

# City of Bellingham Screen House: Condition Assessment and Improvement Report (Task 3.8)

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## 1. Introduction

The City of Bellingham (City) undertook an assessment of the condition of the existing Screen House facility (pictured below in Exhibit 1-1). The condition assessment, as presented herein, covers several key aspects of the Screen House facility, including:

- The 48-inch diameter pipelines
- The overall concrete building structure
- The slide gates and one plug valve
- The two traveling screens



**Exhibit 1-1. Screen House**

## 1.1 Prior Study

It has been known for several years that the three 48-inch diameter pipelines within the facility have substantial corrosion and are in need of repair. Repairing these pipelines is a challenging and costly endeavor. Therefore, the City undertook the condition assessment of the overall Screen House facility to evaluate its long-term viability and functionality prior to committing funds for repair of the pipelines.

The City commissioned two studies in 2012 to assess the condition of the three subject 48-inch diameter pipelines and to identify alternative repair solutions. The 2012 condition assessment work on the 48-inch diameter pipelines identified severe deterioration and the need for repair in the near-term future.

The first study was completed in June of 2012 by Black and Veatch. The second study was completed by CH2M HILL. The Black and Veatch report was incorporated as an appendix to the CH2M HILL report. The CH2M HILL report, with the appended Black and Veatch report, is attached to this technical memorandum as Appendix A.

## 1.2 Purpose of This Work

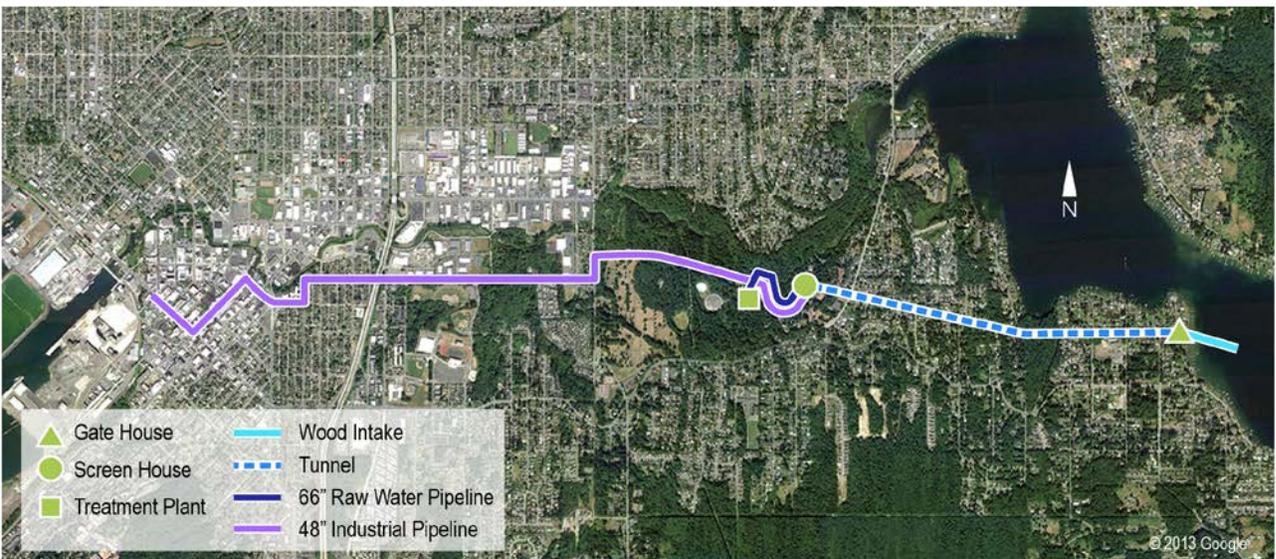
The purpose of this work is to document the condition of the Screen House facility, identify repair needs, and develop estimated costs for those repairs. This information will be used by the City to decide whether or not to repair the 48-inch diameter pipes and make other Screen House improvements. If the City decides the existing Screen House facility does not have adequate long-term functionality and viability, alternative screening and flow-splitting approaches will be considered and evaluated for potential implementation.

The four elements of the Screen House that were assessed for this work were deemed the most important for enabling the City to make key decisions regarding pursuing improvements at the Screen House and its continued use. Other elements of the Screen House facility, such as electrical, telemetry, HVAC, windows, code-compliance were not assessed with respect to their condition or design adequacy. These other elements were not deemed to be sufficiently impactful with respect to decisions regarding the future of the Screen House.

## 2. Description of Existing Facility

The Screen House was constructed in 1940. It was constructed during at the same time as the adjacent upstream tunnel, the Gate House on the shore of Lake Whatcom, and the wood-stave intake pipeline in Lake Whatcom. These four key facility elements comprise the City’s primary water supply system for both municipal needs as well as industrial needs on the City’s waterfront. The key components of the City’s current water supply system are presented in Exhibit 2-1, along with the pipelines that extend from the Screen House to the City’s lone industrial supply user and to the City’s Whatcom Falls Water Treatment Plant.

Over the years, these downstream pipelines have been replaced with newer pipelines with greater capacity. In 1968, the City constructed its Whatcom Falls Water Treatment Plant (WTP) roughly 1,500 feet to the west of the Screen House. Supply from the Screen House to the WTP was conveyed through a new 66-inch diameter concrete cylinder pipeline.



**Exhibit 2-1. City of Bellingham Water Supply Facilities**

## 3. Inspection Approach

The Screen House inspection was completed over the course of two days. On April 15, 2014 the readily-accessible portions of the Screen House were inspected with respect to the concrete building structure, only. On April 23, 2014, the normally-inundated caisson portion of the Screen House was inspected. This confined-space area contains the screened portion of the travelling screens, the slide gates separating various chambers of the caisson, and direct access to the inside of the three 48-inch pipes that were already known to be corroded.

In addition to City staff being present during the inspection, the April 23 inspection included CH2M HILL staff addressing each of the key facility elements addressed: structure, gates and valves, pipes, and traveling screens. Also present were representatives from International Flow Technologies, Inc. to assess the potential to install a temporary plug in the tunnel. The temporary plug, if implemented, would enable bypassing flow from the tunnel around the Screen House caisson to enable downstream repairs. More discussion regarding this potential temporary plug is presented later in this report. In addition, representatives from Fibwrap, Inc. and Structural Technologies, Inc. were in attendance to assess the repair

approach for the three 48-inch diameter pipelines. These two specialty rehabilitation firms identified a repair approach for the pipes, which is addressed later in this report.

## 4. Results of Inspection

Inspection results are presented herein for the 48-inch diameter pipelines, the concrete Screen House structure, the slide gates and mud valve, and the traveling screens. Each of these elements of the Screen House is identified in Figure 1.

### 4.1 48-Inch Outlet Pipelines

The focus of the inspection was the three parallel sections of 48-inch diameter, 20-foot long steel pipeline that were installed at the time the Screen House was constructed in 1940. These three sections are highlighted in Figure 1. The pipe section to the south is connected to the industrial supply system that formerly supplied untreated water to the Georgia Pacific Pulp and Paper Mill. The other two adjacent pipelines to the north serve as redundant and/or combined conduits for the municipal supply system to the WTP. As stated previously, condition assessment work on these pipeline sections from 2012 revealed deteriorated pipe conditions. The inspection on April 23, 2014 allowed for inspection of the inside of these deteriorated pipes under dry conditions.

#### 4.1.1 Summary of Observations

Observations were made inside each of the three 48-inch diameter steel outlet pipelines from the upstream slide gate frame to the downstream flanged connection to the cement-mortar-lined steel pipe (1980 construction) in the Chlorine Injection Room. These three parallel pipe sections with deteriorated conditions are relatively short (just less than 20 feet) and buried between the outlet well of the traveling screen caisson and the Chlorine Injection Room. Each of the round, 48-inch diameter outlet pipelines are connected to the rectangular slide gate frames in the outlet well wall with short steel transition spools.

Rust tubercles were extensive inside each of the three 20-foot-long pipeline sections. Approximately 2 inches of sediment was present on the bottom of the industrial pipeline, which is believed the result of low and water velocities and extended period of zero flow in this pipeline. No significant sediment was observed in the two pipelines conveying water to the WTP. The general condition of the interior of each of the outlet pipelines is shown in Photographs B-1 to B-3 (Appendix B).

A small water flow drained from the industrial pipeline back into the outlet well of the Screen House caisson during the inspection, reflecting apparent infiltration into the industrial pipeline at some point downstream. No similar drainage was observed from the other two pipelines.

Each of the three pipeline sections are lined with a relatively thick, black material that appears to be coal-tar based. Coal-tar was commonly used to line and coat steel pipelines during the timeframe when the Screen House was constructed. The lining is essentially intact with fair to poor adhesion to the pipe surface. It is approximately 0.15 to 0.20-inch thick.

Even though the coal-tar lining is intact, it no longer provides significant corrosion protection to the metal surface. Water permeation through the lining is allowing corrosion of the underlying steel. Rust tubercles (mounds of corrosion product) are present inside all three outlet pipelines, as shown in Photographs B-4 and B-5 (Appendix B).

Small sections of the lining and corrosion products were removed to allow inspection and testing of the pipe wall. The pipe wall was found to have a moderate amount of uniform corrosion with some relatively shallow pitting. The maximum measured pit depth was 0.05-inch. The condition of the underlying steel is shown in Photographs B-6 to B-9 (Appendix B).

Each of the three parallel deteriorated pipe sections connects downstream to newer sections of cement-mortar-lined steel pipe. Observations were extended to these newer sections. The cement mortar lining and stainless steel mixer components inside the newer (1980) steel pipe in the Chlorine Injection Room is in good condition. The cement mortar lining is mainly intact. Some localized rust staining was observed at the stainless steel static mixer connection points to the two municipal supply pipelines. As stated previously, the static mixers are only installed in the two municipal supply pipelines. See Photographs B-10 and B-11 (Appendix B).

Previous condition assessment work at the Screen House from 2012 (provided in Appendix A) identified extensive external corrosion and reduction in wall thickness of the three outlet pipes at the concrete wall penetrations inside the Chlorine Injection Room. The extent of this external corrosion upstream of this point (behind the Chlorine Injection Room wall) to the direct-buried area of these three pipeline sections is not known. The three outlet pipelines are direct-buried between the outlet well of the Screen House caisson and the Chlorine Injection Room, shown in Figure 1. The most likely form of corrosion on the soil side of the pipe sections is localized corrosion (pitting). Leakage from localized corrosion start as pinhole leaks that can grow over time. Non-destructive testing to determine the presence of localized corrosion (pitting) on these short sections of pipe is not economically feasible. Visual verification of the non-destructing testing results would also be costly.

#### **4.1.2 Conclusions**

As determined from the condition assessment in 2012 (see Appendix A), the short (approximately 18 inches) section of each of the three pipelines that extend into the Chlorine Injection Room are in need of structural repair or replacement. If the City continues to keep the Screen House facility in long-term service, a long-term solution to this condition is necessary.

The inside of the 20-foot section of each of these outlet pipelines between the Chlorine Injection Room and the outlet well of the Screen House caisson shows extensive corrosion and deterioration of the coal tar lining. Corrosion will continue unless the lining is replaced. The external, direct-buried portion of this section of pipe cannot economically be examined. It is reasonable to assume, given the roughly 75 years these pipes have been in service, that substantial external corrosion is present.

It would not be prudent to repair or replace only the 18-inch long downstream portion of the 20-foot long sections of pipe and leave the remaining portion in its degraded condition. Therefore, the entire 20-foot length of each of the three pipelines between the outlet well of the Screen House Caisson and the Chlorine Injection Room must be repaired or replaced with a long-term improvement that enables the Screen House to continue reliable service for the long-term future. Discussion of the recommended improvement approach is presented in Section 5.

## **4.2 Structure**

The condition assessment of the Screen House building structure was limited to current physical condition and does not include evaluation of structural strength, performance under seismic conditions, or compliance with current or past building codes. That stated, the building structure, including the superstructure (above ground) and substructure (below ground), appears to be in relatively good condition based on visual inspection and limited testing in areas that were accessible. The superstructure showed little signs of deterioration with very minor hairline cracks while the substructure showed some localized areas of deterioration due to erosion in some areas of the concrete walls. Such localized erosion is not unexpected, can easily be repaired, and not indicative of concern.

### **4.2.1 Testing Methods**

Part of the condition assessment included completion of on-site and laboratory testing. Material Testing & Consulting, Inc (MTC) was contracted to undertake compressive testing of the existing concrete and radar scans for the reinforcing in the substructure. MTC's testing reports are included as Appendix C. Concrete

core compressive testing included three separate tests with results of 4,370, 5,220, and 5,360 psi – somewhat higher than expected – reflective of relatively high-strength concrete.

Ground Penetrating Radar Scanning (GPRS) was also performed in limited areas of the substructure to confirm the presence of reinforcing steel within the walls, identify any wall delamination, and detect any extensive reinforcing corrosion. No wall delamination or extensive reinforcing corrosion was detected. Vertical reinforcing was detected. However, where GPRS scans were made in the exterior walls of the Screen House caisson substructure, horizontal reinforcing was not detected. This result is unexpected and should be verified. Extensive horizontal reinforcing is shown on the original design drawings for the Screen House. Subsequent GPRS by a different testing firm or other non-destructive testing methods should be undertaken to confirm the existence of horizontal reinforcing.

#### **4.2.2 Superstructure**

The building superstructure has an approximate plan dimension of 73 ft by 32 ft at grade with a top eave height of approximately 28 ft. The structure is comprised of monolithically cast-in-place reinforced concrete elements such as walls, slabs, beams, columns and pilasters along with a wood roof. The top portion of the well structure rises 10 ft above ground and has two floors above the well structure. Structural drawings of the concrete reinforcing for the superstructure are presented in Appendix D. The interior of much of the superstructure had been recently painted, which could have potentially hidden minor cracks and corrosion. However, it didn't appear there were any such conditions except one specific location noted below.

The exterior walls of the superstructure exhibited minor cracking that is of no structural concern and is quite common in reinforced concrete structures. The south and north exterior walls exhibited cracks below the window and were measured at 0.005-0.05 inches in width (Photo B-12 and B-13). Some of the cracks in the south elevation had been previously patched but has since re-opened following the patch repair (Photo B-14). This type of crack will tend to re-open since the crack is resolving the buildings volume changes through expansion and contraction due to temperature changes.

Hairline cracks were also observed on the east elevation of the exterior wall below a construction joint (Photo B-15). There is evidence of previous (no longer active) water leakage through this horizontal construction joint. Given that construction of the Screen House was in 1940, it is unlikely that waterstops of any type were incorporated into the design. A vertical crack below the construction joint has also re-opened through the coating and has a hairline crack measuring 0.005-0.007 inches (Photo B-16). These cracks are not a structural concern.

A pilaster on the external wall of the Screen House structure, viewed from inside the building on the second floor, where the traveling screens are installed exhibited spalled concrete along a vertical reinforcing bar. Photo B-17a shows this location at the time of the April 15, 2014 inspection after it had been painted. Two photos (B-17b and B-17c) from several months before (prior to the re-painting) show this same location. There is a void in the concrete around the vertical reinforcing bar and much of the reinforcing bar itself at this location is corroded away. The reason this bar corroded is unclear, but it appears there was insufficient concrete coverage over the bar. There likely was a moisture source that no longer exists. The condition appears to have stabilized and this location can easily be patched to stop further corrosion. This location does not present a structural concern because it is localized, relatively high within the structure, and representative of only a fraction of the building structure. No repair is necessary, but patching of this area would help to ensure further corrosion is terminated. Overall, the walls of the superstructure appear to be in satisfactory condition with no structural concerns.

The floor slabs throughout appear to be in excellent condition and exhibited minimal amount of cracks based on areas that were accessible or visible.

#### **4.2.3 Substructure**

The substructure includes the below-ground portions of the building, including the wet-well (caisson) structure and the lower interior levels housing the three 48-inch diameter pipelines (Chlorine Injection

Room). The structure is comprised of monolithically cast-in-place reinforced concrete elements such as walls, slabs, beams, and columns. This section focuses on the caisson, as there were no significant deterioration issues with other portions of the substructure. Drawings of the original construction including one structural drawing showing the general reinforcing of the wet well are included in Appendix D.

The Screen House caisson, which is typically submerged, appears to have been painted white several years ago. Discussion with City staff reveals that it was likely painted 25 years ago or even earlier. This coating appears to be in relatively good condition. Sounding tests for delaminated concrete were taken in many areas of the caisson. No hollow sounds indicative of delaminated concrete were detected. There was also no evidence of cracking in the concrete walls. There was also no evidence of reinforcing corrosion. There were a few areas of minor concrete erosion due to hydraulic action.

The subsequent sections address the various “wells” of the Screen House caisson, including: Outlet Well, Screen Wells (south side and north side), Intake Well, and Waste Well. These wells are identified in Figure 1.

**Outlet Well.** The bottom slab was covered in sludge; therefore, it was not possible to confirm its condition. The underside of the roof appears from a distance to be in good condition with only minor spot corrosion marks showing through the coating from what appear to be form ties (Photo B-18). Sludge residue was present on the walls throughout each well (chamber) of the caisson. But, the sludge was typically easily wiped away which was adequate to identify cracks and assess wall condition. The walls were all in relatively good condition. In the outlet well there was one area where there was a horizontal void line several feet in length where the voids extended 1.5-2 inches into the concrete (Photo B-19a and B-19b). This void line most likely appeared at a construction or cold joint line where the interface at the joint was weaker and subject to the eroding action of the water.

Some minor erosion or spalled concrete was observed at the top of the 5 ft opening that leads to the screen well (Photo B-20). Other areas exhibited some minor void formation or “pop-out” of concrete (Photo B-21). One concrete core was taken from the outlet well for testing and yielded a high compressive strength of 5,220 psi. The outlet well structure is in satisfactory condition based on areas that could be viewed or accessed.

**North Side Screen Well.** The north side screen well, housing the north traveling screen, was drained and the floors and walls on the upstream side of the screen could be viewed quite well. Similar to the outlet well, the underside of the roof looks in good condition with only minor spot corrosion marks showing through the coating (Photo B-22). The coating on the floor of the screen well was still intact and the bottom slab appeared to be in good condition. The wall surfaces and top of wall openings exhibited some minor voids from erosion or pop-outs (Photo B-23). The north side screen well structure is in satisfactory condition based on areas that could be viewed or accessed.

**South Side Screen Well.** The south side screen well, housing the south traveling screen, was accessed from the downstream side. Similar to the outlet well, the underside of the roof appears to be in good condition with only minor spot corrosion marks showing through the coating (Photo B-24). The wall surfaces and top of wall openings exhibited some minor voids from erosion or pop-outs (Photo B-25). Direct access to the upstream east side of the screen towards the intake was viewed from the intake well. Inspection of this side of the south screen well was limited. The south side screen well structure is in satisfactory condition based on areas that could be viewed or accessed.

**Intake Well.** The intake well could not be fully drained because the slide gate connecting the intake well with the waste well could not be opened. There was over a foot of water depth in the intake well, which limited inspection of the floor slab. Similar to the other wells the underside of the roof appeared to be in good condition with only minor spot corrosion marks showing through the coating (Photo B-26). The wall surfaces exhibited minor voids from erosion or pop-outs. Two concrete cores were taken for testing and yielded a high compressive strength of 4,370 psi and 5,360 psi. The inlet well structure is in satisfactory condition based on areas that could be viewed or accessed.

**Waste Well.** The waste well exhibited the greatest amount of deterioration due to the hydraulic action of the water. Turbulence is far greater in this well than in the others because of the high velocities that occur when the small waste gates are opened between the screen wells and the waste well. Unlike the other well areas, this well did not receive a protective coating. The wall surfaces showed significant voids in the wall caused by the erosive effects of the water (Photos B-27 and B-28). Above the 4-ft square gate, a deep void pocket was formed in the wall that penetrates to a maximum depth of 4 to 5 in (Photo B-29). This scoured area currently affects a wall area of approximately one square foot. This deterioration was likely in an area where the concrete had less strength or was not well consolidated. Other eroded areas include multiple areas on all sides of the well travelling up the well. Some eroded areas show a distinct horizontal line where the concrete above the line was affected but the concrete below was not. This may have occurred due to a construction joint or the formation of a cold joint where the scouring effect will erode any less consolidated concrete areas (Photo B-30). The concrete around the 12 in square gate showed surface erosion but no observed voids or deep pits into the concrete (Photo B-31). Despite the extensive areas of concrete erosion, the condition of the waste well is still structurally sound. Re-conditioning/patching would alleviate the erosion issue and prevent further deterioration.

### 4.3 Slide Gates and Mud Valve

The Screen House includes ten slide gates and a single mud valve. These gates and valve provide the following primary functions:

- Isolation of the two traveling screens
- Isolation of the three downstream 48-inch diameter water supply pipes
- Sediment sluicing and Drain the tunnel of water from Lake Whatcom

The gates and valve appear to date from the original construction of the facility, with the exception of the two 12-inch square screen well sluice gates which have been replaced within the last 10 years. The function and condition of the slide gates and mud valve are summarized in Table 4-1. Locations of each are also shown in Figure 2. Recommendations for continued operation are also provided. Photos of the gates and valve are provided in Appendix B (Photos B-32 through B-48).

TABLE 4-1  
**Summary of Slide Gates and Mud Valve**

No.	Size and Type	Location	Function	Condition
1	5'-0" high x 6'-0" wide gate	Intake well (south)	Isolates traveling screen from intake well	Fair
2	5'-0" high x 6'-0" wide gate	Intake well (north)	Isolates traveling screen from intake well	Fair
3	4'-0" square gate	Intake well	Sluices sediment from intake well to waste well and drains the tunnel	Fair <sup>1</sup>
4	12" square gate	Screen well (south)	Sluices sediment from screen well to waste well	Good
5	12" square gate	Screen well (north)	Sluices sediment from screen well to waste well	Good
6	5'-0" high x 6'-0" wide gate	Outlet well (south)	Isolates traveling screen from outlet well	Poor
7	5'-0" high x 6'-0" wide gate	Outlet well (north)	Isolates traveling screen from outlet well	Poor
8	12" mud valve	Outlet well	Sluices sediment from outlet well to waste line and drains the outlet well	Non-functional
9	4'-0" square gate	Outlet well (south)	Isolates industrial supply line from outlet well	Poor
10	4'-0" square gate	Outlet well (middle)	Isolates domestic supply line from outlet well	Poor
11	4'-0" square gate	Outlet well (north)	Isolates domestic supply line from outlet well	Poor

<sup>1</sup> Gate was not functioning (frozen in place) at the time of the inspection, but is otherwise in fair condition.

### 4.3.1 Intake Well

The three slide gates in the intake well (Nos. 1, 2, and 3) appear to be cast iron with a lead-based primer and a black coal-tar based coating. The gates are in fair condition; however, a significant amount of corrosion including large tubercles (mounds of corrosion products) was visible on all three gates and embedded wall thimbles (gate-opening frames). Gates Nos. 1 and 2 are regularly exercised during operation of the traveling screens, and this has kept the guides relatively clean. Gate No. 3 was frozen in the closed position at the time of the inspection, and it is understood that City of Bellingham staff will work to clean these guides in the next few months to resume operability of this gate.

The gate operating stems and guides are in fair condition. The floor stands on the upper, operating deck above the caisson are also in fair condition, and have operating nuts to receive crank operators.

### 4.3.2 Screen Wells

The slide gates in the screen wells (Nos. 4 and 5) appear to be cast iron with an epoxy coating, and are in good condition. Labels on the equipment indicate that it was provided by Rodney Hunt located in Orange, Massachusetts. These gates were replaced within the last 10 years. The operating stems, guides and floor stands also appear to have been replaced at that time and are in good condition. The floor stands have crank operators attached. The wall thimbles appear to date from the original construction of the facility.

### 4.3.3 Outlet Well

The gates and valve in the outlet well are generally in worse condition than the gates elsewhere in the structure. The slide gates (Nos. 6, 7, 9, 10, and 11) and the mud valve (No. 8) appear to be cast iron with a lead-based primer and a black coating. The gates are in poor condition and large amount of corrosion including large tubercles was visible on all 5 gates, the valve, and their thimbles. Gate Nos. 6 and 7 are regularly exercised during operation of the traveling screens, and this has kept the guides relatively clean. Gate No. 9 is not regularly exercised and may be inoperable. Gate Nos. 10 and 11 are operational and exercised every other month. The mud valve operating stem was broken, rendering it inoperable.

It is unknown whether Gate Nos. 9, 10 and 11 were operable. However their frames and guides appeared to be heavily corroded and a significant amount of corroded material was easily removed with a pocket knife. Pit depths up to 0.3-inch were measured.

The gate operating stems and guides are also in poor condition. The floor stands on the deck are in fair condition, and have operating nuts to receive crank operators.

## 4.4 Traveling Screen

The Screen House includes two Rex traveling screens located in screen wells on the south and north sides of the structure. The screens can be isolated and operated independently as discussed above. It is understood that the City typically alternates operation between the two screens, operating each one every other month. The online screen is rotated via timer, with one full rotation occurring approximately every 24 hours.

The screens are conventional traveling screens with typical screen baskets and do not include any special provisions for fish protection. The screen material is No. 12 mesh wire cloth with 25 gauge wire and a 2-inch square backing mesh. A high-pressure spray wash system on the deck directs debris into the waste well and from there to the 42-inch outfall on Whatcom Creek. Each screen well also includes a 12-inch square sluice gate at the invert to direct sediment to the waste well. This gate can also be used to drain the screen well.

The traveling screens appear to be in good condition and were rehabilitated within the last 12 years (including the motor, reduction gears, chain, and chain guides). The screen mesh is sound with no visible gaps or tears, and the screen baskets have only minor surface corrosion. The screen frames are epoxy-coated (white) and show little degradation at the time of inspection. No large gaps between the screen, frame and concrete structure were visible. The drive mechanism was clean and appeared to have been recently lubricated. Photos B-49 through B-55 in Appendix B show the traveling screen.

## 5. Recommended Facility Improvements

Inspection of the Screen House facility pipelines, structure, slide gates and mud valve, and traveling screens enabled development of the recommended facility improvements presented in the following sections.

### 5.1 48-Inch Outlet Pipelines

Several repair/rehabilitation alternatives were identified and considered in the 2012 report included as Appendix A. Most of those alternatives are not feasible or do not represent reliable, long-term improvement approaches that will keep the Screen House facility in operation. Discussion of these inadequacies is presented in Appendix A. However, one alternative for repair/replacement of the three existing 20-foot long sections of pipe appears to be feasible. That alternative is the use of a carbon fiber reinforced plastic (CFRP) to form a new, structurally-independent pipe inside the existing corroded pipe, as depicted in Figure 3. The two specialty contractors that attended the April 23, 2014 inspection of the Screen House caisson and the interior of the three pipelines are certified installers of CFRP and have confirmed the application of CFRP for the three pipeline sections.

CFRP is installed inside the existing pipe – using the existing pipe as a form. Once installed and cured the CFRP serves as a standalone pipe. Pipe strength is achieved by applying the CFRP wrap in both the horizontal (hoop strength) and longitudinal (length strength) in alternating layers that are bound to each other by the impregnating resins. Installation of the CFRP is completed manually after a thorough blasting and cleaning of the existing pipe lining. The installed material is NSF approved for water service, is corrosion resistant, and provides service comparable to new pipe installation.

As shown in Figure 3, the CFRP repair for the three pipes will extend on the upstream end from the caisson outlet well wall (perpendicular to the pipe length), onto the rectangular transition section of the 48-inch diameter pipelines, then onto the round 48-inch diameter pipe sections, then finally terminating at the downstream end onto the 1980 steel pipe section.

The existing mortar lining of the downstream pipe will need to be removed several inches into the downstream pipe to allow the CFRP system to bond directly to the 1980 steel pipe that is in good condition. The existing stainless steel static mixers that are installed just inside this downstream pipe section will need to be removed to enable termination of the CFRP lining. Additionally, these static mixers must be removed to enable access to the downstream 24-inch diameter man-ways, shown in Figure 3, during CFRP installation. This downstream access man-way is necessary for ventilation past the installation section as well as worker access. The existing static mixers could be replaced to enable continued mixing of the chlorine solution added at this location, or they could be left out if mixing is not deemed to be necessary. The need for re-installation of the static mixers will be assessed at the time the pipe improvement is implemented.

On the upstream end of the CFRP installation, the three existing corroded slide gates will be removed because of their deteriorated condition. This removal will facilitate pipe rehabilitation and enable termination of the CFRP onto the flat, vertical face of the caisson outlet well wall so that the entire corroded steel pipe section is replaced. No replacement of these slide gates is proposed because the proposed Screen Bypass includes new butterfly valves that render slide gates at this location unnecessary.

To install the CFRP it is necessary to isolate the Screen House for approximately three weeks to complete this work. Effective and safe isolation of the Screen House for this purpose is the key challenge to enabling this work – other than the inherent challenge of the CFRP installation itself. Discussion of an approach to bypass the Screen House during this time is presented in Section 6.

## 5.2 Structure

Overall, despite its 75 years of service, the condition of the Screen House structure is good. Some structural re-conditioning is recommended, but the extent of this is relatively minimal. Recommended improvements are presented in the following sections for the Superstructure and the Substructure.

### 5.2.1 Superstructure

Some of the cracking observed in the exterior walls below windows have previously been patched and the patches have not performed well. This type of cracking around windows is common. Further similar patching of these areas is not likely to be successful. Such patching involves using relatively weak, brittle materials that fail with continued thermal expansion and contraction. A more effective approach is to use an injection method. An epoxy injection could be used; however, even though the epoxy is very strong, it is still a brittle material and subject to re-cracking. A urethane injection is not a structural repair, but it does seal cracks from water migration and is the appropriate repair for these areas. Urethane is a flexible material that can withstand the thermal expansion that will continue. The urgency for making these repairs is low, but in the event they are desired, they should be undertaken using urethane injection.

Cracking was also observed in the east elevation, which is part of the exterior wall of the inlet well. These cracks are associated with shrinkage soon after the casting of the concrete, and appear to be related to a construction cold joint that likely does not have a waterstop. Urethane injection or epoxy injection would be appropriate to seal these cracks given that they do not appear to be related to thermal expansion and contraction.

Repairs to the spalled concrete and corroded rebar at the pilaster on the second floor should be restored using a grout repair system. The more of the corroded reinforcing would be exposed and cleaned of corrosion product. The concrete would be prepared to adhere to a bonding agent and a cementitious grout systems. If other similar areas of the superstructure are discovered (none discovered during the April 23, 2014 inspection), they could be repaired similarly.

### 5.2.2 Wet Well Caisson

Given the extensive sediment in the wet well, the submergence of the floor in the intake well of the wet well at the time of inspection, and the lack of non-destructive testing confirmation of horizontal reinforcement, an additional structural inspection should be considered. Cleaning of the wet well floor and lower walls should be undertaken throughout the wet well prior to the additional inspection.

This additional inspection would help to confirm the apparent good condition of the structure and its suitability for rehabilitation. In addition, the extent of needed patching repairs should be refined. Also, confirming the presence of horizontal reinforcing in the caisson should be considered despite the apparent good condition of the caisson walls.

The only repairs identified were in the outlet well on the wall, on the underside of the slide gate opening between the outlet well and the traveling screen well, and several locations within the waste well. These repairs can be completed in a matter of a few days with a cement-based or epoxy-based grout. Once the walls of the wet well are cleaned, additional patching needs may be identified.

The existing coating within the wet well appears to be in good condition and does not need to be replaced. Minor repairs may be desired based on the results of the subsequent inspection. An NSF-certified potable water coating system would be used. The waste well is the only area observed that had not been coated. It is not known why this well was not coated, however it is recommended that this well be coated after all of the required concrete repairs have been performed.

The total amount of time needed to complete the grout-patching repairs throughout the Screen House is anticipated to be up to two weeks.

## 5.3 Slide Gates and Mud Valve

As presented in Table 4-1, the condition of each of the slide gates that haven't already been replaced includes characterizations of non-functional (waste well slide gate), poor, and fair. The two 12-inch square slide gates were replaced within the last 10 years and appear to be in good condition. The non-functional waste well slide gate is anticipated to be in poor to fair condition if it can be restored to functional condition. City staff plan to rehabilitate this slide gate in autumn of 2014 to enable further inspection and work within the inlet well of the caisson.

The mud valve in the outlet well is non-functional and must be replaced. The entire mud valve assembly (floor thimble/frame, plug valve, 30-foot long valve stem, and valve stem supports) must be replaced. Replacing the thimble will require removal of the concrete immediately surrounding the existing thimble. The existing reinforcing steel must be preserved to the greatest extent possible and/or new reinforcing will need to be installed. Temporary forms will then need to be placed and the replacement thimble supported and cast directly into the floor. Catalog information for a new mud valve is presented in Appendix F.

The Screen House slide gates from the original 1940 construction have between 5 and 15 years remaining useful life. The City could appropriately elect to keep some or all of these gates in continued operation for that period of time. If the City elects to keep these gates in continued operation, cleaning of the extensive corrosion product on the gates is not recommended. Doing so will only accelerate the corrosion process and potentially damage the gate structure.

However, near-term future replacement of the slide gates is expected to be necessary because of deteriorated condition. Replacing each of the slide gates during the same time frame and project as the 48-inch diameter pipes will reduce the overall cost of slide gate replacement because the Screen House facility will already be out of service. New slide gates will improve "leak-tightness" for future repairs and replacements. Therefore, for the purpose of this evaluation, it is assumed that all of the slide gates except the two 12-inch square slide gates and the three downstream 4-foot square slide gates will be replaced at the same time as the repair to the 48-inch diameter pipes.

The two 12-inch slide gates are in good condition and do not warrant replacement at any time in the near future. The three 4-foot square slide gates in the outlet well need to be removed because of their poor condition. However, they do not need to be replaced because they will become redundant once new butterfly valves are installed just downstream of the Screen House facility into each of the 48-inch diameter pipelines. These new 48-inch diameter butterfly valves are identified below in Section 6 as part of the discussion of the Screen House bypass.

Slide gate replacement would likely be made in a manner similar to the 12-inch square gates (Gate Nos. 4 and 5), wherein the replacement gate is installed over the existing wall thimble. Stainless steel, fiberglass reinforced plastic, and painted steel gates should be considered for implementation. Additional catalog information for stainless steel gates is presented in Appendix G.

## 5.4 Traveling Screens

Given that the existing traveling screens are in relatively good condition, the City should continue to exercise and maintain them as it has done since the screens were first installed. With continued maintenance, the traveling screens likely have a remaining operating life of approximately 20 years before the next major overhaul or replacement.

When the screens are eventually replaced, the City will likely wish to investigate alternative screen materials and technologies, such as polymer screens, which significantly reduce weight. Doing so would facilitate screen installation and operation. Polymer screens are resistant to corrosion and eliminate the traditional bottom sprocket which is a submerged piece of moving equipment requiring maintenance and repair.

Newer screen technology also incorporates fish protection enhancements, if desired, or if required by Washington State Department of Fish and Wildlife.

Additional traveling screen catalog information is presented in Appendix H. For the purpose of this evaluation and estimating life cycle costs, it was assumed both of the traveling screens would be replaced in their entirety in 20 years.

## 5.5 Summary of Recommended Improvements

A summary of the improvements recommended for implementation is presented in Table 5-1.

TABLE 5-1  
**Summary of Recommended Improvements**

Improvement Type	Year of Implementation	Comments
48-inch Diameter Outlet Pipelines	2016	Carbon fiber reinforced plastic liner by specialty contractor.
Structure	2016	Miscellaneous grout patching. Work duration up to two weeks. Painting of Waste Well.
Slide Gates and Mud Valve	2016	Replace 5 of 10 slide gates. Remove (no replacement) 3 of 10 slide gates. Replace mud valve.
Traveling Screens	2034	Replace traveling screens in approximately 20 years.

## 6. Screen House Bypass

Water from Lake Whatcom to the City’s WTP flows through the Screen House. This flow can be interrupted for a maximum period of 24 hours, depending on the time of year. Some repairs and rehabilitation activities at the Screen House described in Section 5 can be made under these time constraints. However, it is not possible to rehabilitate the 48-inch diameter pipelines during this short duration, and this rehabilitation is the most critical and in need of implementation in the next year or two.

Approximately three to four weeks are needed for the pipeline rehabilitation work. While other repair work could be undertaken simultaneous to this repair work, some work will need to be undertaken before and after this time frame. Therefore, the total duration of repair work at the Screen House could take approximately two months to complete.

Therefore, the Screen House must be effectively, reliably, and safely isolated to enable repair, replacement, and rehabilitation within the structure. The purpose of the bypass approach described herein is to enable the Screen House to be temporarily isolated during construction of repairs. The bypass will not include any screening between Lake Whatcom and the WTP and is not intended for extended use or alternative use in lieu of flowing through the traveling screens. Use of the bypass should be minimized and reserved only for repair, rehabilitation, and equipment replacement at the Screen House.

### 6.1 Description of Bypass

The Screen House bypass approach presented herein can be used on a temporary basis to enable the rehabilitation described in Section 5, but it is also a permanent improvement that can also be used in the future to enable implementation of future repairs and equipment replacements, such as replacement of the traveling screens and other activities.

The bypass presented herein involves diverting water from the tunnel, just upstream of the Screen House structure, and reintroducing it to each of the three 48-inch diameter pipelines just downstream of the Screen House. A plan view of this approach and location of isolation valves are presented in Figure 4. Details of the upstream and downstream connections to the existing system are presented in Figure 5.

The bypass presented in Figures 4 and 5 is comprised of 30-inch diameter ductile iron pipe, four 30-inch diameter butterfly valves, three 48-inch diameter butterfly valves, associated fittings, and an air release/vacuum vent at the high point of the bypass. The bypass system enables isolation of all parts of the Screen House facility, except for the inlet well of the caisson. The three gates in the inlet well must be closed to divert water around the remainder of the Screen House facility.

As such, isolation of the inlet well is not possible and repairs to the Screen House structure in the inlet well and replacement of slide gates must be completed during a series of three 24 to 36 hour supply system shut downs by closing the upstream Gate House slide gate. These shut downs would be undertaken with one or two days in between to enable re-filling of the City's storage reservoirs. Thus, replacement of these three slide gates would be implemented over a period of 10 to 14 consecutive days during the winter months.

International Flow Technologies, Inc. investigated the possibility of installing a temporary tunnel plug upstream of the inlet well, but it was not successful in developing a reliable or cost-effective design approach. While other temporary plugging approaches of the tunnel may be possible, they are not necessary because the needed rehabilitation work in the inlet well of the Screen House caisson is minimal and can be undertaken during the short-duration shut-downs, as described above.

## 6.2 Bypass Capacity

There is adequate hydraulic capacity in the City's supply system between Lake Whatcom and the WTP to enable the Screen House bypass to adequately supply the City during most of the year based on current City water usage. Given the 30-inch diameter system presented herein, the capacity would be limited to 24 mgd based on a limiting velocity criteria of 8 ft/sec. The maximum velocity criteria of 8 ft/sec is somewhat arbitrary, but is common maximum velocity criteria, intended to limit pipe wear. Exceeding this velocity criteria could be possible given the very infrequent intended use of the bypass.

The City may also wish to consider reducing the size of the bypass system presented herein to 24 inches in diameter to reduce cost and reduce risk associated with making the connection to the tunnel. If a 24-inch diameter system were implemented, the capacity based on a maximum velocity criteria of 8 ft/sec would be 16 mgd. This reduced capacity would still enable use of the bypass without impact to meeting customer demand as long as its use was scheduled to avoid the summertime peak demand season.

Note that the City's maximum day demand in 2012 and 2013 was 14 mgd in each of those years. Therefore, in recognition of the fact that the bypass is only intended to be used for short, focused periods of time for making key repairs or equipment replacements, 16 mgd should be adequate well into the future. Scheduling use of the bypass outside of the peak summertime demand season would be prudent and likely necessary in the longer-term future.

## 6.3 Key Bypass Elements

Key elements of the Screen House bypass include the following:

### 6.3.1 Tunnel Connection

This connection represents the most challenging aspect of the tunnel bypass and additional information must be collected prior to its implementation. This additional information would be collected by conducting geotechnical borehole drilling from the existing ground surface adjacent to the tunnel at several locations and by also conducting two core drilling holes from inside of the tunnel at the planned tunnel connection location. The geotechnical borehole drilling would be conducted first and would not require a shut-down of flow through the tunnel. The two core drilling holes from inside the tunnel would require a 24 to 36-hour shut down of the tunnel.

These drilling activities would confirm the subgrade and tunnel liner conditions. To make the tunnel connection as presented herein, it is necessary for the tunnel to be constructed in solid rock, as indicated from the original construction drawings. If the tunnel is not constructed in solid rock conditions, it will not be possible to make the tunnel connection as presented herein.

The reason for this is that the tunnel was designed such that the solid rock conditions counter-balance the forces associated with the water under pressure inside the tunnel. The concrete tunnel liner itself was not designed to withstand either internal forces associated with water pressure or external forces associated with the weight of unconsolidated soil and rock material. The tunnel was designed and constructed through rock conditions, which enables it to exist, self-supported, without the structural support of the tunnel liner. The tunnel liner was designed to protect the excavated tunnel from the erosive forces of the water flowing through the tunnel.

However, if the concrete tunnel liner is exposed to atmosphere by deep excavation - removing the confining rock material around the tunnel liner. The tunnel liner cannot contain the approximately 10 psi of water pressure inside the tunnel. It will crack and/or rupture catastrophically. Therefore, the tunnel must be contained within rock at the connection location and the connection to the tunnel must be made using a trenchless method such as an auger boring machine.

Auger boring would be horizontal, undertaken from approximately 10 feet from the tunnel in plan view. Boring would continue while the tunnel is in service to within 3 or 4 feet of the tunnel liner. At that point, the tunnel would be removed from service and the boring would continue through the remaining rock material and through the tunnel liner into the tunnel interior. The auger tunnel boring operation would result in placement of a steel casing pipe of 36 inches diameter. A steel carrier pipe of 30 inches diameter would be inserted and the annular space grouted with a quick-cure material. A flange would be welded onto the carrier pipe and a blind flange bolted on. The carrier pipe would be temporarily restrained while the tunnel is placed back into service to replenish the City's reservoirs. Once that replenishment is complete, the tunnel would be removed from service once again, the blind flange removed, and the connection to the remainder of the Screen House bypass piping would be completed before placing the tunnel back in service.

A deep excavation (most likely including sheet piling) on the exterior of the tunnel just to the east of the Screen House will be necessary to set up the horizontal auger boring operation. The excavation would be approximately 20 to 25 feet deep and 40 feet by 15 feet in plan view.

Key aspects of this tunnel connection are summarized as follows:

- Geotechnical borings are needed to confirm the feasibility of the proposed connection
- Two core drilled holes from inside the tunnel are needed to confirm the feasibility of the proposed connection
- The auger boring launching pit excavation (likely sheet piled) will be costly and result in the removal of surrounding trees

- Complete 4 feet of drilling, penetrate tunnel liner, place carrier pipe, grout annular space, weld on flange, bolt on blind flange, provide thrust restraint – all of this in approximately 30 hours

Note that key additional information is needed prior to selecting this bypass approach for implementation.

### 6.3.2 Mid-Section

The profile of the bypass includes connections to the existing system at the upstream and downstream ends that exceed 20 feet in depth and therefore present substantial challenge and cost impacts. Between these two connection points, the bypass will only have four to five feet of cover to minimize cost and impact to the adjacent Screen House structure and adjacent trees. Despite the shallow depth of bury of this portion of the bypass system, at least one tree will need to be removed. This portion of the system can be installed without any shut-downs of the supply.

### 6.3.3 Downstream Connection

The downstream connection actually includes three separate connections – one to each of the three 48-inch diameter pipelines downstream of the Screen House. Similar to the tunnel connection, a deep excavation will be necessary. Three separate supply shut-downs will be required for these three connections. Each of these connections will include the cutting of the existing 48-inch pipeline and installing a tee, a 48-inch diameter butterfly valve, a pipe spool and fittings. A fourth shut-down will be required for installation of the vertical 30-inch diameter piping and the associated shallow-bury, 30-inch diameter butterfly valves. It should be noted, however, that no confined-space entry into the Screen House or 48-inch piping will be necessary during these shut-downs. Key associated challenges include:

- The 21-foot depth of excavation (no trees should be impacted)
- The associated costs of the deep excavation, which will need to be at least partially sheet-piled adjacent to the Screen House building
- The multiple short-duration shut-downs and the associated inefficiency and cost

Clearly, the challenging elements of constructing the Screen House bypass are the upstream and downstream connections. While the downstream connection requires more short-term shut-downs, it should be noted that this same area has apparently been excavated twice in the past.

The first of the two excavations was part of the 1968 construction of the City's WTP. The Screen House portion of that 1968 project involved replacement of two of three venturi meters that were installed in the Chlorine Injection Room. The two venturi meters were replaced with steel pipe sections.

The second excavation was in 1979 and was part of the project to install the new 48-inch diameter concrete cylinder pipeline from the Screen House to the Georgia-Pacific pulp and paper mill on the City's waterfront. This 1979 project involved replacement of the third venturi meter that was not replaced in 1968. It also included replacement of both of the steel pipe sections that were installed in 1968. The 1979 project resulted in the installation of the current pipe sections in the Chlorination Injection Room that include 8-inch diameter pipe drains, static mixers in two of the three pipe sections, and 24-inch diameter access ports in each of the three pipes.

These two prior excavations included cutting the Screen House wall through Chlorine Injection Room. The excavation needed for the downstream connection for the Screen House bypass would not require cutting this same wall.

## 6.4 Temporary Variation Considered

A variation of the bypass approach presented herein was considered that included pumping from the inlet well of the caisson instead of a permanent connection to the tunnel and temporary, shallow-buried piping, and a connection to the 66-inch diameter supply pipeline roughly 200 feet west of the Screen House facility.

This alternative would require some modification of the main floor of the Screen House structure to pass one or two temporary discharge pipes from sump pumps located in the inlet well of the Screen House.

Because this alternative includes pumping, is only partially a permanent installation, and would include additional control complexity to operate, it was not considered further. However, pending review and evaluation of the alternative presented herein as well as alternative screening approaches to be presented under separate cover, this alternative may warrant further consideration.

## 6.5 Alternative for Further Development

The Screen House bypass approach presented in Section 6.1 will enable the City to address the immediate need of rehabilitating the three 48-inch diameter pipelines at the Screen House. It will also enable future Screen House rehabilitation and equipment replacement. The bypass approach relies on the continued operation of the upstream components of the City's water supply, which include the wood-stave intake pipe in Lake Whatcom, the Gate House on the shore of Lake Whatcom, and the tunnel.

Another alternative approach to bypassing the Screen House was identified during this study and is one the City intends to evaluate. This alternative bypass approach is to develop the water supply system that supplies the adjacent Washington State Department of Fish and Wildlife (WDFW) fish hatchery into a redundant backup supply that can enable temporary isolation of the Screen House. These periods of temporary isolation could be up to several weeks at a time.

Based on a few old drawings and documents that City staff have obtained, the supply system that conveys water to the fish hatchery appears to be one that was originally used to supply the City of Bellingham prior to the current supply system. Its use as a supply to the City appears to have been discontinued by 1940. The WDFW fish hatchery appears to be the only user of this supply.

This old supply system appears to include the following:

- A pipeline extending from the fish hatchery toward Bloedel Donovan Park
- A flow-splitting/chlorination facility just downstream of the City's control dam
- A brick-lined tunnel extending across Bloedal Donovan Park from the flow/splitting/chlorination facility to an intake
- A 600-foot long wood-stave intake in Lake Whatcom.

Further investigation and verification would be necessary to confirm whether these facilities are as they are described, determine their condition, establish their precise location, and to establish ownership.

A review of old drawings of the supply system indicates that it could potentially be connected to the City's current primary supply system downstream of the Screen House. The approximate connection location would be 200 feet southwest of the Screen House in the 66-inch diameter municipal supply pipeline. Approximately 300 feet of new 24 or 30-inch diameter would be necessary to connect to the alternative supply. New butterfly isolation valves would be necessary in the 66-inch diameter pipe and in the 30-inch diameter pipe.

This alternative bypass approach, if feasible, would have the following potential advantages:

- Lower capital cost than the bypass approach presented in Section 6.1
- Allows isolation of the entire Screen House, including the inlet well of the caisson
- Enables bypassing of not only the Screen House, but also the tunnel, Gate House, and wood-stave intake
- Provides an emergency, backup supply source from Lake Whatcom

- Enables avoiding the risk of potentially damaging the tunnel during construction of the tunnel connection for the Screen House bypass described in Section 6.3.1

This alternative approach is, in essence, a redundant supply that could be used on a temporary basis. To assess the feasibility of this approach, the following activities are necessary:

- Determine ownership of the facilities that comprise this alternative supply – from Lake Whatcom to the fish hatchery
- Determine whether there are any inter-agency agreements regarding use of the supply system between the City and WDFW
- Determine property rights associated with each of the component elements of the supply system
- Determine the condition of these supply facilities
- Determine water rights impacts and issues associated with use of this supply
- Determine compliance of this supply system with WDFW fish protection requirements
- Estimate the hydraulic capacity of the supply system
- Establish the water supply (quantity) needs of the fish hatchery and how those needs are distributed over the calendar year
- Coordinate with fish hatchery regarding its needs and concerns and develop a usage agreement

## 7. Estimated Costs

Estimated initial capital costs were developed for the recommended improvements presented in Section 5 as well as the Screen House bypass presented in Section 6. In addition to these initial capital costs, annual operations and maintenance costs and 20-year life-cycle costs were developed for continued use of the Screen house facility. These estimated costs were developed to the “concept level” or “Class 5” level of accuracy as defined by the Association for the Advancement of Cost Engineering International (ACEI). This level of cost estimating is considered accurate to +50 to -30 percent.

These estimated costs were prepared for guidance in evaluating the recommended improvement approach for the Screen House facility based on information available at the time of the estimate. The final cost of the project will depend upon the actual labor and material costs, competitive market conditions, implementation schedule, and other variable factors. As a result, the final project costs will vary from the estimates presented herein. Because of this variation, project feasibility and funding needs must be carefully reviewed prior to making specific financial decisions.

A summary of these estimated initial capital costs is presented below in Table 7-1. The following markups are incorporated into the construction costs listed in Table 6-1:

- Contractor overhead: 10%
- Contractor profit: 6%
- Mobilization/bond/insurance: 10%
- Contingency: 30%

TABLE 7-1

**Summary of Estimated Initial Project Costs - Screen House Improvements**

<b>Construction Costs:</b>	
Slide gates	\$551,000
12-inch mud valve	\$66,000
Grout repair/concrete patching	\$26,000
48-inch pipe repair	\$559,000
Screen House bypass	
Tunnel connection	
Auger boring	\$281,000
Excavation & dewatering	\$356,000
Pipe & valve installation	
Pipe/fittings	\$276,000
Valves	\$186,000
Downstream excavation & dewatering	\$357,000
	<b>CONSTRUCTION SUBTOTAL</b>
	<b>\$2,658,000</b>
Escalation to February 2016 (6.5%)	\$2,831,000
Construction w/ Sales Tax (8.7%)	\$3,078,000
<b>Non-construction Costs:</b>	
Permitting Allowance	\$100,000
Engineering and Construction Management <sup>1</sup>	\$770,000
	<b>TOTAL</b>
	<b>\$3,948,000</b>

Notes:

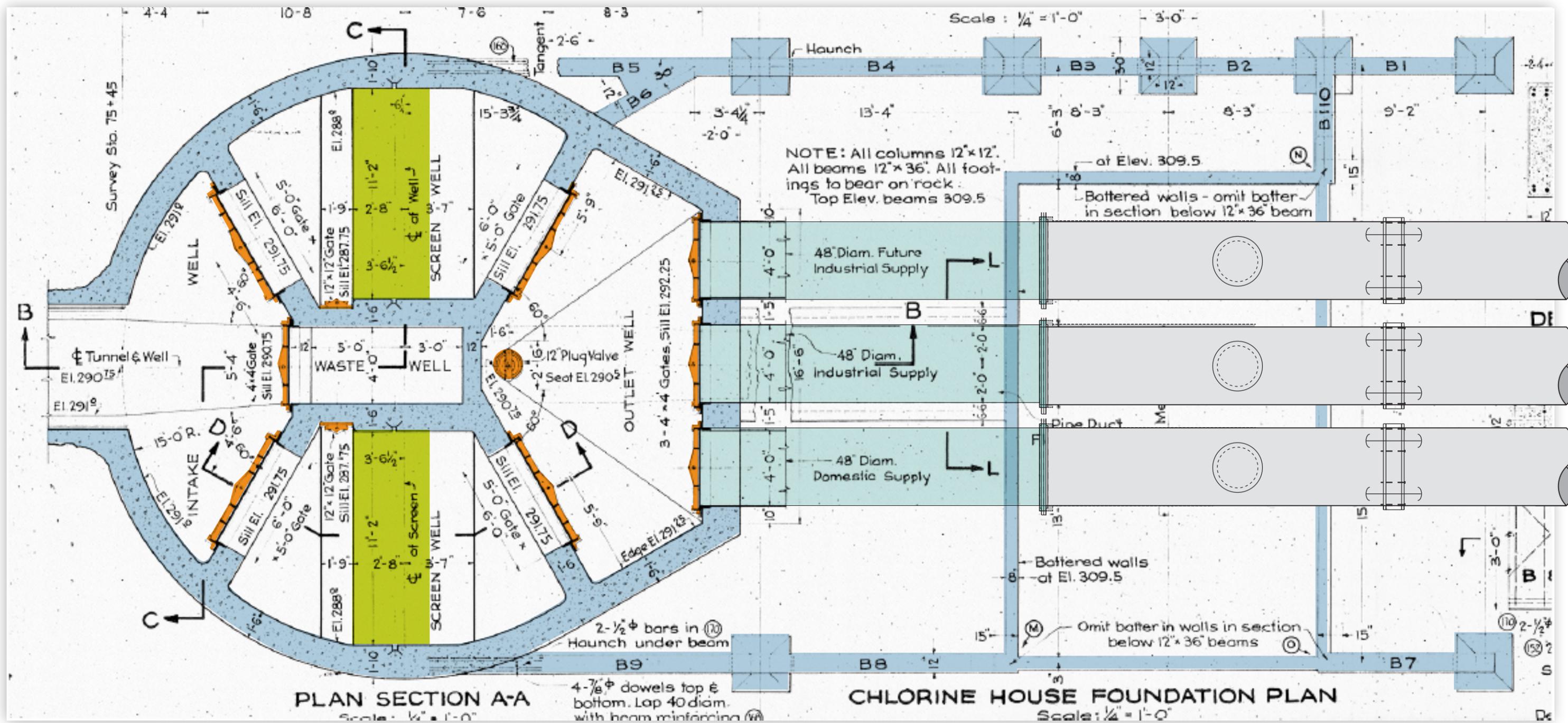
<sup>1</sup> Engineering and Construction Management costs estimated as 25 percent of construction subtotal with sales tax.



