53
Sick Leave	13*8= 104	*20.41= 2122.64	/2080=	\$1.02
Bereavement Leave	2*8= 16	*20.41= 326.56	/2080=	\$0.16
DRS		20.41*	.1118=	\$1.88
Medical Insurance (ES/Fam Avg)				\$9.21
				<hr/>
				\$14.66

QUINCY-COLUMBIA BASIN IRRIGATION DISTRICT
RESOLUTION 2017 -11

Water Conservation Field Services Program - Grant BOR-PN-17-F001

WHEREAS, the Quincy-Columbia Basin Irrigation District is in receipt of the U.S. Bureau of Reclamation Funding Opportunity Announcement No. BOR-PN-17-F001: *Pacific Northwest Region, Water Conservation Field Services Program Grant Program for FY 2017; Federal funding limited to \$25,000*; and

WHEREAS, the Quincy-Columbia Basin Irrigation District has legal authority to enter into a grant agreement with the U.S. Bureau of Reclamation; and

WHEREAS, the Board of Directors of the Quincy-Columbia Basin Irrigation District supports the application submitted; and

WHEREAS, the Quincy-Columbia Basin Irrigation District is capable of providing the minimum 50% matching amount of funding and/or in-kind contributions specified in the funding plan; and

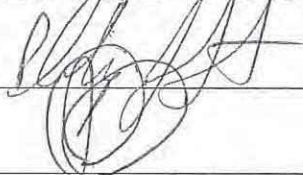
WHEREAS, the Quincy-Columbia Basin Irrigation District will work with the U.S. Bureau of Reclamation to meet established deadlines for entering into a cooperative agreement; and


WHEREAS, receiving financial assistance through a Water Conservation Field Services Grant does not subject the Quincy-Columbia Basin Irrigation District to the discretionary provisions of the Reclamation Reform Act of 1982;


NOW, THEREFORE, BE IT HEREBY RESOLVED by the Board of Directors that the Quincy-Columbia Basin Irrigation District is committed to the financial and legal obligations associated with receipt of Water Conservation Field Services Grant financial assistance.

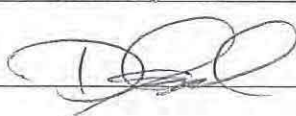
DULY ADOPTED during the regular meeting of the Board of Directors this 7th day of February 2017.

BOARD OF DIRECTORS





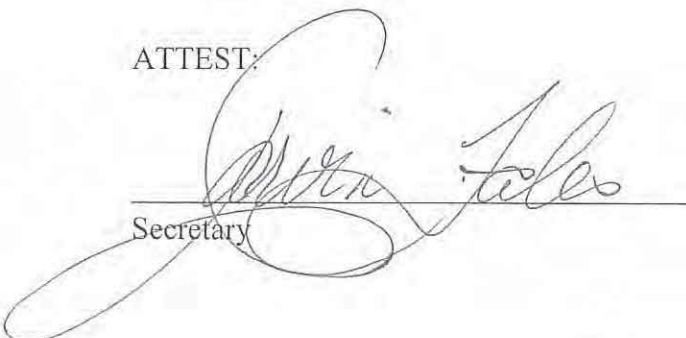




(SEAL)

ATTEST:

Secretary



Secretary



QUOTATION

Date: February 1, 2017

To: Roger Sonnichsen
Company: Quincy Columbia Basin Irrigation District
Address: 1720 South Central Avenue
PO Box 188
Quincy, WA 98848

Phone: (509) 787-3591 ext 229

Project: Modelling and Analysis of West Canal Operating Scenarios
Quote #: Q500713
Valid For: 60 days

Rubicon Water

Fort Collins
1501 S. Lemay, Suite 101
Fort Collins, CO 80524
Toll Free 1-877-440-6080
Telephone 970-482-3200
Facsimile 970-482-3222

Modesto
615 Kansas Avenue, Unit B
Modesto, CA 95350

Imperial
415 W Aten Road
Imperial, CA 92251

www.rubiconwater.com
usainquiry@rubiconwater.com

Shipping Terms: FOB Fort Collins, CO, USA
Billing Terms: Net 30 days (see Payment Terms for details)
Prepared by: Damien Pearson

It is with pleasure that Rubicon Water submits this quotation to undertake a hydraulic modelling and demand response analysis of Quincy Columbia Irrigation District's West Canal.

