CITY OF Grand Junction COLORADO

LETTER OF INTENT

Date: May 19, 2020

Company: Mobley Engineering, Inc.

Project: Design/Build Aeration Project for Juniata Reservoir RFP-4792-20-DH

Based upon review of the proposal responses received, and negotiations, for Design/Build Aeration Project for Juniata Reservoir RFP-4792-20-DH, your company has been selected as the preferred proposer of this solicitation process.

This project must be approved by the City Council prior to award and a contract being issued.

Upon receipt of a fully signed contract, please provide the Purchasing Division the signed Contract, Payment & Performance Bonds, and your Insurance Certificate, as per the solicitation documents.

Please feel free to contact me with any questions at 970-244-1545.

Thank you and Best Regards

Duane Hoff Jr., Senior Buyer

CITY OF Grand Junction COLORADO

CITY OF GRAND JUNCTION, COLORADO

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CONTRACT

This CONTRACT made and entered into this 4th day of June, 2020 by and between the **City of Grand Junction, Colorado,** a government entity in the County of Mesa, State of Colorado, hereinafter in the Contract Documents referred to as the "Owner" and **Mobley Engineering, Inc.** hereinafter in the Contract Documents referred to as the "Contractor."

WITNESSETH:

WHEREAS, the Owner advertised that sealed Responses would be received for furnishing all labor, tools, supplies, equipment, materials, and everything necessary and required for the Project described by the Contract Documents and known as **Design/Build Aeration Project for Juniata Reservoir RFP-4792-20-DH**.

WHEREAS, the Contract has been awarded to the above named Contractor by the Owner, and said Contractor is now ready, willing and able to perform the Work specified in the Notice of Award, in accordance with the Contract Documents;

NOW, THEREFORE, in consideration of the compensation to be paid the Contractor, the mutual covenants hereinafter set forth and subject to the terms hereinafter stated, it is mutually covenanted and agreed as follows:

ARTICLE 1

Contract Documents: It is agreed by the parties hereto that the following list of instruments, drawings, and documents which are attached hereto, bound herewith, or incorporated herein by reference constitute and shall be referred to either as the "Contract Documents" or the "Contract", and all of said instruments, drawings, and documents taken together as a whole constitute the Contract between the parties hereto, and they are fully a part of this agreement as if they were set out verbatim and in full herein:

The order of contract document governance shall be as follows:

a. The body of this contract agreement
b. Negotiated Terms and Conditions/Scope of Work etc.
c. Solicitation Documents for the Project; **Design/build Aeration Project for Juniata Reservoir;**
d. Intent to Award
e. Contractors Response to the Solicitation

f. Work Change Requests (directing that changed work be performed);
g. Field Orders
h. Change Orders.

ARTICLE 2

Definitions: The clauses provided in the Solicitation apply to the terms used in the Contract and all the Contract Documents.

ARTICLE 3

Contract Work: The Contractor agrees to furnish all labor, tools, supplies, equipment, materials, and all that is necessary and required to complete the tasks associated with the Work described, set forth, shown, and included in the Contract Documents as indicated in the Solicitation Document.

ARTICLE 4

Contract Time and Liquidated Damages: Time is of the essence with respect to this Contract. The Contractor hereby agrees to commence Work under the Contract on or before the date specified in the Solicitation from the Owner, and to achieve Substantial Completion and Final Completion of the Work within the time or times specified in the Contractor's submitted proposal project schedule. In the event the Work is not completed in the times set forth and as agreed upon, the Contractor further agrees to pay Liquidated Damages to the Owner as set forth in the Solicitation. The Contractor acknowledges and recognizes the delays, expenses and difficulties involved in proving in a legal proceeding the actual losses suffered by the Owner if the work is not completed on time. Accordingly, instead of requiring any such proof, the Owner and the Contractor agree that as Liquidated Damages for delay, but not as a penalty, the Contractor shall pay to the Owner the amounts specified in the Solicitation.

ARTICLE 5

Contract Price and Payment Procedures: The Contractor shall accept as full and complete compensation for the performance and completion of all of the Work specified in the Contract Documents, the negotiated estimated sum of **Two Hundred Fourteen Thousand Nine Hundred Ninety Six and 00/100 Dollars ($214,996.00). This amount is based on a "Cost Plus a Fixed Fee" pricing structure. This amount also includes the Contractor's Fixed Fee of Forty-Five Thousand Eight Hundred Fifty and 00/100 Dollars ($45,850.00).** If this Contract contains unit price pay items, the Contract Price shall be adjusted in accordance with the actual quantities of items completed and accepted by the Owner at the unit prices quoted in the Solicitation Response. The amount of the Contract Price is and has heretofore been appropriated by the Grand Junction City Council for the use and benefit of this Project. The Contract Price shall not be modified except by Change Order or other written directive of the Owner. The Owner shall not issue a Change Order or other written directive which requires additional work to be performed, which work causes the aggregate amount payable under this Contract to exceed the amount appropriated for this Project, unless and until the Owner provides

Contractor written assurance that lawful appropriations to cover the costs of the additional work have been made.

Unless otherwise provided in the Solicitation, monthly partial payments shall be made as the Work progresses. Applications for partial and Final Payment shall be prepared by the Contractor and approved by the Owner in accordance with the Solicitation.

Upon Final Completion of the Work under the Contract and before the Contractor shall receive final payment, the Owner shall publish at least twice in a newspaper of general circulation published in the County a notice that: 1. the Owner has accepted such Work as completed according to the Contract Documents; 2. the Contractor is entitled to final payment therefore; 3. thirty days after the first publication, specifying the exact date, the Owner shall pay the full balance due under the Contract; and 4. persons having claims for labor, materials, team hire, sustenance, provisions, provender, or other supplies used or consumed by the Contractor or a subcontractor shall file a verified statement of the amount due and unpaid on account of such claim prior to the date specified for such payment. Nothing herein shall be construed as relieving the Contractor and the Sureties on the Contractor's Bonds from any claim or claims for work or labor done or materials or supplies furnished in the execution of the Contract.

ARTICLE 6

Bonds: The Contractor shall furnish currently herewith the Bonds required by the Contract Documents, such Bonds being attached hereto. The Performance Bond shall be in an amount not less than one hundred percent (100%) of the Contract Price set forth in Article 5. The Payment Bond shall be in an amount not less than one hundred (100%) of the Contract Price set forth in Article 5.

ARTICLE 7

Contract Binding: The Owner and the Contractor each binds itself, its partners, successors, assigns and legal representatives to the other party hereto in respect to all covenants, agreements and obligations contained in the Contract Documents. The Contract Documents constitute the entire agreement between the Owner and Contractor and may only be altered, amended or repealed by a duly executed written instrument. Neither the Owner nor the Contractor shall, without the prior written consent of the other, assign or sublet in whole or in part its interest under any of the Contract Documents and specifically, the Contractor shall not assign any moneys due or to become due without the prior written consent of the Owner.

ARTICLE 8

Severability: If any part, portion or provision of the Contract shall be found or declared null, void or unenforceable for any reason whatsoever by any court of competent jurisdiction or any governmental agency having the authority thereover, only such part, portion or provision shall be effected thereby and all other parts, portions and provisions of the Contract shall remain in full force and effect.

IN WITNESS WHEREOF, City of Grand Junction, Colorado, has caused this Contract to be subscribed and sealed and attested in its behalf; and the Contractor has signed this Contract the day and the year first mentioned herein.

The Contract is executed in two counterparts.

CITY OF GRAND JUNCTION, COLORADO

DocuSigned by:

By: Duane Hoff Jr., Senior Buyer - City of Grand Junction 6/8/2020 | 15:38 MDT

Duane Hoff Jr., Senior Buyer Date

Mobley Engineering, Inc.

DocuSigned by:

By: 6/8/2020 | 12:11 MDT

Susan Mobley, President - Mobley Engineering, Inc. President Date

SECTION 7.0: SOLICITATION RESPONSE FORM

RFP-4792-20-DH

"Design/Build Aeration Project for Juniata Reservoir"

Offeror must submit entire Form completed, dated and signed.

1) Total "Fixed Fee", per scope/specifications:

TOTAL $ 45, 850.00

WRITTEN: FORTY FIVE THOUSAND EIGHT HUNDRED + FIFTY **dollars.**

The Owner reserves the right to accept any portion of the work to be performed at its discretion

The undersigned has thoroughly examined the entire Request for Proposals and therefore submits the proposal and schedule of fees and services attached hereto.

This offer is firm and irrevocable for sixty (60) days after the time and date set for receipt of proposals.

The undersigned Offeror agrees to provide services and products in accordance with the terms and conditions contained in this Request for Proposal and as described in the Offeror's proposal attached hereto; as accepted by the Owner.

Prices in the proposal have not knowingly been disclosed with another provider and will not be prior to award.

- Prices in this proposal have been arrived at independently, without consultation, communication or agreement for the purpose of restricting competition.
- No attempt has been made nor will be to induce any other person or firm to submit a proposal for the purpose of restricting competition.
- The individual signing this proposal certifies they are a legal agent of the offeror, authorized to represent the offeror and is legally responsible for the offer with regard to supporting documentation and prices provided.
- Direct purchases by the City of Grand Junction are tax exempt from Colorado Sales or Use Tax. Tax exempt No. 98-903544. The undersigned certifies that no Federal, State, County or Municipal tax will be added to the above quoted prices.
- City of Grand Junction payment terms shall be Net 30 days.
- Prompt payment discount of ________ percent of the net dollar will be offered to the Owner if the invoice is paid within __________ days after the receipt of the invoice.

RECEIPT OF ADDENDA: the undersigned Contractor acknowledges receipt of Addenda to the Solicitation, Specifications, and other Contract Documents.

State number of Addenda received: 1.

It is the responsibility of the Proposer to ensure all Addenda have been received and acknowledged.

MOBLEY ENGINEERING, INC.	SUSAN MOBLEY
Company Name – (Typed or Printed)	Authorized Agent – (Typed or Printed)
[signature]	865.494.0600
Authorized Agent Signature	Phone Number
30 HICKORY TRL, POB 600	susan@mobleyengineering.com
Address of Offeror	E-mail Address of Agent
NORRIS TN 37828-0600	May 4, 2020
City, State, and Zip Code	Date

Mobley Engineering

PO Box 600, Norris, Tennessee 37828-0600 *phone (865) 494-0600*

May 5, 2020

Duane Hoff Jr., Senior Buyer
City of Grand Junction, CO

RFP-4792-20-DH, Design/Build Aeration Project for Juniata Reservoir

This letter introduces a proposal to provide a reservoir diffuser system for the City of Grand Junction in response to RFP-4792-20-DH, Design/Build Aeration Project for Juniata Reservoir. Mobley Engineering, Inc. (MEI) would provide detailed design and furnish all materials, equipment and labor required to install and place into successful operation the diffuser piping for the Juniata Reservoir Hypolimnetic Oxygenation System. The MEI diffuser system is a proven design that offers flexible operation, low maintenance and proven results. The MEI oxygen diffuser system is successfully being used to enhance water quality and reduce treatment costs at over 20 water supply reservoirs across the United States. The MEI system will be assembled and deployed by an experienced crew for a trouble free installation.

We look forward to working with you on this project.

Susan R. Mobley

President
Mobley Engineering, Inc.

Mobley Engineering

PO Box 600, Norris, Tennessee 37828-0600 phone (865) 494-0600

PROPOSAL:

RFP-4792-20-DH

DESIGN/BUILD AERATION PROJECT FOR JUNIATA RESERVOIR

INTRODUCTION:

Mobley Engineering, Inc. offers the design, installation and initial operation of hypolimnetic oxygen diffuser systems for hydropower projects and water supply utilities. These diffusers are based on a design that was originally developed by the Tennessee Valley Authority for hydropower reservoir release improvements. The diffuser can deliver large quantities of oxygen with maximum oxygen transfer efficiency by providing an economical means to spread the oxygen into a large water volume in the reservoir. Diffuser lines are often more than a mile long. The diffuser system can also be specifically designed to create and maintain fish habitat or enhance specific water quality parameters within the reservoir. The buoyant oxygen bubble plume is spread over the long lines to avoid sediment disturbance or disruption of the reservoir stratification.

GENERAL DIFFUSER DESCRIPTION:

The diffusers supplied by MEI are constructed of high density polyethylene (HDPE) piping, porous hose, concrete anchors and stainless steel connecting components as shown in Figure 1. The porous hose is manufactured from linear low density polyethylene and rubber from recycled car tires. The porous hose has demonstrated the capability of distributing oxygen in reservoirs for 10 years or more without excessive degradation or clogging. All HDPE connections are joined by a heat fusion procedure including all anchor and gas piping connections. Anchor tethers are constructed of nylon coated stainless steel cable. Diffuser lines are deployed and retrieved without need for divers. Porous hose sections provide a uniform bubble pattern along the full length of the diffuser lines.

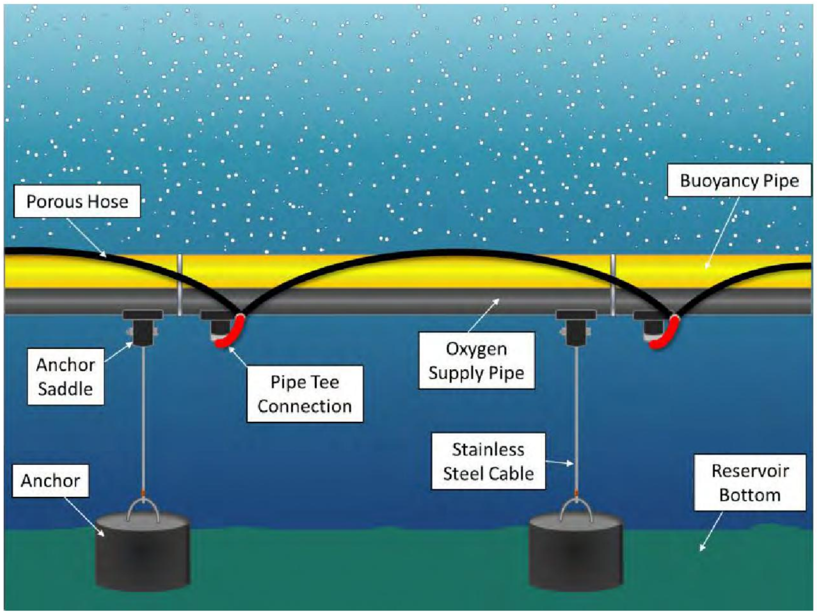

Figure 1: MEI Diffuser Components

QUALIFICATIONS, EXPERIENCE AND CREDENTIALS:

MEI is an experienced contractor for diffuser installations with twenty-one hypolimnetic oxygenation system installations operating successfully in water supply reservoirs. A list is presented in Table 1. Mark Mobley and Mobley Engineering have been responsible for a total of over 50 diffuser applications in the past twenty seven years including several very large installations for hydropower reservoirs. A list of all line diffuser installations is attached separately. About half of the diffuser systems listed have been operated for at least 7 years. Most of these systems are larger than that specified for Juniata Reservoir. MEI maintains boats, specialized HDPE pipe fusion equipment and an experienced crew that would be deployed to install the diffusers in Juniata Reservoir. Results from most of the installations are available on our website or by request. Mark Mobley and several colleagues recently authored a peer reviewed paper presenting results at eight case study reservoirs for the North American Lake Management Society Journal; *Mark Mobley, Paul Gantzer, Pam Benskin, Imad Hannoun, Susan McMahon, David Austin & Roger Scharf (2019) Hypolimnetic oxygenation of water supply reservoirs using bubble plume diffusers, Lake and Reservoir Management, 35:3, 247-265,* also attached separately.

Mark H. Mobley, PE maintains Professional Engineering Licenses in; Tennessee, Colorado and Alabama.

Mobley Engineering maintains insurance to meet all coverage requirements in the RFP. Additional insured status for all coverages will be obtained. COI for all coverages will be provided to the City. Payment and Performance bonds will be obtained.

	Mobley Engineering						
	Water Supply Oxygenation Installations						
	Reservoir	**Owner**	**Location**	**Total Diffuser Length (m)**	**Diffuser Depth (m)**	**Oxygen Capacity (kg/day)**	**Installation Year**
	Juniata	Grand Junction	Grand Junction, CO	337	20	2,850	Proposed
	Bois d'Arc	North Texas Municipal Water District	Bonham, TX	3,292	21	35,500	Contracted
	Boyd Lake	City of Greeley	Loveland, CO	905	15	12,000	Contracted
	Loch Lomond	Santa Cruz Water Department	Ben Lomond, CA	370	37	1,950	Contracted
	Anza	East Bay Municipal Parks	Berkeley, CA	168	13	400	Contracted
21	Blalock	Clayton County Water Authority	Jonesboro, GA	401	6	1,000	2019
20	Shamrock	Clayton County Water Authority	Jonesboro, GA	232	5	1,200	2019
19	Lake Bowen	Spartanburg Water	Spartanburg, SC	2,743	11	14,500	2016
18	Reservoir 1	Spartanburg Water	Spartanburg, SC	549	10	3,000	2016
17	Bear Lake	Lake Alpine Water	Bear Lake, CA	46	15	75	2016
16	Aurora	Aurora Water	Aurora, CO	701	22	2,300	2015
15	Lake Casitas	Casitas Municipal Water District	Oak View, CA	1,646	67	27,300	2015
14	Almaden	Santa Clara Valley Water District	San Jose, CA	366	20	675	2014
13	Pleasant Lake	Saint Paul Regional Water Services	Saint Paul, MN	562	15	7,500	2013
12	Guadalupe	Santa Clara Valley Water District	San Jose, CA	427	22	675	2013
11	Stevens Creek	Santa Clara Valley Water District	San Jose, CA	305	29	675	2012
10	Upper San Leandro	East Bay Municipal Utility District	Oakland, CA	2,073	27	8,200	2001, 2012
9	Occoquan	Fairfax Water Authority	Fairfax, VA	792	20	3,000	2012
8	Calero	Santa Clara Valley Water District	San Jose, CA	305	18	675	2011
7	Lake Vadnais	Saint Paul Regional Water Services	Saint Paul, MN	914	15	6,500	2011
6	San Antonio	San Francisco Public Utility Commission	San Francisco, CA	1,152	37	8,200	2009
5	Crystal	Cheyenne Board of Public Utilities	Cheyenne WY	366	30	6,400	2009
4	Calaveras	San Francisco Public Utility Commission	San Francisco, CA	610	34	3,400	2005
3	Carvins Cove	Western Virginia Water Authority	Roanoke VA	1,219	18	3,650	2005
2	Spring Hollow	County of Roanoke Utility District	Salem, VA	610	55	1,100	1997, 2005
1	Los Vaqueros	Contra Costa Water District	Concord, CA	2,438	27	12,750	2000

Table 1: List of Hypolimnetic Oxygenation Systems by Mobley Engineering for Water Supply Reservoirs

Strategy and Implementation Plan for Juniata Reservoir Oxygenation Project

This proposed scope of work would be design and installation of the supply piping connecting to the customer interface connection downstream of the flow control manifold on the LOx equipment slab, supply piping in the trench from the LOx facility to the reservoir, and all of the supply and diffuser piping in the reservoir.

MEI would provide work boats, HDPE fusion equipment, work tents, experienced crewmembers certified in HDPE fusion techniques, an engineer onsite, all materials and all hand tools, radios, vehicles and equipment to provide a complete installation of the diffuser(s). MEI will provide a limited 1 year warranty against defects in workmanship or materials in the diffusers. The warranty does not cover any damage that may occur to the diffuser after acceptance by the Owner. MEI will provide operating manuals, onsite operator training and engineering assistance during initial startup of the system as specified.

I. Oxygen Diffuser Design:

Mobley Engineering has provided conceptual diffuser drawings with this proposal and will commence detailed design on notice to proceed. Detailed design drawings will be provided for review by the City within two weeks from NTP. Detailed design will include bubble plume modeling to determine oxygen transfer efficiency, and compressible gas flow modeling to determine pipe sizes, flow control orifice sizes, pressure requirements and flow distribution.

General System Description:

a. The system shall be designed to deliver gaseous oxygen uniformly to deep sections of the lake while suspended from the lake bottom.
b. The system shall be capable of supplying oxygen at an intermittent and variable flow, or at a constant flow rate between 100 and 3920 SCFH

The diffuser will be completely serviceable from the surface:

a. The diffuser will include a floatation system (i.e. buoyancy pipe) designed to sink the diffuser into position or float the diffuser to the surface using compressed air or gaseous oxygen.
b. An anchoring system will be designed to maintain the diffuser at 2 to 2.5 feet above the sediment/water interface at the lake bottom.
c. The anchoring system will be sufficient to prevent the diffuser from moving in the lake but allow the diffuser to float to the surface when using compressed air or gaseous oxygen to fill the buoyancy pipe.

Oxygen Delivery Capacity, Flow Rate and Distribution:

a. The diffuser will be sized to deliver up to 2,850 kg/day to the reservoir hypolimnion.
b. The diffuser will accommodate intermittent and variable flow, as well as constant flow.
c. The diffuser will be capable of continuous operation at a constant oxygen flow rate under the following conditions:

Maximum Flow (SCFH)	3920
Average Flow (SCFH)	2200
Minimum Flow (SCFH)	100

d. The orifice and porous hose assembly will be designed to deliver a uniform flow of oxygen across the entire length of diffuser that is equipped with porous hose.
e. Protective sleeve piping will be designed to route the oxygen supply and buoyancy piping at the shoreline.

SUBMITTALS

- Complete headloss and orifice calculations for oxygen gas flow through the diffuser.
- Working pressure ratings using oxygen for selected HDPE pipes
- Preliminary diffuser and flow control manifold design
- Final design with detailed drawings
- Data sheets or catalog cuts on all system components.
- Details of linear diffuser construction, fabrication, and materials.
- Detailed procedures to be used in fabricating, storing, and installing the linear diffuser.
- Diffuser testing procedures.
- Diffuser cleaning procedures
- Results of the diffuser field testing
- Manufacturer's Certificate of Compliance
- Manufacturer's Certificate of Proper Installation
- Operation and Maintenance Manual

II. OXYGEN DIFFUSER INSTALLATION:

Once the diffuser design is accepted by the City, MEI will procure materials and complete shop assemblies for shipping to the project site. The MEI construction crew will require two to three weeks onsite to assemble and deploy the diffuser. Detailed bathymetry will be obtained in order to verify and optimize the diffuser layout. The diffuser construction area will be along the shoreline at a location accessible to tractor trailer trucks. Oxygen supply will be needed for pressure testing and deploying the diffusers.

a. All components and subsystems of the diffuser shall be constructed in a safe and accessible manner, complying with the local, State of Colorado, and national codes and requirements.

b. All piping, valves, valve seats, seals, gaskets, and welds to be used with oxygen, must be resistant to degradation from gaseous oxygen.

c. Cleaning for Oxygen Service:

   1) All equipment, piping, valves, instrumentation, and accessories in oxygen service shall be cleaned in compliance with the Compressed Gas Association (CGA) Pamphlet G-4.1, "Cleaning Equipment for Oxygen Service," latest edition.
   2) For items cleaned prior to shipment to the construction site, they shall be properly packaged for protection from contamination. Provide directions for storage at the site prior to installation. Pre-cleaned items shall not require further cleaning after installation only if they meet the requirements of the CGA.

d. Tether Cables: Type 304 stainless steel cable with a break strength of 900 lbs. and a 7 x 7 strand construction shall be used to tether the diffuser assembly to the anchors.

e. The oxygen supply pipe and buoyancy pipe shall be fastened together at regular intervals with marine grade worm screw clamps.

f. Diffuser Assembly:

   1) Diffuser assembly shall occur on land.
   2) Prior to final installation, diffuser assemblies may be stored on the water surface by floating the assembly near the shoreline bank where assembled during construction.
   3) The diffuser assembly shall be anchored securely to the shoreline to prevent damage and avoid creating a boating hazard.

g. Diffuser Pressure Test
   1) Supply piping to the diffuser will be tested to a percentage of working pressure rating using onsite oxygen supply.

h. Diffuser Deployment:
   1) The diffuser shall be positioned on the surface according to the design diffuser layout.
   2) Positioning will be executed using sonar underwater topographical mapping equipment.
   3) The diffuser will be secured with appropriate lines and mooring.
   4) The buoyancy pipe will be pumped full of water to deploy the diffuser to the bottom.
   5) Once the entire diffuser is resting on the bottom, the diffuser position will be inspected and evaluated to ensure optimal placement in reservoir.

III. Diffuser Field Testing:

The diffuser system will be operated to verify oxygen delivery capacity, pressure requirements and bubble pattern.

a. The oxygen supply system shall be operated at rated capacity and oxygen flow and pressure measured with onsite instrumentation at the flow control manifold to assure adequate supply and oxygen flow is being delivered to the reservoir.
b. The diffuser shall demonstrate correct bubble patterns once in position along the bottom when operated and visually observed during calm conditions. No large leaks or dead spots shall be evident on the surface.

IV. Start-up Performance Testing and Training:

MEI will provide a formal operator training class for Owner personnel including diffuser operation and results at previous installations. MEI will provide the expertise needed to start-up, test and initially operate the Juniata Reservoir Hypolimnetic Oxygenation System to meet project requirements.

V. Time Schedule

MEI has evaluated the time to complete the diffuser installation tasks and placed the tasks in a schedule based on notice to proceed from the City. The proposed MEI schedule is presented in Figure 2. This schedule provides a total of 10 weeks from NTP to Completion Date to allow for procuring materials, shop assembly and shipping after final design review by the City. An oxygen supply facility must be operational to provide the oxygen flow needed to test the diffusers before and during deployment. MEI will work with the City to set up an overall construction schedule to meet project completion objectives but expects the City to make allowance for schedule disruptions due to the ongoing pandemic. MEI will also work to provide the City with an opportunity to minimize mobilization costs by providing flexibility to schedule the Juniata installation directly following an MEI diffuser installation for the City of Greeley CO in Boyd Lake.

CONCEPTUAL PLANS/DRAWINGS:

MEI has provided conceptual drawings showing general diffuser piping, assembly details and a diffuser layout. The conceptual diffuser layout was developed from the information available in the RFP. The diffuser piping would extend about 1,100 feet in the deepest part of the reservoir. Underwater supply piping would extend about 1,400 feet from the diffuser to the shoreline nearest the LOx facility. A HDPE sleeve pipe will protect the supply piping for 40 feet at the shoreline. The supply piping will be routed in a trench for about 200 feet from the shoreline to the LOx facility. Stainless steel risers will connect the underground HDPE piping to the customer interface connection on the LOx facility slab. The conceptual diffuser layout will be optimized with detailed bathymetry data obtained by MEI onsite.

All of the conceptual plans and drawings are labeled "**Confidential Disclosure**" and are submitted separately as "**Proprietary Information**" as they contain the details of the MEI diffuser design.

REFERENCES:

References for recent MEI diffuser installations are attached separately.

FEE PROPOSAL:

This Design Build project is bid as a "Cost Plus a Fixed Fee".

MEI has submitted rate sheets that include:

- Hourly rates for MEI employees
- Per diem rate for MEI employees
- Mileage rate for MEI owned trucks
- Daily rates for MEI owned work boats
- Project rate for MEI owned tools and equipment
- Per part rates for diffuser components pre-assembled and shipped from MEI shop in Norris TN.

MEI has submitted Section 7.0 Response Form for a Total "Fixed Fee" of $ 45,850.

EXCEPTIONS AND SUBSTITUTIONS:

MEI takes exception to the fixed Completion Date of July 17, 2020 and has substituted a schedule based on ten weeks from Notice to Proceed.

ADDITIONAL DATA:

RESERVOIR DISSOLVED OXYGEN LEVELS

Based on extensive experience, MEI is confident the oxygen diffuser system has sufficient capacity as specified in the RFP to maintain the project objective of 5 mg/L throughout the water column of Juniata Reservoir. Detailed capacity calculations are presented in Table 2. However, the timing and operation of the system will control the dissolved oxygen (DO) levels. If the system is first operated after hypolimnion DO levels have decreased below 5 mg/L, the oxygen system will need to match and exceed reservoir oxygen demands to increase DO. The design capacity includes a "System Shutdown Recovery" oxygen flow to increase DO but it is limited to 0.1 to 0.2 mg/L per day during worst case oxygen demands. Therefore, if the hypolimnion DO has decreased to 2 mg/L it could take several weeks to increase the DO back to 5 mg/L.

MOBILIZATION SAVINGS

MEI will work to provide the City with an opportunity to significantly reduce costs by mobilizing MEI boats, crew and equipment from Loveland, CO instead of TN. This could save 20 man-days and associated travel expenses. MEI is under contract for a diffuser installation for the City of Greeley Colorado in Boyd Lake. That project is currently scheduled for July 2020 but the schedule is uncertain due to the ongoing pandemic. To take advantage of this savings opportunity, the City would need to allow the Greeley project schedule to control the installation dates at Juniata.

BUDGET COST ESTIMATE

Based on the conceptual design completed to date, MEI expects the design build scope of this proposal to cost approximately $190K including the Fixed Fee and bonding.

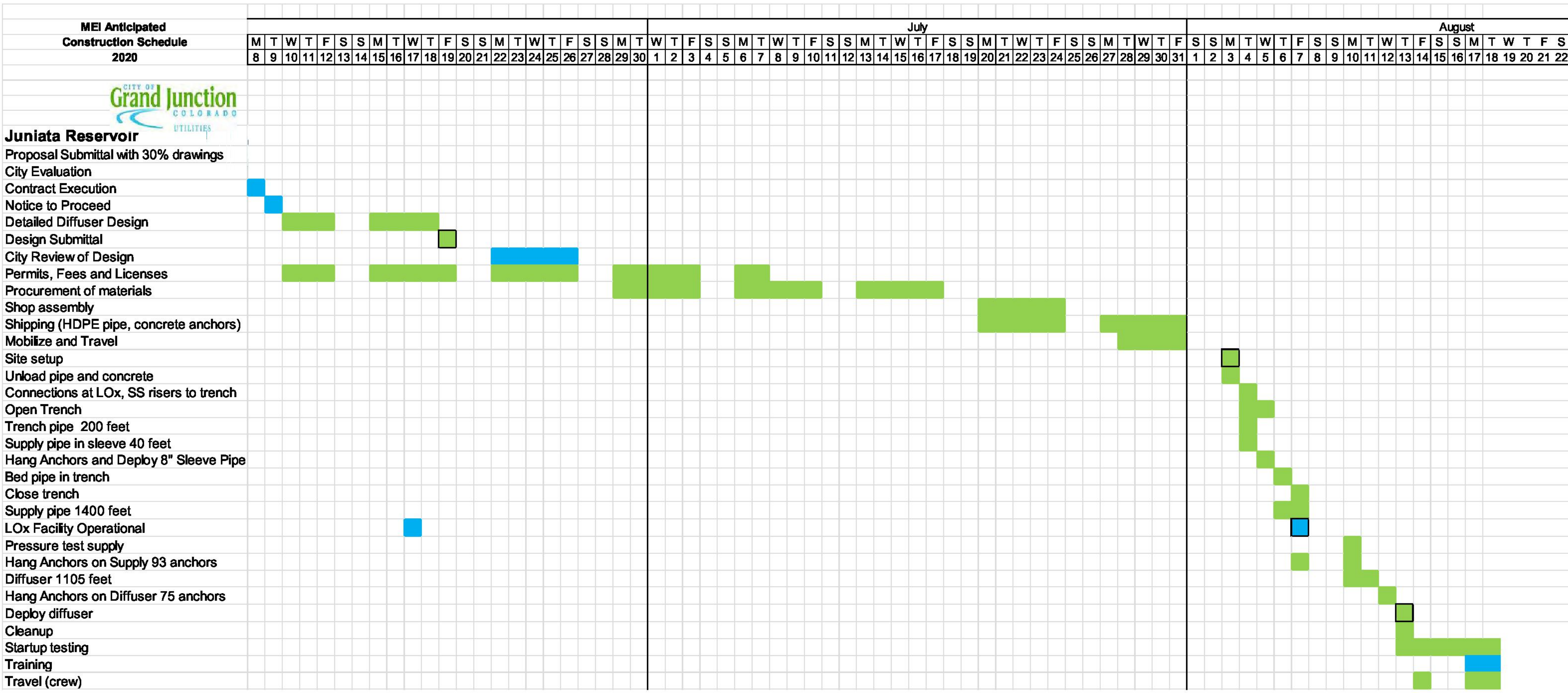

Figure 2: Proposed Diffuser Installation Schedule (Blue indicates City commitment)

RESERVOIR OXYGEN DIFFUSER SYSTEM

Juniata Reservoir (City of Grand Junction)

SYSTEM DESIGN CALCULATIONS

Mobley Engineering, Inc.

