Supplement No 1 – Filter Rerate Evaluation

Project:	Supplements to the JVWTP Capacity and Site Optimization Study		
Client:	Jordan Valley Water Conservancy District	**Issue Date:**	December 30, 2015
Purpose:	Evaluate rerating the existing filters to a higher rate as an additional plant expansion option	**Project No.:**	9635B.00

1.0 INTRODUCTION

1.1 Background

Jordan Valley Water Conservancy District completed the Jordan Valley Water Treatment Plant Capacity and Site Optimization Study in July 2015 (Carollo Engineers). The study explored four options to expand the Jordan Valley Water Treatment Plant (JVWTP) by 75 million gallons per day (mgd). Three options expanded existing facilities, and one option added 75 mgd of new facilities as a new water treatment plant (WTP) west of the existing WTP.

The study mentioned the possibility of rerating the existing filters above the Utah Division of Drinking Water's (DDW) maximum rating of 6.0 gallons per minute per square foot (gpm/sf), but it was beyond the scope of that study to validate the possibility.

1.2 Project Purpose

The purpose of this project is to explore the existing filter design and evaluate the feasibility of rerating the existing filters to achieve 75 mgd of additional filter capacity without constructing new filters. DDW requires pilot data – either bench scale or full scale – to validate any requests above 6.0 gpm/sf (DDW R309-525-15). This project will focus on a desktop evaluation of the existing filters, and any piloting will be done as a separate effort.

2.0 FILTER DESIGN

2.1 Existing Design Criteria and New Design Criteria

There are sixteen existing filters; each filter consists of two filter cells. Assuming managed filtration (one filter is always either in backwash or in rest waiting to return to service) and fifteen filters online @ 180 mgd, the filtration rate is 5.9 gpm/sf. Assuming managed filtration with an additional flow of 75 mgd and fifteen filters online @ 255 mgd, the filtration rate increases to 8.4 gpm/sf. The following table describes the size and design criteria of the filters, and changes at the higher filtration rate. Note that additional backwash facilities are required to support more frequent backwashes as a result of the higher filtration rate.

Table 1.1 Filter Design Criteria
JVWTP Filter Rerate Evaluation
Jordan Valley Water Conservancy District

Description	Units	Existing Filters	Rerated Filters and Required BW Facilities	Comments
Filtration				
Type: Gravity, dual media, influent weir	No.	16	NC	
Area Each	ft^2	1,408	NC	
Total Area	ft^2	22,528	NC	
Nominal Rate	gpm/ft^2	5.6	7.9	6 gpm/ft^2 max rate for dual media
Max Rate (one in backwash)	gpm/ft^2	5.9	8.4	6 gpm/ft^2 max rate for dual media
Flow Rate, Each (@ max rate)	mgd	12.0	17.0	
Typical Unit Filter Run Volume	$gal/ft^2/run$	8,500	NC	
Filter Run Time	hrs	24	17	
Filter Plant Production Efficiency	%	96.7%	96.7%	
Estimated Daily Backwashes	No.	16	23*	*It may not be possible to perform 23 backwashes.
Backwash Vol, per wash (incl RTW)	gal/wash	377,000	377,000	
Waste BW Vol, per wash (incl RTW)	gal/cycle	377,000	377,000	
Total Estimated Vol Backwash, Daily	gpd	6,409,000	8,671,000	
Backwash Supply				
Type: Elevated circular tank	No.	1	2	
Volume	gal	1,000,000	2,000,000	
Number Backwash Volumes	No.	2	5	
Backwash Supply Pumps	No.	4	4	
Pumping Capacity (one in stdby)	gpm	10,000	10,000	
Time to Replace BW Volume	hrs	0.6	0.6	

Notes:
(1) NC = No Change.

2.2 Comparison to Similar High Rate WTPs

Several WTPs in Utah operate above 6.0 gpm/sf. Metropolitan Water District of Salt Lake and Sandy's Point of the Mountain WTP was designed in 2005 as a high rate filtration plant at 8.0 gpm/sf. The other WTPs shown in the following table have all been rerated within the last few years or are proposed to be rerated; some involved process improvements, while others did not because of existing robust filter designs. All filters have an L/d ratio (depth of media divided by size of media) of over 1200, with higher filtration rates associated with higher L/d ratios.

