



DATE: January 6, 2014

TO: Chuck Warner, Operations Manager of Engineering  
Rainier View Water Company  
P. O. Box 44427  
Tacoma, WA 98444

FROM: Cullen J. Wilder, P.E.

**SUBJECT: Summary of Pilot Testing, Rainier View Water Company, Behm Well No. 3**

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Dear Mr. Warner,

In accordance with our proposal, ATEC Systems Associates, Inc. pilot tested Rainier View Water Company's Behm Well No. 3. The objective was to determine the efficacy of the ATEC system in removing iron and manganese from this well, and to identify the optimal ATEC filtration equipment for treatment that will reliably remove these constituents to less than the following limits set by the USEPA: iron and manganese to less than one-half their Secondary Maximum Contamination Levels (SMCLs) of 0.300 mg/L and 0.050 mg/L, respectively. The treatment system should have a capacity of 460 gpm.

The pilot filter system is designed to simulate actual operation of an ATEC filter system on a small scale in terms of retention, media depth, flow per cubic foot of media, flow per square foot of media (loading rate) and so forth. For the test, differing amounts of chlorine are applied to the raw water and the loading rates are varied to determine the most economical filtration equipment necessary to meet the treatment objectives. During the pilot testing the pilot trailer's field lab was used to determine chlorine, iron, manganese, H<sub>2</sub>S and ammonia concentrations in the raw and finished water.

Excellent pilot test results were attained for this well. Based on these results, a system comprised of (4) 48-inch diameter vertical filters with 60-inch side walls containing 42-inches of AS-741M media (pyrolusite), is recommended. This system would be shipped on a single skid, finished painted with underdrain support, underdrain, piping, manifolds and valves shop assembled.

Preliminary drawings for the recommended system are included in this report. Dimensions are subject to change and points of connections can be revised to suit field conditions.

The remainder of the report discusses the pilot testing and the recommended system. This report is meant to summarize and document the results of the pilot testing and the basis for the recommended system. This pilot test report should be helpful in preparing a Technical report given in WAC 246-290-110, but is not meant to wholly satisfy the requirements in this section.

### **Treated Water Objectives**

A TEC guarantees the removal of iron and manganese to less than one-half their SMCLs of 0.300 mg/L and 0.050 mg/L, or 0.150 mg/L and 0.025 mg/L, respectively. These values are less than the concentrations we have found will cause odor, taste and staining.

### **General Description of the ATEC Iron, Manganese Removal Process**

A TEC Systems uses its proprietary AS-700 Series Filter Media, based on manganese dioxide mineral ore (Pyrolusite) as the basis for its high rate arsenic, iron, and manganese removal systems. This media is unusually robust, has a very high adsorptive capacity, and lends itself to the design of relatively simple treatment systems that do not require multi-media filter beds or the use of anthracite caps thus eliminating the need for surface wash and air scour systems. Currently ATEC has approximately 350 systems in operation. We have never supplied equipment that has failed to meet its treatment objectives.

The iron is oxidized to its insoluble state and filtered while the manganese is adsorbed on the surface of the media where it is secured and oxidized in place. Chlorine is injected immediately upstream of the filters. The chlorine is used to oxidize the iron and to maintain the filter bed in an oxidized state, not to oxidize and precipitate the manganese as is the case with most other treatment systems. This key difference allows for high loading rates and correspondingly small equipment footprints.

This is in sharp contrast with the more commonly used oxidation-precipitation-filtration methods where the iron is typically oxidized first with the addition of chlorine; manganese is often oxidized later with potassium permanganate prior to filtration. Depending on the pH of the water and other factors, detention often follows the

Introduction of these oxidants to allow for the chemical reactions, usually manganese oxidation, to occur and for the oxidized iron and manganese to form a filterable floc.

In this pilot test, chlorine was introduced to the influent immediately ahead of four 6-inch diameter filter columns with 60-inch filter sidewalls. The filters are manifolded together at the inlet and outlet and filled with 42-inches of AS-741M Filter Media. The pilot test characteristics are detailed in Tables 1 and 2.

### **Raw Water Quality, Rainier View Water Company, Behm Well No. 3 Wells**

As given in Tables 3 and 4 and shown in Figures 1, 2, and 3 in this report, iron concentrations varied from 0.300 mg/L to 0.460 mg/L, averaging 0.360 mg/L, or about 120 percent of the SMCL of 0.300 mg/L. Manganese concentrations in the raw water varied from 0.106 mg/L to 0.133 mg/L, averaging 0.121 mg/L or about 242 percent of the SMCL of 0.050 mg/L.

Hydrogen sulfide and ammonia were at non-detect.

Iron and manganese concentrations at these levels are likely the cause of reported problems with taste, odor and staining.

The following table summarizes the raw water quality of the wells at the Rainier View Water Company, Behm Well No. 3.

**Rainier View Water Company, Behm Well No. 3 Wells  
Raw Water Quality**

<b>Parameter</b>	<b>Low</b>	<b>High</b>	<b>Average</b>
Iron	0.300 mg/L	0.460 mg/L	0.360 mg/L
Manganese	0.106 mg/L	0.133 mg/L	0.121 mg/L

### **Pilot Test Results, Rainier View Water Company, Behm Well No. 3 Wells**

Pilot testing was performed on November 13, 2013. A total of 8 samples were taken over a period of 3.5 hours.

Influent flow was varied from a low of 6.17 gpm to a high of 8.33 gpm corresponding to loading rates of 7.85 gpm/sqft and 10.61 gpm/sqft with an average loading rate of 9.50 gpm/sqft.<sup>1</sup>

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<sup>1</sup> Area of the filter testing equipment is 0.784 sqft.

Chlorine was added to the influent water in varying amounts from a low of 1.43 mg/L to a high of 1.94 mg/L, averaging 1.61 mg/L. Total Chlorine concentration in the finish water varied from a low of 0.65 mg/L to a high of 0.78 mg/L, averaging 0.75 mg/L. Chlorine demand averaged 0.86 mg/L

In order for the media to remain charged, it is necessary to maintain a residual chlorine concentration. ATEC recommends a free chlorine residual of no less than 0.600 mg/L after filtration.

Iron removal was excellent. Finish water iron concentrations varied from 0.010 mg/L to 0.080 mg/L, averaging 0.050 mg/L less than 17 percent of the SMCL of 0.300 mg/L SMCL.

Manganese removal was excellent as well. Finish water manganese concentrations varied from 0.004 mg/L to 0.016 mg/L, averaging 0.009 mg/L or 17.5 percent of the SMCL of 0.05 mg/L.

The following table summarizes the pilot testing of the Rainier View Water Company, Behm Well No. 3 Wells.