This hydraulic analysis will allow the District to validate decisions relating to Water Management Improvement Designs being developed by the Irrigation District to improve operations efficiency and make more water available for beneficial use.

Rubicon is pleased to provide these modeling, simulation, and operations scenario evaluation services at a price of \$38,500.

+ tax @ 7.9% = \$ 3,042

This price excludes all applicable taxes.

TOTAL \$ 41,542

Background

A design analysis of the West Canal has established that there is an opportunity to recover large volumes of water lost to operational spill from the Lower West Canal. The existing canal operations have been developed under an upstream level control philosophy which by its nature requires surplus flows to be delivered through the canal network. The District is considering reconfiguring the Lower West Canal control infrastructure to provide a demand-driven control paradigm by utilizing Total Channel Control (TCC) technology.

The conversion to a demand-driven automated system will precisely match supplied flows to demand and maintain stable supply levels at each check structure on the Lower West Canal. By matching supply to demand, the TCC implementation will reduce spill into Goose Lake and divert this recovered water to Potholes Reservoir (or allow the recovered water to be retained in storage further up the system).

Scope of Work

In order for the proposed Total Channel Control implementation to be successful, there must be available buffering storage upstream of the Frenchman Hills Tunnel to act as an on-demand source of water to supply the precise flow requirements of the Lower West Canal.

The West Canal is presently supplied with relatively slowly varying flow setpoints from the Billy Clapp Lake diversion. These relatively slowly varying flow releases will supply a potentially rapidly varying demand at the Frenchman Hills Tunnel. This imbalance between real-time flows into the 40 Mile Check and the real-time demand at the Rolling Hills Tunnel will require a balancing volume to buffer the differing inflows and outflows. It is proposed that the 25 mile length of canal between 40 Mile Check and the Frenchman Hills Tunnel can be utilized as a 25 mile long distributed reservoir.

To verify this opportunity to utilize the existing canal infrastructure to buffer flow imbalances, a dynamic model of the West Canal's conveyance hydraulics will be developed. This model will be used to assess the fluctuation in pool supply levels along the West Canal that will result as the demand in the Lower West Canal changes in response to the Total Channel Control's precision time-varying flow deliveries.

The simulation of water level fluctuations resulting from use of the two pools between 40 Mile Check and Frenchman Hills Tunnel will evaluate whether Evergreen Reservoir will be required to buffer surplus flows en-route from Billy Clapp Reservoir, and whether there is a requirement for a lift station to supply additional flow from the 645 Wasteway to supplement available flows at the Frenchman Hills Tunnel inlet.



Figure 1 - The Lower West Canal (Blue) and the West Canal (Green) to be analyzed in this study

This research task will develop a mathematical dynamic model to analyze the length of the West Canal between 40 Mile Check and the Frenchman Hills Tunnel (indicated by the green canal trace in Figure 1 above).

The dynamic model will be developed to define the Time Constant and Time Delay of the two pools spanning this 25 mile stretch of canal, and the Time Constant and Time Delay of the upstream conveyance pools supplying water from Billy Clapp Reservoir.

This dynamic model will be used to simulate the water level fluctuations that will occur in the two pools between 40 Mile Check and Frenchman Hills Tunnel that will result from a range of demand profiles and a range of diversion strategies from the Billy Clap Diversion.

The response behavior of the supply levels will be analyzed and management methodologies will be proposed to coordinate the real-time measurements of these water levels with the diversions from Billy Clapp Reservoir and with operations of Evergreen Reservoir to buffer surplus flows being delivered from the West Canal.

This analysis will determine whether Evergreen Reservoir will be required to buffer surplus flows en-route from the Billy Clapp Reservoir, and whether there would be a requirement for a lift station to supply additional flow from the 645 Wasteway to supplement available flows at the Frenchman Hills Tunnel inlet.

Payment Terms

Payments are to be made as follows:

- Net 30 days after completion and presentation of the research findings.

All payments are to be made by check to Rubicon Systems America Inc.

Rubicon Water Standard Terms of Sale applies to this Quotation and is appended to the end of this quotation.

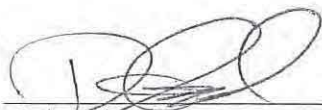
Delivery

It is anticipated that this modeling and simulation activity will require approximately 12-14 weeks.

