Jacobs

Technical Memorandum

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Subject	**Lake Whatcom Screenhouse Condition Assessment Report (Task 4.2) (Final)**
Project Name	Raw Water Intake Condition Assessment and Intertie Pipeline Design
Attention	Steve Day, PE / Project Manager for City of Bellingham
From	Phil Martinez, PE / Jacobs Kenny Moffat, PE / Jacobs
Date	August 23, 2024

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1. Introduction

The City of Bellingham (City) undertook an assessment in the first half of 2024 of the condition of the Screenhouse facility (pictured below in Exhibit 1-1). This assessment follows up a similar assessment that was completed in 2014. The condition assessment, as presented herein, covers several key aspects of the Screenhouse facility, including:

- The 48-inch diameter pipelines on the downstream side of the main screen caisson
- The overall concrete building structure
- The slide gates and one plug valve
- The two traveling screens

This technical memorandum documents the findings of the March 2024 Screenhouse inspection. The Screenhouse facility and overall raw water supply system that conveys water to the City's Whatcom Falls Water Treatment Plant (WTP) is owned by the City.

The purpose of this assessment is to document the condition of the Screenhouse facility, identify repair needs, identify if there has been any further deterioration since the previous condition assessment in 2014, and develop estimated costs for repairs and replacements. This information will be used by the City to budget and plan the repairs and replacements. As is the case for most of the key facilities that comprise the City's water supply system between Lake Whatcom and the WTP, there are no redundant facilities for the Screenhouse. Consequently, continued reliable service for the Screenhouse is essential to enabling uninterrupted supply to the City's customers.

Exhibit 1-1. Screenhouse

Of the key elements of the Screenhouse, it is the three 18- to 20-foot sections of 48-inch diameter steel pipe on the outlet of the screen caisson that have presented the greatest concern in recent years. Previous condition assessments, dating back to 2012, have identified severe external corrosion in the short (18-inch) segments of each of these three pipes. A complete summary of observations from prior investigations is provided in the *City of Bellingham Screen House Condition Assessment and improvement Report (Task 3.8)* (CH2M Hill, 2014).

The focus of this condition assessment was on key elements that are known to warrant repair or replacement and have the potential to stopping or severely disrupting water supply through the Screenhouse. Elements of the facility that may warrant rehabilitation, but that do not present similar risk to continued supply, were not investigated. These include: electrical, telemetry, HVAC, windows, and general code-compliance.

2. Description of Existing Facility

The Screenhouse was constructed in 1940 during the same time period as the adjacent upstream tunnel, the Gatehouse 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 untreated water for cooling the powerplant 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 Screenhouse to the City's lone user of untreated water (the purple "Industrial Pipeline") and to the City's WTP (the dark blue "Raw Water Pipeline").

Several drawings from the original 1940 Screenhouse design drawings (also referred to at the time as the "Chlorinating House") are included in Attachment A. The original intention and function of the Screenhouse included the addition of chlorine as a disinfectant. That continued for decades, but was discontinued in the early 2000s.

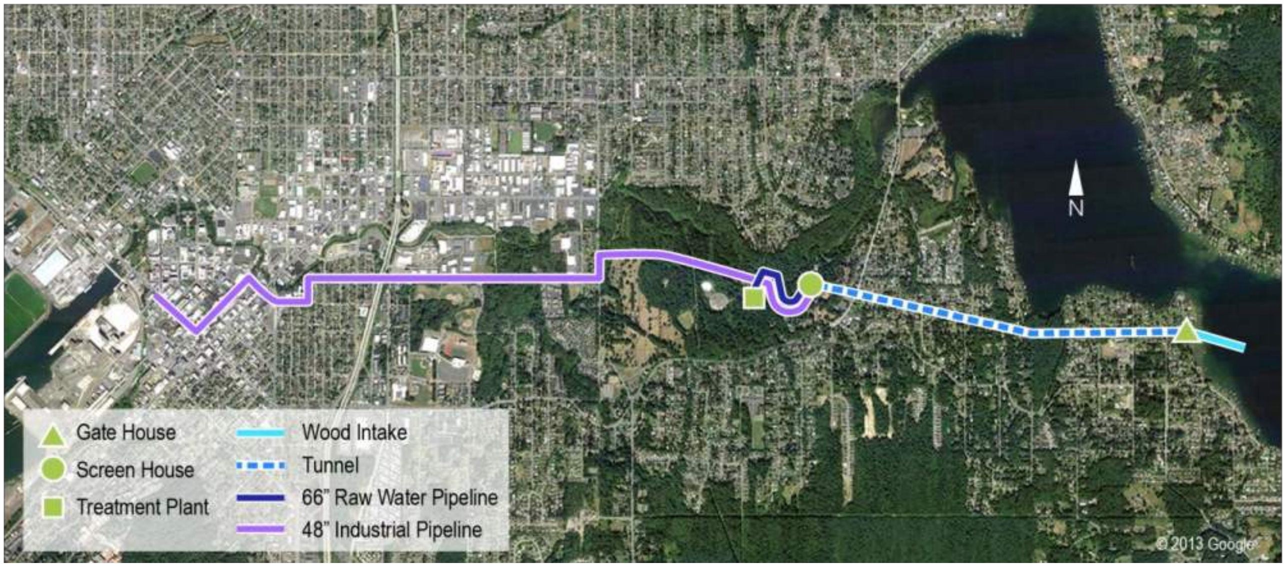


Exhibit 2-1. City of Bellingham Water Supply Facilities

3. Inspection Approach

The Screenhouse inspection was completed on March 20th, 2024. This inspection coincided with the Lake Whatcom Raw Water tunnel and Gatehouse inspections, which were performed on the same day. Dewatering of the Screenhouse and the upstream tunnel was performed City staff overnight prior to the inspection team arriving on-site. This allowed for the inspection team to evaluate both the readily accessible (non-submerged) portions of the Screenhouse facility, as well as the normally inundated caisson portion of the Screenhouse, where the tunnel, gates, screens and three 48-inch discharge pipeline connections are located. An annotated record drawing showing the pipe and tunnel connections and configuration of the caisson is presented in Figure 1.

The typically inundated caisson portion of the Screenhouse was accessed from the second floor inspection wells via confined space entry using two separate (of the four total) access hatches. An access hatch upstream of the screens was used to access the tunnel well while an access hatch downstream of the screens was used to access the Screenhouse outlet well to allow for inspection of the three 48-inch diameter pipes.

Performance of the inspection work included a robust team of representatives from Jacobs, the City and a standby emergency rescue subcontractor, Life Rescue, Inc., to support and execute the inspection field work. The Jacobs contingent evaluating the Screenhouse included subject matter experts in the following areas:

- Structural
- Corrosion
- Pipeline Condition Assessment

- Screens and Valves
- Health, Safety & Environment

Beyond the roles identified above the Jacobs Project Manager supported the Screenhouse inspection. The tunnel inspection team was also present to enter at the Screenhouse tunnel well to access the tunnel.

4. Inspection Observations

Inspection observations are presented herein for the 48-inch diameter pipelines, the concrete structure, the slide gates and mud valve, and the traveling screens. Each of these elements of the Screenhouse is identified in Figure 1. Photos of each of the Screenhouse facility components taken during the March 2024 assessment are present in Attachment B.

4.1 48-Inch Outlet Pipelines

The three parallel 48-inch diameter steel pipelines, which were installed at the time the Screenhouse was constructed in 1940, had been identified during previous inspections to be a primary focus area within the Screenhouse. These three sections, measuring approximately 20-feet in length, are highlighted in Figure 1.

The downstream ends of each of these pipes extend into the Chlorine Injection Room of the Screenhouse by 18-inches. Each of these 18-inch segments have extensive external corrosion-induced pitting, based on prior inspections (these segments have since been covered with an external coating system). Because of the coating system over the external corrosion, it was not possible to inspect the exterior of the short segments. Just downstream of each of these three 20-feet sections of 1940-vintage steel pipe are sections of newer steel pipe that was installed in 1981. These newer pipe sections are in excellent condition.

Of the three 1940-vintage parallel pipes, the southern-most pipe is connected to untreated water system that supplies cooling water to the powerplant on the City's waterfront. The other two adjacent pipelines to the north serve as dual conduits for the WTP. They are connected just to the west of the Screenhouse to form a single 66-inch diameter steel pipeline that extends to the WTP. The inspection on March 20, 2024, allowed for inspection of the inside of the three deteriorated, 20-feet sections of 1940-vintage pipe 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 (1981 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 and corrosion were extensive inside each of the three 20-foot-long pipeline sections as shown in Exhibit 4-1. Fine sediment measuring one to three inches was present on the bottom of the industrial pipeline, which is believed to be the result of low water velocities and extended periods of zero flow in this pipeline. No significant sediment was observed in the two pipelines conveying water to the WTP.

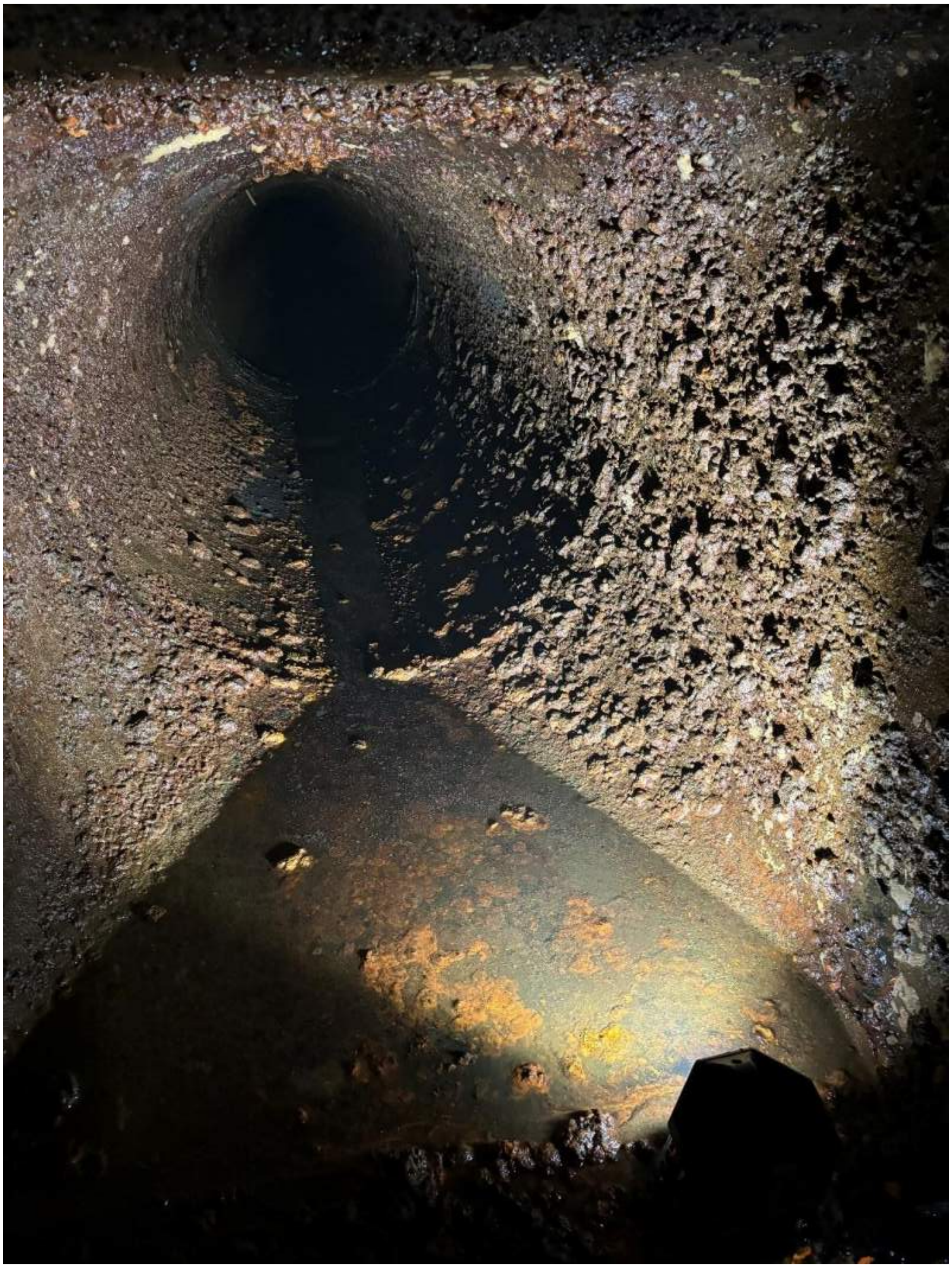


Exhibit 4-1. Tuberculation and Corrosion Product on South (Industrial) 48-inch Diameter Pipeline

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 Screenhouse was constructed. The lining is essentially intact, but with fair to poor adhesion to the pipe surface. The coal tar thickness was measured to be approximately 0.15 to 0.20-inch thick during the 2014 inspection. Observations during the 2024 inspection indicate negligible change to the lining material from what was observed in 2014. 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 presumably allowing corrosion of the underlying steel.

