MWD
METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

Weymouth Water Treatment Plant

Filter Rehabilitation Project Conceptual Design

Final Technical Memorandum

MWH Project No. 10503518
Agr. 136698 TO-2

MWH

Metropolitan Water District of Southern California

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LIST OF ABBREVIATIONS

Abbreviation	Description
AMSL	Above Mean Sea Level
CFE	Combined Filter Effluent
CPVC	Chlorinated Polyvinyl Chloride
DP	Differential Pressure
EL	Elevation
FB1	Filter Building 1
FB2	Filter Building 2
FF	Finished Floor
FRP	Fiberglass-Reinforced Plastic
HDPE	High-Density Polyethylene
HGL	Hydraulic Grade Line
HWL	High Water Level
LP	Low Profile (a type of proprietary underdrain block)
LWL	Low Water Level
mgd	Million Gallons per Day
MWD	Metropolitan Water District of Southern California
NTU	Nephelometric Turbidity Unit
NAVD88	North American Vertical Datum of 1988
OPCC	Opinion of Probable Construction Cost
PVC	Polyvinyl Chloride
RFC	Rate-of-Flow Controller
SCADA	Supervisory Control and Data Acquisition
SG	Specific Gravity
Study	F. E. Weymouth WTP Filter Rehabilitation Study
TM	Technical Memorandum
TOC	Top of Concrete
TOM	Top of Media
TOW	Top of Wall
UC	Uniformity Coefficient
UFRV	Unit Filter Run Volume
WTP	Water Treatment Plant

Section 1
Introduction and Background

The dual-media filters at the F.E. Weymouth Water Treatment Plant (WTP) are to be rehabilitated for improved performance and operational longevity. This Technical Memorandum (TM) will lay out the required elements of this rehabilitation and establish the design criteria that will be utilized for the detailed design.

1.1 BACKGROUND

The Metropolitan Water District of Southern California (MWD) owns and operates the Weymouth WTP, located in La Verne, CA. This plant is rated for a peak capacity of 520 million gallons per day (mgd), and typically treats a flow of around 200-300 mgd.

The Weymouth plant has a total of 48 individual filters, which were built in different stages. Filters #1 through #12 were part of the original Weymouth WTP construction and went into service in 1941. Filters #13 through #24 were added in 1949 as part of Expansion No. 1, and Filters #25 through #48 were completed in 1962 as part of Expansion No. 2. The filters are divided between two buildings: Filters #1 through #24 are in Filter Building 1 (FB1), while Filters #25 through #48 are in Filter Building 2 (FB2).

The existing filters utilize a dual-media design with layers of anthracite and sand on top of gravel and clay pipe or concrete teepee underdrains. Filtration follows the coagulation, flocculation, and sedimentation processes at this plant. The filters treat settled water to produce effluent with very low turbidity. During the filtration cycle, the water level in the filter influent channel is held at a constant setpoint, and electrically actuated rate-of-flow control valves regulate the flow through each filter. The filters are cleaned with a combination of surface wash and water-only backwash, with flow provided by gravity from one of two storage tanks. The filters do not employ air scour during backwash or a filter-to-waste cycle after cleaning,

MWD prepared a report entitled "F. E. Weymouth Water Treatment Plant Filter Rehabilitation Study" in December 2013. That report (hereinafter referred to as the "Study") was a culmination of a demonstration testing project to investigate the cause of several operational problems with the Weymouth filters, including deteriorating performance and media loss. As part of the Study, four filters were rehabilitated with various configurations of underdrains, troughs, surface wash, and media, and their performance was closely monitored along with several unmodified "control" filters over the course of a year. As a result of the Study recommendations, MWD will rebuild all filters at the Weymouth WTP.

1.2 FILTER REHABILITATION OVERVIEW

The main objective of this project is to rehabilitate the filters at the Weymouth WTP for reliable and improved performance, and achieve a consistent installation across both filter buildings and

all 48 filters. The filters should be designed to be very robust and long-lasting, with features of the rehabilitation expected to have a life cycle of 50 years or more.

This project will mainly cover internal features of the filter box, along with process instrumentation and site features around the filter buildings. Other items associated with the filtration process, mainly mechanical equipment, will be refurbished in a separate Filter Valve Rehabilitation Project. Since the Filter Valve Rehabilitation Project is to be completed after this project, there is the potential that leaking valves may become a construction issue this project. Addressing these leaking valves is not an element of this rehabilitation project. Elements of this rehabilitation project include:

- Underdrain replacement
- Filter media replacement
- Backwash trough replacement
- Partial demolition and reconstruction of gullet walls
- Structural rehabilitation, including concrete repair, seismic bracing of walkways, and drain chute replacement
- Surface wash system replacement
- Demolition of the surface spray system in each filter box
- Lower gullet air vent and access hatch replacement
- Rehabilitation of the upper gullet baffles
- Replacement of some differential pressure cells and installation of new pressure sensors for the filter effluent channel and backwash header
- Demolition of filter box lighting
- Site handrail replacement
- Demolition of sand pan drains
- Replacement of access hatch covers

The filtration process design criteria and hydraulics are discussed in **Section 2**, and the elements listed above are described in detail in **Section 3**. Important considerations for construction sequencing are found in **Section 4**. Finally, an updated Opinion of Probable Construction Cost (OPCC) is provided in **Section 5**.

Section 2
Filtration Process

This section summarizes the information that will serve as a basis for the final design. This includes the six existing filter configurations; the process design criteria used for the rehabilitation design; and hydraulic considerations for filtration and backwash.

2.1 EXISTING CONDITIONS

All the filters operate the same way during filtration, and they have the same horizontal layout with two cells (13 feet 4 inches by 72 feet 6 inches each cell) on either side of a central gullet. The surface of each filter is approximately 1,933 ft^2. FB1 filters receive settled water from Sedimentation Basins 1 through 4, and FB2 receives settled water from Sedimentation Basins 5 to 8. No additional chemicals such as filter aid polymer or backwash conditioning polymer are added for the filtration process. The influent water enters from the filter influent channel through the inlet pipe. The water flows through the filter media, reaches the underdrain, and is conveyed to the lower gullet. The lower gullet then discharges into the filter effluent channel. Each filter building has its own effluent channel. They both combine into the Combined Filter Effluent Channel at the North-West corner of the plant. The water is then conveyed by gravity to a 50 million gallon Finished Water Reservoir.

Although the filters all have the same plan-view dimensions, there are six different filter configurations currently in operation at Weymouth. These different configurations, as summarized in **Table 2-1** and **Table 2-2,** resulted from expansion phases No. 1 and No. 2 and the recent Demonstration Study. The different configurations include the four filters modified during the Study, along with the un-modified filters in each building.

Table 2-1. Existing Conditions in FB1.

	FILTER BUILDING 1		
	Unmodified Filters (22)	**Test Filter #12**	**Test Filter #23**
Media			
Anthracite	20 inches	26 inches	18 inches
Sand	8 inches	9 inches	9 inches
Gravel	15 inches	None	None
L/d Ratio	914	1,118	914
Underdrain	Vitrified clay pipe	Plastic block / media retention plate (new)	Stainless steel (new)
Troughs (number)	Concrete (10)	Fiberglass (10 new)	Concrete (10 existing)
Surface Wash	Baylis system	New modified Baylis	New modified Baylis

L/d Ratio = Length (depth) of filter layer / media effective size

Table 2-2. Existing Conditions in FB2.

	FILTER BUILDING 2		
	Unmodified Filters (22)	Test Filter #34	Test Filter #36
Media			
Anthracite	12 inches	12 inches	32 inches
Sand	9 inches	10 inches	8 inches
Gravel	22 inches	16 inches	None
L/d Ratio	762	813	1,219
Underdrain	Concrete teepee	Concrete teepee (existing)	Plastic block / media retention plate (new)
Troughs (number)	Concrete (10)	Concrete (10 existing)	None
Surface Wash	Baylis system	New modified Baylis	New modified Baylis

L/d Ratio = Length (depth) of filter layer / media effective size

As shown in the tables above, there are some elements that differ between filters. The major elements of the existing installation, including differences between filters, are described below:

- *Troughs.* During the filter backwash, the troughs collect the backwash water to drain it into the upper gullet for conveyance to the washwater sump. They are regularly spaced above the filter surface. There are 10 troughs per cell. In FB1, the troughs have sloped bottoms and reach 27 inches depth at the gullet wall; in FB2, the troughs are level and 21 inches deep. All the filters currently have concrete troughs, except for Filters #12 and #36. Filter #12 has fiberglass troughs while Filter #36 is troughless.

- *Underdrains.* The underdrain collects the filtered water at the base of the filter and conveys it to the lower gullet. Vitrified clay pipes were used as underdrains in FB1. Gravel was used on top of the vitrified clay pipes underdrain to retain the media. As part of the Study, underdrains were modified in Filters #12 and #23. The vitrified clay pipe underdrains and gravel were removed in Filters #12 and #23, and replaced by a plastic block system with media retention plate and a stainless steel system, respectively. Concrete teepee underdrains with gravel are in place in FB2, except for Filter #36 where the teepee system was replaced by a plastic block underdrain with media retention plate.

- *Media.* Anthracite and sand are used as filter media in all filters with various depths, depending on the specific filter design. All filters have gravel just above the underdrain for media retention excepting Filters #12, #23 and #36 where the gravel was replaced by retention plates. Originally, the filters had 0.5 mm sand and 1.0 mm anthracite, which is the basis for the L/d ratios shown in the tables. Note that the media has become coarser over time as fine particles have been lost at a greater rate, as discussed in **Section 3**.

- *Surface wash.* The existing surface wash designs are detailed in MWH Surface Wash Memorandum (MWH, 2009). For the Demonstration Study filters, the existing Baylis system was modified according to MWH's recommendation: the number of nozzles was increased and the orifices were enlarged. Filters #12, #23, #34, and #36 currently have the new modified Baylis surface wash system.

2.2 PROCESS DESIGN CRITERIA

2.2.1 Basis of Design Overview

The proposed process design basis for the rehabilitated Weymouth filters is summarized in **Table 2-3**. The design criteria are grouped into five categories.

Table 2-3. Proposed Basis of Process Design.

PARAMETER	UNIT	DESIGN VALUE	SOURCE AND ASSUMPTIONS
1. Influent			
Flow Rate			
Low Flow	mgd	60	MWD Data (Appx A)
Average Flow	mgd	230	MWD Data (Appx A)
Design Capacity	mgd	520	MWD Data (Appx A)
Temporary Max Flow	mgd	600	MWD Data (Appx A)
Water Quality			
Settled Water Turbidity	NTU	0.0 to 3.9 (avg = 0.65)	MWD Data (Appx A)
Water Temperature	°C	7 to 30 (avg = 19)	MWD Data (Appx A)
Plant Alum Dose	mg/L	1 to 40 (avg = 8.1)	MWD Data (Appx A)
Plant Polymer Dose	mg/L	0.1 to 5 (avg = 2.4)	MWD Data (Appx A)
2. Filter Configuration			
Filter Cell Length	ft	72.5	Existing
Filter Cell Width	ft	13.33	Existing
Cells per Filter	-	2	Existing
Filter Cell Area	ft^2	1,933	Existing
Number of Filters	-	48	Existing
3. Media Configuration			
Media - Top Layer			
Media Type	-	Anthracite	Tested in MWD Study
Specific Gravity	g/cm^3	1.6 to 1.75	Tested in MWD Study
Effective Size	mm	0.95 to 1.05	Tested in MWD Study
Uniformity	-	<1.4	Tested in MWD Study
Layer Depth	in	26	Tested in MWD Study
Layer L/d Ratio	-	660	Calculated (Appx B)
Media - Bottom Layer			
Media Type	-	Sand	
Specific Gravity	g/cm^3	2.60 to 2.65	Tested in MWD Study
Effective Size	mm	0.47 to 0.53	Tested in MWD Study
Uniformity	-	<1.4	Tested in MWD Study
Bed Depth	in	8	Tested in MWD Study
Layer L/d Ratio	-	406	Calculated (Appx B)
Overall L/d Ratio	-	1,067	Calculated (Appx B)

PARAMETER	UNIT	DESIGN VALUE	SOURCE AND ASSUMPTIONS
Media Support System			
Underdrain	-	HDPE Block	Tested in MWD Study
Support Media Type	-	Media Retention Plate	Tested in MWD Study
4. Filtration Cycle			
Operation			
Filtration Rate	gpm/ft^2	2.8 to 4.06	Tested in MWD Study
Temporary Max Rate	gpm/ft^2	4.69	MWD Data (Appx A)
Target Turbidity	NTU	<0.1	MWD Data (Appx A)
Expected Turbidity	NTU	0.02 to 0.04	Filter Model (Appx D)
Expected UFRV	gal/ft^2	4,800 to 9,400	Filter Model (Appx D)
Hydraulic Profile			
Filter Box Water Level	ft AMSL	1092.62 to 1093.33	Calculated (Appx C) for FB1
Filter Box Water Level	ft AMSL	1092.79 to 1093.50	Calculated (Appx C) for FB2
Clean Bed Headloss	ft	0.7 to 1.0	Calculated (Appx B)
Initial Headloss	ft	1.0 to 1.5	Calculated (Appx C)
Terminal Headloss	ft	6	Calculated (Appx C)
Effluent Channel Level	ft AMSL	1083.0 to 1083.8	Calculated (Appx C)
5. Backwash Cycle			
Backwash Frequency	hr	20 to 50	Filter Model (Appx D)
Backwash Troughs			
Number per Cell	-	8	Calculated (Appx B)
Inside Cross Section	in x in	16 x 24	Calculated (Appx B)
Backwash Water			
Maximum Rate	gpm/ft^2	16	Tested in MWD Study
Backwash Supply	cfs	68.9	Calculated (Appx B)
Total Headloss	ft	4.9	Calculated (Appx C)
Bed Expansion	%	10 to 15	Tested in MWD Study
Surface Wash			
Rate	gpm/ft^2	3	Tested in MWD Study
Surface Wash Supply	cfs	12.9	Calculated (Appx B)
Nozzle Jet Velocity	ft/s	22.5	Calculated (Appx B)

All elevations on North American Vertical Datum of 1988 (NAVD88)

Some of these parameters (as noted in the table) are based on results of the Study, or data provided by MWD in **Appendix A**. Other parameters are derived from the conceptual design calculations in **Appendix B,** hydraulic calculations in **Appendix C**, and filter modeling calculations in **Appendix D.** Key assumptions and results associated with each category are summarized below.

1) *Influent.* The assumed flow and quality of the influent to the filters were provided by MWD to MWH, as shown in **Appendix A**. On average, the filters currently treat 230 mgd (mean plant flow) of settled water with turbidity of approximately 0.4 NTU.

2) *Filter Configuration.* The existing dimensions of the filter cells are fixed and will remain unchanged during rehabilitation.

3) *Media Configuration.* The selected media configuration is 26 inches of 1 mm anthracite for the top layer, and 8 inches of 0.5 mm sand for the bottom layer. The media will be supported by a low-profile high-density polyethylene (HDPE) block underdrain and porous media retention plate.

4) *Filtration Cycle.* Filtration rates for the filters will be between 2.8 and 4.06 gpm/sf. The 2.8 gpm/sf filtration rate is at the low end of the typical range for dual-media filters (Reynolds and Richards, 1996). This low filtration rate is based on the desire for floc to penetrate into the media for depth filtration, to avoid surface removal and the resulting rapid headloss accumulation. Performance of the rehabilitated filters was predicted with a calibrated filter model, as described in the technical memorandum by MWH (2013). As shown in **Appendix D,** the expected turbidity and unit filter run volume (UFRV) will be between 0.02 and 0.04 NTU and between 4,800 and 9,400 gal/sf, respectively. A total terminal headloss of 6 ft is recommended to avoid negative pressure in the filter bed or the effluent piping. Based on the results of the Study, a filter-to-waste cycle is not required.

5) *Backwash Cycle.* The filters will typically be backwashed at a 16 gpm/sf rate, but this will be adjusted with the water temperature. Backwash frequency will be every 20 to 50 hours according to the filter model. Backwash may be needed more frequently if influent turbidity is high or air entrainment occurs. Since most of the headloss contribution occurs near the top of the media, a 3 gpm/sf surface wash will also be provided. Both the backwash and surface wash rates were confirmed in the Study. The Study also confirmed that the filters are effectively cleaned without air scour.

2.2.2 Operating Window

The proposed "operating window" for the system was defined by calculating the filtration rate with any number of filters online at the low, average, plant capacity, and temporary maximum flow rates. The results of these calculations are shown in **Table 2-4**. Note that there are a variety of possible configurations that will maintain the filtration rate within the tested range of 2.8 to 4.06 gpm/sf. However, at the temporary maximum capacity of 600 mgd, the filters will operate at 4.69 gpm/sf.

The number of filters online at any given time is set by considering both hydraulic loading and turbidity loading. At a given plant flow rate, a larger number of filters might be brought online if settled water turbidity increases, in order to improve filter run time and avoid turbidity breakthrough. At very high turbidity, this may entail operating below 2.8 gpm/sf, which would likely improve turbidity removal at the price of lower UFRV. The operating sequence for the rehabilitated filters will be defined during the final design phase.

Table 2-4. Operating Window at Various Flows.

Buildings Required	Filters Online	Filtration Velocity (gpm/sf) Low Flow 60 mgd	Average Flow 230 mgd	Plant Capacity 520 mgd	Temporary Maximum Capacity 600 mgd
2	48	0.45	1.72	3.89	4.49
2	46	0.47	1.80	4.06	4.69
2	44	0.49	1.88	4.25	4.90
2	42	0.51	1.97	4.45	5.13
2	40	0.54	2.07	4.67	5.39
2	38	0.57	2.17	4.92	5.67
2	36	0.60	2.30	5.19	5.99
2	34	0.63	2.43	5.49	6.34
2	32	0.67	2.58	5.84	6.74
2	30	0.72	2.75	6.23	7.19
2	28	0.77	2.95	6.67	7.70
2	26	0.83	3.18	7.19	8.29
1	24	0.90	3.44	7.78	8.98
1	22	0.98	3.76	8.49	9.80
1	20	1.08	4.13	9.34	10.78
1	18	1.20	4.59	10.38	11.98
1	16	1.35	5.16	11.68	13.47
1	14	1.54	5.90	13.34	15.40
1	12	1.80	6.89	15.57	17.96
1	10	2.16	8.26	18.68	21.56
1	8	2.69	10.33	23.35	26.94
1	6	3.59	13.77	31.14	35.93
1	4	5.39	20.66	46.70	53.89
1	2	10.78	41.31	93.41	107.78

2.2.3 Proposed Filter Sections

The major elements of this project are the removal and replacement of materials and components within the filter boxes. The proposed cross-sections of the rehabilitated filters are shown in **Figure 2-1** for FB1 and **Figure 2-2** for FB2, along with approximate elevations of significant points.

The elevations in **Figure 2-1** and **Figure 2-2** are calculated based on the NAVD88. This required an average adjustment of 2.3 ft to convert elevations from drawings made before 1991, because these drawings used a now-obsolete datum. Supporting calculations for the elevations shown in the cross-section diagrams are found in **Appendix B.**

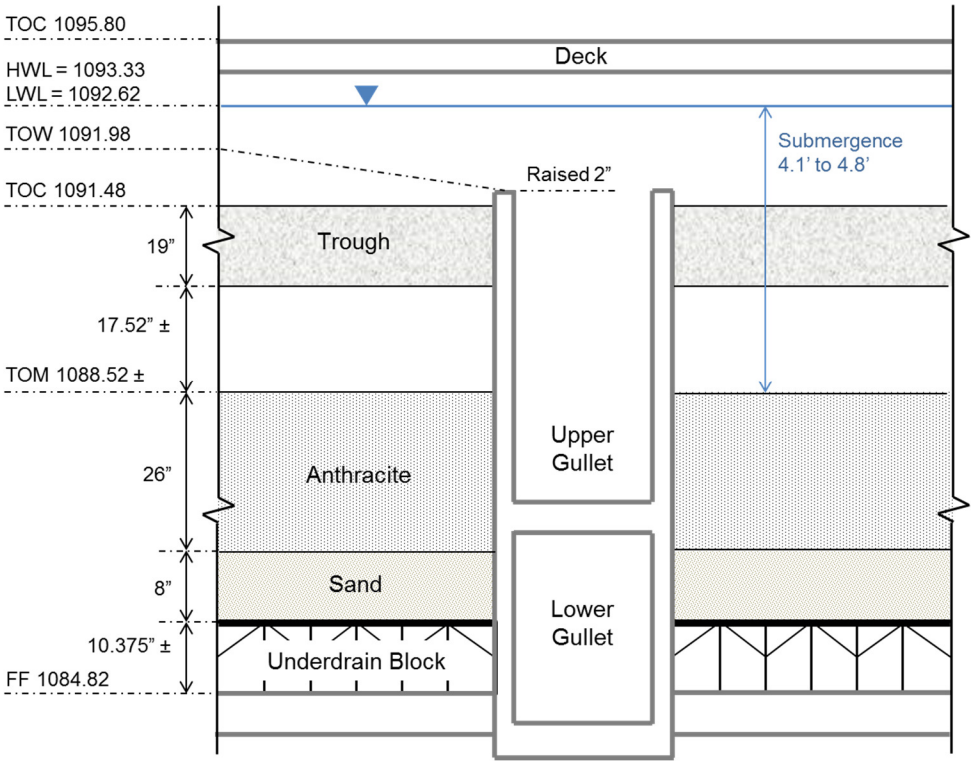

Figure 2-1. Proposed Section of Filters in FB1 on NAVD88.

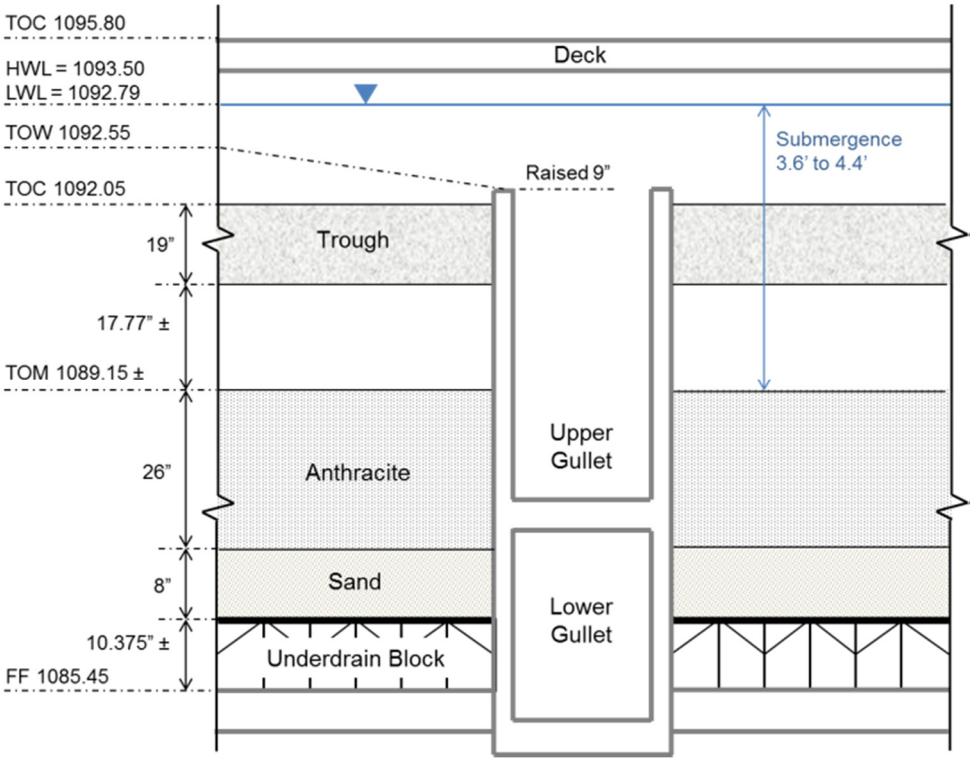

Figure 2-2. Proposed Section of Filters in FB2 on NAVD88.

As shown in **Figure 2-1** and **Figure 2-2**, the filter boxes are relatively shallow. Therefore, MWD has selected a low-profile HDPE block underdrain system with a porous media retention plate to eliminate the need for support gravel and create more space for media in the filter boxes, and the gullet walls will also be raised. The media expansion space will be 49% of bed depth in FB1 and 46% of bed depth in FB2 between the top of the media and the bottom of the troughs. Assuming the media expands about 15% during backwash, all filters will have around 11 inches of freeboard (i.e. space between the top of the expanded media and the bottom of the backwash troughs). This additional space will help reduce media loss.

2.3 PROCESS HYDRAULICS

2.3.1 Filter Box Hydraulic Profile

The Weymouth filters operate as a constant-level, constant-rate system. During the filtration cycle, water is held at a constant level setpoint in the filter boxes by the rate-of-flow control (RFC) valves. These valves actuate automatically based on feedback from the Venturi meter and filter box level transmitter.

Headloss across the filter is measured from the open water surface in the filter box to the upstream side of the Venturi meter. Important headlosses in the filtration cycle include:

- *Clean-bed headloss:* headloss through the clean media bed, attributable only to friction with the media particles themselves.
- *Initial headloss:* total headloss at the beginning of a filtration cycle, which includes the clean-bed headloss through the media along with additional minor losses in the underdrain and effluent piping.
- *Terminal headloss:* total headloss at the end of a filtration cycle, which is the initial headloss plus the maximum allowable additional headloss attributable to entrained solids in the filter media.

Preliminary hydraulic profiles have been developed showing the hydraulic grade line (HGL) through the filter boxes. These are shown in **Figure 2-3** and **Figure 2-4** for FB1 and FB2, respectively, with elevations defined on **Table 2-5** and **Table 2-6**. Supporting calculations are found in **Appendix C.** These profiles a show the HGL corresponding to both the clean-bed and terminal headloss conditions, with the terminal headloss assumed to be 6 ft. Hydraulic profile calculations were carried out at 2.8 gpm/sf and 4.06 gpm/sf, which represent the low and high ends of the range of typical filtration rates. Calculations were also done for 4.69 gpm/sf, which corresponds to the temporary maximum plant flow of 600 mgd.

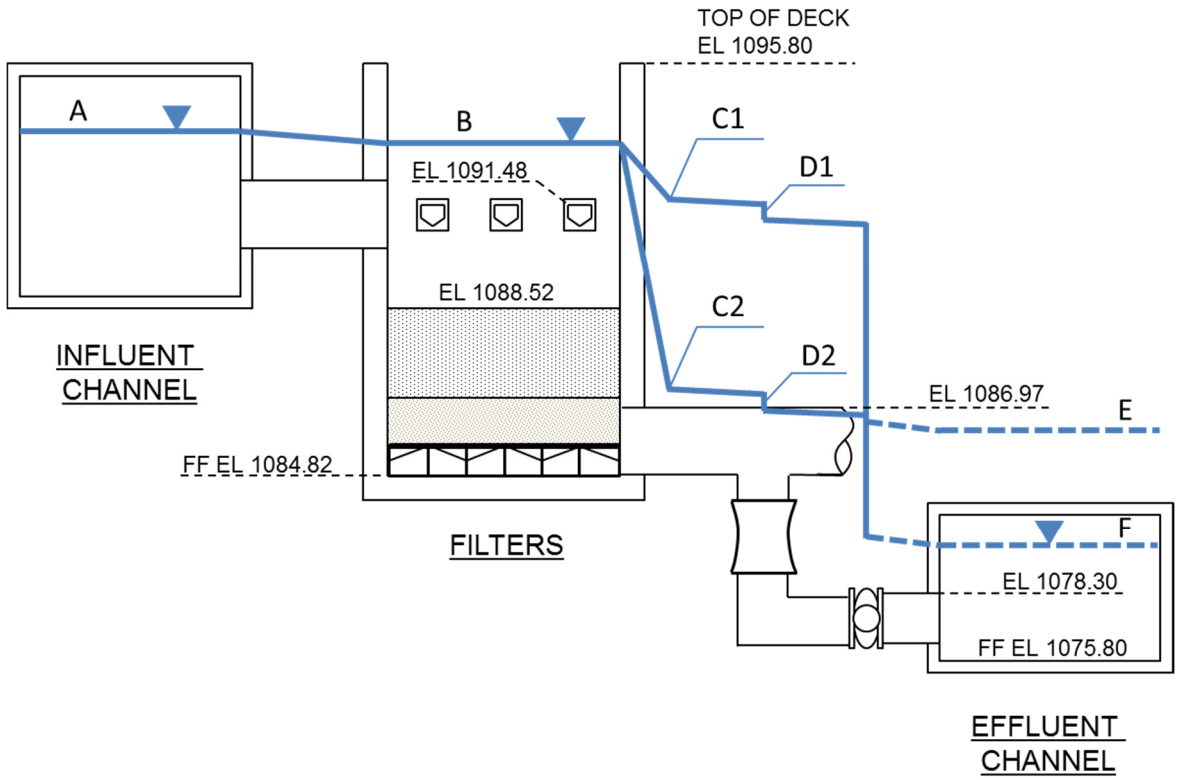

Figure 2-3. Hydraulic Profile for FB1 on NAVD88.

Table 2-5. HGL Elevations for FB1 Hydraulic Profile.

Point	Description	2.8 gpm/sf		4.06 gpm/sf		4.69 gpm/sf	
		LWL	HWL	LWL	HWL	LWL	HWL
A	Filter Influent Channel	1093.10	1093.50	1093.10	1093.50	1093.10	1093.50
B	Filter Box	1092.93	1093.33	1092.74	1093.14	1092.62	1093.02
C1	Filter Outlet (Initial Headloss)	1092.00	1092.40	1091.50	1091.90	1091.23	1091.63
C2	Filter Outlet (Terminal Headloss)	1087.04	1087.44	1086.97	1087.37	1086.92	1087.32
D1	Venturi Meter (Initial Headloss)	1091.89	1092.29	1091.27	1091.67	1090.92	1091.32
D2	Venturi Meter (Terminal Headloss)	1086.93	1087.33	1086.74	1087.14	1086.62	1087.02
E	Effluent Channel - Max	1086.48		1085.79		1085.36	
F	Effluent Channel - Min	1079.30		1079.30		1079.30	

All elevations on NAVD88

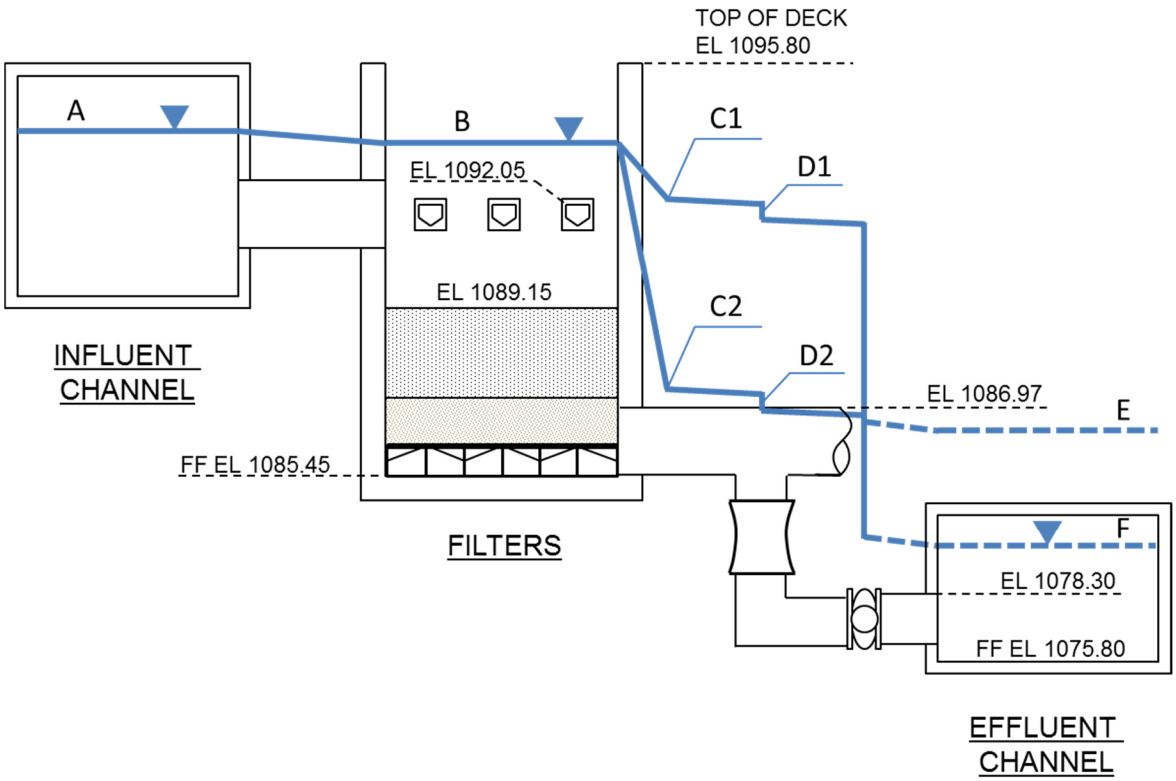

Figure 2-4. Hydraulic profile for FB2 on NAVD88.

Table 2-6. HGL Elevations for FB2 Hydraulic Profile.

Point	Description	2.8 gpm/sf		4.06 gpm/sf		4.69 gpm/sf	
		LWL	HWL	LWL	HWL	LWL	HWL
A	Influent Channel	1093.28	1093.68	1093.28	1093.68	1093.28	1093.68
B	Filter Box	1093.10	1093.50	1092.91	1093.31	1092.79	1093.19
C1	Filter Outlet (Initial Headloss)	1092.17	1092.57	1091.67	1092.07	1091.40	1091.80
C2	Filter Outlet (Terminal Headloss)	1087.21	1087.61	1087.14	1087.54	1087.10	1087.50
D1	Venturi Meter (Initial Headloss)	1092.06	1092.46	1091.44	1091.84	1091.09	1091.49
D2	Venturi Meter (Terminal Headloss)	1087.10	1087.50	1086.91	1087.31	1086.79	1087.19
E	Effluent Channel - Max	1086.65		1085.97		1085.53	
F	Effluent Channel - Min	1079.30		1079.30		1079.30	

All elevations on NAVD88

From the point of view of these hydraulic profiles, the critical operating parameters include:

- *Terminal headloss.* If the filters are run to a terminal headloss much greater than 6 ft, the HGL will drop below the top of the effluent piping. This creates negative pressure in the effluent piping and may de-water the Venturi meter for the RFC. This is one consideration that sets the maximum allowable terminal headloss.

- *Filter effluent channel level.* The water level in the filter effluent channel must be kept at a high enough level to submerge the RFC valve. However, if the HGL in the effluent channel is too high, it may back up water in the filter influent channel. These considerations set the theoretical minimum and maximum HGL elevations in the filter effluent channel from the point of view of filter operation. To prevent adverse effects on the filter system, the effluent spillway must be operated to keep the water level within the range defined by the dashed lines in in **Figure 2-3** and **Figure 2-4.**

2.3.2 Filter Bed Pressure Profile

A pressure profile through the filter beds at the terminal headloss has been developed, as shown in **Figure 2-5**, to check for negative gauge pressure in the media during the filtration cycle. This pressure profile shows the inside of the filter boxes in cross-section view, and defines both the static pressure head with no flow through the filter, and the actual pressure head while the filter is in operation.

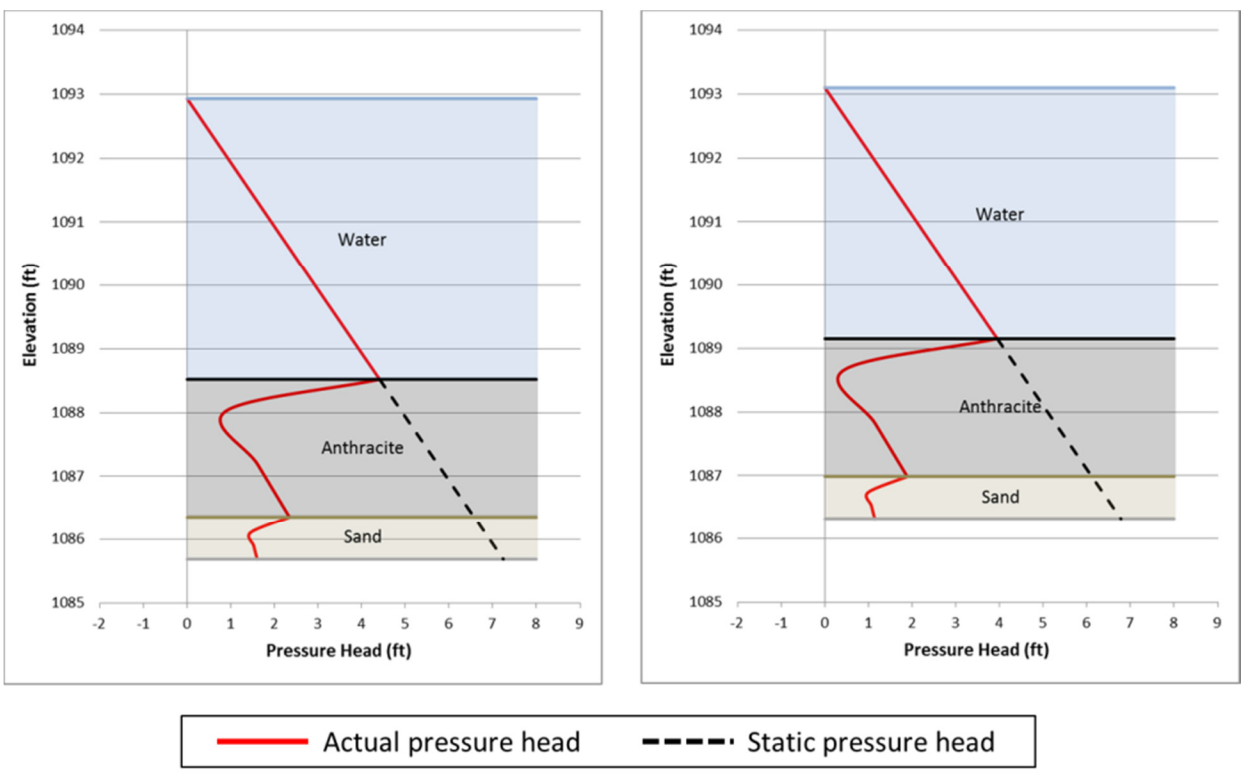

Figure 2-5. Media Pressure Profiles for FB1 (left) and FB2 (right) at 2.8 gpm/sf.

This pressure profile is based on the following assumptions, which represent a reasonable and conservative scenario for preventing negative pressure in the media. Supporting calculations are found in **Appendix C**.

- Clean bed headloss is evenly distributed through the anthracite and sand layers.
- Headloss accumulation occurs in the top 6 inches of the anthracite layer and the top 3 inches of the sand layer, consistent with the observations by MWD during the Study.
- Only 20% of the headloss accumulation takes place in the sand layer. That is, the vast majority of entrained solids are found in the anthracite.
- Filters are run at a low filtration rate of 2.8 gpm/sf, which means that entrained solids contribute a greater share of the terminal headloss. This is more conservative than a higher filtration rate, because the accumulated headloss at the top of the anthracite layer will be more severe.
- The water level in the filter influent channel is at the low setpoint, providing the minimum media submergence.
- The terminal headloss setpoint is 6 ft to the differential pressure cell.
- After subtracting out headlosses through the underdrain, the clean media, and the effluent piping, the total accumulated headloss in the media at 2.8 gpm/sf is about 5 ft.

As shown in **Figure 2-5**, the pressure head approaches zero in the anthracite layer under the assumptions detailed above, which leads to a risk of air binding in the filters. Because air is often entrained in the Weymouth plant influent and air binding was frequently observed during the Study, negative pressures in the filter bed should be avoided. Maintaining media submergence to the maximum extent possible will be important to counteract this effect.

2.3.3 Operational Recommendations to Avoid Negative Pressure

The filters should be operated to avoid negative pressure, both in the effluent piping and in the media bed itself. The risk for negative pressure exists in this system because of both the low HGL at the filter effluent piping (**Figure 2-3** and **Figure 2-4**) and the pressure head in the media approaching zero (**Figure 2-5**). Therefore, several operational strategies are recommended:

- The terminal headloss for the rehabilitated filters should be no greater than 6 ft. This recommendation is confirmed by MWD operating experience.
- The filter influent channel water level should be set as high as possible to maintain maximum media submergence.

2.3.4 Downstream Hydraulic Profile

The water level in the combined filter effluent channel depends on the way the plant is operated downstream of the filters. There are three ways that filtered water flows to the reservoir:

1) *Over the by-pass weir.* This is the preferred flow path since it provides mixing energy for caustic, chlorine, and ammonia, and a greater contact time.
2) *Through the by-pass weir.* Flow can go through the weir via a 3 ft by 4 ft gate. This is mainly used for flows higher than 300 mgd, and passes 50-60 mgd through the weir wall.
3) *Via the by-pass channel.* When flow is higher than 300 mgd, the by-pass channel has a 10 ft by 10 ft square butterfly valve that modulates to keep the water elevation by Spillway No. 1 at an operator-defined level.

The target operating level in the effluent channel is limited by a hatch in combined filter effluent channel between the west and the east part of FB1 in the pipe gallery. The top of this hatch is at 1084.80 ft above mean sea level (AMSL) (NAVD88). Weymouth WTP operators report that this hatch begins to flood at flows above 300 mgd, as the HGL in the effluent channel gets too high.

A hydraulic profile has been developed showing the hydraulic grade line downstream of the filter effluent to the combined effluent weir, and is shown on **Figure 2-6**. Supporting calculations for this hydraulic profile are found in **Appendix C,** and elevations are listed in **Table 2-7**. This profile was developed for the low plant flow of 60 mgd, an average flow of 230 mgd, and a high flow of 300 mgd, above which the gate and butterfly valve will be used to modulate the level.

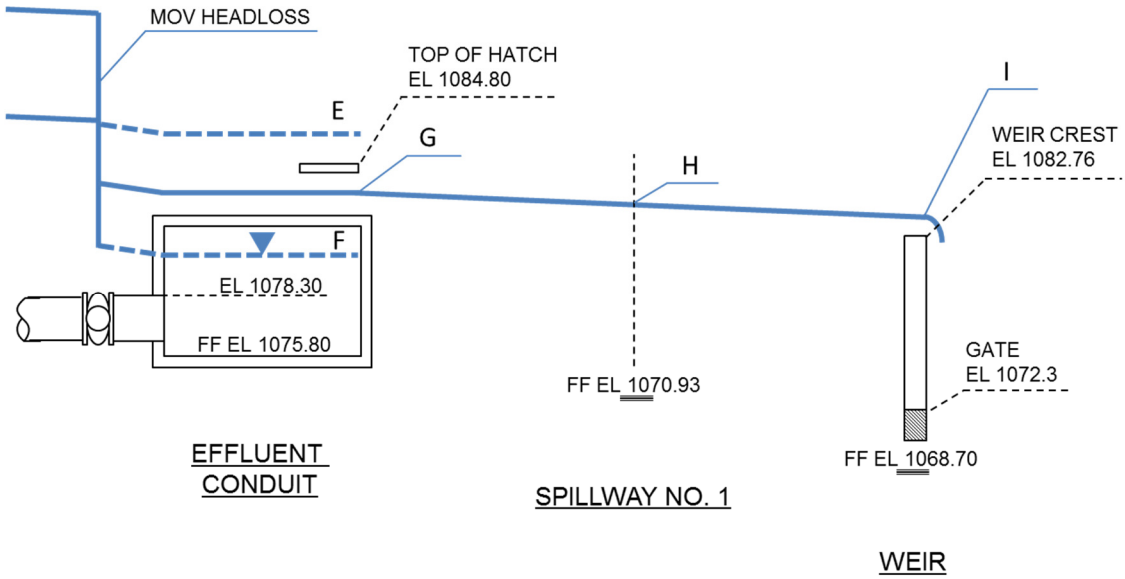

Figure 2-6. Hydraulic profile from filter effluent channel to weir on NAVD88.

Table 2-7. HGL Elevations for Downstream Hydraulic Profile.

Point	Description	60 mgd		230 mgd		300 mgd	
		LWL	HWL	LWL	HWL	LWL	HWL
E	Effluent Channel - Max	1085.36		1085.36		1085.36	
F	Effluent Channel - Min	1079.30		1079.30		1079.30	
G	Effluent Channel	1083.03	1083.04	1083.54	1083.62	1083.76	1083.88
H	Spillway No. 1	1083.02		1083.42		1083.55	
I	Upstream of Weir	1083.02		1083.41		1083.53	

All elevations on NAVD88

The key operational goals for the effluent channel are listed below. Note that all elevations are on NAVD88.

- Keep the HGL in the filter effluent channel between 1079.30 ft AMSL (Point F) and 1085.36 ft AMSL (Point E), to avoid affecting operation of the filters.
- Allow at least some water to flow over the effluent weir crest at 1082.76 ft AMSL, to improve mixing and contact time.
- Prevent flooding of the hatch by keeping the water in the filter effluent channel (Point G) below 1083.8 ft AMSL, 1 ft below the top of the hatch.

To meet these goals, the following operating strategy is recommended:

- For flows below 300 mgd, allow all water to pass over the weir.
- For higher flows or when the effluent channel water level reaches 1083.8 ft, begin using the weir bypass gate and butterfly valve to modulate the water level.
- When modulating the level with the gate and butterfly valve, the target HGL in the effluent channel should be between 1083 ft AMSL and 1083.8 ft AMSL, so that some water flows over the weir without flooding the hatch. This corresponds to a water level (above the floor) of 7.2 to 8 ft in the effluent channel and 12 to 13 ft in Spillway No. 1.

To better monitor and control the water level in the effluent channel and combined filter effluent channel, new pressure sensors will be installed as discussed in **Section 3.9**. The operators will use data from these sensors to help control the HGL elevation in the effluent channel and verify that it is within the allowable range.

2.3.5 Backwash Hydraulics

The cleaning process for the Weymouth filters is driven by gravity, with water flowing from the wash tanks to the surface wash and backwash headers to provide flow for surface wash and backwash, respectively. This flow is controlled by RFCs based on setpoints programmed into the plant SCADA system. Backwash flow enters the filters through the lower gullet and is distributed by the underdrain into the media bed, where it fluidizes the media and carries away entrained solids.

The headloss across each filter during the backwash process was estimated as shown in **Appendix C**, based on a maximum wash rate of 16 gpm/sf as suggested by the Study. Important headlosses during backwash include:

- *Underdrain:* headloss through the underdrain blocks, as water flows through the laterals, orifices, and media retention plate. This is estimated to be about 14 inches based on manufacturer data for HDPE underdrain systems (see **Appendix C**).
- *Fluidized media:* head required to fluidize the media, which is the equal to the buoyant weight of the media bed. This will be about 17 inches based on assumed media properties, which is calculated in **Appendix C**.
- *Troughs:* headloss as water spills over the edge of the wash troughs, which act as rectangular weirs. This will be about 1.6 inches given the proposed trough dimensions.

Considering the losses listed above, along with minor losses in the piping and the elevation change to the top of the troughs, the total backwash headloss is expected to be about 4.9 ft (2.1 psi) from the backwash header to the water surface above the troughs.

To monitor the backwash headloss, new pressure sensors will be installed on the backwash headers as discussed in **Section 3.9**. When a filter goes into backwash, the readout from the nearest backwash header pressure sensor will be logged by the SCADA system and associated with that filter, so that the backwash headloss of each filter can be tracked over time. Insights from this data will include the following:

- If the headloss at a given wash rate is fairly consistent, the filter is operating properly.
- If a filter's backwash headloss is noted to be increasing over time, this could indicate fouling of the underdrain or media retention plate in that filter.
- High headloss across the underdrain block or media retention plate can lead to underdrain failure. These pressure sensors can provide an "early warning" before this type of failure occurs.

Section 3
Elements of Design

The Weymouth Filter Rehabilitation Design includes replacement of the underdrains, filter media, backwash troughs, and surface wash system; along with modifications to associated items such as air vents, handrails, instruments, lighting, and site features. Some modifications will be required in the original concrete filter structure to accommodate these changes. Key changes and associated rehabilitation tasks are summarized in **Table 3-8** and described in detail below.

Table 3-8. Summary of Rehabilitation Elements.

Element of Design	Rehabilitation Tasks
Underdrains	Demolish exiting underdrains, and replace with low-profile HDPE block system and media retention plate.
Filter Media	Remove existing media, and replace with new sand (8 inch layer) and anthracite (26 inch layer).
Backwash Troughs	Demolish existing troughs, and replace with 8 new pre-cast concrete troughs per filter cell.
Gullet Walls and Structural Rehabilitation	Demolish and replace the upper portion of the gullet wall in each filter building, and raise the top elevation. Repair various concrete issues and drain chute plates.
Surface Wash System	Demolish and replace surface wash laterals in all filters, repair the surface wash header wall thimbles in FB1, and replace the surface wash headers in FB2.
Surface Spray System	Demolish existing surface spray piping and nozzles, and replace with piping to the deck and hose bibs.
Lower Gullet Air Vents and Access Hatch	Demolish existing air vent piping, and replace with a standard air vent piping arrangement for all filters. Demolish existing lower gullet access hatch, and replace with a stainless steel hatch and frame for all filters.
Upper Gullet Baffles	Move baffle mounting location in FB1. Demolish and replace baffles and hardware in FB2.
Pressure Sensors	Demolish existing differential pressure cells in FB1 and FB2, modify the sensor piping for FB2, and replace with new cells for consistency across all filters. Install new pressure sensors in the backwash header and filter effluent channel.
Lighting	Demolish any existing light fixtures and conduit in the filter boxes.
Handrails	Demolish existing handrails around the filter buildings and replace with anodized aluminum railing. Demolish and replace light poles in the handrail system.
Site Features	Demolish and fill existing sand pan drains. Demolish and replace backwash sump covers in FB2.

3.1 UNDERDRAIN REPLACEMENT

3.1.1 Existing Underdrains

The existing underdrains for the Weymouth filters include vitrified clay pipes in FB1 and concrete teepees in FB2. Both systems required a layer of gravel covering the underdrain to support the sand and anthracite media. These underdrains are shown in the photographs in **Figure 3-7**. These systems are reaching the end of their useful life, and the mounding of media observed in several filters (**Figure 3-8**) indicates that at least some of the underdrains are no longer adequately distributing backwash flow. These underdrain systems will be demolished during rehabilitation and replaced with a consistent installation across both filter buildings.

Figure 3-7. Existing underdrains in FB1 (left) and FB2 (right).

Figure 3-8. Mounding of media in Filter #24.

3.1.2 System Selection and Technical Considerations

Based on the results of the Study, MWD has selected HDPE block underdrains for use in the rehabilitated filters. Typically, HDPE block underdrains are furnished as vendor-supplied systems. These underdrains will be installed with porous media retention plates in lieu of a gravel layer, to reduce media loss by allowing for additional freeboard space.

The specification of a new underdrain block system will cover the following issues:

- *Flow distribution.* The most basic function of the underdrain is to provide good flow distribution during backwash. Flow out of the underdrain block should be uniform to within ±5% along and between laterals over the range of backwash rates. Plastic block underdrains typically achieve this with a "dual parallel lateral" system, where each underdrain lateral consists of a parallel feeder conduit and compensating conduit to counteract the effects of pressure recovery along the length of the lateral.

- *Profile.* A low-profile underdrain block is desirable to provide space for deeper media layers and additional media freeboard. The underdrain system selected should be a low-profile design with an installed height of no more than 10.5 inches from the filter floor.

- *Material.* The underdrain should be made from HDPE with stainless steel hardware to provide a durable and corrosion-resistant system. The material must be sufficiently strong to avoid crushing by the media and water load, which will be about 580 psf. HDPE block underdrains typically provide more than 1400 psf of crushing strength.

- *Underdrain header.* In FB1, the existing underdrain pipes connect directly to the lower gullet. The new underdrain system should have a header to distribute flow among the laterals, most likely in the form of a shop-fabricated cutout along the gullet wall (**Figure 3-9**). In FB2, there is an existing header built into the floor of each filter cell, which the underdrain blocks must be able to span (**Figure 3-10**).

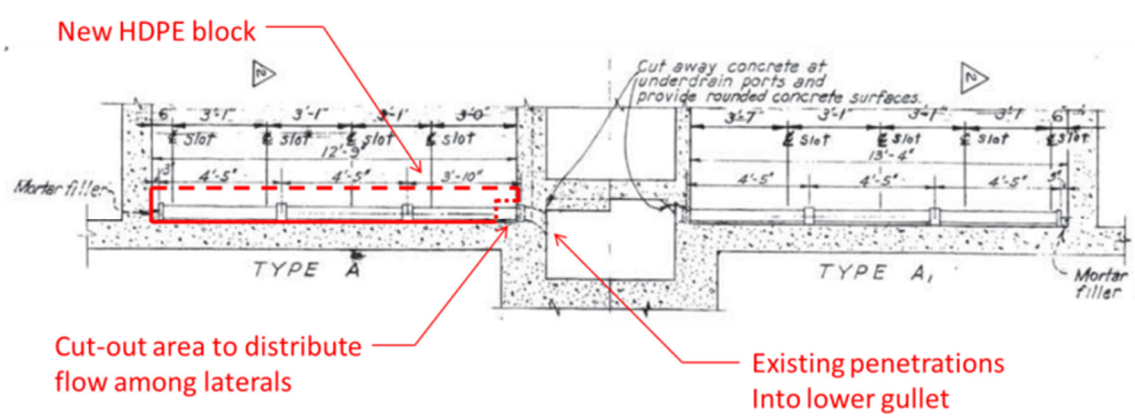

Figure 3-9. New underdrain with cutout in FB1.

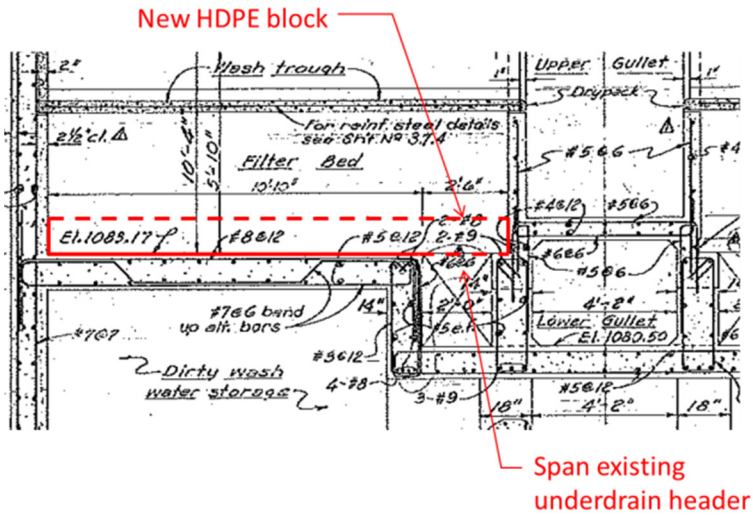

Figure 3-10. New underdrain spanning existing header in FB2.

- *Uplift strength and attachment.* One of the most significant loads that the underdrain must resist is uplift during the backwash process. This is important at the Weymouth plant because of the large available backwash head – if a valve in the backwash system fails or opens too quickly, the underdrains could be exposed to high uplift pressures. The primary hold-down for HDPE block underdrains is the grout that adheres to the plastic ribs on each block; however, some systems are available with a secondary hold-down system such as anchor rods, angle irons, or integral grout pockets. A secondary system will be specified at this installation to provide additional uplift strength. The major disadvantage of secondary hold-downs is increased material and installation cost. A system requiring anchors into the filter floor will also be constrained by the limited slab thickness and the large amount of existing rebar that will make drilling anchor bolts difficult.

- *Media retention plate.* A media retention plate will be provided, of suitable pore size to prevent the entrance of sand and anthracite media. One style of media retention plate is constructed from plastic beads, sintered together to form a porous plate with 0.4-0.5 mm pores. The other common style consists of a plastic plate with 0.2 mm slots. Either type of system can fail under excessive pressure, due to external backwash head or clogging of the openings. The most common cause of clogging is biofilm growth or scale precipitation in the small spaces between slots or beads. While MWD does not expect biological or chemical fouling of media retention plates at Weymouth, the clean bed and backwash headloss should be monitored to ensure that they are not increasing over time, as this could indicate clogging of the media retention plate.

- *Quality assurance.* Manufacturers of underdrain blocks can provide various types of modeling and testing data for quality assurance purposes. They can be required to submit strength data for their system and verify the flow distribution performance through computational fluid dynamic modeling or hydraulic testing. Some suppliers also test the quality of the media retention plate through airflow testing.

3.1.3 Vendor-Supplied Products

Two leading HDPE block underdrain systems on the market are the Tetra LP Block® manufactured by Severn Trent Services and the Leopold Type XA® block manufactured by Xylem Inc. These products are shown in **Figure 3-11**. In addition to the technical and quality assurance issues described above, the specification section will cover experience, total installed capacity, and installation size requirements for the underdrain block manufacturer.

Figure 3-11. Tetra LP Block (left) and Leopold Type XA block (right).

3.2 FILTER MEDIA REPLACEMENT

3.2.1 Existing Filter Media

The existing sand and anthracite filter media at Weymouth is in need of replacement. Significant media loss has taken place over time, because of problems such as high surface wash velocities, air entrainment, and low freeboard space. The media has also become coarser on average (**Figure 3-12**), because fine particles are preferentially removed when media is lost.

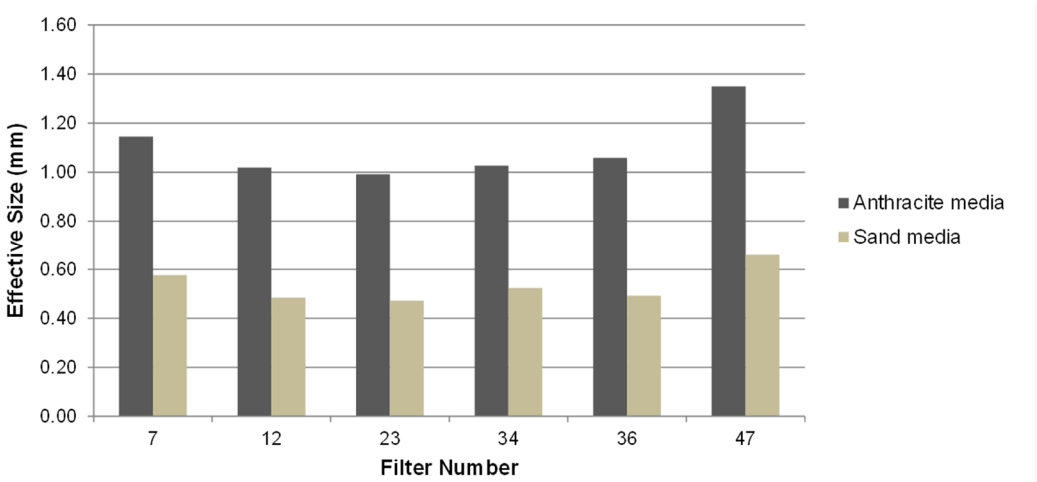

Figure 3-12. Coarser media in non-rehabilitated filters (#7 and #47) compared with test filters rehabilitated during the Study, from MWD (2013).

3.2.2 System Selection and Technical Considerations

The new media to be installed in the rehabilitated filters is summarized in **Table 3-9**.

Table 3-9. New Media Characteristics.

Parameter	Unit	Top Layer	Bottom Layer
Material	-	Anthracite	Sand
Effective Size	mm	1.00 ± 0.05	0.5 ± 0.03
Uniformity Coefficient	-	<1.4	<1.4
Specific Gravity	g/cm^3	1.6 to 1.75	2.60 to 2.65
Layer Depth	in	26	8

This media is designed to meet the performance criteria defined in **Section 2**. The appropriateness of the proposed media design in **Table 3-9** is supported by:

- MWD Study results, where media specified with the properties in **Table 3-9** performed effectively in the demonstration filters.
- Filter modeling results (**Appendix D**), which predict very good turbidity removal performance and reasonable UFRV for filters with this proposed media configuration.

3.2.3 Media Quality Assurance

In addition to meeting the above criteria, the media must be of sufficient purity and cleanliness for this application. Sand media should have a hardness of 7 on the Mohs scale and no more than 5% acid solubility. For both layers, the percentage of foreign material should not exceed 1% by weight, and the media should be washed to remove fine particles after placement in the filter and before the filter goes into service. The anthracite layer may need to be placed and cleaned in multiple lifts.

The contractor will be required to prepare several submittals for the filter media during construction of this project, as part of the quality assurance process. An initial submittal will provide product data for the proposed material. Once the product data has been approved, samples will be taken and tested during the shop drawing review process, during production of the media, and during placement of the media.

The media supplied for the rehabilitated filters must be checked for backwash compatibility – that is, the anthracite and sand layers should have comparable fluidizing behavior at a given backwash rate. This compatibility check is done with the following equation (Kawamura, 2000), where the two sides of the equation should agree to within ±5%:

$$\frac{d_{10-Bot} \times UC_{Bot}}{d_{10-Top} \times UC_{Top}} = \left(\frac{SG_{Top} - 1}{SG_{Bot} - 1}\right)^{\frac{2}{3}}$$

where d_{10} is the effective size (mm), UC is the uniformity coefficient (dimensionless), and SG is the specific gravity of the media (dimensionless); and the subscripts "Bot" and "Top" denote the

bottom and top media layers, respectively. This compatibility check for the media is documentd in **Appendix B** for the design media, which found the selected sand and anthracite to be compatible. The construction contractor will be required to provide product data and samples for the sand and anthracite, which will include this compatibility check on the material to be used.

3.3 BACKWASH TROUGH REPLACEMENT

3.3.1 Existing Backwash Troughs

Currently, each filter cell, with the exception of Filter #12 and #36, contains 10 concrete backwash troughs from the original installation. Each filter contains a total of 20 troughs. Filter #12 contains 20 fiber-reinforced plastic (FRP) troughs and Filter #36 is troughless. Furthermore, there are slight differences in trough configuration and elevations between FB1 and FB2 arising from the successive plant expansions. This project will unify trough configurations, elevations, and dimensions throughout all 48 filters.

As part of the Study, different trough layouts (troughless versus troughs) and trough materials (FRP or concrete) were investigated. The results of the Study served as a basis for trough selection. FRP troughs were recommended at the time of the Study; however, they exhibited several issues during the year-long testing period and, as a result, concrete backwash troughs were reconsidered as a potential alternative.

The selection for the new backwash troughs was based on the following: trough configuration, trough material, life cycle, and cost. Some considerations that limited the design were filter depths, media depths, media loss, and supporting structural column locations.

3.3.2 System Selection and Technical Considerations

- *Trough versus troughless design*. The Demonstration Study indicated that the presence of backwash troughs provided better results compared to a troughless configuration. Based on this finding, new backwash troughs will be installed in all 48 filters.

- *Trough configuration.* Various alternate trough configurations were investigated to reduce the number of troughs while maintaining backwashing capabilities.

Table 3-10 below summarizes the two trough configurations discussed above, along with trough dimensions. Supporting calculations are found in **Appendix B.**

Table 3-10. Comparison of Ten- and Eight-Trough Configurations.

Troughs per Cell	Flow per Trough (cfs)	Inside Trough Dimensions			Trough Spacing (in)	Filter Coverage
		Length (ft)	Width (in)	Depth (in)		
10 (FB1)	4.09	13.3	22	18	87	32%
10 (FB2)	4.09	13.3	34	27	87	46%
8 (new)	5.12	13.3	24	16	108.75	26%

The eight-trough configuration is recommended over the existing ten-trough layout, based on the following considerations:

- This new configuration reduces the number of troughs that must be fabricated, delivered, and installed.
- This new configuration avoids placing troughs underneath deck support piers, as is required with ten troughs.
- This new configuration reduces the percent coverage of the filter bed, and therefore reduces the degree of fluid acceleration between the troughs.

3.3.3 Trough Material and Cost

Initially, the Demonstration Study recommended FRP material for the troughs. However, several operational issues were observed after the report was submitted that resulted in reconsidering FRP material. During the Study, FRP troughs were installed in Filter #12 and the filter continued to operate under normal plant conditions after the completion of the study. The following are issues observed in Filter #12 during extended operations after the Study:

- The FRP troughs warped due to a combination of deflection from backwashing operations and premature weathering of the material.
- The condition of the troughs deteriorated quickly due to environmental effects, possibly accelerated by exposure of troughs as they were not continually submerged in water.
- The plant operators were restricted access to the upper gullet through the trough openings. The FRP troughs had internal bracing, which impeded operator access. The FRP troughs also had decreased ability to carry the weight of a plant operator.
- The FRP troughs had decreased structural capacity to support the surface wash system.

Concrete troughs were also evaluated as an alternative to FRP troughs. These troughs would be pre-cast at a shop and delivered to the site for installation. The existing concrete troughs are the original installations and have been operational for over 70 years without any major issues. Concrete troughs have performed well and can meet structural considerations regarding load, deflection, and pipe supports as well as ability to handle weathering.

MWD specifies that the new troughs shall have a life cycle of approximately 50 years. Trough manufacturers have indicated that concrete troughs typically last 40 to 50 years while FRP troughs last approximately 20 years. In addition, concrete troughs are approximately two-thirds the cost of FRP troughs to fabricate and deliver to the site – in the case of this project, the number of troughs that will be needed creates an economy of scale for pre-cast concrete troughs. **Table 3-11** below compares cost and life cycles between the two trough material types. Concrete troughs are recommended based on this information, and they will be used for this project.

Table 3-11. Trough Cost and Life Cycle Comparison

Trough Material	Approximate Cost per Trough	Life Cycle (years)
Concrete	$1,100	40-50
FRP	$1,600-$2,100	~ 20

Cost does not include installation

3.3.4 Trough Layout and Sizing

The proposed trough configuration is shown in **Figure 3-13**. This configuration of eight concrete troughs per filter cell is recommended based on cost, performance, and life cycle.