**Rainier View Water Company, Behm Well No. 3 Wells  
Pilot Test Summary**

<b>Parameter</b>	<b>Low</b>	<b>High</b>	<b>Average</b>	<b>Percent of SMCL</b>
Iron	0.010 mg/L	0.080 mg/L	0.005 mg/L	16.7 %
Manganese	0.004 mg/L	0.016 mg/L	0.009 mg/L	17.5 %
Loading Rate	7.85 gpm/sqft	10.61 gpm/sqft	10.16 gpm/sqft	-

**Recommended System**

At the 460 gpm required capacity, the recommended system of (4) 48-inch diameter filters would have a loading rate of 9.36 gpm/sq ft during production and 12.47 gpm/sqft during backwash when one filter is out of production. The system would be shipped finish painted on a single skid, pre-plumbed, pre-wired, fusion epoxy coated tanks and manifolds, 0.25-inch heads and sidewalls. This includes 6-inch inlet and outlet manifolds, 4-inch backwash line, and a 120 VAC automatic controller. If desired and shipped loose, ATEC can provide a 4-inch backwash assembly 75-inches long, which has a threaded port for a sight glass, and a tapped orifice for a backwash meter to set the backwash at the correct rate of 350 gpm (28 gpm/sqft).

A TEC guarantees this system will remove iron and manganese to less than one-half their respective SMCLs. However, on the basis of the pilot tests, we expect removal should be much better.

## Backwash

Based on A TEC's experience with similar water, we expect that the backwash interval should be set at 24 hours of production initially. It should be observed for several weeks to see if the interval needs to be decreased or if it can be increased.

The required backwash rate for the media is 28 gpm/sf, or 350 gpm for the 48-inch filters recommended. The gate valve provided is used to set the flow to that rate.

A minimum service pressure of 30 psi must be maintained in order to regulate the backwash. The pressure at the site is less than that required (less than 10 psi was noted during the pilot test) and therefore the design must incorporate a pressure sustaining valve downstream from the filtration system controlled to actuate only during backwash to provide the necessary minimum pressure.

Filters are backwashed sequentially for five minutes each, using a portion of the finish water produced by the other filters. During the 20 minutes of backwash 350 gpm of the 460 gpm produced by the wells would be used for backwash while approximately 110 gpm would be provided to the system.

### Operating Characteristics of the Recommended Filter System

<u>Parameter</u>	<u>Value</u>
Production Rate	460 gpm
Loading Rate	9.36 gpm/sqft
Backwash Rate	28 gpm/sqft
Backwash Flow	350 gpm
Backwash Duration	5-minutes per filter
Maximum Backwash Frequency	24 hours of production
Backwash Amount	7,000 gallons
Production Between Backwash Cycles	662,400 gallons
Backwash as a Percentage of Production	1.06 %

Please contact me if you have any questions, or need further information.

Yours truly,

*Cullen Wilder*

Cullen J. Wilder, P. E.

858-755-7702 (Direct)

**Table 1  
Pilot Test Equipment Characteristics**

<b>Pilot Filters<sup>1</sup></b>	
Sidewall Height (inches)	48 to 60
Overall Height (inches)	62 to 74
Diameter (inches)	6
Filter Surface Area (each) (ft. <sup>2</sup> )	0.1964
Total Filter Surface Area (ft <sup>2</sup> )	0.7854
Underdrain	Stainless Steel Wedgewire, 0.01" slots
Media Support	¾" minus crushed granite, 4"
Source Water Connections	¾" Standard Hose
Recommended Minimum/Maximum Working Pressure	20/90 psi
<b>Filter Media<sup>2</sup></b>	
Depth in Filters (inches)	36 to 48
Volume in Filters (ft <sup>3</sup> )	2.36 to 3.15
Approximate Weight in Filters (lbs.)	285
Weight (lbs./ft <sup>3</sup> )	120.5
Physical Size (mm)	0.32 –to–0.85
<b>Maximum Removal Capacity</b>	
Iron Removal (mg/L)	10
Manganese Removal (mg/L)	10
Hydrogen Sulfide Removal (mg/L)	5
Non-Adsorptive Removal (microns)	>20
<b>Chemical Dosing Equipment<sup>3</sup></b>	
Stenner Peristaltic Solution Metering Pumps (up to 17.0 gpd @ 100 psi)	
LMI Solution Metering Pumps (various capacities)	
<b>Analytical Equipment</b>	
See following page.	

<sup>1/</sup> The pilot filter plant consists of four, 6" filter columns connected by common manifolds for influent, effluent and backwash water. Each filter is controlled by a three-way ball valve. The system is set up to closely mimic a full-scale filter system in terms of media depth, application rates in terms of both area (gpm/ft<sup>2</sup> of filter area) and volume (gpm/ft<sup>3</sup> of media), and backwash characteristics to the extent possible. Source water is metered using a totalizing flow meter. Pressure is measured on the influent and effluent manifold to determine headloss. Chemical injection points are located as close to the filter as possible to simulate actual operation. In cases where extended contact time is desired before the source water enters the filters, a pipe section of pre-determined volume is placed between the chemical injection points and the filters to provide accurate contact time measurement. Sidewall height is variable to a maximum of 60" without modification, allowing a maximum media bed depth of 48".

<sup>2/</sup> AS-721M and AS-741M Filter Media, 0.85 to 2.36mm and 0.42mm to 0.85mm, respectively, are both granular manganese dioxide media, derived from naturally occurring pyrolusite, and are certified to ANSI/NSQFT Standard 61.

<sup>3/</sup> Solution metering pumps are available for the injection of up to three chemicals, if needed. Normally, the only chemical injected is chlorine. And in the case of arsenic, ferric chloride. There are, however, provisions for special circumstances, such as pH adjustment for corrosion control or the treatment of water at fish hatcheries that do not permit chlorine.

*Table 2 Analytical Equipment*

The following analytical equipment is normally carried on our pilot trailers.

Spectrophotometer, Model DR/2800, Hach Co., Loveland, CO  
Digital Titrator, Hach Co., Loveland, CO  
pH Meter, Model 266, Orion Co., Boston, MA  
Stir Plate, Hach Co., Loveland, CO  
0.45-Micron Filter, Nalgene

**Glassware—beakers, flasks, columns, sample cells, 10 and 25 ml**

Although not normally carried in each trailer, a turbidity meter is available.