Table 1.2 Utah WTPs Operating Higher than 6.0 gpm/sf
JVWTP Filter Rerate Evaluation
Jordan Valley Water Conservancy District

Description	Value	Units	Comments
Point of the Mountain[2]			
Filtration Rate (max)	8.0	gpm/sf	
Sand, 0.6 mm	12	in	
Anthracite, 1.1 mm	48	in	
L/d[1]	1600		See Note 1.
Weber South (proposed)			WTP has not officially been rerated.
Filtration Rate (max)	7.8	gpm/sf	
Sand, 0.6 mm	15	in	
Anthracite, 1.1 mm	30	in	
L/d[1]	1325		
Davis North (proposed)			WTP has not officially been rerated.
Filtration Rate (max)	7.6	gpm/sf	
Sand, 0.6 mm	15	in	
Anthracite, 1.2 mm	30	in	
L/d[1]	1270		
Utah Valley			
Filtration Rate (max)	8.65	gpm/sf	
Sand, 0.6 mm	10	in	
Anthracite, 1.25 mm	60	in	
L/d[1]	1640		
Quail Creek			
Filtration Rate (max)	7.2	gpm/sf	
Sand, 0.6 mm	12	in	
Anthracite, 1.0 mm	27	in	
L/d[1]	1200		

Notes:

(1) L/d is the ratio of filter media depth (L) to its effective size (d). Knowing L/d can provide insight into the effectiveness of a particular design and its suitability for higher filtration rates. The general range for L/d is from 1000 to 2000.

(2) Little Cottonwood WTP has been rerated and also operates above 6.0 gpm/sf.

2.3 JVWTP Filter Design Evaluation

The following table summarizes the design criteria and relevant parameters for the existing filters at the JVWTP.

Table 1.3 Existing Filter Media Design
JVWTP Filter Rerate Evaluation
Jordan Valley Water Conservancy District

Description	Value	Units	Comments
Sand			
Effective Size	0.5	mm	
Uniformity Coefficient	1.4		
Specific Gravity	2.6		
Depth	10	in	
Calculated Backwash Rate	16.9	gpm/sf	Backwash rate is lower than that for anthracite. Ideal effective size to match anthracite is 0.6 mm.
Anthracite			
Effective Size	1.0	mm	
Uniformity Coefficient	1.4		
Specific Gravity	1.6		
Depth	20	in	
Calculated Backwash Rate	17.6	gpm/sf	
Filter Bed			
L/d:	1000		This is at the low end of the acceptable range and much lower than WTPs approved for high rate filter operations.
Empty Bed Contact Time	3.2	min	
Filter Elevations (no datum adjustment)			
Filter Floor Elevation	4728.25	ft	
Filter Media Elevation	4730.75	ft	
Filter Trough Elevation, top of trough (troughs are 18” deep)	4735.00	ft	The existing trough height will allow 12-24 inches of additional media, assuming 50% bed expansion.
Maximum Filter WSE	4741.50	ft	
Clean Bed Headloss			
@ 180 mgd	3.1	ft	
@ 255 mgd	5.9	ft	
Headloss Available for Solids Accumulation			
@ 180 mgd	7.7	ft	
@ 255 mgd	4.9	ft	

2.4 Recommendations for the Existing Filters

The existing filters at the JVWTP have a low L/d ratio when compared to typical contemporary filter designs, and when compared to other WTPs operating above 6.0 gpm/sf. Existing media is at least 30 years old and has broken down to a smaller effective size; a recent media sieve analysis is attached. The media should be replaced with new filter media with a minimum target L/d ratio of 1250, which could be obtained with 12 inches of 0.6 mm sand and 30 inches of 1.0 mm anthracite, and would not require modifications to the existing filter troughs.

The actual media size, configuration, and total depth will be determined by piloting, and may recommend more than 12 inches of additional media, and/or larger media size. Adding more than 12 inches of media may require raising the backwash troughs. The cost estimate for this report assumes complete media replacement with 12 inches of additional media, replacement of the existing filter nozzles, and no modifications to the backwash troughs.