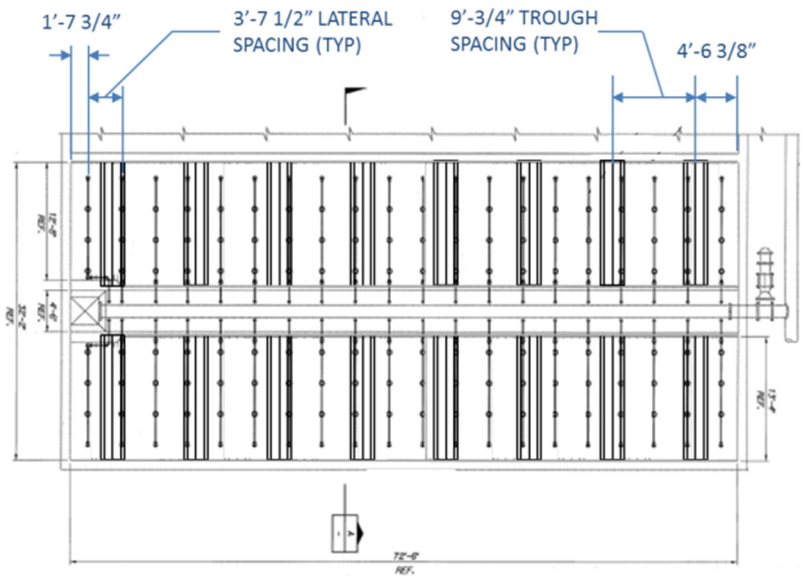

Figure 3-13. Plan-view filter layout showing trough spacing.

The troughs were sized to convey wash water at 19 gpm/sf (16 gpm/sf backwash and 3 gpm/sf surface wash), while maintaining at least 3 inches of freeboard between the water surface in the trough and the top of the trough walls. The trough depth will be the same throughout the entire length. Sizing calculations are found in **Appendix A.** The proposed trough dimensions are illustrated in **Figure 3-14**.

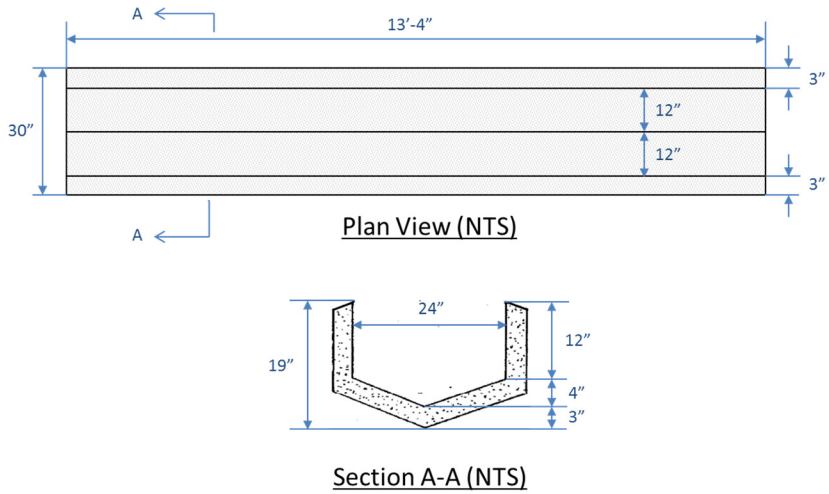

Figure 3-14. Proposed dimensions of the concrete troughs.

The backwash troughs are an important structural element of the filters. They must withstand loads including backwash uplift, water weight, and operator weight for access. During final design, the structural engineer of record will specify the concrete mix and rebar configuration for the pre-cast troughs; check them for adequacy with the applied loads; and develop details for connection to the gullet walls.

3.4 GULLET WALL AND STRUCTURAL REHABILITATION

3.4.1 Existing Gullet Walls

Each gullet wall currently supports 10 concrete troughs. Since the new design will include 8 troughs, the trough support locations in the wall will completely change.

3.4.2 System Selection and Technical Considerations

To maintain structural strength and facilitate the new troughs installation, gullet walls will be demolished as shown on **Figure 3-16** and **Figure 3-17** for FB1 and FB2, respectively. Gullet wall concrete will be cut 2 feet 7 inches and 2 feet 4 inches below the top of the existing wall of FB1 and FB2, respectively. This will allow for removal of grout under the trough. The gullet wall will also be cut around the troughs below the deck support, while maintaining enough concrete to safely support the deck.

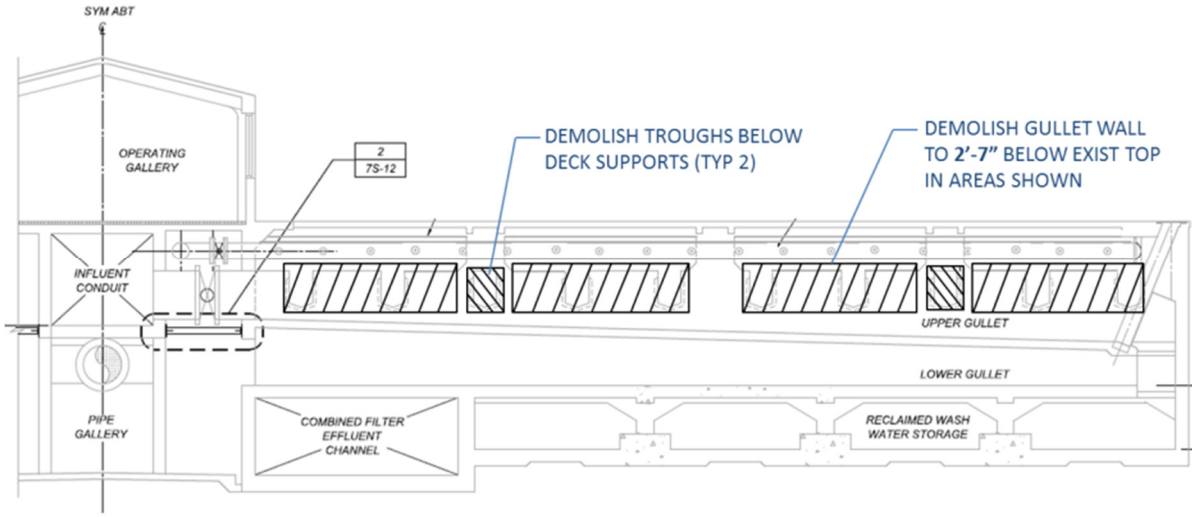

Figure 3-15. Gullet wall demolition for FB1.

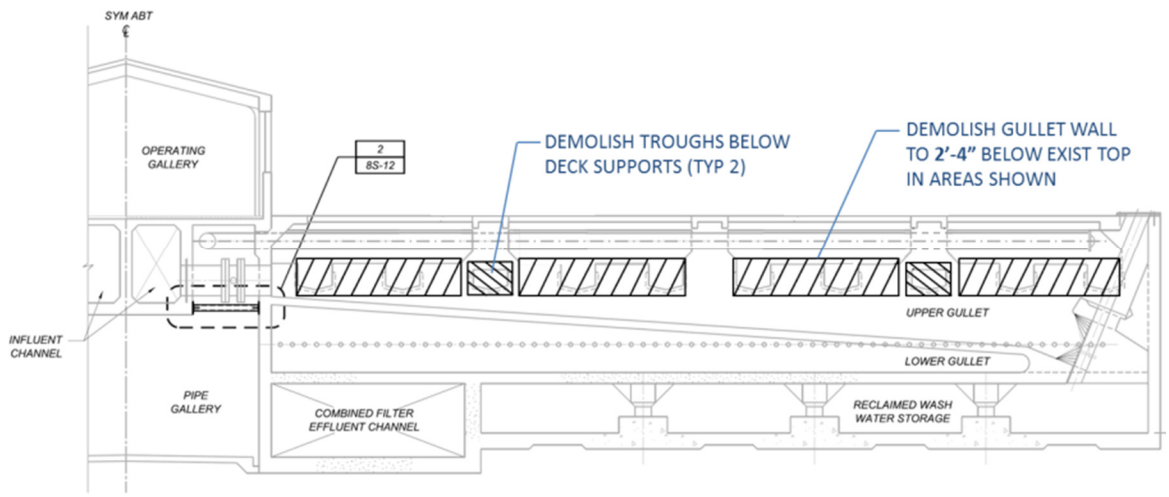

Figure 3-16. Gullet wall demolition for FB2.

The gullet wall will be rebuilt with new concrete above the cut line as shown on **Figure 3-17**. At both ends, i.e. at the filter influent and at the backwash gate, there will be space between the top of the gullet wall and the bottom of the deck. This will allow for operator access and removal of the surface wash header. In these areas, the gullet wall will be raised to allow for more media expansion space, as calculated in **Appendix B.** In between, the gullet wall will be raised up to the deck level.

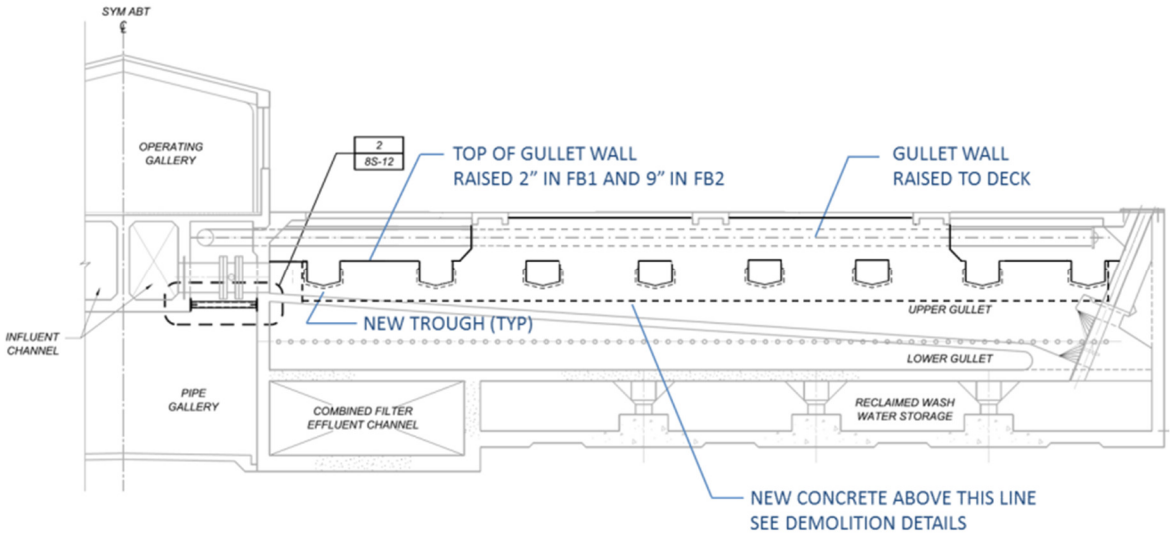

Figure 3-17. New gullet wall section.

Rehabilitation of the gullet walls will also encompass seismic bracing of the wall and decking. Raising the gullet wall to deck level will provide improved lateral strength for the filters in the longitudinal direction.

3.4.3 Structural Design Criteria

Structural design criteria for this project are found in **Appendix G.** These criteria will be used for the detailed design of the gullet wall improvements, along with any other structurally critical items related to this project (e.g. backwash troughs and surface wash lateral supports).

3.4.4 Additional Structural Rehabilitation Items

During repair of the gullet walls, some additional structural rehabilitation items will also be addressed:

- *Concrete cracking.* Numerous cracks in the concrete have been observed, as shown in **Figure 3-18**. In FB1, corroded Uni-strut was found above the upper gullet on the bottom of the deck. Cracks were also observed on both sides of the deck extending from these locations. The cracks and corroded Uni-strut are shown in **Figure 3-19**.
- *Exposed aggregate.* Exposed aggregate was observed at various locations in the upper gullet as shown on **Figure 3-20**. Damaged concrete adjacent to the filter backwash gates was observed in several filters.
- *Exposed rebar.* Exposed rebar were observed at different locations in both filter buildings as shown on **Figure 3-21**.
- *Corroded drain chutes.* The drain chutes from the upper gullet to the backwash sump are lined with carbon steel plates. These plates exhibit pitting and other corrosion damage.

During final design, these issues will be further investigated. In some cases, it may be determined that they are of minimal significance and do not warrant additional work. In other cases, MWD structural designers will help to produce repair details and identify locations where repairs may be required.

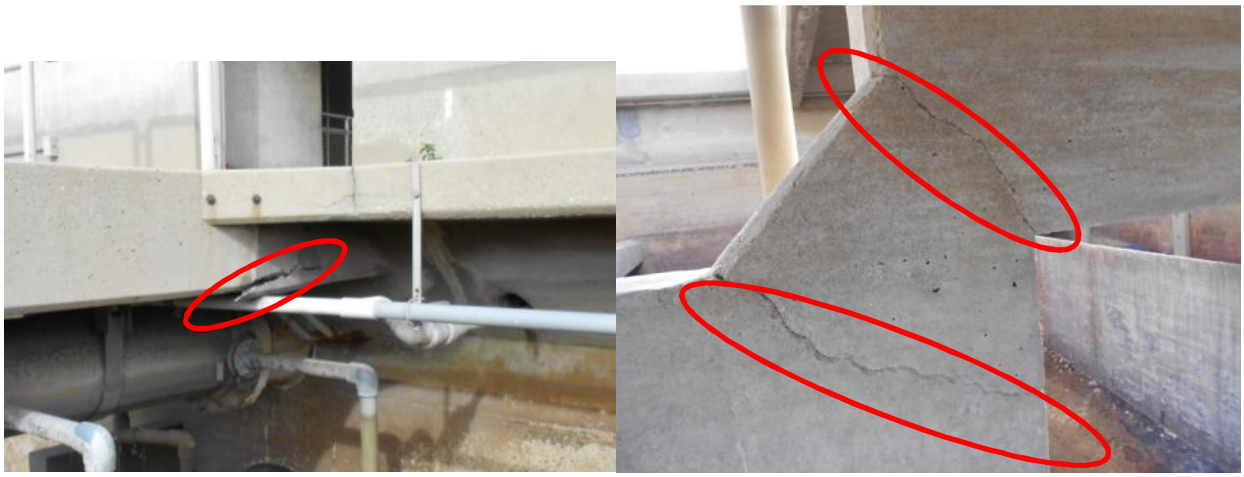

Figure 3-18. Severe cracks on the concrete structure. Crack on the deck (left), and crack on the deck support (right) above a trough penetration.

Figure 3-19. Concrete cracking along corroded Uni-strut below (left), and associated reflective cracking at deck level (right).

Figure 3-20. Damaged concrete (left) and exposed aggregate (right).

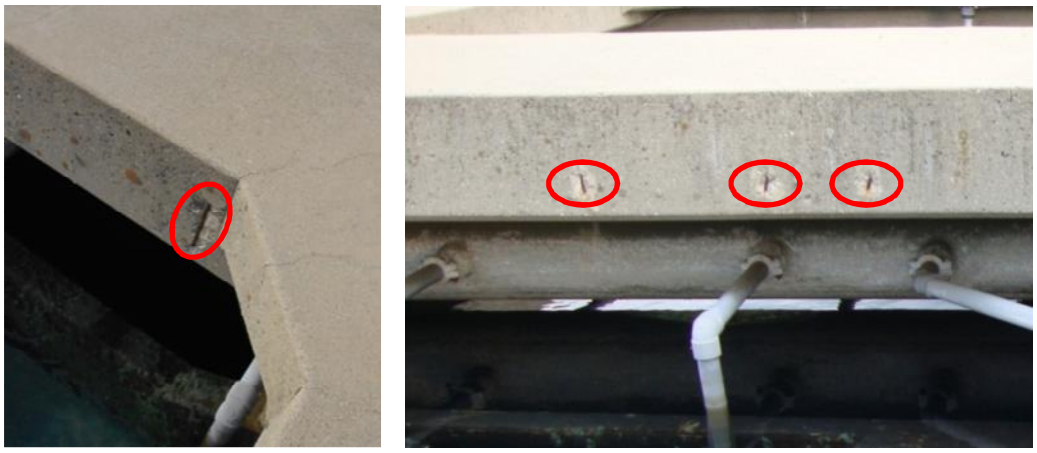

Figure 3-21. Exposed and corroded rebars.

3.5 SURFACE WASH SYSTEM REPLACEMENT

3.5.1 Existing Surface Wash System

FB1 and FB2 are currently using Baylis surface wash systems with slightly different configurations. Laterals are regularly spaced on each side of each trough, and each one of the 10 troughs supports two PVC laterals as seen in **Figure 3-22.** Each lateral has three nozzles, with 0.218-inch orifices in FB1 and 0.238-inch orifices in FB2. The original surface wash header design specified a carbon steel pipe. In a previous project, the carbon steel header in FB1 was replaced by a stainless steel pipe that has shown much better resistance to corrosion.

Figure 3-22. Surface wash laterals supported by concrete troughs.

3.5.2 System Selection and Technical Considerations

During demolition, laterals and nozzles will be replaced in all filters. In FB1, laterals are attached to the surface wash header by a flange as shown on **Figure 3-22**. These aterals will be removed at the flange during demolition. In addition, the header pipes will be replaced in FB2 to match the new stainless steel design in FB1. The header pipe will be removed in segments through the gullet wall openings.

A modified Baylis-type surface wash system was tested by MWD during the Study and will replace the existing system for the 48 filters. The flow velocity through each orifice will be decreased to 22.5 ft/sec. This is expected to reduce media loss and improve surface cleaning efficiency (MWH, 2009). The new system design criteria are summarized in **Table 3-12,** and supporting calculations are found in **Appendix B**.

Table 3-12. Design Criteria for Surface Wash.

Parameter	Unit	Value
Number of laterals per filter	-	40
Number of nozzles per lateral	-	4
Nozzle spacing	in x in	40 x 43.5
Area served by each nozzle	sf	12.083
Surface wash rate	gpm/sf	3.12
Surface wash rate	in/min	5
Nozzle flow rate	gpm	37.7
Number of orifices per nozzle	-	7
Orifice diameter	in	0.3125
Nozzle jet velocity	ft/s	22.5

The existing system had three nozzles per lateral, with the spacing from the walls to the first nozzle equal to the spacing between nozzles. As a result, nozzles near the wall had a greater area to serve, and the media near the filter wall was not effectively cleaned. In the rehabilitated system, each nozzle will serve the same surface area: at both ends of each lateral, the nozzle will be installed at a distance from the wall of half of the center-to-center nozzle spacing. The increased number of nozzles and improved spacing arrangement likely explains the better surface cleaning observed during the Study.

In the initial design for the new Baylis surface wash system, the laterals are mounted on each side of the troughs. The number of troughs will be reduced to 8, but the surface wash laterals locations will remain the same. Stainless steel support struts in each cell will supply structural support for the 20 laterals, and will be anchored to the concrete troughs. This will be part of the load the troughs must be designed to support. A layout of the surface wash system is shown on **Figure 3-13**, and it can be seen that troughs and laterals will sometimes overlap. Room will be available under the troughs to install the laterals, where required.

3.5.3 Surface Wash Header Wall Thimbles

In FB1, the original carbon steel headers were replaced with stainless steel pipes. During this replacement, the existing pipe was cut a few feet out from the wall, and the original wall thimble was left in place. In order to address the corrosion issue, the wall thimble was cleaned and re-coated with epoxy. A new flange was field-welded to the wall thimble, and it was connected to the new stainless-steel pipe with an insulating flange kit. This is shown in **Figure 3-23**.

Figure 3-23. Repaired wall thimble in FB1 (left), and corroded wall thimble in FB2 (right)

The surface wash header wall thimbles in FB2 were visually observed to be in poor condition (**Figure 3-23**). During final design, MWD corrosion and metallurgical specialists will investigate these thimbles. If they have sufficient metal remaining to be repaired, they will be cleaned and re-coated as was done for FB1. However, if they are damaged beyond repair, they will need to be cut out of the wall. In this case, a new stainless-steel spool will be cast in.

3.6 SURFACE SPRAY NOZZLE DEMOLITION

All filters have a surface spray system consisting of four nozzles, mounted from the deck along the influent side of the filter box. This system was originally installed for foam abatement, but MWD staff report that it does not work well and is not essential for filter performance. In addition, the existing surface spray nozzles and piping are in poor condition: many nozzles are broken, and the piping is corroded in some places. Therefore, this system will be demolished.

In both filter buildings, access to hose bibs delivering utility water on the filter deck must be maintained for filter wash-down. Therefore, piping will be demolished as shown on **Figure 3-24**. New piping will be run from the wall penetration, and ¾ inch and 2 inch hose bibs will be provided for every two filters.

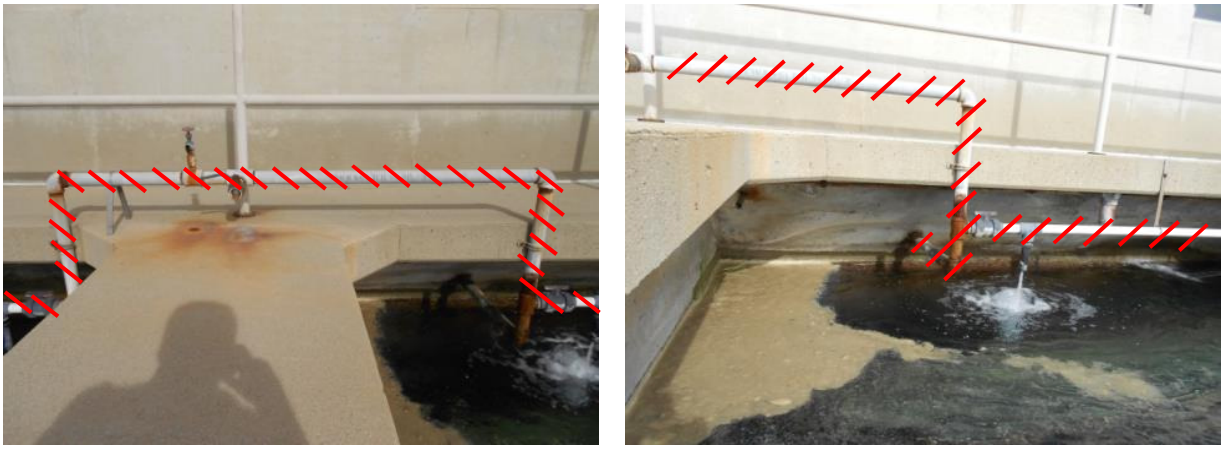

Figure 3-24. Surface spray demolition back to wall penetration.

3.7 LOWER GULLET ACCESS HATCH AND AIR VENT REPLACEMENT

3.7.1 Existing Access Hatches and Air Vents

Three different designs are currently in place. In Filters #1 to #12, the air vent is located at the center of the upper gullet, at the influent pipe entrance as shown on **Figure 3-25** (left). The lower gullet access hatch is rectangular and at the center of the upper gullet in between the two first troughs. In Filters #13 to #24, the air vent runs through the manhole as shown on **Figure 3-25** (right). The lower gullet access hatch is at the center of the upper gullet. It is circular and in between the first two troughs. In FB2, the air vent is located on the side of the upper gullet, attached to the gullet wall as shown in **Figure 3-26**. The lower gullet access hatch is at the center of the upper gullet. It is coated with tar in most FB2 filters.

3.7.2 System Selection and Technical Considerations

The lower gullet access hatches are heavily corroded in the plate and frame. The original access hatches, including their frames, will be cut out of the concrete. The access hatches will be replaced by stainless steel hatches that will be cast into the concrete. The new access hatch will be a round design. Design requirements include:

- *Corrosion resistance.* The manhole material must be suitable for submerged service.
- *Seal.* The manhole must be leak-proof to avoid a cross-connection between the upper and lower gullets. The system must be effectively sealed with gaskets.
- *Uplift strength.* The manhole must be able to resist uplift pressure in the lower gullet during backwash, without being removed or losing seal.

The lower gullet air vents are also corroded. Once they are removed, new stainless steel air vent pipe spools with weep rings will be cast into the upper gullet floor. The stainless steel spools will connect to UV resistant CPVC piping running up to a gooseneck at deck level. The CPVC piping for the gooseneck will be painted to increase its UV resistance and useful life. The gooseneck will be visible to allow operators to observe air being vented, and it will be provided with bird screen. The demolition and construction details will be determined in the design phase.

Figure 3-25. Lower gullet access hatches with air vents. Round (right) and square (left) designs.

Figure 3-26. Existing manhole (left) air vent (right) and in FB2.

3.7.3 Old Air Vent Demolition

In the FB1 filters, a smaller 1-inch copper air vent was initially built. It was later either removed or abandoned once the new 2 inch vents were placed in the upper gullet floor or the lower gullet access hatch. An old air vent is shown on **Figure 3-28** (left). In some filters in FB1, this vent was removed, and a cap was put in place to close the opening as shown in **Figure 3-28** (right). The cap appears to have some sort of sealant used to help seal the vent.

The old vent will be removed where it is still in place to avoid any potential cross-connection between the upper and the lower gullet. The opening in the upper gullet floor will be filled with concrete. In filters where a plate was put on top of the vent opening, the plate will be removed and the opening filled with concrete.

Figure 3-28. Initial air vent design still in place (left), and in some filters a plate covers the original vent opening (right).

3.8 UPPER GULLET BAFFLES

All filters have three sets of baffles installed in the upper gullet, to counteract the effects of high inlet velocities as the filter box is being filled. MWD staff report that the baffles work well from a hydraulic standpoint, but their condition varies between filter buildings.

The baffles in FB1 consist of wood boards mounted with stainless steel angles and structural members. They are mounted to the inside face of three of the existing concrete troughs. The baffles will have to be re-located with the new trough arrangement shown in **Figure 3-13**. However, the baffles themselves and their mounting hardware are in good condition as shown in **Figure 3-29,** and they can be re-used.

The baffles in FB2 are mounted differently, with steel bars connecting the top of the gullet wall to the top of the baffle board. Both the wood and the steel mounting hardware are in poor condition (**Figure 3-29**), so the baffles in FB2 will be replaced as part of this project to match the FB1 installation detail.

Figure 3-29. Upper gullet baffles in FB1 (left) and FB2 (right).

3.9 PRESSURE SENSOR INSTALLATION

3.9.1 Existing Differential Pressure Cells

Differential Pressure cells (DP cells) measure the difference in pressure between two points. The DP cells installed in FB1 and FB2 are shown in **Figure 3-30**. Each filter has two DP cells:

- One DP cell measures the pressure difference between the water level in the filter box and the top of the Venturi meter in each filter's effluent piping. It measures the headloss that accumulates in the filter during a filtration cycle. A backwash is triggered once the headloss measured by the DP cell reaches the terminal value, as discussed in **Section 2**.
- The other DP cell measures the pressure difference between the inlet side and the throat of the Venturi meter. This cell is used to track the flow through the filter and control the filtration rate.

3.9.2 System Selection and Technical Considerations

All DP cells in FB1 and FB2 will be replaced with Rosemount 3051 models, with local displays and 3-valve isolation manifolds, to match instrumentation used elsewhere in the plant. Both sensors – for the filter headloss and the Venturi meter – will be replaced for each filter. The existing copper piping leading to the sensors is acceptable, and only the sensors will be replaced. The inlet screens in the filter box (**Figure 3-31**) will also be repaired. These inlets consist of a short vertical pipe segment, topped with a nylon suction strainer with stainless steel 60-mesh screen.

The existing DP cells in FB2 are newer and were more recently replaced. However, they were not correctly installed and have some runs of horizontal piping. The sensors will be replaced so that all DP cells will be uniform, and the piping will be re-plumbed so that all pipes segments are vertical. This will prevent air bubbles from becoming trapped in the sensor piping.

Figure 3-30. Different pressure cells. Old design in FB1 (left) and new design in FB2 with some horizontal piping (right).

Figure 3-31. Inlet screen for the DP Cells.

3.9.3 Additional Pressure Sensors

In addition to the DP cell replacement at each filter, new pressure sensors will be installed in the locations shown in **Figure 3-32**. These sensors will also be Rosemount 3051 pressure transmitters to match existing plant instrumentation. The purpose of these sensors is discussed in **Section 2**. New pressure sensors will be installed in the following locations:

- *Backwash header:* four sensors, measuring pressure in psi.
- *Filter effluent channel:* four sensors, measuring pressure in feet of water.

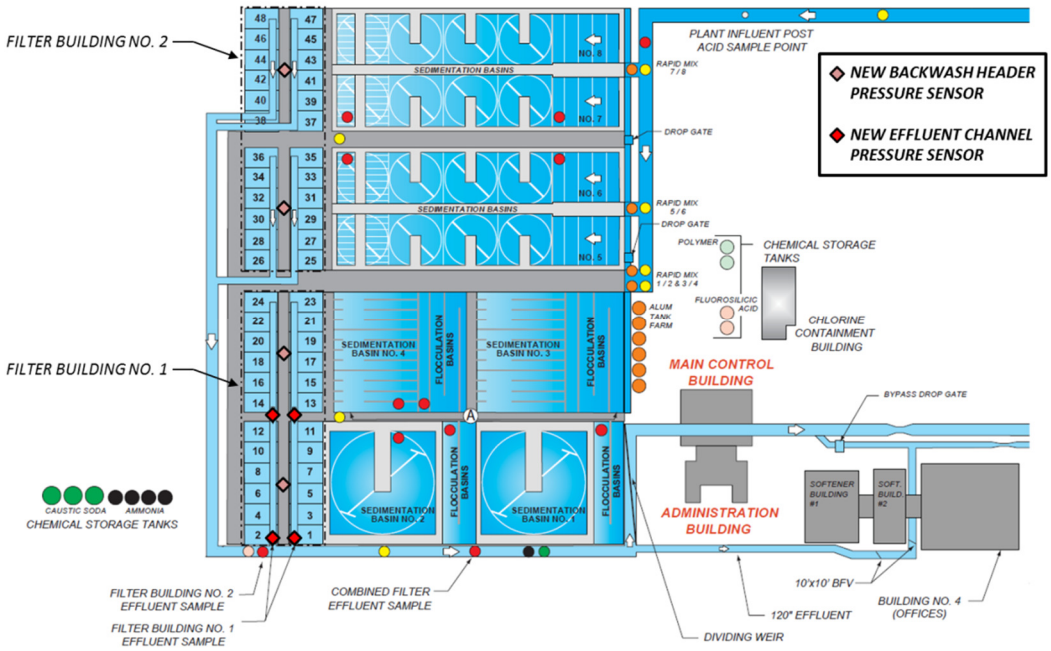

Figure 3-32. New pressure sensor locations.

The new backwash pressure sensors will be installed off of the backwash header, and the effluent level sensors will require new penetrations into the effluent channel. The sensors themselves should be located so that they are easily accessed by the operators for maintenance.

3.10 LIGHTING SYSTEM REMOVAL

In most of the filters in FB2 and some filters in FB1, lighting fixtures, associated electrical conduits, and supports are still in place as shown on **Figure 3-33**. They are abandoned and in poor condition, so they will be removed during filter rehabilitation. These supports will be cut out of the concrete, and the hole will be filled in to prevent exposure of the rebar.

Figure 3-33. Conduits, junction box (left), and fixtures (right) to be demolished.

All the conduits and the lighting fixtures will be demolished. The conduit bringing electrical power to the junction box will be kept for potential future usage, e.g. for new instrumentation. The old junction box will be removed and replaced by a new, more corrosion-resistant box.

The existing conduit for the drain gate actuators is also in poor condition and in need of replacement. This conduit will be demolished and replaced with PVC-coated rigid conduit as part of the separate Valve Rehabilitation Project.

Figure 3-34. Corroded conduit for drain gate actuators.

3.11 HANDRAIL REPLACEMENT

The handrail currently in place around FB1 and FB2 will be removed and replaced. This includes the handrail around the filters, along with external stairs and stairwells in the filter area. No new handrail will be provided – that is, areas that currently do not have handrailing will not have new railing installed. Handrail details for the modification of the Coagulant Tank Farm Modification at Weymouth will be used for the handrail replacement.

In November 2013, MWH conducted a field survey in order to anticipate potential issues for the design and installation of the new handrail system. The survey findings are detailed in **Appendix I**. Key findings and anticipated issues are summarized below, as well as proposed design concepts and recommendations.

- *Connection to the settling basin handrail*. The FB1 handrail is connected to the settling basin handrail on the south-west corner of the building. During the removal and replacement, the old handrail will be cut at the junction pole as displayed on **Figure 3-35**. The new handrail (installed where existing handrail is demolished in the figure) will be connected to the existing junction pole.

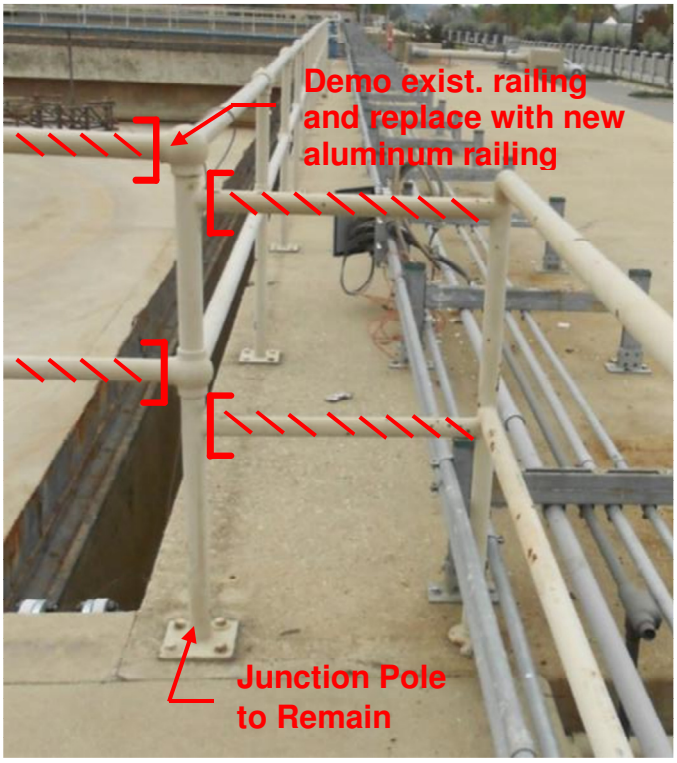

Figure 3-35. Junction pole between settling basin and FB1.

- *Lamps.* All the lamps already on site and included in the handrail (**Figure 3-36**) will be demolished and replaced. There are a total of 11 lamps that are integral to the filter handrailing, all of which will be replaced in kind.

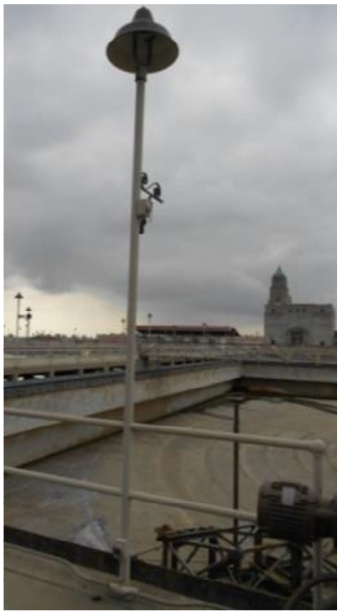

Figure 3-36. Lamp integral to handrailing.

- *Access gates.* Filter access gates will be replaced by gates at the same location as shown on **Figure 3-37**.

Figure 3-37. Current access gate.

- *Backwash gates.* The handrail surrounding the backwash drain gate actuators varies according to the location. The design that will be used for all rehabilitated filters is similar to the one shown on **Figure 3-38**. Each of the two handrails above the filter drain gate will be removable to allow for removal of the actuator and drain gate as needed. The handrailing pattern around the other actuators will not be replaced in kind.

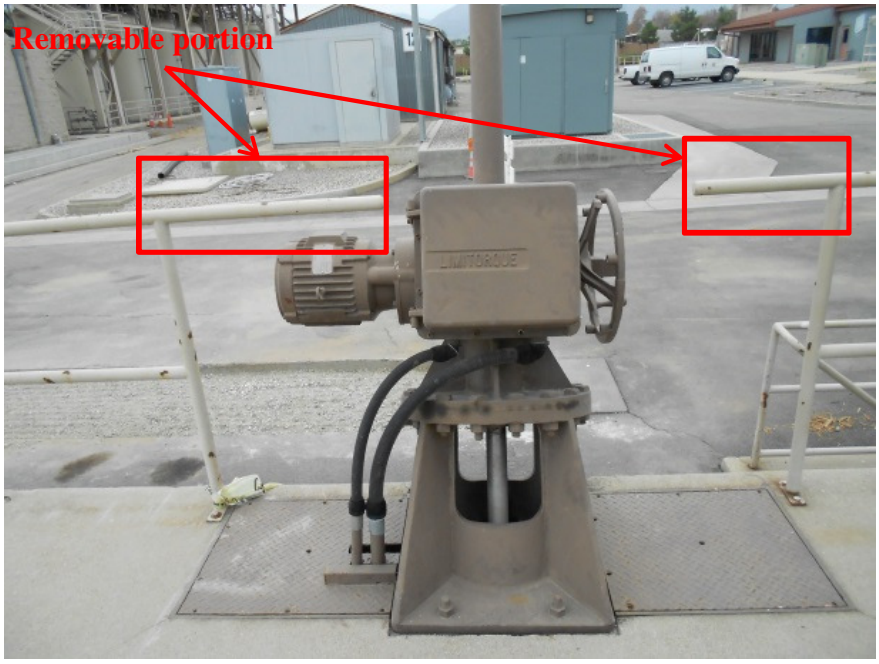

Figure 3-38. Backwash gates handrail layout.

- *Stairs.* The handrail will be replaced for several stairs in the vicinity of FB1 and FB2. The stairs locations are marked-up on the location maps in **Appendix I**. Some of these stairs with handrail are displayed in **Figure 3-38**. A complete inventory of all stairs with their location is provided in **Appendix I**.

Figure 3-39. Stairs with handrailing around FB1.

- *Joints.* Joints in both buildings have been located during the site survey. Their location and pictures are compiled in **Appendix G**. The buildings were built before 1980, so the caulk may contain PCBs. That could potentially cause health and safety issues during the filter rehabilitation. Additionally, some of those joints are old and damaged, and might have to be removed and replaced. Some of the handrail anchors are also drilled directly into the caulk as shown on **Figure 3-40**, which will be an issue during the bolt removal.

Figure 3-40. Joints and anchor bolts embedded in caulk.

- *Generator Vent.* An old generator vent with a wooden cover was identified on the north side of FB2 during the field survey. The conduit, cover, and handrail are shown on **Figure 3-41**. The location is also provided on a location map in **Appendix G**. The handrail around the vent will be demolished, but not replaced. The remaining steel vent will be removed and concrete will be used to fill in the hole.

Figure 3-41. Old generator vent handrail and cover.

- *Miscellaneous interferences.* Various items of equipment attached to the handrail, or potentially interfering with its replacement, were found as shown in **Figure 3-41**. Some of the interfering conduits will be demolished before the project starts. Basin wash down pipes will be detached from the old handrail before demolition, and reattached to new pipe supports separate from the handrailing. The handrail close to the chemical piping will be carefully designed to get around it as the current design does.

Figure 3-42. Conduit (upper left), wash-down water pipe (upper right), electrical panel (lower left), chemical pipes (lower right) in the vicinity of the handrail.

3.12 SITE FEATURE MODIFICATIONS

3.12.1 Sand Pan Drains

On the north east side of FB2, the sand pan is connected by two drains to the washwater sump. They are currently closed off by metal plates, as shown in **Figure 3-43**. Since the filter washwater is recycled from the sump, the drains will be permanently capped to prevent stormwater from draining into the sump. The drain piping shown in **Figure 3-43** will be capped, and the drain area will be re-graded with concrete.

Figure 3-43. Sand pans draining to the dirty wash water sump.

3.12.2 Backwash Sump Covers

Backwash sumps are located east of each of the filter buildings. Depending on the building, the backwash sump covers have different design. An inventory of all the covers including their locations and design is provided in **Appendix I**. The current stainless steel design shown in **Figure 3-44** is currently installed for the FB1 covers, and will be used for the FB2 covers.

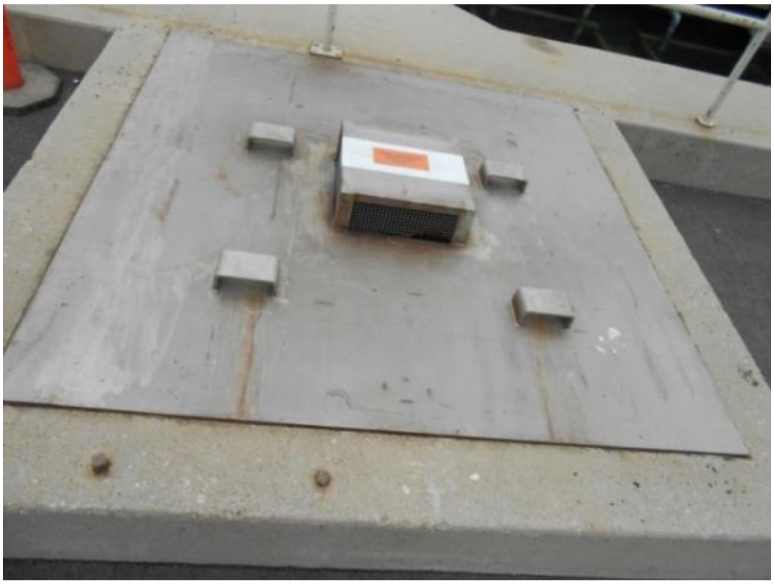

Figure 3-44. Current FB1 sump cover design, to be used in FB2.

The hatches that will be removed and replaced are shown on **Figure 3-45**. They are located adjacent to the filters in FB2.

Figure 3-45. Sump covers in FB2 to be removed and replaced.

3.13 PRELIMINARY DRAWINGS AND FINAL DESIGN

Preliminary drawings of the rehabilitated filters are found in **Appendix E.** These drawings are presented in marked-up form based on existing MWD drawings, to highlight features that are changing as part of this project. A list of drawing sheets and specification sections that will be developed during the final design phase is shown in **Appendix F**.

Section 4
Construction Sequencing

Proper sequencing of construction activities is a key aspect of the filter rehabilitation. This work must coordinate with other scheduled projects at the Weymouth WTP, which constrains the overall project schedule. In addition, construction and demolition activities for the filters must allow the plant to continue operation.

4.1 OVERALL SCHEDULE AND TIME FRAME CONSTRAINTS

The current schedule of major milestones for this project is summarized in **Table 4-13**.

Table 4-13. Schedule of Major Project Milestones.

Activity	Start	Finish
Board Action for Final Design	May 2013	
Preliminary Design	10/4/13	2/7/14
60% Final Design	2/12/14	4/4/14
60% Review	4/7/14	4/18/14
90% Final Design	4/21/14	5/9/14
90% Review and Constructability Review	5/12/14	5/23/14
100% Check Set and Bid Documents	5/26/14	7/11/14
Bid Phase Services	Jul 2014	Sep 2014
Board Action for Construction	Sep 2014	
Contractor Award	Oct 2014	
Construction	Oct 2014	Jan 2016

The other scheduled projects at the Weymouth WTP that are anticipated to pose constraints to the overall schedule of this project include:

- Wash Tank Project, to be completed in late 2014.
- Ozone Retrofit Project, to begin operation in mid-2016.

The Weymouth filter rehabilitation will start after the Wash Tank Project has finished. Because both projects will take place on the north side of the plant, overlapping them would lead to logistical challenges for the contractors. In addition, the rehabilitated filters should be completed and online before operation begins on the Ozone Project. Late 2014 to early 2016 is therefore the construction window for the Filter Rehabilitation Project, and other milestones in **Table 4-13** are set accordingly.

4.2 FILTER REHABILITATION SEQUENCING CONSTRAINTS

The Weymouth WTP must continue to operate while demolition and construction activities are ongoing for this project. Removing filters from service for construction decreases the total capacity of the plant, as shown in **Table 4-14**. This table provides the plant capacity at the maximum filtration rate of 3.0 gpm/sf (for the existing filters), under different rehabilitation scenarios. Each scenario is based on varying the number of filters out of service for rehabilitation, and assuming two additional filters offline.

Table 4-14. Plant Capacity for Various Rehabilitation Scenarios.

Scenario	Filter Configuration			Max Plant Flow
	Rehab	Offline	Online	(mgd)
Rehabilitate one filter building	24	2	22	184
Rehabilitate half of one filter building	12	2	34	284
Rehabilitate one quadrant of filters	6	2	40	334
Rehabilitate half of one quadrant	3	2	43	359

The bid documents for this project must stipulate the number of filters that the contractor may have offline at any point during construction, because this places an important constraint on the construction schedule. This must be specified in a way that balances the following considerations:

- *Plant capacity*. The Weymouth plant must have sufficient capacity for MWD's operations. The minimum acceptable plant capacity may vary seasonally, as demand on the Weymouth WTP is typically higher in the summer and lower in the winter. Therefore, more filters may be allowed offline during certain months of the year.

- *Constructability*. The contractor must have access to a sufficient number of filters so that the project is constructible within the given time frame. Many of the rehabilitation tasks will require a certain minimum duration, and additional time will be required for startup and commissioning of the rehabilitated filters (including disinfection). Having multiple filters offline allows these tasks to be overlapped.

The final design for this project will include a detailed investigation of construction scheduling issues. This will inform the selection of constraints that will be presented to the contractor in the final specifications.

Section 5
Opinion of Probable Construction Cost

An updated OPCC has been developed based on the project scope presented in this TM. The cost information is broken out into a "baseline cost" for the underdrain, media, troughs, surface wash, and gullet walls; along with additional costs for the other items added to the project scope.

5.1 COST ESTIMATE SUMMARY

Given that the level of project definition is between 10% and 40%, this estimate is a Class 3 OPCC as defined by the Association for the Advancement of Cost Engineering:

> *"Typical accuracy ranges for Class 3 estimates are -10% to -20% on the low side, and +10% to +30% on the high side, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination."*

In addition to the rehabilitation elements described in **Section 3** and the preliminary drawings in **Appendix E**, the OPCC was based on the following assumptions:

- 15% estimating contingency
- 2.5% phasing contingency
- 4% escalation
- 8% allowance for general conditions
- 1.2% allowance for bonds and insurance
- 8% allowance for contractor overhead and profit
- Mid-point of construction in mid-2015

The updated OPCC was calculated as shown in **Appendix H**. The total construction cost is estimated at $47.3 million. This cost breaks down as summarized in the following sections.

5.2 BASELINE COST FOR FILTER REHABILITATION

The baseline cost for this project incorporates the following items that were originally part of the scope of the Filter Rehabilitation Project. These are the first five items in **Table 3-8**.

- Underdrain replacement
- Filter media replacement
- Backwash trough replacement
- Gullet wall demolition and reconstruction
- Surface wash system replacement

The baseline costs are calculated as shown in **Appendix H** and summarized in **Table 5-15** below. For each filter building, the estimates in this table include the cost to rehabilitate the 22 unmodified filters and the 2 demonstration study filters.

Table 5-15. Baseline Cost Estimate Summary.

	Filter Building 1	Filter Building 2
Bare Costs by Item		
General demolition	$2.5 million	$2.6 million
New underdrains and troughs	$8.4 million	$8.4 million
New surface wash system	$1.2 million	$2.6 million
New filter media	$1.8 million	$1.8 million
Gullet wall and drain chute repair	$1.1 million	$1 million
Total Costs		
Total bare cost	$15.1 million	$16.5 million
Total with allowances/contingencies	$21.4 million	$23.3 million
BASELINE TOTAL	**$44.7 million**	

5.3 COST FOR ADDITIONAL SCOPE ITEMS

The total construction cost includes some additional items (listed below) which were added to the scope of this project during conceptual design. These constitute the last 7 items in **Table 3-8**.

- Surface spray system demolition
- Demolition and replacement of lower gullet access hatches and air vents
- Rehabilitation of upper gullet baffles
- Replacement and installation of pressure transmitters
- Demolition of filter box lighting
- Replacement of site handrailing
- Modification of site features

The costs for these items are calculated in **Appendix H** and summarized in **Table 5-16**.

Table 5-16. Cost Summary for Additional Items.

	Bare Cost	Total Cost
Surface spray demolition	$448,500	$634,200
Access hatch and air vent replacement	$546,100	$772,300
Baffle rehabilitation	$100,800	$142,500
Pressure transmitter installation	$359,200	$508,000
Filter box lighting demolition	$23,400	$33,200
Site handrailing replacement	$388,400	$549,200
Site feature modification	$14,200	$20,100
ADDITIONAL ITEMS TOTAL	**$1.43 million**	**$2.66 million**

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Appendix A

Data from Metropolitan Water District

Weymouth Plant 2006-2013

Data from Shannon M. Maceiko, MWD Water Quality, 02/18/2014

	Median	Min	Max	Average	St Dev	Design
Flow (MGD)	222.1	61	480	228.7	58.9	60 to 520
Clarifier Turbidity (NTU)	0.6	0	3.89	0.65	0.36	≤ 2
Temperature (C)	19	7	30.1	19	4.8	---
Alum Dose (mg/L)	7.5	5	30	8.09	3.99	1 to 40
Polymer Dose (mg/L)	2.5	2	5	2.4	0.31	0.1 to 5
Filtration Rate (gpm/ft^2)	3.69	2.18	4	3.45	0.49	2.8 to 4.06
Filter Eff Turbidity (NTU)	0.05	0.005	0.6	0.054	0.011	≤ 0.1
SPW (percent)	44.7	0	100	47.8	24.1	---

THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

Date: July 25, 2011

To: Brad Coffey, Water System Operations Assistant Group Manager

From: Sun Liang, Water Purification Unit Manager

Subject: Minimum Sustainable Water Treatment Plant Flows

Summary

The design of Metropolitan's five water treatment plants includes criteria for minimum plant flow and minimum chemical doses. A preliminary review of Metropolitan's water treatment plants indicates that all plants are capable of reliably achieving water quality requirements and goals when sustaining their minimum design flow for a minimum of one week each year. It should be noted for the Diemer plant, minimum flow operation can be sustained with only one influent source; operation with both influent pipelines to achieve a blend of State Project water (from the Yorba Linda Feeder) and Colorado River water (from the Lower Feeder) requires maintaining a total plant influent flow that is 5 million gallons per day (MGD) above the minimum design flow.

The minimum sustainable plant flows and operational limitations discussed in this memorandum have been reported by each of the water treatment plants. In general, the initial review of operational constraints reported for each plant indicates that the limited ability to operate at chemical doses that are less than the minimum feed rate is the primary constraint to operating at flows lower than design rates. It is important to note that the water treatment plants would not be operating at optimal conditions at these low flows. However, these flows would be sustainable for a minimum of one week each year at the water treatment plants.

Further investigation is required to determine whether other operational constraints may also limit the water treatment plants from reliably achieving water quality goals at flows that are below their minimum design. As an example, chemical mixing within the combined filter effluent channel is highly dependent upon turbulent flow since no mechanical device is currently installed to increase mixing energy. Low flow and poor mixing in the combined filter effluent channel may increase precipitation that may clog sodium hydroxide and ammonium hydroxide feed lines, as well as lead to unstable chloramine (dichloramine) formation and increased free ammonia levels. Reduced flows may also result in extended (excessive) mixing that may negatively impact floc formation and settling within the flocculation and sedimentation basins, respectively. Reduced plant flow lengthens the overall detention time, which in turn may increase disinfection byproduct (DBP) formation.

Background

The minimum design flows and the minimum sustainable flows for Metropolitan's five water treatment plants are as shown in Table 1. The ozone design criteria for all of the water treatment

plants have used the minimum design flows shown in the table. For reference, the maximum sustainable design flow is also provided.

Table 1: Minimum and Maximum Design Flows and Minimum Sustainable Flow

Water Treatment Plant	Minimum Design Flow		Minimum Sustainable Flow		Maximum Design Flow	
	(MGD)	(cfs)	(MGD)	(cfs)	(MGD)	(cfs)
Diemer	65	100	70	110	520	800
Jensen	60	90	60	90	750	1160
Mills	25	40	25	40	220	340
Skinner	65	100	65	100	630	970
Weymouth	60	90	60	90	520	800

Operational Concerns

The minimum sustainable flows at most of the water treatment plants are limited by chemical feed turndown capacity. The chemical feed injection points at the plant influent, rapid mix, filter influent, combined filter effluent, and the reservoir influent are designed to be capable of achieving minimum doses at the minimum plant flow. When operating at the low-flow end of a chemical pump's flow range, the pump may sporadically feed chemicals such that the automatic process control program is unable to achieve the target dosage. This can lead to fluctuating chemical concentrations, which can compromise water quality.

In addition, long detention times caused by low flows increase the response time for determining if a target chemical concentration has been achieved. This delay in acquiring a concentration value is extended such that it is difficult to fine tune the chemical feed flow rates, possibly compromising treated water quality. Whether remotely or manually controlled, chemical pump output is likely to fluctuate at the minimum pump design flows, which, in conjunction with increased feedback response time, compounds the difficulty to achieve a target concentration at low plant flows. This issue is exacerbated by the fact that sampling and monitoring points are generally located at fixed points in the treatment plant. At low flows, the detention time to those locations may be 10 times longer than at maximum design flows.

Inadequate mixing energy in the combined filter effluent channel at the low plant flows is another concern for the Jensen, Mills, and Skinner plants. With inadequate mixing, it would be difficult for the plants to assess if the fluctuation in chemical concentration was due to poor mixing or inaccurate chemical feed flow rates. Overfeeding chlorine would lead to exceedance of the target 5 to 1 chlorine to ammonia (w/w) ratio and could lead to loss of disinfectant residual in the finish water reservoirs. Significant effort would be required to coordinate a plant outage and conduct improvements to chemical mixing in the combined filter effluent. Most methods employed to improve mixing impart head loss through the channel. Though effective at low

flow, the additional head loss could constrain the plant when once again operating at higher flows.

Long detention times in the finished water reservoir is also a concern for all water treatment plants at these flows, as this could lead to excessive chloramine decay. Disinfection byproduct formation would increase with longer plant detention times and could lead to exceedance of THM and bromate goals at the treatment plant effluents.

Table 2 summarizes the operational concerns expressed by each water treatment plant to operate at flows less than their minimum sustainable flows shown in Table 1. Additional plant specific concerns are discussed below.

Table 2: Operational Concerns

Water Treatment Plant	Operational Concerns	
	Minimum Chemical Feed Rates	Chemical Mixing in the Combined Filter Effluent Channel
Diemer	X	
Jensen	X	X
Mills	X	X
Skinner	X	X
Weymouth	X	

Diemer

The minimum sustainable plant flow of 70 MGD is approximately 5 MGD higher than the minimum design flow at the Diemer plant. The chemical feed systems are capable of operating at the minimum design flow; however, unstable plant influent flow readings on the Yorba Linda Feeder and the Lower Feeder at low flows upset the flow-paced chemical feed rates at the water treatment plant. The automatic process control program adjusts the target feed rates on all flow-paced chemicals that are dependent on the plant influent flow meter. At low chemical feed rates, the pump outputs can be erratic, causing the automatic process control program to constantly adjust the pump speed when downstream flow meters do not match the target feed flow rates. These abrupt changes in chemical feed rates can lead to poor chemical mixing and under- or over-feeding of treatment chemicals.

Jensen

One filter backwash can abruptly change the combined filter effluent channel level at low plant flows. These changes would impact chloramine formation in the combined filter effluent channel due to the simultaneous lack of mixing energy and sudden overfeeding of chemicals.

The response time to correct the situation would be delayed with the increased detention times brought about by low plant flows.

Mills

The self backwashing filter configuration limits the Mills plant's minimum sustainable flow to the water required for a filter backwash. A minimum 25 MGD flow is required to complete a full backwash on one filter. Therefore, a minimum plant flow of 25 MGD through one filter would provide the minimum flow sufficient to backwash one other filter and maintain plant operation.

The inability to reduce the ozone feed rate is another concern at low plant flows and cold water conditions. An ozone residual greater than 0.25 mg/L at the flocculation basin would off-gas and the automatic process control would shut off the ozone system. Chloramine addition or pH suppression at the contactor influent for bromate control would decrease the ozone demand, thereby further lowering the required ozone dose. Disinfection byproducts would be increased if these bromate control measures were omitted in order to increase ozone demand and better control the ozone feed rate.

Skinner

All chemical systems were designed to meet minimum dosages at a minimum plant flow of 65 MGD with the recent oxidation retrofit program and chemical systems improvements project. In addition to this physical restriction, the lack of adequate mixing within the combined filter effluent channel also limits the plant from lowering the minimum operable plant flow below 65 MGD. Caustic, ammonia, chlorine, and fluorosilicic acid are injected in the combined filter effluent at the Skinner plant. At flows below 65 MGD, inadequate mixing of these chemicals in the combined filter effluent channel could compromise water quality at the plant effluent.

Weymouth

The chemical feed systems limit the minimum plant flow at the Weymouth plant since they were designed for a minimum plant flow of 60 MGD. At this time, no other operational issues related to lowering the plant flow below this design flow are known. It is possible that the lower limit of the Venturi flow meters, which determine the upstream chemical feed rates in the combined filter effluent channel, would restrict the minimum plant flow. A detailed evaluation of each chemical feed system and the lower limit of the combined filter effluent channel Venturi meters would need to be performed to determine if plant operation below the design flow were sustainable.

Conclusion

All water treatment plants are restricted to their minimum sustainable plant flows by issues related to the lower limit of their chemical feed systems. Provision of greater chemical feed system turndown alone, however, may not lower the minimum sustainable plant flows due to other water quality issues at flows below the minimum sustainable plant flows. Increased DBP

formation and increased chloramine decay are a concern for all water treatment plants when operating at low flows.

The difficulty of meeting target chemical concentrations combined with a lack of sufficient mixing energy is a concern for the Jensen, Mills, and Skinner plants to operate at flows below their minimum sustainable flows. In particular, unstable chloramine formation and increased chloramines decay in the combined filter effluent channels could compromise water quality.

As a first step to exploring available options to reduce the minimum sustainable plant flows, the water treatment plants could identify additional plant components that would need improved mixing at low flows, as well as alternative disinfection schemes to ensure that DBPs remain below internal goals at longer detention times. The minimum sustainable flows discussed in this memorandum have been provided by each water treatment plant. Additional inspection is required to evaluate other restrictions that may prevent the treatment plants from sustainably operating below these minimum flows.

Sun Liang

JTL:smh
H:\\memos\jtl minimum wtp flows.docx

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Appendix B

Preliminary Design Supporting Calculations

MWD - Weymouth Filter Rehabilitation

Filter Elevation Tabulation

Abbreviations

BOD	Bottom of Deck	TOEW	Top of Existing Gullet Wall
BOT	Bottom of Trough	TOM	Top of media
MF	Media Freeboard	TORW	Top of Raised Wall
MRP	Media Retention Plate	TOT	Top of Trough
TOD	Top of Deck	TOW	Top of Weir/Gullet Wall
TOEM	Top of Expanded Media		

Media Properties

Anthracite ES	mm	1.0
Sand ES	mm	0.5
Bed Expansion	%	15

Assumptions

Media Freeboard (MF) is defined as the distance between the expanded media and the bottom of the trough.
All values in NAVD88 datum.
The HDPE underdrain is assumed to be 8-5/8" thick with a 1-3/4" media retention plate, per Leopold product data.
The deck is between 6 inches to 1-ft thick.
Assume the gullet wall needs to be 6 inches higher than the top of the troughs.
The goal between TOM and BOT is to enable 30% media expansion without hitting the bottom of the trough.

Summary of Components

Component	**Filter Building 1**	**Filter Building 2**
Backwash Troughs	New, 19" deep, raised	New, 19" deep, raised
Surface Wash System	New	New
Media Freeboard	Meet 9-12" MF	Meet 9-12" MF
Media Layer Depths	8" sand, 26" coal	8" sand, 26" coal
Gravel / Media Support	MRP	MRP
Underdrain	New HDPE Block	New HDPE Block

Elevation Table

Component	Filter Building 1				Filter Building 2			
	Existing		Preliminary Design		Existing		Preliminary Design	
	Value (in)	Elevation (ft)	Value (in)	Elevation (ft)	Value (in)	Elevation (ft)	Value (in)	Elevation (ft)
Deck and Gullet Wall								
Top of Deck		1095.803		1095.803		1095.775		1095.775
Deck Thickness	12		12		12		12	
Bottom of Deck		1094.803		1094.803		1094.775		1094.775
Top of Existing Gullet Wall		1091.813		1091.813		1091.799		1091.799
Dist from TOEW to TOT	6		4		6		-3	
TORW		1091.813		**1091.980**		1091.799		**1092.549**
Dist from TORW to BOD	36		34		36		27	
Dist from TOT to BOD	42		40		42		33	
Troughs and Freeboard								
TOT		1091.313		**1091.480**		1091.299		**1092.049**
Trough Depth	27		19		21		19	
Raise Trough / Gullet Wall			2				9	
BOT		1089.063		1089.896		1089.549		1090.466
TOM to BOT	7.892		16.517		6.14		15.765	
% Exp Space (30% goal)	28%		49%		29%		46%	
TOM		1088.405		**1088.520**		1089.037		**1089.152**
BOT		1089.063		1089.896		1089.549		1090.466
TOEM to BOT (9-12" goal)	5.1		11.4		4.0		10.7	
TOEM		1088.639		1088.945		1089.212		1089.577
Media and Underdrain								
Anthractite	20	1088.405	26	1088.520	12	1089.037	26	1089.152
Sand	8	1086.739	8	1086.353	9	1088.037	8	1086.985
Gravel or MRP	15	1086.072	1.75	1085.687	18	1087.287	1.75	1086.319
Underdrain	0	1084.822	8.625	1085.541	4	1085.787	8.625	1086.173
Floor		1084.822		1084.822		1085.454		1085.454
L/d Ratio, Anthracite	508		660.4		304.8		660.4	
L/d Ratio, Sand	406.4		406.4		457.2		406.4	
L/d Ratio, Total	914.4		1066.8		762		1066.8	

Filter and Media Configurations

Calc by: MJA
February 25, 2014

Filter Dimensions

$L_{Filter} := 72.5ft$ $\quad W_{Cell} := 13.33ft$ — Existing filter box dimensions

$N_{Cells} := 2$ — Two cells per filter

$A_{Filter} := L_{Filter} \cdot W_{Cell} \cdot N_{Cells}$ — Calculate filter area

$A_{Filter} = 1933 \cdot ft^2$

Media Layers

Sand layer:	*Anthracite layer:*	
$H_{Sand} := 8in$	$H_{Anthracite} := 26in$	Layer depth
$\varepsilon_{Sand} := 0.4$	$\varepsilon_{Anthracite} := 0.425$	Porosity
$SG_{Sand} := 2.65$	$SG_{Anthracite} := 1.60$	Specific gravity
$d_{Sand} := 0.5mm$	$d_{Anthracite} := 1.0mm$	Effective size
$UC_{Sand} := 1.4$	$UC_{Anthracite} := 1.4$	Uniformity coefficient

Water Properties

$\nu_{Water} := 1 \frac{mm^2}{s}$ $\quad \rho_{Water} := 1000 \frac{kg}{m^3}$ — Viscosity and density

Filtration Cycle

Filtration Rate

$$V_{Filtration} := \begin{pmatrix} 2.8 \\ 4.06 \\ 4.69 \end{pmatrix} \frac{gpm}{ft^2}$$

- General min of 2.8 gpm/sf to prevent surface removal
- Typical max of 4.06 gpm/sf for 520 MGD plant capacity
- Temporary max of 4.69 gpm/sf for 600 MGD plant capacity

$Q_{Filtration} := V_{Filtration} \cdot A_{Filter}$

Calculate filtration flow rate per filter box

$$Q_{Filtration} = \begin{pmatrix} 7.8 \\ 11.3 \\ 13.1 \end{pmatrix} \cdot mgd$$

Clean Bed Headloss Function

$k_{CK} := 4$

Carman-Kozeny model for clean-bed headloss.

$$HL_{Darcy}(V, H, d, \varepsilon) := \frac{36 \cdot k_{CK} \cdot \nu_{Water}}{g} \cdot \left[\frac{(1-\varepsilon)^2}{\varepsilon^3} \right] \cdot \left(\frac{H}{d^2} \right) \cdot V$$

Estimated Clean Bed Headloss through Media

$$HL_{CleanSand} := HL_{Darcy}(V_{Filtration}, H_{Sand}, d_{Sand}, \varepsilon_{Sand}) = \begin{pmatrix} 5.026 \\ 7.287 \\ 8.418 \end{pmatrix} \cdot in$$

$$HL_{CleanAnthracite} := HL_{Darcy}(V_{Filtration}, H_{Anthracite}, d_{Anthracite}, \varepsilon_{Anthracite}) = \begin{pmatrix} 3.127 \\ 4.534 \\ 5.237 \end{pmatrix} \cdot in$$

$HL_{CleanBed} := HL_{CleanSand} + HL_{CleanAnthracite}$

Calculate clean-bed headloss through both media layers

$$HL_{CleanBed} = \begin{pmatrix} 0.68 \\ 0.99 \\ 1.14 \end{pmatrix} \cdot ft$$

$$K_{CK} := \frac{HL_{CleanBed}}{V_{Filtration}}$$

$$K_{CK_0} = 108.9 \cdot \frac{ft}{fps}$$

Calculate clean-bed headloss coefficient to scale headloss to filtration rate.

L/d Ratios

$$L_d_{Anthracite} := \frac{H_{Anthracite}}{d_{Anthracite}}$$

$L_d_{Anthracite} = 660$

$$L_d_{Sand} := \frac{H_{Sand}}{d_{Sand}}$$

$L_d_{Sand} = 406$

$L_d_{Overall} := L_d_{Anthracite} + L_d_{Sand}$

$L_d_{Overall} = 1067$

Backwash Cycle

Backwash Flow Rate

$V_{Backwash} := 16 \frac{gpm}{ft^2}$ Maximum washwater velocity

$Q_{Backwash} := V_{Backwash} \cdot A_{Filter}$ Calculate backwash water flow rate

$Q_{Backwash} = 68.9 \cdot \frac{ft^3}{s}$

Surface Wash Flow Rate

$V_{SurfaceWash} := 3 \frac{gpm}{ft^2}$ Design surface wash velocity

$Q_{SurfaceWash} := V_{SurfaceWash} \cdot A_{Filter}$ Calculate surface wash flow rate

$Q_{SurfaceWash} = 12.9 \cdot \frac{ft^3}{s}$

Media Compatibility Check

For media layers to have compatible backwash velocities in a dual-media filter, we must have

$$\frac{d_{10-Bot} \times UC_{Bot}}{d_{10-Top} \times UC_{Top}} = \left(\frac{SG_{Top} - 1}{SG_{Bot} - 1}\right)^{\frac{2}{3}}$$

$$\frac{d_{Sand} \cdot UC_{Sand}}{d_{Anthracite} \cdot UC_{Anthracite}} = 0.5$$

$$\left(\frac{SG_{Anthracite} - 1}{SG_{Sand} - 1}\right)^{\frac{2}{3}} = 0.509$$

CONCLUDE: the media layers are balanced to be cleaned at a single back-wash velocity.