Small sections of the lining and corrosion product 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. Wall thickness measurements of the underlying steel were performed using an ultrasonic thickness (UT) gauge. A summary table of observed readings is provided in Table 4-1.

Table 4-1. Ultrasonic Thickness Pipe Wall Measurements (inches)

North Pipe		Center Pipe		South (Industrial) Pipe	
Distance from Pipe Joint	**Clock Position**	**Distance from Pipe Joint**	**Clock Position**	**Distance from Pipe Joint**	**Clock Position**
2′	**9 o'clock**	**10′**	**9 o'clock**	**15′**	**7 o'clock**
0.336		0.325		0.325	
0.367		0.325		0.325	
0.378		0.320		0.320	
6′	**9 o'clock**	**10′**	**9 o'clock**	**15′**	**10 o'clock**
0.333		0.336		0.336	
0.334		0.336		0.336	
0.337		0.330		0.330	
12′	**3 o'clock**	**10′**	**3 o'clock**	**15′**	**2 o'clock**
0.318		0.347		0.342	
0.315		0.350		0.350	
0.320		0.340		0.320	

Review of record drawing did not indicate an original pipe wall thickness, but based on the observed readings at the time of the inspection and review of previous evaluation efforts, it is reasonable to assume a nominal pipe wall thickness of 3/8″ (0.375 inches) at the time of installation. Using this 3/8″ wall thickness as a baseline condition, the measured wall loss from installation to the time of inspection ranged from 0% to 16%. While these few, isolated wall thickness measurements suggest only minor, generalized wall loss since the 1940 installation, any potential localized external pitting that may exist cannot be practically identified by such spot measurements made from inside these pipes.

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 (1981) steel pipe in the Chlorine Injection Room are 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.

Previous condition assessment work at the Screenhouse identified extensive external corrosion pitting and localized reduction in wall thickness of the three outlet pipes at the concrete wall penetrations inside the Chlorine Injection Room (the furthest downstream 18-inch portion of each of the three deteriorated pipe sections). The extent to which this same external corrosion may be present upstream of this point (behind the Chlorine Injection Room wall) within the direct-buried area of these three pipeline sections is not known. These three outlet pipelines are direct buried between the outlet well of the Screenhouse caisson and the Chlorine Injection Room, shown in Figure 1. The external side of this portion of these three pipe segments is completely inaccessible.

The most likely form of corrosion on the soil side of the pipe sections is localized corrosion (pitting). Again, it is not known if there is such pitting, but external corrosion of pipe after 85 years in direct contact with soil would not be uncommon. Leakage from localized corrosion starts as pinhole leaks that can grow over time. Non-destructive testing from inside these pipes to determine the presence of potential localized external corrosion (pitting) along the segments of these pipes that are direct buried is not feasible.

4.1.2 Conclusions

The corroded and deeply pitted short (18-inch length) downstream sections of each of the three 48-inch outlet pipes in question were not inspected externally because of the thick coating system applied in 2013. The condition of these short section is described in Appendix A of the 2014 Condition Assessment Report. Progression of the underlying external corrosion is not known. An image of the discharge pipelines, including the flanged connection, is present in Exhibit 4-2.

Removing the external coating is risky and is not recommended without installing permanent or temporary isolation within each pipe. The potential to damage and/or pierce the pipe wall is considerable. It is not feasible to accurately assess the progression or change in these external pits with UT measurements from the pipe interior. Regardless of the progression of corrosion-induced pitting (whether continued or stopped) these short sections should be rehabilitated and not left in their current condition. This path-forward conclusion remains the same as presented in the 2014 Condition Assessment Report.

The 18-feet of each of these three degraded pipes, just upstream of these three short externally-pitted segments, does not appear to have general wall loss due to corrosion as observed and measured from the pipe interior. The presence and extent of external corrosion-induced pitting of each of these sections of pipe is not known and cannot reasonably be discovered. Consequently, the path-forward conclusion to include these segments of pipe in a combined rehabilitation strategy with the 18-inch, externally-corroded segments, remains the same as presented in the 2014 Condition Assessment Report.

Exhibit 4-2. Discharge Pipelines in Chlorine Injection Room

4.2 Structure

Similar to the 2014 condition assessment, the condition assessment of the Screenhouse 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. The building structure, including the superstructure (above ground) and substructure (below ground), appears to be in relatively good condition (similar to 2014) based on visual inspection in areas that were accessible. The 2024 structural inspection was primarily visual and undertaken in recognition that the structure is in relatively good condition (based on the results of the 2014 condition assessment) with focus on only a few key areas of suspected deterioration.

4.2.1 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 Attachment A. The interior of much of the superstructure has been painted, which could have potentially hidden minor cracks and corrosion; but active corrosion would still be noticeable through the paint coating and no such corrosion was observed.

The exterior walls of the superstructure exhibited minor cracks, including some minor cracking below the window openings. These cracks are common in reinforced concrete structures and present no structural concerns.

A pilaster on the external wall of the Screenhouse structure, viewed from inside the building on the second floor, where the traveling screens are installed, exhibited spalled concrete along a vertical reinforcing bar, as shown in Exhibit 4-3. 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 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.

Exhibit 4-3. Spalled Concrete and Void Around the Exposed Reinforcing Bar

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

4.2.2 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 Screenhouse caisson includes outlet well, screen wells (south side and north side), intake well, and waste well as identified in Figure 1.

The structure is comprised of monolithically cast-in-place reinforced concrete elements such as walls, slabs, beams, and columns. Drawings of the original construction, including one structural drawing showing the general reinforcing of the wet well, are included in Attachment A.

The coating within the Screenhouse caisson appears to be in relatively good condition. There was 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. It was not possible to enter the central waste well of the caisson structure because the gate accessing that chamber was stuck in the closed position. The north and south screen well chambers were not easily accessible because of the water depth in the Inlet Well and the sludge depth in the Outlet Well. Therefore, observations were made into these screen chambers. No areas of concern were observed, which is in alignment with the results of the 2014 condition assessment.

In the 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. 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, as shown in Exhibit 4-4. 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.

Exhibit 4-4. Outlet Well Cold Joint Line where Voids in Concrete Have Formed

Other areas exhibited some minor void formation or "pop-out" of concrete. During the previous 2014 assessment, 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.

The intake well could not be fully drained. There was almost a foot of water depth in the intake well, which limited inspection of the floor slab. Similar to the Outlet Well the underside of the roof appeared to be in good condition with only minor spot corrosion marks showing through the coating. The wall surfaces exhibited minor voids from erosion or pop-outs. During the previous 2014 inspection, 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.

Some of the original embedded ladder access rungs in the wet well caisson are severely corroded, as shown in Exhibit 4-5. This is a safety concern and these embedded ladders should be replaced or removed. A final decision on whether to replace or remove could be made closer to the time of implementing this improvement with input from key City management and staff at the time.

Exhibit 4-5. Ladder Access Rungs Show Severe Corrosion

4.3 Slide Gates and Mud Valve

The Screenhouse 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 draining of 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 20 years. The function and condition of the slide gates and mud valve are summarized in Table 4-2. Locations of each are also shown in Figure 2. Recommendations for continued operation are also provided. Photos of the slide gates and valve are provided in Attachment B.

TABLE 4-2
Summary of Slide Gates and Mud Valve

No.	Size and Type	Location	Function	2014 Condition	2024 Condition
1	5′-0″ high x 6′-0″ wide gate	Intake well (south)	Isolates traveling screen from intake well	Fair	Poor
2	5′-0″ high x 6′-0″ wide gate	Intake well (north)	Isolates traveling screen from intake well	Fair	Poor
3	4′-0″ square gate	Intake well	Sluices sediment from intake well to waste well and drains the tunnel	[1]Fair	[1]Poor/Non-Functional
4	12″ square gate	Intake well (south)	Sluices sediment from screen well to waste well	Good	[2]Fair to Good
5	12″ square gate	Intake well (north)	Sluices sediment from screen well to waste well	Good	[2]Fair to Good
6	5′-0″ high x 6′-0″ wide gate	Outlet well (south)	Isolates traveling screen from outlet well	Poor	Poor
7	5′-0″ high x 6′-0″ wide gate	Outlet well (north)	Isolates traveling screen from outlet well	Poor	Poor
8	12″ mud valve	Outlet well	Sluices sediment from outlet well to waste line and drains the outlet well	Non-functional	Non-functional
9	4′-0″ square gate	Outlet well (south)	Isolates industrial supply line from outlet well	Poor	Poor
10	4′-0″ square gate	Outlet well (middle)	Isolates domestic supply line from outlet well	Poor	Poor
11	4′-0″ square gate	Outlet well (north)	Isolates domestic supply line from outlet well	Poor	Poor

[1] Gate No. 3 was not functioning (frozen in place) at the time of the 2014 inspection, and corrosion of gate frame and guide slots is extensive.

[2] Epoxy coated12″ square gate panels are “good” condition, but corrosion is evident on uncoated components (wedge blocks and connection of stem to gate panel) which was not evident in prior 2014 inspection and are now 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 poor condition with a significant amount of corrosion including large tubercules (mounds of corrosion products) 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 is understood to have been inoperable since the prior 2014 inspection which also documented the gate being frozen in place. Corrosion within the guides of Gate No. 3 is extensive and will likely result in poor sealing ability even if cleaning and rehabilitation of the existing gate was to be pursued due to loss of material.

The gate operating stems for all gates in the intake well have less visible corrosion and tubercules than the stems of the gates in the outlet well. However, the overall condition is still poor. The floor stands on the upper, operating deck above the caisson are 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 fair to good condition. Labels on the equipment indicate that it was provided by Rodney Hunt located in Orange, Massachusetts. These gates, including the operating stems, guides, and floor stands were replaced within the last 20 years.

All components with epoxy coating are in good condition, however, corrosion is evident on all uncoated components (such as the wedge blocks and the connection of stem to the gate panels). Corrosion of these components was not evident in the prior 2014 inspection. The development of corrosion within the past 10 years was fairly significant and indicates a trend that, if left unaddressed, will result in poor operability and function of the two 12-inch sediment sluicing gates in the screen wells.

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 in the intake well, though all would be considered to be in poor condition. 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 amounts of corrosion product, including large tubercules, were visible on all 5 gates, the mud 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. Gates No. 9 and 10 do not appear to be regularly exercised based on the formation of tubercules within the guides and their operability is not known. Gate No. 11 appears to be operational and regularly exercised based on the guides being relatively clean and free of tubercules. The mud valve operating stem was broken, rendering it inoperable.

The frames and guides of Gate Nos. 9, 10 and 11 appeared to be heavily corroded with large tubercules. A wedge block from Gate No. 11 was found on the intake floor, having broken off from the gate due to corrosion.

The gate operating stems and guides are also in poor condition, with more extensive corrosion visible compared to the gate operating stems in the intake well. The floor stands on the deck are in fair condition and have operating nuts to receive crank operators.

