Jacobs

Technical Memorandum

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Subject	**Lake Whatcom Tunnel Condition Assessment Report (Task 5.2) (Final)**
Project Name	Raw Water Intake Condition Assessment and Intertie Pipeline Design
Attention	Steve Day, PE / Project Manager for City of Bellingham
From	Robert Martin, PE / Jacobs Phil Martinez, PE / Jacobs Kenny Moffat, PE / Jacobs
Date	June 14, 2024

Contents of Memorandum

1. Introduction

This condition assessment report documents the March 2024 Lake Whatcom Raw Water Tunnel (tunnel) condition assessment. The tunnel and overall raw water conveyance system is owned by the City of Bellingham. The tunnel extends on its upstream end from the Gatehouse on the shore of Lake Whatcom to the Screenhouse on the downstream end where traveling screens remove debris from the flow stream that is conveyed downstream to the Whatcom Falls Water Treatment Plant (WTP).

The City of Bellingham (City) completed assessments of the tunnel on four previous occasions starting with the first inspection in 1988, 1990, 2012, 2014, and 2015. A summary and assessment of the 1988, 1990, 2012, and 2014 inspections are presented in the Draft July 2015 Lake Whatcom Tunnel Condition Assessment (CH2M HILL). This 2015 report was never revised or finalized, but it comprises a robust documentation of work completed prior to March 2024 inspection. The results presented herein enable direct comparison to the results of the 2015 condition assessment work.

2. Description of Tunnel

The Lake Whatcom Raw Water Tunnel is located in Bellingham Washington, extending from Lake Whatcom to the City's Screenhouse, as shown in Figure 1. It is a horseshoe-shaped tunnel constructed in 1939 with a length of 7,560 linear feet (LF) and a diameter of 6.5 ft. It has a capacity of approximately 100 million gallons per day (mgd). It appears the tunnel was constructed using drill and blast methods. It is fitted with a cast-in-place concrete lining. The tunnel conveys raw water from the upstream Gatehouse on the west shore of Lake Whatcom to the downstream Screenhouse in Whatcom Falls Park. A summary of the tunnel design is presented in Table 1.

Up until the closure of the Georgia Pacific Pulp and Paper Mill, which occurred over time between 2001 and 2007, the tunnel conveyed in excess of 50 mgd at times and regularly conveyed over 30 mgd for decades. Currently, flow through the tunnel is primarily to serve the City's municipal needs, which range from peak daily usage of 20 mgd to an average daily usage of 10 mgd. Other average daily water usage through the tunnel includes approximately 1 mgd associated with the downstream Puget Sound Energy Cogeneration power generating facility. Additionally, there is "return flow," estimated to be 5 mgd, from the upstream side of the traveling screens in the Screenhouse to Whatcom Creek. The resulting current average daily flow through the tunnel is approximately 16 mgd, which equates to a tunnel velocity of approximately 1 foot per second.

Two photographs each of the Gatehouse and Screenhouse are presented as Exhibits 1 and 2, respectively. Drawings from the original design and construction of the tunnel are presented in Attachment A. These drawings include a plan and profile, typical sections, tunnel details, shaft structure design details, geologic information, and progress chart from the original tunnel construction showing the geology encountered along the alignment.

FIGURE 1
Alignment of Lake Whatcom Raw Water Tunnel

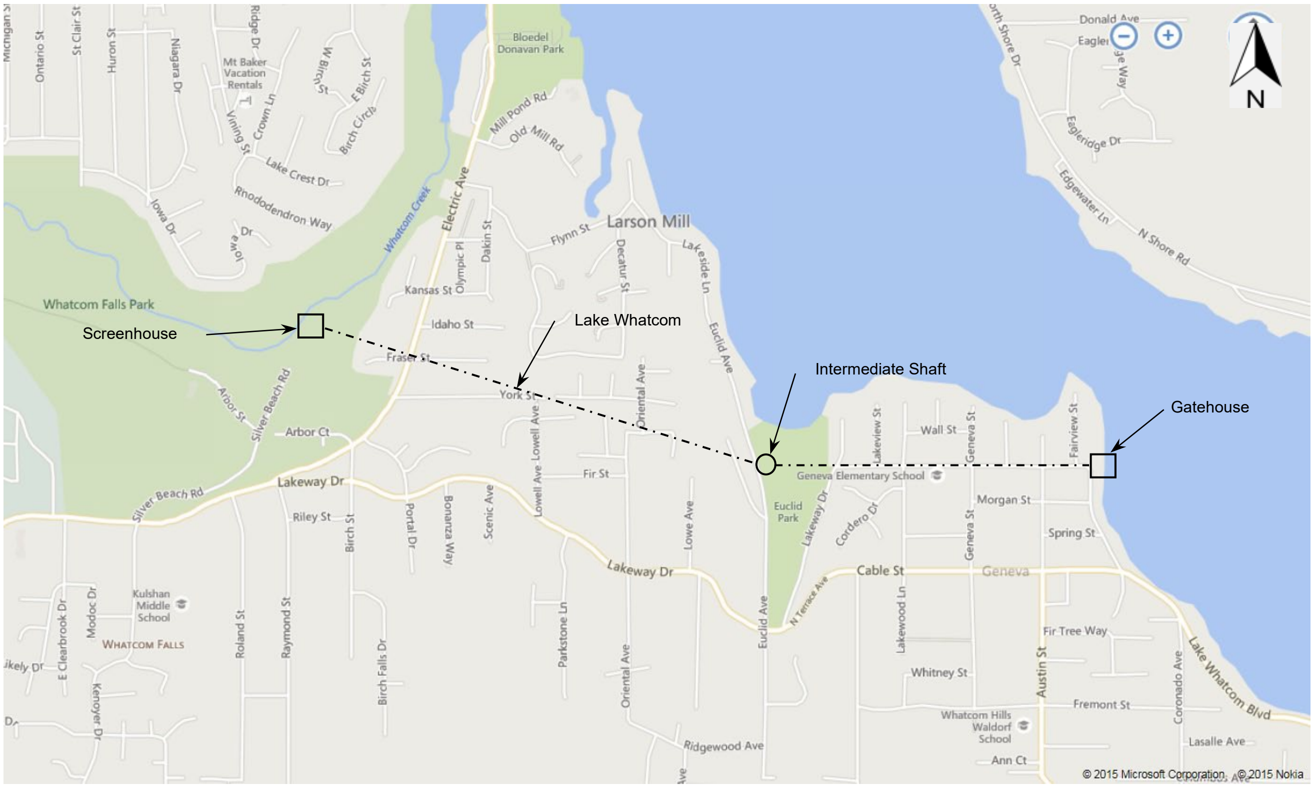


TABLE 1
Lake Whatcom Raw Water Tunnel Design Summary

Parameter	Description
Designer	Baar and Cunningham
Contractor	B.H Sheldon (Tunnel Contractor)
Construction Completed	1939
Tunnel length	7,560 feet (1.4 miles)
Upstream Elevation	298.5 feet
Downstream Elevation	290.94 feet
Tunnel slope	0.1%
Cross section per plan	Horseshoe; 5.0 feet bottom width × 6.25 feet high
Cross section (lined) as observed	Horseshoe; 6.3 feet Spring line width × 6.5 feet high