Headloss through Fluidized Media

Once the media is fluidized, the headloss through the media will be its buoyant weight:

$$HL_{BW.Media} := H_{Sand} \cdot (1 - \varepsilon_{Sand})(SG_{Sand} - 1) + H_{Anthracite} \cdot (1 - \varepsilon_{Anthracite})(SG_{Anthracite} - 1)$$

$HL_{BW.Media} = 1.41 \cdot ft$

Weymouth Filter Rehab: Backwash Trough Sizing

Calc by: MJA
February 4, 2014

Backwash Parameters

Filter Geometry:

$L_{Filter} := 72.5ft$

Existing filter box geometry (2 cells)

$W_{Cell} := 13.33ft$

$W_{Filter} := 2 \cdot W_{Cell} = 26.7 \cdot ft$

$A_{Filter} := L_{Filter} \cdot W_{Filter} = 1933 \cdot ft^2$

Backwash Flow Rate:

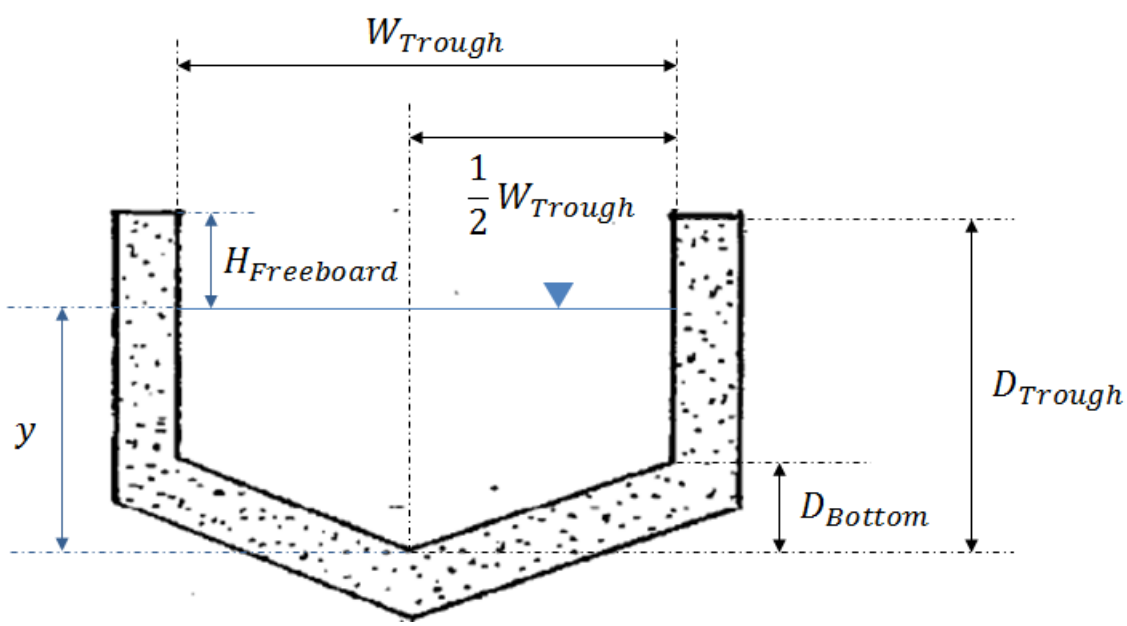
$V_{BW} := 19 \frac{gpm}{ft^2}$

Assumed backwash velocity - 16 gpm/sf for washwater plus 3 gpm/sf surface wash

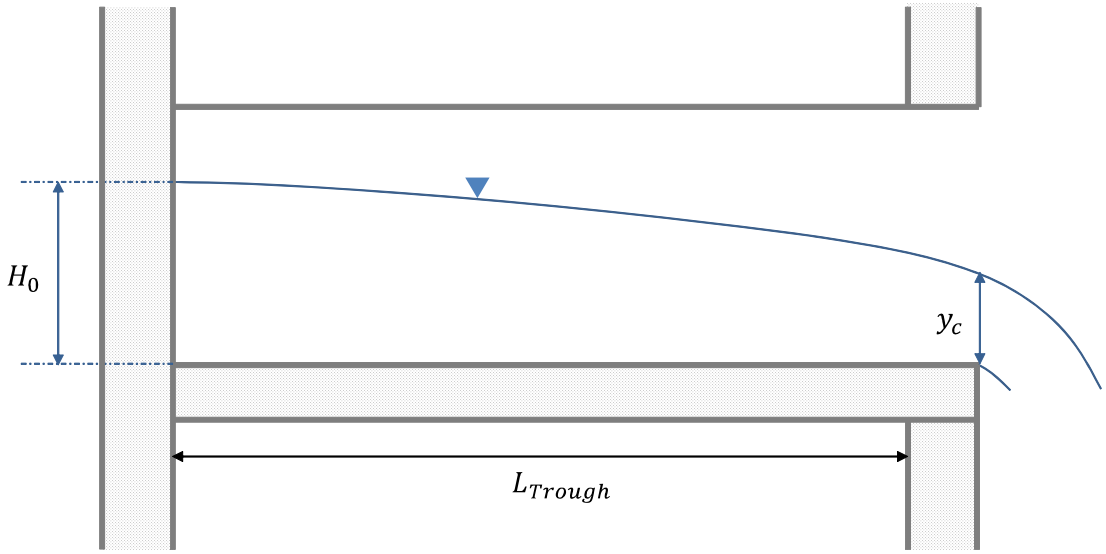
$Q_{BW} := V_{BW} A_{Filter} = 81.8 \cdot \frac{ft^3}{s}$

Trough Configuration

Definition Sketch - Cross Section:



Definition Sketch - Longitudinal Section:



Design Configuration: $N_{Troughs} := 8$ $W_{Trough} := 24in$

$$Q_{Trough} := \frac{Q_{BW}}{2N_{Troughs}}$$ $Q_{Trough} = 5.1 \cdot cfs$

$$S_{Trough} := \frac{L_{Filter}}{N_{Troughs}}$$ $S_{Trough} = 108.75 \cdot in$

Additional Assumptions:

- The troughs are concrete, with a Manning roughness coefficient of $n_{Trough} := 0.020$
- The troughs are $L_{Trough} := W_{Cell} = 13.3 \cdot ft$ long with bottoms $D_{Bottom} := 4in$ deep
- A minimum freeboard of $H_{Freeboard} := 3in$ will be required
- The trough concrete thickness is $T_{Trough} := 3in$

Required Trough Depth: Define Functions

Based on the method presented by Reynolds and Richards (1996), p. 311-313.

Flow Area:

$$A_{Flow}(y, W, D_{Bottom}) := \frac{1}{2} \cdot W \cdot D_{Bottom} + W \cdot (y - D_{Bottom})$$

Wetted Perimeter:

$$P_W(y, W, D_{Bottom}) := 2\cdot(y - D_{Bottom}) + 2\sqrt{\left(\frac{1}{2}\cdot W\right)^2 + (D_{Bottom})^2}$$

Hydraulic Radius:

$$R_H(y, W, D_{Bottom}) := \frac{A_{Flow}(y, W, D_{Bottom})}{P_W(y, W, D_{Bottom})}$$

Flow Velocity:

$$V_{Flow}(Q, A_{Flow}) := \frac{Q}{A_{Flow}}$$

Critical Depth:

Depth y_c for which the Froude number $\dfrac{V_{Flow}}{\sqrt{g\cdot\dfrac{A_{Flow}}{W_{Trough}}}} = 1$

$$y_c(Q, W, D_{Bottom}) := \mathrm{root}\left(1 - \frac{V_{Flow}(Q, A_{Flow}(y_{c0}, W, D_{Bottom}))}{\sqrt{g\cdot\dfrac{A_{Flow}(y_{c0}, W, D_{Bottom})}{W}}}, y_{c0}\right)$$

Upstream Depth (Camp equation):

$$C_F(Q, W, L, n, y_c, y_{Avg}, R_{H.Avg}) := \left[\frac{n^2\cdot\left(\frac{L}{m}\right)\cdot\left(\frac{Q}{\frac{m^3}{s}}\right)^2}{\left(\frac{W}{m}\right)^2\cdot\left(\frac{R_{H.Avg}}{m}\right)^{\frac{4}{3}}\cdot\left(\frac{y_{Avg}}{m}\right)}\right]\cdot m^2$$

Factor accounting for channel friction losses.

$$H_0(Q, W, L, n, y_c, y_{Avg}, R_{H.Avg}) := \sqrt{y_c^{\,2} + \frac{2\cdot Q^2}{g\cdot W^2\cdot y_c} + \frac{2}{3}\cdot C_F(Q, W, L, n, y_c, y_{Avg}, R_{H.Avg})}$$

Average Depth:

$$y_{Avg}(H_0, y_c) := H_0 - \frac{1}{3}\cdot(H_0 - y_c)$$

Assumes a parabolic water surface

Solve for Required Trough Depth and Dimensions

Critical Depth:

$$y_{c.Trough} := y_c\left(Q_{Trough}, W_{Trough}, D_{Bottom}\right) = 9.1 \cdot in$$

Average Depth:

Upstream depth equation with design values - only variables are depth and hydraulic radius:

$$H_{0.Design}\left(y, R_H\right) := H_0\left(Q_{Trough}, W_{Trough}, L_{Trough}, n_{Trough}, y_{c.Trough}, y, R_H\right)$$

Iterative solution for the average depth y_{Avg}:

$$y_{Avg.Trough} := root\left(y_{Avg}\left(H_{0.Design}\left(y_0, R_H\left(y_0, W_{Trough}, D_{Bottom}\right)\right), y_{c.Trough}\right) - y_0, y_0\right) = 11.6$$

Maximum Flow Depth and Minimum Trough Depth:

Solve the average depth equation for H_0:

$$H_{0.Trough} := \frac{1}{2} \cdot \left(3 \cdot y_{Avg.Trough} - y_{c.Trough}\right) \qquad H_{0.Trough} = 12.8 \cdot in$$

$$D_{TroughMin} := H_{0.Trough} + H_{Freeboard} \qquad D_{TroughMin} = 15.8 \cdot in$$

Actual Trough Dimensions:

$$D_{Trough} := ceil\left(\frac{D_{TroughMin}}{in}\right) \cdot in$$

$$D_{TroughOutside} := D_{Trough} + T_{Trough}$$

$$W_{TroughOutside} := W_{Trough} + 2 \cdot T_{Trough}$$

The inside dimensions of the troughs are $D_{Trough} = 16 \cdot in$ by $W_{Trough} = 24 \cdot in$.

The outside dimensions of the troughs are $D_{TroughOutside} = 19 \cdot in$ by $W_{TroughOutside} = 30 \cdot in$

Percentage Cover of Filter Area:

$$A_{Troughs} := N_{Troughs} \cdot W_{TroughOutside} \cdot W_{Filter} = 533.2 \cdot ft^2$$

$$Cover := \frac{A_{Troughs}}{A_{Filter}} \qquad Cover = 27.6 \cdot \%$$

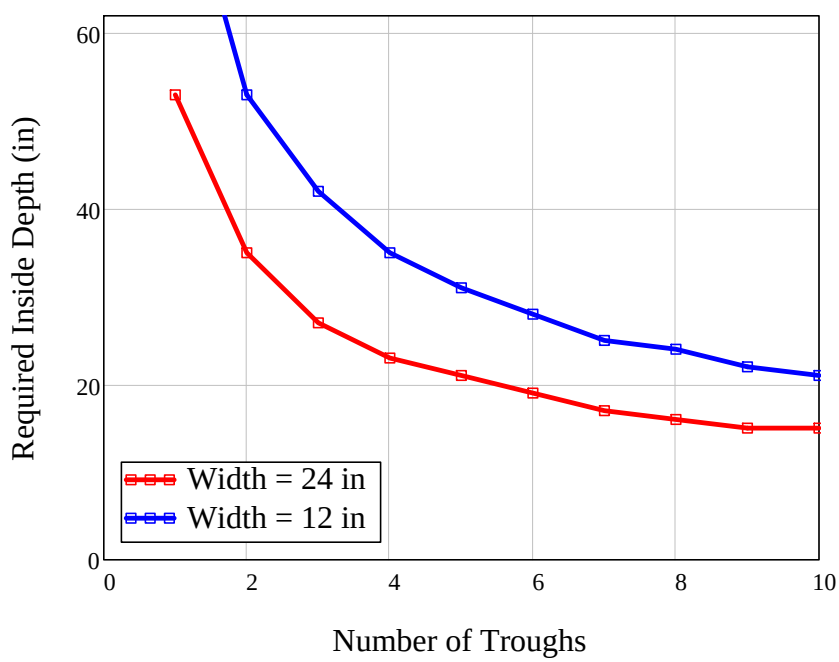
Evaluate Possible Trough Configurations

Table of Required Depths:

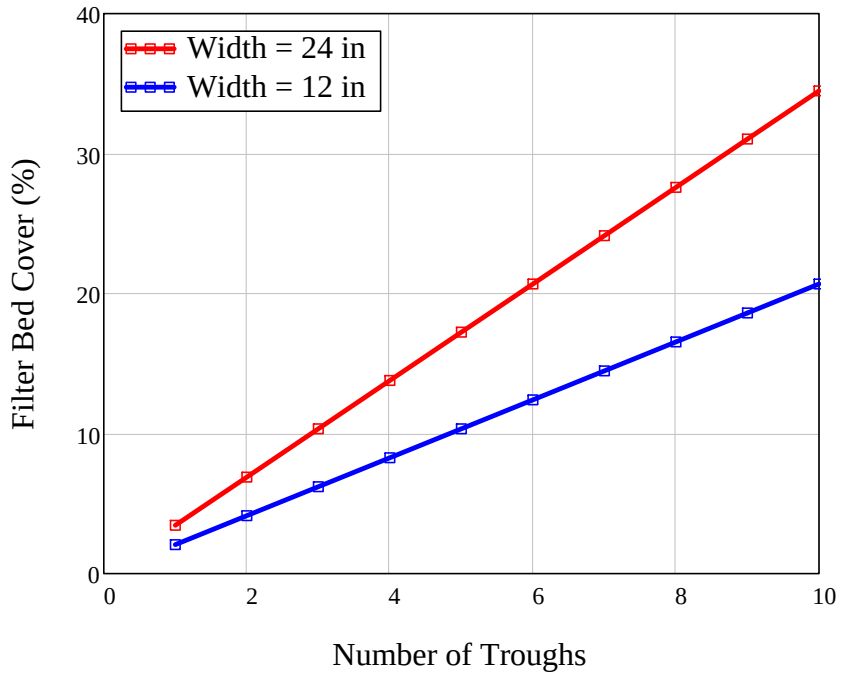
Assumes trough width is $W_{Trough} = 24 \cdot in$

Number of troughs: N_{Range} =	*Water depth:* D_{Water} = ·in	*Trough depth (inside):* D_{Design} = ·in
1	49.4	53
2	31.2	35
3	24	27
4	19.9	23
5	17.2	21
6	15.3	19
7	13.9	17
8	12.8	16
9	11.9	15
10	11.2	15

Plot of Design Depth vs. Number of Troughs:



Plot of Bed Cover vs. Number of Troughs:



MWD - Weymouth Filter Rehabilitation

Trough Configurations - Sizing

W_{Filter} =	13.333	ft	Width of the filter cell (parallel to troughs)
L_{Filter} =	72.5	ft	Length of the filter cell (perpendicular to troughs)
N_{Cells} =	2		Number of cells per filter
A_{Filter} =	1933	ft^2	Filter area
$V_{Backwash}$ =	19	gpm/sf	Design backwash velocity
$Q_{Backwash}$ =	81.8	cfs	Backwash flow to be conveyed by troughs
L_{Trough} =	13.333	ft	Length of a single trough
$H_{Freeboard}$ =	3	in	Freeboard height in trough
T_{Trough} =	3	in	Trough concrete thickness

Number	Flow Per Trough (cfs)	Inside Dimensions (in)			Outside Dimensions (in)		Spacing (in)	Coverage (%)
		Width	Water Depth	Trough Depth	Width	Depth		
10	4.09	24	11.2	15	30	18	87.00	34%
9	4.55	24	11.9	15	30	18	96.67	31%
8	5.12	24	12.8	16	30	19	108.75	28%
7	5.85	24	13.9	17	30	20	124.29	24%
6	6.82	24	15.3	19	30	22	145.00	21%
5	8.18	24	17.2	21	30	24	174.00	17%
4	10.23	24	19.9	23	30	26	217.50	14%
3	13.64	24	24.0	27	30	30	290.00	10%
2	20.46	24	31.2	35	30	38	435.00	7%
1	40.92	24	49.4	53	30	56	870.00	3%

MWD - Weymouth Filter Rehabilitation

Trough Configurations - Spacing

$N_{Troughs}$ =	8		Number of troughs
L_{Filter} =	72.5	ft	Length of filter cell
$S_{Troughs}$ =	9.063	ft	Required trough spacing
W_{Trough} =	34	in	Outside width of trough spaces (incl. 2" grout on each side)
$W_{Support}$ =	5	ft	Width of clear area below each deck support

Trough	Position (ft)	
	Centerline	Edges
1	4.531	3.115
		5.948
2	13.594	12.177
		15.010
3	22.656	21.240
		24.073
4	31.719	30.302
		33.135
5	40.781	39.365
		42.198
6	49.844	48.427
		51.260
7	58.906	57.490
		60.323
8	67.969	66.552
		69.385
9	-	-
		-
10	-	-
		-

Deck	Position (ft)	
Support	Centerline	Edges
1	18.125	15.625
		20.625
2	36.25	33.75
		38.75
3	54.375	51.875
		56.875

Weymouth Filter Rehab: Surface Wash Calculations

Calc by: MJA
February 4, 2014

Spacing and Geometry

$L_{Filter} := 72.5ft$

$W_{Cell} := 13ft + 4in$

Filter box dimensions

$N_{Laterals} := 20$ $N_{Nozzles} := 4$

Number of laterals and nozzles per lateral

$S_{x.Nozzle} := \frac{W_{Cell}}{N_{Nozzles}}$ $S_{x.Nozzle} = 40 \cdot in$

$S_{y.Nozzle} := \frac{L_{Filter}}{N_{Laterals}}$ $S_{y.Nozzle} = 43.5 \cdot in$

Nozzle spacing in the x-direction (perpendicular to gullet) and y-direction (parallel to gullet)

Flow Rates

$V_{SurfaceWash} := 5 \frac{in}{min}$ $V_{SurfaceWash} = 3.117 \cdot \frac{gpm}{ft^2}$

Surface wash rate

$A_{Nozzle} := S_{x.Nozzle} \cdot S_{y.Nozzle}$ $A_{Nozzle} = 12.083 \cdot ft^2$

Area served by each nozzle

$Q_{Nozzle} := V_{SurfaceWash} \cdot A_{Nozzle}$ $Q_{Nozzle} = 37.7 \cdot gpm$

Nozzle flow rate

Jet Velocity

$D_{Orifice} := 0.3125in$ $N_{Orifices} := 7$

Number and size of orifices per nozzle

$A_{OrificeTotal} := N_{Orifices} \cdot \pi \cdot \left(\frac{D_{Orifice}}{2}\right)^2$

$V_{Jet} := \frac{Q_{Nozzle}}{A_{OrificeTotal}}$ $V_{Jet} = 22.51 \cdot \frac{ft}{s}$

Jet velocity

Weymouth Filter Rehab: Underdrain Strength

Assumptions and Constants

Calc by: MJA
February 25, 2014

Material Density and Porosity

$\varepsilon_{Sand} := 0.4$ $\quad \varepsilon_{Anthracite} := 0.425$ $\quad \rho_{Water} := 1000 \frac{kg}{m^3}$

$SG_{Sand} := 2.65$ $\quad SG_{Anthracite} := 1.6$

Bulk Density of Media Layers

$\rho_{SandBulk} := \left[\left(1 - \varepsilon_{Sand}\right) \cdot SG_{Sand} + \varepsilon_{Sand}\right] \cdot \rho_{Water}$ $\quad \rho_{SandBulk} = 124.232 \cdot \frac{lb}{ft^3}$

$\rho_{AnthraciteBulk} := \left[\left(1 - \varepsilon_{Anthracite}\right) \cdot SG_{Anthracite} + \varepsilon_{Anthracite}\right] \cdot \rho_{Water}$

$\rho_{AnthraciteBulk} = 83.966 \cdot \frac{lb}{ft^3}$

Crushing Load on Underdrain Blocks

Layer Depths and Submergence

$H_{Sand} := 8in$ $\quad H_{Anthracite} := 26in$

$H_{Submergence} := 5ft$

Media and Water Weight

$W_{Media} := H_{Sand} \cdot \rho_{SandBulk} + H_{Anthracite} \cdot \rho_{AnthraciteBulk}$ $\quad W_{Media} = 264.747 \cdot \frac{lb}{ft^2}$

$W_{Water} := H_{Submergence} \cdot \rho_{Water}$ $\quad W_{Water} = 312.14 \cdot \frac{lb}{ft^2}$

Total Crushing Load

$W_{Total} := W_{Media} + W_{Water}$ $\quad W_{Total} = 577 \cdot \frac{lb}{ft^2}$

Appendix C

Hydraulic Profile Development

METROPOLITAN WATER DISTRICT
WEYMOUTH WTP FILTER REHABILITATION
HYDRAULIC PROFILE CALCULATIONS

Hydraulic Tabulation - FB1 Filters at 2.8 gpm/sf

Calc By: MJA 02/25/2014
Chkd: RL

		Flow (MGD)	Flow Path Characteristics			Velocity (ft/s)	Friction Loss (ft)	Minor Loss (ft)	Total Headloss	HGL Elev - Low	HGL Elev - High
1	Influent Channel									**1093.103**	**1093.503**
2	30" Influent Connection		**Dia (in)**	length (ft)	K						
3	Piping from Influent Channel to Filters	7.8	**30**	8	0	2.46	0.01		0.01		
4	Minor Losses	7.8	**30**	0	1.8	2.46		0.17	0.17		
5	Filter Box									**1092.93**	**1093.33**
6	Underdrain System		**Headloss (in)**								
7	Underdrain Block and Lower Gullet	7.8	**3**					0.25	0.25		
8	Filter Materials		**Area (sf)**	K_{CK} (ft/fps)							
9	Media and Underdrain - Terminal Headloss	7.8	**1933**			0.006	5.89		5.89		
10	Sand and Anthracite - Clean-bed Headloss	7.8	**1933**	108.9		0.006	0.68		0.68		
11	Sand and Anthracite - Accumulated Headloss	7.8	**1933**			0.006	4.96		4.96		
12	Total Filter Box Headloss		**Set Point (ft)**								
13	Total Initial Headloss - to DP Cell	7.8							1.04		
14	Total Terminal Headloss - to DP Cell	7.8	**6**						6.00		
15	Filter Outlet - Clean-bed Headloss									**1092.00**	**1092.40**
16	Filter Outlet - Terminal Headloss									**1087.04**	**1087.44**
17	36" Effluent Piping		**Dia (in)**	length (ft)	K						
18	Piping to Tee	7.8	**36**	4	0	1.71	0.001		0.001		
19	Minor Losses	7.8	**36**	0	2.41	1.71		0.11	0.11		
20	Venturi Meter - Clean-bed Headloss									**1091.89**	**1092.29**
21	Venturi Meter - Terminal Headloss									**1086.93**	**1087.33**
22	24" Effluent Piping		**Dia (in)**	length (ft)	K						
23	Piping to Rate of Flow Controller	7.8	**24**	8	0	3.84	0.016		0.02		
24	Venturi Meter	7.8	**20**	0	0.16	5.53		0.08	0.08		
25	Minor Losses	7.8	**24**	0	0.25			0.06	0.06		
26	Rate of Flow Control Valve - Clean-bed Headloss									**1091.74**	**1092.14**
27	Rate of Flow Control Valve - Terminal Headloss									**1086.78**	**1087.18**
28	Low Water Level & Low Effluent Channel Level		**Dia (in)**								
29	MOV - Begin Filtration Cycle	7.8	**24**			3.84		12.44	12.44		
30	MOV - End Filtration Cycle	7.8	**24**			3.84		7.48	7.48		
31	Low Water Level & High Effluent Channel Level		**Dia (in)**								
32	MOV - Begin Filtration Cycle	7.8	**24**			3.84		5.26	5.26		
33	MOV - End Filtration Cycle	7.8	**24**			3.84		0.30	0.30		
34	High Water Level & Low Effluent Channel Level		**Dia (in)**								
35	MOV - Begin Filtration Cycle	7.8	**24**			3.84		12.84	12.84		
36	MOV - End Filtration Cycle	7.8	**24**			3.84		7.88	7.88		
37	High Water Level & High Effluent Channel Level		**Dia (in)**								
38	MOV - Begin Filtration Cycle	7.8	**24**			3.84		5.66	5.66		
39	MOV - End Filtration Cycle	7.8	**24**			3.84		0.70	0.70		
40	Headloss with MOV Fully Open		**Dia (in)**	length (ft)	K						
41	Piping to Effluent Channel	7.8	**24**	2	0	3.84	0.004		0.00		
42	Minor Losses	7.8	**24**	0	1.3	3.84		0.30	0.30		
43	Effluent Channel									**1079.30**	**1086.48**

Constants

130	**Hazen-Williams "C"**
2.8	**Filtration rate (gpm/sf)**
108.9	**Carman-Kozeny headloss coefficient (ft/fps)**
6	**Terminal headloss (ft)**
3	**Underdrain and gullet headloss (in)**
7.8	**Flow per filter (mgd)**

METROPOLITAN WATER DISTRICT
WEYMOUTH WTP FILTER REHABILITATION
HYDRAULIC PROFILE CALCULATIONS

Hydraulic Tabulation - FB1 Filters at 4.06 gpm/sf

Calc By: MJA 02/25/2014
Chkd: RL

		Flow (MGD)	Flow Path Characteristics			Velocity (ft/s)	Friction Loss (ft)	Minor Loss (ft)	Total Headloss	HGL Elev - Low	HGL Elev - High
1	Influent Channel									**1093.103**	**1093.503**
2	30" Influent Connection		**Dia (in)**	length (ft)	K						
3	Piping from Influent Channel to Filters	11.3	**30**	8	0	3.56	0.01		0.01		
4	Minor Losses	11.3	**30**	0	1.8	3.56		0.35	0.35		
5	Filter Box									**1092.74**	**1093.14**
6	Underdrain System		**Headloss (in)**								
7	Underdrain Block and Lower Gullet	11.3	**3**					0.25	0.25		
8	Filter Materials		**Area (sf)**	K_{CK} (ft/fps)							
9	Media and Underdrain - Terminal Headloss	11.3	**1933**			0.009	5.77		5.77		
10	Sand and Anthracite - Clean-bed Headloss	11.3	**1933**	108.9		0.009	0.99		0.99		
11	Sand and Anthracite - Accumulated Headloss	11.3	**1933**			0.009	4.53		4.53		
12	Total Filter Box Headloss		**Set Point (ft)**								
13	Total Initial Headloss - to DP Cell	11.3							1.47		
14	Total Terminal Headloss - to DP Cell	11.3	**6**						6.00		
15	Filter Outlet - Clean-bed Headloss									**1091.50**	**1091.90**
16	Filter Outlet - Terminal Headloss									**1086.97**	**1087.37**
17	36" Effluent Piping		**Dia (in)**	length (ft)	K						
18	Piping to Tee	11.3	**36**	4	0	2.47	0.002		0.002		
19	Minor Losses	11.3	**36**	0	2.41	2.47		0.23	0.23		
20	Venturi Meter - Clean-bed Headloss									**1091.27**	**1091.67**
21	Venturi Meter - Terminal Headloss									**1086.74**	**1087.14**
22	24" Effluent Piping		**Dia (in)**	length (ft)	K						
23	Piping to Rate of Flow Controller	11.3	**24**	8	0	5.57	0.031		0.03		
24	Venturi Meter	11.3	**20**	0	0.16	8.01		0.16	0.16		
25	Minor Losses	11.3	**24**	0	0.25			0.12	0.12		
26	Rate of Flow Control Valve - Clean-bed Headloss									**1090.96**	**1091.36**
27	Rate of Flow Control Valve - Terminal Headloss									**1086.43**	**1086.83**
28	Low Water Level & Low Effluent Channel Level		**Dia (in)**								
29	MOV - Begin Filtration Cycle	11.3	**24**			5.57		11.66	11.66		
30	MOV - End Filtration Cycle	11.3	**24**			5.57		7.13	7.13		
31	Low Water Level & High Effluent Channel Level		**Dia (in)**								
32	MOV - Begin Filtration Cycle	11.3	**24**			5.57		5.17	5.17		
33	MOV - End Filtration Cycle	11.3	**24**			5.57		0.63	0.63		
34	High Water Level & Low Effluent Channel Level		**Dia (in)**								
35	MOV - Begin Filtration Cycle	11.3	**24**			5.57		12.06	12.06		
36	MOV - End Filtration Cycle	11.3	**24**			5.57		7.53	7.53		
37	High Water Level & High Effluent Channel Level		**Dia (in)**								
38	MOV - Begin Filtration Cycle	11.3	**24**			5.57		5.57	5.57		
39	MOV - End Filtration Cycle	11.3	**24**			5.57		1.03	1.03		
40	Headloss with MOV Fully Open		**Dia (in)**	length (ft)	K						
41	Piping to Effluent Channel	11.3	**24**	2	0	5.57	0.008		0.01		
42	Minor Losses	11.3	**24**	0	1.3	5.57		0.63	0.63		
43	Effluent Channel									**1079.30**	**1085.79**

Constants

130	**Hazen-Williams "C"**
4.06	**Filtration rate (gpm/sf)**
108.9	**Carman-Kozeny headloss coefficient (ft/fps)**
6	**Terminal headloss (ft)**
3	**Underdrain and gullet headloss (in)**
11.3	**Flow per filter (mgd)**

METROPOLITAN WATER DISTRICT
WEYMOUTH WTP FILTER REHABILITATION
HYDRAULIC PROFILE CALCULATIONS

Hydraulic Tabulation - FB1 Filters at 4.69 gpm/sf

Calc By: MJA 02/25/2014
Chkd: RL

		Flow (MGD)	Flow Path Characteristics			Velocity (ft/s)	Friction Loss (ft)	Minor Loss (ft)	Total Headloss	HGL Elev - Low	HGL Elev - High
1	Influent Channel									**1093.103**	**1093.503**
2	30" Influent Connection		**Dia (in)**	length (ft)	K						
3	Piping from Influent Channel to Filters	13.1	**30**	8	0	4.11	0.01		0.01		
4	Minor Losses	13.1	**30**	0	1.8	4.11		0.47	0.47		
5	Filter Box									**1092.62**	**1093.02**
6	Underdrain System		**Headloss (in)**								
7	Underdrain Block and Lower Gullet	13.1	**3**					0.25	0.25		
8	Filter Materials		**Area (sf)**	K_{CK} (ft/fps)							
9	Media and Underdrain - Terminal Headloss	13.1	**1933**			0.010	5.69		5.69		
10	Sand and Anthracite - Clean-bed Headloss	13.1	**1933**	108.9		0.010	1.14		1.14		
11	Sand and Anthracite - Accumulated Headloss	13.1	**1933**			0.010	4.30		4.30		
12	Total Filter Box Headloss		**Set Point (ft)**								
13	Total Initial Headloss - to DP Cell	13.1							1.70		
14	Total Terminal Headloss - to DP Cell	13.1	**6**						6.00		
15	Filter Outlet - Clean-bed Headloss									**1091.23**	**1091.63**
16	Filter Outlet - Terminal Headloss									**1086.92**	**1087.32**
17	36" Effluent Piping		**Dia (in)**	length (ft)	K						
18	Piping to Tee	13.1	**36**	4	0	2.86	0.003		0.003		
19	Minor Losses	13.1	**36**	0	2.41	2.86		0.31	0.31		
20	Venturi Meter - Clean-bed Headloss									**1090.92**	**1091.32**
21	Venturi Meter - Terminal Headloss									**1086.62**	**1087.02**
22	24" Effluent Piping		**Dia (in)**	length (ft)	K						
23	Piping to Rate of Flow Controller	13.1	**24**	8	0	6.43	0.041		0.04		
24	Venturi Meter	13.1	**20**	0	0.16	9.26		0.21	0.21		
25	Minor Losses	13.1	**24**	0	0.25			0.16	0.16		
26	Rate of Flow Control Valve - Clean-bed Headloss									**1090.51**	**1090.91**
27	Rate of Flow Control Valve - Terminal Headloss									**1086.20**	**1086.60**
28	Low Water Level & Low Effluent Channel Level		**Dia (in)**								
29	MOV - Begin Filtration Cycle	13.1	**24**			6.43		11.21	11.21		
30	MOV - End Filtration Cycle	13.1	**24**			6.43		6.90	6.90		
31	Low Water Level & High Effluent Channel Level		**Dia (in)**								
32	MOV - Begin Filtration Cycle	13.1	**24**			6.43		5.15	5.15		
33	MOV - End Filtration Cycle	13.1	**24**			6.43		0.84	0.84		
34	High Water Level & Low Effluent Channel Level		**Dia (in)**								
35	MOV - Begin Filtration Cycle	13.1	**24**			6.43		11.61	11.61		
36	MOV - End Filtration Cycle	13.1	**24**			6.43		7.30	7.30		
37	High Water Level & High Effluent Channel Level		**Dia (in)**								
38	MOV - Begin Filtration Cycle	13.1	**24**			6.43		5.55	5.55		
39	MOV - End Filtration Cycle	13.1	**24**			6.43		1.24	1.24		
40	Headloss with MOV Fully Open		**Dia (in)**	length (ft)	K						
41	Piping to Effluent Channel	13.1	**24**	2	0	6.43	0.010		0.01		
42	Minor Losses	13.1	**24**	0	1.3	6.43		0.83	0.83		
43	Effluent Channel									**1079.30**	**1085.36**

Constants

130	**Hazen-Williams "C"**
4.69	**Filtration rate (gpm/sf)**
108.9	**Carman-Kozeny headloss coefficient (ft/fps)**
6	**Terminal headloss (ft)**
3	**Underdrain and gullet headloss (in)**
13.1	**Flow per filter (mgd)**

METROPOLITAN WATER DISTRICT
WEYMOUTH WTP FILTER REHABILITATION
HYDRAULIC PROFILE CALCULATIONS

Hydraulic Tabulation - FB2 Filters at 2.8 gpm/sf

Calc By: MJA 02/25/2014
Chkd: RL

		Flow (MGD)	Flow Path Characteristics			Velocity (ft/s)	Friction Loss (ft)	Minor Loss (ft)	Total Headloss	HGL Elev - Low	HGL Elev - High
1	Influent Channel									**1093.275**	**1093.675**
2	30" Influent Connection		**Dia (in)**	length (ft)	K						
3	Piping from Influent Channel to Filters	7.8	**30**	8	0	2.46	0.01		0.01		
4	Minor Losses	7.8	**30**	0	1.8	2.46		0.17	0.17		
5	Filter Box									**1093.10**	**1093.50**
6	Underdrain System		**Headloss (in)**								
7	Underdrain Block and Lower Gullet	7.8	**3**					0.25	0.25		
8	Filter Materials		**Area (sf)**	K_{CK} (ft/fps)							
9	Media and Underdrain - Terminal Headloss	7.8	**1933**			0.006	5.89		5.89		
10	Sand and Anthracite - Clean-bed Headloss	7.8	**1933**	108.9		0.006	0.68		0.68		
11	Sand and Anthracite - Accumulated Headloss	7.8	**1933**			0.006	4.96		4.96		
12	Total Filter Box Headloss		**Set Point (ft)**								
13	Total Initial Headloss - to DP Cell	7.8							1.04		
14	Total Terminal Headloss - to DP Cell	7.8	**6**						6.00		
15	Filter Outlet - Clean-bed Headloss									**1092.17**	**1092.57**
16	Filter Outlet - Terminal Headloss									**1087.21**	**1087.61**
17	36" Effluent Piping		**Dia (in)**	length (ft)	K						
18	Piping to Tee	7.8	**36**	4	0	1.71	0.001		0.001		
19	Minor Losses	7.8	**36**	0	2.41	1.71		0.11	0.11		
20	Venturi Meter - Clean-bed Headloss									**1092.06**	**1092.46**
21	Venturi Meter - Terminal Headloss									**1087.10**	**1087.50**
22	24" Effluent Piping		**Dia (in)**	length (ft)	K						
23	Piping to Rate of Flow Controller	7.8	**24**	8	0	3.84	0.016		0.02		
24	Venturi Meter	7.8	**20**	0	0.16	5.53		0.08	0.08		
25	Minor Losses	7.8	**24**	0	0.25			0.06	0.06		
26	Rate of Flow Control Valve - Clean-bed Headloss									**1091.91**	**1092.31**
27	Rate of Flow Control Valve - Terminal Headloss									**1086.95**	**1087.35**
28	Low Water Level & Low Effluent Channel Level		**Dia (in)**								
29	MOV - Begin Filtration Cycle	7.8	**24**			3.84		12.61	12.61		
30	MOV - End Filtration Cycle	7.8	**24**			3.84		7.65	7.65		
31	Low Water Level & High Effluent Channel Level		**Dia (in)**								
32	MOV - Begin Filtration Cycle	7.8	**24**			3.84		5.26	5.26		
33	MOV - End Filtration Cycle	7.8	**24**			3.84		0.30	0.30		
34	High Water Level & Low Effluent Channel Level		**Dia (in)**								
35	MOV - Begin Filtration Cycle	7.8	**24**			3.84		13.01	13.01		
36	MOV - End Filtration Cycle	7.8	**24**			3.84		8.05	8.05		
37	High Water Level & High Effluent Channel Level		**Dia (in)**								
38	MOV - Begin Filtration Cycle	7.8	**24**			3.84		5.66	5.66		
39	MOV - End Filtration Cycle	7.8	**24**			3.84		0.70	0.70		
40	Headloss with MOV Fully Open		**Dia (in)**	length (ft)	K						
41	Piping to Effluent Channel	7.8	**24**	2	0	3.84	0.004		0.00		
42	Minor Losses	7.8	**24**	0	1.3	3.84		0.30	0.30		
43	Effluent Channel									**1079.30**	**1086.65**

Constants

130	**Hazen-Williams "C"**
2.8	**Filtration rate (gpm/sf)**
108.9	**Carman-Kozeny headloss coefficient (ft/fps)**
6	**Terminal headloss (ft)**
3	**Underdrain and gullet headloss (in)**
7.8	**Flow per filter (mgd)**

METROPOLITAN WATER DISTRICT
WEYMOUTH WTP FILTER REHABILITATION
HYDRAULIC PROFILE CALCULATIONS

Hydraulic Tabulation - FB2 Filters at 4.06 gpm/sf

Calc By: MJA 02/25/2014
Chkd: RL

		Flow (MGD)	Flow Path Characteristics			Velocity (ft/s)	Friction Loss (ft)	Minor Loss (ft)	Total Headloss	HGL Elev - Low	HGL Elev - High
1	Influent Channel									**1093.275**	**1093.675**
2	30" Influent Connection		**Dia (in)**	length (ft)	K						
3	Piping from Influent Channel to Filters	11.3	**30**	8	0	3.56	0.01		0.01		
4	Minor Losses	11.3	**30**	0	1.8	3.56		0.35	0.35		
5	Filter Box									**1092.91**	**1093.31**
6	Underdrain System		**Headloss (in)**								
7	Underdrain Block and Lower Gullet	11.3	**3**					0.25	0.25		
8	Filter Materials		**Area (sf)**	K_{CK} (ft/fps)							
9	Media and Underdrain - Terminal Headloss	11.3	**1933**			0.009	5.77		5.77		
10	Sand and Anthracite - Clean-bed Headloss	11.3	**1933**	108.9		0.009	0.99		0.99		
11	Sand and Anthracite - Accumulated Headloss	11.3	**1933**			0.009	4.53		4.53		
12	Total Filter Box Headloss		**Set Point (ft)**								
13	Total Initial Headloss - to DP Cell	11.3							1.47		
14	Total Terminal Headloss - to DP Cell	11.3	**6**						6.00		
15	Filter Outlet - Clean-bed Headloss									**1091.67**	**1092.07**
16	Filter Outlet - Terminal Headloss									**1087.14**	**1087.54**
17	36" Effluent Piping		**Dia (in)**	length (ft)	K						
18	Piping to Tee	11.3	**36**	4	0	2.47	0.002		0.002		
19	Minor Losses	11.3	**36**	0	2.41	2.47		0.23	0.23		
20	Venturi Meter - Clean-bed Headloss									**1091.44**	**1091.84**
21	Venturi Meter - Terminal Headloss									**1086.91**	**1087.31**
22	24" Effluent Piping		**Dia (in)**	length (ft)	K						
23	Piping to Rate of Flow Controller	11.3	**24**	8	0	5.57	0.031		0.03		
24	Venturi Meter	11.3	**20**	0	0.16	8.01		0.16	0.16		
25	Minor Losses	11.3	**24**	0	0.25			0.12	0.12		
26	Rate of Flow Control Valve - Clean-bed Headloss									**1091.13**	**1091.53**
27	Rate of Flow Control Valve - Terminal Headloss									**1086.60**	**1087.00**
28	Low Water Level & Low Effluent Channel Level		**Dia (in)**								
29	MOV - Begin Filtration Cycle	11.3	**24**			5.57		11.83	11.83		
30	MOV - End Filtration Cycle	11.3	**24**			5.57		7.30	7.30		
31	Low Water Level & High Effluent Channel Level		**Dia (in)**								
32	MOV - Begin Filtration Cycle	11.3	**24**			5.57		5.17	5.17		
33	MOV - End Filtration Cycle	11.3	**24**			5.57		0.63	0.63		
34	High Water Level & Low Effluent Channel Level		**Dia (in)**								
35	MOV - Begin Filtration Cycle	11.3	**24**			5.57		12.23	12.23		
36	MOV - End Filtration Cycle	11.3	**24**			5.57		7.70	7.70		
37	High Water Level & High Effluent Channel Level		**Dia (in)**								
38	MOV - Begin Filtration Cycle	11.3	**24**			5.57		5.57	5.57		
39	MOV - End Filtration Cycle	11.3	**24**			5.57		1.03	1.03		
40	Headloss with MOV Fully Open		**Dia (in)**	length (ft)	K						
41	Piping to Effluent Channel	11.3	**24**	2	0	5.57	0.008		0.01		
42	Minor Losses	11.3	**24**	0	1.3	5.57		0.63	0.63		
43	Effluent Channel									**1079.30**	**1085.97**

Constants

130	**Hazen-Williams "C"**
4.06	**Filtration rate (gpm/sf)**
108.9	**Carman-Kozeny headloss coefficient (ft/fps)**
6	**Terminal headloss (ft)**
3	**Underdrain and gullet headloss (in)**
11.3	**Flow per filter (mgd)**

METROPOLITAN WATER DISTRICT
WEYMOUTH WTP FILTER REHABILITATION
HYDRAULIC PROFILE CALCULATIONS

Hydraulic Tabulation - FB2 Filters at 4.69 gpm/sf

Calc By: MJA 02/25/2014
Chkd: RL

		Flow (MGD)	Flow Path Characteristics			Velocity (ft/s)	Friction Loss (ft)	Minor Loss (ft)	Total Headloss	HGL Elev - Low	HGL Elev - High
1	Influent Channel									**1093.275**	**1093.675**
2	30" Influent Connection		**Dia (in)**	length (ft)	K						
3	Piping from Influent Channel to Filters	13.1	**30**	8	0	4.11	0.01		0.01		
4	Minor Losses	13.1	**30**	0	1.8	4.11		0.47	0.47		
5	Filter Box									**1092.79**	**1093.19**
6	Underdrain System		**Headloss (in)**								
7	Underdrain Block and Lower Gullet	13.1	**3**					0.25	0.25		
8	Filter Materials		**Area (sf)**	K_{CK} (ft/fps)							
9	Media and Underdrain - Terminal Headloss	13.1	**1933**			0.010	5.69		5.69		
10	Sand and Anthracite - Clean-bed Headloss	13.1	**1933**	108.9		0.010	1.14		1.14		
11	Sand and Anthracite - Accumulated Headloss	13.1	**1933**			0.010	4.30		4.30		
12	Total Filter Box Headloss		**Set Point (ft)**								
13	Total Initial Headloss - to DP Cell	13.1							1.70		
14	Total Terminal Headloss - to DP Cell	13.1	**6**						6.00		
15	Filter Outlet - Clean-bed Headloss									**1091.40**	**1091.80**
16	Filter Outlet - Terminal Headloss									**1087.10**	**1087.50**
17	36" Effluent Piping		**Dia (in)**	length (ft)	K						
18	Piping to Tee	13.1	**36**	4	0	2.86	0.003		0.003		
19	Minor Losses	13.1	**36**	0	2.41	2.86		0.31	0.31		
20	Venturi Meter - Clean-bed Headloss									**1091.09**	**1091.49**
21	Venturi Meter - Terminal Headloss									**1086.79**	**1087.19**
22	24" Effluent Piping		**Dia (in)**	length (ft)	K						
23	Piping to Rate of Flow Controller	13.1	**24**	8	0	6.43	0.041		0.04		
24	Venturi Meter	13.1	**20**	0	0.16	9.26		0.21	0.21		
25	Minor Losses	13.1	**24**	0	0.25			0.16	0.16		
26	Rate of Flow Control Valve - Clean-bed Headloss									**1090.68**	**1091.08**
27	Rate of Flow Control Valve - Terminal Headloss									**1086.37**	**1086.77**
28	Low Water Level & Low Effluent Channel Level		**Dia (in)**								
29	MOV - Begin Filtration Cycle	13.1	**24**			6.43		11.38	11.38		
30	MOV - End Filtration Cycle	13.1	**24**			6.43		7.07	7.07		
31	Low Water Level & High Effluent Channel Level		**Dia (in)**								
32	MOV - Begin Filtration Cycle	13.1	**24**			6.43		5.15	5.15		
33	MOV - End Filtration Cycle	13.1	**24**			6.43		0.84	0.84		
34	High Water Level & Low Effluent Channel Level		**Dia (in)**								
35	MOV - Begin Filtration Cycle	13.1	**24**			6.43		11.78	11.78		
36	MOV - End Filtration Cycle	13.1	**24**			6.43		7.47	7.47		
37	High Water Level & High Effluent Channel Level		**Dia (in)**								
38	MOV - Begin Filtration Cycle	13.1	**24**			6.43		5.55	5.55		
39	MOV - End Filtration Cycle	13.1	**24**			6.43		1.24	1.24		
40	Headloss with MOV Fully Open		**Dia (in)**	length (ft)	K						
41	Piping to Effluent Channel	13.1	**24**	2	0	6.43	0.010		0.01		
42	Minor Losses	13.1	**24**	0	1.3	6.43		0.83	0.83		
43	Effluent Channel									**1079.30**	**1085.53**

Constants

130	**Hazen-Williams "C"**
4.69	**Filtration rate (gpm/sf)**
108.9	**Carman-Kozeny headloss coefficient (ft/fps)**
6	**Terminal headloss (ft)**
3	**Underdrain and gullet headloss (in)**
13.1	**Flow per filter (mgd)**

METROPOLITAN WATER DISTRICT
WEYMOUTH WTP FILTER REHABILITATION
HYDRAULIC PROFILE CALCULATIONS

Hydraulic Tabulation - Typical Backwash

Calc By: MJA 02/25/2014
Chkd: RL

		Flow (MGD)	Flow Path Characteristics				Velocity (ft/s)	Friction Loss (ft)	Minor Loss (ft)	Total Headloss	Elev - FB1	HGL Elev - FB1	Elev - FB2	HGL Elev - FB2
1	Washwater Header											**1096.54**		**1097.11**
2	36" Influent Connection		**Dia (in)**	length (ft)	K									
3	Piping from Header Pipe to Filter	44.5	**36**	11	0		9.75	0.08		0.08				
4	Minor Losses	44.5	**36**	0	1.45		9.75		2.14	2.14				
5	Filter Box Inlet											**1094.32**		**1094.89**
6	Underdrain System and Filter Bed		**Headloss (in)**											
7	Underdrain Block and Lower Gullet	44.5	**14**						1.17	1.17				
8	Fluidized Media	44.5	**16.9**					1.41		1.41				
9	Wash Troughs		**Troughs**	length (ft)	L_{Weir} (ft)						1091.48		1092.05	
10	Weir Headloss	44.5	**8**	13.33	426.56				0.13	0.13				
11	**Total Backwash Headloss - Header to Troughs**	**44.5**								**4.93**				
12	Wash Trough Water Level											**1091.61**		**1092.18**

Constants

130	**Hazen-Williams "C"**
16	**Backwash rate (gpm/sf)**
14	**Underdrain and gullet headloss (in)**
16.92	**Fluidized media headloss (in)**
44.5	**Flow per filter (mgd)**

PIPE HYDRAULIC ITEMIZATIONS

Pipe Number **00 00 02**

Description Influent piping minor losses

								Increaser		Reducer			
		Ent	Exit	90El	45El	BFT	LFT	from	to	from	to	Ball V	Butterfly V
Elements	L	0.50	1.00	0.25	0.15	0.50	0.15	-0.90	0.90	0.70	-0.70	0.04	0.3
Pipe Entrance		1											
Open Butterfly Valve													1
Pipe Exit			1										
Totals	0	0.50	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30
		1.80											

PIPE HYDRAULIC ITEMIZATIONS

Pipe Number **00 00 17**

Description Effluent piping minor losses - 36"

								Increaser		Reducer			
		Ent	Exit	90El	45El	BFT	LFT	from	to	from	to	Ball V	Butterfly V
Elements	L	0.50	1.00	0.25	0.15	0.50	0.15	-0.90	0.90	36	24	0.04	0.3
Pipe Entrance		1											
Branch Flow Tee						1							
Sudden Contraction										1			
Totals	0	0.50	0.00	0.00	0.00	0.50	0.00	0.00	0.00	1.41		0.00	0.00
		2.41											

PIPE HYDRAULIC ITEMIZATIONS

Pipe Number **00 00 22**

Description Effluent piping minor losses - 24"

								Increaser		Reducer		Venturi Meter			
		Ent	Exit	90El	45El	BFT	LFT	from	to	from	to	Cont	Exp	Ball V	Butterfly V
Elements	L	0.50	1.00	0.25	0.15	0.50	0.15	-0.90	0.90	0.70	-0.70	0.06	0.10	0.04	0.3
Elbow				1											
Venturi Meter												1	1		
Totals	0	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.10	0.00	0.00
		0.41		**0.25**									**0.16**		

PIPE HYDRAULIC ITEMIZATIONS

Pipe Number **00 00 40**

Description Minor Losses with MOV Fully Open

								Increaser		Reducer			
		Ent	Exit	90El	45El	BFT	LFT	from	to	from	to	Ball V	Butterfly V
Elements	L	0.50	1.00	0.25	0.15	0.50	0.15	-0.90	0.90	0.70	-0.70	0.04	0.3
MOV													1
Pipe Exit			1										
Totals	0	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30
		1.30											

PIPE HYDRAULIC ITEMIZATIONS

Pipe Number **00 00 02**

Description Minor Losses from Washwater Header to Filter Inlet

								Increaser		Reducer			
		Ent	Exit	90El	45El	BFT	LFT	from	to	from	to	Ball V	Butterfly V
Elements	L	0.50	1.00	0.25	0.15	0.50	0.15	-0.90	0.90	0.70	-0.70	0.04	0.3
Branch-Flow Tee						1							
Open Butterfly Valve													1
Line-Flow Tee							1						
Exit to Lower Gullet		1											
Totals	0	0.50	0.00	0.00	0.00	0.50	0.15	0.00	0.00	0.00	0.00	0.00	0.30
		1.45											

PIPE HYDRAULIC ITEMIZATIONS

Pipe Number **00 00 02**

Description Minor Losses from Washwater Tank to Filter #38 Connection

								Increaser		Reducer			
		Ent	Exit	90El	45El	BFT	LFT	from	to	from	to	Gate V	Butterfly V
Elements	L	0.50	1.00	0.25	0.15	0.50	0.15	-0.90	0.90	0.70	-0.70	0.1	0.3
Tank Exit / Pipe Entrance		1											
45-Degree Bend					2								
90-Degree Bend				1									
Open Gate Valve												1	
Totals	0	0.50	0.00	0.25	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00
		1.15											

3. LP Block™ - Water With S Plate™:

MWD - Weymouth Filter Rehabilitation

Pressure Profile and Terminal Headloss

Filter Building	1	

Elevations

Water Surface	1092.93	ft AMSL
Top of Anthracite	1088.52	ft AMSL
Top of Sand	1086.353	ft AMSL
Underdrain	1085.687	ft AMSL

Operating Condition

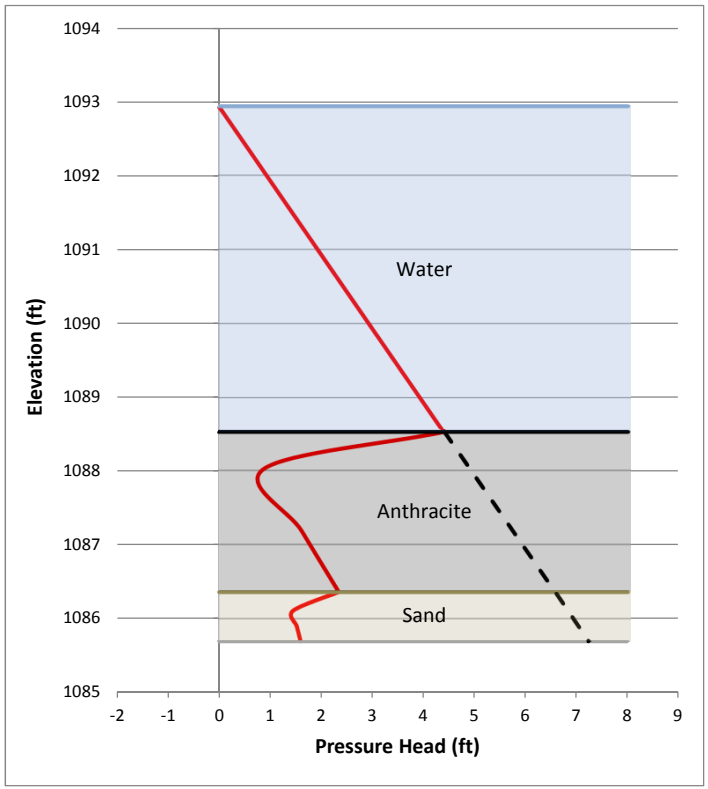
Filtration Rate	2.8	gpm/sf	
Terminal Headloss	5.64	ft	Excluding losses in underdrain and effluent piping
Percent in Sand	20	%	

Media

	Thickness (in)	*$HL_{CleanBed}$ (ft)*	*Solids Entrainment Zone (in)*
Anthracite Layer	26	0.261	6
Sand Layer	8	0.419	3

Pressure Profile

LAYER	HEAD (ft) Elevation	HEAD (ft) Pressure	LENGTH THRU LAYER (in)	HEADLOSS (ft) Clean-bed	HEADLOSS (ft) Accumulation
Water Column	1092.930	0.000			
	1090.000	2.930			
Anthracite	1088.520	4.410	6.00	0.060	3.969
	1088.020	0.881	10.00	0.100	
	1087.187	1.615	10.00	0.100	
	1086.353	2.348			
Sand	1086.353	2.348	3.00	0.157	0.992
	1086.103	1.449	2.50	0.131	
	1085.895	1.526	2.50	0.131	
	1085.687	1.603			
TOTAL				**0.679**	**4.961**



MWD - Weymouth Filter Rehabilitation

Pressure Profile and Terminal Headloss

Filter Building	2	

Elevations

Water Surface	1093.10	ft AMSL
Top of Anthracite	1089.152	ft AMSL
Top of Sand	1086.985	ft AMSL
Underdrain	1086.319	ft AMSL

Operating Condition

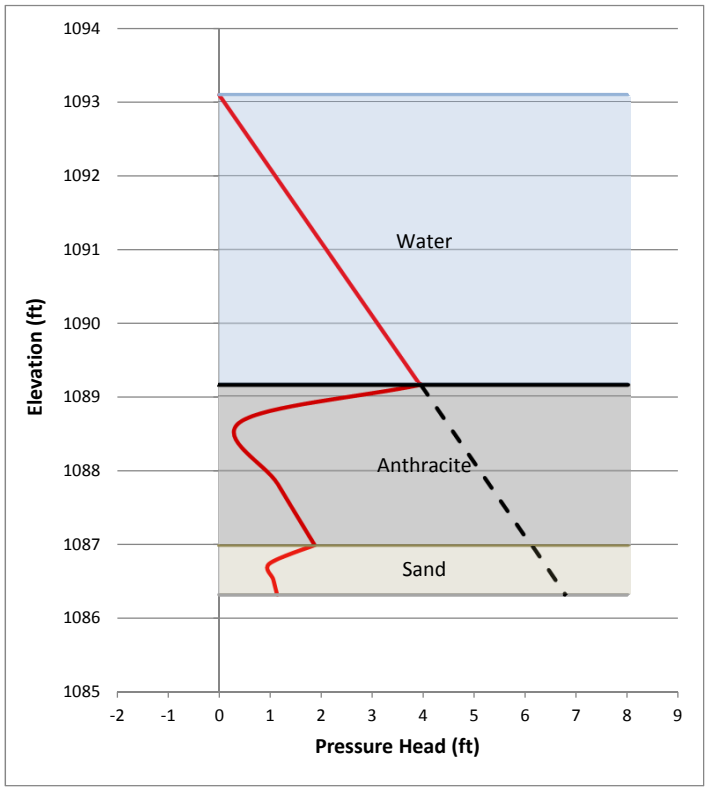
Filtration Rate	2.8	gpm/sf	
Terminal Headloss	5.64	ft	Excluding losses in underdrain and effluent piping
Percent in Sand	20	%	

Media

	Thickness (in)	*$HL_{CleanBed}$ (ft)*	*Solids Entrainment Zone (in)*
Anthracite Layer	26	0.261	6
Sand Layer	8	0.419	3

Pressure Profile

LAYER	HEAD (ft) Elevation	HEAD (ft) Pressure	LENGTH THRU LAYER (in)	HEADLOSS (ft) Clean-bed	HEADLOSS (ft) Accumulation
Water Column	1093.100	0.000			
	1090.000	3.100			
Anthracite	1089.152	3.948	6.00	0.060	3.969
	1088.652	0.419	10.00	0.100	
	1087.819	1.153	10.00	0.100	
	1086.985	1.886			
Sand	1086.985	1.886	3.00	0.157	0.992
	1086.735	0.987	2.50	0.131	
	1086.527	1.064	2.50	0.131	
	1086.319	1.141			
TOTAL				**0.679**	**4.961**



METROPOLITAN WATER DISTRICT
WEYMOUTH WTP FILTER REHABILITATION
HYDRAULIC PROFILE CALCULATIONS

Hydraulic Tabulation - Effluent Channel Profile at 60 mgd

Calc By: SC 12/11/2013
Chkd: MJA

		Flow per Unit	area	mann. n	wet perim.	length	K	width	Headloss	WS Elevation	Bottom of Structure	Hydr Depth	Velocity	Friction Loss	Minor Loss	Conduit Status
1	Filter #38 Effluent	15	72.4	**0.013**	24.5	**10**	**1.8**	**10**	0.003	**1083.04**	**1075.80**	7.24	0.32	0.00	0.00	
2	Filter Effluent Channel - Filters 37 to 48	15	92.4	**0.013**	10.0	**95**	**0.60**	**10**	0.001	**1083.04**	**1075.80**	7.24	0.25	0.00	0.00	
3	Combined Filter Effluent Channel (FB2-1)	15	92.4	**0.013**	28.5	**235**	**0**	**10**	0.000	**1083.04**	**1073.80**	9.24	0.25	0.00	0.00	OPEN CHANNEL
4	Combined Filter Effluent Channel (FB2 -2)	30	92.3	**0.013**	28.5	**575**	**1.8**	**10**	0.009	**1083.04**	**1073.80**	9.24	0.50	0.00	0.01	FULL
5	Filter #1 Effluent	15	120.9	**0.013**	28.5	**10**	**0.60**	**10**	0.000	**1083.03**	**1075.80**	7.23	0.19	0.00	0.00	
6	Filter Effluent Channel - Filter 1 to 24	30	92.3	**0.013**	28.5	**95**	**1.8**	**10**	0.007	**1083.03**	**1062.97**	20.06	0.50	0.00	0.01	OPEN CHANNEL
7	Combined Filter Effluent - Slope	60	145.1	**0.013**	36.2	**350**	**0**	**12**	0.002	**1083.03**	**1073.80**	9.23	0.64	0.00	0.00	FULL
8	Spillway No. 1 (Level Sensor)	60	168.7	**0.013**	40.1	**250**	**0**	**12**	0.001	**1083.02**	**1070.93**	12.09	0.55	0.00	0.00	OPEN CHANNEL
9	Upstream of Weir									**1083.02**						
10	Weir Crest Elevation									**1082.76**	**1068.7**	14.06				

Plant Flow Rate	60	mgd
Additional Headloss	0.00	ft
Spillway No. 1 Elev	1070.93	ft AMSL
Sensor Datum	1070.93	ft AMSL
Sensor Reading	12.09	ft

Weir Coeff.	0.62	
Weir Length	206	ft
Weir Headloss	0.26	ft

$$Q = C_d * \frac{2}{3} * \sqrt{2g} * B * H^{3/2}$$

METROPOLITAN WATER DISTRICT
WEYMOUTH WTP FILTER REHABILITATION
HYDRAULIC PROFILE CALCULATIONS

Hydraulic Tabulation - Effluent Channel Profile at 230 mgd

Calc By: SC 12/11/2013
Chkd: MJA

		Flow per Unit	area	mann. n	wet perim.	length	K	width	Headloss	WS Elevation	Top of Wall	Bottom of Structure	Hydr Depth	Velocity	Friction Loss	Minor Loss	Conduit Status
1	Filter #38 Effluent	57.5	77.8	**0.013**	25.6	**10**	**1.8**	**10**	0.04	**1083.62**	**1081.80**	**1075.80**	7.82	1.14	0.00	0.04	
2	Filter Effluent Channel - Filters 37 to 48	57.5	97.7	**0.013**	10.0	**95**	**0.60**	**10**	0.01	**1083.58**	**1081.80**	**1075.80**	7.78	0.91	0.00	0.01	
3	Combined Filter Effluent Channel (FB2-1)	57.5	97.7	**0.013**	29.5	**235**	**0**	**10**	0.00	**1083.57**	**1083.80**	**1073.80**	9.77	0.91	0.00	0.00	OPEN CHANNEL
4	Combined Filter Effluent Channel (FB2 -2)	115	96.4	**0.013**	29.3	**575**	**1.8**	**10**	0.13	**1083.57**	**1083.80**	**1073.80**	9.77	1.85	0.03	0.10	FULL
5	Filter #1 Effluent	57.5	124.9	**0.013**	29.3	**10**	**0.60**	**10**	0.00	**1083.55**	1081.90	**1075.80**	7.75	0.71	0.00	0.00	
6	Filter Effluent Channel - Filter 1 to 24	115	96.4	**0.013**	29.3	**95**	**1.8**	**10**	0.10	**1083.54**	**1073.80**	**1062.97**	20.57	1.85	0.01	0.10	OPEN CHANNEL
7	Combined Filter Effluent - Slope	230	149.9	**0.013**	37.0	**350**	**0**	**12**	0.02	**1083.44**	**1083.80**	**1073.80**	9.64	2.37	0.02	0.00	FULL
8	Spillway No. 1 (Level Sensor)	230	168.7	**0.013**	40.1	**250**	**0**	**12**	0.01	**1083.42**	**1080.93**	**1070.93**	12.49	2.11	0.01	0.00	OPEN CHANNEL
9	Upstream of Weir									**1083.41**							
10	Weir Crest Elevation										**1082.76**	**1068.7**	14.06				

Plant Flow Rate	230	mgd
Additional Headloss	0.00	ft
Spillway No. 1 Elev	1070.93	ft AMSL
Sensor Datum	1070.93	ft AMSL
Sensor Reading	12.49	ft

