ATEC
SYSTEMS ASSOCIATES

DATE: January 9, 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, Muck Creek Wells 1 and 2

Dear Mr. Warner,

ATEC Systems Associates, Inc. pilot tested Rainier View Water Company's Muck Creek Wells 1 and 2. The objective was to determine the efficacy of the ATEC system in removing iron and manganese from the water of 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 60 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_2S and ammonia concentrations in the raw and finished water.

Based on the results of the pilot testing, a system comprised of (4) 18-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 the designer may revise the points of connection to suit site 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

ATEC 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.

Ammonia and H_2S can also be the cause of taste and odor problems. The ATEC system will also reduce the concentrations of these constituents, if present.

General Description of the ATEC Iron, Manganese Removal Process

ATEC 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. The presence of H_2S, ammonia, and/or organic matter (organic carbon) can make iron and manganese removal more difficult.

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, Muck Creek Wells 1 and 2 Wells

As given in Tables 3 and 4 and shown in Figures 1, 2, and 3 in this report, iron concentrations varied from 0.010 mg/L to 0.410 mg/L, averaging 0.100 mg/L, about 34 percent of the SMCL of 0.300 mg/L. Manganese concentrations in the raw water varied from 0.190 mg/L to 0.241 mg/L, averaging 0.198 mg/L or close to four times the SMCL of 0.050 mg/L.

Two samples hydrogen sulfide were taken, one at 0.008 mg/L and a second at 0.009 mg/L.

Two samples of ammonia were taken, one at 0.130 mg/L and a second at 0.190 mg/L.

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

The following table summarizes the raw water quality of the wells at the Rainier View Water Company, Muck Creek Wells 1 and 2.

Rainier View Water Company, Muck Creek Wells 1 and 2 Wells
Raw Water Quality

Parameter	Low	High	Average
Iron	0.010 mg/L	0.410 mg/L	0.100 mg/L
Manganese	0.190 mg/L	0.241 mg/L	0.198 mg/L
H_2S	0.008 mg/L	0.009 mg/L	0.009 mg/L
Ammonia	0.130 mg/L	0.190 mg/L	0.160 mg/L

Pilot Test Results, Rainier View Water Company, Muck Creek Wells 1 and 2 Wells

Pilot testing was performed on November 14, 2013. A total of 15 samples were taken over a period of 7 hours. Breakthrough, which would have been indicated by the spike in finish water iron and manganese concentrations, did not occur during the test.

Influent flow was varied from a low of 3.44 gpm to a high of 8.30 gpm corresponding to loading rates of 4.38 gpm/sqft and 10.57 gpm/sqft with an average loading rate of 9.63 gpm/sqft.[1]

Chlorine was added to the influent water in varying amounts from a low of 1.16 mg/L to a high of 2.79 mg/L, averaging 1.76 mg/L. Total Chlorine concentration in the finish water varied from a low of 0.90 mg/L to a high of 1.73 mg/L, averaging 1.19 mg/L. Chlorine demand averaged 0.57 mg/L.

In order for the media to remain charged, it is necessary to maintain a residual chlorine concentration and we recommend a free chlorine residual of no less than 0.60 mg/L after filtration.

Finish water iron concentrations varied from Non-detect to 0.170 mg/L, averaging 0.020 mg/L, about 8 percent of the 0.300 mg/L SMCL.

Finish water manganese concentrations varied from 0.001 mg/L to 0.033 mg/L, averaging 0.011 mg/L, about 21 percent of the SMCL of 0.05 mg/L.

Two finish water samples of ammonia were taken at non-detect.[2] As well, two samples of hydrogen sulfide were taken, both at non-detect.

The taste of the finish water was reported as good.

The following table summarizes the pilot testing of the Rainier View Water Company, Muck Creek Wells 1 and 2.

[1] Area of the filter testing equipment is 0.784 sqft.

[2] Oxidation by chlorine can remove ammonia from water. When chlorine is added to water containing ammonia the ammonia initially reacts with hypochlorous acid to form chloramines. Continued contact with chlorine after the "breakpoint" when free chlorine forms, converts the chloramines to nitrogen gas.

Rainier View Water Company, Muck Creek Wells 1 and 2
Pilot Test Summary

Parameter	Low	High	Average	Percent of SMCL
Iron	Non-detect	0.170 mg/L	0.020 mg/L	8.22 %
Manganese	0.001 mg/L	0.033 mg/L	0.011 mg/L	21.07 %
Loading Rate	4.38 gpm/sqft	10.57 gpm/sqft	9.63 gpm/sqft	-

Recommended System

At the 60 gpm required capacity, the recommended system of (4) 18-inch diameter filters would have a loading rate of 8.52 gpm/sqft during production and 11.36 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 3-inch inlet and outlet manifolds, 3-inch backwash line, and a 120 VAC automatic controller. Also available and shipped loose by ATEC Systems, may be a 3-inch backwash assembly 60-inches long, which has a threaded port for a sight glass, and provisions for a backwash meter to set the backwash at the correct rate of 49 gpm (28 gpm/sqft).