				Contract Design		Preliminary Design		Average Operation	
Reservoir Volume									
	WSEL =	5,754	feet	3.22E+08	cubic ft	3.22E+08	cubic ft	3.22E+08	cubic ft
		1,753.8	meters	9.13E+06	cubic meters	9.13E+06	cubic meters	9.13E+06	cubic meters
				2.41E+09	gallons	2.41E+09	gallons	2.41E+09	gallons
				7,400	acre feet	7,400	acre feet	7,400	acre feet
Hyplolimnetic Volume									
	below elevation	5,722	feet	1.39E+08	cubic ft	1.39E+08	cubic ft	1.39E+08	cubic ft
		1,744.0	meters	3.95E+06	cubic meters	3.95E+06	cubic meters	3.95E+06	cubic meters
				1.04E+09	gallons	1.04E+09	gallons	1.04E+09	gallons
				3,200	acre feet	3,200	acre feet	3,200	acre feet
				3.95E+09	liters	3.95E+09	liters	3.95E+09	liters
Water Column Oxygen Demand									
	Oxygen depletion rate (worst case 2019)			0.16	mg/L/day	0.16	mg/L/day	0.10	mg/L/day
	Volume applied:			3.95E+06	cubic meters	3.95E+06	cubic meters	3.95E+06	cubic meters
	DIOD Factor			3.40		2.00		2.00	
	Oxygenation rate required:			2,148	kg/day	1,263	kg/day	790	kg/day
System Shutdown Recovery									
	Volume applied			3.95E+06	cubic meters	3.95E+06	cubic meters	3.95E+06	cubic meters
	Recovery Rate			0.17	mg/L/day	0.10	mg/L/day	0	mg/L/day
	Oxygenation rate required:			687	kg/day	395	kg/day	0	kg/day
TOTAL OXYGENATION REQUIRED:				2,835	kg/day	1,658	kg/day	790	kg/day
Oxygen transfer efficiency				80%		90%		90%	
DESIGN OXYGEN SYSTEM CAPACITY:				3,543	kg/day	1,842	kg/day	877	kg/day
				7,795	lbs/day	4,053	lbs/day	1,930	lbs/day
				3.9	**tons O2/day**	**2.0**	**tons O2/day**	**1.0**	**tons O2/day**
				818	gallons/day	425	gallons/day	203	gallons/day
				0.16	tons O2/hr	0.08	tons O2/hr	0.04	tons O2/hr
				65	SCFM	34	SCFM	16	SCFM
				3,920	**SCFH**	**2,038**	**SCFH**	**971**	**SCFH**

Table 2: Oxygen Capacity Calculations

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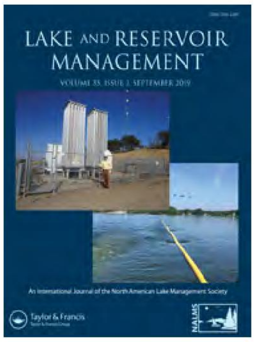
COLORADO LICENSED
MARK HUGH MOBLEY
PE.0052931
PROFESSIONAL ENGINEER

Diffuser Layout

Customer: City of Grand Junction		Project: Juniata	
Designed by: MHM	Date: 5/1/2020	Drawn by: Miles M	Date: 5/2/2020
Reviewed by:	Date: 5/2/2020	Plot Scale: 1" = 250'	Drawing #: MEI L1



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Hypolimnetic oxygenation of water supply reservoirs using bubble plume diffusers

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ABSTRACT
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Hypolimnetic oxygenation of water supply reservoirs improves water quality by preventing anoxia. This article summarizes the operational results using linear bubble plume diffuser hypolimnetic oxygenation systems installed in water supply reservoirs. The results obtained for 8 sites demonstrate that diffuser technology was effective at increasing hypolimnetic dissolved oxygen (DO) and spreading it to blanket sediments. The diffuser systems maintained increased DO in the hypolimnion during successive years of operation at every site. Improved oxygen levels reduced anoxic products and nutrients to mitigate the causes of taste and odor in the water supplied to water treatment facilities. This yielded additional treatment capacity, reduced treatment costs, and provided alternatives to water treatment plant modifications. The diffuser systems provide a simple and effective hypolimnetic oxygenation system, with 19 in operation. The hypolimnetic oxygenation systems (HOS) functions without a water pump and can obtain favorable oxygen transfer efficiencies. The diffusers are installed and maintained from the surface without divers. Diffusers provide an economical means to distribute oxygen input over large areas of the reservoir hypolimnion. Diffuser system installation costs run between $0.5M and $2.5M ($40 to $800 per hectare meter), with annual operating costs between $30K and $140K ($5 to $36 per hectare meter). Capital and operational costs vary depending on site specific conditions. With diffuser oxygenation, customer complaints were reduced and, in some cases, substantial monetary savings were realized by reduced treatment costs. Our results demonstrate that diffusers are a cost-effective treatment option for water supply reservoirs in which anoxia induces water quality problems.

KEYWORDS
Bubble plume; diffuser; hypolimnion; oxygenation; water supply

Anoxic conditions in the hypolimnion of water supply reservoirs can cause many issues and concerns related to water quality and taste and odor (Cooke and Kennedy 2001). Dissolved metals and algae blooms deplete water treatment plant capacity and increase treatment costs (Jung et al. 1999). In extreme cases, metals and algae can make the sources unusable, even with increased treatment (SFPUC 2019). Hypolimnetic oxygenation systems (HOS) are defined as systems that add dissolved oxygen (DO) to the hypolimnion using pure oxygen gas while preserving thermal stratification. A successful HOS can eliminate anoxic products (Gantzer et al. 2009), reduce nutrient cycling and algae blooms (Beutel and Horne 1999), and control issues related to taste and odor (Jung et al. 1999). The addition of HOS can increase overall water treatment capacity and reduce water treatment operating costs (Benskin 2018). There are several HOS designs that have been applied successfully, including side stream supersaturation, submerged contact chambers, and diffused oxygen bubble plumes (Speece and Malina 1973, Ashley 1985, Little 1995, Burris and Little 1998, McGinnis and Little 2002), with no single system type ideal for all

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applications (Wagner 2015). Of the HOS in operation for water supply reservoirs reported by Wagner (2015), 19 currently utilize bubble plume line diffusers.

When designed properly, diffusers successfully add oxygen to the deep waters of the hypolimnion, while preserving thermal stratification and avoiding sediment disturbance. Bubble plumes, near-field mixing patterns related to plumes, and flow regimes within the plume have been the subject of several studies (Miller et al. 2001, McGinnis et al. 2004, Socolofsky and Adams 2003, and Singleton et al. 2007).

Bubble plume diffuser HOS are little reported in the peer reviewed literature, mainly consisting of review of diffusers as a form of HOS (Beutel and Horne 1999, Singleton and Little 2006, Wagner 2015), but limited with regard to water quality results. This work is the first survey of water quality effects of bubble plume diffuser HOS improvements across a range of reservoirs with corresponding customer satisfaction and cost benefits. Moreover, very little work has been performed in regard to oxygen distribution or to water quality improvements in water supply reservoirs following diffuser operation. A concurrent focus of this work, therefore, is to demonstrate oxygen spreading beyond direct contact with the diffuser.

Study sites

Of the 19 water supply reservoirs currently utilizing bubble plume diffuser HOS, 8 sites were selected that provided the most complete data available for this study (Table 1).

Virginia

Spring Hollow Reservoir and Carvins Cove Reservoir are human-made water-supply reservoirs operated by the Western Virginia Water Authority (WVWA) that serve the city of Roanoke and surrounding counties (Gantzer et al. 2009). Spring Hollow Reservoir is a pumped storage reservoir that was supplied by withdrawing water from the Roanoke River during high flow periods with a storage capacity of 12 million cubic meters (3.2 billion gallons) and a maximum depth of 64 m (210 feet). Spring Hollow Reservoir was the first water supply application of this bubble plume line diffuser design when it was installed in 1997. It had one 610 m (2000 feet) long diffuser installed with 1100 kg/d (1.2 tons/d) oxygen delivery capacity. Carvins Cove Reservoir was supplied by 2 natural tributaries that flow through agriculturally dominated lands and by 2 creeks from an adjoining watershed that are routed through diversion tunnels

Table 1. Summary of study sites showing characteristics of each reservoir and oxygenation system.

Reservoir	Storage volume (hectare meter)	Maximum depth (m)	HOS installation date	HOS capacity (kg/d)	Total length of diffuser (m)
Spring Hollow Western Virginia Water Authority Salem, VA	1210	64	1997/2004	1100	610
Carvins Cove Western Virginia Water Authority Roanoke, VA	2430	21	2005	3600	1220
Calaveras San Francisco Public Utility Commission Sunol, CA	11,800	37	2005	3400	610
San Antonio San Francisco Public Utility Commission Sunol, CA	6780	40	2009	8200	1150
Vadnais Lake Saint Paul Regional Water Services Saint Paul, MN	1110	18	2011	6500	910
Pleasant Lake Saint Paul Regional Water Services Saint Paul, MN	1220	15.2	2013	7500	560
Lake Casitas Casitas Municipal Water District Oak View, CA	29,330	70	2015	27,300	1650
Aurora Reservoir City of Aurora Aurora, CO	3820	27.4	2015	2300	700

with a storage capacity of 24 million cubic meters (6.1 billion gallons) and maximum depth of 21 m (70 feet). Carvins Cove Reservoir was equipped with two 610 m (2000 feet) long line diffusers that were installed in 2005, capable of distributing 3600 kg (4 tons) of oxygen per day into the hypolimnion.

California

Calaveras and San Antonio reservoirs are operated by the San Francisco Public Utilities Commission (SFPUC). Calaveras Reservoir is fed by Arroyo Hondo and Calaveras Creek. The reservoir was equipped with two 305 m (1000 feet) long lengths of line diffuser installed in 2005, capable of distributing 3350 kg (3.7 tons) of oxygen per day into the hypolimnion. When the diffuser was installed, Calaveras Reservoir was operated with a seismic restricted storage capacity of 42 million cubic meters (11 billion gallons) and a maximum depth of 18 m (60 feet). Since then, a new replacement dam has been constructed that is currently refilling to return the reservoir to 118 million cubic meters (31 billion gallons) capacity and a maximum depth of 37 m (120 feet) (SFPUC 2018).

San Antonio Reservoir was fed by San Antonio and Indian creeks. It has a capacity of 68 million cubic meters (18 billion gallons) and a maximum depth of 40 m (130 feet). San Antonio Reservoir was equipped with 2 line diffusers installed in 2005 with a total length of 1150 m (3780 feet), capable of distributing 3350 kg (3.7 tons) of oxygen per day into the hypolimnion.

Lake Casitas, operated by the Casitas Municipal Water District (CMWD) located in Ventura County, has a capacity of approximately 300 million cubic meters (78 billion gallons). The maximum water depth is 70 m (230 feet) when full; however, recent drought conditions reduced the current maximum depth to less than 50 m and adversely impacted water quality conditions. Lake Casitas receives its inflows from the surrounding watershed including flows from the Ventura River Diversion and Santa Ana and Coyote Creeks. Withdrawals from the lake are made to supply a water treatment plant, which provides water for domestic and agricultural uses. Lake Casitas was equipped with 3 diffusers positioned at 4 different elevations, with a total length of 1650 m (5400 feet). The system was installed in 2015 and could distribute 27,000 kg (30 tons) of oxygen per day into the hypolimnion.

Colorado

Aurora Reservoir is a Colorado Front Range terminal storage reservoir for the city of Aurora, Colorado. The reservoir is a part of the Aurora Water Prairie Waters Project and is utilized by 2 City of Aurora water purification facilities. The reservoir provides 38 million cubic meters (10 billion gallons) of storage and has a maximum depth of 27 m (90 feet). Aurora Reservoir was equipped with one 700 m (2300 feet) long diffuser that was installed in 2015 to distribute up to 2300 kg (2.5 tons) of oxygen per day into the hypolimnion.

Minnesota

Saint Paul Regional Water Services (SPRWS) pumps Mississippi River water from north of Saint Paul, Minnesota, through a chain of lakes: Charley, Pleasant, Sucker, and Vadnais (Walker et al. 1989). This water supply system has been in operation for more than a century. Two lakes are deep enough to have stable thermal stratification in the summer: Vadnais Lake has a storage capacity of 11.1 million cubic meters (3 billion gallons) and a maximum depth 16.5 m (54 feet). Pleasant Lake has a storage capacity of 12.2 million cubic meters (3.2 billion gallons) and a maximum depth of 15 m (49 feet). Vadnais Lake was equipped with 2 diffusers with a total length of 915 m (3000 feet) that were installed in 2011 and could distribute 6500 kg (7 tons) of oxygen per day into the hypolimnion. Pleasant Lake was equipped with 2 diffusers with a total length of 553 m (1845 feet) that were installed in 2013 and could distribute 7500 kg (8.3 tons) of oxygen per day into the hypolimnion.

Materials and methods

HOS consist of 3 main components: an oxygen supply facility, flow control, and the diffuser.

Oxygen supply facilities and equipment

Hypolimnetic oxygenation systems require a land-based facility to supply and control oxygen flow to the diffusers in the reservoir. Oxygen supply is usually provided by truck delivery of bulk liquid oxygen (LOx) or onsite generation commonly using pressure swing adsorption technology. Flow control can be simple and operated manually or equipped for remote control.

A liquid oxygen supply facility requires tanker truck access and includes an equipment pad, tank foundations, an insulated storage tank, and ambient air vaporizers. The liquid oxygen is converted to gas as it passes through the vaporizers. The vaporization process and corresponding expansion create the necessary pressure to supply the oxygen gas flow to the diffusers in the reservoir. Because of the driving pressure created from gaseous expansion, no pumps or compressors are needed, even for deep reservoirs. The LOx facility equipment can be leased or purchased, with the contracted bulk gas supplier providing maintenance and monitoring. As a part of the contract, the supplier will usually monitor the tank level and dispatch trucks to refill the facility as needed. Liquid oxygen systems are available with very large delivery capacities and are being used to supply reservoir diffusers with up to 180,000 kg/d (200 tons/d). Even larger capacity LOx systems are available.

Onsite oxygen generation utilizes a pressure swing adsorption (PSA) or vacuum swing absorption (VSA) process to isolate oxygen from a compressed air stream using a zeolite sieve. A PSA/VSA oxygen supply system requires an equipment building, air compressor, air receiver tank, electric supply, molecular sieve tanks, control valves, and an oxygen receiver tank. During operation, the compressed air stream is fed through one of the molecular sieves. During the pressurization phase nitrogen is trapped and oxygen passes through. At the end of the pressurization cycle, the sieve is depressurized and vented, releasing the trapped nitrogen to the atmosphere. PSA/VSA systems commonly consist of 2 molecular sieves, of which 1 sieve is in the pressurization phase and the other is being depressurized and vented. PSA produces oxygen gas with a nominal purity of 93% up to 4.5 bar (65 psig), whereas a VSA delivers the same purity at pressures of 1 bar (15 psig). An oxygen booster to increase oxygen supply pressures may be required. PSA systems are readily available at capacities up to 4500 kg/d (5 tons/d) for off-the-shelf units. Larger industrial PSA and VSA systems are also available.

A LOx supply facility will have lower capital costs and less maintenance than a similarly sized onsite generation system, but onsite systems can usually provide oxygen at less cost than that delivered to a LOx facility. LOx systems can supply oxygen for a short term at higher applied gas flow rates than originally designed and can economically be oversized or modified to supply higher gas flow rates, which can be valuable if circumstances dictate unforeseen high oxygen demands. All of the study sites used LOx oxygen supply facilities for the time periods in this report; however, the 2 sites in Virginia are currently being converted to PSA.

Flow control

A flow control manifold is used to regulate the applied gas flow rate to each diffuser. A flow control manifold consists of a flow meter, flow control valve, isolation and vent valves, and pressure gauges for each diffuser. The flow control can be as simple as a rotameter and manual valves or can utilize electronic flow control with remote operation depending on client requirements.

Bubble plume diffusers

The bubble plume diffusers in the water supply reservoirs of this study are based on a linear design originally developed by the Tennessee Valley Authority for hydropower reservoir release improvements (Mobley and Brock 1995, Mobley 1997). The linear diffusers are constructed of high-density polyethylene (HDPE) piping, porous hose, concrete anchors, and stainless steel connecting components. All HDPE connections are joined by a heat fusion procedure, including all anchor and gas piping connections. Flow control orifices along the length of the diffuser are used to provide a uniform bubble pattern along the full length of the porous hose sections. Diffusers are often more than 1000 m long. Pressure requirements for operating the diffuser include hydrostatic pressure of the water depth of the reservoir and the head loss across the flow control orifices and supply pipes. The HDPE working pressure rating is reduced for contact with oxygen gas and for expected ambient temperatures. Anchor tethers are constructed of nylon-coated stainless steel cable. The tether cable lengths can be designed to hold the diffuser at a specific elevation or distance above the bottom. The diffuser lines are deployed and retrieved without need for divers, utilizing a buoyancy pipe to raise and lower the diffuser in the reservoir. The porous hose is manufactured from linear low-density polyethylene and rubber from recycled car tires. The hose has been shown to provide high oxygen transfer efficiency (DeMoyer et al. 2001) and is capable of distributing oxygen in reservoirs for up to 15 yr without excessive degradation or clogging. The diffuser lines require no maintenance during that time unless the porous hose or piping is damaged by boat anchors or other means.

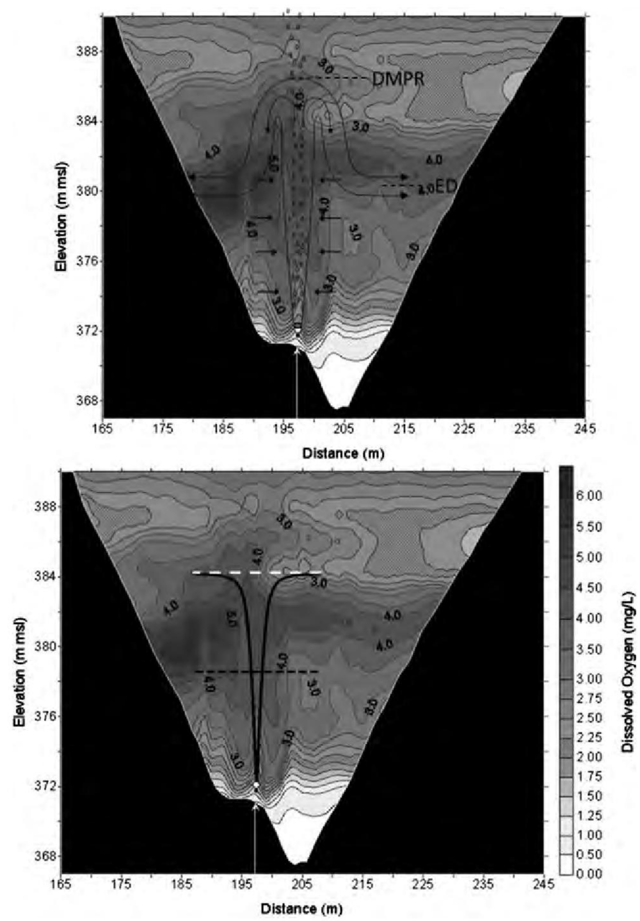

Figure 1. Images of DO measurements collected in Spring Hollow Reservoir after 24 h of diffuser operation, comparing an idealized plume (top) and a modeled plume (bottom).

Design and layout

In a thermally stratified reservoir when (oxygen) gas is applied to the diffuser, the gas bubbles rise from the diffuser and entrain cold water from the elevation at which the diffuser is installed. The bubble–water mixture forms a plume and moves upward. As the plume rises, oxygen is transferred from the bubbles to the water. The momentum imparted to the plume is eventually used up as the entrained (cold) water moves up into warmer and less dense water near the top of the hypolimnion below the thermocline. This is the elevation of maximum plume rise (EMPR), where the water in the plume detrains and falls away from the plume (Figure 1). As the oxygenated water falls away from the plume, a portion in the near field plunges to a depth at or below the diffuser elevation (McGinnis et al. 2004), while the remaining portion falls to an elevation of equal density (EED), because the water from the plume is colder than the surrounding water but warmer than it was where it was entrained, and at that elevation it spreads laterally (Figure 1). Any remaining bubbles continue to rise toward the surface, entraining ambient water and creating a new plume.

Bubble plumes have been studied in thermally stratified reservoirs (Wuest et al. 1992, McGinnis et al. 2004), leading to the development of bubble plume models (Hauser 2004, Singleton et al. 2007). Bubble plume models are an integral part of the design process and are used to predict oxygen placement, plume dynamics related to the EMPR and EED, and oxygen addition to the water column. The EMPR is critical in the design to identify whether a single plume can adequately mix the full depth of the hypolimnion as well as ensure the thermocline is preserved. The EED is important to identify lateral and longitudinal regions of mixing. The initial vertical oxygen placement is well predicted by bubble plume models, as can be seen when the plume model predictions are overlaid on the field measurements for comparison (Figure 1).

Once the oxygen input and plume characteristics have been identified, the diffuser layout is designed using available bathymetry and compressible flow modeling software. The flow model is used to identify required pressures, head losses, and desired pipe sizing to optimize the gas flow of the diffuser. For most installations, line diffusers are positioned along the thalweg at a consistent distance above the bottom, such as Spring Hollow Reservoir and Aurora Reservoir. Depending on the oxygen input needed and the reservoir bathymetry, multiple diffusers may be required to place oxygen in the desired volumes of the reservoir, as at Vadnais and Pleasant lakes. For wide, relatively flat bottom conditions, such as in Carvins Cove Reservoir, diffusers were positioned in parallel and evenly spaced to promote uniform lateral mixing.

In deeper reservoirs, an engineered vertical plume placement can increase the effectiveness of the system. Placing diffusers in the deepest portion of the reservoir can result in oxygen plumes that are completely adsorbed before the plume reaches the thermocline. Additional diffusers at higher elevations may be required to spread oxygen higher in the water column. With an engineered plume placement, the diffusers are installed at set elevations with varying length anchor cables over the bottom topography. With multiple diffuser elevations, the individual diffuser capacity can be sized for the specific volume and oxygen demands for each level. For example, the lowest reservoir elevation zone usually will have the smallest water volume while higher elevations may have significantly more water volume and require more diffuser capacity. A multiple diffuser elevation design was chosen for Lake Casitas. The Casitas design includes 4 diffuser elevations selected with plume model predictions for oxygen placement (Figure 2). Verification of the plume model predictions was obtained with field measurements during initial operation of the system at Lake Casitas (Figure 3). The diffuser elevations are shown and the vertical oxygen placement and lateral density spread are delineated by measured DO increase. Engineered plume placement can be especially beneficial to reservoirs with multilevel outlet structures, such as Casitas, so that operators can choose the best water quality layer available and operate the oxygen system to target specific layers.

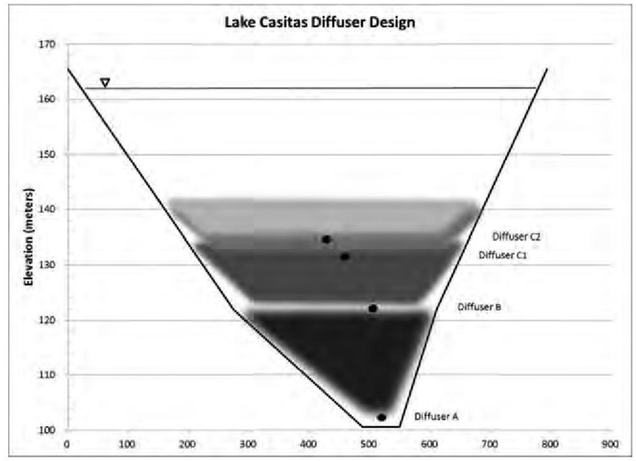

Figure 2. Example of Casitas Reservoir diffuser layout, showing multiple diffusers installed at different elevations and their model predicted zone of oxygenation. Oxygenation is expected in the zone above each dot.

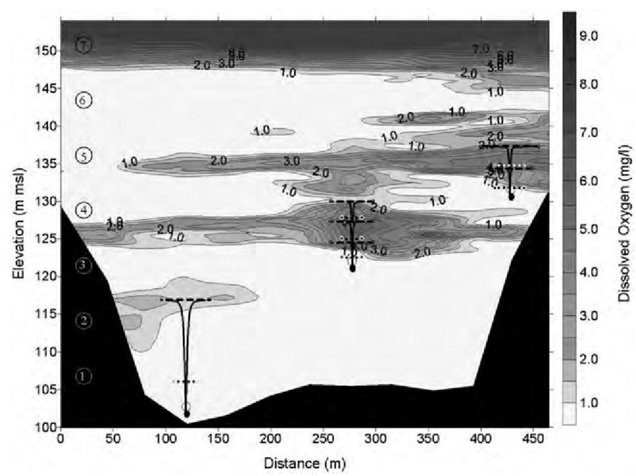

Figure 3. Initial oxygen input observed in Casitas Reservoir following 24 h of operation, showing lateral distribution from diffuser operation. Numbered circles represent plant withdrawal elevations, solid lines show modeled plumes, and dashed lines show corresonding elevation of maximum plume rise (EMPR) and elevation of equal density (EED) for each plume.

Data collection

All data were provided by each municipality/utility and collected using required protocol and standards per regulatory and reporting guidelines. Oxygen contour plots collected for Casitas, Spring Hollow Reservoir, and Carvins Cove Reservoir were obtained using a SeaBird Electronics 19PlusV2 high-resolution profiler. The 19PlusV2 has a 4 Hz sample rate, provides a fast response, and can collect data down to the sediments because the internal pump design continuously circulates water over the sensors.

Aurora Water uses the following methods to obtain data presented in this article:

- Dissolved oxygen —YSI EXO2 Multiparameter Sonde equipped with EXO optical Dissolved Oxygen Smart Sensor.
- Metals (Mn)—USEPA Method 200.8 metals by inductively coupled plasma, mass spectrometry.
- Total phosphorus (as P)—Standard Methods 4500-P G 21st edition and Hach QuikChem Method 10-115-01-1-F. Determination of total phosphorus by flow injection analysis colorimetry (acid persulfate digestion method).
- Soluble reactive phosphorus (dissolved PO_4-P)—Standard Methods 4500-P G 21st edition and Hach QuikChem Method 10-115-01-1-M, determination of orthophosphate in waters by flow injection analysis colorimetry.

Operation

Hypolimnetic oxygenation systems are typically operated during thermal stratification. The diffuser systems are designed to meet highest oxygen demands in the reservoir, with additional capacity to recover from a shutdown or if start-up occurs following the onset of stratification. With the capacity to dramatically increase DO content, the diffusers are rarely operated at maximum capacity during a normal operating season. For example, Carvins Cove Reservoir was originally designed to deliver 2000 kg/d; however, following the first year of operation in 2005, applied gas flow rates were closer to 1000 kg/d for subsequent years. Most installations adjust oxygen flows every few days or weekly based on feedback from water quality data obtained from the reservoir or treatment plant operation. During recent years, several bubble plume diffuser systems (Spring Hollow, Carvins Cove, Pleasant, Vadnais Casitas, and Aurora) are being operated year-round, making seasonal adjustments to the applied gas flow rate.

Results and discussion

The first observation following a successful installation and operation of a bubble plume diffuser is increased oxygen content. This was ubiquitous with all 8 systems. During continued operation, dissolved oxygen spreads throughout the hypolimnion for a significant distance from the diffuser and dissolved oxygen concentrations are maintained at high levels year-round. With maintenance of high DO levels in the hypolimnion, anoxic by-products were reduced or eliminated, such as soluble manganese (Mn), iron (Fe), and phosphorus (P). Consecutive years of operation at the study sites resulted in consistently improved water quality to the water treatment plant, and in some cases the annual oxygen usage to maintain hypolimnetic DO has decreased. Reduction in oxygen capacity requirements over time has allowed the Spring Hollow and Carvins Cove installations the option of changing to onsite oxygen generation.

Oxygen content

When properly designed, bubble plume diffusers have been observed to be very effective at increasing and maintaining oxygen content throughout the hypolimnion, both in the bulk water and down to the sediment. Lateral oxygen distribution was predicted using the plume model, as well as being observed during initial operation of diffuser systems such as in Spring Hollow Reservoir (Figure 1) and Casitas Reservoir (Figure 3). For these systems, start-up of the diffuser system occurred during low DO conditions, which allowed the DO increase to be observed. DO was observed to increase almost immediately with initial operation and increased steadily following continued operation of the diffuser system (Figure 4).

During subsequent years of operation, DO was observed to remain at elevated levels in the hypolimnion. Casitas Municipal Water District operated the diffuser system to achieve DO levels greater than 8 mg/L over the sediments in the portion of the reservoir hypolimnion near the outlet structure in front of the dam (Figure 5).

This goal has continued to be achieved with strategic operation of the diffusers.

Aurora Water has been operating the diffuser system to maintain DO levels greater than 7 mg/L throughout the hypolimnion (Benskin 2018). Dissolved oxygen improvements in the hypolimnion, measured 1 m off the bottom in Aurora Reservoir, were observed to achieve the target concentration with hypolimnion DO measurements observed to match surface measurement year-round (Figure 6).

There was an oxygen sag in the metalimnion in 2017, most severe in August, with DO dropping below 2 mg/L (Figure 7). Cause of the DO sag is likely decay of settled algae and seston perched on a density gradient at the top of the hypolimnion, which was aerobic. The oxygen delivery rate was 1905 kg/d 01–10 August and 2014 kg/d 10–31 August. To maintain metalimnetic DO concentrations greater than 2.0 mg/L, the oxygen delivery rates were increased in 2018: 2014 kg/d 01–09 August and 2177 kg/d 10–31 August. Because of increased oxygen delivery, median DO concentrations were significantly higher ($p < 0.0001$) in August 2018 than in August 2017 (Figure 8) for the epilimnion (7.5 and 7.6 mg/L), metalimnion (3.2 and 4.9 mg/L), and hypolimnion (7.2 and 9.2 mg/L).