Weir Coeff.	0.62	
Weir Length	206	ft
Weir Headloss	0.65	ft

$$Q = C_d * \frac{2}{3} * \sqrt{2g} * B * H^{3/2}$$

METROPOLITAN WATER DISTRICT
WEYMOUTH WTP FILTER REHABILITATION
HYDRAULIC PROFILE CALCULATIONS

Hydraulic Tabulation - Effluent Channel Profile at 300 mgd

Calc By: SC 12/11/2013
Chkd: MJA

		Flow per Unit	area	mann. n	wet perim.	length	K	width	Headloss	WS Elevation	Top of Wall	Bottom of Structure	Hydr Depth	Velocity	Friction Loss	Minor Loss	Conduit Status
1	Filter #38 Effluent	75	80.2	**0.013**	26.0	**10**	**1.8**	**10**	0.06	**1083.88**	**1081.80**	**1075.80**	8.08	1.45	0.00	0.06	
2	Filter Effluent Channel - Filters 37 to 48	75	100.0	**0.013**	10.0	**95**	**0.60**	**10**	0.01	**1083.82**	**1081.80**	**1075.80**	8.02	1.16	0.00	0.01	
3	Combined Filter Effluent Channel (FB2-1)	75	100.0	**0.013**	30.0	**235**	**0**	**10**	0.00	**1083.80**	**1083.80**	**1073.80**	10.00	1.16	0.00	0.00	OPEN CHANNEL
4	Combined Filter Effluent Channel (FB2-2)	150	97.9	**0.013**	29.6	**575**	**1.8**	**10**	0.21	**1083.80**	**1083.80**	**1073.80**	10.00	2.37	0.05	0.16	FULL
5	Filter #1 Effluent	75	126.2	**0.013**	29.6	**10**	**0.60**	**10**	0.01	**1083.77**	**1081.90**	**1075.80**	7.97	0.92	0.00	0.01	
6	Filter Effluent Channel - Filter 1 to 24	150	97.9	**0.013**	29.6	**95**	**1.8**	**10**	0.17	**1083.76**	**1073.80**	**1062.97**	20.79	2.37	0.01	0.16	OPEN CHANNEL
7	Combined Filter Effluent - Slope	300	151.5	**0.013**	37.2	**350**	**0**	**12**	0.04	**1083.59**	**1083.80**	**1073.80**	9.79	3.06	0.04	0.00	FULL
8	Spillway No. 1 (Level Sensor)	300	168.7	**0.013**	40.1	**250**	**0**	**12**	0.02	**1083.55**	**1080.93**	**1070.93**	12.62	2.75	0.02	0.00	OPEN CHANNEL
9	Upstream of Weir									**1083.53**							
10	Weir Crest Elevation										**1082.76**	**1068.7**	14.06				

Plant Flow Rate	300	mgd
Additional Headloss	0.00	ft
Spillway No. 1 Elev	1070.93	ft AMSL
Sensor Datum	1070.93	ft AMSL
Sensor Reading	12.62	ft

Weir Coeff.	0.62	
Weir Length	206	ft
Weir Headloss	0.77	ft

$$Q = C_d * \frac{2}{3} * \sqrt{2g} * B * H^{3/2}$$

METROPOLITAN WATER DISTRICT
WEYMOUTH WTP FILTER REHABILITATION
HYDRAULIC PROFILE CALCULATIONS

Hydraulic Tabulation - Effluent Channel Profile at 600 mgd

Calc By: SC
Chkd: MJA

		Flow per Unit	area	mann. n	wet perim.	length	K	width	Headloss	WS Elevation	Top of Wall	Bottom of Structure	Hydr Depth	Velocity	Friction Loss	Minor Loss	Conduit Status
1	Filter #38 Effluent	150	91.9	**0.013**	28.4	**10**	**1.8**	**10**	0.18	**1085.17**	**1081.80**	**1075.80**	9.37	2.52	0.00	0.18	
2	Filter Effluent Channel - Filters 37 to 48	150	111.5	**0.013**	10.0	**95**	**0.60**	**10**	0.04	**1084.99**	**1081.80**	**1075.80**	9.19	2.08	0.00	0.04	
3	Combined Filter Effluent Channel (FB2-1)	150	111.4	**0.013**	32.3	**235**	**0**	**10**	0.01	**1084.95**	**1083.80**	**1073.80**	11.15	2.08	0.01	0.00	FULL
4	Combined Filter Effluent Channel (FB2 -2)	300	104.1	**0.013**	30.8	**575**	**1.8**	**10**	0.73	**1084.94**	**1083.80**	**1073.80**	11.14	4.46	0.17	0.56	FULL
5	Filter #1 Effluent	150	131.4	**0.013**	30.8	**10**	**0.60**	**10**	0.03	**1084.82**	**1081.90**	**1075.80**	9.02	1.77	0.00	0.03	
6	Filter Effluent Channel - Filter 1 to 24	300	104.1	**0.013**	30.8	**95**	**1.8**	**10**	0.58	**1084.79**	**1073.80**	**1062.97**	21.82	4.46	0.03	0.56	FULL
7	Combined Filter Effluent - Slope	600	157.7	**0.013**	38.3	**350**	**0**	**12**	0.14	**1084.21**	**1083.80**	**1073.80**	10.41	5.89	0.14	0.00	FULL
8	Spillway No. 1 (Level Sensor)	600	168.7	**0.013**	40.1	**250**	**0**	**12**	0.08	**1084.07**	**1080.93**	**1070.93**	13.14	5.50	0.08	0.00	OPEN CHANNEL
9	Upstream of Weir									**1083.99**							
10	Weir Crest Elevation										**1082.76**	**1068.7**	14.06				

Plant Flow Rate	600	mgd
Additional Headloss	0.00	ft
Spillway No. 1 Elev	1070.93	ft AMSL
Sensor Datum	1070.93	ft AMSL
Sensor Reading	13.14	ft

Weir Coeff.	0.62	
Weir Length	206	ft
Weir Headloss	1.23	ft

$$Q = C_d * \frac{2}{3} * \sqrt{2g} * B * H^{3/2}$$

CHANNEL HYDRAULIC ITEMIZATIONS

Elements	L	Ent 0.50	Exit 1.00	Branch tee (flow) 0.30	Expension (pipe) 0.20	Contraction open channel 0.10
Minor Losses		0		1	1	1
Totals	0	0.00 **0.60**	0.00	0.30	0.20	0.10

CHANNEL HYDRAULIC ITEMIZATIONS

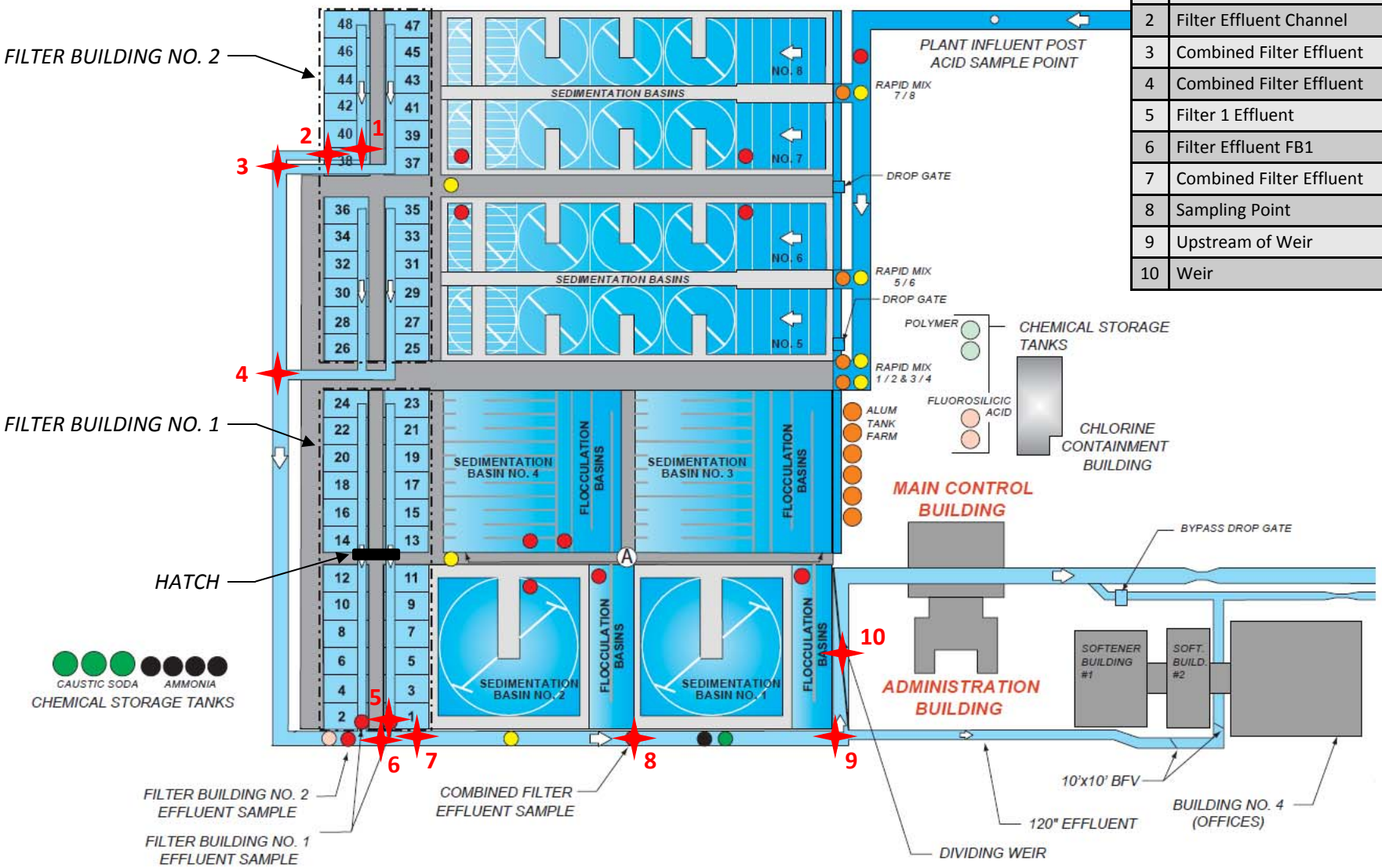
Elements	L	Ent 0.50	90 degrees (pipe) 0.80	90 degrees (channel) 1.00	45El 0.15
Minor Losses		0	1	1	
Totals	0	0.00 **1.80**	0.80	1.00	0.00

CHANNEL HYDRAULIC ITEMIZATIONS

Elements	L	Ent 0.50	90 degrees (channel) 1.00	Tee (branch flow) 0.30	Expansion 0.20
Minor Losses		0	1	2	1
Totals	0	0.00 **1.80**	1.00	0.60	0.20

FILTER EFFLUENT HYDRAULIC PROFILE LOCATIONS

1	**Filter #38 Effluent**
2	Filter Effluent Channel
3	Combined Filter Effluent
4	Combined Filter Effluent
5	Filter 1 Effluent
6	Filter Effluent FB1
7	Combined Filter Effluent
8	Sampling Point
9	Upstream of Weir
10	Weir



Appendix D

Filtration Model Results

CONCEPTUAL DESIGN AND MODEL PREDICTIONS

Filter Configuration

Parameter		Unit	Value
Top Layer	d_{10}	mm	1.0
	SG	g/cm^3	1.60
	UC	-	1.4
	Depth	in	26
Bottom Layer	d_{10}	mm	0.50
	SG	g/cm^3	2.65
	UC	-	1.4
	Depth	in	8
Terminal head loss		ft	6.0

Input Cells

Condition	Test 1
Building	FB1

Predicted Turbidity (NTU)

0.026	FB1	FB2
Test 1	0.026	0.034
Test 2	0.028	0.023
Test 3	0.031	0.031
Test 4	0.035	0.031
Test 5	0.026	0.034
Test 7	0.030	0.037

Predicted UFRV (gal/sf)

8,916	FB1	FB2
Test 1	8,916	6,126
Test 2	9,093	6,470
Test 3	6,930	8,185
Test 4	9,424	5,972
Test 5	8,126	4,948
Test 7	4,832	5,697

Predicted Filter Run Time (hr)

52	FB1	FB2
Test 1	52	36
Test 2	51	37
Test 3	29	34
Test 4	39	25
Test 5	48	29
Test 7	20	23

Dual-media Filtration Performance Model

USER INPUT DATA

Parameter		Unit	Value
Operating conditions			
Particle count		#/mL	105
Turbidity		NTU	0.35
Suspended solids		mg/L	0.44
Coagulant dose		mg/L	10.0
Filter aid dose		mg/L	0
Filtration rate		m/hr	7.00
Temperature		°C	22.5
Media characteristics			
Top Layer	d_{10}	mm	1.00
	SG	g/cm^3	1.60
	UC	-	1.40
	Depth	m	0.66
Bottom Layer	d_{10}	mm	0.50
	SG	g/cm^3	2.65
	UC	-	1.40
	Depth	m	0.20
Terminal head loss		m	1.83

®R. Trussell
Montgomery Watson, 1993

DATABASE LOOKUP

Data type	Lookup value
Operating conditions	Test 1
Media characteristics	Design
Filter building	FB1

CALIBRATION PARAMETERS

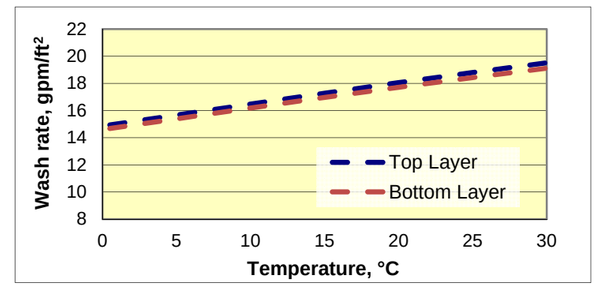
Variable	Typ. Value	Significance	Value
b	0.5 to 50	Increase time to breakthrough	3
f	0.35 to 35	Reduce time to headloss	2.57
k	0.4 to 40	Increase final particle count	0.10
p	2.5 to 10	Reduce final turbidity	0.81
n	0.0175	Increase clean bed headloss	0.023
T	20	Calibration temperature for n	20

COLOR KEY

= Operating conditions data
= Media characteristics data
= Calibration parameters
= Model predictions
= Reference or pilot-testing data

MODEL OUTPUT

Clean bed headloss =	0.26	m	10.3	in
Headloss accumulation =	0.03	m/hr	1.2	iph
Time to breakthrough =	83.5	hr		
Time to headloss =	51.9	hr		
UFRV =	363	m	8,916	gal/ft^2
NWP =	166	m/d	4,067	gpd/ft^2
Final particles =	19	#/mL		
Particle removal =	0.75	log		
Operating turbidity =	0.026	NTU		
Backwash rate =	44.1	m/hr	18.0	gpm/ft^2
Overall L/d ratio =	1067			



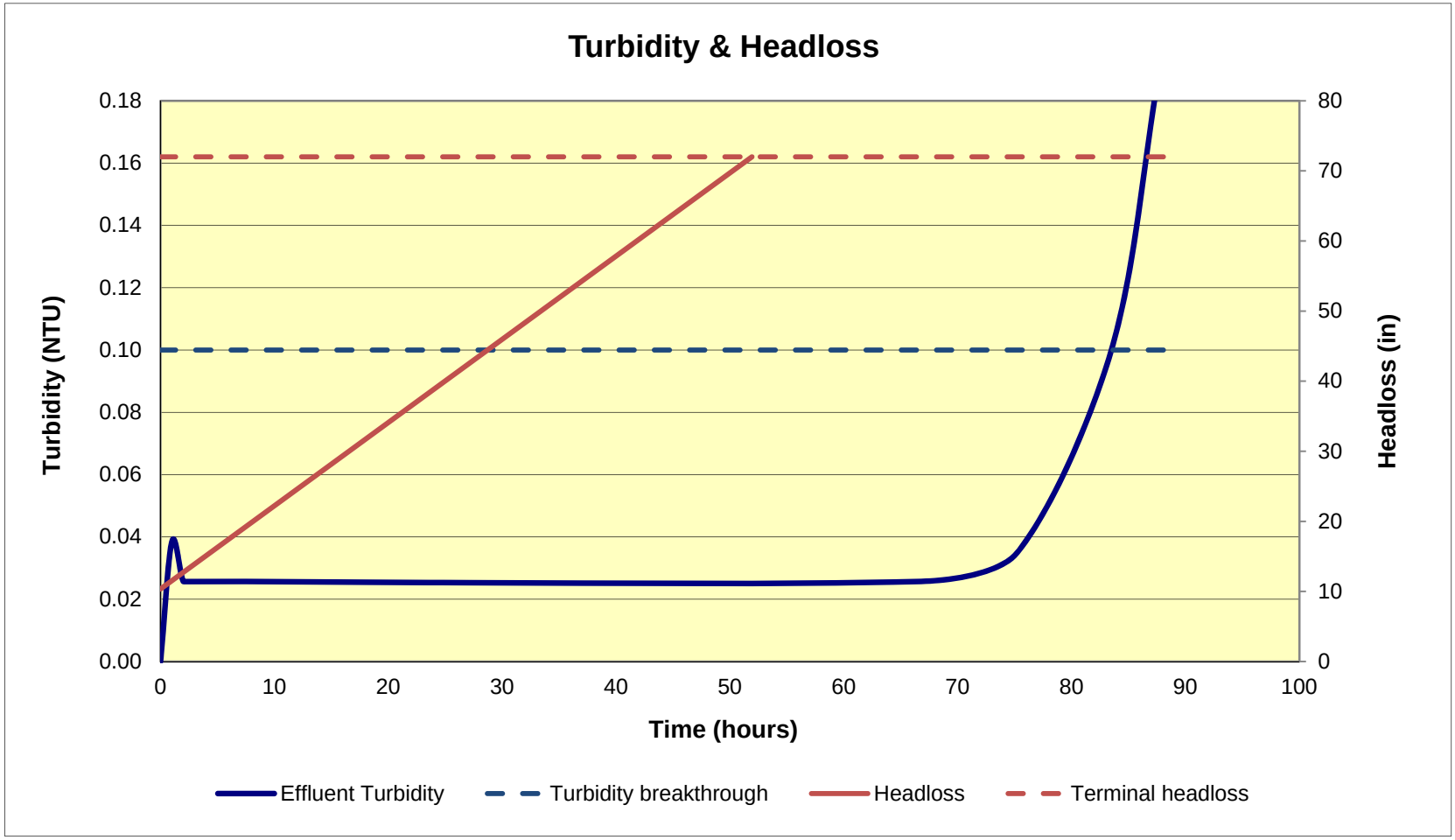
Backwash compatibility check

$$\frac{d_{10-Bot} \times UC_{Bot}}{d_{10-Top} \times UC_{Top}} = \left(\frac{SG_{Top} - 1}{SG_{Bot} - 1}\right)^{\frac{2}{3}}$$

0.500 = 0.509

Media Balanced

GRAPH OF PREDICTED FILTER RUN



FILTER PERFORMANCE CALCULATIONS

Overall L/d Ratio

L_{top}/d_{top} =	0.660	
$L_{top}/d_{top}+L_{bot}/d_{bot}$ =	1.067	
Overall L/d =	1067	
Total bed depth L =	0.86	m

Clean-bed Headloss

$\nu[T_{Cal}]$ =	1.004	mm^2/s
$\nu[T]$ =	0.948	mm^2/s
ν_{Ratio} =	0.944	
$H[L_{top}/d_{top}]$ =	0.131	m
$H[L_{top}/d_{top}+L_{bot}/d_{bot}]$ =	0.263	m
Clean bed headloss =	0.26	m

c_1 =	-9.85E-06
c_2 =	0.0011
c_3 =	-0.0577
b =	1.7845

$$\nu(T) \approx c_1T^3 + c_2T^2 + c_3T + b$$

$$HL_{Clean} = nV_a\left(\frac{L_{top}}{{d_{top}}^2} + 1.3\frac{L_{bot}}{{d_{bot}}^2}\right)\left(\frac{\nu[T]}{\nu[T_{Cal}]}\right)$$

Influent Concentrations

Raw Particles =	105	#/mL
Raw Turbidity =	0.35	#/mL
Suspended Solids =	0.44	mg/L
Alum =	10.00	mg/L
Influent concentration C_0 =	1.68	mg/L

If given, these values are taken from user input data.
If not given, these values are estimated empirically:

$$Raw\ Particles \approx (Raw\ Turb - 0.018) \times 32{,}000$$

$$Raw\ SS \approx Raw\ Turb\ \times 1.25$$

$$C_0 \approx 3.8 \times Raw\ SS \approx a \times Raw\ Turb + Alum$$

Filter Cycle Time

Sigma (breakthrough) =	1,134	
Gamma (headloss) =	2.57E-03	
Breakthrough time =	83.5	hrs
Headloss time =	51.9	hrs
Filter run time =	51.9	hrs
Headloss accumulation =	0.030	m/hr

Scaling factors:

$$\sigma = b{V_a}^c{d_{10}}^d\left(1 + \frac{eC_{fa}}{C_{alum}}\right)^i$$

$$\Gamma = f{V_a}^g{d_{10}}^h\left(1 + \frac{eC_{fa}}{C_{alum}}\right)^j$$

Estimated run time:

$$t_b = \frac{\sigma L}{V_aC_0} \qquad t_h = \frac{H_d - H_0}{\Gamma V_aC_0} \qquad \frac{dH}{dt} = \Gamma V_aC_0$$

Filter Water Efficiency

Unit backwash volume =	3	m
Backwash time =	15	min
Net water production =	166	m/day
Unit filter run volume =	363	m

$$NWP = V_a\left(24\ hr - \frac{24\ hr}{t_{Fi}\ hr} \times \frac{t_{BW}\ min}{60\ min}\right) - UFBV \times \frac{24\ hr}{t_{Fi}\ hr}$$

$$UFRV = V_at_{Fi}$$

Filtrate Quality

Final particles =	19	#/mL
Particle removal =	0.75	log
Operating turbidity =	0.026	NTU

Final particles:

$$N_{out} = \frac{k{d_{bot}}^l{V_a}^r}{\left[1 + m\left(\frac{L}{d}\right)\right]^q}$$

Turbidity:

$$NTU_{out} = 0.018 + \frac{N_{out}}{p}$$

Model Parameters from Pilot Tests:

a =	0.10	Alum, influent turbidity and C_0
b =	3.0E+03	Basic sigma coeff
c =	-0.5	Sigma and filter rate
d =	-1	Sigma and d_{10}
e =	200	Sigma, gamma and filter aid
f =	2.6E-03	Basic gamma coeff
g =	-1.5	Gamma and filter rate
h =	0	Gamma and d_{10}
i =	0.15	Sigma and filter aid
j =	1.50	Gamma and filter aid
k =	1.0E+02	Basic particle/mL coeff
l =	0.25	Effluent particles & sand size
m =	0.05	Effluent particles and L/d
n =	0.023	Carman-Kozeny constant
o =	0.018	Turbidity of pure water
p =	2422	Effluent turbidity coeff
q =	0.5	Effluent particles and L/d [exp]
r =	0.25	Particles and filtration rate
s =	0.2	Particles and filter aid

BACKWASH VELOCITY CALCULATIONS

Ref: Kawamura, S., "Design and Operation of High-Rate Filters - Part I," *J. AWWA* , 10/75 [equation 7, Figure 4]

$$V_{Backwash} = \kappa \left(\frac{\rho_{Media} - \rho_{Water}}{\rho_{Water}} g \right)^{\frac{2}{3}} \nu_{Water}{}^{-\frac{1}{3}} d_{60}$$

Basic physical properties

Temperature	°C	0.5	5	10	15	20	25	30
Abs. temperature	K	273.65	278.15	283.15	288.15	293.15	298.15	303.15
Water density	g/cm^3	1.0001	1.0001	0.9997	0.9991	0.9982	0.9971	0.9957
Kinematic viscosity	mm^2/s	1.7559	1.5228	1.3104	1.1399	1.0039	0.8950	0.8058
κ and g factor		0.738	0.738	0.738	0.738	0.738	0.738	0.738

Top layer velocities

Anthracite d_{60} = 1.4 mm

Temperature	°C	0.5	5	10	15	20	25	30
Backwash velocity	m/min	0.61	0.64	0.67	0.70	0.74	0.77	0.80
	in/min	24.0	25.1	26.5	27.7	29.0	30.2	31.3
	m/hr	36.6	38.3	40.3	42.3	44.2	46.0	47.8
	gpm/ft^2	14.9	15.7	16.5	17.3	18.1	18.8	19.5

Bottom layer velocities

Sand d_{60} = 0.70 mm

Temperature	°C	0.5	5	10	15	20	25	30
Backwash velocity	m/min	0.60	0.63	0.66	0.69	0.72	0.75	0.78
	in/min	23.5	24.7	26.0	27.2	28.4	29.6	30.7
	m/hr	35.9	37.6	39.6	41.5	43.3	45.1	46.7
	gpm/ft^2	14.7	15.4	16.2	17.0	17.7	18.4	19.1

Required velocity at given temperature

Top layer	m/hr	44.9
Bottom layer	m/hr	44.1
Recommended	m/hr	44.1
Difference	%	2%

DATABASE OF TEST CONDITIONS

General Summary

Parameter	Test 1	Test 2	Test 3	Test 4	Test 5	Test 7
Air entrainment in filters	No	No	No	No	Yes	Yes
Filtration velocity	Low	Low	High	High	Low	High
Raw water temperature	High	Low	High	Low	High	High
Plant alum dose	High	Low	Low	High	High	Low

Filter Building #1

Parameter	Unit	Test 1	Test 2	Test 3	Test 4	Test 5	Test 7
Settled water turbidity	NTU	0.35	0.23	0.26	0.31	0.35	0.24
Settled water particles	#/mL	105	53	111	394	221	106
Filtration rate	m/h	7.00	7.27	9.88	9.90	6.89	9.92
	gpm/sf	2.86	2.98	4.04	4.05	2.82	4.06
Alum dose	mg/L	10.0	5.00	5.00	10.0	10.0	5.00
Temperature	°C	22.5	17.2	21.6	14.3	25.9	22.1

Filter Building #2

Parameter	Unit	Test 1	Test 2	Test 3	Test 4	Test 5	Test 7
Settled water turbidity	NTU	0.60	0.59	0.39	0.66	0.60	0.46
Settled water particles	#/mL	1139	1965	1538	1885	1290	2759
Filtration rate	m/h	7.01	7.12	9.91	9.91	6.87	9.93
	gpm/sf	2.87	2.91	4.05	4.05	2.81	4.06
Alum dose	mg/L	10.0	5.00	5.00	5.00	10.0	5.00
Temperature	°C	23.0	17.2	21.4	14.2	25.7	22.0

DATABASE OF MODEL CALIBRATION PARAMETERS

Key to Conditions

Parameter	Unit	Low	High
Temperature	°C	15 - 20	20 - 25
Alum dose	mg/L	5.0	10.0
Velocity	m/hr	~3	~4

Carman-Kozeny Coefficient

Application	Temp (°C)	n Value
General	20	0.023
Filters 23, 47	20	0.041

Filter Building #1

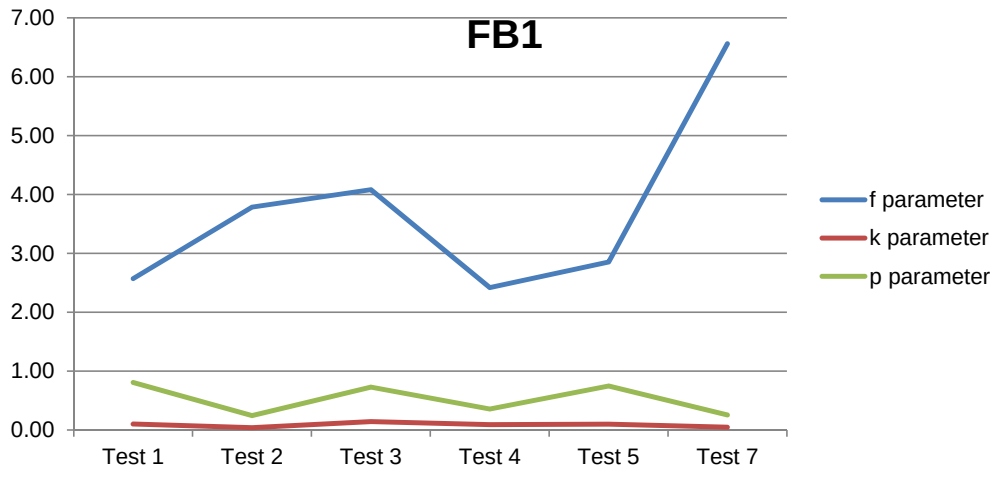
Test ID	CONDITIONS				FITTING PARAMETERS			
	Air entrained?	Temperature	Alum Dose	Velocity	b	f	k	p
Test 1	No	High	High	Low	3	2.57	0.10	0.81
Test 2		Low	Low	Low	3	3.79	0.04	0.24
Test 3		High	Low	High	3	4.08	0.14	0.73
Test 4		Low	High	High	3	2.42	0.09	0.36
Test 5	Yes	High	High	Low	3	2.85	0.10	0.75
Test 7		High	Low	High	3	6.56	0.04	0.26

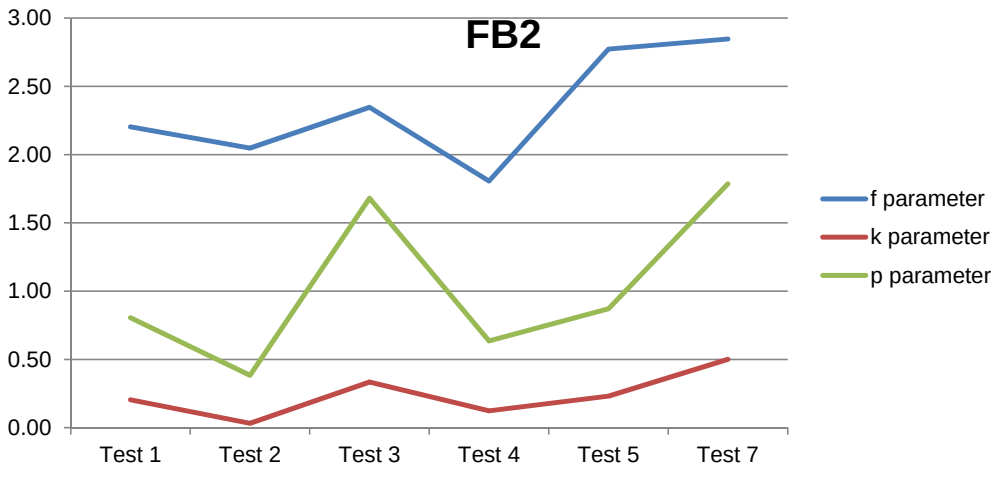
Filter Building #2

Test ID	CONDITIONS				FITTING PARAMETERS			
	Air entrained?	Temperature	Alum Dose	Velocity	b	f	k	p
Test 1	No	High	High	Low	3	2.20	0.20	0.80
Test 2		Low	Low	Low	3	2.05	0.03	0.38
Test 3		High	Low	High	3	2.35	0.33	1.68
Test 4		Low	High	High	3	1.81	0.12	0.64
Test 5	Yes	High	High	Low	3	2.77	0.23	0.87
Test 7		High	Low	High	3	2.85	0.50	1.79

Note: Parameter b in this calibration is taken to be 3 for all sets of conditions. Breakthrough was not observed with sufficient frequency to calibrate this parameter.

Plots of Calibration Parameters



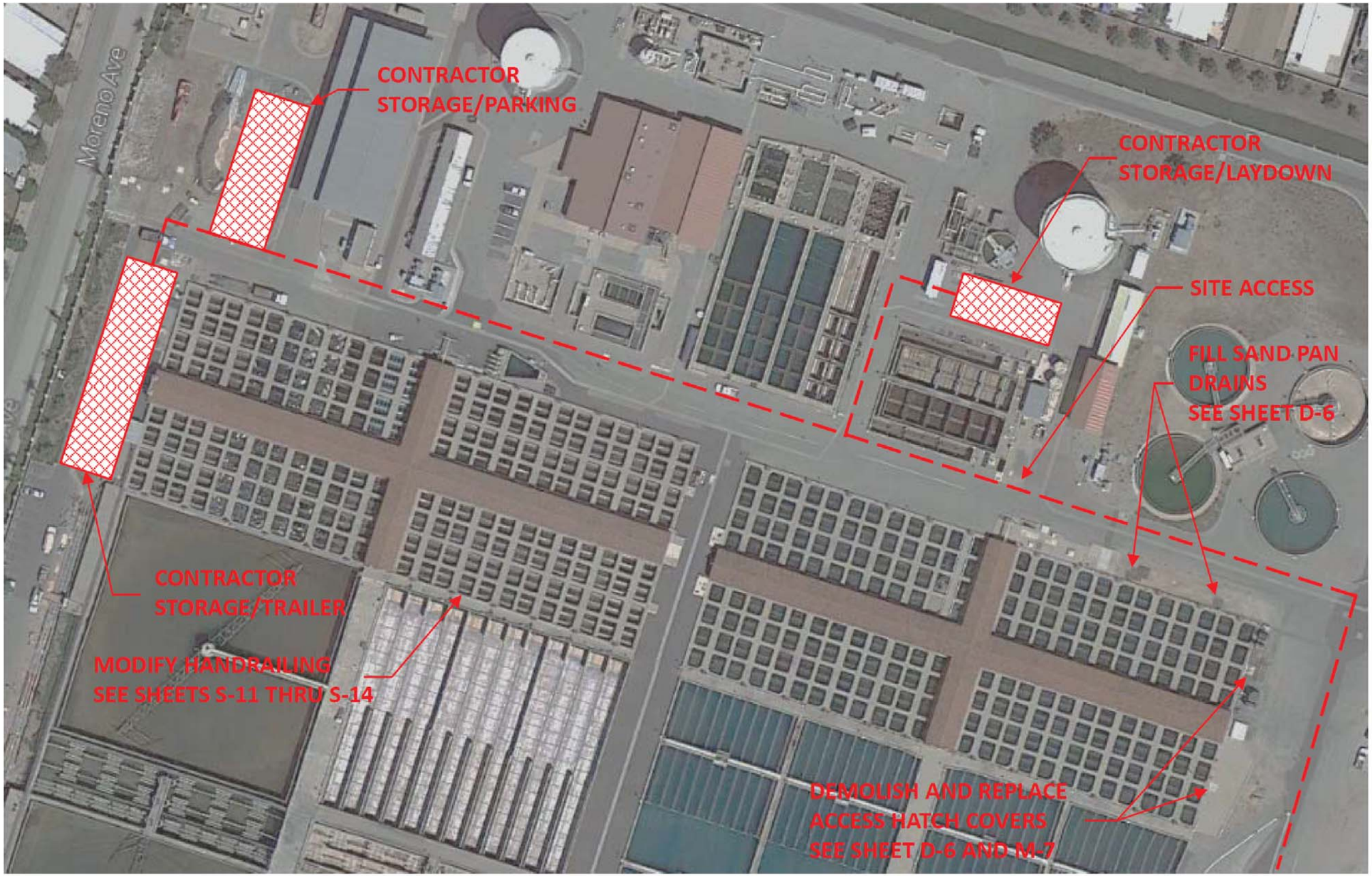


COMPARISON OF MODEL WITH STUDY DATA

Filter ID	Parameter	Unit	Test 1		Test 2		Test 3		Test 4		Test 5		Test 7	
			Data	Model	Data	Model	Data	Model	Data	Model	Data	Model	Data	Model
#7	Clean bed headloss	ft	0.58	0.59	0.73	0.70	1.14	0.86	1.30	1.02	0.52	0.54	1.10	0.85
	Headloss accum. rate	in/hr	0.984	0.922	0.927	0.959	1.735	1.591	1.138	1.168	1.177	1.075	2.741	2.248
	Time to headloss	hr	69.7	71.0	68.8	66.9	35.0	39.1	52.2	51.5	58.5	61.4	21.7	27.7
	Unit filter run volume	gal/ft^2	11,897	12,142	12,300	11,979	8,513	9,512	12,710	12,553	9,925	10,456	5,280	6,756
	Net water production	gpm/ft^2	2.82	2.80	2.96	2.93	4.02	3.94	4.03	3.97	2.81	2.78	4.01	3.89
	Effluent particles	#/mL	22	22	15	9	10	34	49	22	15	22	10	10
	Particle removal	log	0.70	0.7	0.56	0.8	1.00	0.5	0.84	1.2	1.18	1.0	0.93	1.0
	Effluent turbidity	NTU	0.033	0.027	0.043	0.030	0.041	0.033	0.049	0.038	0.035	0.028	0.043	0.030
#12	Clean bed headloss	ft	0.67	0.96	0.84	1.12	1.32	1.36	1.70	1.64	0.70	0.87	1.32	1.35
	Headloss accum. rate	in/hr	0.997	0.994	0.999	1.119	1.875	1.900	1.330	1.312	1.347	1.333	2.623	2.701
	Time to headloss	hr	67.6	61.0	62.6	52.4	32.0	29.4	42.7	40.0	49.6	46.3	21.6	20.7
	Unit filter run volume	gal/ft^2	11,716	10,605	11,184	9,381	7,783	7,143	10,417	9,748	8,374	7,835	5,275	5,056
	Net water production	gpm/ft^2	2.87	2.83	2.95	2.91	4.01	3.89	4.03	3.95	2.79	2.74	4.02	3.84
	Effluent particles	#/mL	17	18	4	7	72	27	7	18	18	18	8	8
	Particle removal	log	0.75	0.7	1.03	0.8	0.17	0.6	1.76	1.3	1.07	1.1	1.17	1.2
	Effluent turbidity	NTU	0.026	0.025	0.023	0.028	0.023	0.031	0.024	0.034	0.027	0.026	0.024	0.028
#23	Clean bed headloss	ft	1.24	1.60	1.57	1.88	2.27	2.28	2.52	2.79	0.97	1.45	2.16	2.28
	Headloss accum. rate	in/hr	1.323	1.423	1.380	1.215	1.955	2.116	1.433	1.419	1.103	1.232	2.550	3.150
	Time to headloss	hr	47.4	37.5	40.0	41.1	24.0	21.3	30.1	27.5	56.5	44.7	18.5	14.3
	Unit filter run volume	gal/ft^2	8,061	6,378	7,085	7,297	5,794	5,135	7,277	6,640	9,470	7,510	4,478	3,472
	Net water production	gpm/ft^2	2.81	2.74	2.93	2.87	3.96	3.80	3.98	3.85	2.78	2.72	3.97	3.71
	Effluent particles	#/mL	20.90	19	5	8	76	30	7	19	23	19	11	8
	Particle removal	log	0.71	0.7	1.06	0.9	0.23	0.6	1.80	1.4	0.98	1.1	1.03	1.1
	Effluent turbidity	NTU	0.024	0.026	0.025	0.029	0.033	0.031	0.034	0.036	0.024	0.027	0.034	0.029
#34	Clean bed headloss	ft	0.67	0.73	0.88	0.87	1.54	1.07	1.66	1.30	0.64	0.69	1.56	1.06
	Headloss accum. rate	in/hr	1.473	1.798	1.376	1.592	1.412	1.654	1.911	2.093	1.797	2.105	2.157	2.228
	Time to headloss	hr	48.7	35.5	45.8	39.0	38.0	36.1	27.7	27.2	37.1	30.6	25.2	26.9
	Unit filter run volume	gal/ft^2	8,408	6,122	8,083	6,902	9,201	8,747	6,723	6,616	6,308	5,204	6,132	6,536
	Net water production	gpm/ft^2	2.86	2.77	2.92	2.85	4.01	3.91	4.02	3.88	2.81	2.71	4.01	3.88
	Effluent particles	#/mL	21	44	7	7	51	79	6	29	20	50	66	119
	Particle removal	log	1.65	1.3	2.47	2.5	1.49	1.3	2.55	1.8	1.79	1.4	1.63	1.4
	Effluent turbidity	NTU	0.029	0.036	0.022	0.024	0.027	0.034	0.024	0.033	0.029	0.037	0.031	0.040
#36	Clean bed headloss	ft	0.74	0.90	0.91	1.05	1.48	1.31	1.70	1.56	0.66	0.83	1.47	1.30
	Headloss accum. rate	in/hr	1.502	1.606	1.353	1.487	1.309	1.572	1.692	2.055	1.856	1.967	2.231	2.324
	Time to headloss	hr	47.3	38.5	46.7	40.4	42.0	36.2	30.9	26.3	35.4	31.9	26.2	24.6
	Unit filter run volume	gal/ft^2	8,200	6,666	8,176	7,075	10,212	8,815	7,534	6,397	5,990	5,396	6,384	5,980
	Net water production	gpm/ft^2	2.86	2.78	2.89	2.82	4.02	3.92	4.02	3.88	2.79	2.70	4.00	3.87
	Effluent particles	#/mL	70	35	7	5	68	63	3	23	81	40	99	96
	Particle removal	log	1.18	1.5	2.48	2.6	1.36	1.4	2.61	1.8	1.21	1.5	1.45	1.5
	Effluent turbidity	NTU	0.049	0.033	0.028	0.023	0.039	0.031	0.042	0.030	0.059	0.033	0.042	0.036
#47	Clean bed headloss	ft	0.65	0.75	0.73	0.86	1.44	1.11	1.45	1.33	0.60	0.68	1.36	1.09
	Headloss accum. rate	in/hr	1.259	1.007	1.245	1.019	1.382	1.056	1.763	1.401	1.583	1.313	1.702	1.594
	Time to headloss	hr	54.3	63.2	52.1	61.2	39.9	56.2	31.2	40.5	42.9	49.1	33.9	37.4
	Unit filter run volume	gal/ft^2	9,299	10,805	8,967	10,557	9,740	13,717	7,593	9,857	7,134	8,172	8,291	9,147
	Net water production	gpm/ft^2	2.83	2.79	2.84	2.81	4.04	3.99	4.01	3.94	2.74	2.70	4.05	3.95
	Effluent particles	#/mL	33	54	8	8	129	97	97	35	38	61	208	147
	Particle removal	log	1.63	1.4	2.41	2.4	1.06	1.2	1.36	1.8	1.55	1.3	1.11	1.3
	Effluent turbidity	NTU	0.029	0.040	0.026	0.025	0.038	0.037	0.039	0.036	0.027	0.042	0.049	0.045

Appendix E

Preliminary Design Drawings



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SCALE BARS

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ISSUE DESCRIPTION
ORIGINAL ISSUE

ISSUE DATE OCTOBER 2009

MWD
METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

DESIGNED CONSULTANT
DRAWN CONSULTANT
CHECKED

FOR DRAWING APPROVALS SEE
B-132793

DISTRIBUTION SYSTEM
F.E. WEYMOUTH WATER TREATMENT PLANT
FILTER REHABILITATION DEMONSTRATION

SITE PLAN AND LIMITS OF CONSTRUCTION

SPECIFICATIONS 1652
PROJECT NUMBER 103880
SHEET G-5
DWG B-132765
REV 0

BRDR DATE: 01/29/2009
PEN TABLE: MWDFBW.TBL
PLOT TIME: 08-OCT-2009 12:13
USERID: Consultant
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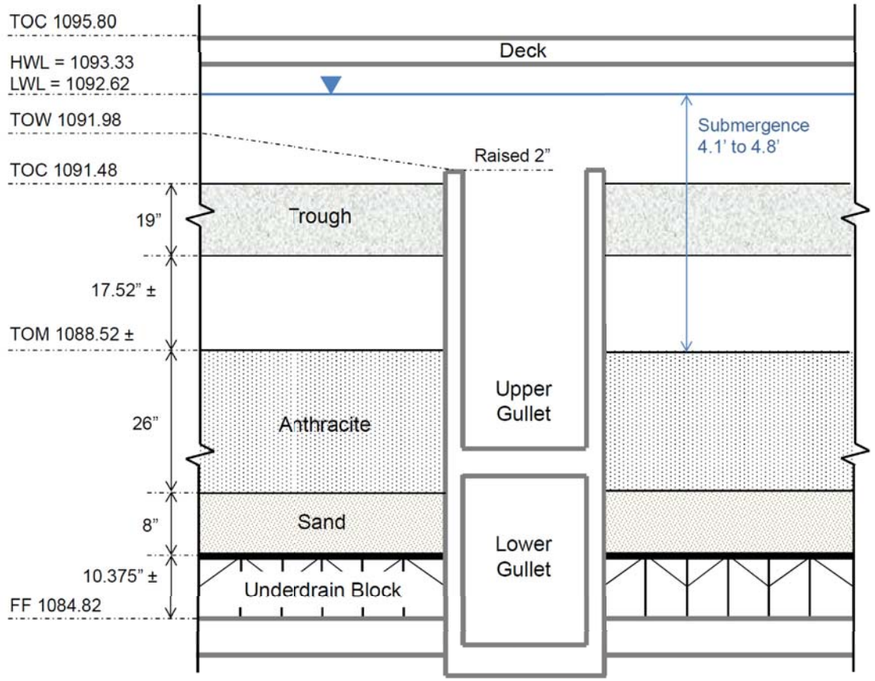
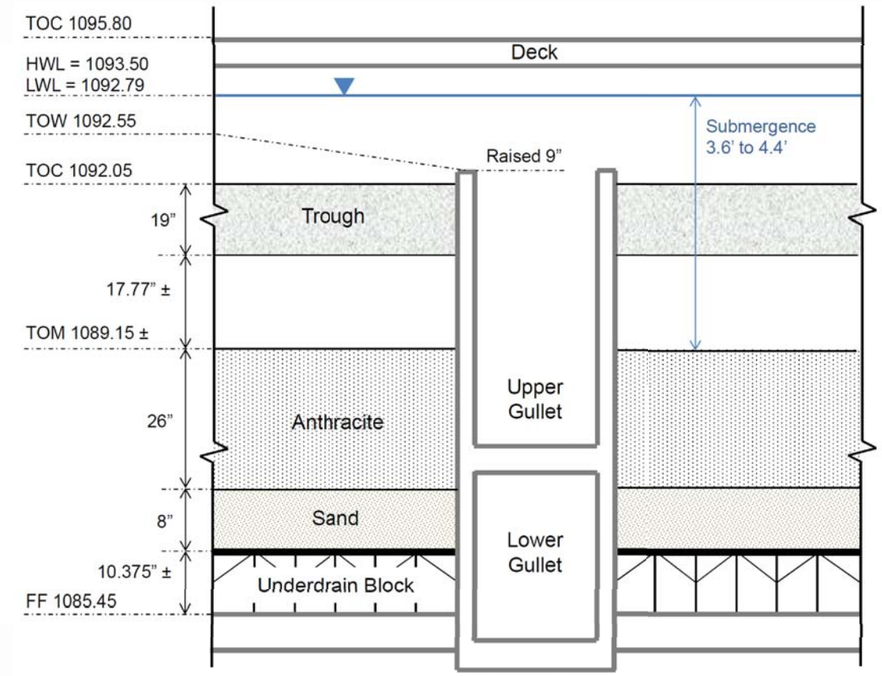


FILTER BUILDING NO 1
GENERAL PROFILE



FILTER BUILDING NO 2
GENERAL PROFILE

SCHEDULE OF WORK

PARAMETER	UNITS	~~ALTERNATIVE DEMONSTRATION DESIGN~~			
		~~MEDIA REPLACEMENT~~	FILTER BUILDING NO 1 - EXISTING	FILTER BUILDING NO 2 - EXISTING	ALL FILTERS - REHABILITATED
~~DESIGNER'S INTENT~~	-	~~TEST MEDIA~~	~~TEST MEDIA AND UNDERDRAIN~~	~~TEST MEDIA, UNDERDRAIN AND TROUGH~~	~~ALTERNATIVE DESIGN W/ADDITIONAL MEDIA~~
FILTER TO BE MODIFIED	-	~~FILTER 34~~	FILTERS 1-24	FILTERS 25-48	FILTERS 1-48
UNDERDRAIN	-	~~EXISTING~~	VITRIFIED CLAY PIPE	CONCRETE TEEPEE	HDPE BLOCK
MEDIA SUPPORT (DEPTH)	(IN)	~~GRAVEL (16)~~	GRAVEL (15)	GRAVEL (15)	MEDIA RETENTION PLATE
ANTHRACITE (DEPTH)	(IN)	~~12~~	20	12	26
SAND (DEPTH)	(IN)	~~10~~	8	9	8
L/D RATIO	-	~~813~~	914	762	1,067
SURFACE WASH		~~MODIFY - BAYLISS (NEW SURFACE WASH HEADER AND NOZZLES)~~	BAYLIS SYSTEM 3 NOZZLES PER LATERAL	BAYLIS SYSTEM 3 NOZZLES PER LATERAL	MODIFIED BAYLIS NEW HEADERS (FB2), LATERALS AND NOZZLES (ALL)
BACKWASH TROUGHS			CONCRETE TROUGHS, 10 PER CELL	CONCRETE TROUGHS, 10 PER CELL	NEW CONCRETE TROUGHS, 8 PER CELL

NOTES:
1. FILTER MEDIA EFFECTIVE SIZE (ES) AND UNIFORMITY COEFFICIENT (UC) ARE AS FOLLOWS:
   SAND: ES - 0.47 TO 0.53 MM, UC ≤ 1.40
   ANTHRACITE: ES - 1.0 TO 1.1 MM, UC ≤ 1.40
2. NEW MODIFIED BAYLISS SURFACE WASH SYSTEM WILL HAVE A NEW SURFACE WASH HEADER IN FB2 AND NOZZLES.
3. UPPER GULLET MANHOLE AND AIR VENT SYSTEM TO BE DEMOLISHED AND REPLACED IN ALL FILTERS.
4. DIFFERENTIAL PRESSURE (DP) CELLS AND DP CELL INLETS TO BE REPLACED IN ALL FILTERS.
5. SURFACE SPRAY PIPING TO BE DEMOLISHED IN ALL FILTERS AND NEW HOSE BIBS INSTALLED.
6. LIGHTING AND CONDUIT TO BE DEMOLISHED IN ALL FILTERS WHERE EXISTING.
7. ALL ELEVATIONS IN NAVD88

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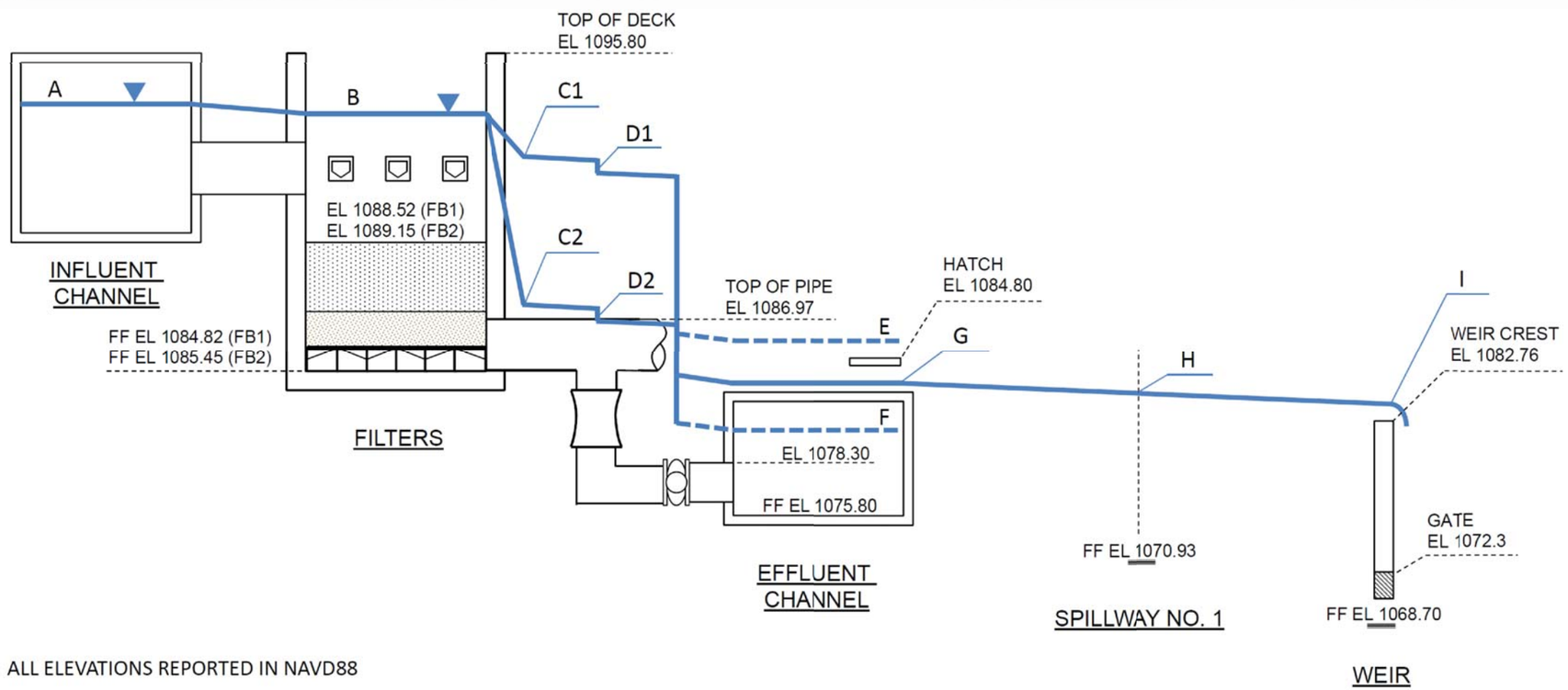
DISTRIBUTION SYSTEM
F.E. WEYMOUTH WATER TREATMENT PLANT
FILTER REHABILITATION DEMONSTRATION

DESIGN CRITERIA AND PROFILE

SPECIFICATIONS 1652
PROJECT NUMBER 103880
SHEET G-6
DWG B-132765 REV 0

BRDR DATE: 01/29/2009 PEN TABLE: MWDFBW.TBL PLOT TIME: 08-OCT-2009 12:13 USERID: Consultant FILE NAME: I652_I03880_00g006_I.dgn



NOTE: ALL ELEVATIONS REPORTED IN NAVD88

POINT	DESCRIPTION	FILTER BUILDING 1						FILTER BUILDING 2					
		2.0 GPM/SF		4.06 GPM/SF		4.69 GPM/SF		2.0 GPM/SF		4.06 GPM/SF		4.69 GPM/SF	
		LWL	HWL	LWL	HWL	LWL	HWL	LWL	HWL	LWL	HWL	LWL	HWL
A	INFLUENT CHANNEL	1093.10	1093.50	1093.10	1093.50	1093.10	1093.50	1093.28	1093.68	1093.28	1093.68	1093.28	1093.68
B	FILTER BOX	1092.93	1093.33	1092.74	1093.14	1092.62	1093.02	1093.10	1093.50	1092.91	1093.31	1092.79	1093.19
C1	FILTER OUTLET	1092.00	1092.40	1091.50	1091.90	1091.23	1091.63	1092.17	1092.57	1091.67	1092.07	1091.40	1091.80
C2	FILTER OUTLET	1087.04	1087.44	1086.97	1087.37	1086.92	1087.32	1087.21	1087.61	1087.14	1087.54	1087.10	1087.50
D1	VENTURI METER	1091.89	1092.29	1091.27	1091.67	1090.92	1091.32	1092.06	1092.46	1091.44	1091.84	1091.09	1091.49
D2	VENTURI METER	1086.93	1087.33	1086.74	1087.14	1086.62	1087.02	1087.10	1087.50	1086.91	1087.31	1086.79	1087.19
E	EFFLUENT CHANNEL - MAX	1086.48		1085.79		**1085.36**		1086.65		1085.97		1085.53	
F	EFFLUENT CHANNEL - MIN	1079.30		1079.30		1079.30		1079.30		1079.30		1079.30	

1 = HGL ELEVATION AT INITIAL HEADLOSS
2 = HGL ELEVATION AT TERMINAL HEADLOSS

POINT	DESCRIPTION	60 MGD		230 MGD		300 MGD	
		LWL	HWL	LWL	HWL	LWL	HWL
E	EFFLUENT CHANNEL - MAX	1085.36		1085.36		1085.36	
F	EFFLUENT CHANNEL - MIN	1079.30		1079.30		1079.30	
G	EFFLUENT CHANNEL	1083.0	1083.0	1083.5	1083.6	1083.8	1083.9
H	SPILLWAY NO. 1	1083.02		1083.42		1083.55	
I	UPSTREAM OF WEIR	1083.02		1083.41		1083.53	

ELEVATIONS ASSUME ALL FLOW IS DIRECTED OVER THE WEIR
FOR FLOWS GREATER THAN 300 MGD, THE GATE AND BYPASS LINES ARE TO BE USED
TO MODULATE EFFLUENT CHANNEL WATER ELEVATION BETWEEN 1083 – 1083.5 FT.

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DISTRIBUTION SYSTEM
F.E. WEYMOUTH WATER TREATMENT PLANT
FILTER REHABILITATION DEMONSTRATION

HYDRAULIC PROFILE

SPECIFICATIONS 1652
PROJECT NUMBER 103880
SHEET G-7
DWG B-132765
REV 0

BRDR DATE: 01/29/2009
PEN TABLE: MWDFBW.TBL
PLOT TIME: 08-OCT-2009 12:13
USERID: Consultant
FILE NAME: I652_I03880_00g006_I.dgn

NOTES:

1. FOR NOTES, ABBREVIATIONS AND LEGEND SEE SHEETS G-3 AND G-4.

2. ~~FOR NEW FILTER CONFIGURATIONS AND ADDITIONAL REQUIREMENTS, SEE:~~
   ~~7M-1 FILTER 23~~
   ~~7M-2 FILTER 12~~
   ~~8M-1 FILTER 34~~
   ~~8M-2 FILTER 36~~

3. FILTER DEMOLITION SHALL BE AS FOLLOWS:
   ~~FILTER 12:~~
   DEMOLISH FILTER MEDIA, UNDERDRAINS, SURFACE WASH AND TROUGHS
   ~~FILTER 23:~~
   ~~DEMOLISH FILTER MEDIA, UNDERDRAINS AND SURFACE WASH~~
   FILTER 34:
   ~~DEMOLISH FILTER MEDIA AND SURFACE WASH~~

4. SEE FILTER DEMOLITION SCHEDULE BELOW FOR RELEVANT FILTER DIMENSIONS AND DEMOLITION QUANTITIES.

5. CONTRACTOR SHALL REPAIR CONCRETE FILTER BED TO FLAT, LEVEL CONDITION AFTER DEMOLITION OF UNDERDRAINS AND ANCHOR BOLTS. EXPOSED STEEL SHALL BE COATED WITH CORROSION INHIBITING AGENT PER SPEC SECTION 09900.

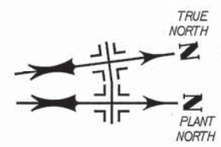
6. REMOVE COAL AND MEDIA FROM LOWER GULLET.