**Reagents for the following field tests:**

Spectrophotometer

**Free Chlorine**, DPD, Method 8021 and 10059 (300 tests)  
**Total Chlorine**, DPD, Method 8167 or 10060 (300 tests)

**Iron**, FerroZine Method, Method 8147 (500 tests)  
**Iron**, Total, FerroVer Method, Method 8008 (300 tests)

**Manganese**, Low Range, PAN Method, Method 8149 (500 tests)

**Nitrogen, Ammonia**, Salicylate Method, Method 8155 (100 tests)

**Sulfide**, Methylene Blue Method, Method 8131 (100 tests)

**Silica**, Molybdate Method, Method 8282 (100 tests)

Digital Titrator

**Alkalinity**, Phenolphthalein and Total Method, Method 8203 (100 tests)  
**Hardness**, Phenolphthalein and Total Method, Method 8203 (100 tests)  
**Total Chlorine**, Iodometric Method, Method 8209 (100 tests)

Field tests not listed above may be available. Please note that we send all tests for arsenic and other contaminants that require digestion or distillation to a commercial laboratory.



### ATEC Iron and Manganese Removal Pilot Plant



The exterior of ATEC Systems' pilot trailer is shown above. The source and product water connections are shown entering and exiting the trailer. Inside dimensions are 14' x 6' x 6½'.



The front one-half of the trailer is shown above. The instrument foreground on the wall is an in-line chlorine analyzer. The smaller boxes on the wall above the light are electronic flow meters used to monitor cumulative as well as instantaneous flow for each treatment train in the pilot plant.



Picture above shows the interior of the pilot plant trailer from the rear. The sample outlets and the analytical equipment are on the desk in the front of the trailer.



The picture on the left shows one set of filters. Source water enters through the hose inlet in the wall, passes through a flow meter, past a chlorine injection point, through an in-line static mixer, into the inlet manifold, down through the filter media. Product water is discharged through the wall. The pail holding the sodium hypochlorite solution can be seen to the right of the filter vessels and the in-line chlorine analyzer is on the wall above the NaOCl container. The sample ports and analytical equipment is forward of the chlorine analyzer. A second container of Ferric Chloride solution and feed pump is provided for pilot testing for arsenic removal.

**Table 3**  
**Summary of Pilot Study Test Conditions**  
**Rainier View Water Company, Behm Well 3**  
**November 12, 2013**

<u>Date</u>	<u>Sample Number</u>	<u>Time</u>	<u>Meter Reading (Gallons)</u>	<u>Average Flow (gpm)</u>	<u>Loading Rate (gpm/ft<sup>2</sup>)</u>	<u>Loading Rate (gpm/ft<sup>3</sup>)</u>	<u>Media Contact Time (Minutes)</u>	<u>Cl<sub>2</sub> Dose (mg/L)</u>	<u>Temp °C</u>
11/12	Start	12:30	588.4	7.89	10.05	2.87	3.32	1.51	10.9
	1	13:00	838.4	8.33	10.61	3.03	2.12	1.43	10.3
	2	13:30	1,023.4	6.17	7.85	2.24	2.86	1.94	10.3
	3	14:00	1,238.4	7.17	9.12	2.61	2.46	1.67	10.5
	4	14:30	1,458.9	7.35	9.36	2.67	2.40	1.62	10.5
	5	15:00	1,700.1	8.04	10.24	2.92	2.20	1.48	10.4
	6	15:30	1,935.8	7.86	10.00	2.86	2.25	1.52	10.4
	7	16:00	2,142.2	6.88	8.76	2.50	2.57	1.73	10.4
	<b>Total or Average</b>		<b>2,142.20</b>	<b>7.46</b>	<b>9.50</b>	<b>2.71</b>	<b>2.52</b>	<b>1.61</b>	<b>10.5</b>

**NA**, indicates Not Applicable for this test

**Not Dosed**, (ND) indicating the period of the test

**Not Tested**, (NT) indicating no value entered because there was no sample to test

**Media** contact time = Empty bed contact time

450 gpm, <10 psi

Used 42" AS-741 media

Sodium Hypochlorite titrated @ 4995.0

BW start and end of the test

Used Rochelle Salts

Valved well to 210 gpm

Stopped test at client's request

**Table 4**  
**Summary of Pilot Test Results**  
**Rainier View Water Company, Behm Well 3**  
**November 12, 2013**

Sample Number	Source Water							Product Water								
	pH (Units)	Fe (mg/L)	Mn (mg/L)	H <sub>2</sub> S (mg/L)	Ammonia (mg/L)	Silica (mg/L)	PSI	pH (Units)	Cl <sub>2</sub> (F) (mg/L)	Cl <sub>2</sub> (T) (mg/L)	Fe (mg/L)	Mn (mg/L)	H <sub>2</sub> S (mg/L)	Ammonia (mg/L)	Silica (mg/L)	PSI
Start	7.56	0.46	0.106			NT	20	7.54	0.66	0.77	0.08	0.009			NT	15
1	7.53	0.44	0.121				20	7.54	0.56	0.78	0.05	0.004				15
2	7.56	0.35	0.125				20	7.54	0.56	0.79	0.04	0.005				15
3	7.54	0.32	0.108				20	7.49	0.57	0.78	0.05	0.014				15
4	7.59	0.30	0.133	-	-		20	7.57	0.62	0.76	0.04	0.006	-	-		15
5	7.52	0.31	0.123				20	7.53	0.63	0.78	0.01	0.004				15
6	7.56	0.36	0.127				20	7.57	0.62	0.70	0.06	0.016				15
7	7.60	0.33	0.123				25	7.53	0.58	0.65	0.07	0.012				15
<b>Total or Average</b>	<b>7.56</b>	<b>0.36</b>	<b>0.121</b>	<b>-</b>	<b>-</b>	<b>NT</b>	<b>21</b>	<b>7.54</b>	<b>0.60</b>	<b>0.75</b>	<b>0.05</b>	<b>0.009</b>	<b>-</b>	<b>-</b>	<b>NT</b>	<b>15</b>
<b>Average as Percent of MCL</b>		<b>119.6%</b>	<b>241.5%</b>								<b>16.67%</b>	<b>17.50%</b>				
<b>Average Removal Rate</b>											<b>86.1%</b>	<b>92.75%</b>				

**Non Detect**, indicating the absence of a metal or chemical at or above the method detection limit is shown as "-" and calculated in the total or average as zero.