3.0 OTHER PROCESS CONSIDERATIONS

The JVWTP typically sees low raw water turbidity (< 8 NTU), and feeds a low dose of primary coagulant (< 6 mg/L), but the flocculation and sedimentation basins do not produce sweep floc. Settled water turbidity climbs to 2 NTU or more when operating the WTP at or near 180 mgd. The Capacity and Site Optimization Study and the Clarification and Washwater Report, Process Enhancements Study (Carollo, July 2005) both discussed limitations of the existing flocculation and sedimentation basins to produce high quality, low turbidity settled water (<= 1 NTU).

This is a result of the 1985 project that expanded plant processes to 132 mgd matching existing design criteria (detention time, surface loading rates, etc.) and included modifications for hydraulic expansion to 180 mgd with accommodations for tube settlers in the 1985 basins for the eventual process expansion to 180 mgd. The plant currently operates at 180 mgd by operating beyond the originally established design criteria without the tube settlers. Plant staff have operated this way successfully for many years, but plant staff feel that the filters compensate for the flocculation and sedimentation basin performance. The filters will likely not be able to continue to compensate at filtration rates of 8.4 gpm/sf.

The high rate WTPs listed in Table 3 all produce settled water around 1 NTU, and have higher L/d ratios. Rerating the existing JVWTP filters should be paired with an expansion alternative that improves settled water quality in order to provide a robust process combination that is not overly dependent on filter performance and is a sustainable combination that does not require excessive filter backwashes.

Expansion alternatives as described in the Capacity and Site Optimization Study are as follows:

Alternative 1: Modify the existing rectangular 1985 basins with plate settlers.

Alternative 2: New conventional flocculation/sedimentation (floc/sed) basins parallel to the 1985 basins.

Alternative 3: New high rate (shorter) basins with plates parallel to the 1985 basins.

Alternative 1 will improve settled water quality and is a viable alternative to pair with high rate filters. This alternative will reduce the amount of solids that need to be removed by the filters and will improve filter efficiency, reducing the number of daily backwashes.

Alternative 2 will not change settled water quality, and therefore is not considered a viable alternative to pair with high rate filters.

Alternative 3 will have a minimal impact to improve settled water quality; the new basins will produce lower turbidity settled water, and the resulting blend with the existing basins will be slightly lower than the existing basins alone. The new basins could be designed to reduce the surface loading rate of the existing basins by making the new basins larger. A modified Alternative 3 with larger high rate basins with plates is a viable alternative to pair with high rate filters.

3.1 Hydraulics

The Capacity and Site Optimization Study identified three hydraulic constraints in the existing WTP: finished water piping, flocculation basin baffle walls, and raw water piping in the Raw Water Meter Vault.

Finished Water Piping: This report assumes that excessive headloss at 255 mgd caused by the weir wall in the Inlet, Overflow, and Bypass structure (IOB) and the 60-inch and 72-inch inlets to the existing 8 million gallon (MG) finished water reservoir (FWR) is reduced when these facilities are reconfigured as part of the current new finished water reservoir project.

Flocculation Basin Baffle Walls: This restriction applies to Alternative 1, and the cost estimate includes modifications to the existing baffle walls to ease this restriction.

Raw Water Piping: The cost estimate in this report includes costs to reconfigure the Raw Water Meter Vault and reduce headloss.

3.2 Phased Implementation

Rerating the existing filters to 8.4 gpm/sf provides the opportunity to phase in expansion facilities, recognizing the entire 75 mgd expansion capacity will not be needed immediately. The cost estimate reflects phased improvements for both Alternative 1 and Alternative 3.

4.0 COST ESTIMATE

Table 4 lists the project costs for Alternatives 1 and 3, and projected costs given a phased approach to construction of expansion facilities. Multiple projects are generally less efficient than a single project. Phase II assumes a 15 percent premium for a phased approach.

Filter costs include removal and disposal of existing media, removal and replacement of the filter nozzles, and installation of 12 inches of sand and 30 inches of anthracite.

