Technical Memorandum

To: *Sheboygan Water Utility*

From: *CDM Smith Inc.*

Date: *March 20, 2023*

Subject: *WTP Filter Rehabilitation and Underdrain Evaluation- Updated Memorandum*

ES.0 Executive Summary

The Sheboygan Water Utility (Utility) commissioned CDM Smith to evaluate alternatives for rehabilitating existing filters following the failed underdrain media support caps. This memorandum provides a summary of the rehabilitation alternatives, projected costs, non-cost evaluation of underdrain options, and recommendations.

Following a detailed evaluation of underdrain options and consideration of non-cost factors, the two stainless steel underdrain options are being considered for design and construction. The Utility will also consider ways to incorporate air scour in a future filter retrofit.

1.0 Background

The Sheboygan Water Utility (Utility) owns and operates a water treatment plant (WTP) that serves the City of Sheboygan, City of Sheboygan Falls, and Village of Kohler. The WTP has a design capacity of 36 million gallons per day (MGD) with an average flow of 13 MGD. The WTP treats raw water from Lake Michigan with a series of treatment steps, including alum/polymer coagulation, rapid mixing, flocculation, sedimentation, tri-media filtration, and disinfection using UV and chlorine.

1.1 Current Filter Operation

The WTP has eleven (11) granular-media filters, with the following dimensions:

- Filter Nos, 1 through 9 each have a surface area of approximately 698 square feet. Each filter is divided into two cells (11.25 feet by 31 feet each cell) by a center gullet.
- Filter Nos. 10 and 11 have a surface area of approximately 1,040 square feet. Each filter is divided into two cells (17.33 feet by 30 feet each cell) by a center gullet.

Typical filter run times between backwashes are reported to be approximately 150 hours in the winter and 100 – 125 hours in the summer. Media is cleaned through a conventional backwash procedure that includes surface wash (with surface sweeps) followed by low-rate and high-rate backwash. Backwash water is supplied from a washwater tank, using chlorinated water. The backwash process is controlled manually by Utility staff. A valve on the washwater supply to each filter is modulated to control the flow of backwash water into the filters.

Filter Media Analysis

The filter media profile appears to produce excellent water quality, and CDM Smith recommends maintaining the same profile. The current media profile is shown below:

- Filter Nos, 1 through 9:
  - 16 inches of anthracite
  - 12 inches of sand
  - 3 ½ inches of garnet sand
  - 2 inches of garnet gravel
- Filter Nos. 10 and 11:
  - 8 inches of anthracite
  - 12 inches of sand
  - 3 ½ inches of garnet sand
  - 2 inches of garnet gravel

The Utility collected filter media samples from Filter No. 6. **Table 1-1** shows the results of the filter media analysis conducted by Bowser-Morner, Inc. Six samples were collected each from sand and anthracite layers. The results appear to shows that the media is starting to show sign of its age. The uniformity coefficient is above the AWWA recommended value and above CDM Smith's specification. It is CDM Smith's recommendation that the media be replace with the same existing profile when the underdrains are replaced. Appendix A includes the media sample analysis results provided by the Utility.

Table 1-1. Analysis of Filter Media Samples

	Anthracite		Silica Sand	
Property	AWWA B100-16	Sheboygan Filter	AWWA B100-16	Sheboygan Filter
Specific Gravity	> 1.4	1.70 – 1.85	> 2.5	2.65 – 2.75
Acid Solubility	< 5%	2.4% - 3.7%	< 5%	1.6% - 1.9%
Effective Size, mm	0.60 – 1.60	0.56 – 0.93	0.35 – 0.65	0.31 – 0.34
Uniformity Coefficient	≤1.7	1.4 – 2.1	≤1.7	1.8
Mohs Hardness	>2.7	3	N/A	7
Elemental Analysis	N/A		Across the 6 samples analyzed, the percent composition of Calcium ranged from 4.2% to 7.5%. The Aluminum in the samples ranged from 4.8% to 5.6%.	

1.2 Previous Filter Rehabilitations

Filter Nos. 1 through 9 were renovated in phases between 1996 and 1999. The renovation included new filter underdrains, new media, and new surface wash sweeps. The installed underdrains were Universal Type S plastic (HDPE) block underdrains manufactured by Leopold, now known as Xylem Leopold (Leopold). The underdrains included an IMS (Integral Media Support) Cap media support layer. With a thickness of approximately 1-inch, the IMS Cap takes less space than traditional gravel media support which has a thickness of approximately 12 inches. The IMS Cap allowed space for increased depth of filter media within the filter cells than if traditional gravel support media was used. The IMS caps were constructed by sintering plastic beads to create a complex path that prevents media entry into the underdrain.

Filter Nos. 10 and 11 were renovated in 2002. The renovation included new filter underdrains, new media, and new surface wash sweeps. The installed underdrains were Leopold Universal Type SL plastic (HDPE) block underdrains and included the use of IMS caps.

Following an underdrain failure in Filter No. 11 in 2007, the underdrains and media in this filter were replaced in kind. Following an underdrain failure in Filter No. 10 in 2018, the underdrains and media in this filter were replaced using Leopold Type XA plastic (HDPE) block underdrains. The new underdrains installed in Filter No. 10 included the IMS 200 media support cap. While similar in function to the original IMS cap, the IMS 200 cap is constructed differently, which provides for more control of the media retention slot sizing. The IMS 200 caps appear to be less susceptible to plugging than the original IMS caps.

1.3 2022 Filter Underdrain Failure

During a filter inspection in August 2022 various sink holes were observed in the top of the media in Filter No. 5, suggesting a potential breech in the underdrain system. Utility staff arranged for the media to be removed from both cells of Filter No. 5. Inspection of the filter underdrain system found split IMS caps on two of the underdrains along with signs of sealant failure at the ends of most of the caps. These signs indicated a suspected plugging of the IMS caps, as have been seen at many other water treatment plants that utilize this filter underdrain product. Two representative IMS caps were removed from Filter No. 5 and sent to Leopold for autopsy analysis. The testing conducted by Leopold confirmed that the IMS caps within Filter No. 5 were plugged.

Utility staff procured new IMS 200 caps from Leopold to replace the existing IMS caps within Filter No. 5 as an interim solution. Utility staff completed all necessary underdrain preparations and installed the replacement IMS 200 caps within Filter No. 5. Utility staff procured and installed new filter media and returned Filter No. 5 to service on December 12, 2022.

1.4 Filter Underdrain Rehabilitation

Following the 2022 failure of Filter No. 5, Utility staff conducted pressure monitoring of all the filter basins at the Sheboygan WTP which identified that nearly all the filters are showing some degree of increased pressure that is expected to be the result of plugging of the IMS caps. Filter No. 6 in particular is showing higher than expected pressure, and the Utility is moving forward with cap replacement.

As a result of these failures and concerns, the Utility commissioned CDM Smith to evaluate alternative underdrains with the intent to move forward with a new underdrain system.

3.0 Underdrain Manufacturer Workshops

To gather information for determining the best path forward for rehabilitating the filters, CDM Smith led virtual workshops with three leading underdrain manufacturers (AWI, Roberts and Leopold) and the Utility on November 10 and 11, 2022.

The manufacturers presented options for underdrain configurations that could be applied to the rehabilitation of the filters. Following these presentations, CDM Smith provided further recommendations regarding which underdrain configurations should be allowed for bidding.

3.1 AWI – Stainless Steel Underdrains

AWI presented their Phoenix underdrain with separate air and water chambers. This underdrain is stainless steel with punched media retention slots and does not require support gravel. **Figure 3-1** shows a sample of the underdrain lateral.

Figure 3-1: AWI Phoenix Underdrain Lateral

This underdrain is installed with grout strips over the flume and anchor bolts across the length of the lateral. This reduces installation schedule since it does not require grout to be applied over the filter slab. The lateral does not lay flush on the filter floor. The distribution orifices are custom cut based on hydraulic modeling to optimize uniform distribution throughout the filter. The laterals are manufactured in the US.

This underdrain is compatible with air scour; the connection to the air header for this configuration utilized flexible tubing, while the rest of the piping was stainless steel. **Figure 3-2** shows how air and water move through the underdrains.

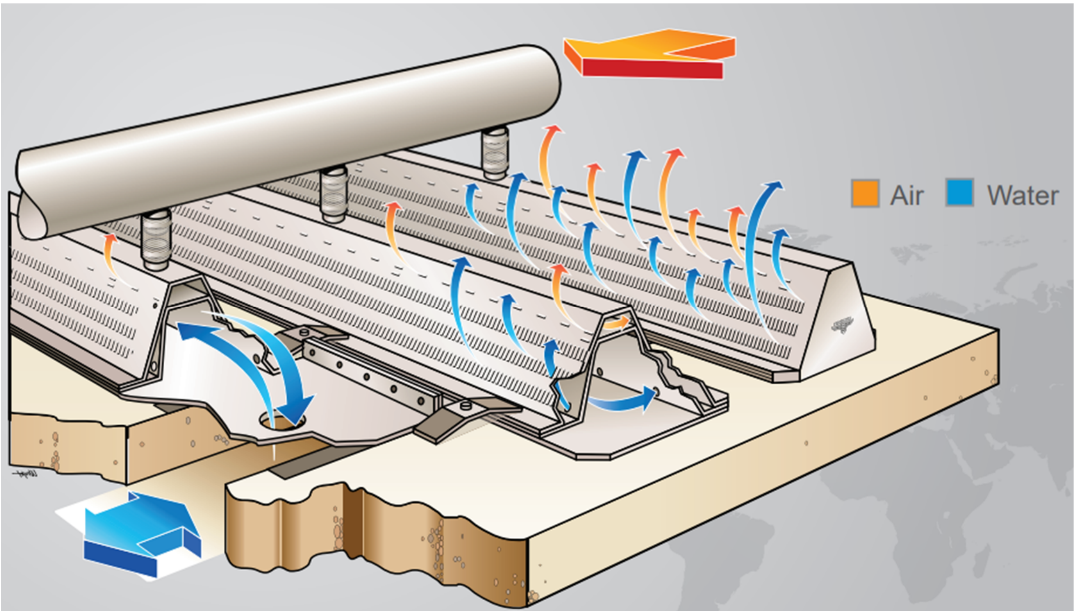


Figure 3-2: Air and water distribution through AWI Phoenix laterals.

AWI's Phoenix underdrain is made in three difference heights: Ultra Low Profile, Low Profile, and High Volume. With the lower profile options, the maximum length of the lateral is more limited than the high volume option. Additionally, the headloss would be greater in the same application for a ultra-low then for low profile or high volume. Based on the length of the filters AWI recommends the low profile lateral. However, with the low profile option, the headloss through the underdrain would be much higher than for the comparable underdrains from the other manufacturers. For this reason, the high volume option may be considered instead as it has a lower headloss than the low profile.

3.2 Roberts – Stainless Steel Underdrains

Roberts presented their Trilateral underdrains with options for combined and separated air and water chambers. Drawings for this design are included in **Appendix B**. These underdrains are stainless steel with punched retention slots and do not require support gravel but may be used with it. The Trilateral product with separate air and water chambers is a new offering from Roberts and does not have many installations; however, the technology is similar to the AWI Phoenix product. **Figure 3-3** shows an installation of the Roberts stainless trilateral underdrain.

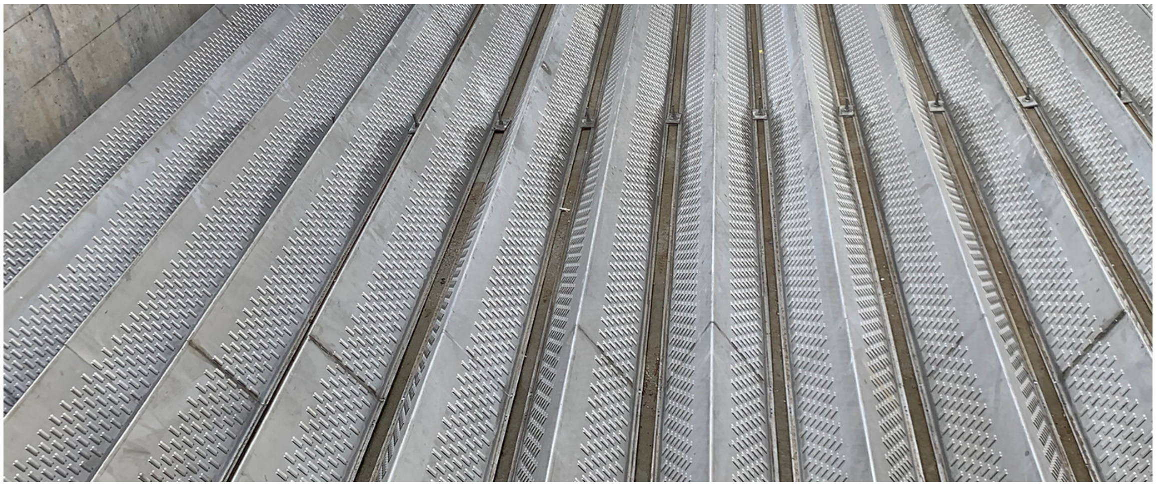


Figure 3-3: Roberts Trilateral Stainless-steel underdrain installation

This stainless-steel underdrain installation requires a level floor. The laterals are then mechanically anchored and bolted flush onto the floor. This system is also compatible with air scour and uses entirely stainless-steel piping and the laterals themselves are made with 14-gauge stainless steel. The punched media retention orifices feature a winged shape, each orifice being connected to the lateral on three sides.

3.3 Leopold – Plastic Underdrains

Leopold presented their Type XA, Type SA, and Type 360 underdrains, all plastic underdrains of varying shapes. Types XA and SA were presented with or without an IMS® 200 media support cap, which requires support gravel if the cap is omitted. The Type 360 underdrains were as a new product designed with orifices for air and water on all sides of the raised underdrain. The Type S was originally installed in the Utility's filters with older sintered bead media support cap design, or the original IMS® cap. This media support cap has had failures in other installations and has been replaced by a media support cap with laser cut slots. **Figures 3-4** shows the Type XA underdrain block. The Type 360 is shown in **Figure 3-5**.

Figure 3-4: Type XA underdrain without cap

Figure 3-5: Type 360 underdrain

The Type XA block is newer and has a lower profile than the Type S, leaving more room for media above. The Type XA also has a structure underneath that allows greater uplift resistance in the grout installation. The Type XA can be used with air scour, using the IMS® cap or gravel for media retention. The plastic block installation requires grout poured under and around the plastic blocks to form a monolithic structure regardless of the underdrain block type. This installation may be considered more challenging than the installation for the stainless-steel options. Additionally, single laterals cannot be removed for repair or inspection without taking all underdrains out of the filter.

The Type 360 is installed similarly to the stainless steel laterals presented by other manufacturers, with anchored bolts to hold down the laterals instead of the grout used for the plastic block products. There are orifices on all sides of the lateral for air and water to pass through and these orifices are sized to retain the media in the filter. This underdrain product is new and does not have many installations. Due to this limited experience with the Type 360 product, the Type XA product will be the focus for comparison to other underdrains.

4.0 Findings and Discussion

Following the underdrain manufacturer workshops, CDM Smith developed a table of non-cost factors to be used in comparing the underdrain options presented. For each manufacturer, a preferred product for the Sheboygan WTP application was selected based on manufacturer recommendation for the application and CDM Smith experience with the product. For Leopold this was the Type XA Underdrain with IMS® 200 Media Support Cap, for AWI this would be the Low Profile Phoenix Underdrain (although the High Volume may be beneficial for lower headloss), and for Roberts the stainless-steel Trilateral with separate air and water chambers was selected for comparison. **Table 4-1** provides a comparison between the preferred products from each manufacturer.

Table 4-1. Summary of Preferred Underdrain Product from Each Manufacturer for Sheboygan WTP Application

	Leopold	AWI	Roberts
Product	XA Underdrain with IMS® 200 Cap	Phoenix Low Profile	Trilateral SS
Material	HDPE	316L SS	316L SS
Description	Grout and mechanical hold-down anchor system	316L Stainless steel mechanical hold downs epoxy anchored into the filter box	316L Stainless steel mechanical hold downs epoxy anchored into the filter box
Lateral Height	10 3/8-inches	5 1/4 – inches	8 inches
Warranty	5 years	5 years	5 years
Advantages	- Familiar product/operation - Plastic material results in lower purchase cost for laterals.	- Could be installed in-house - Can remove single lateral for repair - Minimal risk of fouling - Easier installation. - Allows for more reliable quality control as mechanical anchors can be tested to verify correct installation.	- Could be installed in-house - Can remove single lateral for repair - Minimal risk of fouling - Easier installation - Thicker gauge SS - Allows for more reliable quality control as mechanical anchors can be tested to verify correct installation.
Disadvantages	- Cannot remove single lateral without impacting other laterals. - More complex and labor-intensive installation that requires close quality control of grout and placement to be successful.	- Dead space under lateral. Stainless steel material results in higher purchase price of laterals. - Slight risk of corrosion	- Stainless steel material results in higher purchase price of laterals. - Slight risk of corrosion
Fail points	- Failure of media retention caps - Sealant failure - Relies on good quality and placement of grout (grout under tension)	- Hold down anchor failure - Corrosion	- Hold down anchor failure - Corrosion
Headloss	32"	65"	32"
Uplift Pressure	Type XA is 30 psi. (IMS® 200 cap is 15 psi	2,400 PSF (16.7 psi)	1,200 PSF (8.3 psi) with 5/16" think plates between the laterals and 2,400 PSF (16.7 psi) with 1/2" plates
Number of Installations	Type S - >1,500 Type XA - >500	approximately 240	14

4.1 Additional Concerns and Recommendations for the Filter Underdrains

4.1.1 Potential for Backwash Flow Maldistribution

Maldistribution in the backwash supply could result in zones of higher backwash pressure and zones of poor backwashing. Modern filter installations can overcome these challenges through the following strategies:

- Use of varying sized openings/orifices in the center underdrain blocks to obtain a consistent backwash flow along the full length of the filter center backwash feed gullet;
- Use of influent flow baffles as the backwash water enters the gullet to reduce the influent water velocity;
- Use of computational fluid dynamic (CFD) modeling of the filter installation to design the location and size of the block openings and baffles;
- Post-installation backwash flow or piezometer testing to field verify the installation matches the results of the CFD design.

These strategies are applicable to all of the underdrain products being considered for the Sheboygan WTP and should be implemented regardless of which underdrain product is selected.

4.1.2 No Backwash Relief Piping

The Utility does have air relief venting, but currently there is no vent relief outlet for the backwash supply water piping at the filter gullet. Vent relief piping are typically added to reduce the potential for future catastrophic filter underdrain failures. The Utility did note that the maximum head available for backwash supply from the backwash tank is not high, and since there is no backwash pumping supply in this case, adding backwash relief piping is not as critical in this case.

4.1.3 Use of Air Scour In Lieu of Surface Wash for Auxiliary Wash

The addition of air scour to a filter backwash procedure has been shown to significantly improve the backwash cleaning effectiveness. The addition of air scour might provide a measurable benefit to the WTP in improved filter performance and lower backwash water use. Life-cycle cost evaluations conducted on other Midwestern water facilities locations have shown that operation and maintenance cost savings can off-set the capital cost associated with implementing air scour.

New air scour blowers, air scour header piping, and appurtenances would be required to implement air scour at WTP, but all underdrain options for retrofit are compatible with air scour.

4.2 Non-Cost Evaluation

CDM Smith prepared a matrix of criteria to be used to evaluate non-cost items about each potential underdrain product. **Table 4-2** shows this matric with scores filled in by Sheboygan staff in discussion with the CDM Smith team. The weighting of each sub criterium within the primary criteria and weighting of each primary criterium within the total score is also shown in the table. In this evaluation, AWI and Roberts ranked similarly, around 3.6, while Leopold ranked behind these two with a score of 2.3. Based on this non-cost evaluation, the top two vendors are used in the final cost or budgeting (Table 5-2).

Table 4-2. Non-cost evaluation matrix of underdrain alternatives

Primary Criteria (PC) and Weight	Sub-criteria (SC) and Weight	Unweighted SC scores			Weighted PC Scores			Reasoning for Score
		AWI	Roberts	Leopold	AWI	Roberts	Leopold	
Installation (30%)					1.29	1.095	0.765	
	Ease of Installation (25%)	4.7	4.1	2				Leopold requires the more grout and leveling
	Number of Installations (25%)	4	3	4.2				Leopold has the most installations, followed by AWI
	Ease of Repair /Replacement (25%)	4	3	1				Stainless Steel Underdrains can be removed as a single lateral
	Ability to add Air Scour (25%)	4.5	4.5	3				AWI and Roberts design for future air scour addition
Impact on Media/WQ (20%)					0.94	0.9	0.52	
	Height of Underdrain (and room for media and freeboard) (50%)	5	4.4	2.1				Based on lateral height and whether support gravel is needed
	Filter Performance /Longevity (50%)	4.4	4.6	3.1				Leopold has experienced more failures
Reliability and Performance (30%)					1.1	1.28	0.86	
	Potential Fail Points (33%)	3	4	1				Grout failure and clogging more likely with Leopold. Corrosion as a fail point for AWI and Roberts. Space under lateral as fail point for AWI.
	Headloss (33%)	4	4	4				Comparable headloss
	Material of Construction /Corrosion (33%)	4.1	4.8	3.6				Roberts provides stronger gauge stainless than AWI. Leopold is plastic.
Company Experience and Service Record (20%)					0.72	0.75	0.59	
	Experience (50%)	4.2	4.5	4.9				Leopold has most installations
	Service Record (50%)	3	3	1				AWI and Roberts Service not tested, but Leopold was challenging to work with in initial stages of filter failure
	Cumulative Weighted Score:				**4.06**	**4.02**	**2.73**	

5.0 Alternatives and Next Steps

The following is a summary of various alternatives to address the underdrains at the WTP. The description of each alternative includes advantages and disadvantages.