**Figure 1**  
**Pilot Test Results**  
**Chlorine Dosage and Free Residual Concentrations**  
**Rainier View Water Company, Behm Well 3**  
**November 12, 2013**

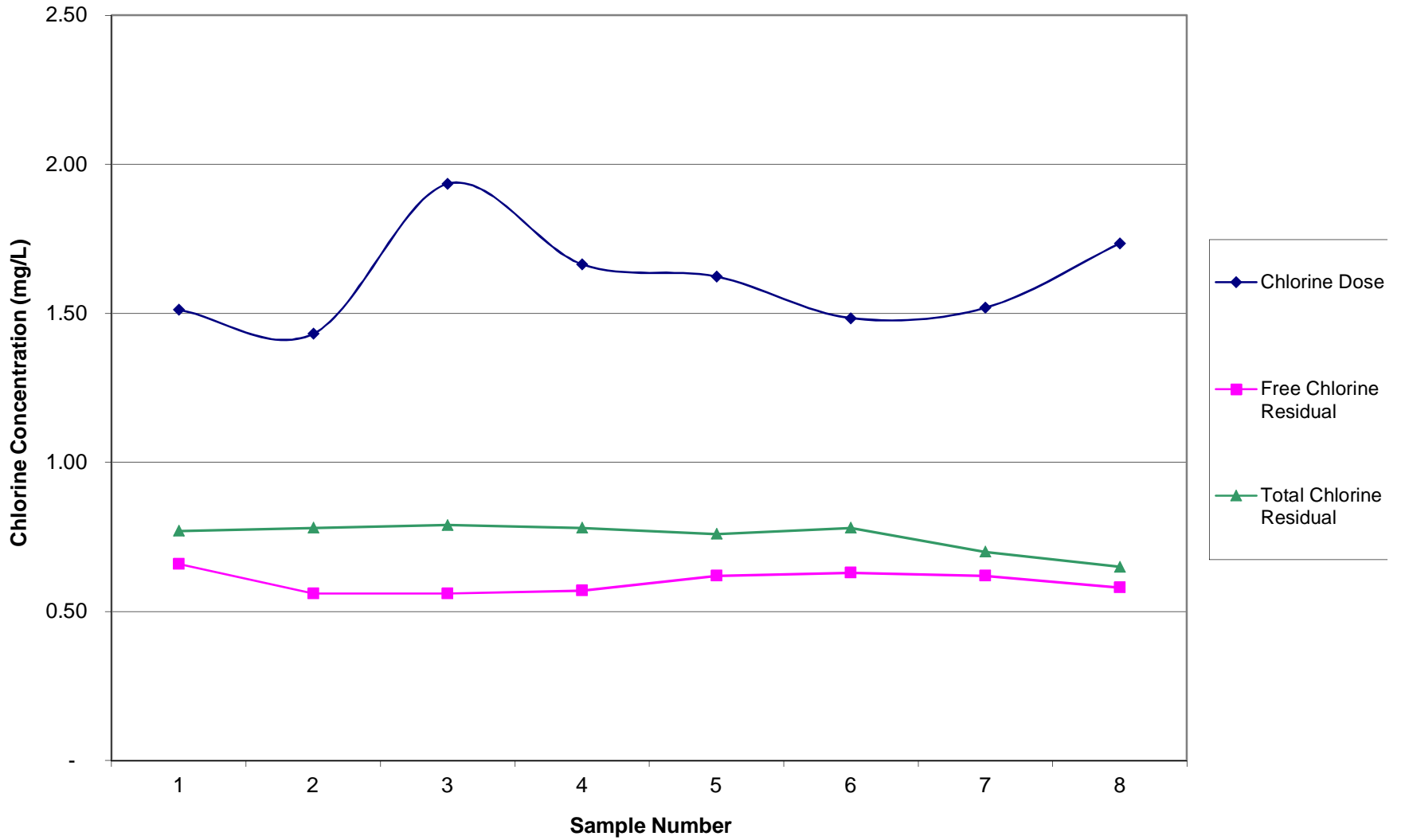


Figure 2  
Pilot Test Results  
Manganese Removal Using AS-741M Filter Media  
Rainier View Water Company, Behm Well 3  
November 12, 2013