The Next Step:

To accept this quotation and begin the procurement process, please sign here and return:

Customer:

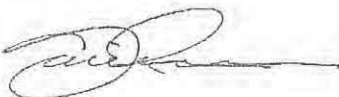


Authorized Signature

2-7-17

Date

Authorized By:



General Manager, North America

RUBICON WATER

STANDARD TERMS AND CONDITIONS

1. APPLICATION OF TERMS AND CONDITIONS

Unless otherwise agreed in writing, these terms will apply to the provision of all Products, Software and Services within the USA by Rubicon Systems America Inc of 4563 Denrose Court, Fort Collins, Colorado 80524. Any terms and conditions contained in your purchase order or otherwise notified to us will apply only if they are specifically accepted in writing by us.

2. ORDERS

(a) Purchase orders, including agreement to our quotations, are to be submitted in writing and are subject to our final acceptance. Subject to (b) below, purchase orders will be deemed accepted when we receive them, unless we advise you otherwise in writing.

(b) Written quotations of prices payable by you for the Products, Software and/or Services (Prices), will remain valid for 60 days and after that will be subject to our revalidation.

3. PRODUCTS

(a) Unless otherwise specified in writing, we warrant that for a period of 12 MONTHS from the date of commissioning (Product Warranty Period) all Products of our own manufacture will conform to our applicable design specifications.

(b) It is your responsibility to ensure that the Products you order are fit for your intended purpose.

(c) We reserve the right to replace Products with new or alternative Products with similar functionality.

4. SOFTWARE

(a) Unless otherwise specified in writing, we warrant that for a period of 12 MONTHS from the date of delivery (Software Warranty Period) all Software of our own manufacture will substantially perform in accordance with our functional specifications. This does not mean that we warrant that the Software will be error or bug free.

(b) We grant you a revocable, non-exclusive, non-transferable license to use the Software in conjunction with our Products subject to any restrictions we specify in writing. This license is subject to revocation upon any breach by you of these Standard Terms and Conditions or the termination of any contract between Rubicon and, you. You may use the Software for the operations or applications for which it was furnished by us, but not for any other purpose without our prior written consent. You may not use of the Software in violation of any other restriction contained in these Standard Terms and Conditions, or after termination of the license.

(c) You acknowledge that ownership in the Software does not pass to you and your rights are limited to the conditions specified in these terms.

(d) You may use and copy the Software as reasonably required for back-up, maintenance or training purposes but otherwise the Software is not to be copied or altered without our prior consent. All copies of the Software must bear our original copyright and other proprietary notices, and shall remain property of Rubicon. You may not permit any third party to use or make copies of the Software.

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(f) Without our prior written consent, which may be withheld in our sole discretion, you may not: (i) sell, assign or otherwise transfer in any manner to any third party any rights in or to the Software, (ii) allow any third party to use the Software; or (iii) sublicense, publish, display, distribute, or otherwise transfer to a third party the Software or any copy, in whole or in part.

5. SERVICES

(a) We warrant that for a period of 12 MONTHS from the date they are performed (Services Warranty Period), all Services will be provided by us with due expedition and consistent with the required industry standards or professional skills and advice required for carrying out such Services.

(b) We will act professionally at all times and exercise skill, care and diligence in performing the Services.

6. OUR OBLIGATIONS

(a) In providing the Products, Software and/or Services, we will:
(i) act in a skilful, diligent, workmanlike, careful, safe and proper manner;

(ii) keep you appropriately informed of the progress of the provision of the Products, Software and/or Services;

(iii) act in accordance with standards and practices normally exercised in the water industry;

(iv) be entitled to exercise our judgment and use our skills as we considers most appropriate;

(v) complete the provision of Products, Software and/or Services in a timely manner.

(b) If we are delayed or we become aware of the likelihood of a delay in the provision of the Products, Software and/or Services, we will notify you as soon as possible after becoming aware of those circumstances.

7. YOUR OBLIGATIONS

In engaging us, you will:

(a) provide us with all relevant information necessary for the provision of the Products, Software and/or Services including site information, technical environment, relevant data, intelligence and instructions on an ongoing and timely basis as may be necessary and prudent;

(b) provide us with access to your personnel, premises, systems, facilities, confidential information, and/or records to enable us to provide the Products, Software and/or Services.

(c) acknowledge that if you do not meet these obligations you may cause or contribute to an increase in our estimated fees; we may incur additional costs, charges and expenses; and there is likely to be delays in the completion of the supply of the Products, Software and/or Services.

(d) not be obliged to disclose information that is not reasonably relevant.