ATEC guarantees this system will remove iron and manganese to or less than one-half their respective SMCLs.

Backwash

Based on ATEC's experience with similar water, we expect that the backwash interval proven with experience could be set at 24 hours of production.

The required backwash rate for the media is 28 gpm/sf, or 49 gpm for the 18-inch filters recommended. The gate valve provided in a backwash assembly is used to set the flow to that rate.

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 49 gpm of the amount the well pump produced would be used for backwash and the remainder would be provided to the system.

The well operates at low pressure, recorded at the time of the test at 7 psi. In order to regulate backwash, a minimum of 30 - 40 psi is required. Therefore, the designer must provide a pressure sustaining valve in the treated water piping that would be activated to provide the minimum pressure when the system is in backwash. The designer should also determine that at least 49 gpm can be provided by the well pump under the additional head.

Operating Characteristics of the Recommended Filter System

Parameter	Value
Production Rate	60 gpm
Loading Rate	8.52 gpm/sqft
Backwash Rate	28 gpm/sqft
Backwash Flow	49 gpm
Backwash Duration	5-minutes per filter
Maximum Backwash Frequency	24 hours of production
Backwash Amount	980 gallons
Production Between Backwash Cycles	86,400 gallons
Backwash as a Percentage of Production	1.13 %

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

Pilot Filters[1]	
Sidewall Height (inches)	48 to 60
Overall Height (inches)	62 to 74
Diameter (inches)	6
Filter Surface Area (each) ($ft.^2$)	0.1964
Total Filter Surface Area (ft^2)	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
Filter Media[2]	
Depth in Filters (inches)	36 to 48
Volume in Filters (ft^3)	2.36 to 3.15
Approximate Weight in Filters (lbs.)	285
Weight (lbs./ft^3)	120.5
Physical Size (mm)	0.32 –to-0.85
Maximum Removal Capacity	
Iron Removal (mg/L)	10
Manganese Removal (mg/L)	10
Hydrogen Sulfide Removal (mg/L)	5
Non-Adsorptive Removal (microns)	>20
Chemical Dosing Equipment[3]	
Stenner Peristaltic Solution Metering Pumps (up to 17.0 gpd @ 100 psi)	
LMI Solution Metering Pumps (various capacities)	
Analytical Equipment	
See following page.	

1/ 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^2 of filter area) and volume (gpm/ft^3 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".

2/ 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.

3/ 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' x6½'.

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, Muck Creek Wells 1 & 2
November 14, 2013

Date	Sample Number	Time	Meter Reading (Gallons)	Average Flow (gpm)	Loading Rate (gpm/ft^2)	Loading Rate (gpm/ft^3)	Media Contact Time (Minutes)	Cl_2 Dose (mg/L)	Temp ^oC
11/14	Start	8:30	-	7.90	10.06	2.87	3.31	1.21	10.0
	1	9:00	249.0	8.30	10.57	3.02	2.13	1.16	10.1
	2	9:30	479.5	7.68	9.78	2.80	2.30	1.25	10.1
	3	10:00	709.4	7.66	9.76	2.79	2.30	1.25	10.2
	4	10:30	944.8	7.85	9.99	2.85	2.25	1.22	10.3
	5	11:00	1,189.9	8.17	10.40	2.97	2.16	1.17	10.3
	6	11:30	1,436.1	8.21	10.45	2.99	2.15	1.17	10.3
	7	12:00	1,642.5	3.44	4.38	1.25	5.13	2.79	10.5
	8	12:30	1,869.5	7.57	9.63	2.75	2.33	1.27	10.3
	9	13:00	2,109.0	7.98	10.16	2.90	2.21	1.20	10.3
	10	13:30	2,373.3	8.81	11.22	3.20	2.00	2.22	10.3
	11	14:00	2,589.5	7.21	9.18	2.62	2.45	2.71	10.3
	12	14:30	2,830.0	8.02	10.21	2.92	2.20	2.44	10.3
	13	15:00	3,035.2	6.84	8.71	2.49	2.58	2.86	10.2
	14	15:30	3,269.2	7.80	9.93	2.84	2.26	2.50	10.3
	Total or Average		**3,269.20**	7.56	9.63	2.75	2.52	1.76	10.3

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

55-60 gpm (pumped at 45 gpm, 62 psi), < 7 psi
Used 42" AS-741 media
Sodium Hypochlorite titrated @ 3196.8
BW start of the test
Used Rochelle Salts beginning at 11:30
Hardness = 78 mg/L as $CaCO_3$

Table 4
Summary of Pilot Test Results
Rainier View Water Company, Muck Creek Wells 1 & 2
November 14, 2013