EXHIBIT 1

Screenhouse (Downstream End of Tunnel)

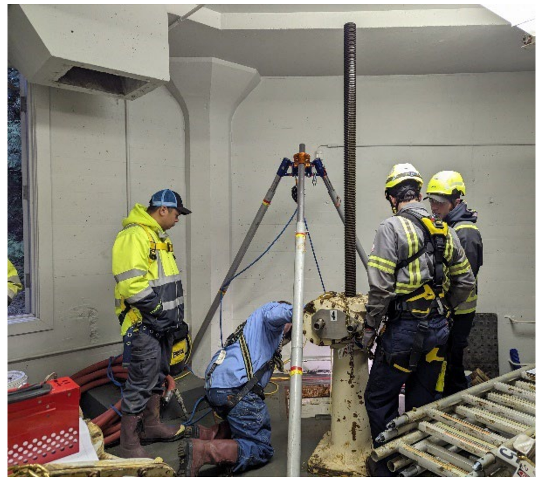


EXHIBIT 2

Gatehouse (Upstream End of Tunnel) and Slide Gate Stem

3. Summary of Prior Inspections

Prior to the March 2024 inspection, the tunnel was formally inspected on four separate occasions. Documentation on these prior inspections is presented in the 2015 Condition Assessment Report: Lake Whatcom Tunnel Condition Assessment Report (Task 2.3.3), July 2015, CH2M HILL. For reference, these prior reports are listed below:

- 1988 Tunnel Liner Observation and Preliminary Geotechnical Engineering Assessment, Hart Crowser
- 1990 Geotechnical Engineering Assessment, Tunnel Observations, Repairs, Tests and Exploratory Work, Hart Crowser
- 2012 ROV Inspection Report, iPi: Laser scanning data (discussed further below); ROV camera inspection video; Support diver helmet camera video

- 2014 City of Bellingham Lake Whatcom Tunnel: Preliminary Condition Assessment and Improvement Report (Task 2.2.2), November 7, 2014, CH2M HILL
- 2015 Condition Assessment Report: Lake Whatcom Tunnel Condition Assessment Report (Task 2.3.3), July 2015, CH2M HILL

Review of the reports summarizing the prior inspection and condition assessment efforts aided the work planning for the March 2024 tunnel inspection.

4. Field Inspection Methods and Approach

The inspection of the tunnel liner was completed on March 20, 2024 in conformance with industry accepted practices and standards. The inspection approach implemented was based on practices and standards defined by the National Association of Sewer Service Companies (NASSCO) Pipe Assessment Condition Program (PACP) for small diameter pipelines. These practices and standards were modified for the Lake Whatcom tunnel inspection, reflecting Jacobs' standard approach, as there are no similar defined condition assessment standards for large diameter tunnels in the US.

4.1 Defect Coding, Scoring, and Rehabilitation Priority

Defect terminology, associated defect codes, and concrete liner rating used during the field inspection is presented in Attachment B. Also presented in Attachment B, are associated rehabilitation priorities associated with the defect scoring. An understanding of the defect coding, liner rating values, and rehabilitation priority presented in Attachment B is necessary to understand the inspection results presented in Section 5.

The standard inspection defect coding used for this project is grouped into three main categories: structural, operational, and other.

Structural defects consist of the fractures, cracks, collapse, breaks, and surface damage. Definitions of the structural codes used for this inspection are presented in Attachment B. Operational defects include debris, deposits, protruding structures, and infiltration. Definitions of the operational codes used for this inspection are presented in Attachment B. Codes characterized as "other" consist of construction features and miscellaneous observations that typically do not require rehabilitation or renewal activities.

Each 100-foot length of the concrete liner of the tunnel (from station to station) was rated or "scored" with respect to defects in conformance with the rating methodology presented in Attachment B. The priority for rehabilitation of each of the 100-foot lengths was then developed based on the NASSCO standardized approach. While operational and other defects are included in the condition rating, the frequency and severity of structural defects is typically driver of the overall condition rating and corresponding rehabilitation prioritization.

4.2 Inspection Plan and Safety

The *Inspection Plan for Lake Whatcom Screenhouse, Tunnel and Gatehouse, dated February 2024* included in Attachment C was prepared to guide the tunnel inspection, which was completed over the course of a single day between the hours of 9:00 am to 4:30 pm.

The tunnel was entered under confined space entry safety procedures in conformance with a tunnel entry safety plan that was developed under separate cover. Life Rescue, Inc provided safety support for the tunnel entrants based on the safety plan. A pre-entry safety coordination meeting was conducted the morning prior to the tunnel entry. Confined space entry attendants were stationed at the upstream, intermediate, and downstream tunnel access points (two at each; 6 total plus one supervisor). An air monitor was present at each access point and the inspection teams were equipped with air monitors, as well. Jacobs' safety manager was present on site throughout the day to serve as the overall safety lead for the tunnel entry.

Air flow through the tunnel was enhanced using a 10,000 cfm blower at the Gatehouse opening. The blower system appeared to provide more than adequate ventilation. In alignment with the inspection plan, air monitoring checks were performed at each access point prior to the blower being turned on to document background conditions. The background conditions were found to not exceed any limits on the 5-gas monitor.

As the inspection team neared the Gatehouse, as they completed the inspection, the blower was turned off. Even after the blower was turned off there was noticeable air flow through the tunnel. Even during this time air quality was measured continually. Oxygen levels remained above 20.5 percent and no detection of carbon monoxide; hydrogen sulfide; nor methane was noted at any time during the course of the inspection, consistent with the background readings prior to inspection activities and use of the blower.

4.3 Tunnel Stationing

During the previous inspection (2015) permanent markers were placed every 100 feet on the south side of the tunnel to aid location of inspection documentation and to aid future inspections. The permanent markers consist of an aluminum washer stamped with the year "2015" and the corresponding station number, as shown in Exhibit 3. Washers were affixed to stainless steel friction anchors that were pounded into holes drilled with a rotary hammer drill. All markers were intact and, while experiencing some corrosion, were generally legible when observed through the course of completing the 2024 inspection.

EXHIBIT 3

Permanent Station Markers Installed in the Tunnel

5. Inspection Results

Key results of the March 2024 inspection of the concrete tunnel liner along with a comparison of ratings to the previous 2015 inspection are presented in Table 2. The liner rating was computed, and the rehabilitation priority developed on a per-100-foot section based on the methodology presented in Attachment B. The major defect types contributing to the "high" rehabilitation priority are presented in Table 2 and factors that contributed to a change in rating. The changes in rehabilitation priority rows are highlighted. A graphical representation of the rehabilitation priority changes is presented in Attachment D. In addition to presenting distribution of rehabilitation priority along the tunnel, the figure in Attachment D presents the location of tunnel defects with a score or weighting of 4, the highest severity observed (no tunnel defects with a score of 5 were observed). New defects identified as part of the March 2024 inspection are presented in RED.