8. WARRANTY

(a) Products, Software and/or Services not manufactured by us are excluded from our Warranty but we will seek to extend to you any warranty received from the original manufacturer or supplier so far as we are permitted to do so.

(b) In the event of a defect, malfunction or failure to conform to specification during the applicable Warranty Period we will, as determined by us:

(i) repair or replace defective Products;

(ii) replace or correct all reproducible deficiencies and errors in Software manufactured by us which fail as a direct result of our defective materials or workmanship;

(iii) re-perform the Services; or

(iv) refund the Price for such defective Products, Software or Services.

(c) Product warranty repair is provided at our facility and Software warranty is provided online. You will pay the return transport costs for sending the Products for repair. Where warranty repairs are required to be undertaken on site, you will pay all costs incurred by us other than the cost of actually undertaking the repairs. In the event that the defects are due to causes outside our warranty obligation, you will pay for the cost of repair or replacement at our then current charges.

(d) Product and Software warranties will not apply to any Products or Software other than in their original condition which we determine have not been subjected to operating or environmental conditions in excess of the their maximum limits, or otherwise have not been subjected to misuse, improper installation, repair, alteration, or accidental damage, whether or not caused by you.

(e) EXCEPT FOR THE LIMITED WARRANTIES SET FORTH IN THESE STANDARD TERMS AND CONDITIONS, ALL PRODUCTS, SOFTWARE AND SERVICES ARE PROVIDED "AS IS." THESE LIMITED WARRANTIES ARE EXCLUSIVE AND IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. We shall not be liable to you or any user of any Products, Software or Services for any indirect, special, incidental, exemplary or consequential damages (including, without limitation, lost profits) related to these Standard Terms and Conditions or resulting from use or inability to use the Products, Software or Services, arising from any cause of action whatsoever, including contract, warranty, strict liability, or negligence, even if

RUBICON WATER STANDARD TERMS AND CONDITIONS

we have been notified of the possibility of such damages. Under no circumstances shall our liability to you or any user of the Products, Software or Services exceed the amounts paid to us by you for the Product, Software or Service involved. No action under the foregoing limited warranties or these Standard Terms and Conditions may be brought more than one (1) year after the cause of action arises. Exclusive subject matter and personal jurisdiction for all disputes arising under this Agreement shall be the Larimer County District Court in Fort Collins, Colorado.

(f) You warrant that you have not relied on any representation, description, illustration, specification or any other material which has not been expressly published by us or agreed by us in writing.

(g) You warrant that the information you need to provide to us will be sufficiently comprehensive to enable us to meet our obligations and will be free from errors and omissions.

(h) Please note that whilst we warrant that all Products of our own manufacture will conform to our applicable design specifications for a period of 12 MONTHS from the date of shipment, unless you engage our services to evaluate your needs and accept our written recommendations it is your responsibility to ensure that the Products you order are correctly sized and fit for your intended purpose.

9 SOFTWARE MAINTENANCE AND SUPPORT SERVICES

(a) From the time of installation we will provide you with your desired level of Software maintenance and support services.

(b) Software maintenance and support services do not include services involving correction of faults, errors or defects caused by:

(i) operation of the Software in a manner which contravenes your obligations;

(ii) failure by you to operate the Software in accordance with the relevant specifications which have been made known by us to you;

(iii) use of the Software in an environment other than that provided for in the relevant specifications;

(iv) Product maintenance performed by a person other than us or persons approved by us;

(v) modifications to the Software made by you or a third party, unless authorized by us.

(c) A condition of the provision of Software maintenance and support is that you must purchase the Software maintenance and support on a continuous basis from the time of installation. In the event that there is any period during which we do not provide Software maintenance and support, as a condition precedent to us undertaking any future Software maintenance and support we reserve the right to undertake at your expense an investigation of the Software and provide any required remedial maintenance to bring the Software to an acceptable level.

10 PRICES

(a) In consideration of the provision of the Products, Software and/or Services, You will pay the applicable Prices and at the times specified in our quotations or as specified in our published Price lists.

(b) We reserve the right:

(i) without liability on our part, to correct any errors or omissions in any offer, quotation, order confirmation, invoice or other documentation issued by us;

(ii) to pass on to you any additional costs (including merchant fees) incurred by us where you pay us by credit card;

(iii) to adjust the Prices to cover any exchange rate variations on imports and variations in labor and material costs to the date of invoice. We will reimburse to you any cost or benefit of variations incurred by us.