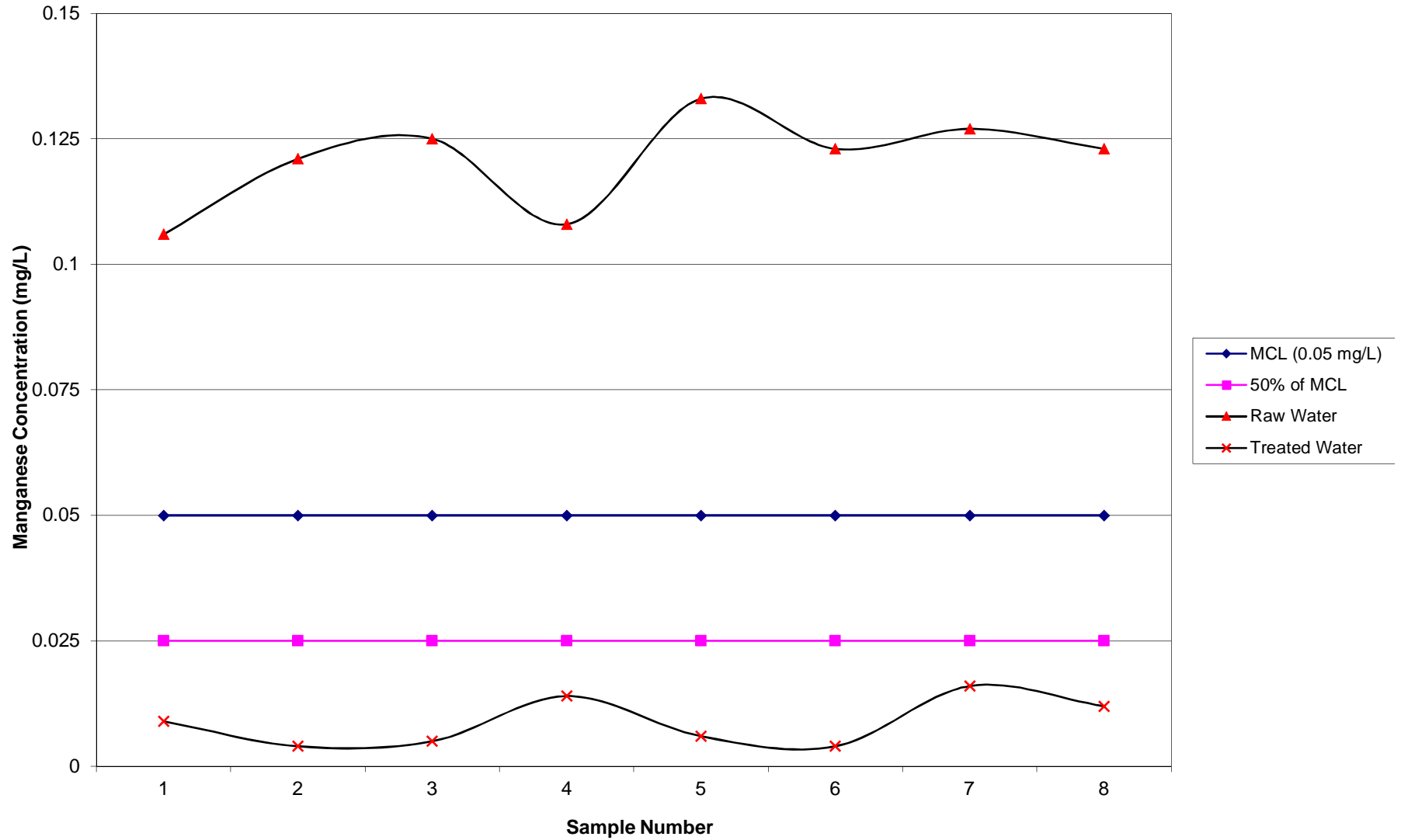
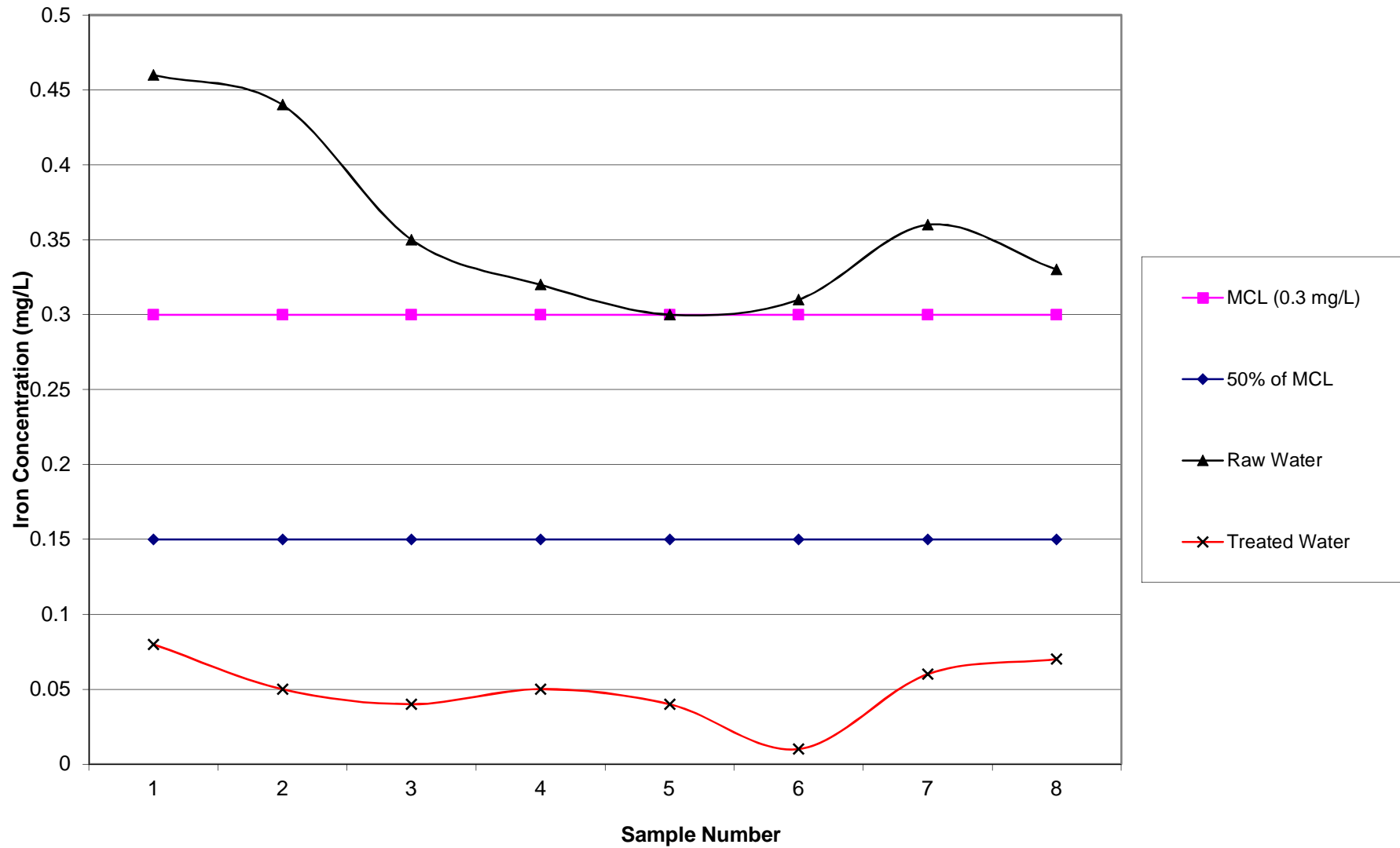
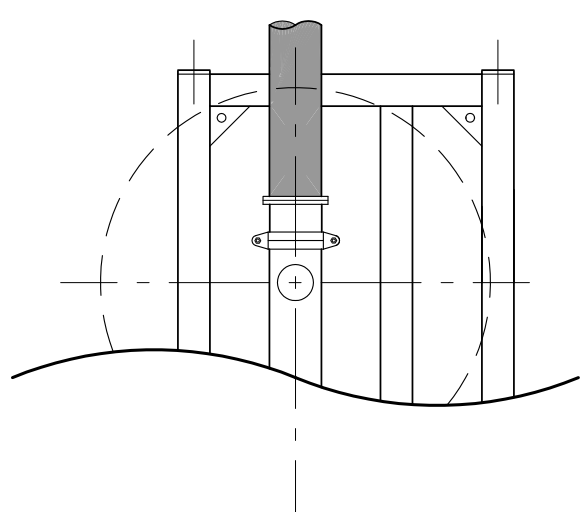