5.1 Alternative 1 Replace Existing Underdrains with new Leopold XA Plastic Block Underdrains

This alternative includes the removal and replacement of the existing underdrains with the latest version of the Leopold XA underdrain with IMS200 caps (shown in Figure **5-1**). Under this alternative, the existing underdrains would be demolished and removed from the filter basins. A bed of grout would be applied to the filter floor before the laterals (made of connected plastic blocks with IMS200® Caps factory installed on top of the blocks) are placed. A new mechanical anchoring system would be installed around the laterals. After 12 hours, grout would be placed to fill in the space around the laterals.

The advantages and disadvantages of this alternative include the following:

Alternative 2 Advantages:

- HDPE material used in Leopold's XA Plastic Block would eliminate concern about underdrain corrosion.

Alternative 2 Disadvantages:

- The installation process for this type of plastic underdrain is relatively complex. Close supervision would be required during installation of the underdrains and grout to ensure a complete and reliable underdrain system.
- While the XA underdrain has a lower profile than the existing Leopold S block, it is taller than either the AWI or Roberts options and thus would have less freeboard for media expansion than the other underdrain options.
- While this IMS200® Cap design appears to be less prone to plugging than the existing IMS® Caps, there is limited long-term data on the performance of this system, particularly for the treatment of Great Lakes water.

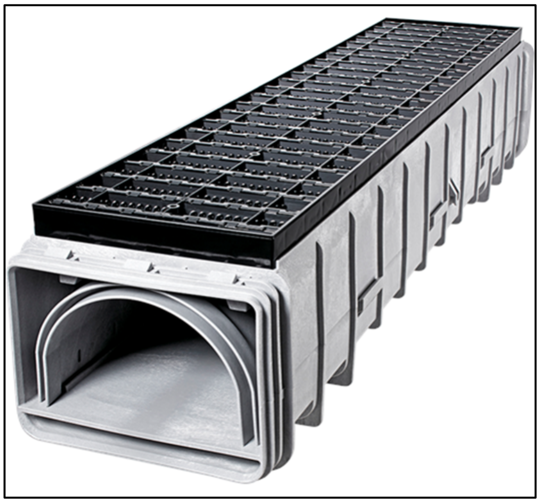


Figure 5-1. Type XA underdrain with IMS® 200 cap.

5.2 Alternative 2 Replace Existing Underdrain with New AWI Phoenix Stainless Steel Underdrain

This alternative includes the removal and replacement of the existing underdrains with new stainless steel underdrains. AWI Stainless steel laterals come in a trapezoidal (shown in **Figure 5-2**) shape. Direct media support is attained through the usage of a dual folded plate system with a series of bridge punches in the top plate. The double 90-degree plates create high shear velocity of the water passing through, thus minimizes fouling. Stainless steel laterals provide greater corrosion resistance than cast iron laterals that were once commonly used in filter underdrain designs. The risk of corrosion is low because the laterals are nearly always submerged. This is supported by field experience of AWI underdrains operating for many years with no signs of corrosion.

These underdrains have a simpler installation process than plastic block underdrains. A gasket atop grout strips seal off the flume, then concrete anchors and hold-down clamps are used to secure the

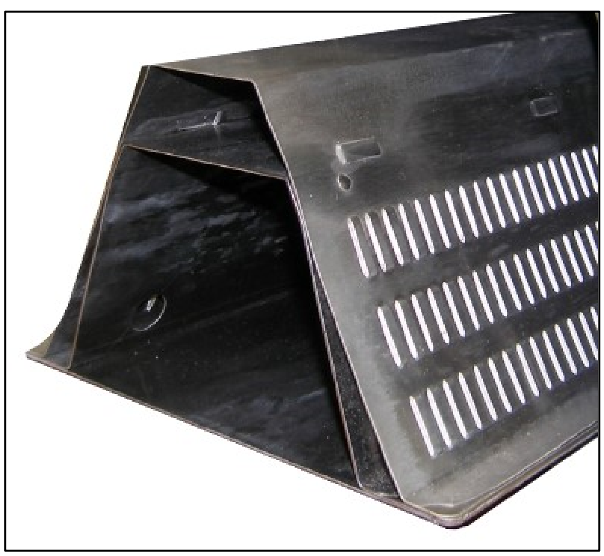


Figure 5-2. Stainless steel underdrain from AWI

lateral to the filter floor. The AWI Phoenix installation does not require grout poured to level the entire filter floor. Instead, the underdrains rest on the grout strips at each end, when a small space between the underdrain and the middle of the filter floor. The underdrains are held in place with mechanical anchoring.

Alternative 2 Advantages:

- The AWI Phoenix underdrain has the lowest profile among all three alternatives, leaving the most room for additional media or filter bed expansion.
- The installation process for the stainless steel underdrains is relatively simple allowing for quicker installation and filter downtime.
- Unlike plastic block underdrains, stainless steel underdrains can be readily removed for cleaning, inspection, and maintenance, if ever needed, and then reinstalled without impacts to the structural integrity of the system.

Alternative 2 Disadvantages:

- Stainless steel underdrains do face a slight risk of corrosion, although this has only been seen in rare instances and is typically related to filters that are kept out of service, without being submerged for long periods of time.

5.3 Alternative 3 Replace Existing Underdrains with New Roberts Trilateral Stainless Steel Underdrains

This alternative includes the removal and replacement of the existing underdrains with new stainless steel underdrains. The Roberts trilateral underdrain comes in a triangular (shown in **Figure 5-3**) shape. Direct media support is attained through the usage of a dual folded plate system with a series of punches in the top plate. Each of these punches is supported by the plate on three sides of the punch. The double 90-degree plates create high shear velocity of the water passing through, thus minimizes fouling. Stainless steel laterals provide greater corrosion resistance than cast iron laterals that were once commonly used in filter underdrain designs. The risk of corrosion is low because the laterals are nearly always submerged.

Installation of the Roberts Trilateral underdrain requires beginning with a level filter floor, which requires a pour of grout over the clean filter floor. Then the Trilateral underdrain rests flush on the bottom of the floor, held in place with a mechanical anchor system.

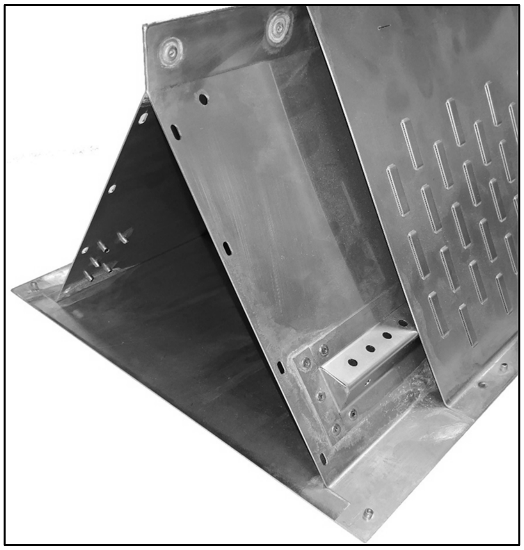


Figure 5-3. Stainless steel underdrain from Roberts Filter

The advantages and disadvantages of this alternative include the following:

Alternative 3 Advantages:

- The Roberts Trilateral has a lower profile than the Leopold XA Block underdrain.
- The installation process for the stainless steel underdrains is relatively simple allowing for quicker installation and filter downtime.
- Unlike plastic block underdrains, stainless steel underdrains can be readily removed for cleaning, inspection, and maintenance, if ever needed, and then reinstalled without impacts to the structural integrity of the system.

Alternative 3 Disadvantages:

- Stainless steel underdrains do face a slight risk of corrosion, although this has only been seen in rare instances and is typically related to filters that are kept out of service, without being submerged for long periods of time.

5.5 Conceptual Cost Comparison of Alternatives

Vendors for the alternatives in **Table 5-1** have provided budgetary level estimates for underdrain laterals for the Utility to consider. These estimates do not include the costs for new air scour blowers and header pipe. These costs also do not include installation. The actual cost of the recommended alternative will depend on actual labor and material costs, competitive market conditions, final project scope, implementation schedule, and other factors.

Table 5-1. Conceptual Equipment Costs of New Filter Underdrain Alternatives(1, 2)

Alternatives	Budgetary Underdrain Equipment Estimate for 11 Filters
Leopold Type XA Underdrains with IMS® 200 Cap	$1,000,000
Leopold Type 360 Underdrains	$870,000
AWI Phoenix Low Profile Underdrains	$1,900,000
Roberts Trilateral Underdrains (3)	$2,200,000

Notes:

(1) Costs do not include any costs for filter pipe gallery improvements.
(2) Costs are based budgetary level estimates provided by the vendors in late 2022 – early 2023. Above costs do not include construction, which can be lower for the stainless steel options.
(3) Roberts estimate was provided including media, for a total of $2,988,625. They report that 73% of this total is for underdrains and the other 27% is the media.

Conceptual estimates the total project costs have been developed and are shown in **Table 5-2**. Based on the rankings from the non-cost comparison in **Table 4-2**, only stainless-steel underdrains from AWI and Roberts were considered moving forward. A contingency of 25% is added to the construction cost to cover undeveloped design details, such as installation of pressure monitoring devices for backwash water supply and installation of backwash vent line provisions. This 25% contingency also covers the development of a sequence of construction and associated site constraints.

A mark-up 15% is added to the construction cost for engineering design, construction management, administrative, and legal. A 10% mark-up is added to cover contractor's overhead and profit.

These contingencies and mark-ups are appropriate at a planning level to allow for unforeseen and undefined cost items. It is important to note that the cost estimates are in today's dollars (not escalated) and are preliminary planning-level costs based on information available at the time of the estimates and are "order of magnitude". The actual cost of the recommended alternative will depend on actual labor and material costs, competitive market conditions, final project scope, implementation schedule, and other factors. As a result, the final costs will most likely vary from the estimates presented herein. Finally, cost does not include engineering design or construction management.

Table 5-2. Conceptual Capital Costs of Filter Retrofit (1, 2, 3, 4)

	Conceptual Capital Costs per Filter	Conceptual Capital Costs for 11 Filters
Stainless Steel Underdrains	$ 600,000	$ 6,600,000
Install Air Scour Blower and Piping	Not Applicable	$ 2,000,000
Install New Media	$ 160,000	$ 1,800,000
Total:		**$ 10,400,000**

Notes:

(1) Costs do not include any costs for filter pipe gallery improvements.
(2) Costs are in today's dollars and have not been escalated.
(3) Costs include the mark-ups noted above
(4) Costs are based on cost information from recent similar projects.

5.6 PFAS Regulations

On March 14th, 2023, EPA proposed National Drinking Water Standards for six PFAS (PFOS, PFOA, PFNA, PFBS, PFHxS, and GenX). The draft rule proposes a combination of traditional Maximum Contaminant Levels (MCLs) and a novel Hazard Index (HI) concept.

The proposed MCLs and HI are as follows:

- 4.0 ng/L or ppt MCL PFOA
- 4.0 ng/L or ppt MCL PFOS
- 1.0 (unitless, NOT 1 ppt) Hazard Index (HI) for a mixture of PFNA, PFHxS, PFBS, and GenX

Based on historical testing done by the Utility, levels of PFOA and PFOS are below the proposed MCLs, however the Utility will continue to monitor for PFAS to confirm that it will comply with the proposed rules. There is currently a 60-day public comment period with the Final Rule anticipated to be released by early 2024. The proposed rule requires compliance 3 years after promulgation.

As part of this Filter Rehabilitation Project, the Utility will evaluate if a different media option should be considered to allow removal of PFAS.

5.7 Recommendations and Next Steps

In addition to underdrain and media replacement, CDM Smith also recommends the following additional steps:

- Continue to closely monitor filter operation, backwash pressure and other filter parameters until the filters are fully rehabilitated.
- Consider incorporating air scour and backwash supply modifications at the WTP as part of the filter rehabilitation project for operation and maintenance cost savings and improved filter performance.

Appendix A – Filter Media Analysis Results

BOWSER-MORNER, INC.

Delivery Address: 4518 Taylorsville Rd • Dayton, Ohio 45424 **Mailing Address:** P.O. Box 51 • Dayton, Ohio 45401

AASHTO/ISO 17025 Accredited • USACE Validated ACIL INDEPENDENCE

LABORATORY REPORT

Report To:	Sheboygan Water Utility Attn: Bill Swearingen 72 Park Ave. Sheboygan, WI 53081	**Report Date:** **Job No.:** **Report No.:** **No. of Pages:**	02/15/23 208715 118928 2
Project/Plant:	Filter #6 Media Core Testing	**Date Received:**	01/19/23
Test Method:	AWWA B100-16	**Date Sampled:**	01/16/23
Sample ID:	**Anthracite Sample 1 Top**		

USA Std.	Nominal, mm	Effective, mm	Percent Passing
#8	2.36	2.36	**100.0**
#10	2.00	2.004	**99.6**
#12	1.70	1.724	**97.1**
#14	1.40	1.369	**78.1**
#16	1.18	1.195	**42.7**
#18	1.00	1.003	**17.5**
#20	0.850	0.870	**11.0**
#25	0.710	0.715	**10.1**
#30	0.600	0.598	**9.6**
#35	0.500	0.500	**7.6**
#40	0.425	0.418	**3.6**
#45	0.355	0.353	**1.8**
#50	0.300	0.289	**1.5**
#60	0.250	0.242	**0.8**
Effective Size, mm:			**0.69**
Uniformity Coefficient:			**1.9**
Acid Solubility, %:			**3.7**
Specific Gravity, (Apparent):			**1.70**
Moh's Hardness:			**3**

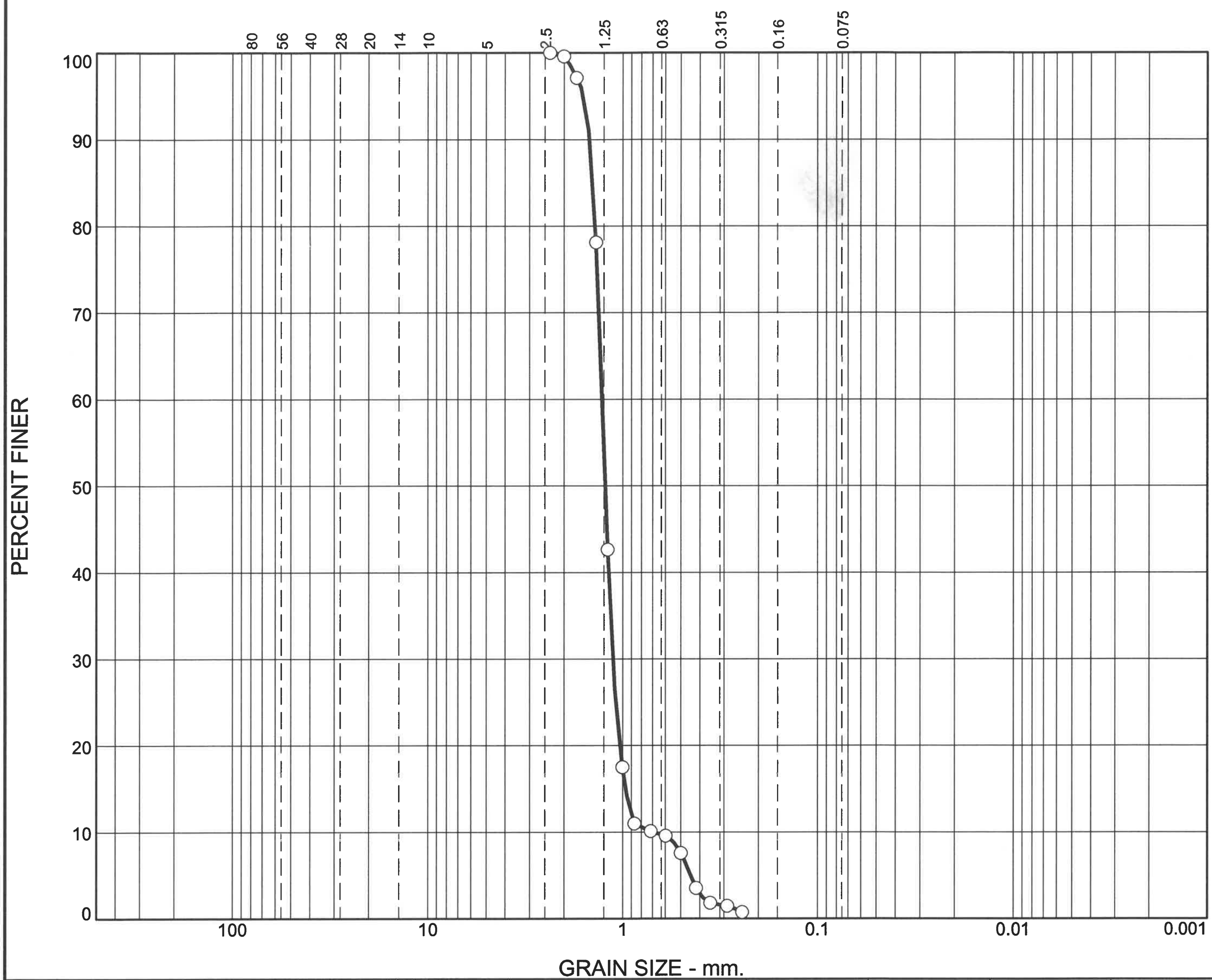
Should you have any questions or if we may be of further service, please contact me at 937-236-8805, extension 322.

Respectfully submitted,
BOWSER-MORNER, INC.

Karl A. Fletcher
Vice President
Director of Laboratory Services

KAF/ras/drj
118928
1-File
1-billswearingen@sheboyganwater.org

GRAIN SIZE DISTRIBUTION REPORT



	C_u	C_u spec.	D_{10}	D_{10} spec.	C_u	D_{10}	D_{60}	% - #30
○	1.85		0.6900				1.2754	9.6

Material and Supplier

○ Anthracite Sample 1 Top

Project No. 208715 **Client:** Sheboygan Water

Project: Filter #6 Media Core Testing

○ **Location:** Date Received: 1/19/23

Remarks:

BOWSER-MORNER, INC.

Dayton, Ohio

Tested By: RAS

BOWSER-MORNER, INC.

Delivery Address: 4518 Taylorsville Rd • Dayton, Ohio 45424 **Mailing Address:** P.O. Box 51 • Dayton, Ohio 45401

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LABORATORY REPORT

Report To:	Sheboygan Water Utility Attn: Bill Swearingen 72 Park Ave. Sheboygan, WI 53081	**Report Date:** **Job No.:** **Report No.:** **No. of Pages:**	02/15/23 208715 118929 2
Project/Plant:	Filter #6 Media Core Testing	**Date Received:**	01/19/23
Test Method:	AWWA B100-16	**Date Sampled:**	01/16/23

Sample ID: **Anthracite Sample 2 Top**

USA Std.	Nominal, mm	Effective, mm	Percent Passing
#10	2.00	2.004	**100.0**
#12	1.70	1.724	**98.6**
#14	1.40	1.369	**82.6**
#16	1.18	1.195	**48.0**
#18	1.00	1.003	**16.7**
#20	0.850	0.870	**7.2**
#25	0.710	0.715	**5.8**
#30	0.600	0.598	**5.4**
#35	0.500	0.500	**4.7**
#40	0.425	0.418	**2.3**
#45	0.355	0.353	**0.8**
#50	0.300	0.289	**0.5**
Effective Size, mm:			**0.93**
Uniformity Coefficient:			**1.4**
Acid Solubility, %:			**2.8**
Specific Gravity, (Apparent):			**1.73**
Moh's Hardness:			**3**

Should you have any questions or if we may be of further service, please contact me at 937-236-8805, extension 322.

Respectfully submitted,
BOWSER-MORNER, INC.