**Figures**

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WBG101013133232SEA

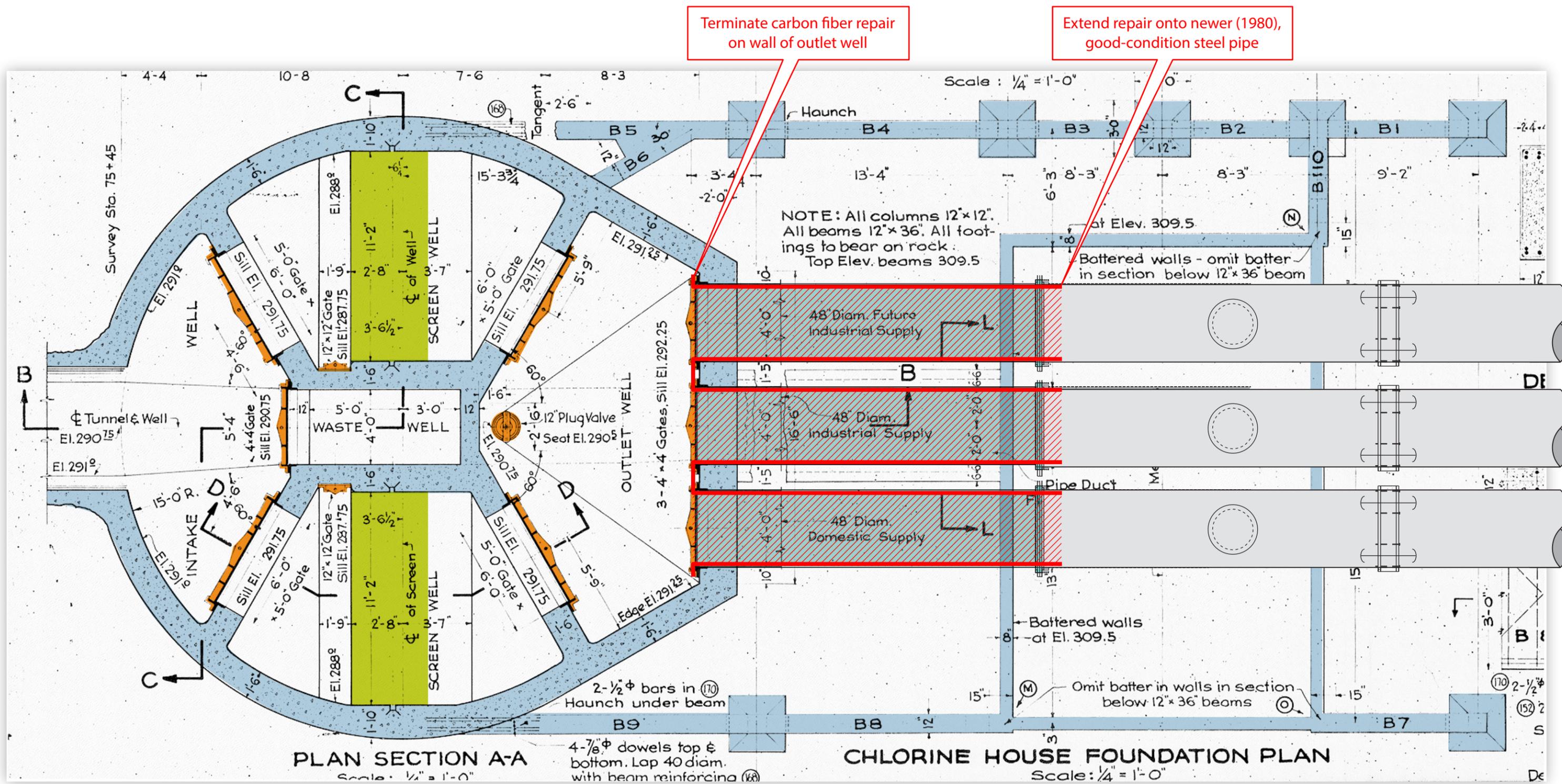
- Slide Gates and Plug Valve
- 48-Inch Steel Pipe Spools
- Concrete Structure
- Traveling Screen

Figure 1  
Screen House Plan View









Terminate carbon fiber repair on wall of outlet well

Extend repair onto newer (1980), good-condition steel pipe

WBG101013133232SEA

- Carbon Fiber Pipe Repair
- Slide Gates and Plug Valve
- 48-Inch Steel Pipe Spools
- Concrete Structure
- Traveling Screen

Figure 3  
**Recommended Pipeline Improvements**



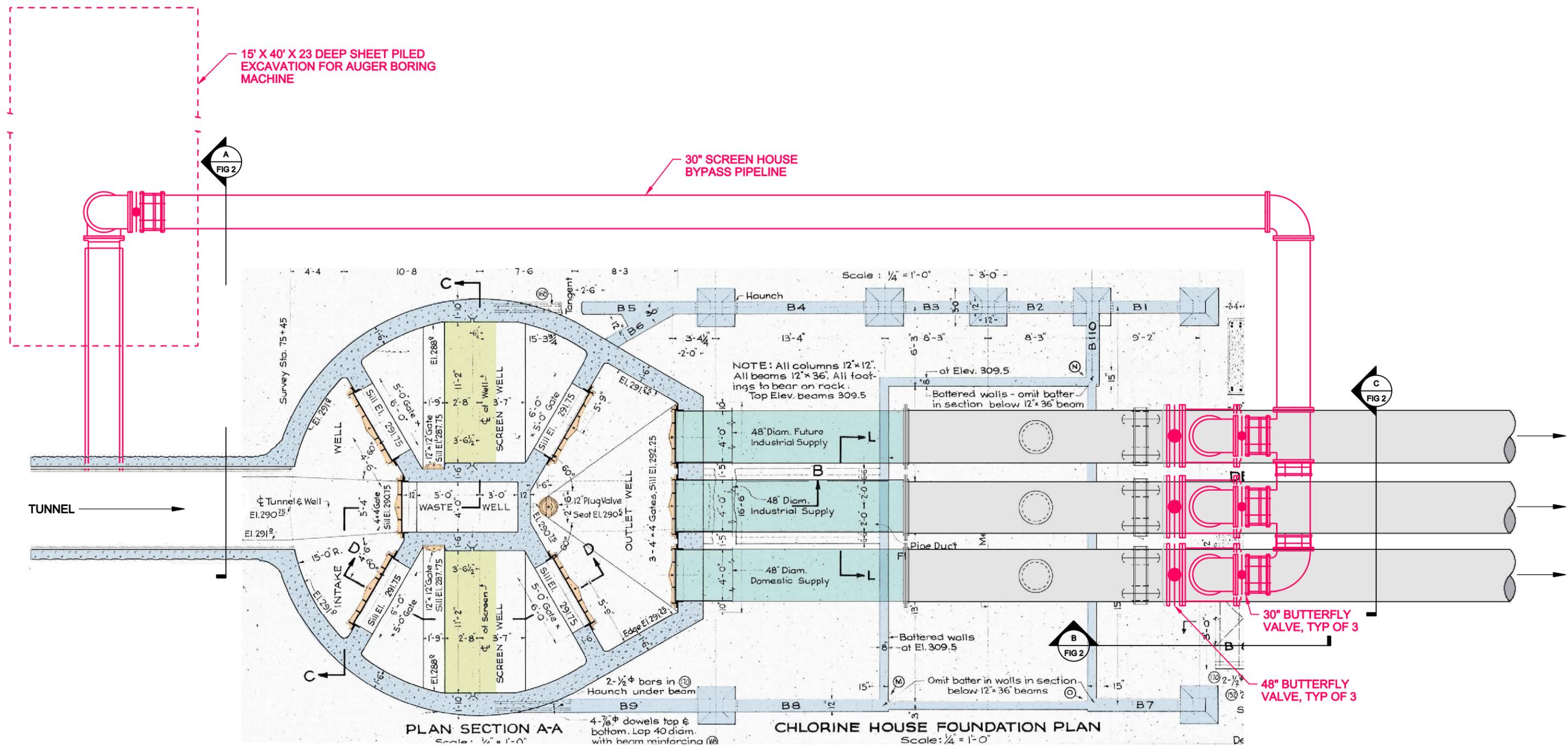
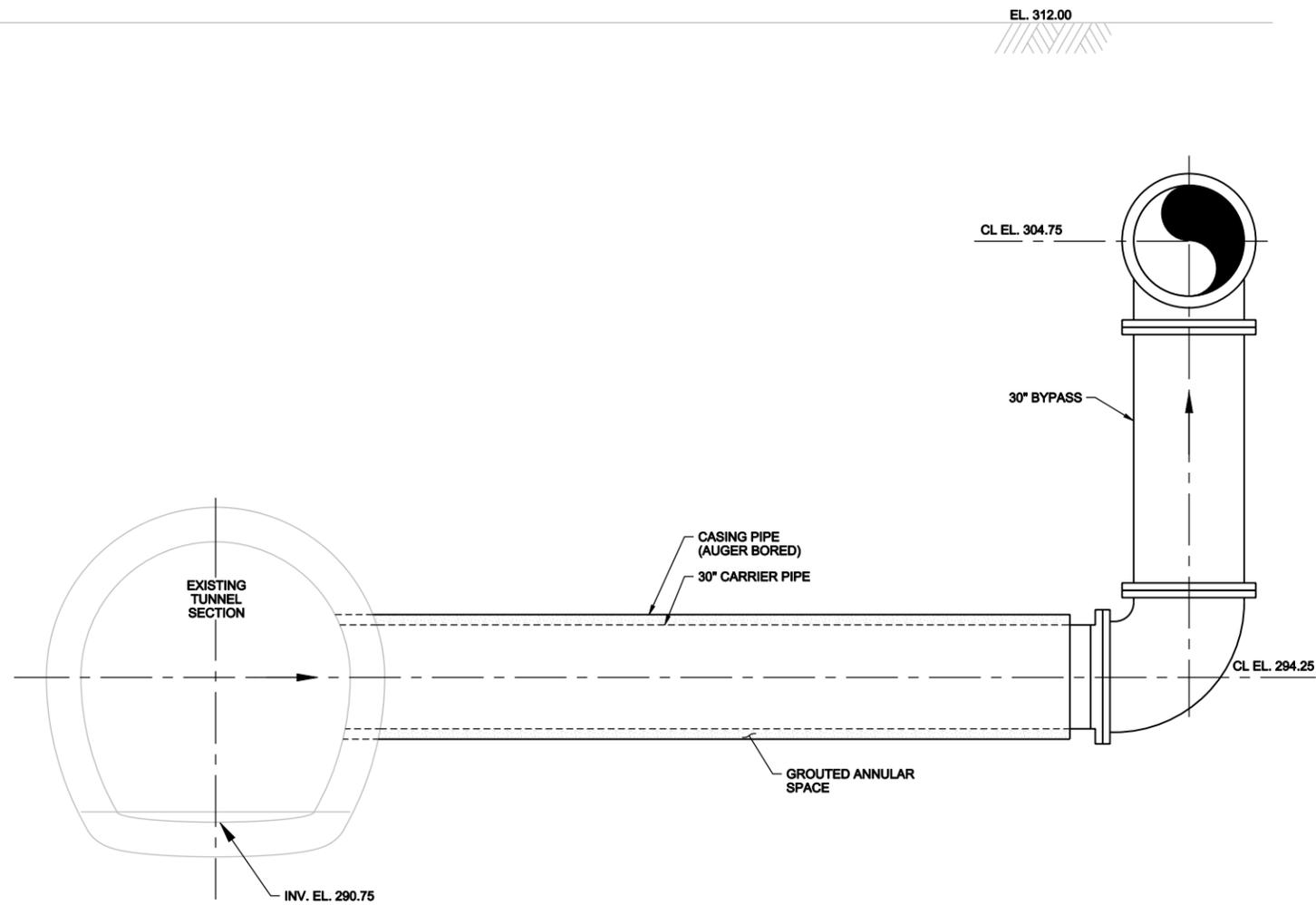
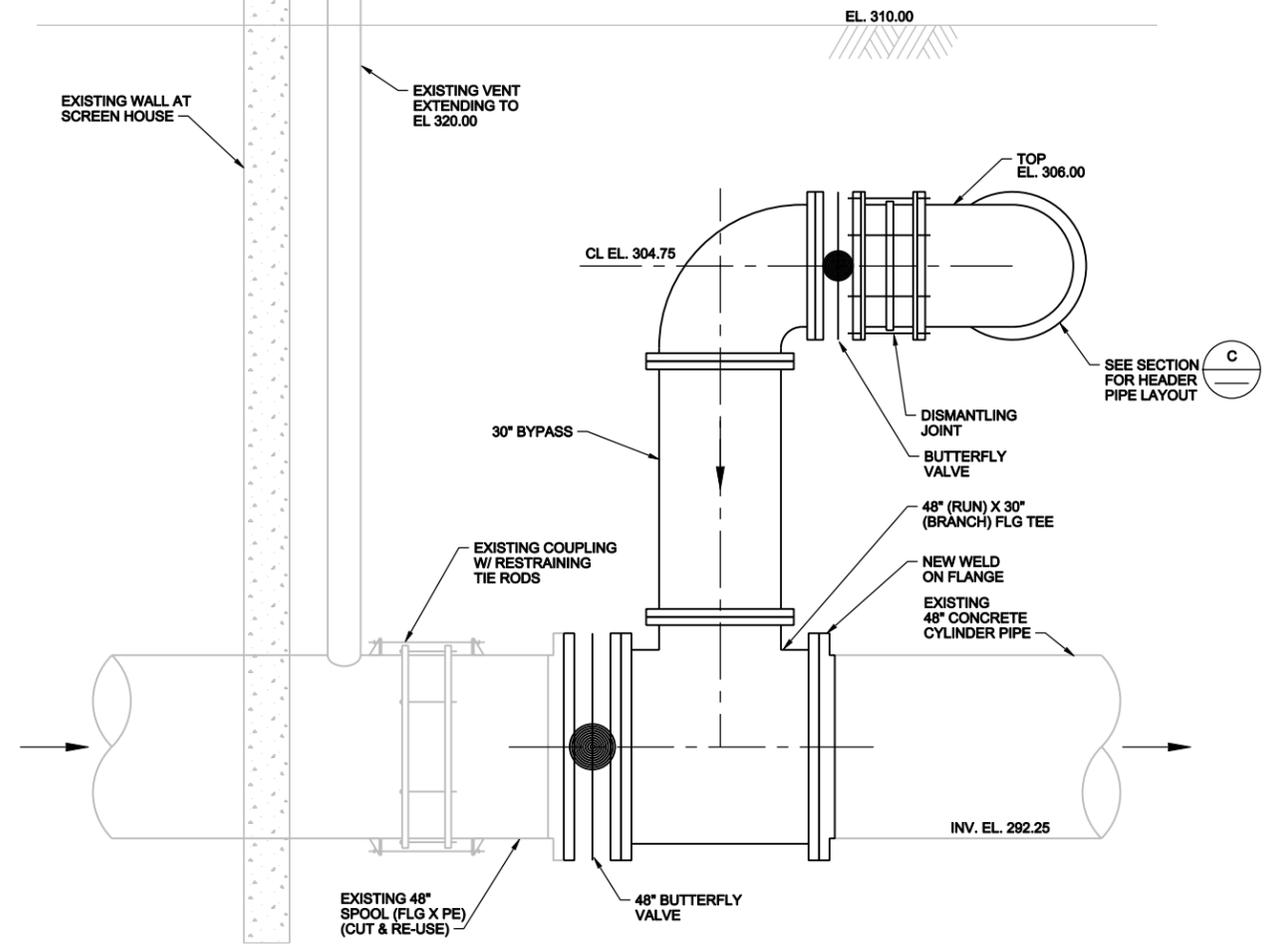


Figure 4  
**Plan View of Screen House Bypass**

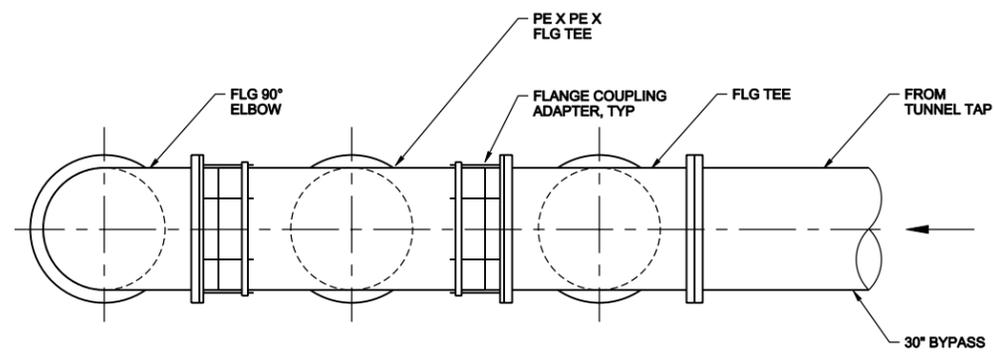




**A** TUNNEL CONNECTION DETAIL (AUGER BORED)  
1/4"=1'-0"



**B** DOWNSTREAM CONNECTION DETAIL  
1/4"=1'-0"



**C** DOWNSTREAM DISTRIBUTION HEADER  
1/4"=1'-0"

**Figure 5**  
**Connection Details**  
**for Screen House Bypass**



**Appendix A –  
Evaluation of Alternatives for Corroded Pipe  
at Screen House (CH2M HILL 2012)**

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# Evaluation of Alternatives for Corroded Pipe at Screen House

Prepared for  
City of Bellingham, Washington

Prepared by  
**CH2MHILL**®

September 13, 2012



This report was prepared under the direct supervision of a registered engineer.

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# 1. Introduction

This report summarizes the results of an assessment by CH2M HILL of the condition of the inside of three 48-inch diameter welded steel raw water pipelines at the City's Screen House as well as development of one or more potential mitigation alternatives. The Screen House is a City of Bellingham facility that provides debris-screening of water conveyed from Lake Whatcom to the City's Whatcom Falls Water Treatment Plant and to other non-treated industrial uses downstream.

Prior to conducting this condition assessment, CH2M HILL reviewed a report prepared by Black and Veatch, entitled "Evaluation of Screen House Corroded Piping Mitigation Options," dated June 12, 2012. The Black and Veatch report summarizes an evaluation of several alternatives based on a review of the external condition of exposed portions of each of three subject pipelines. The Black and Veatch report recommends bypassing the downstream portion of the existing Screen House facility. While bypassing the Screen House is a viable alternative for a reliable temporary or even long-term permanent replacement of the questionable pipe, it would be relatively expensive and disruptive to the area around the Screen House. The key objective of CH2M HILL's condition assessment work was to identify whether or not there is a feasible lower-cost mitigation alternative that will meet the City's requirement to extend the life of the existing pipe at a reasonable cost without introducing an unacceptable level of risk to the facility.

This report includes information that supplements the Black and Veatch report and enables consideration by the City of alternatives that are based on not only the exterior condition of the existing pipe (where it can be observed) but also the condition of the inside of each of the 48-inch diameter pipelines. Consequently, no additional discussion or commentary of the alternatives identified and evaluated in the Black and Veatch report - other than referencing this previously-developed information - is presented herein. The Black and Veatch report is appended as Appendix A to this report.

A description of the Screen House facility, a chronology of historical improvements at the facility, and condition observations of the exterior of the three pipelines in question, are presented in the Black and Veatch report in Appendix A.

The CH2M HILL condition assessment and development of alternatives was undertaken in recognition of three key factors:

- The City cannot take the Lake Whatcom supply off line for more than 24 hours at a single time. This limits the feasibility of alternatives considered for this evaluation as well as those presented previously to the City.
- The City recognizes that the Screen House facility is over 70 years old and generally approaching the end of its use life. While the need for a replacement facility or a replacement of debris-screening, chlorine injection, and flow-splitting functionality is understood, the City prefers to extend the useful life of the Screen House facility, if possible, for as much as 5 to 10 additional years. This additional useful life would enable the City to evaluate incorporation of these functions into other facility improvements, such as the proposed dissolved air flotation (DAF) treatment process at the Whatcom Falls Water Treatment Plant. As a result, a risk-sensitive mitigation approach for this

issue would ideally be relatively low in cost – given that it would be a temporary measure with a fairly short life cycle.

- With any alternative the City may select for pursuit – whether it is one developed as presented herein or one presented previously presented to the City – there will be some associated risk of incomplete success. Such risk includes the possibility of encountering unforeseen difficulties implementing the mitigation strategy up to and including the potential to precipitate substantial leakage or failure in one or more of the inlet pipes. In general, the level of risk associated with feasible alternatives is inversely proportional to the cost of the alternatives. A key objective of this work was to identify alternatives that are relatively low cost and provide temporary extension of service life. Therefore, the City must consider the associated risk when making a selection of which alternative to pursue.

## 2. Observations

CH2M HILL subcontracted the services of H2O Solutions, LLC to enter each of the three pipelines while they remained in a submerged condition to enable visual observations by camera. In addition, pipe wall thickness measurements were collected using an ultrasonic gauge. The condition assessment dive was conducted on July 17, 2012 in the presence of CH2M HILL and City of Bellingham project staff. Downstream valves at the Whatcom Falls Water Treatment Plant and in the industrial pipeline were closed to prohibit flow through the three pipelines during the inspection. The slide gate entrances to each of the pipelines from the Screen House outlet wet well were left open to permit access by the divers.

The upstream slide gates between the traveling screens and the outlet wet well of the screen house were also left open to maintain a supply of flow from the upstream tunnel to the wet well. This was necessitated by the drain valve in the outlet wet well being stuck in the open position – draining water back to Whatcom Creek. In recognition of the unknown condition of each of the pipelines, it was decided that it would be safer and pose less risk of damaging to the pipelines to conduct the inspection of the inside of each of the three steel pipelines while submerged in a slightly pressurized condition, rather than drain the pipes via the outlet wet well drain line. As it turned out, the condition of the inside of each of the three pipelines was in relatively good condition given the approximately 70 years of service.

The dive was conducted in conformance with the safety plans developed by CH2M HILL and H2O. H2O's dive team consisted of a primary diver entering each of the pipelines, a secondary diver remaining submerged in the outlet chamber of the Screen House wet well in visual contact with the primary diver, a third H2O staff person monitoring umbilical connections and conditions at the entrance to the wet well, and a fourth H2O staff person monitoring the air-supply system, and audio/visual communication systems.

As stated, the overall condition of the inside of each of the three pipelines was observed to be relatively good based on visual inspection. However, moderate corrosion product was present throughout each of the pipes and most-extensively at the downstream end – the same area observed in the chlorine injection room to have extensive external corrosion. The pipelines appeared to have a degraded coal-tar enamel lining still partially present. The divers were able to rub and scrape the minor corrosion product on the inside of the pipe

with relative ease. Some pitting of the pipe may have been evident; however, it was difficult to quantify the extent and severity.

The Industrial Pipeline had about three to four inches of sediment deposited in the bottom of the pipeline. The reason for this is that the Industrial Pipeline only conveys 1 mgd or less to the downstream Puget Sound Energy Co-Generation facility, which results in negligible velocity in the pipe. There was only minor such deposition in the two municipal drinking water supply pipelines.

Pipeline wall thickness measurements were taken by the divers using their MX-3 Ultrasonic thickness gauge by Dakota Ultrasonics. Measurements were generally collected at positions of 12, 3, 6, 9 (clock positions) near the downstream end of each of the three pipelines at multiple locations around the circumference of the pipe corresponding to the 18-inch extension of each pipe into the chlorine injection room in the Screen House. At these downstream locations, thickness measurements indicated a remaining wall thickness of 0.215 to 0.250 inches in the industrial pipeline at the invert, but 0.3 inches of remaining thickness at all other locations measured. Because of the extensive corrosion observed on the exterior of the pipes at this downstream location, it is apparent that readings were not picking up any of the external pitting anticipated at this location. It is likely that if the ultrasonic gage could have been situated exactly under an external pit that a wall thickness reading less than that reported above would have been recorded.

Measurements were also collected in each pipeline approximately 5 or 6 feet upstream of this area – toward the upstream slide gate. In each of the pipes, the upstream measurements reflected a wall thickness of 0.3 inches – equivalent to what is believed to be the original wall thickness of the pipeline. Clearly, it is possible that there is pitting and some corrosion on the external, buried pipe wall in this area that was not picked up with the ultrasonic gauge. However, such pitting as well as extensive external corrosion would not typically be expected for a direct-burial condition.

What is clear is the extensive corrosion on the 18-inch externally-exposed length of each of the three 48-inch diameter pipelines. We concur with the April 25, 2012 Norton Corrosion letter report, citing severe metal loss. While observing the interior of each pipe was helpful in assessing the pipe condition upstream of this area (behind the east concrete wall of the chlorine injection room), it is also important to identify the likely contributing factors to the observed localized external corrosion. It is also important to note that the observed corrosion is almost entirely external to the pipe. Internal pipe corrosion appears to be relatively minor and uniform from the upstream to downstream ends of each of the 18-foot long pipe sections and is consistent with the age and usage of the pipes.

We believe there are three key factors contributing to the observed corrosion that are not present upstream in each of the pipes. These three key factors are:

- **Chlorine Injection:** Chlorine was injected for many years at this location. Chlorine is a strong oxidant that promotes corrosion in the presence of oxygen. While extensive corrosion is not observed on the inside of the pipeline (a lower oxygen environment), leaky chlorine injection ports appear to have allowed concentrated chlorine solution to run over the exterior of the pipes.
- **Multiple Pipe Penetrations of Varying Metal Types:** On each of the three pipelines are there six to eight pipe penetrations within the 18-inch length of corroded pipe with associated

corporation stops, caps, plugs, and old valves. The attached metallic elements can be assumed to have stimulated corrosive activity because of the dissimilar metals they have introduced in direct contact to the pipe wall.

- **Multiple Pipe Penetrations:** The pipe penetrations described above each involve cutting the 48-inch diameter carrier pipes – creating uncoated edges and pipe area that are inherently vulnerable to corrosion. Adding the presence of a concentrated chlorine solution and dissimilar metal contact creates an extremely corrosive condition that is damaging to the pipe.

### 3. Mitigation Alternatives

Upon completion of the July 17, 2012 condition assessment, mitigation alternatives were developed that were not among the alternatives originally considered in the Black and Veatch report. These (new) alternatives specifically address the City’s desire to extend the useful life of the existing, corroded pipelines, and therefore the overall Screen House facility, for another 5 to 10 years, and they are not meant to serve as permanent mitigation approaches.

Development of these alternatives was possible given the relatively good condition of the inside of the 48-inch diameter three pipelines that were observed to be corroded on their exposed portions in the chlorine room. The mitigation alternatives presented herein represent varying but relatively low cost approaches to mitigating the corroded-pipe condition at the Screen House and therefore may be more attractive to the City than bypassing the facility with new pipelines. However, because these alternatives are intended as temporary mitigation approaches, there is some risk that must be accepted with respect to their implementation that they may not prove successful upon initial installation or they may result in leakage within the next 5 to 10 years. These alternatives fall into two general categories based on the repair improvement approach to the inside of each pipe:

- **Weko-Seal Alternatives** (Sub-alternatives 1A, 1B, 1C, 1D)
- **Fibrwrap Alternatives** (Sub-alternatives 2A, 2B, 2C, 2D)

Each of the two main alternative categories is comprised of “sub alternatives” based on the approach to mitigating the external condition. These sub-alternatives include:

- **Nothing:** This sub-alternative involves leaving the pipe exterior in its current condition to avoid potentially damaging the pipe or exposing pinhole leaks by brush cleaning/removing the existing corrosion nodules.
- **Cement Mortar Coating:** This sub-alternative involves a process to remove heavy and loose rust product, coating the pipe exterior with a cement mortar to reduce corrosion, and installing an additional concrete pipe support to address the added weight of the cement mortar coating.
- **Paint:** This sub-alternative involves a process to remove heavy and loose rust product, solvent cleaning the resulting, still-rusty surface, applying one coat of a rust converter product, and then apply two coats of rust converting urethane coating.
- **Concrete Encasement:** This sub-alternative involves encasing each of the three pipelines in a single, reinforced concrete block that extends approximately 2.5 feet from the east wall of the chlorine injection room to approximately 12 inches behind the flange. The

encasement would be extended to roughly one foot over the top of the pipe. The concrete encasement would likely include drilled, epoxy anchors to the adjacent walls, some roughening of the east wall around each pipe, and the addition of a hydrophilic joint sealer on the east wall around each pipe to form a leakage barrier at this location.

A summary of the mitigation alternatives considered for this work is presented in Table 1. The mitigation alternatives and their associated sub-alternatives are also presented in graphical form in Figures 1 and 2 at the end of this report.

**TABLE 1**  
Description of Alternatives

<b>Alternative Category</b>	<b>Alternative Name</b>	<b>Alternative No.</b>	<b>Interior Mitigation</b>	<b>Exterior Mitigation</b>
Weko-Seal	Weko Seal/Nothing	1A	Weko Seal	Nothing
	Weko Seal/Mortar Coating	1B	Weko Seal	Cement mortar coating and concrete support
	Weko Seal/Paint	1C	Weko Seal	Paint
	Weko Seal/Concrete Encasement	1D	Weko Seal	Concrete encasement extending 1 foot above pipe and 1 foot behind flange
Fibrwrap	Fibrwrap/Nothing	2A	Fibrwrap	Nothing
	Fibrwrap/Mortar Coating	2B	Fibrwrap	Cement mortar coating & concrete support
	Fibrwrap/Paint	2C	Fibrwrap	Paint
	Fibrwrap/Concrete Encasement	2D	Fibrwrap	Concrete encasement extending 1 foot above pipe and 1 foot behind flange

### 3.1. Weko-Seal Mitigation Approach

The Weko-Seal™ alternatives are based on the installation of a Weko-Seal™ on the inside of each of the 48-inch diameter pipelines and making one of several improvements on the outside of the pipelines. The purpose of the Weko-Seal™ would be to span the externally-corroded, 18-inch section of each pipeline where it is exposed in the chlorine room to provide leak prevention from the inside. The Weko-Seal™ is a proprietary product that provides leakage sealing from the inside of a pipeline – typically across leaking joints. The Weko-Seal™ for this application would be comprised of an NSF-approved EPDM rubber “boot,” roughly 30 to 36 inches in length, that is supported and tensioned on the inside of the pipe with circumferential stainless steel bands at each end of the boot. Catalogue information of the Weko-Seal™ is presented in Appendix B.

Weko-Seal™ comes in standard sizes with the largest being 18 inches in width. The standard sizes have ribbed under-sides and tapered ends. However, the standard width is not sufficient to span the 18 inches of corroded exterior pipe. In cases such as this, Miller Pipeline Corporation, the owner of Weko-Seal™ technology, has developed a sealing approach that extends up to 48 inches in length using 3/8-inch EPDM rubber without the standard end-

ribbing and tapered ends. The use of two stainless steel bands (one at the upstream end and one at the downstream end) would be the same as for a standard Weko-Seal™.

Weko-Seal™ is typically installed in dry conditions. The pipeline lining at the upstream and downstream ends of the Weko-Seal™, where they are compressed by the stainless steel bands, must be cleaned to enable the leak-tight connection between the Weko-Seal™ rubber and the pipe lining. The pipe lining between these two bands does not need to be cleaned to a smooth condition but cannot have large, protruding rust nodules remaining.

The Weko-Seal™ can also be installed in submerged conditions, as could be the case for this application. A 4-inch-wide area around the entire circumference of the pipe must be cleaned to enable the 2-inch-wide stainless steel band to compress the EPDM rubber and create a water-tight seal. This cleaned-area is necessary at the upstream and downstream ends of the Weko-Seal™. Larger rust deposits and flaking portions of the degraded coal tar enamel coating must be removed. Weko-Seal™ include a test port that will be used to assess whether a water-tight seal is achieved, so it will be immediately clear whether or not a water-tight seal has been developed.

There is no guarantee or warranty that can be obtained on the installation of the Weko-Seals in the submerged condition. Installing Weko-Seal™ in a submerged condition is not common enough and includes inherent challenges. As presented later in this report, submerged installation of Weko-Seal™ is substantially less costly than installing them in a dry condition. Consequently, pursuit of submerged installation of Weko-Seal™ must include the acceptance that it may not be possible to achieve the necessary water-tight seal. That stated, the potential sunk cost in the event that water-tight seals are not achieved is relatively low compared to the cost of the other alternatives. Conversely, it would be possible to obtain a warranty on installation in the dry condition if installed by an approved Weko-Seal™ installer. As described previously, the cost of dry installation is substantially greater than wet installation.

In the two municipal drinking water supply pipelines there is a static mixer that extends to within three to four inches of the flange face between the upstream, externally-corroded pipeline and the downstream, un-corroded pipeline. The downstream end of the Weko-Seal™ would need to be installed on the downstream, newer-vintage pipeline to ensure an effective seal, and it appears there is just enough room for that to happen. Because there is no static mixer on the industrial pipeline, the Weko-Seal™ can be extended into the downstream, newer pipeline to the extent desired. Finally, in both of the municipal supply pipelines, there is a 1-inch diameter chlorine injection pipe (no longer used) that extends approximately 9 inches or so into the flow stream, that would need to be cut off and removed by the divers during installation to enable the Weko-Seal™ to be installed.

Refer to the two photos at the end of this report that show the following:

- **Photo 1. Interface Between Older and New Pipes:** Note the minor to moderate corroded condition on the inside of the older pipe in contrast with the cement mortar coating of the adjacent, newer pipe. Also shown in the photo is the ultrasonic measurement gauge and the welded support for the static mixer.
- **Photo 2. Static Mixer and Chlorine Injection Pipe:** This photo shows the static mixer that is present in each of the two municipal supply pipelines. Note the chlorine injection pipe that must be cut off flush with the pipe wall and the adjacent corrosion product that

would need to be cut/scraped/smoothed to enable flush-cutting of the injection pipe and installation of the Weko-Seal (as well as the Fibrwrap).

The adjacent downstream pipe is understood to be constructed of 0.5-inch thick welded steel. It has a cement mortar lining. The Weko-Seal can be installed directly over the cement mortar lining, which should require minimal surface preparation prior to installation.

Weko-Seal™ installation is anticipated to take at least five consecutive days and depending on the amount of cleaning/surface preparation necessary, could take up to ten days. The City should plan for a 10-working-day (two consecutive weeks) window for installation of the Weko-Seal™. During this timeframe, it is presumed downstream valves in the industrial and municipal supply pipelines would be closed while the divers worked on cleaning and installation. The divers would work during much of the day and the water treatment plant to be placed back into service each evening and overnight to re-fill storage reservoirs. Presumably, this approach is feasible during the low-demand period of winter.

## 3.2. Fibrwrap Mitigation Approach

The Fibrwrap mitigation approach is based on the use of the carbon fiber-reinforced polymer system described in Section 3.3 of the Black and Veatch report presented in Appendix A. The Fibrwrap system provides a leak-tight repair pipe segment inside the existing corroded pipe segment that is also structurally-rigid like the pipe for which it serves as a repair. The Fibrwrap system would be installed on the inside of each of the existing 48-inch diameter pipelines – extending from just upstream of the corroded section to just downstream of the corroded section – on the adjacent newer-vintage steel pipe.

A dry work area is necessary for the fibrwrap installation and would be provided by installing two inflatable plugs upstream of the work area and two similar plugs downstream of the work area. The work area for each pipe would be accessible via the single 24-inch-diameter access manway in the chlorine room of the Screen House. Isolating the work area with the inflatable plugs would allow each, single pipeline to remain out of service, as long as necessary to complete the fibrwrap installation, while the other two pipelines remain in service. The existing static mixers in each of the two municipal drinking water supply pipelines would need to be cut up in the wet by divers and extracted from the pipes via the Screen House wet well to enable developing subsequent access to the work area in a dry, isolated condition.

The process of installing Fibrwrap in each of the three pipelines would involve iterative steps of placing and removing inflatable plugs and cutting out the existing static mixers. The Fibrwrap installation would need to be installed sequentially – requiring approximately one week for each of the three pipe installations and one week between each installation. The total duration of the Fibrwrap installation should be expected to be six to eight weeks with multiple short disruptions to supply operations.

A copy of a quote/proposal from Fibrwrap to undertake the installation described herein is presented in Appendix C.

## 4. Evaluation of Alternatives

The mitigation alternatives were evaluated qualitatively with respect to the two general categories of alternatives, Weko-Seal alternatives and Fibrwrap alternatives as well as each of the “sub-alternatives” relating to the external mitigation approach. The two general categories, which relate to the internal pipe mitigation approach, were evaluated separately from the external mitigation approaches. The primary reason for this is that there is a larger cost impact associated with these internal improvements and because the external improvements are the same for the Weko-Seal and the Fibrwrap alternatives.

### 4.1. Comparison of Weko-Seal and Fibrwrap Mitigation Approaches

Weko-Seal™ and Fibrwrap are both valid and feasible improvement approaches that can extend the useful life of the pipes into which they are installed. As is understood to be part of the City’s main objective, these improvement approaches should be considered temporary – not permanent. The main differences between the Weko-Seal™ and Fibrwrap improvements are as follows:

- Weko-Seal™ provide leakage protection but do not provide additional structural support. Weko-Seal™ requires that the existing, corroded pipe remain mostly intact. Fibrwrap provides both leakage protection and structural support and does not rely on the permanence of the existing, corroded pipe. By implementing a Fibrwrap mitigation approach, it would be less critical to address continued external corrosion or provide additional structural support for the pipes.
- Weko-Seal™ is easier and less-costly to install than Fibrwrap. Fibrwrap requires the interior pipe be cleaned to a bare white metal condition to ensure an integral leak-tight and structural connection between the fibrwrap and the existing pipe wall. Weko-Seal™ requires a relatively clean and smooth interior surface but bare metal is not necessary. As a result, the potential for damaging the existing pipe is less for a Weko-Seal™ installation.
- Weko-Seal™ can be installed in a submerged, wet condition, or in a dry condition. However, Fibrwrap requires a completely dry condition for installation. The cost of enabling dry installation is substantial because of what is necessary to isolate the work area. Also, the impacts to the City’s water supply operations are far greater if creating dry conditions are required. The two existing static mixers would need to be cut out of the two municipal supply pipelines in preparation of preparing a dry condition because they are located between the access manway in the chlorine injection room and the repair area within the pipes.
- Wet installation of Weko-Seal™ can be done essentially in one continual process over the course of one to two weeks with diver-installation work commencing during the day while supply service is temporarily disrupted. Supply to the water treatment plant would commence each evening after completion of the diving work. This work would be undertaken during the low-demand winter seasons to minimize impacts to meeting customer demand. Dry installation of Weko-Seals or Fibrwrap requires completing

installation on one pipe at a time, which includes associated installation and removal of inflatable plugs. As stated above, this essentially extends the project to about 6 to 8 weeks with multiple steps and plant shutdowns to cut and extract the static mixers, install inflatable plugs, dry the work area, work in the dry, remove inflatable plugs, move to the next pipe, etc. This extended process would have cost impacts to divers as well as the installation contractor for the Fibrwrap and Weko-Seals.

- The main disadvantage of installing Weko-Seal™ – particularly in a submerged condition is the possibility of not being able to achieve the water-tight seal at each end because a sufficiently-smooth inner pipeline wall surface cannot be achieved. Related to this same disadvantage is the potential to damage the existing pipe from the inside by removal of corrosion product. If damage were to occur while the pipe is filled with water, it would create an unsafe condition and result in extended disruption of supply. The greatest concern related to this aspect is the larger corrosion deposits near the existing chlorine injection pipe. Much of this corrosion product would need to be removed to cut off the injection pipe flush with the sidewall of the pipe to enable installation of Weko-Seal™.

Estimated installation costs for the Weko-Seal™ and Fibrwrap (not including professional engineering services) are presented in Table 2.

**TABLE 2**  
Estimated Costs For Internal Mitigation Approach

Cost Element	Weko-Seal™ (wet)	Weko-Seal™ (dry)	Fibrwrap
Weko-Seal™ install (wet)	\$50,000	--	--
Inflatable plug install	--	\$50,000	\$50,000
Divers extract Static Mixers	--	\$50,000	\$50,000
Weko-Seal™ (dry)	--	\$100,000	--
Fibrwrap Installation	--	--	\$240,000
30% Contingency	\$15,000	\$60,000	\$41,000
<b>Internal Installation Subtotal</b>	<b>\$65,000</b>	<b>\$260,000</b>	<b>\$381,000</b>

## 4.2. Comparison of External Mitigation Approaches

A comparison of the advantages and disadvantages of each of the external mitigation approaches is presented Table 3.

For the purpose of comparing the external mitigation approaches, it is assumed that pursuit of installing Weko-Seal™ in the submerged, wet condition is preferred and will be the selected internal mitigation approach. This represents a good starting point – given the far lower cost for this internal mitigation approach. This assumption enables comparison of the external mitigation approaches on an equal basis. Another way to view comparison of the external mitigation approaches is to assume that no internal mitigation approach is pursued (a higher-risk; lower-cost approach) after implementation of the external mitigation approach. Also, it is understood that if the more-costly Fibrwrap internal mitigation approach were to be pursued first, issues related to potential pipe damage from

implementation of an external mitigation approach become less of a concern, and an external mitigation approach may not be necessary.

Of the external mitigation approaches, concrete encasement affords the greatest benefit while avoiding a key risk element of damaging the pipe during cleaning/brushing that would be necessary for a mortar coating or paint approach. Concrete encasement does not require any surface preparation of the existing pipe – even though it would be preferable to remove the larger, delaminated corrosion product. The risk of potential damage to the pipe from cleaning and surface preparation is substantial and despite the presence of an internal Weko-Seal™, could result in extended supply disruption while a structural repair to the pipe is implemented.

An important element of the concrete encasement approach is the hydrophilic sealant that would be applied around the perimeter of each pipe at the east wall. This location is the primary leakage path location in the event of a future pipe leak within the encased pipe area. The sealant could be expected to obstruct most leakage, but may not obstruct larger leakage resulting from a pipe rupture at the interface between the wall and the concrete encasement. Catalogue information for the hydrophilic waterstop sealant is presented in Appendix D.

As stated above, if a Fibrwrap mitigation approach were selected, additional consideration of the other sub-alternatives, besides concrete encasement, would be warranted. The reason for this is that damaging the existing corroded pipe would, in theory, be irrelevant given the new, interior Fibrwrap structural pipe.

Minimal effort was expended on developing estimated costs for the external mitigation approaches (other than concrete encasement) because they are low in relation to the internal mitigation approaches. Additionally, the cost of the external mitigation approaches likely will not be a key factor in the selecting an approach for implementation because the anticipated performance of each of the four approaches vary substantially.

Clearly, the cost of the “nothing” external mitigation approach is \$0. The concrete encasement approach was estimated to be \$30,000 – not including design and construction over-sight costs, which could add another \$15,000. Therefore, the City should plan for approximately \$45,000 to implement the concrete encasement mitigation approach. No estimate of the mortar coating approach was developed, but it should be assumed to be less than the concrete encasement approach. The painting approach would be even less costly to implement than the mortar coating approach.

## 5. Low-Cost Mitigation Approach

A low-cost mitigation approach to extend the useful life of the three existing corroded pipelines and the Screen House facility is to install the external concrete encasement first and the internal Weko-Seal™ (submerged condition) second. This approach includes the risk that installation of the concrete encasement results in settlement that cracks one or more of the existing pipes, resulting in leakage, and/or installation of Weko-Seal™ is not successful or results in additional damage to the pipeline and additional leakage. Successful installation of Weko-Seal™ would mitigate leakage created by concrete encasement

**TABLE 3**  
Comparison of External Mitigation Approaches

<b>External Mitigation</b>	<b>Advantages</b>	<b>Disadvantages</b>
Nothing	Minimizes external interaction with weakened, corroded pipe and therefore potential damage.	External corrosion will continue, which could increase the risk of pipe wall cracking that could produce leakage and/or catastrophic failure in the event of an earthquake.
Mortar Coating	Provides corrosion protection with less added weight than concrete encasement. Added concrete pipe support would mitigate any impact associated with added cement mortar.	Requires exterior surface prep, which could potentially damage the existing pipe. Mortar coating needs to be monitored closely and will need to be re-applied in 1 to 5 years because the mortar coating may not be sufficient to stop external corrosion process.
Paint	No added weight to pipes and facility structure.	Requires exterior surface prep, which could potentially damage the existing pipe. The system may not be effective and should be monitored monthly. Annual re-application may be necessary.
Concrete Encasement	Will inhibit additional corrosion and provides additional support and confinement for pipes in the event of earthquake. To some degree, would provide a secondary, concrete pipe that would be limited in performance. Minimal surface prep of each pipe is necessary - avoiding damage to pipe.	Encasement would eliminate future external access to the pipes at the repair location. Also, additional weight is applied to the facility structure, which could potentially result in settlement that could induce pipe wall cracking.

settlement damage, but if the Weko-Seal™ cannot be successfully installed, additional corrective measures would need to be pursued.

Installation of Weko-Seal™ prior to installation of concrete encasement could be considered; however, if cleaning and surface preparation of the pipeline results in damage and leakage, it would not be possible to implement concrete encasement. In this case supply would be disrupted either partially or entirely until a repair could be implemented. The advantage of successful installation of Weko-Seal™ is that it reduces risks associated with subsequent implementation of an external mitigation approach. With the successful implementation of the internal Weko-Seal™ mitigation approach, external mitigation other than concrete encasement may warrant greater consideration.

Should the City select implementation of concrete encasement prior to installation of Weko-Seal™, it should purchase the Weko-Seal installation materials and equipment and have them on hand during implementation of concrete encasement. The divers installing the Weko-Seal™ would need to be on site or available for immediate installation of the Weko-Seals™.

It should also be noted that upon successful installation of concrete encasement, the City could consider avoidance of Weko-Seal installation to avoid the potential damage associated with Weko-Seal™ installation. In doing so, the City would keep the Weko-Seal™ materials and equipment available for subsequent installation in the event a future leak develops. This approach would defer initial risk associated with Weko-Seal™ installation to a later time when Weko-Seal™ could prevent potential future leakage from occurring.

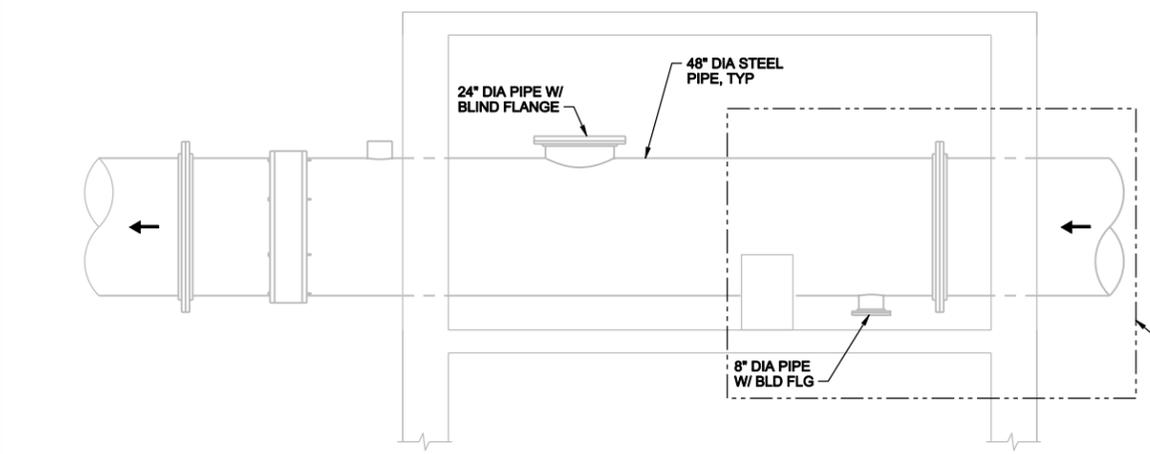
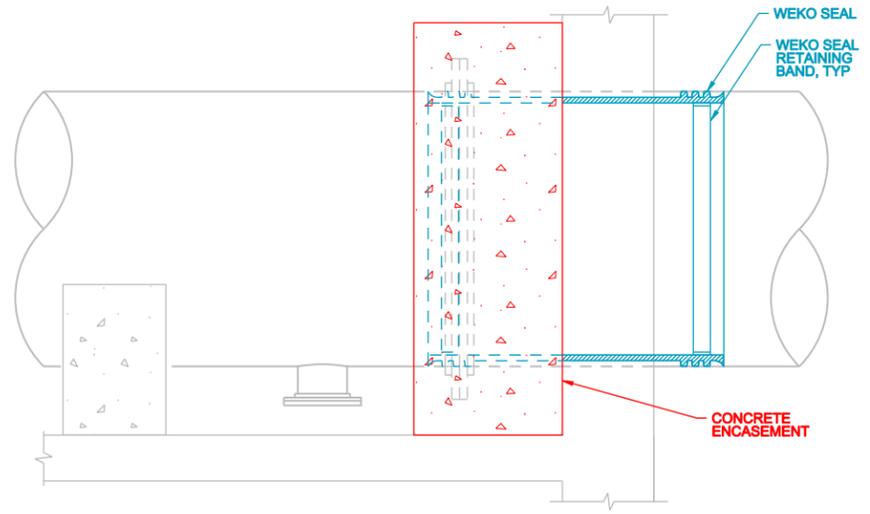
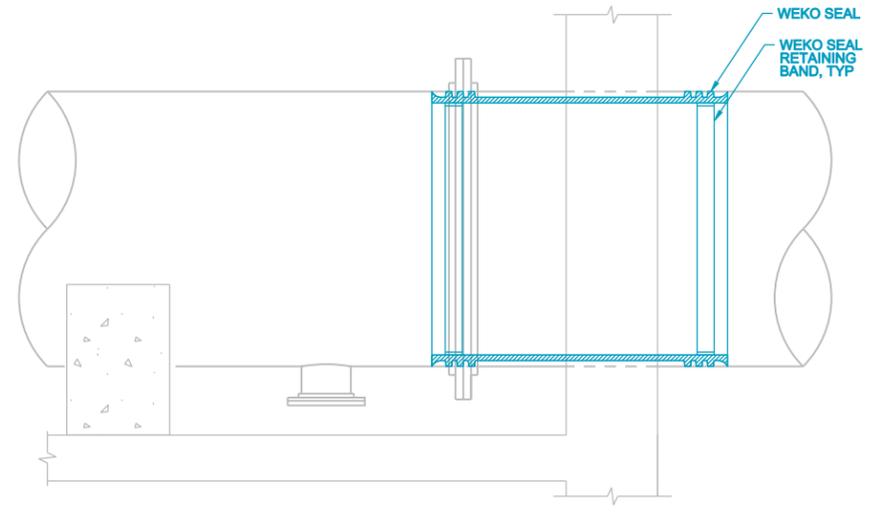
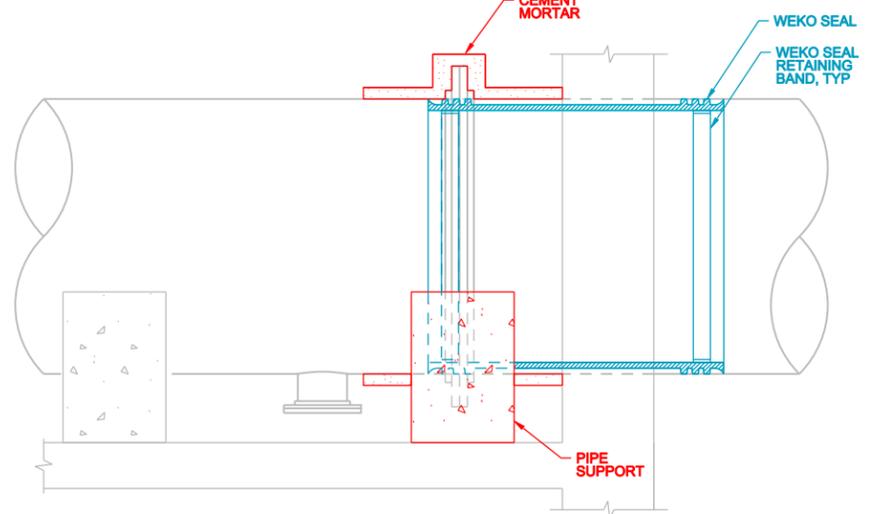
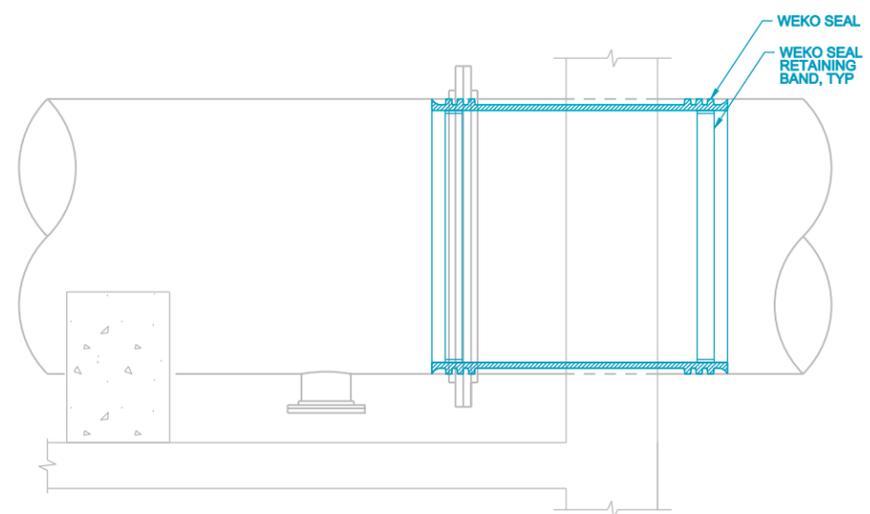
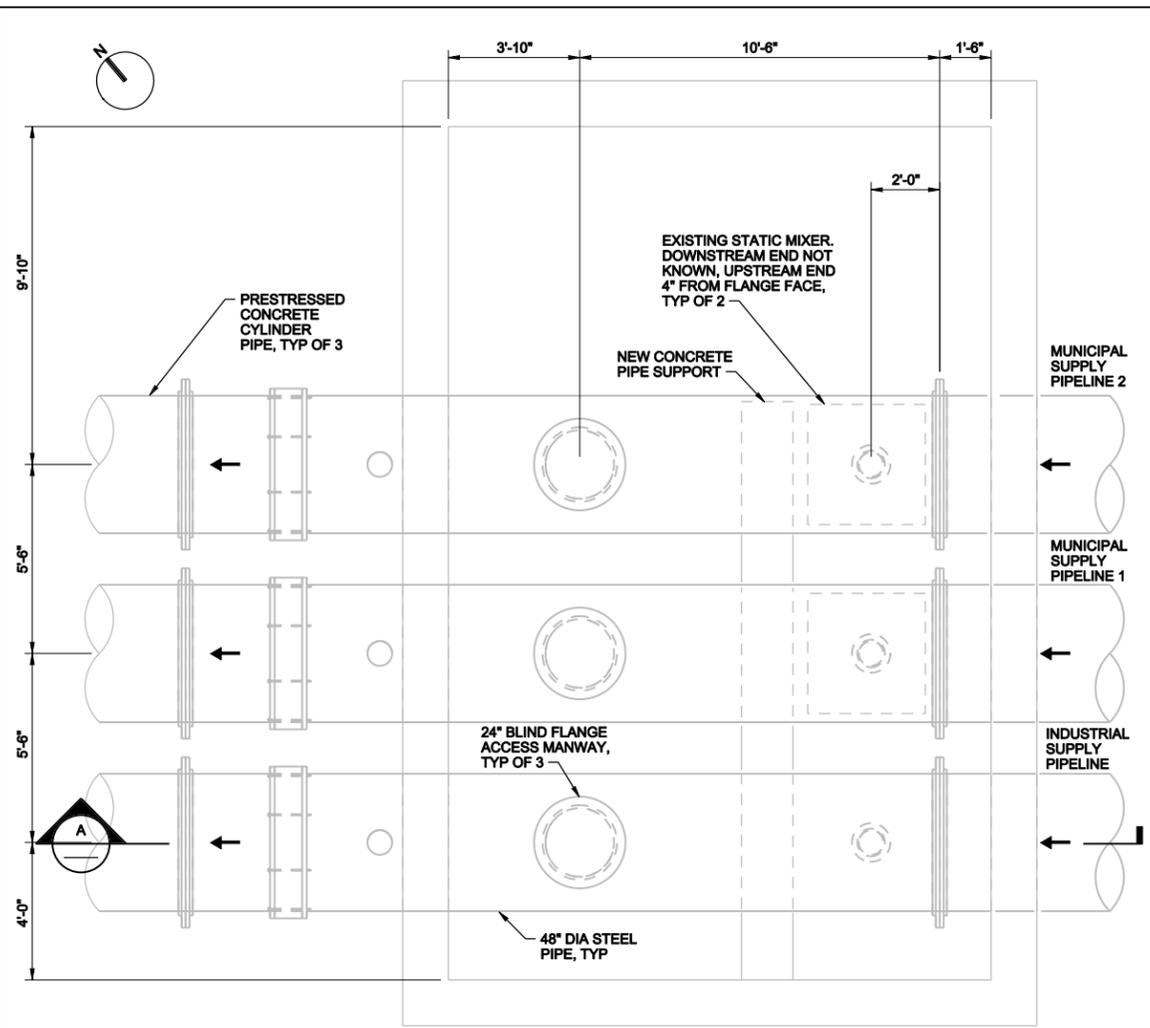
In the event that either concrete encasement and/or Weko-Seal™ installation results in leakage that cannot be addressed by either of these two mitigation approaches (a possible outcome), the City could consider the installation of inflatable plugs to isolate the leaking pipe sections and effect a repair that could involve welding repair plates, installation of fibwrap, dry-installation of Weko-Seal™, or potentially other solution. Implementing these other alternatives would be challenging and very disruptive to maintaining uninterrupted supply to the City.

The City must carefully assess the level of risk it is willing to accept in implement the low-cost mitigation approach developed herein before pursuit of this strategy. As part of that assessment, the City may wish to more fully develop a back-up mitigation strategy that could be implemented quickly in the event that Weko-Seal™ and/or concrete encasement result in a leakage condition that warrants immediate correction.