4.4 Traveling Screens

The Screenhouse includes two Rex traveling screens located in screen wells on the south and north sides of the structure. The screens can be isolated using the existing slide gates and operated independently as discussed above. The City typically alternates operation between the two screens, operating each one every other month. The screens are fully-redundant with respect to capacity. Both screens are not needed to be in operation concurrently. When each screen is in operation, it 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 aside from the fine opening sizes which exclude organisms from passing through the screens. Original screen drawings were obtained from the manufacturer confirming that the original screen material is No. 12 mesh wire cloth (12 openings per inch) with #21 W&M (Washburn & Moen) gauge wire and a 2-inch square backing mesh. These original drawings are provided in Attachment C. Current screen mesh observed during inspection appears to match these dimensions, with a resulting opening size of approximately 1.3-mm. 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 two traveling screens appear to be in fair to good condition. The south screen was rehabilitated in 2009. The north screen was completely rehabilitated in 2017. The level of rebuild/rehabilitation differs between the two screens. The rehabilitation on the north screen was more extensive and more recent. Consequently, it appears to be in somewhat better condition than the south screen.

It is understood that the south screen was rehabilitated by City staff, including replacement of the chain and reduction gears, and kept the original drive motors in place. This renewal did not involve new epoxy coating of the screen basket frames and therefore greater levels of corrosion and loss of material to the screen basket frames are present, and likely are present on the internal structural frame, as well.

The north screen was noted by operators to have been rehabilitated by Gary Harper Construction. The north screen rehabilitation included replacement of the drive motor and gearing, and new epoxy coating which has resulted in significantly less visible corrosion to the north screen framing. The screen mesh is sound with no visible gaps or tears, indicating that the debris loading on both screens is low with little damage to the thin wire used for the fine opening size of the screens. No large gaps between the screen, frame and concrete structure were visible.

The drive mechanism for both screens were clean and appeared to have been recently lubricated. Refer to Attachment B for photos showing the traveling screen.

5. Recommended Facility Improvements

Inspection of the Screenhouse 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

To rehabilitate the area of known concern and risk associated with the three deteriorated outlet pipelines (the short 18-inch segments with deep external corrosion-induced pitting), the recommended approach is to proceed with implementing a fully structural liner of the entire 20-foot long, 1940-vintage pipe segments. Doing so effectively addresses risk associated with potential failure of these pipe segments.

Previous investigations identified implementation of a fully structural fiber reinforced polymer (FRP) renewal (internal liner) strategy. This strategy remains the recommended approach, as it has a history of successful implementation. Recently, there have been advancements within the industry for other NSF 61 approved structural liner systems that could also potentially be implemented for these applications, including a geopolymer spray-applied lining. This system and potentially others could be considered for implementation, as advancements in these structural lining systems continue to be brought to market.

FRP is a renewal option that uses the existing pipe as a form. When designed and installed as a fully structural system, which is the recommendation at this site, the FRP acts as a standalone pipe following curing. Pipe strength is achieved by applying the FRP wrap in both the horizontal (hoop strength) and longitudinal (length strength) in alternating layers that are bound to each other by the impregnating resins. FRP options include both carbon (CFRP), glass (GFRP), or a combination of these two. CFRP is more expensive, but also stronger, than GFRP. Installation of the FRP is completed manually after a thorough blasting and cleaning of the existing pipe lining to expose bare metal. The installed material is NSF 61 approved for water service, is corrosion resistant, and provides service comparable to new pipe installation.

Installing an FRP liner system within the three deteriorated pipes can be expected to take up to a month to complete, including preparation, application of liner systems, curing, and final cleaning. To enable this installation, the Screenhouse will need to be bypassed for this period of time or longer. The City is considering options for bypass, but it is anticipated that implementing a bypass system will take several years. Advancing development of a bypass system should be considered a high priority given that the condition of these pipes will only degrade further over time, increasing risk of major supply disruption. A figure showing how the internal FRP 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 is presented in Figure 3.

That stated, given the primary known area of concern with respect to these pipes is the short 18-inch segment that is accessible within the Chlorine Injection Room, the City may consider a strategy that can be implemented sooner. Such a strategy would be to implement an external FRP system on the three short 18-inch segments in the Chlorine Injection Room. This would be a targeted, but less-holistic strategy that focuses on the known area of severe corrosion pitting and can be implemented without the benefit of a bypass supply to the City's WTP. Doing so would reduce risk. If implemented, it should be considered as an interim strategy, and not as a full-replacement, to the more-complete internal lining system described above.

Due to the surface preparation needs for application of FRP, and the potential to damage the aging host pipe during this activity due to the existing pitting and wall loss, repair activities would need to be performed while the outlet pipes are sequentially isolated. Isolation would be created using the upstream existing outlet pipe slide gates along with two inflatable plugs (one downstream of the 18-inch long segment and a second upstream). Each pipe would need to be externally lined sequentially or perhaps the two municipal pipes could be externally lined simultaneously. The combined duration of this work would be up to one month, including intermediate shut-down and isolation coordination with City staff.

Despite the much shorter length of this rehabilitation approach, it comes with greater inefficiencies for the specialty contractor with respect to multiple mobilizations. Consequently, the cost for a specialty contractor to undertake this targeted strategy would be approximately one-half to two-thirds the cost of the more-complete internal lining strategy.

5.2 Structure

Overall, despite its 85 years of service, the condition of the Screenhouse 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 Wet Well Caisson.

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. Reinforcing showing signs of corrosion should be exposed and cleaned of corrosion product. The concrete would be prepared to adhere to a bonding agent and a cementitious grout system.

5.2.2 Substructure

Future inspections should include full draining of the wet well caisson as well as sediment removal to enable inspection of the floor. The extent of needed patching repairs should be refined based on these future observations. Horizontal reinforcing bars could not be identified during the March inspection. Confirming the presence of horizontal reinforcing in the caisson should be considered despite the apparent good condition of the wet well 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 61-certified potable water coating system would be used. In the 2014 inspection, it was identified that the waste well was not 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.

Many of the access ladder rungs into the wet well caisson were heavily corroded while others were partially corroded. Although it is not urgent, these embedded ladders should be replaced, entirely, or removed, entirely. As stated in Section 4.2.2, a final decision on whether to replace or remove could be made closer to the time of implementation of this improvement. Although it could potentially be done in a series of a few 24-hour shutdowns, this improvement should be undertaken when it is possible to take the Screenhouse out of service for an extended period. If a replacement ladder system is selected for implementation, it should be based on vertical support from the floor, and at several points along the wall, and should be installed in coordination with cutting off the existing rungs.

In the meantime, before that extended supply-outage is possible, when the wet well caisson is next accessed, temporary supplemental (scaffolding) ladders should be installed in front of the existing ladder rungs. The scaffold ladder needs to be fitted with safety bolts between ladder segments and needs to be tied to the existing ladder rungs from each segment of the scaffold ladder. Along with the required tripod-supported safety tethering/harnessing, the temporary scaffold ladders are adequate for safe access prior to implementing the permanent ladder replacement.

5.3 Slide Gates and Mud Valve

As presented in Table 4-2, the condition of each of the eight original cast iron slide gates within the Screenhouse includes characterizations of non-functional (waste well slide gate) or poor. The Screenhouse slide gates from the original 1940 construction are near the end of useful life and are recommended for immediate replacement due to the deteriorated condition caused by extensive corrosion. Cleaning of the extensive corrosion product on the gates is not recommended, as doing so will only accelerate the corrosion process and potentially damage the gate structure as material is broken off and removed. New slide gates will improve "leak-tightness" for future repairs and replacements.

It is assumed for purposes of this evaluation that all existing wall thimbles may be reused, allowing slide gate replacement to be made in a manner similar to the replacement of the original 12-inch square gates (Gate Nos. 4 and 5), wherein the replacement gate is installed over the existing wall thimble. Evaluation from a gate manufacturer will be necessary to confirm that the existing wall thimbles are acceptable to reuse with new gates, and any conflicts with anchorage requirements for the new gates that will need to be addressed.

In addition to in-kind replacement with epoxy coated cast iron gates, other materials such as stainless steel, fiberglass reinforced plastic, and painted steel gates should be considered for implementation for corrosion resistance and long period of useful life. Equipment costs provided within Section 6 of this report assume in-kind replacement with epoxy coated cast iron which have generally been shown to provide a long useful life of over 80 years in the screenhouse.

The three 4-foot square slide gates in the outlet well need to be removed and replaced because of their poor condition.

The two 12-inch square sediment sluicing gates which were replaced within the last 20 years appear to be in fair to good condition, but are beginning to show signs of corrosion on uncoated components which was not present during the prior 2014 inspection. Although not needed imminently, these two gates should be considered for replacement with additional corrosion resistant materials or coating at the same time as replacement of the larger slide gates given the nominal cost component relative to the larger slide gates.

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.

Given the extent of improvements to mechanical components identified, the most cost-efficient implementation schedule is for a prolonged outage that corresponds with an Alternative Water Intake Strategy. It may be possible that individual components may be replaced through a series of one-day outages; however, the logistics and mobilization fees, as well as the risk of delays during one of these short shut downs, are such that they are not a preferred strategy. With that said, it is likely shut downs will be necessary as part of the planning, and proposal efforts for Contractors and/or equipment manufacturers to enter into the caisson to observe the existing configuration, condition and structure of wet well components prior to any prolonged outage in which the construction would take place.

5.4 Traveling Screens

The existing traveling screens are in fair to good condition, the City should continue to exercise and maintain them as it has done since the screens were first installed. With continued routine maintenance, the traveling screens likely have a remaining operating life of approximately 10 years before replacement is required. Since the screens have already been rehabilitated, at least once since they were installed in 1939 (and likely several times in different aspects), full replacement is recommended as opposed to another rehabilitation.

When the screens are eventually replaced, modern replacement screens are available from the original screen manufacturer (now owned by Evoqua/Xylem) which would be made to fit within the existing screen wells and utilize the existing screen guides. Modern traveling screens typically eliminate the bottom sprocket and instead have a simple bottom guide that eliminates a submerged moving part which is susceptible to wear on the existing screens. Several manufacturers are capable of making replacement screens custom sized to fit within the existing screen wells, and could be pursued to use alternative screen materials and technologies, such as polymer screens, which significantly reduce weight and susceptibility to corrosion. Doing so may facilitate easier screen installation.

Newer screen technology also incorporates fish protection enhancements, if desired, or if required by Washington State Department of Fish and Wildlife. Incorporation of fish handling systems would require some modifications to provide suitable fish return pipe routing as opposed to the vertical drop that the existing debris spray wash follows into the waste well.

For the purpose of this evaluation equipment quotes have been obtained for replacement screens from the original manufacturer, Evoqua/Xylem. Labor costs for installation will likely be high given the lack of direct overhead access to lower fully assembled screens into place from above, and instead bring short sections in through the openings in the Screenhouse and largely assemble the screens in place. One screen could reasonably be replaced at a time without impact to water supply as long as good seal is provided by the slide gates used to isolate the upstream and downstream side of each of the north and south screen wells. If the entire screenhouse will be taken offline for repair of the 48-inch diameter pipes and/or slide gates, it would be advantageous to replace both of the vertical traveling screens at that time.

5.5 Implementation of Recommended Improvements

It might be possible to undertake some of the recommended improvements presented herein during multiple single-day shutdowns of the raw water supply system. The improvements where this might be possible would include: (1) replacement of the traveling screens, (2) some of the miscellaneous concrete patching, and (3) ladder rung replacements. That stated, these recommended improvements are not urgent and do not need to be implemented within the next few years.

However, the more critical and urgent rehabilitation of the three 48-inch diameter pipes extending downstream of the wet well caisson, with an internal structural lining system, can only be undertaken with an extended period of dry conditions. Similarly, replacement of the slide gates can only be done efficiently under these similar extended dry conditions.

Consequently, it is essential the City continue to advance its efforts to develop a temporary bypass system that enables it to supply its WTP for several weeks to several months, without conveying water through the

Screenhouse. This will enable the City to undertake the urgent rehabilitation of the 48-inch diameter pipes and eliminate this as a critical risk factor. Then, the other recommended rehabilitation improvements can be undertaken in an effective manner, during an extended period when the Screenhouse is removed from service. It is understood that developing a suitable bypass will take several years to implement.