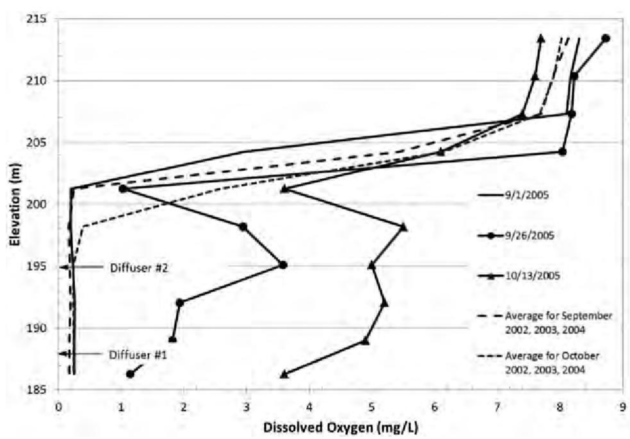

Figure 4. Initial operation DO Increases in Calaveras Reservoir. Dashed lines show historical averages without oxygenation.

Pleasant and Vadnais lakes experienced sharp improvements to median hypolimnetic DO with hypolimnetic oxygenation. With hypolimnetic oxygenation, the median DO was 4.2 and 8.5 mg/L in Pleasant and Vadnais lakes, respectively. These values were significantly higher ($p < 0.0001$) than hypolimnetic DO in previous periods without hypolimnetic aeration or oxygenation (0.11 and 0.2 mg/L) and with hypolimnetic aeration (1.7 and 2/7 mg/L).

Oxygen distribution in the hypolimnion

A key benefit of bubble plume diffuser technology is the ability to add large quantities of oxygen over large areas. As previously discussed, the plume generated by the diffuser promotes circulation within the hypolimnion as water is continuously entrained by the plume. Oxygen distribution

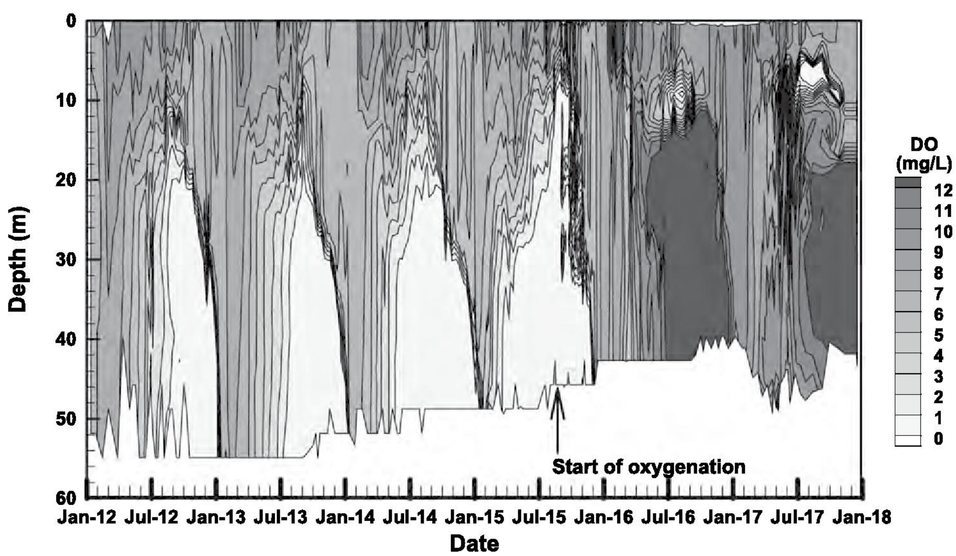

Figure 5. Dissolved oxygen concentrations near the dam at Lake Casitas, showing seasonal anoxia before HOS installation and elevated DO following HOS installation in September 2015.

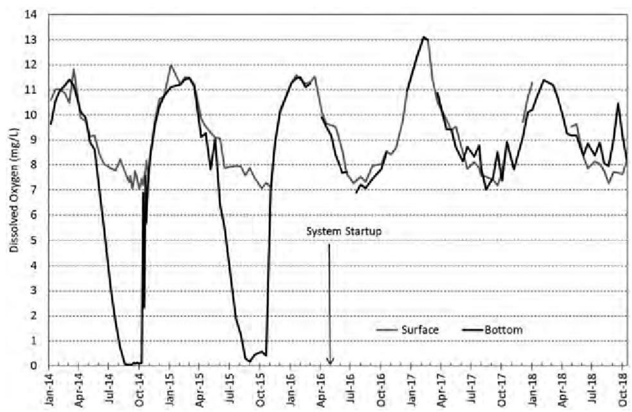

Figure 6. Surface and bottom DO in Aurora Reservoir, showing sustained DO in the bottom waters following diffuser start-up in 2016.

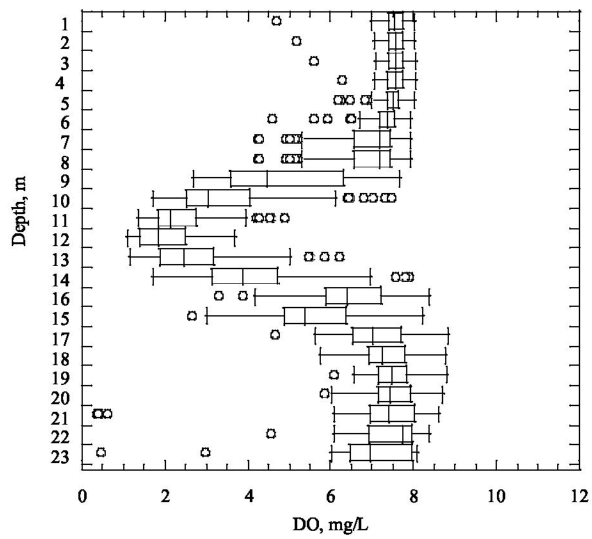

Figure 7. DO by depth for August 2017. In the 2017 operating season, there is a sag in DO in the thermocline layer.

has been observed to spread along density layers both laterally and horizontally away from the diffuser as identified in field observations.

During the first year of oxygenation in Carvins Cove Reservoir, water column data were collected at 2-m increments across the reservoir before and after diffuser operation. Data were comprised of 90 profiles, providing the initial signature of DO placement and subsequent spreading throughout the hypolimnion. Prior to diffuser operation, DO was observed to be ≤2.5 mg/L throughout the hypolimnion and <2.0 near the sediments (Figure 9). The thermocline was identified to be in the vicinity of elevation 346 m msl. After 45 d of operation, applying 32 Nm^3/h (20 SCFM) to each diffuser, results showed a dramatic increase

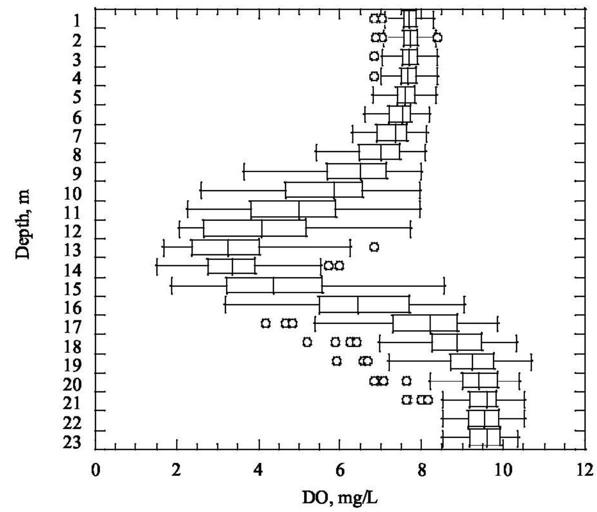

Figure 8. DO by depth for August 2018. In 2018, oxygen input was increased to maintain DO kevels >2.0 mg/L in the thermocline layer.

in DO to greater than 5 mg/L throughout the entire hypolimnion and down to and along the sediments, as shown in data collected at Carvins Cove (Figure 10). The oxygen placement was distributed bank to bank throughout the vertical elevation of the hypolimnion. This represented spreading over 100 m perpendicular to the placement of the diffuser. Additionally, the water with 4 mg/L at the thermocline was still present, demonstrating that the bubble plumes had not destratified the reservoir. Oxygen was observed to blanket the sediments including in the original channel, which is below the elevation of the diffuser.

Carvins Cove Reservoir had 2 diffusers that were relatively short compared to the overall length of the reservoir. The diffusers in Carvins Cove Reservoir were 600 m long and positioned in the deepest part of the reservoir between 100 and 700 m upstream of the withdrawal structure. This left a large portion of the hypolimnion not in direct contact with the diffusers. Water column profiles collected along the length of the reservoir documented elevated DO levels throughout the hypolimnion and oxygen in excess of 8.0 mg/L at the sediments spreading over 2000 m upstream from the diffusers (Figure 11).

Anoxic by-products

As previously shown, diffuser operation was observed to successfully increase and maintain

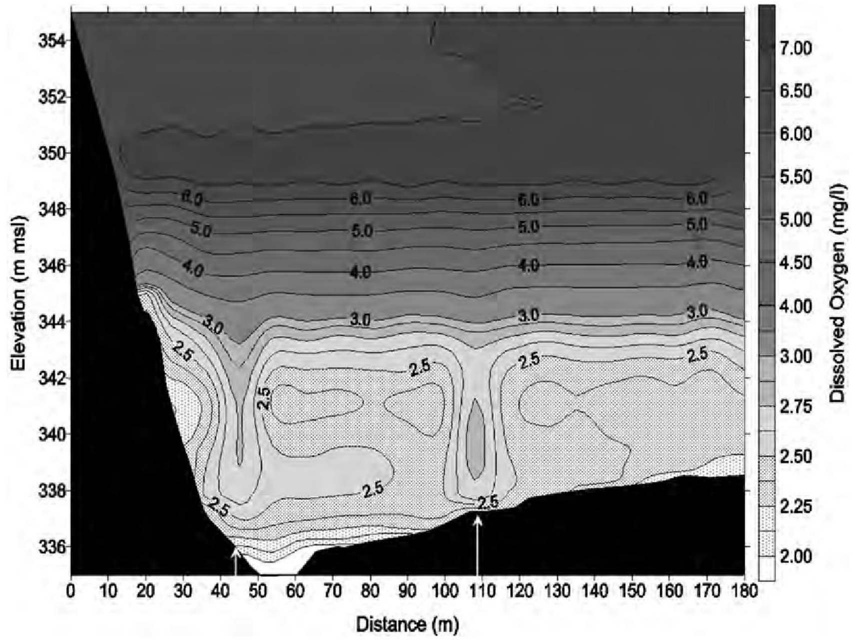

Figure 9. DO data collected 180 m laterally across Carvins Cove Reservoir at the onset of diffuser operation, applying 32 Nm^3/h (20 SCFM) to each diffuser. Arrows at ~45 and 110 m represent diffuser locations.

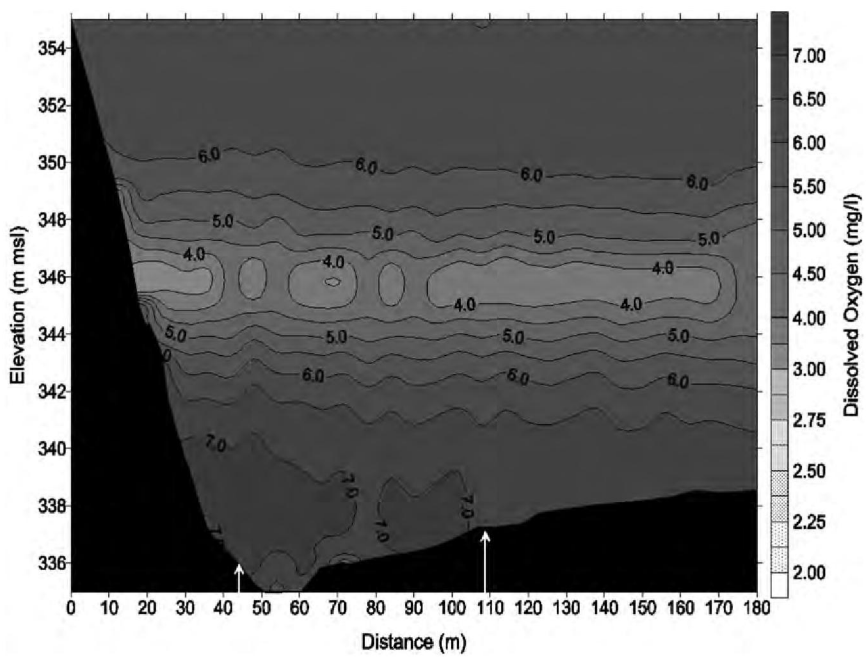

Figure 10. DO data collected 180 m laterally across Carvins Cove Reservoir after 45 d of diffuser operation, applying 32 Nm^3/h (20 SCFM) to each diffuser, showing spreading of DO throughout the hypolimnion and over sediment. Arrows at ~45 and 110 m represent diffuser locations.

oxygen conditions in the hypolimnion. As a result of increased DO, anoxia and elevated levels of anoxic by-products such as soluble iron (Fe), manganese (Mn), and phosphorus (P) were mitigated. The study site diffuser systems have worked so well in preventing Fe and Mn from going into solution that some sites rarely even sample for them anymore (SFPUC 2019).

Iron

Iron levels for Carvins Cove Reservoir were observed to decrease from the onset of diffuser

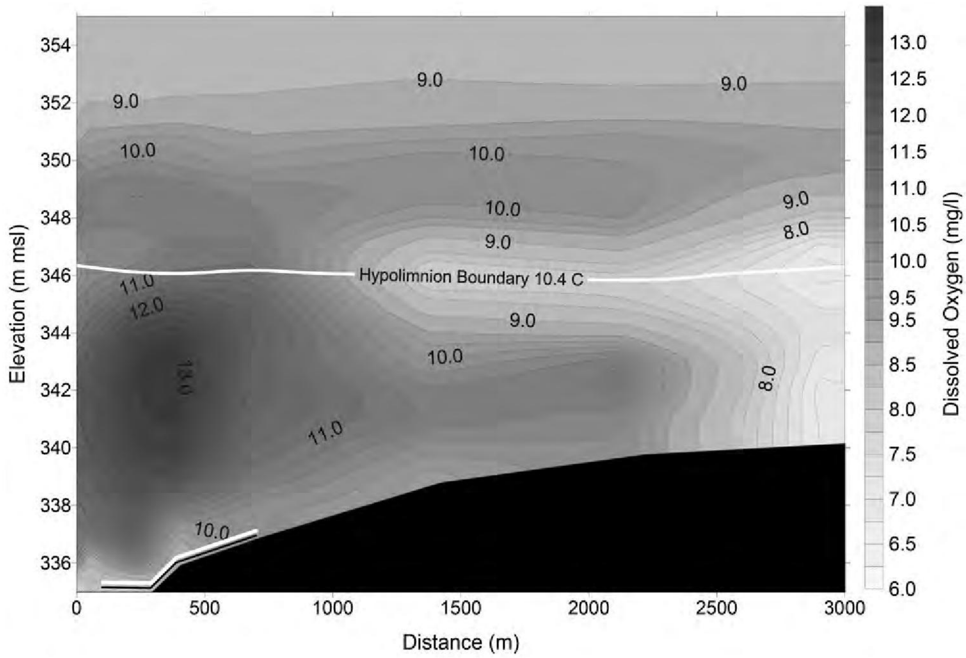

Figure 11. DO data collected horizontally along Carvins Cove Reservoir during 2006, showing horizontal spreading over 2000 m upstream of the diffuser. The diffuser is represented by the white line that extends along the bottom from about 100 to 700 m.

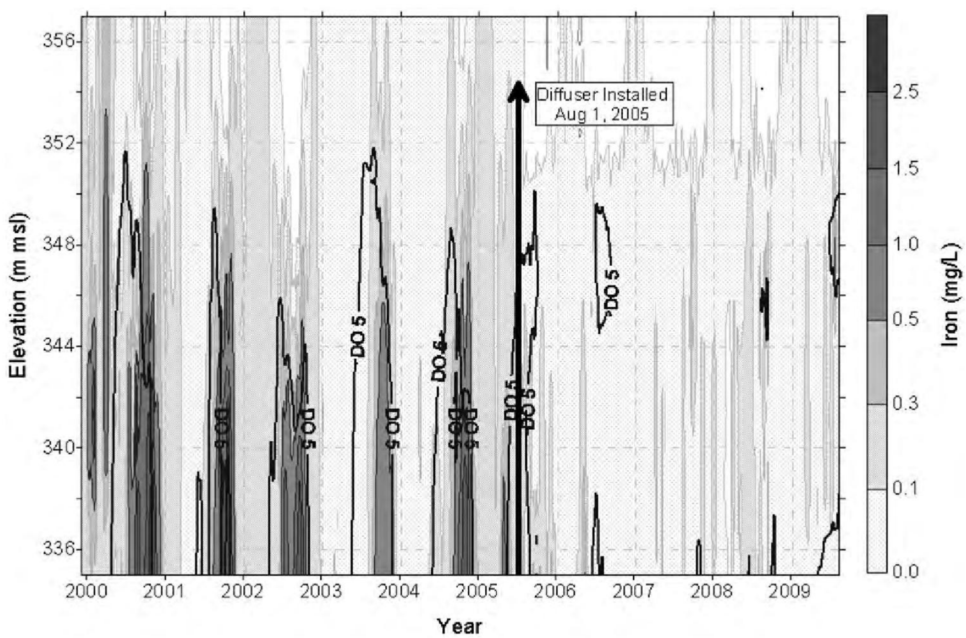

Figure 12. Total Fe concentrations reported throughout the water column in Carvins Cove Reservoir between 2000 and 2009, showing elevated Fe levels each year corresponding to DO dropping below 5 mg/L outlined as DO 5 followed by significant decrease in Fe concentrations after diffuser start-up in 2005.

operation and remain low throughout consecutive years (Figure 12). Review of the pre-oxygenation data shows total Fe concentrations in the hypolimnion to exceed 1.5 mg/L with levels observed greater than 0.3 mg/L throughout the water column each year following fall turnover. Ambient DO of less than 5 mg/L was observed to correspond to elevated Fe levels (Figure 12). Since the diffuser system was installed, Fe levels were consistently observed to be less than

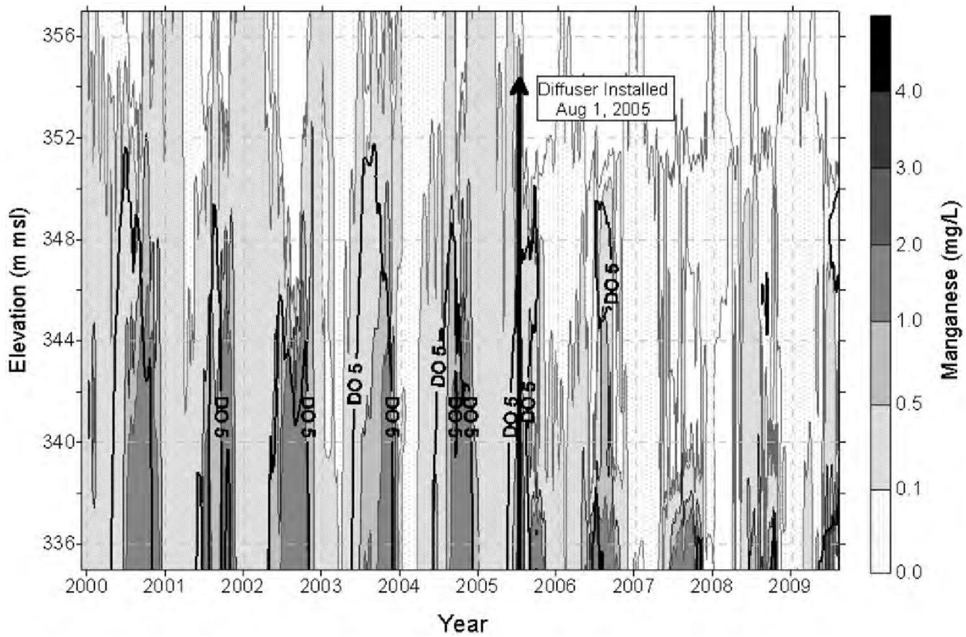

Figure 13. Total Mn concentrations reported throughout the water column in Carvins Cove Reservoir between 2000 and 2009, showing elevated Mn levels each year corresponding to DO below 5 mg/L outlined as DO 5 followed by decreased Mn concentrations throughout the water column after diffuser start-up in 2005.

0.3 mg/L in the hypolimnion and 0.1 mg/L or less throughout the entire water column following the fall turnover during isothermal conditions.

Manganese

Total Mn concentrations were also observed to decrease with diffuser operation in Carvins Cove Reservoir. Prior to the diffuser installation, total Mn concentrations were observed to exceed 3.0 mg/L in the bottom 6 m of the hypolimnion, with levels near 0.5 mg/L throughout the water column later in the year following fall turnover. After the installation of the diffuser in 2005, (1) elevated Mn levels were isolated to the bottom meter and were observed to range between 1.0 and 2.0 mg/L, (2) levels in the bulk hypolimnion were observed between 0.1 and 0.5 mg/L, and (3) Mn levels throughout the entire water column during isothermal conditions following fall turnover were less than 0.1 mg/L (Figure 13).

Decreased levels of total Mn were also observed in the Aurora Reservoir throughout the water column, including a dramatic shift in the amount of dissolved Mn contributing to total Mn. Results observed in Aurora showed that prior to diffuser operation nearly all Mn from samples collected near the bottom consisted of the dissolved form of Mn, with levels being observed in excess of 0.50 mg/L. With diffuser operation, total Mn was observed to decrease by more than half, but more importantly, dissolved Mn contribution to total was significantly less than before oxygen addition. During the first year of diffuser operation in 2016, maximum dissolved Mn concentration was observed just over 0.10 mg/L, with subsequent years observed less than 0.10 mg/L (Figure 14). Increased oxygen input to maintain DO values >2.0 mg/L at the thermocline was utilized in 2018 and may have been responible for decreasing the manganese release in 2018 compared to 2017. With the large reduction in dissolved Mn, water from the hypolimnion can be treated at both Aurora Water water purification facilities year-round as needed, and pre-oxidant chemical demand has been greatly reduced.

In Lake Casitas, prior to diffuser installation, maximum Mn levels were observed as high as 0.86 mg/L. Following installation and operation of the diffuser, maximum Mn levels were observed to be reduced by 90%, with a maximum concentration of 0.09 mg/L in 2017 (Table 2).

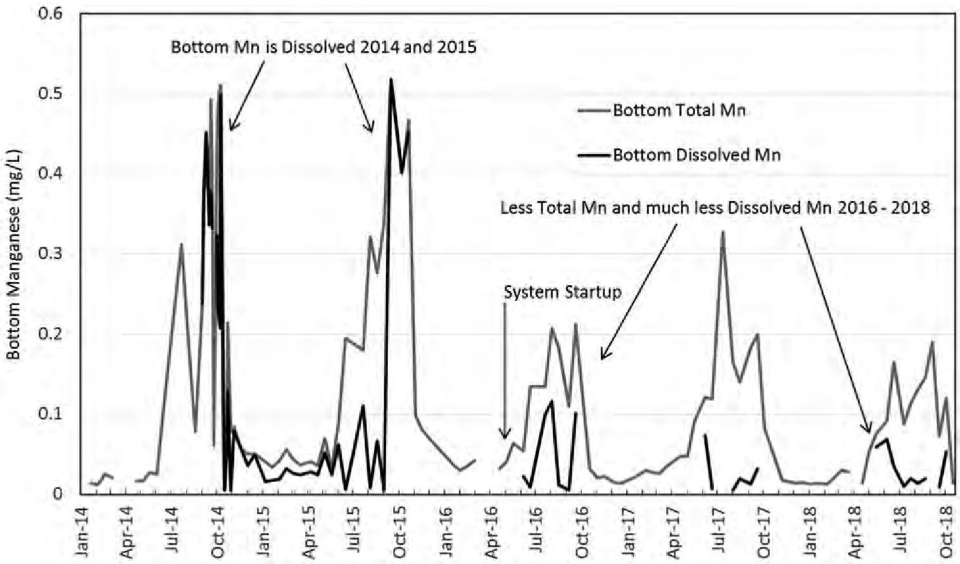

Figure 14. Total and dissolved Mn concentrations collected near the bottom in Aurora Reservoir, showing Mn spikes in excess of 0.500 mg/L prior to diffuser operation, consisting mainly of the dissolved form of Mn, followed by both decreased total Mn concentrations and decreased contribution from the dissolved form of Mn after diffuser installation.

Table 2. Summary of water quality parameters assessed at Lake Casitas from 2012 to 2017.

Year	Bubbler[1] HOS operation	End-of-year WSEL (m)	Measured DO < 1.5 mg/L[2] (at 36.6 m)	Max. total dissolved phosphorus (μg/L)	Max. ammonia-N (mg/L)	Avg. growing season[3] Secchi (m)	Max. manganese (mg/L)	Yearly taste/ odor customer complaints[4]
2012	Bubbler	164.0	16/34 (47%)	290	0.423	3.3	0.070	48
2013	Bubbler	159.7	18/38 (47%)	280	0.3	2.9	0.350	22
2014	Bubbler	156.1	28/41 (68%)	390	1.35	2.2	0.350	100
2015	Bubbler/HOS	152.1	51/63 (81%)	350	1.29	2.5	0.860	140
2016	HOS	148.1	0/41 (0%)	140	0.088	3.5	0.050	0
2017	HOS	149.4	0/27 (0%)	50	0.087	2.7[5]	0.090	0

[1]Bubbler refers to a series of aerators installed in 2005 to provide vertical mixing above elev121 m.
[2]A percentage of DO measurements <1.5 mg/L is presented in addition to the number of recorded measurements satisfying this criterion.
[3]Secchi depth is averaged over the algal growing season (Feb–Oct).
[4]Customer complaints related to lake water quality issues.
[5]No data from July through September for 2017.

Phosphorus

Internal phosphorus loading was identified as one of the primary sources of nutrient loading in Aurora Reservoir. Huisman et al. (2004) identified that cyanobacteria can access nutrients via diel vertical migration to a critical depth (~20 m). For water supply reservoirs with a thermocline less then 20 m deep, such as Aurora Reservoir, oxidation of the hypolimnion could reduce a nutrient availability to cyanobacteria. Therefore, controlling internal phosphorus loading, especially soluble reactive phosphorus, was a primary objective of the oxygenation system for Aurora Water.

Prior to diffuser installation in Aurora Reservoir, total and soluble reactive phosphorus samples collected near the bottom were observed to be greater than 150 and 130 μg/L, respectively (Figure 15). After diffuser start-up in May 2016, maximum total phosphorus levels were observed between 50 and 60 μg/L for 2016 and 2018 and 100 μg/L for 2017. Soluble reactive phosphorus levels were observed between 40 and 50 μg/L for 2016 and 2018. In 2017 soluble reactive phosphorus concentration peaked at 86 μg/L, higher than in 2016 and 2018 but still representing a 35% reduction from pre-oxygenation values. Higher oxygen input in 2018 may have contributed to lower phosphorus levels. As a result of the decreased phosphorus in Aurora Reservoir, the Trophic State Index for total phosphorus was reduced from 48.9 (2015) to 41.1 (2018) (Benskin 2018).

At Calaveras and San Antonio reservoirs, SFPUC found that even when keeping the bulk hypolimnion volume oxygenated, some phosphorus

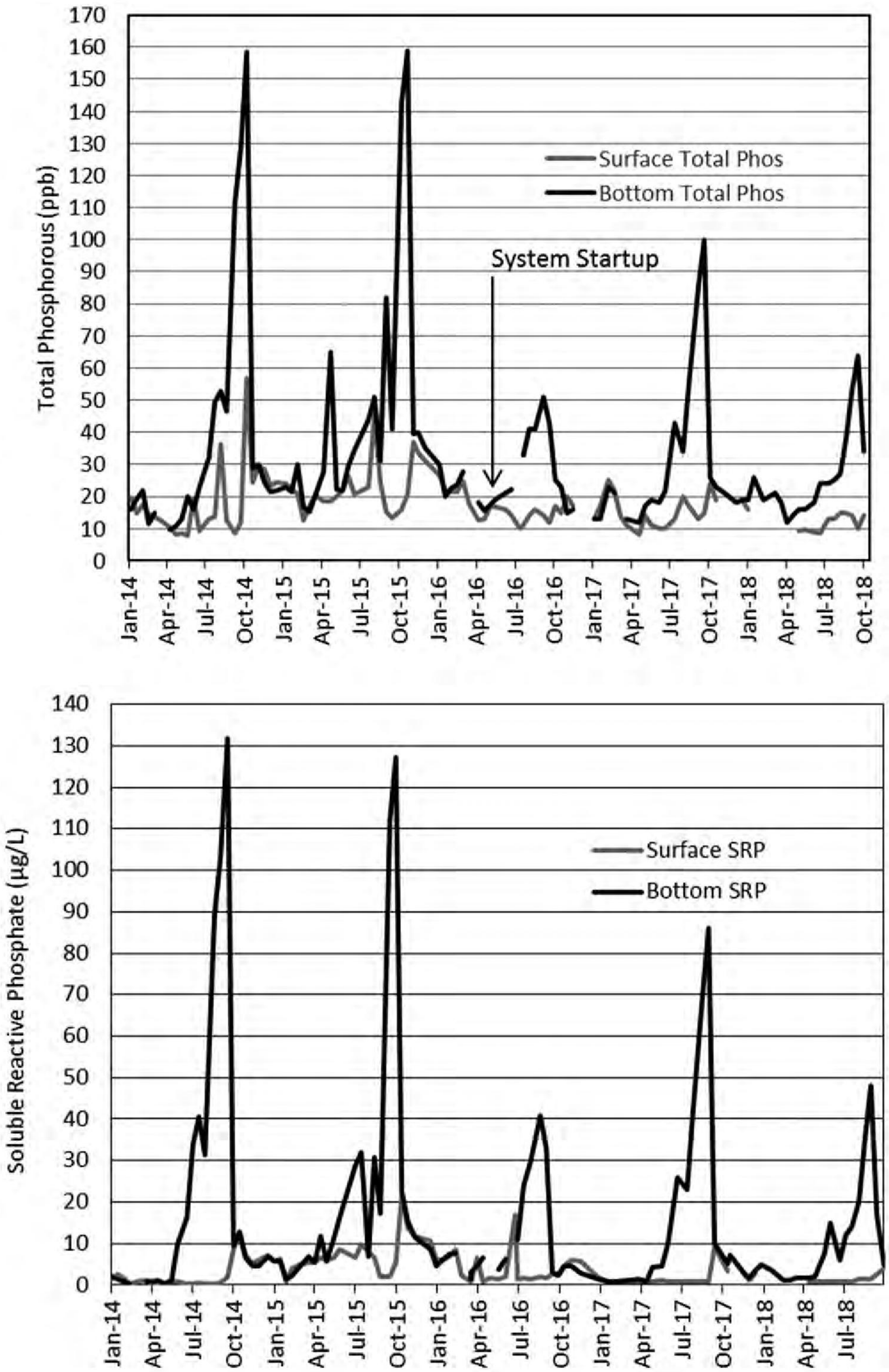

Figure 15. Total (top) and soluble reactive (bottom) phosphorus collected at the surface and near the bottom in Aurora Reservoir, showing decreased levels of both following diffuser start-up in 2016.

was going into solution. This was attributed to letting the DO at the bottom get too low before increasing the oxygen input rate. SFPUC was not increasing the input rate until the bottom measurements reached 2 mg/L or lower, which may have left some anoxic or very low DO volumes where phosphorus was released from the sediments. In 2018, SFPUC changed its operating criteria and is now using a trigger of 5 mg/L to increase the oxygen input rate. No results from this change are yet available (SFPUC 2019).