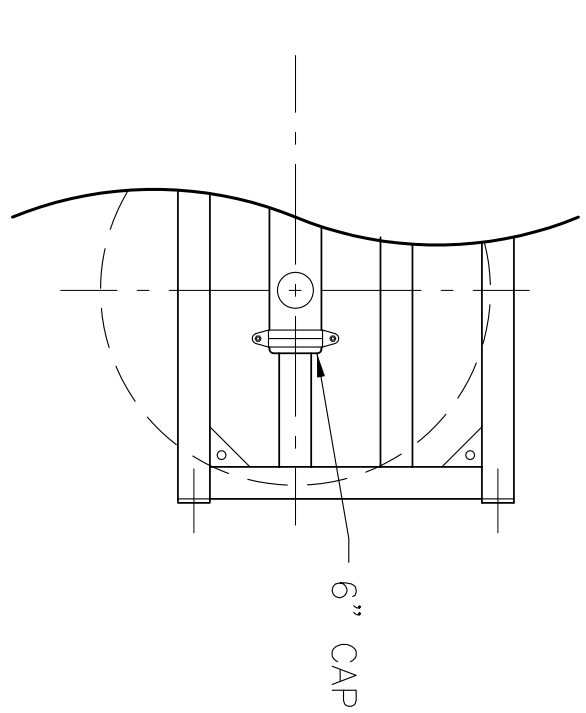
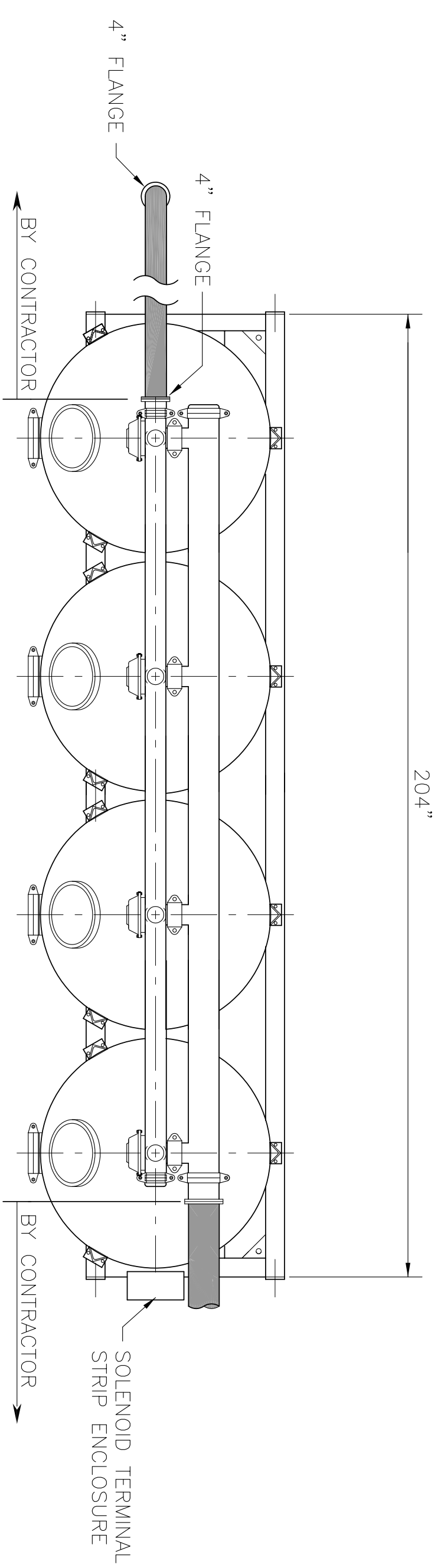
Figure 3  
Pilot Test Results  
Iron Removal Using ATEC AS-741M Filter Media  
Rainier View Water Company, Behm Well 3  
November 12, 2013



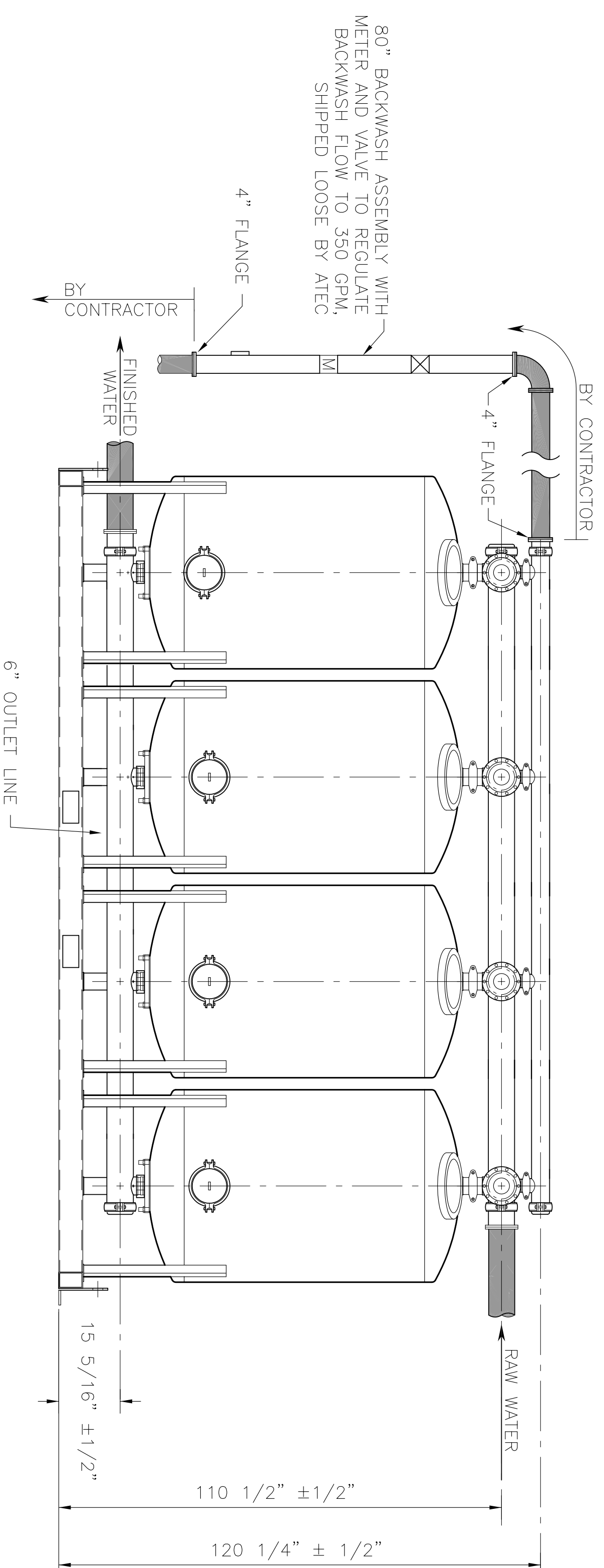




LEFT SIDE, FILTERS REMOVED



RIGHT SIDE, FILTERS REMOVED



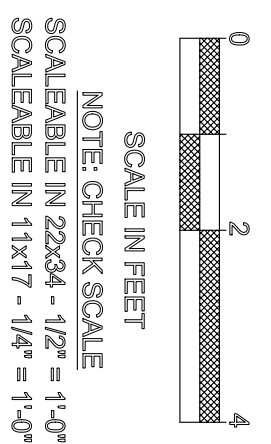
FILTER/SYSTEM INFORMATION	
ITEM	
CAPACITY	. GPM
Fe	mg/L
mN	mg/L
COLOR	
BACKWASH	350 GPM

- NOTES:
- [A] THE FOUR (4) FILTER SYSTEM IS DELIVERED ON (1) FILTER SKID.
  - [B] AIR RELIEF/VACUUM RELIEF VALVE WILL BE SUPPLIED FOR INSTALL ON 2" COUPLING ON INLET LINE.
  - [C] SHADED PIPING BY CONTRACTOR.
  - [D] FILTER PIPING CONNECTIONS WILL BE PROVIDED TO SUIT FIELD CONDITIONS.