5.6 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	Comments
48-inch Diameter Outlet Pipelines	Fiber reinforced polymer liner to mitigate the severe external corrosion pitting as soon as Screenhouse can be taken out of service for extended period.
Structure	Miscellaneous grout patching, ladder replacement, and wet well caisson repainting as soon as Screenhouse can be taken out of service for extended period.
Slide Gates and Mud Valve	Replace all 10 slide gates and single mud valve as soon as Screenhouse can be taken out of service for extended period.
Traveling Screens	Replace both traveling screens within next 10 to 15 years.

6. Estimated Costs

Estimated capital costs were developed for the recommended improvements described throughout Section 5 and summarized in Section 5.5. 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 (AACEI). This level of cost estimating is considered accurate to +50 to -30 percent.

These estimated costs were prepared for guidance in budgeting for the recommended improvements based on information available at the time of the estimate. Final costs 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.

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

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

TABLE 6-1
Summary of Estimated Capital Costs - Screenhouse Improvements

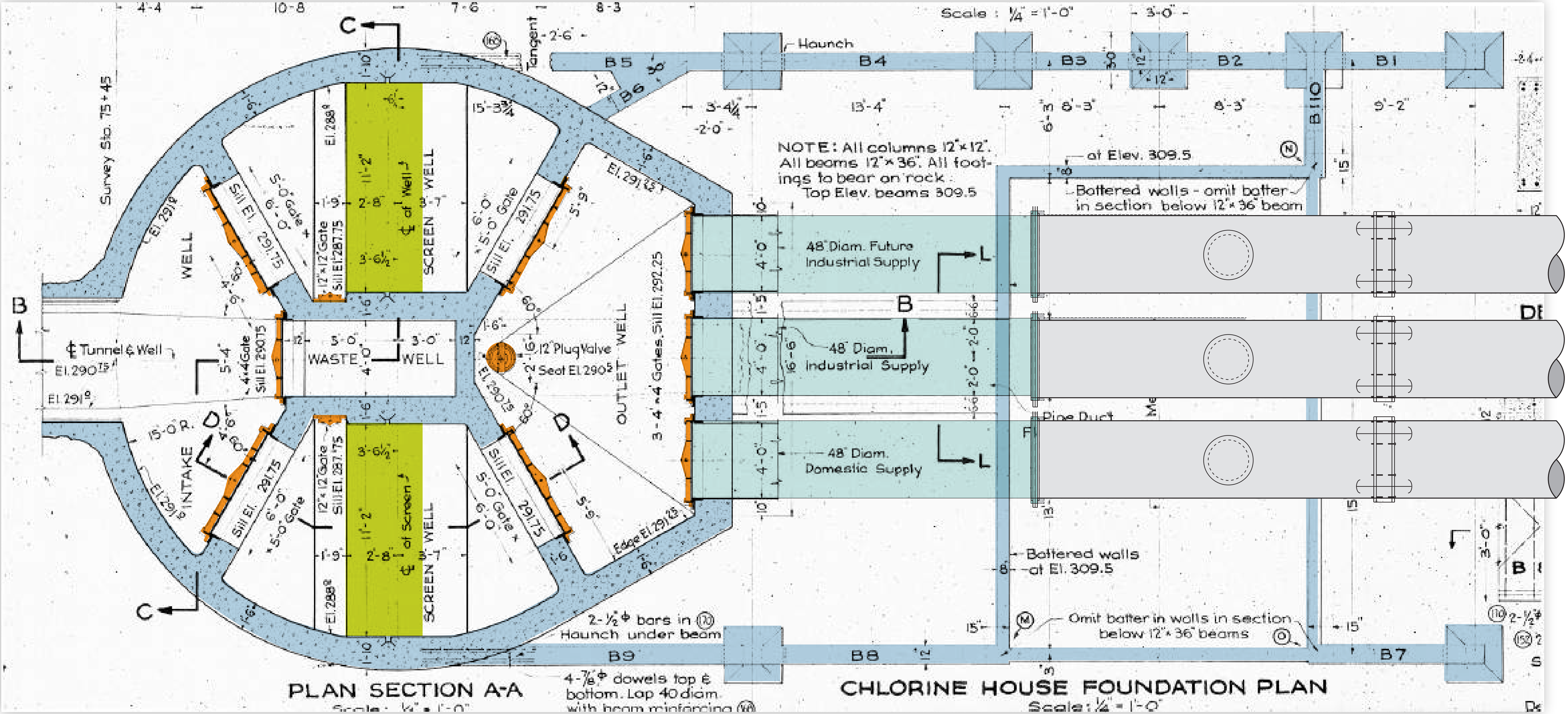
48-inch Outlet Pipe Improvements		
Internal Structural Liner (20-foot length)		$450,000
Safety and Confined Space Entry Support for Outlet Pipe Improvements		$75,000
Miscellaneous Additional Outlet Pipe Improvements (Demo, Disposal, General Conditions, etc.)		$100,000
External Structural Lining (18-inch length) [1])		
48-inch Outlet Pipe Improvements Subtotal		$625,000
Structural Improvements		
Grout repair/Concrete Patching/Ladder Improvements		$100,000
Mechanical Slide Gate Costs:		
Intake Well Slide Gates(North and South [2 Total])		$250,000
Intake Well Sluice Gate (4' X 4')		$50,000
Waste Well Slide Gates (12" square [2 total])		$50,000
Outlet Well Traveling Screens (North and South [2 total])		$250,000
12-inch Mud Valve		$20,000
Outlet Pipe Isolation Gates (North, Middle and South [3 total])		$150,000
Gates and Mud Valve Installation Labor		$400,000
Mechanical Slide Gate and Mud Valve Subtotal		$1,170,000
Traveling Screen Costs:		
Traveling Screens (2 Standard Thru-Flow Traveling Water Screen)		$600,000
Traveling Screen Installation Labor		$200,000
Traveling Screen Subtotal		
	CONSTRUCTION SUBTOTAL	**$2,695,000**
Contingency (30%)		$810,000
Sales Tax (9.0%)		$315,000
Construction with Contingency & Sales Tax		**$3,820,000**
Non-construction Costs:		
Permitting Allowance		$100,000
Engineering and Construction Management[2]		$760,000
	TOTAL	**$4,680,000**

Notes:

[1] Despite the much shorter length of this lining strategy, and greater accessibility, the cost for a specialty contractor to perform this work would be approximately 2/3 the cost of an internal lining strategy because of inefficiencies with respect to multiple mobilizations. This fee is not included in subtotal or total estimated costs.

[2] Engineering and Construction Management costs estimated as 20 percent of construction subtotal with sales tax.