Karl A. Fletcher
Vice President
Director of Laboratory Services

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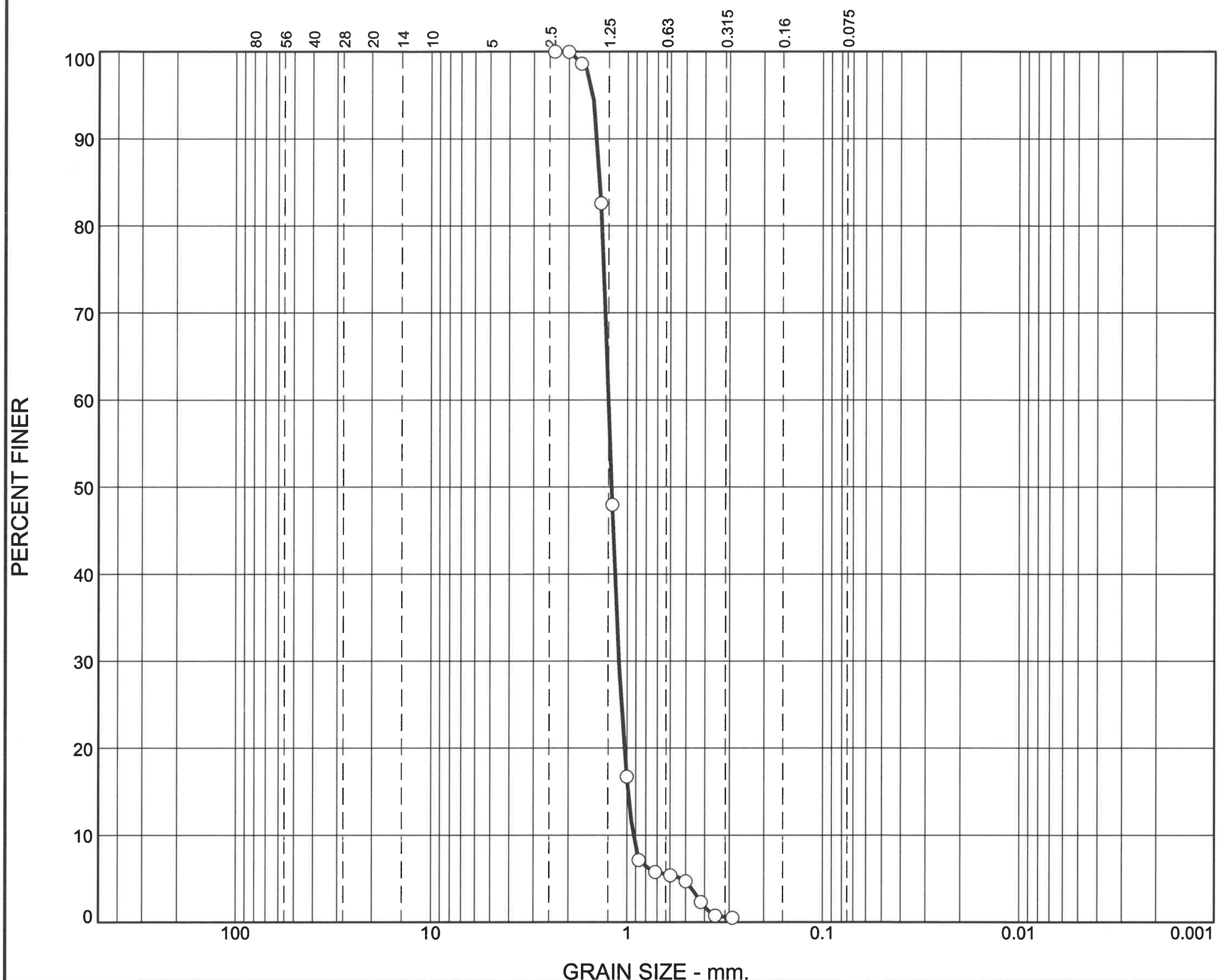
GRAIN SIZE DISTRIBUTION REPORT



	C_u	C_u spec.	D_{10}	D_{10} spec.	C_u	D_{10}	D_{60}	% - #30
○	1.35		0.9264				1.2502	5.4

Material and Supplier

○ Anthracite Sample 2 Top

Project No. 208715 **Client:** Sheboygan Water

Project: Filter #6 Media Core Testing

○ **Location:** Date Received: 1/19/23

Remarks:

BOWSER-MORNER, INC.

Dayton, Ohio

Tested By: RAS

BOWSER-MORNER, INC.

Delivery Address: 4518 Taylorsville Rd • Dayton, Ohio 45424 **Mailing Address:** P.O. Box 51 • Dayton, Ohio 45401

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LABORATORY REPORT

Report To: Sheboygan Water Utility
Attn: Bill Swearingen
72 Park Ave.
Sheboygan, WI 53081

Report Date: 02/15/23
Job No.: 208715
Report No.: 118930
No. of Pages: 2

Project/Plant: Filter #6 Media Core Testing
Test Method: AWWA B100-16

Date Received: 01/19/23
Date Sampled: 01/16/23

Sample ID: **Anthracite Sample 3 Top**

USA Std.	Nominal, mm	Effective, mm	Percent Passing
#8	2.36	2.36	**100.0**
#10	2.00	2.004	**99.7**
#12	1.70	1.724	**98.4**
#14	1.40	1.369	**82.9**
#16	1.18	1.195	**50.3**
#18	1.00	1.003	**20.8**
#20	0.850	0.870	**11.5**
#25	0.710	0.715	**9.9**
#30	0.600	0.598	**8.5**
#35	0.500	0.500	**5.2**
#40	0.425	0.418	**2.4**
#45	0.355	0.353	**1.4**
#50	0.300	0.289	**1.0**
#60	0.250	0.242	**0.5**
Effective Size, mm:			**0.72**
Uniformity Coefficient:			**1.7**
Acid Solubility, %:			**2.8**
Specific Gravity, (Apparent):			**1.81**
Moh's Hardness:			**3**

Should you have any questions or if we may be of further service, please contact me at 937-236-8805, extension 322.

Respectfully submitted,
BOWSER-MORNER, INC.

Karl A. Fletcher
Vice President
Director of Laboratory Services

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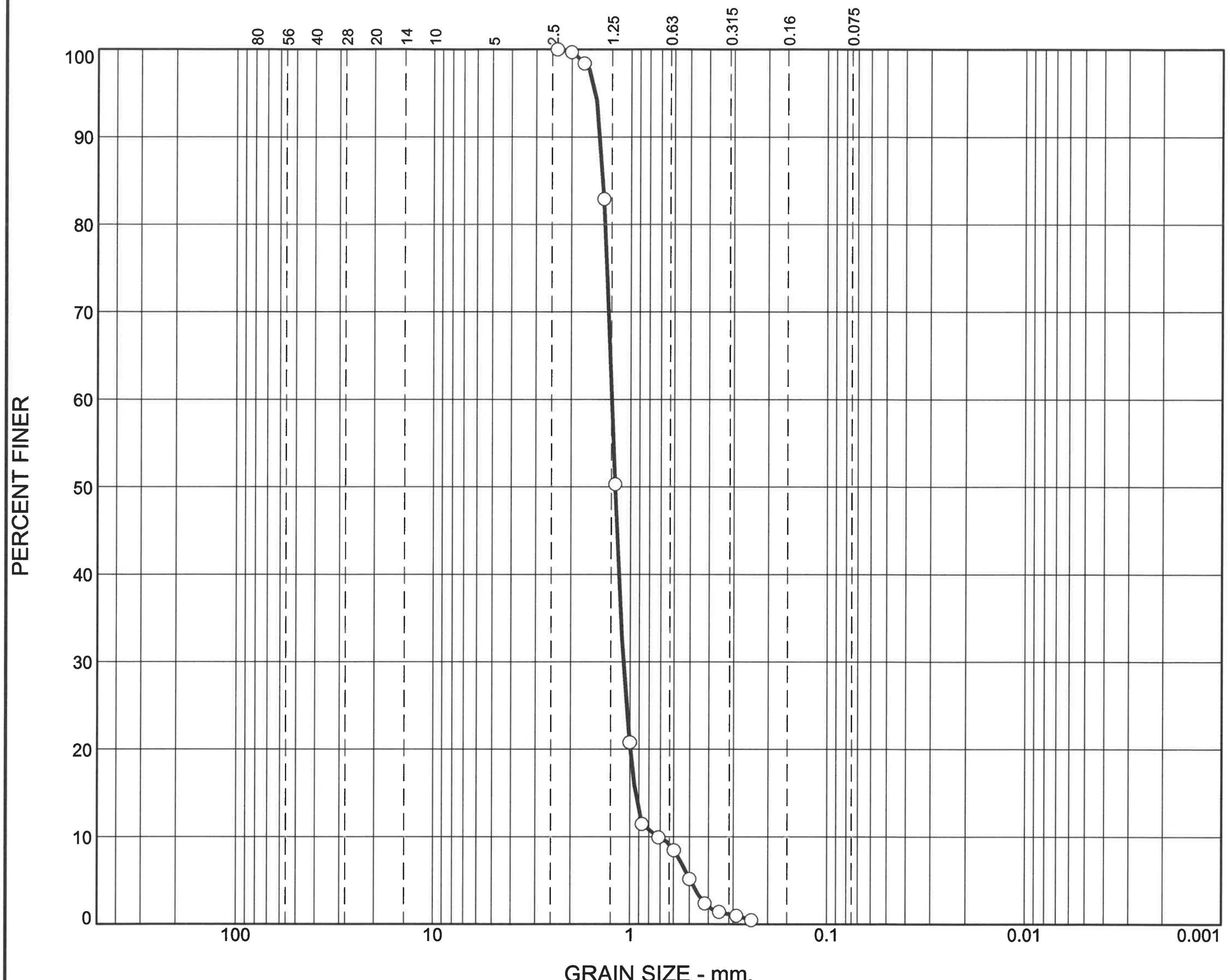
GRAIN SIZE DISTRIBUTION REPORT



	C_u	C_u spec.	D_{10}	D_{10} spec.	C_u	D_{10}	D_{60}	% - #30
○	1.72		0.7213				1.2424	8.5

Material and Supplier

○ Anthracite Sample 3

Project No. 208715 **Client:** Sheboygan Water

Project: Filter #6 Media Core Testing

○ **Location:** Date Received: 1/19/23

BOWSER-MORNER, INC.

Dayton, Ohio

Remarks:

Tested By: RAS

BOWSER-MORNER, INC.

Delivery Address: 4518 Taylorsville Rd • Dayton, Ohio 45424 **Mailing Address:** P.O. Box 51 • Dayton, Ohio 45401

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LABORATORY REPORT

Report To: Sheboygan Water Utility
Attn: Bill Swearingen
72 Park Ave.
Sheboygan, WI 53081

Report Date: 02/15/23
Job No.: 208715
Report No.: 118931
No. of Pages: 2

Project/Plant: Filter #6 Media Core Testing
Test Method: AWWA B100-16

Date Received: 01/19/23
Date Sampled: 01/16/23

Sample ID: **Anthracite Sample 4 Top**

USA Std.	Nominal, mm	Effective, mm	Percent Passing
#8	2.36	2.36	**100.0**
#10	2.00	2.004	**99.8**
#12	1.70	1.724	**96.7**
#14	1.40	1.369	**77.8**
#16	1.18	1.195	**47.2**
#18	1.00	1.003	**17.2**
#20	0.850	0.870	**10.6**
#25	0.710	0.715	**9.6**
#30	0.600	0.598	**8.3**
#35	0.500	0.500	**5.7**
#40	0.425	0.418	**3.0**
#45	0.355	0.353	**1.7**
#50	0.300	0.289	**1.2**
#60	0.250	0.242	**0.5**
Effective Size, mm:			**0.82**
Uniformity Coefficient:			**1.5**
Acid Solubility, %:			**2.4**
Specific Gravity, (Apparent):			**1.85**
Moh's Hardness:			**3**

Should you have any questions or if we may be of further service, please contact me at 937-236-8805, extension 322.

Respectfully submitted,
BOWSER-MORNER, INC.

Karl A. Fletcher
Vice President
Director of Laboratory Services

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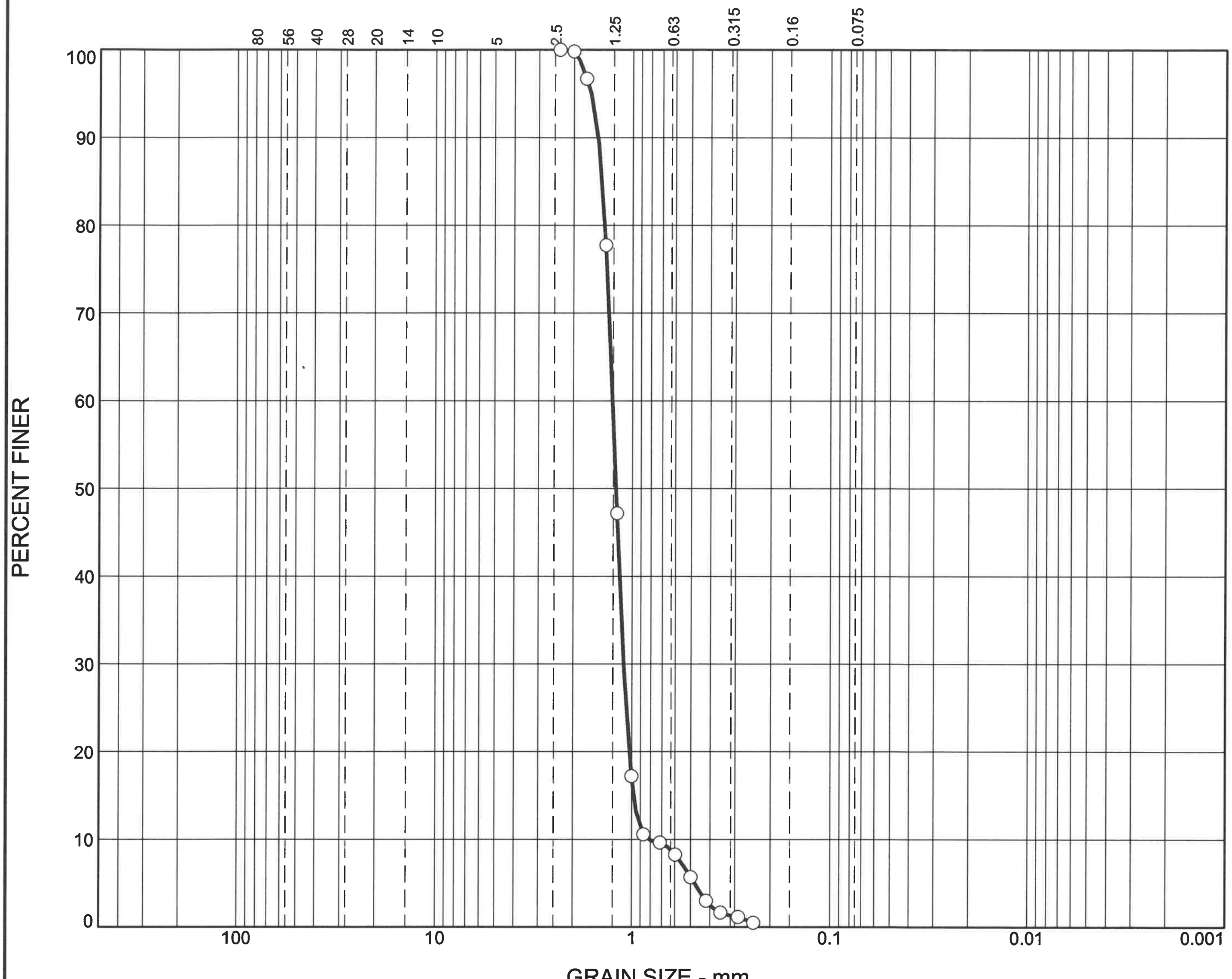
GRAIN SIZE DISTRIBUTION REPORT



	C_u	C_u spec.	D_{10}	D_{10} spec.	C_u	D_{10}	D_{60}	% - #30
○	1.54		0.8214				1.2613	8.3

Material and Supplier

○ Anthracite Sample 4

Project No. 208715 **Client:** Sheboygan Water

Project: Filter #6 Media Core Testing

○ **Location:** Date Received: 1/19/23

Remarks:

BOWSER-MORNER, INC.

Dayton, Ohio

Tested By: RAS

BOWSER-MORNER, INC.

Delivery Address: 4518 Taylorsville Rd • Dayton, Ohio 45424 **Mailing Address:** P.O. Box 51 • Dayton, Ohio 45401

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LABORATORY REPORT

Report To:	Sheboygan Water Utility Attn: Bill Swearingen 72 Park Ave. Sheboygan, WI 53081	**Report Date:** **Job No.:** **Report No.:** **No. of Pages:**	02/15/23 208715 118932 2
Project/Plant:	Filter #6 Media Core Testing	**Date Received:**	01/19/23
Test Method:	AWWA B100-16	**Date Sampled:**	01/16/23

Sample ID: **Anthracite Sample 5 Top**

USA Std.	Nominal, mm	Effective, mm	Percent Passing
#8	2.36	2.36	**100.0**
#10	2.00	2.004	**99.8**
#12	1.70	1.724	**98.4**
#14	1.40	1.369	**87.6**
#16	1.18	1.195	**60.6**
#18	1.00	1.003	**29.9**
#20	0.850	0.870	**17.4**
#25	0.710	0.715	**14.9**
#30	0.600	0.598	**11.7**
#35	0.500	0.500	**7.0**
#40	0.425	0.418	**3.5**
#45	0.355	0.353	**2.2**
#50	0.300	0.289	**1.4**
#60	0.250	0.242	**0.5**
Effective Size, mm:			**0.56**
Uniformity Coefficient:			**2.1**
Acid Solubility, %:			**2.7**
Specific Gravity, (Apparent):			**1.74**
Moh's Hardness:			**3**

Should you have any questions or if we may be of further service, please contact me at 937-236-8805, extension 322.

Respectfully submitted,
BOWSER-MORNER, INC.

Karl A. Fletcher
Vice President
Director of Laboratory Services

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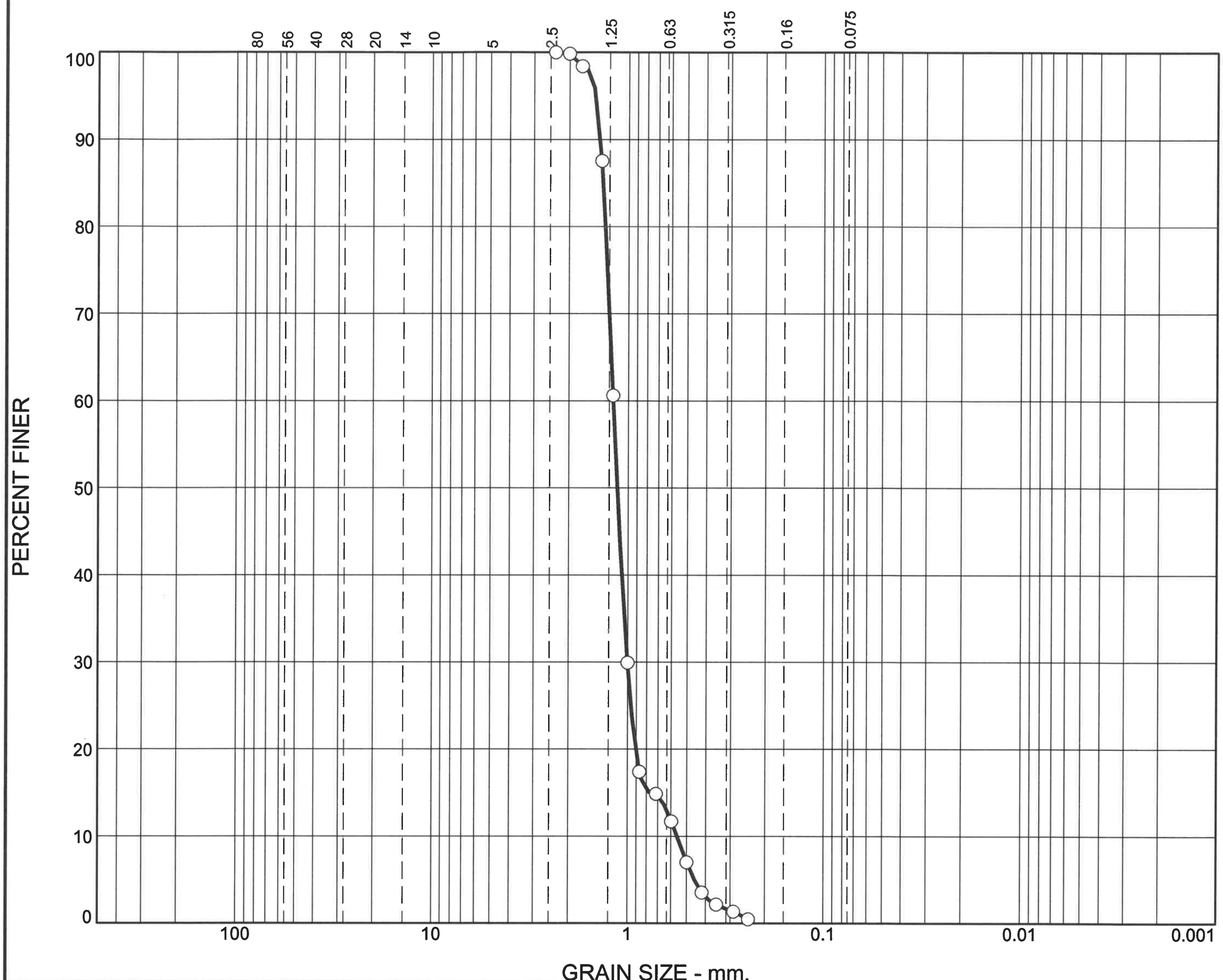
GRAIN SIZE DISTRIBUTION REPORT



☒	C_u	C_u spec.	D_{10}	D_{10} spec.	C_u	D_{10}	D_{60}	% - #30
○	2.13		0.5604				1.1914	11.8

Material and Supplier

○ Anthracite Sample 5

Project No. 208715 **Client:** Sheboygan Water

Project: Filter #6 Media Core Testing

○ **Location:** Date Received: 1/19/23

Remarks:

BOWSER-MORNER, INC.

