19 July 2010

Longview MFRWTP May 2010 Study Summary

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Subject: City of Longview, Washington
Longview Mint Farm Regional Water Supply Project
K/J Project No. 0997003*00

Introduction and Purpose

The purpose of this pilot study was to confirm the performance of granular media filtration at the site of the production wells, using deep monitoring well No. 9 (DW9) as the source water.

Treated Water Goals

Treated water quality goals for the pilot study are the same as used in the previous pilot study performed in April and May 2009, and are presented in Table 1.

Table 1: Filtered Water Quality Goals

Parameter	Water Quality Goal	MCL	SMCL
Total Iron	≤ 0.05 mg/L	-	0.3 mg/L
Total Manganese	≤ 0.02 mg/L	-	0.05 mg/L
Total Arsenic	≤ 5 μg/L	10 μg/L	-

Note: MCL = maximum contaminant level
SMCL = secondary maximum contaminant level
mg/L = milligrams per liter
μg/L = micrograms per liter

Pilot Study Equipment and Methods

The pilot filter equipment was the same as used in the previous study and consists of two skid-mounted filters each with a diameter of 6 inches. The operator set the flow rate through the filters, and that flow rate was maintained by on-board controls. The filter skid included instrumentation to measure filter head loss, and the flow rate through each filter. The skid is designed to operate automatically and, as such, did not require regular attention to maintain normal operations. Chemicals were dosed using chemical feed pumps. Stock chemical solutions were prepared at specific concentrations, at the required dosages. Operator attention was required to verify that the system operated properly, to address system alarms, to check and replenish chemicals, and to collect water quality samples.

The media design for the pilot filters is presented in Table 2. Sieve analyses were performed on the media at the conclusion of pilot testing to determine the effective size and uniformity coefficient.

Table 2: Pilot Filter Media Design

Parameter	Filter 1 Deep Bed[a]	Filter 2 Typical Bed[b]
Top Media	Anthracite	Anthracite
Depth (inches)	30	18
Effective size (mm)	0.69	0.69
Uniformity coefficient	1.75	1.75
Specific gravity	1.67	1.67
Bottom Media	Greensand	Greensand
Depth (inch)	16	16
Effective size (mm)	0.37	0.36
Uniformity coefficient	1.59	1.58
Specific gravity	2.57	2.71

Notes: mm = millimeters

Pilot Study Experimental Matrix

During the first week of the study, the following activities were performed:

- Well flushing
- Pilot equipment delivery, set-up, plumbing, and trouble-shooting
- Media soaking in potassium permanganate solution
- Media washing and preliminary runs with chlorinated water

In the subsequent three weeks the raw water was chlorinated at a dose of approximately 3.5 mg/L followed by filtration. Chlorine was the only oxidant used. Hydraulic loading rates of 4 and 6 gpm/ft^2 were tested along with a cationic polymer, dosed at 1 mg/L, upstream of the filters (essentially at the same location as the chlorine feed).

Pilot Study Operations

The pilot equipment vendor provided pilot operation training at the beginning of the study. Kennedy/Jenks Consultants operated the pilot equipment, thereafter. The pilot operator performed backwashing using simultaneous air scour and water wash followed by water wash (without air scour) to achieve a bed expansion of approximately 40 percent.

Sampling and Analysis Plan

The sampling and analysis plan for the pilot study is presented in Table 3. Temperature, pH, oxidation/reduction potential and dissolved oxygen were measured on-site using standardized probes. Chlorine residual was measured using a portable spectrophotometer.

Table 3: Sampling and Analysis Plan

Parameter	Raw	Filter Effluents
Hand-Recorded Data:		
Flow rate (gpm)		3 / day
Head loss (ft)		3 / day
On-Site Analyses:		
Temperature (°C)	1 / day	-
Chlorine Residual		1 / day
pH[(a)]	2 / week	2 / week
Oxidation reduction potential (ORP)	1 / week	1 / week
Dissolved Oxygen	1 / week	1 / week
Samples to be Shipped to Certified Lab:		
Iron, Manganese, Arsenic (Total)	3 / week	3 / day
Arsenic Species (As-III and As-V)	1 / study	
Total organic carbon	2 / study	2 / study
Inorganics [(b)]	2 / study	

Note: [(a)] pH to be measured before and after addition of chlorine to the raw water.
[(b)] Includes fluoride, nitrate/nitrite, ammonia, calcium, magnesium, color, turbidity, chloride, sulfate, total dissolved solids, conductivity, reactive silica, total phosphorus, pH, alkalinity

Pilot Filtration Testing Results

A summary of well raw water quality is presented in Table 4. The Prudential Boulevard Test Well data were collected in April and May 2009. The DW9 data were collected in April and May 2010. The DW9 well water is lower in iron, manganese, and arsenic compared to the Prudential Boulevard Test Well.