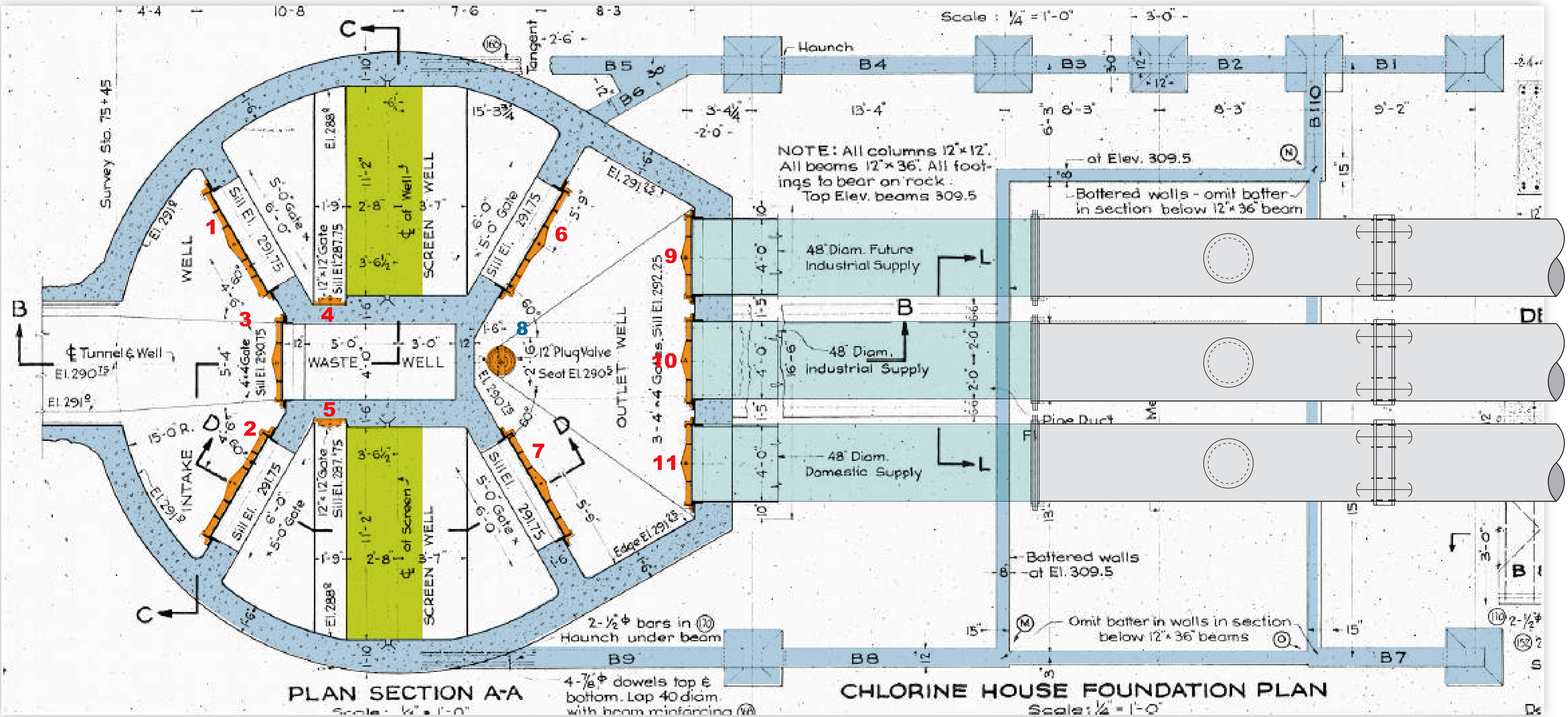
Figures



WBG101013133232SEA

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

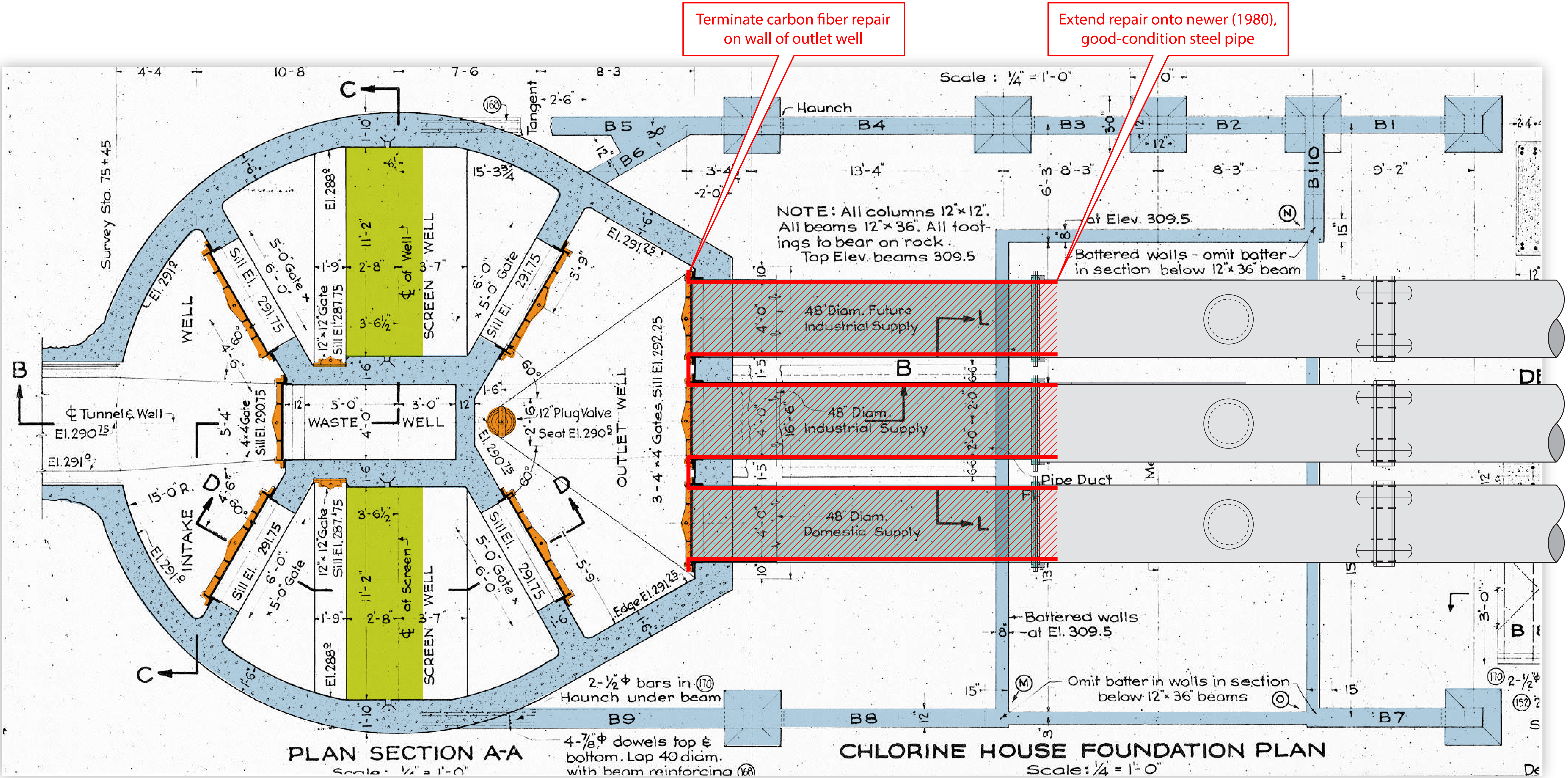
Figure 1
Screen House Plan View



WBG101013133232SEA

11 Slide Gate Number (see Table 4-1) **8** Plug Valve Number (see Table 4-1) Slide Gates and Plug Valve 48-Inch Steel Pipe Spools Concrete Structure Traveling Screen