The common effect of diffuser operation as reported by the municipalities contributing to this work has been a significant suppression of internal loading of Fe, Mn, and P.

Taste and odor

Several factors contribute to taste and odor in water supply reservoirs, such as geosmin and 2-MIB from cyanobacteria in surface waters (Srinivasan and Sorial 2011) and Mn and hydrogen sulfide (H_2S) from hypolimnetic anoxia in bottom waters (Gerling et al. 2014). Taste and odor issues in water-supply reservoirs often lead directly to customer complaints.

Prior to diffuser installation in Lake Casitas, drought conditions were observed to have had a negative impact on water quality. This was reflected in the raw water where Mn and H_2S levels increased to 0.4 mg/L and 2 mg/L, respectively (Water Quality Solutions 2018). Customer complaints during this time period increased dramatically (WQS 2018). During 2014 there were 104 complaints. In 2015, there were 140 complaints. The diffuser system was initially operated in late September 2015. Manganese concentrations in the hypolimnion, lake raw effluent, and treatment plant effluent dropped significantly within a week of the start of oxygenation (WQS 2018). Hydrogen sulfide concentrations in the hypolimnion were also observed to drop significantly within a few weeks of the start of oxygenation (WQS 2018). Customer complaints related to lake water quality issues dropped to zero (WQS 2018). These are complaints due to lake water quality issues, not miscellaneous customer complaints. In subsequent years with increased hypolimnetic DO levels, concentrations of phosphorus, ammonia-N, and manganese have been decreased in Lake Casitas (Table 2). CMWD does not monitor for MIB/geosmin, but there have been no seasonal algal-related taste/odor complaints since installation of the diffusers, and no algaecide treatments for cyanobacteria since installation of the diffusers. As a result of continued diffuser operation, and despite continued drought conditions, customer complaints related to taste and odor have nearly disappeared.

With initial operation of the hypolimnetic oxygenation, Aurora Water also experienced a dramatic decrease in taste and odor complaints related to the use of Aurora Reservoir source water. With diffuser system operation, water could be withdrawn from the hypolimnion year round, allowing the utility to avoid geosmin-producing cyanobacteria that are present in the epilimnion during the warmer months of the year. Complaints were reduced from approximately 100 per summer to fewer than 10 total complaints related to the use of Aurora Reservoir water in the last 3 yr with oxygenation (Benskin 2018).

Turbidity

One of the existing turbidity standards for the CMWD filtration plant at Lake Casitas is that effluent turbidity shall be less than or equal to 0.2 NTU in at least 95% of the measurements taken each month based on 4-h readings with a turbidity performance goal of 0.10 NTU. Additionally, when any individual filter is placed back into service following a backwash or other interruption event, the filtered water turbidity of the effluent from that filter shall not exceed 0.2 NTU after the filter has been in operation for 4 h. Following the installation of the diffuser in 2015, CMWD conducted a diffuser operational test to identify the impact on effluent filter water turbidity. Approximately 1 week after beginning the continuous operational test, the average turbidity of the combined effluent dropped from 0.10 to 0.07 NTU (Table 3). Also, with the diffuser operating continuously, the treatment staff members reported that they were able to more easily achieve the 0.2 NTU standard. For each year that the diffuser system has been fully operational (2016–2018) the percentage of turbidity measurements equal to or less than 0.20 NTU increased to 100% (Table 4).

Installation and operation costs

Installation costs vary widely for both the oxygen supply and reservoir diffuser system, depending on site-specific conditions and requirements. A requirement for a new truck access road, architectural requirements around the tank, and the

Table 3. Summary table of averaged treatment water turbidity at Lake Casitas during 2015 diffuser operational testing.

Date	Turbidity (NTU)*	Diffuser operation
08/01/15–08/25/15	0.10	Pre start-up
08/26/15–09/08/15	0.15	Start-up; sporadic operation
09/09/15–09/23/15	0.08	Start-up; continuous operation
09/24/15–10/28/15	0.06	35 d trial

*Averaged treatment water turbidity (4 h increments).

Table 4. Summary of turbidity measurements collected in 4 h increments reported by CMWD for 2014–2017. Data provided show minimum, maximum, average, and percentage <0.20 measured.

	Turbidity (NTU)			
Year	Minimum	Maximum	Average	% <0.20
2014	0.01	0.40	0.05	99.6
2015	0.02	0.26	0.05	99.8
2016	0.02	0.11	0.03	100.0
2017	0.00	0.10	0.03	100.0
2018	0.01	0.07	0.03	100.0

distance from the facility to the reservoir were observed to dramatically affect the installation costs of the oxygen supply facility. Similarly, the distance from the reservoir piping access point to the diffuser location(s) in the reservoir was observed to affect the installation costs of the diffuser. Actual costs from installations at the study sites show a wide variation of costs, mostly due to site-specific requirements (Table 5). These projects have an average installation cost of about $200/kg/d of oxygen addition capacity with a range of $40 to $400/kg/d.

In some cases, costs for water treatment plant (WTP) modifications or upgrades to treat problematic anoxic products were avoided by the installation of a diffuser system in the reservoir. At Crystal Lake Reservoir the City of Cheyenne, Wyoming, avoided an expensive WTP upgrade with an oxygenation system installed in 2009 (Brandhuber et al. 2010). In the southeastern United States, an undisclosed client avoided a tens of million dollars expenditure on a WTP modification with an oxygenation system installed in 2016.

Operation costs include the costs for the oxygen used and maintenance of the oxygen supply and diffusers. Oxygen costs were observed to vary depending on the availability in the region, the delivery distance, and the contract amount. Current bulk liquid oxygen costs are around $0.09/kg ($84/ton) (current price at Aurora in 2019), $0.11/kg ($96/ton) (current price at CMWD in 2018), and $0.15/kg ($136/ton) (current price at SPRWS in 2019). Maintenance of a liquid oxygen facility is minimal as there are very few moving parts. Maintenance and monitoring of the facility were often contracted to the bulk gas supplier providing the oxygen deliveries. Maintenance is part of the unit costs given for CMWD and SPRWS. The cost of on-site oxygen

Table 5. Installation and operating costs.

	Installation costs					Operating costs	
Reservoir	HOS capacity (kg/d)	Oxygen supply (1000 $)	Diffuser (1000 $)	HOS total (1000 $)	Cost per capacity ($/kg/d)	Annual operating costs (1000 $)	Cost per volume ($ per hectare m)
Spring Hollow Western Virginia Water Authority Salem, VA	1100	NA	NA	NA	NA	NA	NA
Carvins Cove Western Virginia Water Authority Roanoke, VA	3600	NA	195	NA	NA	NA	NA
Calaveras San Francisco Public Utility Commission Sunol, CA	3400	736	241	977	287	108	9.15
San Antonio San Francisco Public Utility Commission Sunol, CA	8200	580	416	996	121	35	5.16
Vadnais Lake Saint Paul Regional Water Services Saint Paul, MN	6500	336	380	716	110	33	29.73
Pleasant Lake Saint Paul Regional Water Services Saint Paul, MN	7500	558	380	938	125	44	36.07
Lake Casitas Casitas Municipal Water District Oak View, CA	27,300	670	530	1200	44	140	4.77
Aurora Reservoir City of Aurora Aurora, CO	2300	803	197	1000	435	37	9.69

generation depends on the available electricity cost but was usually less expensive than liquid oxygen delivery at about $0.06/kg ($52/ton) for lo-pressure delivery (1.0 barg, 15 psig) to $0.10/kg ($90/ton) for high-pressure delivery (3.0 barg, 65 psig) using an average electrical cost of $0.12/kWh (AirSep 2016). Maintenance of a PSA system will include maintenance of the air compressor, air filtration systems, and solenoid valves. Typical diffuser maintenance is porous hose replacement every 12 to 15 yr at a cost of about $3.30 per meter of diffuser length.

Oxygen usage was observed to vary at each reservoir due to ambient conditions such as seasonal weather conditions and inflow water quality. How accurately the operators maintain a desired DO level through monitoring and flow adjustments and any other variation in operation pattern was also observed to have a big impact on oxygen costs. The length of the oxygenation season also impacts operation costs. For example, the Aurora reservoir diffuser system is typically operated at design levels for 60 to 90 d per year, while Vadnais and Pleasant are operated for up to 270 d per year, resulting in significantly higher oxygen costs. Actual annual oxygen costs averaged $66,000, $16 per hectare meter for the study site (Table 5).

In some cases, cost savings in water treatment plant chemicals can far exceed oxygen costs. At the Aurora Water's Bimney Water Purification Facility, the installation and use of the hypolimnetic oxygen system resulted in significant savings in each year it has been in use. In the years prior to the installation of the oxygen system, water was treated from a withdrawal gate in the epilimnion to avoid high levels of dissolved manganese in the hypolimnion. During 2014 and 2015, geosmin-producing cyanobacteria were seasonally present in the epilimnion, so a major portion of the Aurora Reservoir water was treated through granular activated carbon (GAC) adsorbers to reduce geosmin taste and odor impacts. This resulted in a significant cost of approximately $350,000/yr. Since the installation of the oxygen diffuser system, this extra treatment step has not been necessary, saving the utility that expense. In addition, the oxidation of released manganese in the reservoir with oxygen, rather than in the treatment plant with potassium permanganate, has also resulted in a marked decrease in spending on that pre-oxidation chemical. Finally, withdrawing water from the hypolimnion (where algae and total organic carbon levels are lower than in the epilimnion) has allowed for a significant reduction in coagulation chemical use, as compared to their average use in the years prior to the oxygenation system installation, Considering all of these recaptured savings, the hypolimnetic oxygen system at Aurora Reservoir has provided total cost savings of more than $1.4M in 3 yr of operation, more than paying back the initial $1.0M installation cost in 8 separate reservoirs (Table 6).

Table 6. Annual oxygen costs and chemical cost savings at Aurora Reservoir (Benskin 2018).

Aurora Reservoir	2016	2017	2018
Granular activated carbon (GAC)	$350,000	$350,000	$350,000
Potassium permanganate	$15,000	$80,000	$75,000
Coagulant chemicals	$43,000	$83,000	$140,000
Chemical savings	$408,000	$513,000	$565,000
Oxygen costs	$39,000	$32,000	$40,000
Total annual savings	$369,000	$481,000	$525,000

Conclusion

The authors evaluated the benefits to the water column and treatment plant operation after installing and operating a hypolimnetic oxygenation system employing a bubble plume line diffuser. It has been observed that when designed, monitored, and operated properly, diffusers successfully add and spread dissolved oxygen to the deep waters of the hypolimnion, and over the sediments, while preserving thermal stratification.

The results obtained for the projects presented demonstrate how effective diffuser technology was able to (1) increase the DO and spread it laterally and longitudinally throughout the hypolimnion, (2) maintain elevated DO throughout the hypolimnion during successive years of operation, and (3) blanket the sediments with oxygen, even below the installation depth of the diffuser. Additionally, it was shown that with proper engineering, oxygen placement can be engineered to target specific areas or elevation layers of a reservoir.

Bubble plume line diffusers are an established, effective, and successful hypolimnetic oxygenation system design with 19 systems in operation in the United States. The system obtains high oxygen transfer efficiencies without need for a water pump or intake structure. The line diffusers are installed and maintained without divers. Diffusers provide an economical means to distribute oxygen input over large areas of the reservoir hypolimnion.

Diffusers are an attractive treatment option for water supply. Maintaining oxygen levels in the reservoir directly reduces anoxic products and nutrients and mitigates the causes of taste and odor in the reservoir before the raw water enters the treatment plant. For example, manganese that is released from bottom sediments can be almost entirely pre-oxidized by the oxygenation system in the reservoir, rather than depending on chemical oxidation at the water treatment plant. Lower algae levels during summer can allow for a significant decrease in coagulant chemical use. By addressing these problems through oxygenation in the reservoir, more of the water treatment plant capacity is available for other needs, increasing overall treatment capacity.

Installation costs vary widely depending on site specific conditions but can provide an attractive alternative to expensive water treatment plant modifications. Typical liquid oxygen supplied water supply installations run between \$0.5M and \$2.5M, but average about \$100/kg/d. Operating costs are mainly the oxygen usage with low maintenance costs. In some conditions, it is possible to obtain substantial savings by avoiding algaecide applications and chemical treatment costs in the WTP. Several reservoirs with oxygenation systems are experiencing a reduction in oxygen use and costs over time. The results show that bubble plume line diffusers are a cost-effective treatment option for water supply reservoirs.

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Mobley Engineering
PO Box 600, Norris, Tennessee 37828-0600 phone (865) 494-0600

LINE DIFFUSER SYSTEM INSTALLATIONS

Water Supply Reservoirs 31 (28 MEI)

Blalock (2019)

- Clayton County Water District, Jonesboro, GA
- 19 feet deep
- One diffuser line, 1,315 feet total
- 2.2 ton per day hypolimnetic oxygenation system

Shamrock (2019)

- Clayton County Water District, Jonesboro, GA
- 17 feet deep
- One diffuser line, 760 feet total
- 1.1 ton per day hypolimnetic oxygenation system

Hooper (2019)

- Clayton County Water District, Jonesboro, GA
- 660 acre feet, 9 feet deep
- Three diffuser lines, 1,980 feet total
- 108 scfm compressed air destratification system

Ni River Reservoir (2018)

- Spotsylvania County, Spotsylvania GA
- 3,683 acre feet, 22 feet deep
- Two diffuser lines, 9,200 feet total
- 180 scfm compressed air destratification system

Tanabe Reservoir (2018)

- Denver Water, Henderson CO
- 360 acre feet, 15 feet deep
- One diffuser line, 1,670 feet total
- 50 scfm compressed air destratification system
-

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Dunes Reservoir (2018)

- Denver Water, Henderson CO
- 2,363 acre feet, 32 feet deep
- One diffuser line, 3,450 feet total
- 150 scfm compressed air destratification system

Welby Reservoir (2018)

- Denver Water, Commerce City CO
- 1,590 acre feet, 27 feet deep
- One diffuser line, 2,190 feet total
- 100 scfm compressed air destratification system

Bambie-Walker Reservoir (2018)

- Denver Water, Commerce City CO
- 2,080 acre feet, 40 feet deep
- One diffuser lines, 1,890 feet total
- 100 scfm compressed air destratification system

Lake Bowen (2016)

- Spartanburg Water, Spartanburg, SC
- 23,900 acre feet, 1,440 acres
- Three diffuser lines, 9,000 feet total
- 16 tons per day (271 scfm) oxygen distribution capacity
- Diffuser $1.2M

Reservoir 1 (2016)

- Spartanburg Water, Spartanburg, SC
- 2,500 acre feet, 276 acres
- Two diffuser lines, 1,800 feet total
- 3.2 tons per day (271 scfm) oxygen distribution capacity
- Diffuser $301K

Bear Lake (2016)

- Lake Alpine Water, Bear Lake, CA
- 300 acre feet reservoir volume, 20 acres
- 150 feet of diffuser
- 75 kg/day oxygen capacity

Aurora Reservoir (2015)

- Aurora Water, Aurora, CO
- 31,000 acre feet, 800 acres
- One diffuser line, 2,300 feet total
- 2.5 tons per day (42 scfm) oxygen distribution capacity
- Diffuser $197K, Total $997,000

Lake Casitas (2015)

- Casitas Municipal Water District, Oak View, CA
- 161,500 acre feet (52 billion gallons) full
- Currently 70,000 acre feet, 1,088 acres
- Three diffuser lines, 5,400 feet total
- 30 tons per day oxygen distribution capacity
- Diffuser $530K Total $1.2M

Barberton Reservoir (2015)

- City of Barberton, OH
- 200 acres
- Side stream saturation system using two Speece Cones and onsite oxygen generation
- Four diffuser lines, 3,040 feet total to distribute oxygenated water
- 1 ton per day oxygen distribution capacity

Boyette Road Reservoir (2015)

- Pasco County Master Reuse System, Wesley Chapel, FL
- The Boyette Reservoir is the largest reclaimed water reservoir in the country (to date), containing 500 million gallons of water when full, and encompassing 80 acres with an approximate depth of 28 feet
- Three diffused air / destratification lines, 400 feet total
- 400 scfm air distribution capacity
- Circulates 100% to 150% of reservoir volume per day

C. W. Bill Young Regional Reservoir (2014)

- Tampa Bay Water, Lithia, FL
- 56,000 acre feet (18 billion gallons) to 2,000 acre feet
- Four diffused air / destratification lines, 15,000 feet total
- 1,200 scfm air distribution capacity
- Circulates 50% to 100% of reservoir volume per day

Almaden Reservoir (2014)

- Santa Clara Valley Water District, San Jose, CA
- 1,586 acre feet (9.3GL) to 300 acre feet, 62 acres
- Two diffuser lines, 1,200 feet total, 12 scfm oxygen delivery capacity (675 kg/day)
- Project goal: Eliminate methylated mercury
- Current (2014) reservoir volume too low to operate
- Diffuser $281K

Pleasant Lake (2013)

- Saint Paul Regional Water Services, Saint Paul, MN
- 9,900 acre feet
- Two lines, 1,845 feet total, 140 scfm oxygen delivery capacity (7,500 kg/day)

Guadalupe Reservoir (2013)

- Santa Clara Valley Water District, San Jose, CA
- 3,415 acre feet to 500 acre feet, 74 acres
- Two diffuser lines, 1,400 feet total, 12 scfm oxygen delivery capacity (675 kg/day)
- Project goal: Eliminate methylated mercury
- Current (2014) reservoir volume too low to operate
- Diffuser $281K

Stevens Creek Reservoir (2012)

- Santa Clara Valley Water District, San Jose, CA
- 3,138 acre feet to 200 acre feet, 92 acres
- One line, 1,000 feet total, 12 scfm oxygen delivery capacity (675 kg/day)
- Project goal: Eliminate methylated mercury
- Current (2014) reservoir volume too low to operate

Falling Creek Reservoir (2012)

- Western Virginia Water Authority, Roanoke Virginia
  - Side stream saturation and destratification systems
  - 27 kg per day oxygen delivery capacity

Upper San Leandro Reservoir (2001, 2012)

- East Bay Municipal Utility District, Oakland, California
  - 750 acres, 36,000 acre feet (44GL)
  - Refurbished and extended 2012
  - Three lines, 6,800 feet total, 9 tons per day oxygen delivery capacity

Occoquan Reservoir (2012)

- Fairfax Water Authority, Fairfax, VA
- 39,700 acre feet (49GL)
- One line, 2,600 feet total, 54 scfm oxygen delivery capacity (3,000 kg/day)

Calero Reservoir (2011)

- Santa Clara Valley Water District, San Jose, CA
- 7,500 acre feet (9.3GL), 110 acres
- One line, 1,000 feet
- 12 scfm oxygen delivery capacity (675 kg/day)
- Project goal: Eliminate methylated mercury
- 2014 showed dramatic decrease in MeHG

Lake Vadnais (2011)

- Saint Paul Regional Water Services, Saint Paul, MN
- 9,000 acre feet (11GL), 622 acres
- Two lines, 3,000 feet total
- 120 scfm oxygen delivery capacity (6,500 kg/day)
- Diffuser $380K

Peace River Reservoir #2 (2010)

- Peace River Manasota Regional Water Authority, Port Charlotte FL
    - 6 billion gallons (22GL)
    - Four lines, 12,240 feet total, 750 scfm air delivery capacity
    - Project goal: Destratify and aerate reservoir
    - Circulates 50% to 75% of reservoir volume per day

San Antonio Reservoir (2009)

- San Francisco Public Utility Commission , San Francisco, California
    - 55,000 acre feet (68GL)
    - Two lines, 3,780 feet total, 9 tons per day oxygen delivery capacity

Crystal Reservoir (2009)

- Board of Public Utilities, Cheyenne Wyoming
    - 3,988 acre-feet (5GL)
    - Two lines, 1,200 feet total, 7 ton per day oxygen delivery capacity

Peace River Reservoir #1 (2008)

- Peace River Manasota Regional Water Authority, Port Charlotte FL
    - 625,000,000 gallons (2.3 GL)
    - Two lines, 3,630 feet total, 200 scfm air delivery capacity

Calaveras Reservoir (2005)

- San Francisco Public Utility Commission , San Francisco, California
- 860 acres, 34,000 acre feet (42GL)
    - Two lines, 2,000 feet total, 3.7 tons per day oxygen delivery capacity

Carvin Cove Reservoir (2005)

- Western Virginia Water Authority, Roanoke Virginia
    - Two lines, 4,000 feet total, 4 tons per day oxygen delivery capacity

Spring Hollow Reservoir (TVA 1997, Mobley Engineering 2005)

- County of Roanoke Utility District, Salem, Virginia
    - One 3,500-foot diffuser, 120 to 170-scfm air capacity
    - Modified to one 2,000 foot diffuser utilizing oxygen (2004)
    - 1.2 tons per day average oxygen delivery capacity

Los Vaqueros Reservoir (2000)

- Contra Costa Water District, Concord, California
    - Two lines, 8,000 feet total, 14 tons per day oxygen delivery capacity

Embalse de Pinilla (Centro de Estudios Hidrograficos and TVA 1995)

- Customer: Ministerio de Obras Publicas, Transportes y Medio Ambiente, Madrid, Spain
    - Two lines, 670 meters total, 1,600-kg/day oxygen system capacity
    - Experimental – no longer in use

Normandy Reservoir (TVA 1994 – 1996)

- Customer: TVA Reservoir Releases Task Force
    - 6 diffuser lines, 16,500 feet total, 250-scfm air system capacity

Hydro Power Reservoirs 22 (13 MEI)

Logan Martin (Mobley Engineering, 2017)

- Alabama Power, Alpine AL
  - 7 diffuser lines, 22,500 feet total, 190 tons per day oxygen capacity
  - Enhance hydro release DO to FERC requirements
  - Diffuser $1.8M
  - Oxygen supply $2.1M
  - Site work $1.5

Tippy Hydroelectric Plant (Mobley Engineering, 2012)

- Consumers Energy, Wellston, MI
  - Three 15 foot diameter upwelling diffusers near intakes
  - One line diffuser upstream of dam
  - Supplied by air compressor
  - Project goal: Enhance turbine release temperatures for downstream fish habitat

Lake Tillery (Mobley Engineering, 2011)

- Progress Energy, Mount Gilead, NC
  - 4 diffuser lines, 14,000 feet total, 150 tons per day oxygen capacity
  - Enhance hydro release DO to FERC requirements

J. Strom Thurmond (Mobley Engineering, 2010 – 2011)

- U.S. Army Corps of Engineers, Savannah District
  - 9 diffuser lines, 11,880 feet total, 200 tons per day oxygen capacity
  - Project goal: Create and maintain striped bass fish habitat

Gulf Island Pond (Mobley Engineering 2009, 2010)

- FPL Energy, Gulf Island Pond Operating Partnership, Lewiston, Maine
  - 6 diffuser lines, 10,400 feet total, 50 tons per day oxygen capacity

Mio Hydroelectric Plant (Mobley Engineering, 2008)

- Consumers Energy, Mio, MI
  - Two 25 foot diameter upwelling diffusers
  - Supplied by portable air compressor
  - Enhance turbine release temperatures for fish habitat

Croton Hydroelectric Plant (Mobley Engineering, 2008)

- Consumers Energy, Newago, MI
  - Two 25 foot diameter upwelling diffusers
  - Supplied by portable air compressor
  - Enhance turbine release temperatures for fish habitat

Hodenpyl Hydroelectric Plant (Mobley Engineering, 2007)

- Consumers Energy, Mesick, MI
  - Two 15 foot diameter upwelling diffusers
  - Supplied by portable air compressor
  - Enhance turbine release temperatures for downstream fish habitat

Broken Bow Dam (Mobley Engineering, 2007)

- Oklahoma Department of Wildlife Conservation
  - Three 15 foot diameter upwelling diffusers
  - Supplied by portable air compressors
  - Experimental attempt at enhancing turbine release temperatures for downstream fish habitat

Lake Lillinonah, Shepaug Dam (Mobley Engineering 2006)

- Northeast Generation Services New Milford, CT
  - 3 diffuser lines, 11,160 total, 90 tons per day oxygen capacity

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Lake Wallenpaupack (Mobley Engineering 2004, 2012)

- Pennsylvania Power and Light Hawley, PA
    - 1 diffuser line, 3,000 total, 200-scfm air capacity
- Project goal: Eliminate H2S in hydro releases

Tims Ford Reservoir (TVA 2005)

- TVA Lake Improvement Plan II
    - 12,400 acres, 600,000 acre-feet
    - 4 lines, 15,500 feet total

Norris Reservoir (TVA 2004)

- TVA Lake Improvement Plan II
- 34,000 acres, 2,500,000 acre-feet
- 3 lines, 12,000 feet total

Nottely Reservoir (TVA 2004)

- TVA Lake Improvement Plan II
- 4,000 acres, 174,00 acre-feet
- 2 lines, 8,000 feet total

Richard B. Russell Reservoir (Mobley Engineering, TVA 2002)

- US Army Corps of Engineers, Savannah District
- Ten lines, 42,000 feet total, 200 tons per day oxygen delivery capacity

Buzzard Roost Hydroelectric Station- Lake Greenwood (TVA 1997, MEI 2012)

- Duke Power Company, Greenwood, South Carolina
    - Three lines, 9,000 feet total, 22-tons/day oxygen system capacity

Watts Bar Reservoir (TVA 1996, 2003)

- 39,000 acres, 1,175,000 acre-feet
- TVA Lake Improvement Plan
    - Six lines, 44,000 feet total, 50-tons/day oxygen system capacity

Hiwassee Reservoir (TVA 1995)

- 6,000 acres, 430,000 acre-feet
- TVA Lake Improvement Plan
  - 15-ton oxygen per day pressure swing adsorption system 1997
  - Three lines 12,600 feet total
  - PSA system replaced with LOx tank and vaporizers in 1999

Fort Loudoun Reservoir (TVA 1995, 2004)

- 14,000 acres, 393,000 acre-feet
- TVA Lake Improvement Plan
  - Three lines, 15,000 feet total, 36-tons/day oxygen system capacity

Cherokee Reservoir (TVA 1994 – 1995)

- 30,000 acres, 1,500,000 acre-feet
- TVA Lake Improvement Plan
  - Sixteen lines 48,000 feet total 150-tons/day oxygen system capacity

Blue Ridge Reservoir (TVA 1994, 2003)

- 3,200 acres, 195,000 acre-feet
- TVA Lake Improvement Plan
  - Five lines, 8,450 feet total, 24-tons/day oxygen system capacity

Douglas Reservoir (TVA 1993, 1995, 1996, 2003)

- 30,000 acres, 1,476,000 acre-feet
- TVA Lake Improvement Plan
  - 10 lines, 35,000 feet total, 110-tons/day oxygen system capacity

Natural Lakes (2)

South Twin Lake (Mobley Engineering 2010)

* Colville Consolidated Tribes Indian Reservation, Inchelium, WA
* 30,000 acre feet
  - One line, 3,920 feet total, 5 tons per day oxygen delivery capacity
  - Enhance fish habitat during summer stratification period

North Twin Lake (Mobley Engineering 2008)

* Colville Consolidated Tribes Indian Reservation, Inchelium, WA
* 917 acres, 29,600 acre feet
  - One line, 2,450 feet total, 5 tons per day oxygen delivery capacity
  - Enhance fish habitat during summer stratification period

Other:

Sequoyah Nuclear Plant (TVA 1995)

- TVA Nuclear - Environmental Compliance
  - One 1,500 foot long line diffuser
  - Supplied by portable air compressor
  - Fish habitat maintained in intake channel

Rock Creek (Mobley Engineering 2019)

- Anne Arundel County, Baltimore, MD
  - Two 700 foot long line diffusers
  - Supplied by 360 scfm air blower
  - Destratification of Chesapeake Bay embayment to eliminate H2S odors

Client References:

Mobley Engineering, Inc.,

P.O. Box 600 Norris, TN 37828

2019

The following are projects and references for recent diffuser installations by Mobley Engineering, Inc.:

Denver Water, Tanabe, Dunes, Bambie-Walker and Welby Reservoirs (2018)

Design and installation of an air destratification system to enhance dissolved oxygen levels and eliminate H_2S formation in the reservoirs. One diffuser line per reservoir, 9,200 feet total.

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Alabama Power, Logan Martin Reservoir (2017)

Design and installation of an oxygen diffuser system to enhance dissolved oxygen levels in the hydropower releases from this 128 MW plant. Seven diffuser lines, 22,500 feet total, 190 tons per day oxygen delivery capacity.

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Manager, Hydro Services
Southern Company Generation
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Aurora Water, Aurora Reservoir (2015)

Design and installation of an oxygen diffuser system to enhance dissolved oxygen levels in this 10 billion gallon water supply reservoir. One diffuser line, 2,300 feet long, 2.5 tons per day oxygen delivery capacity.

Pamela Benskin
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Casitas Municipal Water District, Lake Casitas (2015)

Design and installation of diffused air destratification diffuser system to enhance dissolved oxygen levels in this 52 billion gallon water supply reservoir. Three diffuser lines, 5,400 feet total, 30 tons per day oxygen delivery capacity. Quick results made local newspaper in October, 2015.

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President
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Tampa Bay Water, C. W. Bill Young Regional Reservoir (2014)

Design and installation of diffused air destratification diffuser system to enhance dissolved oxygen levels in this 18 billion gallon side stream water supply reservoir. Four diffuser lines, 15,000 feet total, 1,200 scfm air delivery capacity mixes 50 to 100% of the total reservoir volume per day.

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Curt Wade, PE
Reservoir Compliance Manager
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Santa Clara Valley Water District, Calero Reservoir (2011), Stevens Creek Reservoir (2012), Guadalupe Reservoir (2013), Almaden Reservoir (2014):

Design and installation of oxygen diffuser systems to maintain target dissolved oxygen levels and reduce methylated mercury levels in the reservoir. One or two oxygen diffuser lines, with 1,000 to 1,400 feet total length in each reservoir. PSA oxygen supply systems.

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Shree Dharasker
Engineering Unit Manager
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Saint Paul Regional Water Services, Lake Vadnais (2011), Pleasant Lake (2013):

Design and installation of oxygen diffuser systems to maintain dissolved oxygen levels in the reservoirs to decrease anoxic products and taste and odor problems. Two oxygen diffuser lines in each reservoir, 3,000 feet total, 70 tons per day oxygen delivery capacity.

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East Bay Municipal Utility District, Upper San Leandro Reservoir (2001, 2012):

Design and installation of a hypolimnetic oxygenation system to reduce anoxic products in the reservoir and chemical treatment required for water supply withdrawals. Three diffuser lines, 6,800 feet total, 9 tons per day oxygen delivery capacity, 30,000 ac-ft reservoir. System was refurbished and extended in 2012 to place oxygen deeper in reservoir and further into a large cove.

Pongsiri (Eng) Prachyaratanawooti
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Hubert Lai
Project Manager
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Fairfax Water, Occoquan Reservoir (2012):

Installation of a hypolimnetic oxygenation system to reduce anoxic products in the reservoir and chemical treatment required for water supply withdrawals. One diffuser line, 2,600 feet total, 4 tons per day oxygen delivery capacity, 20,000 ac-ft reservoir.