	Source Water							Product Water								
Sample Number	**pH (Units)**	**Fe (mg/L)**	**Mn (mg/L)**	**H_2S (mg//L)**	**Ammonia (mg//L)**	**Silica (mg/L)**	**PSI**	**pH (Units)**	**Cl_2 (F) (mg/L)**	**Cl_2 (T) (mg/L)**	**Fe (mg/L)**	**Mn (mg/L)**	**H_2S (mg//L)**	**Ammonia (mg//L)**	**Silica (mg/L)**	**PSI**
Start	**8.12**	0.41	0.241				19	**7.98**	**0.86**	**0.93**	0.17	0.033				15
1	**7.92**	0.16	0.209				23	**7.74**	**0.99**	**1.02**	0.05	0.012				19
2	**7.79**	0.12	0.198			36.20	23	**7.78**	**0.85**	**0.92**	0.02	0.012			37.40	19
3	**7.72**	0.15	0.196				24	**7.72**	**0.86**	**0.93**	0.05	0.019				21
4	**7.71**	0.14	0.190				24	**7.72**	**0.88**	**0.94**	0.06	0.013				19
5	**7.72**	0.08	0.198			37.20	23	**7.51**	**0.91**	**1.01**	0.01	0.010			37.90	19
6	**7.70**	0.06	0.195				23	**7.50**	**0.93**	**1.09**	-	0.005				19
7	**7.68**	0.06	0.192				22	**7.68**	**0.96**	**1.03**	-	0.004				19
8	**7.76**	0.02	0.195				23	**7.20**	**0.92**	**0.90**	-	0.006				19
9	**7.74**	0.06	0.190	0.009			23	**7.72**	**0.93**	**1.11**	-	0.004	-			20
10	**7.75**	0.09	0.195				23	**7.72**	**1.21**	**1.14**	-	0.001				19
11	**7.73**	0.06	0.190		0.190		23	**7.75**	**1.58**	**1.70**	-	0.010		-		19
12	**7.26**	0.01	0.195	0.008			22	**7.21**	**1.53**	**1.72**	0.01	0.008	-			18
13	**7.22**	0.03	0.192		0.130		22	**7.73**	**1.56**	**1.72**	-	0.010		-		18
14	**7.76**	0.06	0.199				22	**7.76**	**1.55**	**1.73**	-	0.011				19
Total or Average	**7.71**	**0.10**	**0.198**	**0.009**	**0.160**	**36.70**	**23**	**7.65**	**1.10**	**1.19**	**0.02**	**0.011**	**-**	**-**	**37.65**	19
Average as Percent of MCL		***33.6%***	***396.7%***								***8.22%***	***21.07%***				
Average Removal Rate											***75.5%***	***94.69%***				

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, Muck Creek Wells 1 2
November 14, 2013