**ATEC**  
SYSTEMS ASSOCIATES  
P.O. BOX 10329  
BAINBRIDGE ISLAND, WASHINGTON 98110-0329  
PHONE: (360) 414-9223 FAX: (360) 397-0375

DESIGN BY:	
DRAWN BY:	
CHECKED BY:	
APRD BY:	

NO.	DATE	BY	APVD

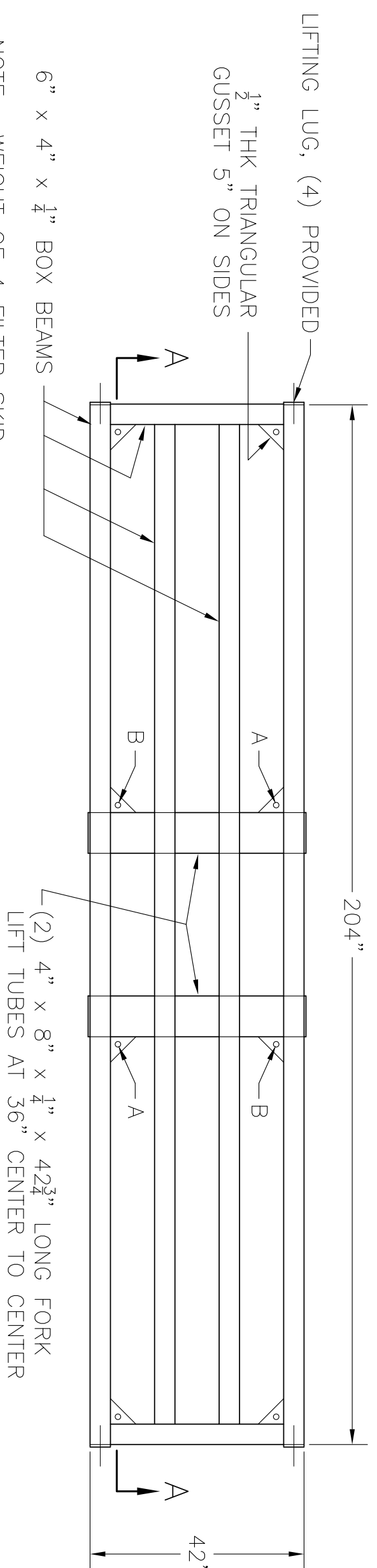


RAINIER VIEW WATER CO.  
BEHM WELL 3  
450 GPM IRON AND MANGANESE  
TREATMENT SYSTEM

FILTER DETAILS

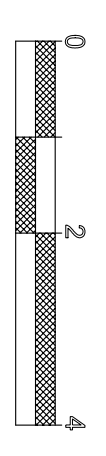
SHEET NO.	1 of 2
DWG. NO.	
DATE:	12-30-2013
FILE:	Filter 48 Inch Behm No 3



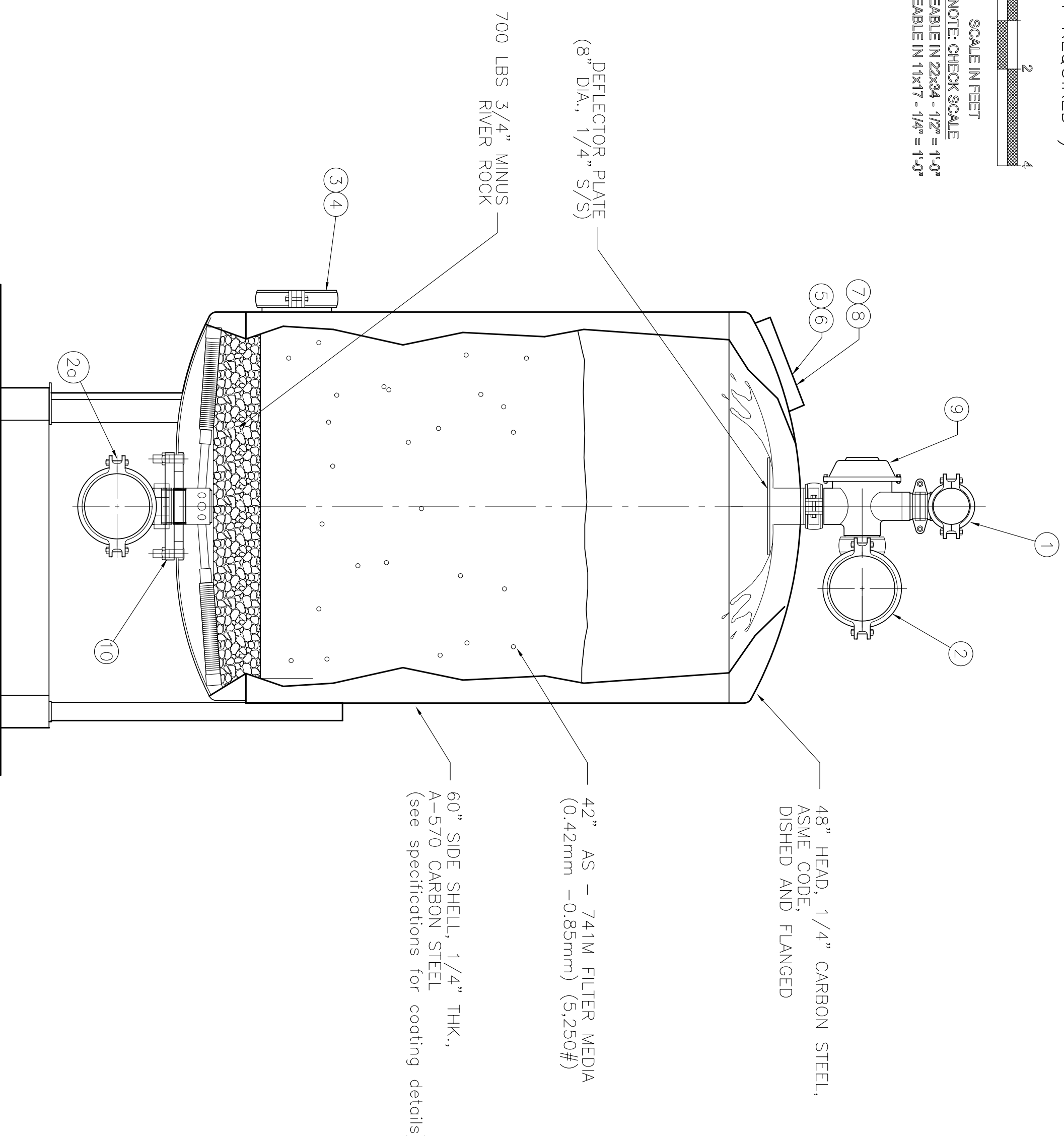


NOTE: WEIGHT OF 4 FILTER SKID:  
WITH MEDIA AND WATER 48,000#

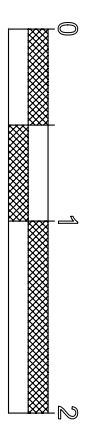
4 FILTER SKID  
( 1 REQUIRED )