## Figures

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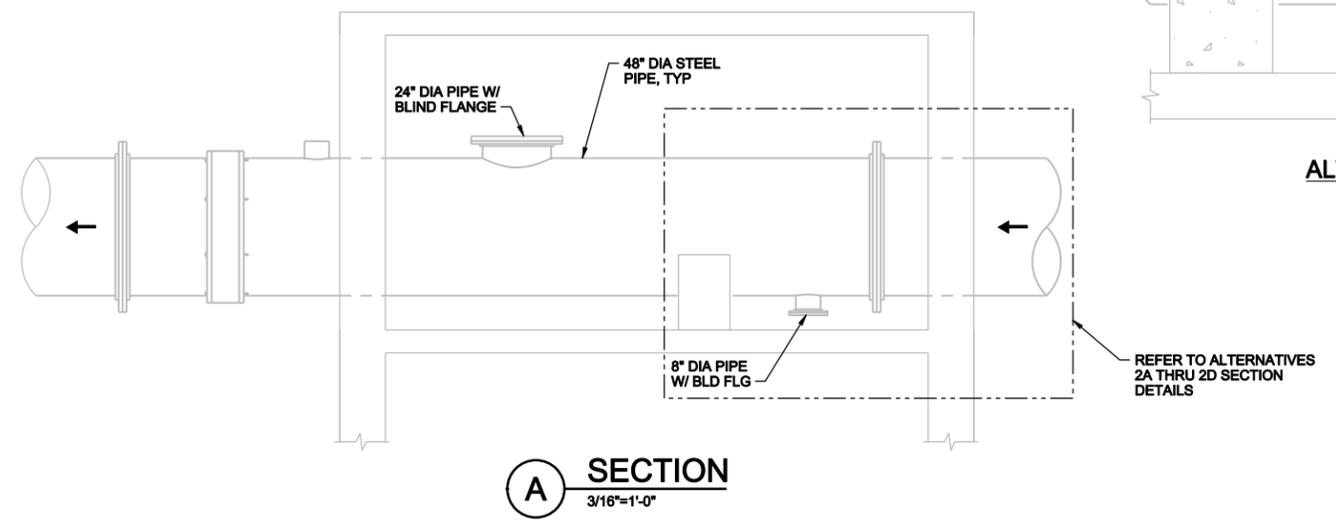
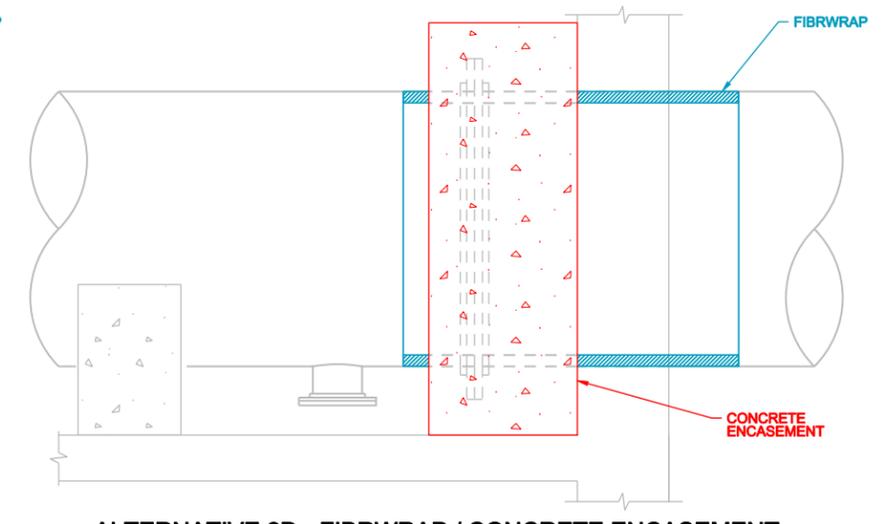
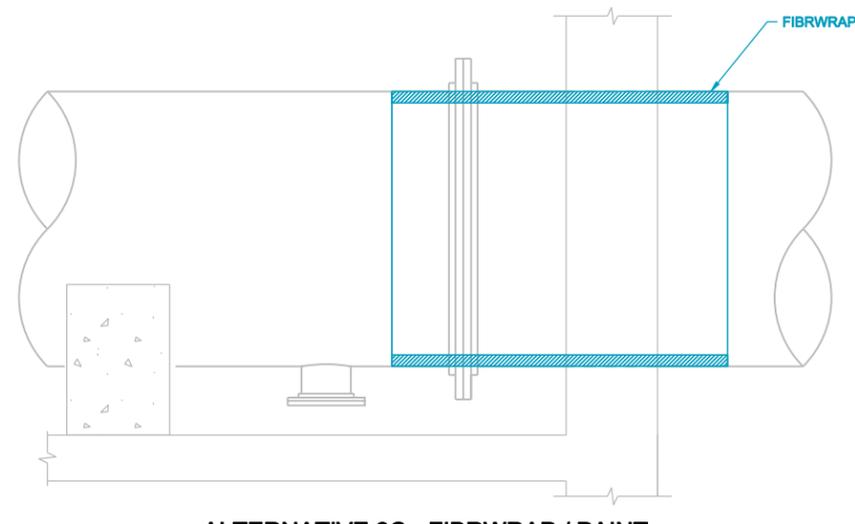
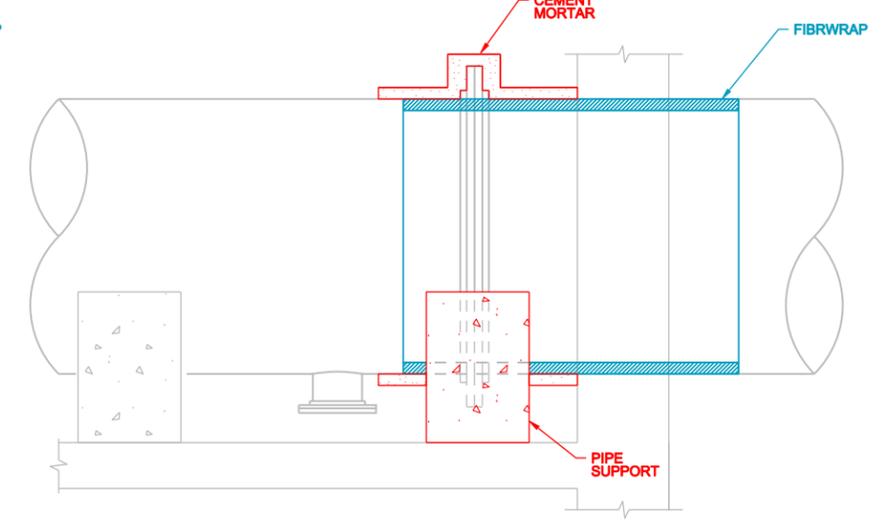
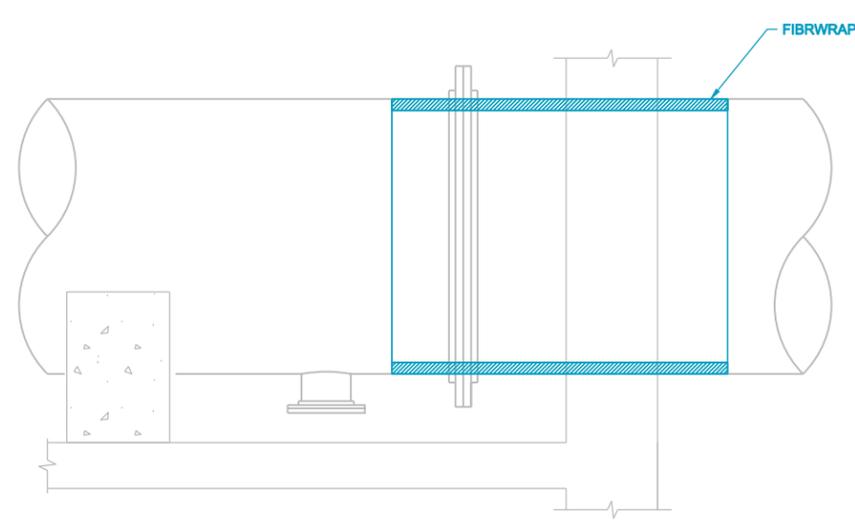
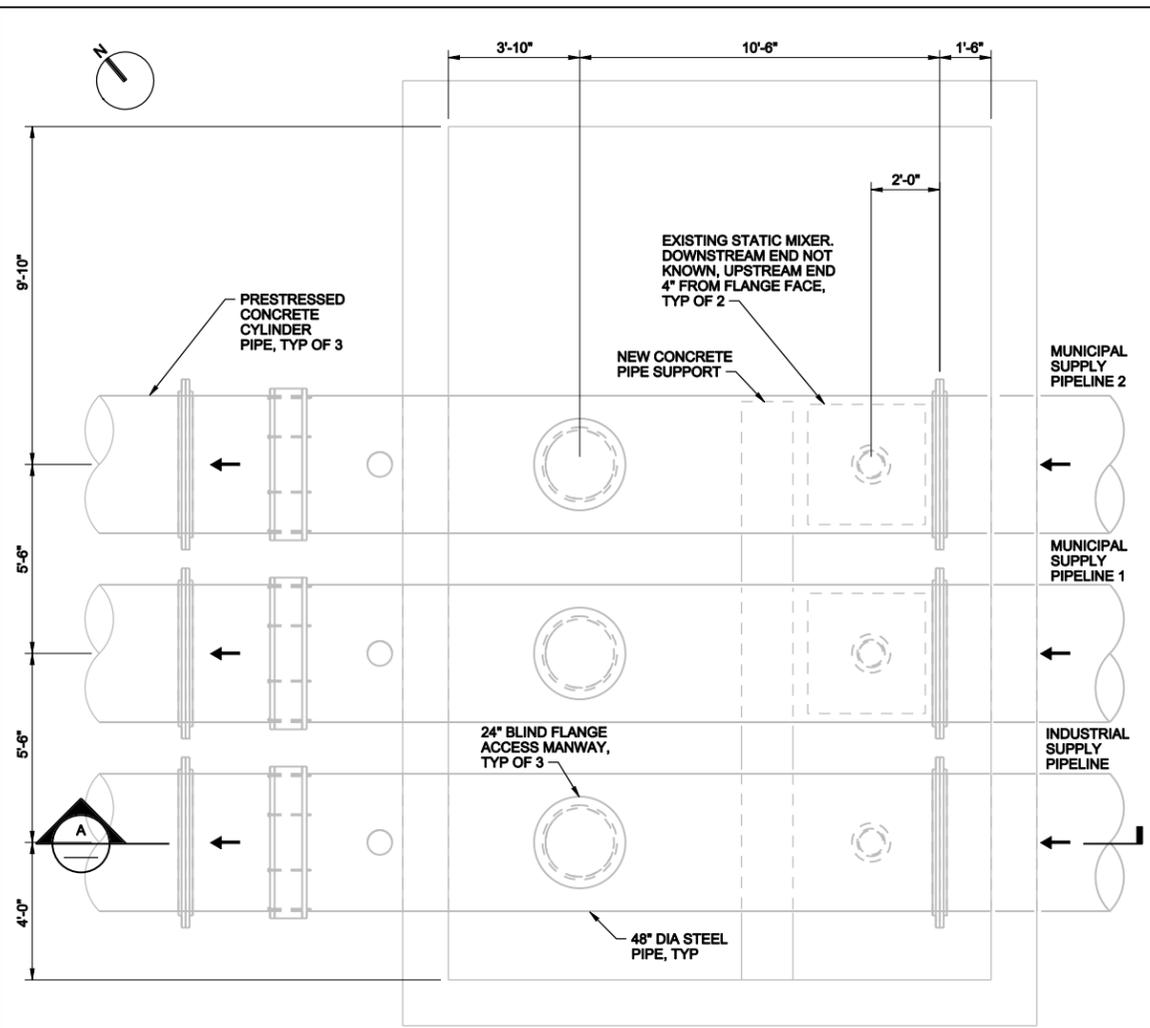




REFER TO ALTERNATIVES 1A THRU 1D SECTION DETAILS

**FIGURE 1 - WEKO SEAL ALTERNATIVES**  
EVALUATION OF ALTERNATIVES FOR CORRODED PIPE AT SCREENHOUSE CITY OF BELLINGHAM





**FIGURE 2 - FIBRWRAP ALTERNATIVES**  
EVALUATION OF ALTERNATIVES FOR CORRODED PIPE AT SCREENHOUSE CITY OF BELLINGHAM



**Photos**

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Photo 1. Interface Between Older and New Pipes

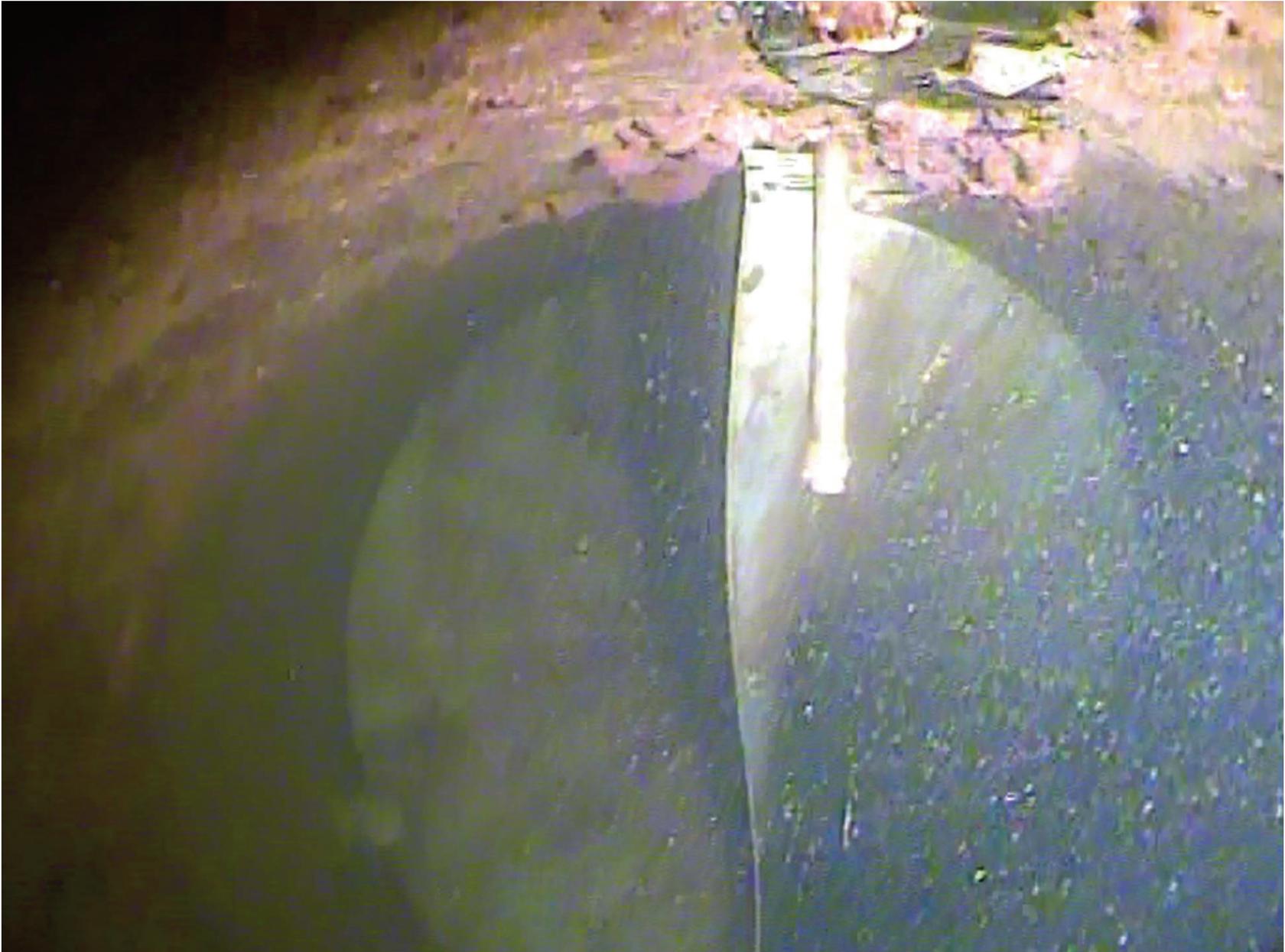


Photo 2. Static Mixer and Chlorine Injection Pipe

**Appendix A**  
**Black and Veatch Report**

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FINAL

# EVALUATION OF SCREEN HOUSE CORRODED PIPING MITIGATION OPTIONS

B&V PROJECT NO. 176749



EXPIRES: 8-24-2012

Lawrence M. Magura, P.E.

Project Manager

PREPARED FOR

City of Bellingham, WA

12 JUNE 2012





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## 1.0 Introduction

The City of Bellingham executed Contract No. 2012-0309 with Black & Veatch Corporation on April 23, 2012 to conduct an assessment of a severely corroded pipe condition inside the Screen House that conveys water from Whatcom Lake to the City's Whatcom Falls Water Treatment Plant. The plant was originally constructed in 1968 and has a maximum hydraulic capacity of approximately 29 million gallons per day (MGD). Various upgrades to the plant have been made over the years, including replacement of piping from the Screen House to the plant in 1979-81. The plant treats water by a combination of coagulation and filtration through granular media filters.

The Screen House was constructed around 1940 at the end of the Whatcom Lake diversion tunnel, and was originally designed to serve the dual function of being the facility that housed a traveling screen to remove suspended material from the raw water diverted from Whatcom Lake prior to it entering the municipal water distribution system, and to also provide a point where chlorine was injected into the water to provide disinfection. The form of chlorine used for disinfection and how it was originally stored at the Screen House cannot be determined from available construction drawings for the Screen House dated January 1940 that were provided by the City as part of this review. Prior to the construction of the water treatment plant in 1968, no other treatment was provided beyond screening and disinfection by injection on chlorine at the Screen House. Although chlorine is still injected into the water at the Screen House, at some point in the past, storage of chlorine was moved from the Screen House to the water treatment plant, and a chlorine supply pipeline from the water treatment plant back to the Screen House was constructed.

Significant changes to the operation of the water treatment plant and the Screen House facility occurred in the period 1979-1981, when piping from the Screen House to the treatment plant and from the Screen House and Treatment plant to Woburn Street was replaced. As part of this project, significant changes to the piping inside the Screen House were also made. Construction drawings provided by the City show that the three 48-inch pipes running through what was originally known as the Chlorine House, which is the downstream section of the Screen House, were replaced with new steel pipe of the same diameter beginning at a flange located about 18 inches past the northeast wall of the Chlorine House through to the outside of the building. An existing venturi and flow meter on the middle pipe was also removed from the Chlorine House at this time, and fixed-vane in-line static mixers were welded into the new pipes. The new steel pipe sections terminate a few feet past the outer face of the Northwest wall of the Chlorine House foundation, where they tie into three 48-inch diameter prestressed concrete cylinder pipes (PCCP) (also part of the 1979-1981 improvements) which serve the water treatment plant and the industrial water supply pipeline, which bypasses the treatment plant. Two of the three 48-inch PCCP pipes merge into a single 66-inch PCCP pipe approximately 100 feet downstream of the Screen House, which then supplies water to the water treatment plant.



## 2.0 Observations from April 26, 2012 Site Visit to the Screen House

On April 26, 2012, Lawrence Magura, P.E., of the Portland regional office of Black & Veatch made a visit to the Bellingham Screen House facility with representatives of the City of Bellingham. The purpose of the visit was to observe firsthand the corrosion problem reported by City staff at the Screen House.

Upon entering the Screen House, the short sections of each of the three original (1940 vintage) 48-inch diameter steel pipes that enter the northeastern wall of the Chlorine House portion of the Screen House were observed to exhibit an extreme amount of localized exterior corrosion between the northeastern foundation wall of the building and a flange located about 18 inches from the wall. At the flange, new piping from the 1979-1981 improvements to the facility continues on through the building, exiting through the northwestern wall. None of the pipe wall penetrations appear to be in sleeves or wall pipes. The concrete walls were apparently simply cast around the pipes. No obvious corrosion damage to the exterior of the newer (1979-81 vintage) piping could be observed. Full circumferential corrosion damage was observed on the exposed section of all three of the 1940-vintage pipe sections, with the most severe corrosion evident on the bottom portion of each of the pipes. The condition of the pipe behind the interior face of the northeastern foundation wall is unknown, but it seems unlikely that the intense corrosion attack simply terminates at the wall face. Figures 1, 2 and 3 show the extent of the corrosion problem that is visible within the building on Pipe 1, the most accessible of the three pipes. Pipes 2 and 3 appear to have suffered a very similar degree of corrosion-induced deterioration.

Prior to making the site visit, Mr. Magura reviewed the April 25, 2012 report prepared by Norton Corrosion Limited, which presents the results of a series of wall thickness tests they recently performed on the subject pipes at the request of the City. A copy of the Norton Report is appended to this report as Appendix A. The Norton report noted that the pipes in question had an original nominal wall thickness of 0.300 inches, and that this has been reduced to 0.150 inches by corrosion at the most seriously-corroded areas on the sides and top of the pipe and to a greater degree at the bottom of the pipe. If these measurements are correct, the pipes have lost 50% of their wall thickness on the sides and top of the pipe to corrosion. The Norton report also notes that even more metal loss (possibly up to 75% of the barrel thickness) has probably occurred at the bottom of the pipes.

Since no significant corrosion on the pipes was noted on the construction drawings prepared by STRAAM Engineers, Inc. for the 1979-81 piping improvements, it seems logical therefore that the corrosion problem started sometime after the improvements were completed in 1981. We concur with the Norton report's comment that there may be multiple factors that have been in play for years that have contributed to the corrosion

problem. These factors could include long-term chlorine leakage, lack of adequate maintenance, and flaws in the original design and construction of the facility.



**Figure 1 - View of bottom of Pipe 1 at the Flange Showing Extensive Corrosion and Delamination of the Pipe Barrel**



**Figure 2 - Accumulation of Corrosion Scale and Corrosion by Products on the Floor Below Pipe 1**



**Figure 3 - Crown of Pipe 1 Shows Some Evidence of Corrosion Near Contact with the Chlorine House Foundation Wall**

Based on the statements made in the Norton Corrosion Limited report, and the observations made during the April 26th site visit, the corroded pipes appear to be in a very fragile condition and should be repaired or replaced as soon as possible. Given the observed advanced state of deterioration, removal of delaminated steel pipe corrosion byproduct scale from the pipe barrels is not recommended, since corrosion may have already nearly eaten through the pipe barrel in some places and the simple act of attempting to clean the pipes may precipitate a failure. Assessing the full extent and criticality of this corrosion problem is difficult to quantify, because the potential full extent of the problem is not exposed and available for observation and inspection, since a portion of the pipe is buried behind the building wall. It is possible that, due to accumulated stresses, the section of pipe passing through the southeast basement wall may be in as bad or worse condition than the exposed section in the Chlorine House. Due to their close proximity, the failure of one pipe could precipitate a cascading failure of one or both of the other pipes as well, which would greatly interfere with the ability to deliver water to the water treatment plant and to the Industrial water supply pipeline.



### 3.0 Discussion of Potential Repair Methodologies

Several different methodologies could be considered for repairing the corroded pipes, which are briefly described below. The options described include the following:

- Do Nothing
- Concrete encasement
- Carbon Fiber Reinforced Polymer Repair
- Cured in Place Liner
- Fold and Form Pipe
- Sliplining
- Install Permanent Bypass Piping

#### 3.1 DO NOTHING

Under this alternative, no attempts to repair or stabilize the corroded pipes would be made, and eventually one or more of the pipes will fail. Failure could be precipitated by the continuation of the on-going corrosion problem, or from a minor earthquake that the weakened pipes are no longer capable of resisting. Since all three pipes are in an approximately equally weakened condition, they are all more or less equally vulnerable to an earthquake-induced failure. Due to their close proximity, the failure of one pipe may cause the failure of one or both of the other pipes. The failure of one or more of the pipes will seriously impact the ability of the system to continue to deliver water to the water treatment plant and the industrial supply pipeline. Because of its potential for serious adverse impacts on the City's water system, the do nothing option is not recommended.

#### 3.2 CONCRETE ENCASEMENT

Under this option, the entire pipe gallery section that is exposed in the Chlorine House basement level would be encased in a monolithic block of reinforced concrete to provide support for the corrosion-weakened pipes. No temporary service shutdowns would be required for this alternative. While this approach would certainly provide support around each of the three pipes, it would do very little to solve the corrosion problem or prevent significant leakage from developing at the interface of the pipes with the northeastern wall of the Chlorine House basement when the pipes do eventually experience a corrosion-induced failure. The only way to provide a tight seal at the wall interface would be to remove a ring of the concrete wall from around the immediate circumference of each pipe to create a receiving/bonding pocket for new concrete around the most likely point of failure. Since this activity would inevitably require some inadvertent direct contact by power tools with the pipe wall, it is unlikely that this operation could be performed without further damaging or actually precipitating a failure of the corrosion-weakened pipes. As an alternative, sandblasting the area with a heavy grit might sufficiently pit the concrete

around the pipe (assuming the pipe is protected from the sandblasting operation with a protective wrap) and then applying a bonding agent to allow for reasonable bonding between the old and new concrete could also be considered.

Before any further serious consideration is given to this option, a structural evaluation should be performed to determine if the building floor and foundation can withstand the additional dead load of the concrete. The condition of the pipes inside the basement wall is unknown at this time, but some significant corrosion of the pipes is likely to exist inside at least a portion of the wall. Also, it would be necessary to drill in reinforcing steel dowels into the floor beneath the pipes as part of the formation of the reinforced concrete block. This action will create a significant amount of vibration, which could also precipitate a failure of the corrosion-weakened pipes. Since this option contains several risks of precipitating a pipe failure during the installation phase, and is unlikely to provide a long-term water-tight seal, it is not recommended for further consideration.

An alternative that could be considered an interim measure until more permanent repairs can be accomplished would be to cast concrete saddle supports under each pipe to help relieve the dead weight of the water-filled pipes. If this interim measure is adopted, the saddle supports should engage about one-quarter (90°) of the each pipe barrel. Two supports per pipe should be constructed. Obviously, great care would need to be used in forming up the supports so that the pipes are not inadvertently damaged, which could precipitate a failure.

### **3.3 CARBON FIBER-REINFORCED POLYMER REPAIR ALTERNATIVE**

Carbon fiber-reinforced polymers (CFRP) have been used to structurally rehabilitate steel pipe for several years. The CFRP composite is used to strengthen the pipe by providing additional tensile strength to the pipe wall by bonding the CFRP composite to the steel pipe, thus supplementing the strength of the existing material. CFRPs consist of thousands of high-tensile strength carbon filament fibers combined with an epoxy resin matrix, the polymer component. The epoxy resin matrix serves as a load path between each fiber filament, making the composite pliable and also protecting the carbon fiber. This “fabric” provides a method to rehabilitate segments of the pipe that are damaged. The design of the rehabilitation normally includes building up multiple layers of the fabric to achieve the desired structural strength.

The basic process for installation of CFRP is as follows:

1. Assess condition of existing pipe to determine bonding capability and access.
2. Determine safety plans to provide monitoring of confined space, ensure emergency plans are developed, set up ventilation and dehumidification systems.
3. Prepare the surface by removing remaining lining or coating, corrosion, or scale.

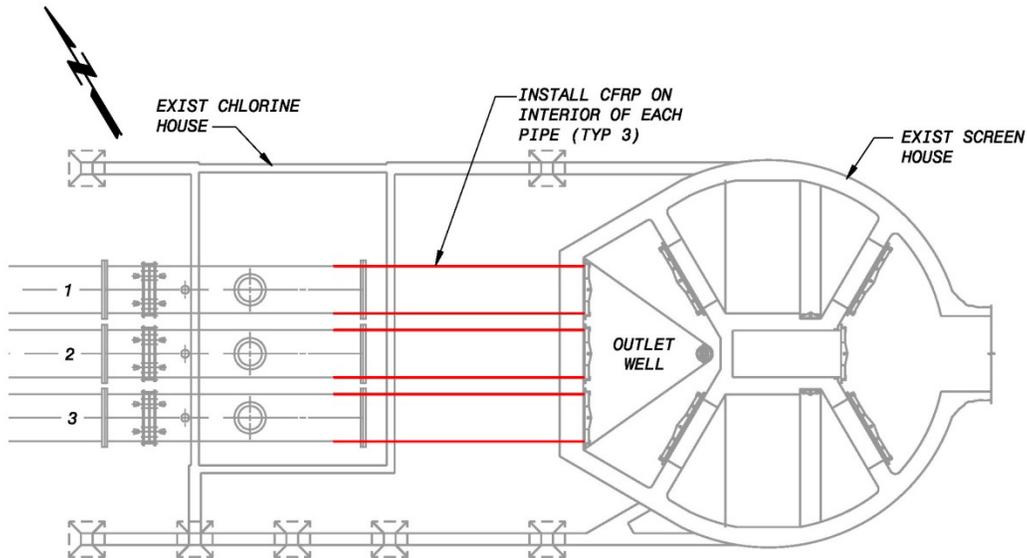
4. After the surface is prepared and dried, any additional required repairs to the pipe, such as plugging corporation stops, holes or welding holes, are completed.
5. The surface that is to be reinforced with the CFRP is then primed for application of the composite.
6. The epoxy resins are mixed and the fiber is saturated on site with specially designed equipment. The composite must be applied within 3 hours.
7. The saturated rolls of composite are hand-applied to the pipe wall. The composites are applied circumferentially for hoop strength and longitudinally for bending strength.
8. A final epoxy top coat is applied to protect the composite layers.

Based on the condition of the pipe and the lack of competent pipe on either side for the carbon fiber to anchor onto, an externally applied carbon fiber system could leak at the edges of the repair as the pipe continues to degrade. Therefore, only the use of an internally applied carbon fiber system appears to be feasible. The proposed approach would be to line from the screen house past the flanges and connect to the newer pipe as shown in Figure 4. Access to each pipe could be provided by the existing access ports on the top side of each of the 1981-vintage sections of pipe.

A preliminary cost estimate for accomplishing and internal repair was requested from FIBRWRAP®, an Ontario, California-based company that supplies these services. This cost estimate appears as Appendix B to this report. Please note that the estimate should be regarded as preliminary only, and does not include any contingencies such as installation of temporary bulkheads in the Screen House outlet well, or the services to be provided by Black & Veatch, or some other qualified engineering firm serving as the owner's authorized representative for the project. Additional facts and information applicable to this type of repair are the following:

- In order to allow for bonding of the fiber wrap system to competent material on both sides of the repair area, internal strengthening of this pipeline versus external strengthening would be recommended for this application. An external strengthening would not allow the fiber wrap system to be connected to competent material on both sides of the fiber wrap repair zone, thereby risking leakage at both ends of the fiber wrapped repair area. The internal segment of the pipe from the Screen House to the Chlorination House could be lined to provide the required repair if access is available.
- A shutdown window of 24 hours is not adequate for dewatering and drying out the interior of the pipe, interior surface preparation, application of the CFRP system and curing of the material. A longer pipeline shutdown window would be needed in order to complete this project using the application of a fiber wrap

system. The work could be done in phases to each of the pipes during separate outages to allow the water treatment plant to refill the City's storage reservoirs.



**Figure 4 - Possible Repairs Utilizing CFRP**

- Prior to commencing work in a pipe, it will be necessary install a temporary pneumatic plug in the pipe downstream of the work area, to ensure that water from the other pipes, which are inter connected, doesn't backflood the work area.
- Surface preparation of the interior of each pipe would be necessary before application of the CFRP. Surface preparation of the steel pipe would involve removal of any remaining liner material, rust and corrosion on the pipe surface and exposing bare metal prior to application of the fiber wrap system. This work would require completely dry working conditions. In the event that closure of the existing slide gate valves on the Screen House outlet well end of each of the three pipes fail to provide a water-tight seal so that the pipes can be completely dried out, fabrication and installation of a temporary bulkhead cofferdam around the outlet well end of each pipe would allow each of the pipes to be taken out of service sequentially for installation and curing of the CFRP.
- When installation of the CFRP liner in the first pipe is completed it would be sealed using an inflatable plug to allow time for curing to complete and the distribution system to be re-supplied. Then the system would be sequentially taken out of service for each of the remaining two pipelines.

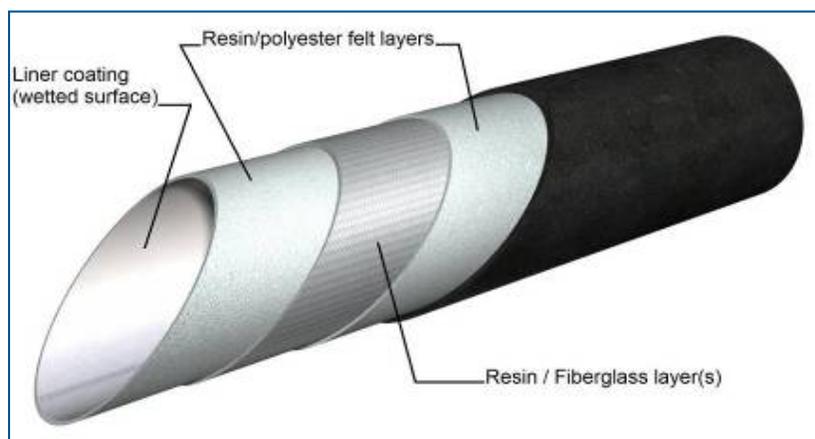
While CRFP offers some potential to provide a solution to this problem, given the complexities of this particular situation, it may not, in the final analysis, be the lowest cost

and most practical alternative. Further consideration of CFRP is therefore not recommended.

### 3.4 CURED-IN-PLACE PIPE

The cured-in-place pipe (CIPP) for pressure applications is a relatively new technology and there is not a long history for the product. There are two manufacturers of this product that we are aware of, Insituform and Norditube. This technology would require the work be completed in stages to allow for installation and curing. The installation of a temporary bulkhead in the Screen House wet well would allow the ends of each of the three pipes to be sequentially taken out of service, leaving the other two pipes in operation.

The Insituform and Norditube products are composite materials consisting of polyester fiber, fiberglass and a specially formulated epoxy resin system. A thin polyethylene layer on the inside surface increases the pipe's smoothness, reduces surface friction and provides an additional corrosion barrier for the pipe. The system can be designed as fully structural, Class IV system in accordance with ASTM F1216 guidelines. This system does not rely on the host pipe for any structural support.



**Figure 5 - Cured-in-Place Pipe Detail**

The system can be designed as a Class III system, which relies on the host pipe for some structural support. A diagram of a cured in place pipe retrofit is presented in Figure 5.

The cured-in-place system requires the host pipe to be cleaned and dry prior to installation. Each pipe segment would have to be out of service for the duration of the cleaning, installation and curing. Prior to cleaning a closed-circuit television (CCTV) inspection could be conducted to confirm the condition of the host pipe and ensure the pipe is clean and free of obstructions. The liner is installed by inverting the liner through the host pipe with water pressure and then curing it in place with heated water. After curing the pipe cools and the ends are cut and seals installed.

Prior to commencing work inside a pipe, it will be necessary install a temporary pneumatic plug in the pipe downstream of the work area, to ensure that water from the other pipes, which are inter connected, doesn't backflow the work area.

The installation of a cured in place liner would provide most of the required structural strength and protect the pipe from further corrosion. Installation of additional external pipe supports across the floor of the Chlorine House may be desirable as well, to avoid possible damage to the new liner when the pipes ultimately fail and become dead weight that the liner would otherwise be required to support alone. The cured in place liner has an improved flow characteristic and an increase in flow capacity resulting from the improved friction factor. The flow loss from the reduced diameter is recovered in the improved flow characteristics. Design of CIPP is determined by the normal working pressures and a factor for surge. These normal working pressures should be confirmed during design. The use of CIPP is considered to be potentially feasible for the rehabilitation of the pipes, although it is acknowledged that getting access to the pipes and dewatering them will be problematic and probably expensive to accomplish.

### **3.5 FOLD AND FORM PIPE**

This Insituform proprietary installation process is similar to cured in place pipe liner but uses a close fitting polyethylene pipe that is custom designed to match the existing conditions for the pipe to be rehabilitated. The pipe is fused together in the length required for the project and then held together by bands that are broken after installation into the host pipe, as shown in Figure 6. This process allows for any length of pipe to be used for installation. The ends of the pipe would be sealed with an end seal to provide a watertight connection. The polyethylene wall thickness is designed to meet the operating and surge conditions to provide the required strength to span openings. Any flow loss from the reduced diameter is usually recovered by the improved flow characteristics.

This method has the advantage that no time is required for curing the pipe. The work would still need to be conducted in phases to allow for the installation in each pipe separately, and it would require opening up holes in the walls of the Screen House to provide access for the folded pipe, and the removal of some trees from behind the Screen House to provide sufficient clear space to set up the equipment and laying out the pipe to be inserted. Once folded, the pipe becomes fairly rigid, and it is doubtful if sufficient clearance exists inside the Screen House

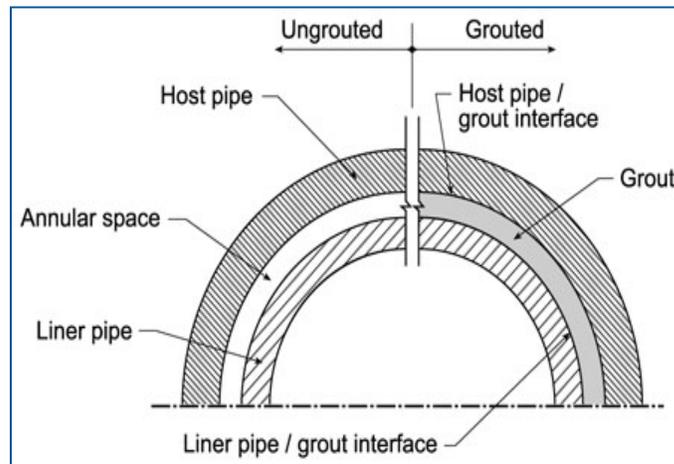


**Figure 6 - Rehabilitation with Insituform Polyfold Technology**

to allow for maneuvering the folded pipe into the host pipes for this concept to be employed. Consultation with a qualified contractor would be required before proceeding with this option to confirm that it is feasible.

### **3.6 SLIPLINING**

Slip-lining is the addition of a thermoplastic liner such as High Density Polyethylene Pipe (HDPE) applied directly into an existing pipeline, as shown in Figure 7. Typically the new pipe is thermally fused above ground to create one uninterrupted pipeline. This method can use any flexible thermoplastic liner. Generally the outside diameter of the new pipe is at least one size smaller than the inside diameter of the host pipe. The new pipe is either pushed through the pipeline from the inlet or, more typically, pulled through the existing pipeline from the outlet. Slip lining would significantly reduce the potential of leaks due to further corrosion and the gradual disintegration of the pipe. There would still be the potential of leaks from failure of the liner due to cracking or other concentrated stresses that can cause failure in these materials. The application of a sliplining solution to the Screen House corroded pipe situation is hampered by the lack of suitable access points at each end of the pipes to be sliplined for inserting and pulling the liner pipe. One access point would be required at each end of each of the three sections of pipe that would need to be slip lined. No adequate access at either end of the pipes exists at present, so if this alternative were to be implemented, it would first be necessary to develop the required access points, which would probably require partial demolition of portions of the walls of the Screen House.



**Figure 7 - Sliplining Diagram**

Due to the problems associated with developing the needed access for a sliplining solution, this alternative does not appear to be feasible for this application.

Another potentially fatal obstacle for any inside-the-pipe solution is the fact that the two 48-inch pipes that serve the water treatment plant currently have static mixers installed in them to ensure good mixing of chlorine. Unless it is decided to eliminate the mixers, all of these types of repair cannot be used because the interior of the pipe is obstructed by the mixers, which we understand are welded to the pipe wall.

### **3.7 INSTALL PERMANENT BYPASS PIPING**

Under this alternative, permanent bypass pipes would be installed around the northeastern and southwestern sides of the Chlorine House and connected to the existing 66-inch PCCP pipe that serves the water treatment plant and the 48-inch industrial water supply pipeline. The existing corroded pipes would be either removed or capped, filled with concrete, and abandoned in place. Figure 8 shows a schematic layout for this concept.

Available as-built drawings for the Screen House provided by the City do not show any trees in the immediate vicinity of the structure, however, during the site visit, and in subsequent discussions with City staff, it has become apparent that a significant number of large trees are in close proximity to the building, particularly on the northeast side. A revised configuration of the bypass concept shown in Figure 8 that would utilize only the south side of the Screen House, thereby minimizing impacts to trees, is also possible but was not developed as part of this report due to budgetary limitations. The trees may have grown up since the facility was originally constructed in 1940. Since the Screen House is located in a City park, tree removal will need to be coordinated carefully with the City Department of Parks & Recreation. This is likely to add time and may create additional public interest in the project.





City staff has indicated that shut downs of water deliveries to the treatment plant must be limited to no more than 24 hours duration so that the City's storage reservoirs, which will keep the system supplied during the outage, don't run dry. There may also be an issue regarding temporarily shutting down the industrial supply line, which is used to supply cooling water to a PSE power plant in town. We have learned from City staff that PSE's contract with the City for water includes a non-interruptible supply clause. At a minimum, PSE would need to be coordinated with in advance regarding temporary water service shut downs, which are a common feature of all of the repair and restoration alternatives discussed in this report.

If the service outages and the non-interruptible supply issues prove to be too difficult to resolve equitably, an alternative solution would be to install a temporary bypass pumping plant that would allow both lines (the water treatment plant 66-inch pipeline and the 48-inch industrial supply line) to remain in service while construction of the new permanent bypass lines proceeds without any outages.

If a temporary bypass pumping system is not utilized, this alternative would require a series of four fairly closely-spaced service outages, each not to exceed 24 hours in duration, and a sequence of activity as outlined below:

- During outage #1, a 66-inch isolation gate valve and thimble would be installed on the northeast wall of the Screen House outlet well.
- Between outage #1 and outage #2, approximately 148 linear feet of new 66-inch steel pipeline will be installed as shown in Figure 8 around the northeastern side of the Screen House, tested, and then connected to the wall thimble at the Screen House and the flexible coupling adaptor.
- During outage #2, a flexible coupling adaptor will be installed on the existing 66-inch diameter PCCP pipeline serving the water treatment plant at the approximate location shown in Figure 8, and the 66-inch diameter steel bypass pipe connected to it.
- During outage #3, a 48-inch isolation gate valve and thimble would be installed in the southwestern face of the Screen House outlet well.
- Between outages #3 and #4, approximately 97 linear feet of new 48-inch diameter steel pipe will be installed around the southwestern side of the Screen House, tested and connected to the Screen House 48-inch wall thimble installed during outage #3 as shown in Figure 8.
- During outage #4, a flexible coupling adaptor will be installed on the existing 48-inch diameter PCCP pipeline serving the industrial water supply pipeline and the new 48-inch diameter steel pipeline will be connected to it at the approximate location shown on Figure 8.

This alternative appears to be the most feasible and constructible permanent solution to the Screen House corroded pipe problem. A planning-level cost estimate for this alternative appears in Table 1, below.

**Table 1 - Planning Level Cost Estimate for Installation of Permanent Bypass Piping Around the Screen House**

ITEM	ESTIMATED COST
Install 48" slide gate and thimble	\$12,500
Install 66' slide gate and thimble	\$24,000
Concrete cutting for valve installations – 1 job	\$15,000
Excavate, install and connect approx. 97 linear feet of 48-inch, 0.25 inch wall steel pipe	\$125,000
Excavate, install and connect approx. 148 linear feet of 66-inch, 0.30 inch wall steel pipe	\$237,500
Cap and plug or demo and remove existing 48-inch corroded pipes from the Screen House – 1 job	\$15,000
Tap existing 42" drain pipe and install valve from new 48" bypass pipe	\$50,000
Sub Total	\$479,000
Construction Contingency @ 20%	\$95,800
<b>Estimate construction cost</b>	<b>\$574,800</b>
Project Design *	\$75,000
Construction Admin and precon services	\$45,000
<b>Total Project Cost</b>	<b>\$694,800</b>
*: includes estimated costs for locating, potholing and surveying all existing underground utilities in the vicinity of the project site as shown on Figure 8.	

## 4.0 Conclusions and Recommendations

- A. The degraded condition of the Screen House corroded pipes is a critical situation for which time is of the essence. Based on the corrosion evaluation performed by Norton Corrosion Limited, the three pipes in the basement of the Screen House are considered to be corroded and deteriorated to the point where they collectively have little or no remaining factor of safety. A sudden catastrophic failure of any one or all three of the pipes could therefore occur at any time, either from continuing weakening of the pipes by ongoing corrosion, a moderate earthquake, or from minor ground settlement in or near the Screen House. Such an event would have the potential to seriously impact or interfere with water service throughout the City. In consideration of this situation, it is recommended that the City consider declaring an emergency and immediately embark on a plan of action to replace the failing pipes with permanent steel bypass pipes along the lines of the bypass alternative shown in Figure 8.
- B. Under the authority of the emergency declaration, the City should immediately authorize commencement of the selection of a final configuration and design of a bypass system similar to the one schematically shown in Figure 8, and, in the interests of timeliness, consider directly procuring from the manufacturers the longer lead time elements of the bypass system (i.e., valves and valve assemblies, flexible coupling adaptors and steel pipe). If the City directly procures these items, then they become owner-supplied equipment furnished to the contractor, and the City will save the 10-15% mark-up that the contractor would apply to these items in his bid. This approach will save the City both time and money.
- C. This is not a project that the City should rely on the normal competitive bidding process to produce a contractor who is both fully competent to successfully complete it, and who is also the low responsive bidder. Given the complexities associated with executing the recommended solution, it is also recommended that the City, under the emergency authorization, consider issuing an advance notice to bidders and conduct a prequalification process to select ***the most qualified contractor*** to perform the installation of the project. This prequalification process can run in tandem with the design phase of the project.
- D. The precise locations and depths of the active 48 and 66-inch PCCP pipes that were installed as part of the 1979-81 improvements cannot be accurately determined from the available as-built information supplied by the City. It is therefore recommended that City staff immediately undertake a locating and potholing program to provide coordinates and depth of cover information for the pipes so that this critical information will be available when the team responsible for the design of the permanent bypass commences their work.



## 5.0 Final Thoughts

The situation surrounding the corroded pipes in the Screen House is a serious matter that threatens the ability of the City to continue to reliably supply water to the water treatment plant and the industrial supply pipeline. While this situation is certainly deserving of a prompt and thorough response by the City in its own right, the problem should also be viewed in the broader context of other needed improvements in the City's aging water diversion and treatment system infrastructure. Black & Veatch is aware of the following issues that also relate to the City's water diversion and treatment system that also have a high priority:

- In November 2012, the City plans to inspect the interior of the 7,500-foot long Lake Whatcom diversion tunnel using a remotely piloted submersible. This is the first inspection of this submerged tunnel, which was constructed along with the Screen House in 1940, since 1990. The results of this inspection may identify additional urgent water supply system maintenance action items.
- The current problems with the Screen House pipes are causing City staff to reconsider the future of this facility. The traveling screen in the Screen House is reliable, but seriously outdated technology. Several more modern and less labor and energy intensive alternatives to traveling screens exist which could be installed either at the Gate House, or on the Lake Whatcom diversion tunnel entrance. If a new screening alternative is adopted by the City, the existing Screen House could be either demolished or bypassed, which would simplify mitigation of the Screen House corroded pipes problem.
- The 42,463 foot long, 40-inch diameter prestressed concrete cylinder pipeline that conveys water from the Middle Fork Nooksack River diversion to Lake Whatcom was constructed in 1961 and has experienced at least four major failures in recent years and may be nearing the end of its useful life. The City needs to conduct a thorough inspection of the pipeline and develop an assessment of its remaining useful life so that the planning process for its phased replacement can begin. This project may have to compete for funds with the other water supply infrastructure needs discussed in this report.
- By the end of 2012, the City expects to advertise for design services for a dissolved air flotation (DAF) pretreatment system for the water treatment plant as a permanent fix to a summertime algae problem. According to Superintendent of Operations Bob Bandarra, that procurement action is likely to also contain separate work tasks focusing on the Screen House corroded pipes issue and resolution of the whole screening technology issue as well. Hopefully, the Screen House corroded pipes will not fail before a comprehensive suite of water diversion and treatment infrastructure fixes can be implemented.



## **Appendix A**

**April 25, 2012 letter report by Norton Corrosion Limited**





# NORTON CORROSION LIMITED

8820 222<sup>nd</sup> Street SE, Woodinville, WA 98077  
Phone (425) 483-1616 • Fax (425) 485-1754  
e-mail: sales@nortoncorrosion.com

April 25, 2012

City of Bellingham  
Attn: Robert Johnson  
Dept. Of Public Works  
200 McKenzie Ave.  
Bellingham, WA 98225

Subject: **CITY OF BELLINGHAM  
SCREENHOUSE PIPING  
CORROSION INSPECTION**

Dear Mr. Johnson:

On April 20 2012, Norton Corrosion Limited (NCL) conducted an inspection of three 48-inch pipelines within the basement of the screenhouse. Authorization to complete this work was issued on April 11, 2012.

## **Work Performed**

NCL visually examined the three pipelines within the screenhouse basement. Ultrasonic Thickness (UT) testing was conducted to establish a baseline wall thickness. NCL then utilized a pit depth gauge to determine the amount of metal lost at locations around the pipe. UT measurements could not be obtained at areas with substantial corrosion as the surface was no longer uniform and further grinding on the pipe could have resulted in penetration. NCL took multiple photographs of the damage, which have been included at the end of this report.

## **Results/Conclusions**

UT measurements indicate the damaged piping has a nominal wall thickness of 0.300 inches. The center and south pipe were found to have substantial metal loss at locations around the pipe. The maximum pit depth measured on the top and sides of the piping was found to be 0.150 inches, which represents a 50% wall loss. The bottom of the pipe was found to have substantial delamination. Half-inch thick segments of corrosion product were easily removed from the bottom of the pipe. It should be noted that corrosion byproducts can be misleading as the thickness of the material can be much greater than the actual wall loss. In this particular case, the material removed was considerably dense. It is extremely difficult to determine the specific amount of metal loss at the bottom of the pipe, as a pit depth gauge requires a uniform surface to be used as a reference point. NCL suspects that the metal loss at the bottom of the pipe could easily be approaching 75% wall loss.

There are likely multiple factors contributing to the corrosion as found. The screenhouse drawings indicate this piping was installed in the 1940's, so many factors may have been causing problems for years. The presence of a chlorine injection system between the wall and

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Page 2

the isolation flange could certainly have contributed to this problem, if leaking were to occur. Moisture was found to have seeped through the concrete, creating a wet environment. There may have also been some issues with condensation. All these factors combined with a lack of maintenance of the coating have likely contributed to this problem.

One thing that is not known is the condition of the buried piping prior to entering the screenhouse. None of the pipes have cathodic protection (CP) based on the test conducted from inside the screenhouse. It is believed that the original CP system was designed for piping that leaves the screenhouse to the northwest. So while repairs could likely be made to the piping within the screenhouse, the condition outside of the building will remain unknown without excavation, or the use of inline inspection tools.

### **Recommendations**

There are several options to consider.

1. Pipeline replacement.
2. A steel jacket could be welded in place over the existing piping. This won't resolve the issue outside of the building (if any) but would likely provide reinforcement to the aging piping.
3. As a temporary solution, while planning for replacement, the pipe surface could be manually wire brushed clean, then after the piping is dried out, wax tape could be applied around the pipe, preventing excess moisture from making contact with the steel.

NCL also recommends the use of monitoring equipment, so in the event of a leak, immediate action can be taken.

NCL appreciates this opportunity to serve the City of Bellingham. If you have any questions or additional concerns, please contact this office.

Sincerely,

***Matt Slosson***

Matt Slosson  
Corrosion Engineer  
NACE CP Specialist #7783

City of Bellingham  
April 25, 2012  
Page 3

## Pictures



Image 1: Corrosion product after removal of an adjacent segment. As found on the bottom of the center pipe. Corrosion product found was approximately a half-inch thick.



Image 2: Corrosion damage to the weld surrounding the nipple.

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Image 3: Moisture present on the surface of the pipe.



Image 4: Corrosion damage, after removing a segment of metal adjacent to the nipple.  
Located on the southernmost pipe

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Image 5: Corrosion damage as found on the bottom of the southernmost pipe.



## **Appendix B**

### **Proposal from FIBRWRAP® for Carbon Fiber Upgrade**





May 22, 2012

Mr. Bryon Livingston  
Black & Veatch  
8400 Ward Parkway  
KC, MO 64114  
913-458-3368 P  
livingstonb@bv.com

**RE: City of Bellingham**

**Subject: 48-inch Steel Pipe Carbon Fiber Upgrade**

**Proposal No. FCS- 13950-12**

Dear Livingston,

It is a pleasure to provide the following budget estimate to supply and install the Fyfe Co., LLC Tyfo® Fibrwrap® system at the designated segment of 48-inch diameter Steel pipe for City of Bellingham. This budget proposal is based upon information provided by Black and Veatch and Fyfe Company, LLC.

Fibrwrap Construction has significant experience in the implementation of Carbon Fiber repairs and rehabilitation. Fibrwrap Construction is the certified installer of the Fyfe Company Tyfo® Fibrwrap® system, and has been in business for over 23 years. Fibrwrap has completed over 6,000 projects which include applications such as pipeline rehabilitation, seismic strengthening, bridge rehabilitation, industrial structure upgrades, and commercial property enhancements such as additional load bearing capacity for multi-story buildings or parking decks.

The construction crews utilized by Fibrwrap are direct employees and are trained and certified by Fyfe Company for application of these specialized materials. In addition to this benefit, working with Fibrwrap ensures all parties that the manpower utilized are properly trained in all aspects of the work including the safe work practices necessary in underground repair applications. The Safety of our workforce, Engineers, employees and Inspectors is our primary focus when working on confined space applications, such as the proposed pipeline project.

Fibrwrap Construction began installation of Carbon Fiber in pipelines over 14 years ago and was the pioneer organization in this field. Our experience has afforded us the opportunity to create a streamlined process which begins as soon as the underground structure is entered and ends with Quality Control steps and the final walk through with the Inspection team. Our goal throughout the entire process beginning with assisting with project budgeting and planning up through and including the successful repair sequence will be to create the best value for City of Bellingham.



## **Section 1 – Background and Solution Development:**

The rehabilitation taking place at the designated 48-inch diameter steel pipe for the City of Bellingham, project located in Washington includes leak protection, corrosion protection, and structurally strengthening inside steel pipes. Designated pipes are in need of a scheduled emergency repair due to corrosion. The long term upgrade solution for the pipeline is using Carbon Fiber Reinforced Polymer, as manufactured by Fyfe Company, LLC, to be installed at the interior of the designated pipeline segments.

The Tyfo® Fibrwrap® system has been used for these types of pipeline projects since the late 1990s. The Fyfe materials have the proper durability testing in place to ensure that with the effective design the Carbon Fiber upgrade will provide the desired 50-year life cycle. As discussed above, Fibrwrap Construction is the certified installer of the Fyfe Company materials and has performed over 100 projects similar to the scope presented by the City of Bellingham.

The overall scope of work includes internal strengthening of three (3) segments, each approximately 15 lineal feet of 48-inches in diameter, as shown in documents provided by Black and Veatch. The pipelines can only be down one line at a time, so each of the three (3) segments will be completed separately. The work will be completed as a scheduled maintenance, and the Fiber Wrap system will be designed to provide structural integrity of the line for a 50-year design life. It is assumed that Fibrwrap can enter the pipe from inside the screen house, lining distance to the corroded section of pipe in the chlorination building.

The preliminary design has encompassed the following assumptions:

- Operating pressure = 100 psi
- Operating + surge = 150 psi
- Soil cover height = 14 LF of pipe under 30 feet of cover and 2 LF of pipe in a vault.
- Assume 1,000 soil modulus and max 10 feet of water column above pipe.
- Provide a stand-alone carbon fiber design for the pipeline which does not rely on the existing pipe for structural integrity.

Upon issuance of a contract Fibrwrap will prepare a complete submittal package which will include shop drawings, project schedule, product data, MSDSs, our Quality Assurance plan for the project and Site Specific Safety & Health plan. The submittal will be forwarded for approval.

Once the submittal is approved, on the designated date Fibrwrap will mobilize to the site. Following site-specific training, set up of all safety equipment required will commence. Following this ventilation equipment will be staged and placed for entry. Once entry into designated pipeline segment is established the surface preparation process will begin. Immediately following surface preparation the areas of preparation will be examined per Quality Assurance procedures.

The installation of the Tyfo® system begins topside with the proper saturation of the Tyfo® SEH and SCH fabric using a mechanical saturator. Quality Assurance procedures will be utilized to ensure the proper ratio of epoxy to each roll of fabric. Upon completion of saturation the materials are transported into the pipeline for wet lay-up installation. The Tyfo® SCH system will be installed to



meet design requirements. As each layer of material is installed proper Quality Assurance procedures will be followed to ensure proper project implementation.

Fibrwrap Construction will provide all labor, materials and equipment to complete the installation of the Tyfo® system to meet design requirements, as detailed above. It is assumed that the City of Bellingham will employ the use of either city personnel or an independent third party for inspection of the installation process and adherence to the Quality Assurance Plan. Fibrwrap will work with City of Bellingham to streamline the inspection, documentation of the project steps and any testing required throughout the project. Following is the detailed scope of work and budget pricing.

### **Section 2 - Proposed scope of work:**

1. Provide submittal package including design calculations, drawings, product data, schedule, and safety plan signed and sealed by a registered Structural Engineer.
2. Mobilization of all materials, equipment and personnel to jobsite.
3. Provide all materials and equipment to perform the tasks listed below.
4. Prepare and provide OSHA certified mining and tunneling health and safety confined space entry plan and procedures.
5. Set ventilation equipment to allow for confined space entry and to ensure proper environment for Tyfo® system installation.
6. Begin installation of Tyfo® systems by preparing surface areas per manufacturer recommendations.
7. Milestone: Quality Assurance procedures following surface preparation.
8. Cleaning and dehumidification of all surface areas prior to application.
9. Prime clean surface areas with Tyfo® WP and/or Tyfo® WS Epoxy.
10. Application of layer of Tyfo SEH-51A as dielectric barrier.
11. Apply specified layer(s) of the Tyfo® SCH Carbon system to meet the design requirements.
12. Milestone: Quality Assurance procedures during and following Fiber installation.
13. Apply thickened Tyfo® S epoxy as a final durability coating to the composite.
14. Heating and dehumidification of pipe sections to allow for curing.
15. Milestone: Quality Assurance procedures during and following after finish coating.
16. On-site fabrication of sample panels throughout as called for in Quality Assurance Plan.
17. Testing of samples by a certified laboratory.
18. Quality Assurance Plan final documentation of project turned over to City of Bellingham.

### **Section 3 - Fibrwrap Construction Services, Inc. to provide:**

1. Manufacturer certified and licensed personnel for all phases of proposed scope of work.
2. Manufacturer certified materials and equipment for all phases of proposed scope of work.
3. All items specified in proposed scope of work; section 2.
4. Training of personnel for Inspection by Fyfe Company (no charge).
5. Support of Quality Assurance Plan as prepared by Fibrwrap throughout project.



**Section 4 - Owner to provide:**

1. Access to work areas, including manhole cover removal and valve lock-outs as necessary during designated outage periods.
2. Dewatering and sanitation of pipeline segment(s).
3. Access to potable water.
4. Coordination with local agencies.
5. Traffic control, as required.

**Section 5 - General notes:**

1. Budget proposal assumes one mobilization.
2. Payment - net 30 days.
3. Budget proposal valid for 180 days.
4. Tax included.
5. Pricing based on prevailing, non-union wage rates.
6. Assumes a maximum of 4 days downtime between completion and start of each pipeline rehabilitation. Each additional day of standby time will be billed at \$3,000 per day.

**Section 6 - Client investment: Budget estimate**

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**Implementation of Tyfo® Fibrwrap® Carbon Fiber upgrade ... \$ 278,000.00**

Fibrwrap has performed over 100 pipeline projects similar to this and our experience set in large diameter lines is extensive - these applications are complicated and our goal is to ensure that your Station receives a proper installation of materials by experienced crews using materials which have been proof-tested in the field.