As noted in Table 2, the vast majority of the major defects that impact rehabilitation priority are holes and longitudinal fractures. Holes and longitudinal fractures in the liner are of particular concern because they often indicate the presence of voids behind the concrete liner. Voids are a major concern because they typically form from the migration of material outside of the tunnel liner. Small voids are not as much of a concern as are larger voids. But voids can change shape and grow over time. When this happens, these voids prevent the even-distribution of support from the surrounding sub-surface. Stress concentrations on the liner can result in damage or failure to the liner, which can result in even greater damage outside and/or above the tunnel – potentially extending to the surface. Consequently, because of their potential criticality, the specific locations of hole and longitudinal fracture defects observed during the inspection are presented in the table in Attachment E so that these areas can be target in future investigations.

The specific defects contributing to the "low" and "medium" rehabilitation priority are not presented in Table 2, but instead can be reviewed in the detailed tunnel inspection report notes included in Attachment F. These tunnel inspection report notes present descriptions of each of the tunnel liner defects, as observed in the field. The tunnel inspection report notes presented in Attachment F are comprised of the 2015 inspection report notes with updates as applicable for each defect. This approach ensured that all of the defects observed in 2015 were re-inspected and that the differences are clearly identified. These differences, as well as newly observed defects in 2024, are identified in red text within Attachment F.

Table 2
Tunnel Liner Rating, Rehabilitation Priority, and Defects Per 100 foot Tunnel Segment

Start Station	End Station	Concrete Tunnel Liner Rating (2015)	Concrete Tunnel Liner Rating (2024)	Rehabilitation Priority	Major Defect Noted
0+00	1+00	2	2	Low	Refer to Attachment F
1+00	2+00	2	2	Low	Refer to Attachment F
2+00	3+00	3	3	Medium	Refer to Attachment F
3+00	4+00	3	3	Medium	Refer to Attachment F
4+00	5+00	0	0	Not Required	Refer to Attachment F
5+00	6+00	2	2	Low	Refer to Attachment F
6+00	7+00	0	4	High	Fracture Longitudinal
7+00	8+00	3	3	Medium	Refer to Attachment F
8+00	9+00	3	3	Medium	Refer to Attachment F
9+00	10+00	3	3	Medium	Refer to Attachment F
10+00	11+00	3	3	Medium	Refer to Attachment F
11+00	12+00	3	3	Medium	Refer to Attachment F
12+00	13+00	3	3	Medium	Refer to Attachment F
13+00	14+00	3	3	Medium	Refer to Attachment F
14+00	15+00	3	3	Medium	Refer to Attachment F
15+00	16+00	3	3	Medium	Refer to Attachment F
16+00	17+00	4	4	High	Hole Void Visible
17+00	18+00	4	4	High	Fracture Longitudinal
18+00	19+00	3	3	Medium	Refer to Attachment F
19+00	20+00	3	3	Medium	Refer to Attachment F
20+00	21+00	4	4	High	Hole Void Visible
21+00	22+00	4	4	High	Fracture Longitudinal

Start Station	End Station	Concrete Tunnel Liner Rating (2015)	Concrete Tunnel Liner Rating (2024)	Rehabilitation Priority	Major Defect Noted
22+00	23+00	3	4	High	Fracture Longitudinal
23+00	24+00	4	4	High	Fracture Longitudinal
24+00	25+00	3	3	Medium	Refer to Attachment F
25+00	26+00	3	3	Medium	Refer to Attachment F
26+00	27+00	3	3	Medium	Refer to Attachment F
27+00	28+00	4	4	High	Hole Void Visible
28+00	29+00	3	3	Medium	Refer to Attachment F
29+00	30+00	3	3	Medium	Refer to Attachment F
30+00	31+00	3	3	Medium	Refer to Attachment F
31+00	32+00	3	3	Medium	Refer to Attachment F
32+00	33+00	4	4	High	Hole Void Visible
33+00	34+00	3	3	Medium	Refer to Attachment F
34+00	35+00	4	4	High	Hole Void Visible
35+00	36+00	0	0	Not Required	Refer to Attachment F
36+00	37+00	3	3	Medium	Refer to Attachment F
37+00	38+00	1	1	Not Required	Refer to Attachment F
38+00	39+00	4	4	High	Hole Void Visible
39+00	40+00	2	3	Medium	Fracture Longitudinal
40+00	41+00	0	0	Not Required	Refer to Attachment F
41+00	42+00	4	4	High	Fracture Longitudinal
42+00	43+00	3	3	Medium	Refer to Attachment F
43+00	44+00	3	3	Medium	Refer to Attachment F
44+00	45+00	2	2	Low	Refer to Attachment F
45+00	46+00	3	3	Medium	Refer to Attachment F
46+00	47+00	3	3	Medium	Refer to Attachment F
47+00	48+00	4	4	High	Hole Void Visible
48+00	49+00	3	3	Medium	Refer to Attachment F
49+00	50+00	4	4	High	Hole Void Visible
50+00	51+00	4	4	High	Hole Soil Visible
51+00	52+00	3	3	Medium	Refer to Attachment F
52+00	53+00	0	0	Not Required	Refer to Attachment F
53+00	54+00	0	0	Not Required	Refer to Attachment F
54+00	55+00	0	0	Not Required	Refer to Attachment F
55+00	56+00	0	0	Not Required	Refer to Attachment F
56+00	57+00	0	0	Not Required	Refer to Attachment F
57+00	58+00	4	4	High	Hole Void Visible
58+00	59+00	4	4	High	Hole Soil Visible
59+00	60+00	4	4	High	Hole Void Visible
60+00	61+00	4	4	High	Fracture Longitudinal
61+00	62+00	3	3	Medium	Refer to Attachment F
62+00	63+00	4	4	High	Hole Void Visible
63+00	64+00	4	4	High	Hole Soil Visible
64+00	65+00	4	4	High	Hole Soil Visible

Start Station	End Station	Concrete Tunnel Liner Rating (2015)	Concrete Tunnel Liner Rating (2024)	Rehabilitation Priority	Major Defect Noted
65+00	66+00	3	3	Medium	Refer to Attachment F
66+00	67+00	2	2	Low	Refer to Attachment F
67+00	68+00	4	4	High	Hole Void Visible
68+00	69+00	0	0	Not Required	Refer to Attachment F
69+00	70+00	0	0	Not Required	Refer to Attachment F
70+00	71+00	0	0	Not Required	Refer to Attachment F
71+00	72+00	4	4	High	Hole Soil Visible
72+00	73+00	3	3	Medium	Refer to Attachment F
73+00	74+00	2	2	Low	Refer to Attachment F
74+00	75+00	0	3	Medium	Fracture Longitudinal
75+00	76+00	2	2	Low	Refer to Attachment F

Note: 100-foot segments showing a change in priority rating from 2015 to 2024 are highlighted in blue.