Dayton, Ohio

Tested By: RAS

BOWSER-MORNER, INC.

Delivery Address: 4518 Taylorsville Rd • Dayton, Ohio 45424 **Mailing Address:** P.O. Box 51 • Dayton, Ohio 45401

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LABORATORY REPORT

Report To:	Sheboygan Water Utility Attn: Bill Swearingen 72 Park Ave. Sheboygan, WI 53081	**Report Date:** **Job No.:** **Report No.:** **No. of Pages:**	02/15/23 208715 118933 2
Project/Plant:	Filter #6 Media Core Testing	**Date Received:**	01/19/23
Test Method:	AWWA B100-16	**Date Sampled:**	01/16/23

Sample ID: **Anthracite Sample 6 Top**

USA Std.	Nominal, mm	Effective, mm	Percent Passing
#8	2.36	2.36	**100.0**
#10	2.00	2.004	**99.9**
#12	1.70	1.724	**98.8**
#14	1.40	1.369	**86.2**
#16	1.18	1.195	**53.5**
#18	1.00	1.003	**21.4**
#20	0.850	0.870	**10.3**
#25	0.710	0.715	**8.5**
#30	0.600	0.598	**8.0**
#35	0.500	0.500	**6.9**
#40	0.425	0.418	**3.6**
#45	0.355	0.353	**1.5**
#50	0.300	0.289	**1.0**
#60	0.250	0.242	**0.6**
Effective Size, mm:			**0.85**
Uniformity Coefficient:			**1.4**
Acid Solubility, %:			**2.9**
Specific Gravity, (Apparent):			**1.74**
Moh's Hardness:			**3**

Should you have any questions or if we may be of further service, please contact me at 937-236-8805, extension 322.

Respectfully submitted,
BOWSER-MORNER, INC.

Karl A. Fletcher
Vice President
Director of Laboratory Services

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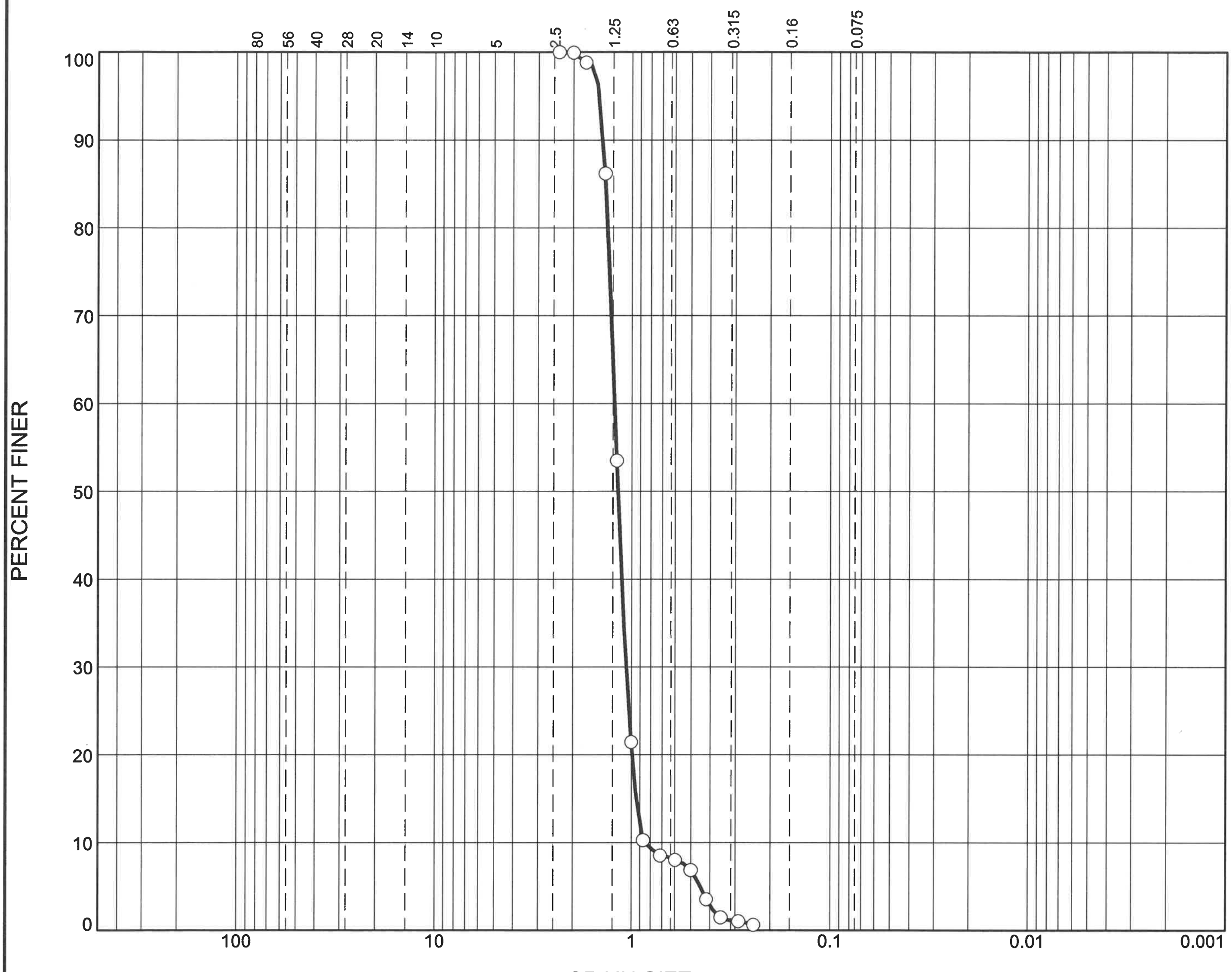
1-billswearingen@sheboyganwater.org

GRAIN SIZE DISTRIBUTION REPORT



	C_u	C_u spec.	D_{10}	D_{10} spec.	C_u	D_{10}	D_{60}	% - #30
○	1.44		0.8490				1.2259	8.0

Material and Supplier

○ Anthracite Sample 6

Project No. 208715 **Client:** Sheboygan Water

Project: Filter #6 Media Core Testing

○ **Location:** Date Received: 1/19/23

Remarks:

BOWSER-MORNER, INC.

Dayton, Ohio

Tested By: RAS

BOWSER-MORNER, INC.

Delivery Address: 4518 Taylorsville Rd • Dayton, Ohio 45424 **Mailing Address:** P.O. Box 51 • Dayton, Ohio 45401

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LABORATORY REPORT

Report To:	Sheboygan Water Utility		**Report Date:**	02/15/23
	Attn: Bill Swearingen		**Job No.:**	208715
	72 Park Ave.		**Report No.:**	118934
	Sheboygan, WI 53081		**No. of Pages:**	2
Project/Plant:	Filter #6 Media Core Testing		**Date Received:**	01/19/23
Test Method:	AWWA B100-16		**Date Sampled:**	01/16/23
Sample ID:	**Sand Sample 1 Bottom**			

USA Std.	Nominal, mm	Effective, mm	Percent Passing
#8	2.36	2.36	**100.0**
#10	2.00	2.044	**99.9**
#12	1.70	1.703	**99.6**
#14	1.40	1.400	**97.9**
#16	1.18	1.200	**94.5**
#18	1.00	0.994	**91.1**
#20	0.850	0.870	**89.7**
#25	0.710	0.706	**84.8**
#30	0.600	0.605	**60.8**
#35	0.500	0.499	**29.0**
#40	0.425	0.414	**20.0**
#45	0.355	0.345	**10.2**
#50	0.300	0.297	**4.6**
#60	0.250	0.247	**1.0**
#70	0.212	0.212	**0.4**
Effective Size, mm:			**0.34**
Uniformity Coefficient:			**1.8**
Acid Solubility, %:			**1.6**
Specific Gravity, (Apparent):			**2.75**
Moh's Hardness:			**7**
Aluminum, %:			**4.9**
Calcium, %:			**7.5**

Should you have any questions or if we may be of further service, please contact me at 937-236-8805, extension 322.

Respectfully submitted,

BOWSER-MORNER, INC.

Karl A. Fletcher
Vice President
Director of Laboratory Services

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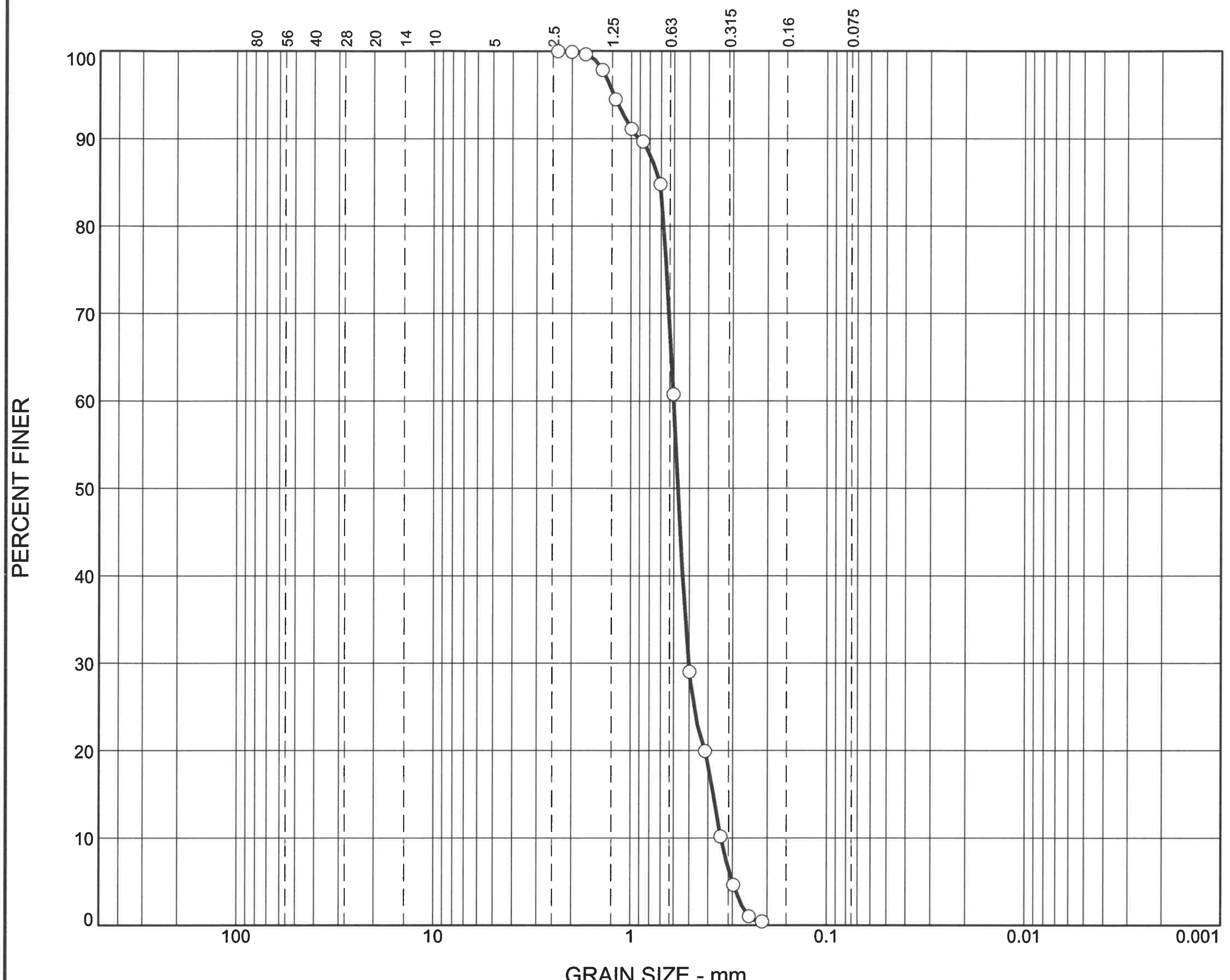
1-billswearingen@sheboyganwater.org

GRAIN SIZE DISTRIBUTION REPORT



☒	C_u	C_u spec.	D_{10}	D_{10} spec.	C_u	D_{10}	D_{60}	% - #30
○	1.75		0.3438				0.6025	59.2

Material and Supplier

○ Sand Sample 1

Project No. 208715 **Client:** Sheboygan Water

Project: Filter #6 Media Core Testing

○ **Location:** Date Received: 1/19/23

Remarks:

BOWSER-MORNER, INC.

Dayton, Ohio

Tested By: RAS

BOWSER-MORNER, INC.

Delivery Address: 4518 Taylorsville Rd • Dayton, Ohio 45424 **Mailing Address:** P.O. Box 51 • Dayton, Ohio 45401

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LABORATORY REPORT

Report To:	Sheboygan Water Utility Attn: Bill Swearingen 72 Park Ave. Sheboygan, WI 53081	**Report Date:** **Job No.:** **Report No.:** **No. of Pages:**	02/15/23 208715 118935 2
Project/Plant:	Filter #6 Media Core Testing	**Date Received:**	01/19/23
Test Method:	AWWA B100-16	**Date Sampled:**	01/16/23
Sample ID:	**Sand Sample 2 Bottom**		

USA Std.	Nominal, mm	Effective, mm	Percent Passing
#10	2.00	2.044	**100.0**
#12	1.70	1.703	**99.4**
#14	1.40	1.400	**97.8**
#16	1.18	1.200	**95.9**
#18	1.00	0.994	**94.5**
#20	0.850	0.870	**93.8**
#25	0.710	0.706	**90.0**
#30	0.600	0.605	**68.6**
#35	0.500	0.499	**32.4**
#40	0.425	0.414	**22.2**
#45	0.355	0.345	**13.9**
#50	0.300	0.297	**6.8**
#60	0.250	0.247	**1.6**
#70	0.212	0.212	**0.6**
Effective Size, mm:			**0.32**
Uniformity Coefficient:			**1.8**
Acid Solubility, %:			**1.6**
Specific Gravity, (Apparent):			**2.75**
Moh's Hardness:			**7**
Aluminum, %:			**4.9**
Calcium, %:			**6.5**

Should you have any questions or if we may be of further service, please contact me at 937-236-8805, extension 322.

Respectfully submitted,

BOWSER-MORNER, INC.

Karl A. Fletcher
Vice President
Director of Laboratory Services

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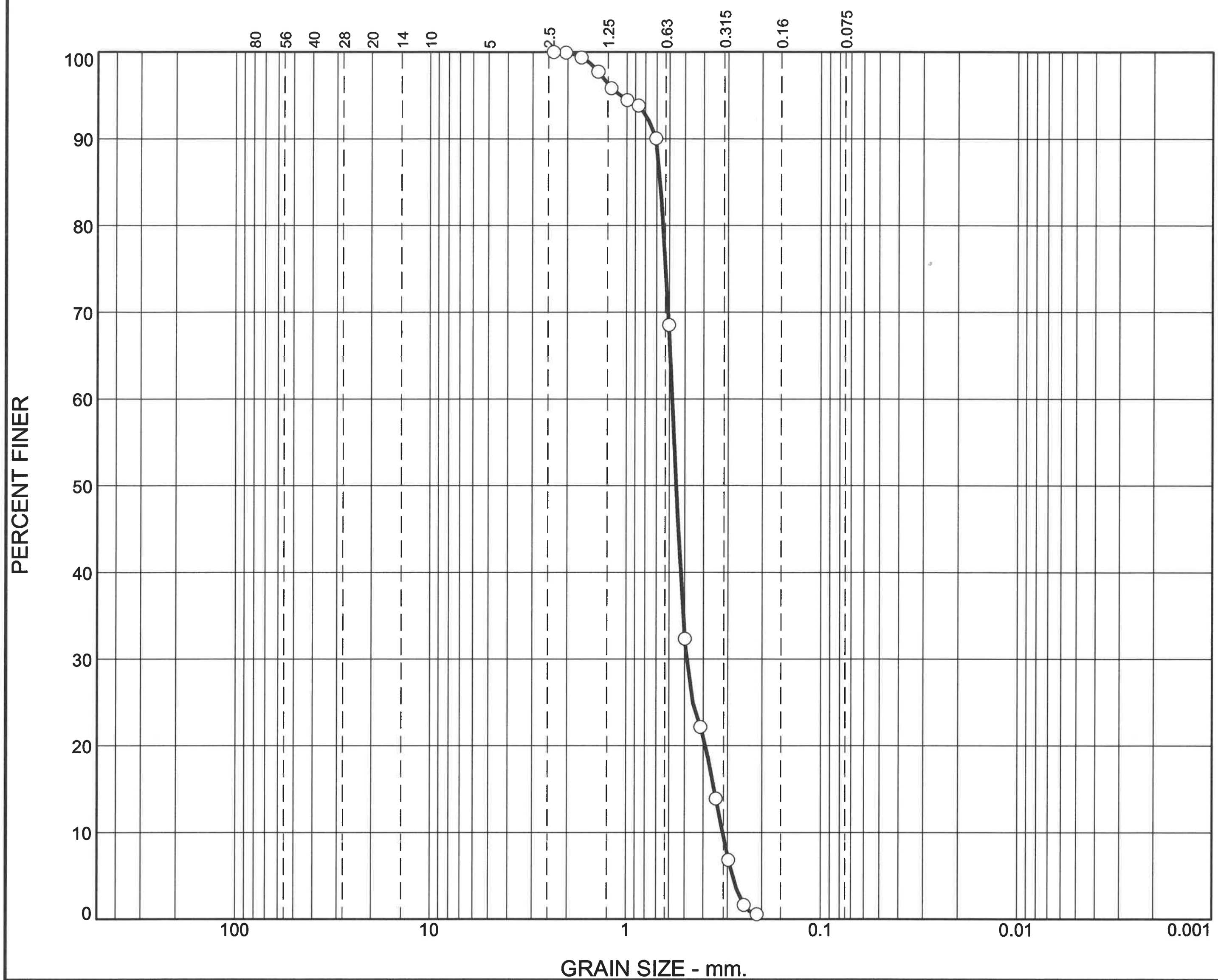
GRAIN SIZE DISTRIBUTION REPORT



	C_u	C_u spec.	D_{10}	D_{10} spec.	C_u	D_{10}	D_{60}	% - #30
○	1.82		0.3190				0.5798	66.9

Material and Supplier

○ Sand Sample 2

Project No. 208715 **Client:** Sheboygan Water

Project: Filter #6 Media Core Testing

○ **Location:** Date Received: 1/19/23

Remarks:

BOWSER-MORNER, INC.

Dayton, Ohio

Tested By: RAS

BOWSER-MORNER, INC.

Delivery Address: 4518 Taylorsville Rd • Dayton, Ohio 45424 **Mailing Address:** P.O. Box 51 • Dayton, Ohio 45401

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LABORATORY REPORT

Report To: Sheboygan Water Utility
Attn: Bill Swearingen
72 Park Ave.
Sheboygan, WI 53081

Report Date: 02/15/23
Job No.: 208715
Report No.: 118936
No. of Pages: 2

Project/Plant: Filter #6 Media Core Testing
Test Method: AWWA B100-16
Sample ID: **Sand Sample 3 Bottom**

Date Received: 01/19/23
Date Sampled: 01/16/23

USA Std.	Nominal, mm	Effective, mm	Percent Passing
#8	2.36	2.36	**100.0**
#10	2.00	2.044	**99.8**
#12	1.70	1.703	**99.1**
#14	1.40	1.400	**96.6**
#16	1.18	1.200	**92.8**
#18	1.00	0.994	**89.5**
#20	0.850	0.870	**88.2**
#25	0.710	0.706	**84.7**
#30	0.600	0.605	**65.2**
#35	0.500	0.499	**30.9**
#40	0.425	0.414	**20.1**
#45	0.355	0.345	**11.7**
#50	0.300	0.297	**5.9**
#60	0.250	0.247	**1.4**
#70	0.212	0.212	**0.1**
Effective Size, mm:			**0.33**
Uniformity Coefficient:			**1.8**
Acid Solubility, %:			**1.8**
Specific Gravity, (Apparent):			**2.71**
Moh's Hardness:			**7**
Aluminum, %:			**5.0**
Calcium, %:			**6.4**

Should you have any questions or if we may be of further service, please contact me at 937-236-8805, extension 322.

Respectfully submitted,

BOWSER-MORNER, INC.