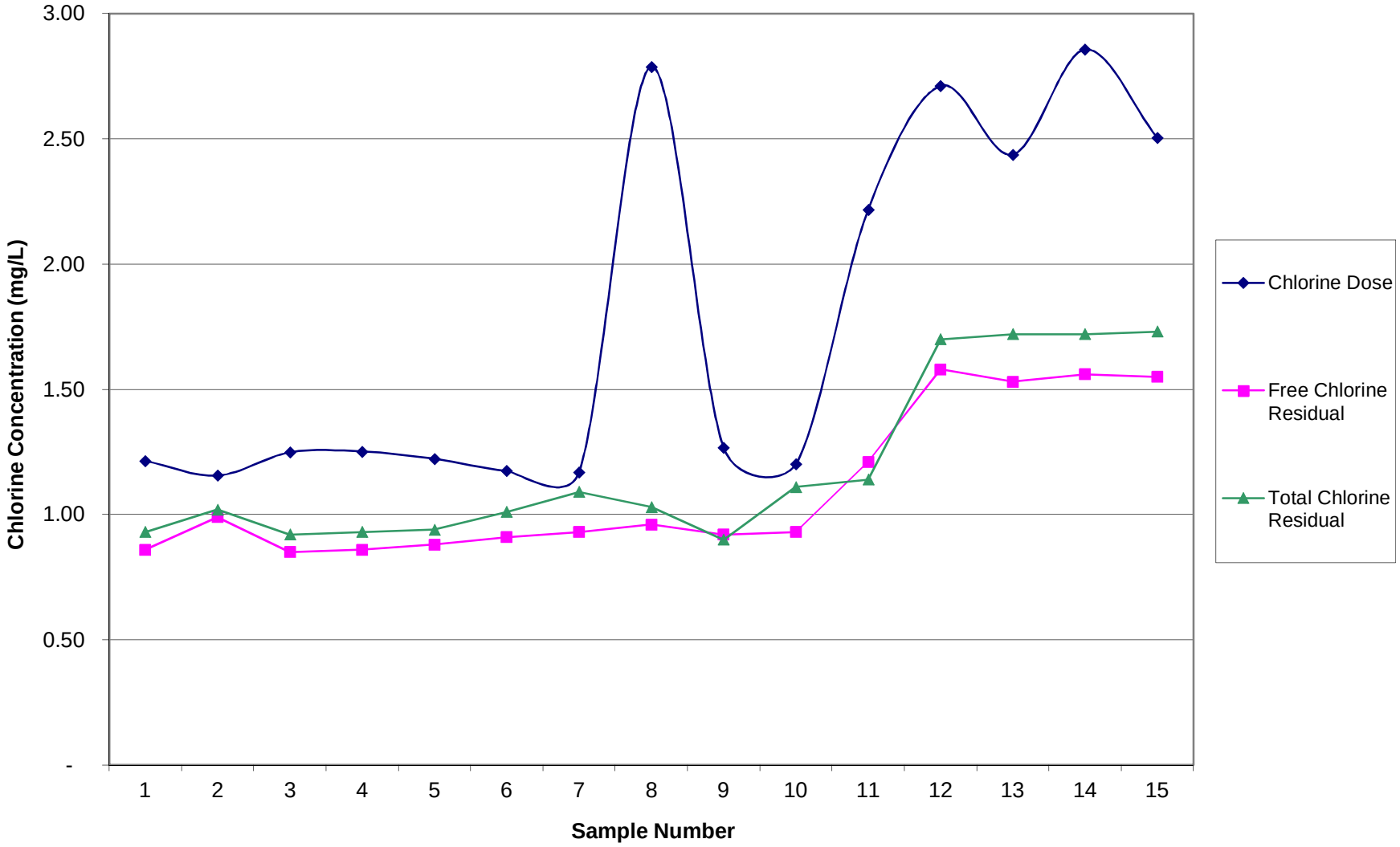


Figure 2
Pilot Test Results
Manganese Removal Using AS-741M Filter Media
Rainier View Water Company, Muck Creek Wells 1 2
November 14, 2013