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Thomas J. Grizzard, P.E., Ph.D.
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Western Virginia Water Authority, Carvins Cove Reservoir (2005), Spring Hollow Reservoir (2005), Falling Creek Reservoir (2012):

Design and installation of a hypolimnetic oxygenation system to reduce anoxic products in the reservoir and chemical treatment required for water supply withdrawals. A destratification diffuser system and side stream oxygen saturation system in Falling Creek. Two diffuser lines, 4,000 feet total, 4 tons per day oxygen delivery capacity in Carvins Cove, a 19,600 ac-ft reservoir. One 2,000 foot diffuser with 1.2 tons per day oxygen delivery capacity in Spring Hollow.

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Progress Energy, Tillery Hydroelectric Plant (2011):

Design and installation of an oxygen diffuser system to maintain target dissolved oxygen levels of 5 mg/L in the hydropower releases. Four oxygen diffuser lines, 14,000 feet total, 150 tons per day oxygen delivery capacity.

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U.S. Army Corps of Engineers, Savannah District,
J. Strom Thurmond Reservoir (2010 - 2011):

Design and installation of a reservoir diffuser system to create and maintain striped bass habitat in the 434,000 ac-ft reservoir and enhance dissolved oxygen levels in the releases from the 280 MW hydropower facility. The MEI oxygen diffuser system includes nine lines, 1,320 feet long each, for a total of 200 tons per day oxygen capacity. The diffusers are located 5 miles upstream of the dam with plume strength and diffuser elevations designed to place oxygen in the 18°C to 24°C striped bass habitat range.

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Peace River Manasota Regional Water Supply Authority
Reservoir #1 (2008), Reservoir #2 (2010, 2013, 2015, 2016):

Design and installation of aeration mixing systems to aerate water near the reservoir bottom and mix the relatively shallow reservoirs to reduce algae and enhance quality of water supply withdrawals. Reservoir #1: two diffuser lines, 3,630 feet total, 200 scfm air capacity. Reservoir #2: four diffuser lines, 12,240 feet total, 1,050 scfm air capacity.

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City of San Francisco Public Utilities Commission
Calaveras Reservoir (2005), San Antonio Reservoir (2009):

Design and installation of hypolimnetic oxygenation systems to create and maintain fish habitat in the reservoir, reduce anoxic products in the reservoirs and reduce chemical treatment required for water supply withdrawals. Two diffuser lines, 2,000 feet total, 4 tons per day oxygen delivery capacity, in Calaveras Reservoir 34,000 ac-ft volume. Two diffuser lines, 3,780 feet total, 9 tons per day oxygen delivery capacity, in San Antonio Reservoir 55,000 ac-ft volume.

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Mobley Engineering, Inc.
2020 Rates

Personnel:

• Mark H. Mobley, PE	Principal Engineer	$ 127.50/hour
• Jeff S. Hale	Site Supervisor	$ 79.75/hour
• Ken C. Kolesar	Associate Engineer, CAD	$ 76.50/hour
• Miles H. Mobley	Mechanical Engineer	$ 67.00/hour
• Lisa Bernard	HDPE Specialist	$ 63.75/hour
• Construction Crewmember		$ 55.80/hour*
• Apprentice Construction Crewmember		$ 39.75/hour*

Overtime rates of 1.5 x hourly rate applies at over 8 hours/day or over 40 hours/week
*These rates may change to comply with local prevailing wage requirements

Per Diem:

$ 175/day/person

Mileage:

- MEI 4WD pickup trucks and box truck

$0.575 per mile

MEI Owned Boats, Tools and Equipment:

- Work Boats:
  - Fully outfitted 20 foot jon boats with; 4 stroke outboard, crane, specialty pipe racks, anchor attachment tables, GPS depth finder, life vests, trailer

$ 225/day/per boat

- MEI Site Installation Tools and Equipment:
  - HDPE welders, pipe racks, work tables, tents, generators, water pumps, radios, hand tools and personal protection equipment

$ 3,500 per project

Shop Assemblies:

- Diffuser components pre-assembled in MEI shop in Norris TN:
    - Drilled and tapped HDPE Supply Saddle $ 15.92
    - Drilled HDPE Anchor Saddle $ 9.00
    - Branch Tee Assembly $ 8.05
    - Porous Hose Rolls with hose barb tees (1,000 feet) $ 2,386.50
    - Anchor Cable Assembly $ 11.33

Mobley Engineering, Inc. is part of a team of experts on dissolved oxygen enhancements and aeration techniques and can offer additional resources from consultants in hydropower, water quality assessments, computer modeling and water quality monitoring as needed.

Request for Proposal
RFP-4792-20-DH

Design/Build Aeration Project for Juniata Reservoir

RESPONSES DUE:
May 5, 2020 Prior to 3:30 PM MDT
Accepting Electronic Responses Only
Responses Only Submitted Through the Rocky Mountain E-Purchasing System (RMEPS)
https://www.rockymountainbidsystem.com/default.asp
(Purchasing Representative does not have access or control of the vendor side of RMEPS. If website or other problems arise during response submission, vendor MUST contact RMEPS to resolve issue prior to the response deadline. 800-835-4603)

PURCHASING REPRESENTATIVE:
Duane Hoff Jr., Senior Buyer
duaneh@gjcity.org
970-244-1545

This solicitation has been developed specifically for a Request for Proposal intended to solicit competitive responses for this solicitation, and may not be the same as previous City of Grand Junction solicitations. All offerors are urged to thoroughly review this solicitation prior to submitting. Submittal by **FAX, EMAIL or HARD COPY IS NOT ACCEPTABLE** for this solicitation.

REQUEST FOR PROPOSAL

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REQUEST FOR PROPOSAL

SECTION 1.0: ADMINISTRATIVE INFORMATION & CONDITIONS FOR SUBMITTAL

1.1 Issuing Office: This Request for Proposal (RFP) is issued by the City of Grand Junction. All contact regarding this RFP shall be directed to:
RFP Questions:
Duane Hoff Jr., Senior Buyer
duaneh@gjcity.org

1.2 Purpose: The purpose of this RFP is to obtain proposals from qualified professional firms to design, provide, and install a new aeration system for Juniata Reservoir.

1.3 The Owner: The Owner is the City of Grand Junction, Colorado and is referred to throughout this Solicitation. The term Owner means the Owner or his authorized representative.

1.4 Compliance: All participating Offerors, by their signature hereunder, shall agree to comply with all conditions, requirements, and instructions of this RFP as stated or implied herein. Should the Owner omit anything from this packet which is necessary to the clear understanding of the requirements, or should it appear that various instructions are in conflict, the Offeror(s) shall secure instructions from the Purchasing Division prior to the date and time of the submittal deadline shown in this RFP.

1.5 Submission: Please refer to section 5.0 for what is to be included. ***Each proposal shall be submitted in electronic format only, and only through the Rocky Mountain E-Purchasing website (https://www.rockymountainbidsystem.com/default.asp).*** *This site offers both "free" and "paying" registration options that allow for full access of the Owner's documents and for electronic submission of proposals.* *(Note: "free" registration may take up to 24 hours to process. Please Plan accordingly.)* Please view our "**Electronic Vendor Registration Guide"** at http://www.gjcity.org/business-and-economic-development/bids/ for details. For proper comparison and evaluation, the City requests that proposals be formatted as directed in Section 5.0 "Preparation and Submittal of Proposals." Submittals received that fail to follow this format may be ruled non-responsive. (Purchasing Representative does not have access or control of the vendor side of RMEPS. If website or other problems arise during response submission, vendor **MUST** contact RMEPS to resolve issue prior to the response deadline. **800-835-4603**)

1.6 Altering Proposals: Any alterations made prior to opening date and time must be initialed by the signer of the proposal, guaranteeing authenticity. Proposals cannot be altered or amended after submission deadline.

1.7 Withdrawal of Proposal: A proposal must be firm and valid for award and may not be withdrawn or canceled by the Offeror for sixty (60) days following the submittal deadline date, and only prior to award. The Offeror so agrees upon submittal of their proposal. After award this statement is not applicable.

1.8 Addenda: All Questions shall be submitted in writing to the appropriate person as shown in Section 1.1. Any interpretations, corrections and changes to this RFP or extensions to the opening/receipt date shall be made by a written Addendum to the RFP by the Owner. Sole authority to authorize addenda shall be vested in the City of Grand Junction Purchasing Representative. Addenda will be issued electronically through the Rocky Mountain E-Purchasing website at www.rockymountainbidsystem.com and http://www.gjcity.org/business-and-economic-development/bids/ Offerors shall acknowledge receipt of all addenda in their proposal.

1.9 Exceptions and Substitutions: All proposals meeting the intent of this RFP shall be considered for award. Offerors taking exception to the specifications shall do so at their own risk. The Owner reserves the right to accept or reject any or all substitutions or alternatives. When offering substitutions and/or alternatives, Offeror must state these exceptions in the section pertaining to that area. Exception/substitution, if accepted, must meet or exceed the stated intent and/or specifications. The absence of such a list shall indicate that the Offeror has not taken exceptions, and if awarded a contract, shall hold the Offeror responsible to perform in strict accordance with the specifications or scope of work contained herein.

1.10 Confidential Material: All materials submitted in response to this RFP shall ultimately become public record and shall be subject to inspection after contract award. "**Proprietary or Confidential Information"** is defined as any information that is not generally known to competitors and which provides a competitive advantage. Unrestricted disclosure of proprietary information places it in the public domain. Only submittal information clearly identified with the words "***Confidential Disclosure***" and uploaded as a separate document shall establish a confidential, proprietary relationship. Any material to be treated as confidential or proprietary in nature must include a justification for the request. The request shall be reviewed and either approved or denied by the Owner. If denied, the proposer shall have the opportunity to withdraw its entire proposal, or to remove the confidential or proprietary restrictions. Neither cost nor pricing information nor the total proposal shall be considered confidential or proprietary

1.11 Response Material Ownership: All proposals become the property of the Owner upon receipt and shall only be returned to the proposer at the Owner's option. Selection or rejection of the proposal shall not affect this right. The Owner shall have the right to use all ideas or adaptations of the ideas contained in any proposal received in response to this RFP, subject to limitations outlined in the section titled "Confidential Material". Disqualification of a proposal does not eliminate this right.

1.12 Minimal Standards for Responsible Prospective Offerors: A prospective Offeror must affirmably demonstrate their responsibility. A prospective Offeror must meet the following requirements:

- Have adequate financial resources, or the ability to obtain such resources as required.
- Be able to comply with the required or proposed completion schedule.
- Have a satisfactory record of performance.
- Have a satisfactory record of integrity and ethics.
- Be otherwise qualified and eligible to receive an award and enter into a contract with the Owner.

1.13 Nonconforming Terms and Conditions: A proposal that includes terms and conditions that do not conform to the terms and conditions of this Request for Proposal is subject to rejection as non-responsive. The Owner reserves the right to permit the Offeror to withdraw nonconforming terms and conditions from its proposal prior to a determination by the Owner of non-responsiveness based on the submission of nonconforming terms and conditions

1.14 Open Records: All proposals shall be open for public inspection after the contract is awarded. Trade secrets and confidential information contained in the proposal so identified by offer as such shall be treated as confidential by the Owner to the extent allowable in the Open Records Act.

1.15 Sales Tax: City of Grand Junction is, by statute, exempt from the State Sales Tax and Federal Excise Tax; therefore, all fees shall not include taxes.

1.16 Public Opening: Proposals shall be opened in the City Hall Auditorium, 250 North 5th Street, Grand Junction, CO 81501, immediately following the proposal deadline. Offerors, their representatives and interested persons may be present. Only the names and locations on the proposing firms will be disclosed.

SECTION 2.0: GENERAL CONTRACT TERMS AND CONDITIONS

2.1. Acceptance of RFP Terms: A proposal submitted in response to this RFP shall constitute a binding offer. Acknowledgment of this condition shall be indicated on the Cover Letter by the Offeror or an officer of the Offeror legally authorized to execute contractual obligations. A submission in response to the RFP acknowledges acceptance by the Offeror of all terms and conditions, as set forth herein. An Offeror shall identify clearly and thoroughly any variations between its proposal and the Owner's RFP requirements. Failure to do so shall be deemed a waiver of any rights to subsequently modify the terms of performance, except as outlined or specified in the RFP.

2.2. Execution, Correlation, Intent, and Interpretations: The Contract Documents shall be signed by the Owner and Contractor. By executing the contract, the Contractor represents that they have familiarized themselves with the local conditions under which the Work is to be performed and correlated their observations with the requirements of the Contract Documents. The Contract Documents are complementary, and what is required by any one, shall be as binding as if required by all. The intention of the documents is to include all labor, materials, equipment, services and other items necessary for the proper execution and completion of the scope of work as defined in the technical specifications and drawings contained herein. All drawings, specifications and copies furnished by the Owner are, and shall remain, Owner property. They are not to be used on any other project.

2.3. Permits, Fees, & Notices: The Contractor shall secure and pay for all permits, fees and licenses necessary for the proper execution and completion of the work. The Contractor shall give all notices and comply with all laws, ordinances, rules, regulations and orders of any public authority bearing on the performance of the work. If the Contractor observes that any of the Contract Documents are at variance in any respect, Contractor shall promptly notify the Owner in writing, and any necessary changes shall be adjusted by change order/amendment. If the Contractor performs any work knowing it to be contrary to such laws, ordinances, rules and regulations, and without such notice to the Owner, Contractor shall assume full responsibility and shall bear all costs attributable.

2.4. Responsibility for those Performing the Work: The Contractor shall be responsible to the Owner for the acts and omissions of all their employees and all other persons performing any of the work under a contract with the Contractor.

2.5. Use of the Site: The Contractor shall confine operations at the site to areas permitted by law, ordinances, permits and the Contract Documents, and shall not unreasonably encumber the site with any materials or equipment.

2.6. Cleanup: The Contractor at all times shall keep the premises free from accumulation of waste materials or rubbish caused by their operations. At the completion of work they shall remove all their waste materials and rubbish from and about the project, as well as all their equipment and surplus materials.

2.7. Payment & Completion: The Contract Sum is stated in the Contract and is the total amount payable by the Owner to the Contractor for the performance of the work under the Contract Documents. Upon receipt of written notice that the work is ready for final inspection and acceptance and upon receipt of application for payment, the Owner's Project Manager will promptly make such inspection and, when Owner finds the work acceptable under the Contract Documents and the Contract fully performed, the Owner shall make payment in the manner provided in the Contract Documents. Partial payments will be based upon estimates, prepared by the Contractor, of the value of Work performed and materials placed in accordance with the Contract Documents.

2.8. Performance & Payment Bonds: Contractor shall furnish a Performance and a Payment Bond, each in an amount at least equal to that specified for the contract amount as security for the faithful performance and payment of all Contractor's obligations under the Contract Documents. These bonds shall remain in effect for the duration of the Warranty Period (as specified in the Special Conditions). Contractor shall also furnish other bonds that may be required by the Special Conditions. All bonds shall be in the forms prescribed by the Contract Documents and be executed by such sureties as (1) are licensed to conduct business in the State of Colorado and (2) are named in the current list of "Companies Holding Certificates of Authority as Acceptable Sureties on Federal Bonds and as Acceptable Reinsuring Companies" as published in Circular 570 (amended) by the Audit Staff, Bureau of Accounts, U.S. Treasury Department. All bonds singed by an agent must be accompanied by a certified copy of the Authority Act. If the surety on any bond furnished by the Contractor is declared bankrupt, or becomes insolvent, or its rights to do business in Colorado are terminated, or it ceases to meet the requirements of clauses (1) and (2) of this section, Contractor shall within five (5) days thereafter substitute another bond and surety, both of which shall be acceptable to the City.

2.9. Retention: The Owner will deduct money from the partial payments in amounts considered necessary to protect the interest of the Owner and will retain this money until after completion of the entire contract. The amount to be retained from partial payments will be five (5) percent of the value of the completed work, and not greater than five (5) percent of the amount of the Contract. When the retainage has reached five (5) percent of the amount of the Contract no further retainage will be made and this amount will be retained until such time as final payment is made.

2.10. Liquidated Damages for Failure to Meet Project Completion Schedule: If the Contractor does not achieve Final Completion by the required date, whether by neglect, refusal or any other reason, the parties agree and stipulate that the Contractor shall pay liquidated damages to the City for each such day that final completion is late. As provided elsewhere, this provision does not apply for delays caused by the City. The date for Final Completion may be extended in writing by the Owner.

The Contractor agrees that as a part of the consideration for the City's awarding of this Contract liquidated damages in the daily amount of $**500.00** is reasonable and necessary to pay for the actual damages resulting from such delay. The parties agree that the real costs and injury to the City for such delay include hard to quantify items such as: additional engineering, inspection and oversight by the City and its agents; additional contract administration; inability to apply the efforts of those employees to the other work of the City; perceived inefficiency of the City; citizens having to deal with the construction and the Work, rather than having the benefit of a completed Work, on time; inconvenience to the public; loss of reputation and community standing for the City during times when such things are very important and very difficult to maintain.

The Contractor must complete the Work and achieve final completion included under the Bid Schedule in the number of consecutive calendar days after the City gives is written Notice to Proceed. When the Contractor considers the entire Work ready for its intended use, Contractor shall certify in writing that the Work is substantially complete. In addition to the Work being substantially complete, Final Completion date is the date by which the Contractor shall have fully completed all clean-up, and all items that were identified by the City in the inspection for final completion. Unless otherwise stated in the Special Conditions, for purposes of this liquidated damages clause, the Work shall not be finished and the Contract time shall continue to accrue until the City gives its written Final Acceptance.

If the Contractor shall fail to pay said liquidated damages promptly upon demand thereof after having failed to achieve Final Completion on time, the City shall first look to any retainage or other funds from which to pay said liquidated damages; if retainage or other liquid funds are not available to pay said liquidated damages amounts, the Surety on the Contractor's Performance Bond and Payment Bond shall pay such liquidated damages. In addition, the City may withhold all, or any part of, such liquidated damages from any payment otherwise due the Contractor.
Liquidated damages as provided do not include any sums to reimburse the City for extra costs which the City may become obligated to pay on other contracts which were delayed or extended because of the Contractor's failure to complete the Work within the Contract Time. Should the City incur additional costs because of delays or extensions to other contracts resulting from the Contractor's failure of timely performance, the Contractor agrees to pay these costs that the City incurs because of the Contractor's delay, and these payments are separate from and in addition to any liquidated damages.

The Contractor agrees that the City may use its own forces or hire other parties to obtain Substantial or Final Completion of the work if the time of completion has elapsed and the

Contractor is not diligently pursuing completion. In addition to the Liquidated Damages provided for, the Contractor agrees to reimburse the City for all expenses thus incurred.

2.11. Contingency/Force Account: Contingency/Force Account work will be authorized by the Owner's Project Manager and is defined as minor expenses to cover miscellaneous or unforeseen expenses related to the project. The expenses are not included in the Drawings, Specifications, or Scope of Work and are necessary to accomplish the scope of this contract. Contingency/Force Account Authorization will be directed by the Owner through an approved form. Contingency/Force Account funds are the property of the Owner and any Contingency/Force Account funds, not required for project completion, shall remain the property of the Owner. Contractor is not entitled to any Contingency/Force Account funds, that are not authorized by Owner or Owner's Project Manager.

2.12. Protection of Persons & Property: The Contractor shall comply with all applicable laws, ordinances, rules, regulations and orders of any public authority having jurisdiction for the safety of persons or property or to protect them from damage, injury or loss. Contractor shall erect and maintain, as required by existing safeguards for safety and protection, and all reasonable precautions, including posting danger signs or other warnings against hazards promulgating safety regulations and notifying owners and users of adjacent utilities. When or where any direct or indirect damage or injury is done to public or private property by or on account of any act, omission, neglect, or misconduct by the Contractor in the execution of the work, or in consequence of the non-execution thereof by the Contractor, they shall restore, at their own expense, such property to a condition similar or equal to that existing before such damage or injury was done, by repairing, rebuilding, or otherwise restoring as may be directed, or it shall make good such damage or injury in an acceptable manner.

2.13. Changes in the Work: The Owner, without invalidating the contract, may order changes in the work within the general scope of the contract consisting of additions, deletions or other revisions. All such changes in the work shall be authorized by Change Order and shall be executed under the applicable conditions of the contract documents. A Change Order is a written order to the Contractor signed by the Owner issued after the execution of the contract, authorizing a change in the work or an adjustment in the contract sum or the contract time.

2.14. Minor Changes in the Work: The Owner shall have authority to order minor changes in the work not involving an adjustment in the contract sum or an extension of the contract time and not inconsistent with the intent of the contract documents.

2.15. Uncovering & Correction of Work: The Contractor shall promptly correct all work found by the Owner as defective or as failing to conform to the contract documents. The Contractor shall bear all costs of correcting such rejected work, including the cost of the Owner's additional services thereby made necessary. The Owner shall give such notice promptly after discovering of condition. All such defective or non-conforming work under the above paragraphs shall be removed from the site where necessary and the work shall be corrected to comply with the contract documents without cost to the Owner.

2.16. Acceptance Not Waiver: The Owner's acceptance or approval of any work furnished hereunder shall not in any way relieve the proposer of their present responsibility to maintain the high quality, integrity and timeliness of his work. The Owner's approval or acceptance of, or payment for, any services shall not be construed as a future waiver of any rights under this Contract, or of any cause of action arising out of performance under this Contract.

2.17. Change Order/Amendment: No oral statement of any person shall modify or otherwise change, or affect the terms, conditions or specifications stated in the resulting contract. All change orders/amendments to the contract shall be made in writing by the Owner Purchasing Division.

2.18. Assignment: The Offeror shall not sell, assign, transfer or convey any contract resulting from this RFP, in whole or in part, without the prior written approval from the Owner.

2.19. Compliance with Laws: Proposals must comply with all Federal, State, County and local laws governing or covering this type of service and the fulfillment of all ADA (Americans with Disabilities Act) requirements. Contractor hereby warrants that it is qualified to assume the responsibilities and render the services described herein and has all requisite corporate authority and professional licenses in good standing, required by law.

2.20. Debarment/Suspension: The Contractor herby certifies that the Contractor is not presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by any Governmental department or agency.

2.21. Confidentiality: All information disclosed by the Owner to the Contractor for the purpose of the work to be done or information that comes to the attention of the Contractor during the course of performing such work is to be kept strictly confidential.

2.22. Conflict of Interest: No public official and/or Owner employee shall have interest in any contract resulting from this RFP.

2.23. Contract: This Request for Proposal, submitted documents, and any negotiations, when properly accepted by the Owner, shall constitute a contract equally binding between the Owner and Offeror. The contract represents the entire and integrated agreement between the parties hereto and supersedes all prior negotiations, representations, or agreements, either written or oral, including the Proposal documents. The contract may be amended or modified with Change Orders, Field Orders, or Amendment.

2.24. Project Manager/Administrator: The Project Manager, on behalf of the Owner, shall render decisions in a timely manner pertaining to the work proposed or performed by the Offeror. The Project Manager shall be responsible for approval and/or acceptance of any related performance of the Scope of Work.

2.25. Cancelation of Solicitation: Any solicitation may be canceled by the Owner or any solicitation response by a vendor may be rejected in whole or in part when it is in the best interest of the Owner.

2.26. Contract Termination: This contract shall remain in effect until any of the following occurs: (1) contract expires; (2) completion of services; (3) acceptance of services or, (4) for convenience terminated by either party with a written *Notice of Cancellation* stating therein the reasons for such cancellation and the effective date of cancellation at least thirty days past notification.

2.27. Employment Discrimination: During the performance of any services per agreement with the Owner, the Offeror, by submitting a Proposal, agrees to the following conditions:

2.27.1. The Offeror shall not discriminate against any employee or applicant for employment because of race, religion, color, sex, age, disability, citizenship status, marital status, veteran status, sexual orientation, national origin, or any legally protected status except when such condition is a legitimate occupational qualification reasonably necessary for the normal operations of the Offeror. The Offeror agrees to post in conspicuous places, visible to employees and applicants for employment, notices setting forth the provisions of this nondiscrimination clause.

2.27.2. The Offeror, in all solicitations or advertisements for employees placed by or on behalf of the Offeror, shall state that such Offeror is an Equal Opportunity Employer.

2.27.3. Notices, advertisements, and solicitations placed in accordance with federal law, rule, or regulation shall be deemed sufficient for the purpose of meeting the requirements of this section.

2.28. Immigration Reform and Control Act of 1986 and Immigration Compliance: The Offeror certifies that it does not and will not during the performance of the contract employ illegal alien workers or otherwise violate the provisions of the Federal Immigration Reform and Control Act of 1986 and/or the immigration compliance requirements of State of Colorado C.R.S. § 8-17.5-101, *et.seq.* (House Bill 06-1343).

2.29. Ethics: The Offeror shall not accept or offer gifts or anything of value nor enter into any business arrangement with any employee, official, or agent of the Owner.

2.30. Failure to Deliver: In the event of failure of the Offeror to deliver services in accordance with the contract terms and conditions, the Owner, after due oral or written notice, may procure the services from other sources and hold the Offeror responsible for any costs resulting in additional purchase and administrative services. This remedy shall be in addition to any other remedies that the Owner may have.

2.31. Failure to Enforce: Failure by the Owner at any time to enforce the provisions of the contract shall not be construed as a waiver of any such provisions. Such failure to enforce shall not affect the validity of the contract or any part thereof or the right of the Owner to enforce any provision at any time in accordance with its terms.

2.32. Force Majeure: The Offeror shall not be held responsible for failure to perform the duties and responsibilities imposed by the contract due to legal strikes, fires, riots, rebellions, and acts of God beyond the control of the Offeror, unless otherwise specified in the contract.

2.33. Indemnification: Offeror shall defend, indemnify and save harmless the Owner and all its officers, employees, insurers, and self-insurance pool, from and against all liability, suits, actions, or other claims of any character, name and description brought for or on account of any injuries or damages received or sustained by any person, persons, or property on account of any negligent act or fault of the Offeror, or of any Offeror's agent, employee, subcontractor or supplier in the execution of, or performance under, any contract which may result from proposal award. Offeror shall pay any judgment with cost which may be obtained against the Owner growing out of such injury or damages.

2.34. Independent Firm: The Offeror shall be legally considered an Independent Firm and neither the Firm nor its employees shall, under any circumstances, be considered servants or agents of the Owner. The Owner shall be at no time legally responsible for any negligence or other wrongdoing by the Firm, its servants, or agents. The Owner shall not withhold from the contract payments to the Firm any federal or state unemployment taxes, federal or state income taxes, Social Security Tax or any other amounts for benefits to the Firm. Further, the Owner shall not provide to the Firm any insurance coverage or other benefits, including Workers' Compensation, normally provided by the Owner for its employees.

2.35. Ownership: All plans, prints, designs, concepts, etc., shall become the property of the Owner.

2.36. Oral Statements: No oral statement of any person shall modify or otherwise affect the terms, conditions, or specifications stated in this document and/or resulting agreement. All modifications to this request and any agreement must be made in writing by the Owner.

2.37. Patents/Copyrights: The Offeror agrees to protect the Owner from any claims involving infringements of patents and/or copyrights. In no event shall the Owner be liable to the Offeror for any/all suits arising on the grounds of patent(s)/copyright(s) infringement. Patent/copyright infringement shall null and void any agreement resulting from response to this RFP.

2.38. Remedies: The Offeror and Owner agree that both parties have all rights, duties, and remedies available as stated in the Uniform Commercial Code.

2.39. Venue: Any agreement as a result of responding to this RFP shall be deemed to have been made in, and shall be construed and interpreted in accordance with, the laws of the City of Grand Junction, Mesa County, Colorado.

2.40. Expenses: Expenses incurred in preparation, submission and presentation of this RFP are the responsibility of the company and can not be charged to the Owner.

2.41. Sovereign Immunity: The Owner specifically reserves its right to sovereign immunity pursuant to Colorado State Law as a defense to any action arising in conjunction to this agreement.

2.42. Public Funds/Non-Appropriation of Funds: Funds for payment have been provided through the Owner's budget approved by the City Council/Board of County Commissioners for the stated fiscal year only. State of Colorado statutes prohibit the obligation and expenditure of public funds beyond the fiscal year for which a budget has been approved. Therefore, anticipated orders or other obligations that may arise past the end of the stated Owner's fiscal year shall be subject to budget approval. Any contract will be subject to and must contain a governmental non-appropriation of funds clause.

2.43. Collusion Clause: Each Offeror by submitting a proposal certifies that it is not party to any collusive action or any action that may be in violation of the Sherman Antitrust Act. Any and all proposals shall be rejected if there is evidence or reason for believing that collusion exists among the proposers. The Owner may or may not, at the discretion of the Owner Purchasing Representative, accept future proposals for the same service or commodities for participants in such collusion.

2.44. Gratuities: The Contractor certifies and agrees that no gratuities or kickbacks were paid in connection with this contract, nor were any fees, commissions, gifts or other considerations made contingent upon the award of this contract. If the Contractor breaches or violates this warranty, the Owner may, at their discretion, terminate this contract without liability to the Owner.

2.45. OSHA Standards: All Offerors agree and warrant that services performed in response to this invitation shall conform to the standards declared by the US Department of Labor under the Occupational Safety and Health Act of 1970 (OSHA). In the event the services do not conform to OSHA Standards, the Owner may require the services to be redone at no additional expense to the Owner.

2.46. Performance of the Contract: The Owner reserves the right to enforce the performance of the contract in any manner prescribed by law or deemed to be in the best interest of the Owner in the event of breach or default of resulting contract award.

2.47. Benefit Claims: The Owner shall not provide to the Contractor any insurance coverage or other benefits, including Worker's Compensation, normally provided by the Owner for its employees.

2.48. Default: The Owner reserves the right to terminate the contract immediately in the event the Contractor fails to meet delivery or completion schedules, or otherwise perform in accordance with the accepted proposal. Breach of contract or default authorizes the Owner to purchase like services elsewhere and charge the full increase in cost to the defaulting Contractor.

2.49. Multiple Offers: Proposers must determine for themselves which product or service to offer. If said proposer chooses to submit more than one offer, THE ALTERNATE OFFER must be clearly marked "Alternate Proposal". The Owner reserves the right to make award in the best interest of the Owner.

2.50. Cooperative Purchasing: Purchases as a result of this solicitation are primarily for the Owner. Other governmental entities may be extended the opportunity to utilize the resultant contract award with the agreement of the successful provider and the participating agencies. All participating entities will be required to abide by the specifications, terms, conditions and pricings established in this Proposal. The quantities furnished in this proposal document are for only the Owner. It does not include quantities for any other jurisdiction. The Owner will be responsible only for the award for our jurisdiction. Other participating entities will place their own awards on their respective Purchase Orders through their purchasing office or use their purchasing card for purchase/payment as authorized or agreed upon between the provider and the individual entity. The Owner accepts no liability for payment of orders placed by other participating jurisdictions that choose to piggy-back on our solicitation. Orders placed by participating jurisdictions under the terms of this solicitation will indicate their specific delivery and invoicing instructions.

2.51. Definitions:

2.51.1. "Offeror" and/or "Proposer" refers to the person or persons legally authorized by the Consultant to make an offer and/or submit a response (fee) proposal in response to the Owner's RFP.

2.51.2. The term "Work" includes all labor, materials, equipment, and/or services necessary to produce the requirements of the Contract Documents.

2.51.3. "Contractor" is the person, organization, firm or consultant identified as such in the Agreement and is referred to throughout the Contract Documents. The term Contractor means the Contractor or his authorized representative. The Contractor shall carefully study and compare the General Contract Conditions of the Contract, Specification and Drawings, Scope of Work, Addenda and Modifications and shall at once report to the Owner any error, inconsistency or omission he may discover. Contractor shall not be liable to the Owner for any damage resulting from such errors, inconsistencies or omissions. The Contractor shall not commence work without clarifying Drawings, Specifications, or Interpretations.