6. Summary of Key Results

In general, the Lake Whatcom Raw Water tunnel liner is in fair condition and appears to be stable. In 2015 seventy-one (71) percent of the tunnel has a rehabilitation priority of “Not Required” to “Medium” (liner rating levels of 0 to 3). In 2024 sixty-two (62) percent of the tunnel has a rehabilitation priority of “Not Required” to “Medium” (liner rating levels of 0 to 3) resulting in a degradation of the tunnel of nine (9) percent. These portions of the tunnel require further monitoring and repairs that should be implemented within 5 to 10 years.

In 2015 twenty nine (29) percent of the tunnel was assigned a rehabilitation priority of “High” (liner rating level of 4). In 2024 thirty-eight (38) percent of the tunnel was assigned a rehabilitation priority of “High” (liner rating level of 4). These portions of the tunnel warrant repairs within one year to prevent the damage associated with these defects from further degradation of the tunnel. No sections of the tunnel were given a rehabilitation priority of “Immediate” (liner rating level of 5).

As presented in the table in Attachment E, a total of 52 locations within the tunnel were identified as either a hole with a visible void (Hole Void Visible) or a hole with visible migration of soil (Hole Soil Visible) in 2015. In 2024 a total of 56 locations within the tunnel were identified as either a hole with a visible void or a hole with visible migration of soil.

A particularly large void was observed behind the liner at station 75+11 to 75+14. In 2015, the void appeared to be approximately 3-feet in diameter and at least 7-inches deep, but may have extended further. When this location was revisited during the 2024 inspection, the liner was still intact over the void and does not appear to have grown over the last 10 years.

In 2015, 103 locations with longitudinal fracturing of the concrete tunnel liner were identified. In 2024, 115 locations with longitudinal fracturing of the concrete tunnel liner were identified. Five of these fractures had offsets of up to 0.19 inches during the 2015 inspection, which were observed to be up to 0.22 inches during the 2024 inspection as presented in Exhibit 4. Longitudinal fracturing is a significant structural defect that suggests the lack of support between the liner and the excavated surface. The importance of these fractures is dependent on the extent to which there is change in their size and offset. In this instance there is evidence of movement of the liner suggesting external pressure is displacing the concrete liner.

There were several tunnel liner locations (5+47 to 5+49, 30+45, 33+01 to 33+02, and 33+06 to 33+07) where the liner was thin or deteriorating to a point where the concrete could easily be scraped away at the surface. One notable example of this deterioration is presented in Exhibit 6 showing a comparison from 2015 to 2024 where the liner has continued to move approximately 0.06 inches since 2015.

EXHIBIT 4

Offset Longitudinal Fracture in Tunnel Liner Comparison from 2015 on the left to 2024 on the right

EXHIBIT 5

Typical Holes Found in the Tunnel Liner

EXHIBIT 6
Deteriorated Concrete Tunnel Liner from 2015 on the left to 2024 on the right

7. Recommendations for Next Steps

As stated above, the Lake Whatcom tunnel is generally in fair condition, able to continue providing beneficial service to the City; however, capital expenditure to keep it in a useful condition is warranted, evidenced by the degradation of almost 10 percent in 10 years since the prior inspection. Although the tunnel has provided relatively minimal- to low-cost service for over 80 years, rehabilitation of the tunnel is necessary and regular monitoring is essential to extend its useful life. Replacement of the tunnel would far exceed the cost of rehabilitation. Action to rehabilitate the tunnel should be implemented as a high priority.

The structural defects (holes and fractures) observed in the liner and voids that may be present behind the liner wall represent the greatest threats to the integrity and continued use of the tunnel. These structural defects contributed to almost 40 percent of the liner receiving a "High" rehabilitation priority. A concrete tunnel liner rating of 4 corresponds with a recommended repair implementation within the next year. It is understood that repairs are likely not feasible within the next year, or even the next two or three years, because the tunnel cannot be removed from service for an extended period of time. That stated, actions to address these "High" priority defects should be initiated as soon as practical.

Specific recommendations presented in the sections below relate to:

- **Non-Destructive Investigation of Structural Defects.** This effort is necessary to improve understanding of specific structural defects that are a threat to the integrity of the concrete tunnel liner.
- **Develop Alternative Intake Strategy.** Identification of an alternative supply source to allow for extended tunnel outage (several months) will enable effective repair of defects in the tunnel. Without an extended period where there is no water flow through the tunnel, the effective repair of voids is likely not feasible.
- **Invasive Investigation of Suspected Voids and Longitudinal Cracks.** Following implementation of alternative intake strategy perform thorough investigations, which may include coring of the concrete liner and behind the liner, to improve understanding of void presence and extents, as well as the driver for longitudinal cracks.
- **Repair Structural Defects.** Following implementation of alternative intake strategy and further evaluation of voids behind the concrete liner, implement structural repairs of voids behind the liner and surficial defects within the liner itself.

7.1 Non-Destructive Investigation of Structural Defects

The initial goal is to identify and characterize void presence behind the cast-in-place liner. An attempt should be made within the next year using non-destructive testing methods such as handheld ground penetrating radar (GPR) or pull along GPR units. The initial attempt at characterizing of voids can be accomplished during a single, "24-hr" single shutdown event, similar to the March 20, 2024, inspection event, with the radar-inspection team being in the tunnel for a period of up to 12 hours. Scanning would be targeted at structural defect locations with defect weight of 4 or greater. But it is anticipated that several thousand feet of the tunnel could be radar-inspected during this single event. Subsequent radar-inspections could be implemented, if warranted, depending on the results and success of the initial radar-inspection. For budgeting purposes, considering the involvement of the tunnel consultant, radar technician(s), a professional extraction safety team, and associated planning and report documentation, the estimated cost would be $100,000, not including City-staff time.

7.2 Develop Alternative Water Intake Strategy

To effectively implement rehabilitation of the tunnel liner to correct structural defects, it will be necessary for the tunnel to be taken out of service for an extended period of time. Currently, it's not possible to have access to the tunnel for more than approximately 24 continuous hours at any given time. This is because the tunnel is the sole means of getting water from Lake Whatcom to the City's Whatcom Falls Water Treatment Plant. Without being able to take the tunnel out of service for an extended period of time, investigating and repairing holes and voids would require many short shut downs of the tunnel. Such short shutdowns may be able to accommodate investigation, but likely not repairs. It is understood the City is planning its consideration of alternatives for a secondary means of getting water from Lake Whatcom to its WTP.