Thank you for the opportunity to provide this budget proposal. Fibrwrap, along with Fyfe Company, looks forward to continuing to work with you and your group on the development of this project. We are prepared to supply any information helpful in the budgeting and planning process. If you should have any questions or need any information regarding this budget estimate please contact me at any of the following:

Direct: (909)-322-0459  
Email: [markg@fclp.com](mailto:markg@fclp.com)

Respectfully submitted,

Mark Geraghty

cc: Jason Alexander, Fibrwrap  
Anna Pridmore, Fyfe Company, LLC

**Appendix B**  
**Weko-Seal Catalogue Information**

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WEKO-SEAL® Internal Joint Sealing

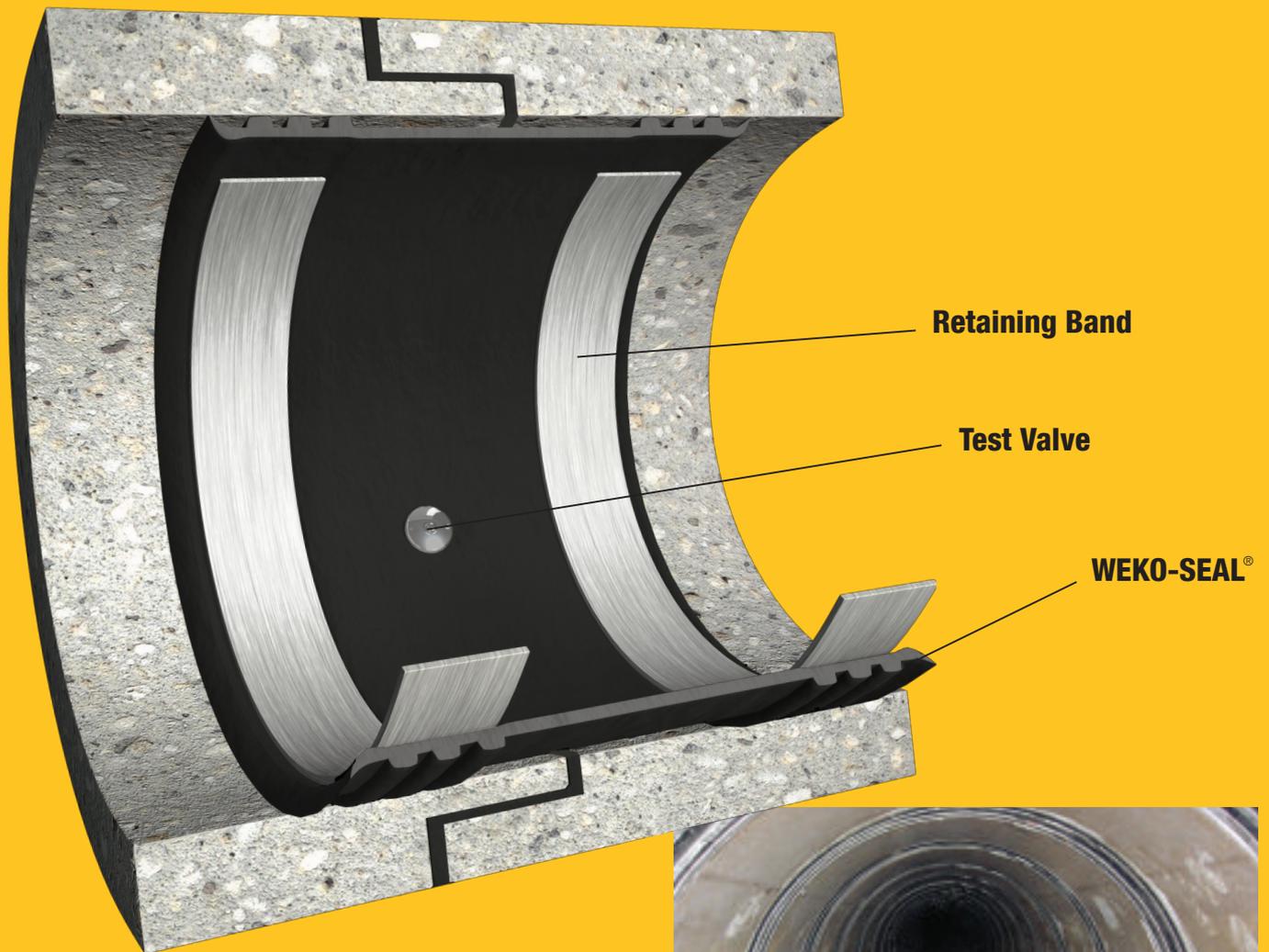


**Miller Pipeline Corp.**



**WEKO-SEAL®**  
internal pipe-joint sealing

**We know seals inside and out.**



**WEKO-SEAL® is the leading trenchless system for internally and economically renewing leaking joints in water, wastewater, natural gas and industrial piping 16 inches up through 216 inches and larger.**

The WEKO-SEAL® is a flexible rubber leak clamp that ensures a non-corrodible, bottle-tight seal around the full inside circumference of the pipe-joint area. Its unique design incorporates a series of proprietary lip seals that create a leakproof fit on either side of the joint.



## Miller Pipeline Corp.

# WEKO-SEAL® advantages over conventional pipe-joint repair methods...

### Permanent

- Non-corrodible, bottle-tight seal with minimal reduction of the pipeline's interior diameter
- Handles operating pressures in excess of 300 psi and 100 feet of external head pressure, with proper design

### Flexible

- Accommodates normal pipe movement from ground shifting, thermal expansion or contraction, and vibration
- Proven patented technology with a positive mechanical locking wedge design
- Test valves standard in all seals
- Durable cross-sectional seal thickness
- Design and installation options for standard round pipes as well as lines with unusual shapes including oval, square or those having compound angles

### Trenchless Installation

- Minimum surface disturbance
- Access openings can be in excess of 2,000 feet apart
- Entrance through manholes, vaults, fittings or cut-outs
- Fast installation lends itself to immediate or emergency situations

### Cost-Effective

- Savings of up to 60 percent over conventional repair methods
- Maintenance free

### Wide Range Of Application

- Water, wastewater, natural gas pipelines and more
- Steel, cast iron, ductile iron, reinforced concrete and more
- 16 inches to 216 inches in diameter and larger

## Why choose Miller Pipeline Corp.

### Experience

- Over 30 years of turnkey installation experience
- With 225,000 seals installed, we are the most experienced contractor in the industry
- Skilled confined space installation technicians

### Guaranteed Standards

- The highest standards of material integrity and workmanship are continually monitored and maintained
- All installations are warranted

### Trained Personnel

- Trained, experienced personnel handle the seal installation process in full compliance with OSHA's 29 CFR 1910.146 Permit-Required Confined-Space regulations with rescue and retrieval equipment on the job site at all times
- Miller crews are trained and certified in first aid, CPR, SCBA and emergency rescue procedures

**With Miller Pipeline,  
the leak stops here.**

## Range of Applications

**WEKO-SEAL® can be used for trenchless rehabilitation of a variety of pipeline configurations and materials.**



Installed internally with up to 2,000 feet between access points, WEKO-SEAL® technology can be utilized in square, rectangular, round and elliptical pipe, including transitions, fittings, and even vertical offsets or specialty configurations. The WEKO-SEAL® is appropriate for installation in natural gas and industrial piping, potable water distribution lines, sanitary sewers, and storm sewers. In nuclear and fossil fuel power plant applications, the WEKO-SEAL® is routinely used for sealing leaks in both fresh and seawater cooling and circulation lines. In all cases our customers are left with bottle-tight joints that will provide years of worry-free maintenance.

Miller Pipeline's trained, experienced personnel handle the seal installation process in full compliance with OSHA's 29 CFR 1910.146 Permit-Required Confined-Space

regulations with full rescue and retrieval equipment on-site at all times. Miller's crews are also trained in CPR, SCBA, First Aid and emergency rescue procedures.

The material specifications for the WEKO-SEAL® fall into four main application categories: water, wastewater, natural gas and seawater/brackish water. Almost all installations can be categorized into one of the four identified application categories. Each application has materials specifically engineered to provide years of worry-free maintenance through the proper rubber seal and stainless steel retaining band selections.



## Specifications Summary

### Pipeline Material

Concrete	Vitrified Clay
Reinforced Concrete	Cement Lined
Prestressed Concrete Cylinder Pipe	PE
Cast Iron	PVC
Ductile Iron	
Steel	

### Pipeline Applications

Potable Water	Service Water
Natural Gas	Circulation Water
Sanitary Sewer	Treatment Plant
Storm Sewer	Air Lines
Nuclear Power Plant	
Cooling Water	

### Pipeline Sizes

16 inches up through 216 inches in diameter and larger



## Water

Seals designed for use in potable water applications are made from EPDM (Ethylene Propylene Diene Monomer) rubber seal and type 304 stainless steel retaining bands. All components used for potable water applications are NSF 61 drinking water approved classified by Underwriters Laboratories. Storm water installations use the exact material components as identified for potable applications.



\* NSF 61 approval valid for pipe sizes 14- 210 inches in diameter

## Natural Gas

Seals designed for natural gas applications are constructed of Nitrile (butadiene acrylonitrile) rubber. This material provides superior resistance to gas, oil, petroleum, alcohol, impact and electricity. The seal retaining bands are constructed from 1018 carbon steel.

## Wastewater

Wastewater applications use the EPDM (Ethylene Propylene Diene Monomer) rubber seal and type 316/316L stainless steel retaining bands.

## Seawater/Brackish Water

Installations in salt water environments consist of an EPDM (Ethylene Propylene Diene Monomer) rubber seal and AL6XN retaining bands. Made from this exotic super stainless steel, they exhibit superior long-term resistance.

Miller Pipeline's staff can quickly aid in specifying the proper materials for your applications, and even provide custom designs for those one-of-a-kind situations.

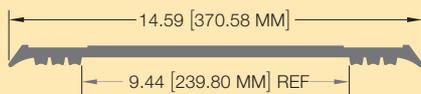


**Our rugged EPDM rubber seal and AL6XN super stainless steel retaining bands meet or exceed requirements for the nuclear power industry.**

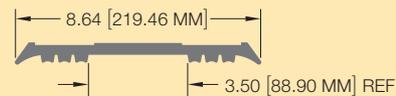
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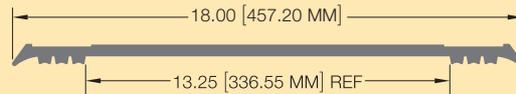
**Standard WEKO-SEAL®**



**Extra-wide WEKO-SEAL®**



**Regular WEKO-SEAL®**

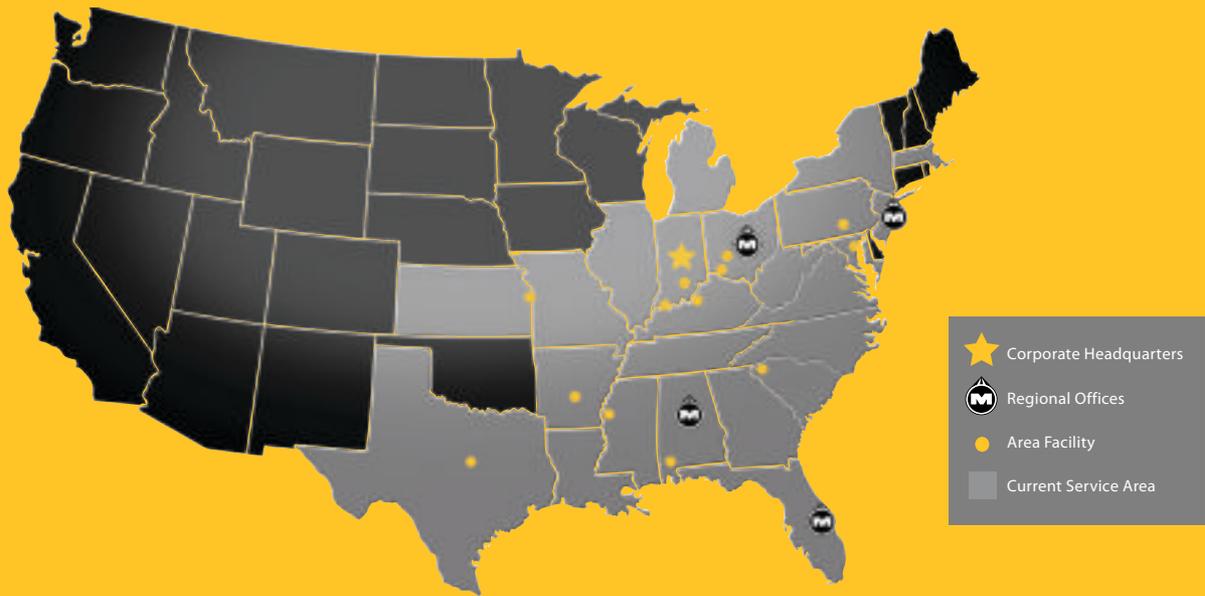


**Double-wide WEKO-SEAL®**



## Miller Pipeline Corp.

Miller Pipeline Corporation is one of the nation's premier natural gas distribution, transmission pipeline and utility contractors. We provide a comprehensive range of pipeline contracting and rehabilitation services for natural gas, liquids, water and wastewater pipelines. Specialty products and services for the industrial and telecommunication industries are also offered. With our corporate headquarters in Indianapolis, Indiana, and area facilities throughout the country, our steadily expanding geographic footprint enables us to ensure the availability of local resources and expertise to support your project.



Our representatives will be glad to discuss your pipeline needs. For further information, or to arrange an on-site inspection, please contact us.

### Corporate Headquarters

P.O. Box 34141  
8850 Crawfordsville Road  
Indianapolis, IN 46234  
Toll-Free: 800-428-3742  
Tel: 317-293-0278  
Fax: 317-293-8502

### Regional Offices

Ohio Operation  
4990 Scioto Darby Road  
Hilliard, OH 43026  
Tel: 614-777-8377  
Fax: 614-771-5651

Alabama Operation  
3611 Industrial Parkway  
Birmingham, AL 35217  
Tel: 205-849-5331  
Fax: 205-849-5311

New Jersey Operation  
378 Whitehead Avenue  
South River, NJ 08882  
Toll-Free: 800-524-1002  
Tel: 732-238-2151  
Fax: 732-238-2265

Florida Operation  
727 Cheston Street  
New Smyrna Beach, FL 32168  
Toll-Free: 866-423-6621  
Tel: 386-423-6621  
Fax: 386-423-6627

[millerpipeline.com](http://millerpipeline.com)

**Appendix C**  
**Fibrwrap Proposal**

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August 9, 2012

Mr. Phil Martinez  
CH2M HILL  
425.233.3662 P  
[Phil.martinez@CH2M.com](mailto:Phil.martinez@CH2M.com)

**RE: City of Bellingham**

**Subject: 48-inch Steel Pipe Carbon Fiber Upgrade**

**Proposal No. FCS- 13950-12**

Dear Martinez,

It is a pleasure to provide the following budget estimate to supply and install the Fyfe Co., LLC Tyfo® Fibrwrap® system at the designated segment of 48-inch diameter Steel pipe for City of Bellingham. This budget proposal is based upon information provided by CH2M HILL and Fyfe Company, LLC.

Fibrwrap Construction has significant experience in the implementation of Carbon Fiber repairs and rehabilitation. Fibrwrap Construction is the certified installer of the Fyfe Company Tyfo® Fibrwrap® system, and has been in business for over 23 years. Fibrwrap has completed over 6,000 projects which include applications such as pipeline rehabilitation, seismic strengthening, bridge rehabilitation, industrial structure upgrades, and commercial property enhancements such as additional load bearing capacity for multi-story buildings or parking decks.

The construction crews utilized by Fibrwrap are direct employees and are trained and certified by Fyfe Company for application of these specialized materials. In addition to this benefit, working with Fibrwrap ensures all parties that the manpower utilized are properly trained in all aspects of the work including the safe work practices necessary in underground repair applications. The Safety of our workforce, Engineers, employees and Inspectors is our primary focus when working on confined space applications, such as the proposed pipeline project.

Fibrwrap Construction began installation of Carbon Fiber in pipelines over 14 years ago and was the pioneer organization in this field. Our experience has afforded us the opportunity to create a streamlined process which begins as soon as the underground structure is entered and ends with Quality Control steps and the final walk through with the Inspection team. Our goal throughout the entire process beginning with assisting with project budgeting and planning up through and including the successful repair sequence will be to create the best value for City of Bellingham.



## Section 1 – Background and Solution Development:

The rehabilitation taking place at the designated 48-inch diameter steel pipes for the City of Bellingham, project located in Washington includes leak protection, corrosion protection, and structurally strengthening inside steel pipes. Designated pipes are in need of a scheduled emergency repair due to corrosion. The long term upgrade solution for the pipeline is using Carbon Fiber Reinforced Polymer, as manufactured by Fyfe Company, LLC, to be installed at the interior of the designated pipeline segments.

The Tyfo® Fibrwrap® system has been used for these types of pipeline projects since the late 1990s. The Fyfe materials have the proper durability testing in place to ensure that with the effective design the Carbon Fiber upgrade will provide the desired 50-year life cycle. As discussed above, Fibrwrap Construction is the certified installer of the Fyfe Company materials and has performed over 100 projects similar to the scope presented by the City of Bellingham.

The overall scope of work includes internal strengthening of three (3) segments, each approximately 6 lineal feet of 48-inches in diameter, as shown in documents provided by CH2M HILL. These segments are each located on different pipelines and the pipelines can only be down one line at a time, so each of the three (3) segments will be completed separately, with a minimum of 5 business days between access into each pipeline.

The work will be completed as a scheduled maintenance, and the Fiber Wrap system will be designed to provide structural integrity of the line for a 50-year design life. Based on discussions with CH2M HILL, it is assumed that Fibrwrap can enter the pipes from access manholes, one per pipe, inside the screen house. This access manhole will be the only entrance and exit per pipe, so special safety precautions, access plans, and ventilation plans need to be developed to allow for safe worker access into the pipes.

The preliminary design has encompassed the following assumptions:

- Operating pressure = 100 psi
- Operating + surge = 150 psi
- Soil cover height = 14 LF of pipe under 30 feet of cover and 2 LF of pipe in a vault.
- Assume 1,000 soil modulus and max 10 feet of water column above pipe.
- Provide a stand-alone carbon fiber design for the pipeline which does not rely on the existing pipe for structural integrity.

Upon issuance of a contract Fibrwrap will prepare a complete submittal package which will include shop drawings, project schedule, product data, MSDSs, our Quality Assurance plan for the project and Site Specific Safety & Health plan. The submittal will be forwarded for approval.

Once the submittal is approved, on the designated date Fibrwrap will mobilize to the site. Following site-specific training, set up of all safety equipment required will commence. Following this, scaffolding and ventilation equipment will be staged and placed for entry. Once entry into designated pipeline segment is established the surface preparation process will begin. Immediately following surface preparation the areas of preparation will be examined per Quality Assurance procedures.



The installation of the Tyfo® system begins topside with the proper saturation of the Tyfo® SEH and SCH fabric using a mechanical saturator. Quality Assurance procedures will be utilized to ensure the proper ratio of epoxy to each roll of fabric. Upon completion of saturation the materials are transported into the pipeline for wet lay-up installation. The Tyfo® SCH system will be installed to meet design requirements. As each layer of material is installed proper Quality Assurance procedures will be followed to ensure proper project implementation.

Fibrwrap Construction will provide all labor, materials and equipment to complete the installation of the Tyfo® system to meet design requirements, as detailed above. It is assumed that the City of Bellingham will employ the use of either city personnel or an independent third party for inspection of the installation process and adherence to the Quality Assurance Plan. Fibrwrap will work with City of Bellingham to streamline the inspection, documentation of the project steps and any testing required throughout the project. Following is the detailed scope of work and budget pricing.

## **Section 2 - Proposed scope of work:**

1. Provide submittal package including design calculations, drawings, product data, schedule, and safety plan signed and sealed by a registered Structural Engineer.
2. Mobilization of all materials, equipment and personnel to jobsite.
3. Provide all materials and equipment to perform the tasks listed below.
4. Provide scaffolding surrounding the pipelines to allow for safe access to the manhole entry ports located on top of the pipelines in the screen building. There is approximately 4 feet of vertical clearance between the top of the pipes and the ceiling.
5. Prepare and provide OSHA confined space entry plan and procedures.
6. Provide sheets of plastic draped over large equipment to mitigate spread of dust. Per CH2M HILL, no other dust control measures are required.
7. Set ventilation equipment to allow for confined space entry and to ensure proper environment for Tyfo® system installation.
8. The pipe segment with severe deterioration and the area upstream is coated with a coal tar enamel. The area downstream of the repair has a mortar lining. Both the coal tar enamel and the mortar lining. Both the mortar lining and the coal tar enamel will be removed and the steel will be abrasively blasted per manufacturer recommendations.
9. If through thickness wall penetrations are discovered, the steel plates are to be welded to span over the holes (performed by others).
10. Cleaning and dehumidification of all surface areas prior to application.
11. Prime clean surface areas with Tyfo® WP and/or Tyfo® TC Epoxy.
12. Application of layer of Tyfo SEH-51A as dielectric barrier.
13. Apply specified layer(s) of the Tyfo® SCH Carbon system to meet the design requirements.
14. Apply thickened Tyfo® S epoxy as a final durability coating to the composite.
15. Heating and dehumidification of pipe sections to allow for curing.
16. On-site fabrication of sample panels throughout as called for in Quality Assurance Plan.
17. Testing of samples by a certified laboratory.
18. Quality Assurance Plan final documentation of project turned over to City of Bellingham.



**Section 3 - Fibrwrap Construction Services, Inc. to provide:**

1. Manufacturer certified and licensed personnel for all phases of proposed scope of work.
2. Manufacturer certified materials and equipment for all phases of proposed scope of work.
3. All items specified in proposed scope of work; section 2.
4. Training of personnel for Inspection by Fyfe Company (no charge).
5. Support of Quality Assurance Plan as prepared by Fibrwrap throughout project.

**Section 4 - Owner to provide:**

1. Access to work areas, including manhole cover removal and valve lock-outs as necessary during designated outage periods.
2. Dewatering of pipeline segment(s). It is assumed that the installed plugs allow for safe worker access into the pipeline and will not lead water into the work area.
3. Welding of any holes in the pipe, as needed.
4. Access to potable water.
5. Coordination with local agencies.
6. Traffic control, as required.

**Section 5 – General notes:**

1. Budget proposal assumes three mobilizations of personnel and some of the equipment, but storage of the remainder of the equipment and materials on-site between phases.
2. Payment – net 30 days.
3. Budget proposal valid for 180 days.
4. Tax included.
5. Pricing based on prevailing, non-union wage rates.
6. Assumes a minimum of 5 business days downtime between completion and start of each pipeline rehabilitation. A minimum of 5 business days notification of the start dates for the first phase of construction is assumed.
7. Each day of standby time, beyond the days assumed, between applications will be billed at \$2,650.00 per day.
8. If 460 volt three phase power is available on-site, potential cost savings of approximately \$ 6,500 could be achieved for the project by avoiding the use of a diesel generator to power equipment.

**Section 6 – Client investment: Budget estimate**

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<b>Implementation of Tyfo® Fibrwrap® Carbon Fiber upgrade ...</b>	<b>\$ 242,000.00</b>
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Fibrwrap has performed over 100 pipeline projects similar to this and our experience set in large diameter lines is extensive – these applications are complicated and our goal is to ensure that your Station receives a proper installation of materials by experienced crews using materials which have been proof-tested in the field.

Thank you for the opportunity to provide this budget proposal. Fibrwrap, along with Fyfe Company, looks forward to continuing to work with you and your group on the development of this project. We are prepared to supply any information helpful in the budgeting and planning process. If you should have any questions or need any information regarding this budget estimate please contact me at any of the following:

Direct: (909)-322-0459

Email: [markg@fclp.com](mailto:markg@fclp.com)

Respectfully submitted,

Mark Geraghty

cc: Jason Alexander, Fibrwrap  
Chris De Letto, Fibrwrap  
Anna Pridmore, Fyfe Company, LLC



**Appendix D**  
**Hydrophilic Waterstop**

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# **SWELLSEAL<sup>®</sup>**

***Hydrophilic Waterstop Solutions***



Waterproofing the WORLD

**dh** **de neef<sup>®</sup>**  
CONSTRUCTION CHEMICALS, INC.

# **SWELLSEAL® PRODUCTS** - Why Hydrophilic Waterstops?

**SWELLSEAL®** hydrophilic waterstops expand upon contact with water to fill a void or joint and create a compression seal waterstop. Unlike traditional molded waterstops that are a fixed sized and must be placed in fresh concrete, **SWELLSEAL®** hydrophilic waterstops can be placed in any joint or interface. Old to new concrete, concrete to steel joints, between precast concrete members, or even steel to steel interfaces are no problem for **SWELLSEAL®** hydrophilic waterstops. Available in extruded rubber shapes or as a gun grade paste, **SWELLSEAL®** hydrophilic waterstops offer effective solutions for difficult surface to surface sealing applications.

## **Scope of SWELLSEAL® Applications:**

- Waterproofing cold joints
- Waterproofing construction joints
- Waterproofing joints between precast elements
- Sealing pipe penetrations
- Sealing encased steel H-beam penetrations
- Sealing steel to steel and steel to concrete joints

## **Typical SWELLSEAL® Applications:**

- Wastewater treatment plants
- Water purification plants & reservoirs
- Manhole covers & grade rings
- Box culverts
- Underground parking structures
- Reservoirs
- Sheet pile interlocks
- Water tanks
- Precast manhole sections
- Sewer systems
- Underground structures
- Tunnel and metro works
- Swimming Pools



Seals horizontal and vertical cold joints



Seals between precast members

## **SWELLSEAL® 8**

### **Properties and Advantages:**

- Up to 800% expansion in water
- Greatest expansion of **SWELLSEAL®** products
- Flat profile  $\frac{3}{4}$ " x  $\frac{1}{8}$ "
- Round profile  $\frac{1}{4}$ " diameter
- 600% Elongation
- Requires only 6 inches of fresh concrete cover
- Good chemical resistance
- Concrete can be placed immediately after installation
- Easy installation with nails, screws, or adhesives

### **Ideal applications for SWELLSEAL® 8:**

#### **• SWELLSEAL® 8 F**

- Between pre-cast members
- Thick wall pours
- Blockout repairs
- Poured in place concrete joints

#### **• SWELLSEAL® 8 R**

- Gasket forming material around pre-cast members
- Manhole covers
- Sheet pile interlocks

# SWELLSEAL® 2010

## Properties and Advantages:

- 200% Expansion in water
- Rectangular preformed profile of  $\frac{3}{8}$ " x  $\frac{3}{4}$ "
- 600% Elongation
- Requires only 4 inches of fresh concrete cover\*
- Delayed reaction in water - full expansion in 10 days
- Good chemical resistance
- Concrete can be placed immediately after installation
- Easy installation with nails, screws, or adhesives

## Ideal Applications for SWELLSEAL® 2010:

- Poured in place concrete joints
- Slow expansion is desired
- Low pressure from expansion is required.

\* Cover can be reduced to 3.28 inches in all directions if concrete strength is at least 4260 psi or greater



Specially treated for delayed reaction in water



Seals against highest head pressure



Seals with least expansion pressure on structure

# SWELLSEAL® JOINT

## Properties and Advantages:

- Up to 670% expansion in water
- Highest head pressure resistance
- Rectangular in overall shape **SWELLSEAL® JOINT** contains an inner compression seal for the purpose of balancing pressure during expansion of the outer hydrophilic shoulders
- Excellent chemical resistance
- Highest of tensile strengths among **SWELLSEAL®** products
- Lowest in overall pressure exertion on structure during expansion
- Concrete can be placed immediately after installation
- Easy installation with nails, screws, or adhesives

## Ideal applications for SWELLSEAL® JOINT:

- Poured in place concrete joints
- Tunnel and metro works
- Wastewater treatment plants

# SWELLSEAL® WA

## Properties and Advantages:

- 200% Expansion in water
- Gunnable paste ideal for rough, irregular surfaces
- Adjustable bead size and shape
- Withstands head pressures in excess of 330 feet
- Elongation greater than 600%
- Excellent adhesive qualities, can be used to adhere preformed materials in place
- Good chemical resistance
- May be placed underwater if concrete can be poured immediately upon installation



Seals pipe penetrations and uneven surfaces

## Ideal applications for SWELLSEAL® WA:

- Sheet pile interlocks
- Pipe penetrations
- Manhole covers
- Sealing encased steel H-beam penetrations
- Precast members
- Sealing steel to steel and steel to concrete joints
- Concrete wall ties
- Between rough repair concrete and new pours



## SWELLSEAL® PRODUCT COMPARISON CHART

	SWELLSEAL® 8F	SWELLSEAL® 8R	SWELLSEAL® 2010	SWELLSEAL® JOINT	SWELLSEAL® WA
Physical form	preformed flat	preformed round	preformed rectangle	preformed rectangle	gunnable mastic
Profile	3/4" x 1/8"	1/4" diameter	3/8" x 3/4"	1" x 5/16"	minimum 3/8" bead
Minimum Concrete Cover (inches)	6	6	4	3-3/4	3
Expansion in Water	580% 1 Day 785% 4 Days	340% 1 Day 720% 4 Days	200% 10 Days	Joint 100% 4 Days Shoulders 540% 4 Days	200%
Tensile Strength (psi)	1109	1109	1493	Joint 1706 Shoulders 1308	312
Elongation at Break	600%	620%	600%	Joint 610% Shoulders 670%	625%
Shore A Hardness	53	53	52	Joint 53 Shoulders 50	22
Specific Density	1.2	1.2	1.2	1.23-1.27	1.45
Maximum Head Pressure	> 100 ft	> 100 ft	> 100 ft	>660 ft.	>330 ft.
Cure Time Before Pour	immediate	immediate	immediate	immediate	immediate

Waterproofing the WORLD



**DE NEEF CONSTRUCTION CHEMICALS**

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Tel: 1 713 896 0123 Toll Free: 1 800 732 0166

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# SHEETPILE INSTALLATION

## PRODUCT NAME

### **SWELLSEAL<sup>®</sup> WA**

Gungrade Polyurethane Waterstop

## MANUFACTURER

De Neef Construction Chemicals, Inc.  
5610 Brystone Drive  
Houston, TX 77041  
1(800) 732-0166

## APPLICATION

Sheet Pile Applications  
Surface Preparation and Installation

## OVERVIEW

**SWELLSEAL<sup>®</sup> WA** may be used for stopping the ingress of water through sheet piling knuckles in two ways. **SWELLSEAL<sup>®</sup> WA** can be applied to the female opening of the piles, and allowed to fully cure before driving. This method is useful if the piles are to be pretreated in the contractor yard or plant prior to shipping them to the jobsite. **SWELLSEAL<sup>®</sup> WA** can also be applied in the field and the sheets drive before the material is cured. This “wet driving” method allows the contractor to drive the sheet immediately after installation of the **SWELLSEAL<sup>®</sup> WA**.

There are two methods that can be used to apply Swellseal<sup>®</sup> WA to sheet piles; the wet drive method and the cure and drive method. The wet drive method is generally preferred since it assures full fill of the sheet pile joint knuckle regardless of sheet movement during driving. Using the wet method, sheets can be driven, and re-driven for up to 24 hours without concern for the sealant. After about 24 hours, the sealant fully cures and develops a strong adhesive bond with both sheets. Attempting to re-drive the sheets after the sealant has fully cured can result in cohesive failure in the sealant.



If there is a need to drive after 24 hours, you might be well served to use the cure and drive method. Using the cure and drive method allows the sealant to adhere to only one sheet, with the cured face of the sealant sliding against the other sheet during the driving process. This allows for driving and re-driving of a sheet, regardless of how long the sheet has been exposed to below ground moisture.

## PREFERRED WET DRIVE METHOD

### Surface preparation and installation:

1. Lay sheets out with the female side of the pile accessible.
2. Clean all foreign material and the surface layer of oxidation from the knuckle by OSHA approved chemical, flame, or abrasive method.
3. Immediately before applying sealant, blow the knuckle clean with compressed air. Compressed air must be free of oil and water.
4. Apply an 3/8" bead of **SWELLSEAL<sup>®</sup> WA** into the female knuckle. Do not overfill knuckle.
5. Drive the sheet pile.

## **CURE AND DRIVE METHOD**

### **Surface preparation and installation:**

1. Lay sheets out with the female side of the pile accessible.
2. Clean all foreign material and the surface layer of oxidation from the knuckle by OSHA approved chemical, flame, or abrasive method.
3. Immediately before applying sealant, solvent wipe the knuckle.
4. After the solvent flashes off, apply an 3/8" bead of **SWELLSEAL® WA** into the female knuckle. Do not overfill knuckle.
5. Tool the **SWELLSEAL® WA** in the knuckle to roughly the shape of the male interlocking member of the sheet pile.
6. Store sheet piles in such a way that they will not get standing water in the knuckle.

Rev. 01/2012

# TECHNICAL INFORMATION

## WATERSTOPS

### PRODUCT NAME

## SWELLSEAL<sup>®</sup> WA

Gungrade Polyurethane Waterstop

### MANUFACTURER

De Neef Construction Chemicals, Inc.  
5610 Brystone Drive  
Houston, TX 77041  
1(800) 732-0166

### PRODUCT DESCRIPTION

**SWELLSEAL<sup>®</sup> WA** is a single component hydrophilic mastic, designed for sealing smooth to very irregular construction joints and pipe penetrations. **SWELLSEAL<sup>®</sup> WA** is supplied in cartridges or sausages. Material cures and swells in the presence of moisture or water. Curing time is dependent on temperature and humidity, i.e. curing time will decrease if temperature and RH are higher. **SWELLSEAL<sup>®</sup> WA** will become firm in 24-36 hours.

### APPROPRIATE APPLICATIONS

- Sealing of rough and smooth construction joints of cast in-place or precast concrete in wet and underwater applications.
- Sealing joints between pre-cast segments in wet or underwater applications (e.g. manholes, box culverts, cable ducts and pipes)
- Sealing of the joints between sheet piles.
- Used to secure **Deneef Hydrophilic Waterstops** to rough surfaces.

### ADVANTAGES

- Solvent free
- Due to its special formulation, **SWELLSEAL<sup>®</sup> WA** can be applied to wet surfaces or in underwater applications.

### TYPICAL PROPERTIES

Property	Value	Test Standard
Solids	100%	
<b>Uncured</b>		
Viscosity	Paste	
Density (at 20°C, 68°F)	Approx. 90 lbs/cu.ft.	ASTM D 3574 95
Slump in vertical applications	1/8 inch	
Skins over	6-10 hr	
Flash Point	> 266 °F	ASTM D 93
<b>Cured 7 days at 77°F (25°C) 3/8" thick)</b>		
Elongation at break	Approx. 625%	ASTM D 3574 95
Tensile strength	Approx. 312 psi	ASTM D-412
Resistance to hydrostatic pressure	>330 feet of head	DNCC
Swelling capacity in contact with water	200%	DNCC

### Appearance

During application: pasty, Cured: rubbery; Color: Gray

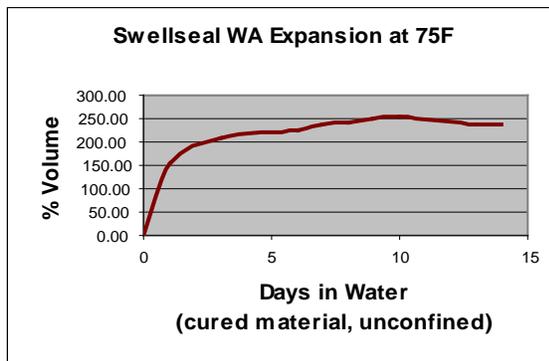
- **SWELLSEAL<sup>®</sup> WA** adheres to concrete, PVC, HDPE, steel, and fiberglass.
- In contact with water **SWELLSEAL<sup>®</sup> WA** will expand to more than 200% of its original cured volume.
- Flexible system, which adapts to the irregular surfaces
- Easy application with standard caulking guns
- Durable cured material will exceed the life of the structure.
- Good chemical resistance\*.
- Resistant to petroleum products, greases, mineral and vegetable oils

\* Chemical Resistance Chart available upon request.

## Coverage

The consumption of **SWELLSEAL® WA** per linear foot depends on the quality of the surface of the concrete.

	Bead Diameter	Coverage
Cartridges 10.5 oz.	1/4 inch	25 – 35 ft.
	5/16 inch	12 – 15 ft.
	3/8 inch	approx. 10 ft.
Sausages 20 oz.	1/4 inch	50 – 70 ft.
	5/16 inch	24 – 30 ft.
	3/8 inch	approx. 20 ft.



**SWELLSEAL® WA 200% Expansion**

## PACKAGING

10.5 oz. cartridge	20 oz. sausage
12 per carton 6 lbs. net	12 per carton 24 lbs. net
1 pallet = 105 cartons 630 lbs.	1 pallet = 60 cartons 1500 lbs.
Weight per cartridge:	Weight per sausage:
1.2 lbs. gross	2.2 lbs. gross
1.1 lbs. net	2.0 lbs. net

## LIMITATIONS

- **SWELLSEAL® WA** must be fully confined to perform properly. When used in precast or joints, minimum concrete cover is 3" on all sides.
- **SWELLSEAL® WA** is not suitable for surface applications.
- Uncured material may expand much greater than 200% if unconfined, and will expand preferentially in the direction of least resistance.
- Applied at temperatures below 40°F, the material will take approximately 10 to 15 days to cure.

## INSTALLATION PROCEDURES

**SWELLSEAL® WA** should be applied onto a dust-free concrete surface. The surface can be rough or smooth, moist or dry.

**Application Method for 10.5 oz. Cartridges:** Break the moisture proofing aluminum foil on the top of the cartridge and remove the plug from the bottom. Screw on the nozzle and cut diagonally at the appropriate position. Place the cartridge into the caulking gun.

**For 20oz. Sausages:** Put the sausage in the empty tube of the bulk caulking gun and cut 1/8 inch off the top of the sausage. Close the tube and install the nozzle. Nozzles are supplied with the appropriate opening. **SWELLSEAL® WA** must be applied in an uninterrupted band (minimum 3/8" bead), gunned in the middle of the joint or precast element. Concrete cover should be at least 3 inches on all sides, in order to avoid cracks from the pressure of material swelling. If **SWELLSEAL® WA** is to be installed under water or during heavy rain the concrete operation should begin within 2 hours of application to provide confinement for the material or premature swelling may result lowering the effectiveness of the material.

## STORAGE & HANDLING

Store in dry area for up to 12 months from date of production at temperatures between 40°F and 85°F for best performance. See shelf life details on the material packaging.

## PRECAUTIONS

Always use protective clothing, gloves and goggles consistent with OSHA regulations during use. Avoid eye and skin contact. Do not ingest. Refer to Material Safety Data Sheet for detailed safety precautions.

## SAFETY INFORMATION

In the event of an EMERGENCY call:  
CHEM-TREC 800-424-9300.

## WARRANTY INFORMATION

De Neef Construction Chemicals, Inc. products are warranted under the policy set forth under the WARRANTY section of the DeNeef Construction Chemicals Inc., product catalog. Warranty information can also be obtained via the DeNeef Construction Chemicals Inc. website at [www.deneef.com](http://www.deneef.com), or by calling 713-896-0123 or toll free at 1-800-732-0166.

Rev. 01/2012

## **Appendix B - Photographs**

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Photo B-1. IMG\_4624. General condition of the south 48-inch industrial pipeline. The project team observed approximately 2-inches of sediment in the bottom, and a constant trickle of water from the pipe to the downstream chamber. Photo date: 4-23-2014.



Photo B-2. IMG\_4627. General condition of the center 48-inch diameter raw water pipeline. No significant sediment was observed. The stainless steel mixer is visible in the background. Photo date: 4-23-2014.



Photo B-3. IMG\_4629. General condition of the north 48-inch diameter raw water pipeline. No significant sediment was observed. The stainless steel mixer is visible in the background. Photo date: 4-23-2014.



Photo B-4. IMG\_3642. Rust tuberculation on steel transition between outlet well wall and pipe (center 48-inch raw water). Photo date: 4-23-2014.



Photo B-5. IMG\_3670. Close-up view of the condition of the pipe wall in the center 48-inch diameter pipeline. Coal tar enamel lining is intact, but is checked and cracked. The lining material is brittle and relatively easy to remove from the pipe wall. Extensive rust and tuberculation was observed at the surface. Photo date: 4-23-2014.



Photo B-6. IMG\_3673. Condition of the pipe wall after removal of coal tar enamel lining and corrosion products. Pitting (localized corrosion) up to 0.05 inch was measured. Photo date: 4-23-2014.



Photo B-7. IMG\_3676. Condition of the pipe wall in the south 48-inch diameter raw water pipeline was similar to that observed in the center pipeline. Remnants of coal tar enamel lining are visible around the exposed metal. Photo date: 4-23-2014.



Photo B-8. IMG\_3688. Condition of the pipe wall at the third inspection point shows the same corrosion pattern as the previous two inspection points (Photos B-6 and B-7). Photo date: 4-23-2014.



Photo B-9. IMG\_3715. Close-up view of corrosion at the fourth inspection point. The metal loss at this location was slightly more uniform (i.e., fewer pits) than the location shown in Photos B-6 and B-7. Photo date: 4-23-2014.



Photo B-10. IMG\_3679. Heavy rust tuberculation at the injection pipe presentation. Note the rust spots on the surface of the cement mortar lining (left and at attachment point). Photo date: 4-23-2014.



Photo B-11. IMG\_3681. Corrosion product at the stainless steel mixer attachment point (center of photo). Rust staining of the cement mortar was also observed (just to the right of photo's center). Photo date: 4-23-2014.



Photo B-12. IMG\_1702 : Hairline crack below window on south elevation. Crack width is 0.005-0.007". Photo date: 4-15-2014.



Photo B-13. IMG\_1710: Hairline crack below window on the north elevation. Crack width is 0.005-0.05". This crack was also observed in the interior of the building. Photo date: 4-15-2014.



Photo B-14. IMG\_1703: Hairline cracks below window on each side. Crack was previously patched but has since re-opened. Crack width is 0.003-0.005 inches. Photo date: 4-15-2014.



Photo B-15. IMG\_1704: Hairline cracks on the exterior southeast corner shows previous leakage at a construction joint but this leakage is not currently active. Photo date: 4-15-2014.



Photo B-16. IMG\_1705: Hairline crack on the exterior southeast corner where the crack has opened after wall was painted. Crack width is 0.005-0.007 inches. Photo date: 4-15-2014.



Photo B-17a. IMG\_1751: Spalled concrete and void around an exposed column longitudinal reinforcing bar. No evidence of corrosion, however, this may have been covered by the coating. Photo date: 4-15-2014.



Photo B-17b. PM 131: Same location as shown in Photo B-17a, prior to painting. Photo date: 9-24-2013.



Photo B-17c. PM 132: Close-up view of the same location as shown in Photos B-17a and 17b, prior to painting. Photo date: 9-24-2013.



Photo B-18. IMG\_1767: Outlet well roof underside showing a white coating with only minor spot corrosion marks. Photo date: 4-23-2014.

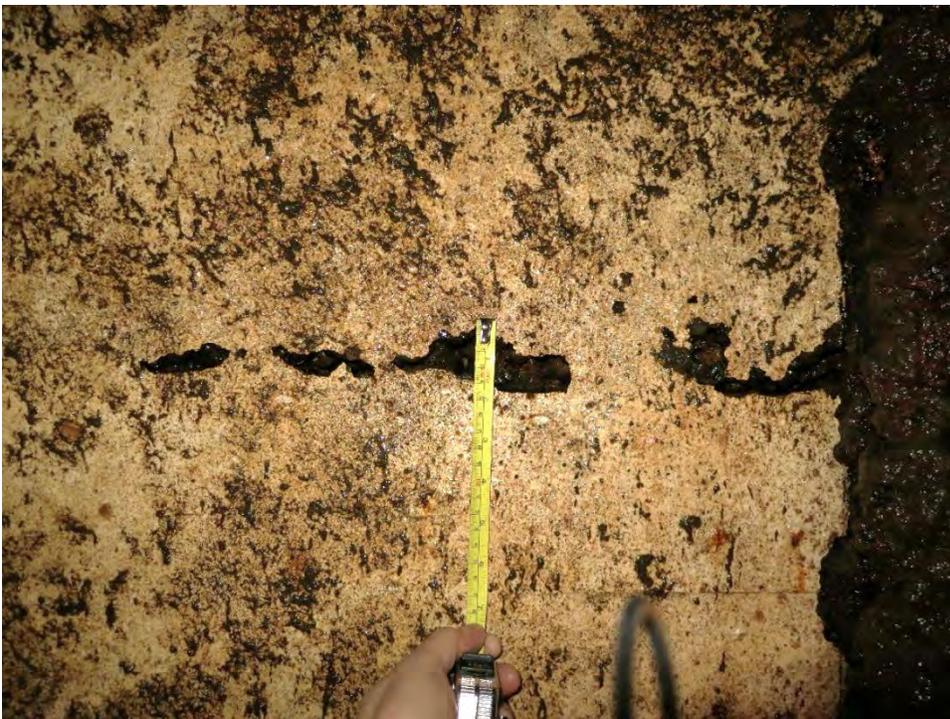


Photo B-19a. IMG\_1776 Outlet well cold joint line where voids in concrete from 1.5" -2" deep have formed. Photo date: 4-23-2014.



Photo B-19b. IMG\_1777: Outlet well cold joint line where voids in concrete from 1.5" -2" deep have formed. Photo date: 4-23-2014.

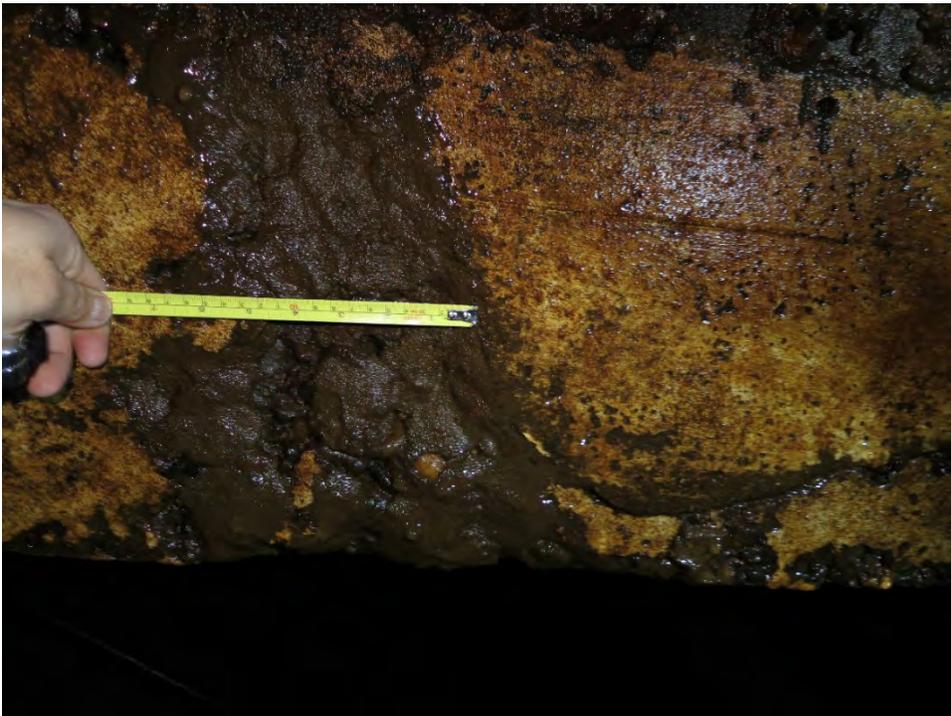


Photo B-20. IMG\_1779: Outlet well eroded or spalled concrete at top of opening in the wall. Photo date: 4-23-2014.



Photo B-21. IMG\_1783: Outlet well small voids in the wall. Photo date: 4-23-2014.



Photo B-22. IMG\_1795: Screen well (North side) roof underside showing a white coating with only minor spot corrosion marks. Photo date: 4-23-2014.



Photo B-23. IMG\_1789: Screen well (North side) eroded concrete in top of opening that leads to the intake well. Photo date: 4-23-2014.



Photo B-24. IMG\_1825: Screen well (South side) walls with minor voids and underside of roof showing a whit coating. Photo date: 4-23-2014.



Photo B-25. IMG\_1823: Screen well (South side) walls near screen shows some erosion. Photo date: 4-23-2014.



Photo B-26. IMG\_1819: Intake well roof underside showing a white coating with only minor spot corrosion marks. Photo date: 4-23-2014.



Photo B-27. IMG\_1826: Waste well voids or eroded concrete in the wall. Photo date: 4-23-2014.



Photo B-28. IMG\_1853: Waste well voids in wall near 4'x4' gate caused by erosion of weak or insufficiently consolidated concrete. Photo date: 4-23-2014.



Photo B-29. IMG\_1842: Waste well eroded concrete above outlet. Photo date: 4-23-2014.



Photo B-30. IMG\_1836: Waste well wall eroded concrete at a cold joint or construction joint. Photo date: 4-23-2014.



Photo B-31. IMG\_1844: Waste well surface eroded concrete around 12"x12" slide gate. Photo date: 4-23-2014.



Photos B-32. Slide gate (1) in intake well. Photo date: 4-23-2014.



Photo B-33. Slide gate (1) wall thimble, guide and frame. Photo date: 4-23-2014.



Photo B-34. Slide gate (2) in intake well. Photo date: 4-23-2014.



Photo B-35. Slide gate (3) downstream side and wall thimble. Photo date: 4-23-2014.



Photo B-36. Slide gate (3) in intake well frozen in closed position. Photo date: 4-23-2014.



Photo B-37. Slide gate (5) in screen well in good condition. Photo date: 4-23-2014.

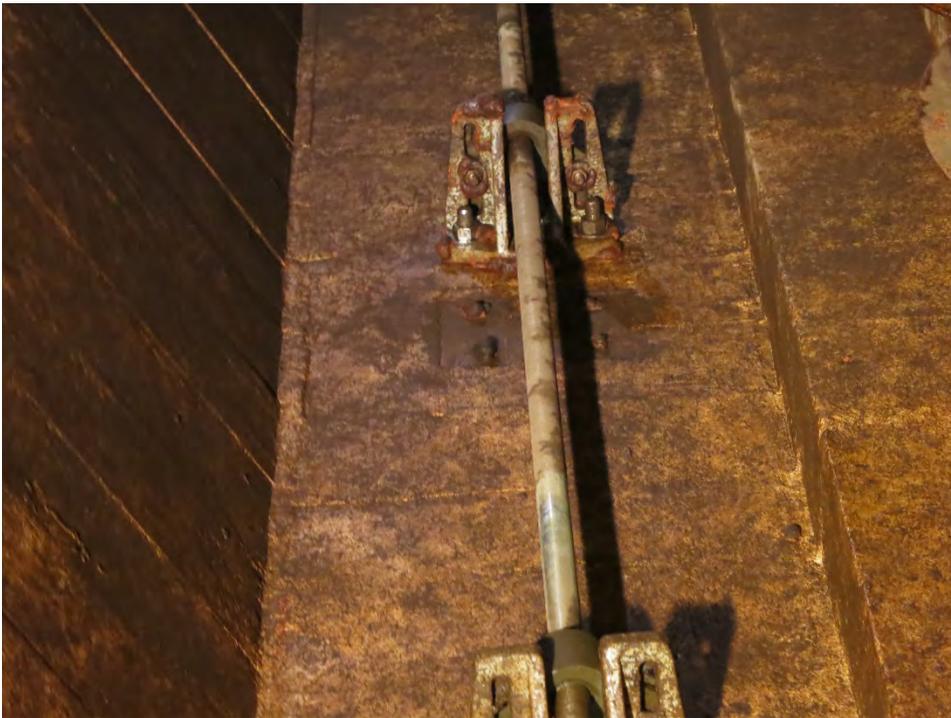


Photo B-38. Slide gate (5) operating stem and guides. Photo date: 4-23-2014.



Photo B-39. Slide gate (5) wall thimble from downstream side. Photo date: 4-23-2014.



Photo B-40. Slide gate (6) in outlet well. Photo date: 4-23-2014.



Photo B-41. Slide gate (7) in outlet well. Photo date: 4-23-2014.



Photo B-42. Plug (mud) valve (8) in outlet well with detached operating stem. Photo date: 4-23-2014.



Photo B-43. Plug (mud) valve (8) operating stem. Photo date: 4-23-2014.



Photo B-44. Plug (mud) valve (8) outlet from below. Photo date: 4-23-2014.



Photo B-45. Slide gate (9) in outlet well. Photo date: 4-23-2014.



Photo B-46. Slide gate (10) in outlet well. Photo date: 4-23-2014.



Photo B-47. Slide gate (10) operating stem. Photo date: 4-23-2014.



Photo B-48. Slide gate (11) in outlet well. Photo date: 4-23-2014.



Photo B-49. Closeup view of traveling screen (right) at deck level. Photo date: 4-23-2014.



Photo B-50. Traveling screen at deck level. Photo date: 4-23-2014.



Photo B-51. Opposite view of traveling screen at deck level. Photo date: 4-23-2014.



Photo B-52. Traveling screen at screen well invert. Photo date: 4-23-2014.



Photo B-53. Traveling screen (right) at screen well invert. Photo date: 4-23-2014.



Photo B-54. View upward of traveling screen from screen well invert. Photo date: 4-23-2014.



Photo B-55. Closeup view of traveling screen fine mesh. Photo date: 4-23-2014.



## **Appendix C – MTC Reports**

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# Materials Testing & Consulting, Inc.

Geotechnical Engineering • Materials Testing • Special Inspection • Environmental Consulting



May 8, 2014

## **CH2MHill**

**Attn: Mr. Phil Martinez**

*Project Manager*

1100 112th Ave NE, Suite 400

Bellingham, WA 98228

e-mail: [phil.martinez@ch2m.com](mailto:phil.martinez@ch2m.com)

**Subject: Geophysical Consultation & Limited Investigation for  
Structural Assessment – Rev1**

Whatcom Falls Park Chlorine House

Bellingham, WA 98228

MTC Project No.: **14W022**

Dear Mr. Martinez:

At your request, Materials Testing & Consulting, Inc. (MTC) has completed a limited-scope geophysical structure scan investigation and consultation, including site reconnaissance and scans testing at the above referenced site for characterization of structural conditions as it pertains to the areas of concern as documented by the Client. The project site is located at Whatcom Falls Park off of Lakeway Blvd. in Bellingham, Washington. The property is heavily vegetated and also contains a fish hatchery and various play sets and walking paths, adjacent to Whatcom Creek and Falls. The chlorine house site is relatively flat and grassy and is located between Whatcom Falls to the north and a forested slope and embankment to the south and Lakeway Blvd.

MTC was contacted for a limited scope geophysical structural assessment and consultation to concur with a structural assessment being performed by the Client to determine reuse potential for the existing water supply chlorine house at Whatcom Falls Park in Bellingham, Washington. Several locations were considered during the investigation within the water inlet, outlet and screening level at the chlorine house. MTC agreed to attend a structural assessment meeting involving confined space entry procedures and provide limited preliminary assessment of existing concrete walls and ground penetrating radar (GPR) scans to identify the presence of reinforcing steel.

MTC has performed this geophysical structural investigation in accordance with project discussions with the client and our proposal dated April 18, 2014. This letter summarizes project information and the findings of our GPR exploration, addresses the interpretation of GPR data, and provides general

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Geotechnical Engineering • Materials Testing • Special Inspection • Environmental Consulting



recommendations. Design of site repairs was outside the scope of this study. However at the client's request, MTC may be retained for additional geotechnical or investigation services and permit assistance.

## ***Project Background and General Conditions:***

The existing Whatcom Falls Park chlorine house and associated site improvements were constructed approximately 78 years ago. According to the Client and our initial site walkthrough performed on April 16, 2014, interim improvements to the existing structure have been performed over the time period from 1936 to present. Such improvements appear to include concrete patches, paint & coatings, and some pipe penetrations. The areas involving the pipe penetrations were not included in this scope of MTC's geophysical investigation. The areas of concern that were noted during our initial visual assessment with the Client included primarily the walls within the lowest level inlet and outlet chambers and screen rooms.

The lower level inlet and outlet wells and screen rooms consisted of multiple rooms housed within one eccentrically round footprint. One main receiving chamber approximately 20 feet by 15 feet receives water from Lake Whatcom via an approximately 6 foot diameter concrete tunnel. The water is then directed to either side of a central waste well into two approximately 8 foot by 8 foot rooms each containing rotating, self-cleaning screens. The water then passes from the two screen rooms back into a single outlet well approximately the same dimensions as the receiving chamber and into three 4-foot diameter shafts that eventually deliver water to the City of Bellingham.

## ***Site Investigation and Methodology:***

On April 23, 2014, an MTC Engineer and Inspector visited the site to meet with the Client, perform visual reconnaissance, GPR scans, and concrete coring for compressive strength samples. The concrete coring results have been provided under separate cover. Concrete was cored at three locations within the inlet and outlet wells. Please see the attached Figure 2 – GPR Sketch for approximate scan profile and concrete coring locations. Photographs showing typical work are located in Appendix A. The areas of concern that were assessed by the Client and MTC's GPR scans were the walls of the inlet and outlet wells. There was not time for improving access to acquire GPR data and cores within the screen rooms.

## ***GPR Methodology:***

Ground Penetrating RADAR (GPR) typically uses a radio energy source to scan the subsurface for buried objects, structural or textural changes. MTC's GPR method employed the SIR-3000 unit, produced by Geophysical Survey Systems, Inc. with a 1600-MHz (megahertz) bi-static antenna. The bi-static antenna houses both the radio source and reflected signal receiver.

In the GPR method, a spherical radio wave is generated by the antenna, whose design causes the radio energy to be directed primarily into the ground. The wave penetrates the subsurface nearly instantaneously, whose speed depends upon the magnetic susceptibility, or the density, of the medium being investigated. As the wave propagates through the subsurface, when a material with significantly different density is encountered, a reflection is returned to the antenna. The reflected wave returns to the antenna in the “two-way travel time”, measured in nanoseconds. Based on the medium’s density and the reflection’s two-way travel time, the SIR-3000 computes a target equivalent depth (in feet). All GPR profiles reveal encountered reflections, or anomalies, as well as showing the signal of the surrounding medium, the “background” signal.

The shape and amplitude of each anomaly depends on its composition and that of the surrounding medium. Typically, an air void or lighter density region will return an anomaly characterized by dark, or weak, bands with a span dependent on the depth and extent of the void. A dense or electrically conductive object encased in concrete, like rebar or post-tension tendon, will return a positive reflection, characterized by a bright signal with apex at the top of the bar. A positive reflector, if sufficiently dense or metallic, can also produce multiple reflections that continue downward through the profile, a result of the reflected wave bouncing off the object and antenna continuously.