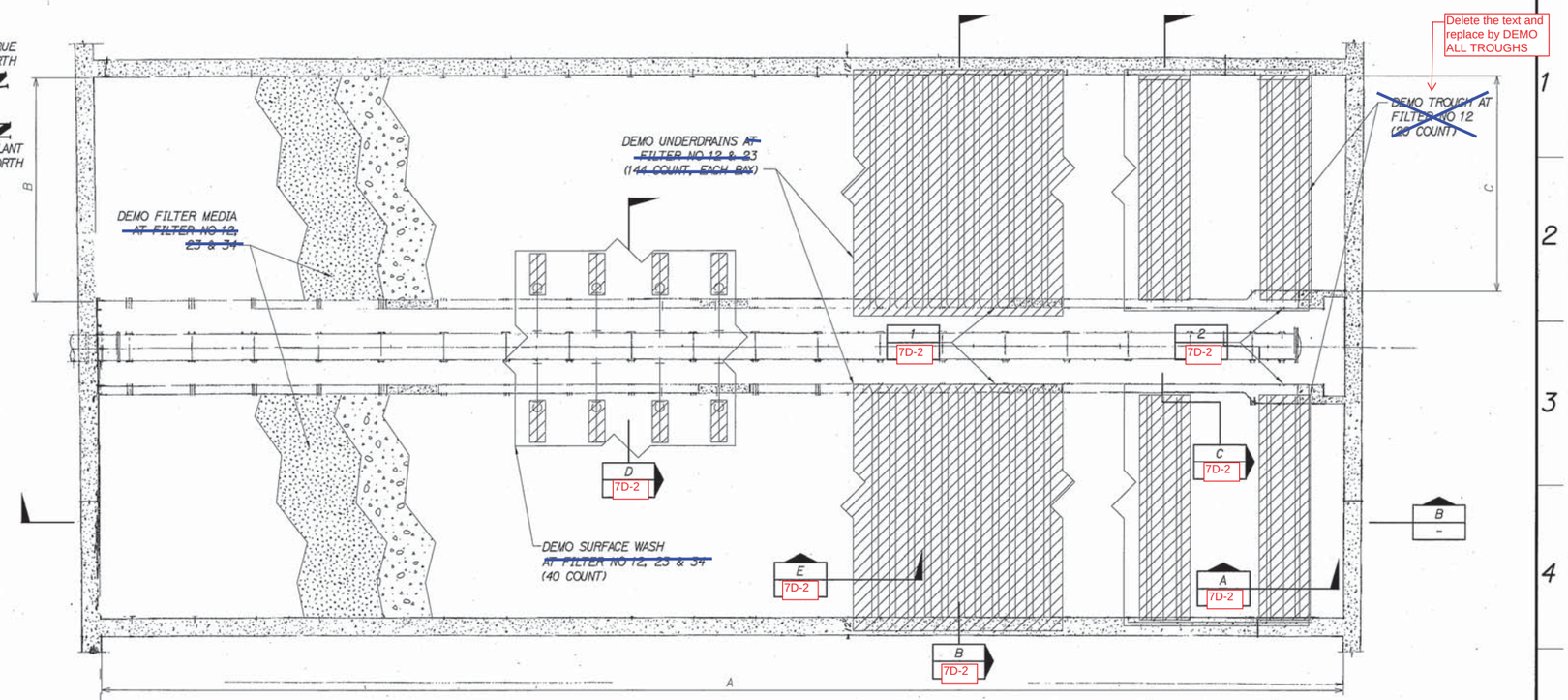
7. ~~90% OF GRAVEL SUPPORT AND 100% OF COAL AND SAND HAVE BEEN REMOVED FROM FILTER 23.~~

FILTER DEMOLITION SCHEDULE

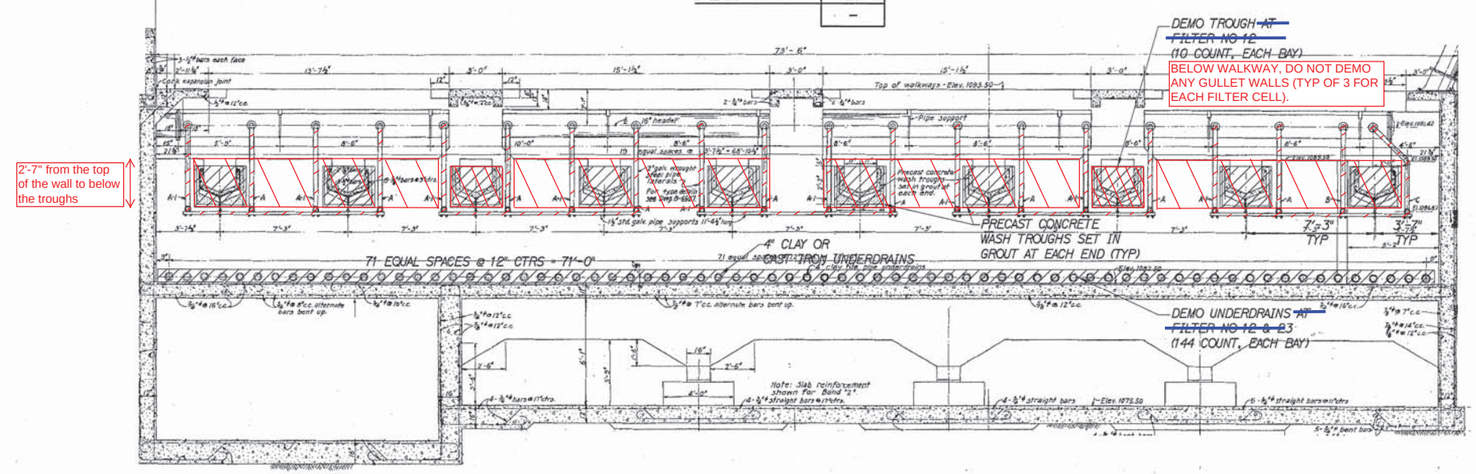
	FILTER BUILDING 1	~~23~~	2
FILTER DIMENSIONS			
A	72'-6"	72'-6"	72'-6"
B	13'-4"	13'-4"	13'-4"
C	12'-9"	12'-8"	13'-0"
FILTER MEDIA DEPTH (IN)			
ANTHRACITE	20"	20"	12"
SAND	8"	8"	9"
GRAVEL	15"	15"	22"
UNDERDRAIN LATERALS (QUANTITY)	144	144	148
SURFACE WASH LATERALS (QUANTITY)	40	40	40
TROUGHS (QUANTITY)	20	N/A	20

Add one lilne named Filters.
In the Filter Building 1 column, complete with: 1 to 24 except for 12 and 23.
In the Filter Building 2 column, complete with: 25 to 48 except for 36





PLAN A –



LONGITUDINAL SECTION OF FILTER PARALLEL TO GULLET B –

Richard Brady & Associates
3770 Ruffin Road, San Diego, California 92123
tel: 858-496-0300 fax: 858-496-0305

MWH

SCALE BARS 1/4" = 1'-0" 0 4 8 12 FEET

STAMPING ENGINEER IS RESPONSIBLE FOR CURRENT DRAWING REVISION

REGISTERED PROFESSIONAL ENGINEER SCOTT C. SPIKER No. 72878 Exp. 6/30/10 CIVIL STATE OF CALIFORNIA 10.06.09

ISSUE DESCRIPTION: ORIGINAL ISSUE

ISSUE DATE: OCTOBER 2009

MWD METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

DESIGNED CONSULTANT
DRAWN CONSULTANT
CHECKED

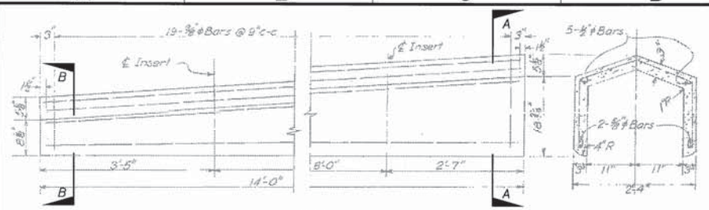
FOR DRAWING APPROVALS SEE B-132793

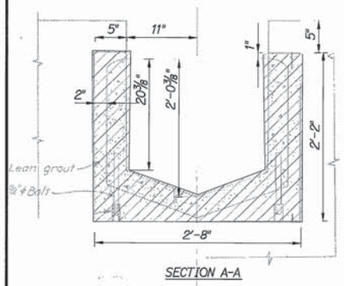
DISTRIBUTION SYSTEM
F.E. WEYMOUTH WATER TREATMENT PLANT
FILTER REHABILITATION ~~DEMONSTRATION~~

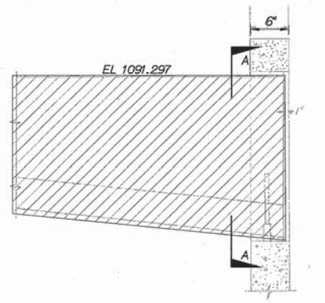
MODIFICATION OF FILTERS, BUILDING 1 PLAN AND SECTION

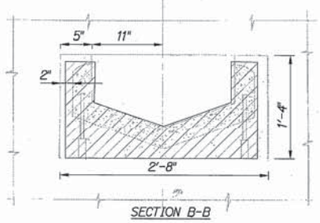
SPECIFICATIONS 1652
PROJECT NUMBER 103880
SHEET 7D-1
DWG B-132766 REV 0

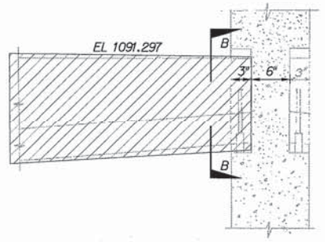
BRDR DATE: 01/29/2009 PEN TABLE: MWDFBW.TBL PLOT TIME: 05-OCT-2009 15:04 USERID: Consultant FILE NAME: 1652_103880_00g007_1.dgn



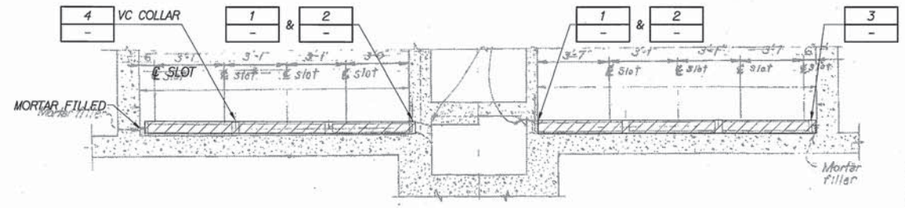




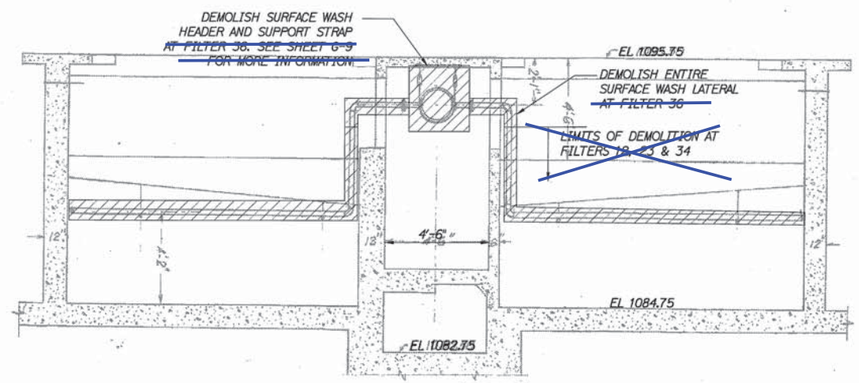




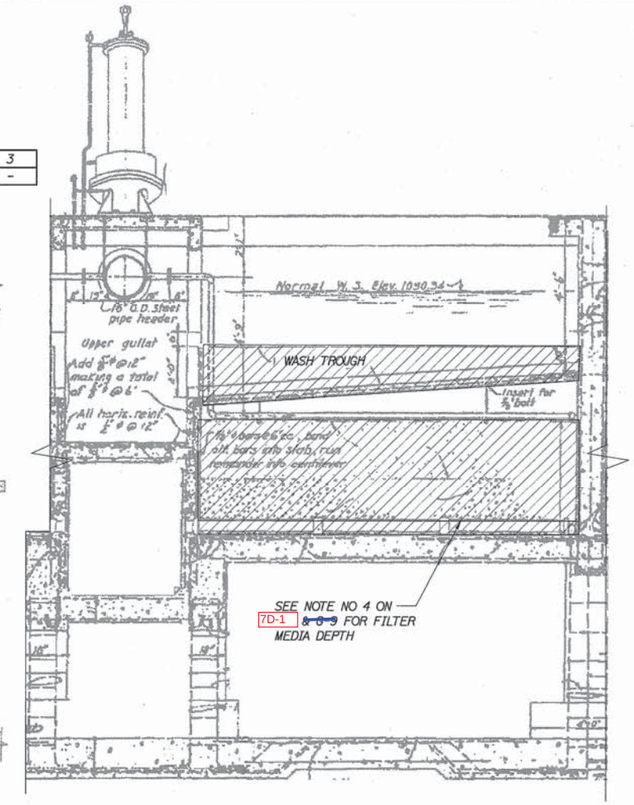
FILTER 12 TROUGH SECTIONS — A / 7D-1
NTS



SECTION B — 7D-1
NTS



SECTION D — 7D-1
NTS



SECTION C — 7D-1
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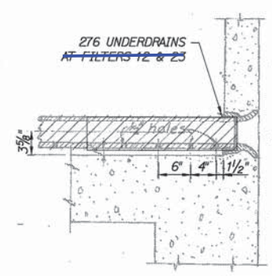

DETAIL 1 — 7D-1
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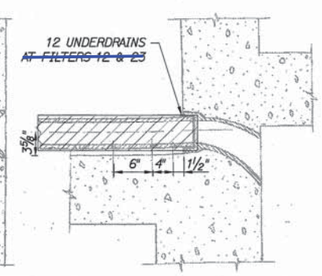

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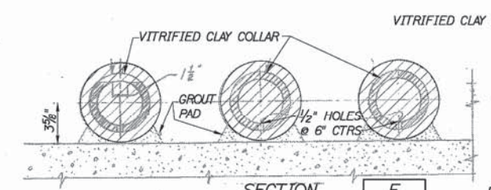
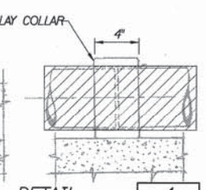
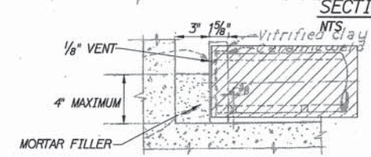


SECTION E — 7D-1
NTS



DETAIL 4
NTS



DETAIL 3
NTS

NOTE:

1. FOR NOTES, ABBREVIATIONS AND LEGEND SEE SHEETS G-3 AND G-4.
2. ~~FOR NEW FILTER CONFIGURATIONS, SEE:~~
   ~~7M-1 FILTER 23~~
   ~~7M-2 FILTER 12~~
   ~~8M-1 FILTER 34~~
   ~~8M-2 FILTER 36~~

Richard Brady & Associates
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MWH

SCALE BARS

STAMPING ENGINEER IS RESPONSIBLE FOR CURRENT DRAWING REVISION

REGISTERED PROFESSIONAL ENGINEER — SCOTT C. SPROUL — No. 72576 — Exp. 6/30/10 — CIVIL — STATE OF CALIFORNIA — 10.06.09

ISSUE DESCRIPTION: ORIGINAL ISSUE

ISSUE DATE: OCTOBER 2009

MWD — METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

DESIGNED CONSULTANT
DRAWN CONSULTANT
CHECKED

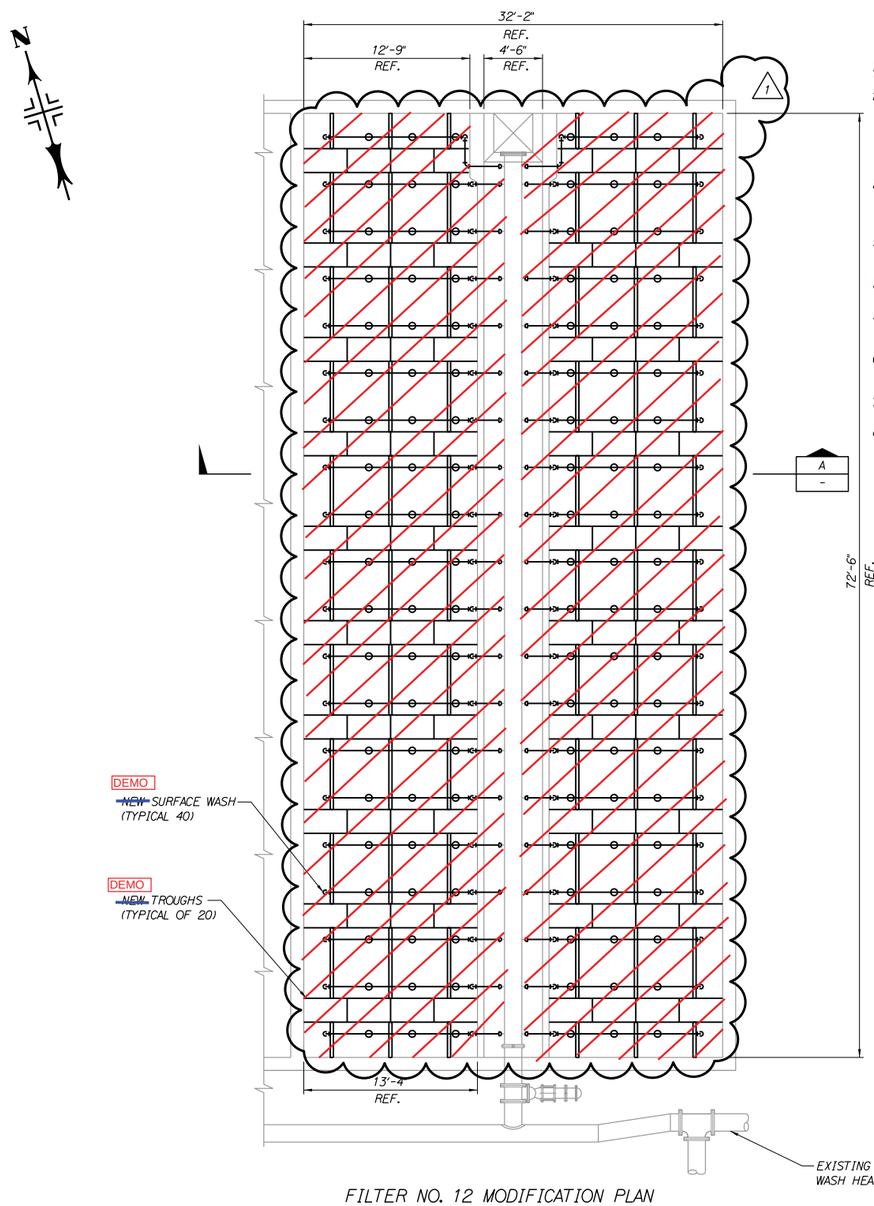
FOR DRAWING APPROVALS SEE B-132793

DISTRIBUTION SYSTEM
F.E. WEYMOUTH WATER TREATMENT PLANT
FILTER REHABILITATION DEMONSTRATION

MODIFICATION OF FILTERS, BUILDING 1
SECTIONS AND DETAILS

SPECIFICATIONS 1652
PROJECT NUMBER 103880
SHEET 7D-2
DWG B-132767 REV 0

BRDR DATE: 01/29/2009 | PEN TABLE: MWDFBW.TBL | PLOT TIME: 05-OCT-2009 16:05 | USERID: Consultant | FILE NAME: 1652_103880_00g008_1.dgn

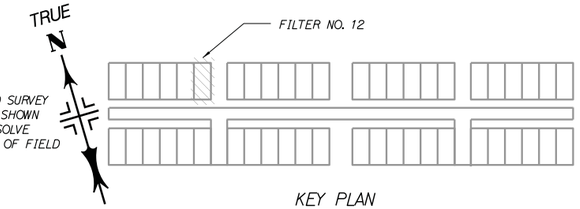


FILTER NO. 12 MODIFICATION PLAN

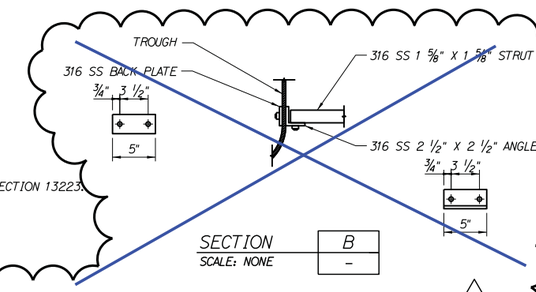
SCALE: 3/16" = 1'-0"

NOTES:

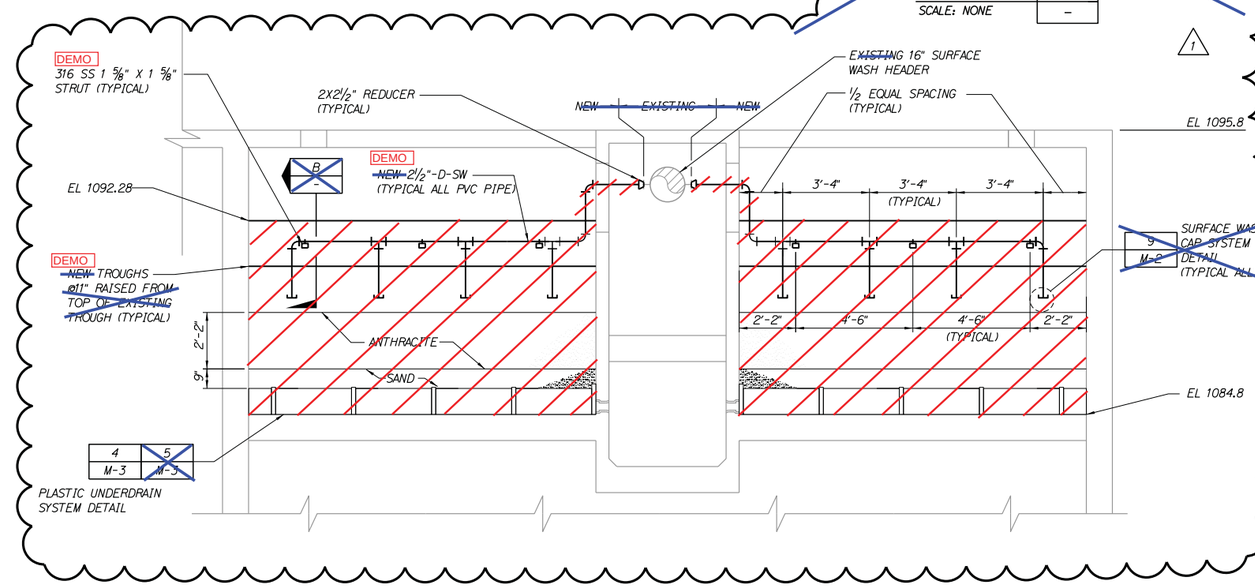
1. FOR WORK WITHIN AND CONNECTING TO EXISTING FACILITIES, CONTRACTOR SHALL PREPARE A DETAILED FIELD SURVEY OF EXISTING CONDITIONS AND IDENTIFY ANY CONFLICTS BETWEEN EXISTING CONDITIONS AND REQUIREMENTS SHOWN ON THE DRAWINGS PRIOR TO SUBMITTAL OF SHOP DRAWINGS. CONTRACTOR SHALL PROPOSE SOLUTIONS TO RESOLVE CONFLICTS IN ADVANCE OF SUBMITTING SHOP DRAWINGS. SHOP DRAWING SUBMITTALS SHALL INCLUDE RESULTS OF FIELD SURVEYS COMPLETED.
2. CONTRACTOR SHALL PROTECT ALL OTHER EXISTING OPERATING FACILITIES IN PLACE DURING DEMOLITION AND CONSTRUCTION WORKS. CONTRACTOR SHALL NOT ALLOW DEMOLITION DEBRIS TO BE WASHED OR IN ANY WAY WASTED THROUGH FILTER WASTE WATER, FINISHED WATER ROUTES, OR ANY OTHER OPERATING FILTERS.
3. CONTRACTOR SHALL REMOVE AND DISPOSE OF EXISTING FILTER, ANTHRACITE, SAND ~~AND SUPPORT GRAVEL~~ PER SPECIFICATION SECTION 02010 - DEMOLITION AND SECTION 01572 - SPENT FILTER MEDIA DISPOSAL.
4. ~~CONTRACTOR SHALL REUSE EXSTING PIPING AND INSTALL NEW PIPES, PIPE SUPPORTS AND SURFACE WASH AS SHOWN.~~ IN SHEET XX
5. CONTRACTOR SHALL REMOVE AND DISPOSE OF EXISTING UNDERDRAIN SYSTEM AND REPLACE WITH NEW UNDERDRAIN AS SHOWN AND PER SPECIFICATION SECTION 13222.
6. CONTRACTOR SHALL REMOVE AND DISPOSE OF EXISTING TROUGHS AND REPLACE WITH NEW TROUGHS AS SHOWN AND PER SHEET 7S-1. REPLACE WITH NEW SHEET NO. REPLACE WITH NEW SHEET NO.
7. CONTRACTOR SHALL PROVIDE AND INSTALL NEW FILTER MEDIA AS SHOWN IN DRAWING G-6 AND AS PER SPECIFICATION SECTION 13223.
8. ELEVATIONS SHOWN ARE BASED ON NAD88 SURVEY DATA.



KEY PLAN



SECTION B
SCALE: NONE



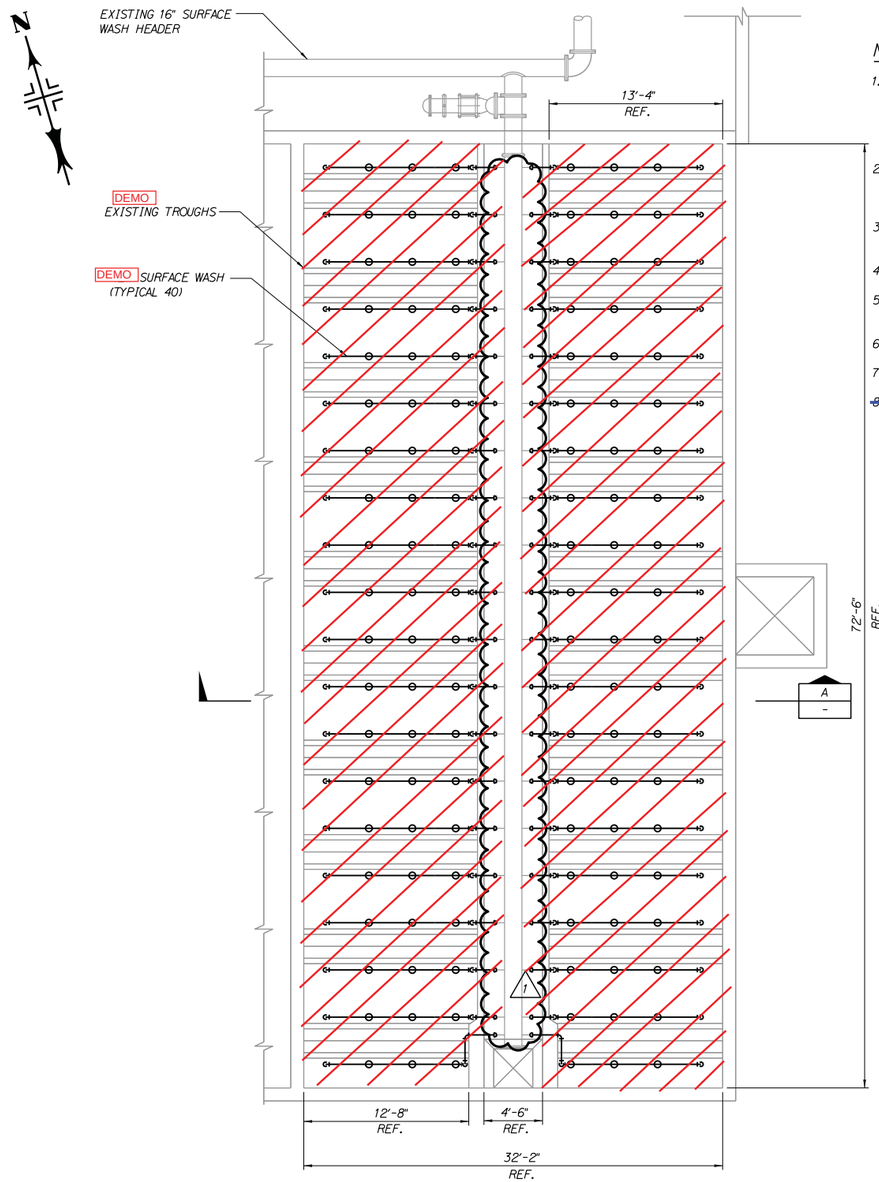
SECTION A
SCALE: 3/8" = 1'-0"

ORIGINAL DRAWING STAMPED BY PROFESSIONAL ENGINEER CHIN CHUAN TEY NO. M029976 EXPIRES 6/30/2010	ISSUE DESCRIPTION: RECORD DRAWING CONSTRUCTED AS SHOWN COMPLETION DATE [02/15/2011]
ISSUE DATE	MAY 2012
MWD METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA	
DESIGNED CONSULTANT	FOR DRAWING APPROVALS SEE
DRAWN CONSULTANT	B-133785
CHECKED	
DISTRIBUTION SYSTEM	F.E. WEYMOUTH WATER TREATMENT PLANT
MODIFICATION OF DEMONSTRATION STUDY FILTERS -	
FILTER NO. 12 ~~NEW FILTER~~ PLAN AND SECTION	
SPECIFICATIONS	1652
PROJECT NUMBER	103880
SHEET	7D-3
DWG	B-132778
REV	1

Richard Brady & Associates
Engineers and Consultants
MWH

SCALE BARS

BRDR DATE: 01/29/2009 | PEN TABLE: MWDFBW.TBL | PLOT TIME: 10-MAY-2012 11:05 | USERID: brandon j shin | FILE NAME: IP_PWP:d0223212\652_103880_07m002_3.dgn

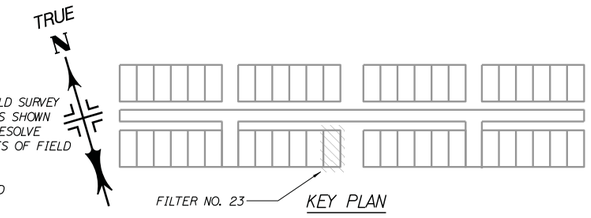


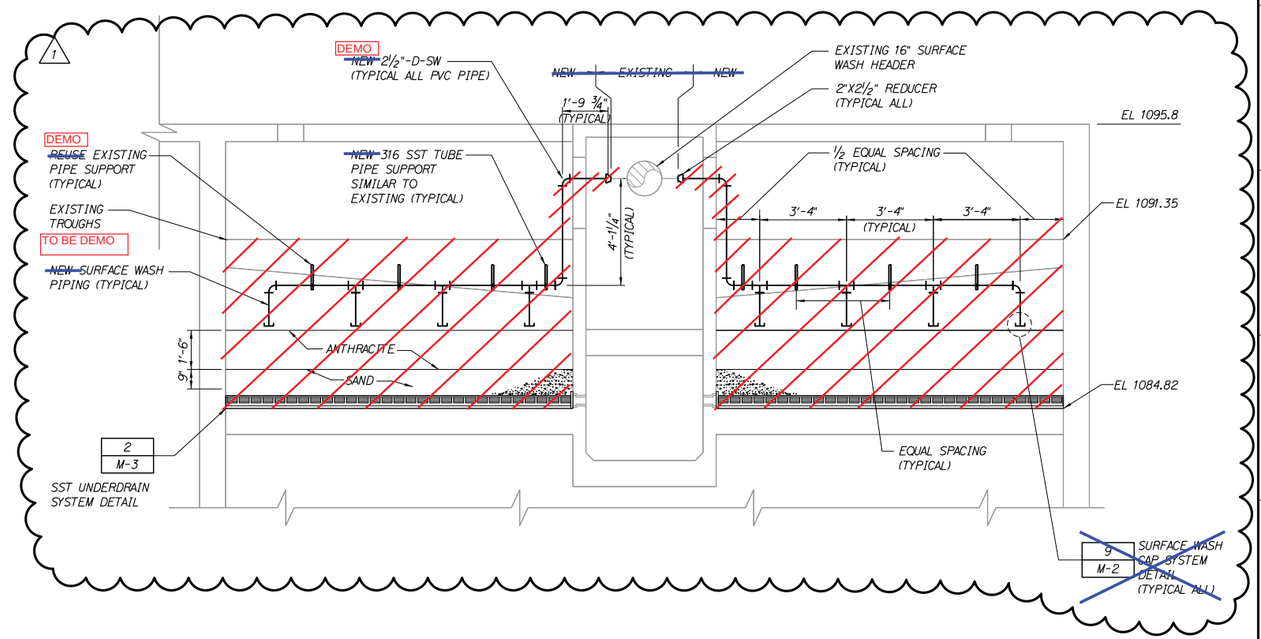
FILTER NO. 23 MODIFICATION PLAN

SCALE: 3/16" = 1'-0"

NOTES:

1. FOR WORK WITHIN AND CONNECTING TO EXISTING FACILITIES, CONTRACTOR SHALL PREPARE A DETAILED FIELD SURVEY OF EXISTING CONDITIONS AND IDENTIFY ANY CONFLICTS BETWEEN EXISTING CONDITIONS AND REQUIREMENTS SHOWN ON THE DRAWINGS PRIOR TO SUBMITTAL OF SHOP DRAWINGS. CONTRACTOR SHALL PROPOSE SOLUTIONS TO RESOLVE CONFLICTS IN ADVANCE OF SUBMITTING SHOP DRAWINGS. SHOP DRAWING SUBMITTALS SHALL INCLUDE RESULTS OF FIELD SURVEYS COMPLETED.
2. CONTRACTOR SHALL PROTECT ALL OTHER EXISTING OPERATING FACILITIES IN PLACE DURING DEMOLITION AND CONSTRUCTION WORKS. CONTRACTOR SHALL NOT ALLOW DEMOLITION DEBRIS TO BE WASHED OR IN ANY WAY WASTED THROUGH FILTER WASTE WATER, FINISHED WATER ROUTES, OR ANY OTHER OPERATING FILTERS.
3. CONTRACTOR SHALL REMOVE AND DISPOSE OF EXISTING FILTER, ANTHRACITE, SAND AND SURFACE WASH PER SPECIFICATION SECTION 02010 - DEMOLITION AND SECTION 01572 - SPENT FILTER MEDIA DISPOSAL.
4. ~~CONTRACTOR SHALL REUSE PIPING AND INSTALL NEW PIPES, PIPE SUPPORTS AND SURFACE WASH AS SHOWN.~~
5. CONTRACTOR SHALL REMOVE AND DISPOSE OF EXISTING UNDERDRAIN SYSTEM AND REPLACE WITH NEW UNDERDRAIN AS SHOWN AND PER SPECIFICATION SECTION 13222A. IN SHEET XX
6. CONTRACTOR SHALL PROVIDE AND INSTALL NEW FILTER MEDIA AS SHOWN IN DRAWING G-6 AND AS PER SPECIFICATION SECTION 13223. REPLACE WITH NEW SHEET NO.
7. ELEVATIONS SHOWN ARE BASED ON NAD88 SURVEY DATA.
8. ~~ALL NEW PIPE SUPPORT SHALL BE TYPE SST 316.~~





SECTION A

SCALE: 3/8" = 1'-0"

Richard Brady & Associates
Engineers and Contractors
MWH.

SCALE BARS

ORIGINAL DRAWING STAMPED BY PROFESSIONAL ENGINEER CHIN CHUAN TEY NO. M029976 EXPIRES 6/30/2010

ISSUE DESCRIPTION
RECORD DRAWING
CONSTRUCTED AS SHOWN
COMPLETION DATE [02/15/2011]

ISSUE DATE MAY 2012

MWD METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

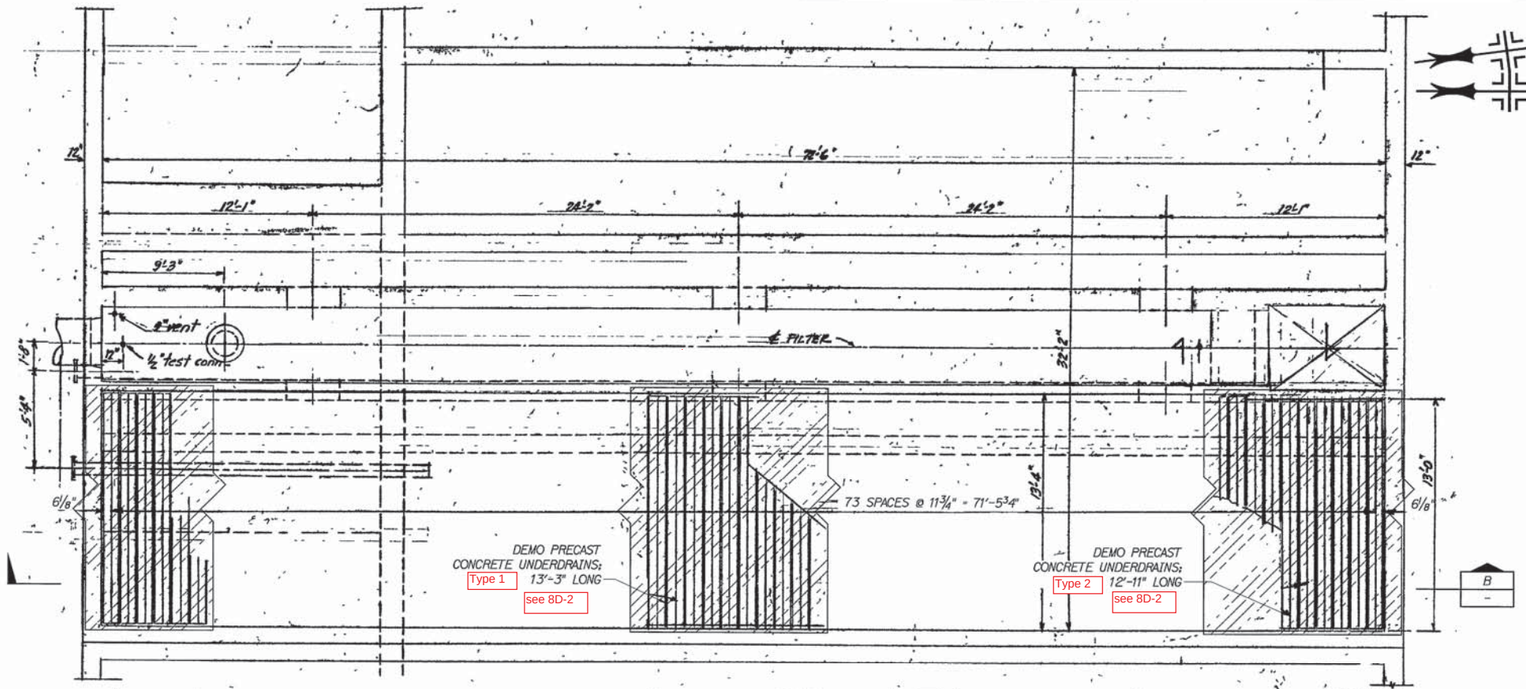
DESIGNED CONSULTANT
DRAWN CONSULTANT
CHECKED

FOR DRAWING APPROVALS SEE B-133785

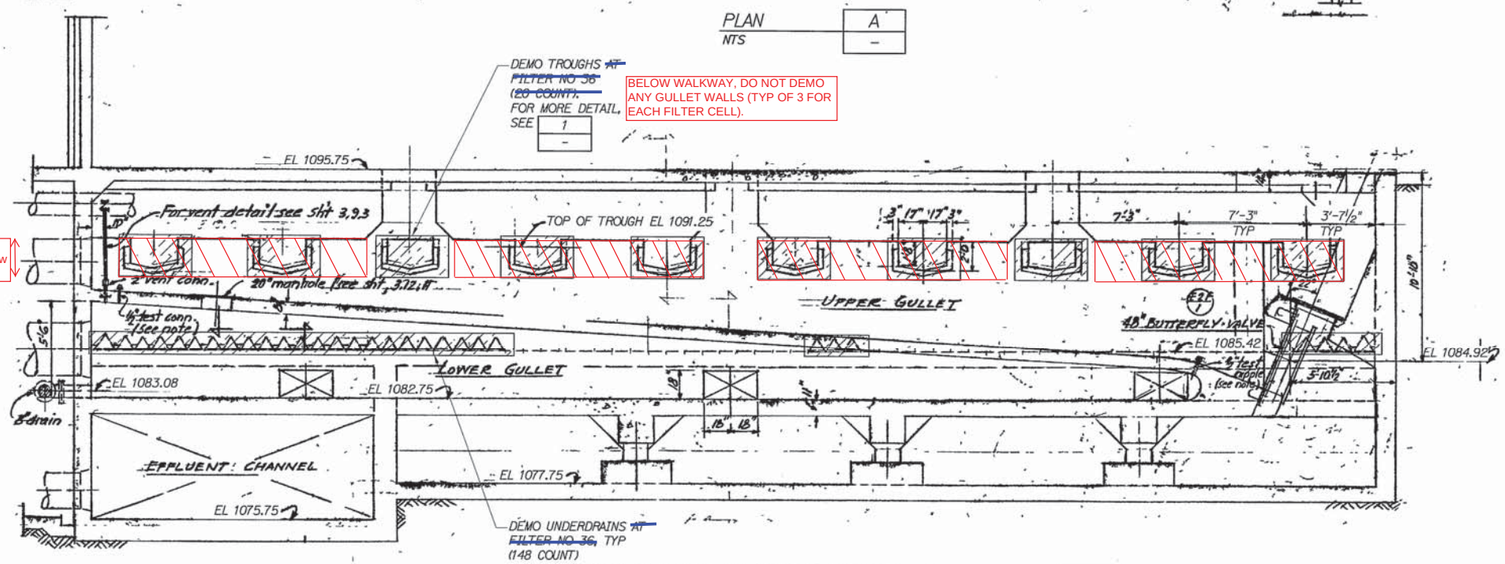
DISTRIBUTION SYSTEM
F.E. WEYMOUTH WATER TREATMENT PLANT
MODIFICATION OF DEMONSTRATION STUDY FILTERS -
FILTER NO. 23
~~NEW UNDERDRAIN~~
PLAN AND SECTION

SPECIFICATIONS 1652
PROJECT NUMBER 103880
SHEET 7D-4
DWG B-132777
REV 1

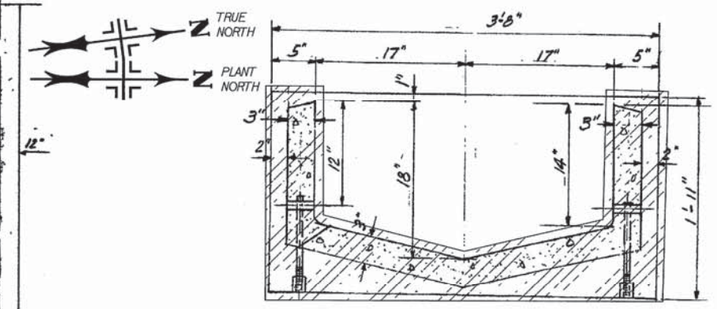
BRDR DATE: 01/29/2009
PEN TABLE: MWDFBW.TBL
PLOT TIME: 10-MAY-2012 11:05
USERID: brandon j shin
FILE NAME: IP_PWP:d0223212\652_103880_07m001_3.dgn

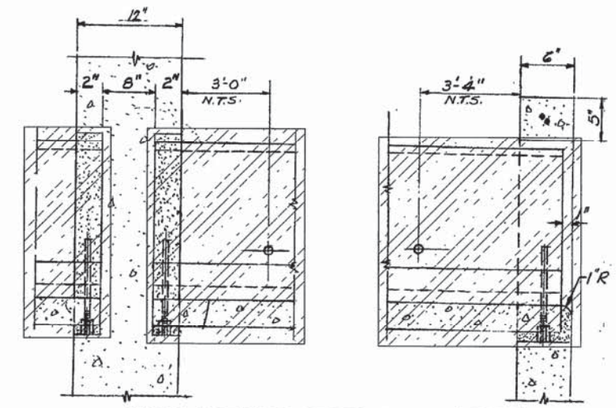


PLAN — A / -
NTS



LONGITUDINAL SECTION OF FILTER PARALLEL TO GULLET — B / -
NTS





FILTER 36 TROUGH SECTIONS — 1 / -
NTS

NOTES:

1. FOR NOTES, ABBREVIATIONS AND LEGEND SEE SHEETS G-3 AND G-4.
2. ~~FOR NEW FILTER CONFIGURATIONS AND ADDITIONAL REQUIREMENTS, SEE:~~
   ~~7M-1 FILTER 23~~
   ~~7M-2 FILTER 19~~
   ~~8M-1 FILTER 34~~
   ~~8M-2 FILTER 36~~
3. CONTRACTOR SHALL REPAIR CONCRETE FILTER BED TO FLAT, LEVEL CONDITION AFTER DEMOLITION OF UNDERDRAINS AND ANCHOR BOLTS. EXPOSED STEEL SHALL BE COATED WITH CORROSION INHIBITING AGENT PER SPEC SECTION 09900.
4. FILTER ~~NO 36~~ SHALL INCLUDE DEMOLITION OF FILTER MEDIA, UNDERDRAINS, SURFACE WASH, SURFACE WASH HEADER AND TROUGHS. SEE FILTER ~~NO 36~~ DEMOLITION SCHEDULE BELOW FOR RELEVANT FILTER DIMENSIONS AND DEMOLITION QUANTITIES.
5. SEE SECTION D ON 7D-2 FOR DEMOLITION OF SURFACE WASH LATERALS AND SURFACE WASH HEADER.
6. REMOVE COAL FROM LOWER GULLET.

FILTER BUILDING 2 FILTERS DEMOLITION SCHEDULE (EXCEPT FOR FILTER 36)

FILTER MEDIA DEPTH (IN)	
ANTHRACITE	12"
SAND	9"
GRAVEL	22"
UNDERDRAIN LATERALS (QUANTITY)	148
SURFACE WASH LATERALS (QUANTITY)	40
TROUGHS (QUANTITY)	20

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tel: 858/496-0500 fax: 858/496-0505

MWH

SCALE BARS: 1/4" = 1'-0" 0 4 8 12 FEET

STAMPING ENGINEER IS RESPONSIBLE FOR CURRENT DRAWING REVISION

REGISTERED PROFESSIONAL ENGINEER SCOTT C. SHROPE No. 72846 Exp. 6/30/10 CIVIL STATE OF CALIFORNIA 10.06.09

ISSUE DESCRIPTION: ORIGINAL ISSUE
ISSUE DATE: OCTOBER 2009

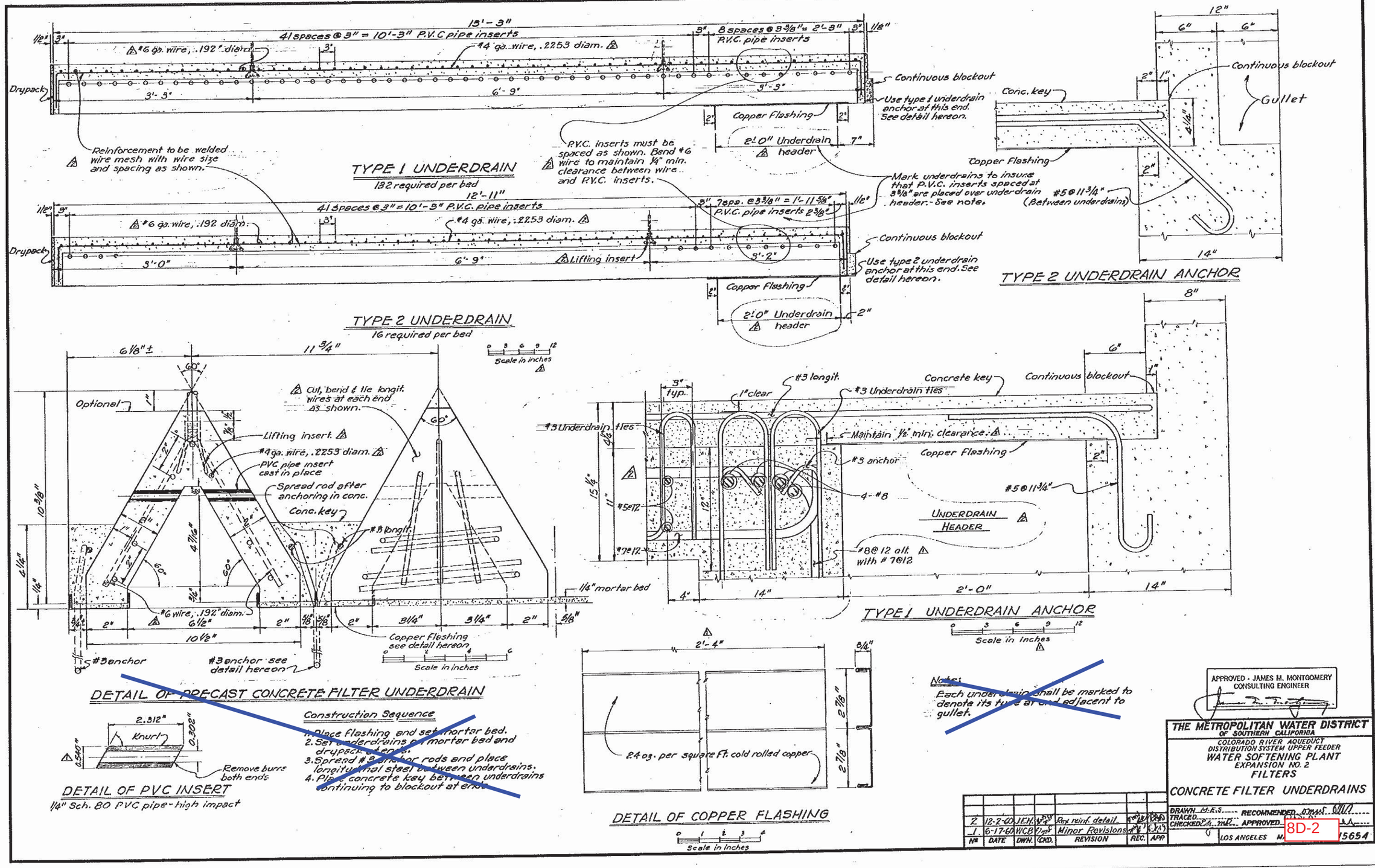
MWD METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA
DESIGNED CONSULTANT
DRAWN CONSULTANT
CHECKED
FOR DRAWING APPROVALS SEE B-132793

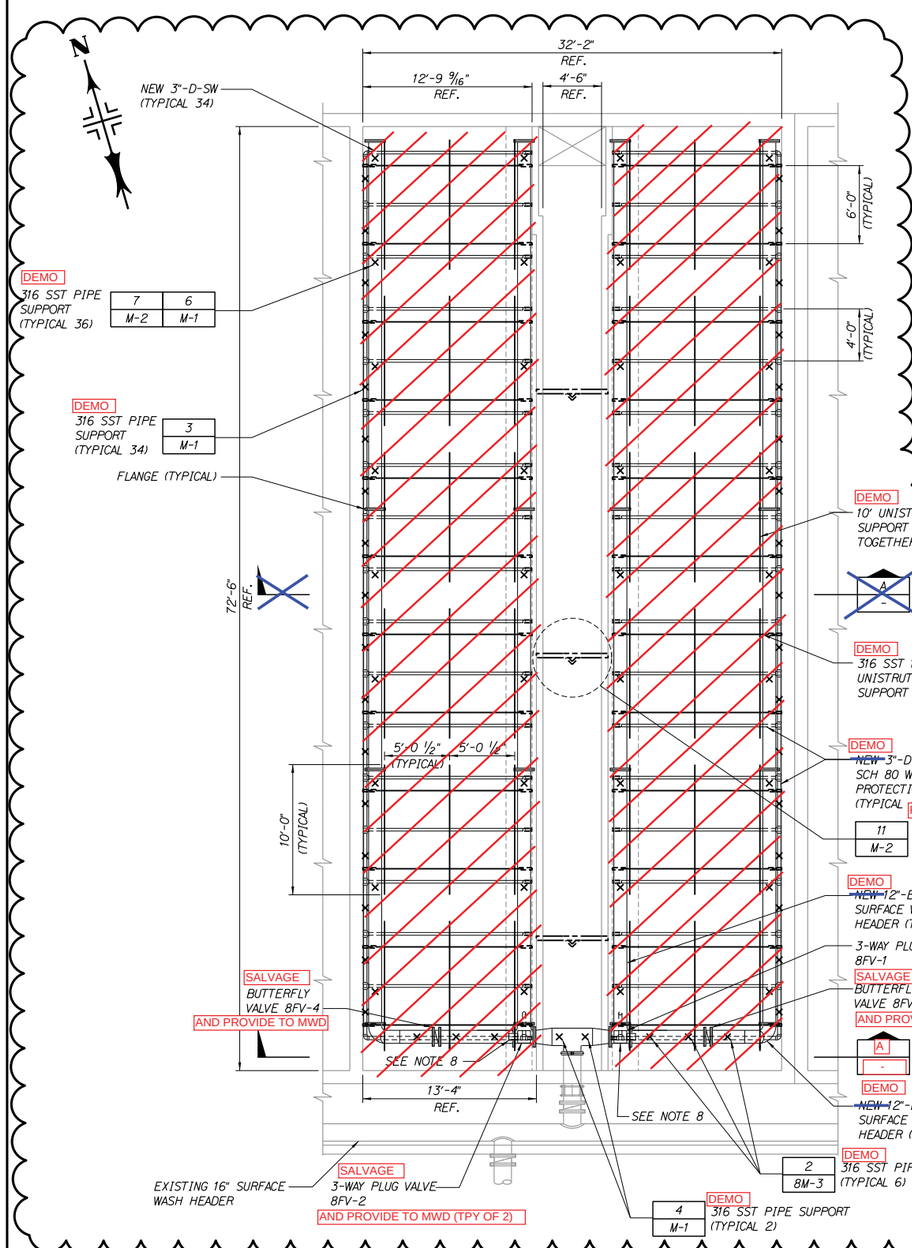
DISTRIBUTION SYSTEM
F.E. WEYMOUTH WATER TREATMENT PLANT
FILTER REHABILITATION ~~DEMONSTRATION~~

MODIFICATION OF FILTERS, BUILDING 2 PLAN AND SECTION

SPECIFICATIONS 1652
PROJECT NUMBER 103880
SHEET 8D-1
DWG B-132768
REV 0

BRDR DATE: 01/29/2009 | PEN TABLE: MWDFBW.TBL | PLOT TIME: 08-OCT-2009 11:19 | USERID: Consultant | FILE NAME: 1652_103880_00g009_1.dgn


13'-3"
41 spaces @ 3" = 10'-3" P.V.C pipe inserts
8 spaces @ 3 3/8" = 2'-3" P.V.C. pipe inserts
#6 ga. wire, .192" diam.
#4 ga. wire, .2253 diam.
Drypack
3'-3"
6'-9"
5'-3"
Continuous blockout
Use type 1 underdrain anchor at this end. See detail hereon.
Copper Flashing
2'-0" Underdrain header
Reinforcement to be welded wire mesh with wire size and spacing as shown.
P.V.C. inserts must be spaced as shown. Bend #6 wire to maintain 1/4" min. clearance between wire and P.V.C. inserts.
TYPE 1 UNDERDRAIN
132 required per bed
12'-11"
41 spaces @ 3" = 10'-3" P.V.C. pipe inserts
7 spa. @ 3 3/8" = 1'-11 5/8" P.V.C. pipe inserts 2 3/8"
Lifting insert
3'-0"
6'-9"
3'-2"
Use type 2 underdrain anchor at this end. See detail hereon.
Mark underdrains to insure that P.V.C. inserts spaced at 3 3/8" are placed over underdrain header. - See note.
TYPE 2 UNDERDRAIN
16 required per bed
Scale in inches
Conc. key
Gullet
#5 @ 11 3/4" (Between underdrains)
TYPE 2 UNDERDRAIN ANCHOR
6 1/8" ±
11 3/4"
60°
Optional
Cut, bend & tie longit. wires at each end as shown.
Lifting insert
#4 ga. wire, .2253 diam.
PVC pipe insert cast in place
Spread rod after anchoring in conc.
Conc. key
#3 longit.
#6 wire, .192" diam.
1 1/4" mortar bed
Copper Flashing see detail hereon
#3 anchor
#3 anchor see detail hereon
DETAIL OF PRECAST CONCRETE FILTER UNDERDRAIN
#3 longit.
Concrete key
Continuous blockout
#3 Underdrain ties
1" clear
Maintain 1/2" min. clearance.
Copper Flashing
#3 anchor
4-#8
#5 @ 11 3/4"
UNDERDRAIN HEADER
#8 @ 12 alt. with #7 @ 12
2'-0"
14"
TYPE 1 UNDERDRAIN ANCHOR
2.312"
Knurl
0.302"
0.540"
Remove burrs both ends
DETAIL OF PVC INSERT
1/4" Sch. 80 PVC pipe - high impact
Construction Sequence
1. Place flashing and set mortar bed.
2. Set underdrains on mortar bed and drypack ends.
3. Spread #3 anchor rods and place longitudinal steel between underdrains.
4. Place concrete key between underdrains continuing to blockout at ends.
2'-4"
24 oz. per square ft. cold rolled copper
DETAIL OF COPPER FLASHING
Note:
Each underdrain shall be marked to denote its type at and adjacent to gullet.
APPROVED - JAMES M. MONTGOMERY CONSULTING ENGINEER
THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA
COLORADO RIVER AQUEDUCT
DISTRIBUTION SYSTEM UPPER FEEDER
WATER SOFTENING PLANT
EXPANSION NO. 2
FILTERS
CONCRETE FILTER UNDERDRAINS
DRAWN M.R.S. RECOMMENDED
TRACED APPROVED
CHECKED
LOS ANGELES
15654
8D-2
2 12-2-60 JEH Rev. reinf. detail
1 6-17-60 WCB Minor Revisions
No. DATE DWN. CKD. REVISION REC. APP.

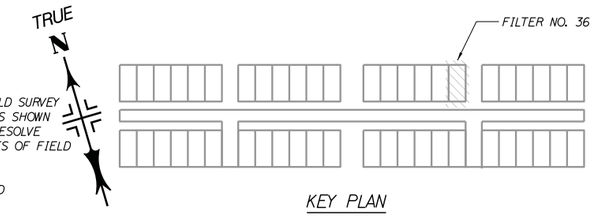


FILTER NO. 36 MODIFICATION PLAN

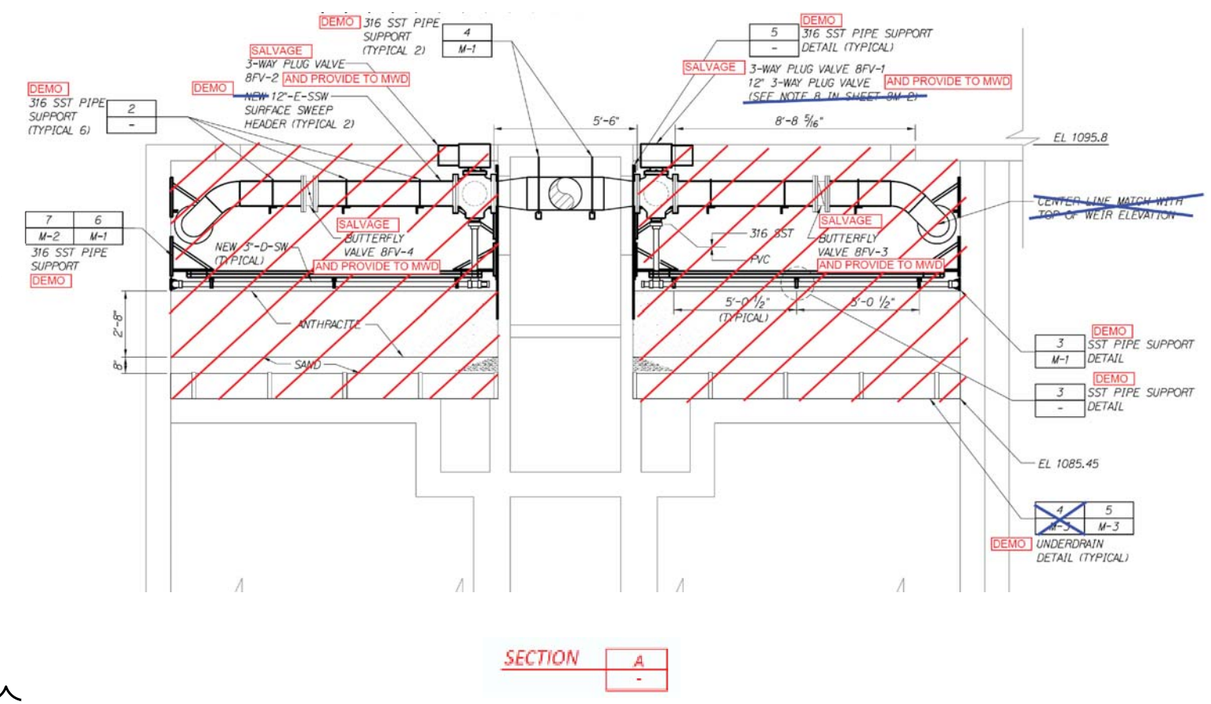
SCALE: 3/16" = 1'-0"

NOTES:

1. FOR WORK WITHIN AND CONNECTING TO EXISTING FACILITIES, CONTRACTOR SHALL PREPARE A DETAILED FIELD SURVEY OF EXISTING CONDITIONS AND IDENTIFY ANY CONFLICTS BETWEEN EXISTING CONDITIONS AND REQUIREMENTS SHOWN ON THE DRAWINGS PRIOR TO SUBMITTAL OF SHOP DRAWINGS. CONTRACTOR SHALL PROPOSE SOLUTIONS TO RESOLVE CONFLICTS IN ADVANCE OF SUBMITTING SHOP DRAWINGS. SHOP DRAWING SUBMITTALS SHALL INCLUDE RESULTS OF FIELD SURVEYS COMPLETED.
2. CONTRACTOR SHALL PROTECT ALL OTHER EXISTING OPERATING FACILITIES IN PLACE DURING DEMOLITION AND CONSTRUCTION WORKS. CONTRACTOR SHALL NOT ALLOW DEMOLITION DEBRIS TO BE WASHED OR IN ANY WAY WASTED THROUGH FILTER WASTE WATER, FINISHED WATER ROUTES, OR ANY OTHER OPERATING FILTERS.
3. CONTRACTOR SHALL REMOVE AND DISPOSE OF EXISTING FILTER, ANTHRACITE, SAND AND SURFACE WASH PER SPECIFICATION SECTION 02010 - DEMOLITION AND SECTION 01572 - SPENT FILTER MDEIA DISPOSAL.
4. ~~CONTRACTOR SHALL REMOVE AND DISPOSE OF EXISTING TROUGH PER SHEET 8S-1 FOR STRUCTURAL DETAIL.~~ IN SHEET XX
5. CONTRACTOR SHALL REMOVE AND DISPOSE OF EXISTING UNDERDRAIN SYSTEM AND REPLACE WITH NEW UNDERDRAIN AS SHOWN AND PER SPECIFICATION 13222. REPLACE WITH NEW SHEET NO.
6. CONTRACTOR SHALL PROVIDE AND INSTALL NEW FILTER MEDIA AS SHOWN IN DRAWING G-6 AND AS PER SPECIFICATION SECTION 13223.
7. ELEVATIONS SHOWN ARE BASED ON NAD88 SURVEY DATA.
8. ~~'OPEN' - VALVES OPEN TO SURFACE WASH AND CLOSED TO SURFACE SWEEP. 'CLOSED' - VALVES CLOSED TO SURFACE WASH AND OPEN TO SURFACE SWEEP.~~
9. CONTRACTOR SHALL REPLACE EXISTING CHANNEL BAFFLES AND VERIFY LOCATION.
10. ALL ANCHORS TO BE DEMOLISHED. ALL ANCHORS SHALL BE BURNT BACK 1 INCH AND SEALED WITH NON-SHRINK GROUT.



KEY PLAN

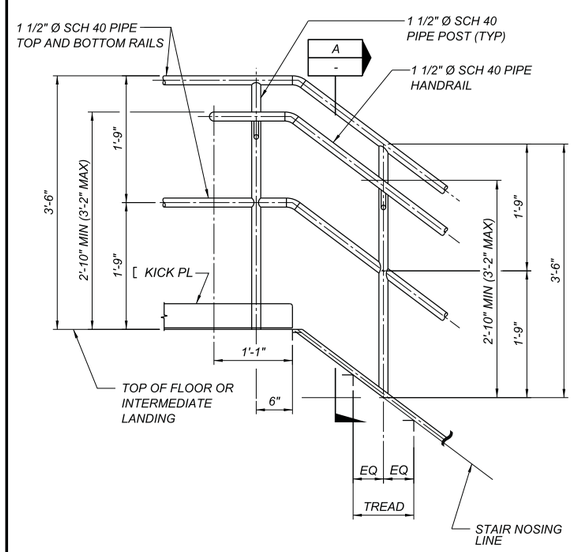


SECTION A -

SCALE BARS	ORIGINAL DRAWING STAMPED BY PROFESSIONAL ENGINEER CHIN CHUAN TEY NO. M029976 EXPIRES 6/30/2010	ISSUE DESCRIPTION: RECORD DRAWING CONSTRUCTED AS SHOWN COMPLETION DATE [02/15/2011]	MWD METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA	DISTRIBUTION SYSTEM: F.E. WEYMOUTH WATER TREATMENT PLANT	SPECIFICATIONS 1652
		ISSUE DATE MAY 2012	DESIGNED CONSULTANT / DRAWN CONSULTANT / CHECKED	MODIFICATION OF DEMONSTRATION STUDY FILTERS -	PROJECT NUMBER 103880
			FOR DRAWING APPROVALS SEE B-133785	FILTER NO. 36 TROUGHLESS PLAN AND SECTION	SHEET 8D-3
					DWG B-132780 REV 1

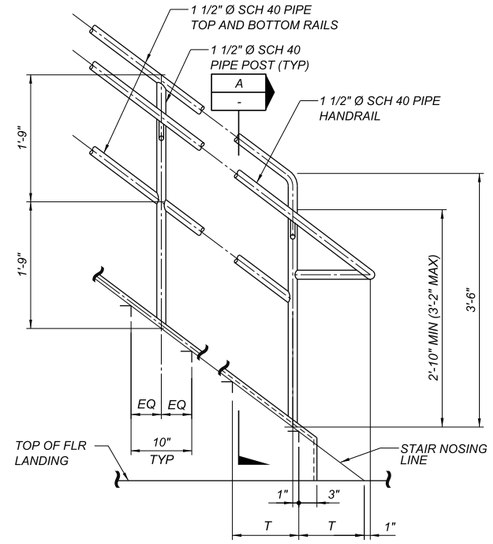
BRDR DATE: 01/29/2009 PEN TABLE: MWDFBW.TBL PLOT TIME: 10-MAY-2012 11:06 USERID: brandon j shin FILE NAME: IP_PWP:d0223212\652_103880_08m002_3.dgn

MWH. Richard, Brady et Associates Engineers and Contractors



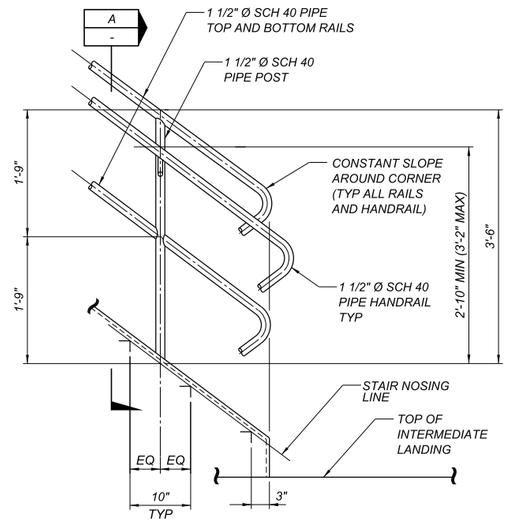
DETAIL 1

NOTE:
STEEL STAIR CONDITION SHOWN. CONCRETE STAIR CONDITION SIMILAR. FOR POST CONNECTIONS, SEE SHEET S5-2.



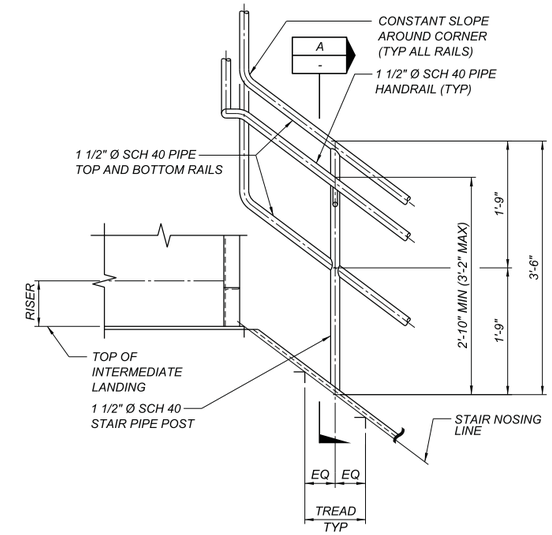
DETAIL 2

NOTE:
STEEL STAIR CONDITION SHOWN. CONCRETE STAIR CONDITION SIMILAR. FOR POST CONNECTIONS, SEE SHEET S5-2.



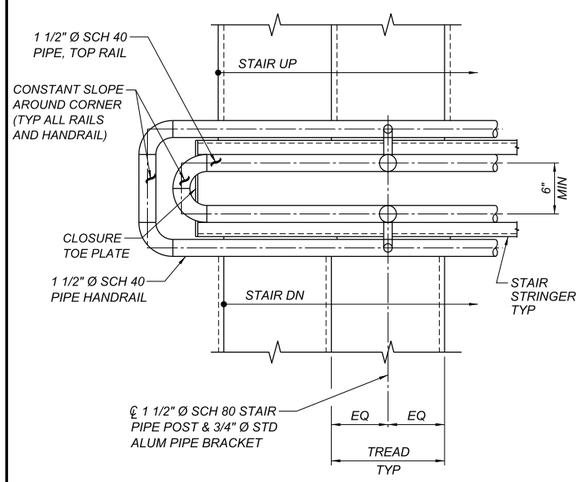
DETAIL 3

NOTE:
STEEL STAIR CONDITION SHOWN. CONCRETE STAIR CONDITION SIMILAR. FOR POST CONNECTIONS, SEE SHEET S5-2.

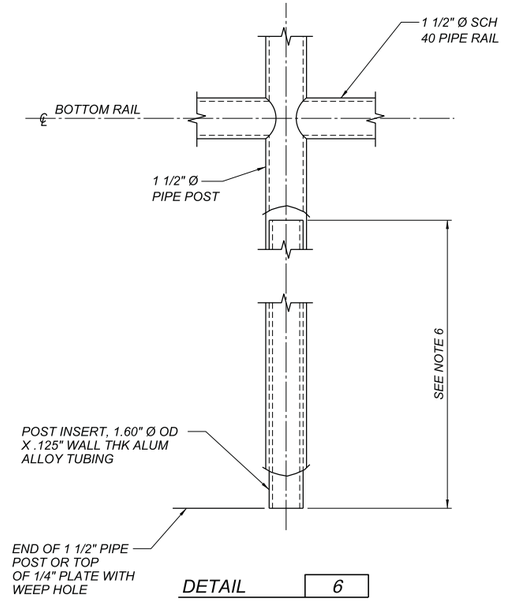


DETAIL 4

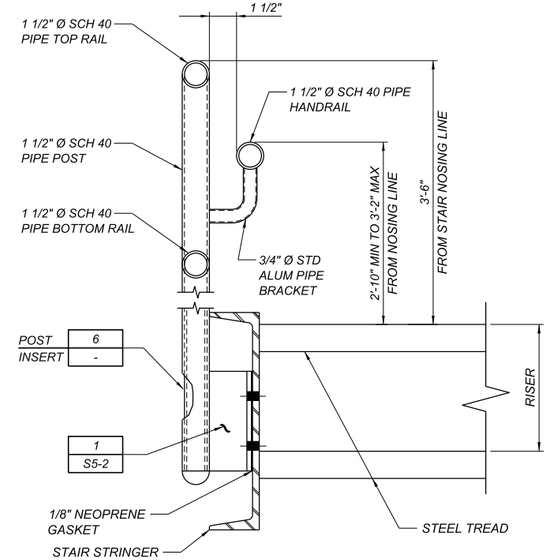
NOTE:
STEEL STAIR CONDITION SHOWN. CONCRETE STAIR CONDITION SIMILAR. FOR POST CONNECTIONS, SEE SHEET S5-2.



DETAIL 5



DETAIL 6



SECTION A

NOTES:

1. FOR GENERAL NOTES, DESIGN STANDARDS, DESIGN CRITERIA, MATERIAL PROPERTIES AND CONCRETE NOTES, SEE SHEET S-1
2. FOR ABBREVIATIONS, SYMBOLS AND LEGEND, SEE SHEET S-2
3. FOR ADDITIONAL HANDRAIL INFORMATION NOT SHOWN, SEE SHEET S-8
4. ALL HANDRAIL MATERIAL SHALL BE ALUMINUM, UNO.
5. FABRICATE ALL HANDRAIL AND GUARDRAIL CONNECTING MEMBERS WITH CONCEALED MECHANICAL FASTENERS AND FITTINGS, UNO.
6. INSERT LENGTH SHALL BE AS REQUIRED TO MEET LOADING CRITERIA STATED IN SPECIFICATION.