In addition to developing an alternative water intake strategy to take the tunnel out of service, the leakage through the slide gate in the Gatehouse will need to be reduced, if not eliminated. Reducing or eliminating leakage could be done via slide gate replacement, which is already being contemplated by the City. Other methods for addressing leakage could be considered, such as removing corrosion product or other means of plugging the gaps between the slide gate and gate frame. Refer to Exhibit 7 below for the slide gate leakage observed during the March 2024 tunnel inspection.

EXHIBIT 7
Seepage through Gate at Gatehouse (Non- PACP code)

7.3 Invasive Investigation of Suspected Voids and Longitudinal Cracks

Once an alternative water intake supply is in-place and there is time for construction crews to spend prolonged periods within the tunnel of up to several weeks or months, more in-depth (and invasive) investigative techniques may be deployed to better understand the nature of structural defects behind the liner. Concrete coring may be performed at void locations identified as part of the non-destructive GPR scanning or at notable locations experiencing longitudinal fracturing. At locations with fractures, the rock sample should be characterized and tested for swell potential. Additionally, crack gauges may be deployed at specific locations to track any changes over time to fracture offset.

7.4 Repair Structural Defects

As noted above, there were 56 locations in the tunnel liner where holes were identified. Left unrepaired, these holes will allow for the continued migration of fine grained material and the growth of voids behind the concrete tunnel liner. The result could be instability of the liner and potentially collapse.

Following completion of the preceding recommended investigative and alternative supply actions, repairs to address structural defects in the liner and voids behind the line can be implemented. Quantification and scoping of these repairs can be completed after the invasive investigations described above are completed.

8. Representative Photos

During the course of the March 2024 tunnel inspection various structural and operational defects (as defined within Subsection 4.1) were observed and are shown below.

8.1 Structural Defects

The following subsection presents representative structural defects observed during the tunnel inspection.

EXHIBIT 8
Fracture Multiple (Approx Sta 50+90 @ 3 o'clock position in pipe)

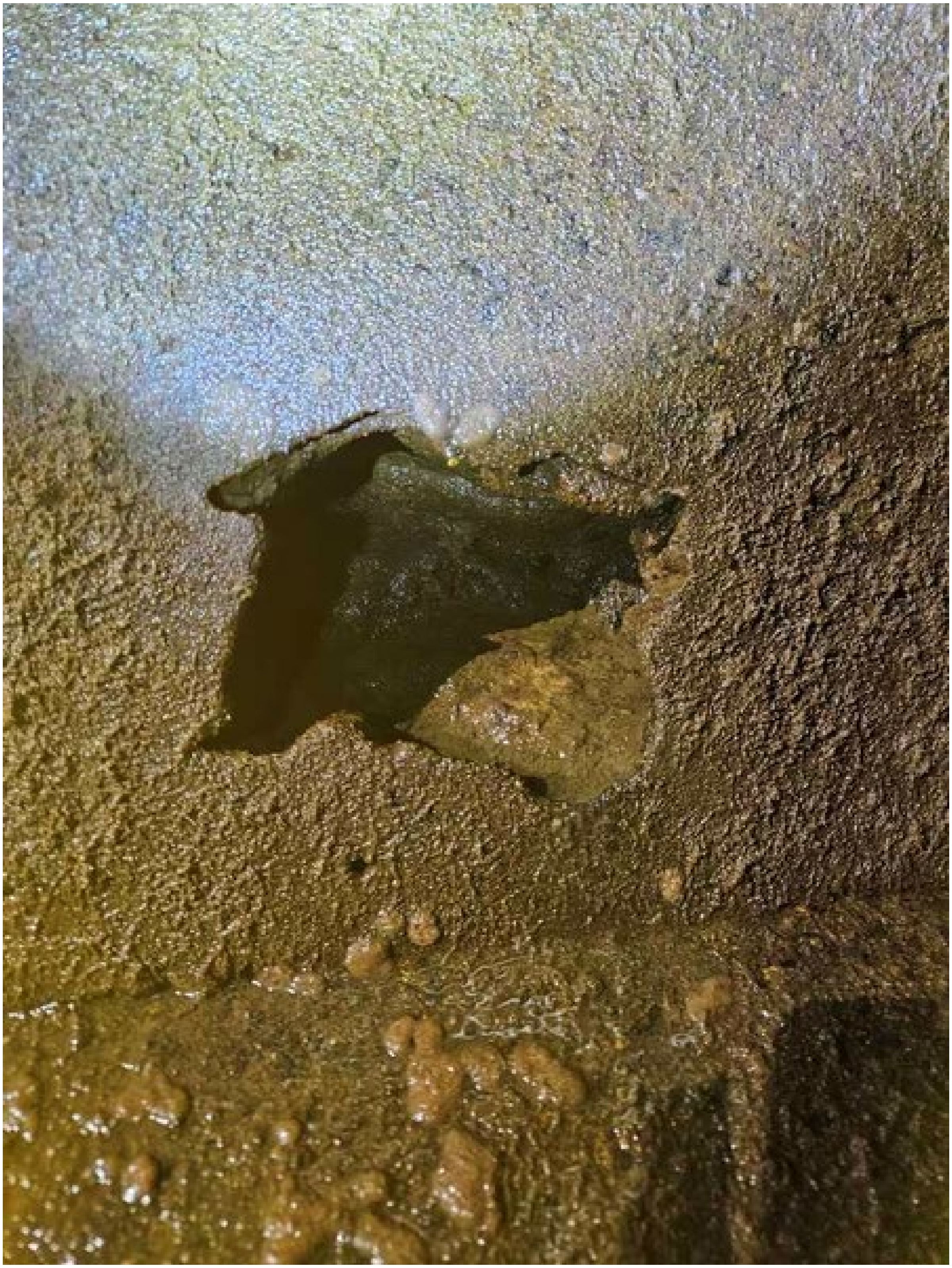
EXHIBIT 9

Hole Soil Visible (Approx Sta 51+10 @ 5 o'clock position in pipe)

EXHIBIT 10
Hole Soil Visible (Approx Sta 53+40 @ 5 o'clock position in pipe)

EXHIBIT 11

Hole Soil Visible (Approx Sta 59+60 @ 7 o'clock position in pipe)