Figure 2
Screen House Plan View - Slide Gates and Plug (Mud) Valve

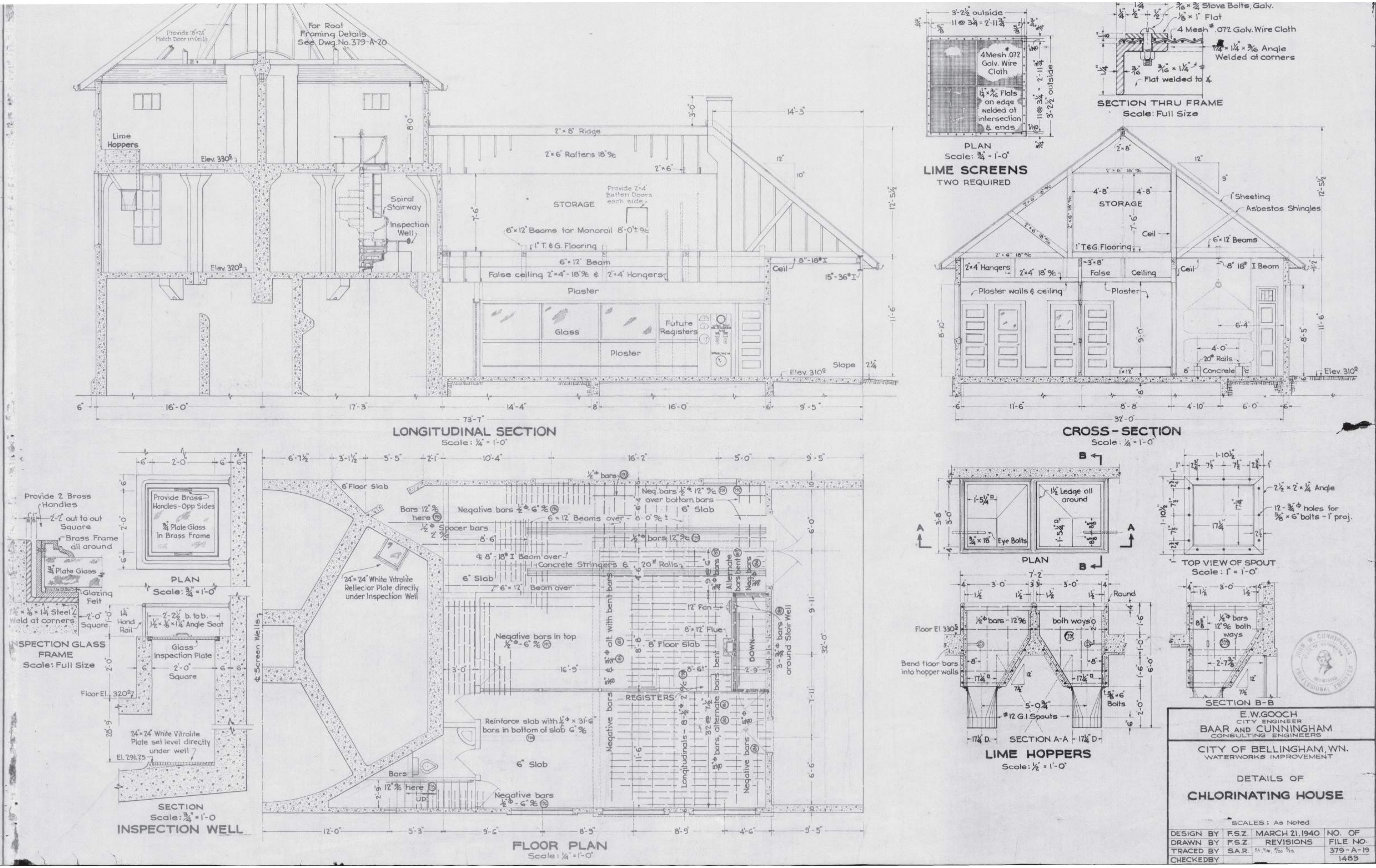


WBG101013133232SEA

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

Figure 3
Recommended Pipeline Improvements

Attachment A
Screenhouse Structural Drawings



E. W. GOOCH
CITY ENGINEER

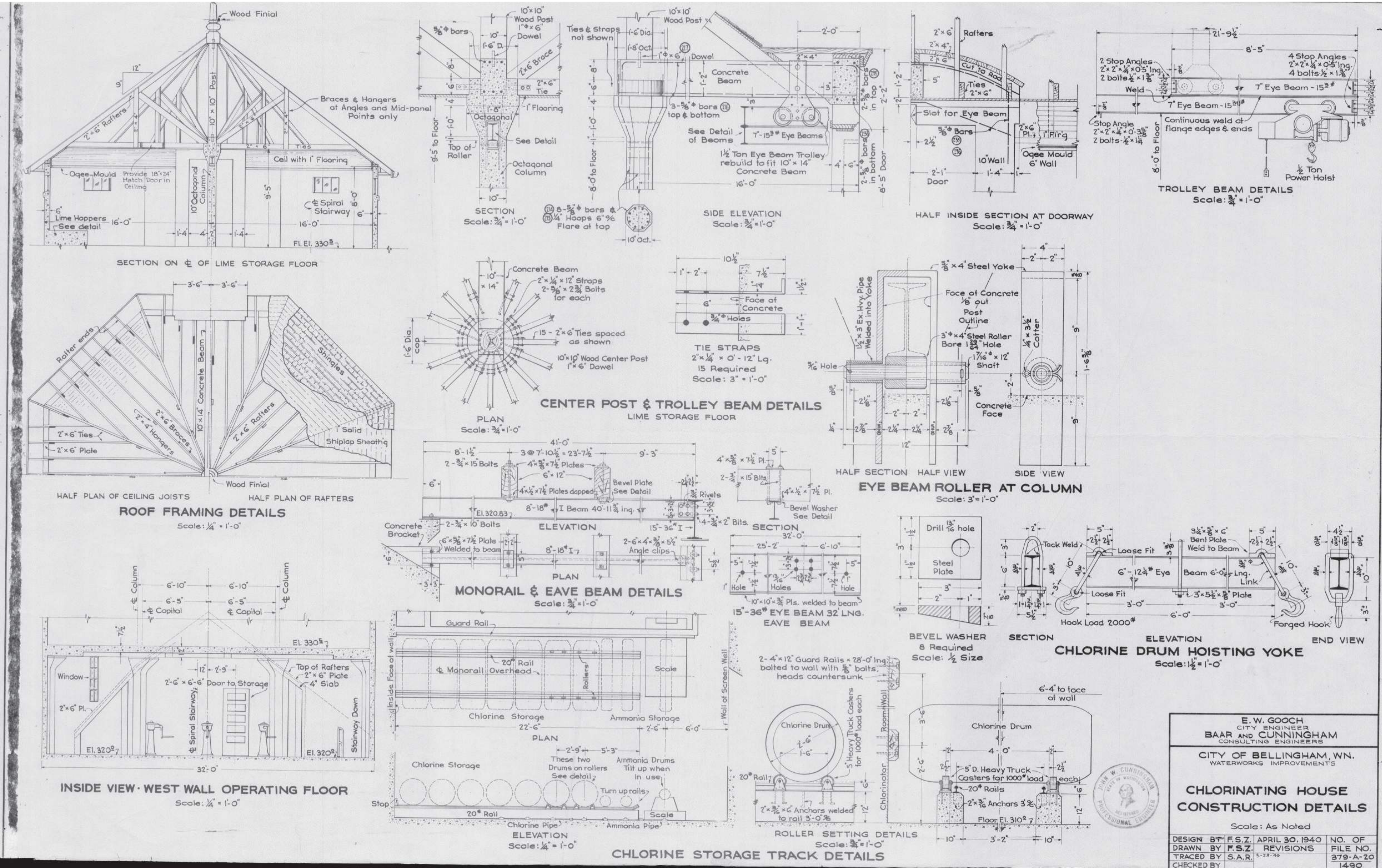
BAAR AND CUNNINGHAM
CONSULTING ENGINEERS

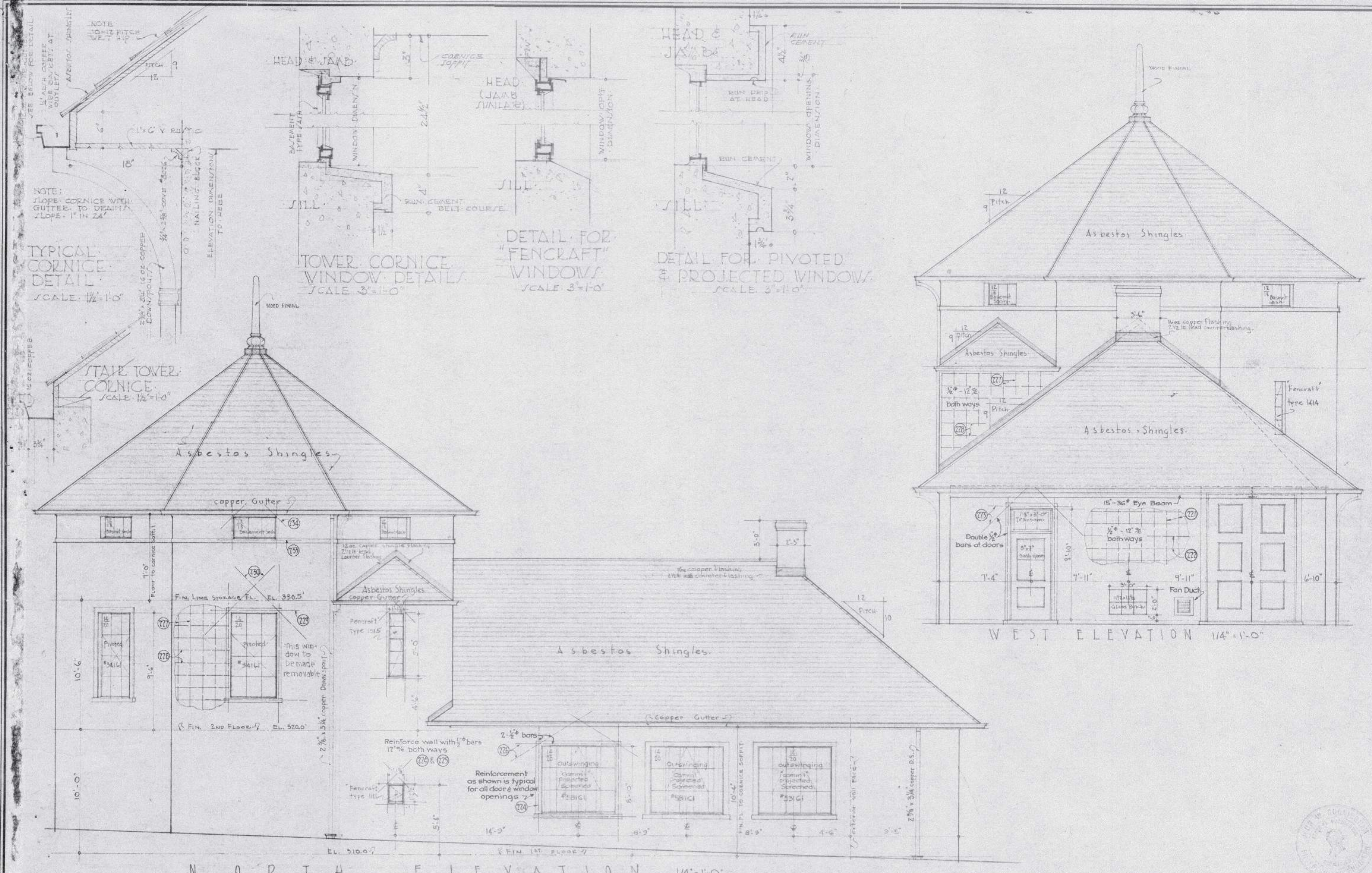
CITY OF BELLINGHAM, WN.
WATERWORKS IMPROVEMENT

DETAILS OF
CHLORINATING HOUSE

SCALES: As Noted

DESIGN BY	F.S.Z.	MARCH 21, 1940	NO. OF
DRAWN BY	F.S.Z.	REVISIONS	FILE NO.
TRACED BY	S.A.R.		379-A-19
CHECKED BY			1483


SECTION ON ℄ OF LIME STORAGE FLOOR
HALF PLAN OF CEILING JOISTS
HALF PLAN OF RAFTERS
ROOF FRAMING DETAILS
Scale: 1/4" = 1'-0"
SECTION
Scale: 3/4" = 1'-0"
SIDE ELEVATION
Scale: 3/4" = 1'-0"
HALF INSIDE SECTION AT DOORWAY
Scale: 3/4" = 1'-0"
TROLLEY BEAM DETAILS
Scale: 3/4" = 1'-0"
PLAN
Scale: 3/4" = 1'-0"
TIE STRAPS
2" × 1/4" × 0'-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"
ELEVATION
PLAN
SECTION
MONORAIL & EAVE BEAM DETAILS
Scale: 3/4" = 1'-0"
15"-36# EYE BEAM 32' LNG.
EAVE BEAM
BEVEL WASHER
8 Required
Scale: 1/2 Size
SECTION
ELEVATION
END VIEW
CHLORINE DRUM HOISTING YOKE
Scale: 1 1/2" = 1'-0"
INSIDE VIEW - WEST WALL OPERATING FLOOR
Scale: 1/4" = 1'-0"
PLAN
ELEVATION
Scale: 1/4" = 1'-0"
ROLLER SETTING DETAILS
Scale: 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.
DRAWN BY F.S.Z.
TRACED BY S.A.R.
CHECKED BY
APRIL 30, 1940
REVISIONS
NO. OF
FILE NO.
379-A-20
1490



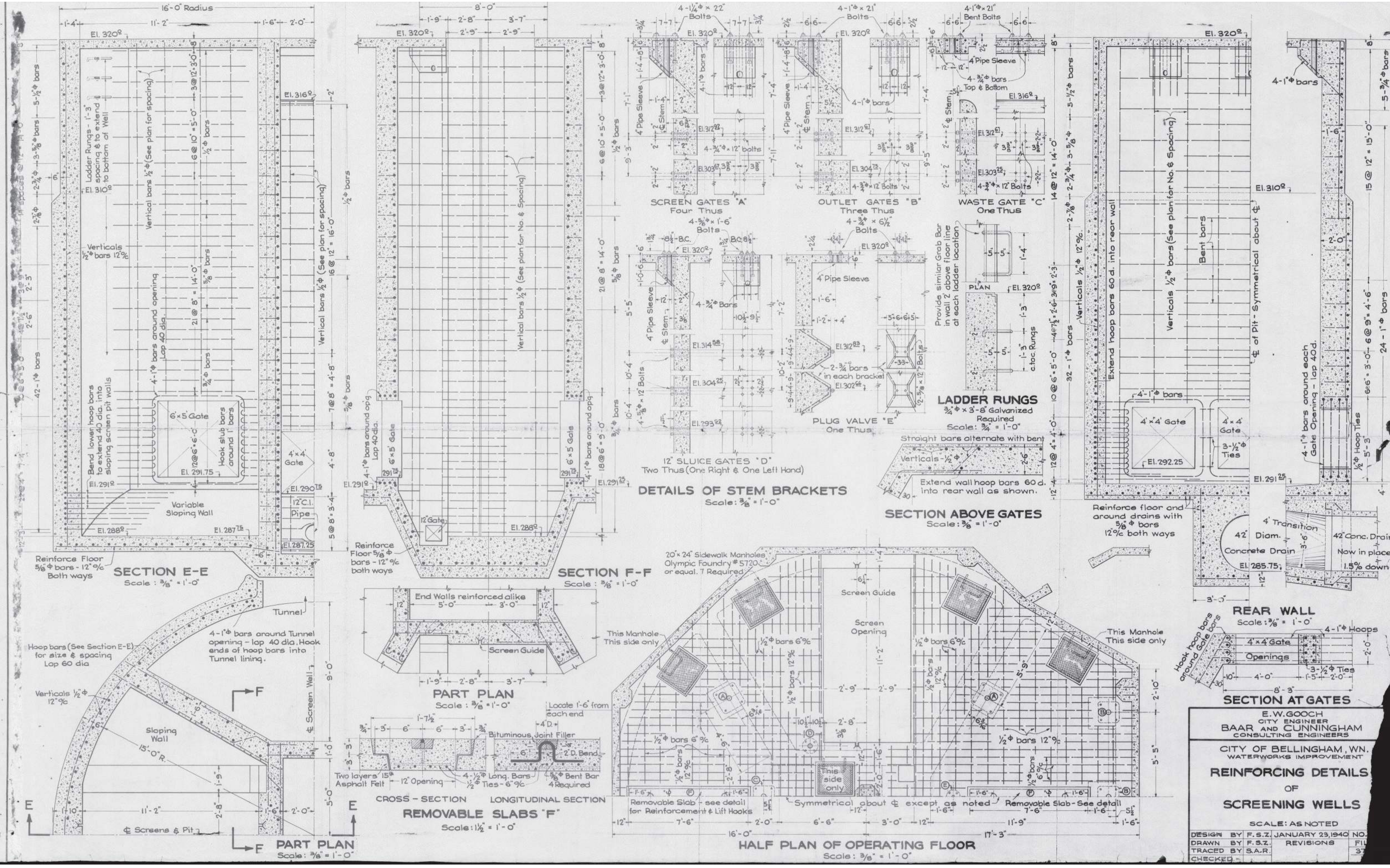
CHLORINATION PLANT
BELLINGHAM WASHINGTON

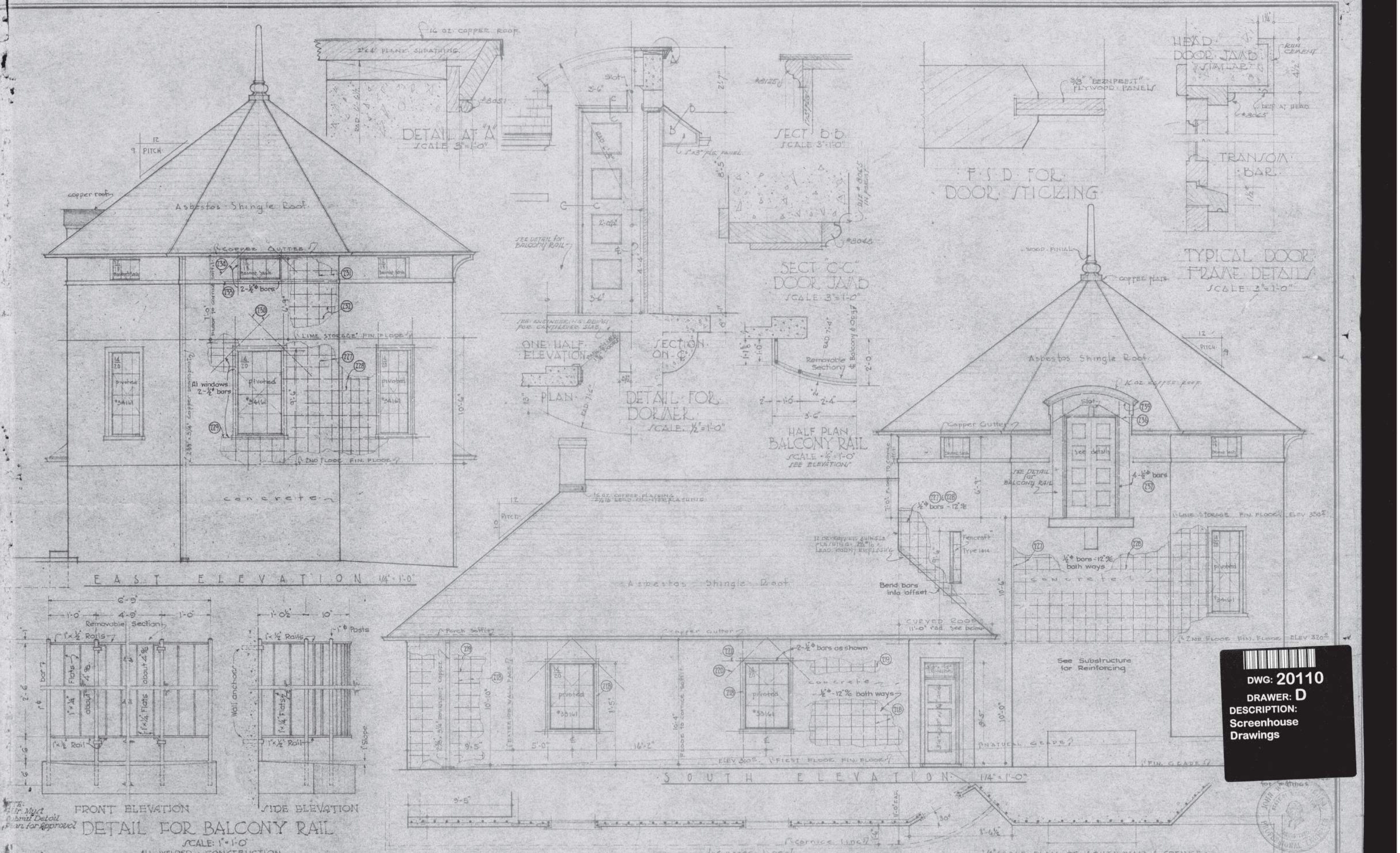
ELEVATIONS & DETAILS
SCALE AS NOTED

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

JOB 401 SHEET
DATE 2
REV.