SCALE = NONE

METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

Drawing Check By

Contact Metropolitan's Technical Control Team for approval documentation

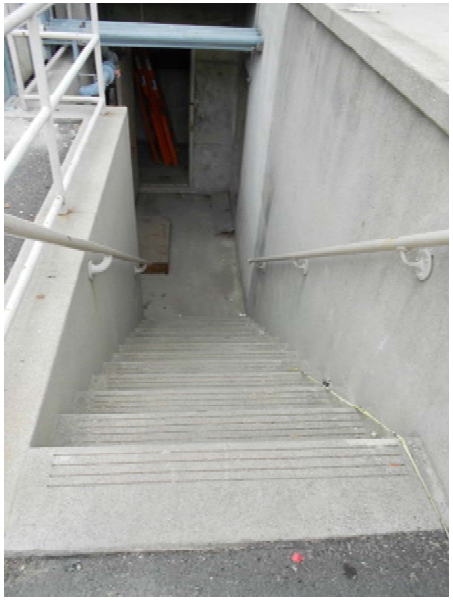
METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA
STANDARD DETAILS

ALUMINUM STAIR HANDRAILS
TYPICAL DETAILS AND SECTION

PUBLICATION
JANUARY 2014

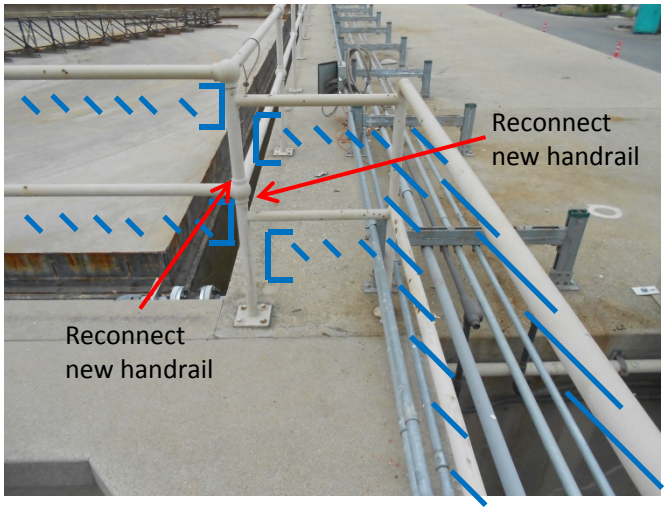
SHEET
S-7

Detail 1 – Stairs 1. Demolish and replace with same design. Use floor range detail A and wall range C.



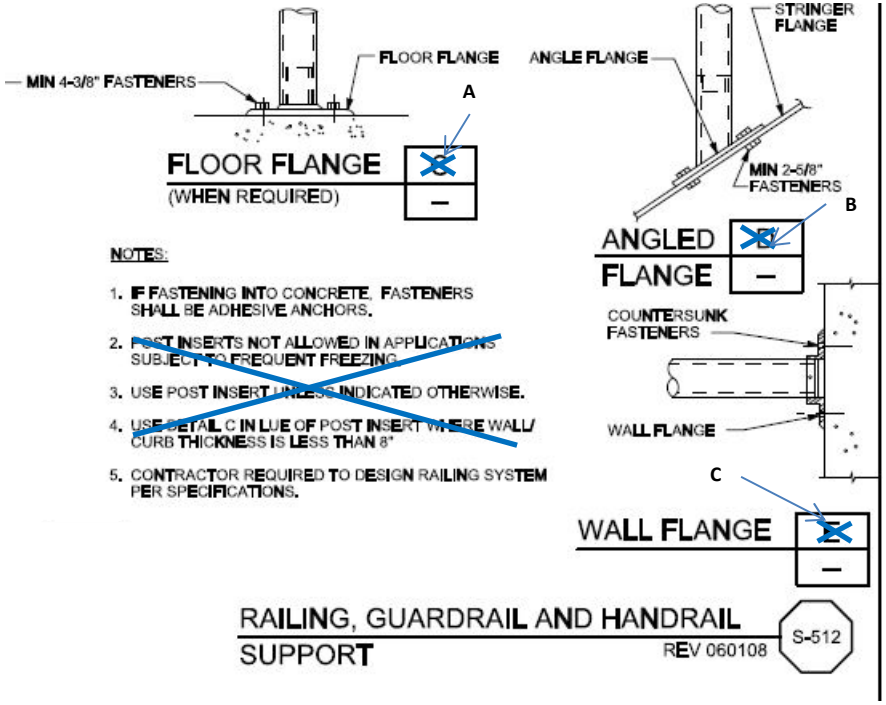
Detail 2 – Stairs 2. Demolish and replace with the same design. Wall range detail C.

Detail 3 – Stairs 3. Handrail. Demolish and replace with the same design.



Detail 4 – Junction . Demolish and replace with same design.

Detail 5 - Ladder handrail. Demolish and replace with the same design.



Detail 6 - Stairs 4 handrail. Demolish and replace with same design.

Detail 7 - Filter backwash gate handrail detail.

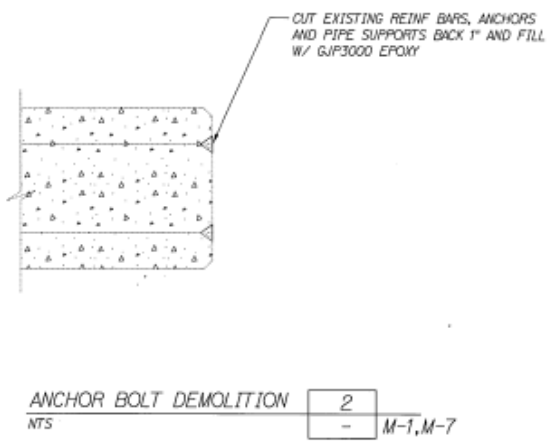
Detail 8 – Access gate details.

Detail 9 – Gate details. Demo and replace by same design.

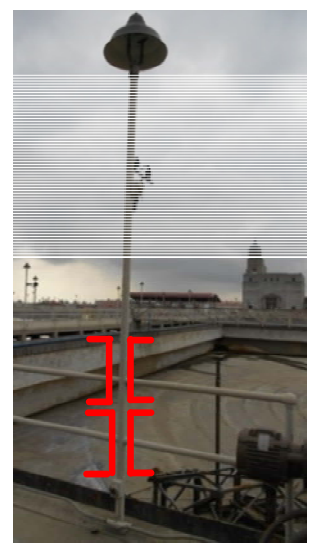
Detail 10 – Gate and handrail design. Dem. No replacement.

Detail 11 – Stairs 5. Demolish and replace with the same design. For wall range, see detail C.

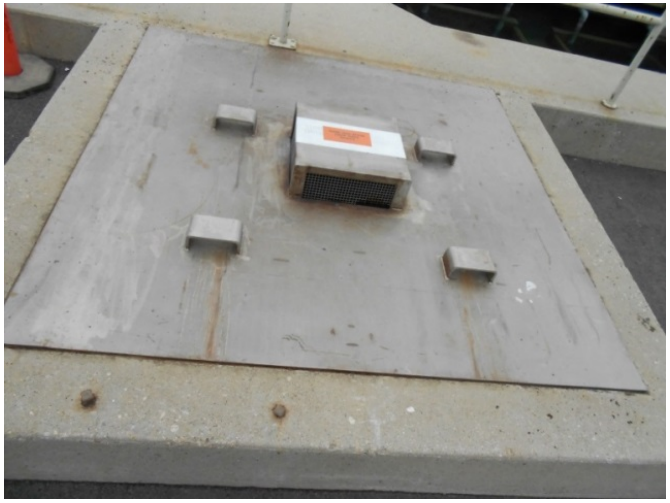
Detail 12 - Demo handrail. Demo conduit and plug hole.



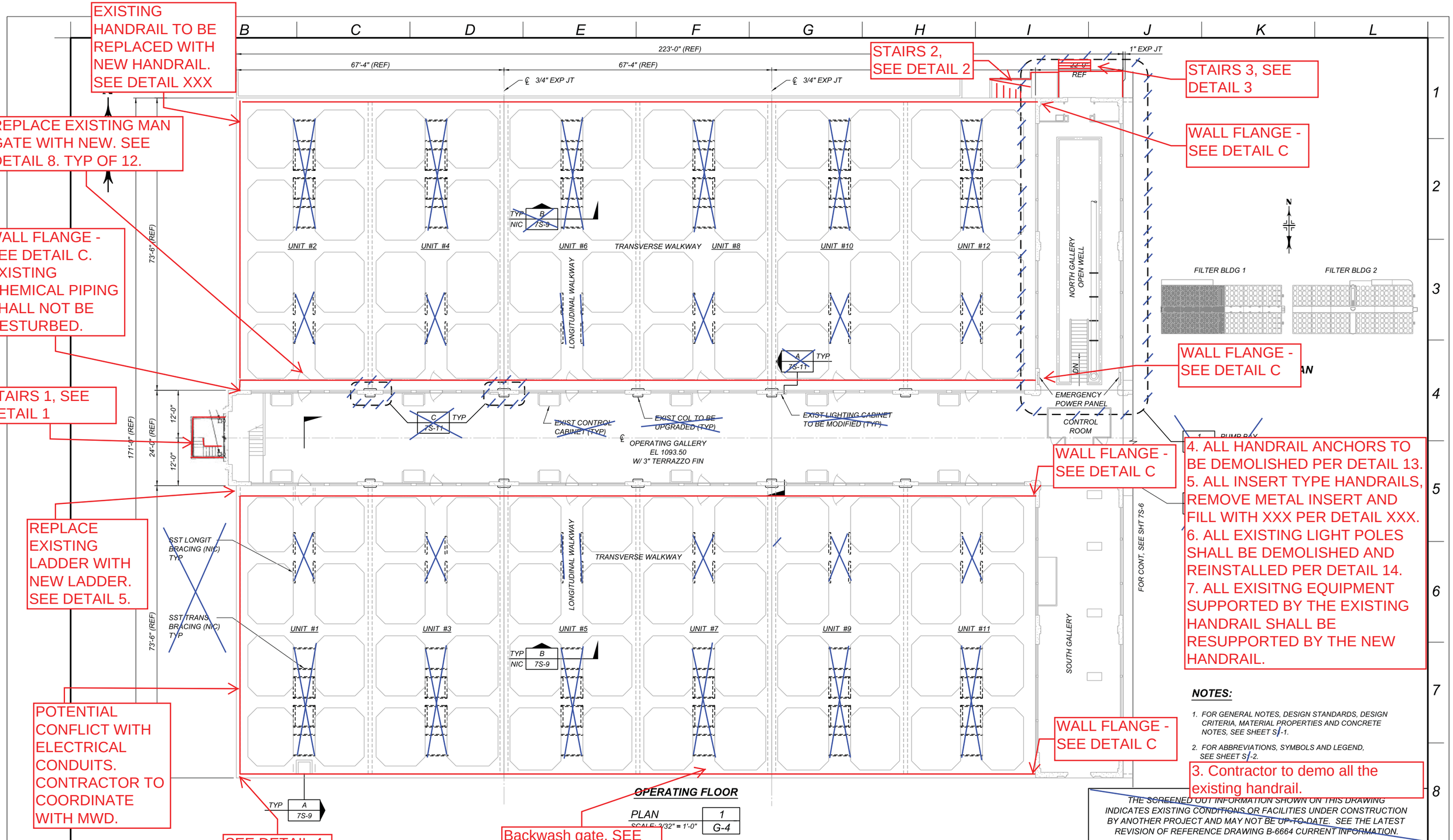
Detail 13 – Handrail anchor demo.



Detail 14 – Cut as indicated, salvage and reconnect to new handrail.



Detail 15 – Demolish and replace by design above.



NOTES:

1. FOR GENERAL NOTES, DESIGN STANDARDS, DESIGN CRITERIA, MATERIAL PROPERTIES AND CONCRETE NOTES, SEE SHEET S-1.
2. FOR ABBREVIATIONS, SYMBOLS AND LEGEND, SEE SHEET S-2.

THE SCREENED OUT INFORMATION SHOWN ON THIS DRAWING INDICATES EXISTING CONDITIONS OR FACILITIES UNDER CONSTRUCTION BY ANOTHER PROJECT AND MAY NOT BE UP-TO-DATE. SEE THE LATEST REVISION OF REFERENCE DRAWING B-6664 CURRENT INFORMATION.

OPERATING FLOOR

PLAN 1 / G-4

SCALE: 3/32" = 1'-0"

SCALE BARS 3/32" = 1'-0" 0 16 32 FEET

STAMPING

90% SUBMITTAL
JANUARY 2013

REGISTERED PROFESSIONAL ENGINEER JAMES J. GINGRICH No. S3023 STRUCTURAL STATE OF CALIFORNIA

REVISION

ISSUE DESCRIPTION: ORIGINAL ISSUE

ISSUE DATE

MWD METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

DESIGNED JJG
DRAWN HSB
CHECKED

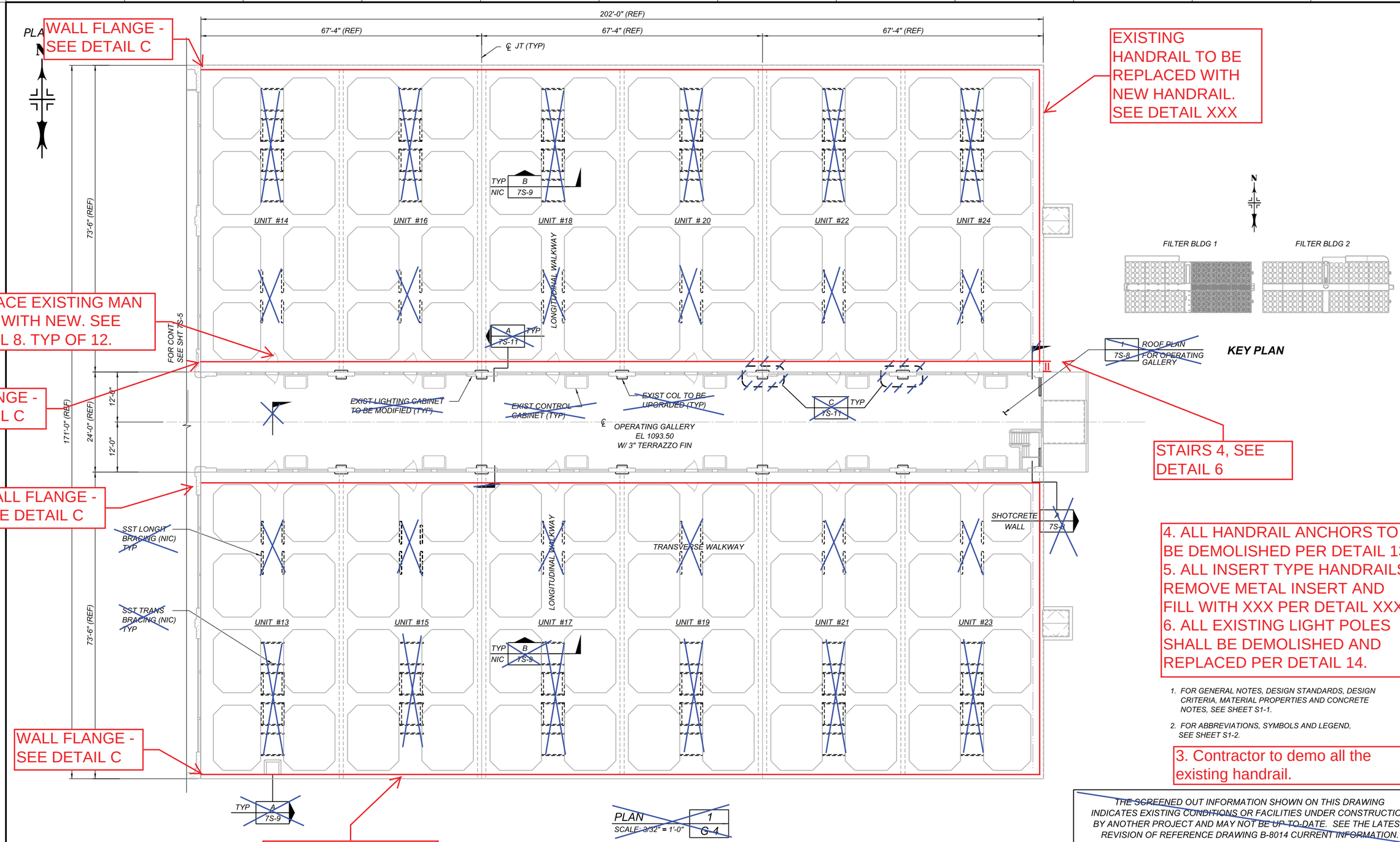
FOR DRAWING APPROVALS SEE B-000000

WATER TREATMENT PLANTS
F.E. WEYMOUTH WATER TREATMENT PLANT
FILTER BUILDINGS SEISMIC UPGRADES

FILTER BUILDING NO. 1 - WEST
Handrail replacement

SPECIFICATIONS 1713
PROJECT NUMBER 104381
SHEET 7S-2
DWG
REV 0

BRDR DATE: 01/29/2009 PEN TABLE: mwdhbw.tbl PLOT TIME: 14-FEB-2013 14:09 USERID: svc_projectwise FILE NAME: \\usmwd222\ds_fileshare\\143\10807_59\1713_104381_07s005.dgn



4. ALL HANDRAIL ANCHORS TO BE DEMOLISHED PER DETAIL 13.
5. ALL INSERT TYPE HANDRAILS, REMOVE METAL INSERT AND FILL WITH XXX PER DETAIL XXX.
6. ALL EXISTING LIGHT POLES SHALL BE DEMOLISHED AND REPLACED PER DETAIL 14.

1. FOR GENERAL NOTES, DESIGN STANDARDS, DESIGN CRITERIA, MATERIAL PROPERTIES AND CONCRETE NOTES, SEE SHEET S1-1.
2. FOR ABBREVIATIONS, SYMBOLS AND LEGEND, SEE SHEET S1-2.

3. Contractor to demo all the existing handrail.

THE SCREENED OUT INFORMATION SHOWN ON THIS DRAWING INDICATES EXISTING CONDITIONS OR FACILITIES UNDER CONSTRUCTION BY ANOTHER PROJECT AND MAY NOT BE UP-TO-DATE. SEE THE LATEST REVISION OF REFERENCE DRAWING B-8014 CURRENT INFORMATION.

SCALE BARS 3/32" = 1'-0" 0 16 32 FEET

STAMPING ENGINEER IS RESPONSIBLE FOR CURRENT DRAWING REVISION

JANUARY 2013

REGISTERED PROFESSIONAL ENGINEER JAMES J. GINGRICH No. S3023 STRUCTURAL STATE OF CALIFORNIA

ISSUE DESCRIPTION
ORIGINAL ISSUE

ISSUE DATE

MWD METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

DESIGNED JJG
DRAWN HSB
CHECKED

FOR DRAWING APPROVALS SEE B-000000

WATER TREATMENT PLANTS
F.E. WEYMOUTH WATER TREATMENT PLANT
FILTER BUILDINGS SEISMIC UPGRADES

FILTER BUILDING NO. 1 - EAST
Handrail replacement

SPECIFICATIONS 1713
PROJECT NUMBER 104381
SHEET 7S-3
DWG
REV 0

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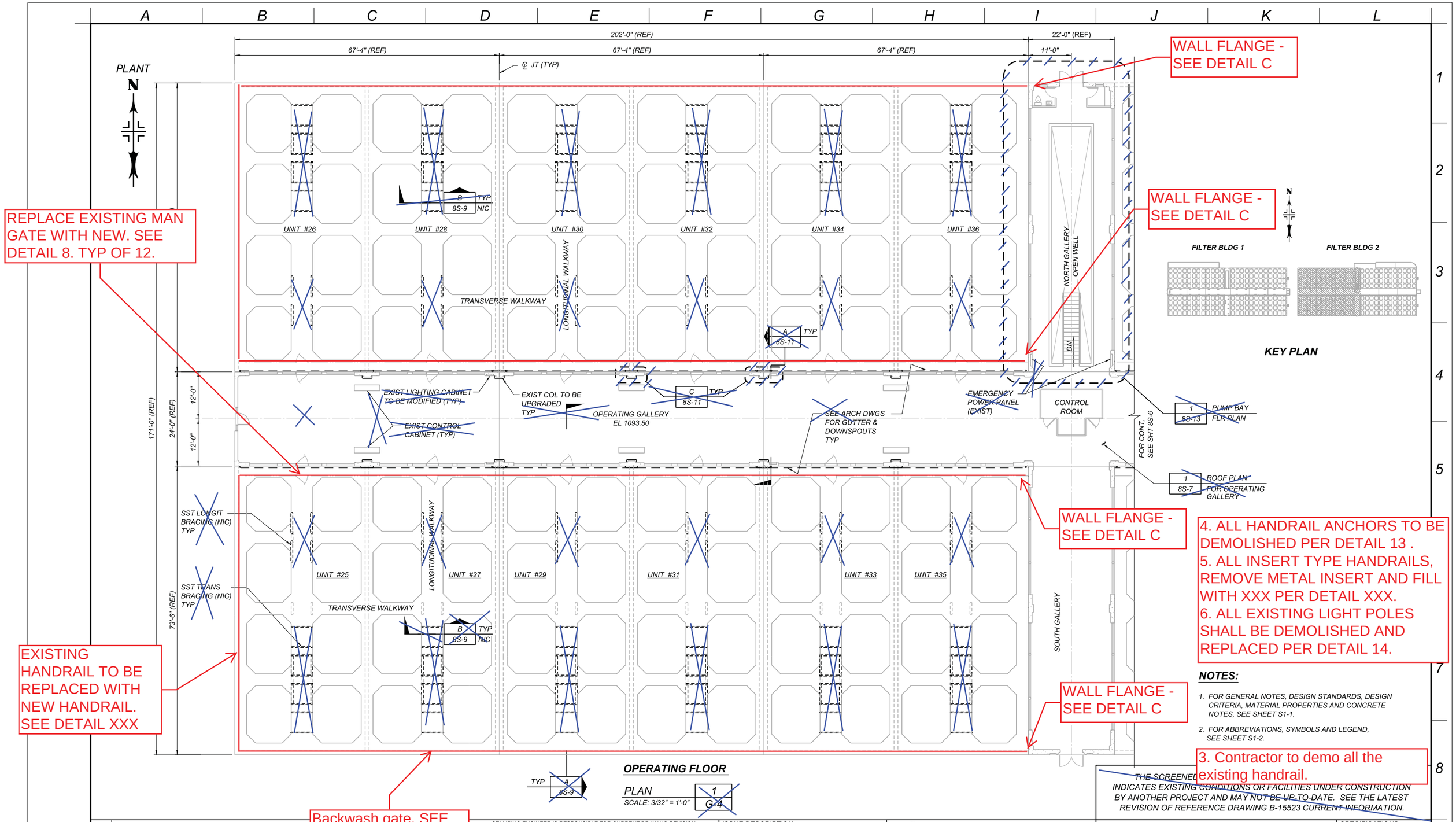
A B C D E F G H I J K L
1 2 3 4 5 7 8
202'-0" (REF)
67'-4" (REF)
67'-4" (REF)
67'-4" (REF)
22'-0" (REF)
11'-0"
℄ JT (TYP)
PLANT
N
171'-0" (REF)
24'-0" (REF)
12'-0"
12'-0"
73'-6" (REF)
UNIT #26
UNIT #28
UNIT #30
UNIT #32
UNIT #34
UNIT #36
UNIT #25
UNIT #27
UNIT #29
UNIT #31
UNIT #33
UNIT #35
TRANSVERSE WALKWAY
LONGITUDINAL WALKWAY
NORTH GALLERY OPEN WELL
SOUTH GALLERY
DN
B TYP
8S-9 NIC
A TYP
8S-11
C TYP
8S-11
EXIST LIGHTING CABINET TO BE MODIFIED (TYP)
EXIST CONTROL CABINET (TYP)
EXIST COL TO BE UPGRADED TYP
OPERATING GALLERY EL 1093.50
SEE ARCH DWGS FOR GUTTER & DOWNSPOUTS TYP
EMERGENCY POWER PANEL (EXIST)
CONTROL ROOM
FOR CONT. SEE SHT 8S-6
1 PUMP BAY
8S-13 FLR PLAN
1 ROOF PLAN
8S-7 FOR OPERATING GALLERY
SST LONGIT BRACING (NIC) TYP
SST TRANS BRACING (NIC) TYP
TYP A
8S-9
OPERATING FLOOR
PLAN
SCALE: 3/32" = 1'-0"
1
G-4
FILTER BLDG 1
FILTER BLDG 2
KEY PLAN
WALL FLANGE - SEE DETAIL C
WALL FLANGE - SEE DETAIL C
WALL FLANGE - SEE DETAIL C
WALL FLANGE - SEE DETAIL C
REPLACE EXISTING MAN GATE WITH NEW. SEE DETAIL 8. TYP OF 12.
EXISTING HANDRAIL TO BE REPLACED WITH NEW HANDRAIL. SEE DETAIL XXX
Backwash gate. SEE DETAIL 7 (TYP OF 12)
4. ALL HANDRAIL ANCHORS TO BE DEMOLISHED PER DETAIL 13 .
5. ALL INSERT TYPE HANDRAILS, REMOVE METAL INSERT AND FILL WITH XXX PER DETAIL XXX.
6. ALL EXISTING LIGHT POLES SHALL BE DEMOLISHED AND REPLACED PER DETAIL 14.
NOTES:
1. FOR GENERAL NOTES, DESIGN STANDARDS, DESIGN CRITERIA, MATERIAL PROPERTIES AND CONCRETE NOTES, SEE SHEET S1-1.
2. FOR ABBREVIATIONS, SYMBOLS AND LEGEND, SEE SHEET S1-2.
3. Contractor to demo all the existing handrail.
THE SCREENED INDICATES EXISTING CONDITIONS OR FACILITIES UNDER CONSTRUCTION BY ANOTHER PROJECT AND MAY NOT BE UP-TO-DATE. SEE THE LATEST REVISION OF REFERENCE DRAWING B-15523 CURRENT INFORMATION.
SCALE BARS
3/32" = 1'-0"
0 16 32 FEET
JANUARY 2013
STAMPING ENGINEER IS RESPONSIBLE FOR CURRENT DRAWING REVISION
REGISTERED PROFESSIONAL ENGINEER JAMES J. GINGRICH No. S3023 STRUCTURAL STATE OF CALIFORNIA
ISSUE DESCRIPTION
ORIGINAL ISSUE
ISSUE DATE
MWD
METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA
DESIGNED JJG
DRAWN HSB
CHECKED
FOR DRAWING APPROVALS SEE
B-000000
WATER TREATMENT PLANTS
F.E. WEYMOUTH WATER TREATMENT PLANT
FILTER BUILDINGS SEISMIC UPGRADES
FILTER BUILDING NO. 2 - WEST
Handrail replacement
SPECIFICATIONS 1713
PROJECT NUMBER 104381
SHEET 8S-2
DWG
REV 0
BRDR DATE: 01/29/2009
PEN TABLE: mwdhbw.tbl
PLOT TIME: 20-FEB-2013 16:11
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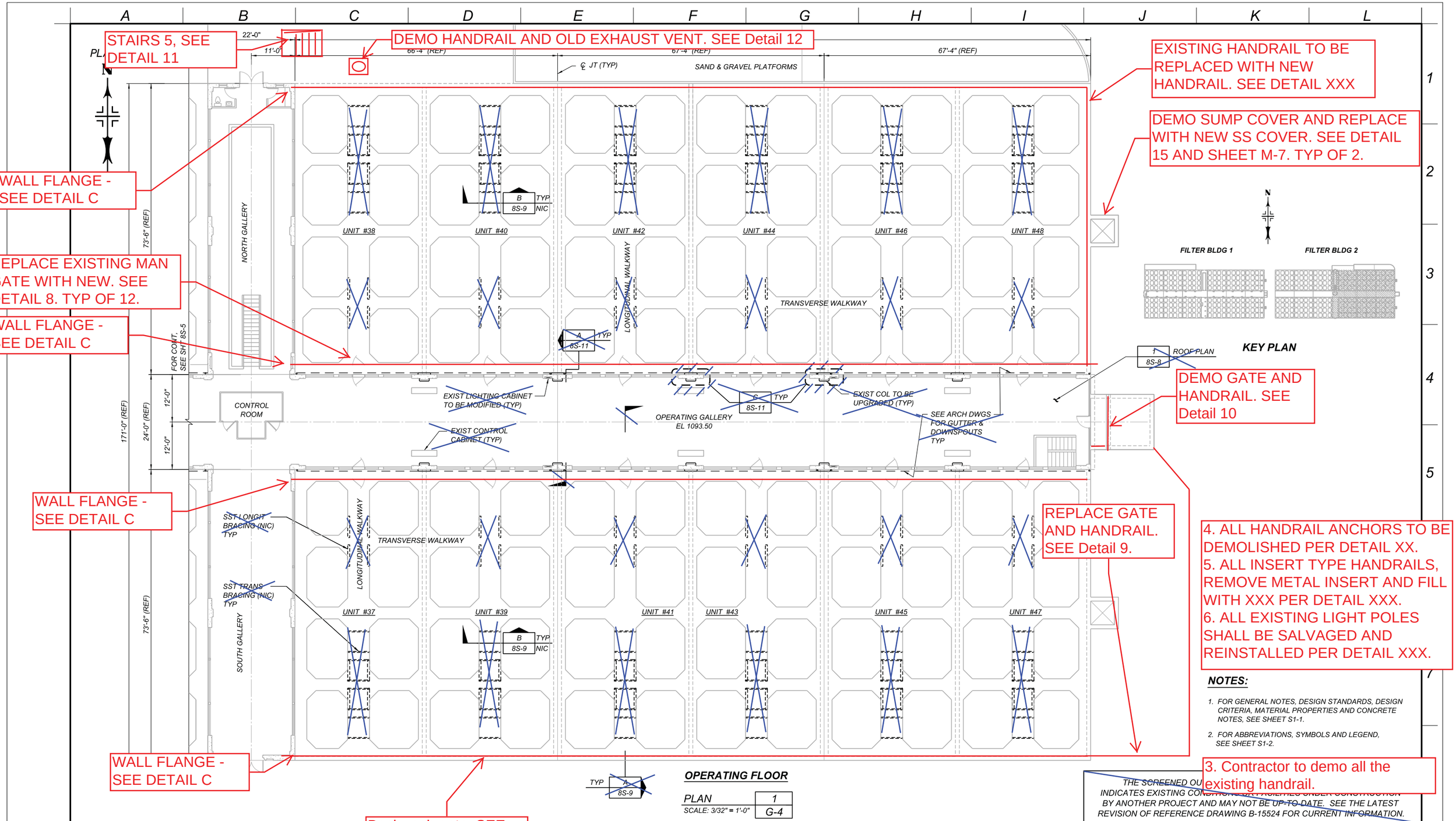
STAIRS 5, SEE DETAIL 11
DEMO HANDRAIL AND OLD EXHAUST VENT. SEE Detail 12
EXISTING HANDRAIL TO BE REPLACED WITH NEW HANDRAIL. SEE DETAIL XXX
DEMO SUMP COVER AND REPLACE WITH NEW SS COVER. SEE DETAIL 15 AND SHEET M-7. TYP OF 2.
WALL FLANGE - SEE DETAIL C
REPLACE EXISTING MAN GATE WITH NEW. SEE DETAIL 8. TYP OF 12.
WALL FLANGE - SEE DETAIL C
DEMO GATE AND HANDRAIL. SEE Detail 10
WALL FLANGE - SEE DETAIL C
REPLACE GATE AND HANDRAIL. SEE Detail 9.
WALL FLANGE - SEE DETAIL C
Backwash gate. SEE DETAIL 7 (TYP OF 12)
4. ALL HANDRAIL ANCHORS TO BE DEMOLISHED PER DETAIL XX.
5. ALL INSERT TYPE HANDRAILS, REMOVE METAL INSERT AND FILL WITH XXX PER DETAIL XXX.
6. ALL EXISTING LIGHT POLES SHALL BE SALVAGED AND REINSTALLED PER DETAIL XXX.
3. Contractor to demo all the existing handrail.
22'-0"
11'-0"
66'-4" (REF)
67'-4" (REF)
67'-4" (REF)
℄ JT (TYP)
SAND & GRAVEL PLATFORMS
73'-6" (REF)
171'-0" (REF)
24'-0" (REF)
12'-0"
12'-0"
FOR CONT. SEE SHT 8S-5
NORTH GALLERY
SOUTH GALLERY
UNIT #38
UNIT #40
UNIT #42
UNIT #44
UNIT #46
UNIT #48
UNIT #37
UNIT #39
UNIT #41
UNIT #43
UNIT #45
UNIT #47
LONGITUDINAL WALKWAY
TRANSVERSE WALKWAY
CONTROL ROOM
EXIST LIGHTING CABINET TO BE MODIFIED (TYP)
EXIST CONTROL CABINET (TYP)
OPERATING GALLERY EL 1093.50
EXIST COL TO BE UPGRADED (TYP)
SEE ARCH DWGS FOR GUTTER & DOWNSPOUTS TYP
SST LONGIT BRACING (NIC) TYP
SST TRANS BRACING (NIC) TYP
B 8S-9 TYP NIC
A 8S-11 TYP
C 8S-11 TYP
1 8S-8 ROOF PLAN
FILTER BLDG 1
FILTER BLDG 2
KEY PLAN
OPERATING FLOOR
PLAN 1
SCALE: 3/32" = 1'-0"
G-4
NOTES:
1. FOR GENERAL NOTES, DESIGN STANDARDS, DESIGN CRITERIA, MATERIAL PROPERTIES AND CONCRETE NOTES, SEE SHEET S1-1.
2. FOR ABBREVIATIONS, SYMBOLS AND LEGEND, SEE SHEET S1-2.
THE SCREENED OUT
INDICATES EXISTING CONDITIONS
BY ANOTHER PROJECT AND MAY NOT BE UP-TO-DATE. SEE THE LATEST
REVISION OF REFERENCE DRAWING B-15524 FOR CURRENT INFORMATION.
SCALE BARS
3/32" = 1'-0"
0 16 32 FEET
90%
JANUARY 2013
ISSUE DESCRIPTION
ORIGINAL ISSUE
ISSUE DATE
MWD
METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA
DESIGNED JJG
DRAWN HSB
CHECKED
FOR DRAWING APPROVALS SEE
B-000000
WATER TREATMENT PLANTS
F.E. WEYMOUTH WATER TREATMENT PLANT
FILTER BUILDINGS SEISMIC UPGRADES
FILTER BUILDING NO. 2 - EAST
Handrail replacement
SPECIFICATIONS 1713
PROJECT NUMBER 104381
SHEET 8S-3
DWG
REV 0
BRDR DATE: 01/29/2009
PEN TABLE: mwdhbw.tbl
PLOT TIME: 20-FEB-2013 16:11
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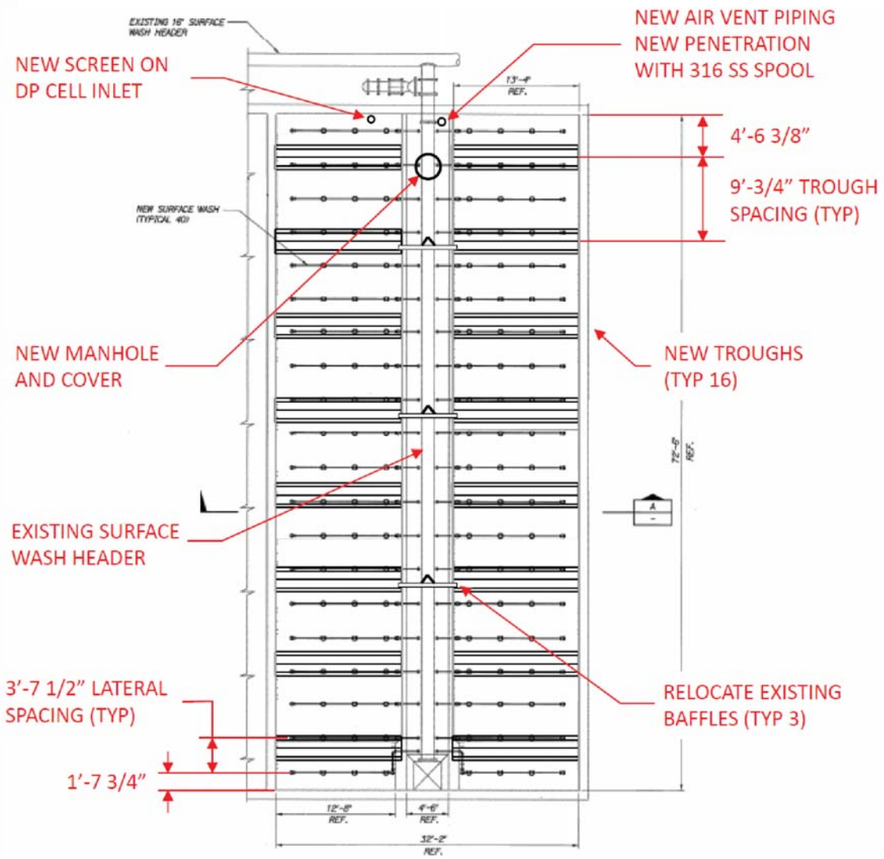
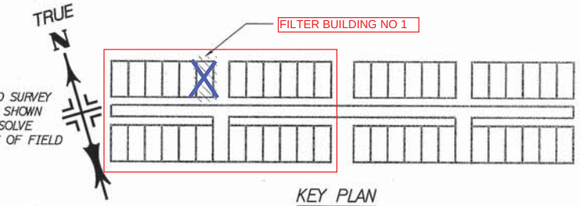


FILTER BUILDING NO 1 TYPICAL PLAN

NOTES:

1. FOR WORK WITHIN AND CONNECTING TO EXISTING FACILITIES, CONTRACTOR SHALL PREPARE A DETAILED FIELD SURVEY OF EXISTING CONDITIONS AND IDENTIFY ANY CONFLICTS BETWEEN EXISTING CONDITIONS AND REQUIREMENTS SHOWN ON THE DRAWINGS PRIOR TO SUBMITTAL OF SHOP DRAWINGS. CONTRACTOR SHALL PROPOSE SOLUTIONS TO RESOLVE CONFLICTS IN ADVANCE OF SUBMITTING SHOP DRAWINGS. SHOP DRAWING SUBMITTALS SHALL INCLUDE RESULTS OF FIELD SURVEYS COMPLETED.
2. CONTRACTOR SHALL PROTECT ALL OTHER EXISTING OPERATING FACILITIES IN PLACE DURING DEMOLITION AND CONSTRUCTION WORKS. CONTRACTOR SHALL NOT ALLOW DEMOLITION DEBRIS TO BE WASHED OR IN ANY WAY WASTED THROUGH FILTER WASTE WATER, FINISHED WATER ROUTES, OR ANY OTHER OPERATING FILTERS.
3. CONTRACTOR SHALL REMOVE AND DISPOSE OF EXISTING FILTER, ANTHRACITE, SAND AND SUPPORT GRAVEL PER SPECIFICATION SECTION 02010 - DEMOLITION AND SECTION 01572 - SPENT FILTER MEDIA DISPOSAL.
4. CONTRACTOR SHALL REUSE EXSTING PIPING AND INSTALL NEW PIPES, PIPE SUPPORTS AND SURFACE WASH AS SHOWN.
5. CONTRACTOR SHALL REMOVE AND DISPOSE OF EXISTING UNDERDRAIN SYSTEM AND REPLACE WITH NEW UNDERDRAIN AS SHOWN AND PER SPECIFICATION SECTION 13222.
6. CONTRACTOR SHALL REMOVE AND DISPOSE OF EXISTING TROUGHS AND REPLACE WITH NEW TROUGHS AS SHOWN AND PER SHEET S-4. CONTRACTOR SHALL RAISE GULLET WALL PER SHEET 7S-1

13. CONTRACTOR SHALL PROVIDE AND INSTALL NEW FILTER MEDIA AS SHOWN IN DRAWING G-6 AND AS PER SPECIFICATION SECTION 13223.
14. ELEVATIONS SHOWN ARE BASED ON NAVD88 SURVEY DATA



KEY PLAN

7. CONTRACTOR SHALL DEMOLISH THE EXISTING SURFACE SPRAY SYSTEM, AND INSTALL NEW 3/4" AND 2" HOSE BIBS.

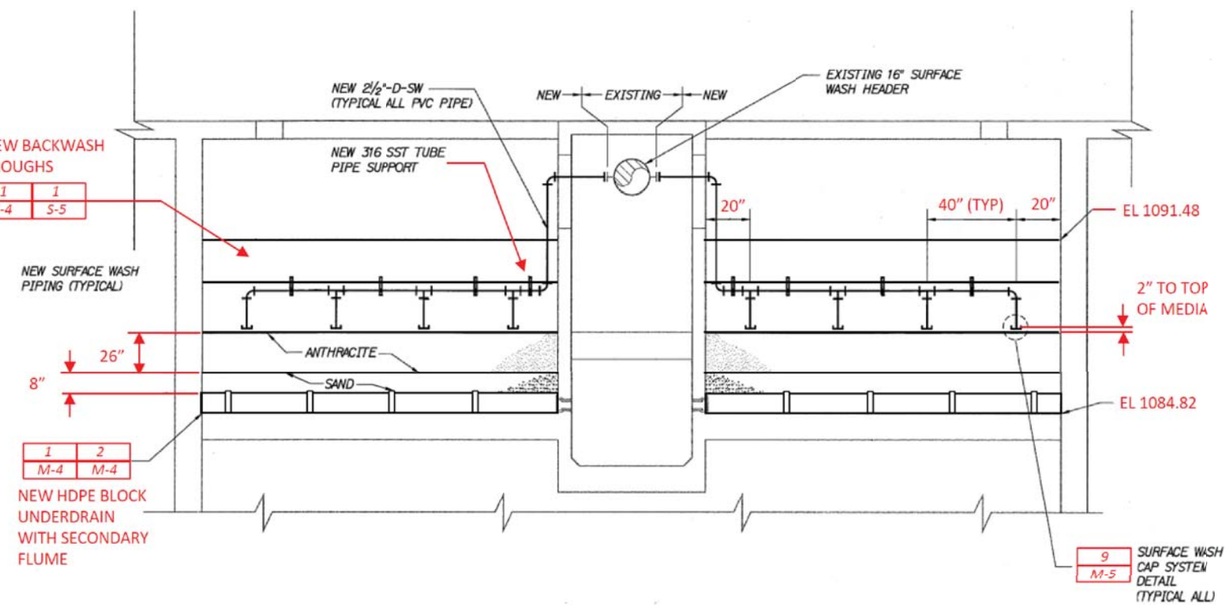
8. CONTRACTOR SHALL DEMOLISH AND REPLACE THE EXISTING UPPER GULLET MANHOLE AND FRAME PER SHEET M-6.

9. CONTRACTOR SHALL DEMOLISH ALL EXISTING AIR VENT PIPING AND PLATES PER SHEET D-3, AND INSTALL NEW AIR VENT PIPING PER SHEET M-6.

10. CONTRACTOR SHALL RELOCATE UPPER GULLET BAFFLES AS SHOWN AND PER SHEET M-3.

11. CONTRACTOR SHALL REPLACE DP CELL INLET SCREEN PER SHEET D-6 AND I-2.

12. CONTRACTOR SHALL DEMOLISH EXISTING LIGHTING AND CONDUIT WHERE INDICATED ON SHEET D-2.



SECTION A
SCALE: 3/8" = 1'-0" –

MWH

SCALE BARS

STAMPING ENGINEER IS RESPONSIBLE FOR CURRENT DRAWING REVISION

ISSUE DESCRIPTION
ORIGINAL ISSUE

ISSUE DATE OCTOBER 2009

MWD
METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

DESIGNED CONSULTANT
DRAWN CONSULTANT
CHECKED

FOR DRAWING APPROVALS SEE
B-132793

DISTRIBUTION SYSTEM
F.E. WEYMOUTH WATER TREATMENT PLANT
FILTER REHABILITATION DEMONSTRATION

FILTER BUILDING NO 1 TYPICAL

PLAN AND SECTION

SPECIFICATIONS 1652
PROJECT NUMBER 103880
SHEET 7M-1
DWG B-132778
REV 0

BRDR DATE: 01/29/2009
PEN TABLE: MWDFBW.TBL
PLOT TIME: 08-OCT-2009 14:37
USERID: Catherine Corral
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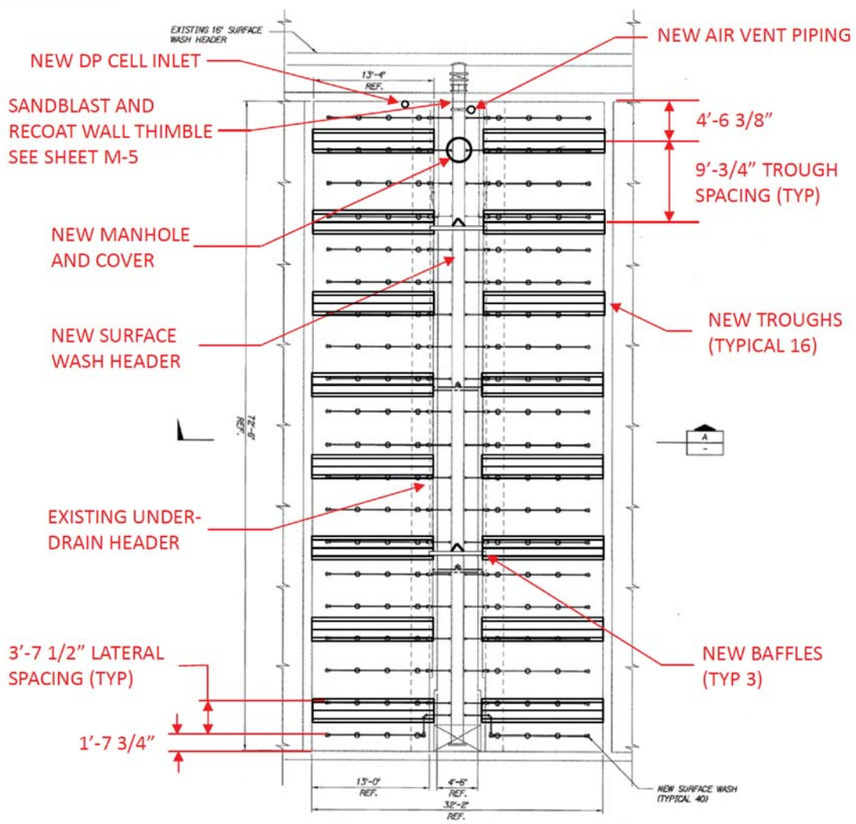
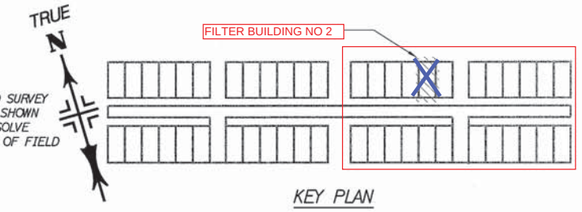


FILTER BUILDING NO. 2 TYPICAL PLAN

NOTES:

1. FOR WORK WITHIN AND CONNECTING TO EXISTING FACILITIES, CONTRACTOR SHALL PREPARE A DETAILED FIELD SURVEY OF EXISTING CONDITIONS AND IDENTIFY ANY CONFLICTS BETWEEN EXISTING CONDITIONS AND REQUIREMENTS SHOWN ON THE DRAWINGS PRIOR TO SUBMITTAL OF SHOP DRAWINGS. CONTRACTOR SHALL PROPOSE SOLUTIONS TO RESOLVE CONFLICTS IN ADVANCE OF SUBMITTING SHOP DRAWINGS. SHOP DRAWING SUBMITTALS SHALL INCLUDE RESULTS OF FIELD SURVEYS COMPLETED.
2. CONTRACTOR SHALL PROTECT ALL OTHER EXISTING OPERATING FACILITIES IN PLACE DURING DEMOLITION AND CONSTRUCTION WORKS. CONTRACTOR SHALL NOT ALLOW DEMOLITION DEBRIS TO BE WASHED OR IN ANY WAY WASTED THROUGH FILTER WASTE WATER, FINISHED WATER ROUTES, OR ANY OTHER OPERATING FILTERS.
3. CONTRACTOR SHALL REMOVE AND DISPOSE OF EXISTING FILTER, ANTHRACITE, SAND AND SUPPORT GRAVEL PER SPECIFICATION SECTION 02010 - DEMOLITION AND SECTION 01572 - SPENT FILTER MDEIA DISPOSAL.
4. CONTRACTOR SHALL ~~REUSE PIPING AND~~ INSTALL NEW PIPES AND SURFACE WASH AS SHOWN.
5. CONTRACTOR SHALL PROVIDE AND INSTALL NEW FILTER MEDIA AS SHOWN IN DRAWING G-6 AND AS PER SPECIFICATION SECTION 13223.
6. ELEVATIONS SHOWN ARE BASED ON NAVD88 SURVEY DATA
7. CONTRACTOR SHALL REPAIR CONCRETE FILTER BOTTOM TO LEVEL THE FILTER BOTTOM.
8. ~~GRAVEL IS FROM THE BOTTOM OF THE TEEPEE UNDERDRAIN.~~
12. CONTRACTOR SHALL REPLACE EXISTING CHANNEL BAFFLES AS SHOWN AND PER SHEET M-3.



KEY PLAN

8. CONTRACTOR SHALL DEMOLISH THE EXISTING CONCRETE TEEPEE UNDERDRAIN AND REPLACE WITH HDPE BLOCK UNDERDRAIN SYSTEM SPANNING THE EXISTING UNDERDRAIN HEADER PER SHEET M-4.

10. CONTRACTOR SHALL DEMOLISH EXISTING CONCRETE TROUGHS, RAISE THE EXISTING GULLET WALL, AND REPLACE WITH NEW CONCRETE TROUGHS AS SHOWN.

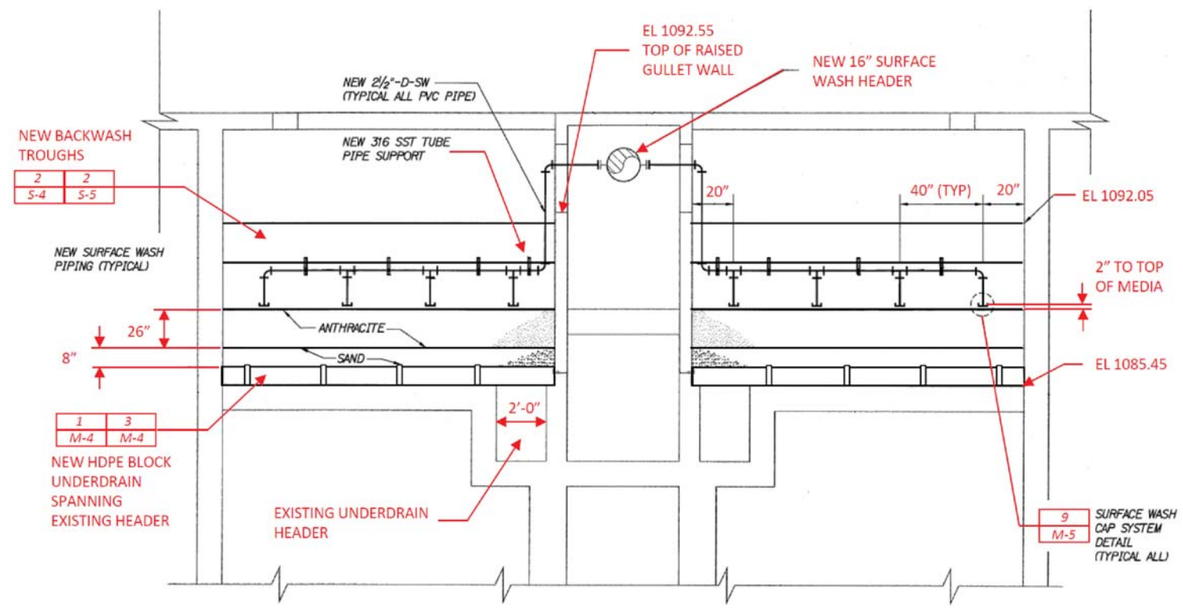
7. CONTRACTOR SHALL DEMOLISH THE EXISTING SURFACE SPRAY SYSTEM, AND INSTALL NEW 3/4" AND 2" HOSE BIBS.

8. CONTRACTOR SHALL DEMOLISH AND REPLACE THE EXISTING UPPER GULLET MANHOLE AND FRAME PER SHEET M-6.

9. CONTRACTOR SHALL DEMOLISH ALL EXISTING AIR VENT PIPING AND PLATES PER SHEET D-3, AND INSTALL NEW AIR VENT PIPING PER SHEET M-6.

11. CONTRACTOR SHALL REPLACE DP CELL INLET SCREEN PER SHEET D-6 AND I-2.

12. CONTRACTOR SHALL DEMOLISH EXISTING LIGHTING AND CONDUIT WHERE INDICATED ON SHEET D-2.



SECTION A -

MWH

SCALE BARS

STAMPING ENGINEER IS RESPONSIBLE FOR CURRENT DRAWING REVISION

ISSUE DESCRIPTION: ORIGINAL ISSUE

ISSUE DATE: OCTOBER 2009

MWD METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

DESIGNED CONSULTANT
DRAWN CONSULTANT
CHECKED

FOR DRAWING APPROVALS SEE B-132793

DISTRIBUTION SYSTEM
F.E. WEYMOUTH WATER TREATMENT PLANT
FILTER REHABILITATION DEMONSTRATION

FILTER BUILDING NO 2 TYPICAL

PLAN AND SECTION

SPECIFICATIONS 1652
PROJECT NUMBER 103880
SHEET 8M-1
DWG B-132779 REV 0

BRDR DATE: 01/29/2009 PEN TABLE: MWDFBW.TBL PLOT TIME: 08-OCT-2009 14:37 USERID: Catherine Corral FILE NAME: IP_PWP:d022321\2\652_\03880_08m001_3.dgn

Appendix F

Final Design Package

SPECIFICATIONS LIST

Division 1 - General Requirements

01010 Summary of Work
01011 Specifications, Contract Drawings and As-Built Drawings
01040 Project Coordination
01050 Construction Surveying
01060 Safety and Regulatory Requirements
01065 Environmental Requirements
01072 Water Pollution Control Drawings and Plans (WPCD)
01090 Reference Standards and Drawings
01100 Shutdowns
01200 Project Management
01300 Submittals
01312 Construction Schedule
01400 Inspection of the Work
01445 Manufacturer's Field Services
01500 Construction Facilities and Temporary Controls
01505 Mobilization
01510 Temporary Utilities and Services
01530 Protection of Existing Facilities
01540 Load Restrictions
01550 Access, Parking, and Traffic
01572 Construction and Demolition Waste Management
01590 Field Offices
01610 Delivery, Storage, and Handling
01640 Seismic Design of Equipment and Equipment Anchorage
01650 Pipe, Duct, Cable, Tray, Raceway, and Bus Duct Support and Bracing
01730 Operations and Maintenance data
01740 Guarantee and Warranty

Division 2 - Site Work

02020 Demolition
02120 Demolition and Removal of Items Containing Lead
02140 Dewatering
02490 Precast Concrete Manholes and Vaults
02527 Site Work Concrete
02555 Asphalt Concrete Pavement
02575 Surface Restoration
02680 Removal and Disposal of Quagga Mussels and Quagga Mussel Infested Water
02683 Disinfection of Water Systems

Division 3 - Concrete

03100 Concrete Formwork
03210 Reinforcing Steel
03250 Concrete Anchors in Cured Concrete
03251 Expansion Joints, Control Joints, and Waterstops
03300 Cast-in-Place Concrete
03400 Structural and Architectural Precast Concrete
03450 Precast Concrete Backwash Troughs
03600 Grout and Dry-Pack
03700 Concrete Repair and Rehabilitation

Division 4 - Masonry (Not Used)

Division 5 - Metals

05120 Structural Steel
05500 Miscellaneous Metals
05530 Metal Grating
05720 Aluminum Pipe Railing

Divisions 6-8 (Not Used)

Division 9 - Finishes

09900 Painting

Divisions 10-12 (Not Used)

Division 13 - Special Construction

13100 Instrumentation and Control - General Requirements
13221 Plastic Filter Underdrain
13222 Filter Materials
13400 Control Strategies
13460 Pressure Transmitters

Division 14 - Conveying System (Not Used)

Division 15 - Mechanical

15060 General Mechanical Piping
15070 Stainless Steel Pipe and Fittings, Flat-Faced [E-Pipe]
15077 Copper Tubing and Fittings [C-Pipe]
15080 Poly (Vinyl Chloride) (PVC) Plastic Pipe and Fittings [D-Pipe]
15082 Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe and Fittings [DD-Pipe]
15100 Valves for Piping System
15205 Mechanical Identification
15995 Mechanical Completion, Testing, and Commissioning

Division 16 - Electrical

16050 Basic Electrical Materials and Methods
16110 Raceways
16120 Conductors
16195 Electrical Identification
16450 Grounding
16690 Electrical Field Testing

DRAWING INDEX

Sheet	Drawing Title
	APPROVAL DRAWINGS
1	Original Issue Approval Sheet
2	Drawing Approval Sheet Consolidated Addendum
	GENERAL
G-1	General Location and Vicinity Maps
G-2	Drawing Index and Reference Drawing Index
G-3	General Notes
G-4	Legend and Abbreviations
G-5	Site Plan and Limits of Construction
G-6	Design Criteria and Profile
G-7	Hydraulic Profile
	DEMOLITION
D-1	Demolition General Notes
D-2	Filter Components Demolition Schedule
D-3	Filter Internals Demolition Details I
D-4	Filter Internals Demolition Details II
D-5	Filter Internals Demolition Details III
D-6	Filter Internals Demolition Details IV
D-7	Site Feature Modification Details
D-8	Pipe Gallery Demolition Details
D-9	Modification of Demonstration Study Filters - Troughs and Underdrains
7D-1	Modification of Filters, Building 1 - Plan and Section
7D-2	Modification of Filters, Building 1 - Sections and Details
7D-3	Modification of Demonstration Study Filters - Filter 12
7D-4	Modification of Demonstration Study Filters - Filter 23
8D-1	Modification of Filters, Building 2 - Plan and Section
8D-2	Modification of Filters, Building 2 - Underdrains
8D-3	Modification of Demonstration Study Filters - Filter 36
	STRUCTURAL
S-1	General Notes, Design Standards, Design Criteria and Material Properties
S-2	Abbreviations, Symbols, and Legend
S-3	Structural Details and Steel Notes
S-4	Trough and Miscellaneous Details
S-5	Gullet Wall and Trough Mounting Details
S-6	Drain Chute Details
S-7	Handrail Details I
S-8	Handrail Details II
7S-1	Filter Building 1 - Plan and Section
7S-2	Handrail Replacement and Concrete Repair, Building 1 - West
7S-3	Handrail Replacement and Concrete Repair, Building 1 - East
8S-1	Filter Building 2 - Plan and Section
8S-2	Handrail Replacement and Concrete Repair, Building 2 - West
8S-3	Handrail Replacement and Concrete Repair, Building 2 - East

INSTRUMENTATION

I-1	Instrumentation Legend and Symbol Sheet
I-2	Pressure Sensor and DP Cell Details
I-3	Backwash Header and Effluent Channel Sensors P&ID

MECHANICAL

M-1	Mechanical Notes and Details
M-2	Mechanical Details I
M-3	Mechanical Details II
M-4	Underdrain Details
M-5	Surface Wash Details
M-6	Air Vent, Manhole, and Access Hatch Cover Details
M-7	Pipe Gallery DP Cell Replacement
7M-1	Typical Filter Plan and Section, Filter Building 1
7M-2	New Pressure Sensor Locations, Filter Building 1
8M-1	Typical Filter Plan and Section, Filter Building 2
8M-2	New Pressure Sensor Locations, Filter Building 2

ELECTRICAL

E-1	Electrical Abbreviations and General Notes
E-2	Electrical Site Plan
E-3	Conduit and Cable Schedule
7E-1	Filter Building 1 - New Conduit for Pressure Sensors
8E-1	Filter Building 1 - New Conduit for Pressure Sensors

REFERENCE DRAWING INDEX

Spec	Sheet	Drawing Title
312	A-2108	Filters - Wash Troughs
312	B-6589	Filters - General Assembly
312	B-6607	Filters - Surface Wash Piping Details
312	B-6633	Filters - Filter Floor Plan
312	H-2468	Filters - Underdrain System
312	H-2469	Filters - Surface Wash Piping
312	H-2487	Filters - Longitudinal Section thru Filter Bed
371	A-2538	Filters - Underdrains
371	B-8010	Filters - Floor Plan
371	B-8012	Filters - Transverse Section Through Beds
371	B-8014	Filters - Operating Floor Plan
371	B-8023	Filters - Surface Wash Piping Details
371	B-8034	Filters - Connections to Existing Structures
371	B-8125	Filters - Underdrain System
371	B-8137	Filters - Miscellaneous Metals Details
371	H-3325	Filters - Longitudinal Section thru Filter Bed
371	H-3326	Filters - Section Along Gullet
600	B-15525	Filters - Subbasement - Plan and Sections Elevation 1072.0
600	B-15526	Filters - Central Area - Foundation Plan Elevation 1078.0
600	B-15527	Filters - Central Area - Foundation Plan Elevation 1084.0
600	B-15528	Filters - Central Area - Foundation Plan Elevation 1091.50
600	B-15581	Filters - Pipe Gallery Piping Details - Sections
600	B-15533	Filters - Concrete Joint Details

Appendix G

Structural Design Parameters

Structural Rehabilitation Design Parameters

1 General

This section presents the structural design criteria for the Weymouth Filter Rehabilitation Project. The intent of this section is to define the design loads to ensure all components of the Project would meet structural code and material requirements.

2 Applicable Codes, Standards, and References

The design codes, standards, and references in Table 1 are applicable for the evaluation of structures for the Project.

Table 1: Applicable Structural Codes and Standards

Code/Standard	Application and Project Impact
California Building Code (CBC), 2010 Edition	Specifies minimum structural design loads and design requirements for new facilities constructed in California. This code refers to International Building Code (IBC) 2009 for many criteria, which contains more specific details.
American Society of Civil Engineers (ASCE) Standard No. 7-05, "Minimum Design Loads for Buildings and Other Structures."	Specifies minimum structural design loads and design requirements for new facilities.
ACI 318-08 "Building Code Requirements for Reinforced Concrete."	Specifies generic minimum design criteria for reinforced concrete structures.
ACI 350-06. "Code Requirements for Environmental Engineering Concrete Structures."	Contains minimum design criteria for environmental and liquid retaining concrete structures to provide concrete crack and leakage control measures.

3 Geotechnical Criteria

Geotechnical design criteria is based on the memorandum prepared by Robb Bell, Principal Engineer of The Metropolitan Water District of Sothern California, dated March 11, 2010.

4 Seismic Design

The controlling seismic event is a MM 7 1/4 event on the Sierra Madre Fault, located approximately 2.2 kilometers north of the site. The site address is 700 North Moreno Avenue, La Verne, CA 91750-3303. The site coordinates are: Latitude: 34.111972; Longitude: -117.782111.

5 Design Loads

The following loads would be used for design of structures for this Project.

5.1 Load Definitions

D Dead Load (material weights and fixed equipment)
E Earthquake (seismic) Load
E_m Estimated Maximum Earthquake Force (ASCE 7-05 Section 12.43)
f_1 Coefficient defined in 2010 CBC Section 1605.2.1

H Lateral Pressure of Soil and Water in Soil Loads
L Live Load (except roof live load)
L_r Roof Live Load
W Wind Load

5.2 Design Loads

The design loads for dead (D), live (L), fluid (F), wind (W), and earthquake /seismic (E) loads are included as Table 2.

5.3 Load Combinations

The load combinations used for reinforced concrete, steel, and masonry structural design are included as Table 3.

6 Material Properties

The types of materials considered for structural design are indicated in Table 4.

7 Acceptance Criteria

The acceptance criteria for ensuring that structural designs meet the CBC and IBC design requirements are summarized in Table 5.

Table 2: Design Loads

Design Load	Value
Dead Load (D)	
Structure Weight	
Concrete	150 pound per cubic feet (pcf)
Steel	490 pcf
Aluminum	165 pcf
Equipment	Actual weight per vendor
Live Loads (L)	
Roof	20 psf minimum
Fluid Loads (F)	
Hydrostatic Loads	Water density = 62.4 pcf
Wind Loads (W)	
Basic Wind Speed	85 miles per hour (mph)
Exposure	C
Importance Factor I_w	1.15
Wind Loads Factor	ASCE 7-05 Section 6.5.11
Earthquake (Seismic) Loads (E)	
Seismic Coefficients	
Occupancy Category	CBC Table 1604.5
Site Class	D
Site Coefficient (F_a)	1.0
Site Coefficient (F_v)	1.5
Site Coefficients SMs and SDs	S_{MS} = 2.43 and S_{DS} = 1.62
Site Coefficients SM1 and SD1	S_{M1} = 1.79 and S_{D1} = 1.193
Importance Factors	
Structures	I=1.5

Equipment	I_p=1.5
Response Modification Coefficient (R)	
Structures	ASCE 7-05 Table 12.2-1
Equipment	ASCE 7-05 Table 15.4-2

Table 3: Load Combinations

Loading Combination	Reference
Reinforced Concrete Strength Design (SD) Method	
$1.2D+1.6L+0.5L_r$	CBC Section 1605.2, EQN: 16.2
$U=1.2D+1.0E+f_1L$	CBC Section 1605.2, EQN: 16-5
U=0.9D +1.6W+1.6H	CBC Section 1605.2, EQN: 16-6
U=0.9D+1.0E+1.6H	CBC Section 1605.2, EQN: 16-7

7.1 Design Methods

The Ultimate Stress Design (USD) method would be used for design of reinforced concrete structures including walls, slabs, beams, columns and foundations. Concrete liquid containing structures must use 1.3 durability factor in accordance with ACI 350. The foundations for all structures would use the actual unfactored loads and the ASD method for sizing footings, slab on grade, and concrete mat foundations.

7.2 Deflection Criteria

The maximum allowable deflection for troughs for filter and other structural elements would be as follows:

Live Load (L) only	L/360
Total Load (D+L)	L/240

Table 4: Material Properties

Material	Reference
Reinforced Concrete	
Compressive Strength	f'_c=4,000 psi
Reinforcing Steel	ASTM A615, Grade 60
Epoxy for Crack Repairs	
Compressive Strength	10,000 psi
Compressive Modulus	200,000 psi
Tensile Strength, 7 days	7,000 psi
Bond Strength, 2 days	2,000 psi
Flexural Strength, 14 days	14,000 psi

Table 5: Acceptance Criteria for Structural Designs

Criterion		Value
Maximum allowable soil pressure	Normal D,L,F,H loading for slab/mat foundation combinations	2,000 psf
	Wind or Seismic loading combinations only	2,660 psf
Minimum factor of safety for normal (D,L,F,H) loading against buoyancy uplift, sliding, and overturning		1.5
Loading combinations for earthquake (E) or wind (W)	Sliding	E - 1.1; W-1.5
	Overturning	E -1.1; W-1.5
Sliding resistance; soil against concrete friction coefficient		0.35
No net uplift is allowed on any portion of the foundation.		