2.51.4. "Sub-Contractor is a person or organization who has a direct contract with the Contractor to perform any of the work at the site. The term sub-contractor is referred to throughout the contract documents and means a sub-contractor or his authorized representative.

2.52. Public Disclosure Record: If the Proposer has knowledge of their employee(s) or sub-proposers having an immediate family relationship with an Owner employee or elected official, the proposer must provide the Purchasing Representative with the name(s) of these individuals. These individuals are required to file an acceptable "Public Disclosure Record", a statement of financial interest, before conducting business with the Owner.

2.53. Keep Jobs in Colorado Act: Contractor shall be responsible for ensuring compliance with Article 17 of Title 8, Colorado Revised Statutes requiring 80% Colorado labor to be employed on public works. Contractor shall, upon reasonable notice provided by the Owner, permit the Owner to inspect documentation of identification and residency required by C.R.S. §8-17-101(2)(a). If Contractor claims it is entitled to a waiver pursuant to C.R.S. §8-17-101(1), Contractor shall state that there is insufficient Colorado labor to perform the work such that compliance with Article 17 would create an undue burden that would substantially prevent a project from proceeding to completion, and shall include evidence demonstrating the insufficiency and undue burden in its response.

Unless expressly granted a waiver by the Owner pursuant to C.R.S. §8-17-101(1), Contractor shall be responsible for ensuring compliance with Article 17 of Title 8, Colorado Revised Statutes requiring 80% Colorado labor to be employed on public works. Contractor shall, upon reasonable notice provided by the Owner, permit the Owner to inspect documentation of identification and residency required by C.R.S. §8-17-101(2)(a).

2.53.1. "Public Works project" is defined as:

(a) any construction, alteration, repair, demolition, or improvement of any land, building, structure, facility, road, highway, bridge, or other public improvement suitable for and intended for use in the promotion of the public health, welfare, or safety and any maintenance programs for the upkeep of such projects
(b) for which appropriate or expenditure of moneys may be reasonably expected to be $500,000.00 or more in the aggregate for any fiscal year
(c) except any project that receives federal moneys.

SECTION 3.0: INSURANCE REQUIREMENTS

Insurance Requirements: The selected Contractor agrees to procure and maintain, at its own cost, policy(s) of insurance sufficient to insure against all liability, claims, demands, and other obligations assumed by the Contractor pursuant to this Section. Such insurance shall be in addition to any other insurance requirements imposed by this Contract or by law. The Contractor shall not be relieved of any liability, claims, demands, or other obligations assumed pursuant to this Section by reason of its failure to procure or maintain insurance in sufficient amounts, durations, or types. Contractor shall procure and maintain and, if applicable, shall cause any Subcontractor of the Contractor to procure and maintain insurance coverage listed below. Such coverage shall be procured and maintained with forms and insurers acceptable to the Owner. In the case of any claims-made policy, the necessary retroactive dates and extended reporting periods shall be procured to maintain such continuous coverage. Minimum coverage limits shall be as indicated below unless specified otherwise:

(a) Worker Compensation: Contractor shall comply with all State of Colorado Regulations concerning Workers' Compensation insurance coverage.

(b) General Liability insurance with minimum limits of:

ONE MILLION DOLLARS ($1,000,000) each occurrence and
ONE MILLION DOLLARS ($1,000,000) per job aggregate.

The policy shall be applicable to all premises and operations. The policy shall include coverage for bodily injury, broad form property damage (including completed operations), personal injury (including coverage for contractual and employee acts), blanket contractual, products, and completed operations. The policy shall include coverage for explosion, collapse, and underground hazards. The policy shall contain a severability of interests provision.

(c) Comprehensive Automobile Liability insurance with minimum limits for bodily injury and property damage of not less than:

ONE MILLION DOLLARS ($1,000,000) each occurrence and
ONE MILLION DOLLARS ($1,000,000) aggregate

(d) Professional Liability & Errors and Omissions Insurance policy with a minimum of:

ONE MILLION DOLLARS ($1,000,000) per claim

This policy shall provide coverage to protect the contractor against liability incurred as a result of the professional services performed as a result of responding to this Solicitation.

With respect to each of Contractors owned, hired, or non-owned vehicles assigned to be used in performance of the Work. The policy shall contain a severability of interests provision. The policies required by paragraph (b) above shall be endorsed to include the Owner, and the Owner's officers and employees as additional insureds. Every policy required above shall be primary insurance, and any insurance carried by the Owner, its officers, or its employees, or carried by or provided through any insurance pool of the Owner, shall be excess and not contributory insurance to that provided by Bidder. No additional insured endorsement to any required policy shall contain any exclusion for bodily injury or property damage arising from completed operations. The Bidder shall be solely responsible for any deductible losses under any policy required above.

SECTION 4.0: SPECIFICATIONS/SCOPE OF SERVICES

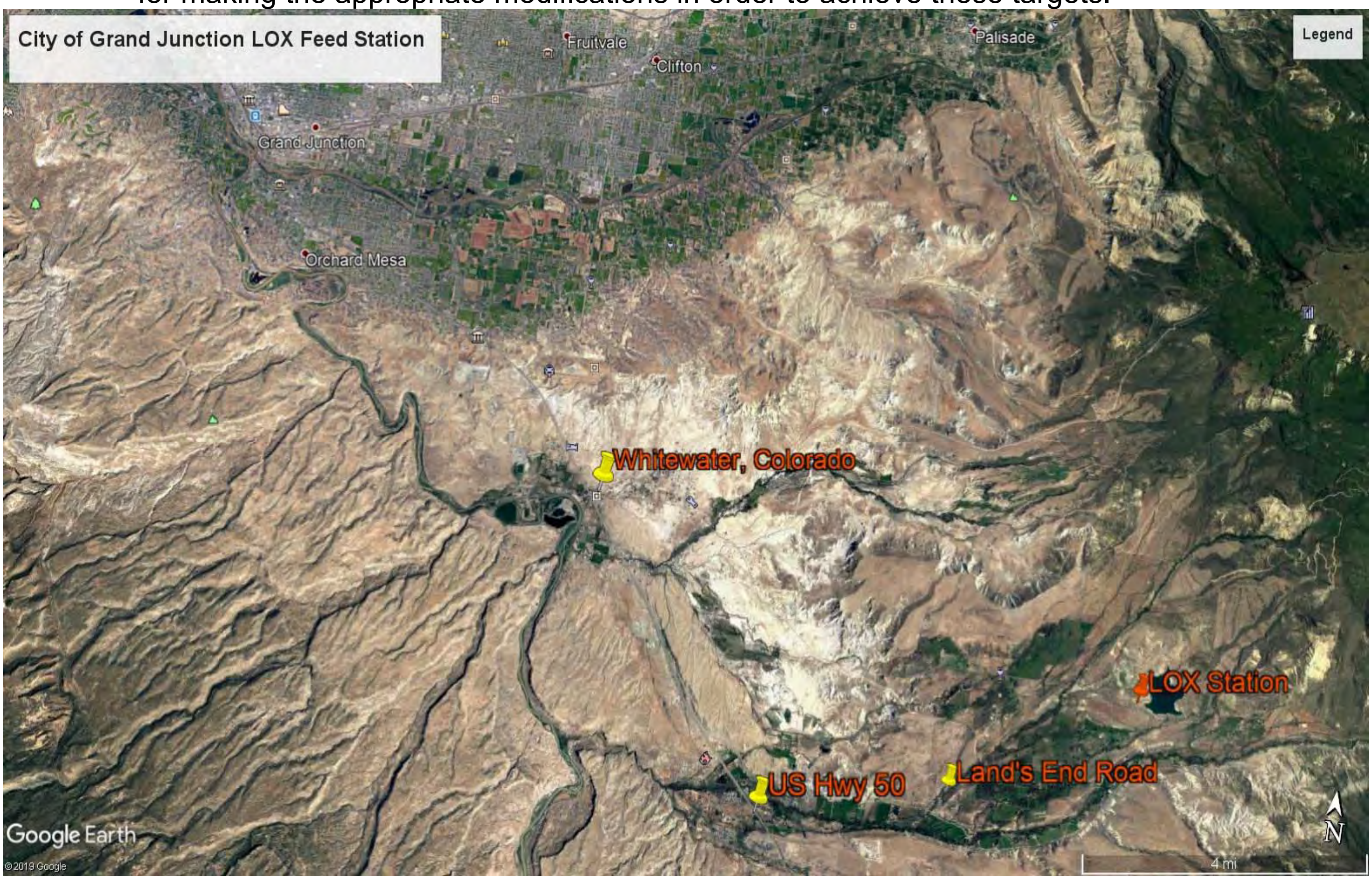
4.1. General/Background: Juniata Reservoir serves as the City's primary storage reservoir with a capacity of 7,291 acre feet. The original Juniata Reservoir provided for the storage of 400 acre feet and was built in 1911. There have been several enlargements made, most recently in 2008, which have expanded it to its current capacity. Historically, water was drawn from the bottom of Juniata Reservoir to fill Purdy Mesa Reservoir, which then fed the pipeline to the City of Grand Junction's water treatment plant. In the late 1980's, in order to improve source water quality to the treatment plant, this pipeline was extended to connect to Juniata Reservoir as well and an outlet was installed at the mid-level of the reservoir.

The City initiated a reservoir monitoring program in 2002. Water quality data collected suggests that dissolved oxygen levels (DO) in Juniata Reservoir's hypolimion have been steadily decreasing and the onset of anoxia is gradually commencing earlier in the summer. This decrease in DO has led to increasing manganese and phosphorus levels. The City's Water Treatment Plant is a direct filtration plant, so issues such as algae blooms and manganese removal, which are related to decreased DO levels, pose a greater challenge than with conventional filtration.

To mitigate these issues associated with the seasonal depletion of DO, the City of Grand Junction plans to have an aeration system installed in Juniata Reservoir during early summer, 2020. This aeration system will be supplied by an onsite liquid oxygen system (LOX).

Juniata Reservoir is located about 8 miles southwest of Whitewater, Coloardo in Mesa County.

4.2 Project Objectives: The scope of work for this project consists of designing, furnishing all materials, equipment, appurtenances, tools, labor, and everything else necessary for completing the Juniata Reservoir Aeration Project. The main elements of work consist of designing and installing a linear diffuser within Juniata reservoir and connecting this system to the customer service connection (valve) located at the LOX (liquid oxygen) storage facility. The new LOX storage and feed facility will consist of a 9,000-gallon horizontal bulk oxygen tank, vaporizers, and associated piping, valves, and flow meter. Additionally, the work includes the materials necessary for and the installation of a pipeline that will deliver the gaseous oxygen from the feed facility to the linear diffuser within the reservoir. Final completion date shall be June 30, 2020. The linear diffuser shall be designed and sized to maintain DO levels of at least 5.0 mg/L throughout the water column in Juniata Reservoir. The City will conduct regular DO profiles at the deepest point of the reservoir as shown on the map below. Should the profiles show the aeration system is unable to achieve a minimum DO level of 5.0 mg/L during the 2021 season, the contractor would be responsible for making the appropriate modifications in order to achieve these targets.



Design of the system layout and construction and connection of the aeration system to the LOX shall be coordinated with the LOX provider. Target date to have the system delivered and installed is July 17, 2020.

4.2. Special Conditions/Provisions:

4.2.1 Licenses and Permits: Contractor is responsible for obtaining all necessary licenses and permits required for Construction, at Contractors expense. <u>See Section 2.3</u>

4.2.2 Freight/Shipping: All freight/shipping shall be F.O.B. Destination – Freight Pre-paid and allowed. Staging area provided at 333 West Ave, Grand Junction, CO 81501. Final location of approximately 39 5’26.072” N Lat 108 13”26.407” W Lon.

4.2.3 Price: Project pricing shall be all inclusive, to include, but not be limited to: labor, materials, equipment, travel, design, drawings, engineer work, supplies, shipping/freight, licenses, permits, fees, etc.

All prices shall be “F.O.B. Destination Freight Pre-Paid and Allowed”. The Owner shall not pay nor be liable for any other additional costs including but not limited to: taxes, shipping charges, insurance, interest, penalties, termination payments, attorney fees, liquidated damages, etc.

Contract shall be established as “Cost Plus a Fixed Fee”. Contractor shall submit their Fixed Fee utilizing the attached form in Section 7.0 Solicitation Response Form.

All fees will be considered by the Owner to be negotiable.

4.2.4 Warranty: Contractor shall submit manufacturer warranty information for Owner’s approval, prior to product ordering. Additionally, Contractor shall provide a minimum 1 year Contractors warranty.

4.2.5 Codes: Contractor shall ensure that project meets all Federal, State, County, and City Codes.

4.2.6 Working Schedule: Time is of the essence with this project. Working schedule shall be Monday – Sunday from 7:00am-7:00pm.

4.2.7 Time of Completion: The scheduled time of Completion for the Project shall be no later than July 17, 2020.

4.2.8 Contract: A binding contract shall consist of: (1) the IFB and any amendments thereto, (2) the bidder’s response (bid) to the IFB, (3) clarification of the bid, if any, and (4) the City’s Purchasing Department’s acceptance of the bid by “Notice of Award” or by “Purchase Order”. All Exhibits and Attachments included in the IFB shall be incorporated into the contract by reference.

A. The contract expresses the complete agreement of the parties and, performance shall be governed solely by the specifications and requirements contained therein.

B. Any change to the contract, whether by modification and/or supplementation, must be accomplished by a formal contract amendment signed and approved by and between the duly authorized representative of the bidder and the City Purchasing Division or by a modified Purchase Order prior to the effective date of such modification. The bidder expressly and explicitly understands and agrees that no other method and/or no other document, including acts and oral communications by or from any person, shall be used or construed as an amendment or modification to the contract.

4.2.9 Plans/Drawings: Contractor shall provide Conceptual ***or*** 30% plans/drawings with their proposal response. The awarded Contractor shall provide full plans/drawings no later than June 19, 2020.

4.2.10 CITY PROJECT MANAGER: The Project Manager for the Project is Mark Ritterbush – Water Services Manager, who can be reached at (970)256-4185. During Construction, all notices, letters, submittals, and other communications directed to the City shall be addressed and mailed or delivered to:

City of Grand Junction
Department of Public Works and Planning
Attn: Mark Ritterbush, Project Manager
244 26 ¼ Road
Grand Junction, CO 81503

4.2.11 Laws, Codes, Rules, and Regulations: Contractor shall ensure that all services provide meet all Federal, State, County, and City laws, codes, rules, and regulations.

4.3. Specifications/Scope of Services: The general scope of services to be obtained as a result of this RFP includes all preconstruction and Construction Services required for successful completion of the project.

LINEAR DIFFUSER

1.01 References:

A. The following is a list of standards which may be referenced in this Section:

1. Compressed Gas Association (CGA):
   a. G-4.1, Cleaning Equipment for Oxygen Service, latest edition.
   b. G-4.4, Industrial Practices for Gaseous Oxygen Transmission and Distribution Piping Systems.

1.02 DESIGN REQUIREMENTS

A. The linear diffusers shall be provided by a qualified linear diffuser installer (LDI).

B. The system shall be designed to deliver gaseous oxygen uniformly to the deep section of the reservoir while suspended from the reservoir bottom.

C. Provide an anchoring system to maintain the linear diffuser at the desired depth. The linear diffuser shall include a floatation system designed to sink the linear diffuser into position or float the linear diffuser to the surface using compressed air or gaseous oxygen. The linear diffuser shall be completely serviceable from the surface.

D. The linear diffusers shall be sized to accommodate intermittent and variable flow, as well as constant flow. The linear diffuser shall be sized to accommodate an oxygen demand ranging from zero to 100 percent of the maximum flow defined herein.

E. Map below shows deepest portion of Juniata Reservoir with respect to the proposed location of the LOX Storage Facility. Linear distance is approximately 2100 feet.

F. Linear diffuser must be capable of maintaining DO levels of at least 5.0 mg/L throughout the water column in the reservoir.

1.03 SUBMITTALS

A. Action Submittals:

1. LDI (Linear Diffuser Installer) qualifications.
2. Shop Drawings:
   a. Details of linear diffuser construction, fabrication, and materials.
   b. Detailed procedures to be used in fabricating, storing, and installing the linear diffuser.
   c. Linear diffusers testing procedures.
   d. Line diffusers cleaning procedures.
   e. Complete drawings and data to describe the overall system and indicate full compliance with these Specifications. As a minimum, this shall include a piping diagram, and data sheets or catalog cuts on all system components.
   f. Complete headloss and orifice calculations for oxygen gas flow through the diffuser.

B. Informational Submittals:

1. Manufacturer's Certificate of Compliance.
2. Manufacturer's Certificate of Proper Installation.

3. Written test reports of each test and inspection.
4. Operation and Maintenance Data.

1.04 QUALITY ASSURANCE

A. LDI Qualifications:

1. Contractor shall be an LDI or subcontract with an LDI that is regularly engaged in the assembly and installation of linear diffuser hypolimnetic oxygenation systems; and who shall employ only tradesmen with specific skill and experience in this type of work.
2. The LDI shall have a minimum of 5 years of experience in the assembly and installation of linear diffusers of equal or greater length used to deliver gaseous oxygen to reservoirs or lakes of equal or greater depth. The LDI shall show evidence of satisfactory service in at least five installations.
3. The Contractor shall submit the name and qualifications of the LDI.

1.05 EXTRA MATERIALS

A. Furnish all tools and spare parts for the normal operation and maintenance of the equipment.

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PART 2 PRODUCTS

2.01 GENERAL

A. All components and subsystems of the linear diffuser shall be constructed in a safe and accessible manner, complying with the local, State of Colorado, and national codes and requirements.

B. The sizing information for the line diffuser specified herein is based on preliminary information that should not supercede information gathered during the design process

C. The line diffuser shall be capable of continuous operation at a constant oxygen flow rate under the following conditions; the maximum depth of Juniata Reservoir is 79 feet when at capacity:

Maximum Flow Rate (SCFH) = 3920

Average Flow Rate (SCFH) = 2200

Minimum /flow Rate (SCFH) = 100

D. The linear diffuser shall be suspended 2 to 2.5 feet above the sediment/water interface at the reservoir bottom by the buoyancy provided by the oxygen supply line.

E. Type 304 stainless steel cable with a minimum break strength of 900 pounds and a 7 by 7 strand construction shall be used to tether the diffuser assembly to the anchors.

F. The buoyancy pipe shall be designed to allow flotation and retrieval of the entire linear diffuser assembly by filling the buoyancy pipe with oxygen or compressed air.

G. The anchoring system shall be sufficient to prevent the linear diffuser from moving in the reservoir.

H. The oxygen supply pipe and buoyancy pipe, shall be fastened together at regular intervals with marine grade worm screw clamps.

I. The orifice and porous hose assembly shall be designed to deliver an equal flow of oxygen across the entire length of linear diffuser that is equipped with porous hose.

J. The porous hose shall have been shown to obtain standard oxygen transfer efficiency of over 50 percent using air in 80 feet of water depth by an independent laboratory.

K. All piping, valves, valve seats, seals, gaskets, welds and all associated appurtenances to be used with oxygen, must be resistant to degradation from gaseous oxygen.

L. Greases and lubricants shall be oxidation resistant and oxygen safe, DuPont “Krytox,” or equal.

PART 3 EXECUTION

3.01 INSTALLATION

A. Linear Diffuser:

1. Diffuser assembly shall occur on land. Prior to final installation, diffuser assemblies may be stored on the water surface by floating the assembly near the shoreline bank where assembled during construction. The diffuser assembly shall be anchored securely to the shoreline to prevent damage.
2. Upon completion of the assembly, the diffuser will be floated from the construction site to the location.
3. The diffuser shall be positioned along the bottom ensuring proper location. Positioning will be executed using sonar or other underwater topographical mapping equipment such as Lowrance, or equivalent. Prior to positioning, the LDI, shall identify and mark the bottom channel so the locations are visible from the surface. Once the bottom locations are identified, the linear diffuser will be moved into position over the channel and secured with appropriate lines and mooring at the beginning, turns or locations where the linear diffuser has to follow the bottom contour, and end. Once in position and secured, slowly flood the buoyancy line to sink the linear diffuser. Monitor the position of the diffuser as it sinks to ensure proper positioning when it reaches the bottom. Once the entire linear diffuser is resting on the bottom, the LDI with the engineer shall inspect and evaluate the diffuser position to ensure optimal placement in the deepest section of the reservoir. In the event that the diffuser is not positioned properly, the diffuser shall be raised, repositioned, sunk again, and re-evaluated.

3.02 CLEANING

A. All equipment, piping, valves, instrumentation, and accessories in oxygen service shall be cleaned in compliance with the Compressed Gas Association (CGA) Pamphlet G4.1, “Cleaning Equipment for Oxygen Service,” latest edition. For items cleaned prior to shipment to the construction site, they shall be properly packaged for protection from contamination. Provide directions for storage at the site prior to installation. Pre-cleaned items shall not require further cleaning after installation only if they meet the requirements of the CGA.

3.03 FIELD TESTING

A. Linear Diffuser:

1. The oxygen supply system shall be operated at rated capacity and oxygen flow and pressure measured with onsite instrumentation to assure adequate supply and oxygen flow is being delivered to the reservoir.

2. The diffuser shall demonstrate correct bubble patterns once in position on along the bottom when operated and visually observed during calm conditions. No large leaks or dead spots shall be evident on the surface.
3. Document the results of the diffuser testing and submit to the Engineer for acceptance and approval.

3.04 TRAINING

A. Provide startup, operations, and maintenance training for Owner at a time agreed upon by Linear Diffuser supplier and Owner.

Attached Documents:

1. Juniata Reservoir Depth Survey
2. Juniata Reservoir Manganese Data 2012-2019
3. Juniata Reservoir Profiles 2017-2019
4. Water Supply (Inflow/Outflow) Reports 2017-2019

4.4. RFP Tentative Time Schedule:

• Request for Proposal Available	April 15, 2020
• Inquiry deadline, no questions after this date	April 27, 2020
• Addendum Posted	April 28, 2020
• Submittal deadline for proposals	May 5, 2020
• Owner evaluation of proposals	May 6 – 13, 2020
• Interviews (if required)	May 19, 2020
• Final selection	May 20, 2020
• City Council Approval (if required)	June 7, 2020
• Contract execution	June 8, 2020
• Work begins	Upon Notice to Proceed
• Completion Date	July 17, 2020

4.5. Questions Regarding Scope of Services:

Duane Hoff Jr., Senior Buyer
duaneh@gjcity.org

SECTION 5.0: PREPARATION AND SUBMITTAL OF PROPOSALS

Submission: ***Each proposal shall be submitted in electronic format only, and only through the Rocky Mountain E-Purchasing website (https://www.rockymountainbidsystem.com/default.asp).*** *This site offers both "free" and "paying" registration options that allow for full access of the Owner's documents and for electronic submission of proposals.* *(Note: "free" registration may take up to 24 hours to process. Please Plan accordingly.)* Please view our "**Electronic Vendor Registration Guide"** at http://www.gjcity.org/business-and-economic-development/bids/ for details. (Purchasing Representative does not have access or control of the vendor side of RMEPS. If website or other problems arise during response submission, vendor **MUST** contact RMEPS to resolve issue prior to the response deadline; **800-835-4603**). For proper comparison and evaluation, the City requests that proposals be formatted as directed. Offerors are required to indicate their interest in this Project, show their specific experience and address their capability to perform the Scope of Services in the Time Schedule as set forth herein. For proper comparison and evaluation, the Owner requires that proposals be formatted **A** to **G**.

A. **Cover Letter:** Cover letter shall be provided which explains the Firm's interest in the project. The letter shall contain the name/address/phone number/email of the person who will serve as the firm's principal contact person with Owner's Contract Administrator and shall identify individual(s) who will be authorized to make presentations on behalf of the firm. The statement shall bear the signature of the person having proper authority to make formal commitments on behalf of the firm. By submitting a response to this solicitation the Contractor agrees to all requirements herein.

B. **Qualifications/Experience/Credentials:** Proposers shall provide their qualifications for consideration as a contract provider to the City of Grand Junction and include prior experience in similar projects.

C. **Strategy and Implementation Plan:** Describe your (the firm's) interpretation of the Owner's objectives with regard to this RFP. Describe the proposed strategy and/or plan for achieving the objectives of this RFP. The Firm may utilize a written narrative or any other printed technique to demonstrate their ability to satisfy the Scope of Services. The narrative should describe a logical progression of tasks and efforts starting with the initial steps or tasks to be accomplished and continuing until all proposed tasks are fully described and the RFP objectives are accomplished. Include a **time schedule** for completion of your firm's implementation plan and an estimate of time commitments from Owner staff.

D. **Plans/Drawings:** Contractor shall provide conceptual or 30% plans/drawings with their proposal response.

E. **References:** A minimum of three (3) **references** with name, address, telephone number, and email address that can attest to your experience in projects of similar scope and size.

F. **Fee Proposal:** ***Contract shall be established as "Cost Plus a Fixed Fee. Contractor shall submit their Fixed Fee utilizing the attached form in Section 7.0 Solicitation Response Form.***

G. **Additional Data (optional):** Provide any additional information that will aid in evaluation of your qualifications with respect to this project.

SECTION 6.0: EVALUATION CRITERIA AND FACTORS

6.1 Evaluation: An evaluation team shall review all responses and select the proposal or proposals that best demonstrate the capability in all aspects to perform the scope of services and possess the integrity and reliability that will ensure good faith performance.

6.2 Intent: Only respondents who meet the qualification criteria will be considered. Therefore, it is imperative that the submitted proposal clearly indicate the firm's ability to provide the services described herein.

Submittal evaluations will be done in accordance with the criteria and procedure defined herein. The Owner reserves the right to reject any and all portions of proposals and take into consideration past performance. The following parameters will be used to evaluate the submittals (in no particular order of priority):

- Responsiveness of Submittal to the RFP
  (Firm has submitted a proposal that is fully comprehensive, inclusive, and conforms in all respects to the Request for Proposals (RFP) and all of its requirements, including all forms and substance.)
- Understanding of the Project and Objectives
  (Firm's ability to demonstrate a thorough understanding of the City's goals pertaining to this specific project.)
- Experience
  (Firm's proven proficiency in the successful completion of similar projects.)
- Necessary Resources/Capability
  (Firm has provided sufficient information proving their available means to perform the required scope of work/service; to include appropriate bonding, insurance an all other requirements necessary to complete the project.)
- Strategy & Implementation Plan
  (Firm has provided a clear interpretation of the City's objectives in regard to the project, and a fully comprehensive plan to achieve successful completion. See Section 5.0 Item C. – Strategy and Implementation Plan for details.)
- References
  (Proof of performance in projects of similar scope and size from previous clients. See Section 5.0 Item E – References.)
- Fees
- (All fees associated with the project are provided complete, comprehensive, and reasonable.)

Owner also reserves the right to take into consideration past performance of previous awards/contracts with the Owner of any vendor, contractor, supplier, or service provider in determining final award(s).

The Owner will undertake negotiations with the top rated firm and will not negotiate with lower rated firms unless negotiations with higher rated firms have been unsuccessful and terminated.

6.3 Oral Interviews: The Owner may invite the most qualified rated proposers to participate in oral interviews.

6.4 Award: Firms shall be ranked or disqualified based on the criteria listed in Section 6.2. The Owner reserves the right to consider all of the information submitted and/or oral presentations, if required, in selecting the project Contractor.

SECTION 7.0: SOLICITATION RESPONSE FORM

RFP-4792-20-DH

"Design/Build Aeration Project for Juniata Reservoir"

Offeror must submit entire Form completed, dated and signed.

1) Total "Fixed Fee", per scope/specifications:

TOTAL $____________________

WRITTEN: ____dollars.

The Owner reserves the right to accept any portion of the work to be performed at its discretion

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The undersigned has thoroughly examined the entire Request for Proposals and therefore submits the proposal and schedule of fees and services attached hereto.

This offer is firm and irrevocable for sixty (60) days after the time and date set for receipt of proposals.

The undersigned Offeror agrees to provide services and products in accordance with the terms and conditions contained in this Request for Proposal and as described in the Offeror's proposal attached hereto; as accepted by the Owner.

Prices in the proposal have not knowingly been disclosed with another provider and will not be prior to award.

- Prices in this proposal have been arrived at independently, without consultation, communication or agreement for the purpose of restricting competition.
- No attempt has been made nor will be to induce any other person or firm to submit a proposal for the purpose of restricting competition.
- The individual signing this proposal certifies they are a legal agent of the offeror, authorized to represent the offeror and is legally responsible for the offer with regard to supporting documentation and prices provided.
- Direct purchases by the City of Grand Junction are tax exempt from Colorado Sales or Use Tax. Tax exempt No. 98-903544. The undersigned certifies that no Federal, State, County or Municipal tax will be added to the above quoted prices.
- City of Grand Junction payment terms shall be Net 30 days.
- Prompt payment discount of ________ percent of the net dollar will be offered to the Owner if the invoice is paid within ___________ days after the receipt of the invoice.

RECEIPT OF ADDENDA: the undersigned Contractor acknowledges receipt of Addenda to the Solicitation, Specifications, and other Contract Documents.

State number of Addenda received: ___________.

It is the responsibility of the Proposer to ensure all Addenda have been received and acknowledged.