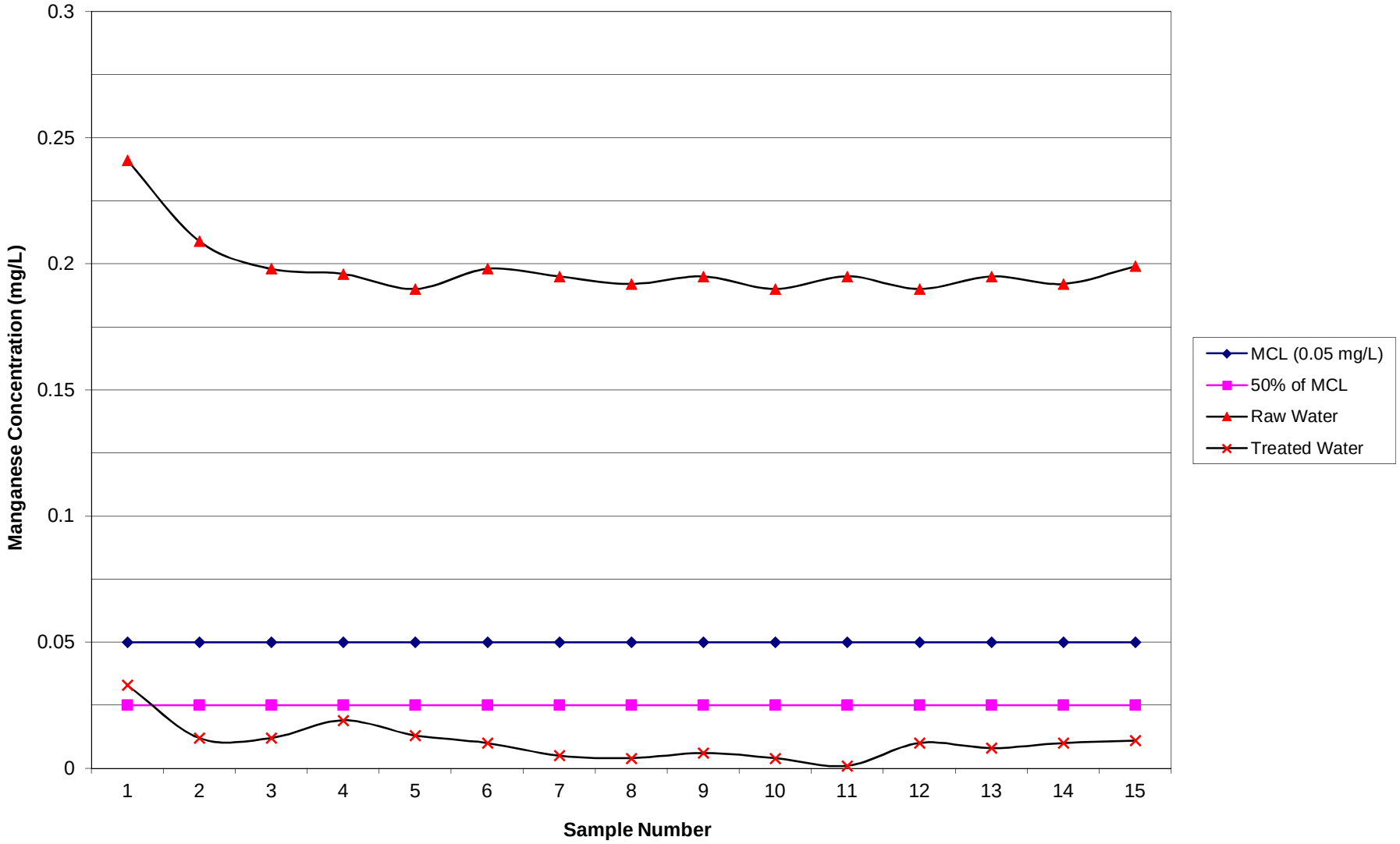
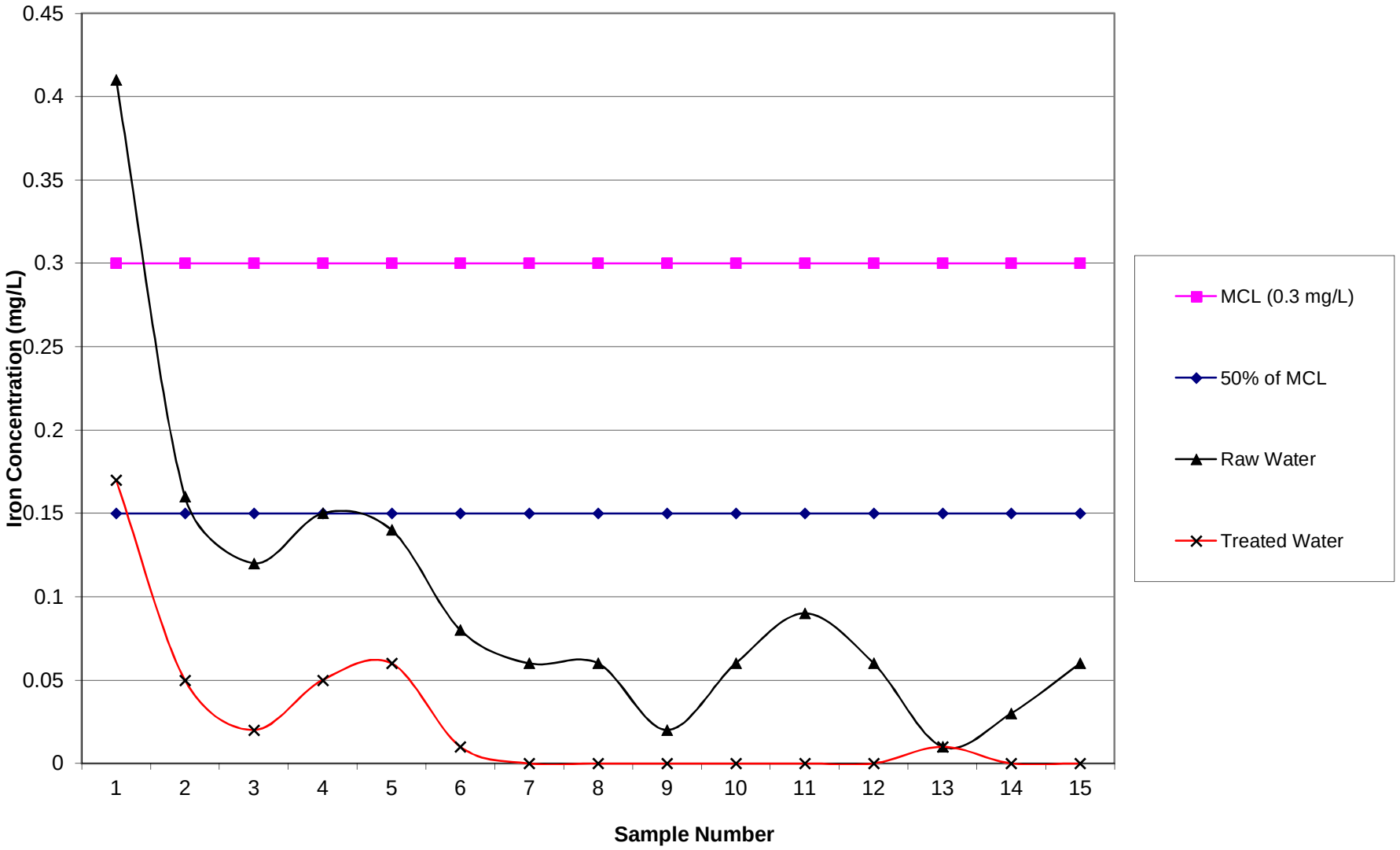
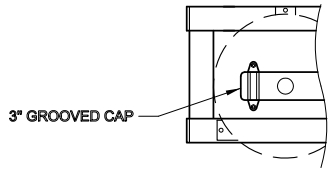