Important limitations of the GPR method for scanning for subsurface objects include but are not limited to the following. The depth of investigation is limited by the type of antenna and the soil type and moisture. Typically the 1600-MHz antenna can penetrate at least 18 inches and up to about 3 feet below the surface under ideal conditions, which comprise concrete with typical embedments. The presence of densely spaced rebar or mesh, and possibly larger aggregate (e.g. 1-inch dia.) can attenuate the GPR signals from deeper embedments, potentially obscuring those objects. The rule of thumb for resolving objects is the 1 inch per 1 foot rule, which states that for every 1 foot of depth, GPR will not detect objects smaller than the equivalent inches in diameter. Therefore, an object that is 2 inches diameter and 2 feet below grade is considered to be at the detectable limit and may or may not be resolvable from the background signal. Materials of lower magnetic susceptibility (e.g. PVC or air-filled conduit) are more difficult to resolve relative to surrounding concrete.

***GPR Results:***

Results of the GPR scans were positive for rebar at most locations during the investigation within the inlet and outlet wells and the water supply tunnel. Figure 2 exhibits the approximate locations of the GPR scans and resulting profiles. Appendix A shows representative photographs of scan and concrete coring areas. Appendix B shows representative GPR scan profiles resulting from horizontal, vertical, and circumference scans taken in the inlet and outlet wells and the supply tunnel.

*GPR Profiles 198 and 199* were scanned in an area of the wall located between the two screen room gates in the outlet well. Profile 198 was taken vertically in order to detect rebar and to verify a “safe” box for concrete coring to be performed. As shown in the attached scan for 198, horizontal rebar signals were acquired, and the joint visible at the concrete surface was also detected. Rebar appeared to be on approximate 1-foot centers. Profile 199 was taken horizontally running toward the left screen room gate as facing toward the inlet well. As shown, one strong vertical rebar signal was encountered between the corner in the wall and the screen room gate opening.

*GPR Profile 205* was scanned on the wall between the left gate in the outlet well and the outlet shaft. As shown in the attached scan for 205, one anomaly possibly positive for horizontal rebar was acquired higher in the record, approximately at the height of the gate. There was much high-frequency noise typical of large aggregate identified in the shallower portion of the profile, which can produce masking of signal from beneath. However, other signals typical for rebar were not observed.

*GPR Profiles 209 and 210* were scanned in the water supply tunnel that feeds the inlet well. Profile 209 was taken horizontally along the axial direction and on the south side of the tunnel wall running toward Lake Whatcom. This scan positively identified signals consistent with rebar oriented transverse to the direction and surrounding the tunnel. Profile 210 was taken vertically and in circumference around the tunnel. This scan positively identified signals consistent with rebar oriented in the axial direction along and surrounding the tunnel. In both profiles, a visible surface joint in the concrete was verified by the GPR scans.

*GPR Profiles 213, 216-217, & 219* were scanned at the wall to the right and left, respectively, of the supply tunnel as one faces Lake Whatcom. This was also the location of the second core hole sample for compressive strength testing. Profile 213 was taken vertically along the wall in order to create a safe coring box as well as identify potential rebar. Anomalies that may potentially indicate but are not verified for rebar were encountered. As shown in Profile 216, also taken vertically, a signal characteristic of surface joint or change was observed with a potentially strong signal beneath it. Profile 217 was the result of a low-pass filter on the same scan to remove high-frequency noise from large aggregate and the surface anomaly, which left a deeper signal that may potentially represent rebar. Other signals positive for rebar were not encountered. Profile 219 was taken horizontally to the left of the tunnel in order to detect possible rebar signals. Signals positive for rebar were acquired on about 1-foot to 16-inch spacings.

*GPR Profile 220* was scanned at the tunnel wall running axially in the direction of the tunnel toward Lake Whatcom. Signals positive for rebar were acquired on approximate 1-foot centers. Again, the visible joint at the concrete surface was also detected, as noted.

GPR Profile 222 was scanned above the closed gate to the central, or waste, well. The scan was performed vertically above the closed gate, and signals positive for the presence of rebar were detected.

***Discussion and Recommendations:***

While on site, MTC took photographs, discussed and observed the areas of concern as directed by the Client. As relayed by the Client, Figures 2A and 2B contain information about the original chlorine house structure, including plan concrete walls and rebar locations.

At most locations of investigation using the GPR method, MTC observed evidence of rebar, with apparent exception to horizontal hoop bars expected to be located to the left and right of the screen room gates to the outlet well, respectively. Signals for horizontal rebar were acquired between the two screen room gates, and some signals positive for vertical rebar were located, albeit not apparently on regular intervals. Again, horizontal hoop bars were not verified on vertical scans to the left and right of the supply tunnel, respectively. However, vertical rebar was identified. Rebar was positively identified above the tunnel ceiling level on the adjacent wall. There were also signals potentially positive for rebar acquired above the tunnel ceiling and top of screen gate levels.

MTC subsequently evaluated all of the scans taken within the inlet and outlet wall areas in order to ascertain the potential for the presence of the horizontal hoop bars. Again, GPR signals positive for vertical bars were confirmed, but the presence of horizontal hoop bars was inconclusive.

GPR scans taken within the supply tunnel were positive and consistent for rebar running both along its length in the direction of Lake Whatcom and surrounding its circumference. Rebar was also detected in a short vertical scan running horizontally above the gate to the central waste well.

MTC recommends that, should the Client wish to better delineate the presence, or lack thereof, of horizontal hoop bars within the inlet and outlet wells, that additional investigation shall be useful.

Results of the Schmidt Hammer tests that were conducted by MTC are included in Appendix C. They were performed concurrently with the concrete coring and compared with the concrete compressive strength results.

***Closing Remarks:***

MTC would be pleased to be retained at the request of the client for additional geophysical structure scans toward the goal of structural assessment. We recommend the results of this geophysical structure scan report and limited investigation be considered by the Client in planning of construction or repair

activities. MTC may be contacted for additional pre-design consultation on the feasibility of potential repair methods based on the discussion and results presented herein.

Mr. Martinez, we trust this report presents the information you require. If you have questions, please do not hesitate to call.

Respectfully Submitted;



---

Leland B. Rupp, P.E.  
Geotechnical Division Manager

- Attached:
- Limitations and Use of this Report
  - Figure 1 – Site Map
  - Figure 2 – GPR Sketch, Structural Plans & Sections
  - Appendix A – Site Photographs
  - Appendix B – Representative GPR Profiles
  - Appendix C – Daily Report with Schmidt Hammer Concrete Results

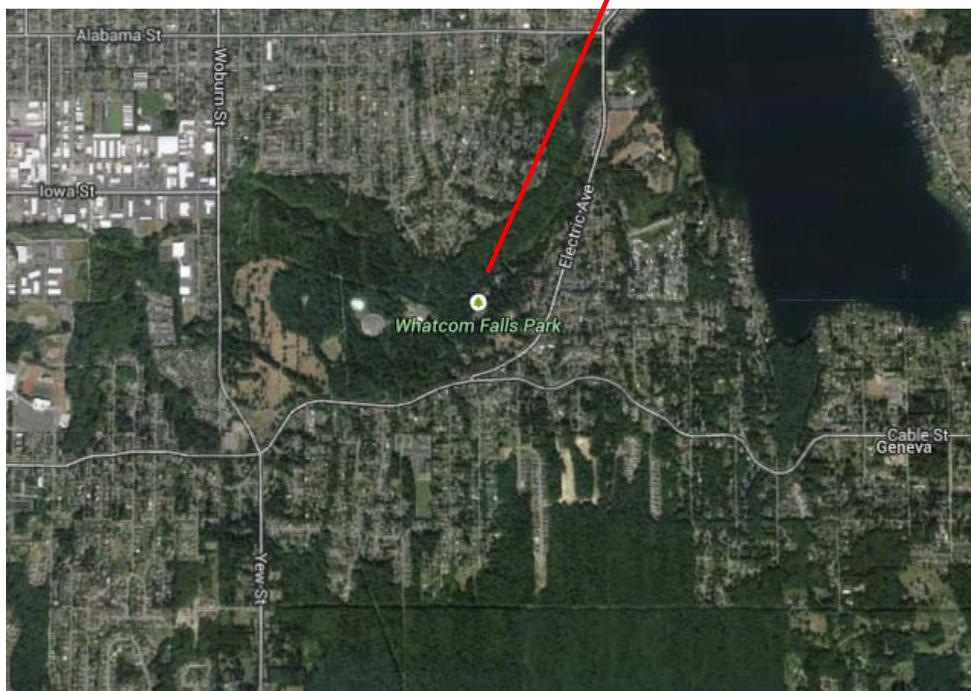
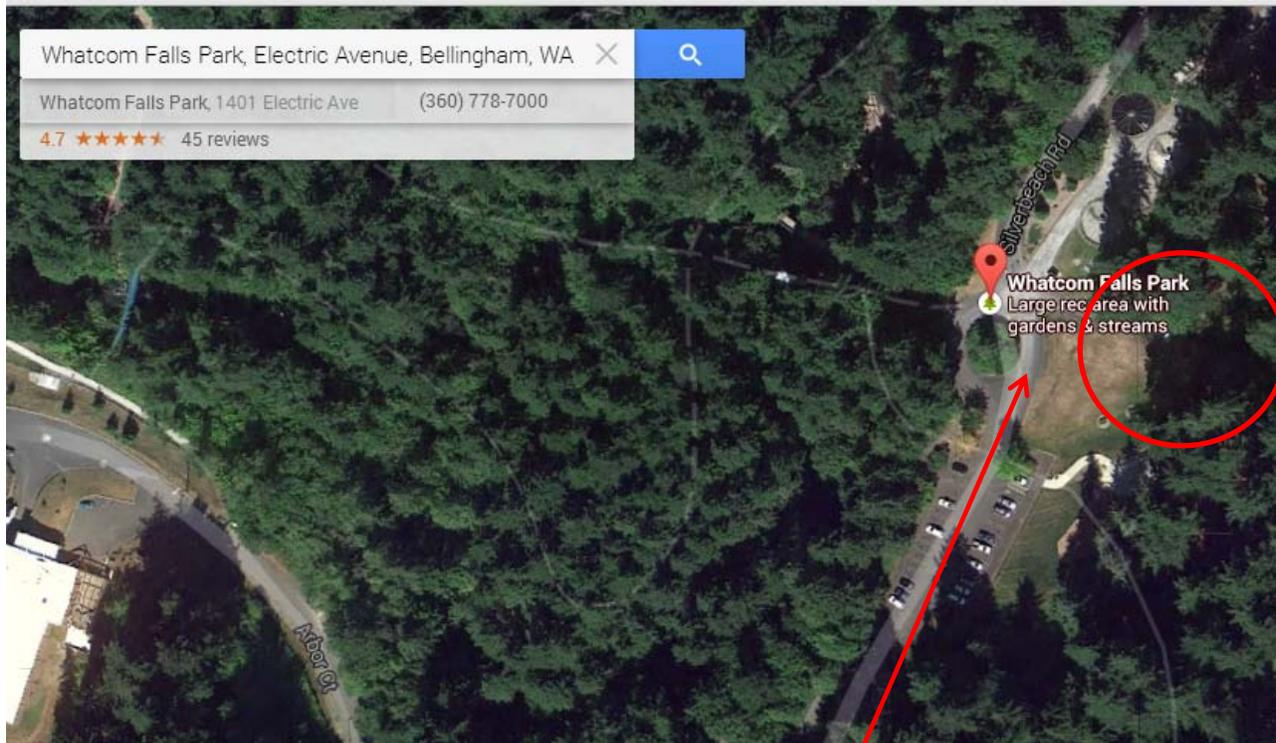
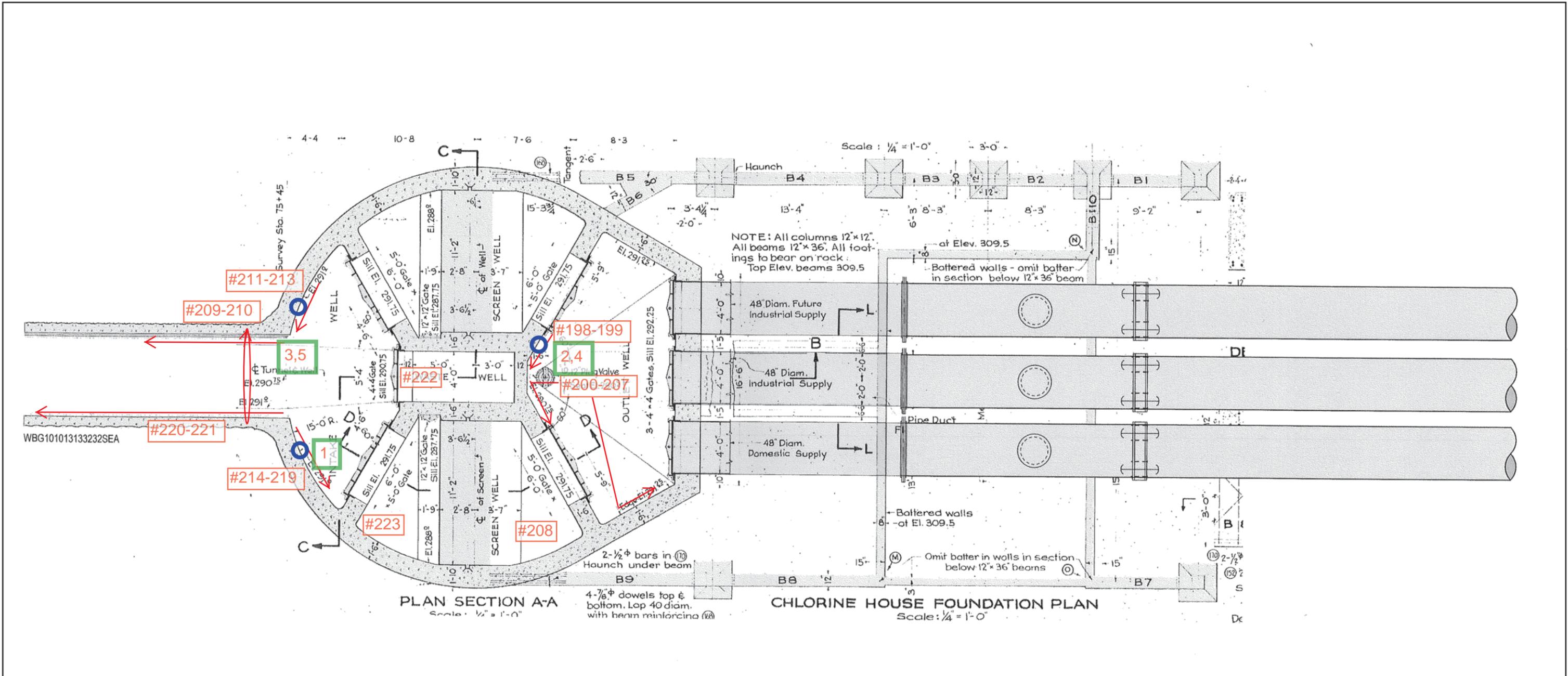


Figure 1 – Site Map  
Project: Whatcom Falls Park – Chlorine House





Legend

- #214-219 Approx. GPR profile & direction
- 1 Location of photograph
- Approx. location of concrete core sample

Figure 2A- GPR Profiles Sketch  
 Whatcom Falls Chlorine House  
 Structural Assessment 4-23-2014



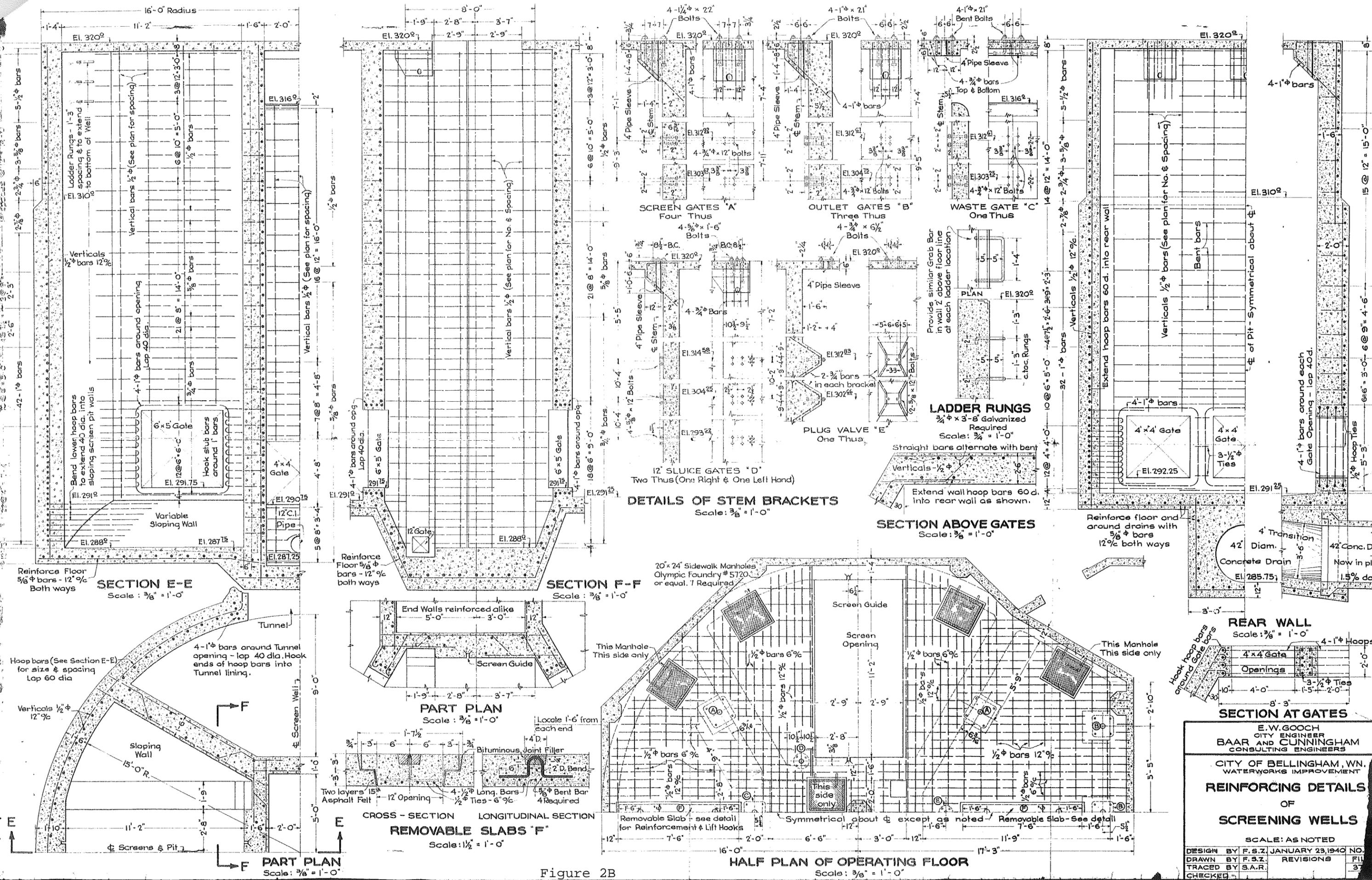


Figure 2B

**E.W. GOOCH**  
 CITY ENGINEER  
**BAAR AND CUNNINGHAM**  
 CONSULTING ENGINEERS

CITY OF BELLINGHAM, WN.  
 WATERWORKS IMPROVEMENT

**REINFORCING DETAILS**  
 OF  
**SCREENING WELLS**

SCALE: AS NOTED

DESIGN BY F.S.Z. JANUARY 23, 1940 NO.	REVISIONS	FILE
DRAWN BY F.S.Z.		
TRACED BY S.A.R.		
CHECKED		



Appendix A

Photographs





**1. PROJECT: Whatcom Falls Chlorine House**

**LOCATION: Bellingham, WA**

Inlet well concrete wall located between water supply tunnel and screen room gate.



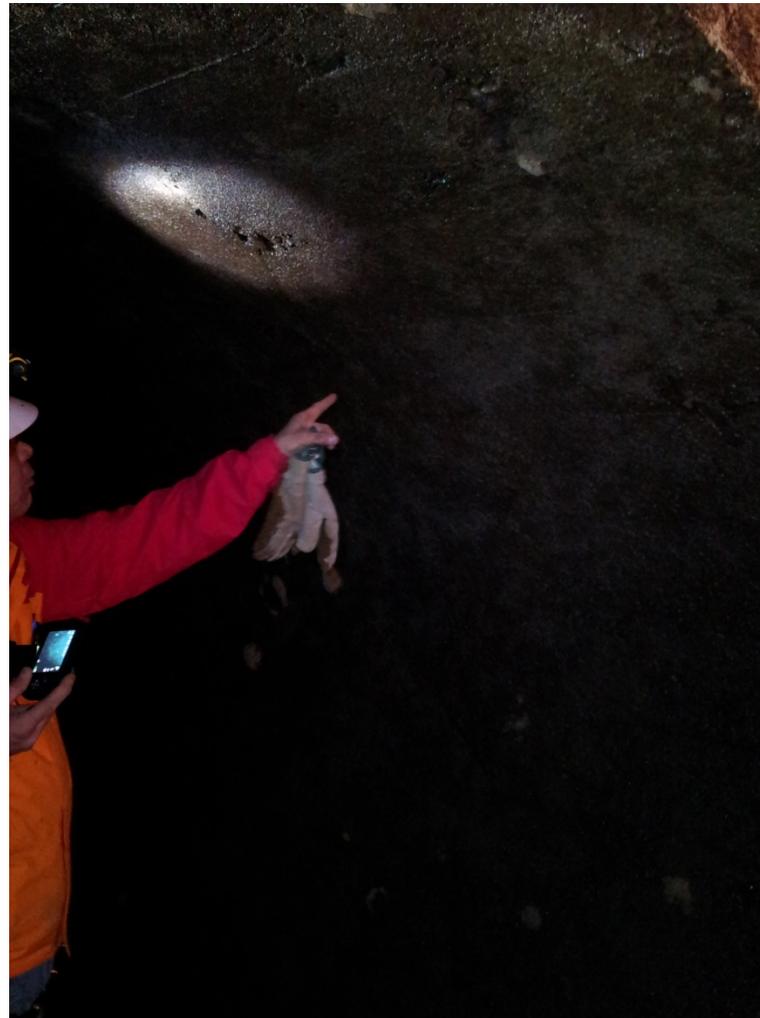
2. Vertical GPR scan being performed along wall adjacent to screen gate in outlet well.



3. Concrete water supply shaft from Lake Whatcom to screenhouse and ultimately Bellingham treatment facility.



4. Reinforced concrete basement wall at chlorine house outlet well cored for compression testing.

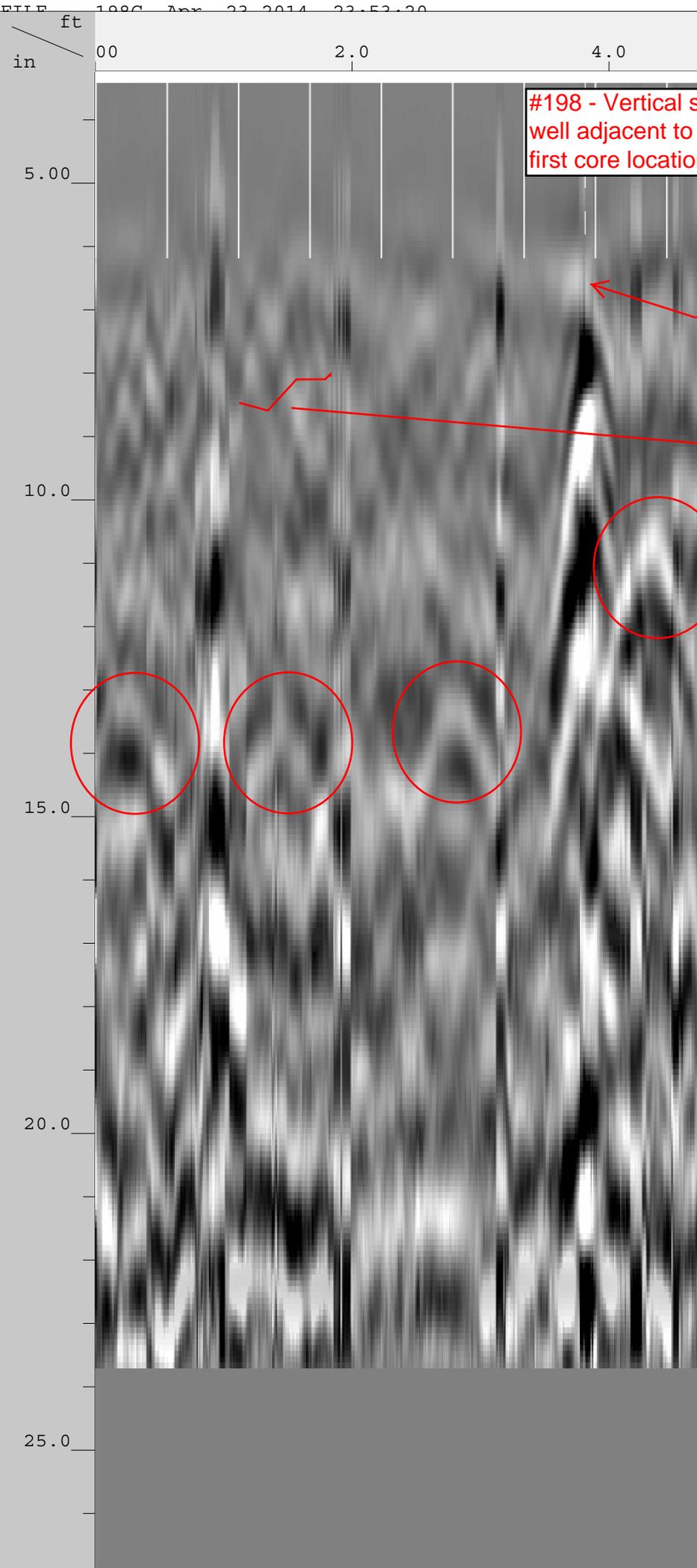


5. Surficial joint exposure running the circumference of the water supply tunnel about 3 feet east of the opening to inlet well.



Appendix B  
Representative GPR Profiles





#198 - Vertical scan at wall in outlet well adjacent to screen room gate and first core location

Scanned over surface joint

Background noise from large aggregate

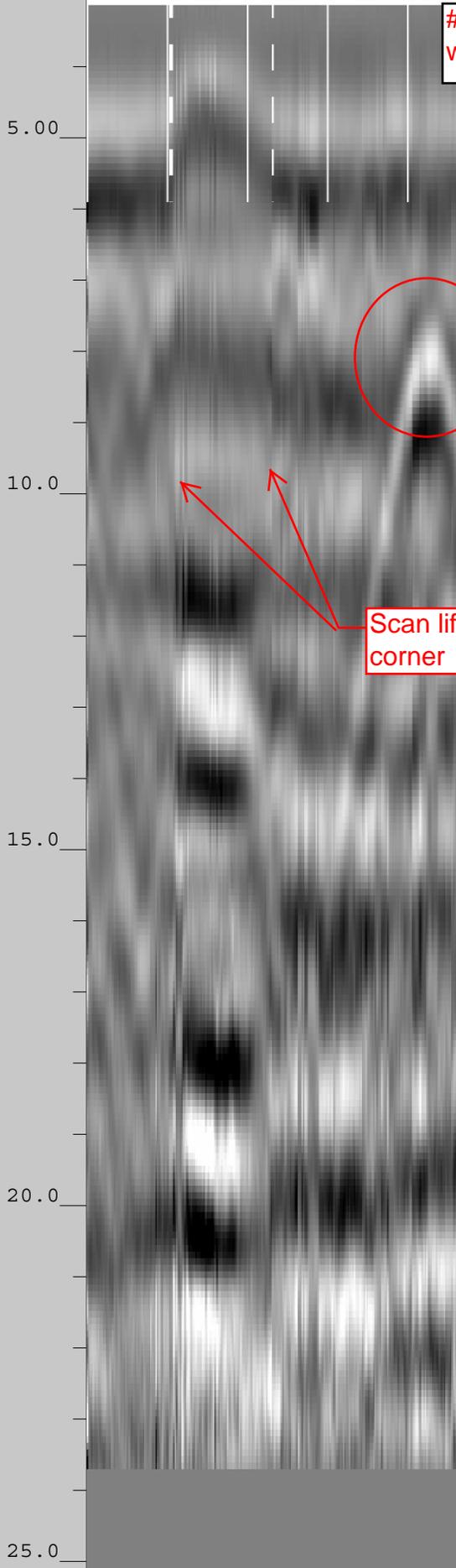
Rebar signals

ft  
in  
00  
2.0  
4.0  
5.00  
10.0  
15.0  
20.0  
25.0



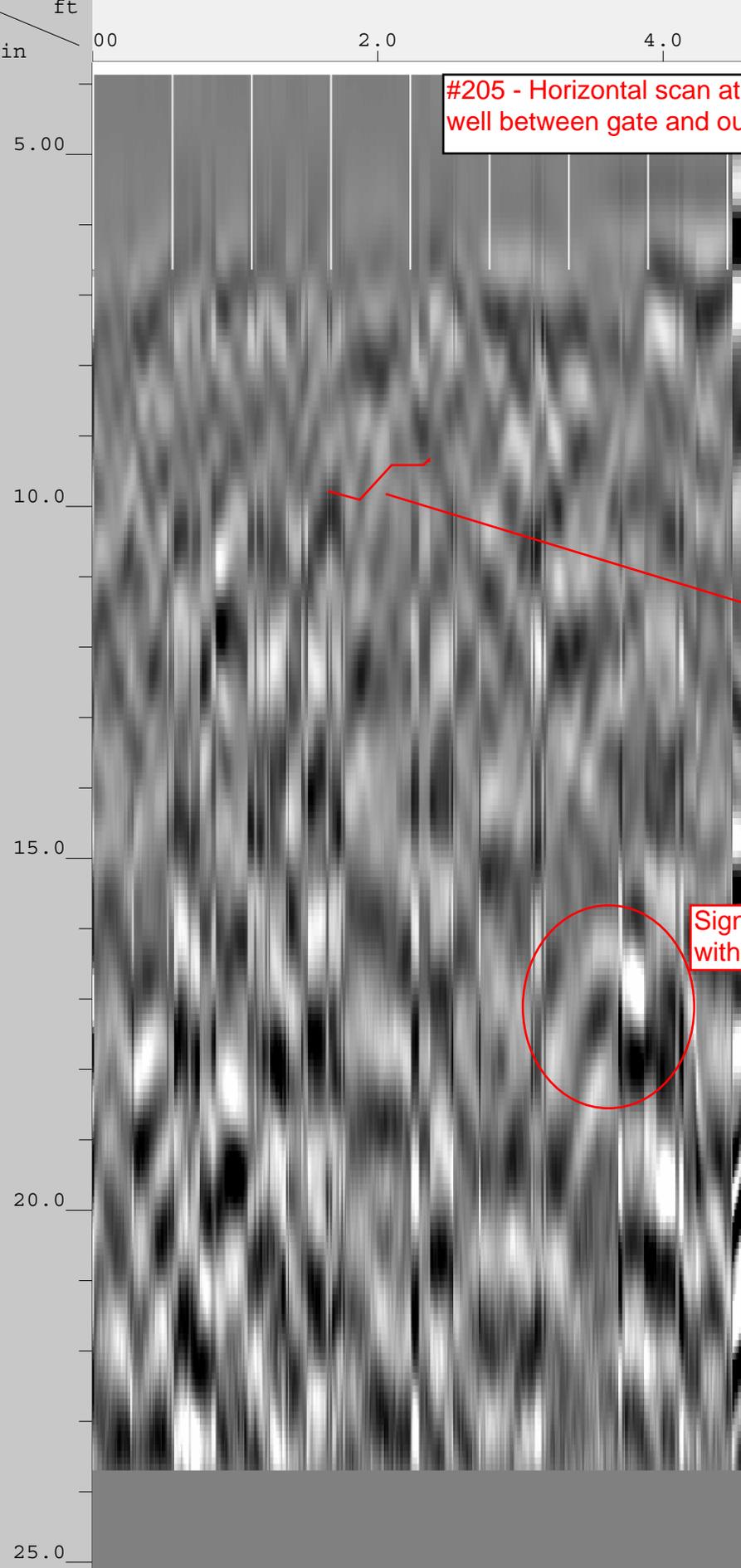
ft  
in 00 2.0

#199 - Horizontal scan at wall in outlet well adjacent to screen room gate



Rebar signal

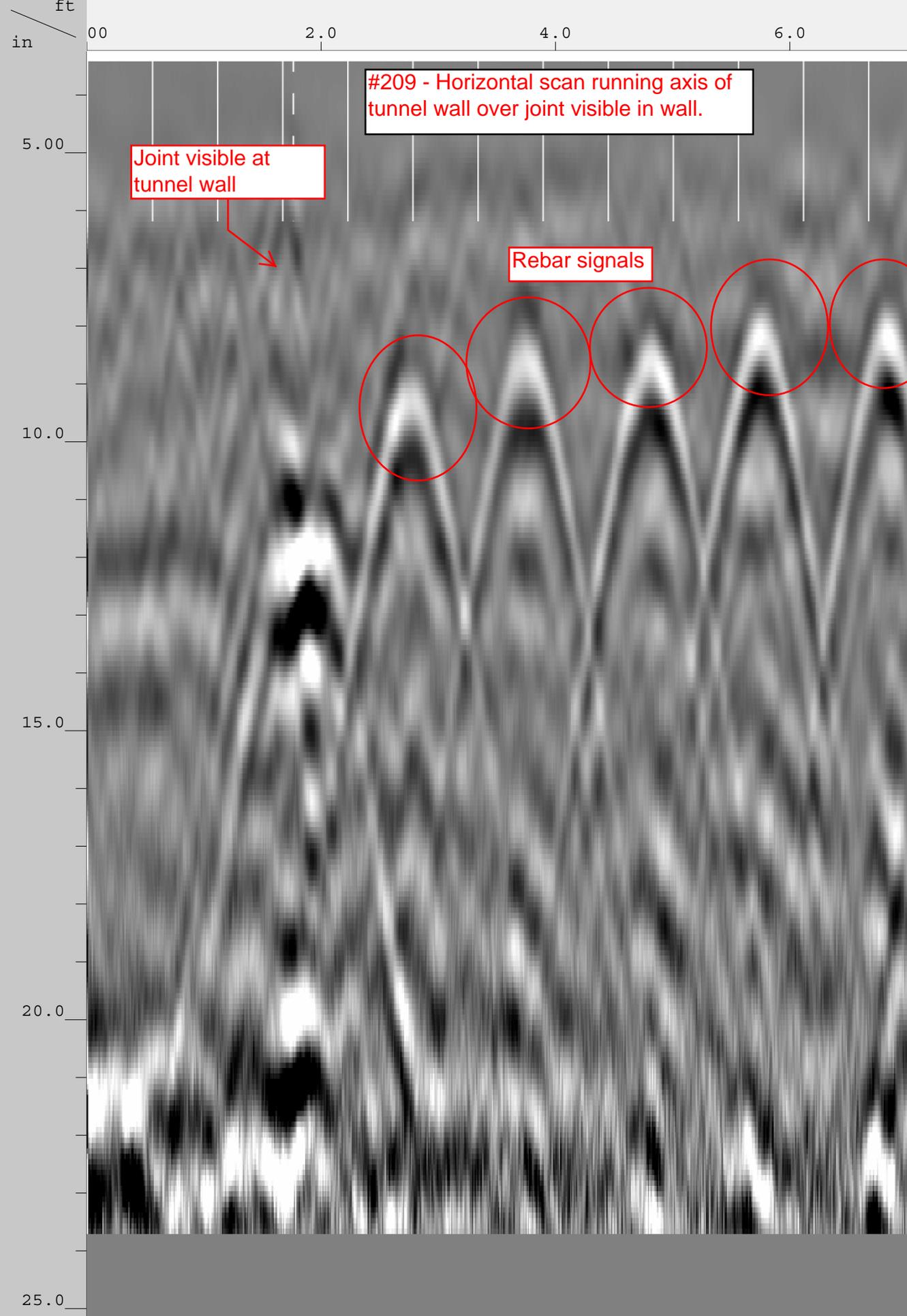
Scan lifted over corner



#205 - Horizontal scan at wall in outlet well between gate and outlet shaft

Background noise from large aggregate

Signal consistent with rebar



in 00 2.0 4.0 6.0 8.0 10.0

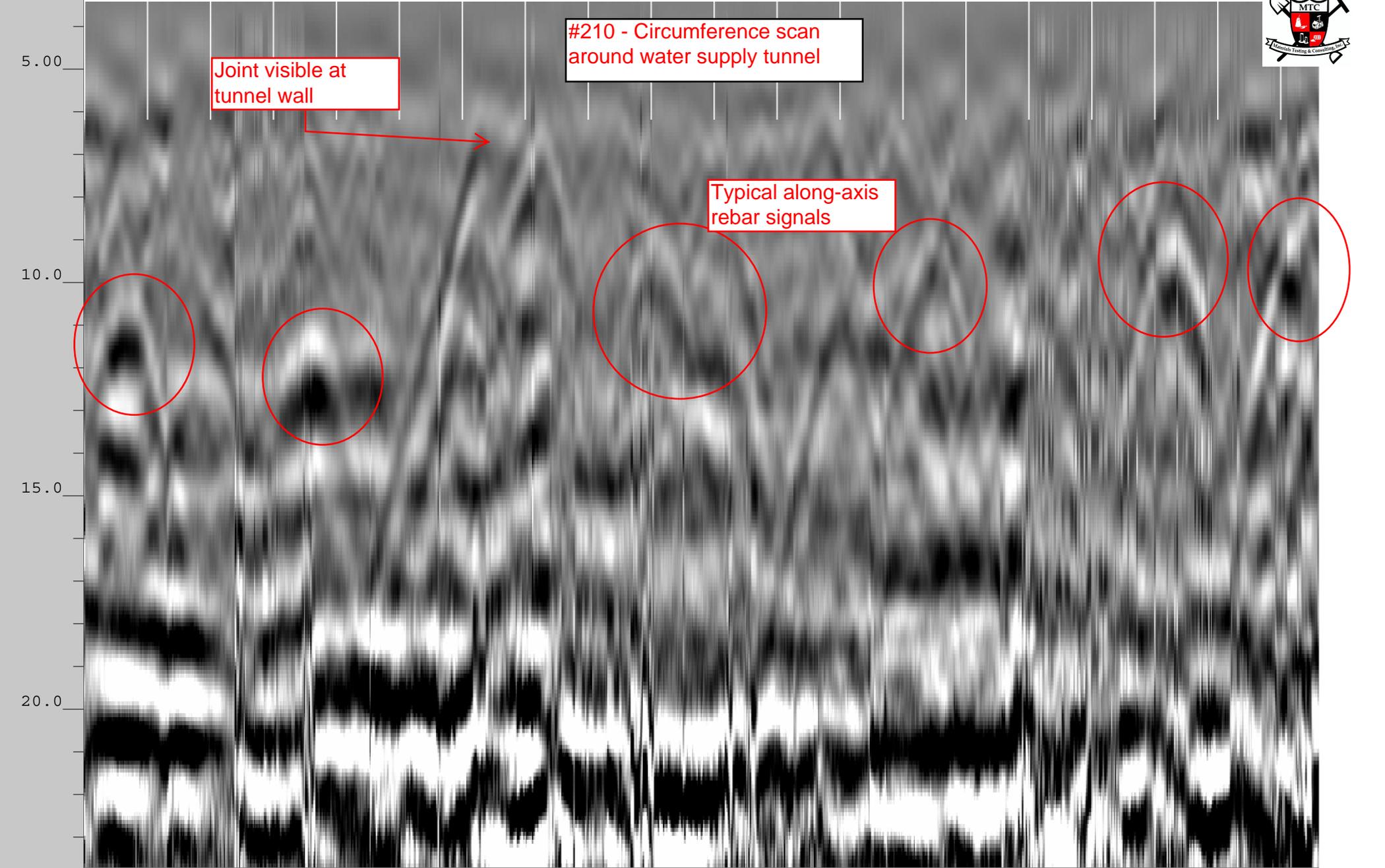
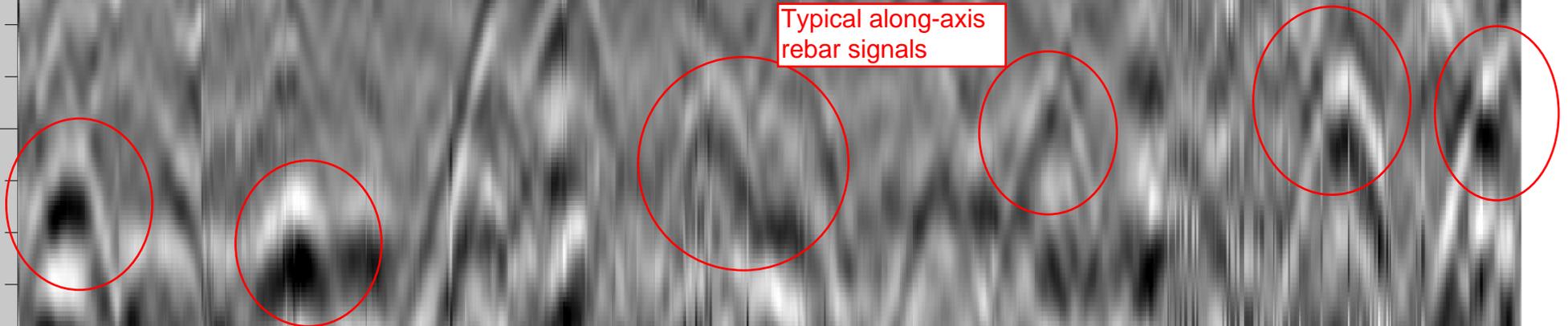


#210 - Circumference scan around water supply tunnel

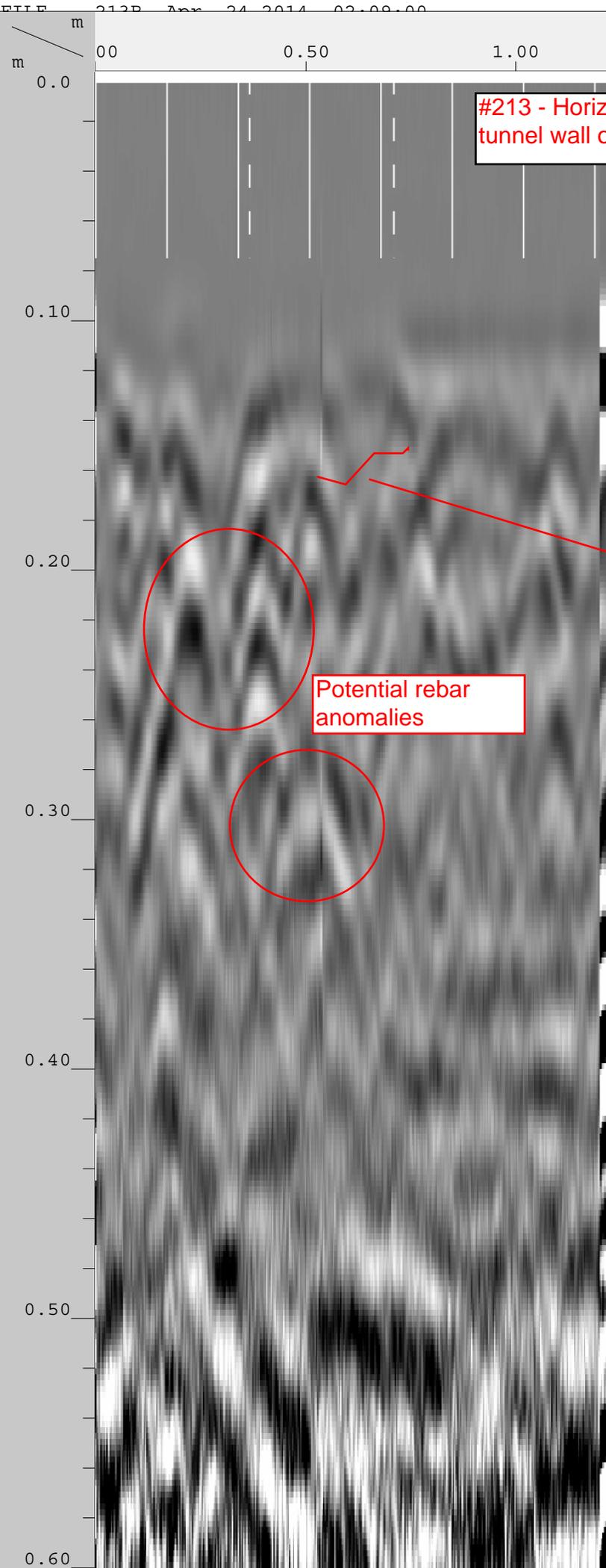
Joint visible at tunnel wall



Typical along-axis rebar signals



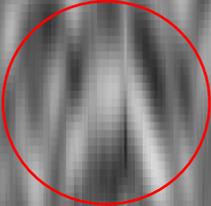
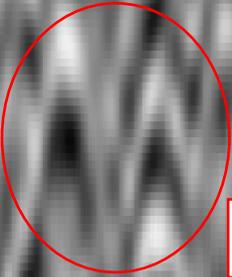
5.00  
10.0  
15.0  
20.0  
25.0

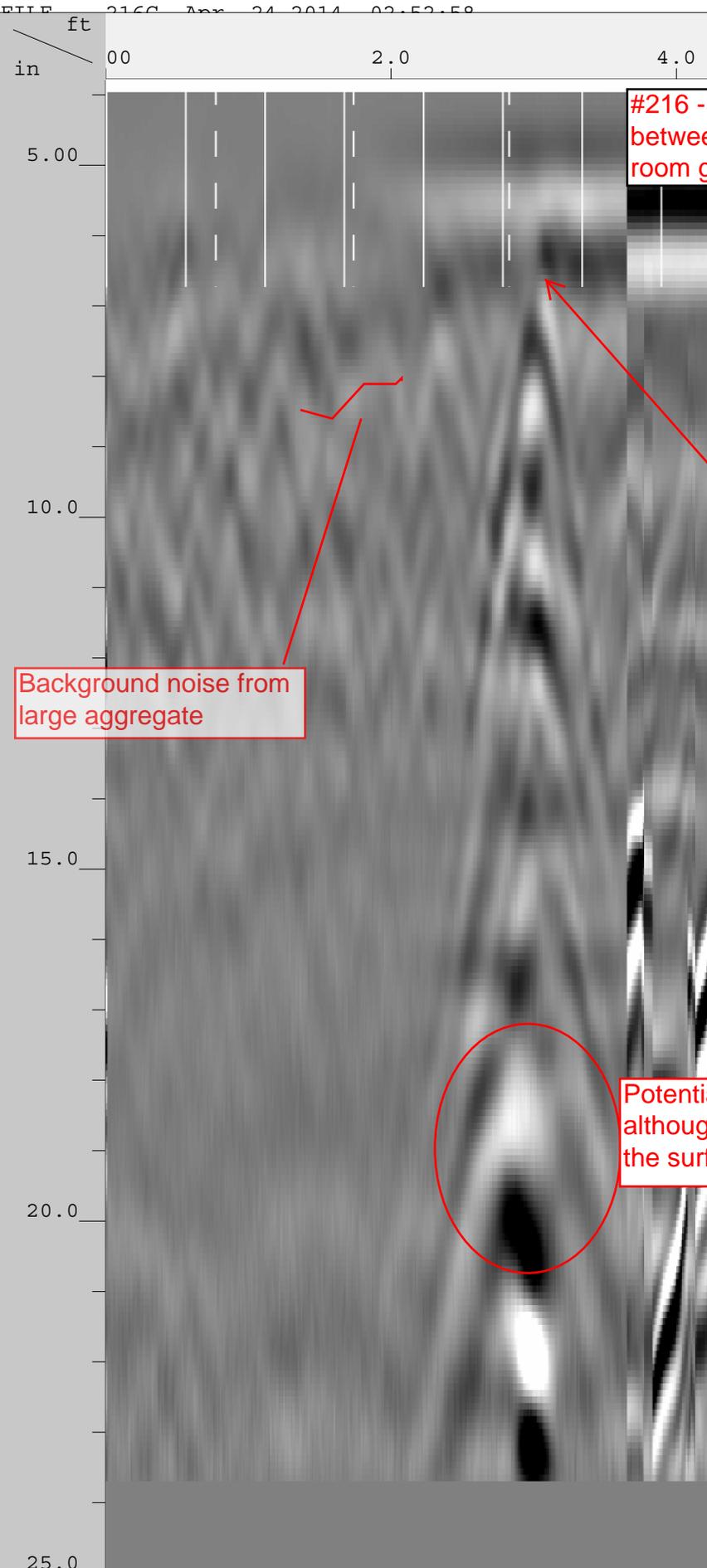


#213 - Horizontal scan running axis of tunnel wall over joint visible in wall.

Background noise from large aggregate

Potential rebar anomalies



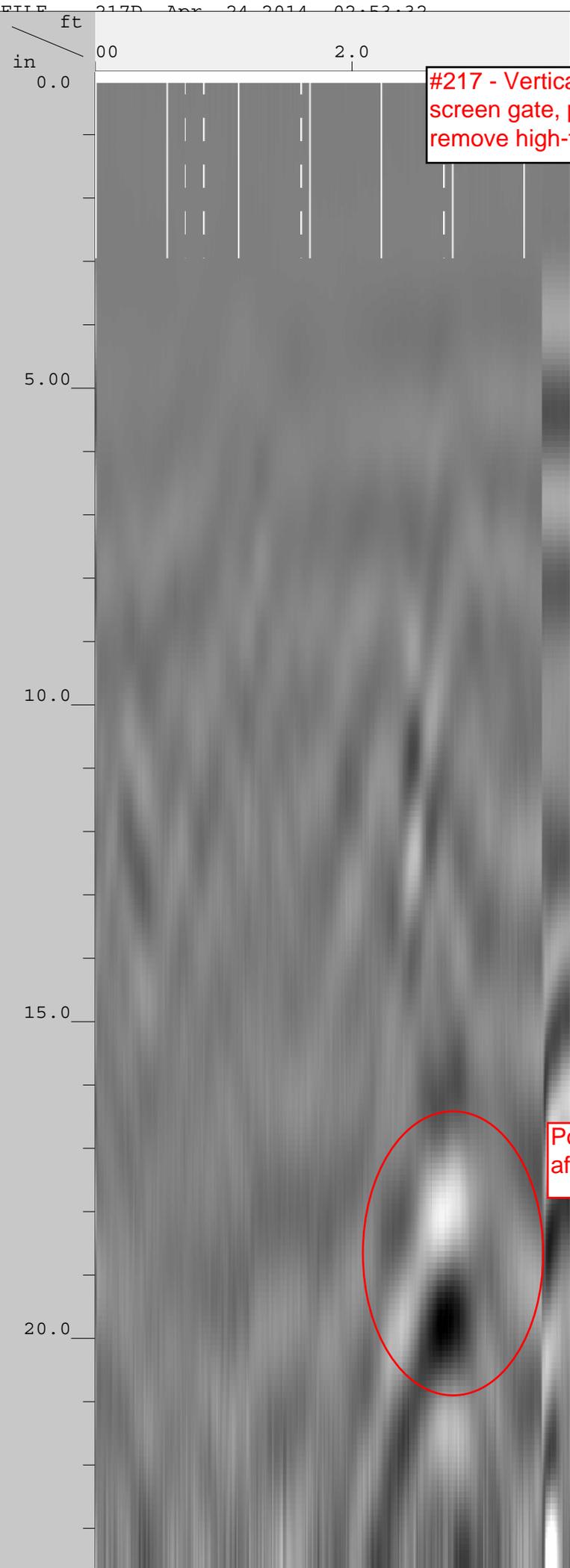


#216 - Vertical scan along wall between supply tunnel and screen room gate.

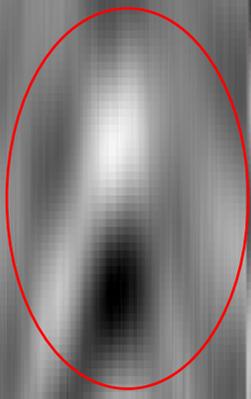
Typical surface joint or other

Background noise from large aggregate

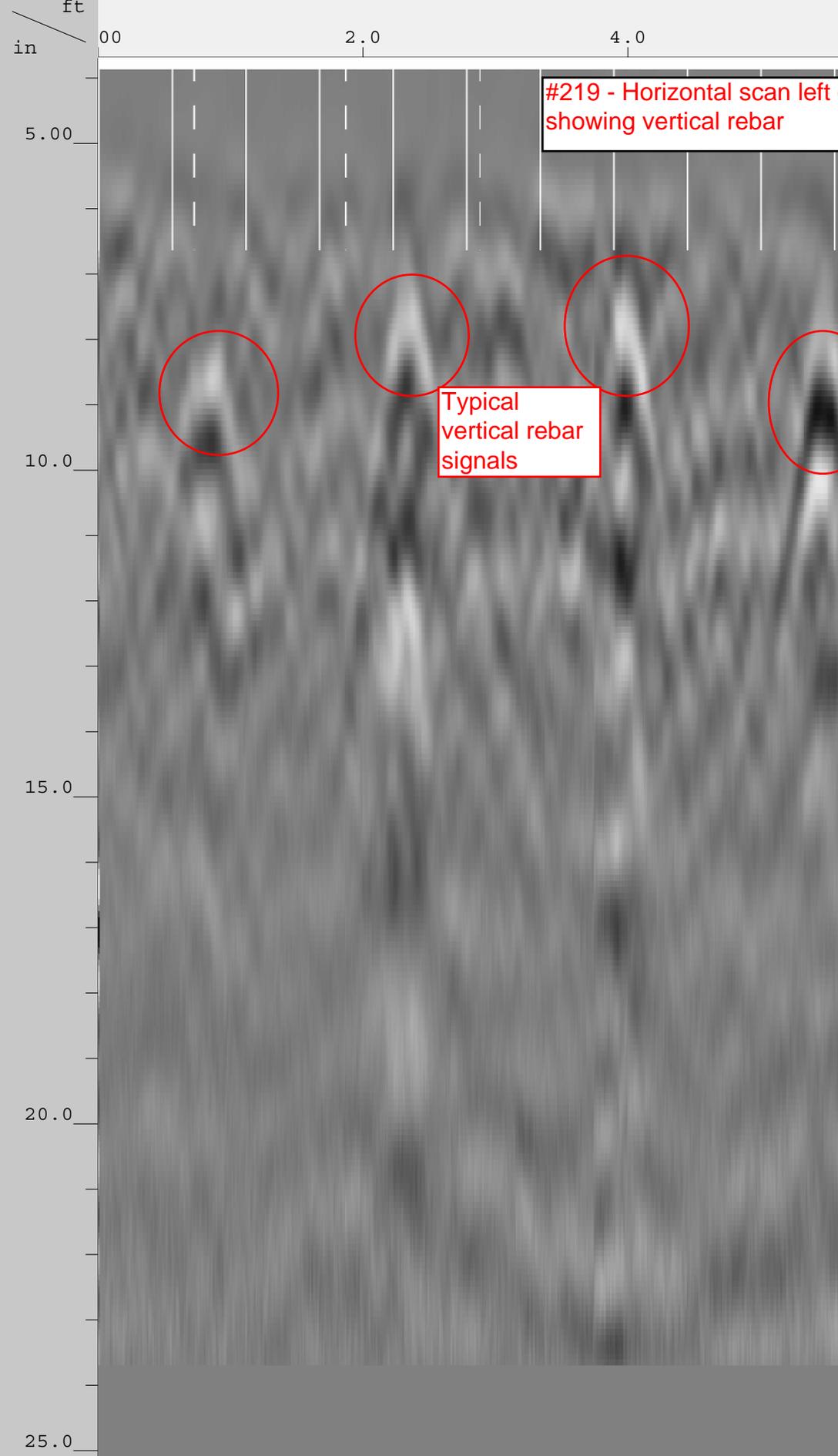
Potential rebar anomaly, although directly beneath the surface anomaly



#217 - Vertical scan between tunnel and screen gate, processed with low-pass filter to remove high-frequency noise



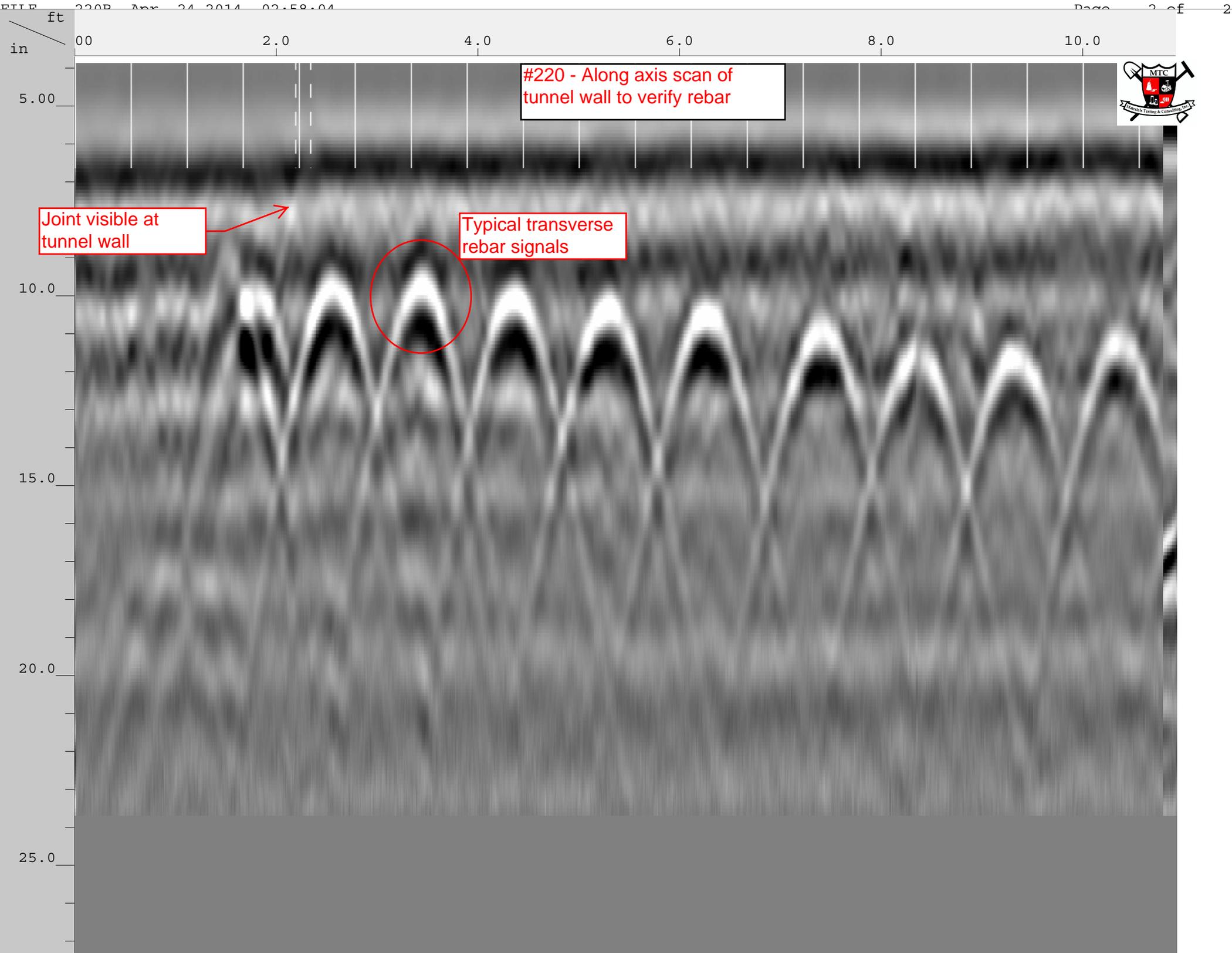
Potential rebar anomaly, after low-pass filter

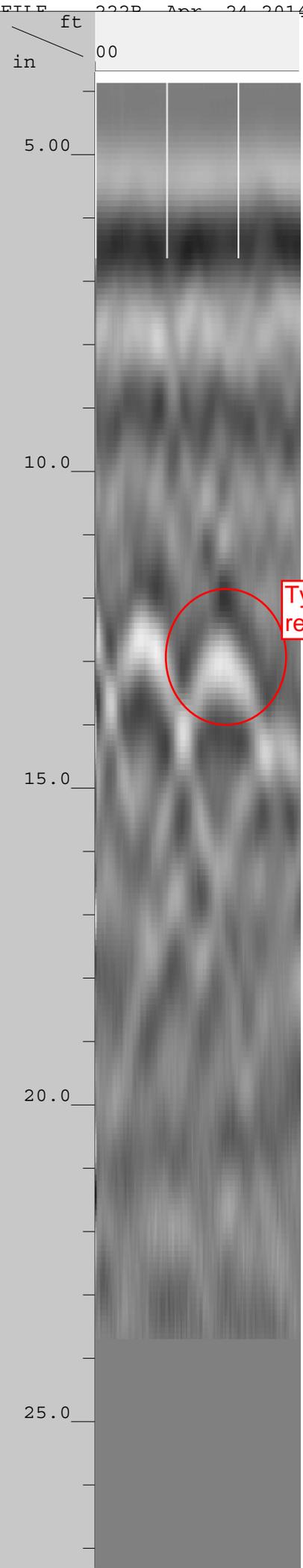


#219 - Horizontal scan left of supply tunnel, showing vertical rebar

Typical vertical rebar signals







#222 - Vertical scan above the gate to the waste well



Typical horizontal rebar signal



## Appendix C

### Daily Report with Schmidt Hammer Results



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## CH2MHill Forensic Investigation - 14W022 - Field Report: Other: Report #F57778

<b>CLIENT</b>	CH2MHill	<b>DATE</b>	04/23/2014
<b>PROJECT LOCATION</b>	TBD Bellingham WA	<b>PERMIT #</b>	

### Inspection Information:

**Inspection Date:** 04/23/2014    **Time Onsite:** 08:00 AM    **Weather Conditions:**

**Inspection Performed:**

### Comments:

MTC on site per client request to conduct coring of concrete and ground penetrating radar scanning on the existing structure during the structural forensic investigation walk through. At this time MTC met with the client representatives on site to discuss the plan of action for the day and the process on how the investigation was going to be organized.