8.2 Operational Defects

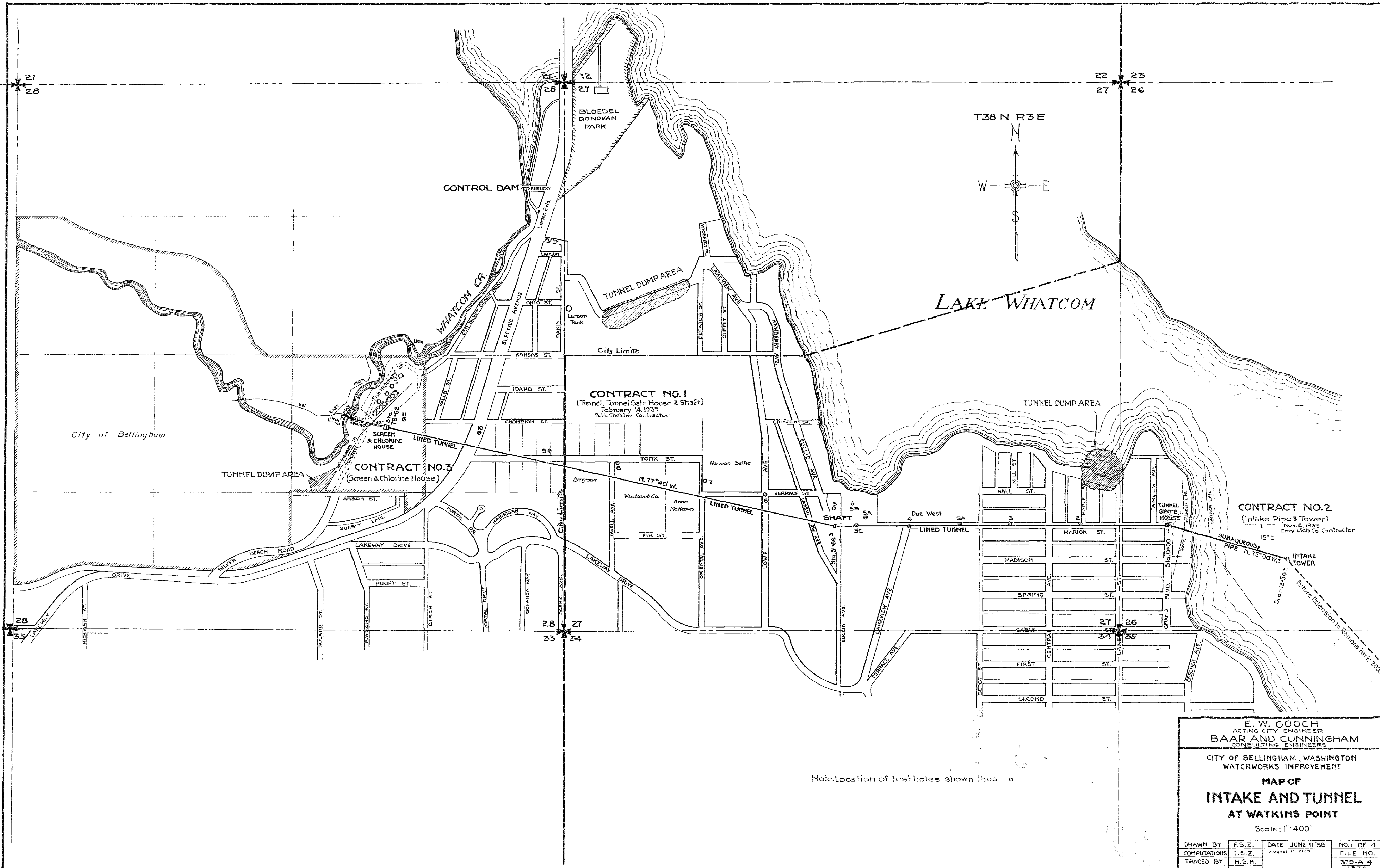
The following subsection presents representative operational defects observed during the tunnel inspection.

EXHIBIT 12

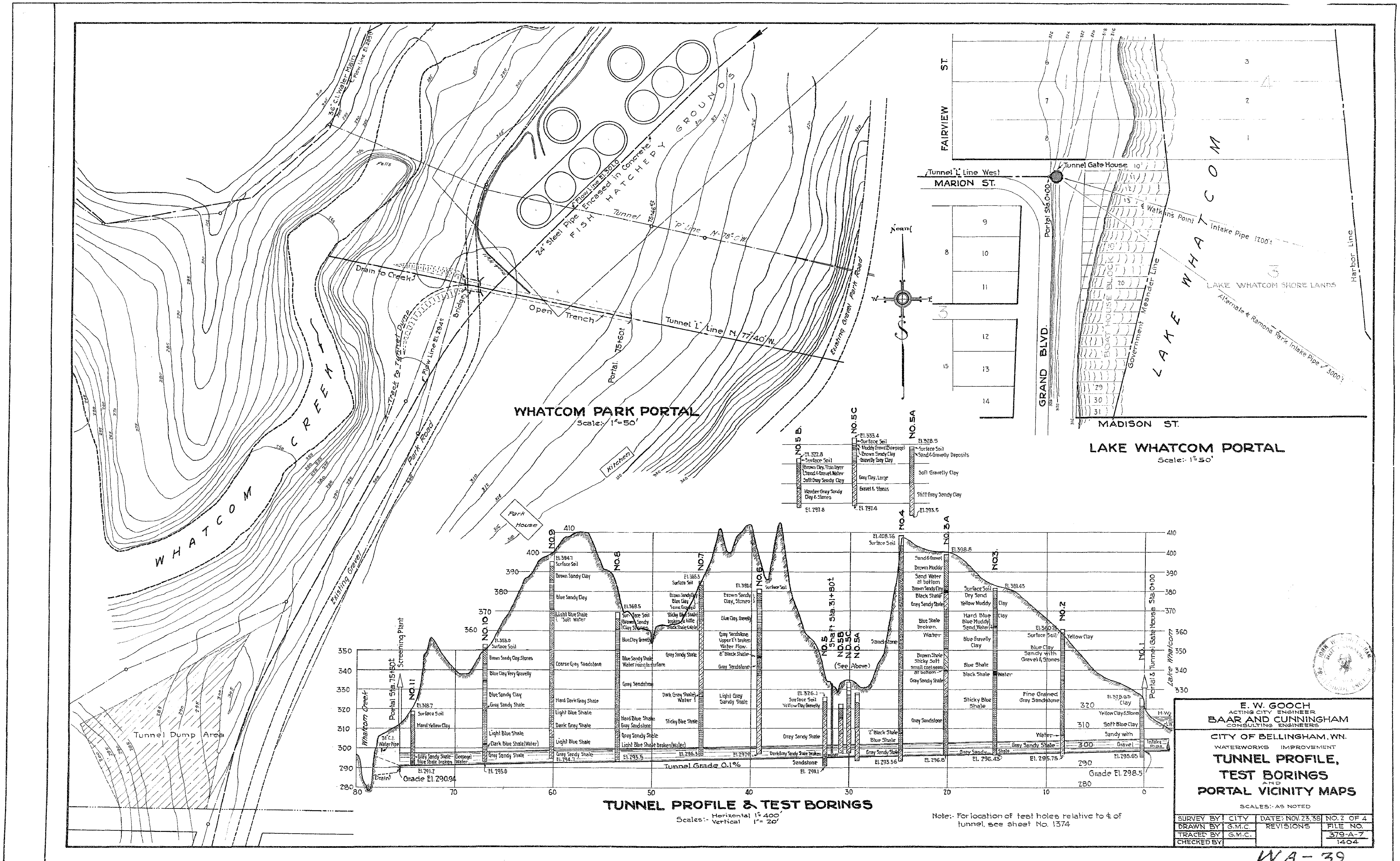
Infiltration Runner Barrel @ 4 o'clock position in pipe