Table 4: Well Water Quality

Parameter		DW9	Prudential Boulevard Test Well
Target Contaminants			
Iron (mg/L)	Total	0.66	1.2
Manganese (mg/L)	Total	0.53	0.601
Arsenic (μg/L)	Total	4.9	12.7
	As-III	3.8	6.54
	As-V	2.4	7.64
Other Water Quality			
pH		7.2	7.8
Alkalinity (mg/L as $CaCO_3$)		100	130
Temperature (°C)		12.3	12
Hardness (mg/L as $CaCO_3$)		90	112
Total Dissolved Solids (mg/L)		150	201
Conductivity (μMhos/cm)		216	307
Total Organic Carbon (mg/L)		1.7	1.8
Total Silica (mg/L)		51.5	25.0
Fluoride (mg/L)		< 0.2	< 0.2
Chloride (mg/L)		5.9	12
Nitrate (mg/L)		< 0.1	0.3
Sulfate (mg/L)		0.83	0.35
Phosphate (mg/L)		0.33	0.55
Ammonia (mg/L)		0.135	NA

Notes:

NA = not available
mg/L = milligrams per liter
μg/L = micrograms per liter
°C = degrees Celsius
$CaCO_3$ = calcium carbonate
μMhos/cm = micromhos per centimeter

Table 5 presents a summary of the filter run times achieved in this pilot study. The filter run was considered to have ended when the concentration of iron or manganese in the filter effluent increased to half the SMCL. The filter run time was defined as the time between re-starting the filter after a backwash and the end of the filter run. The filter runs were found to be two to three times longer than previously achieved using the Prudential Boulevard Test Well. Cationic polymer tended to increase the filter run length slightly for the pilot filter with typical bed depth; however, it significantly improved run length for the deep bed filter. The deep bed filter achieved essentially the same filter run length at a loading rate of 6 gpm/ft^2 with cationic polymer, as at 4 gpm/ft^2 without polymer.

Table 5: Summary of Pilot Filtration Testing Results

Operating Conditions	Filter Run Time (Hours) Filter 1 Deep Bed[(a)]	Filter 2 Typical Bed[(b)]
4 gpm/ft^2	22	24
6 gpm/ft^2	18	14
6 gpm/ft^2 with cationic polymer feed[(c)]	approx. 23	16

(a) 30 inch anthracite/16 inch greensand
(b) 18 inch anthracite/16 inch greensand
(c) Nalco 8105 dosed at 2 mg/L

Backwash Settling Tests

Approach

A sample of the backwash water was collected on May 7, 2010 for a settling test. Settling without any chemical addition and also with anionic polymer addition were tested. A standard jar test apparatus was used. The backwash water samples were mixed at 40 rpm for 2 minutes prior to quiescent settling.

Results

The sample with polymer exhibited much faster settling than the one without polymer, especially within the first five minutes of settling time. After 10 minutes of quiescent settling the turbidities of the samples without polymer and with polymer were 2.5 NTU and 1.3 NTU, respectively. After 20 minutes of settling the sample without polymer contained some fine floc and had a visible orange-tint (the backwash water was reddish brown in color), whereas the other sample appeared to be clear, by visual inspection.

Table 6 presents a summary of backwash water quality results. The addition of polymer resulted in slightly lower concentrations of metals, solids, and turbidity.

Table 6: Backwash Settling Test Results

		Settled Backwash Water[(a)]	
Parameter	Backwash Water	No polymer	10 mg/L anionic polymer
Turbidity (NTU)	83	1.1	0.9
TSS (mg/L)	620	6.0	< 5.0
pH	7.5	7.8	7.8
Alkalinity (mg/L)	110	96	116
Arsenic (µg/L)	-	5.3	4.3
Iron (mg/L)	-	1.39	0.55
Manganese (mg/L)	-	0.67	0.42

(a) Sampled after 90 minutes of settling.

Throughout the study backwash water was collected in a 150 gallon tank. The backwash water was allowed to settle for a period of 24 hours and then the supernatant was siphoned, removed, and disposed. The solids that settled to the bottom of the tank were collected for further testing. A sample of the solids was mixed with an anionic polymer (Nalco 8182) at dosages of 100 and 200 mg/L in order to flocculate the solids as a pretreatment prior to decanting the flocculated solids into geotube bags.

Conclusions and Recommendations

1. **Number of Filters**. The design hydraulic loading rate for the filters can be increased from the previous value of 4 gpm/ft^2 to 6 gpm/ft^2 while maintaining approximately the same filter run time. This higher loading rate results in the elimination of two (out of eight) filters. The design will include six filters to meet the design capacity of 17.5 mgd.

2. **Backwash Water Holding Tank Sizing**. The reduction in the number of filters from 8 to 6 corresponds to a potential reduction in the required backwash tank volume. Each tank could be reduced in size by the volume of a single backwash. On the other hand, oversized tanks provide a factor of safety for operations in the near term and likely eliminate the need to build a third backwash storage tank when the plant is expanded to the ultimate capacity of approximately 25.3 mgd.

3. **Backwash Water Settling**. The majority of the solids in the backwash water settled within 10 to 20 minutes of quiescent settling time. Settling was essentially complete after 90 minutes indicating that the design settling time of 2 hours provides a factor of safety and is appropriate. The addition of polymer to the backwash water tended to encourage aggregation of the solids into larger floc, which settled more rapidly than without polymer addition. However, after approximately 90 minutes there was little difference in the quality of the supernatant water whether or not polymer was added. Polymer addition to aid in settling the solids in the backwash water should be considered for future expansion of the plant if two hours of settling time can no longer be consistently provided.