Figure 3
Pilot Test Results
Iron Removal Using ATEC AS-741M Filter Media
Rainier View Water Company, Muck Creek Wells 1 2
November 14, 2013

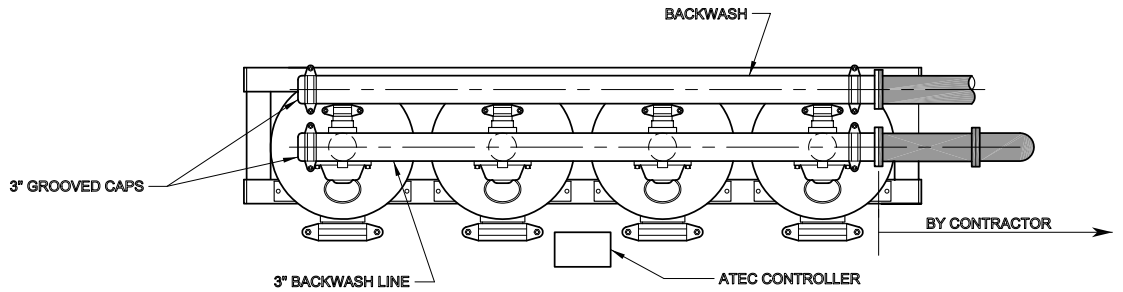


NOTE: ATEC CONTROLLER IS SHIPPED LOOSE FOR INSTALLATION AT FIELD-DETERMINED LOCATION.

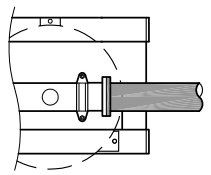
FLOW METER TO BE PROVIDED BY OTHERS AND INSTALLED PER MANUFACTURER'S RECOMMENDATIONS.