Karl A. Fletcher
Vice President
Director of Laboratory Services

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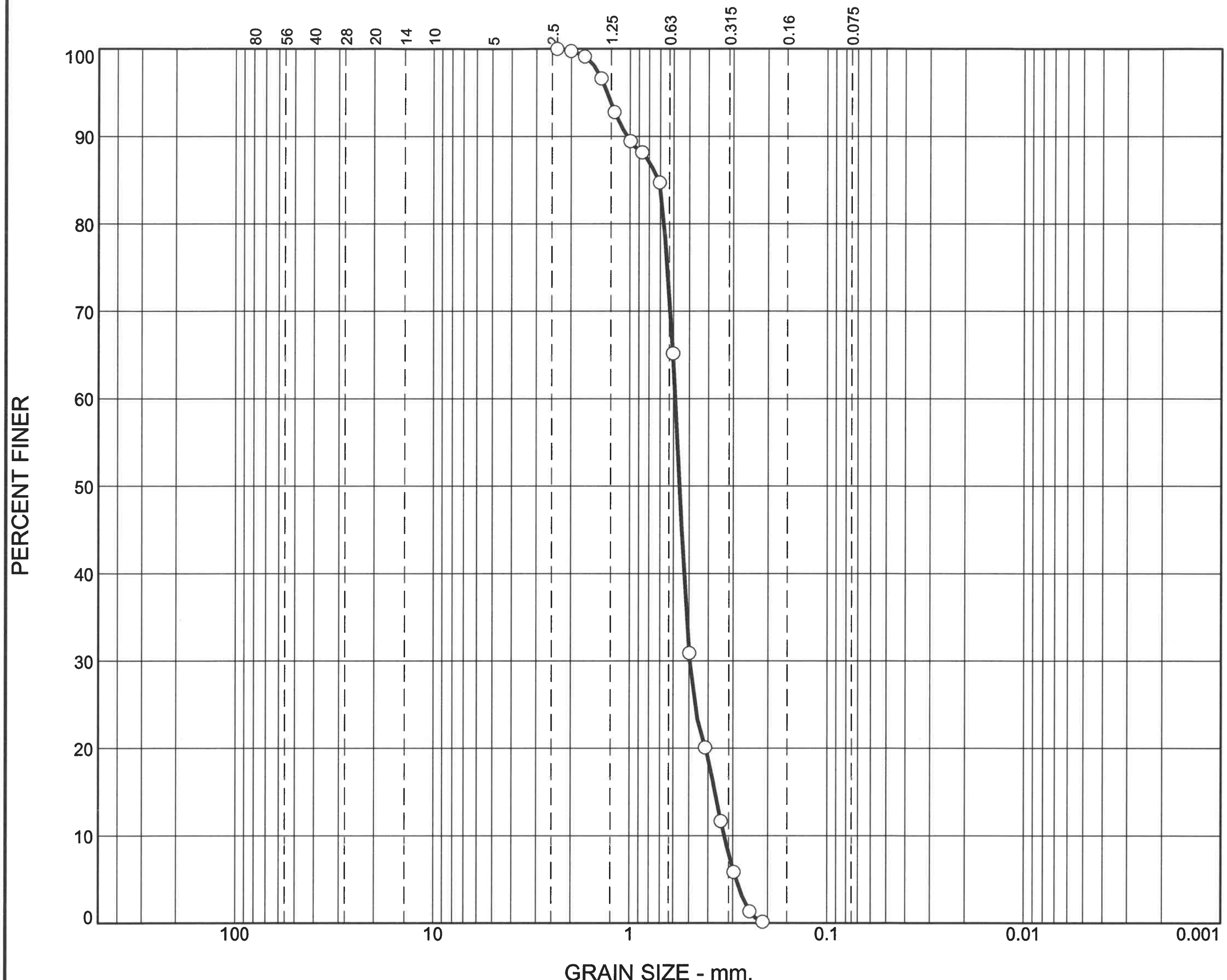
GRAIN SIZE DISTRIBUTION REPORT



☒	C_u	C_u spec.	D_{10}	D_{10} spec.	C_u	D_{10}	D_{60}	% - #30
○	1.77		0.3322				0.5882	63.7

Material and Supplier

○ Sand Sample 3

Project No. 208715 **Client:** Sheboygan Water

Project: Filter #6 Media Core Testing

○ **Location:** Date Received: 1/19/23

Remarks:

BOWSER-MORNER, INC.

Dayton, Ohio

Tested By: RAS

BOWSER-MORNER, INC.

Delivery Address: 4518 Taylorsville Rd • Dayton, Ohio 45424 **Mailing Address:** P.O. Box 51 • Dayton, Ohio 45401

AASHTO/ISO 17025 Accredited • USACE Validated ACIL INDEPENDENCE

LABORATORY REPORT

Report To:	Sheboygan Water Utility Attn: Bill Swearingen 72 Park Ave. Sheboygan, WI 53081	**Report Date:** **Job No.:** **Report No.:** **No. of Pages:**	02/15/23 208715 118937 2
Project/Plant:	Filter #6 Media Core Testing	**Date Received:**	01/19/23
Test Method:	AWWA B100-16	**Date Sampled:**	01/16/23
Sample ID:	**Sand Sample 4 Bottom**		

USA Std.	Nominal, mm	Effective, mm	Percent Passing
#10	2.00	2.044	**100.0**
#12	1.70	1.703	**99.6**
#14	1.40	1.400	**97.7**
#16	1.18	1.200	**95.6**
#18	1.00	0.994	**93.7**
#20	0.850	0.870	**92.8**
#25	0.710	0.706	**89.6**
#30	0.600	0.605	**66.2**
#35	0.500	0.499	**29.8**
#40	0.425	0.414	**21.4**
#45	0.355	0.345	**13.4**
#50	0.300	0.297	**6.3**
#60	0.250	0.247	**1.6**
#70	0.212	0.212	**0.6**
Effective Size, mm:			**0.32**
Uniformity Coefficient:			**1.8**
Acid Solubility, %:			**1.6**
Specific Gravity, (Apparent):			**2.74**
Moh's Hardness:			**7**
Aluminum, %:			**4.8**
Calcium, %:			**6.4**

Should you have any questions or if we may be of further service, please contact me at 937-236-8805, extension 322.

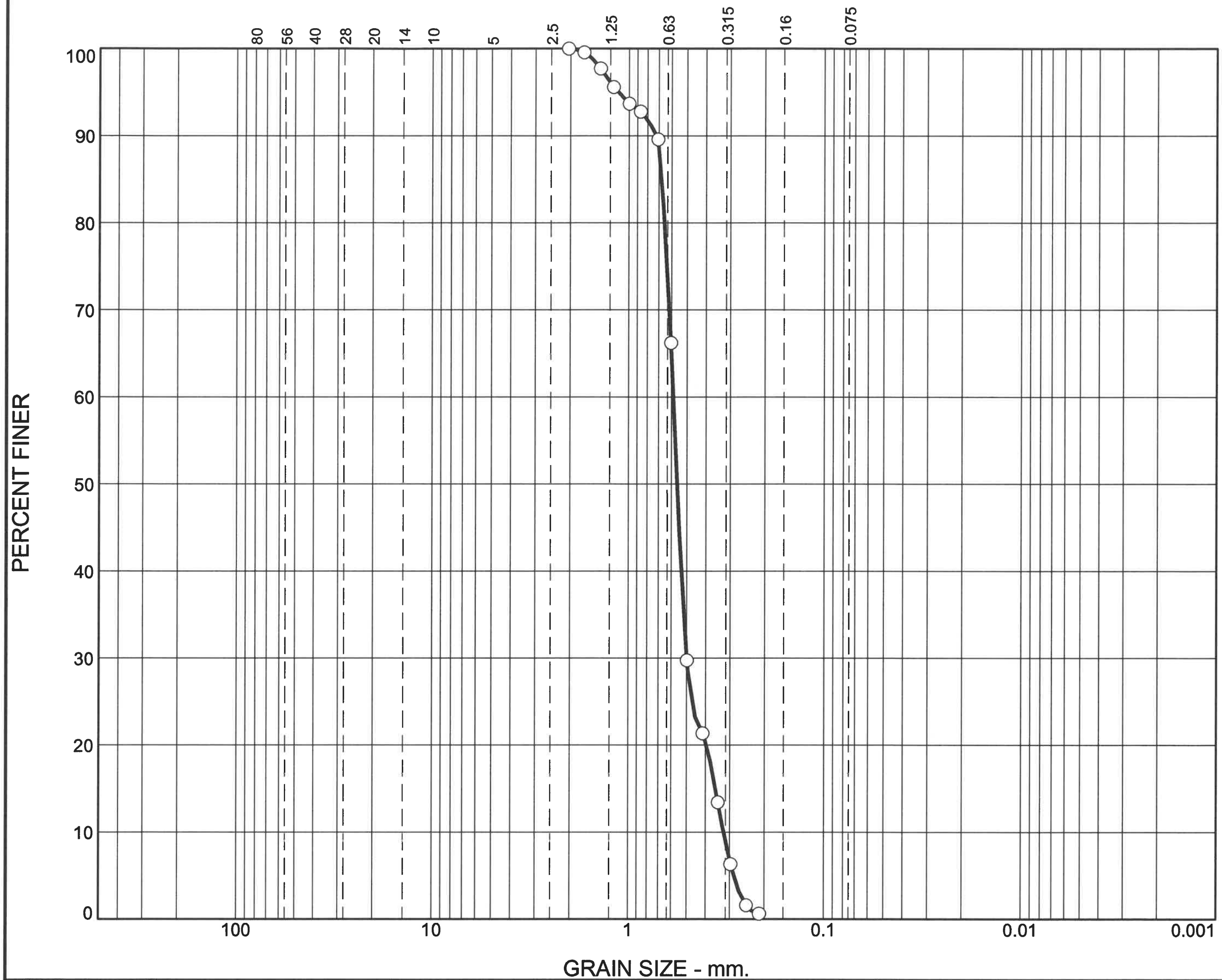
Respectfully submitted,

BOWSER-MORNER, INC.

Karl A. Fletcher
Vice President
Director of Laboratory Services

KAF/ras/drj
118937
1-File
1-billswearingen@sheboyganwater.org

GRAIN SIZE DISTRIBUTION REPORT



	C_u	C_u spec.	D_{10}	D_{10} spec.	C_u	D_{10}	D_{60}	% - #30
○	1.82		0.3226				0.5872	64.5

Material and Supplier

○ Sand Sample 4

Project No. 208715 **Client:** Sheboygan Water

Project: Filter #6 Media Core Testing

○ **Location:** Date Received: 1/19/23

BOWSER-MORNER, INC.

Dayton, Ohio

Remarks:

Tested By: RAS

BOWSER-MORNER, INC.

Delivery Address: 4518 Taylorsville Rd • Dayton, Ohio 45424 **Mailing Address:** P.O. Box 51 • Dayton, Ohio 45401

AASHTO/ISO 17025 Accredited • USACE Validated

LABORATORY REPORT

Report To: Sheboygan Water Utility
Attn: Bill Swearingen
72 Park Ave.
Sheboygan, WI 53081

Report Date: 02/15/23
Job No.: 208715
Report No.: 118938
No. of Pages: 2

Project/Plant: Filter #6 Media Core Testing
Test Method: AWWA B100-16
Sample ID: **Sand Sample 5 Bottom**

Date Received: 01/19/23
Date Sampled: 01/16/23

USA Std.	Nominal, mm	Effective, mm	Percent Passing
#8	2.36	2.36	**100.0**
#10	2.00	2.044	**99.1**
#12	1.70	1.703	**98.2**
#14	1.40	1.400	**93.8**
#16	1.18	1.200	**85.4**
#18	1.00	0.994	**78.6**
#20	0.850	0.870	**76.4**
#25	0.710	0.706	**73.5**
#30	0.600	0.605	**58.7**
#35	0.500	0.499	**30.8**
#40	0.425	0.414	**19.7**
#45	0.355	0.345	**11.0**
#50	0.300	0.297	**5.8**
#60	0.250	0.247	**1.5**
#70	0.212	0.212	**0.6**
Effective Size, mm:			**0.34**
Uniformity Coefficient:			**1.8**
Acid Solubility, %:			**1.9**
Specific Gravity, (Apparent):			**2.70**
Moh's Hardness:			**7**
Aluminum, %:			**5.6**
Calcium, %:			**4.2**

Should you have any questions or if we may be of further service, please contact me at 937-236-8805, extension 322.

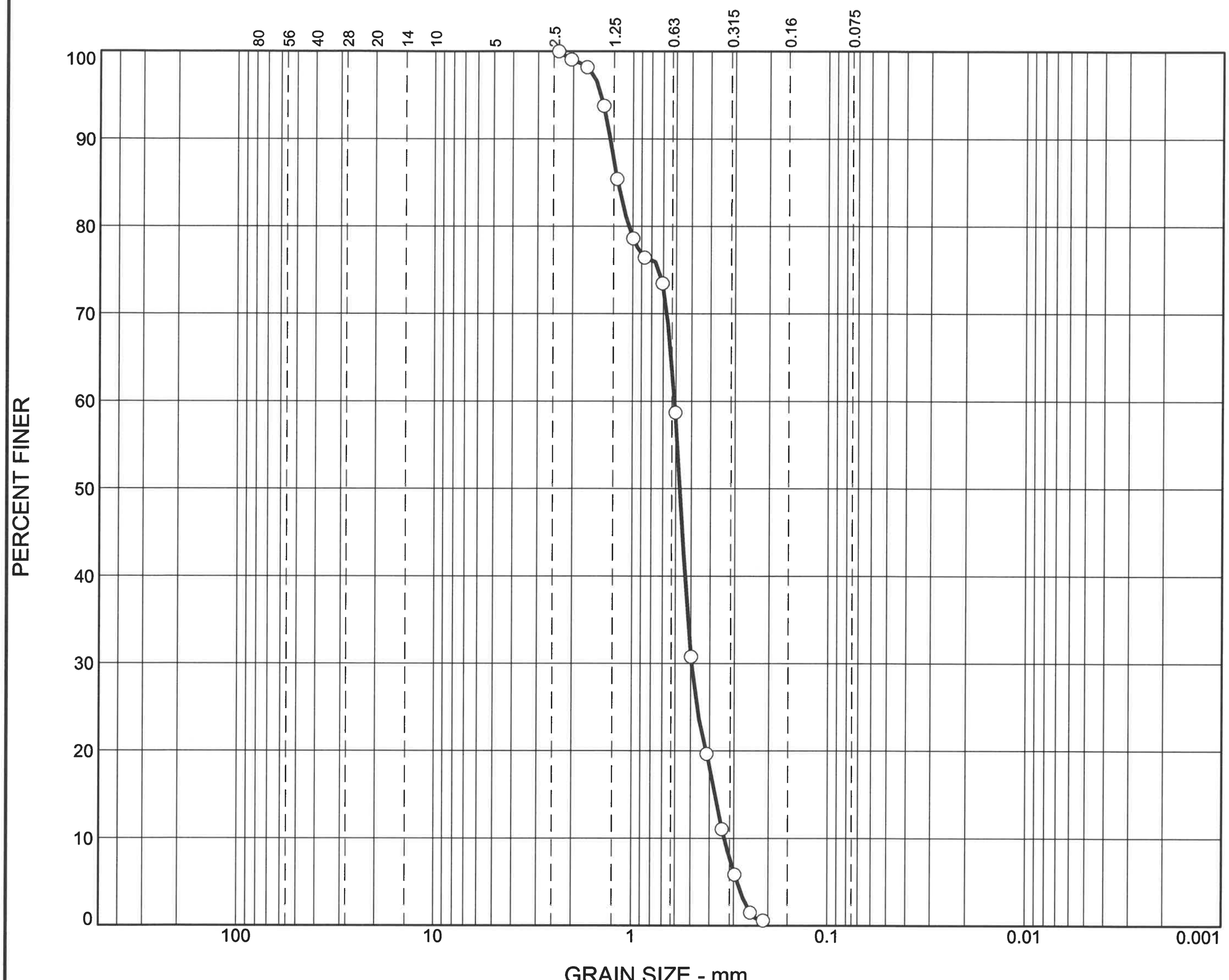
Respectfully submitted,

BOWSER-MORNER, INC.

Karl A. Fletcher
Vice President
Director of Laboratory Services

KAF/ras/drj
118938
1-File
1-billswearingen@sheboyganwater.org

GRAIN SIZE DISTRIBUTION REPORT



☒	C_u	C_u spec.	D_{10}	D_{10} spec.	C_u	D_{10}	D_{60}	% - #30
○	1.82		0.3363				0.6108	57.5

Material and Supplier

○ Sand Sample 5

Project No. 208715 **Client:** Sheboygan Water

Project: Filter #6 Media Core Testing

○ **Location:** Date Received: 1/19/23

Remarks:

BOWSER-MORNER, INC.

Dayton, Ohio

Tested By: RAS

BOWSER-MORNER, INC.

Delivery Address: 4518 Taylorsville Rd • Dayton, Ohio 45424 **Mailing Address:** P.O. Box 51 • Dayton, Ohio 45401

AASHTO/ISO 17025 Accredited • USACE Validated

LABORATORY REPORT

Report To:	Sheboygan Water Utility Attn: Bill Swearingen 72 Park Ave. Sheboygan, WI 53081	**Report Date:** **Job No.:** **Report No.:** **No. of Pages:**	02/15/23 208715 118939 2
Project/Plant:	Filter #6 Media Core Testing	**Date Received:**	01/19/23
Test Method:	AWWA B100-16	**Date Sampled:**	01/16/23
Sample ID:	**Sand Sample 6 Bottom**		

USA Std.	Nominal, mm	Effective, mm	Percent Passing
#8	2.36	2.36	**100.0**
#10	2.00	2.044	**99.7**
#12	1.70	1.703	**98.9**
#14	1.40	1.400	**96.3**
#16	1.18	1.200	**93.1**
#18	1.00	0.994	**91.1**
#20	0.850	0.870	**90.3**
#25	0.710	0.706	**86.7**
#30	0.600	0.605	**67.9**
#35	0.500	0.499	**33.9**
#40	0.425	0.414	**22.3**
#45	0.355	0.345	**14.2**
#50	0.300	0.297	**7.6**
#60	0.250	0.247	**2.0**
#70	0.212	0.212	**1.2**
#80	0.180	0.180	**0.6**
Effective Size, mm:			**0.31**
Uniformity Coefficient:			**1.8**
Acid Solubility, %:			**1.7**
Specific Gravity, (Apparent):			**2.65**
Moh's Hardness:			**7**
Aluminum, %:			**5.0**
Calcium, %:			**6.3**

Should you have any questions or if we may be of further service, please contact me at 937-236-8805, extension 322.

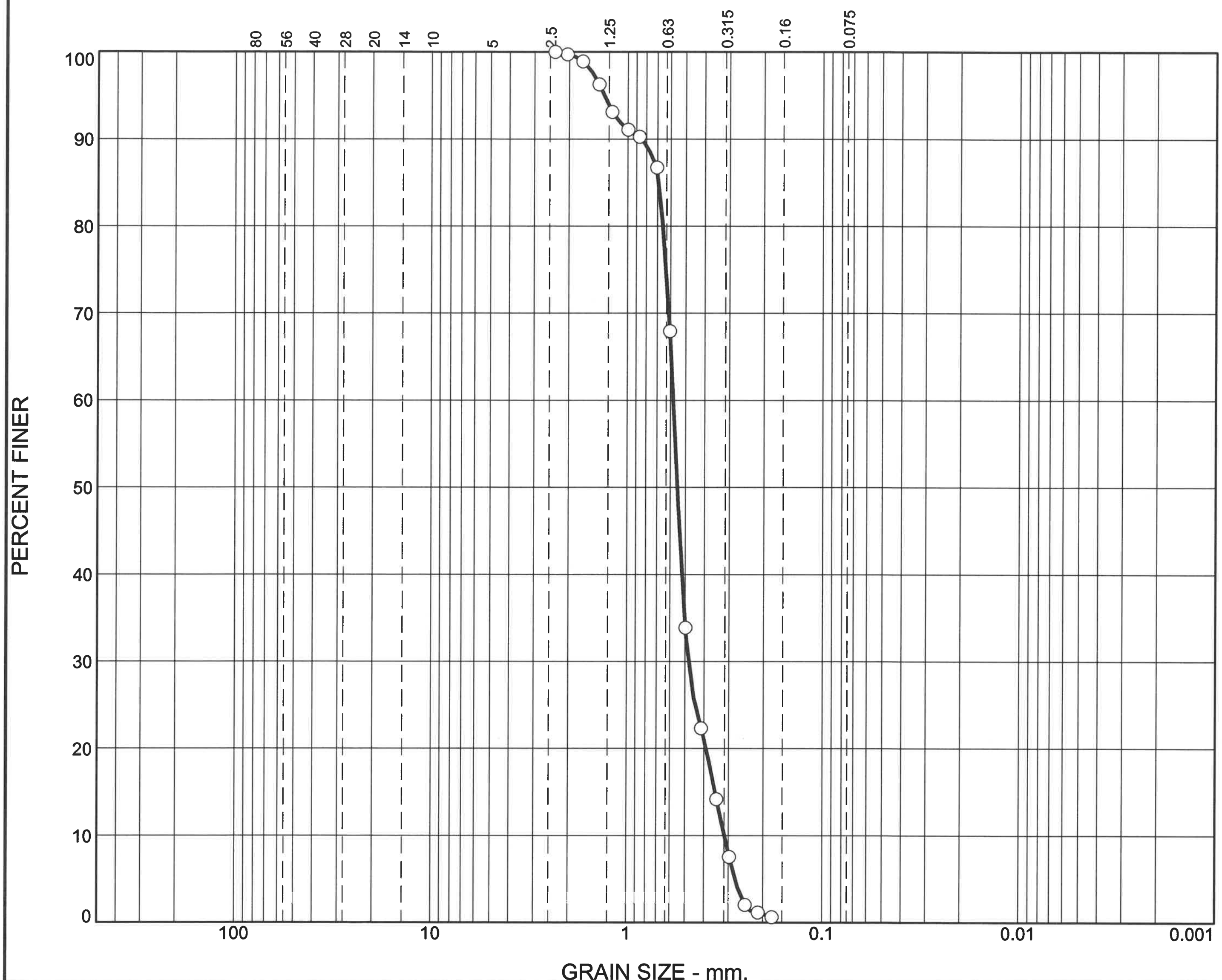
Respectfully submitted,

BOWSER-MORNER, INC.