Table 1.4 Cost Estimate
JVWTP Filter Rerate Evaluation
Jordan Valley Water Conservancy District

Description	**Plates in Existing Basins**	**Alternative 1, Phase I**	**Alternative 1, Phase 2**	**New Full-Size Basins w/Plates**	**Alternative 3, Phase I**	**Alternative 3, Phase 2**
General Conditions	$9,800,000	$2,730,000	$6,370,000	$10,000,000	$2,800,000	$6,510,000
Civil / Sitework	$900,000	$630,000	$270,000	$1,600,000	$1,120,000	$480,000
Raw Water Reservoir, 75 MG	$2,900,000		$2,900,000	$2,900,000		$2,900,000
Yard Piping	$4,000,000	$2,800,000	$1,200,000	$4,100,000	$2,870,000	$1,230,000
Landscaping	$150,000	$75,000	$75,000	$200,000	$100,000	$100,000
Plant Inlet Structure	$350,000	$350,000		$350,000	$350,000	
Flocculation/Sedimentation Basins	$26,400,000	$13,200,000	$13,200,000	$28,200,000	$14,100,000	$14,100,000
Filters	$4,000,000	$4,000,000		$4,000,000	$4,000,000	
UV Disinfection	$0			$0		
Ozone	$37,500,000		$37,500,000	$37,500,000		$37,500,000
15 MG Finished Water Reservoir	$14,000,000		$14,000,000	$14,000,000		$14,000,000
Chemical Feed Facilities	$5,000,000	$3,500,000	$1,500,000	$5,000,000	$3,500,000	$1,500,000
Operations Building	$0			$0		
Backwash Supply Facilities	$3,000,000	$300,000	$3,000,000	$3,000,000	$300,000	$3,000,000
FWW Basin and Pump Station	$2,500,000	$1,750,000	$750,000	$2,500,000	$1,750,000	$750,000
FWW Clarifiers, Recycle PS, Sludge PS	$4,500,000	$3,150,000	$1,350,000	$4,500,000	$3,150,000	$1,350,000
Sludge Lagoons	$3,000,000	$2,100,000	$900,000	$3,000,000	$2,100,000	$900,000
Electrical	$17,700,000	$5,200,000	$12,500,000	$18,200,000	$5,500,000	$12,700,000
Instrumentation	$3,600,000	$1,100,000	$2,500,000	$3,700,000	$1,100,000	$2,600,000
Construction Estimate	**$139,300,000**	**$40,885,000**	**$98,015,000**	**$142,750,000**	**$42,740,000**	**$99,620,000**
Project Contingency @ 30%	$41,790,000	$12,270,000	$29,410,000	$42,830,000	$12,830,000	$29,890,000
Escalation to Midpoint (2.5%, 3 yrs)	$3,490,000	$1,030,000	$2,460,000	$3,570,000	$1,070,000	$2,500,000
Engineering, Legal and Administration Fees (20%)	$27,860,000	$8,180,000	$19,610,000	$28,550,000	$8,550,000	$19,930,000
TOTAL COST (with ozone)	**$212,500,000**	**$62,400,000**	**$149,500,000**	**$217,700,000**	**$65,200,000**	**$152,000,000**
Assume 15% premium added to Phase II for phased approach.			$171,925,000			$174,800,000
TOTAL PROJECT COST			**$234,325,000**			**$240,000,000**

5.0 CONCLUSION

JVWTP filters are excellent candidates to operate at higher filtration rates than DDW's stated maximum of 6.0 gpm/sf. Rerating the filters requires a piloting effort to determine the optimal media configuration, and obtain pilot run data to submit to DDW for approval.

Implementation includes replacement of existing filer media and nozzles with new media per the piloting results, and should be paired with either Alternative 1 of Alternative 3 to improve settled water quality and provide more sustainable filter operations.

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Attachments:
Recent Filter Media Sieve Analysis

ATTACHMENTS - RECENT FILTER MEDIA SIEVE ANALYSIS

Filter 5 Sieve Analysis				
Sieve size (mm)	**Tare (grams)**	**Gross (grams)**	**Net (grams)**	**% Passing**
Pan			2.0	0.0%
0.425			1.8	0.3%
0.500			6.0	0.6%
0.600			14.1	1.5%
0.710			47.2	3.6%
0.850			144.7	10.7%
1.00			174.2	32.5%
1.18			166.4	58.7%
1.40			84.8	83.7%
1.70			17.5	96.4%
2.00			5.3	99.1%
2.36			0.9	99.9%

D60	=	1.191
D10 (E.S.)	=	0.836
U.C.	=	1.42