379-A-23
1500


SECTION E-E
Scale: 3/8" = 1'-0"
SECTION F-F
Scale: 3/8" = 1'-0"
SCREEN GATES "A"
Four Thus
OUTLET GATES "B"
Three Thus
WASTE GATE "C"
One Thus
12" SLUICE GATES "D"
Two Thus (One Right & One Left Hand)
PLUG VALVE "E"
One Thus
DETAILS OF STEM BRACKETS
Scale: 3/8" = 1'-0"
LADDER RUNGS
3/4"Φ × 3'-8" Galvanized Required
Scale: 3/4" = 1'-0"
Provide similar Grab Bar in wall 2' above floor line at each ladder location
Straight bars alternate with bent
Extend wall hoop bars 60 d. into rear wall as shown.
SECTION ABOVE GATES
Scale: 3/8" = 1'-0"
Reinforce floor and around drains with 5/8"Φ bars 12"% both ways
REAR WALL
Scale: 3/8" = 1'-0"
SECTION AT GATES
PART PLAN
Scale: 3/8" = 1'-0"
End Walls reinforced alike
CROSS - SECTION
LONGITUDINAL SECTION
REMOVABLE SLABS "F"
Scale: 1 1/2" = 1'-0"
20" × 24" Sidewalk Manholes Olympic Foundry # S720 or equal. 7 Required
This Manhole This side only
Symmetrical about ℄ except as noted
Removable Slab - see detail for Reinforcement & Lift Hooks
HALF PLAN OF OPERATING FLOOR
Scale: 3/8" = 1'-0"
PART PLAN
Scale: 3/8" = 1'-0"
Reinforce Floor 5/8"Φ bars - 12"% Both ways
Hoop bars (See Section E-E) for size & spacing Lap 60 dia
4-1"Φ bars around Tunnel opening - lap 40 dia. Hook ends of hoop bars into Tunnel lining.
42" Diam. Concrete Drain
42" Conc. Drain Now in place
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.
DRAWN BY F.S.Z.
TRACED BY S.A.R.
CHECKED
JANUARY 23, 1940
REVISIONS



CHLORINATION PLANT
BELLINGHAM WASHINGTON

ELEVATIONS & DETAILS
SCALE AS NOTED

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

JOB 401 | SHEET 1/2
DATE
REV.

DWG: 20110
DRAWER: D
DESCRIPTION: Screenhouse Drawings

Attachment B
March 2024 Inspection Photos

Screenhouse Photos –Attachment B.1 Discharge Pipelines

Photo #1: South [Industrial] Discharge Pipeline

Photo #2: Tuberculation on Gate Frame at South (Industrial) Discharge Pipeline

Photo #3: Mixer and Pipe Wall at Central Discharge Pipe

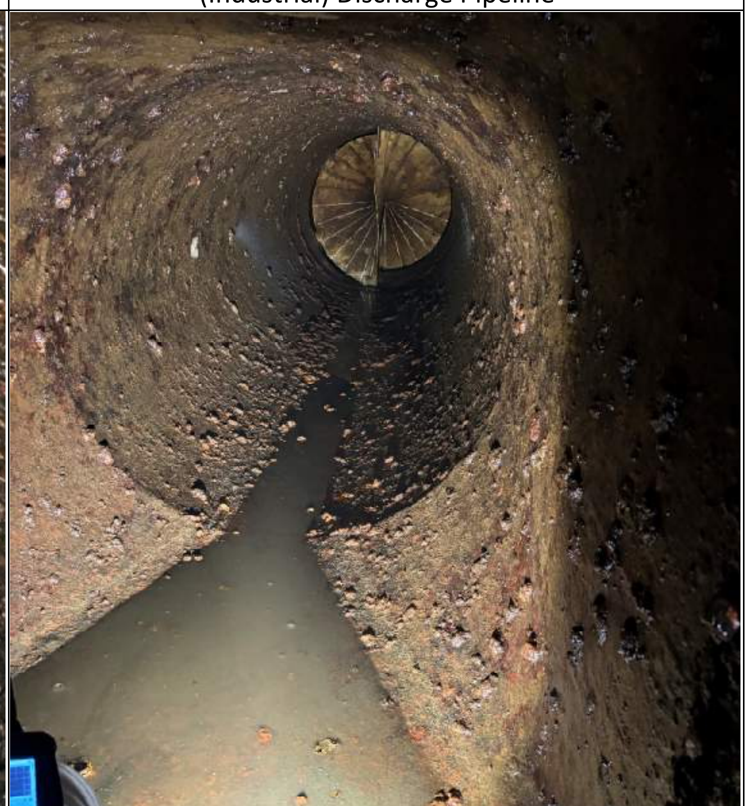


Photo #4: Discharge Pipe and Mixer North Discharge Pipe

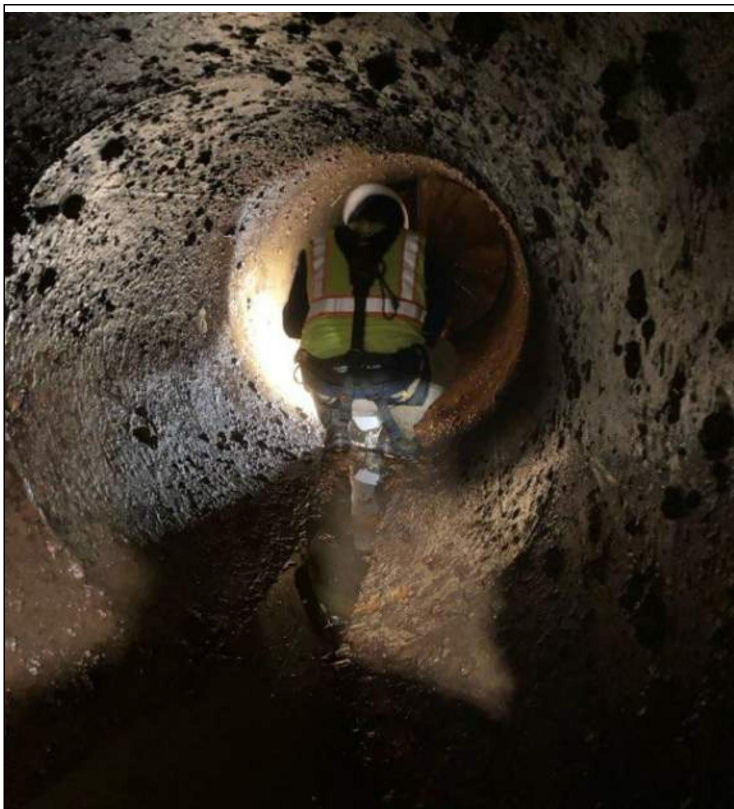


Photo #5: Sampling within Central Discharge Pipe

Photo #6: Thickness Testing Location in North Discharge Pipe

Photo #7: Corrosion on Discharge Pipeline Exterior and Flange in Chlorine Injection Room prior to Coating (Legacy Photo circa 2012)


Photo #8: Discharge Pipeline in Chlorine Injection Room, Coating System (Black) added at Near Flange to Wall in 2013


Photo #9: Discharge Pipelines in Chlorine Injection Room, Prior to Application of Coating System (Legacy Photo Circa 2012), Showing Extensive External Corrosion on Short Sections of 1940-Vintage Pipes.

Screenhouse Photos – Attachment B.2 Structure and Miscellaneous Features

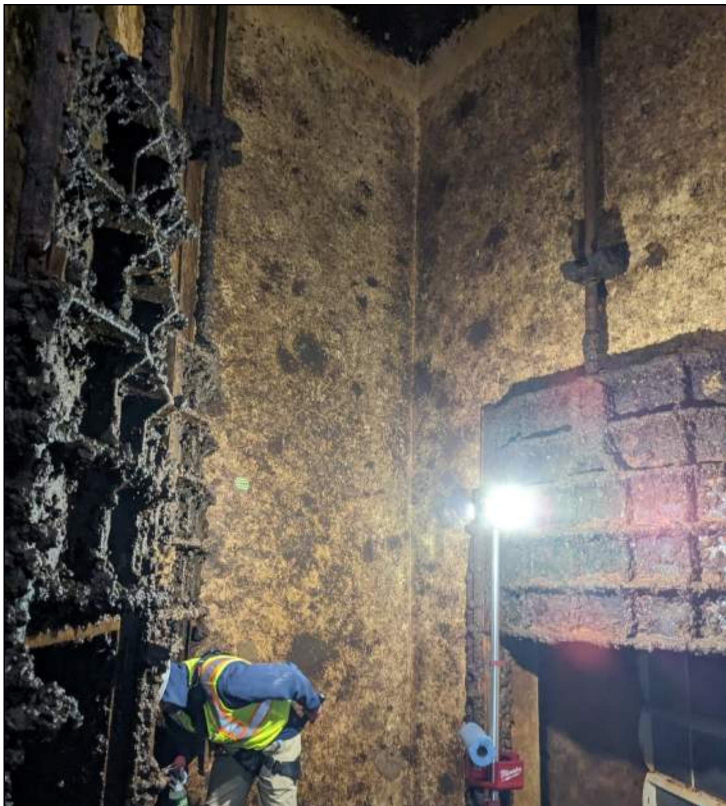


Photo #1: North Wall at Outlet Well

Photo #2: Access Ladder and South Wall at Outlet Well

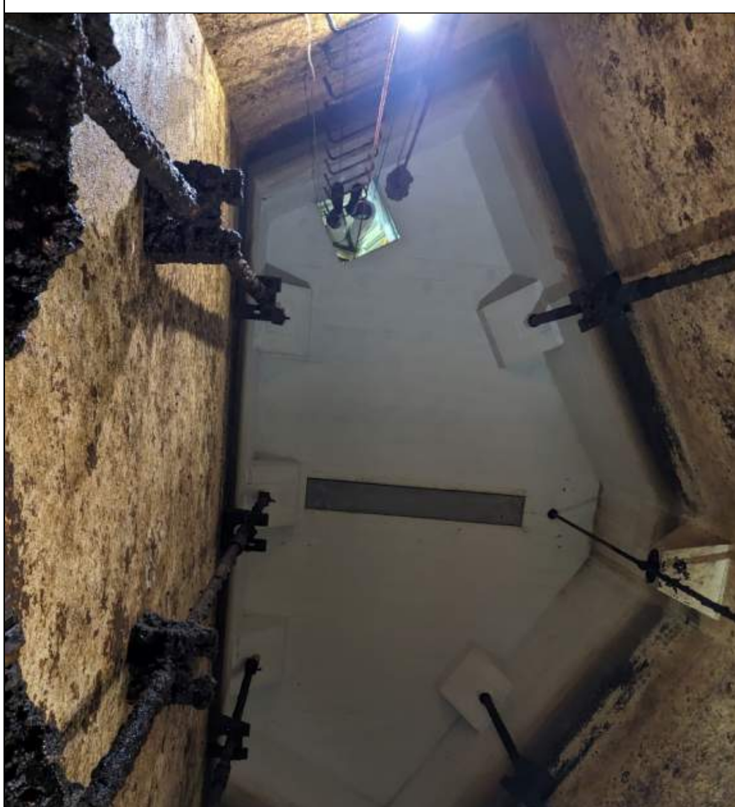


Photo #3: Ceiling at Outlet Well including Removable Gate Access Slot, Access Ladder and Gate Stems

Photo #4: Ceiling at Inlet Well including Removable Gate Access Slot, Access Ladder and Gate Stems

Photo #5: Screenhouse Hoist Rail

Photo #6: Screenhouse Hoist Rail

Photo #7: Screenhouse Structure, South Side

Photo #8: Screenhouse Structure, Rear (Looking West)

Photo #9: Screenhouse Structure, North Side

Photo #10: Screenhouse Structure, Front

Photo #11: Confined Space Entry Setup Over Intake Well

Screenhouse Photos –Attachment B.3 Slide Gates and Mud Valves

Photo #1: Intake Well South Slide Gate

Photo #2: Intake Well South Slide Gate and Gate Stem

Photo #3: Intake Well North Slide Gate

Photo #4: Intake Waste Well Slide Gate (Seized in Closed Position)