EXHIBIT 13
Infiltration Runner Barrel (Multiple) @ 12 o'clock position in pipe

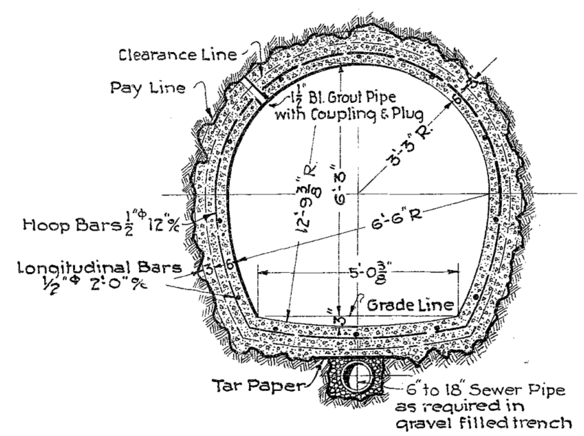
Attachment A
Lake Whatcom Tunnel Drawings


T38 N R3E
N
S
W
E
LAKE WHATCOM
BLOEDEL DONOVAN PARK
CONTROL DAM
WHATCOM CR.
TUNNEL DUMP AREA
Larson Tank
City Limits
CONTRACT NO. 1
(Tunnel, Tunnel Gate House & Shaft)
February 14, 1939
B.H. Sheldon Contractor
CONTRACT NO. 3
(Screen & Chlorine House)
SCREEN & CHLORINE HOUSE
LINED TUNNEL
N. 77° 40' W.
City of Bellingham
SHAFT
Due West
TUNNEL GATE HOUSE
CONTRACT NO. 2
(Intake Pipe & Tower)
Nov. 8, 1939
Croy Lich Co. Contractor
SUBAQUEOUS PIPE N. 75° 00' W.±
INTAKE TOWER
Future Extension to Ramona Park 2000'±
SILVER BEACH ROAD
LAKEWAY DRIVE
City Limits
Note: Location of test holes shown thus o
E. W. GOOCH
ACTING CITY ENGINEER
BAAR AND CUNNINGHAM
CONSULTING ENGINEERS
CITY OF BELLINGHAM, WASHINGTON
WATERWORKS IMPROVEMENT
MAP OF
INTAKE AND TUNNEL
AT WATKINS POINT
Scale: 1" = 400'
DRAWN BY F.S.Z.
COMPUTATIONS F.S.Z.
TRACED BY H.S.B.
DATE JUNE 11 '38
August 11, 1939
NO. 1 OF 4
FILE NO.
379-A-4
1374

WA-38

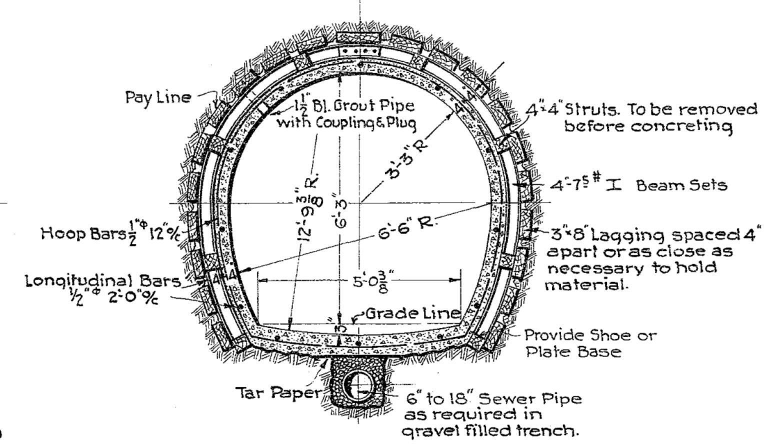


WHATCOM PARK PORTAL
Scale:- 1"=50'
FISH HATCHERY GROUNDS
WHATCOM CREEK
Tunnel "L" Line N. 77°40' W.
Tunnel "P" Line N. 78° W.
24" Steel Pipe Encased in Concrete
Open Trench
Drain to Creek
Bridge
Track to Tunnel Dump
Existing Gravel Park Road
Park Road
Existing Gravel
Portal 75+60±
Kitchen
Park House
Falls
36" C.I. Water Main
Tunnel Dump Area
North
LAKE WHATCOM PORTAL
Scale:- 1"=50'
FAIRVIEW ST.
MARION ST.
MADISON ST.
GRAND BLVD.
Tunnel "L" Line West
Tunnel Gate House
Portal Sta. 0+00
Watkins Point Intake Pipe 1700'±
LAKE WHATCOM SHORE LANDS
Alternate & Ramona Park Intake Pipe 3000'±
Government Meander Line
BOAT HOUSE BLOCK
Harbor Line
LAKE WHATCOM
TUNNEL PROFILE & TEST BORINGS
Scales:- Horizontal 1"=400' Vertical 1"=20'
Tunnel Grade 0.1%
Grade El. 290.94
Grade El. 298.5
Portal Sta. 75+60±
Screening Plant
Whatcom Creek
Shaft Sta. 31+80±
Portal & Tunnel Gate House Sta. 0+00
Lake Whatcom
Note:- For location of test holes relative to ℄ of tunnel, see Sheet No. 1374
E. W. GOOCH
ACTING CITY ENGINEER
BAAR AND CUNNINGHAM
CONSULTING ENGINEERS
CITY OF BELLINGHAM, WN.
WATERWORKS IMPROVEMENT
TUNNEL PROFILE, TEST BORINGS AND PORTAL VICINITY MAPS
SCALES:- AS NOTED
SURVEY BY CITY
DRAWN BY G.M.C.
TRACED BY G.M.C.
CHECKED BY
DATE: NOV. 23, 38
REVISIONS
NO. 2 OF 4
FILE NO. 379-A-7
1404
WA-39



SECTION A

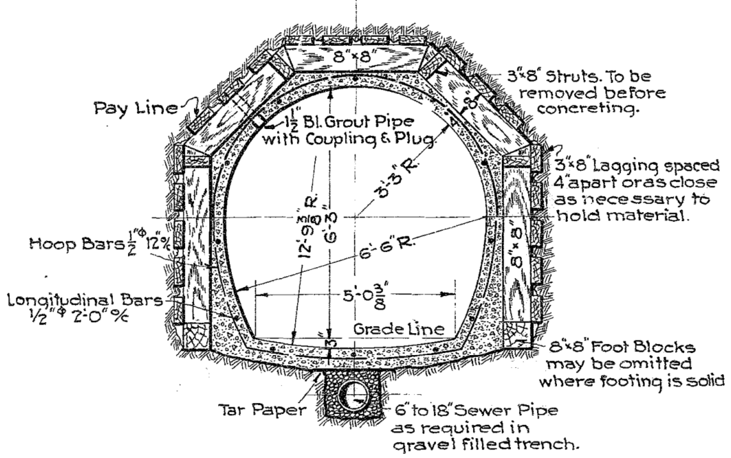
Scale:- ½"=1'-0"