7.3 Design Allowables

For concrete USD, the factored design loads would cause bending moment, shear and axial loads in membranes which must be less than or equal to the strength reduction factor (Φ) times the member capabilities, as determined per Chapter 9.3 of ASCE 7-05.

For loading combinations including wind (W) or earthquake (E) design loads, the allowable could be increased by 33 percent to account for the short-term duration of these loads as allowed in 2010 CBC.

7.4 Foundation Design Criteria

Foundation design would be acceptable provided it meets the entire acceptance criteria specified in Table 5.

8 Special Inspection

Special inspections would be provided by Contractor and Construction Manager in accordance with CBC Chapter 17 for the following constructions:

- Cast-in-place concrete, except concrete with a compressive strength (f'c) of less than 2,500 psi or site-work concrete.
- Placement of concrete reinforcing steel.
- Earthwork including excavations, backfill compaction and grading.
- Where required by the respective International code Council Evaluation Service (ICC-ES) evaluation report, special inspection would be required for mechanical couplers, expansion anchors, and adhesive anchors. Expansion anchor and adhesive anchors would be ICC-ES approved and would be designed based on ICC-ES allowable loads.
- Concrete masonry structures, with the assumption that full stresses were used in the design.

Appendix H

Cost Estimates

METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA
F.E. WEYMOUTH WATER TREATMENT PLANT FILTER REHAB PROJECT
LA VERNE, CALIFORNIA

CONCEPTUAL DESIGN ESTIMATE

February 24, 2014

IEM JOB NUMBER:
14-01

PREPARED BY IEM FOR

Rev 1

INTEGRATED ENGINEERING MANAGEMENT, INC.
302 W. FIFTH STREET, SUITE 207
SAN PEDRO, CA 90731 www.iemcm.com

VOICE: 310-221-0749
FAX: 310-221-0859
RHW: 510-530-5921

PROJECT: METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA
F.E. WEYMOUTH WATER TREATMENT PLANT FILTER REHAB PROJECT
LA VERNE, CALIFORNIA

DATE:	02/24/14
IEM NO:	14-01
REV:	1
PREP BY:	RW
CHK BY:	BZ

OWNER: METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

CLIENT: MONTGOMERY WATSON HARZA

DESIGN TEAM:

ARCHITECTURAL:	NONE
STRUCTURAL:	MWH / RBA
PLUMBING:	MWH / RBA
FIRE PROTECT:	NONE
HVAC:	NONE
ELECTRICAL:	MWH / RBA
CIVIL:	MWH / RBA
LANDSCAPE:	NONE

ESTIMATE LEVEL: CONCEPTUAL DESIGN ESTIMATE

ESTIMATE TYPE: OPINION OF COST

PLAN DATE: 2009-10-15 & 2013-02-20

SPEC DATE: NONE

ESTIMATE BASIS:

THIS COST ESTIMATE IS DEFINED AS AN "OPINION OF COST" MEANING THAT THE COSTS REFLECTED IN THE ESTIMATE ARE THE CONSIDERED OPINION OF THE ESTIMATOR BASED ON THE CURRENT COSTS OF MATERIAL AND LABOR, UPON INFORMATION AVAILABLE IN PUBLISHED REFERENCE SOURCES, HISTORICAL COST DATA, CLIENT OR VENDOR PROVIDED COST DATA AND THE PERSONAL EXPERIENCE OF THE ESTIMATOR. THE FINAL COST OF THE PROJECT MAY VARY FROM THE ESTIMATOR'S "OPINION OF COST" BASED ON FACTORS BEYOND THE CONTROL OF THE ESTIMATOR SUCH AS, BUT NOT LIMITED TO, THE NUMBER OF GENERAL CONTRACTORS AND/OR SUBCONTRACTORS PARTICIPATING IN THE BID PROCESS; SUDDEN CHANGES IN NATIONAL AND LOCAL MARKET CONDITIONS; THE NATIONAL AND LOCAL ECONOMY; AND DECISIONS MADE BY THE CLIENT.

COMPETITIVE BIDDING:

THE PRICES IN THIS ESTIMATE ARE BASED ON COMPETITIVE BIDDING. COMPETITIVE BIDDING IS RECEIVING RESPONSIVE BIDS FROM AT LEAST FIVE OR MORE GENERAL CONTRACTORS AND THREE OR MORE RESPONSIVE BIDS FROM MAJOR SUBCONTRACTORS OR TRADES. MAJOR SUBCONTRACTORS ARE CONCRETE, MASONRY, STRUCTURAL STEEL, FRAMING, ROOFING, MECHANICAL, PLUMBING AND ELECTRICAL SUBCONTRACTORS AND ANY OTHER MAJOR COMPONENTS OF THE PROJECT.

WITHOUT COMPETITIVE BIDDING, CONTRACTOR BIDS CAN AND HAVE RANGED FROM 25% TO 100% AND MORE OVER THE PRICES IN THIS ESTIMATE, DEPENDING ON THE SIZE OF THE JOB. WITH COMPETITIVE BIDDING, CONTRACTOR BIDS CAN RANGE AS LOW AS

CHANGES IN WORK SCOPE:

THE USER IS CAUTIONED THAT SIGNIFICANT CHANGES IN THE SCOPE OF THE PROJECT, OR ALTERATIONS TO THE PROJECT DOCUMENTS AFTER COMPLETION OF THIS OPINION OF COST ESTIMATE CAN CAUSE MAJOR COST CHANGES. IN THIS CIRCUMSTANCE, IEM SHOULD BE NOTIFIED AND AN APPROPRIATE ADJUSTMENT MADE TO THIS OPINION OF COST ESTIMATE.

ESCALATION:

ESCALATION IS BASED ON 3% PER YEAR AND CARRIED TO THE MID-POINT OF CONSTRUCTION IN DEC 2013. ONE MAJOR FACTOR IN ESCALATION IS INFLATION AND WE ARE IN A PERIOD OF POTENTIAL FOR EXTREME INFLATIONARY PRESSURES. THERE ARE TOO MANY VARIABLES TO DETERMINE HOW THIS WILL MANIFEST ITSELF ON ANY SPECIFIC PROJECT. THERE MAY ONLY BE NEGLIGIBLE IMPACT OR IT MAY BE GREATER THAN PREDICTED.

PROJECT SYNOPSIS:

THE PROJECT COVERS THE REPLACEMENT OF FILTER MATERIAL AND THE INSTALLATION OF NEW PIPING AND MISCELLANEOUS COMPONENTS.

WAGE RATES:

THIS OPINION OF COST IS BASED ON MARKET WAGE-RATES & CONDITIONS AND CURRENTLY APPLICABLE PREVAILING WAGES IN LOS ANGELES COUNTY.

CONST. TYPE:

STRUCTURAL:	N/A
FRAMING:	N/A
ROOFING:	N/A
PLUMBING:	N/A
FIRE PROT:	N/A
HVAC:	N/A
ELECTRICAL:	N/A

BUILDINGS/STORIES:

	GSF
	0
	0
	0
TOTAL GSF	0

GROSS SITE AREA:	0	0.0	ACRES	FLAT
SITE AREA SLOPED	0	0.0	ACRES	2.5%

PRORATES: THESE VALUES TRANSFER TO OTHER TABS.

GENERAL CONDITIONS:	8.0%
DESIGN CONTINGENCY:	15.0%
ESCALATION:	4.00%
MARKET FACTOR:	0.0%
LEED PREMIUM:	0.0%
PHASING:	2.5%

SUPPLIER PROVIDED QUOTES:

1. CARBON SALES ANTHRACITE
2. JENSEN PRECAST CONCRETE TROUGHS
3. LEOPOLD XA UNDERDRAINS
4. ROSEMOUNT PRESSURE SENSORS

PHASES: NONE

CONT. BURDENS: THESE VALUES TRANSFER TO OTHER TABS.

BONDS & INSURANCE:	1.2%
OVERHEAD & PROFIT	8.0%

CONST. PERIOD:

START DATE:	12/01/14	12/31/15	FINISH
CONST. LENGTH:	13.2	MONTHS	
MID-POINT:	16.0	MONTHS	
ESCALATION PER YEAR:	3.0%		

GENERAL EXCLUSIONS (UNLESS OTHERWISE NOTED):

1. ARCHITECTURAL FEES, ENGINEERING FEES AND OTHER SOFT COSTS.
2. THE COST OF LAND AND EASEMENT ACQUISITION.
3. HAZARDOUS MATERIAL HANDLING, DISPOSAL AND ABATEMENT.
4. ASSESSMENTS, TAXES, FINANCE, LEGAL AND DEVELOPMENT CHARGES.
5. ENVIRONMENTAL IMPACT MITIGATION.
6. BUILDER'S RISK, PROJECT WRAP-UP AND OTHER OWNER PROVIDED INSURANCE PROGRAMS.
7. COMPRESSION OF SCHEDULE AND PREMIUM OR SHIFT WORK.
8. RESTRICTIONS ON THE CONTRACTOR'S WORKING HOURS.
9. OWNER SUPPLIED AND INSTALLED FURNITURE, FIXTURES AND EQUIPMENT.
10. LOOSE FURNITURE AND EQUIPMENT EXCEPT AS SPECIFICALLY IDENTIFIED.
11. SUSTAINABLE DESIGN AND LEED REQUIREMENTS.

NOTES:

1. SOME QUANTITIES AND UNIT PRICES WHERE PROVIDED BY MJA DATED 01-20-14 AND INCORPORATED AS DIRECTED INTO THIS ESTIMATE REV 1 UPDATE. THOSE CHANGES ARE NOTED TO THE RIGHT OF THE LINE ITEM OUTSIDE THE PRINT RANGE AND VISIBLE ON SCREEN IN THE ORIGINAL EXCEL DOCUMENT. IEM ASSUMES NO RESPONSIBILTY FOR THESE CHANGES.

PROJECT:	F.E. WEYMOUTH WTP FILTER REHAB PROJECT	IEM PROJECT NO:	14-01
LOCATION:	LA VERNE, CA	PREPARED BY:	RW
CLIENT:	METROPOLITAN WATER DISTRICT OF SO. CALIFORNIA	CHECKED BY:	BZ
DESCRIPTION:	ESTIMATE SUMMARY	ESTIMATE DATE:	02/24/14
		REV:	1

CONCEPTUAL DESIGN ESTIMATE

ITEM #	DESCRIPTION	QUANTITY	UNIT	COST	TOTAL
	FILTER BUILDING NO. 1				$ 21,360,458
	FILTER BUILDING NO. 2				$ 23,291,465
	FILTER BUILDINGS BASE TOTAL				$ 44,651,923
	OPT NO. 1 - SURFACE SPRAY NOZZLE DEMO & HOSE BIBB REPLACEMENT				$ 634,242
	OPT NO. 2A - DEMO/REPLACE EXISTING ACCESS HATCHES & AIR VENTS				$ 717,818
	OPT NO. 2B - DEMO OLD AIR VENT PIPES				$ 17,819
	OPT NO. 2C - CUT & DEMO OLD AIR VENT PIPES				$ 36,627
	OPT NO. 3 - MOVE/REPLACE UPPER GULLET BAFFLES				$ 142,546
	OPT NO. 4A - NEW PRESSURE SENSORS				$ 448,000
	OPT NO. 4B - ADDITIONAL PRESSURE SENSORS				$ 59,960
	OPT NO. 5 - LIGHTING SYSTEM REMOVAL				$ 33,151
	OPT NO. 6 - HANDRAIL REPLACEMENT				$ 549,223
	OPT NO. 7A - DEMO & CAP SAND PAN DRAINS				$ 7,637
	OPT NO. 7B - REPLACE EXISTING BACK WASH SUMP COVERS				$ 12,445
	TOTAL OPTIONS				$ 2,659,468
	TOTAL PROJECT BASE COSTS W/ OPTIONS				$ 47,311,391

PROJECT:	F.E. WEYMOUTH WTP FILTER REHAB PROJECT	IEM PROJECT NO:	14-01
LOCATION:	LA VERNE, CA	PREPARED BY:	RW
CLIENT:	METROPOLITAN WATER DISTRICT OF SO. CALIFORNIA	CHECKED BY:	BZ
DESCRIPTION:	FILTER BUILDING NO. 1	ESTIMATE DATE:	02/24/14
		WORK AREA GSF:	N/A

CONCEPTUAL DESIGN ESTIMATE

ITEM #	DESCRIPTION	QUANTITY	UNIT	COST	TOTAL COST
2.20	DEMOLITION				2,527,710
2.30	UNDERDRAINS & CONCRETE TROUGHS				8,449,200
2.40	PLUMBING WORK				1,219,200
2.50	FILTER MEDIA REPLACEMENT				1,779,840
2.60	MISC. PROJECT WORK				120,000
3.00	CONCRETE WORK				1,008,960
	SUBTOTAL FILTER BUILDING NO. 1				**$ 15,104,910**
	PRORATES				
	GENERAL CONDITIONS	8.00%			1,208,393
	DESIGN CONTINGENCY	15.00%			2,265,737
	ESCALATION	4.00%			604,196
	PHASING ALLOWANCE	2.50%			377,623
	DIRECT COST & PRORATES SUBTOTAL				**$ 19,560,859**
	CONTRACTOR BURDENS				
	BONDS & INSURANCE	1.20%			234,730
	OVERHEAD & PROFIT	8.00%			1,564,869
	TOTAL FILTER BUILDING NO. 1				**$ 21,360,458**

PROJECT:	F.E. WEYMOUTH WTP FILTER REHAB PROJECT	IEM PROJECT NO:	14-01
LOCATION:	LA VERNE, CA	PREPARED BY:	RW
CLIENT:	METROPOLITAN WATER DISTRICT OF SO. CALIFORNIA	CHECKED BY:	BZ
DESCRIPTION:	FILTER BUILDING NO. 1	ESTIMATE DATE:	02/24/14
		WORK AREA GSF:	N/A

CONCEPTUAL DESIGN ESTIMATE

ITEM #	DESCRIPTION	QUANTITY	UNIT	COST	TOTAL COST
2.20	**DEMOLITION**				
	REMOVE FILTER MEDIA (ONE TYPICAL CELL) (CELL SIZE, 72.5' X 13.34')				
	REMOVE (E) ANTHRACITE, 20" DEEP	65	CY	35.00	**2,275**
	REMOVE (E) SAND, 8" DEEP	26	CY	35.00	**910**
	REMOVE (E) VCP & GRAVEL, 15" DEEP	49	CY	35.00	**1,715**
	BALANCE OF CELLS (47 EA)	47	EA	4,900.00	**230,300**
	MISC. DEMO WORK				
	DEMO (E) CONCRETE TROUGHS & WALL CONNECTIONS (23 EA X 20 EA)	460	EA	1,250.00	**575,000**
	DEMO (E) FIBERGLASS TROUGHS (FB1 ONLY)	20	EA	750.00	**15,000**
	DEMO (E) TETRA PLASTIC BLOCK UNDERDRAINS (FB1-12 ONLY)	1,934	SF	15.00	**29,010**
	DEMO (E) STAINLESS STEEL UNDERDRAINS (FB1-23 ONLY)	1	EA	1,500.00	**1,500**
	DEMO (E) UPPER GULLET CONCRETE WALLS (150 SF X 48 EA)	7,200	SF	25.00	**180,000**
	DEMO (E) SURFACE WASH LATERALS (24 EA X 40 EA)	960	EA	500.00	**480,000**
	MISC. DEMOLITION (ALLOWANCE)	24	EA	2,500.00	**60,000**
	HAUL & DISPOSAL FEES	1	LS	335,200	**335,200**
	MISC. NON-DEMO ITEMS FOR ONE TYPICAL CELL (CELL SIZE, 72.5' X 13.34')				
	SAWCUT UPPER GULLET CONCRETE WALLS, 12'	160	LF	50.00	**8,000**
	PATCH & REPAIR CELL FLOOR (ALLOWANCE)	970	SF	5.00	**4,850**
	BALANCE OF CELLS (47 EA)	47	EA	12,850.00	**603,950**
					-
	SUBTOTAL 2.2				**$ 2,527,710**

PROJECT:	F.E. WEYMOUTH WTP FILTER REHAB PROJECT	IEM PROJECT NO:	14-01
LOCATION:	LA VERNE, CA	PREPARED BY:	RW
CLIENT:	METROPOLITAN WATER DISTRICT OF SO. CALIFORNIA	CHECKED BY:	BZ
DESCRIPTION:	FILTER BUILDING NO. 1	ESTIMATE DATE:	02/24/14
		WORK AREA GSF:	N/A

CONCEPTUAL DESIGN ESTIMATE

ITEM #	DESCRIPTION	QUANTITY	UNIT	COST	TOTAL COST
2.30	**UNDERDRAINS & CONCRETE TROUGHS**				
	UNDERDRAINS				
	LEOPOLD TYPE XA UNDERDRAINS, FURNISH	24	EA	240,000	**5,760,000**
	LEOPOLD TYPE XA UNDERDRAINS, INSTALL LABOR (10 MIN PER SF X 970 SF X 48 EA)	7,760	MH	65.00	**504,400**
	LEOPOLD TYPE XA UNDERDRAINS, GROUT MATERIAL (3.8 CF PER SF X 970 SF X 48 EA)	6,560	CY	175.00	**1,148,000**
	LEOPOLD SUPPLIER QUOTE PROVIDED BY WAYNE STEEN 724-272-2905				
	CONCRETE TROUGHS				
	PRECAST CONCRETE TROUGHS, FURNISH	384	EA	1,200.00	**460,800**
	PRECAST CONCRETE TROUGHS, INSTALL	384	EA	1,500.00	**576,000**
	INSTALLATION INCLUDES CRANE & CREW, SECURING W/ DOWELS/REBAR & GROUT AT EACH END				
	SUPPLIER QUOTE FROM JENSEN PRECAST, TOM MORALES 909-429-3142				
					-
	SUBTOTAL 2.3				**$ 8,449,200**
2.40	**PLUMBING WORK**				
	SURFACE WASH LATERALS (ONE CELL TYPICAL)				
	SURFACE WASH LATERALS, PVC 2" X 12 LF X 20 EA	240	LF	35.00	**8,400**
	SPRAY NOZZLES, 4 EA X 20 EA	80	EA	150.00	**12,000**
	CONNECT TO HEADER PIPE	20	EA	250.00	**5,000**
	INCLUDES UNISTRUT PIPE SUPPORT				
	BALANCE OF CELLS (47 EA)	47	EA	25,400.00	**1,193,800**
					-
	SUBTOTAL 2.4				**$ 1,219,200**

PROJECT:	F.E. WEYMOUTH WTP FILTER REHAB PROJECT	IEM PROJECT NO:	14-01
LOCATION:	LA VERNE, CA	PREPARED BY:	RW
CLIENT:	METROPOLITAN WATER DISTRICT OF SO. CALIFORNIA	CHECKED BY:	BZ
DESCRIPTION:	FILTER BUILDING NO. 1	ESTIMATE DATE:	02/24/14
		WORK AREA GSF:	N/A

CONCEPTUAL DESIGN ESTIMATE

ITEM #	DESCRIPTION	QUANTITY	UNIT	COST	TOTAL COST
2.50	**FILTER MEDIA REPLACEMENT**				
	FILTER MEDIA FOR ONE TYPICAL CELL (CELL SIZE, 72.5' X 13.34')				
	ANTHRACITE, 26" DEEP, FURNISH	84	CY	215.00	**18,060**
	ANTHRACITE, FREIGHT	84	CY	105.00	**8,820**
	ANTHRACITE, INSTALL	84	CY	75.00	**6,300**
	SUPPLIER QUOTE FROM CARBON SALES, RICK RITTS 800-233-8355				
	RED SAND, 8" DEEP, FURNISH & INSTALL	26	CY	150.00	**3,900**
	NO SOURCE PROVIDED				
	BALANCE OF CELLS (47 EA)	47	EA	37,080.00	**1,742,760**
					-
	SUBTOTAL 2.5				**$ 1,779,840**
2.60	**MISC. PROJECT WORK**				
	DRAIN CHUTE REPAIR (ALLOWANCE)	24	EA	5,000.00	**120,000**
					-
					-
	SUBTOTAL 2.6				**$ 120,000**
3.00	**CONCRETE WORK**				
	INFILL CONCRETE WALLS				
	CONCRETE WALL INFILL, 240 SF X 12" THK INCLUDES EPOXY DOWELS, REBAR, FORMS, PUMP & FINISH	8.9	CY	1,800.00	**16,020**
	BALANCE OF CELLS (47 EA)	47	EA	16,020.00	**752,940**
	PATCH & REPAIR CONCRETE				
	PATCH & REPAIR MISC. CONCRETE CRACKS AT ONE CELL (ALLOWANCE)	48	EA	5,000.00	**240,000**
					-
	SUBTOTAL 3.0				**$ 1,008,960**

PROJECT:	F.E. WEYMOUTH WTP FILTER REHAB PROJECT	IEM PROJECT NO:	14-01
LOCATION:	LA VERNE, CA	PREPARED BY:	RW
CLIENT:	METROPOLITAN WATER DISTRICT OF SO. CALIFORNIA	CHECKED BY:	BZ
DESCRIPTION:	FILTER BUILDING NO. 2	ESTIMATE DATE:	02/24/14
		WORK AREA GSF:	N/A

CONCEPTUAL DESIGN ESTIMATE

ITEM #	DESCRIPTION	QUANTITY	UNIT	COST	TOTAL COST
2.20	DEMOLITION				2,609,210
2.30	UNDERDRAINS & CONCRETE TROUGHS				8,449,200
2.40	PLUMBING WORK				2,623,200
2.50	FILTER MEDIA REPLACEMENT				1,779,840
2.60	MISC. PROJECT WORK				NONE
3.00	CONCRETE WORK				1,008,960
	SUBTOTAL FILTER BUILDING NO. 2				**$ 16,470,410**
	PRORATES				
	GENERAL CONDITIONS	8.00%			1,317,633
	DESIGN CONTINGENCY	15.00%			2,470,562
	ESCALATION	4.00%			658,816
	PHASING ALLOWANCE	2.50%			411,760
	DIRECT COST & PRORATES SUBTOTAL				**$ 21,329,181**
	CONTRACTOR BURDENS				
	BONDS & INSURANCE	1.20%			255,950
	OVERHEAD & PROFIT	8.00%			1,706,334
	TOTAL FILTER BUILDING NO. 2				**$ 23,291,465**

PROJECT:	F.E. WEYMOUTH WTP FILTER REHAB PROJECT	IEM PROJECT NO:	14-01
LOCATION:	LA VERNE, CA	PREPARED BY:	RW
CLIENT:	METROPOLITAN WATER DISTRICT OF SO. CALIFORNIA	CHECKED BY:	BZ
DESCRIPTION:	FILTER BUILDING NO. 2	ESTIMATE DATE:	02/24/14
		WORK AREA GSF:	N/A

CONCEPTUAL DESIGN ESTIMATE

ITEM #	DESCRIPTION	QUANTITY	UNIT	COST	TOTAL COST
2.20	**DEMOLITION**				
	REMOVE FILTER MEDIA (ONE TYPICAL CELL) (CELL SIZE, 72.5' X 13.34')				
	REMOVE (E) ANTHRACITE, 12" DEEP	39	CY	35.00	**1,365**
	REMOVE (E) SAND, 9" DEEP	30	CY	35.00	**1,050**
	REMOVE (E) GRAVEL, 22" DEEP	71	CY	35.00	**2,485**
	BALANCE OF CELLS (47 EA)	47	EA	4,900.00	**230,300**
	MISC. DEMO WORK				
	DEMO (E) CONCRETE TROUGHS & WALL CONNECTIONS (23 EA X 20 EA)	460	EA	1,250.00	**575,000**
	DEMO (E) SURFACE WASH HEADER PIPE & SUPPORT STRIP (FB2 ONLY)	1,728	LF	25.00	**43,200**
	DEMO (E) SURFACE WASH LATERALS, 24 EA X 40 EA	480	EA	150.00	**72,000**
	DEMO (E) SURFACE WASH PIPING (FB2-36 ONLY)	1	EA	1,500.00	**1,500**
	DEMO (E) ROBERTS PLASTIC BLOCK UNDERDRAINS (FB2-36 ONLY)	1,934	SF	15.00	**29,010**
	DEMO (E) CONCRETE UNDERDRAIN "TEEPEES" & REBAR (1,934 SF X 23 EA) (FB2 0NLY)	44,500	SF	10.00	**445,000**
	DEMO (E) UPPER GULLET CONCRETE WALLS (150 SF X 48 EA)	7,200	SF	25.00	**180,000**
	MISC. DEMOLITION (ALLOWANCE)	24	EA	2,500.00	**60,000**
	HAUL & DISPOSAL FEES	1	LS	351,500	**351,500**
	MISC. NON-DEMO ITEMS FOR ONE TYPICAL CELL (CELL SIZE, 72.5' X 13.34')				
	SAWCUT UPPER GULLET CONCRETE WALLS, 12'	160	LF	50.00	**8,000**
	PATCH & REPAIR CELL FLOOR (ALLOWANCE)	970	SF	5.00	**4,850**
	BALANCE OF CELLS (47 EA)	47	EA	12,850.00	**603,950**
					-
	SUBTOTAL 2.2				**$ 2,609,210**

PROJECT:	F.E. WEYMOUTH WTP FILTER REHAB PROJECT	IEM PROJECT NO:	14-01
LOCATION:	LA VERNE, CA	PREPARED BY:	RW
CLIENT:	METROPOLITAN WATER DISTRICT OF SO. CALIFORNIA	CHECKED BY:	BZ
DESCRIPTION:	FILTER BUILDING NO. 2	ESTIMATE DATE:	02/24/14
		WORK AREA GSF:	N/A

CONCEPTUAL DESIGN ESTIMATE

ITEM #	DESCRIPTION	QUANTITY	UNIT	COST	TOTAL COST
2.30	**UNDERDRAINS & CONCRETE TROUGHS**				
	UNDERDRAINS				
	LEOPOLD TYPE XA UNDERDRAINS, FURNISH	24	EA	240,000	**5,760,000**
	LEOPOLD TYPE XA UNDERDRAINS, INSTALL LABOR (10 MIN PER SF X 970 SF X 48 EA)	7,760	MH	65.00	**504,400**
	LEOPOLD TYPE XA UNDERDRAINS, GROUT MATERIAL (3.8 CF PER SF X 970 SF X 48 EA)	6,560	CY	175.00	**1,148,000**
	LEOPOLD SUPPLIER QUOTE PROVIDED BY WAYNE STEEN 724-272-2905				
	CONCRETE TROUGHS				
	PRECAST CONCRETE TROUGHS, FURNISH	384	EA	1,200.00	**460,800**
	PRECAST CONCRETE TROUGHS, INSTALL	384	EA	1,500.00	**576,000**
	INSTALLATION INCLUDES CRANE & CREW, SECURING W/ REBAR & GROUT AT EACH END				
	SUPPLIER QUOTE FROM JENSEN PRECAST, TOM MORALES 909-429-3142				
					-
	SUBTOTAL 2.3				**$ 8,449,200**
2.40	**PLUMBING WORK**				
	SURFACE WASH HEADER (FB2 ONLY)				
	SURFACE WASH HEADER PIPE, SS, 304 SCHD 40, 16'	72	LF	750.00	**54,000**
	CONNECT EACH END, WELD/FLANGE	2	EA	1,500.00	**3,000**
	SANDBLAST & RECOAT WALL PENETRATING SPOOL	1	EA	1,500.00	**1,500**
	INCLUDES PIPE SUPPORT & FILTERS				
	BALANCE OF CELLS (23 EA)	23	EA	58,500.00	**1,345,500**
	SURFACE WASH LATERALS (ONE CELL TYPICAL)				
	SURFACE WASH LATERALS, PVC 2" X 12 LF X 20 EA	240	LF	35.00	**8,400**
	SPRAY NOZZLES	80	EA	150.00	**12,000**
	CONNECT TO HEADER PIPE	20	EA	250.00	**5,000**
	INCLUDES UNISTRUT PIPE SUPPORT				
	BALANCE OF CELLS (47 EA)	47	EA	25,400.00	**1,193,800**
					-
	SUBTOTAL 2.4				**$ 2,623,200**

PROJECT:	F.E. WEYMOUTH WTP FILTER REHAB PROJECT	IEM PROJECT NO:	14-01
LOCATION:	LA VERNE, CA	PREPARED BY:	RW
CLIENT:	METROPOLITAN WATER DISTRICT OF SO. CALIFORNIA	CHECKED BY:	BZ
DESCRIPTION:	FILTER BUILDING NO. 2	ESTIMATE DATE:	02/24/14
		WORK AREA GSF:	N/A

CONCEPTUAL DESIGN ESTIMATE

ITEM #	DESCRIPTION	QUANTITY	UNIT	COST	TOTAL COST
2.50	**FILTER MEDIA REPLACEMENT**				
	FILTER MEDIA FOR ONE TYPICAL CELL (CELL SIZE, 72.5' X 13.34')				
	ANTHRACITE, 26" DEEP, FURNISH	84	CY	215.00	**18,060**
	ANTHRACITE, FREIGHT	84	CY	105.00	**8,820**
	ANTHRACITE, INSTALL	84	CY	75.00	**6,300**
	SUPPLIER QUOTE FROM CARBON SALES, RICK RITTS 800-233-8355				
	RED SAND, 8" DEEP, FURNISH & INSTALL	26	CY	150.00	**3,900**
	NO SOURCE PROVIDED				
	BALANCE OF CELLS (47 EA)	47	EA	37,080.00	**1,742,760**
					-
	SUBTOTAL 2.5				**$ 1,779,840**
2.60	**MISC. PROJECT WORK**				
	NONE				**-**
					-
	SUBTOTAL 2.6				**NONE**
3.00	**CONCRETE WORK**				
	INFILL CONCRETE WALLS				
	CONCRETE WALL INFILL, 240 SF X 12" THK	8.9	CY	1,800.00	**16,020**
	INCLUDES EPOXY DOWELS, REBAR, FORMS, PUMP & FINISH				
	BALANCE OF CELLS (47 EA)	47	EA	16,020.00	**752,940**
	PATCH & REPAIR CONCRETE				
	PATCH & REPAIR MISC. CONCRETE CRACKS AT ONE CELL (ALLOWANCE)	48	EA	5,000.00	**240,000**
					-
	SUBTOTAL 3.0				**$ 1,008,960**

PROJECT:	**F.E. WEYMOUTH WTP FILTER REHAB PROJECT**	IEM PROJECT NO:	**14-01**
LOCATION:	**LA VERNE, CA**	PREPARED BY:	**RW**
CLIENT:	**METROPOLITAN WATER DISTRICT OF SO. CALIFORNIA**	CHECKED BY:	**BZ**
DESCRIPTION:	**OPTIONS**	ESTIMATE DATE:	**02/24/14**
		PROJECT GROSS SQUARE FEET:	**N/A**

CONCEPTUAL DESIGN ESTIMATE

ITEM #	DESCRIPTION	QUANTITY	UNIT	COST	TOTAL COST
	SUMMARY				
1.00	OPT NO. 1 - SURFACE SPRAY NOZZLE DEMO & HOSE BIBB REPLACEMENT				**634,242**
2.00	OPT NO. 2A - DEMO/REPLACE EXISTING ACCESS HATCHES & AIR VENTS				**717,818**
2.10	OPT NO. 2B - DEMO OLD AIR VENT PIPES				**17,819**
2.20	OPT NO. 2C - CUT & DEMO OLD AIR VENT PIPES				**36,627**
3.00	OPT NO. 3 - MOVE/REPLACE UPPER GULLET BAFFLES				**142,546**
4.00	OPT NO. 4A - NEW PRESSURE SENSORS				**448,000**
4.10	OPT NO. 4B - ADDITIONAL PRESSURE SENSORS				**59,960**
5.00	OPT NO. 5 - LIGHTING SYSTEM REMOVAL				**33,151**
6.00	OPT NO. 6 - HANDRAIL REPLACEMENT				**549,223**
7.00	OPT NO. 7A - DEMO & CAP SAND PAN DRAINS				**7,637**
7.10	OPT NO. 7B - REPLACE EXISTING BACK WASH SUMP COVERS				**12,445**
	OPTIONS TOTAL COST				**$ 2,659,468**
	PRORATES				
	GENERAL CONDITIONS	**8.00%**			
	DESIGN CONTINGENCY	**15.00%**			
	ESCALATION	**4.00%**			
	PHASING ALLOWANCE	**2.50%**			
	CONTRACTOR BURDENS				
	BONDS & INSURANCE	**1.20%**			
	OVERHEAD & PROFIT	**8.00%**			

PROJECT:	**F.E. WEYMOUTH WTP FILTER REHAB PROJECT**	IEM PROJECT NO:	**14-01**
LOCATION:	**LA VERNE, CA**	PREPARED BY:	**RW**
CLIENT:	**METROPOLITAN WATER DISTRICT OF SO. CALIFORNIA**	CHECKED BY:	**BZ**
DESCRIPTION:	**OPTIONS**	ESTIMATE DATE:	**02/24/14**
		PROJECT GROSS SQUARE FEET:	**N/A**

CONCEPTUAL DESIGN ESTIMATE

ITEM #	DESCRIPTION	QUANTITY	UNIT	COST	TOTAL COST
1.00	**OPT NO. 1 - SURFACE SPRAY NOZZLE DEMO & HOSE BIBB REPLACEMENT**	**PG 3-15**			
	FILTER BANK 1				
	DEMO (E) NOZZLE LATERALS, 30 LF X 24 EA	720	LF	300.00	**216,000**
	NEW PVC PIPING AT WALL PENETRATION	24	EA	350.00	**8,400**
	NEW HOSE BIBBS, 3/4"	24	EA	75.00	**1,800**
	NEW HOSE BIBBS, 2"	24	EA	200.00	**4,800**
	FILTER BANK 2				
	DEMO (E) NOZZLE LATERALS, 30 LF X 23 EA	690	EA	300.00	**207,000**
	NEW PVC PIPING AT WALL PENETRATION	12	EA	350.00	**4,200**
	NEW HOSE BIBBS, 3/4"	12	EA	75.00	**900**
	NEW HOSE BIBBS, 2"	12	EA	450.00	**5,400**
	DIRECT COST SUBTOTAL				**448,500**
	PRORATES & CONTRACTOR BURDENS			**41.41%**	**185,742**
	TOTAL OPT NO. 1				**$ 634,242**
2.00	**OPT NO. 2A - DEMO/REPLACE EXISTING ACCESS HATCHES & AIR VENTS**	**PG 3-16**			
	FILTER BUILDING 1				
	DEMO (E) PIPE & SPOOL	12	EA	1,100.00	**13,200**
	DEMO (E) ROUND MANHOLES	12	EA	1,100.00	**13,200**
	DEMO (E) SQUARE MANHOLES	12	EA	1,100.00	**13,200**
	INSTALL NEW SS AIR VENT, PIPING & GOOSENECK	24	EA	1,600.00	**38,400**
	INSTALL NEW SS MANHOLE COVERS & FRAMES CAST INTO CONCRETE	24	EA	6,300.00	**151,200**
	BUILDBACK VENT THROUGH GULLET W/ UV COATED PVC PIPE, SS PIPE SPOOL & BIRD SCREEN	24	EA	750.00	**18,000**

PROJECT:	**F.E. WEYMOUTH WTP FILTER REHAB PROJECT**	IEM PROJECT NO:	**14-01**
LOCATION:	**LA VERNE, CA**	PREPARED BY:	**RW**
CLIENT:	**METROPOLITAN WATER DISTRICT OF SO. CALIFORNIA**	CHECKED BY:	**BZ**
DESCRIPTION:	**OPTIONS**	ESTIMATE DATE:	**02/24/14**
		PROJECT GROSS SQUARE FEET:	**N/A**

CONCEPTUAL DESIGN ESTIMATE

ITEM #	DESCRIPTION	QUANTITY	UNIT	COST	TOTAL COST
	FILTER BANK 2				
	DEMO (E) PIPE	24	EA	1,100.00	**26,400**
	DEMO (E) ROUND MANHOLES	24	EA	1,100.00	**26,400**
	INSTALL NEW SS AIR VENT, PIPING & GOOSENECK	24	EA	1,600.00	**38,400**
	INSTALL NEW SS MANHOLE COVERS & FRAMES CAST INTO CONCRETE	24	EA	6,300.00	**151,200**
	BUILDBACK VENT THROUGH GULLET W/ UV COATED PVC PIPE, SS PIPE SPOOL & BIRD SCREEN	24	EA	750.00	**18,000**
	DIRECT COST SUBTOTAL				**507,600**
	PRORATES & CONTRACTOR BURDENS			**41.41%**	**210,218**
	TOTAL OPT NO. 2A				**$ 717,818**
2.10	**OPT NO. 2B - DEMO OLD AIR VENT PIPES**	**PG 3-18**			
	FILTER BANK 1				
	CUT & DEMO (E) CONCRETE & PLATES	7	EA	950.00	**6,650**
	PLUG HOLE WITH CONCRETE & FINISH	7	EA	850.00	**5,950**
	DIRECT COST SUBTOTAL				**12,600**
	PRORATES & CONTRACTOR BURDENS			**41.41%**	**5,219**
	TOTAL OPT NO. 2B				**$ 17,819**
2.20	**OPT NO. 2C - CUT & DEMO OLD AIR VENT PIPES**	**PG 3-17**			
	FILTER BANK 1				
	CUT & DEMO (E) PIPE	14	EA	1,000.00	**14,000**
	PLUG HOLE W/ CONCRETE & FINISH	14	EA	500.00	**7,000**
	DEMO (E) OLD 1" VENT PIPING	14	EA	350.00	**4,900**
	DIRECT COST SUBTOTAL				**25,900**
	PRORATES & CONTRACTOR BURDENS			**41.41%**	**10,727**
	TOTAL OPT NO. 2C				**$ 36,627**
3.00	**OPT NO. 3 - MOVE/REPLACE UPPER GULLET BAFFLES**	**PG 3-18**			
	FILTER BANK 1				
	MOVE/REPLACE UPPER GULLET BAFFLES	72	EA	600.00	**43,200**
	INCLUDES UNISTRUT SUPPORT				

PROJECT:	**F.E. WEYMOUTH WTP FILTER REHAB PROJECT**	IEM PROJECT NO:	**14-01**
LOCATION:	**LA VERNE, CA**	PREPARED BY:	**RW**
CLIENT:	**METROPOLITAN WATER DISTRICT OF SO. CALIFORNIA**	CHECKED BY:	**BZ**
DESCRIPTION:	**OPTIONS**	ESTIMATE DATE:	**02/24/14**
		PROJECT GROSS SQUARE FEET:	**N/A**

CONCEPTUAL DESIGN ESTIMATE

ITEM #	DESCRIPTION	QUANTITY	UNIT	COST	TOTAL COST
	FILTER BANK 2				
	DEMO/REPLACE UPPER GULLET BAFFLES	72	EA	800.00	**57,600**
	INCLUDES UNISTRUT SUPPORT				**-**
	DIRECT COST SUBTOTAL				**100,800**
	PRORATES & CONTRACTOR BURDENS			**41.41%**	**41,746**
	TOTAL OPT NO. 3				**$ 142,546**
4.00	**OPT NO. 4A - NEW PRESSURE SENSORS**	**PG 3-19**			
	FILTER BANK 1				
	ROSEMOUNT 3051 PRESSURE SENSORS, BASE AMOUNT, FURNISH	48	EA	2,600.00	**124,800**
	INSTALL NEW PRESSURE SENSORS W/ INLET SCREENS	48	EA	400.00	**19,200**
	PRESSURE SENSOR START-UP ASSISTANCE	48	EA	75.00	**3,600**
	MODIFY (E) DP CELL INLETS W/ NEW SUCTION STRAINERS	24	EA	100.00	**2,400**
	FILTER BANK 2				
	ROSEMOUNT 3051 PRESSURE SENSORS, BASE AMOUNT, FURNISH	48	EA	2,600.00	**124,800**
	INSTALL NEW PRESSURE SENSORS W/ PIPING & INLET SCREENS	48	EA	750.00	**36,000**
	PRESSURE SENSOR START-UP ASSISTANCE	48	EA	75.00	**3,600**
	MODIFY (E) DP CELL INLETS W/ NEW SUCTION STRAINERS	24	EA	100.00	**2,400**
	SUPPLIER QUOTE FROM ROSEMOUNT INC., CASEY HANLON 800-999-9307				
	DIRECT COST SUBTOTAL				**316,800**
	PRORATES & CONTRACTOR BURDENS			**41.41%**	**131,200**
	TOTAL OPT NO. 4A				**$ 448,000**

PROJECT:	**F.E. WEYMOUTH WTP FILTER REHAB PROJECT**	IEM PROJECT NO:	**14-01**
LOCATION:	**LA VERNE, CA**	PREPARED BY:	**RW**
CLIENT:	**METROPOLITAN WATER DISTRICT OF SO. CALIFORNIA**	CHECKED BY:	**BZ**
DESCRIPTION:	**OPTIONS**	ESTIMATE DATE:	**02/24/14**
		PROJECT GROSS SQUARE FEET:	**N/A**

CONCEPTUAL DESIGN ESTIMATE

ITEM #	DESCRIPTION	QUANTITY	UNIT	COST	TOTAL COST
4.10	**OPT NO. 4B - ADDITIONAL PRESSURE SENSORS**	**PG 3-20**			
	ROSEMOUNT 3051 PRESSURE SENSORS, ADDITIONAL, FURNISH	8	EA	2,600.00	**20,800**
	INSTALL ADDITIONAL PRESSURE SENSORS W/ PIPING & INLET SCREENS	8	EA	750.00	**6,000**
	PRESSURE SENSOR START-UP ASSISTANCE	8	EA	75.00	**600**
	CONDUIT & WIRING (ALLOWANCE)	1,000	LF	15.00	**15,000**
	SUPPLIER QUOTE FROM ROSEMOUNT INC., CASEY HANLON 800-999-9307				
	DIRECT COST SUBTOTAL				**42,400**
	PRORATES & CONTRACTOR BURDENS			**41.41%**	**17,560**
	TOTAL OPT NO. 4B				**$ 59,960**
5.00	**OPT NO. 5 - LIGHTING SYSTEM REMOVAL**	**PG 3-21**			
	FILTER BANK 1				
	DEMO (E) JUNCTION BOXES	8	EA	75.00	**600**
	DEMO (E) CONDUIT RACKS, 7 EA X 3 EA	21	EA	130.00	**2,730**
	DEMO (E) ELECTRICAL CONDUIT, 160 LF X 2 EA	320	LF	2.00	**640**
	DEMO (E) ELECTRICAL LIGHTS, 12 EA X 2 EA	24	EA	10.00	**240**
	BURN BACK ANCHORS 1" & FILL HOLES WITH NON-SHRINK EPOXY GROUT, 12 EA X 6 EA	72	EA	30.00	**2,160**
	FILTER BANK 2				
	DEMO (E) ELECTRICAL CONDUIT, 160 LF X 19 EA	3,040	LF	2.00	**6,080**
	DEMO (E) ELECTRICAL LIGHTS, 12 EA X 19 EA	228	EA	10.00	**2,280**
	BURN BACK ANCHORS 1" & FILL HOLES WITH NON-SHRINK EPOXY GROUT, 12 EA X 24 EA	288	EA	30.00	**8,640**
	CAP OPEN PIPE	24	EA	3.00	**72**
	DIRECT COST SUBTOTAL				**23,442**
	PRORATES & CONTRACTOR BURDENS			**41.41%**	**9,709**
	TOTAL OPT NO. 5				**$ 33,151**

PROJECT:	**F.E. WEYMOUTH WTP FILTER REHAB PROJECT**	IEM PROJECT NO:	**14-01**
LOCATION:	**LA VERNE, CA**	PREPARED BY:	**RW**
CLIENT:	**METROPOLITAN WATER DISTRICT OF SO. CALIFORNIA**	CHECKED BY:	**BZ**
DESCRIPTION:	**OPTIONS**	ESTIMATE DATE:	**02/24/14**
		PROJECT GROSS SQUARE FEET:	**N/A**

CONCEPTUAL DESIGN ESTIMATE

ITEM #	DESCRIPTION	QUANTITY	UNIT	COST	TOTAL COST
6.00	**OPT NO. 6 - HANDRAIL REPLACEMENT**	**PG 3-22**			
	FILTER BANK 1 WEST				
	DEMO (E) METAL HANDRAILS & GATES	954	LF	12.00	**11,448**
	NEW ALUMINUM HANDRAILS	954	LF	75.00	**71,550**
	NEW ALUMINUM STAIR HANDRAIL SETS	2	EA	750.00	**1,500**
	NEW ALUMINUM MAN GATES	12	EA	350.00	**4,200**
	NEW ALUMINUM BACKWASH GATES	12	EA	350.00	**4,200**
	NEW LADDER	1	EA	2,500.00	**2,500**
	GROUT CONCRETE HOLES	1	LS	200.00	**200**
	REMOVE & REINSTALL LIGHT POLES	3	EA	1,200.00	**3,600**
	FILTER BANK 1 EAST				
	DEMO (E) METAL HANDRAILS & GATES	954	LF	12.00	**11,448**
	NEW ALUMINUM HANDRAILS	954	LF	75.00	**71,550**
	NEW ALUMINUM MAN GATES	12	EA	350.00	**4,200**
	NEW ALUMINUM BACKWASH GATES	12	EA	350.00	**4,200**
	REMOVE & REINSTALL LIGHT POLES	3	EA	1,200.00	**3,600**
	FILTER BANK 2 WEST				
	DEMO (E) METAL HANDRAILS & GATES	954	LF	12.00	**11,448**
	NEW ALUMINUM HANDRAILS	954	LF	75.00	**71,550**
	NEW ALUMINUM MAN GATES	12	EA	350.00	**4,200**
	NEW ALUMINUM BACKWASH GATES	12	EA	350.00	**4,200**
	REMOVE & REINSTALL LIGHT POLES	3	EA	1,200.00	**3,600**
	FILTER BANK 2 EAST				
	DEMO (E) METAL HANDRAILS & GATES	1,005	LF	12.00	**12,060**
	NEW ALUMINUM HANDRAILS	1,005	LF	75.00	**75,375**
	NEW ALUMINUM STAIR HANDRAIL SETS	1	EA	750.00	**750**
	NEW ALUMINUM MAN GATES	12	EA	350.00	**4,200**
	NEW ALUMINUM BACKWASH GATES	12	EA	350.00	**4,200**
	GROUT CONCRETE HOLES	1	LS	200.00	**200**
	REMOVE & REINSTALL LIGHT POLES	2	EA	1,200.00	**2,400**
	DIRECT COST SUBTOTAL				**388,379**
	PRORATES & CONTRACTOR BURDENS			**41.41%**	**160,844**
	TOTAL OPT NO. 6				**$ 549,223**

PROJECT:	**F.E. WEYMOUTH WTP FILTER REHAB PROJECT**	IEM PROJECT NO:	**14-01**
LOCATION:	**LA VERNE, CA**	PREPARED BY:	**RW**
CLIENT:	**METROPOLITAN WATER DISTRICT OF SO. CALIFORNIA**	CHECKED BY:	**BZ**
DESCRIPTION:	**OPTIONS**	ESTIMATE DATE:	**02/24/14**
		PROJECT GROSS SQUARE FEET:	**N/A**

CONCEPTUAL DESIGN ESTIMATE

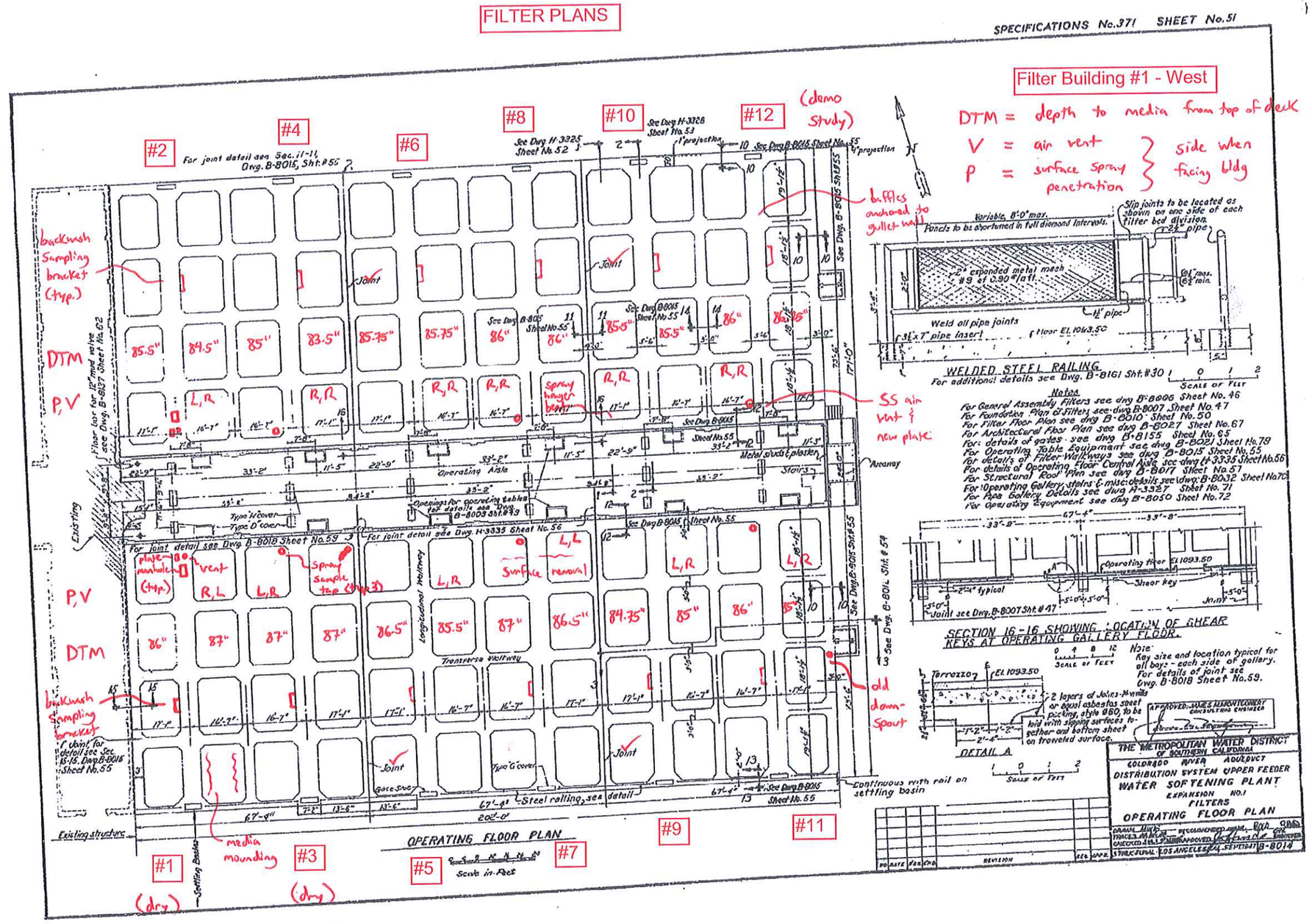
ITEM #	DESCRIPTION	QUANTITY	UNIT	COST	TOTAL COST
7.00	**OPT NO. 7A - DEMO & CAP SAND PAN DRAINS**				
	FILTER BANK 2 EAST				
	DEMO (E) SAND PAN DRAINS & GENERATOR VENTS	3	EA	800.00	**2,400**
	PLUG HOLE W/ CONRETE & DINISH	3	EA	1,000.00	**3,000**
	DIRECT COST SUBTOTAL				**5,400**
	PRORATES & CONTRACTOR BURDENS			**41.41%**	**2,237**
	TOTAL OPT NO. 7A				**$ 7,637**
7.10	**OPT NO. 7B - REPLACE EXISTING BACK WASH SUMP COVERS**				
	FILTER BANK 2 EAST				
	DEMO (E) SUMP COVERS	2	EA	400.00	**800**
	NEW SS SUMP COVERS, 74" X 74"	2	EA	4,000.00	**8,000**
					-
	DIRECT COST SUBTOTAL				**8,800**
	PRORATES & CONTRACTOR BURDENS			**41.41%**	**3,645**
	TOTAL OPT NO. 7B				**$ 12,445**

Appendix I

Site Survey

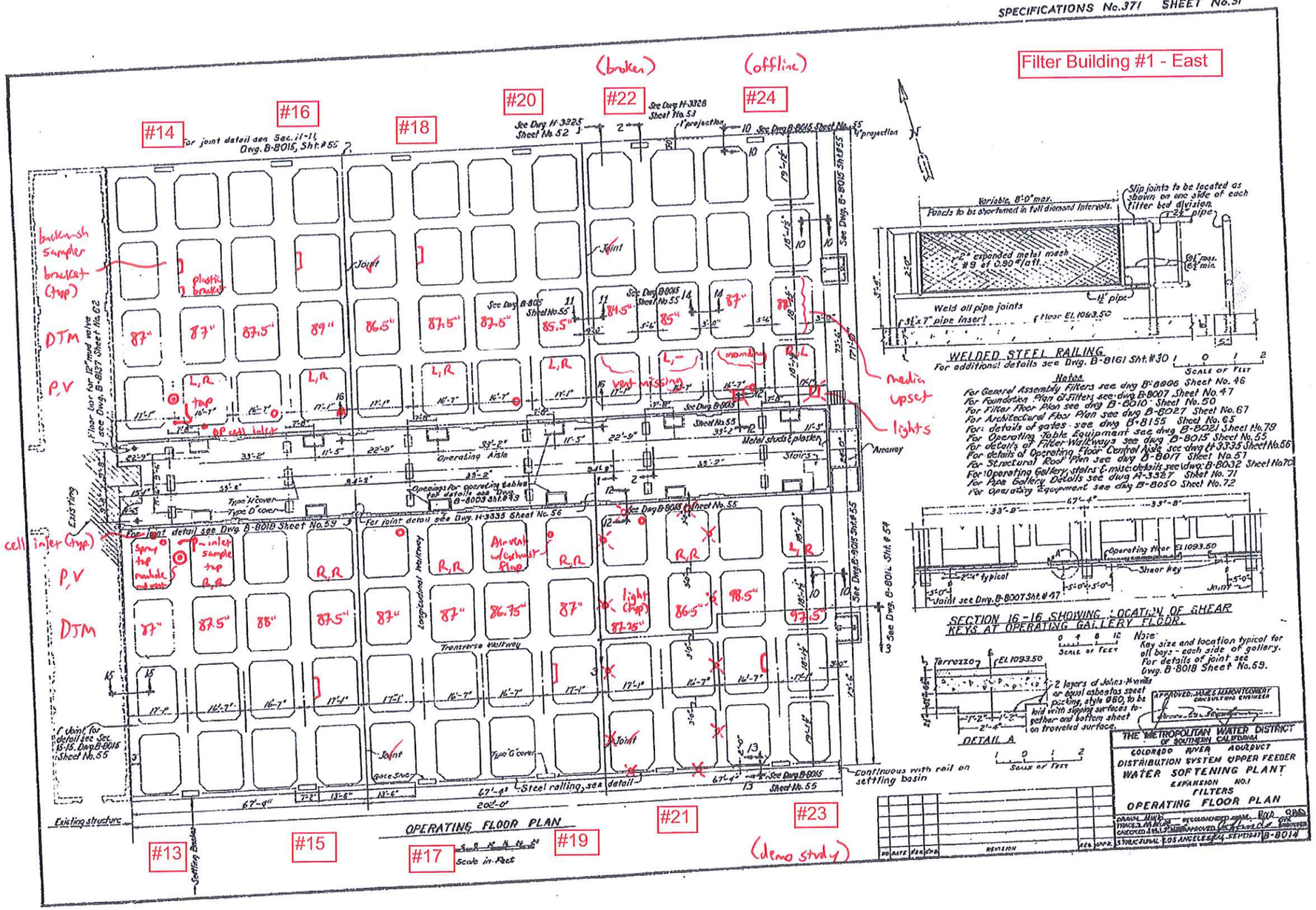
FILTER PLANS

Field Notes
MJA and EF
11/15/2013



B 8014

REFERENCE DRAWING



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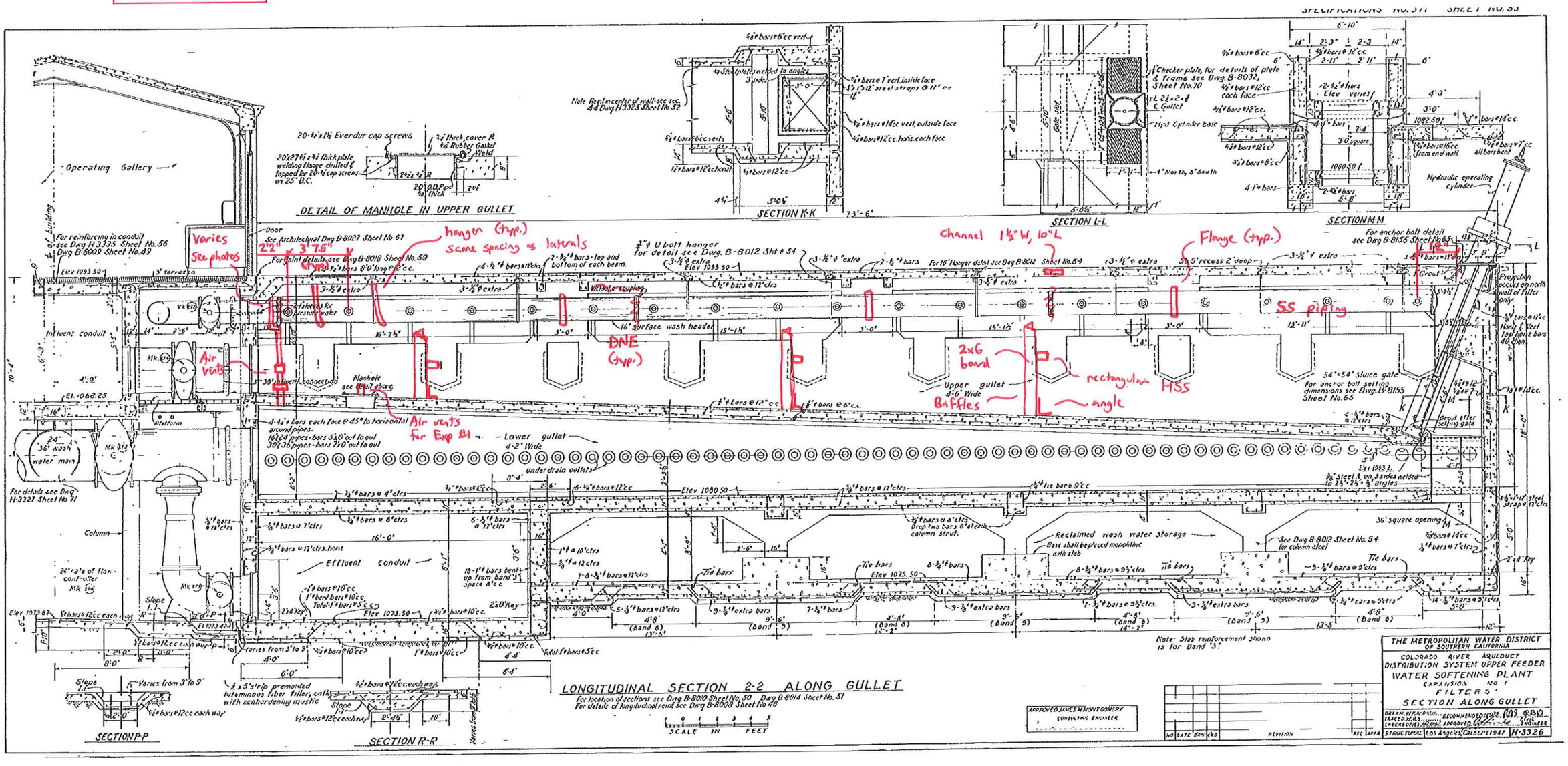
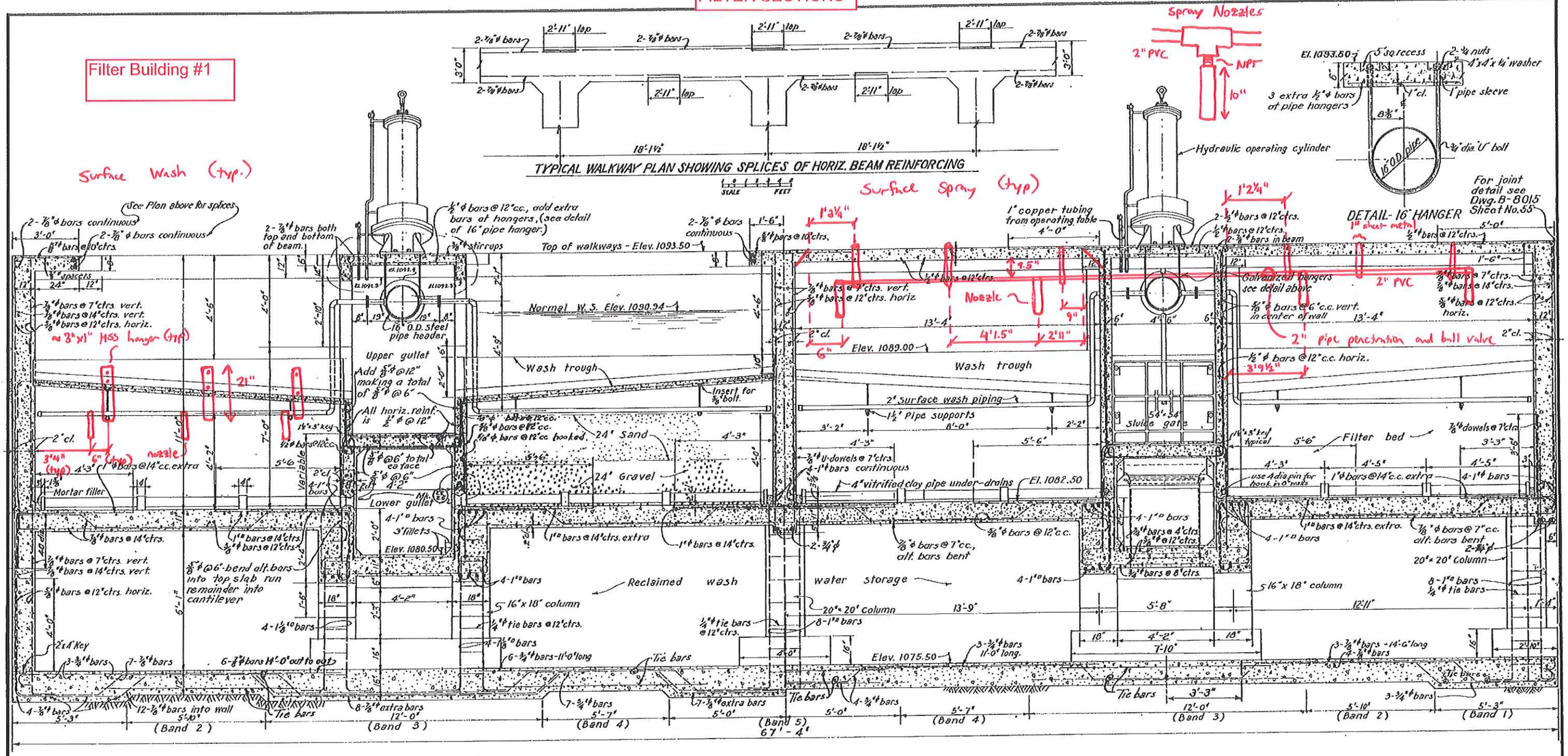
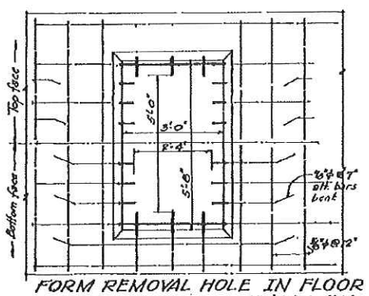
Filter Building #1



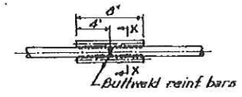
Filter Building #1

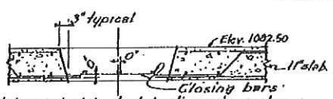




FORM REMOVAL HOLE IN FLOOR OF FILTER BEDS 13 & 14 ONLY
See Dwg. B 8010, sht. 50 for location.

Note: Slab reinforcement steel shown is for Band 'B'. See Dwg. B-8008 Sheet No 48



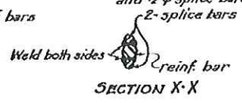


Notes: Cut slab steel to dimensions shown. Replace removed steel with bars of equal size by means of welded joint per detail hereon. Leave adequate shoring inplace under filter floor until opening is filled and concrete has attained at least 2600 p.s.i. strength.

TRANSVERSE SECTION 3-3

For location of section see Dwg. B-8010 Sheet No. 50 & Dwg. B-8014 Sheet No. 51

Use 5/8" ϕ splice bars for 7/8" ϕ reinf. and 1/2" ϕ splice bars for 5/8" ϕ reinf.