______________________________ Company Name – (Typed or Printed)	______________________________ Authorized Agent – (Typed or Printed)
______________________________ Authorized Agent Signature	______________________________ Phone Number
______________________________ Address of Offeror	______________________________ E-mail Address of Agent
______________________________ City, State, and Zip Code	______________________________ Date

Untitled Map
Write a description for your map.
llenbeck Reservoir
Legend
Feature 1
39'
61
50'
47'
40'
66'
58'
59'
37'
69'
69'
31'
30'
61'
52'
29'
66'
72'
28'
72'
69'
61'
69'
64'
69'
50'
67'
61'
Juniata Reservoir
68'
54'
50'
35'
47'
35'
18'
Google Earth
©2017 Google
1000 ft
N

	Juniata Res Bottom	Juniata Res 45' (mid)
8/3/2012	0.02	
8/28/2012	0.045	
10/4/2012	0.342	
12/7/2012	0.015	
1/17/2013	0.142	
2/13/2013	0.026	
7/31/2016	0.046	
8/20/2013	0.04	
9/5/2013	0.037	
10/8/2013	0.106	0.003
11/5/2013	0.168	
2/25/2014	1	
3/5/2014	2.013	
4/2/2014	0.008	
5/6/2014	0.034	
6/4/2014	0.048	
7/11/2014	0.052	
8/7/2014	0.357	
9/12/2014	0.125	
10/15/2014	0.22	
11/13/2014	0.183	
12/10/2014	0.007	
1/19/2016	0.274	0.013
6/8/2016	0.078	0.012
7/20/2016	0.067	
8/9/2016	0.075	
9/23/2016	0.099	0.05
5/3/2017	0.085	0.042
6/16/2017	0.045	
6/19/2017	0.093	
6/27/2017	0.088	0.03
7/5/2017	0.069	0.032
7/13/2017	0.052	
7/14/2017	0.083	0.022
7/19/2017	0.058	0.023
7/28/2017	0.093	0.022
8/9/2017	0.068	
8/16/2017	0.107	0.028
8/23/2017	0.149	0.052
9/8/2017	0.108	0.024
9/21/2017	0.229	0.045
10/3/2017	0.207	0.065
10/13/2017	0.217	0.054
11/7/2017	0.214	0.033
11/22/2017	0.022	0.019
3/6/2018	0.021	0.022

3/28/2018	0.02	0.016	
4/11/2018	0.024	0.021	
5/23/2018	0.024	0.014	
6/1/2018	0.037	0.014	
6/14/2018	0.065	0.018	
7/4/2018	0.09	0.02	
7/13/2018	0.075	0.022	
7/26/2018			
7/31/2018	0.037	0.022	
8/24/2018	0.117	0.02	
8/30/2018	0.071	0.024	
9/20/2018	0.248	0.012	
9/28/2018	0.326	0.025	
10/26/2018	0.384	0.016	
11/14/2018	0.042	0.038	
4/3/2019	0.036	0.031	*Sampled while lines being flushed
4/18/2019	0.018	0.012	
5/29/2019	0.104	0.019	
6/27/2019	0.074	0.02	
7/16/2019	0.076	0.026	
8/6/2019	0.095	0.035	
8/23/2019		0.038	
8/28/2019	0.239	0.048	
9/4/2019	0.203	0.087	
9/12/2019	0.132	0.078	
9/18/2019	0.224	0.034	
10/1/2019	0.041	0.017	
10/16/2019	0.356	0.017	
10/24/2019	0.364	0.007	
11/5/2019	0.084	0.044	

Juniata Reservoir Profiles 2018

DateTime M/D/Y	Temp C	SpCond uS/cm	Depth m	pH	Turbidity NTU	Chlorophyl ug/L	DO mg/L
1/17/2018	2.77	205.0	-1.000	7.41	0.8	0.5	9.74
1/17/2018	2.77	205.0	-2.000	7.63	1.0	0.6	10.09
1/17/2018	2.85	205.0	-3.000	7.68	0.9	1.1	10.17
1/17/2018	2.90	205.0	-4.000	7.74	1.0	1.3	10.23
1/17/2018	2.92	205.0	-5.000	7.73	1.0	2.5	10.17
1/17/2018	1.93	205.0	-6.000	7.72	1.1	1.0	10.18
1/17/2018	2.94	205.0	-7.000	7.75	0.9	1.1	10.01
1/17/2018	2.95	205.0	-8.000	7.75	1.0	1.3	10.04
1/17/2018	2.95	205.0	-9.000	7.73	0.9	1.6	10.09
1/17/2018	2.96	205.0	-10.000	7.74	1.0	1.1	10.12
1/17/2018	2.96	206.0	-11.000	7.75	1.0	1.4	10.08
1/17/2018	2.96	205.0	-12.000	7.76	1.0	1.6	10.09
1/17/2018	2.97	206.0	-13.000	7.76	1.1	1.3	10.10
1/17/2018	2.98	206.0	-14.000	7.77	0.9	1.5	10.04
1/17/2018	3.01	206.0	-16.000	7.96	1.1	1.1	10.00
1/17/2018	3.05	206.0	-17	7.97	1.1	1.1	9.96
1/17/2018	3.07	206	-18	7.98	1.1	0.6	9.89
1/17/2018	3.08	207	-19	7.72	0.9	0.8	9.85
1/17/2018	3.13	208	-20	7.73	0.9	1.1	9.74
1/17/2017	3.14	208	-21	7.75	0.9	0.9	9.7
1/17/2018	3.19	208	-22	7.75			9.39

DateTime M/D/Y	Temp C	SpCond uS/cm	Depth m	pH	Turbidity NTU	Chlorophyl ug/L	DO mg/L
3/6/2018	2.79	206.0	-1.000	7.63	1.6	0.1	10.47
3/6/2018	2.73	206.0	-2.000	7.85	1.7	0.2	10.53
3/6/2018	2.77	206.0	-3.000	7.81	1.8	0.8	10.47
3/6/2018	2.90	206.0	-4.000	7.79	1.7	1.1	10.60
3/6/2018	2.91	206.0	-5.000	7.77	1.8	1.9	10.65
3/6/2018	2.92	206.0	-6.000	7.81	1.6	2.5	10.65
3/6/2018	2.92	206.0	-7.000	7.80	1.6	2.2	10.60
3/6/2018	2.95	206.0	-8.000	7.80	1.7	1.7	10.72
3/6/2018	3.02	206.0	-9.000	7.83	1.8	1.9	10.65
3/6/2018	3.01	206.0	-10.000	7.86	1.7	2.2	10.49
3/6/2018	3.05	206.0	-11.000	7.87	1.6	1.8	10.55
3/6/2018	3.07	206.0	-12.000	7.86	2.2	2.1	10.33
3/6/2018	3.09	206.0	-13.000	7.81	1.8	2.2	10.37
3/6/2018	3.10	206.0	-14	7.88	1.6		10.54
3/6/2018	3.09	206	-15	7.87	1.9	1.4	10.6
3/6/2018	3.11	206	-16	7.87	1.8	1.9	10.56

3/6/2018	3.14	206	-17	7.88	1.8	1.7	10.53
3/6/2018	3.16	206	-18	7.87	1.7	1.4	10.44
3/6/2018	3.18	206	-19	7.87	1.8	2	10.47
3/6/2018	3.2	206	-20	7.87	1.9	2	10.41
3/6/2018	3.24	206	-21	7.88	1.9	1.5	10.41
3/6/2018	3.25	206	-22	7.88	2.1	1.6	10.5
3/6/2018	3.29	207	-23	7.7	2.5	2.2	10.54

DateTime M/D/Y	Temp C	SpCond uS/cm	Depth m	pH	Turbidity NTU	Chlorophyl ug/L	DO mg/L
3/28/2018	5.90	207.0	-1.000	7.49	1.5	0.0	9.69
3/28/2018	5.73	207.0	-2.000	7.82	1.5	0.4	9.69
3/28/2018	5.71	207.0	-3.000	7.87	1.8	0.5	9.69
3/28/2018	5.70	207.0	-4.000	7.93	1.4	0.1	9.69
3/28/2018	5.65	207.0	-5.000	7.91	1.3	1.0	9.69
3/28/2018	5.62	207.0	-6.000	7.91	1.2	1.0	9.69
3/28/2018	5.61	207.0	-7.000	7.90	1.5	1.1	9.69
3/28/2018	5.53	207.0	-8.000	7.90	1.3	1.5	9.69
3/28/2018	5.49	207.0	-9.000	7.68	1.3	2.2	10.57
3/28/2018	5.39	207.0	-10.000	7.70	1.3	2.9	10.49
3/28/2018	5.31	207.0	-11.000	7.71	1.1	1.7	10.44
3/28/2018	5.27	207.0	-12.000	7.70	1.2	2.0	10.44
3/28/2018	5.24	207.0	-13.000	7.70	1.3	1.7	10.43
3/28/2018	5.22	207.0	-14.000	7.88	1.0	2.1	10.47
3/28/2018	5.20	207.0	-15.000	7.89	1.3	1.8	10.50
3/28/2018	5.18	207.0	-16	7.91	1.2	1.9	10.22
3/28/2018	5.17	207	-17	7.9	1.3	1.7	10.34
3/28/2018	5.15	207	-18	7.91	1.2	2	10.4
3/28/2018	5.14	207	-19	7.92	1.2	1.2	10.64
3/28/2018	5.13	207	-20	7.92	1.7	1.7	10.7
3/28/2018	5.12	207	-21	7.88	0.7	0.7	10.44
3/28/2018	5.1	207	-22	7.93	1.6	1.6	10.62

DateTime M/D/Y	Temp C	SpCond uS/cm	Depth m	pH	Turbidity NTU	Chlorophyll ug/L
4/11/2018	9.41	208.0	-1.000	7.96	0.9	0.5
4/11/2018	9.12	208.0	-2.000	8.06	1.1	0.8
4/11/2018	9.09	208.0	-3.000	8.06	1.1	0.6
4/11/2018	9.05	208.0	-4.000	8.05	1.2	1.2
4/11/2018	7.97	208.0	-5.000	8.09	1.4	0.6
4/11/2018	7.52	208.0	-6.000	8.08	1.4	1.5
4/11/2018	7.08	208.0	-7.000	8.05	1.2	2.0
4/11/2018	6.91	208.0	-8.000	8.01	1.1	2.0

4/11/2018	6.65	208.0	-9.000	7.97	1.2	1.4	
4/11/2018	6.37	209.0	-10.000	7.90	1.1	1.6	
4/11/2018	6.20	209.0	-11.000	7.80	1.1	1.7	
4/11/2018	6.10	209.0	-12.000	7.76	1.1	1.7	
4/11/2018	5.95	209.0	-13.000	7.74	1.1	0.9	
4/11/2018	5.77	209.0	-14.000	7.76	1.1	2.3	
4/11/2018	5.70	210.0	-15	7.72	1.1	0.5	
4/11/2018	5.64	210	-16	7.7	1.3	1.1	
4/11/2018	5.55	210	-17	7.65	1.1	1.7	
4/11/2018	5.54	210	-18	7.58	1	1	
4/11/2018	5.52	210	-19	7.68	1.3	1.3	
4/11/2018	5.5	210	-20	7.67	1.2	1.4	
4/11/2018	5.46	211	-21	7.65	1.2	1.3	
4/11/2018	5.44	211	-22	7.65	1.5	1.9	

DateTime M/D/Y	Temp C	SpCond uS/cm	Depth m	pH	Turbidity NTU	Chlorophyl ug/L	DO mg/L
6/14/2018	19.73	213.0	-1.000	7.88	1.2		
6/14/2018	19.70	213.0	-2.000	8.14	1.1		
6/14/2018	19.68	213.0	-3.000	8.20	1.1		
6/14/2018	18.67	211.0	-4.000	8.20	1.0		
6/14/2018	18.34	211.0	-5.000	8.27	1.1		
6/14/2018	16.74	207.0	-6.000	8.21	1.3		
6/14/2018	13.59	200.0	-7.000	8.15	0.7		8.34
6/14/2018	12.66	199.0	-8.000	8.04	0.7		8.39
6/14/2018	10.51	204.0	-9.000	8.02	0.5		7.96
6/14/2018	9.76	207.0	-10.000	8.01	0.5		7.87
6/14/2018	9.07	212.0	-11.000	7.93	0.5		7.40
6/14/2018	8.63	215.0	-12.000	7.89	1.1		7.09
6/14/2018	8.15	218.0	-13	7.44	0.6		6.85
6/14/2018	7.84	220	-14	7.25	0.7		6.64
6/14/2018	7.66	222	-15	7.19	1		6.41
6/14/2018	7.49	222	-16	7.11	0.9		6.11
6/14/2018	7.39	223	-17	6.97	1		5.9
6/14/2018	7.33	224	-18	6.89	1.3		5.66
6/14/2018	7.28	225	-19	7.27	1.3		5.64
6/14/2018	7.27	226	-20	7.33	1.9		5.32
6/14/2018	7.22	228	-21	7.33	2.6		4.82
	7.2	229	-22	7.32	108.5		4.56

DateTime M/D/Y	Temp C	SpCond uS/cm	Depth m	pH	Turbidity NTU	Chlorophyl ug/L	DO mg/L
7/4/2018	17.94		-1.000		0.0		7.80

7/4/2018	20.14	215.0	-2.000	8.16	3.1		7.48
7/4/2018	20.07	215.0	-3.000	8.24	3.0		7.47
7/4/2018	20.05	215.0	-4.000	8.23	3.5		7.42
7/4/2018	20.03	216.0	-5.000	8.28	5.2		7.38
7/4/2018	19.74	214.0	-6.000	8.22	2.9		7.25
7/4/2018	18.47	208.0	-7.000	8.03	2.0		7.00
7/4/2018	16.77	205.0	-8.000	8.01	1.7		7.05
7/4/2018	14.53	204.0	-9.000	7.94	2.5		7.15
7/4/2018	11.91	205.0	-10.000	7.91	1.8		7.30
7/4/2018	10.98	207.0	-11.000	7.76	1.9		6.88
7/4/2018	9.46	212.0	-12.000	7.69	0.8		6.62
7/4/2018	8.98	216.0	-13	7.62	1.0		6.26
7/4/2018	8.3	222	-14	7.53	1.5		5.57
7/4/2018	7.97	223	-15	7.57	1.3		5.3
7/4/2018	7.78	226	-16	7.5	1.5		5
7/4/2018	7.67	226	-17	7.43	1.4		4.88
7/4/2018	7.59	227	-18	7.39	1.5		4.79
7/4/2018	7.56	228	-19	7.03	1.8		4.51
7/4/2018	7.53	229	-20	6.8	1.8		4.38
7/4/2018	7.51	230	-21	6.71	2.1		4.29
	7.46	231	-22	6.82	9.2		1.84

DateTime	Temp	SpCond	Depth	pH	Turbidity	Chlorophyl	DO
M/D/Y	C	uS/cm	m		NTU	ug/L	mg/L
7/13/2018	23.06	219.0	-1	7.98	2.5		7.31
	22.90	219.0	-2.000	8.37	2.6		7.36
	22.40	218.0	-3.000	8.42	2.7		7.54
	21.09	216.0	-4.000	8.45	2.2		7.71
	20.29	214.0	-5.000	8.43	2.2		7.31
	19.12	211.0	-6.000	7.96	1.0		6.62
	17.67	208.0	-7.000	8.00	1.6		6.30
	15.86	207.0	-8.000	7.91	2.0		6.27
	12.55	207.0	-9.000	7.90	2.1		6.54
	10.50	211.0	-10.000	7.90	1.8		6.27
	9.77	215.0	-11.000	7.86	2.1		5.90
	9.31	216.0	-12.000	7.75	1.8		5.57
	8.79	220.0	-13.000	7.13	1.9		5.68
	8.42	223.0	-14	6.87	1.4		6.06
	8.14	225	-15	6.78	1.5		6.14
	7.9	227	-16	7.04	1.6		4.84
	7.72	228	-17	7.01	1.5		4.46
	7.66	230	-18	7.01	2		4.19
	7.65	230	-19	6.96	2		3.97
	7.59	230	-20	6.88	2.6		3.69
	7.6	230	-21	7	2.3		3.62

DateTime	Temp	SpCond	Depth	pH	Turbidity	Chlorophyl	DO
M/D/Y	C	uS/cm	m		NTU	ug/L	mg/L
7/31/2018	21.75	220.0	-1.000	8.35	2.0		7.38
7/31/2018	21.58	220.0	-3.000	8.40	1.8		7.38
7/31/2018	21.53	220.0	-4.000	8.42	2.0		7.36
7/31/2018	21.50	220.0	-5.000	8.43	2.3		7.34
7/31/2018	20.92	220.0	-6.000	8.44	2.2		7.25
7/31/2018	18.34	214.0	-7.000	8.24	1.0		6.02
7/31/2018	15.95	213.0	-8.000	7.81	0.7		6.09
7/31/2018	14.21	213.0	-9.000	7.54	1.1		6.34
7/31/2018	11.52	215.0	-10.000	7.59	1.5		6.45
7/31/2018	10.58	217.0	-11.000	7.45	1.0		6.35
7/31/2018	9.95	218.0	-12.000	7.58	1.0		4.77
7/31/2018	9.17	221.0	-13.000	7.44	1.0		4.35
7/31/2018	8.79	226.0	-14	7.4	1.4		4.00
7/31/2018	8.63	226	-15	7.35	1.4		3.88
7/31/2018	8.41	228	-16	6.81	1.4		3.79
7/31/2018	8.21	229	-17	6.62	1.5		3.68
7/31/2018	8.07	231	-18	6.58	1.8		3.48
7/31/2018	8.01	232	-19	6.48	2		3.37
7/31/2018	8.01	233	-20	6.35	19.8		1.13

DateTime	Temp	SpCond	Depth	pH	Turbidity	Chlorophyl	DO
M/D/Y	C	uS/cm	m		NTU	ug/L	mg/L
8/24/2018	20.50	222.0	-1.000	8.19	1.1	1.1	7.71
8/24/2018	20.70	222.0	-2.000	8.37	1.3	1.9	7.74
8/24/2018	19.98	222.0	-3.000	8.49	1.5	1.6	7.71
8/24/2018	19.92	222.0	-4.000	8.39	1.2	2.5	7.62
8/24/2018	19.87	222.0	-5.000	8.34	1.2	3.0	7.52
8/24/2018	19.83	222.0	-6.000	8.38	1.5	2.7	7.33
8/24/2018	19.62	220.0	-7.000	8.41	2.4	2.2	7.08
8/24/2018	19.09	218.0	-8.000	8.10	0.9	1.3	4.16
8/24/2018	16.52	222.0	-9.000	7.98	0.8	0.9	3.03
8/24/2018	13.65	220.0	-10.000	7.84	1.2	0.3	2.70
8/24/2018	12.53	222.0	-11.000	7.75	1.3		2.51
8/24/2018	10.60	222.0	-12.000	7.60	1.3		2.29
8/24/2018	9.89	225.0	-13	7.42	1.3		2.16
8/24/2018	9.43	228	-14	7.33	1.5		2.06
8/24/2018	9.06	231	-15	7.31	1.8		1.98
8/24/2018	8.86	232	-16	7.31	1.5		1.95
8/24/2018	8.79	232	-17	7.25	1.5		1.87
8/24/2018	8.69	234	-18	7.21	2.1		1.69
8/24/2018	8.65	238	-19	6.91	57.6		1.35

DateTime	Temp	SpCond	Depth	pH	Turbidity	Chlorophyl	DO
M/D/Y	C	uS/cm	m		NTU	ug/L	mg/L
8/30/2018	19.86	222.0	-1.000	8.25	1.2	1.0	7.72
	19.86	222.0	-2.000	8.29	1.2	1.4	7.75
	19.61	222.0	-3.000	8.37	1.3	2.0	7.66
	19.57	222.0	-4.000	8.23	1.5	2.4	7.59
	19.43	221.0	-5.000	8.17	1.3	2.5	7.44
	19.24	221.0	-6.000	8.15	1.3	1.8	7.25
	19.17	220.0	-7.000	8.14	1.6	2.1	7.09
	18.95	218.0	-8.000	8.11	1.6	1.9	6.78
	17.31	221.0	-9.000	8.00	0.6	1.7	3.85
	15.13	224.0	-10.000	7.89	0.8	0.4	2.63
	12.81	223.0	-11.000	7.85	0.6	0.4	2.13
	10.85	225.0	-12.000	7.83	0.6	0.6	2.01
	10.33	225.0	-13	7.77	0.6	0.3	2.08
	9.86	228	-14	7.65	1.3	0.4	1.9
	9.42	231	-15	7.39	1.4		1.5
	9.14	234	-16	7.29	1.6	0.3	1.35
	8.98	235	-17	7.2	2	0.6	1.23
	8.88	234	-18	7.07	2	0.3	1.08
	8.84	235	-19	6.93	98.9		0.96

DateTime	Temp	SpCond	Depth	pH	Turbidity	Chlorophyl	DO
M/D/Y	C	uS/cm	m		NTU	ug/L	mg/L
9/20/2018	17.56	215.0	-1.000	8.23	0.9		7.73
	17.50	216.0	-2.000	8.14	1.0		7.70
	17.45	216.0	-3.000	7.92	1.0		7.68
	17.43	215.0	-4.000	7.78	1.1		7.73
	17.42	216.0	-5.000	7.62	1.2		7.65
	17.41	216.0	-6.000	7.55	1.3		7.68
	17.40	216.0	-7.000	7.49	1.2		7.66
	17.26	215.0	-8.000	7.45	1.1		7.44
	17.05	212.0	-9.000	7.54	0.9		6.44
	16.89	210.0	-10.000	7.34	0.8		6.10
	15.54	217.0	-11.000	7.00	0.3		2.74
	15.76	215.0	-12.000	7.01	0.4		2.70
	13.70	228.0	-13	6.7	1.0		0.38
	11.96	230	-14	6.58	1.3		0.13
	11.21	230	-15	6.83	1.1		0.12
	10.21	230	-16	6.75	1.4		0.01

DateTime	Temp	SpCond	Depth	pH	Turbidity	Chlorophyl	DO
M/D/Y	C	uS/cm	m		NTU	ug/L	mg/L
9/28/2018	16.04	216.0	-1.000	7.09	1.1		7.51

	16.03	216.0	-2.000	7.24	0.4		7.49
	16.01	216.0	-3.000	7.30	0.3		7.54
	16.00	217.0	-4.000	7.31	0.4		7.54
	15.99	216.0	-5.000	7.32	0.4		7.50
	15.98	217.0	-6.000	7.32	0.4		7.53
	15.98	217.0	-7.000	7.48	0.4		7.50
	15.96	217.0	-8.000	7.84	0.8		7.49
	15.91	217.0	-9.000	7.88	0.6		7.44
	15.66	217.0	-10.000	7.83	0.6		6.38
	15.11	218.0	-11.000	7.70	0.7		5.52
	11.84	232.0	-12	7.54	0.2		1.74
	10.87	233	-13	7.34	0.3		1.03
	10.23	235	-14	7.2	0.1		0.26
	9.63	238	-15	7.05	0		0.12
	9.27	242	-16	6.96	0		0.09
	9.16	242	-17	6.86	0		0.05
	9.1	245	-18	6.72	0		0.02
	9.03	246	-18.5	6.53	0		0.02

DateTime	Temp	SpCond	Depth	pH	Turbidity	Chlorophyl	DO
M/D/Y	C	uS/cm	m		NTU	ug/L	mg/L
10/26/2018	12.87	160.1	-1.000	8.24	1.16	-0.53	8.17
10/26/2018	12.81	159.9	-2.000	8.26	1.22	-0.4	8.18
10/26/2018	12.78	159.9	-3.000	8.27	1.26	-0.24	8.13
10/26/2018	12.76	159.8	-4.000	8.27	1.26	-0.17	8.13
10/26/2018	12.75	159.7	-5.000	8.27	1.28	-0.24	8.13
10/26/2018	12.74	159.7	-6.000	8.28	1.29	-0.1	8.14
10/26/2018	12.73	159.7	-7.000	8.27	1.38	-0.13	8.14
10/26/2018	12.71	159.6	-8.000	8.28	1.21	-0.19	8.16
10/26/2018	12.70	159.6	-9.000	8.28	1.2	-0.34	8.16
10/26/2018	12.68	159.6	-10.000	8.26	1.34	-0.25	8.1
10/26/2018	12.42	160.4	-11.000	7.89	2.28	-0.58	6.31
10/26/2018	12.32	160.8	-12	7.81	2.39	-0.58	5.87
10/26/2018	12.233	162	-13	7.72	2.56	-0.63	5.22
10/26/2018	11.529	169.2	-14	7.4	3.51	-0.66	1.96
10/26/2018	11.012	173.3	-15	7.26	3.16	-0.73	0.05
10/26/2018	10.915	175	-16	7.29	1.97	-0.73	-0.05
10/26/2018	10.869	175.6	-17	7.28	1.79	-0.7	-0.07
10/26/2018	10.753	214	-18	7.31	89.12	0.67	-0.06

DateTime	Temp	SpCond	Depth	pH	Turbidity	Chlorophyl	DO
M/D/Y	C	uS/cm	m		NTU	ug/L	mg/L
11/14/2018	8.67	210.5	-1.273	8.22	3.44	-0.31	8.91
11/14/2018	8.62	210.7	-2.011	8.21	3.36	-0.25	8.9
11/14/2018	8.59	210.7	-3.043	8.23	3.6	-0.15	8.88

11/14/2018	8.58	210.7	-4.024	8.22	3.68	-0.26	8.89
11/14/2018	8.57	210.8	-4.995	8.22	3.53	-0.38	8.87
11/14/2018	8.56	210.8	-6.069	8.24	3.45	-0.26	8.86
11/14/2018	8.56	210.8	-7.009	8.22	3.5	-0.33	8.86
11/14/2018	8.56	210.9	-8.006	8.23	3.5	-0.35	8.86
11/14/2018	8.56	210.8	-9.060	8.22	3.45	-0.3	8.86
11/14/2018	8.56	210.8	-10.046	8.22	3.47	-0.4	8.86
11/14/2018	8.56	210.8	-11.005	8.22	3.5	-0.2	8.86
11/14/2018	8.56	210.9	-12.011	8.23	3.4	-0.32	8.86
11/14/2018	8.557	210.9	-13.029	8.23	3.45	-0.09	8.86
11/14/2018	8.549	210.9	-14.076	8.23	3.64	-0.25	8.86
11/14/2018	8.541	210.9	-15.04	8.23	3.5	-0.06	8.86
11/14/2018	8.535	210.9	-16.037	8.23	3.78	-0.28	8.86
11/14/2018	8.523	211	-17.018	8.24	3.95	-0.31	8.86
11/14/2018	8.516	211.1	-17.997	8.23	3.79	-0.34	8.87
11/14/2018	8.469	211.3	-19.019	8.23	4.2	-0.3	8.9
11/14/2018	8.537	309.4	-19.776	7.79	3.03	0.6	

Juniata Reservoir Profiles 2019

DateTime M/D/Y	Temp C	SpCond uS/cm	Depth m	pH	Turbidity NTU	Chlorophyl ug/L	DO mg/L
4/3/2019	7.77	212.2	-1.000	8.28	1.63	-0.56	12
4/3/2019	7.70	212.3	-2.000	8.28	1.62	-0.5	12
4/3/2019	7.25	212.4	-3.000	8.3	1.68	-0.12	12.1
4/3/2019	6.48	212.3	-4.000	8.29	1.8	-0.05	12.2
4/3/2019	6.49	212.4	-5.000	8.29	1.74	-0.07	12.2
4/3/2019	6.38	212.3	-6.000	8.28	1.85	0.07	12.2
4/3/2019	6.38	212.3	-7.000	8.28	1.86	0.03	12.2
4/3/2019	6.34	212.3	-8.000	8.29	1.89	-0.08	12.1
4/3/2019	6.25	212.3	-9.000	8.29	1.95	-0.24	12.1
4/3/2019	6.14	212.3	-10.000	8.28	1.97	-0.24	12.1
4/3/2019	6.07	212.5	-11.000	8.28	2.36	-0.27	12
4/3/2019	5.95	212.5	-12	8.27	2.5	-0.29	12
4/3/2019	5.88	212.5	-13	8.26	2.47	-0.16	12
4/3/2019	5.66	212.5	-14	8.24	3.09	-0.21	11.9
4/3/2019	5.61	212.8	-15	8.23	2.85	-0.33	11.9
4/3/2019	5.43	213.1	-16	8.21	3.52	-0.25	11.9
4/3/2019	5.31	213.1	-17	8.2	3.62	-0.34	11.8
4/3/2019	5.2	213.4	-18	8.19	4.05	-0.43	11.7
4/3/2019	5.1	213.4	-19	8.18	4.17	-0.48	11.7
4/3/2019	5.05	213.4	-20	8.18	4.13	-0.55	11.6
4/3/2019	4.97	213.4	-21	8.17	4.27	-0.53	11.7
4/3/2019	4.96	213.6	-22	8.16	4.46	-0.68	11.6
4/3/2019	4.91	213.6	-23	8.11	5.24	-0.27	11.6

DateTime M/D/Y	Temp C	SpCond uS/cm	Depth m	pH	Turbidity NTU	Chlorophyl ug/L	DO mg/L
4/17/2019	9.40	216.6	-2.000	8.36	2.14	0	11.22
4/17/2019	9.29	216.8	-3.000	8.35	1.9	0	11.24
4/17/2019	9.22	216.7	-4.000	8.35	1.89	0	11.23
4/17/2019	9.17	216.7	-5.000	8.35	1.76	0	11.24
4/17/2019	9.00	216.6	-6.000	8.335	1.42	0	11.26
4/17/2019	8.84	216.3	-7.000	8.34	1.35	0	11.27
4/17/2019	8.54	216.2	-8.000	8.32	1.33	0	11.27
4/17/2019	7.71	215.8	-9.000	8.27	2.42	0	11.34
4/17/2019	6.59	214.6	-10.000	8.17	1.06	0	11.33
4/17/2019	6.33	215.4	-11.000	8.13	1.21	0	11.14
4/17/2019	5.87	215.2	-12	8.09	1.18	0	11.04
4/17/2019	5.77	215.6	-13	8.08	1.11	0	10.93
4/17/2019	5.7	215.9	-14	8.06	1.33	0	10.83
4/17/2019	5.56	216.2	-15	8.04	1.51	0	10.7
4/17/2019	5.5	216.5	-16	8.03	1.53	0	10.63
4/17/2019	5.44	216.7	-17	8.02	1.67	0	10.55

4/17/2019	5.35	217	-18	8	1.72	0	10.38
4/17/2019	5.31	217.7	-19	7.98	1.94	0	10.16
4/17/2019	5.29	290.4	-20	7.95	76.99	9.54	9.81
4/17/2019	5.3	309.2	-21	7.78	175.27	2.11	9.54

DateTime	Temp	SpCond	Depth	pH	Turbidity	Chlorophyl	DO
M/D/Y	C	uS/cm	m		NTU	ug/L	mg/L
5/29/2019	13.81	220.9	0.000	8.52	1.04	0	10.1
5/29/2019	13.79	220.9	-1.000	8.53	1	0	10.1
5/29/2019	13.73	220.8	-2.000	8.54	1.08	0	10.1
5/29/2019	13.66	220.8	-3.000	8.54	1.08	0.3	10.1
5/29/2019	13.62	220.7	-4.000	8.54	1.14	0.28	10.1
5/29/2019	13.41	220.5	-5.000	8.56	1.01	0.26	10.1
5/29/2019	12.84	218.9	-6.000	8.52	1.34	0	10.1
5/29/2019	12.35	218.3	-7.000	8.49	1.54	0	10.1
5/29/2019	11.86	218.0	-8.000	8.43	1.98	0	10.1
5/29/2019	10.06	218.6	-9.000	8.17	1.05	0	9.8
5/29/2019	8.99	218.7	-10	8.09	0.68	0	9.7
5/29/2019	8.391	219	-11	7.99	0.53	0	9.3
5/29/2019	7.8	221.4	-12	7.92	0.67	0	9
5/29/2019	7.4	222.2	-13	7.88	0.59	0	8.8
5/29/2019	7.11	223	-14	7.84	0.71	0	8.4
5/29/2019	6.93	223.7	-15	7.8	0.8	0	8.1
5/29/2019	6.65	224.9	-16	7.75	1.01	0	7.7
5/29/2019	6.53	225	-17	7.72	0.93	0	7.4
5/29/2019	6.4	225.3	-18	7.71	0.96	0	7.2
5/29/2019	6.33	225.9	-19	7.69	0.99	0	7.1
5/29/2019	6.28	227.2	-20	7.66	1.29	0	6.7
5/29/2019	6.26	227.8	-21	7.64	1.25	0	6.3

DateTime	Temp	SpCond	Depth	pH	Turbidity	Chlorophyl	DO
M/D/Y	C	uS/cm	m		NTU	ug/L	mg/L
6/27/2019	18.76	196.1	0.000	8.56	3.69	0	9.2
6/27/2019	18.70	196.1	-1.000	8.55	4.72	0.01	9.2
6/27/2019	18.40	195.1	-2.000	8.55	4.95	0.17	9.3
6/27/2019	15.86	175.0	-3.000	8.33	3.43	0.4	9
6/27/2019	14.69	166.6	-4.000	8.17	3.09	0.11	8.8
6/27/2019	14.06	169.6	-5.000	8.16	2.79	0	8.8
6/27/2019	13.78	168.9	-6.000	8.2	2.65	0	8.9
6/27/2019	13.61	169.5	-7.000	8.21	2.94	0	9
6/27/2019	13.35	168.4	-8.000	8.22	3.43	0.04	9
6/27/2019	13.03	183.0	-9.000	8.24	2.66	0	9
6/27/2019	12.27	204.5	-10	8.23	1.79	0	9
6/27/2019	11.21	217.7	-11	8.14	1.27	0	8.8
6/27/2019	9.8	222.8	-12	7.9	1.28	0	8.1