(c) All Prices are specified in US dollars.

11 TAXES

Unless expressly stated by us, Prices quoted or agreed do not include sales, goods and services, value added or any other applicable government tax or duty payable either before or after invoice from us. Such taxes and duties are payable in addition to the Prices.

12 PAYMENT

(a) We may invoice you for Products, Software and/or Services and all other amounts payable by you under these terms and conditions at any time after we notify you that the Products, Software and/or Services are ready for

collection or we otherwise deliver or attempt to deliver the Products, Software and/or Services.

(b) Unless otherwise agreed and subject to you maintaining an acceptable credit rating, you must pay all invoices within 30 days of the date of the invoice.

(c) If you dispute an invoice you must (except in the case of non-delivery) nonetheless pay the entire amount. We will refund any agreed amount following resolution of the dispute. If you fail to pay any invoice by the due date then, without affecting any other right or remedy available to us, we may:

(i) Suspend any further deliveries to you of the Products or Software in question or any other Products or Software and suspend or refuse to perform any Services to you whether under an existing or new order;

(ii) Charge you interest on the amount unpaid at the rate 5% above our then current overdraft rate until payment in full is made. Such interest is to be compounded daily.

(iii) Exercise a general lien on all of your property in our possession to cover the amount unpaid for the Products, Software and/or Services; and

(iv) Recover from you, in addition to the outstanding amount, all reasonable costs incurred by us in collection of the outstanding amount.

13 DELIVERY TITLE AND RISK

(a) Delivery schedules are estimates only and are subject to adjustment at any time. We will notify you of any changes in our delivery schedule but will not be liable for any additional costs that you may incur.

(b) All Products will be delivered in our standard packaging and will be accepted by you at the time of delivery.

(c) Property and risk in relation to the Products passes to you at the point of delivery to your carrier at our facility or, if you request us to arrange delivery and insurance, upon delivery to you.

(d) Title to the Products passes to you upon the earlier of payment in full for those Products or upon integration of the Products so that they are no longer capable of repossession.

(e) Until Title passes, we may repossess any Products for which payment has not been made in full by the due date.

14 CONFIDENTIALITY

(a) You agree not to disclose any information provided by us to you relating to us and our related entities that we may reasonably regard as confidential or commercially sensitive (including without limitation our pricing information) unless you can establish the information was:

(i) at the time of disclosure, in the public domain;

(ii) subsequent to disclosure, entered into the public domain other than through the breach of a duty owed to us; or

(iii) required to be disclosed by law.

(b) We will use reasonable endeavors to preserve the confidentiality of information supplied to us by you that you designate as confidential information. Nothing in these terms and conditions will impose on us the obligation not to disclose or use information already known to us prior to its disclosure to us by you, or lawfully received by us from a third party, or information published at the date of such disclosure, or information which enters the public domain through no fault of our own, or is required to be disclosed by law.

15 INTELLECTUAL PROPERTY RIGHTS

(a) Intellectual Property Rights includes copyright, trade mark, design, patent, semiconductor or circuit layout rights, know how, trade or other proprietary rights or any rights to registration of such rights or protected by statute.

(b) You will retain ownership of any pre-existing Intellectual Property Rights in materials provided by you to us for use by us for the purposes of providing Products, Software and/or Services.

We will retain ownership of any pre-existing Intellectual Property Rights in materials, information, tools, and methodologies provided by us for the purposes of providing the Products, Software and/or Services (or undertaking any improvements to the Products, Software and/or Services).

(c) You indemnify us against any claims of infringement of any Intellectual Property Rights or misuse of a third party's Confidential Information brought against us as a result of the provision of Products, Software and/or Services in relation to this contract or arising directly or indirectly from the use of any materials or information provided to us by you.

RUBICON WATER STANDARD TERMS AND CONDITIONS

16 EXCLUSIONS AND LIMITATIONS

- (a) We exclude all implied conditions and warranties except any implied condition or warranty that the exclusion of which would contravene any law, statute or cause any part of this paragraph to be void.
- (b) To the extent permitted by law:
- (i) we exclude liability (including from our breach of any express or implied condition or warranty or our negligence) for loss of profits or consequential or indirect loss or damage; and
- (ii) our liability to you from our breach of any express or implied condition or warranty or our negligence is limited, at our option, to supplying the Products, Software and/or Services in respect of which the breach or negligence occurred again; or to paying the cost of having those Products, Software and/or Services supplied again; or refunding the Price for the Products, Software and/or Services.