Karl A. Fletcher
Vice President
Director of Laboratory Services

KAF/ras/drj
118939
1-File
1-billswearingen@sheboyganwater.org

GRAIN SIZE DISTRIBUTION REPORT



	C_u	C_u spec.	D_{10}	D_{10} spec.	C_u	D_{10}	D_{60}	% - #30
○	1.84		0.3148				0.5794	66.5

Material and Supplier

○ Sand Sample 6

Project No. 208715 **Client:** Sheboygan Water

Project: Filter #6 Media Core Testing

○ **Location:** Date Received: 1/19/23

Remarks:

BOWSER-MORNER, INC.

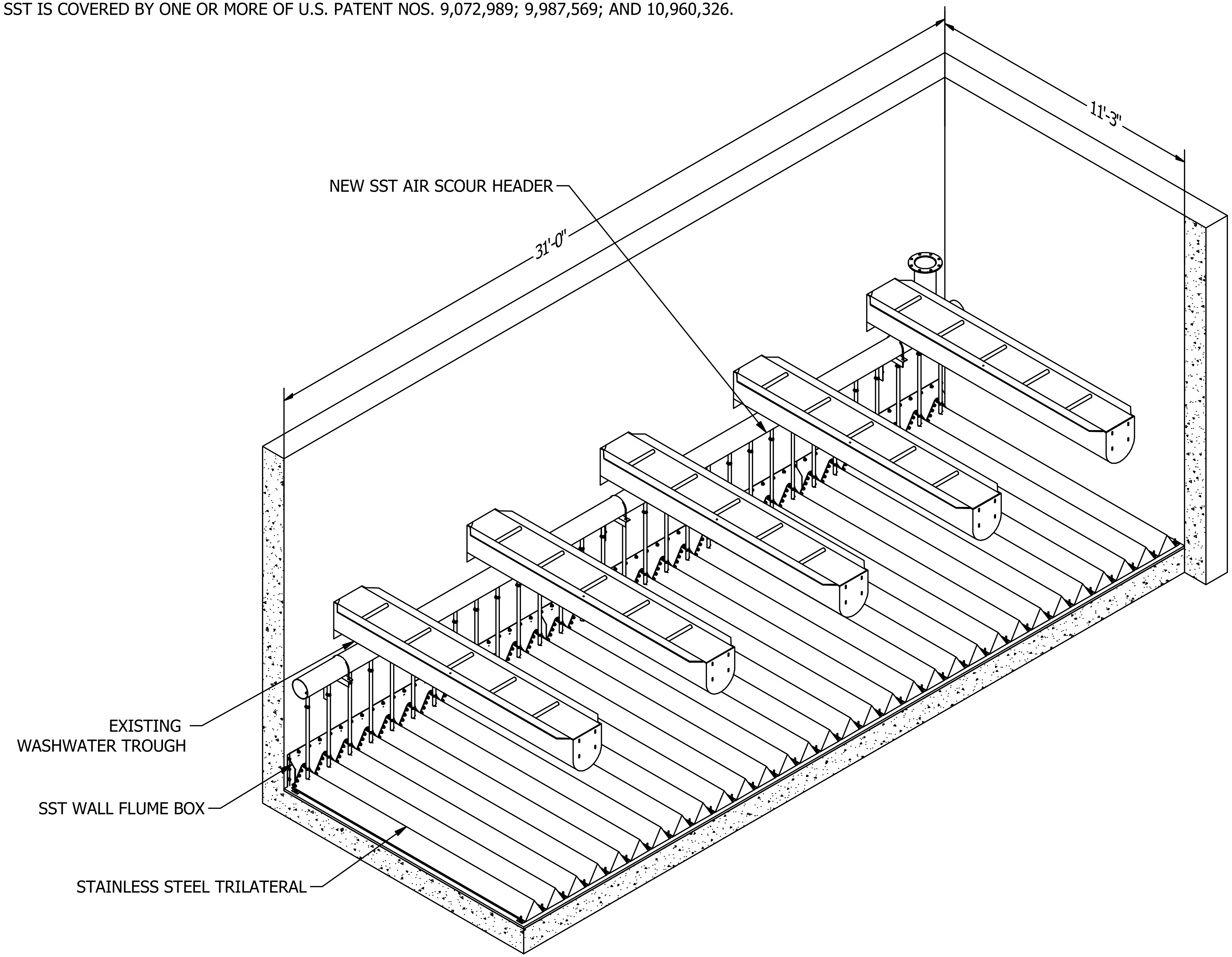
Dayton, Ohio

Tested By: RAS

Appendix B – Roberts Underdrain Drawings

GENERAL NOTES:

1. ROBERTS PROPOSES FURNISHING THE FOLLOWING EQUIPMENT FOR INSTALLATION BY OTHERS IN FILTERS 1-9: THIRTY-ONE (31) STAINLESS STEEL TRILATERAL UNDERDRAIN LATERALS, HOLDDOWNS AND HARDWARE, WALL FLUME BOX AND REPLACEMENT AIR CONNECTION PARTS.
2. DIMENSIONS AND OTHER INFORMATION PRESENTED ON THIS DRAWING REPRESENT ROBERTS INTERPRETATION OF THE PROJECT REQUIREMENTS BASED UPON THE PLANS AND SPECIFICATIONS PREPARED BY OTHERS. ROBERTS HAS NOT AND WILL NOT MAKE ANY SITE SURVEY AND WE EXPECT THE PURCHASER TO VERIFY ALL MEASUREMENTS SHOWN, PROVIDE NEW INFORMATION WHERE REQUIRED, AND ADVISE US OF ANY CONDITIONS NOT HERETOFORE DISCLOSED THAT WILL IMPACT THE DESIGN OR OPERATION OF OUR EQUIPMENT. ROBERTS WILL ASSUME NO RESPONSIBILITY FOR ANY COST ASSOCIATED WITH EXTRA WORK NECESSITATED BY UNDISCLOSED CONDITIONS.
3. DESIGN SHOWN IS PRELIMINARY AND SUBJECT TO CHANGE.
4. ROBERTS TRILATERAL SST IS COVERED BY ONE OR MORE OF U.S. PATENT NOS. 9,072,989; 9,987,569; AND 10,960,326.



ISO VIEW

(REF DWG 22-1212-M8 FOR PLAN VIEW)
(TYP OF FILTERS 1 THRU 9 RIGHT BAY.
LEFT BAY IS A MIRRORED DESIGN)

PRELIMINARY 12/12/2022

DATE:
CHECKED:
DATE: 12/12/2022
DRAWN: CRE

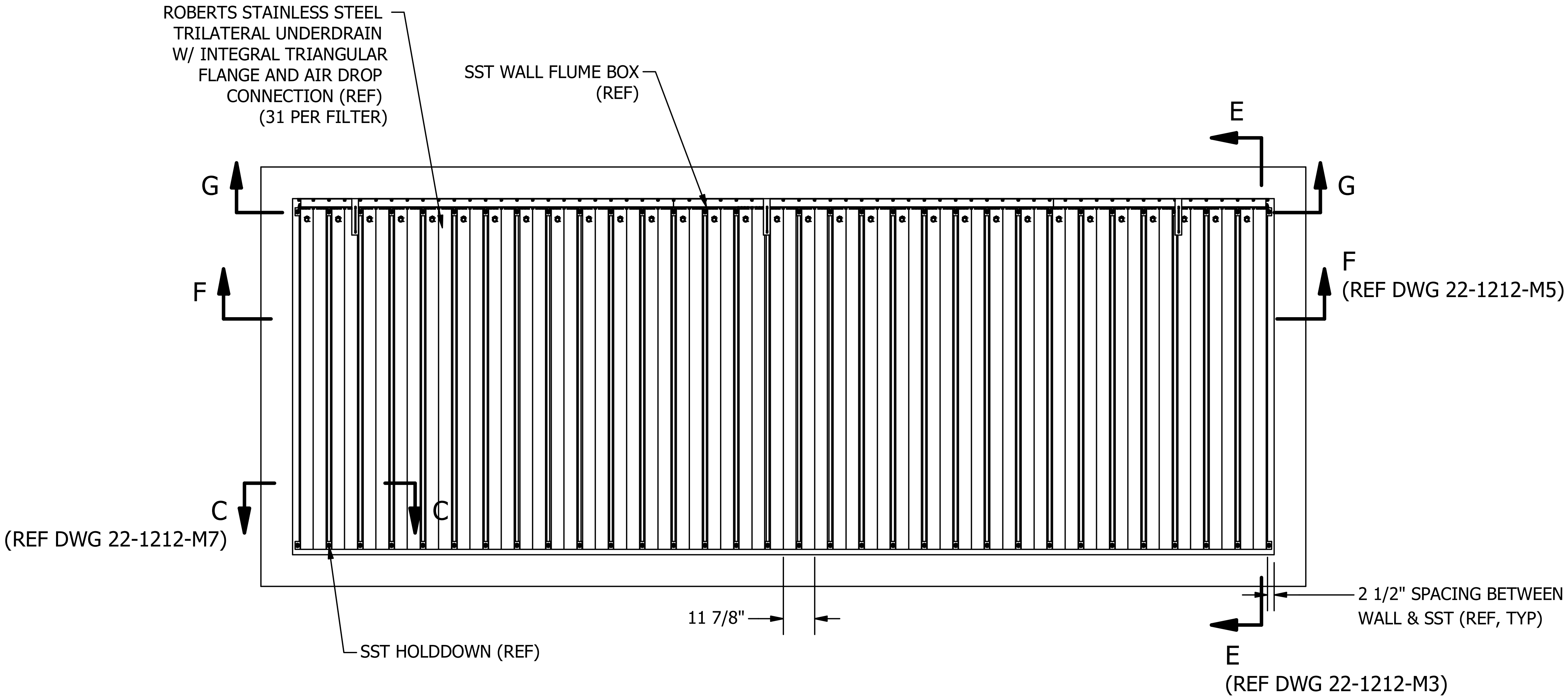
ROBERTS WATER TECHNOLOGIES, INC.
COATESVILLE, PENNSYLVANIA 19320

FILTER 1-9 STAINLESS STEEL TRILATERAL
ISOMETRIC VIEW
SHEBOYGAN, WI

SCALE: 5/16" = 1'
CONTRACT: 22-1212-T
SECTION: A
DWG NO.: 22-1212-M1

NOTES:

- REF DWG 22-1212-M4 FOR ANCHOR LAYOUT.
- TROUGHS AND AIR PIPING HIDDEN FROM PLAN VIEW FOR CLARITY.



PLAN VIEW

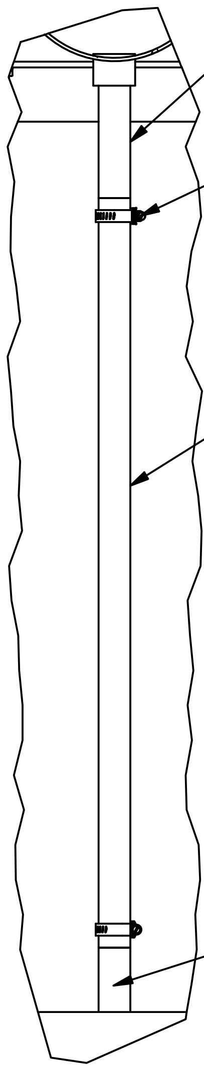
PRELIMINARY 12/12/2022

DATE:
CHECKED:
DATE: 12/12/2022
DRAWN: CRE

©ROBERTS WATER TECHNOLOGIES, INC.
COATESVILLE, PENNSYLVANIA 19320

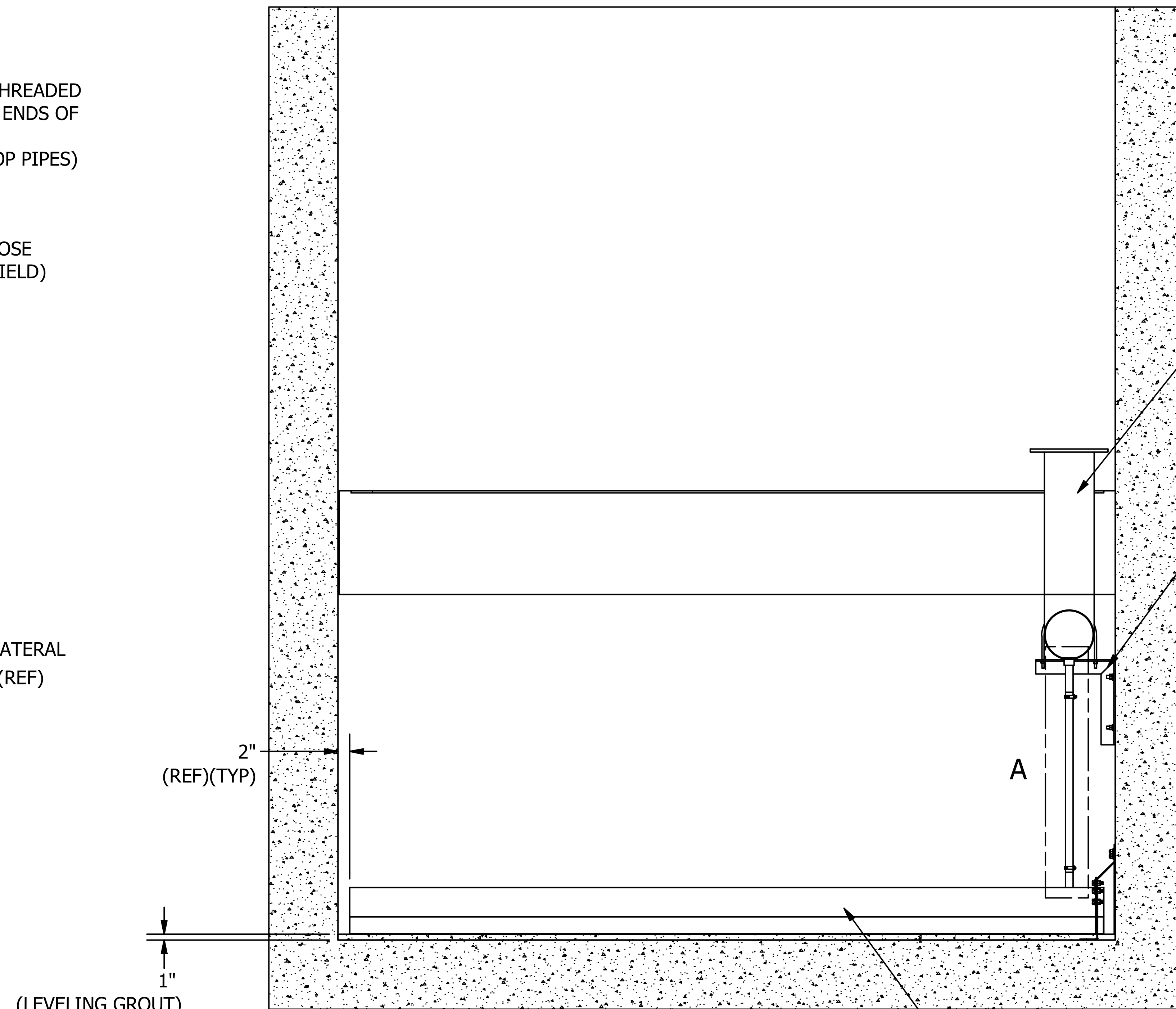
FILTERS 1-9 STAINLESS STEEL TRILATERAL
PLAN VIEW
SHEBOYGAN, WI

SCALE:	3/8" = 1'
CONTRACT:	22-1212-T
SECTION:	A
DWG NO.:	22-1212-M2



DETAIL A

SCALE 1 1/2" = 1'-0"



SECTION E-E

SCALE 1/2" = 1'

PRELIMINARY 12/12/2022

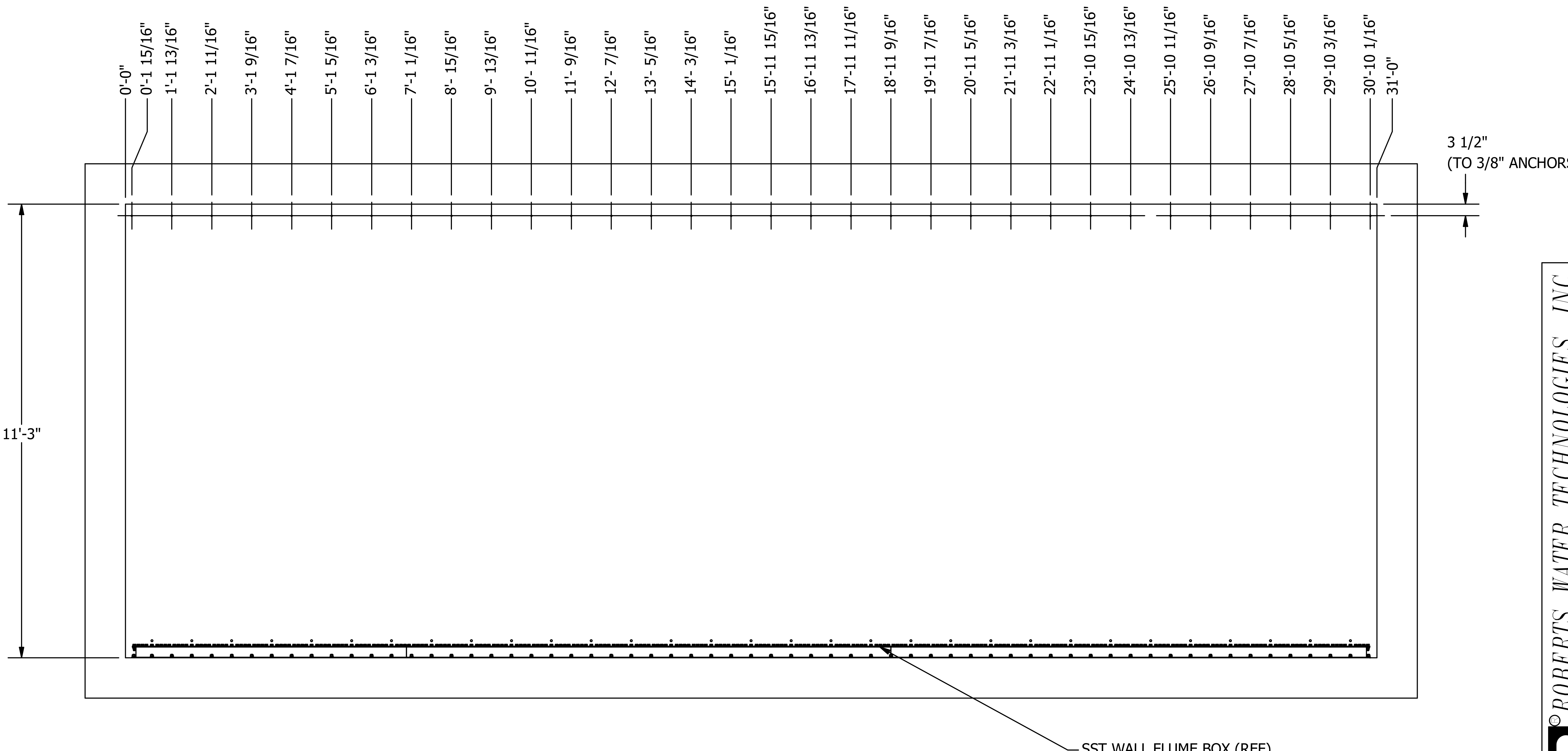
DATE:
CHECKED:
DATE: 12/12/2022
DRAWN: CRE

ROBERTS WATER TECHNOLOGIES, INC.
COATESVILLE, PENNSYLVANIA 19320

FILTERS 1-9 STAINLESS STEEL TRILATERAL
ELEVATION SECTION E-E
SHEBOYGAN, WI

SCALE: AS SHOWN
CONTRACT: 22-1212-T
SECTION: A
DWG NO.: 22-1212-M3

NOTES:
1. LOCATE AND PLACE ANCHORS BEFORE POURING LEVELING GROUT.
2. LEVEL THE FLOOR BY USING LEVELING GROUT AND POUR AROUND ANCHORS.