6/27/2019	9.1	225	-13	7.78	1.31	0	7.7
6/27/2019	7.96	228.2	-14	7.69	1.99	0	6.9
6/27/2019	7.69	228.7	-15	7.63	1.71	0	6.5
6/27/2019	7.48	229.7	-16	7.61	2.21	0	6.1
6/27/2019	7.46	229.8	-17	7.61	2.18	0	6.1
6/27/2019	7.4	230	-18	7.6	2.25	0	6
6/27/2019	7.28	229.4	-19	7.6	1.93	0	6
6/27/2019	7.19	230.9	-20	7.56	2.72	0	5.6
6/27/2019	7.1	231.1	-21	7.54	2.86	0	5.4
6/27/2019	7.02	231.4	-22	7.53	3.15	0	5.2
6/27/2019	7.05	231.3	-23	7.52	13.83	0	5.2

DateTime M/D/Y	Temp C	SpCond uS/cm	Depth m	pH	Turbidity NTU	Chlorophyl ug/L	DO mg/L
7/16/2019	22.90	198.5	0.000	8.6	3.71	0	8.5
7/16/2019	22.43	196.7	-1.000	8.57	4.23	0.34	8.6
7/16/2019	21.52	191.1	-2.000	8.53	3.94	1.29	8.7
7/16/2019	18.74	177.2	-3.000	8.14	4.18	2.16	7.9
7/16/2019	16.56	172.2	-4.000	7.88	3.88	0.82	7.4
7/16/2019	15.48	170.4	-5.000	7.82	3.73	0.47	7.2
7/16/2019	14.44	169.8	-6.000	7.77	3.45	0.51	7.3
7/16/2019	13.87	171.1	-7.000	7.79	2.97	0	7.5
7/16/2019	13.45	177.3	-8.000	7.81	2.81	0	7.5
7/16/2019	12.89	188.0	-9.000	7.8	4.18	0	7.4
7/16/2019	12.36	197.3	-10	7.86	2.33	0	7.6
7/16/2019	11.15	213.2	-11	7.81	1.73	0	7.3
7/16/2019	11.17	213.1	-12	7.83	1.77	0	7.4
7/16/2019	10.34	220.2	-13	7.75	1.38	0	7.1
7/16/2019	9.61	224.4	-14	7.64	1.27	0	6.4
7/16/2019	8.93	227.8	-15	7.59	1.52	0	6
7/16/2019	8.09	231.4	-16	7.5	1.55	0	5.2
7/16/2019	7.8	231.7	-17	7.48	1.44	0	4.8
7/16/2019	7.46	233.9	-18	7.44	1.4	0	4.2
7/16/2019	7.43	235.1	-19	7.41	1.64	0	3.8
7/16/2019	7.39	235.4	-20	7.41	1.58	0	3.6
7/16/2019	7.37	235.6	-21	7.41	1.76	0	3.5
7/16/2019	7.34	235.6	-22	7.4	1.89	0	3.3
7/16/2019	7.28	260.3	-23	7.36		0	2.5

DateTime M/D/Y	Temp C	SpCond uS/cm	Depth m	pH	Turbidity NTU	Chlorophyl ug/L	DO mg/L
8/23/2019	22.04	190.6	0.000	8.88	1.94	0.64	8.3
8/23/2019	22.04	190.6	-1.000	8.86	1.99	0.69	8.3
8/23/2019	22.04	190.6	-2.000	8.84	2	0.75	8.3
8/23/2019	22.03	190.4	-3.000	8.84	1.78	0.91	8.3

8/23/2019	22.01	190.2	-4.000	8.84	1.93	0.97	8.3
8/23/2019	21.46	181.6	-5.000	8.72	1.53	2.55	8.3
8/23/2019	20.40	176.8	-6.000	8.39	1.32	2.32	7.2
8/23/2019	17.93	176.3	-7.000	7.75	1.41	1.48	4.6
8/23/2019	16.49	175.9	-8.000	7.6	1.72	1.72	3.9
8/23/2019	15.11	174.8	-9.000	7.53	1.5	0.55	3.8
8/23/2019	14.13	177.6	-10	7.51	1.38	0.55	4.1
8/23/2019	13.4	183.9	-11	7.51	1.5	0.49	4.5
8/23/2019	11.89	200.8	-12	7.54	1.83	0.35	4.7
8/23/2019	10.06	225.4	-13	7.45	1.77	0.23	4
8/23/2019	9.18	230.1	-14	7.41	1.43	0.14	3.6
8/23/2019	8.75	232.9	-15	7.37	1.68	0.04	3.1
8/23/2019	8.42	235.5	-16	7.32	1.92	0.06	2.6
8/23/2019	8.12	237.7	-17	7.29	1.93	0	2.1
8/23/2019	8.01	238.7	-18	7.26	2.1	0.01	1.7
8/23/2019	7.91	241.5	-19	7.24	4.53	0	1.2
8/23/2019	7.84	241.8	-20	7.22	3.31	0.02	0.8
8/23/2019	7.82	242.1	-21	7.22	3.5	0	0.7

DateTime M/D/Y	Temp C	SpCond uS/cm	Depth m	pH	Turbidity NTU	Chlorophyl ug/L	DO mg/L
8/28/2019	22.21	190.5	0.000	8.87	2.41	0.68	9.2
8/28/2019	21.65	189.9	-1.000	8.78	1.59	0.59	8.4
8/28/2019	21.60	190.3	-2.000	8.77	2.04	0.72	8.3
8/28/2019	21.54	190.1	-3.000	8.76	1.88	0.94	8.2
8/28/2019	21.37	187.3	-4.000	8.69	1.55	1.45	8.1
8/28/2019	20.85	180.8	-5.000	8.53	1.63	2.04	7.6
8/28/2019	20.73	180.5	-6.000	8.51	1.55	2.01	7.5
8/28/2019	18.65	176.7	-7.000	7.73	1.45	1.39	4.6
8/28/2019	16.46	176.6	-8.000	7.51	1.54	2.52	3.4
8/28/2019	14.96	176.1	-9.000	7.43	1.35	0.82	3.4
8/28/2019	13.87	179.5	-10	7.44	1.34	0.43	3.8
8/28/2019	13.05	184.9	-11	7.49	1.45	0.31	4.2
8/28/2019	12.09	195.6	-12	7.51	1.54	0.23	4.3
8/28/2019	10.18	224	-13	7.44	1.87	0.1	3.5
8/28/2019	9.37	231.6	-14	7.4	1.67	0.16	3.1
8/28/2019	8.86	233.2	-15	7.45	1.78	0.18	2.9
8/28/2019	8.54	235.2	-16	7.37	1.71	0.06	2.4
8/28/2019	8.46	235.6	-17	7.36	1.56	0.04	2.3
8/28/2019	8.33	236.7	-18	7.36	1.57	0.04	2.1
8/28/2019	8.18	237.8	-19	7.35	1.8	0	1.7
8/28/2019	8.1	238.8	-20	7.34	1.71	0	1.6
8/28/2019	8.02	239.6	-21	7.33	2.15	0	1.3
8/28/2019	7.92	240.7	-22	7.31	2.14	0.05	0.8
8/28/2019	7.89	242.3	-23	7.31	2.63	0	0.6
8/28/2019	7.86	243.9	-24	7.29	208.5	0	0.3

DateTime	Temp	SpCond	Depth	pH	Turbidity	Chlorophyl	DO
M/D/Y	C	uS/cm	m		NTU	ug/L	mg/L
9/4/2019	22.03	191.0	0.000	8.8	1.7	0.66	8.4
9/4/2019	21.99	191.0	-1.000	8.8	1.75	0.61	8.41
9/4/2019	21.91	190.6	-2.000	8.8	1.5	0.59	8.42
9/4/2019	21.68	189.3	-3.000	8.79	1.34	0.8	8.43
9/4/2019	21.53	189.6	-4.000	8.77	1.44	0.93	8.31
9/4/2019	21.41	188.8	-5.000	8.74	1.32	1.06	8.15
9/4/2019	20.98	187.0	-6.000	8.61	1.29	1.53	7.6
9/4/2019	19.41	179.8	-7.000	7.94	1.21	1.19	5.21
9/4/2019	17.74	178.1	-8.000	7.59	1.34	1.2	3.43
9/4/2019	15.62	175.8	-9.000	7.42	1.23	1.23	2.61
9/4/2019	13.92	179.6	-10	7.41	1.1	0.43	3.05
9/4/2019	13.052	184.1	-11	7.44	1.22	0.56	3.4
9/4/2019	11.914	196.7	-12	7.48	1.47	0.34	3.87
9/4/2019	11.693	198.6	-13	7.48	1.34	0.35	3.66
9/4/2019	10.032	227.5	-14	7.42	1.36	0.19	3.16
9/4/2019	8.948	234.3	-15	7.35	1.57	0.08	2.27
9/4/2019	8.592	236.4	-16	7.33	1.63	0.06	1.81
9/4/2019	8.351	237.6	-17	7.31	1.7	0.02	1.49
9/4/2019	8.215	239.4	-18	7.3	1.71	0.01	1.19
9/4/2019	8.113	240.9	-19	7.31	1.82	0.1	0.82
9/4/2019	8.009	242.1	-20	7.31	1.98	-0.01	0.53
9/4/2019	7.933	243.7	-21	7.3	2.78	-0.04	0.16
9/4/2019	7.882	245.4	-22	7.31	2.6	-0.08	-0.04
9/4/2019	7.882	246.7	-23	7.31	38	0.51	-0.05

DateTime	Temp	SpCond	Depth	pH	Turbidity	Chlorophyl	DO
M/D/Y	C	uS/cm	m		NTU	ug/L	mg/L
9/12/2019	19.82	188.4	0.000	8.72	2.38	0.79	7.76
9/12/2019	19.82	188.4	-1.000	8.72	2.33	0.85	7.75
9/12/2019	19.81	188.4	-2.000	8.71	2.3	0.7	7.73
9/12/2019	19.81	188.5	-3.000	8.7	2.4	0.79	7.72
9/12/2019	19.79	188.5	-4.000	8.68	2.29	0.83	7.71
9/12/2019	19.79	188.4	-5.000	8.68	2.41	0.78	7.7
9/12/2019	19.74	188.3	-6.000	8.66	2.41	0.96	7.59
9/12/2019	16.49	178.8	-7.000	7.6	1.51	0.48	2.2
9/12/2019	14.47	180.1	-8.000	7.48	1.36	0.46	1.99
9/12/2019	13.17	186.1	-9.000	7.43	1.5	0.28	2.34
9/12/2019	10.97	214.4	-10	7.42	1.42	0.22	2.35
9/12/2019	9.753	229.5	-11	7.4	1.42	0.07	2.24
9/12/2019	9.114	234	-12	7.37	1.39	0.08	1.97
9/12/2019	8.793	236.1	-13	7.35	1.7	0.09	1.55
9/12/2019	8.547	238.1	-14	7.34	1.76	0.02	1.3

9/12/2019	8.331	240.1	-15	7.33	1.83	0.07	1
9/12/2019	8.176	241.4	-16	7.32	1.63	0.05	0.64
9/12/2019	8.081	243.4	-17	7.31	1.95	0.04	0.33
9/12/2019	8.044	244.5	-18	7.31	2.14	-0.01	0.16
9/12/2019	8.016	307.9	-19	7.32	382.92	5.38	0.07
9/12/2019	8.025	309.6	-20	7.33	102.51	0.94	0.06

DateTime	Temp	SpCond	Depth	pH	Turbidity	Chlorophyl	DO
M/D/Y	C	uS/cm	m		NTU	ug/L	mg/L
9/18/2019	19.19	188.8	0.000	8.58	1.31	0.35	8.07
9/18/2019	19.14	188.9	-1.000	8.58	1.36	0.52	8.06
9/18/2019	19.10	188.9	-2.000	8.59	1.51	0.7	8.06
9/18/2019	19.09	188.9	-3.000	8.59	1.51	0.75	8.05
9/18/2019	19.07	189.0	-4.000	8.6	1.66	0.72	8.05
9/18/2019	19.07	189.0	-5.000	8.6	1.58	0.7	8.05
9/18/2019	19.07	189.1	-6.000	8.61	1.5	0.6	8.04
9/18/2019	19.02	188.5	-7.000	8.6	1.66	0.49	8
9/18/2019	18.09	184.0	-8.000	7.93	1.34	0.42	4.97
9/18/2019	15.11	178.7	-9.000	7.58	1.22	0.4	2.03
9/18/2019	12.62	194.0	-10	7.41	1.45	0.23	2.19
9/18/2019	11.228	215	-11	7.32	1.27	0.2	2.31
9/18/2019	9.616	231.5	-12	7.19	1.58	0.13	1.89
9/18/2019	8.98	235.7	-13	7.15	1.3	0.08	1.44
9/18/2019	8.598	239	-14	7.13	1.81	0.09	1.04
9/18/2019	8.366	240.1	-15	7.12	1.46	0.03	0.82
9/18/2019	8.271	242.5	-16	7.12	1.89	-0.1	0.52
9/18/2019	8.218	244.4	-17	7.13	2.17	0.01	0.33
9/18/2019	8.14	245.9	-18	7.16	2.12	-0.04	0.14
9/18/2019	8.052	247	-19	7.21	2	-0.04	-0.09

DateTime	Temp	SpCond	Depth	pH	Turbidity	Chlorophyl	DO
M/D/Y	C	uS/cm	m		NTU	ug/L	mg/L
10/1/2019	16.74	188	0.000	8.38	1.98	0.58	8.29
10/1/2019	16.71	188	-1.000	8.37	1.93	0.58	8.28
10/1/2019	16.67	188	-2.000	8.38	1.95	0.58	8.28
10/1/2019	16.66	188	-3.000	8.38	2.03	0.58	8.27
10/1/2019	16.66	188.1	-4.000	8.4	1.9	0.58	8.27
10/1/2019	16.65	188	-5.000	8.4	2.03	0.58	8.25
10/1/2019	16.63	188.1	-6.000	8.4	2.05	0.58	8.23
10/1/2019	16.61	188.1	-7.000	8.4	2.06	0.58	8.2
10/1/2019	16.56	188.1	-8.000	8.39	2.25	0.58	8.15
10/1/2019	15.38	187.5	-9.000	8.03	2.98	0.58	6.26
10/1/2019	10.95	221.7	-10	7.53	2.02	0.58	1.64
10/1/2019	9.353	235.4	-11	7.44	1.78	0.58	1.19
10/1/2019	8.917	238.9	-12	7.4	2.08	0.58	0.82

10/1/2019	8.631	241.2	-13	7.36	1.94	0.58	0.51
10/1/2019	8.469	242.3	-14	7.35	1.79	0.58	0.29
10/1/2019	8.36	243.7	-15	7.34	1.75	0.58	0.1
10/1/2019	8.256	245.9	-16	7.33	1.66	0.58	-0.03

DateTime	Temp	SpCond	Depth	pH	Turbidity	Chlorophyl	DO
M/D/Y	C	uS/cm	m		NTU	ug/L	mg/L
10/16/2019	13.21	190.5	0.000	8.27	1.74	0.17	8.85
10/16/2019	13.17	190.4	-1.000	8.27	1.73	0.22	8.86
10/16/2019	13.14	190.4	-2.000	8.28	1.76	0.47	8.87
10/16/2019	13.13	190.5	-3.000	8.29	1.76	0.42	8.88
10/16/2019	13.12	190.5	-4.000	8.3	1.76	0.34	8.88
10/16/2019	13.11	190.5	-5.000	8.31	1.69	0.35	8.88
10/16/2019	13.10	190.5	-6.000	8.32	1.76	0.37	8.89
10/16/2019	13.10	190.5	-7.000	8.32	1.71	0.37	8.89
10/16/2019	13.09	190.5	-8.000	8.31	1.89	0.64	8.81
10/16/2019	13.08	190.5	-9.000	8.31	1.82	0.46	8.77
10/16/2019	13.08	190.5	-10	8.31	1.86	0.48	8.76
10/16/2019	13.045	190.6	-11	8.31	1.95	0.47	8.74
10/16/2019	12.648	195.2	-12	8.11	2.2	0.25	7.75
10/16/2019	11.825	215.5	-13	7.8	2.14	0.05	5.2
10/16/2019	9.63	236.8	-14	7.48	1.82	0.19	1.13
10/16/2019	8.937	240.5	-15	7.31	1.55	0.07	0.35
10/16/2019	8.62	244.3	-16	7.27	1.8	0.01	0.1
10/16/2019	8.437	246.6	-17	7.27	2.21	0.06	0.03
10/16/2019	8.326	249.2	-18	7.28	2.54	0.07	-0.01
10/16/2019	8.258	252.9	-19	7.28	5.35	0.02	-0.02
10/16/2019	8.196	256.7	-20	7.28	37.89	0.13	-0.03

DateTime	Temp	SpCond	Depth	pH	Turbidity	Chlorophyl	DO
M/D/Y	C	uS/cm	m		NTU	ug/L	mg/L
10/24/2019	11.40	193.4	0.000	8.09	1.91	0.25	9.02
10/24/2019	11.40	193.5	-1.000	8.09	2	0.48	8.98
10/24/2019	11.39	193.6	-2.000	8.09	1.97	0.34	8.94
10/24/2019	11.39	193.6	-3.000	8.11	1.99	0.39	8.93
10/24/2019	11.39	193.6	-4.000	8.12	1.94	0.35	8.92
10/24/2019	11.39	193.6	-5.000	8.13	2.06	0.44	8.91
10/24/2019	11.39	193.6	-6.000	8.14	2	0.28	8.9
10/24/2019	11.38	193.7	-7.000	8.14	1.99	0.38	8.89
10/24/2019	11.37	193.8	-8.000	8.14	2.02	0.26	8.86
10/24/2019	11.36	193.9	-9.000	8.14	1.88	0.33	8.85
10/24/2019	11.35	194	-10	8.13	2.27	0.37	8.79
10/24/2019	11.348	194.1	-11	8.13	1.93	0.44	8.76
10/24/2019	11.316	195	-12	8.09	2.02	0.38	8.58
10/24/2019	10.828	204.9	-13	7.71	2.38	0.26	5.36

10/24/2019	9.046	241.7	-14	7.38	2.13	0.03	0.33
10/24/2019	8.612	246.1	-15	7.32	3.31	0.06	0.08
10/24/2019	8.428	248.2	-16	7.3	3.36	0.03	0.01
10/24/2019	8.314	257.5	-17	7.29	10.72	-0.05	-0.02
10/24/2019	8.205	258.4	-18	7.31	13.15	0.09	-0.04

Daily Flowline Diversion and Reservoir Content Summary

Date	Kannah Creek Flowline									Purdy Mesa Flowline (From Juniata Reservoir Storage)				Somerville Pipeline (Brandon Ditch)			Juniata Ditch Enlarged (To Juniata Reservoir)		City Ditch		Juniata Reservoir		Purdy Mesa Reservoir			
	Kannah Creek Intake Flows				To Secret Ditch	To Juniata Reservoir	To Purdy Mesa Reservoir	To Grand Jct Water Treatment Plant		To Grand Jct Water Treatment Plant		To Kannah Creek Water Treatment Plant		To Grand Jct Water Treatment Plant		Meter Reading	Upper Reservoir Releases	Direct Flow	To Juniata Reservoir		To Purdy Mesa Reservoir		To Grand Jct Water Treatment Plant		To Irrigation	
	Total	Paramount 7.81	# 2 right 3.91	Upper Reservoir Releases																						
	C.F.S. Input	C.F.S. Calc	C.F.S. Calc	C.F.S. Input	C.F.S. Calc	C.F.S. Calc	C.F.S. Input	C.F.S. Calc	M.G Input	C.F.S. Calc	M.G Input	C.F.S. Calc	M.G Input	C.F.S. Calc	M.G Input	Input	C.F.S. Input	C.F.S. Input	C.F.S. Calc	A.F. Input	C.F.S. Calc	A.F. Input	C.F.S. Input	A.F. Calc	C.F.S. Input	A.F. Calc
November-17	277.65	233.71	43.94	0.00	0.00	251.60	0.00	26.05	16.70	96.35	61.76	2.08	1.33	11.98	7.68	8543900	0.00	0.00	33.99	67.50	0.00	0.00	0.00	0.00	0.00	0.00
December-17	252.90	236.26	16.64	0.00	0.00	242.25	0.00	10.65	6.83	93.85	60.16	2.12	1.36	18.38	11.78	20189300	0.00	0.00	78.05	155.00	0.00	0.00	0.00	0.00	0.00	0.00
January-18	12.31	103.35	66.25	1.99	1.27	23.21	14.88	9.11	5.57	0.00	56.35	111.91	0.00	0.00	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
February-18	217.68	215.41	2.27	0.00	0.00	192.30	0.00	25.38	16.27	82.70	53.01	1.77	1.14	17.47	11.20	91481200	0.00	0.00	66.30	131.67	0.00	0.00	0.00	0.00	0.00	0.00
March-18	204.79	191.81	12.98	0.00	0.00	190.50	0.00	14.29	9.16	149.57	95.88	2.14	1.37	1.93	1.24	0	0.00	93.06	46.71	92.76	60.42	120.00	0.00	0.00	0.00	0.00
April-18	221.48	214.70	6.78	0.00	0.00	202.95	0.00	10.53	6.88	206.26	132.22	2.75	1.76	0.00	0.00	47631500	0.00	31.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
May-18	257.71	240.80	2.92	0.00	19.83	208.82	0.00	29.06	18.63	275.56	176.64	3.69	2.37	0.00	0.00	47631500	0.00	62.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
June-18	242.72	214.59	11.94	0.00	40.07	117.41	0.00	85.24	54.64	286.29	183.52	5.20	3.33	0.00	0.00	47631500	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
July-18	285.31	242.07	0.00	0.00	42.89	130.15	0.00	112.27	71.97	310.17	198.83	5.61	3.59	0.00	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
August-18	247.67	215.32	0.00	26.64	4.47	166.90	0.00	76.30	48.91	302.30	193.78	5.29	3.39	0.00	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
September-18	235.00	225.24	0.00	9.50	0.00	210.71	0.00	24.29	15.57	261.92	167.90	4.40	2.82	0.00	0.00	0	158.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
October-18	246.97	241.43	0.00	0.00	0.00	246.13	0.00	0.84	0.54	164.52	105.46	2.24	1.44	0.00	0.00	#REF!	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Totals	**2702.19**	**2574.69**	**134.00**	**38.13**	**108.53**	**2182.92**	**14.88**	**424.02**	**271.67**	**2229.49**	**1485.61**	**149.21**	**23.91**	**49.76**	**31.90**	**#REF!**	**158.50**	**186.56**	**225.04**	**446.93**	**60.42**	**120.00**	**0.00**	**0.00**	**0.00**	**0.00**
												Average	0.066													

Daily Flowline Diversion and Reservoir Content Summary

Date	Kannah Creek Flowline									Purdy Mesa Flowline (From Juniata Reservoir Storage)				Somerville Pipeline (Brandon Ditch)			Juniata Ditch Enlarged (To Juniata Reservoir)		City Ditch		Juniata Reservoir		Purdy Mesa Reservoir			
	Kannah Creek Intake Flows				To Secret Ditch	To Juniata Reservoir	To Purdy Mesa Reservoir	To Grand Jct Water Treatment Plant		To Grand Jct Water Treatment Plant		To Kannah Creek Water Treatment Plant		To Grand Jct Water Treatment Plant		Meter Reading	Upper Reservoir Releases	Direct Flow	To Juniata Reservoir		To Purdy Mesa Reservoir		To Grand Jct Water Treatment Plant		To Irrigation	
	Total	Paramount 7.81	# 2 right 3.91	Upper Reservoir Releases																						
	C.F.S. Input	C.F.S. Calc	C.F.S. Calc	C.F.S. Input	C.F.S. Calc	C.F.S. Calc	C.F.S. Input	C.F.S. Calc	M.G Input	C.F.S. Calc	M.G Input	C.F.S. Calc	M.G Input	C.F.S. Calc	M.G Input	Input	C.F.S. Input	C.F.S. Input	C.F.S. Calc	A.F. Input	C.F.S. Calc	A.F. Input	C.F.S. Input	A.F. Calc	C.F.S. Input	A.F. Calc
November-18	233.09	222.80	10.29	0.00	0.00	226.79	0.00	6.30	4.04	86.85	55.67	2.13	1.37	0.00	0.00	0	0.00	0.00	49.48	98.27	0.00	0.00	0.00	0.00	0.00	0.00
December-18	238.47	236.56	1.91	0.00	0.00	195.66	0.00	42.81	27.44	45.91	29.43	2.42	1.55	27.57	17.67	62523500	0.00	0.00	62.06	123.24	0.00	0.00	0.00	0.00	0.00	0.00
January-19	27.04	43.79	28.07	2.42	1.55	0.00	0.00	62523500.00	0.00	0.00	56.35	111.91	0.00	0.00	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
February-19	197.82	197.82	0.00	0.00	0.00	165.81	0.00	32.01	20.52	45.12	28.92	1.92	1.23	7.43	4.76	62523500	0.00	0.00	17.62	35.00	0.00	0.00	0.00	0.00	0.00	0.00
March-19	255.92	237.43	18.49	0.00	0.00	219.54	0.00	36.38	23.32	53.41	34.24	2.13	1.37	19.34	12.40	0	98.80	0.00	56.35	111.91	0.00	0.00	0.00	0.00	0.00	0.00
April-19	275.51	234.26	16.87	0.00	24.38	229.05	0.00	14.04	9.84	138.56	88.82	2.36	1.51	0.00	0.00	0	0.00	0.00	0.00	0.00	1.01	2.00	0.00	0.00	0.00	0.00
May-19	226.77	226.30	0.47	0.00	0.00	210.75	0.00	16.02	10.27	230.18	147.55	2.60	1.66	0.00	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
June-19	170.31	170.31	0.00	0.00	0.00	166.94	0.00	3.37	2.16	325.60	208.72	15.18	9.73	0.00	0.00	0	0.00	555.60	0.00	0.00	220.02	436.95	0.00	0.00	88.12	175.01
July-19	254.97	240.70	0.00	0.00	7.56	222.29	0.00	25.12	16.10	351.02	225.01	3.84	2.46	0.00	0.00	0	116.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
August-19	246.95	240.82	0.00	0.00	5.20	202.08	0.00	32.68	20.95	346.27	221.97	4.46	2.86	0.00	0.00	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	78.90	156.70
September-19	258.31	232.60	0.00	0.00	30.69	203.08	0.00	24.54	15.73	297.20	190.51	4.07	2.61	0.00	0.00	0	158.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	92.62	183.94
October-19	160.13	159.65	0.00	0.00	0.00	145.58	0.00	14.55	9.33	206.33	132.26	3.71	2.38	0.00	0.00	#REF!	0.00	62.00	0.00	0.00	0.00	0.00	0.00	0.00	38.51	76.48
Totals	**2545.29**	**2443.04**	**76.10**	**2.42**	**69.38**	**2187.58**	**0.00**	**62523747.82**	**159.70**	**2126.44**	**1419.45**	**156.73**	**28.73**	**54.33**	**34.83**	**#REF!**	**373.71**	**617.60**	**185.51**	**368.42**	**221.02**	**438.95**	**0.00**	**0.00**	**298.15**	**592.13**
												Average	0.079													

Purchasing Division

ADDENDUM NO. 1

DATE: April 27, 2020
FROM: City of Grand Junction Purchasing Division
TO: All Offerors
RE: Design/Build Aeration Project for Juniata Reservoir

Offerors responding to the above referenced solicitation are hereby instructed that the requirements have been clarified, modified, superseded and supplemented as to this date as hereinafter described.

Please make note of the following clarifications:

1. Q. Will the City consider extending the schedule to allow for safe travel conditions during and following the corona virus pandemic?

A. Yes

2. Q. In RFP Section 4.4, Contract Execution is scheduled for June 8, 2020 with a Completion Date of July 17, 2020 (6 weeks from June 8) with Work begins upon Notice To Proceed, but no schedule for the NTP. We will need at least 8 weeks from NTP to procure materials and mobilize to the site. Diffuser construction and installation is expected to take 2 weeks onsite. Will the City consider changing the Completion Date to allow for at least 10 weeks after NTP?

A. Yes

3. Q. Will the City consider extending the schedule to save mobilization costs?

A. Yes

4. Q. During these uncertain times the demand for liquidated damages is an unnecessary hardship. Will the City consider eliminating the liquidated damages requirement?

A. Liquidated damage will remain in effect for this project. However, per the solicitation documents, Section 2.32 Force Majeure will be considered when applicable.

5. Q. An oxygen gas supply will be needed to test and deploy the reservoir diffuser system. The permanent liquid oxygen facility (RFP-4787-20-DH Facility Lease and Installation of a Liquid Oxygen System) or a temporary oxygen supply system will need to be fully operational during construction and deployment of the diffuser system. Will the City have an oxygen supply facility operational to support the diffuser installation?

A. The LOX target date for completion is 6/17/2020.

6. Q. We do not usually work with a “Cost Plus a Fixed Fee” contract arrangement.

What are the City’s requirements for documenting “Cost” in a “Cost Plus a Fixed Fee” contract arrangement?

A. For further clarification, in a Cost Plus a Fixed Fee proposal submission, the Contractor shall submit their Fixed Fee Price that would be above and beyond the straight Cost of the project. For Contractor's that will be providing any services/work "in-house" shall also provide their labor rates/fees sheet breakdown with their submission.

Will the city consider a lump sum fixed price contract arrangement?

A. No.

7. Q. There is no schedule or requirement for a design review that would be expected in a Design/Build contract.

Will the City wish to review design drawings before construction?

A. Yes.

Will the City provide additional time in the schedule to conduct a design review?

A. Yes, 1 week.

8. Q. The RFP requires that the Contractor secure and pay for all permits, fees and licenses necessary to complete the work. As an out of state specialty contractor, we do not have information on the permits, fees and licenses that might be required or the procedures and the time required to obtain them. It would be inefficient for us to attempt to obtain permits, fees and licenses for Grand Junction from out of state.

What permits, fees and licenses are necessary to complete the work?

A. The State Engineer's Office has informed the City that they do not require any permitting. Check with Mesa County Planning to determine what permits are necessary, if any for this phase - all filings are able to be done electronically.

Will the City consider taking responsibility for securing the permits, fees and licenses necessary to complete the work?

A. No. The contractor shall be responsible for all applicable permits, fees and licenses necessary for successful completion of the project.

9. Q. Section 4.2 Project Objectives includes "the materials necessary for and the installation of a pipeline that will deliver the gaseous oxygen from the feed facility to the linear diffuser within the reservoir". Will the City provide a trench and bedding for underground routing of the piping between the oxygen facility and the reservoir?

A. No. The contractor shall provide this.

The original solicitation for the project noted above is amended as noted.

All other conditions of subject remain the same.

Respectfully,

Duane Hoff Jr., Senior Buyer
City of Grand Junction, Colorado