17 FORCE MAJEURE

We will not be liable for any failure to perform or delay in performance of any obligation where such failure or delay is due to anything beyond our reasonable control, including but not limited to adverse weather or terrain, strikes, lockouts and other industrial action, material shortages, failure of any of our suppliers to supply, accidents, power failure, breakdowns of plant or machinery or import or export regulations or embargoes.

18 LIABILITY

Except as expressly stated in these terms and conditions, we will not be liable in contract or otherwise for any loss, damage, expense or injury of any sort whatsoever, consequential, indirect or otherwise, arising out of or in connection with the installation, use or failure of the Products, Software and/or Services sold or any defect in them or from any other cause.

19 TERMINATION

- (a) We may, without affecting any other rights we may have, terminate or suspend any contract between us with immediate effect by giving notice to you if:
- (i) you breach any provision of our contract and fail to remedy the breach within 7 days after our notice requiring you to do so;
- (ii) if you breach a material provision of our contract where that breach is not capable of remedy;
- (iii) you cease to be able to pay your debts as they become due;
- (iv) you become subject to any form of insolvency or bankruptcy action that is not dismissed within 60 days or;
- (v) any step is taken by a receiver or mortgagee to take possession or dispose of the whole or any part of your assets.
- (b) If we exercise our rights to terminate or suspend a contract, we will immediately be entitled to invoice you for work in progress at our current rates. This paragraph does not limit or affect any other remedy which may be available to us including seeking compensation for any loss or damage suffered by us.
- (c) If we are unable to perform or complete performance of our obligations wholly or in part due to causes beyond our control, we may unilaterally rescind the contract, or the outstanding portion, without any further liability to any party other than the obligation for you to pay for Products, Software and/or Services provided to the time of such termination.

20 SEVERENCE

If part or all of any provision of these terms and conditions or its application to any person or circumstance is illegal or unenforceable the provision will be interpreted so as to ensure it is not illegal or unenforceable. If any provision or part of it cannot be so interpreted, the provision or part of it will be severed from these terms and conditions and the remaining provisions of these terms and conditions continue in force.

21 GOVERNING LAW

These Standard Terms and Conditions and all contracts between us will be governed by and interpreted according to the laws of the State of Colorado, without regard to conflicts of law's provisions.

22 DISPUTE RESOLUTION; ENFORCEMENT

In the event of any dispute arising between us who are unable to be resolved by negotiation, the matter will be exclusive subject matter and personal jurisdiction shall be the Larimer County District Court in Fort Collins, Colorado. In any such proceeding, the prevailing party shall be entitled to recover from the other party, in addition to any other relief granted, all costs reasonably incurred by the prevailing party in the proceeding, including court costs, witness fees and reasonable attorney's fees.

If you violate any license granted by us or violate or infringe upon any of our intellectual property or other proprietary rights, we may institute proceedings either at law or in equity to obtain damages or equitable relief to enforce our rights. You acknowledge that monetary damages would not be a sufficient remedy for a breach of a license or violation of our intellectual property or other proprietary rights, and that we shall not be required to prove the inadequacy or insufficiency of monetary damages as a remedy in order to obtain equitable relief. No bond or other form of security shall be required in connection with any such injunctive or other equitable relief.

23 RUBICON AGENTS

- i. Our sales agents are only authorized to promote the sale of our Products, Software and/or Services in accordance with our published specifications or variations thereto that we have approved in writing.
- ii. We cannot take responsibility for any representation made by our sales agents that has not been published or authorized by us.
- iii. Our sales agents are expected to comply with all applicable laws, regulations, codes of ethical conduct and where applicable government purchasing requirements and are instructed not to engage in any unethical conduct, payment of kickbacks or gratuities, or provision of any inappropriate benefits.

24 ENTIRE AGREEMENT AND VARIATIONS

- (a) Any variation to these terms will only be effective if in writing and signed by both parties.
- (b) You may, with our prior approval and subject to agreement for an adjustment of Prices, by written order make changes in accordance with the general scope of the contract to the drawings, designs or specifications or method of delivery or packing.
- (c) In the case of such changes, there will be an equitable adjustment to the Prices, delivery schedule and any other provisions of the contract affected by the changes.
- (d) Unless otherwise agreed, all works will be suspended pending agreement on any adjustments to be made resulting from such changes.