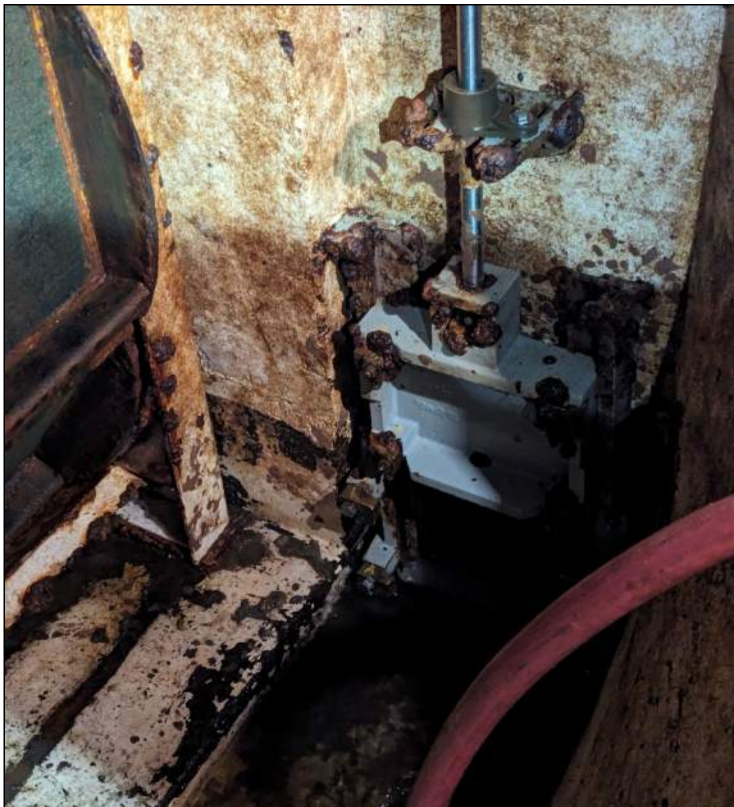


Photo #5: South Waste Well Gate (Replaced early 2000s)

Photo #6: South Waste Well Gate Stem (Replaced early 2000s, Minimal Corrosion)

Photo #7: North Waste Well Gate

Photo #8: North Waste Well Operator (Topside)

Photo #9: Outlet Well South Slide Gate

Photo #10: Outlet Well North Slide Gate

Photo #11: Mud Valve (Covered in Mud) and Valve Stem

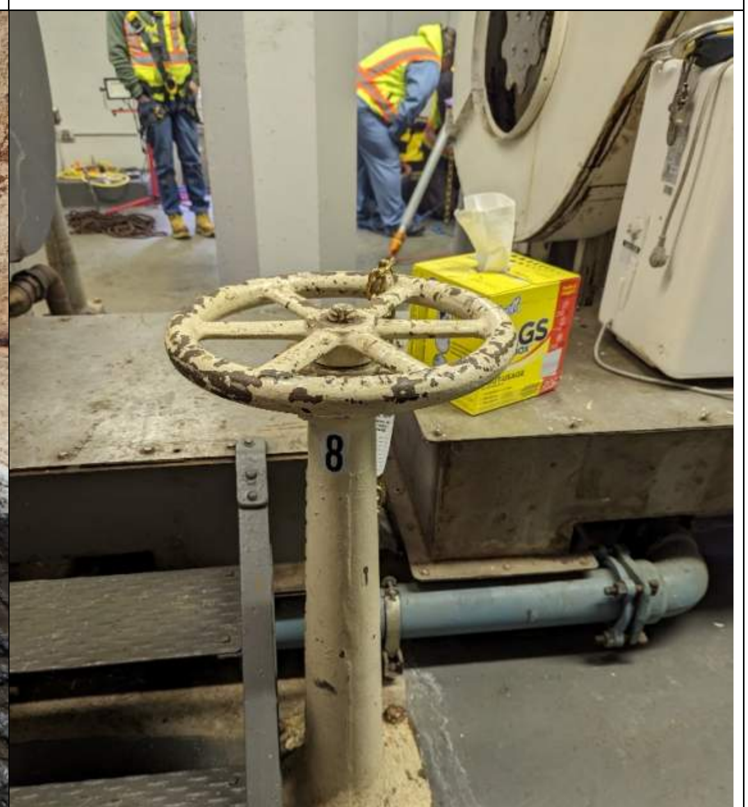
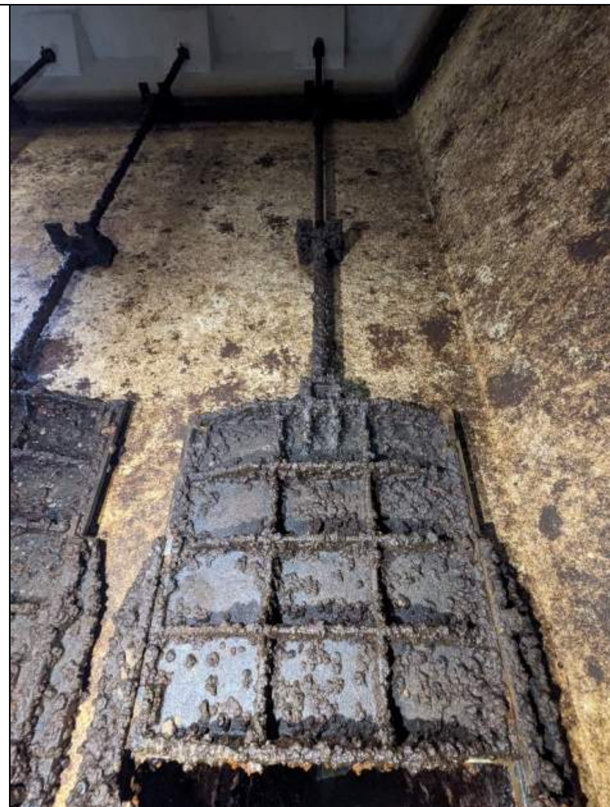


Photo #12: Mud Valve Hand Wheel Operator

	
Photo #13: Discharge Pipeline Slide Gates	Photo #14: Discharge Pipeline Slide Gate (North)

Screenhouse Photos –Attachment B.4 Traveling Screens

	
Photo #1: South Traveling Screen	Photo #2: Detail View of (South) Traveling Screen Mesh
	
Photo #3: (South) Traveling Screen Topside	Photo #4: Traveling Screen Nameplate

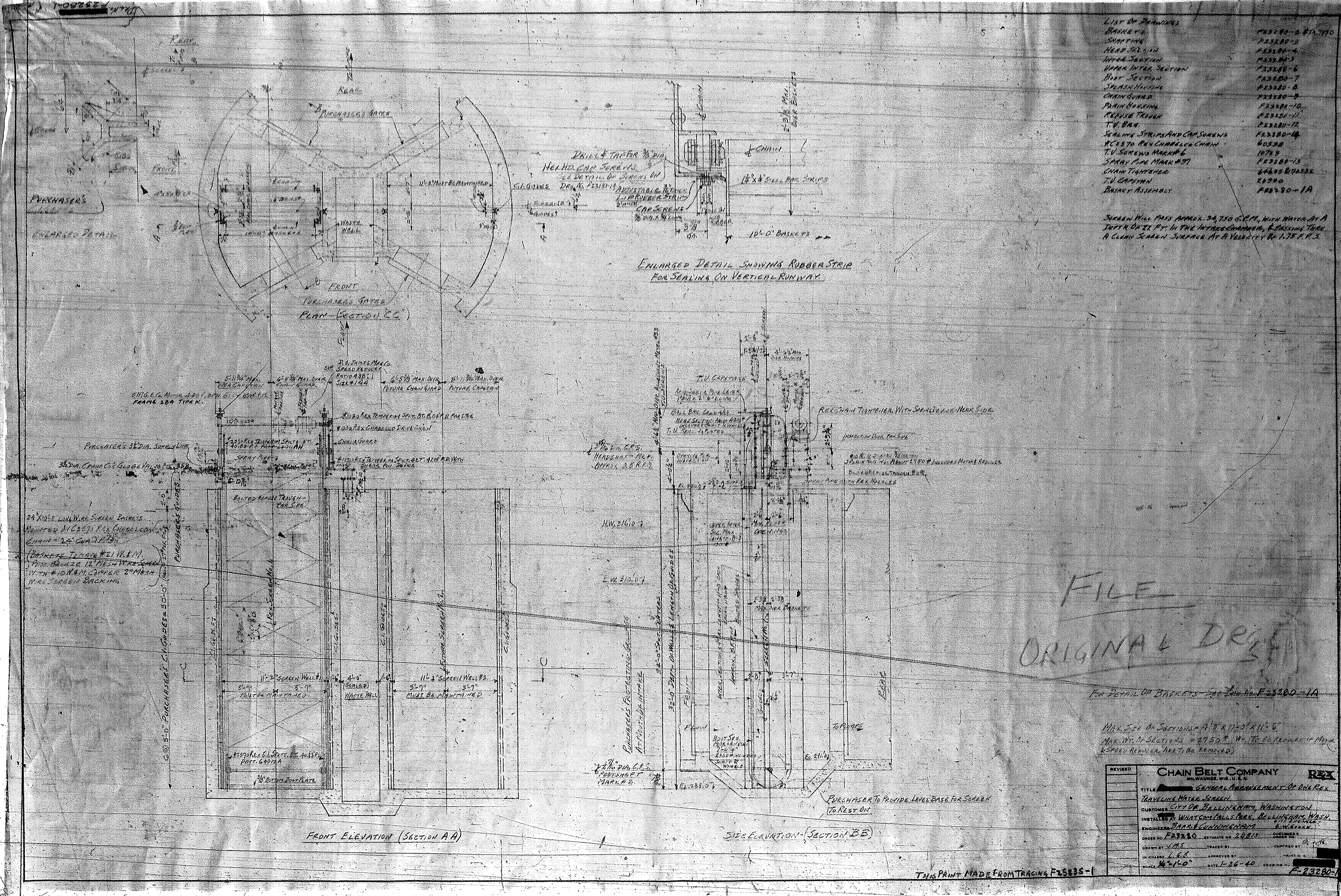
Photo #5: North Traveling Screen

Photo #6: North Traveling Screen, Vertical Angle

Photo #7: North Traveling Screen Topside

Photo #8: North Traveling Screen Topside, Alternate Angle

Attachment C
Traveling Screens Record Drawing (1939)



LIST OF DRAWINGS
BASKETS F23280-2 & 13,990
SHAFTING F23280-3
HEAD SECTION F23280-4
INTER. SECTION F23280-5
UPPER INTER. SECTION F23280-6
BOOT SECTION F23280-7
SPLASH HOUSING F23280-8
CHAIN GUARD F23280-9
DRAIN HOUSING F23280-10
REFUSE TROUGH F23280-11
T.V. BRG. F23280-12
SEALING STRIPS AND CAP SCREWS F23280-14
#C2570 REX CHABELCO CHAIN 60538
T.V. SCREWS MARK #6 10753
SPRAY PIPE MARK #37 F23280-15
CHAIN TIGHTENER
T.V. CAPSTAN
BASKET ASSEMBLY F23280-1A
SCREEN WILL PASS APPROX. 34,750 G.P.M. WITH WATER AT A DEPTH OF 22 FT. IN THE INTAKE CHAMBER, & PASSING THRU A CLEAN SCREEN SURFACE AT A VELOCITY OF 1.75 F.P.S.
ENLARGED DETAIL SHOWING RUBBER STRIP FOR SEALING ON VERTICAL RUNWAY.
10'-0" BASKETS
PURCHASER'S GATES
FRONT
PLAN - SECTION CC
ENLARGED DETAIL
WASTE WELL
FRONT ELEVATION (SECTION AA)
SIDE ELEVATION - (SECTION BB)
PURCHASER TO PROVIDE LEVEL BASE FOR SCREEN TO REST ON
FILE
ORIGINAL DRG.
FOR DETAIL OF BASKETS SEE DWG. NO. F23280-1A
MAX. SIZE OF SECTIONS = 4'-0" X 11'-0" X 11'-6"
MAX. WT. OF SECTIONS = 2750# (WT. TO BE REDUCED IF MOTOR & SPEED REDUCER ARE TO BE REMOVED)
CHAIN BELT COMPANY
MILWAUKEE, WIS., U.S.A.
REX
REVISED
TITLE [redacted] GENERAL ARRANGEMENT OF ONE REX TRAVELING WATER SCREEN
CUSTOMER CITY OF BELLINGHAM, WASHINGTON
INSTALLED AT WHATCOM FALLS PARK, BELLINGHAM, WASH.
ENGINEERS BAAR & CUNNINGHAM
ORDER NO. F23280 ESTIMATE NO. 20813
DRAWN BY J.M.S.
IN CHARGE L.G.C.
SCALE 1/4"=1'-0" DATE 1-26-40
DRAWING NO. [redacted]
F-23280-1
THIS PRINT MADE FROM TRACING F25835-1