PLAN VIEW - ANCHOR & GASKET LAYOUT
SCALE: 3/8" = 1'

PRELIMINARY 12/12/2022

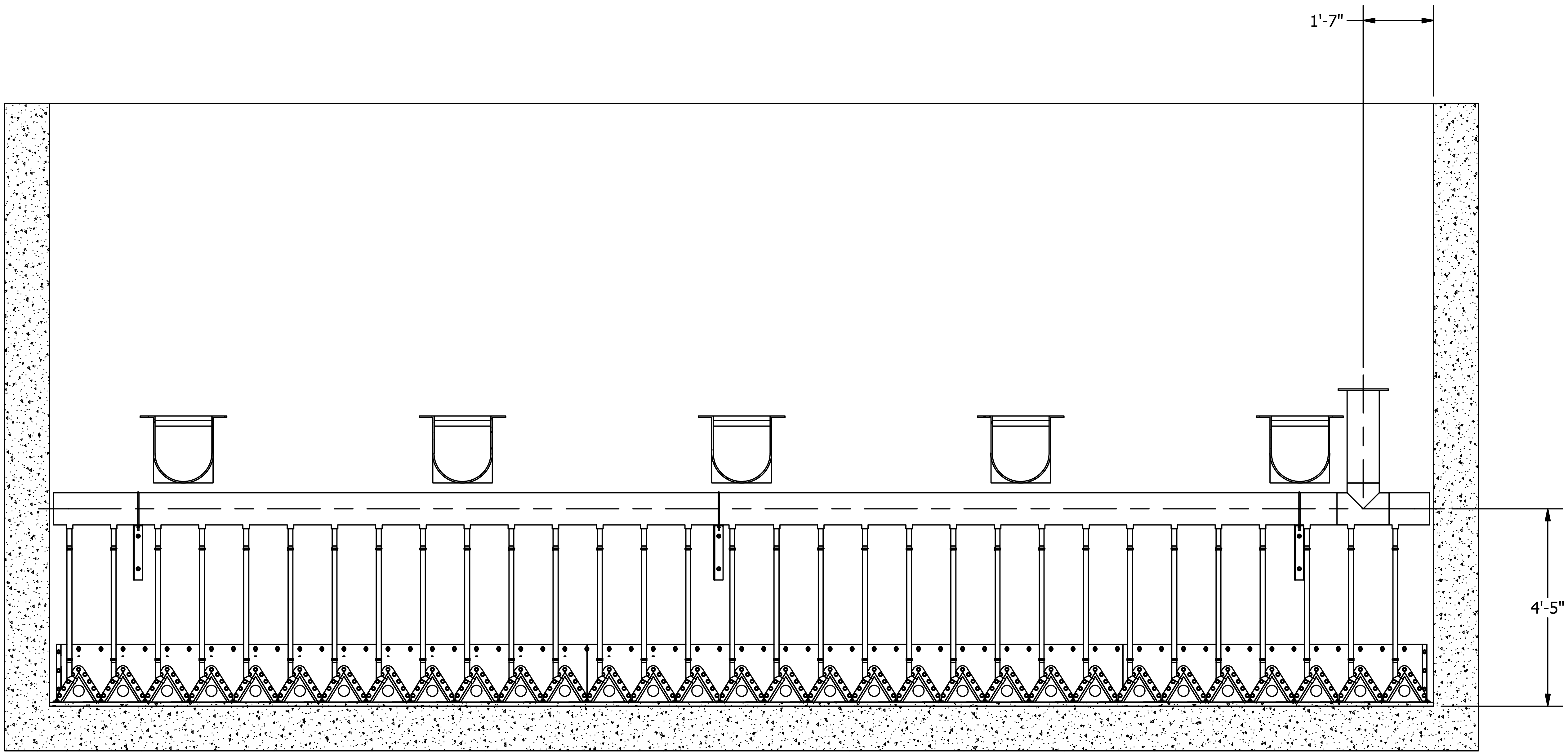
ROBERTS WATER TECHNOLOGIES, INC.
COATESVILLE, PENNSYLVANIA 19320

FILTERS 1-9 ANCHOR/GASKET LAYOUT
FOR STAINLESS STEEL TRILATERAL
SHEBOYGAN, WI

DATE:	
CHECKED:	
DATE:	12/12/2022
DRAWN:	CRE
SCALE:	1/2" - 1'-0"
CONTRACT:	22-1212-T
SECTION:	A
DWG NO.:	22-1212-M4

NOTES:

1. ENSURE PIPE SUPPORTS ARE LEVEL. DIMENSIONS ARE TAKEN FROM FLOOR ASSUMING LEVEL FLOOR.



SECTION F-F

SCALE 3/8" = 1'

(REF DWG 22-1212-M2)

PRELIMINARY 12/12/2022

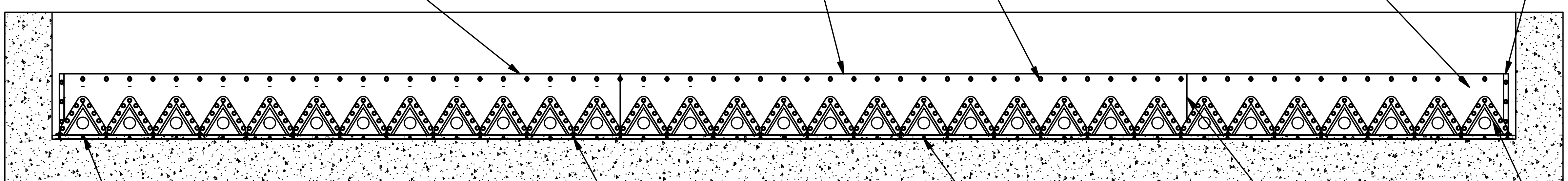
ROBERTS WATER TECHNOLOGIES, INC.
COATESVILLE, PENNSYLVANIA 19320

FILTERS 1-9 FLUME SECTION F-F
HEADER & DROP PIPE ASSEMBLY
SHEBOYGAN, WI

DATE:	
CHECKED:	
DATE:	12/12/2022
DRAWN:	CRE
SCALE:	3/4"=1'
CONTRACT:	22-1212-T
SECTION:	A
DWG NO.:	22-1212-M5

NOTES:

1. BEFORE INSTALLATION, MAKES SURE WALL IS FLAT WITHIN ±1/8", MAKE SURE THE FLOOR IS LEVEL WITHIN ±1/8".
2. USE BOX TO LOCATE ANCHORS THAT ARE TO BE FASTENED INTO FLOOR AND WALL. MAKE SURE BOX IS LEVEL WHEN MARKING PLACEMENT OF ANCHORS. USE SHIMS IF NEEDED.
3. REMOVE BOX, DRILL AND PLACE ANCHORS WITH HILTI HY-200 OR EQUAL.
4. PLACE SIKAFLEX-1A ON THE BACK SIDE OF NEOPRENE GASKET AND PLACE ON THE WALL AND FLOOR AROUND THE ANCHORS TO LINE UP WITH THE OUTER FLANGES OF THE FLUME BOX.
5. PLACE SIKAFLEX-1A ON GASKET OR BOX AND PLACE BOX ONTO FLOOR AND WALL. SECURE BOX IN PLACE WITH HARDWARE.
6. USE LEVELING GROUT TO LEVEL THE FLOOR AND COVER THE BOTTOM OF THE BOX WITH 1" OF GROUT.
7. USE SIKAFLEX-1A ON BOTH SIDES OF THE TRIANGULAR GASKET, USE SIKAFLX-1A ON GASKET AND PLACE ON FLOOR UP AGAINST FLUME BOX. PUT SIKAFLEX ON THE BOTTOM OF THE LATERAL AND INSTALL LATERAL WITH BOLTS AND HARDWARE.
8. SECURE LATERAL TO THE FLOOR WITH HOLDDOWN CLIPS.



SECTION G-G

SCALE 3/8" = 1'

PRELIMINARY 12/12/2022

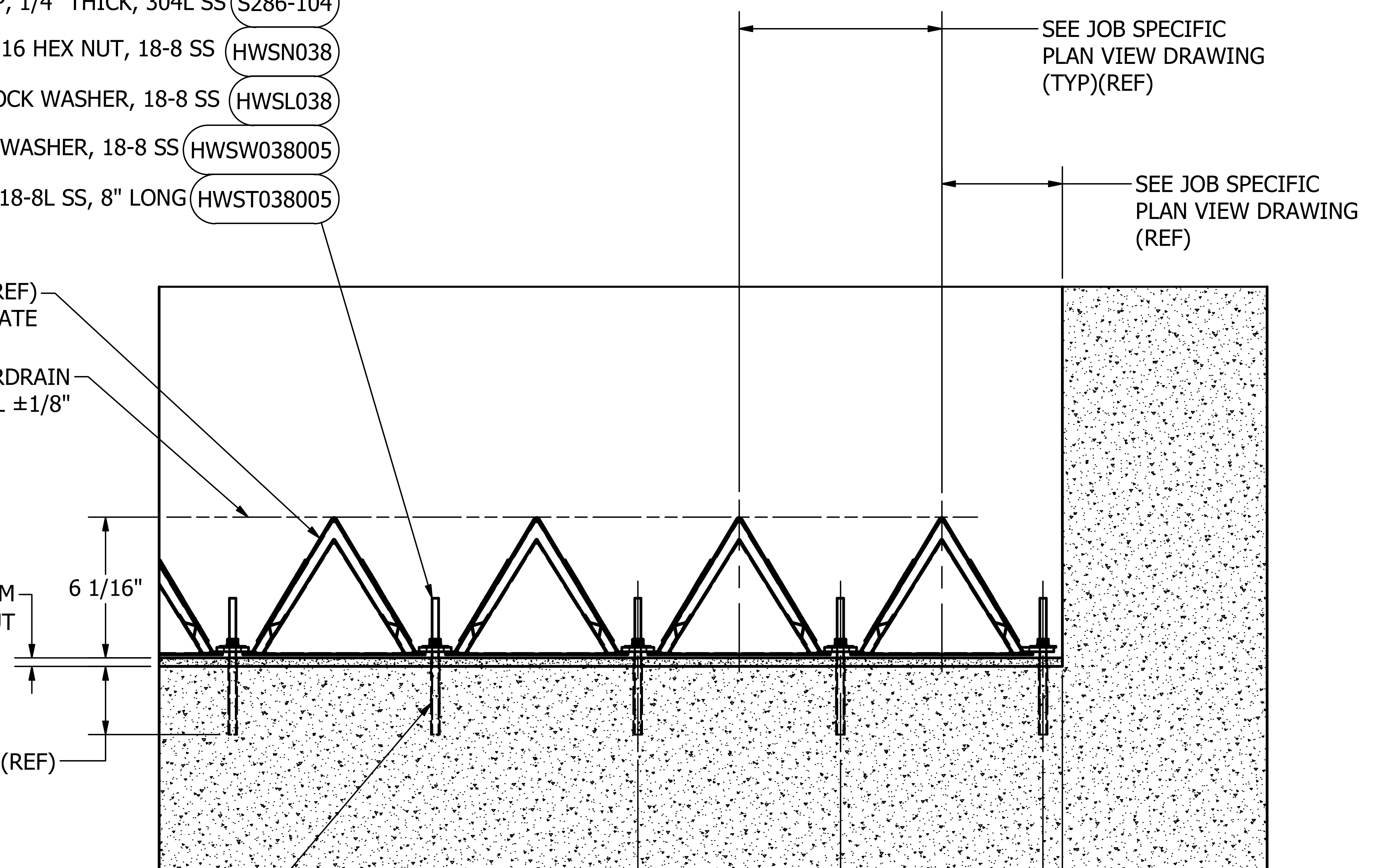
ROBERTS WATER TECHNOLOGIES, INC.
COATESVILLE, PENNSYLVANIA 19320

FILTERS 1-9 FLUME BOX SECTION G-G
STAINLESS STEEL TRILATERAL
SHEBOYGAN, WI

DRAWN: CRE | DATE: 12/12/2022 | CHECKED: | DATE:

SCALE: 1/2" = 1'-0"
CONTRACT: 22-1212-T
SECTION: A
DWG NO.: 22-1212-M6

NOTES:
OUTBOARD HOLDDOWN CLIP S286-104 TO OVERLAP LATERAL EDGE A MINIMUM OF 1/4".



SECTION C-C

SCALE 1 1/2" = 1'-0"
(REF JOB SPECIFIC PLAN VIEW)

S286-M21

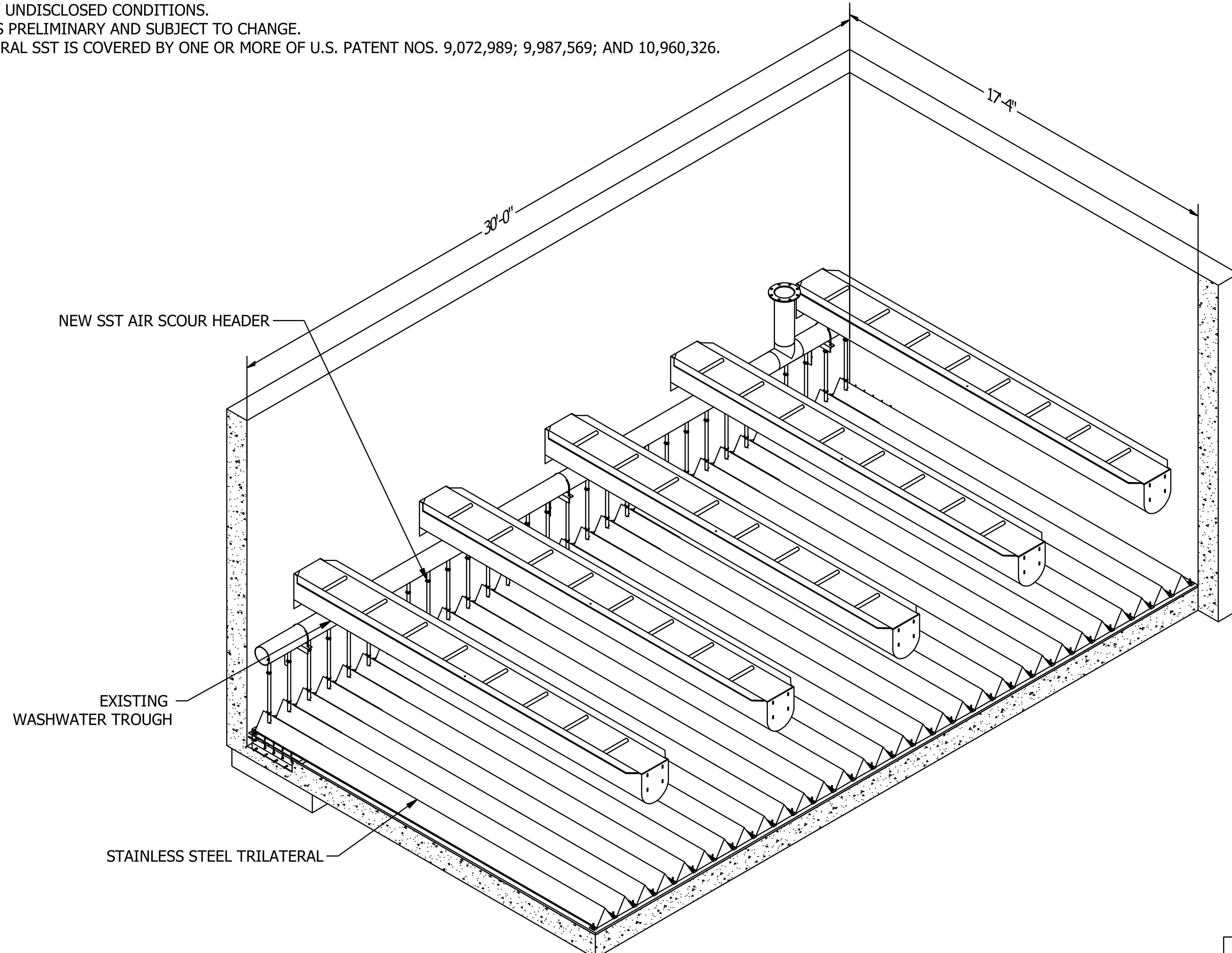
ROBERTS WATER TECHNOLOGIES, INC.
COATESVILLE, PENNSYLVANIA 19320

STAINLESS STEEL TRILATERAL
ELEVATION C-C
(OUTBOARD AUXILIART Ø3/8" ANCHORS, 304 SS)

DRAWN:	CRE
DATE:	12/12/2022
CHECKED:	
DATE:	
SCALE:	1 1/2" = 1'-0"
CONTRACT:	22-1212-T
SECTION:	A
DWG NO.:	22-1212-M7

GENERAL NOTES:

1. ROBERTS PROPOSES FURNISHING THE FOLLOWING EQUIPMENT FOR INSTALLATION BY OTHERS IN FILTERS 10-11: THIRTY (30) STAINLESS STEEL TRILATERAL UNDERDRAIN LATERALS, HOLDDOWNS AND HARDWARE, WALL FLUME BOX AND REPLACEMENT AIR CONNECTION PARTS.
2. DIMENSIONS AND OTHER INFORMATION PRESENTED ON THIS DRAWING REPRESENT ROBERTS INTERPRETATION OF THE PROJECT REQUIREMENTS BASED UPON THE PLANS AND SPECIFICATIONS PREPARED BY OTHERS. ROBERTS HAS NOT AND WILL NOT MAKE ANY SITE SURVEY AND WE EXPECT THE PURCHASER TO VERIFY ALL MEASUREMENTS SHOWN, PROVIDE NEW INFORMATION WHERE REQUIRED, AND ADVISE US OF ANY CONDITIONS NOT HERETOFORE DISCLOSED THAT WILL IMPACT THE DESIGN OR OPERATION OF OUR EQUIPMENT. ROBERTS WILL ASSUME NO RESPONSIBILITY FOR ANY COST ASSOCIATED WITH EXTRA WORK NECESSITATED BY UNDISCLOSED CONDITIONS.
3. DESIGN SHOWN IS PRELIMINARY AND SUBJECT TO CHANGE.
4. ROBERTS TRILATERAL SST IS COVERED BY ONE OR MORE OF U.S. PATENT NOS. 9,072,989; 9,987,569; AND 10,960,326.



ISO VIEW

(REF DWG 22-1212-M11 FOR PLAN VIEW)
(TYP OF FILTERS 10 & 11 RIGHT BAY.
LEFT BAY IS A MIRRORED DESIGN)

PRELIMINARY 12/12/2022

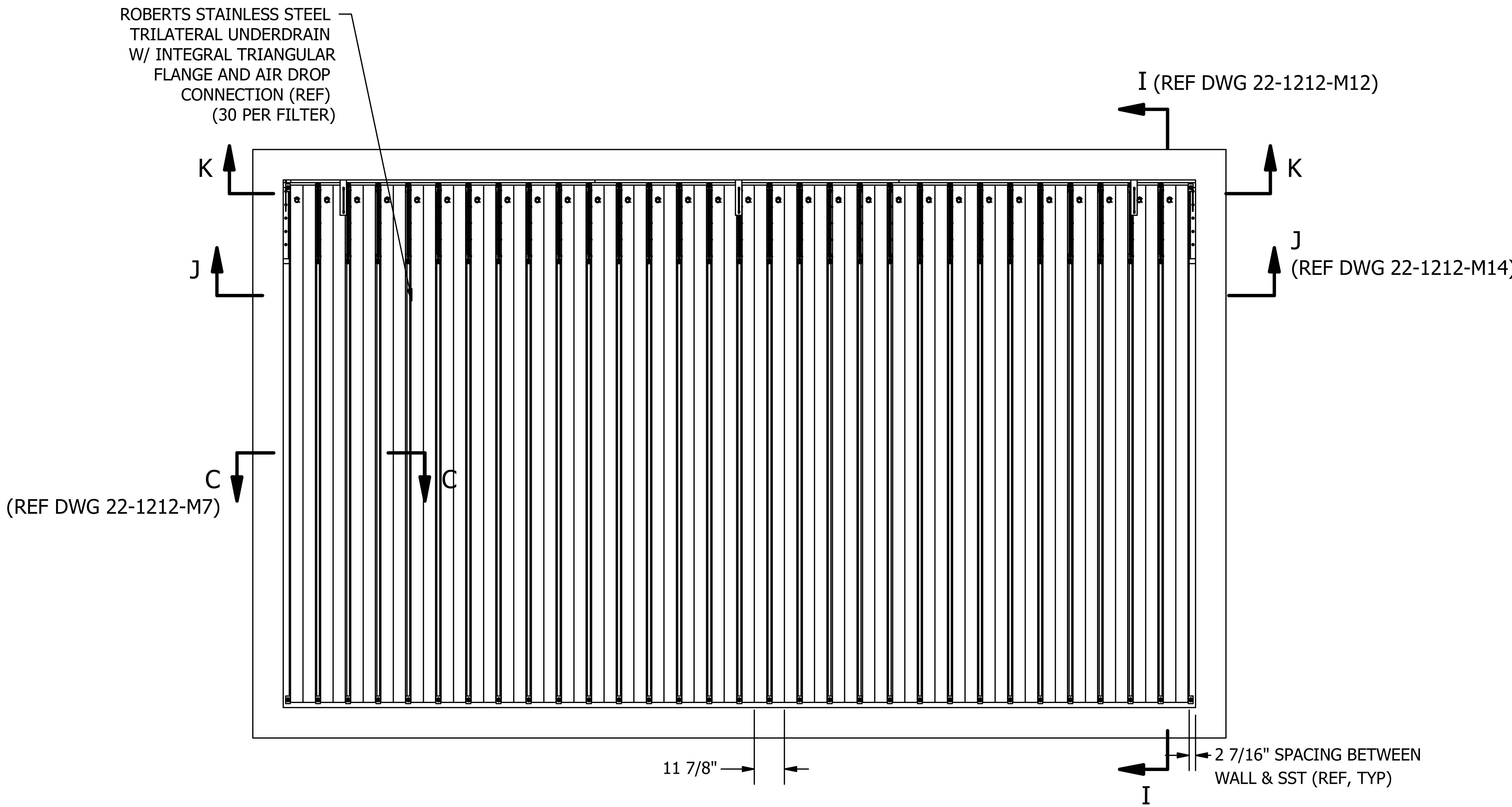
DATE:
CHECKED:
DATE: 12/12/2022
DRAWN: CRE

ROBERTS WATER TECHNOLOGIES, INC.
COATESVILLE, PENNSYLVANIA 19320

FILTER 10-11 STAINLESS STEEL TRILATERAL
ISOMETRIC VIEW
SHEBOYGAN, WI

SCALE: 5/16" = 1'
CONTRACT: 22-1212-T
SECTION: A
DWG NO.: 22-1212-M10

NOTES:
- REF DWG 22-1212-M13 FOR ANCHOR LAYOUT.
- TROUGHS AND AIR PIPING HIDDEN FROM PLAN VIEW FOR CLARITY.