MTC conducted a visual walk through investigation with client to decide on the locations of coring and radar scanning depending on the signs of structural deterioration. Areas of coring and scanning were decided inside the outlet well and the intake well. MTC conducted coring of the existing concrete and GRP scanning inside the outlet well and intake well, and also provided Schmidt hammer testing on the surface of the concrete wall prior to coring for correlation purposes. The areas of coring and compression test results, as well as the results of the Schmidt hammer testing are noted below. As a note Schmidt hammer testing is not an accurate substitute for compressive strength and can range from a 15% to 20% difference.

- 1.) The outlet well left of the north screen well roughly 5' from the bottom: Reference MTC concrete report #C36669, concrete core compressive strength was 5220 psi and the Schmidt hammer surface rebound testing was 44.3 (equates to roughly 5800 psi).
- 2.) The inlet well 3' to the right (South) of the tunnel well pipe and 5' from the bottom: Reference MTC concrete report #C36670, concrete core compressive strength was 4370 psi and the Schmidt hammer surface rebound testing was 36.6 (equates to roughly 4200 psi).
- 3.) The inlet well 4' to the Left (North) of the tunnel well pipe and 5' from the bottom: Reference MTC concrete report #C36671, concrete core compressive strength was 5360 psi and the Schmidt hammer surface rebound testing was 37.2 (equates to roughly 4400 psi).

### Images:

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UPLOADED: 04/27/2014 11:53:00

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UPLOADED: 04/27/2014 11:54:00

REPORTED BY: Michael Currie

REVIEWED BY: Raymond McNamara, Project Manager

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## CH2MHill Forensic Investigation - 14W022 - Compression Test: Concrete: Report #C36669

**CLIENT** CH2MHill **DATE** 04/23/2014  
**PROJECT LOCATION** TBD **PERMIT #**  
Bellingham WA

### Inspection Information:

**Inspection Date:** 04/23/2014 **Time Onsite:** 08:00 AM **Weather Conditions:** Partly Cloudy

**Inspection Performed:** Compression Test: Concrete

### Field Data (ASTM C-31):

**Location of Placement:** Existing concrete wall in the Outlet Well

**Sample Location:** 3" Core by MTC inside the Outlet well left of the north screen well roughly 5' from the bottom.

**Contractor:** CH2MHill **Subcontractor:** N/A **Supplier/Plant:** N/A

**Qty Placed, Cu. Yd.:** N/A **Slump, Inches (ASTM C-143) or W/C Ratio:** N/A **Concrete Temp, °F (ASTM C-1064):** N/A

**Delivery Ticket #:** N/A **Job Spec. Slump:** N/A **Ambient Temp, °F:** N/A

**Truck #:** N/A **Air Content, % (ATSM C-231):** N/A **Min Temp, °F:**

**Batch Time:** N/A **Job Spec. Air:** N/A **Max Temp, °F:**

**Sample Time:** 15:00

**Mix # and Proportions:** Existing Concrete Wall

**Cement, lbs.:**  **Coarse Agg, lbs.:**  **Admixture, oz./cwt:**

**Flyash, lbs.:**  **Coarse Agg, lbs.:**  **Admixture, oz./cwt:**

**Water, gals.:**  **Coarse Agg, lbs.:**  **Admixture, oz./cwt:**

**Fine Agg, lbs.:**  **Coarse Agg, lbs.:**  **Admixture, oz./cwt:**

### Sample Type & Compression Test Results:

**Received** 04/23/2014 **Sample Set** 1 of 3 **Type of Compression Test:** Other

### Lab Tests:

New Log #	Test Age (Days)	Date of Test	Total Load (Lbs.)	Sample Dim. (In.)	Sample Area (Sq. In.)	Comp. Strength (PSI)	Tested By	Break Type	ASTM C-617	ASTM C-1231
1274	1	04/24/2014	30,302	2.72	5.81	5,220	Cheryl Meredith	4	<input checked="" type="checkbox"/>	<input type="checkbox"/>
REQ'D	28									

### Remarks:

MTC on site per client request to conduct coring of existing concrete walls inside of the Outlet well and Intake well. Locations on where to core were from the direction of CH2MHill.

REPORTED BY: Michael Currie      REVIEWED BY: Curtis Shear, Lab Manager

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## CH2MHill Forensic Investigation - 14W022 - Compression Test: Concrete: Report #C36670

CLIENT CH2MHill DATE 04/23/2014  
PROJECT LOCATION TBD PERMIT #  
Bellingham WA

### Inspection Information:

Inspection Date: 04/23/2014 Time Onsite: 08:00 AM Weather Conditions: Partly Cloudy

Inspection Performed: Compression Test: Concrete

### Field Data (ASTM C-31):

Location of Placement: Existing concrete wall in the Inlet Well

Sample Location: 4" Core by MTC inside the Inlet well 3' to the right (South) of the tunnel well pipe and 5' from the bottom.

Contractor: CH2MHill Subcontractor: N/A Supplier/Plant: N/A

Qty Placed, Cu. Yd.: N/A Slump, Inches (ASTM C-143) or W/C Ratio: N/A Concrete Temp, °F (ASTM C-1064): N/A

Delivery Ticket #: N/A Job Spec. Slump: N/A Ambient Temp, °F: N/A

Truck #: N/A Air Content, % (ATSM C-231): N/A Min Temp, °F:

Batch Time: N/A Job Spec. Air: N/A Max Temp, °F:

Sample Time: 15:00

Mix # and Proportions: Existing Concrete Wall

Cement, lbs.: Coarse Agg, lbs.: Admixture, oz./cwt:

Flyash, lbs.: Coarse Agg, lbs.: Admixture, oz./cwt:

Water, gals.: Coarse Agg, lbs.: Admixture, oz./cwt:

Fine Agg, lbs.: Coarse Agg, lbs.: Admixture, oz./cwt:

### Sample Type & Compression Test Results:

Received 04/23/2014 Sample Set 2 of 3 Type of Compression Test: Other

### Lab Tests:

New Log #	Test Age (Days)	Date of Test	Total Load (Lbs.)	Sample Dim. (In.)	Sample Area (Sq. In.)	Comp. Strength (PSI)	Tested By	Break Type	ASTM C-617	ASTM C-1231
1275	1	04/24/2014	54,832	4.00	12.56	4,370	Cheryl Meredith	4	<input checked="" type="checkbox"/>	<input type="checkbox"/>
REQ'D	28									

### Remarks:

MTC on site per client request to conduct coring of existing concrete walls inside of the Outlet well and Intake well. Locations on where to core were from the direction of CH2MHill.

REPORTED BY: Michael Currie REVIEWED BY: Curtis Shear, Lab Manager

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## CH2MHill Forensic Investigation - 14W022 - Compression Test: Concrete: Report #C36671

<b>CLIENT</b>	CH2MHill	<b>DATE</b>	04/23/2014
<b>PROJECT LOCATION</b>	TBD Bellingham WA	<b>PERMIT #</b>	

### Inspection Information:

Inspection Date: 04/23/2014    Time Onsite: 08:00 AM    Weather Conditions:

Inspection Performed:

### Field Data (ASTM C-31):

Location of Placement:

Sample Location:

Contractor:     Subcontractor:     Supplier/Plant:

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Delivery Ticket #:	<input type="text" value="N/A"/>	Job Spec. Slump:	<input type="text" value="N/A"/>	Ambient Temp, °F:	<input type="text" value="N/A"/>
Truck #:	<input type="text" value="N/A"/>	Air Content, % (ATSM C-231):	<input type="text" value="N/A"/>	Min Temp, °F:	<input type="text" value=""/>
Batch Time:	<input type="text" value="N/A"/>	Job Spec. Air:	<input type="text" value="N/A"/>	Max Temp, °F:	<input type="text" value=""/>
Sample Time:	<input type="text" value="15:00"/>				

Mix # and Proportions:

Cement, lbs.:	<input type="text"/>	Coarse Agg, lbs.:	<input type="text"/>	Admixture, oz./cwt:	<input type="text"/>
Flyash, lbs.:	<input type="text"/>	Coarse Agg, lbs.:	<input type="text"/>	Admixture, oz./cwt:	<input type="text"/>
Water, gals.:	<input type="text"/>	Coarse Agg, lbs.:	<input type="text"/>	Admixture, oz./cwt:	<input type="text"/>
Fine Agg, lbs.:	<input type="text"/>	Coarse Agg, lbs.:	<input type="text"/>	Admixture, oz./cwt:	<input type="text"/>

### Sample Type & Compression Test Results:

Received 04/23/2014    Sample Set 3 of 3    Type of Compression Test:

### Lab Tests:

New Log #	Test Age (Days)	Date of Test	Total Load (Lbs.)	Sample Dim. (In.)	Sample Area (Sq. In.)	Comp. Strength (PSI)	Tested By	Break Type	ASTM C-617	ASTM C-1231
1276	1	04/24/2014	67,315	4.00	12.56	5,360	Cheryl Meredith	4	<input checked="" type="checkbox"/>	<input type="checkbox"/>
REQ'D	28									

### Remarks:

MTC on site per client request to conduct coring of existing concrete walls inside of the Outlet well and Intake well. Locations on where to core were from the direction of CH2MHill. A correction factor of .98 was used, due to h/d variation.

REPORTED BY: Michael Currie    REVIEWED BY: Curtis Shear, Lab Manager

All results apply only to actual locations and materials tested. As a mutual protection to clients, the public and ourselves, all reports are submitted as the confidential property of clients, and authorization for publication of statements, conclusions or extracts from or regarding our reports is reserved pending our written approval. © 2008 - 2012 Materials Testing & Consulting, Inc. All rights reserved.

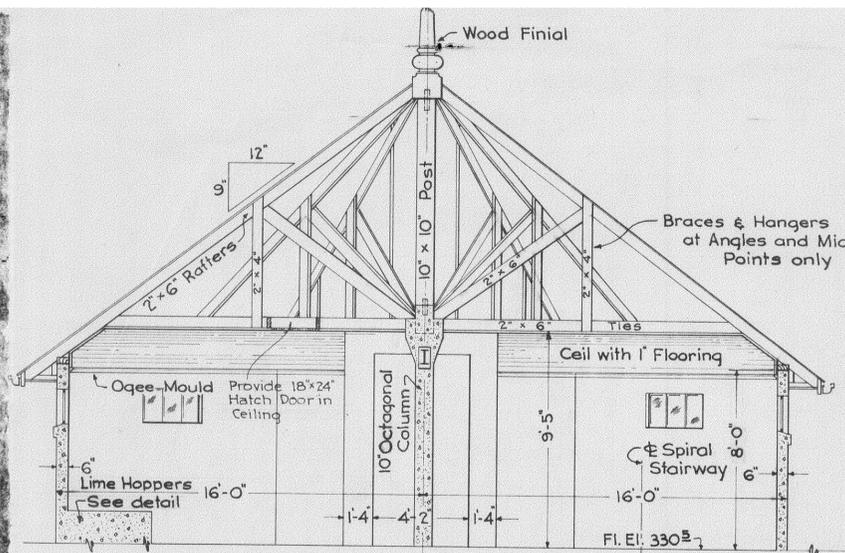
**Appendix D – Screen House Structural  
Drawings**

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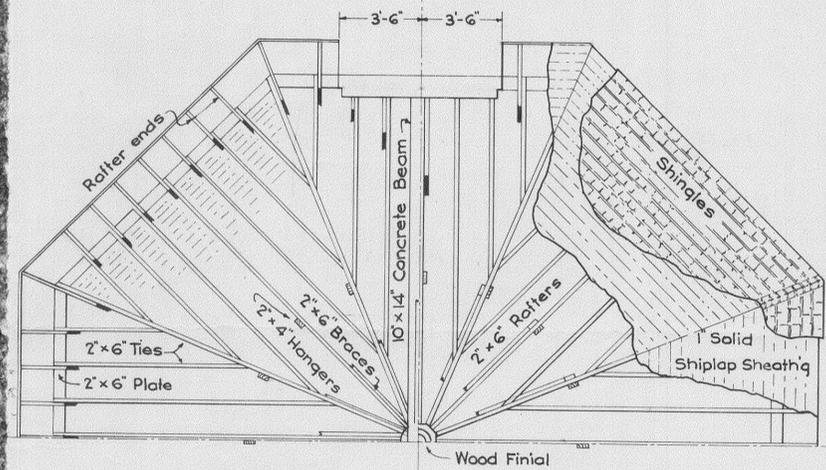




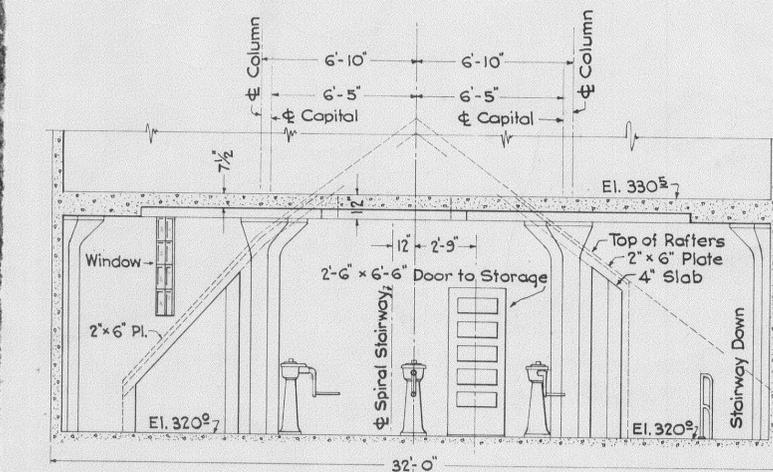




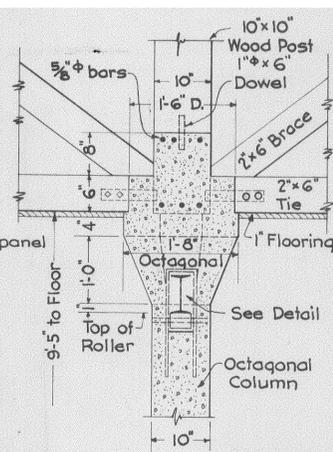
SECTION ON  $\Phi$  OF LIME STORAGE FLOOR



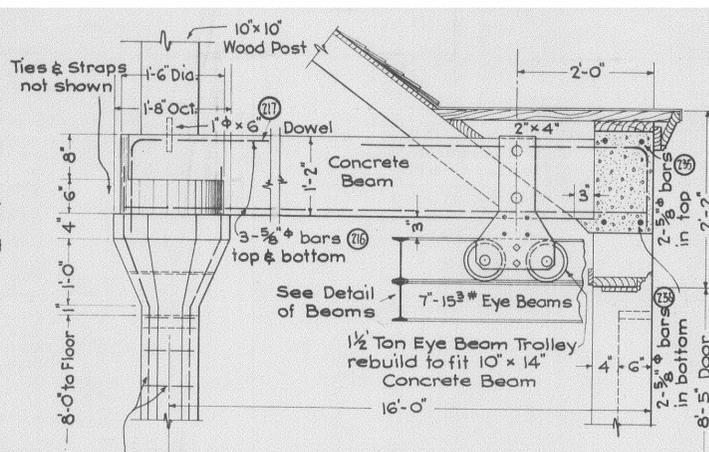
HALF PLAN OF CEILING JOISTS  
HALF PLAN OF RAFTERS  
**ROOF FRAMING DETAILS**  
Scale:  $\frac{1}{4} = 1'-0"$



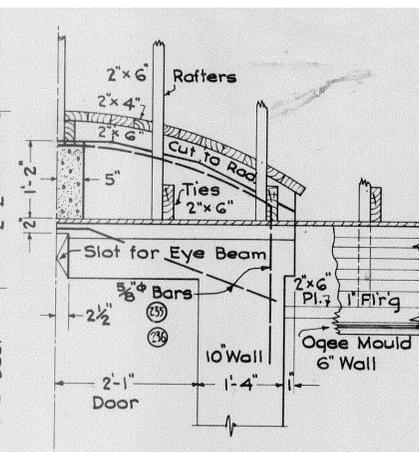
**INSIDE VIEW - WEST WALL OPERATING FLOOR**  
Scale:  $\frac{1}{4} = 1'-0"$



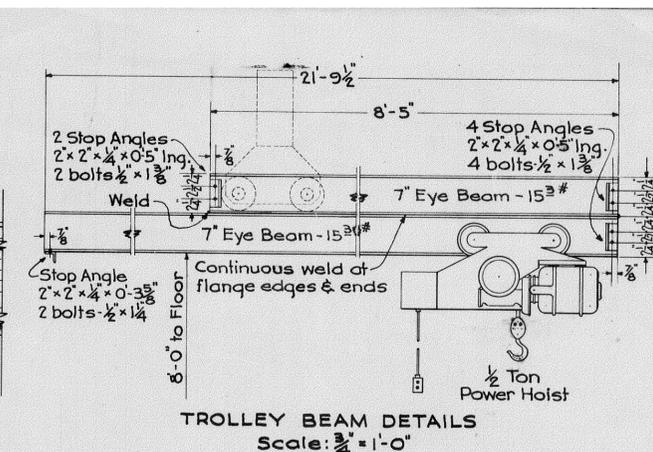
SECTION  
Scale:  $\frac{3}{4} = 1'-0"$



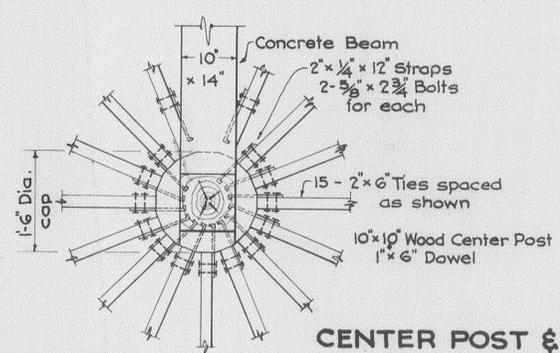
SIDE ELEVATION  
Scale:  $\frac{3}{4} = 1'-0"$



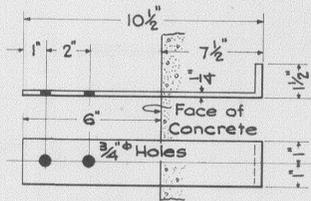
HALF INSIDE SECTION AT DOORWAY  
Scale:  $\frac{3}{4} = 1'-0"$



**TROLLEY BEAM DETAILS**  
Scale:  $\frac{3}{4} = 1'-0"$

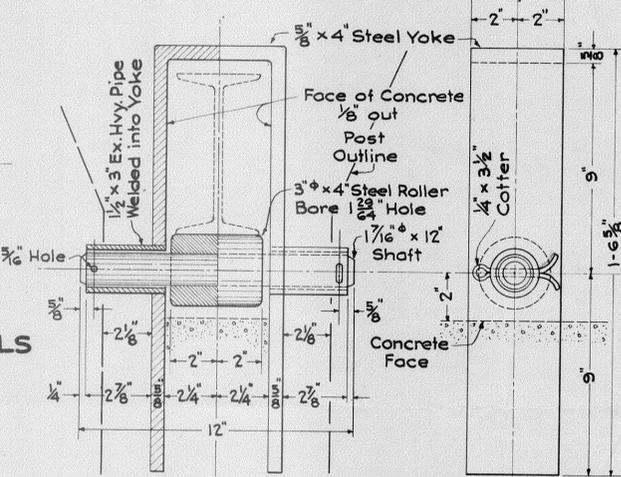


PLAN  
Scale:  $\frac{3}{4} = 1'-0"$

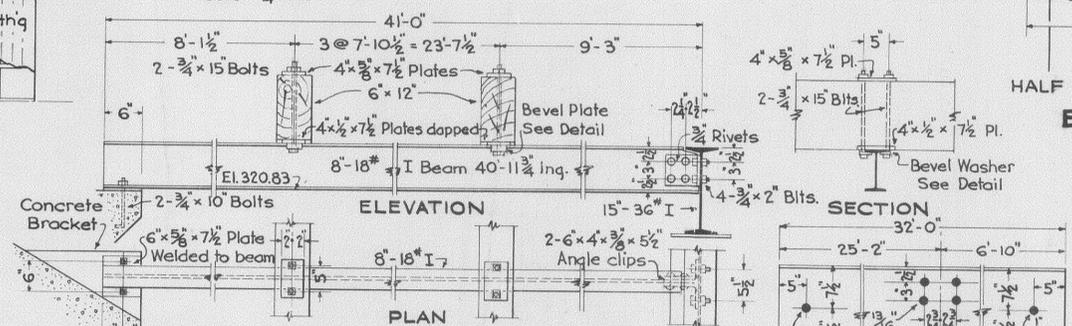


**TIE STRAPS**  
2x $\frac{1}{4}$  x 12 Lg.  
15 Required  
Scale: 3" = 1'-0"

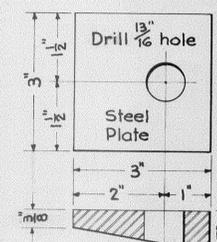
**CENTER POST & TROLLEY BEAM DETAILS**  
LIME STORAGE FLOOR



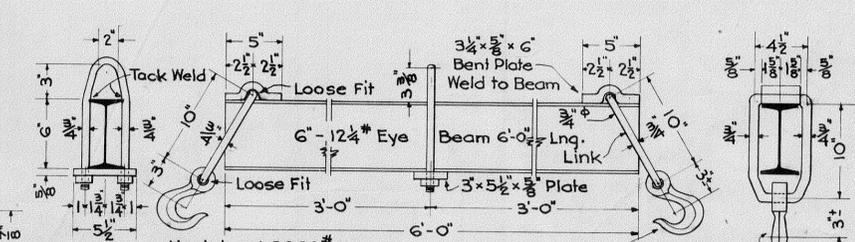
HALF SECTION HALF VIEW  
SIDE VIEW  
**EYE BEAM ROLLER AT COLUMN**  
Scale: 3" = 1'-0"



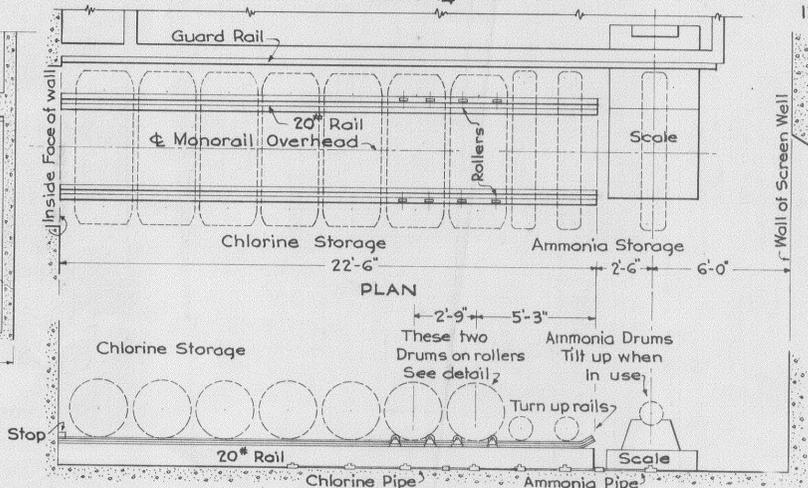
**MONORAIL & EAVE BEAM DETAILS**  
Scale:  $\frac{3}{4} = 1'-0"$



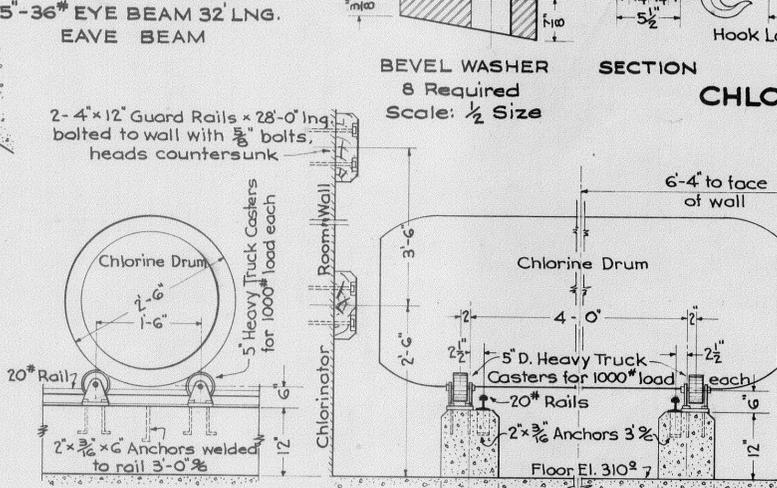
**BEVEL WASHER**  
8 Required  
Scale:  $\frac{1}{2}$  Size



**CHLORINE DRUM HOISTING YOKE**  
Scale:  $1\frac{1}{2} = 1'-0"$

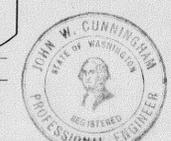


**ELEVATION**  
Scale:  $\frac{1}{4} = 1'-0"$



**ROLLER SETTING DETAILS**  
Scale:  $\frac{3}{4} = 1'-0"$

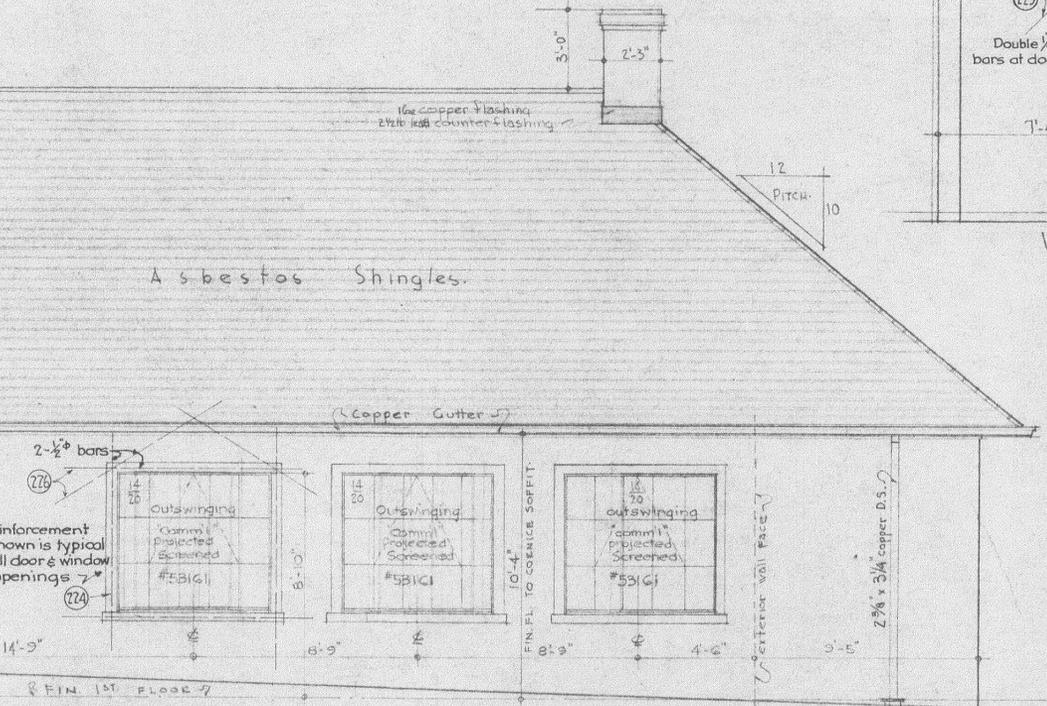
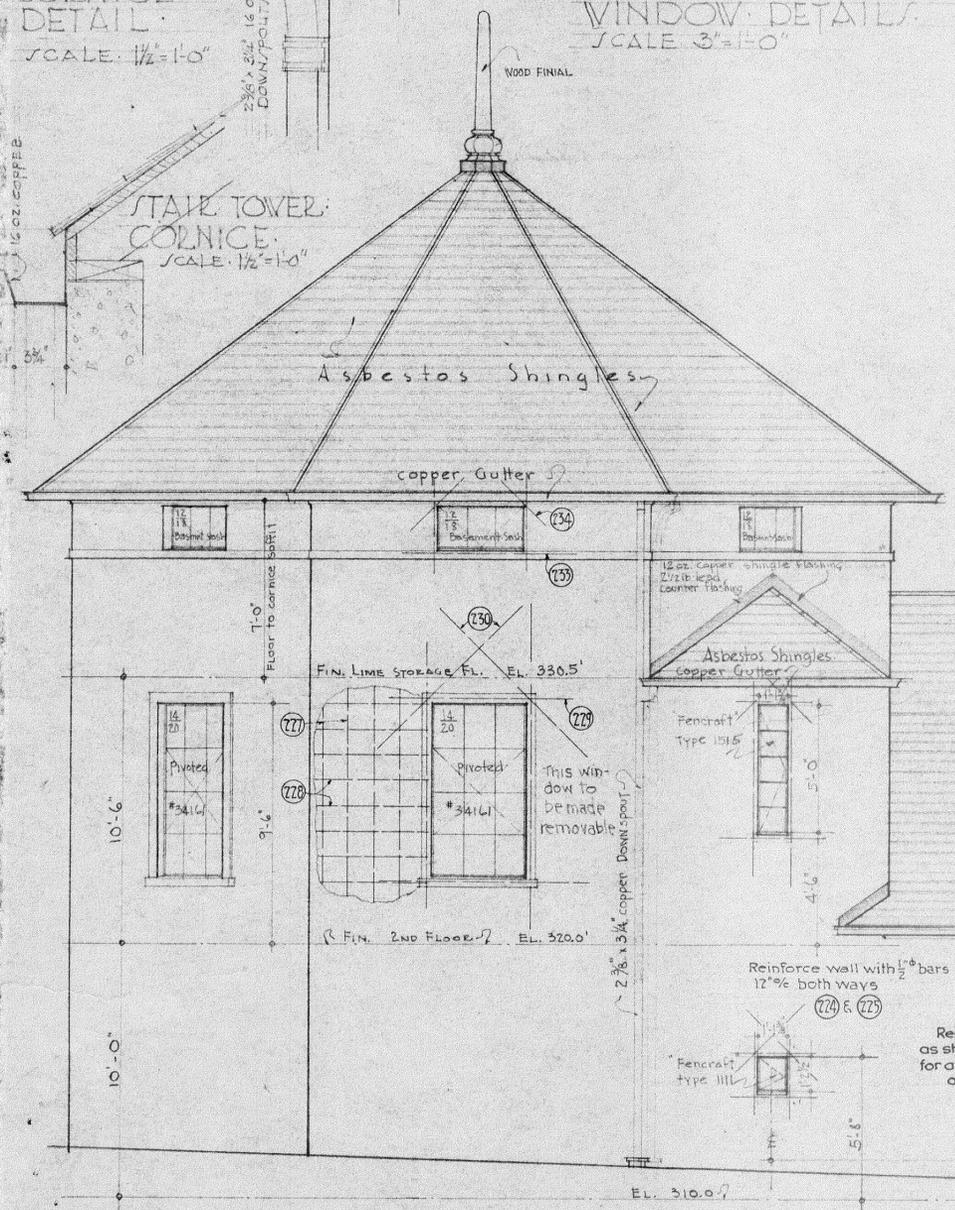
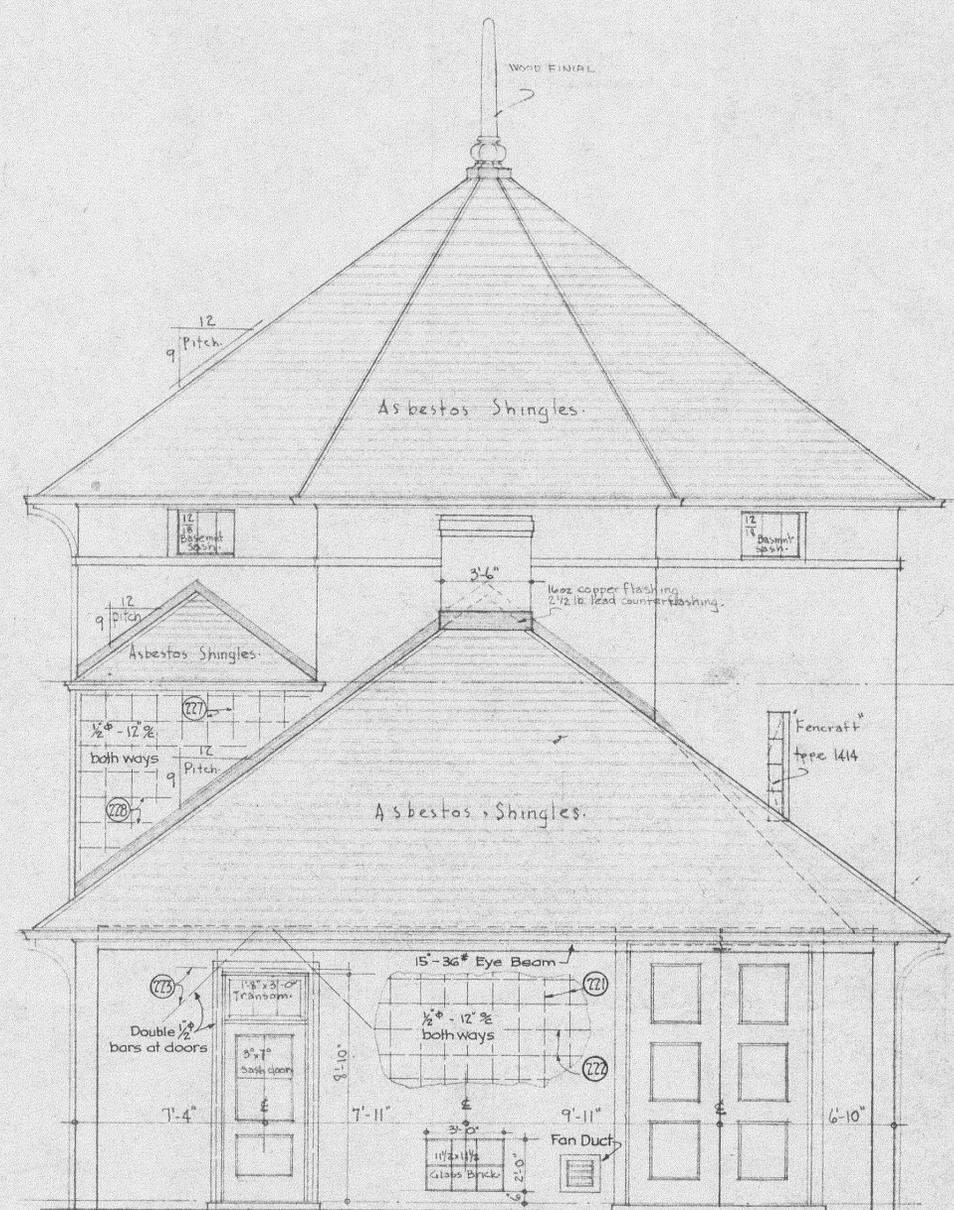
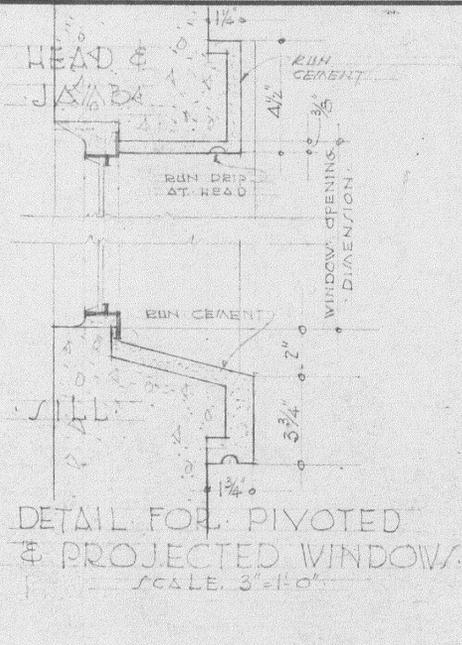
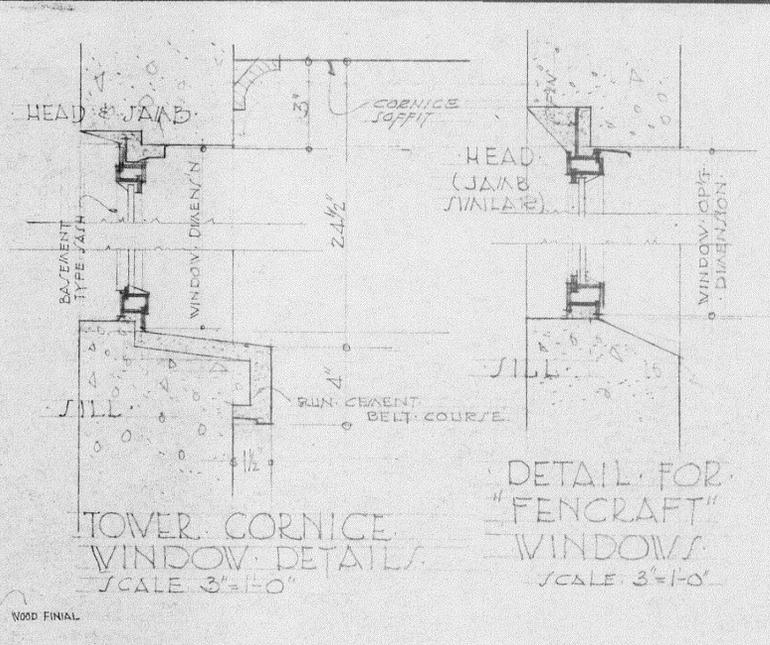
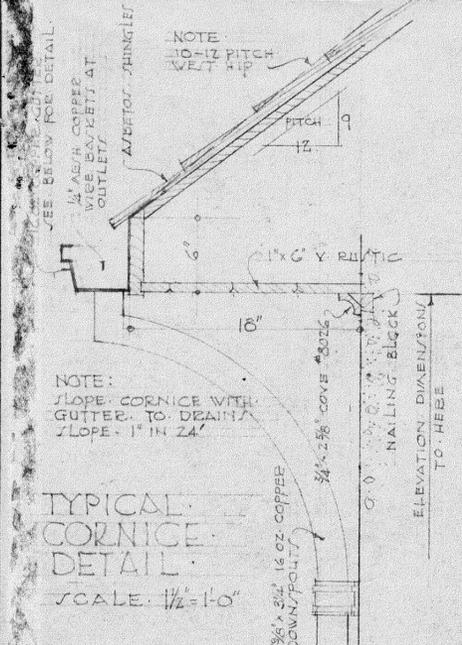
**CHLORINE STORAGE TRACK DETAILS**



E. W. GOOCH  
CITY ENGINEER  
BAAR AND CUNNINGHAM  
CONSULTING ENGINEERS  
CITY OF BELLINGHAM, WN.  
WATERWORKS IMPROVEMENTS  
**CHLORINATING HOUSE**  
CONSTRUCTION DETAILS  
Scale: As Noted

DESIGN BY	F.S.Z.	APRIL 30, 1940	NO. OF
DRAWN BY	F.S.Z.	REVISIONS	FILE NO.
TRACED BY	S.A.R.	5-28-40	379-A-20
CHECKED BY			1490





N O R T H E L E V A T I O N 1/4" = 1'-0"

C H L O R I N A T I O N P L A N T  
B E L L I N G H A M W A S H I N G T O N

E L E V A T I O N S & D E T A I L S  
S C A L E A S N O T E D

TUCKER & WALLMANN  
-ARCHITECTS-  
1938 N.W. IRVING STREET PORTLAND, OREGON

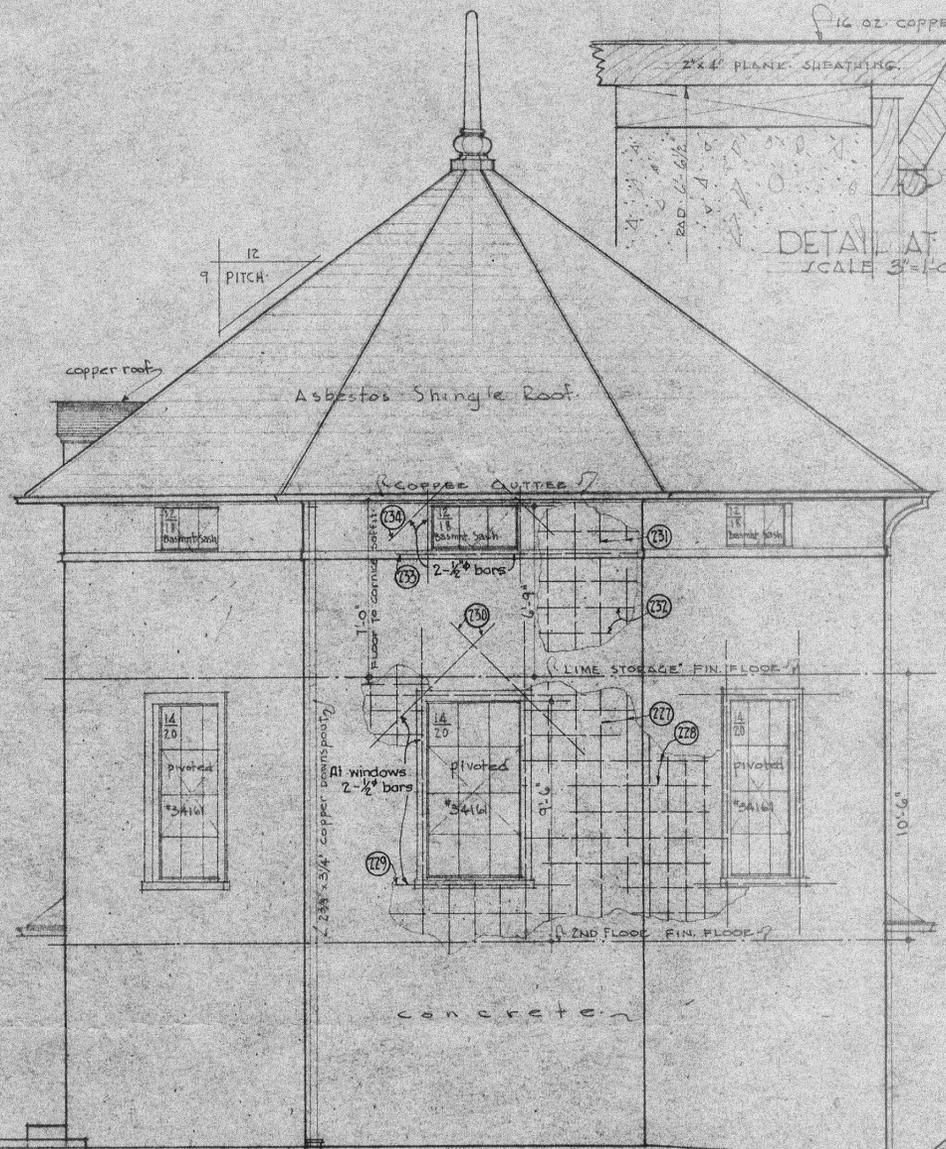
JOB 401 SHEET  
DATE  
REV. 2



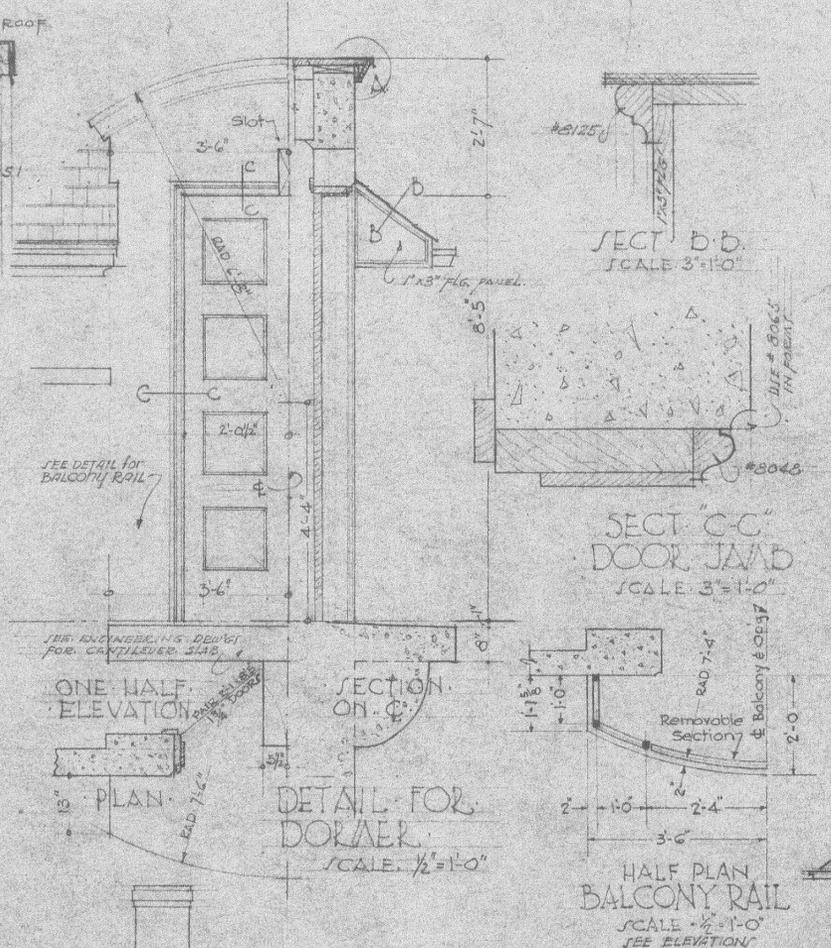








EAST ELEVATION 1/4"=1'-0"



DETAIL AT A  
SCALE 3"=1'-0"

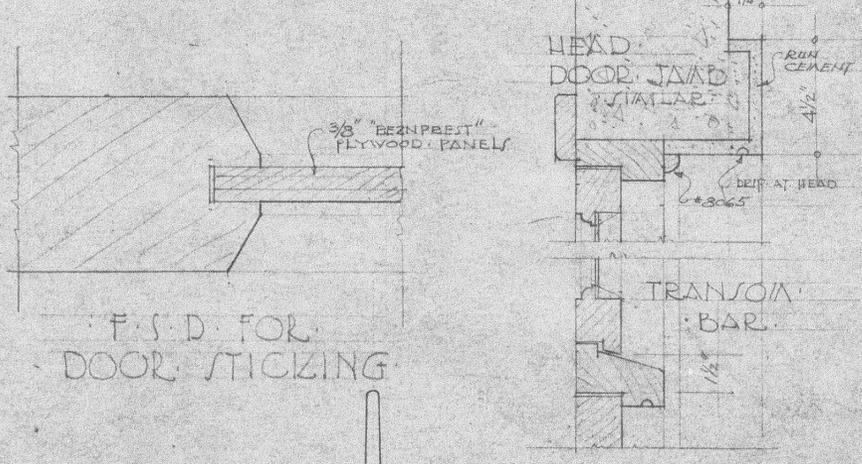
SECTION B-D  
SCALE 3"=1'-0"

SECTION C-C  
DOOR JAMB  
SCALE 3"=1'-0"

ONE HALF ELEVATION  
SCALE 1/2"=1'-0"

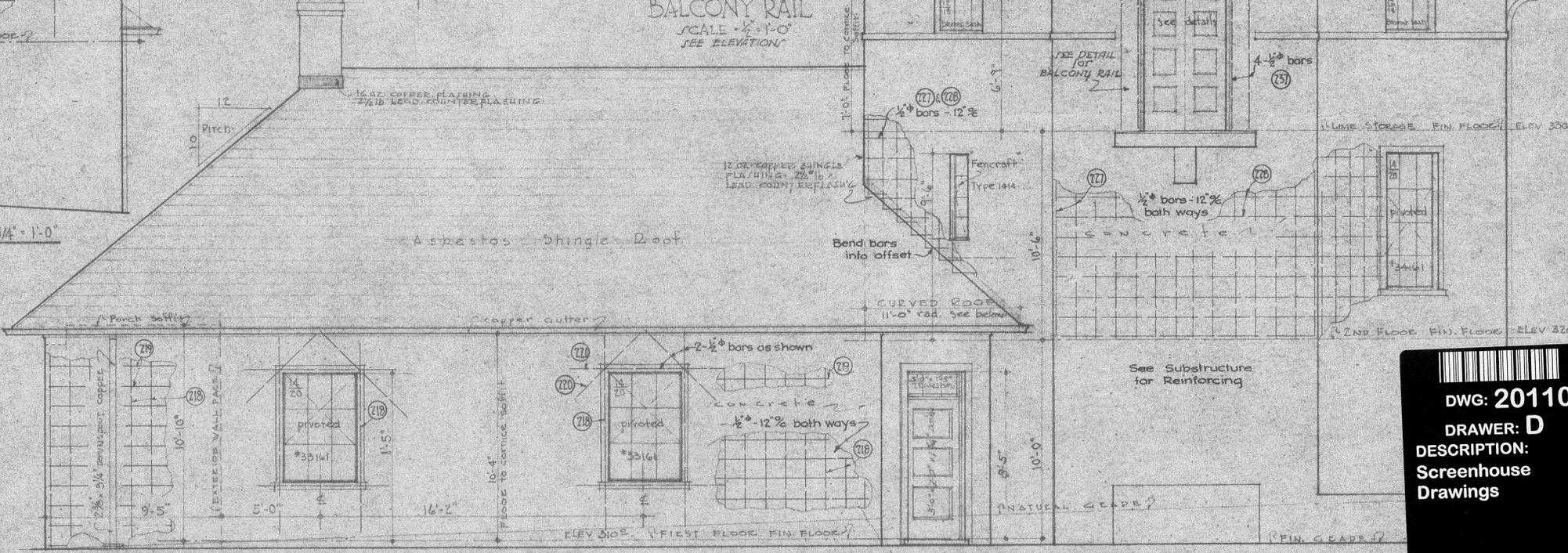
DETAIL FOR DOOR  
SCALE 1/2"=1'-0"

HALF PLAN BALCONY RAIL  
SCALE 1/2"=1'-0"  
SEE ELEVATION

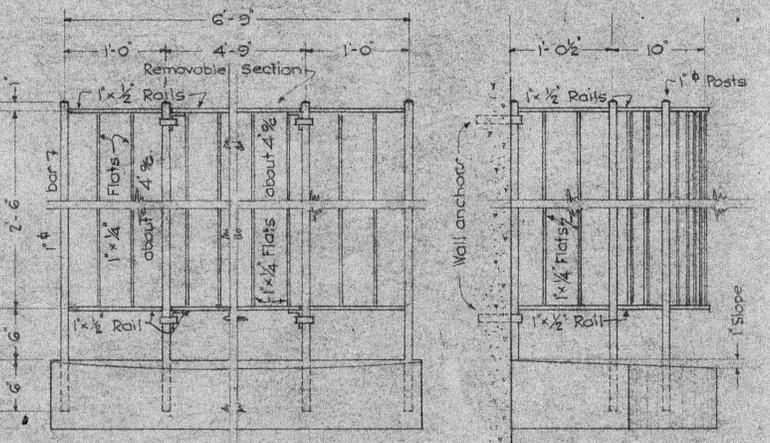


F.S.D. FOR DOOR STICKING

TYPICAL DOOR FRAME DETAIL  
SCALE 3"=1'-0"



SOUTH ELEVATION 1/4"=1'-0"



FRONT ELEVATION  
SIDE ELEVATION  
DETAIL FOR BALCONY RAIL  
SCALE 1"=1'-0"

ALL WELDED CONSTRUCTION

DWG: 20110  
DRAWER: D  
DESCRIPTION: Screenhouse Drawings

C H L O R I N A T I O N P L A N T  
B E L L I N G H A M W A S H I N G T O N

ELEVATIONS & DETAILS  
SCALE AS NOTED

TUCKER & WALLMANN  
-ARCHITECTS-  
1938 N.W. IRVING STREET PORTLAND, OREGON

JOB 401	SHEET
DATE	12
REV	1



**Appendix E – 48-Inch Outlet Pipeline  
Rehabilitation Reports**

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June 9, 2014

Mr. Phil Martinez, PE  
CH2M HILL  
1100 - 112th Avenue NE, Suite 500  
Bellevue, WA, 98004-4504

425.233.3662 (office)  
425.736.8861 (cell)

**Re: City of Bellingham - 48-inch Pipeline Carbon Fiber upgrade**

**Budget Estimate**

Dear Mr. Martinez,

Thank you for the opportunity to provide a budget estimate proposal for the carbon fiber upgrade at the designated pipe segments in Bellingham, Washington. STRUCTURAL (Structural Preservation Systems, LLC.) has been providing infrastructure upgrade services for over 35 years and has the expertise and experience necessary to perform the requested pipeline upgrade scope. This budget estimate is based upon request and information provided by CH2M HILL, along with support from STRUCTURAL TECHNOLOGIES.

**PROJECT OVERVIEW:**

CH2M HILL contacted STRUCTURAL TECHNOLOGIES as part of follow-up from a recent inspection process. CH2M HILL and City of Bellingham are evaluating options for a 48-inch pipeline, and it has been determined that replacement or rehabilitation is needed. STRUCTURAL is a certified applicator of the V-Wrap™ carbon fiber materials and we will service the project from our Los Angeles area office. Following is the project plan we would propose.

**PROJECT PLAN:**

The scope of work presented includes carbon fiber upgrade of the three (3) 48-inch pipeline segments located at City of Bellingham's Chlorination House. The work includes approximately 20LF of each of the three (3) lines, totaling 60LF scheduled for upgrade. The proposal is based upon access to all three (3) pipes simultaneously with access through a ladder to a chamber that accesses all three pipes. It is assumed that the manhole access points at the other ends of the 20LF repairs are available during construction. On the upstream

end, the repair is to be terminated out onto the wall of the chamber. It is assumed that the slide gates will be removed prior to STRUCTURAL mobilizing to the jobsite.