SCALE IN FEET  
NOTE: CHECK SCALE  
SCALEABLE IN 22x34 - 1/2" = 1'-0"  
SCALEABLE IN 11x17 - 1/8" = 1'-0"



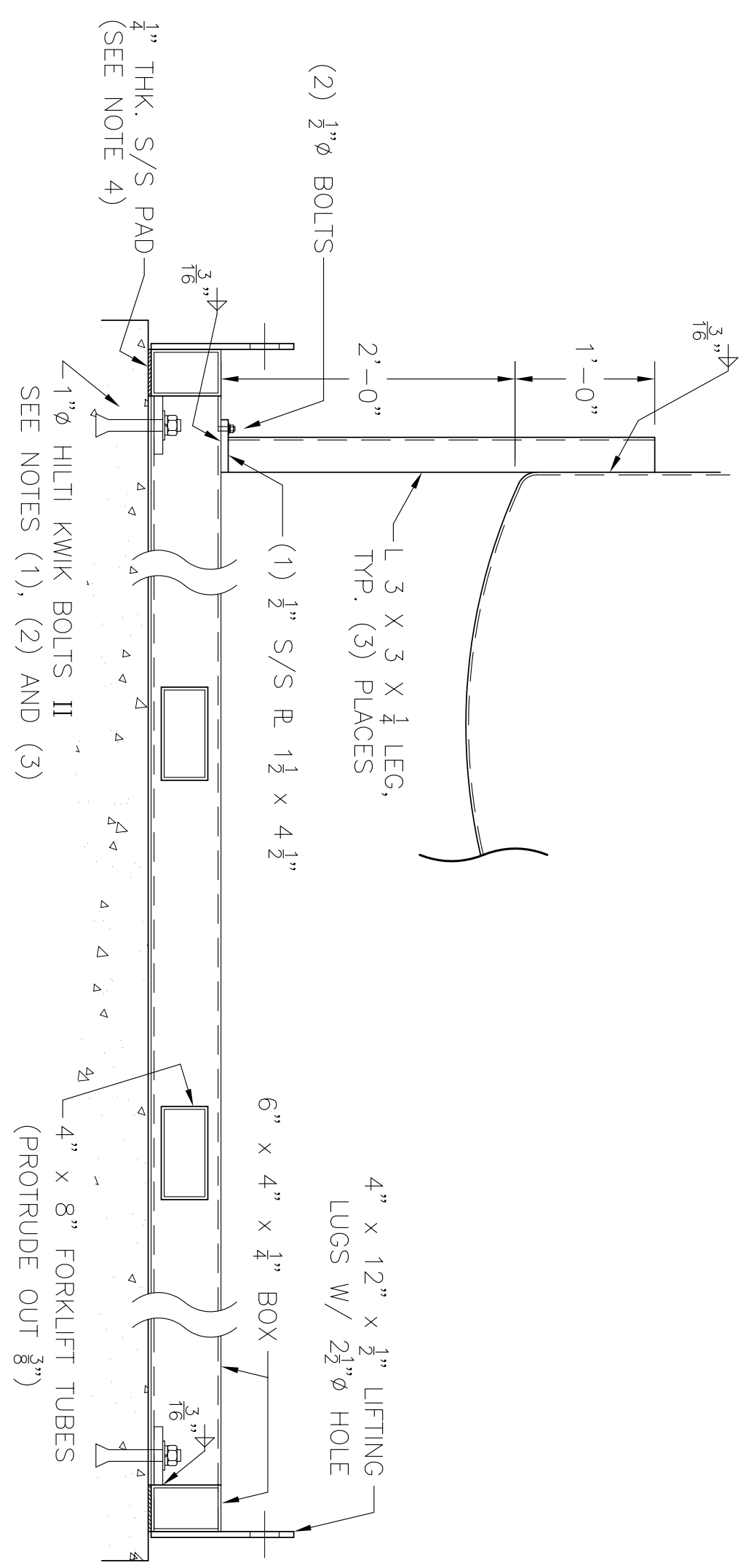
TANK SECTION  
SCALE 1" = 1'-0"



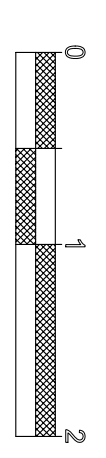
SCALE IN FEET  
NOTE: CHECK SCALE  
SCALEABLE IN 22x34 - 1" = 1'-0"  
SCALEABLE IN 11x17 - 1/2" = 1'-0"

BILL OF MATERIAL		
ITEM	QTY	PART NO. DESCRIPTION
1	1	PFS-CPLO3 4" GROOVED COUPLING, CAST IRON W/ BOLTS & GASKET
2	3	PFS-CPLO4 6" GROOVED COUPLING, CAST IRON W/ BOLTS & GASKET
3	1	PFS-CAPO8 8" GROOVED END CAP
4	1	PFS-CPLO8 8" GROOVED COUPLING, CAST IRON W/ BOLTS & NUTS
5	1	PFS=HHP11 11"x15" HAND HOLE PLATE
6	1	PFS=HHQ11 11"x15" HAND HOLE GASKET
7	1	PFS=HHQS11 11"x15" HAND HOLE BOLT SET
8	1	PFS=HHRT11 11"x15" HAND HOLE HOLD DOWN GRAB
9	1	V-BF4 4"x4"x3" SERIES 350 BERHAD BACKWASH VALVE
10	1	UA SS48 UNDER-DRAIN ASSEMBLY 31BL SS W/ SOH 80 PVC CAP COMPLETE

NOTE: QUANTITIES FOR ONE (1) TANK



SECTION A-A  
SCALE 1" = 1'-0"



SCALE IN FEET  
NOTE: CHECK SCALE  
SCALEABLE IN 22x34 - 1" = 1'-0"  
SCALEABLE IN 11x17 - 1/2" = 1'-0"

**ATEC**  
SYSTEMS ASSOCIATES  
P.O. BOX 10329  
BAINBRIDGE ISLAND, WASHINGTON 98110-0329  
PHONE: (360) 414-9223 FAX: (360) 397-0375

DESIGN BY:	
DRAWN BY:	
CHECKED BY:	
APRD BY:	

NO.	DATE
BY	APVD

SCALE AS NOTED  
RAINIER VIEW WATER CO.  
BEHM WELL 3  
450 GPM IRON AND MANGANESE  
TREATMENT SYSTEM

FILTER DETAILS  
SHEET NO. 2 of 2  
DWG. NO.  
DATE: 12-30-2013  
Rainier 48 Inch Behm No 3