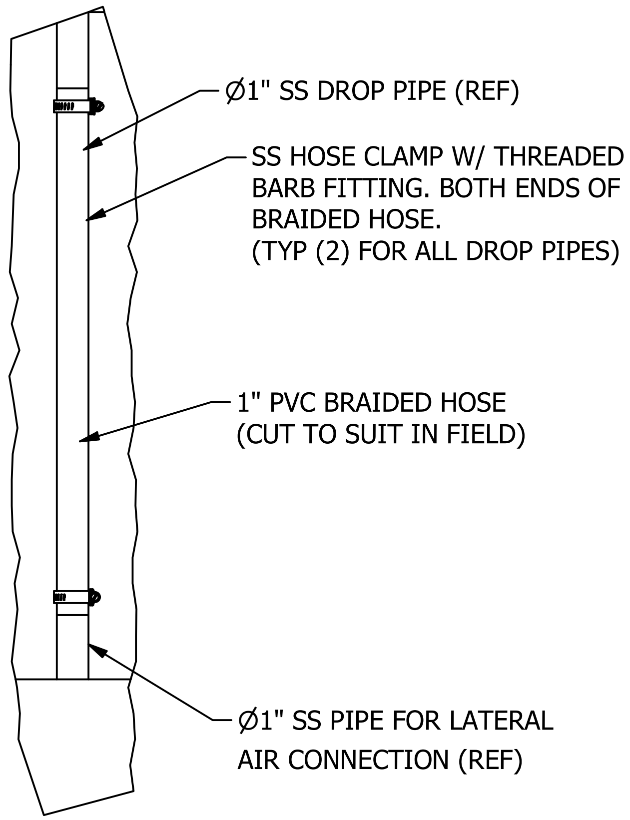
PLAN VIEW

PRELIMINARY 12/12/2022

ROBERTS WATER TECHNOLOGIES, INC.
COATESVILLE, PENNSYLVANIA 19320

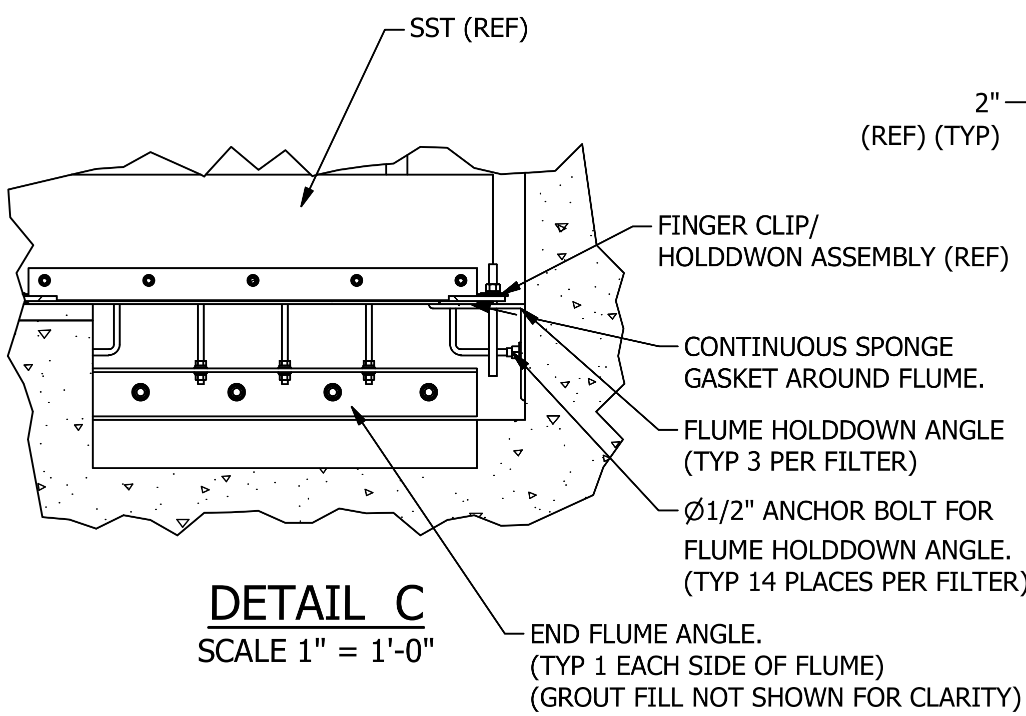
FILTERS 10-11 STAINLESS STEEL TRILATERAL
PLAN VIEW
SHEBOYGAN, WI

DATE:	
CHECKED:	
DATE:	12/12/2022
DRAWN:	CRE
SCALE:	3/8" = 1'
CONTRACT:	22-1212-T
SECTION:	A
DWG NO.:	22-1212-M11



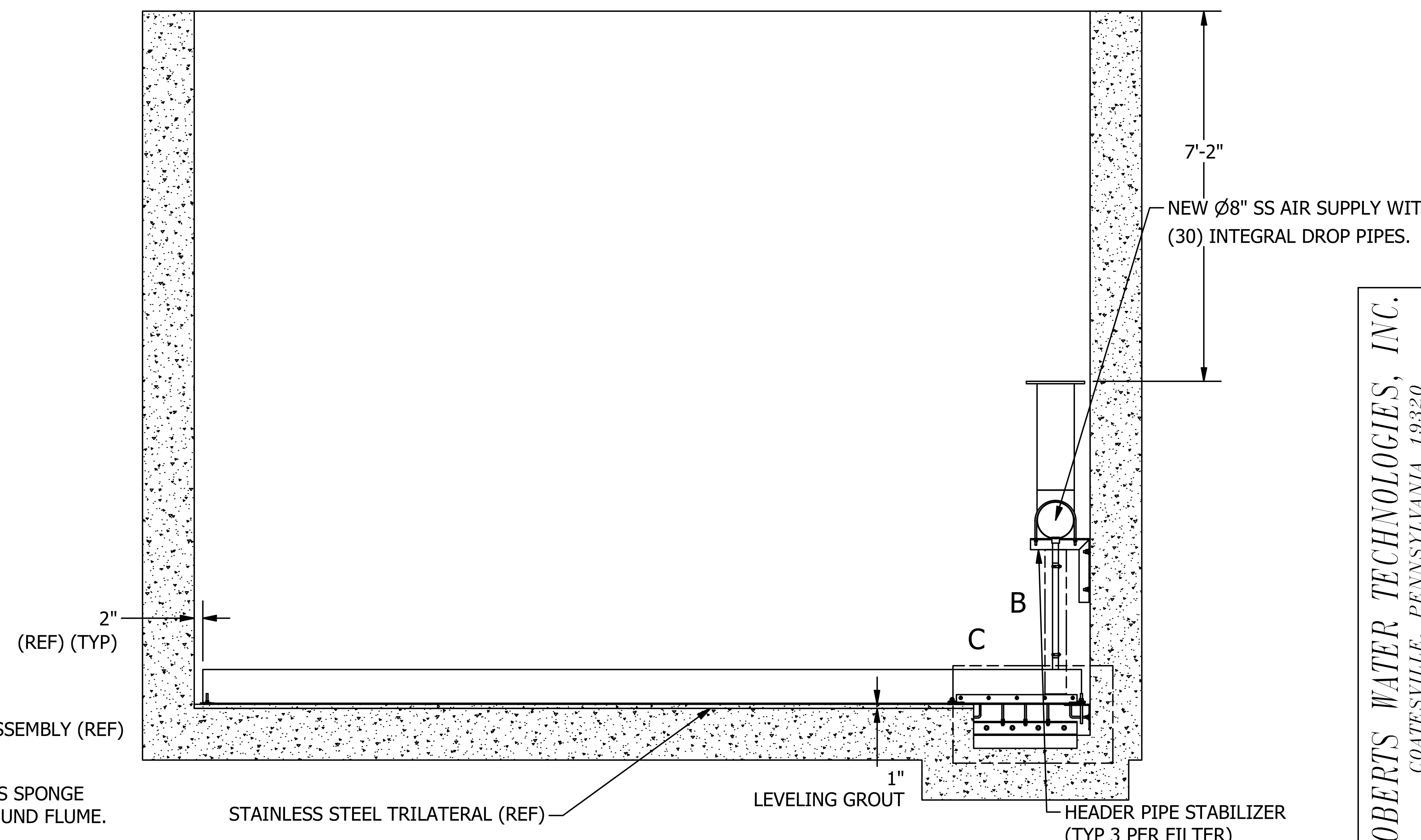
DETAIL B

SCALE 1 1/2" = 1'-0"



DETAIL C

SCALE 1" = 1'-0"



SECTION I-I

SCALE 3/8" = 1'

PRELIMINARY 12/12/2022

©ROBERTS WATER TECHNOLOGIES, INC.
COATESVILLE, PENNSYLVANIA 19320

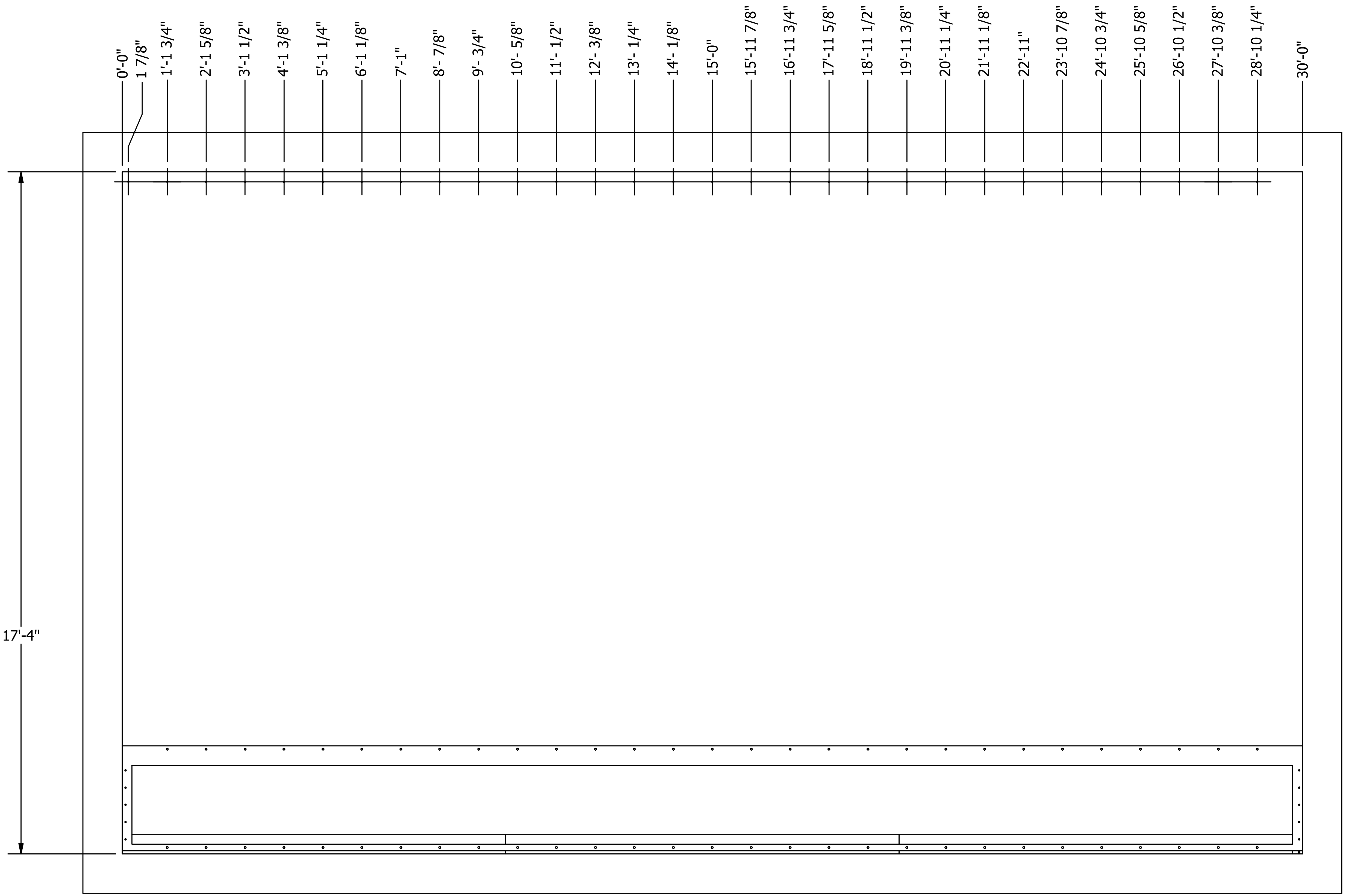
FILTERS 10-11 STAINLESS STEEL TRILATERAL
ELEVATION SECTION E-E
SHEBOYGAN, WI

DATE:
CHECKED:
DATE: 12/12/2022
DRAWN: CRE

SCALE: AS SHOWN
CONTRACT: 22-1212-T
SECTION: A
DWG NO.: 22-1212-M12

NOTES:

1. LOCATE AND PLACE ANCHORS BEFORE POURING LEVELING GROUT.
2. LEVEL THE FLOOR BY USING LEVELING GROUT AND POUR AROUND ANCHORS.



PLAN VIEW - ANCHOR & GASKET LAYOUT

SCALE: 3/8" = 1'

PRELIMINARY 12/12/2022

ROBERTS WATER TECHNOLOGIES, INC.
COATESVILLE, PENNSYLVANIA 19320

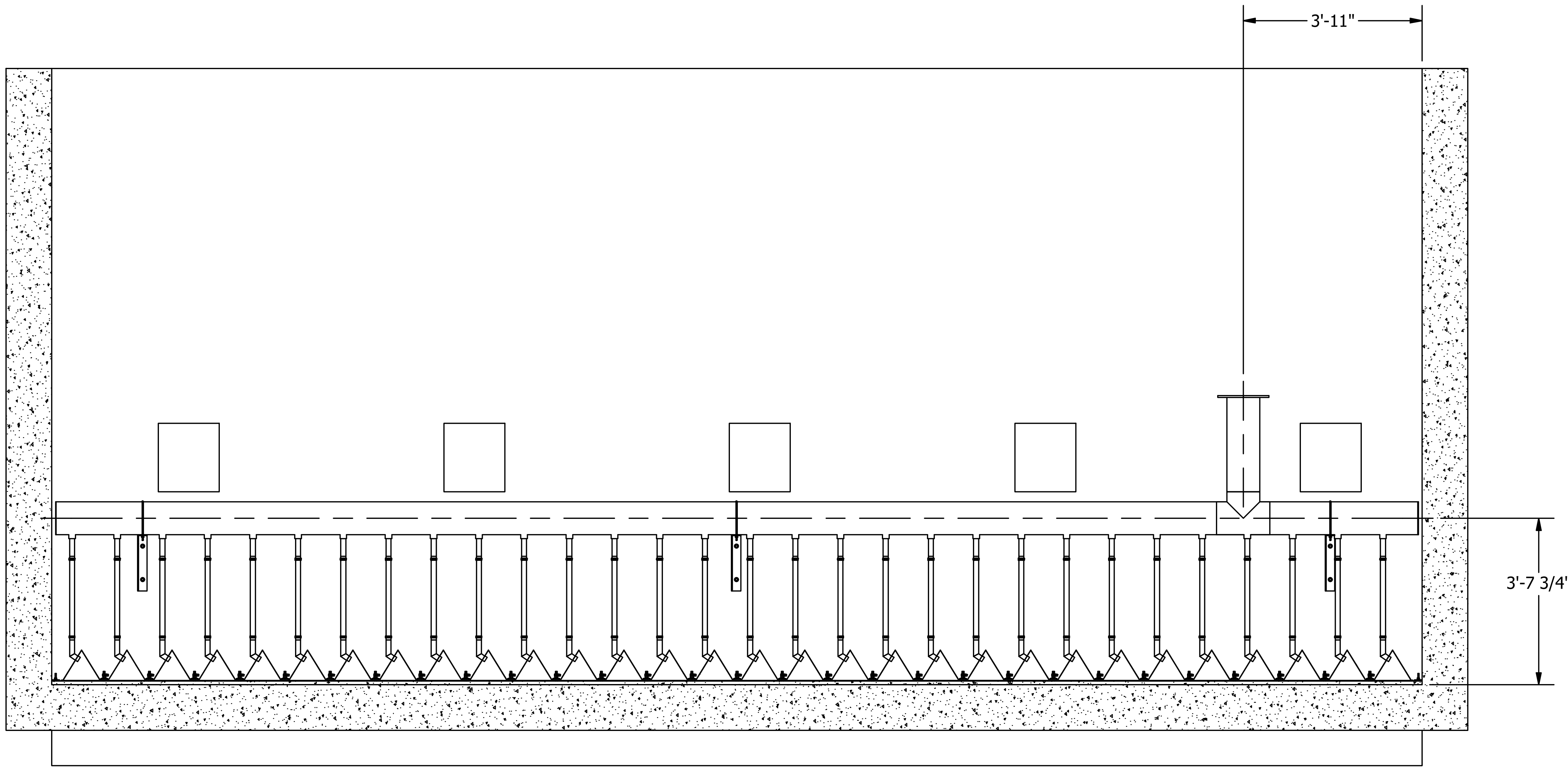
FILTERS 10-11 ANCHOR/GASKET LAYOUT
FOR STAINLESS STEEL TRILATERAL
SHEBOYGAN, WI

DRAWN: CRE
DATE: 12/12/2022
CHECKED:
DATE:

SCALE: 1/2" - 1'-0"
CONTRACT: 22-1212-T
SECTION: A
DWG NO.: 22-1212-M13

NOTES:

1. ENSURE PIPE SUPPORTS ARE LEVEL. DIMENSIONS ARE TAKEN FROM FLOOR ASSUMING LEVEL FLOOR.



SECTION J-J

SCALE 3/8" = 1'

(REF DWG 22-1212-M2)

PRELIMINARY 12/12/2022

ROBERTS WATER TECHNOLOGIES, INC.

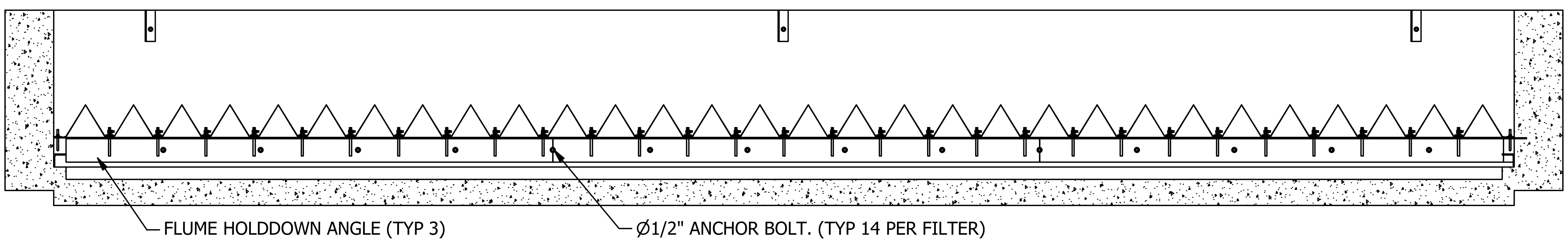
COATESVILLE, PENNSYLVANIA 19320

FILTERS 10-11 FLUME SECTION J-J
HEADER & DROP PIPE ASSEMBLY
SHEBOYGAN, WI

DRAWN:	CRE
DATE:	12/12/2022
CHECKED:	
DATE:	
SCALE:	3/4"=1'
CONTRACT:	22-1212-T
SECTION:	A
DWG NO.:	22-1212-M14

NOTES:

1. PLACE SIKAFLEX-1A ON THE BACK SIDE OF NEOPRENE GASKET AND PLACE ON THE FLOOR AROUND THE ANCHORS.
2. PLACE SIKAFLEX-1A ON GASKET AND PLACE BOX ONTO FLOOR.
3. USE LEVELING GROUT TO LEVEL THE FLOOR WITH 1" OF GROUT.
4. PUT SIKAFLEX ON THE BOTTOM OF THE LATERAL AND INSTALL LATERAL WITH BOLTS AND HARDWARE.
5. SECURE LATERAL TO THE FLOOR WITH HOLDDOWN CLIPS.



SECTION K-K
SCALE 3/8" = 1'

PRELIMINARY 12/12/2022

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COATESVILLE, PENNSYLVANIA 19320

FILTERS 10-11 FLUME BOX SECTION K-K
STAINLESS STEEL TRILATERAL
SHEBOYGAN, WI

DRAWN: CRE
DATE: 12/12/2022
CHECKED:
DATE:

SCALE: 1/2" = 1'-0"
CONTRACT: 22-1212-T
SECTION: A
DWG NO.: 22-1212-M15