The 20LF repair region for each of the 48-inch pipes involves mortar lined steel where the mortar is covering severely deteriorated steel pipeline. Each pipe starts out as a square cross section and within 4-6 LF transitions into circular geometry for the remainder of the pipe region. On the upstream end, the repair is to be terminated out onto the wall of the chamber. In order to ensure water tightness of the end termination at the wall location special detailing will be developed which will involve multiple layers of CFRP extending out onto the concrete wall and the CFRP system anchored to the wall using backing plates. On the downstream end, the repair will be terminated onto good steel pipe where the existing mortar lining will be removed so the CFRP liner can bond to the steel pipe substrate. The end termination at the downstream end will involve utilizing installation of a circular steel expansion ring at the end of the CFRP lining system.

The pipeline will be dewatered by others, with all surface and environment preparation, along with installation of the V-Wrap™ carbon fiber system, to be completed by STRUCTURAL. The City is looking for a full structural rehabilitation, stand-alone design, of the pipe segments, and the following design assumptions have been used to prepare the proposal.

#### DESIGN ASSUMPTIONS:

- 3 segments, 20 LF each of 48in steel pipe totaling 60LF
- Design approach considers the CFRP lining system as a stand-alone design without relying on the host pipe or the casing around the pipe for structural integrity. The carbon fiber lining system and connection details will resolve both structural issues as well as concerns regarding leakage and water tightness.
- $P_w=10$  psi (specified)
- $P_w+P_t=50$  psi (specified)
- $P_v=0$  psi (specified)
- $H=25$  ft in the buried section behind the wall, none in the vault (specified)
- $H_w=10$  ft max over the pipe in the buried section, none in the vault (specified)
- Temperature differential= $\pm 40$ F (assumed)
- Hydraulic thrust=PA (assumed)
- Soil  $M_s=1000$  psi (specified)

STRUCTURAL TECHNOLOGIES has recommended use of the V-Wrap Carbon Fiber system detailed below.

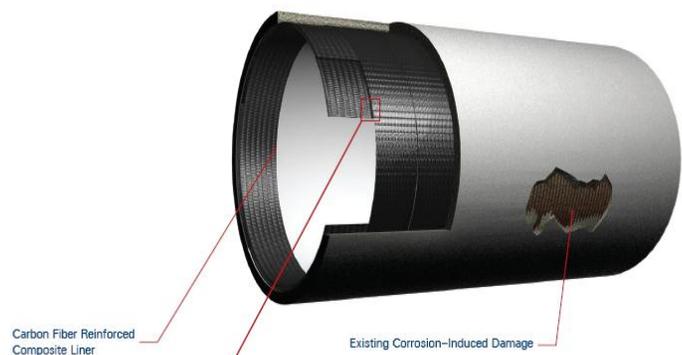
#### V-Wrap™ Carbon Fiber System

The V-Wrap™ Carbon Fiber system is structural strengthening system for restoration of damaged/weakened pressure pipe. It utilizes layers of specially designed carbon fiber reinforced polymer composite which are applied both longitudinally and circumferentially. Carbon fiber design and number of layers are a function of the exact design requirements. The existing piping system becomes a form for the V-Wrap™ CFRP system which becomes the pipe once the system is installed.

#### V-Wrap™ CFRP System

**structural**  
TECHNOLOGIES

structuraltechnologies.com  
800-899-1016



The V-Wrap™ Carbon Fiber system provides the following advantages:

- Restores full function capacity of pressure pipe during very short outage duration.
- Requires no excavation as all repairs can be made with access via existing manhole points.
- Overall system thickness reduces the pipe inside diameter only slightly (.25" to .75").
- Polymer finish coat surface resistance mitigates any loss in pumping head.
- Corrosion resistance provides long service life.
- Fits both straight and curved pipe sections.

**SUPPORT BY OTHERS:**

1. Dewatering of designated pipeline segment (no standing water).
2. Dumpster in proximity of work area for disposal of debris.
3. Any required permits.
4. Removal of the slide gates prior to STRUCTURAL's mobilization to the jobsite.
5. Welding of the steel pipe, if any holes in the pipe are discovered.
6. Parking for service vehicles.
7. Lay down area for equipment.
8. Unobstructed access to work area.
9. Hole watch attendants at entrances into the pipeline.

**GENERAL NOTES:**

1. Proposal based upon single mobilization.
2. The mortar lining on the repair region is assumed to be intact and the mortar is assumed to only be removed at the end termination locations.
3. Pricing is based upon use of non-union workforce using prevailing wages.
4. Payment terms Net 30 days.
5. Proposal based upon acceptance of design.

**PRICING:**

Scope of Service	Budget Range
<b>I. Design, Supply and Installation of V-Wrap™ CFRP system at 48-inch pipeline, 60LF total scope</b>	<b>\$305,000.00- \$335,000.00</b>

We look forward to working with you on this important project, and we are prepared to provide more support as required. We would like the opportunity to meet and discuss this proposal at your convenience. Should you have any questions or require any additional information please contact Anna Pridmore at (714) 824-8869 or by email at [apridmore@structural.net](mailto:apridmore@structural.net).

Respectfully submitted,

Mike Szoke  
Branch Manager

Anna Pridmore, PhD  
Technical Manager

cc: Jack Burnam, CH2M HILL  
Dan Buonodonna, CH2M HILL  
Jason Alexander, STRUCTURAL TECHNOLOGIES



May 7, 2014

Jack Burnam II  
Project Manager/Senior Technologist  
CH2M Hill Inc.  
1100 112th Ave. NE, Suite 400  
Bellevue, Washington 98004

(T) 425.453.5000  
(C) 360-271-8559  
(E) Jack.Burnam@CH2M.com

**RE: City of Bellingham 48" Steel Rehabilitation**

**Subject: AAJA-JEQ5V8 – Budget Estimate**

Mr. Burnam,

It is a pleasure to provide the following budget estimate to supply and install the Fyfe Co., LLC Tyfo® Fibrwrap® system at the designated sections of 48" diameter Steel pipe owned and operated by the City of Bellingham. The 48" pipe are 18' in length – please note that this includes pipe to be rehabilitated and development onto the adjacent pipe. It is our understanding that a minimum of three (3) pipe will require simultaneous rehabilitation. This budget estimate is based upon information and input provided by: The City of Bellingham; CH2MHill; Analytical Engineering; (Analytical); and Fyfe Company, LLC (Fyfe).

A Site Walk was conducted on April 23rd, 2014. During the meeting, it was confirmed that these raw water pipe require immediate structural strengthening; leak protection; and corrosion protection. A condition assessment of the line had been previously conducted. The UT indicated wall thickness of 0.3" and pit depths of 0.15". Corrosion product is circa 1/2" thick. Repairing these pipe using the Tyfo Fibrwrap System has been identified as the most cost effective option.

To facilitate the repair, pipe entry will be from access MH inside the screen house. Ventilation will be facilitated by removal of a static mixer from inside the pipe to allow us access from the entry point downstream. Repair of the three pipe is to be effected simultaneously. Repair will involve the removal of corrosion product, and cement liner from adjacent pipe. Approximately 1'6" will need to be removed for development onto adjacent pipe. If any through holes exist, they can be welded or the Tyfo Weld Alt can be utilized. Tyfo Weld Alt replaces the need for the previous method of welding steel plates over cracks and small holes in steel pressure pipes. This repair can be effected on small hole type repairs, on the order of 2 in. diameter or 3/4 in. wide by 3 in. long, using a 2 layer Tyfo Web patch extending 4" out from damaged area. The Tyfo Web is applied after the leak (if one exists) is stopped using a hydrophobic foam or grout. Fibrwrap then renders the defect with JB Weld or similar steel bonding epoxy to fill the hole to be even with the surface of inner steel substrate. Surface is prepped to near white metal and epoxy and fiber are applied.



Installation of the repair will involve first installing a layer of SEH 51A as a dielectric barrier, then layers of longitudinal and hoop SCH 41 2X will be installed as dictated by the repair designer. Termination on the downstream side will be standard. Termination on the upstream side will utilize Tyfo SCH Composite Anchors and will either involve a retaining plate or development onto the concrete encasement. Fibrwrap has provided sample details for these terminations.

The carbon fiber lining system utilized is the Tyfo® Fibrwrap® system. This patented system is applied utilizing the specified wet-layup method; contains zero VOC's; and is NSF 61 certified. It has been used for these types of pipeline projects since the late 1990s. The Fyfe materials have the proper durability testing in place to ensure that the Carbon Fiber upgrade will provide a 50 year design life. The Tyfo® Fibrwrap® system is manufactured by Fyfe Company, thus the products are from single manufacturer for fiber and resin and consist of compatible products for primer, surface rendering, saturating resin, carbon fiber, intermediate tie coats, and final coats.

In order to ensure a CFRP liner achieves the desired design life, it is necessary to have specified use of materials with ICC code compliance and a proven durability history as well as a conservative design with appropriate strain limitations. It is equally important to select a qualified contractor with extensive experience in the application of CFRP liners for internal repair of pipelines. Careful attention must be given regarding surface preparation, proper saturation of the fabric using a calibrated mechanical saturator, dehumidification and temperature control within the work environment, and installation methods for the CFRP fabric. QA/QC measures such as the bond test and test coupons are also critical to ensuring the overall system achieves its intended lifecycle. When appropriately designed and installed, a CFRP liner can safely and effectively provide a 50-75 year design life renewal of the distressed line.

Fibrwrap Construction has significant experience in the implementation of Carbon Fiber repairs and rehabilitation. Fibrwrap Construction is the certified installer of the Fyfe Company Tyfo® Fibrwrap® system, and has been in business for over 23 years. Fibrwrap has completed over 6,000 projects which include applications such as pipeline rehabilitation, seismic strengthening, URM reinforcement, bridge rehabilitation, industrial structure upgrades, and commercial property enhancements. Fibrwrap has completed over 250 pipeline strengthening projects – more than all of its competitors combined.

The construction crews utilized by Fibrwrap are direct employees and are trained and certified by Fyfe Company for application of these specialized materials. In addition to this benefit, working with Fibrwrap ensures all parties that the manpower utilized are properly trained in all aspects of the work including the safe work practices necessary in underground repair applications. The Safety of our workforce, Engineers, employees and Inspectors is our primary focus when working on confined space applications, such as the proposed watermain project.

Fibrwrap Construction will provide all labor, materials and equipment to complete the installation of the Tyfo® system to meet design requirements, as detailed below. We look forward to working with you to reestablish the structural integrity of this critical asset.



## Section 1: Design

### ***Pipeline Details:***

Pipe type:	Steel
Pipe diameter:	48"
Distance from access point to work area:	15'
Distance to be wrapped:	Three 18' sections

The final design has encompassed the following verified assumptions:

### ***Design Assumptions***

Design Type	Standalone
Operating Pressure	100 psi
Transient Pressure	50 psi
Earth Cover	14' under 30' of cover and 2' in a vault
Water Table Height	10'
Soil Modulus	1000 psi
Traffic Loading	None
Special	Upstream Termination

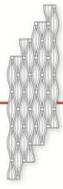
In order for the CFRP system to be compatible with the steel pipe, a dielectric layer is to be installed between the carbon fiber and the pipe. The installation process will begin with a layer of Tyfo® SEH system (GFRP) to create the proper dielectric barrier between the steel pipeline and the Carbon Fiber. Tyfo® SEH is a nonconductive fiberglass layer, therefore, providing the required galvanic protection.

Structural layers of carbon fiber fabric installed include longitudinal and hoop layers of unidirectional Tyfo SCH-41-2X carbon fiber fabric. Longitudinal CFRP layers are designed for longitudinal forces due to Poisson's effects, thermal expansion/contraction, hydraulic thrust, and longitudinal bending. Hoop CFRP layers are designed for the forces due to operating and transient pressures, bending due to soil and live loads, and buckling due to internal negative pressure and external ground water pressure. The design is based on calculating the strains and stress in CFRP and checking structural demands and capacities following the load and resistance factor approach for hoop and longitudinal limit states.

CFRP terminations are designed such that the CFRP laminate is prevented from debonding from the underlying steel. The termination details include consideration of all thrust forces generated in the vicinity of the pipe section to be repaired.

## Section 2 - Proposed scope of work:

1. Preparation and submission of confined space entry plan and procedures to the Owner.
2. Training of all personnel, air testing, safety equipment, and compliance with OSHA requirements
3. Mobilization of all materials, equipment, and personnel to the job site
4. Appropriate ventilation equipment to allow for pipeline entry.
5. Delivery, Storage, and Handling as per the specification
6. Verify the identification of pipe sections to be rehabilitated. The Owner and/or the Engineer shall accompany Fibrwrap during this verification
7. In conditions with an ambient air temperature less than 50°F (10°C), auxiliary clean heat sources will be used to raise the ambient temperature to the desired level.
8. Portable barriers and blowers will be erected at the repair locations to dehumidify the surface of the pipe. The environment will be maintained to meet Fyfe's recommendations. The temperature will be maintained at least 10°F (5.5°C) above the dew point.
9. Any leakage through valves will be mitigated by Fibrwrap by using dams and pumping to prevent any water from entering the pipe to be repaired.
10. All standing water will be removed before dehumidification of the inner surface is begun.
11. Proper dust control and ventilation will be provided to meet OSHA requirements.
12. Remove mortar lining
13. If through holes are discovered water flow must be stopped prior to the installation of the CFRP system using either traditional welding or the Tyfo Weld Alt..
14. Cleaning, drying, and dehumidification of all surface areas prior to application. Verify that the substrate is visibly clean and free of moisture, as per ASTM D4263.
15. Notify the Engineer in writing of any anticipated problems with the installation of the CFRP system on the substrate
16. Perform abrasive blast to obtain near white surface finish prior to installing the Tyfo System.
17. Provide sound surfaces free of laitance, glaze, efflorescence, curing compounds, form release agents, dust, dirt, grease, oil, and other contaminants incompatible with epoxy resin.
18. Mask off adjoining surfaces not receiving CFRP lining to prevent any spillage from affecting other non-repair sections.
19. Perform required adhesion testing per ASTM 4541
20. Installation of the proposed rehabilitation system.
  - a. Provide fabric saturator and rolling mechanism, such that the epoxy-saturated fabric can be transported to the point of application through a manhole, and then applied to the interior surface of the steel in a wet lay-up process.
  - b. Calibrate the saturation machine to ensure the proper fiber-resin ratio.
  - c. After the surface is properly prepared and dry, apply primer.
  - d. Following the primer, all voids in the substrate shall be filled to achieve a smooth surface using tack coat or thickened epoxy below the spring lines.
  - e. Pits in the steel surface less than 2 sq. in. shall be filled with thickened epoxy. Notify the Designer of dents larger than 2 sq. in. for evaluation and determination of repair method.



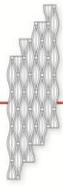
**FIBRWRAP®**

The Future of Construction Technology

- f. Apply the Tyfo® SEH 51-A material in accordance with the design submitted for the carbon fiber system. At minimum, one (1) layer will be laid continuously in the longitudinal direction to provide a dielectric barrier.
  - g. The impregnated fabric shall be pressed onto the steel surface to achieve intimate contact. Entrapped air between layers shall be released or rolled out before the resin sets.
  - h. A thin layer of thickened epoxy shall be applied between all consecutive CFRP layers, over the entire surface.
  - i. Apply Tyfo® SCH 41-2X material in accordance with the design submitted for the carbon fiber system.
  - j. Press the Tyfo® SCH 41-2X into the prepared surface to achieve complete contact. Release or roll entrapped air between the layers without wrinkling the fibers.
  - k. Construct a lap joint when an interruption occurs in the direction of the fibers. The minimum length of a lap splice will be 12 inches. Stagger lap splices on multiple plies. A lap joint is not required in the direction perpendicular to the fiber orientation; however, adjacent fabric layers are expected to be placed against each other, with no separation at any location being greater than 0.02 inches.
  - l. Terminate the CFRP so as to provide a watertight seal that prevents any water from penetrating between the CFRP layers and the steel pipe..
    - i. Downstream termination - Install a single band steel expansion ring on top of the CFRP layers as shown on the accepted detail drawings or provide another fail-safe water barrier (i.e., Weko Seal) deemed acceptable by the Engineer.
    - ii. Install upstream termination as per engineer's direction.
21. Repair of damaged or defective CFRP areas
- a. Small entrapped voids or surface discontinuities, no larger than 1/2 inch in diameter, are not be considered defects, and require no corrective action, unless they occur next to edges or in substantial quantity, i.e., more than 5% of any unit surface area, or more than five (5) such defects in an area of 10 square feet.
  - b. Small defects with a diameter between 1/2 inch and 4 inches will be repaired using low pressure epoxy injection, as long as the defect is local and does not extend through the complete thickness of the laminate.
  - c. In the case of larger defects, the surrounding area, to an extent of at least 3/4 inches in all directions, will be carefully removed with a grinder. The area will be wiped, cleaned, and thoroughly dried prior to being repaired using a CFRP patch with the same characteristics as the original laminate and extending at least 6 inches on all sides of the removed area. Any repairs requiring the removal of plies will be approved by the Owner and the Engineer and will be corrected at the Fibrwrap's expense.
22. Collection, transportation, and disposal of all waste per existing regulations.
23. Final cleaning of the interior of the pipeline.

#### 24. Field Quality Control

- a. Fibrwrap will perform a visual inspection of the installed CFRP prior to epoxy application to inspect for evidence of delamination or damaged wraps. In addition, the Fibrwrap will perform the following quality assurance and quality control measures during the repair:
  - i. A logbook will be maintained containing, but not limited to, the following information:
    - I. Lot numbers for the fabric and epoxy used during each shift and the location of the installation;
    - II. Time, date, resin, fabric lot numbers, fabric weight, and resin weight.
  - ii. Saturated Tyfo® SCH 41-2X test pieces will be prepared and measured to ensure proper spacing on the saturator rollers and an adequate fabric-to-resin weight ratio in accordance with the following:
    - I. The length of the test piece will be a minimum of 2 feet;
    - II. The test piece will be measured and cut from a standard spool of fabric;
    - III. The weight of the unsaturated test piece will be rounded to the nearest 0.01 pound;
    - IV. After running the test piece through the saturator, the saturated test piece will be weighted again;
    - V. The fabric-to-resin weight ratio will be calculated to the nearest 0.01;
    - VI. The fabric-to-resin weight ratio will be within 10% of Fyfe's written recommendation.
  - iii. The fabric-to-resin weight ratio will be determined at the start of each shift. The fabric-to-resin weight ratio will be rechecked if any changes or adjustments are made to the saturator or modifications are made to the resin. The Engineer may randomly require Fibrwrap to check the fabric-to-resin weight ratio. Fibrwrap is responsible for providing in advance all necessary equipment and materials to perform a fabric-to-resin weight ratio test at any time so determined by the Engineer.
  - iv. Balances used to perform each test will be certified for accuracy using NIST traceable standards.
- b. Adhesion Testing of Representative Substrate
  1. Fibrwrap will install a two-ply CFRP patch in at least three (3) 2 foot by 2 foot area to be used for adhesion testing to verify the prepared surface profile and adhesion between the installed CFRP system and the steel. The test patch will consist of two (2) orthogonal plies of CFRP laminate. The location will be representative and selected by the Engineer and may be on an adjacent, non-repair pipe provided that the surface preparation is the same as that to be used for the repair pipe.
  2. Fibrwrap will perform at least three (3) pull-off tests in the adhesion test region, in the presence of the Inspector, according to ASTM 04541 and using testers with documented calibration. Fibrwrap will take precautions to ensure proper alignment and shimming of the test fixture to prevent non-perpendicular forces on the test specimen.



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- c. Tensile Testing of Field Samples
  1. Fibrwrap will provide samples for laboratory testing from each repair site as randomly directed by the Engineer and at the middle of each shift, with a minimum of two (2) test samples taken per pipe section. Test samples will measure 12 inches by 24 inches, made with composite layers to achieve a minimum accumulated thickness of 0.08 inches, with strong fibers in the same direction for multiple layers.
  2. Forward one (1) test sample from each repair site (each rehabilitated pipe) to an ICBO testing laboratory (Owner approved) that is certified to test carbon fiber composites.
  3. Provide the remainder of the test samples to the Engineer for further qualification testing, as determined by the Engineer.
  4. At least ten (10) tensile tests will be performed in accordance with ASTM 03039 and the Manufacturer's specifications. Each test specimen will be tested for material properties in the longitudinal (primary fiber) direction.
  5. Certified test results will be provided to the Engineer within 20 business days of completion of the construction. The testing will provide values for each specimen as follows:
    - a. Ultimate tensile strength;
    - b. Tensile modulus and related specimen thickness;
    - c. Percent elongation.
  6. Fibrwrap will submit a list of testing laboratories to the Engineer for approval prior to any QC tests. Only pre-approved testing laboratories are permitted to conduct tests. QC testing will be performed at Fibrwrap's expense.



### **Section 3: Fibrwrap Construction Services, Inc. to provide:**

1. Manufacturer certified and licensed personnel for all phases of proposed scope of work.
2. Manufacturer certified materials and equipment for all phases of proposed scope of work.
3. All items specified in proposed scope of work; section 2.
4. Saturator machine and air compressors.
5. Generator; dehumidifiers; pipe heating units with blowers and flexible duct
6. Power inside and outside the pipe
7. Enclosure for fiber/epoxy preparation and pipe access.
8. Testing of samples by a certified laboratory.
9. All required Insurances and Bonds
10. Standard Warranty.

### **Section 4: GC/Owner to provide:**

1. Right of Way and Environmental permits for access to work areas.
2. Staging area immediately area surrounding the 24" MH
3. Access to work areas,.
4. Initial dewatering of the pipeline prior to Fibrwrap's crew entering the pipeline. This includes partial draining and isolation of the pipe section.
5. Lock out/Tag out.
6. Third party inspection, testing, permits, and all associated costs.
7. The final surface profile will be approved by the Owner's appointed Field Inspector.
8. De-watering and filling of pipeline
9. Chlorination or sanitizing the pipe.
10. Third party construction inspection services.
11. Coordination with local agencies.

### **Section 5: General notes:**

1. Budget estimate assumes one mobilization.
2. Non union, prevailing wage.
3. Tax included.



## Section 6 – Client investment: Budget estimate

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### Pipeline Rehabilitation Costs

CFRP Repair of 3 (three) 48" diameter 18' long Steel pipe... \$310,000.00

Fibrwrap has performed over 250 pipeline projects similar to this and our experience set in large diameter lines is extensive – these applications are complicated and our goal is to ensure that WSSC receives a proper installation of materials by experienced crews using materials which have been proof-tested in the field.

Thank you for the opportunity to provide this budget estimate. Fibrwrap, along with Fyfe Company, looks forward to continuing to work with you and your group on executing this project. If you should have any questions or need any information regarding this budget estimate please contact me at any of the following:

Cell: 630-383-8934  
Email: dave@fclp.com

Respectfully submitted:

A handwritten signature in blue ink, appearing to read "Dave Caughlin", is written over a horizontal line.

Dave Caughlin

cc: Brian Berger, Fibrwrap  
Chris DeLetto, Fibrwrap

## **Appendix F – Valve Catalog Sheets**

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**Parts List**

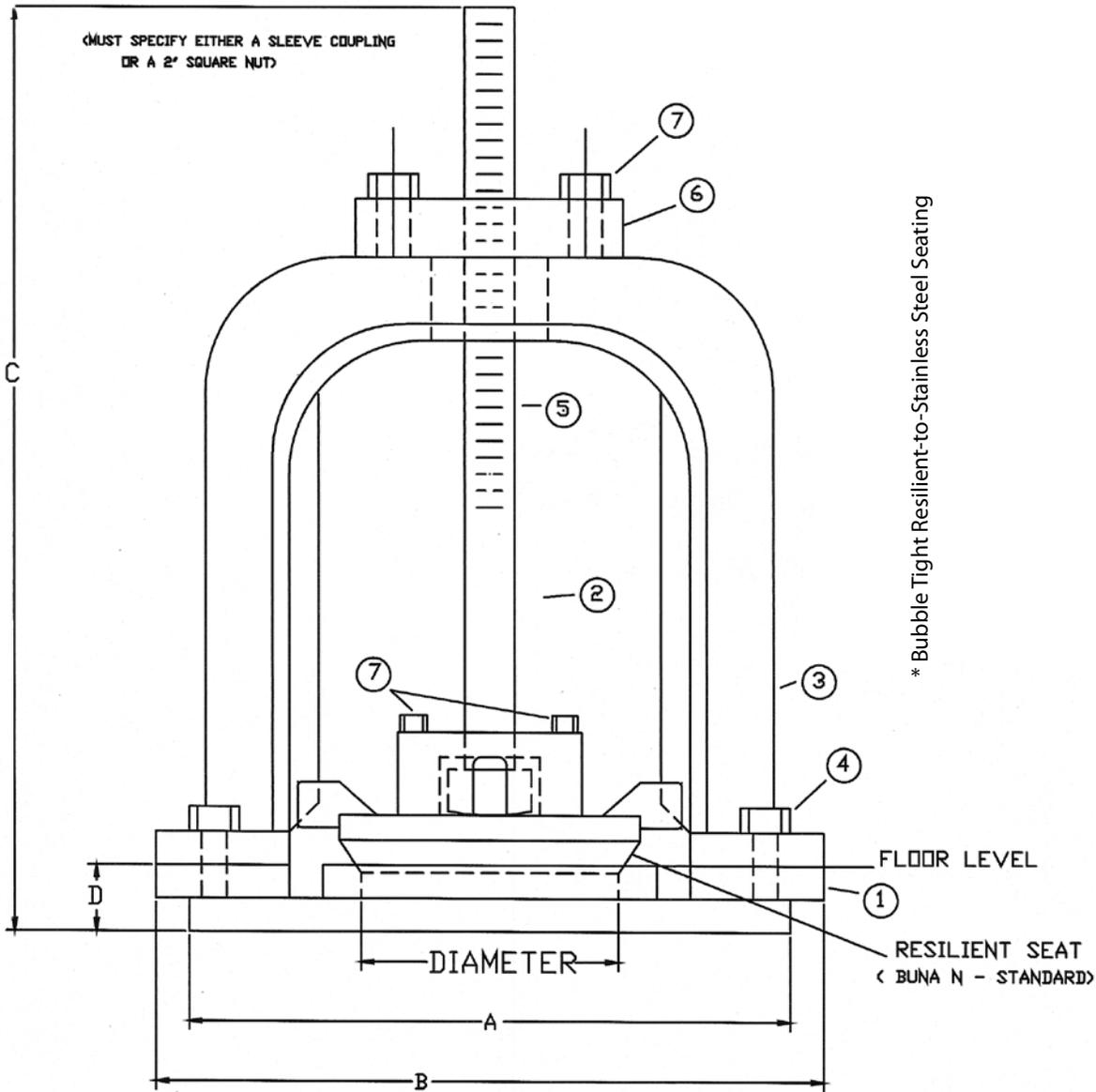
Item	Description	Required	Material
1	Frame	1	316SS
2	Plug	1	316SS
3	Yoke	1	316SS
4	Cap Screw	4	316SS
5	Stem	1	316SS
6	Thrust Nut	1	Stainless Steel
7	Cap Screw	4	316SS
8	Plug Cap	1	316SS

Size	4	6	8	10	12
A	9	11	13 1/2	16	19
B	10	12	15	17 5/8	20 3/16
C	13 7/8	14 3/8	18 1/2	22	23 7/8
D	3/4	7/8	7/8	1	1
E	6	6	8	8	10
F	7 1/2	9 1/2	11 3/4	14 1/4	17

**Flange Information:**

D - Diameter of Holes  
 E - Number of Holes  
 F - Bolt Circle Diameter

SUPPLIED WITH SLEEVE COUPLING OR 2" SQUARE STEM OR 2" SQUARE DP NUT



STAINLESS STEEL MUD VALVE—RISING STEM

MATERIAL:

DATE:

**TROY VALVE**  
 Troy, PA

NO.

A25612RBCSS

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## **MUD VALVES**

- **Troy Valve** Mud Valves are designed for use in drain lines found in waterworks and wastewater treatment basins, irrigation, industrial applications, and fluid retaining basins. Mud valves are available in both non-rising and rising stem versions. **Troy Valve** manufactures mud valves in a cast iron model as well as a stainless steel model in order to meet the needs of a wide variety of applications.
- Custom extension stems made to material type, diameter, and length specified may be manufactured by **Troy Valve**. Operators such as hand wheels, 2" AWWA square nut and floor stands may be used with the valve extension stem. The custom length required and material required must be stated when the order is placed.

*Troy Valve.....simply the best.*

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**TROY VALVE**

A Division of Penn-Troy Manufacturing Inc.

**Toll Free: (800) 232-4442 ■ [sales@troyvalve.com](mailto:sales@troyvalve.com)**

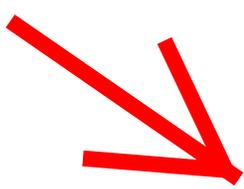
650 Railroad Street, Troy, PA 16947 ■ Ph: (570) 297-4442 Fax: (570) 297-4136

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## **CAST IRON MUD VALVES**

### **Cast Iron Mud Valve Specifications**

- The mud valve shall be of the heavy duty flanged type designed to provide a positive seal under both seating and unseating head conditions. The valves shall be (non-rising, rising stem) stem style as detailed on the schedule or the plans. The frame, plug, and yoke shall be cast iron (A126B). The valve operating stem and lift nut shall be bronze (B421). The seat ring shall be bronze (B62), with an accurately machined tapered seating face. The plug seat shall be a seamless molded, tapered resilient ring of BUNA-N, designed to accurately mate with the seat ring for a positive seal.
- Where required the manufacturer shall provide valve operating stems, floor stands, and stem guides as specified in the valve schedule or plans.
- The mud valves are to be coated using TNEMEC Pota Pox two-part epoxy, NSF approved coating. Standard coating is one coat of 3-4 mils dry film thickness.
- Valves and accessories shall be manufactured by Troy Valve model A25600RB (non-rising stem), A25612 (rising stem), or approved equal.



### **Stainless Steel Mud Valve Specifications**

The Mud Valve shall be of the flanged type and designed to provide a positive seal under both seating and unseating head conditions. The valve shall be non-rising or rising stem style. Frame, Plug, Operating Stem, Yoke and Seating surface shall be stainless Steel. The Plug Seat shall be nitrate buna-n for a positive seal.

Where required, the manufacturer shall provide valve operating stems, floor stands, and stem guides as specified in the valve schedule or plans.

Valves and accessories shall be manufactured by Troy Valve model A25600\_NRS\_(316 or 304) or approved equal.

***Troy Valve.....simply the best.***

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**TROY VALVE**

A Division of Penn-Troy Manufacturing Inc.

**Toll Free: (800) 232-4442 ■ [sales@troyvalve.com](mailto:sales@troyvalve.com)**

**650 Railroad Street, Troy, PA 16947 ■ Ph: (570) 297-4442 Fax: (570) 297-4136**

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**MUD VALVES****Operation**

- The valve is opened by rotating operating mechanism in a counter clockwise direction (open left).
- The valve is closed by rotating the operating mechanism in a clockwise direction (close right).
- The valve operating mechanism may be a 2" square nut, hand wheel, or floor stand connected to the mud valve, using an extension stem that is attached directly to the valve stem using a coupling.

**Maintenance**

- The body, yoke, plug, and frame of the cast iron mud valves are preserved with a two-part epoxy coating that is NSF approved for applications in both potable water and waste water applications. Stainless Steel Mud Valves do not have a coating.
- Lubrication: the valve is lubricated after manufacture with a white food-quality grease. The stem and lifting nut in the plug should be lubricated with a quality grease when the valve is accessible due to general tank maintenance.

**Installation**

- The valve shall be mounted to a standard 125-lb. flange. The mud valve should be recessed so that the top of the valve flange is flush with the floor to allow complete drainage. Precaution must be taken during installation to prevent damage to the bronze seat in the frame from heavy grit (concrete, etc.) to prevent gouging of the machined seat face.

**Parts**

- Parts are available from Troy Valve, Troy, PA.

***Troy Valve.....simply the best.***

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**TROY VALVE**

A Division of Penn-Troy Manufacturing Inc.

**Toll Free: (800) 232-4442 ■ [sales@troyvalve.com](mailto:sales@troyvalve.com)**

**650 Railroad Street, Troy, PA 16947 ■ Ph: (570) 297-4442 Fax: (570) 297-4136**

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## Appendix G – Gate Catalog Sheets



## **SERIES 20, 25, 40**

Fabricated Stainless Steel Gates





# Fontaine®

## Engineering

Fontaine has been a leader in fabricated gate design for over a generation, engineering high quality products to meet a variety of application needs. We strive for excellence in all aspects of the business from design assistance and support to installation and after-market service. We are fully committed to our customers and we will continue to develop the most cost-effective gate solutions to meet the challenging needs of the municipal and industrial water control market.

## Innovation

With our ongoing investment in research and technology, we are continually developing new design, manufacturing, and installation solutions that make our gates the most cost-effective in the industry. Our self-adjusting seal technology outperforms the AWWA Standard and is far ahead of the marketplace with long-term tight sealing that extends the life of the gate and eliminates the need for maintenance. This and other innovative solutions allow us to provide the best products and services to meet your needs.

## Quality

Fontaine brings exceptional quality to every project from design to manufacturing and testing. As part of Rodney Hunt, we now offer one of the most flexible and comprehensive metal fabrication, machining, and testing operations in North America. This allows us to monitor and ensure quality in all aspects of production and provide consistent, reliable and superior products. We are ISO-9001:2008 certified.

## Service

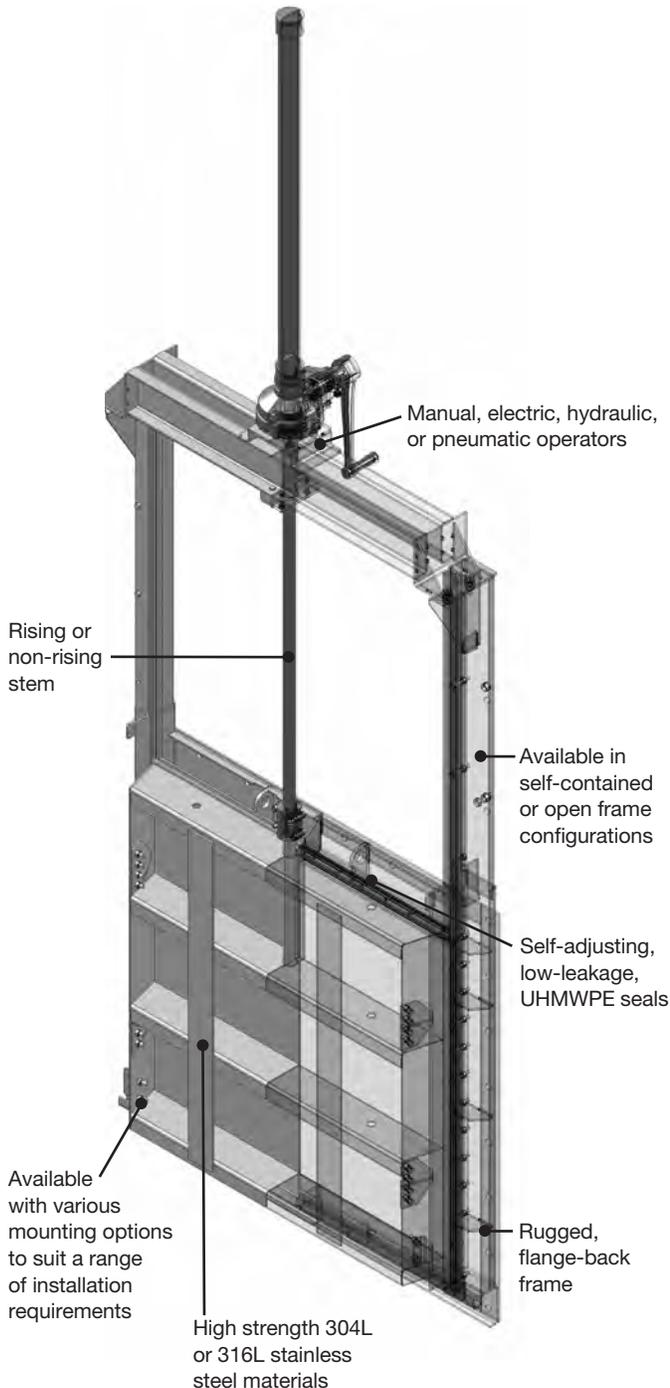
Fontaine not only brings a wealth of knowledge to each project, but also genuine responsiveness to your needs throughout the equipment selection, manufacturing, and installation process. Combined with Rodney Hunt, we now offer the most comprehensive service and support in the industry.



## SERIES 20, 25, and 40

### Fabricated Stainless Steel Gates

Solid stainless steel construction and high corrosion and erosion resistance ensures many years of trouble-free operation. The one-piece, welded, flange-back design makes all Series 20, 25, and 40 gates more robust and durable.



Fontaine Series 20, 25, and 40 Fabricated Stainless Steel Gates fully comply with AWWA Standard C561 and are NSF-61 certified for contact with drinking water.

### Guaranteed Leakage Rate

All gates have a guaranteed leakage rate that has been tested below AWWA C561 and other worldwide standards.

### Unique Self-Adjusting Seals

Side and top seals are self-adjusting type, constructed of UHMWPE (Ultra-high Molecular Weight Polyethylene) with a nitrile compression cord, which assures long-term tight sealing.

### Rugged and Corrosion Resistant

High strength 304L or 316L stainless steel materials create long term corrosion resistance, lengthening the life of the gate.

### Mounting Flexibility

Gates are available for wall mounting, in channel, embedded, round manhole, and flange mount designs.

### Ease of Installation

Fontaine gates are typically wall mounted directly to a concrete wall using an EPDM gasket — no grouting and no thimbles required. Gates arrive at the jobsite fully assembled with no field adjustments required.

### Tested and Certified

Fontaine Series 20, 25, and 40 gates have successfully undergone 25,000 cycle testing to ensure long-term reliability. Every gate is rigorously tested prior to leaving the factory.

### Maintenance Free

Self-adjusting design eliminates maintenance required with competitive J seal designs. Seals have no metal-to-metal contact to ensure no sticking, even after years of non-operation.



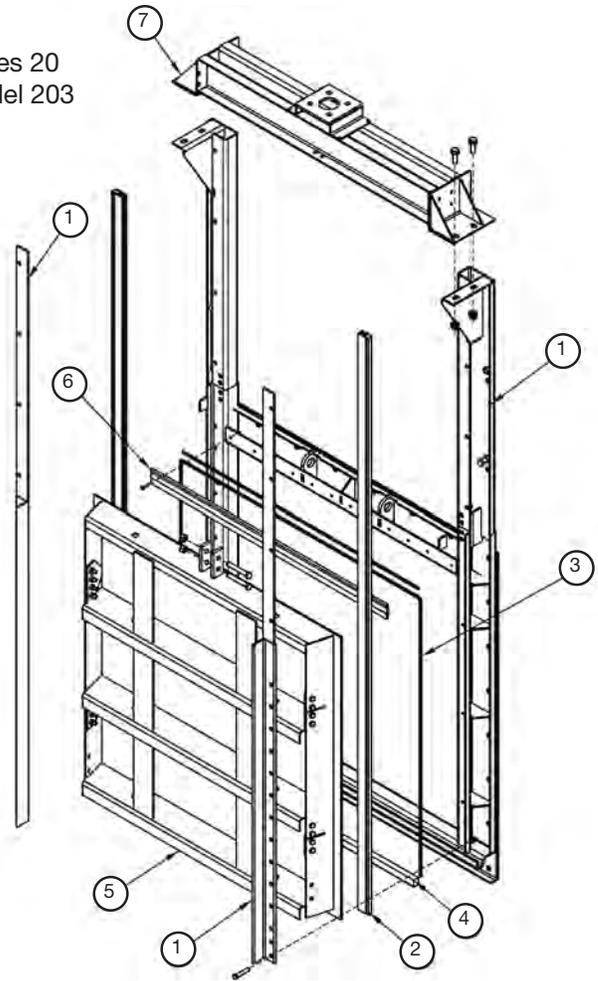
Certified to  
ISO 9001:2008



Series 20  
Model 203

### Standard Materials

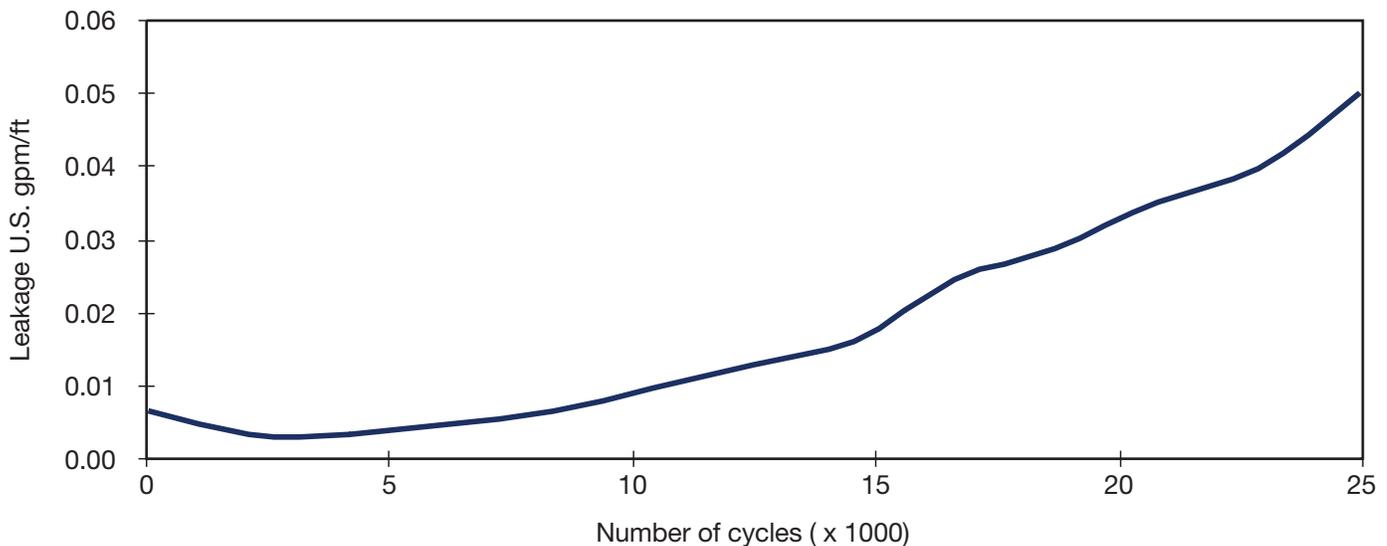
No.	Part	Material
1	Frame	Stainless steel ASTM A-240 Type 304L or 316L
2	Guides and Side Seals	Ultra high molecular weight polyethylene (UHMWPE) ASTM D-4020
3	Compression Cord	Nitrile ASTM D-2000 M6BG 708, A14, B14, E014, E034
4	Bottom Seal	Neoprene ASTM D-2000 Grade 2 BC-510
5	Slide	Stainless steel ASTM A-240 Type 304L or 316L
6	Top Seal	Ultra high molecular weight polyethylene (UHMWPE) ASTM D-4020
7	Yoke	Stainless steel ASTM A-240 Type 304L or 316L



### Leakage Test Results

The UHMWPE self-adjusting seals were evaluated in terms of life expectancy and performance through a series of tests on a 24" x 24" sluice gate. The gate was installed in an abrasive environment to simulate extreme conditions. The maximum wear on the seal after 25,000 cycles (equivalent of 68 years with one cycle per day) produced a leakage rate of 0.05 US gpm per foot of perimeter at an unseating head of 30 feet. The result: the Fontaine leakage rate was still less than half the allowable rate per the AWWA C561 standard.

Series 20 Gate 24" x 24"





All Fontaine gates are versatile, durable, easy to install, and require little or no maintenance.



### Series 20 Sluice Gates

Fontaine Sluice Gates are made entirely of stainless steel, and have very high corrosion and erosion resistance, ensuring many years of operation with minimum maintenance. Series 20 sluice gates also have a one-piece welded flange-back design that makes them more robust.



### Series 25 Channel Gates

The Series 25 Fontaine Channel Gate can be adapted to all types of channels and applications. Fontaine Channel Gates feature a flange back made of stainless steel along with a reinforced slide. It is solidly built in one piece, making it easy to install.

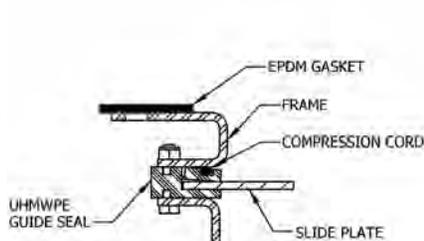


### Series 40 Weir Gates

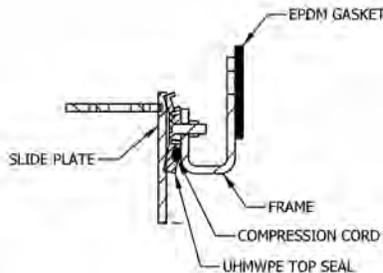
The Fontaine Downward Opening Weir Gate is used for flow control in various applications where water flows over the slide. Series 40 weir gates feature a stainless steel flange back and a reinforced slide.

### Exclusive UHMWPE Seals

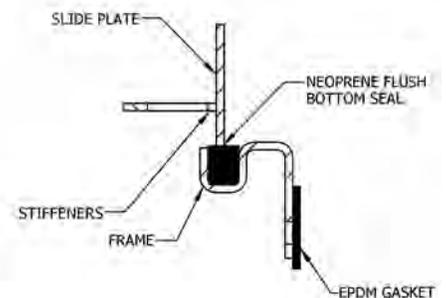
The side and top seals of the Series 20, 25, and 40 gates are made from self-lubricating ultra high molecular weight polyethylene (UHMWPE), allowing no metal-to-metal contact. With a friction coefficient of 0.2, the seals make the gate easier to operate, even after long periods of non-operation. The “self-adjusting” feature is achieved by a continuous compression cord that ensures a tight seal between the slide and the frame in both seating and unseating conditions. The wedging action of the compression cord enables the gate to control flow by only allowing water through the open portion of the gate.



Flanged back design for wall mounting with UHMWPE seal



Self-adjusting UHMWPE seal with twin contact surfaces and compression cord



Resilient neoprene seal forms flush bottom



## Engineered Flow Control Products from Rodney Hunt-Fontaine

### Gates

- Sluice Gates
- Bonneted Gates
- Channel Gates
- Weir Gates
- Crest Gates (including Bascule® and Pelican® designs)
- Tainter Gates
- Slide Gates
- Roller Gates
- Bulkhead Gates
- Velocity Control Gates
- Stop Logs
- Flap Gates

### Valves

- Jet Flow Valves
- Rotovalve® Cone Valves
- Howell-Bunger® and Ring Jet® Valves
- RIKO® Plunger Valves
- EKN® Butterfly Valves
- Streamseal® Circular and Rectangular Butterfly Valves

### Actuation

Manual, electric, and hydraulic actuation systems are available.

### Service



Rodney Hunt-Fontaine offers the very best in Aftermarket Services, including: Field Inspection and Evaluation, Valve and Gate Refurbishment and Repair, Supply and Replacement Parts, Control System Evaluation and Repair, Flow Control Design Support, and a full range of in-house capabilities. Contact our experienced and dedicated team at [parts.service@rodneyhunt.com](mailto:parts.service@rodneyhunt.com) for all your Aftermarket needs.

**For more information** about Fontaine products or to contact a sales representative, visit our website - [www.hfontaine.com](http://www.hfontaine.com)

#### In the United States

46 Mill Street • Orange, MA 01364 USA • 1-800-448-8860 • [info@rodneyhunt.com](mailto:info@rodneyhunt.com)

#### In Canada

4699 Blvd Bourque • Sherbrooke, Quebec, Canada J1N 2G6 • 819-823-3068 • [info@hfontaine.com](mailto:info@hfontaine.com)



Rodney Hunt, Fontaine, and GA Industries are now the **Valve and Gate Group**. We will continue to market our products under our heritage brands — but the breadth and depth of our product offerings, technology options, and engineering capabilities have expanded exponentially.

Together, we provide the most comprehensive line of flow control solutions in the industry. Learn more about us at [www.vag-usa.com](http://www.vag-usa.com).



*Maximum leakage rate is less than half of the AWWA allowable  
Can be adapted to any channel  
Low-maintenance gates*

\*\*\*

### General Description

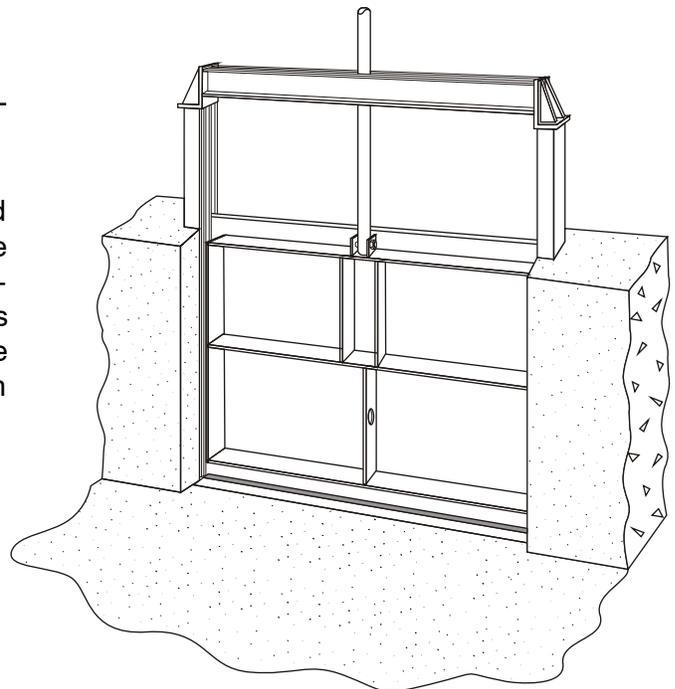
The Fontaine SERIES 25 gate is designed to control water flows in channels. It is the same construction as the SERIES 20 with the exception that it is not equipped with a top seal. The maximum allowable leakage is 0.05 U.S. gpm per foot (0.60 l/min per meter) of perimeter in seating and unseating head conditions (head conditions taken is equal to the height of the slide). It is available in sizes up to 120" (3048 mm).

### Stainless Steel Construction

Because of its stainless steel construction, the SERIES 25 has a very good corrosion and erosion resistance and can be operated many years with a minimum maintenance. The stainless steel construction allows a very large design flexibility, the result being a lighter weight and easier-to-install channel gate.

### AWWA Standards

The SERIES 25 gates are designed to meet and exceed all AWWA C513 standards with the exception of the material. The result is a high-quality gate with a very long life expectancy. As specified in the AWWA standard, most Fontaine SERIES 25 water gates are tested for operation before shipping.



**Stainless Steel Frame**

The stainless steel frame on the SERIES 25 is offered in flange back type for installation on a concrete wall at the end of a channel. It is also available for installation in an existing channel or embedded into the walls of a new channel. The frame can be either open (no yoke) or self-contained configurations, providing a solid one-piece gate. The open frame is usually used for the manual gates (no operator). In the case of an open frame with operator, an operating floor located over the channel to support the pedestal is necessary. The inferior section is available in flush-bottom frame (embedded or wall mounted) or conventional seating (existing channel).

No.	Part	Material
1	Frame	Stainless steel ASTM A-240 Type 304L or 316L
2	Guides	Ultra high molecular weight polyethylene (UHMWPE) ASTM D-4020
3	Compression cord	Nitrile ASTM D-2000 M6BG 708, A14, B14, E014, E034
4	Bottom seal	Neoprene ASTM D-2000 Grade 2 BC-510
5	Slide	Stainless steel ASTM A-240 Type 304L or 316L
6	Yoke	Stainless steel ASTM A-240 Type 304L or 316L

**Reinforced Slide**

The slide consists of a stainless steel plate reinforced with horizontal members welded to the plate, making it a solid single piece.

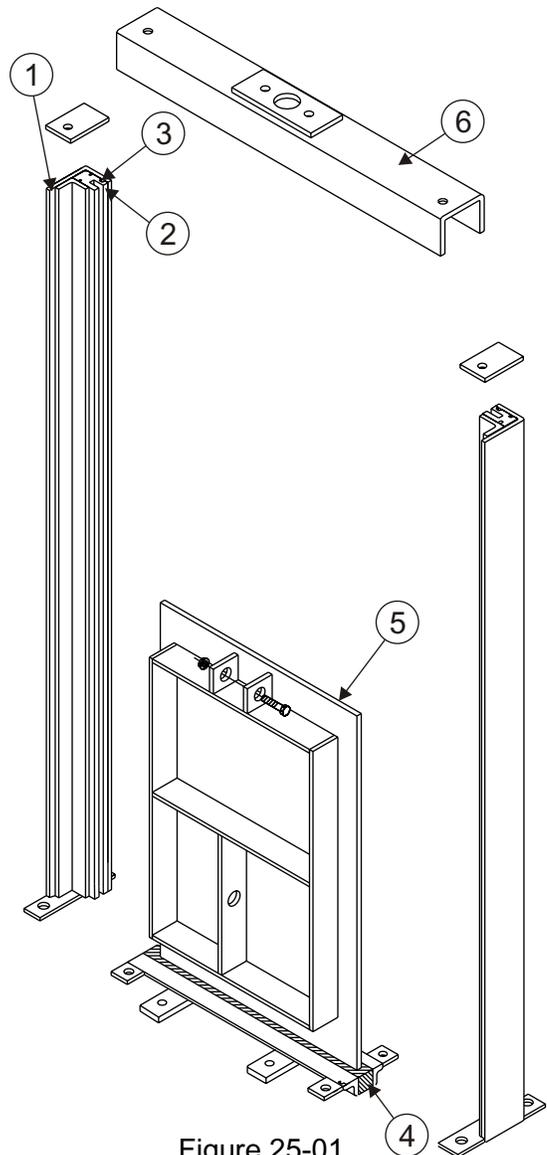
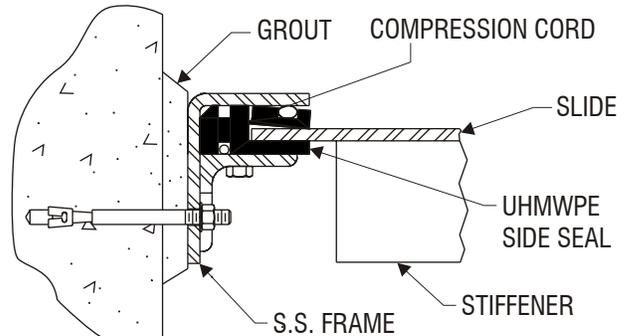


Figure 25-01  
Exploded view shown : embedded frame, self-contained (Model 253)

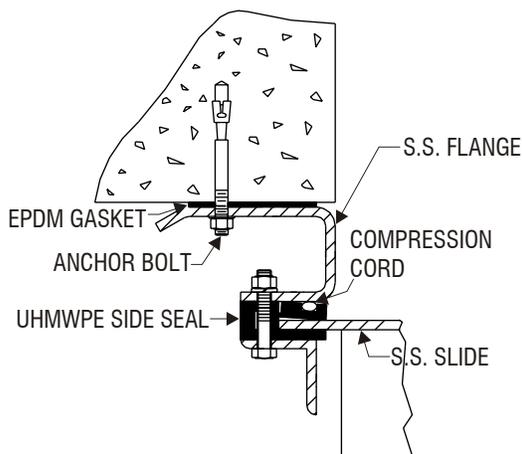
**UHMWPE Seals**  
(U.S. and Canadian Patents)

The unique side seals of the SERIES 25 are the same as on the SERIES 20 and allow no metal-to-metal contact. They are made of a self-lubricating ultra high molecular weight polyethylene (UHMWPE). With a friction coefficient of 0.2, the seals make the gate easy to open even when not operated for a long period. The self-adjusting quality is obtained by a compression cord that guarantees a perfect watertight seal between the slide and the frame in both seating and unseating conditions. The seals extend all the way to the top of the frame making the SERIES 25 a water control gate in addition to having the characteristics of a channel gate.

The SERIES 25 is designed for many applications. Details 25-01, 02, 03 show the three most common mountings.



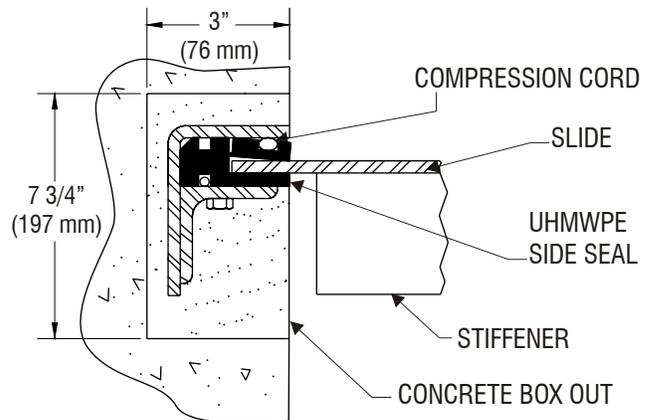
**Detail 25-02**  
Side section of an existing channel-mounted gate (EC)  
(Model shown has frame less than 54" (1372 mm) projecting above operating floor.)



**Detail 25-01**  
Side section of a wall-mounted gate (CW)

*(Details 25-01, 02 and 03 refer to figures 25-02, 03 and 04 on pages 5, 6 and 7)*

(\*) All these frames can be adapted to one another to fit in any channel.



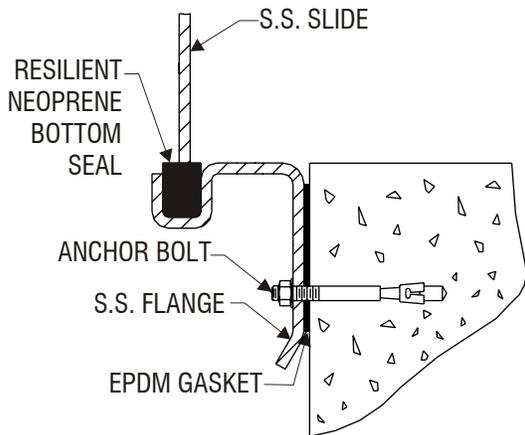
**Detail 25-03**  
Side section "A-A"  
of an embedded frame gate (FE)  
(Model shown has frame less than 54" (1372 mm) over operating floor.)