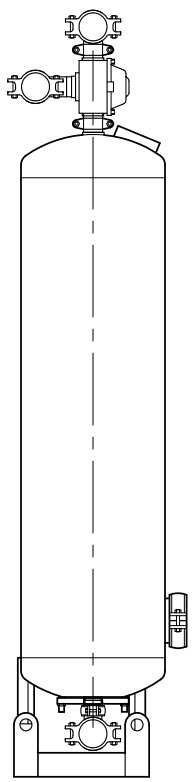
LEFT SIDE
FILTERS REMOVED



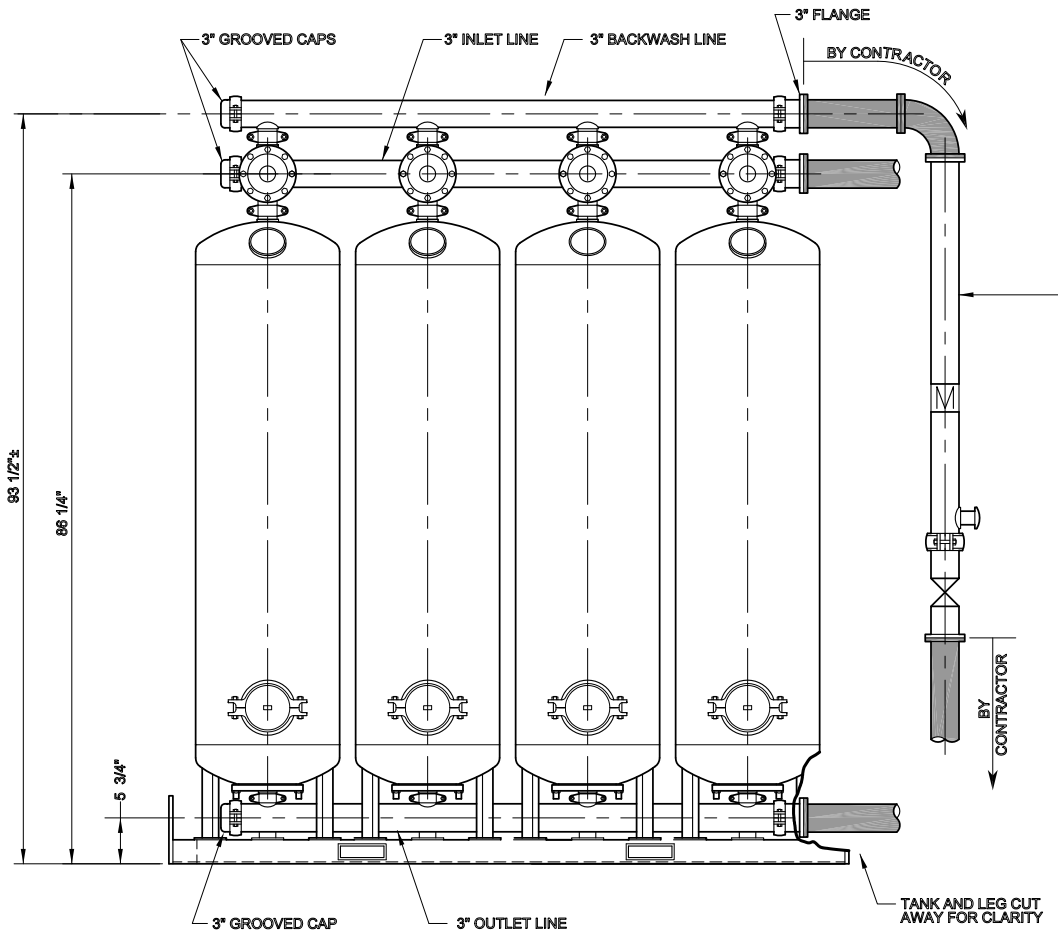
PLAN VIEW



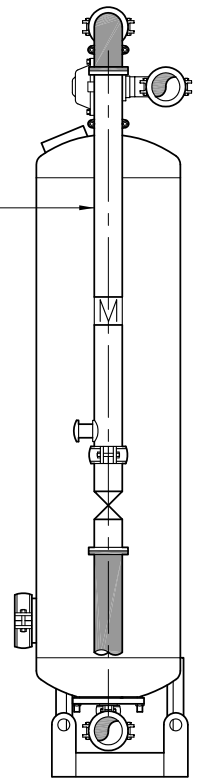
RIGHT SIDE
FILTERS REMOVED



LEFT ELEVATION



FRONT ELEVATION



RIGHT ELEVATION

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:	.
APR'D BY:	.