SECTION X-X

SCALE FEET

Note: Slab reinforcement steel shown is for Band 'B'. See Dwg. B-8008 Sheet No. 48

APPROVED: JAMES M. MONTGOMERY CONSULTING ENGINEER

NO.	DATE	DWN.	CKD.	REVISION	REC.	APPR.
4	1/31/50	J.J.	R.K.	As constructed		
3	6/6/48	W.N.	J.L.	Added form removal hole - changed reinf. Sect. 5-5	RBB	RBB
2	4/10/48	M.S.P.	J.L.	Changed reinf. bar lengths & added dimensions	RBB	RBB
1	9/5/47	M.S.	J.L.	Added Reinforcing - revise bar spacing	RBB	RBB

THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

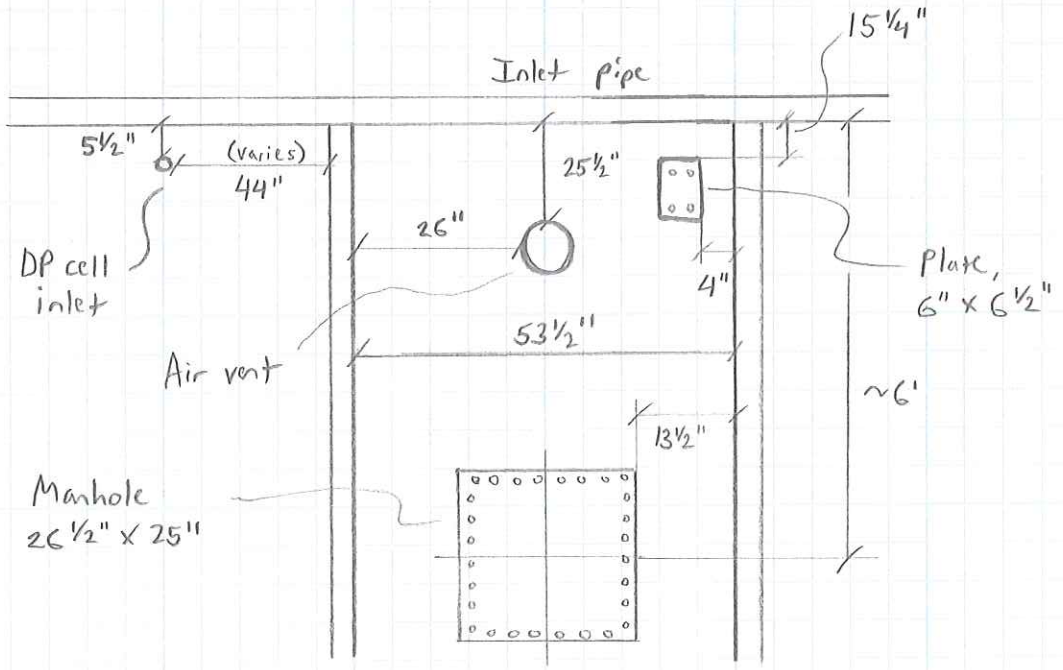
COLORADO RIVER AQUEDUCT
DISTRIBUTION SYSTEM UPPER FEEDER
WATER SOFTENING PLANT
EXPANSION NO. 1
FILTERS
TRANSVERSE SECTION THROUGH BEDS

DRAWN: J.H.K.-W.R.K. TRACED: E.H.K.-W.R.K. CHECKED: J.M.L.-J.D. RECOMMENDED: RBB CHIEF ENGINEER APPROVED: CHIEF ENGINEER
STRUCTURAL Los Angeles, Cal. SEPT. 1947 B-8012

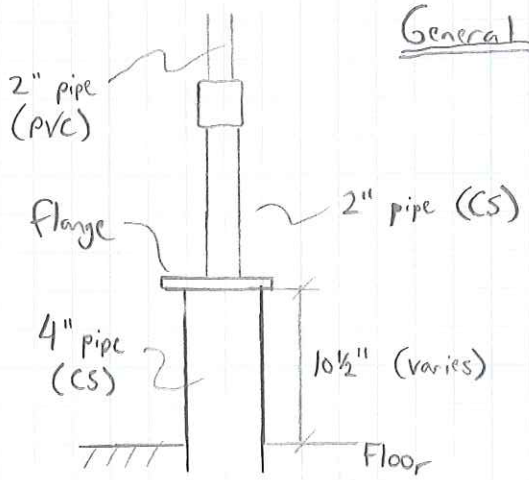
MWH

By SC Date 12/2/2013 Client MWD - Weymouth Filter Rehab Sheet 1 of 2

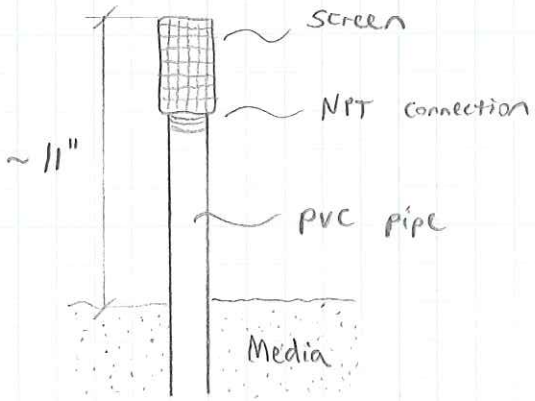
Chkd. By MJA Description FB1 - Filter #6 Upper Gullet Job No. 10503518



General Plan View



Air Vent Detail

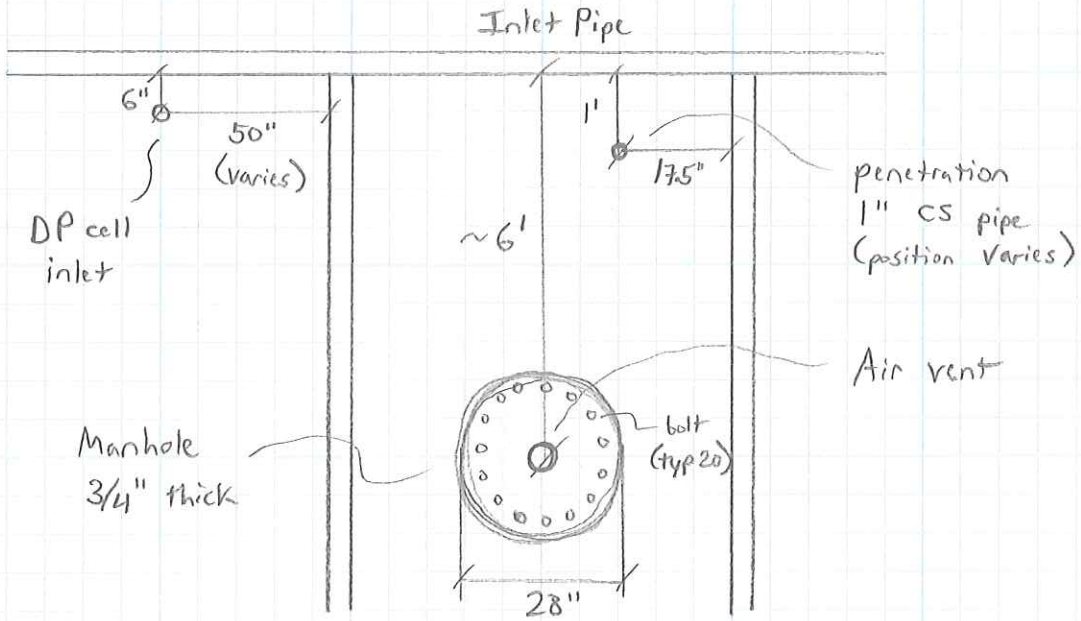


DP Cell Inlet Detail

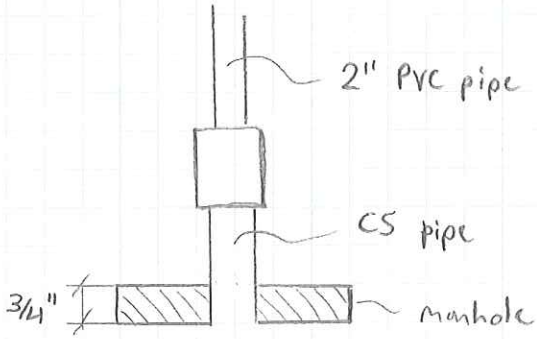
MWH

By MJA Date 12/2/2013 Client MWD - Weymouth Filter Rehab Sheet 2 of 2

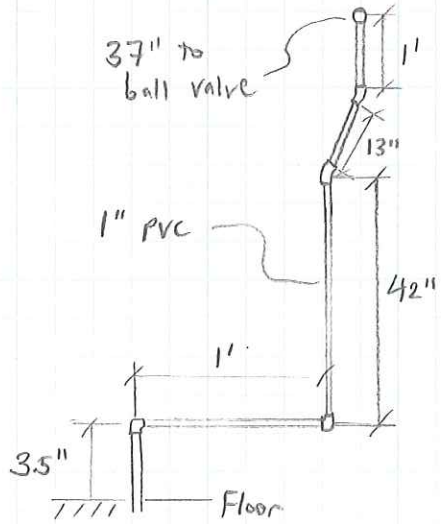
Chkd. By SC Description FB1 - Filter #21 Upper Gullet Job No. 10503518



General Plan View

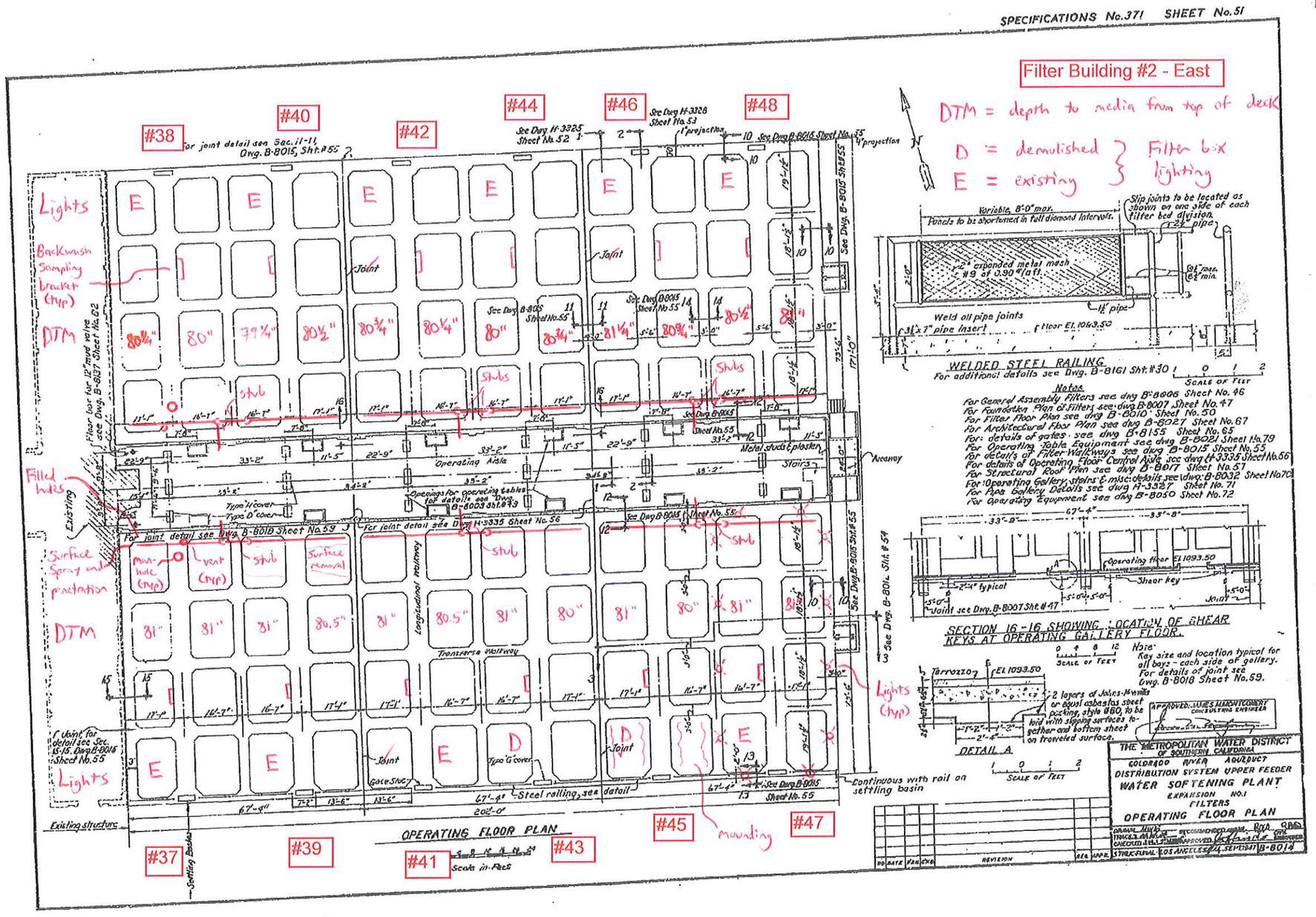


Newer Air Vent Detail



Older Air Vent Detail

Field Notes
MJA and EF
12/2/2013



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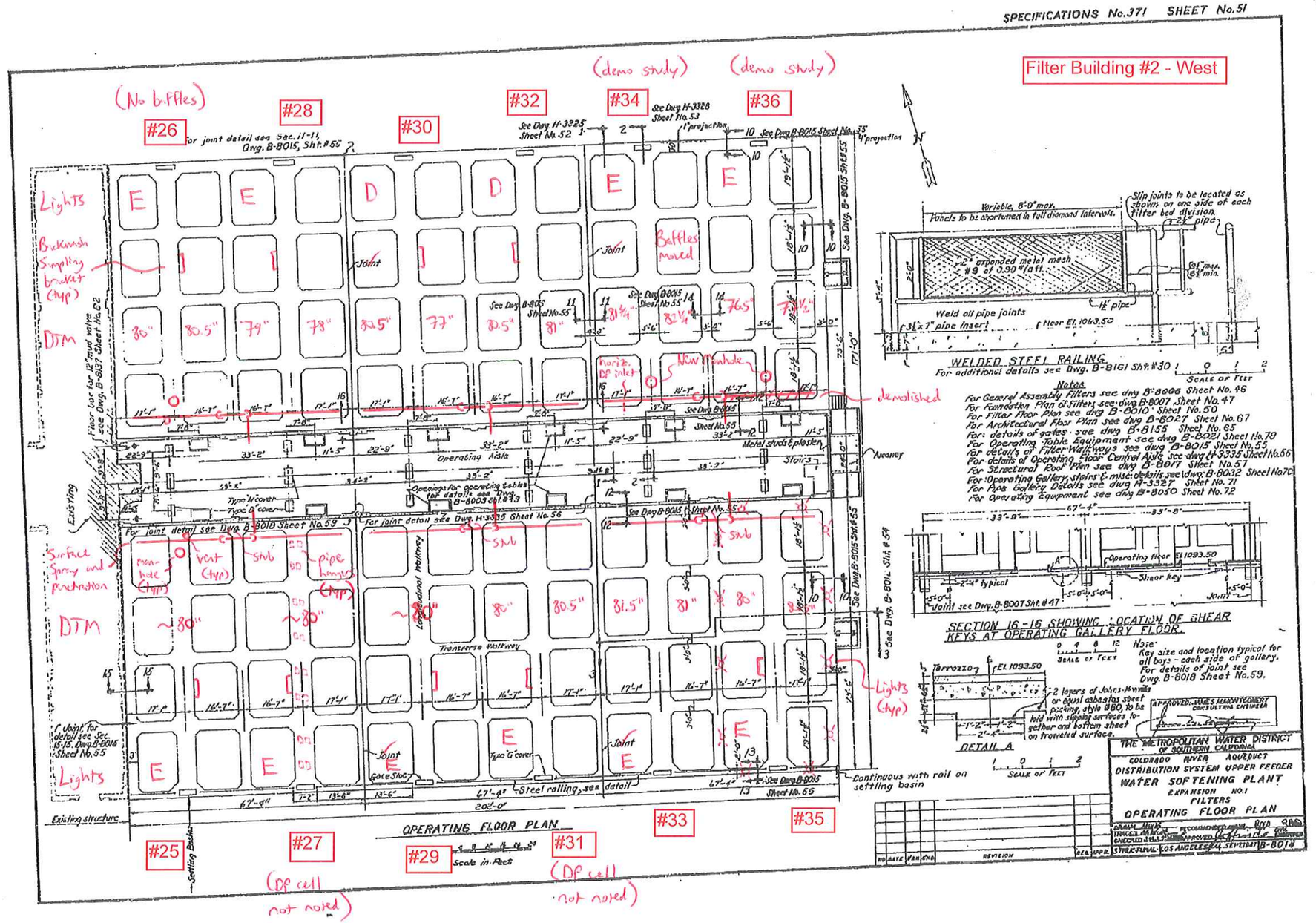
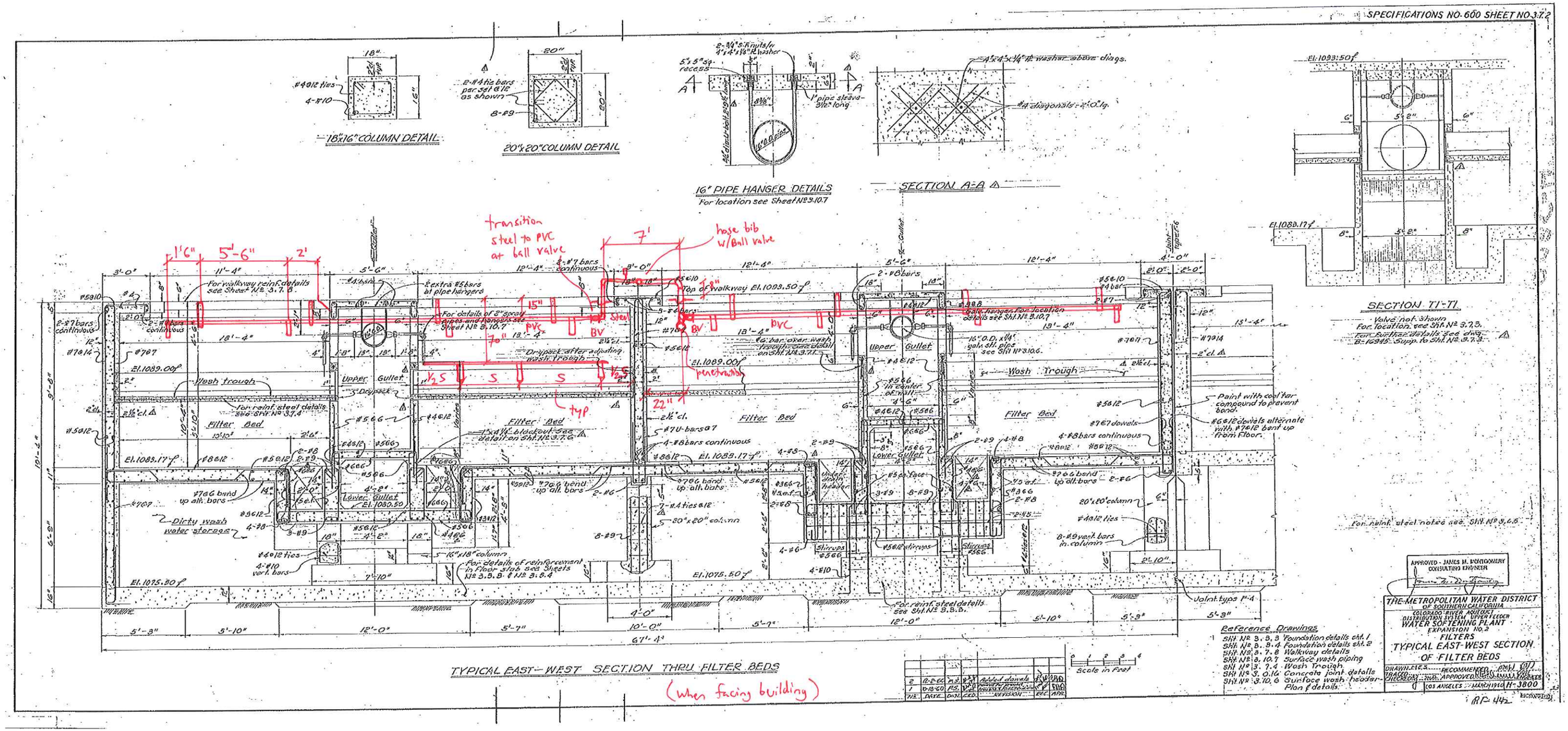


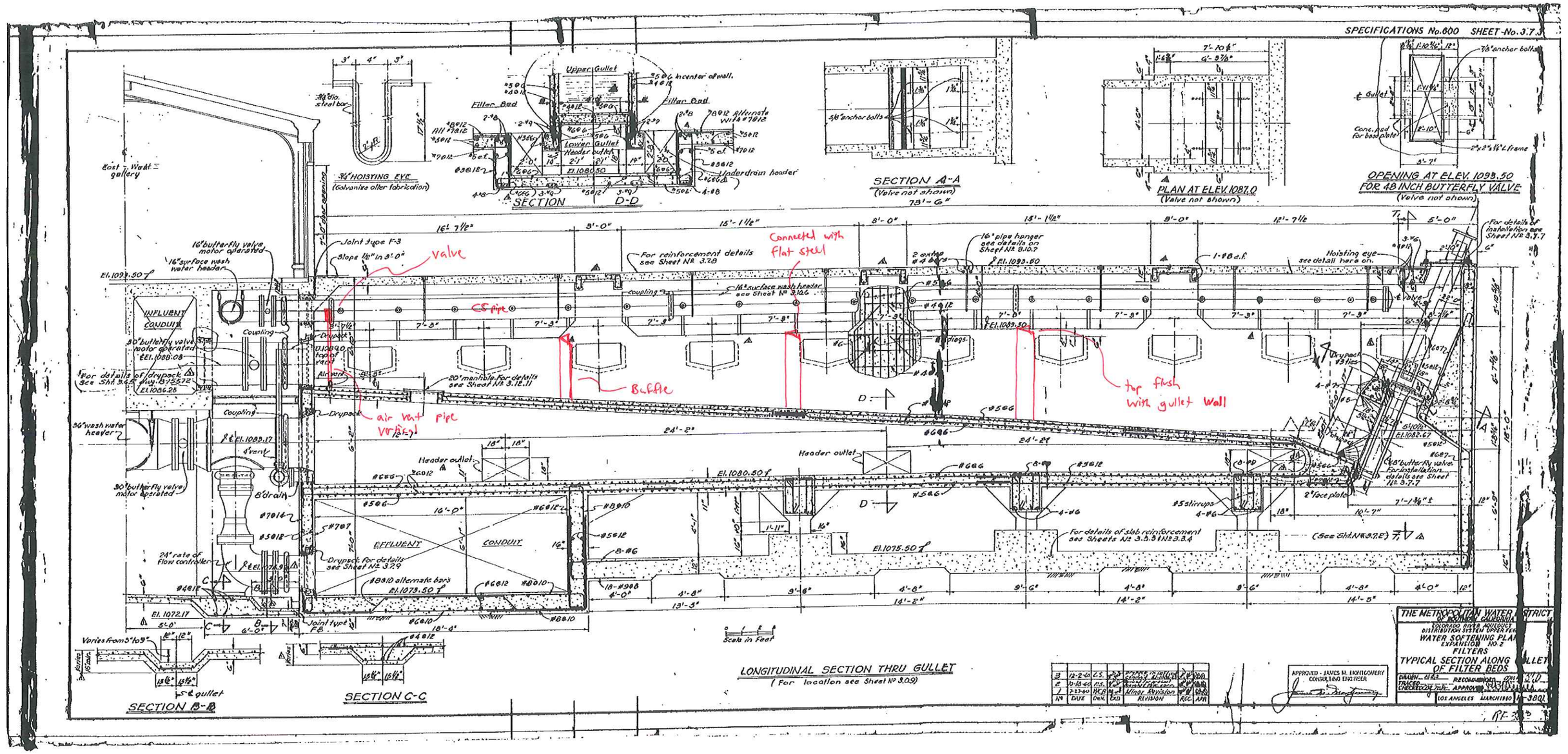
B 8014

REFERENCE DRAWING

Filter Building #2



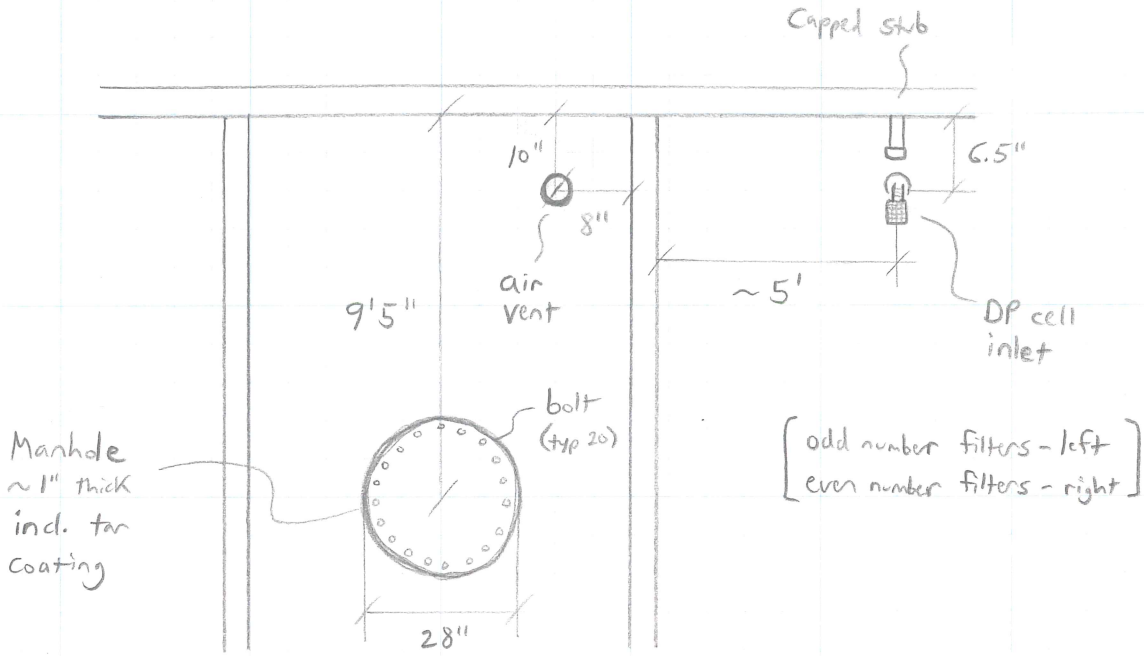
Filter Building #2



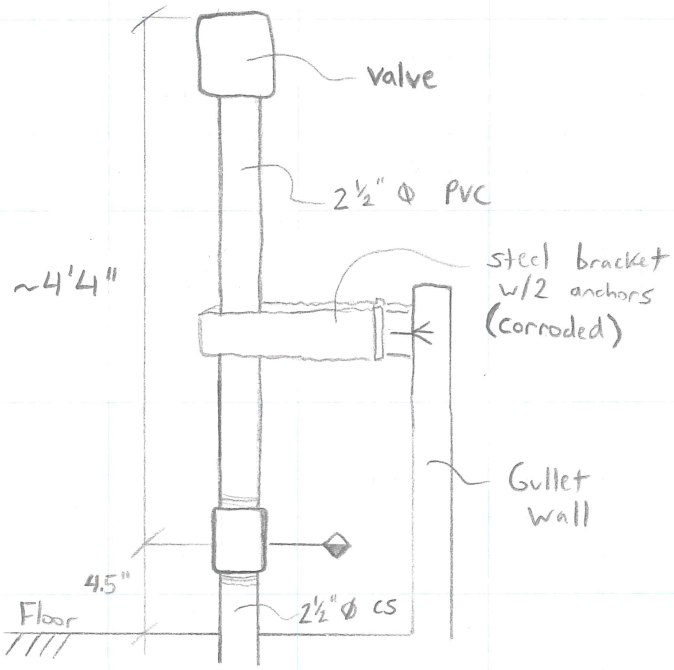
MWH®

By MJA Date 01/23/2014 Client MWD - Weymouth Filter Rehab Sheet 1 of 1

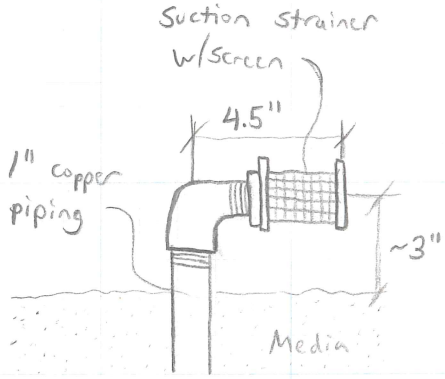
Chkd. By TH Description FB 2 - Filter #32 Upper Gullet Job No. 10503518



General Plan View



Air Vent Detail



DP Cell Inlet Detail

Legend

Photo Location and Direction

MWH

29 Nov 2013

Filer Rehabilitation Project

Weymouth Water Treatment Plant - Filter Building 1

Client:	**Metropolitan Water District**	**Project:**	**Filer Rehabilitation Project**
Site Name:	**Filter Building 1**	**Site Location:**	**Weymouth Water Treatment Plant - Filter Building 1**

Photograph ID: 1

Photo Location:
Filter Building 1. Filters #1, #3, #5, #7, #9, #11.

Survey Date:
11/14/2013

Comments:
South-west corner junction. The handrail from FB1 is merging with the one from the settling basins.

Photograph ID: 2

Photo Location:
Filter Building 1. Filters #1, #3, #5, #7, #9, #11.

Survey Date:
11/14/2013

Comments:
Electrical equipment and pipe interference.

Client:	**Metropolitan Water District**	**Project:**	**Filer Rehabilitation Project**
Site Name:	**Filter Building 1**	**Site Location:**	**Weymouth Water Treatment Plant - Filter Building 1**

Photograph ID: 3

Photo Location:
Filter Building 1. Filters #1, #3, #5, #7, #9, #11.

Survey Date:
11/14/2013

Comments:
Access ladder.

Photograph ID: 4

Photo Location:
Filter Building 1. Filters #1, #3, #5, #7, #9, #11.

Survey Date:
11/14/2013

Comments:
Stairs.

Client:	**Metropolitan Water District**	**Project:**	**Filer Rehabilitation Project**
Site Name:	**Filter Building 1**	**Site Location:**	**Weymouth Water Treatment Plant - Filter Building 1**

Photograph ID: 5

Photo Location:
Filter Building 1. Filters #1, #3, #5, #7, #9, #11.

Survey Date:
11/14/2013

Comments:
Stairs. Do not replace the handrail.

Photograph ID: 6

Photo Location:
Filter Building 1. Filters #1, #3, #5, #7, #9, #11.

Survey Date:
11/14/2013

Comments:
Access door.

Client:	**Metropolitan Water District**	**Project:**	**Filer Rehabilitation Project**
Site Name:	**Filter Building 1**	**Site Location:**	**Weymouth Water Treatment Plant - Filter Building 1**

Photograph ID: 7

Photo Location:
Filter Building 1. Filters #1, #3, #5, #7, #9, #11.

Survey Date:
11/14/2013

Comments:
Joint.

Photograph ID: 8

Photo Location:
Filter Building 1. Filters #1, #3, #5, #7, #9, #11.

Survey Date:
11/14/2013

Comments:
Joint.

Client:	**Metropolitan Water District**	**Project:**	**Filer Rehabilitation Project**
Site Name:	**Filter Building 1**	**Site Location:**	**Weymouth Water Treatment Plant - Filter Building 1**

Photograph ID: 9

Photo Location:
Filter Building 1. Filters #1, #3, #5, #7, #9, #11.

Survey Date:
11/14/2013

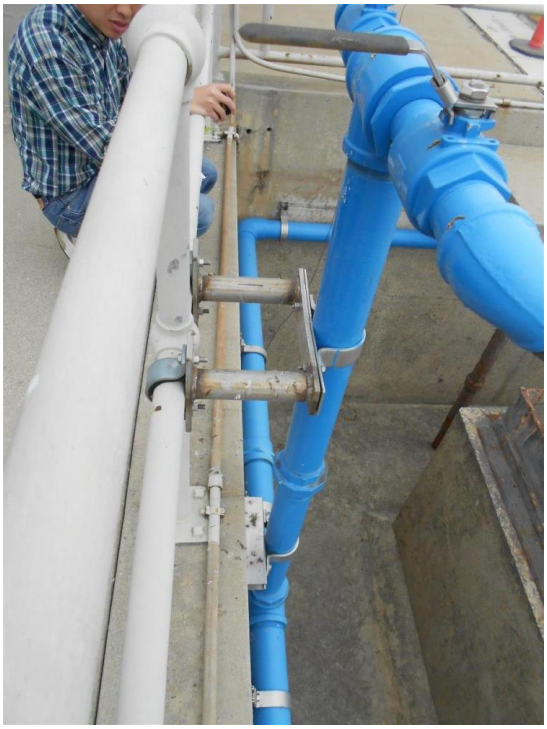
Comments:
Handrail junction between the settling basin and filter #11.

Photograph ID: 10

Photo Location:
Filter Building 1. Filters #1, #3, #5, #7, #9, #11.

Survey Date:
11/14/2013

Comments:
Attached basin wash-down water piping and pipe support.



Client:	**Metropolitan Water District**	**Project:**	**Filer Rehabilitation Project**
Site Name:	**Filter Building 1**	**Site Location:**	**Weymouth Water Treatment Plant - Filter Building 1**

Photograph ID: 11

Photo Location:
Filter Building 1. Filters #1, #3, #5, #7, #9, #11.

Survey Date:
11/14/2013

Comments:
Lamp layout.

Photograph ID: 12

Photo Location:
Filter Building 1. Filters #1, #3, #5, #7, #9, #11.

Survey Date:
11/14/2013

Comments:
Handrail layout at gate locations and light system.

Client:	**Metropolitan Water District**	**Project:**	**Filer Rehabilitation Project**
Site Name:	**Filter Building 1**	**Site Location:**	**Weymouth Water Treatment Plant - Filter Building 1**

Photograph ID: 13

Photo Location:
Filter Building 1. Filters #1, #3, #5, #7, #9, #11.

Survey Date:
11/14/2013

Comments:
Attached basin wash-down water piping and pipe support.

Photograph ID: 14

Photo Location:
Filter Building 1. Filters #1, #3, #5, #7, #9, #11.

Survey Date:
11/14/2013

Comments:
Attached basin wash-down water piping and pipe support.

Client:	**Metropolitan Water District**	**Project:**	**Filer Rehabilitation Project**
Site Name:	**Filter Building 1**	**Site Location:**	**Weymouth Water Treatment Plant - Filter Building 1**

Photograph ID: 15

Photo Location:
Filter Building 1. Filters #2, #4, #6, #8, #10, #12.

Survey Date:
11/14/2013

Comments:
South-west corner junction.

Photograph ID: 16

Photo Location:
Filter Building 1. Filters #2, #4, #6, #8, #10, #12.

Survey Date:
11/14/2013

Comments:
North-west corner.

Client:	**Metropolitan Water District**	**Project:**	**Filer Rehabilitation Project**
Site Name:	**Filter Building 1**	**Site Location:**	**Weymouth Water Treatment Plant - Filter Building 1**

Photograph ID: 17

Photo Location:
Filter Building 1. Filters #2, #4, #6, #8, #10, #12.

Survey Date:
11/14/2013

Comments:
Gate layout.

Photograph ID: 18

Photo Location:
Filter Building 1. Filters #2, #4, #6, #8, #10, #12.

Survey Date:
11/14/2013

Comments:
Joint.

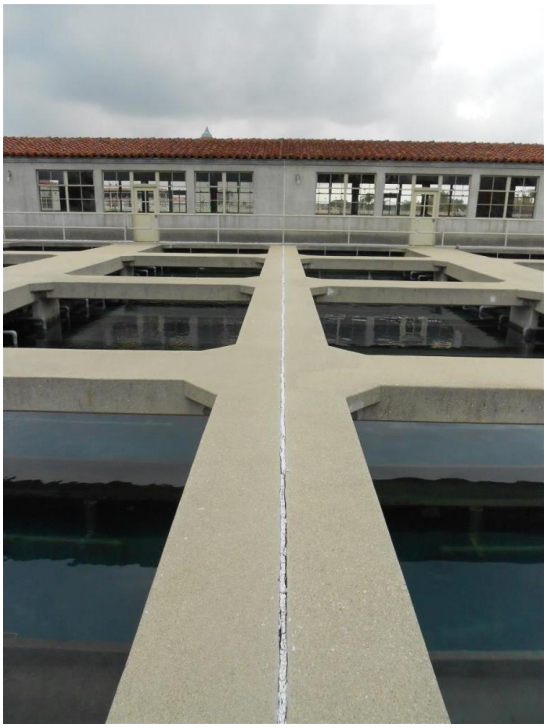
Client:	**Metropolitan Water District**	**Project:**	**Filer Rehabilitation Project**
Site Name:	**Filter Building 1**	**Site Location:**	**Weymouth Water Treatment Plant - Filter Building 1**

Photograph ID: 19

Photo Location:
Filter Building 1. Filters #2, #4, #6, #8, #10, #12.

Survey Date:
11/14/2013

Comments:
Joint.



Photograph ID: 20

Photo Location:
Filter Building 1. Filters #2, #4, #6, #8, #10, #12.

Survey Date:
11/14/2013

Comments:
Handrail support and joint.

Client:	**Metropolitan Water District**	**Project:**	**Filer Rehabilitation Project**
Site Name:	**Filter Building 1**	**Site Location:**	**Weymouth Water Treatment Plant - Filter Building 1**

Photograph ID: 21

Photo Location:
Filter Building 1. Filters #2, #4, #6, #8, #10, #12.

Survey Date:
11/14/2013

Comments:
Handrail support and joint.

Photograph ID: 22

Photo Location:
Filter Building 1. North entrance.

Survey Date:
11/14/2013

Comments:
Entrance stairs hand-rail.

Client:	**Metropolitan Water District**	**Project:**	**Filer Rehabilitation Project**
Site Name:	**Filter Building 1**	**Site Location:**	**Weymouth Water Treatment Plant - Filter Building 1**

Photograph ID: 23

Photo Location:
Filter Building 1. North entrance.

Survey Date:
11/14/2013

Comments:
Entrance gate, electrical equipment and additional lateral stairs (west of the north entrance).

Photograph ID: 24

Photo Location:
Filter Building 1. North entrance.

Survey Date:
11/14/2013

Comments:
Lateral stairs west of the north entrance.

Client:	**Metropolitan Water District**	**Project:**	**Filer Rehabilitation Project**
Site Name:	**Filter Building 1**	**Site Location:**	**Weymouth Water Treatment Plant - Filter Building 1**

Photograph ID: 25

Photo Location:
Filter Building 1. Filters #13, #15, #17, #19, #21, #23.

Survey Date:
11/15/2013

Comments:
Gates and handrail overview.

Photograph ID: 26

Photo Location:
Filter Building 1. Filters #13, #15, #17, #19, #21, #23.

Survey Date:
11/15/2013

Comments:
Gate layout.

Client:	**Metropolitan Water District**	**Project:**	**Filer Rehabilitation Project**
Site Name:	**Filter Building 1**	**Site Location:**	**Weymouth Water Treatment Plant - Filter Building 1**

Photograph ID: 27

Photo Location:
Filter Building 1. Filters #13, #15, #17, #19, #21, #23.

Survey Date:
11/15/2013

Comments:
Joint.

Photograph ID: 28

Photo Location:
Filter Building 1. Filters #13, #15, #17, #19, #21, #23.

Survey Date:
11/15/2013

Comments:
Joint.

Client:	**Metropolitan Water District**	**Project:**	**Filer Rehabilitation Project**
Site Name:	**Filter Building 1**	**Site Location:**	**Weymouth Water Treatment Plant - Filter Building 1**

Photograph ID: 29

Photo Location:
Filter Building 1. Filters #13, #15, #17, #19, #21, #23.

Survey Date:
11/15/2013

Comments:
South-east corner.

Photograph ID: 30

Photo Location:
Filter Building 1. Filters #13, #15, #17, #19, #21, #23.

Survey Date:
11/15/2013

Comments:
Backwash sump cover.

Client:	**Metropolitan Water District**	**Project:**	**Filer Rehabilitation Project**
Site Name:	**Filter Building 1**	**Site Location:**	**Weymouth Water Treatment Plant - Filter Building 1**

Photograph ID: 31

Photo Location:
Filter Building 1. Filters #13, #15, #17, #19, #21, #23.

Survey Date:
11/15/2013

Comments:
Wall junction.

Photograph ID: 32

Photo Location:
Filter Building 1. Filters #14, #16, #18, #20, #22, #24.

Survey Date:
11/15/2013

Comments:
North-east entrance stairs.

Client:	**Metropolitan Water District**	**Project:**	**Filer Rehabilitation Project**
Site Name:	**Filter Building 1**	**Site Location:**	**Weymouth Water Treatment Plant - Filter Building 1**

Photograph ID: 33

Photo Location:
Filter Building 1. Filters #14, #16, #18, #20, #22, #24.

Survey Date:
11/15/2013

Comments:
Joint.

Photograph ID: 34

Photo Location:
Filter Building 1. Filters #14, #16, #18, #20, #22, #24.

Survey Date:
11/15/2013

Comments:
Handrail support at joint location.

Client:	**Metropolitan Water District**	**Project:**	**Filer Rehabilitation Project**
Site Name:	**Filter Building 1**	**Site Location:**	**Weymouth Water Treatment Plant - Filter Building 1**

Photograph ID: 35

Photo Location:
Filter Building 1. Filters #14, #16, #18, #20, #22, #24.

Survey Date:
11/15/2013

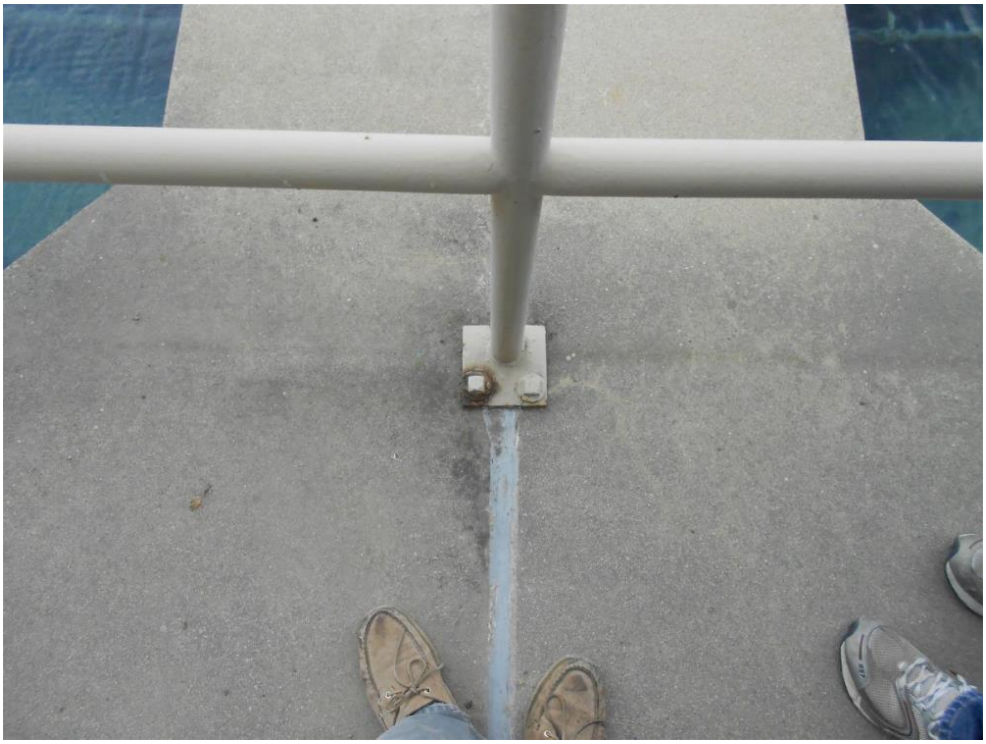
Comments:
Joint.

Photograph ID: 36

Photo Location:
Filter Building 1. Filters #14, #16, #18, #20, #22, #24.

Survey Date:
11/15/2013

Comments:
Handrail support at joint location.



Client:	**Metropolitan Water District**	**Project:**	**Filer Rehabilitation Project**
Site Name:	**Filter Building 1**	**Site Location:**	**Weymouth Water Treatment Plant - Filter Building 1**

Photograph ID: 37

Photo Location:
Filter Building 1. Filters #14, #16, #18, #20, #22, #24.

Survey Date:
11/15/2013

Comments:
Wall-junction.

Photograph ID: 38

Photo Location:
Filter Building 1. Filters #14, #16, #18, #20, #22, #24.

Survey Date:
11/15/2013

Comments:
Gate layout.

Client:	**Metropolitan Water District**	**Project:**	**Filer Rehabilitation Project**
Site Name:	**Filter Building 1**	**Site Location:**	**Weymouth Water Treatment Plant - Filter Building 1**

Photograph ID: 39

Photo Location:
Filter Building 1. Filters #14, #16, #18, #20, #22, #24.

Survey Date:
11/15/2013

Comments:
Gate, electrical conduits and electrical equipment.

Photograph ID: 40

Photo Location:
Filter Building 1. Filters #14, #16, #18, #20, #22, #24.

Survey Date:
11/15/2013

Comments:
North-east corner.

Client:	**Metropolitan Water District**	**Project:**	**Filer Rehabilitation Project**
Site Name:	**Filter Building 1**	**Site Location:**	**Weymouth Water Treatment Plant - Filter Building 1**

Photograph ID: 41

Photo Location:
Filter Building 1. Filters #14, #16, #18, #20, #22, #24.

Survey Date:
11/15/2013

Comments:
Backwash sump cover.

Legend

Photo Location and Direction

MWH

29 Nov 2013

Filter Rehabilitation Project

Weymouth Water Treatment Plan - Filter Building 2

Client:	**Metropolitan Water District**	**Project:**	**Filter Rehabilitation Project**
Site Name:	**Filter Building 2**	**Site Location:**	**Weymouth Water Treatment Plan - Filter Building 2**

Photograph ID: 1

Photo Location:
Filter Building 2. Filters #25, #27, #29, #31, #33, #35.

Survey Date:
11/15/2013

Comments:
Lamp.

Photograph ID: 2

Photo Location:
Filter Building 2. Filters #25, #27, #29, #31, #33, #35.

Survey Date:
11/15/2013

Comments:
Lamps.

Client:	**Metropolitan Water District**	**Project:**	**Filter Rehabilitation Project**
Site Name:	**Filter Building 2**	**Site Location:**	**Weymouth Water Treatment Plan - Filter Building 2**

Photograph ID: 3

Photo Location:
Filter Building 2. Filters #25, #27, #29, #31, #33, #35.

Survey Date:
11/15/2013

Comments:
Handrail anchor with sealant.

Photograph ID: 4

Photo Location:
Filter Building 2. Filters #25, #27, #29, #31, #33, #35.

Survey Date:
11/15/2013

Comments:
Backwash sump cover.

Client:	**Metropolitan Water District**	**Project:**	**Filter Rehabilitation Project**
Site Name:	**Filter Building 2**	**Site Location:**	**Weymouth Water Treatment Plan - Filter Building 2**

Photograph ID: 5

Photo Location:
Filter Building 2. Filters #25, #27, #29, #31, #33, #35.

Survey Date:
11/15/2013

Comments:
Gate layout.

Photograph ID: 6

Photo Location:
Filter Building 2. Filters #25, #27, #29, #31, #33, #35.

Survey Date:
11/15/2013

Comments:
Gate layout.

Client:	**Metropolitan Water District**	**Project:**	**Filter Rehabilitation Project**
Site Name:	**Filter Building 2**	**Site Location:**	**Weymouth Water Treatment Plan - Filter Building 2**

Photograph ID: 7

Photo Location:
Filter Building 2. Filters #25, #27, #29, #31, #33, #35.

Survey Date:
11/15/2013

Comments:
Joint.

Photograph ID: 8

Photo Location:
Filter Building 2. Filters #25, #27, #29, #31, #33, #35.

Survey Date:
11/15/2013

Comments:
Joint.

Client:	**Metropolitan Water District**	**Project:**	**Filter Rehabilitation Project**
Site Name:	**Filter Building 2**	**Site Location:**	**Weymouth Water Treatment Plan - Filter Building 2**

Photograph ID: 9

Photo Location:
Filter Building 2. Filters #25, #27, #29, #31, #33, #35.

Survey Date:
11/15/2013

Comments:
Wall junction.

Photograph ID: 10

Photo Location:
Filter Building 2. Filters #25, #27, #29, #31, #33, #35.

Survey Date:
11/15/2013

Comments:
Wall junction.

Client:	**Metropolitan Water District**	**Project:**	**Filter Rehabilitation Project**
Site Name:	**Filter Building 2**	**Site Location:**	**Weymouth Water Treatment Plan - Filter Building 2**

Photograph ID: 11

Photo Location:
Filter Building 2. Filters #26, #28, #30, #32, #34, #36.

Survey Date:
11/15/2013

Comments:
Wall junction and backwash sump.

Photograph ID: 12

Photo Location:
Filter Building 2. Filters #26, #28, #30, #32, #34, #36.

Survey Date:
11/15/2013

Comments:
Lamp.

Client:	**Metropolitan Water District**	**Project:**	**Filter Rehabilitation Project**
Site Name:	**Filter Building 2**	**Site Location:**	**Weymouth Water Treatment Plan - Filter Building 2**

Photograph ID: 13

Photo Location:
Filter Building 2. Filters #26, #28, #30, #32, #34, #36.

Survey Date:
11/15/2013

Comments:
Gate layout.

Photograph ID: 14

Photo Location:
Filter Building 2. Filters #26, #28, #30, #32, #34, #36.

Survey Date:
11/15/2013

Comments:
Joint.

Client:	**Metropolitan Water District**	**Project:**	**Filter Rehabilitation Project**
Site Name:	**Filter Building 2**	**Site Location:**	**Weymouth Water Treatment Plan - Filter Building 2**

Photograph ID: 15

Photo Location:
Filter Building 2. Filters #26, #28, #30, #32, #34, #36.

Survey Date:
11/15/2013

Comments:
Joint.

Photograph ID: 16

Photo Location:
Filter Building 2. Filters #37, #39, #41, #43, #45, #47.

Survey Date:
11/15/2013

Comments:
Wall junction.

Client:	**Metropolitan Water District**	**Project:**	**Filter Rehabilitation Project**
Site Name:	**Filter Building 2**	**Site Location:**	**Weymouth Water Treatment Plan - Filter Building 2**

Photograph ID: 17

Photo Location:
Filter Building 2. Filters #37, #39, #41, #43, #45, #47.

Survey Date:
11/15/2013

Comments:
Wall junction.

Photograph ID: 18

Photo Location:
Filter Building 2. Filters #37, #39, #41, #43, #45, #47.

Survey Date:
11/15/2013

Comments:
Gate layout.

Client:	**Metropolitan Water District**	**Project:**	**Filter Rehabilitation Project**
Site Name:	**Filter Building 2**	**Site Location:**	**Weymouth Water Treatment Plan - Filter Building 2**

Photograph ID: 19

Photo Location:
Filter Building 2. Filters #37, #39, #41, #43, #45, #47.

Survey Date:
11/15/2013

Comments:
Joint.

Photograph ID: 20

Photo Location:
Filter Building 2. Filters #37, #39, #41, #43, #45, #47.

Survey Date:
11/15/2013

Comments:
Joint.

Client:	**Metropolitan Water District**	**Project:**	**Filter Rehabilitation Project**
Site Name:	**Filter Building 2**	**Site Location:**	**Weymouth Water Treatment Plan - Filter Building 2**

Photograph ID: 21

Photo Location:
Filter Building 2. Filters #37, #39, #41, #43, #45, #47.

Survey Date:
11/15/2013

Comments:
South-east corner.

Photograph ID: 22

Photo Location:
Filter Building 2. Filters #37, #39, #41, #43, #45, #47.

Survey Date:
11/15/2013

Comments:
South-east corner gate.

Client:	**Metropolitan Water District**	**Project:**	**Filter Rehabilitation Project**
Site Name:	**Filter Building 2**	**Site Location:**	**Weymouth Water Treatment Plan - Filter Building 2**

Photograph ID: 23

Photo Location:
Filter Building 2. Filters #37, #39, #41, #43, #45, #47.

Survey Date:
11/15/2013

Comments:
South-east handrail portion.

Photograph ID: 24

Photo Location:
Filter Building 2. Filters #37, #39, #41, #43, #45, #47.

Survey Date:
11/15/2013

Comments:
Joint and south-east handrail portion.

Client:	**Metropolitan Water District**	**Project:**	**Filter Rehabilitation Project**
Site Name:	**Filter Building 2**	**Site Location:**	**Weymouth Water Treatment Plan - Filter Building 2**

Photograph ID: 25

Photo Location:
Filter Building 2. Filters #37, #39, #41, #43, #45, #47.

Survey Date:
11/15/2013

Comments:
Joint and south-east handrail portion.

Photograph ID: 26

Photo Location:
Filter Building 2. Filters #37, #39, #41, #43, #45, #47.

Survey Date:
11/15/2013

Comments:
South-east handrail portion.

Client:	**Metropolitan Water District**	**Project:**	**Filter Rehabilitation Project**
Site Name:	**Filter Building 2**	**Site Location:**	**Weymouth Water Treatment Plan - Filter Building 2**

Photograph ID: 27

Photo Location:
Filter Building 2. Filters #37, #39, #41, #43, #45, #47.

Survey Date:
11/15/2013

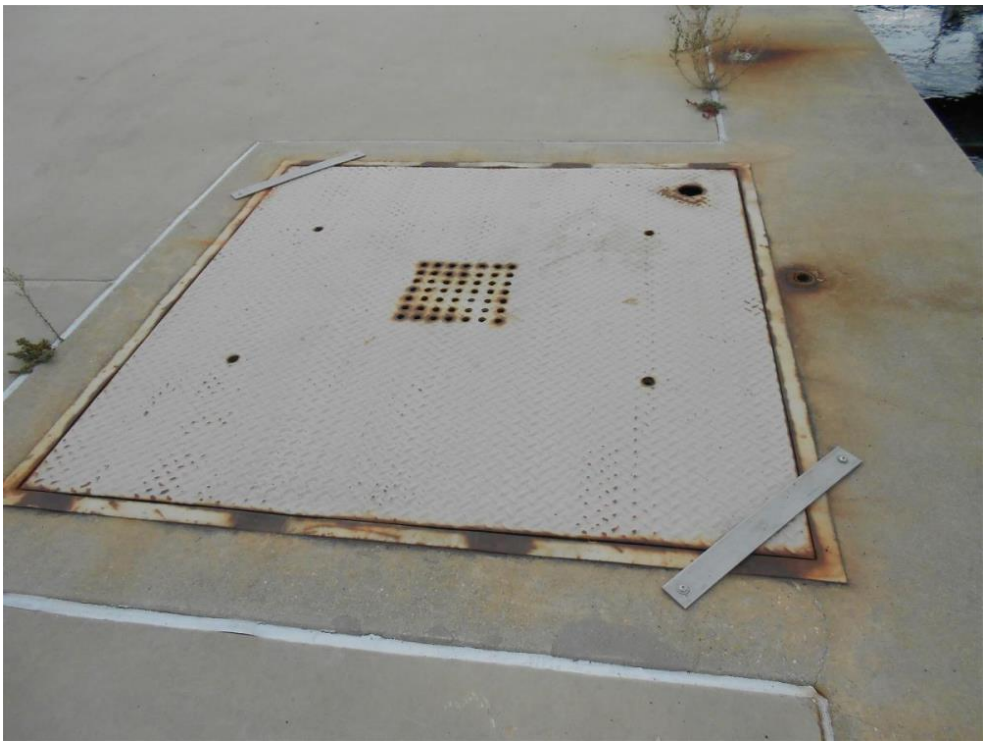
Comments:
Junction.

Photograph ID: 28

Photo Location:
Filter Building 2. Filters #37, #39, #41, #43, #45, #47.

Survey Date:
11/15/2013

Comments:
Backwash sump.



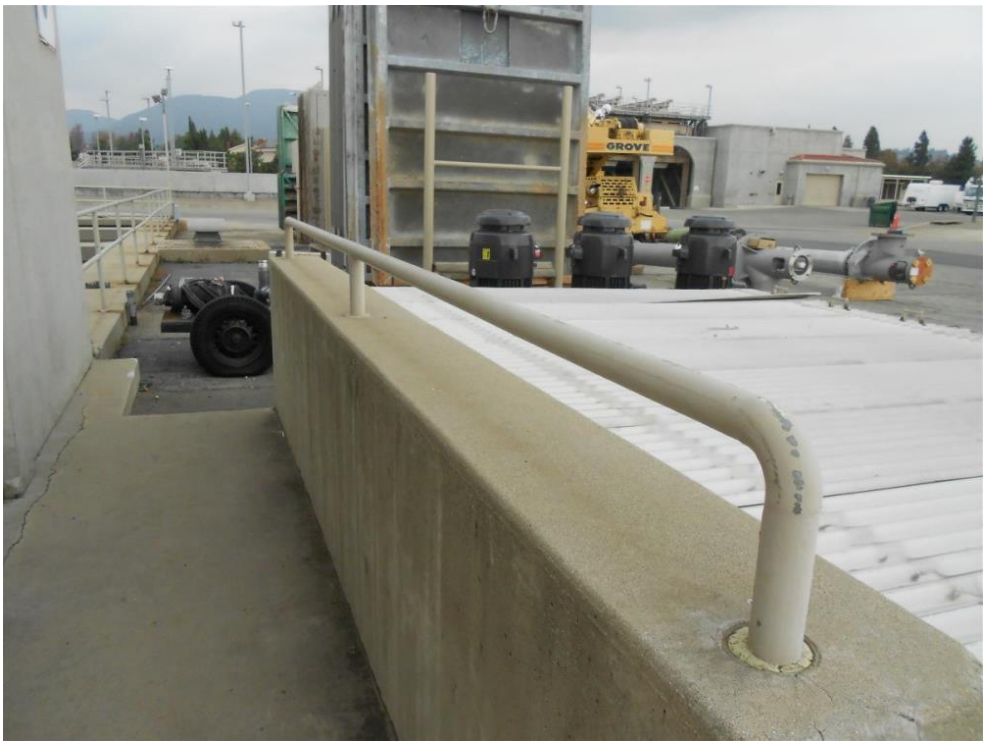
Client:	**Metropolitan Water District**	**Project:**	**Filter Rehabilitation Project**
Site Name:	**Filter Building 2**	**Site Location:**	**Weymouth Water Treatment Plan - Filter Building 2**

Photograph ID: 29

Photo Location:
Filter Building 2. Filters #37, #39, #41, #43, #45, #47.

Survey Date:
11/15/2013

Comments:
Handrail portion.



Photograph ID: 30

Photo Location:
Filter Building 2. Filters #38, #40, #42, #44, #46, #48.

Survey Date:
11/15/2013

Comments:
Wall junction.

Client:	**Metropolitan Water District**	**Project:**	**Filter Rehabilitation Project**
Site Name:	**Filter Building 2**	**Site Location:**	**Weymouth Water Treatment Plan - Filter Building 2**

Photograph ID: 31

Photo Location:
Filter Building 2. Filters #38, #40, #42, #44, #46, #48.

Survey Date:
11/15/2013

Comments:
Wall junction and electrical panel.

Photograph ID: 32

Photo Location:
Filter Building 2. Filters #38, #40, #42, #44, #46, #48.

Survey Date:
11/15/2013

Comments:
Handrail anchorage.

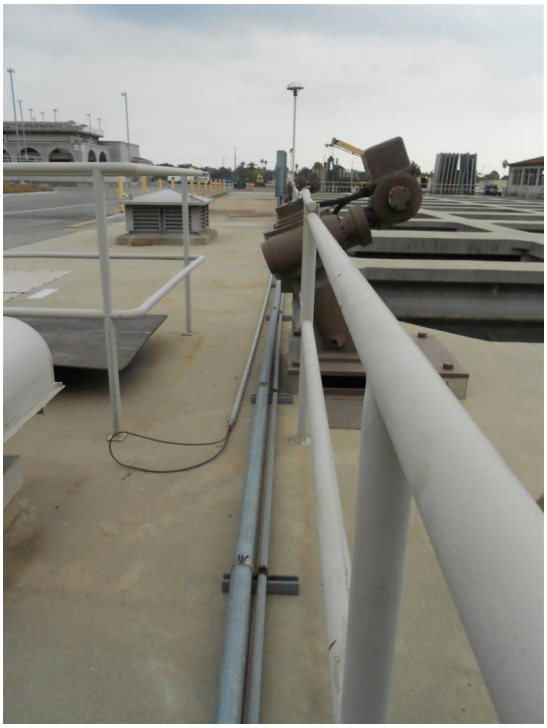
Client:	**Metropolitan Water District**	**Project:**	**Filter Rehabilitation Project**
Site Name:	**Filter Building 2**	**Site Location:**	**Weymouth Water Treatment Plan - Filter Building 2**

Photograph ID: 33

Photo Location:
Filter Building 2. Filters #38, #40, #42, #44, #46, #48.

Survey Date:
11/15/2013

Comments:
Gate layout.



Photograph ID: 34

Photo Location:
Filter Building 2. Filters #38, #40, #42, #44, #46, #48.

Survey Date:
11/15/2013

Comments:
Joint.

Client:	**Metropolitan Water District**	**Project:**	**Filter Rehabilitation Project**
Site Name:	**Filter Building 2**	**Site Location:**	**Weymouth Water Treatment Plan - Filter Building 2**

Photograph ID: 35

Photo Location:
Filter Building 2. Filters #38, #40, #42, #44, #46, #48.

Survey Date:
11/15/2013

Comments:
Joint.

Photograph ID: 36

Photo Location:
Filter Building 2. Filters #38, #40, #42, #44, #46, #48.

Survey Date:
11/15/2013

Comments:
North-east corner. Lamp.

Client:	**Metropolitan Water District**	**Project:**	**Filter Rehabilitation Project**
Site Name:	**Filter Building 2**	**Site Location:**	**Weymouth Water Treatment Plan - Filter Building 2**

Photograph ID: 37

Photo Location:
Filter Building 2. Filters #38, #40, #42, #44, #46, #48.

Survey Date:
11/15/2013

Comments:
Handrail anchor.

Photograph ID: 38

Photo Location:
Filter Building 2. Filters #38, #40, #42, #44, #46, #48.

Survey Date:
11/15/2013

Comments:
Backwash sump.

Client:	**Metropolitan Water District**	**Project:**	**Filter Rehabilitation Project**
Site Name:	**Filter Building 2**	**Site Location:**	**Weymouth Water Treatment Plan - Filter Building 2**

Photograph ID: 39

Photo Location:
Filter Building 2. Filters #38, #40, #42, #44, #46, #48.

Survey Date:
11/15/2013

Comments:
Electrical equipment and north-east zone.

Photograph ID: 40

Photo Location:
Filter Building 2. Filters #38, #40, #42, #44, #46, #48.

Survey Date:
11/15/2013

Comments:
North-east zone and sand pan.

Client:	**Metropolitan Water District**	**Project:**	**Filter Rehabilitation Project**
Site Name:	**Filter Building 2**	**Site Location:**	**Weymouth Water Treatment Plan - Filter Building 2**

Photograph ID: 41

Photo Location:
Filter Building 2. Filters #38, #40, #42, #44, #46, #48.

Survey Date:
11/15/2013

Comments:
North-east zone.

Photograph ID: 42

Photo Location:
Filter Building 2. Filters #38, #40, #42, #44, #46, #48.

Survey Date:
11/15/2013

Comments:
Opened electrical box.

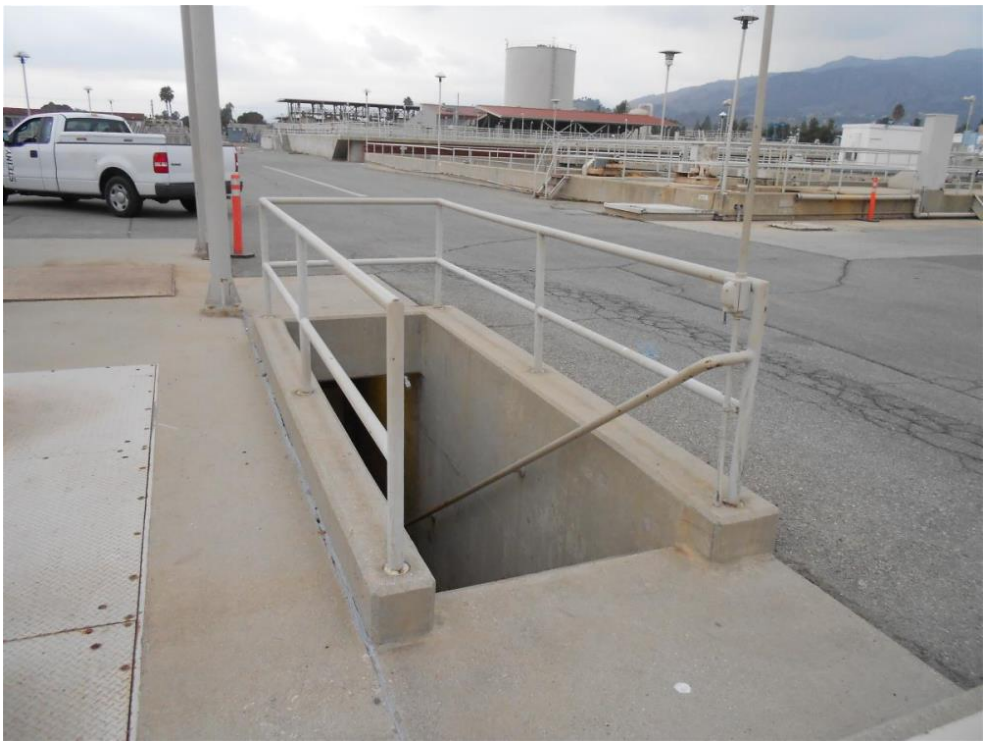
Client:	**Metropolitan Water District**	**Project:**	**Filter Rehabilitation Project**
Site Name:	**Filter Building 2**	**Site Location:**	**Weymouth Water Treatment Plan - Filter Building 2**

Photograph ID: 43

Photo Location:
Filter Building 2. Filters #38, #40, #42, #44, #46, #48.

Survey Date:
11/15/2013

Comments:
Stairs.



Photograph ID: 44

Photo Location:
Filter Building 2. Filters #38, #40, #42, #44, #46, #48.

Survey Date:
11/15/2013

Comments:
Electrical conduit, old generator cover, and handrail.

Client:	**Metropolitan Water District**	**Project:**	**Filter Rehabilitation Project**
Site Name:	**Filter Building 2**	**Site Location:**	**Weymouth Water Treatment Plan - Filter Building 2**

Photograph ID: 45

Photo Location:
Filter Building 2. Filters #38, #40, #42, #44, #46, #48.

Survey Date:
11/15/2013

Comments:
North entrance.