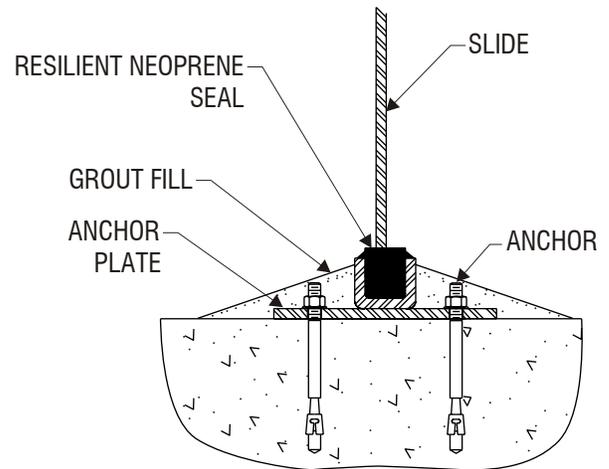
**SERIES 25**  
WATER CONTROL AND STOP GATES

The flush-bottom seal, made of resilient neoprene, leaves the opening unobstructed when the slide is in the open position.

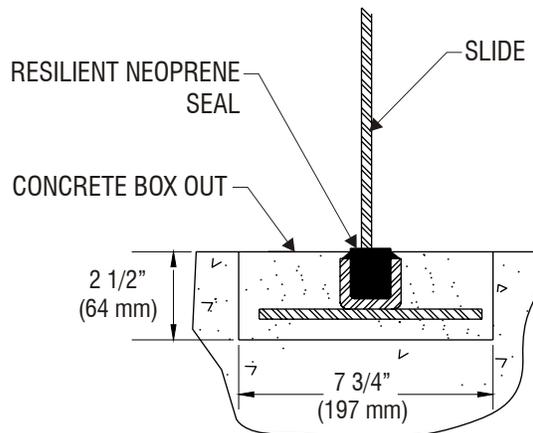
Figures 25-04, 05, 06 show the bottom section of the channel gate installed on different kinds of channels.



**Detail 25-05**  
Bottom section of a concrete wall-mounted channel gate (CW.)



**Detail 25-04**  
Bottom section of an existing channel mounted gate (EC)  
(Model shown has frame less than 54" (1372 mm) projecting above operating floor.)



**Detail 25-06**  
Bottom section "B-B"  
of an embedded frame channel gate (FE)  
(Model shown has frame less than 54" (1372 mm) projecting above operating floor.)

(Details 25-04, 05 and 06 refer to figures 25-02, 03 and 04 on pages 5, 6 and 7)

(\*) All these frames can be adapted to one another to fit in any channel.

**Frame and Stem Configurations**

The following Figures 25-02, 03 and 04 are the most common frame and stem configurations.

(See page 3 and 4 for sections A, B)

**Model 253**

Frame-embedded (FE)  
with yoke-mounted  
gear box and crank  
operator (MNE)  
Rising stem (RS2)

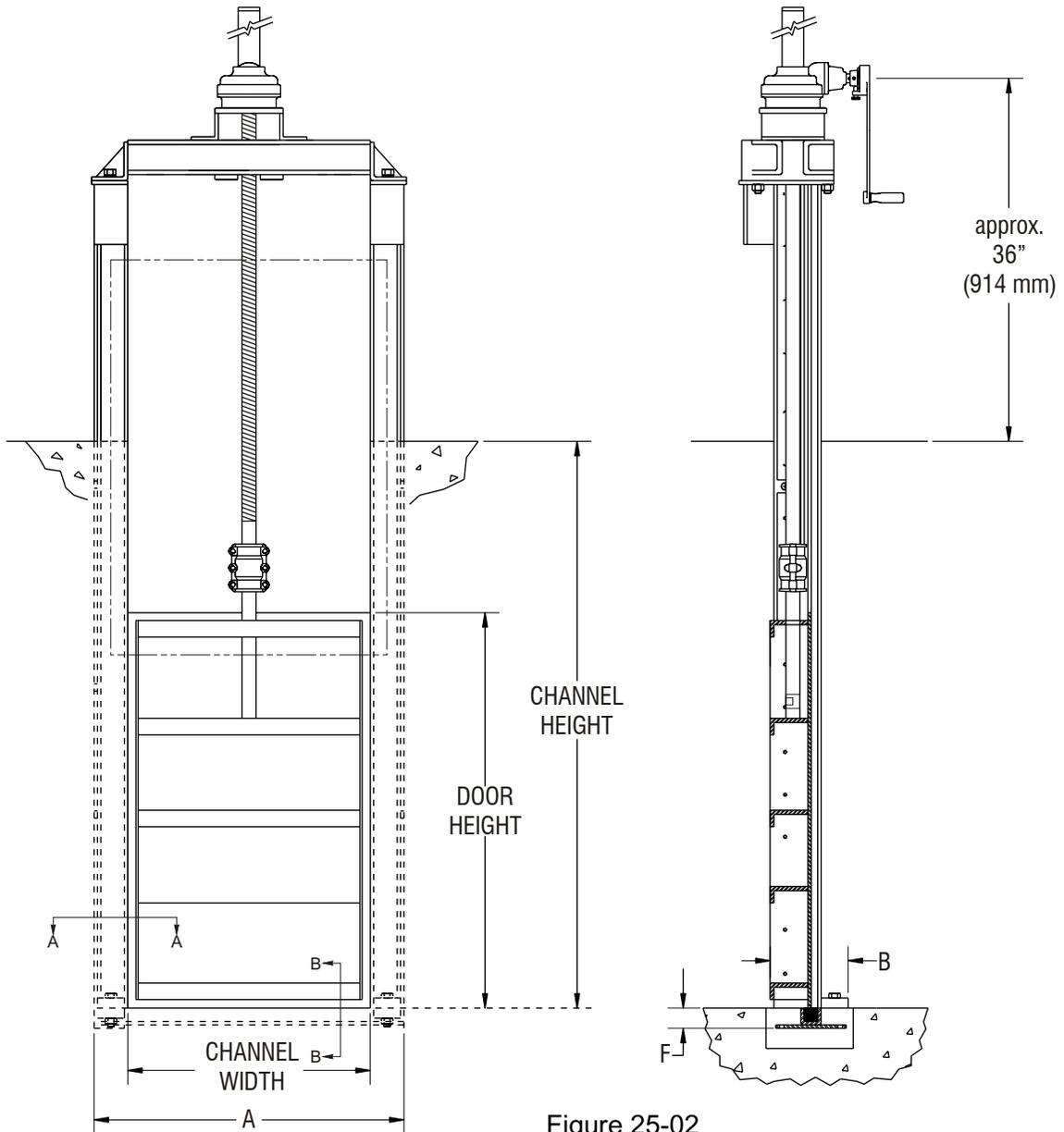


Figure 25-02

\* For special applications, refer to "Frame and Stem Configurations" in the Introduction section.

**Frame and Stem Configurations**

**Model 253**

Wall mounted (CW)  
with yoke-mounted  
handwheel operator (V)  
Rising stem (RS2)

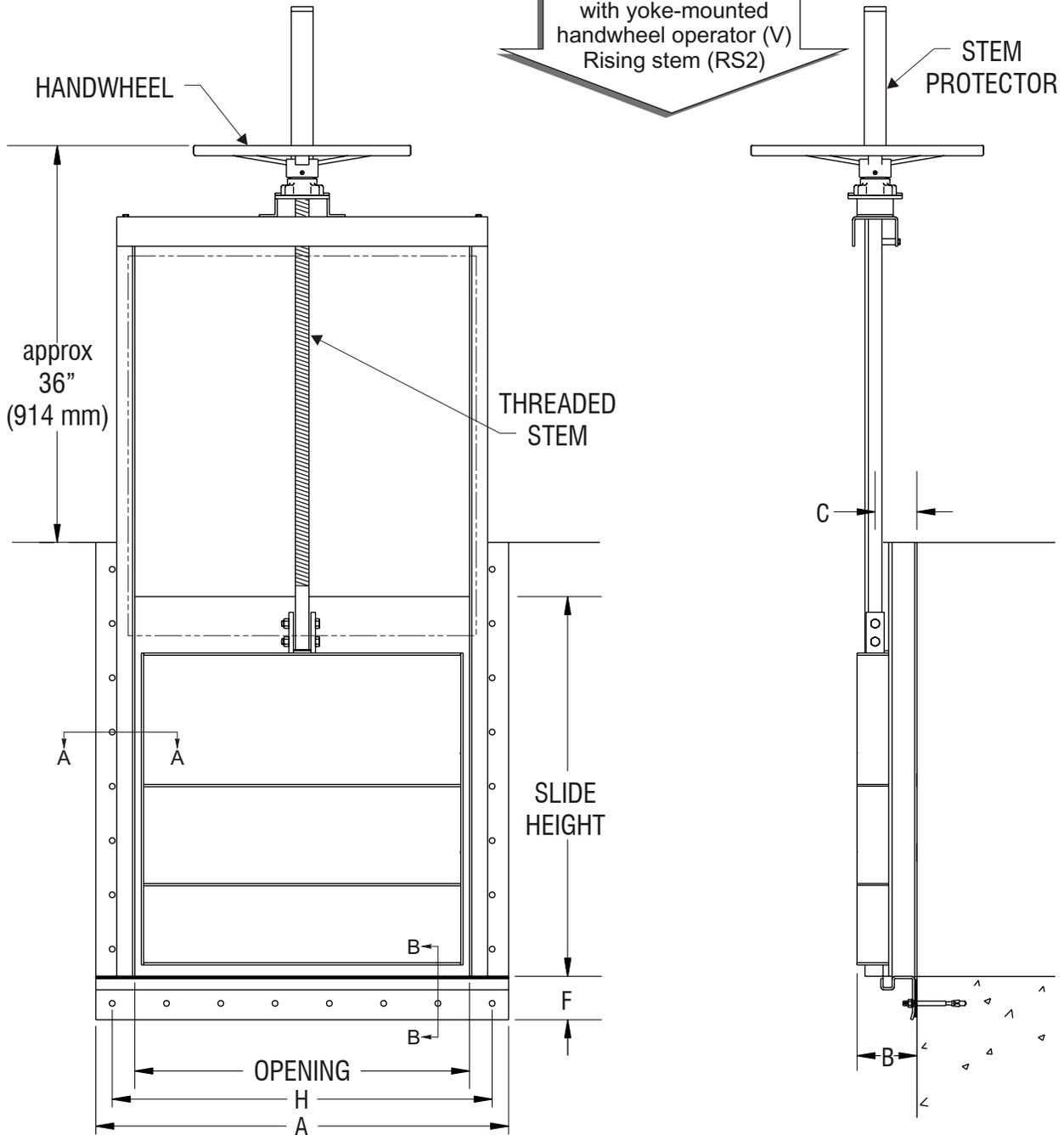


Figure 25-03

(See page 3 and 4 for sections A, B)

\* For special applications, refer to "Frame and Stem Configurations" in the Introduction section.



**SERIES 25**  
WATER CONTROL AND STOP GATES

**Frame and Stem Configurations**

(See page 3 and 4 for sections A, B)

**Model 253**

Inside an Existing Channel (EC) with yoke-mounted gear box and crank operator (MNE) Rising stem (RS2)

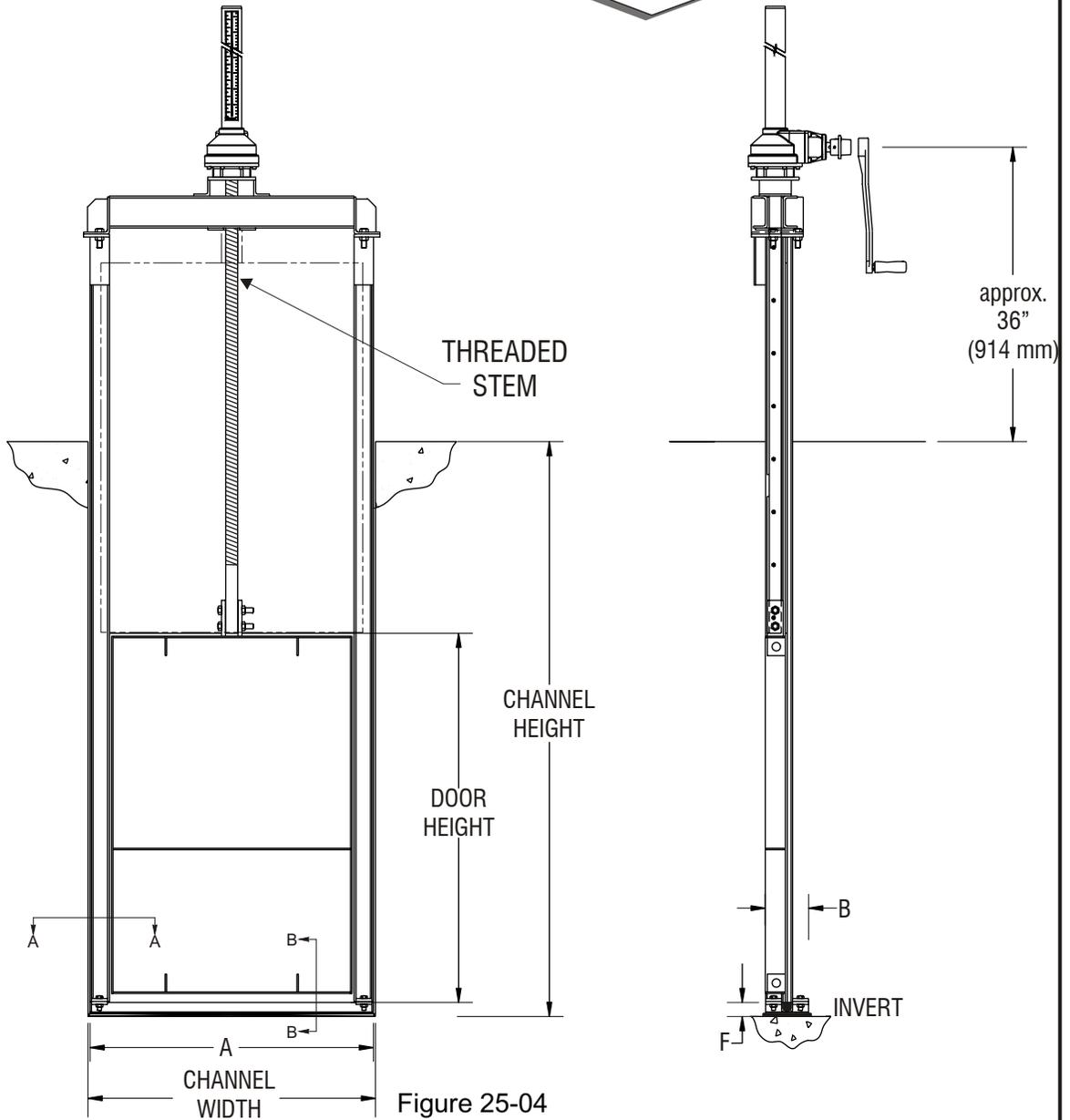


Figure 25-04

(See page 3 and 4 for sections A, B)

\* For special applications, refer to "Frame and Stem Configurations" in the Introduction section.



**SERIES 25**  
WATER CONTROL AND STOP GATES

**Dimensional Chart\***

DO NOT USE FOR SELF-CONTAINED GATES WITH FRAME EXTENDING MORE THAN 84" (2134 mm) OVER OPERATING FLOOR

FE MODEL

EC MODEL

Gate size (**) (in / mm)	A	B	F
12 x 12	16 7/8	5 9/32	1 3/8
300 x 300	424	134	35
16 x 16	20 7/8	5 9/32	1 3/8
400 x 400	524	134	35
21 x 21	25 7/8	5 5/16	1 3/8
500 x 500	624	135	35
24 x 24	28 7/8	5 5/16	1 3/8
600 x 600	723	135	35
30 x 30	34 7/8	5 5/16	1 3/8
750 x 750	874	135	35
32 x 32	36 7/8	5 5/16	1 3/8
800 x 800	924	135	35
36 x 36	40 7/8	5 5/16	1 3/8
900 x 900	1024	135	35
40 x 40	44 7/8	5 5/16	1 3/8
1000 x 1000	1124	135	35
42 x 42	46 7/8	5 5/16	1 3/8
1100 x 1100	1224	135	35
48 x 48	52 7/8	6 5/16	1 3/8
1200 x 1200	1323	160	35
54 x 54	58 7/8	6 5/16	1 3/8
1400 x 1400	1523	160	35
60 x 60	64 7/8	6 5/16	1 3/8
1500 x 1500	1624	160	35
72 x 72	76 7/8	6 13/16	1 3/8
1800 x 1800	1924	173	35
84 x 84	88 7/8	7 13/16	1 3/8
2000 x 200	2123	198	35
96 x 96	100 7/8	8 13/16	1 3/8
2400 x 2400	2527	224	35
108 x 108	112 7/8	9 13/16	1 3/8
2800 x 2800	2923	249	35
120 x 120	124 7/8	10 5/16	1 3/8
3000 x 3000	3124	262	35

Gate size (**) (in / mm)	A	B	F	Clear opening
12 x 12	11 1/2	5 9/32	1 3/8	6 5/8
300 x 300	287	134	35	163
16 x 16	15 1/2	5 9/32	1 3/8	10 5/8
400 x 400	388	134	35	264
21 x 21	20 1/2	5 5/16	1 3/8	15 5/8
500 x 500	488	135	35	364
24 x 24	23 1/2	5 5/16	1 3/8	18 5/8
600 x 600	587	135	35	463
30 x 30	29 1/2	5 5/16	1 3/8	24 5/8
750 x 750	737	135	35	613
32 x 32	31 1/2	5 5/16	1 3/8	26 5/8
800 x 800	787	135	35	663
36 x 36	35 1/2	5 5/16	1 3/8	30 5/8
900 x 900	888	135	35	764
40 x 40	39 1/2	5 5/16	1 3/8	34 5/8
1000 x 1000	987	135	35	863
42 x 42	41 1/2	5 5/16	1 3/8	36 5/8
1100 x 1100	1087	135	35	963
48 x 48	47 1/2	6 5/16	1 3/8	42 5/8
1200 x 1200	1187	160	35	1063
54 x 54	53 1/2	6 5/16	1 3/8	48 5/8
1400 x 1400	1387	160	35	1263
60 x 60	59 1/2	6 5/16	1 3/8	54 5/8
1500 x 1500	1487	160	35	1363
72 x 72	71 1/2	6 13/16	1 3/8	66 5/8
1800 x 1800	1787	173	35	1663
84 x 84	83 1/2	7 13/16	1 3/8	78 5/8
2000 x 200	1987	198	35	1863
96 x 96	95 1/2	8 13/16	1 3/8	90 5/8
2400 x 2400	2391	224	35	2267
108 x 108	107 1/2	9 13/16	1 3/8	102 5/8
2800 x 2800	2787	249	35	2663
120 x 120	119 1/2	10 5/16	1 3/8	114 5/8
3000 x 3000	2987	262	35	2863

Note :

EC gates are designed to fit inside channel with a grout finish to fill the remaining gap.

(\*) These dimensions are for information only. Do not use for installation or submittal purposes.

(\*\*) Fontaine Gates are also available for rectangular openings and in sizes other than those specified in this chart.

STAINLESS STEEL CHANNEL GATES



**SERIES 25**  
WATER CONTROL AND STOP GATES

**Dimensional Chart\***

DO NOT USE FOR SELF-CONTAINED GATES WITH FRAME EXTENDING MORE THAN 84" (2134 mm) OVER OPERATING FLOOR

CW MODEL

Gate size (**) (in / mm)	A	B	C	F	H
12 x 12 300 x 300	21 1/2 541	6 152	4 11/16 119	4 3/4 121	18 452
16 x 16 400 x 400	25 1/2 642	6 152	4 11/16 119	4 3/4 121	22 553
21 x 21 500 x 500	30 1/2 742	6 152	4 3/4 121	4 3/4 121	27 653
24 x 24 600 x 600	33 1/2 841	6 152	4 3/4 121	4 3/4 121	30 752
				4 3/4 121	36 902
				4 3/4 121	38 952
				4 3/4 121	42 1053
				4 3/4 121	46 1152
1000 x 1000	1241	152	121	121	1152
42 x 42	51 1/2	6	4 3/4	4 3/4	48
1100 x 1100	1141	152	121	121	1252
48 x 48	57 1/2	7	4 3/4	4 3/4	54
1200 x 1200	1441	178	121	121	1352
54 x 54	63 1/2	7	4 3/4	4 3/4	60
1400 x 1400	1641	178	121	121	1552
60 x 60	69 1/2	7	5	4 3/4	66
1500 x 1500	1741	178	127	121	1652
72 x 72	81 1/2	7 1/2	5	4 3/4	78
1800 x 1800	2041	191	127	121	1952
84 x 84	93 1/2	8 1/2	5 1/4	4 3/4	90
2000 x 200	2241	216	133	121	2152
96 x 96	105 1/2	9 1/2	5 1/4	4 3/4	102
2400 x 2400	2645	241	133	121	2556
108 x 108	117 1/2	10 1/2	5 1/2	4 3/4	114
2800 x 2800	3041	267	140	121	2952
120 x 120	129 1/2	11	5 1/2	4 3/4	126
3000 x 3000	3241	279	140	121	3152

Note: Custom gate sizes, such as 5'-0" high and 6'-0" wide, are available.

(\*) These dimensions are for information only. Do not use for installation or submittal purposes.  
(\*\*) Fontaine Gates are also available for rectangular openings and in sizes other than those specified in this chart.



### Typical Specifications

#### **1. GENERAL CONDITIONS**

**1.1. SCOPE.** This section covers Stainless Steel Channel Gates and operators.

**1.2. GENERAL.** The equipment provided under this section shall be fabricated, assembled, erected, and placed in proper operating condition in full conformity with the drawings, specifications, engineering data, instructions and recommendations of the equipment manufacturer unless exceptions are noted by the engineer.

Gates and operators shall be supplied with all the necessary parts and accessories indicated on the drawings, specified or otherwise required for a complete, properly operating installation and shall be the latest standard product of a manufacturer regularly engaged in the production of water control gates.

Gates supplied under this section shall be Series 25 Stainless Steel Channel Gates as manufactured by H.Fontaine Ltd.

**1.3. GOVERNING STANDARDS.** Except as modified or supplemented herein, all gates and operators shall conform to the applicable requirements of AWWA C513, latest edition.

#### **1.4. QUALITY ASSURANCE**

**1.4.1.** The manufacturer shall have experience in the production of substantially similar equipment, and shall show evidence of satisfactory operation in at least 50 installations. The manufacturer's shop welds, welding procedures and welders shall be qualified and certified in accordance with the requirement of the latest edition of ASME, Section IX.

**1.4.2.** Gates shall be shop inspected for proper operation before shipping.

**1.4.3.** The manufacturer shall be ISO 9001 : 2000 certified.

**1.5. SUBMITTALS.** The manufacturer shall submit, for approval by the purchaser, drawings showing the main dimensions, general construction and materials used in the gate and lift mechanism.

#### **2. PERFORMANCE**

**2.1. LEAKAGE.** Channel gates shall be substantially watertight under the design head conditions. Leakage shall not exceed 0.05 U.S. gallon per minute per foot (0.60 l/min per meter) of seal periphery under the design seating head and unseating head.

**2.2. DESIGN HEAD.** The slide gates shall be designed to withstand the maximum design head (maximum design head shall be taken as the height of the slide unless otherwise shown in the schedule).

**2.3. SEAL PERFORMANCE TEST.** The gate's sealing system should have been tested through a cycle test in an abrasive environment and should show that the leakage requirements are still obtained after 25,000 cycles with a minimum deterioration.

#### **3. PRODUCT**

##### **3.1. CHANNEL GATES**

**3.1.1. GENERAL DESIGN.** Gates shall be either self-contained or non-self-contained and of the rising stem or non-rising stem configuration, as indicated on the gate schedule.

**3.1.2. FRAME.** The gate frame shall be constructed of structural members or formed plate. The frame shall be suitable for mounting on a concrete wall (CW) at the end of a channel, embedded inside a channel (FE) or mounted on the channel surface (EC). The guide slot shall be of UHMWPE (ultra high molecular weight polyethylene). The frame configuration shall be of the flush-bottom type.

**3.1.3. SLIDE.** The slide shall consist of a flat plate reinforced with formed plates or structural members to limit its deflection to 1/720 of the gate's span under the design head.



## SERIES 25

### WATER CONTROL AND STOP GATES

**3.1.4. GUIDES AND SEALS.** Guides shall be made of UHMWPE (ultra high molecular weight polyethylene) and shall be of such length as to retain and support at least two thirds (2/3) of the vertical height of the slide in the fully open position.

Side seals shall be made of UHMWPE (ultra high molecular weight polyethylene) of the self-adjusting type. A compression cord shall ensure contact between the UHMWPE guide and the gate in all positions. The sealing system shall maintain efficient sealing in any position of the slide and let the water flow only in the open part of the gate.

Seals shall maintain the specified leakage rate in both seating and unseating conditions. The bottom seal shall be made of resilient neoprene set into the bottom member of the frame and shall form a flush-bottom.

### 3.2. OPERATORS AND STEM

**3.2.1. STEM AND COUPLINGS.** The operating stem shall be of stainless steel designed to transmit in compression at least two (2) times the rated output of the operating manual mechanism with a 40 lbs (178 N) effort on the crank or handwheel.

The stem shall have a slenderness ratio (L/r) less than 200. The threaded portion of the stem shall have machine cut threads of the Acme type.

Where a hydraulic, pneumatic or electric operator is used, the stem design force shall not be less than 1.25 times the output thrust of the hydraulic or pneumatic cylinder with a pressure equal to the maximum working pressure of the supply, or 1.25 times the output thrust of the electric motor in the stalled condition.

**3.2.1.1.** For stems in more than one piece and with a diameter of 1 3/4 inches (45 mm) and larger, the different sections shall be joined together by solid bronze couplings. Stem with a diameter smaller than 1 3/4 inches (45 mm) shall be pinned to an extension tube.

The couplings shall be grooved and keyed and shall be of greater strength than the stem.

**3.2.1.2.** Gates having width equal to or greater than two times their height shall be provided with two lifting mechanisms connected by a tandem shaft.

**3.2.2. STEM GUIDES.** Stem guides shall be fabricated from type 304L (or 316L) stainless steel. The guide shall be equipped with a UHMWPE bushing. Guides shall be adjustable and spaced in accordance with the manufacturer's recommendation. The L/r ratio shall not be greater than 200.

**3.2.3. STEM COVER.** Rising stem gates shall be provided with a clear polycarbonate stem cover. The stem cover shall have a cap and condensation vents as well as a clear mylar position indicating tape. The tape shall be field applied to the stem cover after the gate has been installed and positioned.

**3.2.4. LIFTING MECHANISM.** Manual operators of the types listed in the schedule shall be provided by the gate manufacturer.

All bearings and gears shall be totally enclosed in a weather tight housing. The pinion shaft of crank-operated mechanisms shall be constructed of stainless steel and supported by roller or needle bearings.

Each manual operator shall be designed to operate the gate under the maximum specified seating and unseating heads by using a maximum effort of 40 lbs (178 N) on the crank or handwheel and shall be able to withstand, without damage, an effort of 80 lbs (356 N).

The crank shall be removable and fitted with a corrosion resistant rotating handle. The maximum crank radius shall be 15 inches (381 mm) and the maximum handwheel diameter shall be 24 inches (610 mm).

**3.2.5. YOKE.** Self-contained gates shall be provided with a yoke made of structural members or formed plates. The maximum deflection shall be 1/360 of the gate's span.



#### **4. MATERIALS**

Part	Material
Frame, yoke, stem guides, slide, stem extension	Stainless steel ASTM A-240 Type 304L or 316L
Guides, side seals, stem guide liner	Ultra high molecular weight polyethylene (UHMWPE) ASTM D-4020
Compression cord	Nitrile ASTM D-2000 M6BG 708, A14, B14, E014, E034
Bottom seal	Neoprene ASTM D-2000 Grade 2 BC-510
Threaded stem	Stainless steel ASTM A-276 Type 303 MX or 316
Fasteners	ASTM F593 and F594 GR1 for type 304 and GR2 for type 316
Pedestal, handwheel, crank	Tenzaloy aluminum
Gasket (between frame and wall)	EPDM ASTM 1056
Stem cover	Polycarbonate ASTM D-3935
Lift nut, couplings	Manganese bronze ASTM B584 UNS-C86500

#### **5. SCHEDULE**

<b>Gate Identification</b>		
<b>Gate Type</b>		
<b>Size</b> Width x Height		
<b>Operating Floor Elevation</b>		
<b>Invert Elevation</b>		
<b>Head</b> (Seating / Unseating)		
<b>Mounting</b>		

**Gate Type:** Open or self-contained

**Mounting:** CW- Mounted on a concrete wall at the end of the channel  
 FE- Frame embedded inside the channel  
 EC- Mounted on the surface of the channel

#### **6. EXECUTION**

**6.1. INSTALLATION.** Gates and appurtenances shall be handled and installed in accordance with the manufacturer's recommendations.

##### **6.2. FIELD TESTS**

**6.2.1.** Following the completion of each gate installation, the gates shall be operated through at least two complete open/close cycles. If an electric or hydraulic operator is used, limit switches shall be adjusted following the manufacturer's instructions.

**6.2.2.** Gates should be checked for leakage by the contractor (refer to the "Performance" section for approval criteria).

**Appendix H – Traveling Screen Catalog  
Sheets**

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## Comparing Polymer and Steel Screens

Hydrolox engineered polymer components and innovative screen frame design combine to produce traveling water screens with significant, measurable advantages over conventional chain and basket steel screens.

Major Screen Issues	Steel Screen Problems	Hydrolox Engineered Polymer Solutions
Limited Screen Life	Screen life is severely limited by highly abrasive environments. Uneven wear on basket chains causes mistracking and shortens screen life.	Engineered polymer screens last 2-5 times longer than steel. Positive drive system eliminates uneven wear and mistracking.
Maintenance	Submerged moving parts increase maintenance and are not easily accessible.	Zero submerged moving parts. Near-zero unscheduled maintenance and downtime.
Operational Costs	Requires frequent maintenance, including repairs that cannot be done on site.	Modular design allows for repairs to be made on site and lowers operational costs.
Corrosion	Steel screening material is highly corrosive, especially in saltwater environments.	Polymers do not corrode.
Bio-foul	Steel components readily bio-foul.	Engineered polymer less likely to bio-foul.
Safety	Heavy steel baskets are difficult to handle and can present safety hazards.	Compact design is approximately 40% lighter. Lightweight engineered polymer material improves worker safety.
316(b) Compliance		Unique fish handling design reduces fish impingement mortality. Smooth polymer surface reduces fish injury. Smaller slot size reduces entrainment while maintaining a generous open area.
Debris Carryover		Enhanced design of the screen's spray bar has better mesh coverage and reduces carryover.

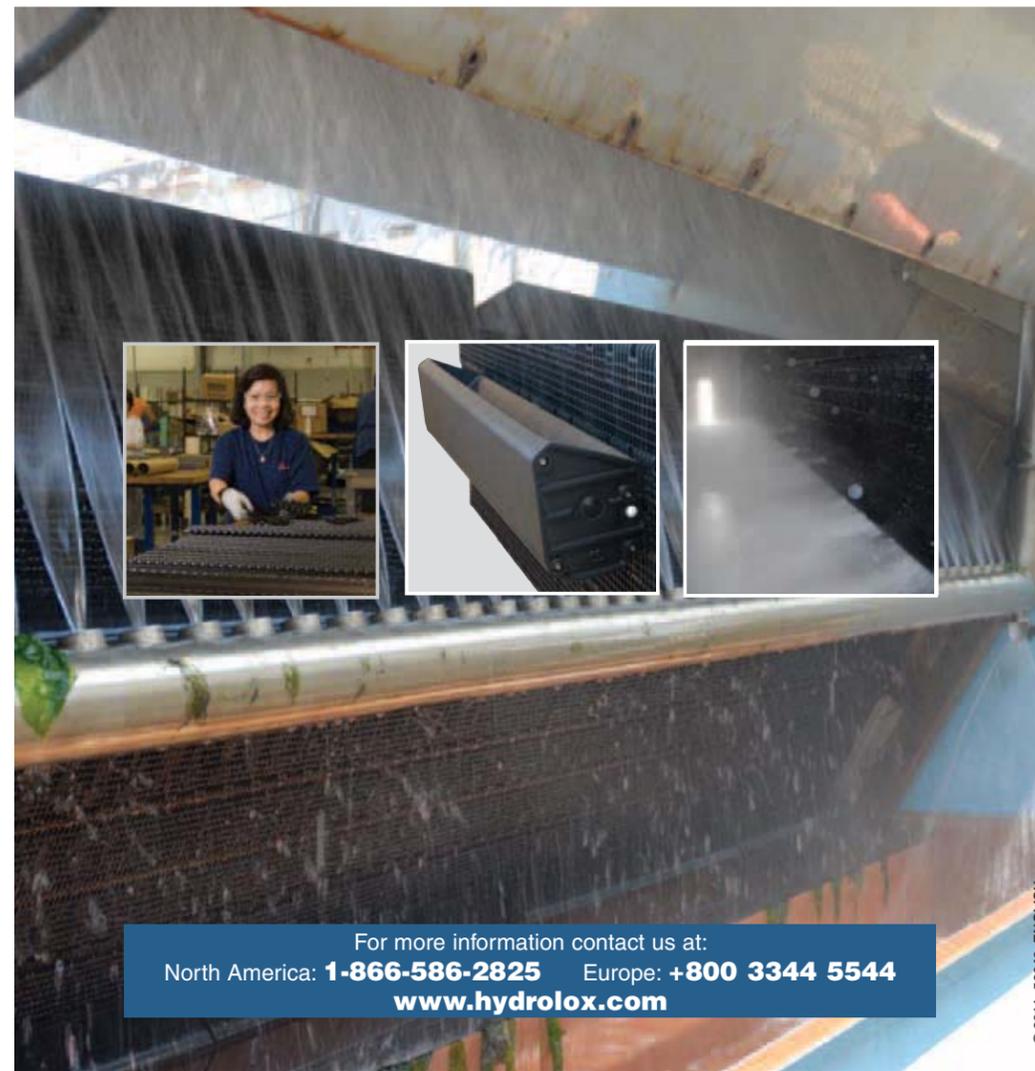
## The Versatile, Affordable Compliance Solution

Hydrolox traveling water screens are equipped with either debris-handling flights or fish-handling scoops. Both feature a patented, three-piece design. The two devices are easily interchangeable, with minimum downtime and labor—allowing easy changeover for compliance with the EPA Clean Water Act, Section 316(b).

The Hydrolox fish handling system has been proven successful at meeting impingement reductions, in testing at Alden Research Laboratory. Also, the system's extended wear life can bring dramatic savings over the life of the screen as more power plants run water screens continuously in order to comply with EPA guidelines.

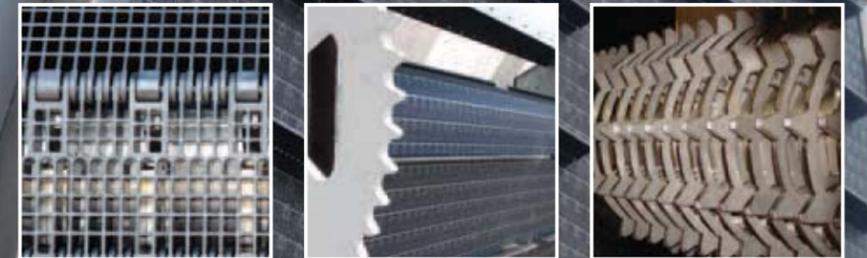


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Hydrolox traveling water screen technology for today and tomorrow.



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# The anti-corrosion, anti-abrasion, low-maintenance traveling water screen solution

Hydrolox vertical traveling water screens are engineered and constructed to combat the costliest and most persistent cooling water intake issues.

Even in the most abrasive and corrosive environments, Hydrolox water screens improve operational efficiencies and virtually eliminate maintenance costs.

## A Better Water Screen Idea

Hydrolox engineered polymer technology is changing the way power plant operators think about water screen performance—with longer-lasting, easy-to-install engineered polymer screens.

It's proven technology, with significant advantages over traditional steel mesh screens, including reduced maintenance and operations costs. In addition, Hydrolox screens are approximately 40% lighter than comparable steel screens, which makes them safer and easier to work with.

The versatile Hydrolox water screen is easily configured for use in applications where fish impingement regulations are in effect.

## Built-in Strength and Durability

Hydrolox water screens derive much of their longevity and ease of operation from the positive drive system in which the modular screen mesh articulates around engineered polymer hinge rods and high-strength stainless steel sprockets. This drive system has proven its durability in thousands of applications world-wide.

*All Hydrolox mesh components are molded in-house. Large inventories are maintained for meeting standard and emergency deliveries.*

## The Modular Screen Concept

Hydrolox water screens are assembled in an interlocked, bricklaid pattern with full-length hinge rods—an inherently strong system that allows fast, in-place maintenance and repairs without special tools.

Individual modules are molded with easy-to-clean surfaces that are less likely to bio-foul. Screens are manufactured to order in virtually any width and length.



## Extended Water Screen Life

Our traveling water screens are molded in impact-resistant, engineered polymer materials that last two to five times longer than traditional steel chain and basket screen components.

This level of screen performance extends scheduled maintenance intervals and reduces the frequency of screen mesh replacement. All of this adds up to lower operating costs and more efficient labor allocation.



# Inside the Hydrolox Water Screen

**Positive Drive System** distributes load across entire screen width. Eliminates edge-driven system weaknesses including mistracking and uneven wear; extends system life.

**Frames fit into existing guide slots**—no need to modify existing intake structure. Screens are manufactured to order in virtually any width and length.

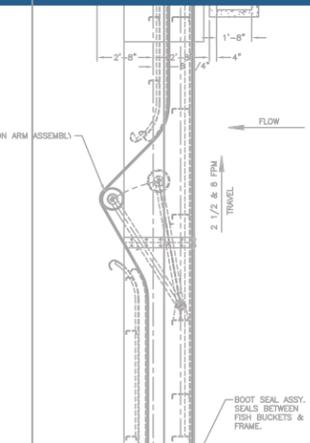
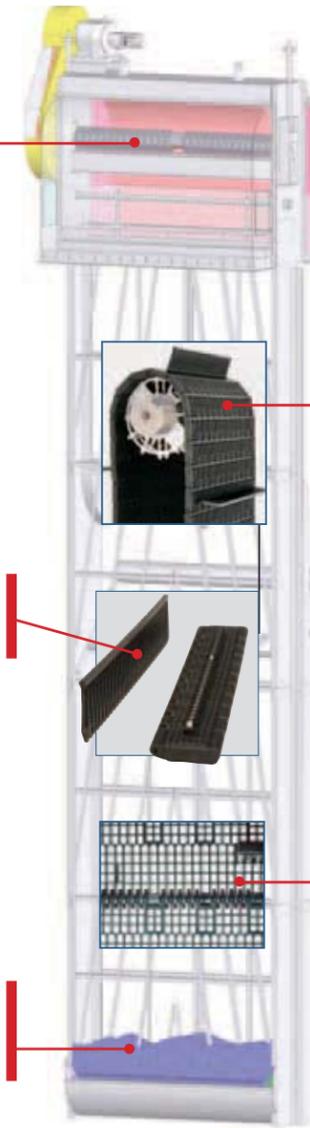
**Modules articulate around engineered polymer hinge rods** and high-strength stainless steel sprockets.

**Unique tensioning system** actively maintains the correct screen tension. The deck level indicator eliminates guesswork and minimizes unscheduled maintenance.

**Patented, detachable debris-handling flights** absorb most debris impact without damage. Easily replaced with fish-handling attachments.

**Screen has no gaps larger than mesh hole openings, reducing debris pass-through.** 0.25" X 0.30" openings are smaller, while still providing effective open area equivalent to a traditional screen.

**No submerged moving parts** - patented seal and static shoe at the boot section eliminate the high maintenance common with submerged foot sprockets, bearings, and carrier chains.



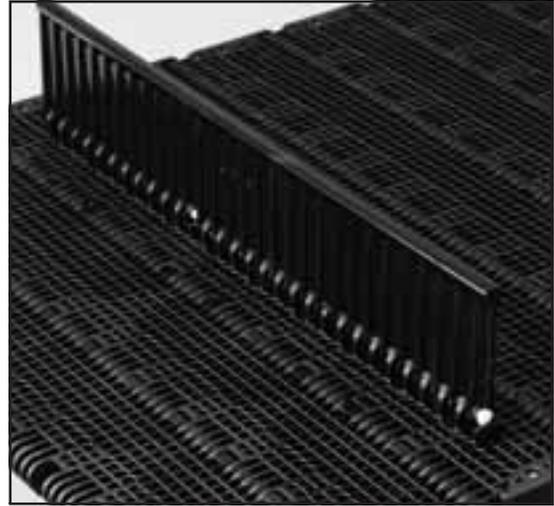
# Product Line Extension

## Series 6000 Hydrolox™ Engineered Polymer Screen

Designed for cooling water intake screen applications, the Hydrolox S6000 substantially reduces capital and operating costs. Compared to other screen technologies, engineered polymer screens perform twice as long and make installation simple by fitting into existing slots made for traditional steel vertical traveling screens.

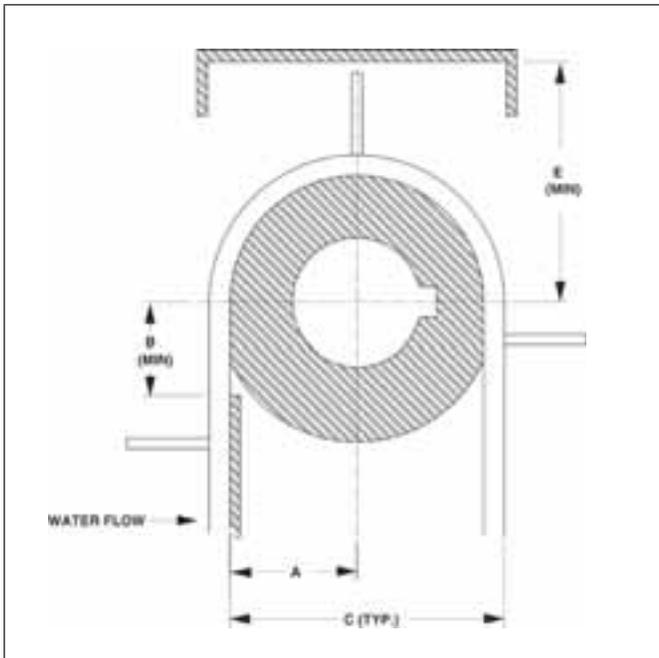
Flights can be placed at various distances on the Hydrolox S6000 screen to prevent debris carryover. The 3-piece flight design allows end users to perform maintenance on-site without the costly removal of the screen with a crane. Fish scoops may be interchanged with flights to help power companies comply with laws for preventing fish impingement.

- 2-5 times longer screen life than steel vertical traveling screens in abrasive applications.
- Average screen size capable of withstanding differential pressure of 5 feet (1.5 meters).
- Slot opening design and smooth screen surface facilitate effective cleaning.
- Labor costs related to maintenance reduced over life of screen. Less frequent maintenance needs and lighter screen weight also improves worker safety.



Contact Hydrolox today for a sample of this new product or for more information.

Sprocket Description			A		B		C		E	
Pitch Diameter		No. Teeth	Range (Bottom to Top)		in.	mm	in.	mm	in.	mm
in.	mm		in.	mm						
13.5	348	12	5.9	150	4.07	103	13.3	337	7.19	183



**Sprocket Spacing as a Function of Belt Strength Utilized**



### HYDROLOX

301 Plantation Road • Harahan, Louisiana 70123 • USA  
Toll Free Customer Service: 1-866-586-2825



# Product Line Extension

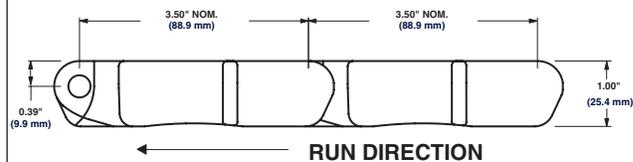
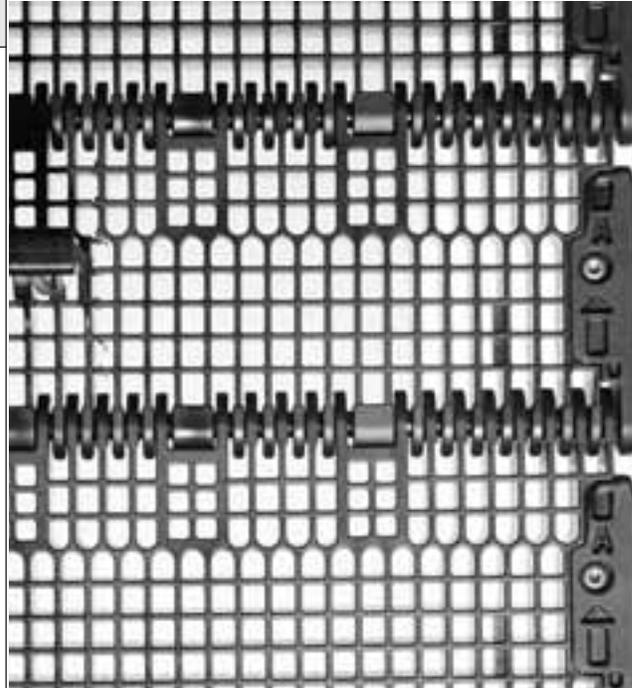
## Engineered Polymer Screen

	in.	mm
Pitch	3.50	89.9
Minimum Width	10	254
Width Increments	2.00	50.8
Opening Size (approximate)	0.25 x 0.30	6.35 x 7.62
Open Area	48%	
Hinge Style	Closed	
Drive Method	Hinge-Driven	



### Product Notes

- Always check with Customer Service for precise screen width measurement and stock status before designing a screen or ordering a belt.
- Always contact Hydrolox technical support for strength requirements, frame guidelines, etc.
- Fully flush edges with recessed rods prevent edge damage and rod migration.
- Available with other Series 6000 accessories.
- Made of corrosion resistant polymer.
- A T20 Torx driver is need to remove screw holding Endcap to belt edge.
- Minimum sprocket spacing is 2 inches (50.8 mm) and is recommended for an adjusted belt pull greater than 1500 lb/ft (2231 kg/m). Maximum sprocket spacing is 6 inches (152.4 mm).



### Belt Data

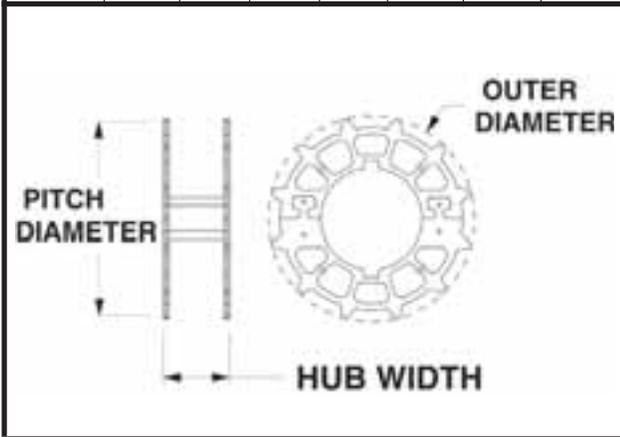
Belt Material	Standard Rod Material Ø 0.31 in. (7.9 mm)	BS Belt Strength <sup>a</sup>		Temperature Range (continuous)		W Belt Weight	
		lb/ft	kg/m	°F	°C	lb/ft <sup>2</sup>	kg/m <sup>2</sup>
Engineered Polymer	Engineered Polymer	3000	4462	-50 to 240	-46 to 116	2.40	11.8

<sup>a</sup> Belt strength of 4000 lbs/ft (5953 kg/m) for spike loads.

# Product Line Extension

## Metal Sprocket Assembly Data

No. of Teeth (Chordal Action)	Nom. Pitch Dia. in.	Nom. Pitch Dia. mm	Nom. Outer Dia. in.	Nom. Outer Dia. mm	Nom. Hub Width in.	Nom. Hub Width mm	Round Bore Sizes	
							in.	mm
12 (3.412%)	13.5	342.9	13.6	345.4	2.9	73	6.25	158.8



## 3-Piece Debris Flight

Available Flight Height		Material
in.	mm	
4	102	Engineered Polymer

**Note:** Flights consist of 3 pieces: the base module, the attachment, and the rod.

**Note:** Flight surface has 0% open area and a no-cling surface. The base module has the S6000 FG design.

**Note:** The minimum indent is 4 in. (102 mm).



# Product Line Extension

## The Hydrolox™ Screen Concept

Hydrolox™ screens are made from engineered polymer modules. Screens are assembled in an interlocked, bricklaid pattern with full length hinge rods – an inherently strong design.

Screens can be made to order in virtually any width and length. Modular components also allow for fast, on-site maintenance without having to replace an entire screen.

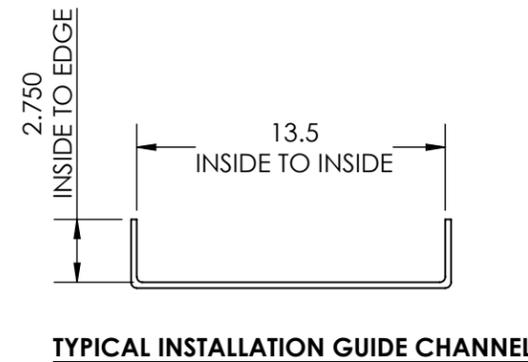
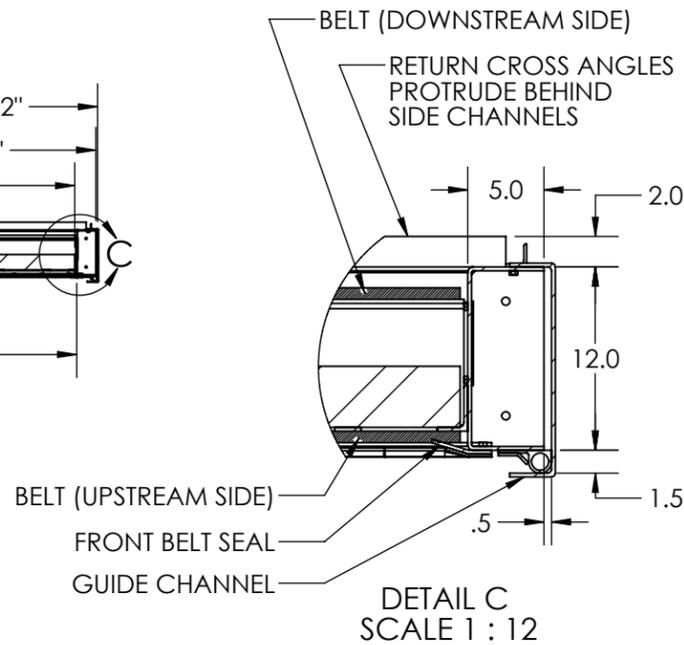
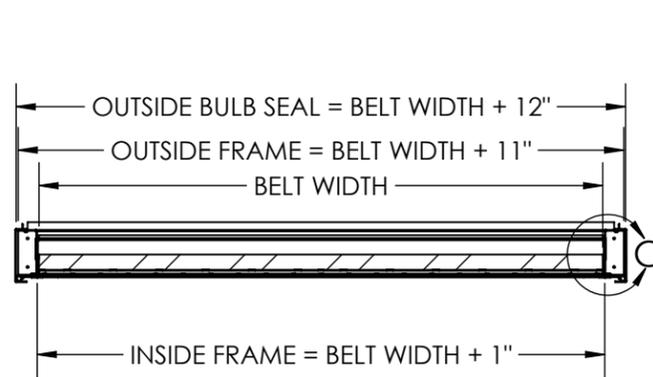
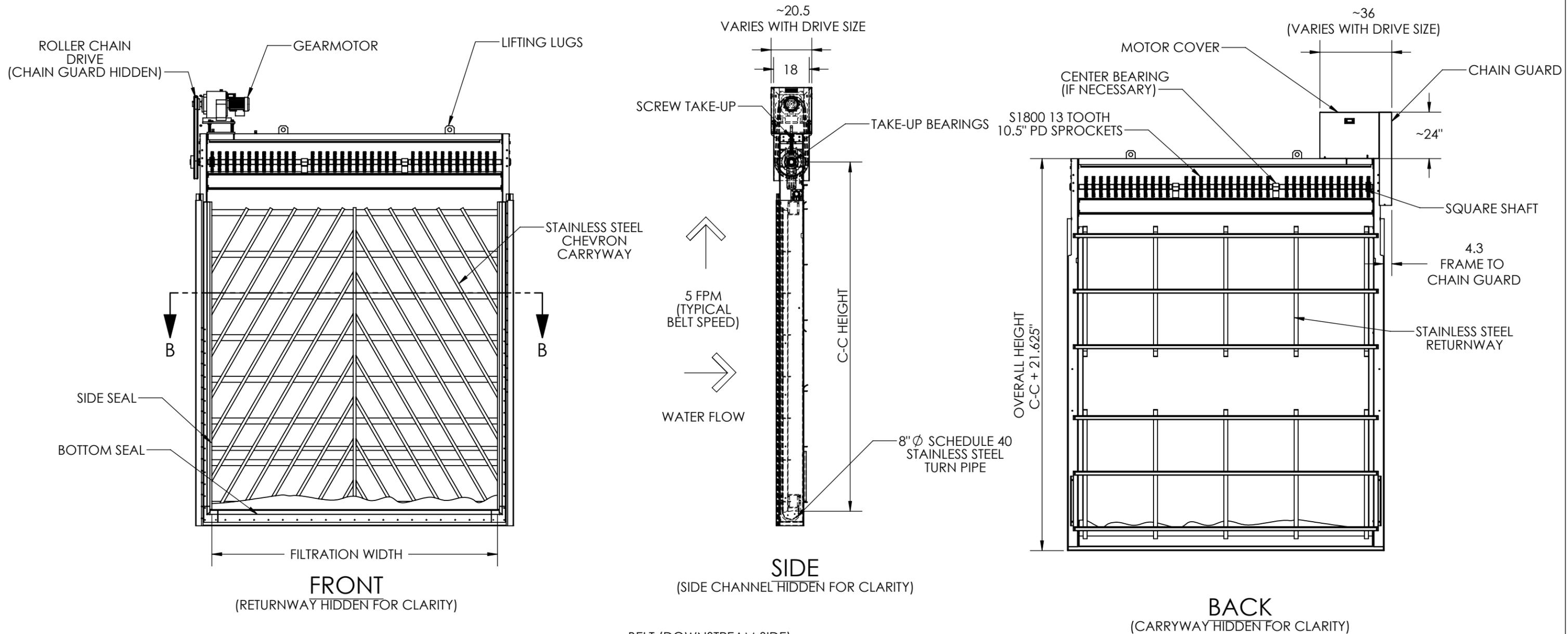
Hydrolox™ molds all components in-house and maintains an extensive inventory in order to meet both your normal and emergency delivery needs.



## The Answer to All Your Screening Needs

Hydrolox™ Engineered Polymer Screens offer effective performance, ease of maintenance and longevity, all of which adds up to superior value for the end user.

Major Screen Issues	Steel Vertical Traveling Screen Problems	Hydrolox™ Engineered Polymer Vertical Traveling Screen Solutions
Limited Screen Life	<ul style="list-style-type: none"> <li>Screen life severely limited by highly abrasive environments. Uneven wear on basket chains prone to mistracking and shortens life.</li> </ul>	<ul style="list-style-type: none"> <li>Engineered polymer screen life 2-5 times longer than steel. Positive drive system eliminates uneven wear and mistracking.</li> </ul>
Maintenance	<ul style="list-style-type: none"> <li>Submerged moving parts increase maintenance and are not easily accessible.</li> </ul>	<ul style="list-style-type: none"> <li>Zero submerged moving parts. Near-zero unscheduled maintenance and downtime.</li> </ul>
Operational Costs	<ul style="list-style-type: none"> <li>Requires frequent maintenance, including repairs that cannot be done on site.</li> </ul>	<ul style="list-style-type: none"> <li>Modular design allows for repairs to be made on site and lowers operational costs.</li> </ul>
Corrosion	<ul style="list-style-type: none"> <li>Steel screening material highly corrosive in saltwater environments.</li> </ul>	<ul style="list-style-type: none"> <li>Engineered polymer does not corrode.</li> </ul>
Bio-foul	<ul style="list-style-type: none"> <li>Steel components likely to bio-foul.</li> </ul>	<ul style="list-style-type: none"> <li>Engineered polymer minimizes bio-foul.</li> <li>Optional additives are available to eliminate bio-foul.</li> </ul>
Safety	<ul style="list-style-type: none"> <li>Heavy steel baskets difficult to handle and can be a safety hazard.</li> </ul>	<ul style="list-style-type: none"> <li>Compact design is approximately 40% lighter.</li> <li>Light-weight engineered polymer material improves worker safety.</li> </ul>
316(b) Compliance		<ul style="list-style-type: none"> <li>Unique fish handling design reduces fish impingement mortality.</li> <li>Smooth polymer surface reduces fish injury.</li> <li>Smaller slot size reduces entrainment while maintaining a generous 48% open area.</li> </ul>



**hydrolox™**  
ENGINEERED POLYMER SCREENS

Mailing Address:  
P.O. Box 50699  
New Orleans, LA 70150  
Tel: 866-586-2825

TITLE  
S1800 Vertical Traveling Screen  
Typical Arrangement

SCALE 1:48	SIZE <b>B</b>	<b>DO NOT SCALE THIS DRAWING</b>	SHEET 1 OF 1
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