NO.	DATE		BY	APVD

0 1 2
SCALE IN FEET

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

RAINIER WATER CO.
MUCK CREEK WELLS 1 & 2
IRON AND MANGANES TREATMENT SYSTEM
60 GPM

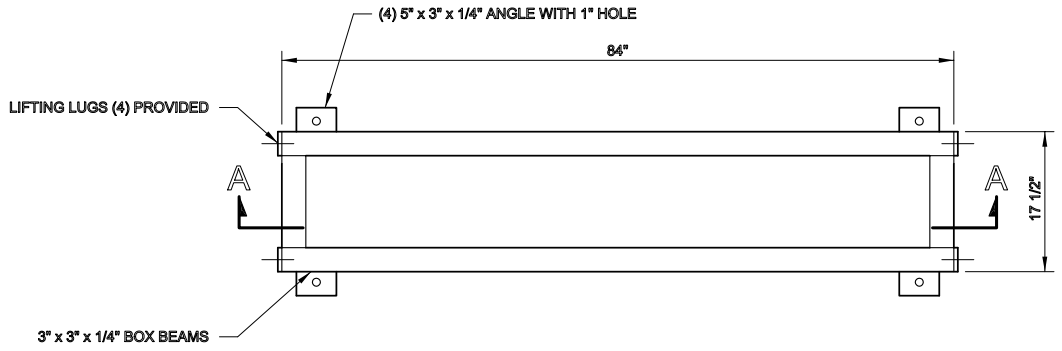
FILTER PLAN
& ELEVATIONS

SHEET NO. 1 of 2
DWG. NO.
DATE: 01-01-14
FILE: Rainier Muck Creek 1 & 2

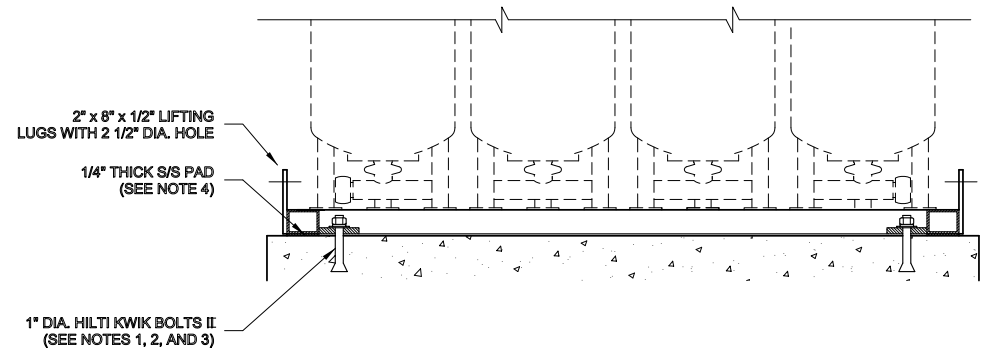
BILL OF MATERIALS

ITEM			
1	4	PFS-CPL02	3" GROOVED COUPLING, CAST IRON W/ BOLTS & GASKET
2	1	PFS-CAP05	3" GROOVED COUPLING
3	1	PFS=HHP6	6"x8" HAND HOLE PLATE
4	1	PFS-HHG6	6"x8" HAND HOLE GASKET
5	1	PFS-HHBS6	6"x8" HAND HOLE BOLT SET
6	1	PFS-HHCR6	6"x8" HAND HOLE HOLD DOWN CRAB
7	1	V-BBF2	2"x2"x2" BACKFLUSH VALVE, BERMAD
8	1	UASS18	UNDER-DRAIN ASSEMBLY 316L S.S. W/ SCH 80 CAP COMPLETE
9	1	73PP9YZCM24VAC	SOLENOID VALVE, PETER PAUL(NOT SHOWN)
10	1	PFS-CPL05	8" GROOVED COUPLING, CAST IRON, W/BOLTS & GASKET
11	1	PFS-CA08	8" GROOVED END CAP

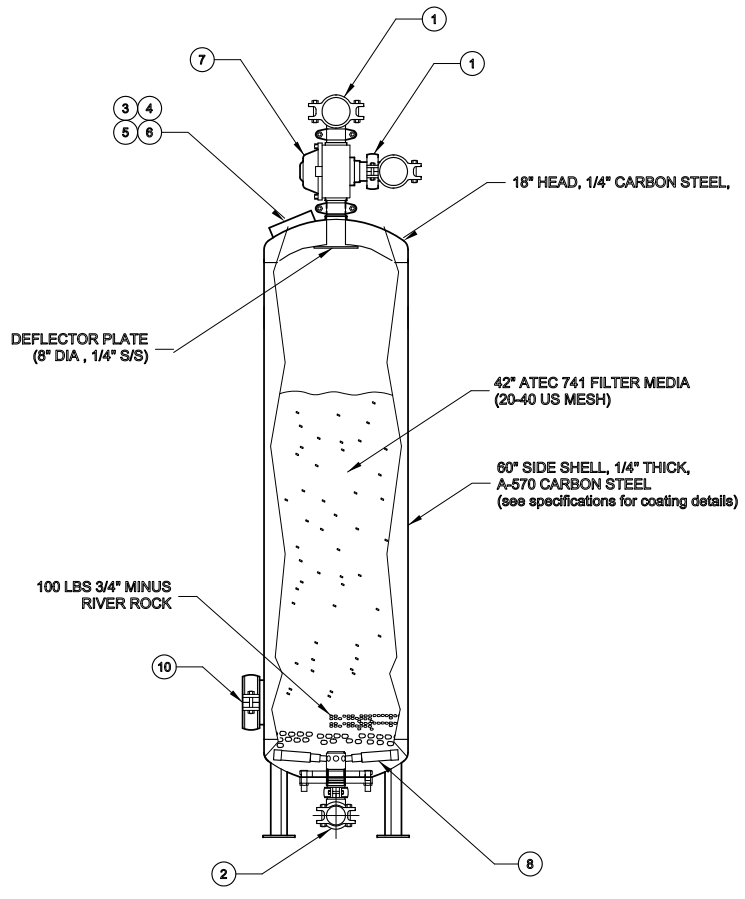
NOTE: QUANTITIES SHOWN ARE FOR (1) ONE TANK



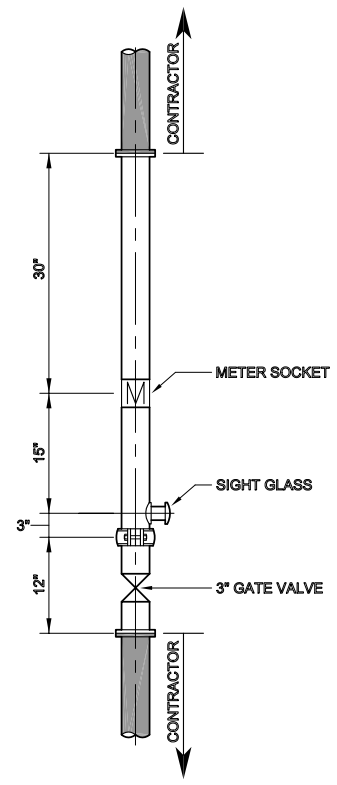
4-FILTER SKID PLAN
ONE REQUIRED



SECTION A-A



SECTION THROUGH TANK



BACKWASH ASSEMBLY
(SHIPPED LOOSE)

NOTE: METER AND VALVE TO BE SHIPPED LOOSE FOR BACKWASH ADJUSTMENT

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: .
APR'D BY: .

NO.	DATE		BY	APVD

0 1 2
SCALE IN FEET

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

RAINIER WATER CO.
MUCK CREEK WELLS 1 & 2
IRON AND MANGANES TREATMENT SYSTEM
60 GPM

FILTER DETAILS

SHEET NO. 2 of 2
DWG. NO.
DATE: 01-01-14
FILE: Rainier Muck Creek 1 & 2