SECTION B

Scale:- ½"=1'-0"

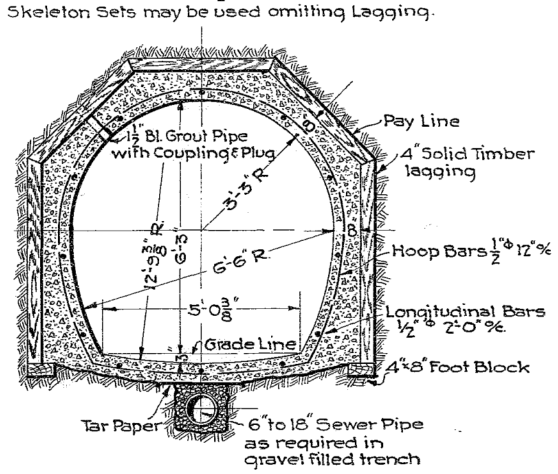
Skeleton Sets may be used omitting Lagging.



SECTION C

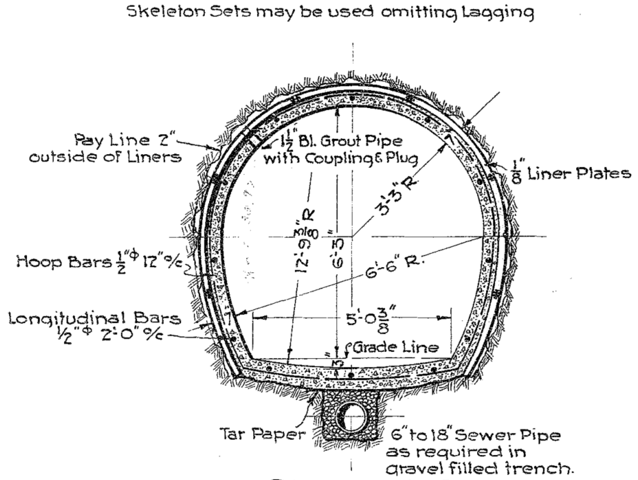
Scale:- ½"=1'-0"

Skeleton Sets may be used omitting Lagging



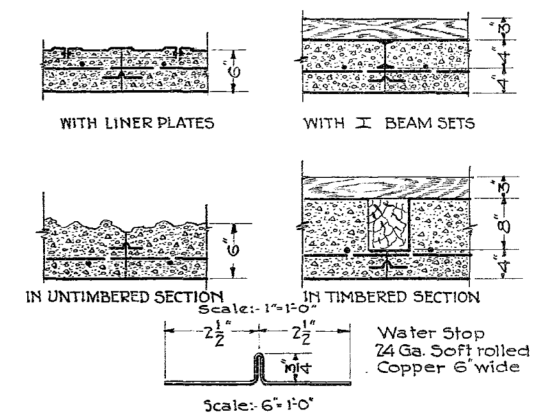
SECTION D

Scale:- ½"=1'-0"

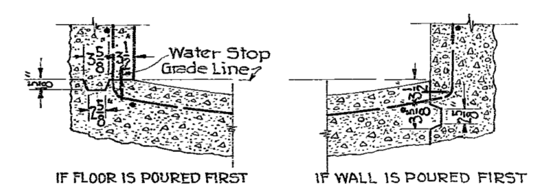


SECTION E

Scale:- ½"=1'-0"

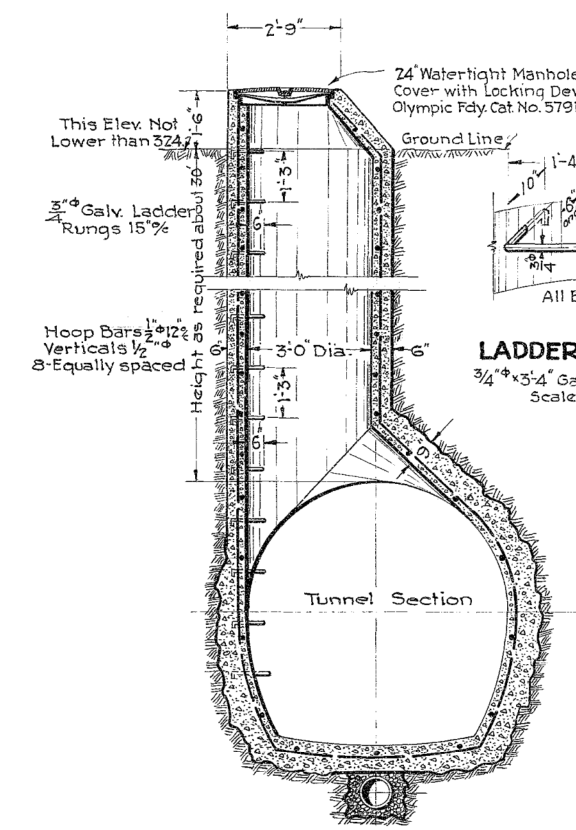


CIRCUMFERENTIAL JOINTS IN LINING



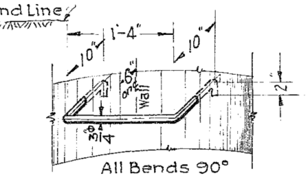
JOINT BETWEEN FLOOR & WALL

Scale:- 1"=1'-0"



TUNNEL SHAFT

Scale:- ½"=1'-0"



LADDER RUNGS

¾"φ x 3'-4" Galvanized

Scale:- 1"=1'-0"

HYDRAULIC PROPERTIES

Q = 167.5 cu. ft./sec.
A = 35.34 sq. ft.
P = 21.51 ft.
R = 1.64 ft.
V = 4.74 ft./sec.
N = .014
S = 1.0 ft./1000

COMPARATIVE QUANTITIES

Section and Type	Excavation Cu.Yds./Ft.	Concrete Cu.Yds./Ft.	Reinf Steel Lbs./Ft.	Lumber F.B.M./Ft.	Str. Steel Lbs./Ft.
A Untimbered	1.982	.673	27	0	0
C1 Permanently Timbered	2.491	1.094	27	34.8	0
C With Lagging	2.602	.712	27	74.8	0
E With Liner Plates	1.943	.634	27	0	150
B1 With I Beam Sets	2.111	.800	27	10.3	35
B With Lagging	2.227	.792	27	52.3	35
D With Solid Timber Lagging	2.238	.665	27	85.5	0

Note:- Timber and Eye Beam Sets considered 4'-0" ℄ to ℄
Drain Trench not included in above excavation.

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

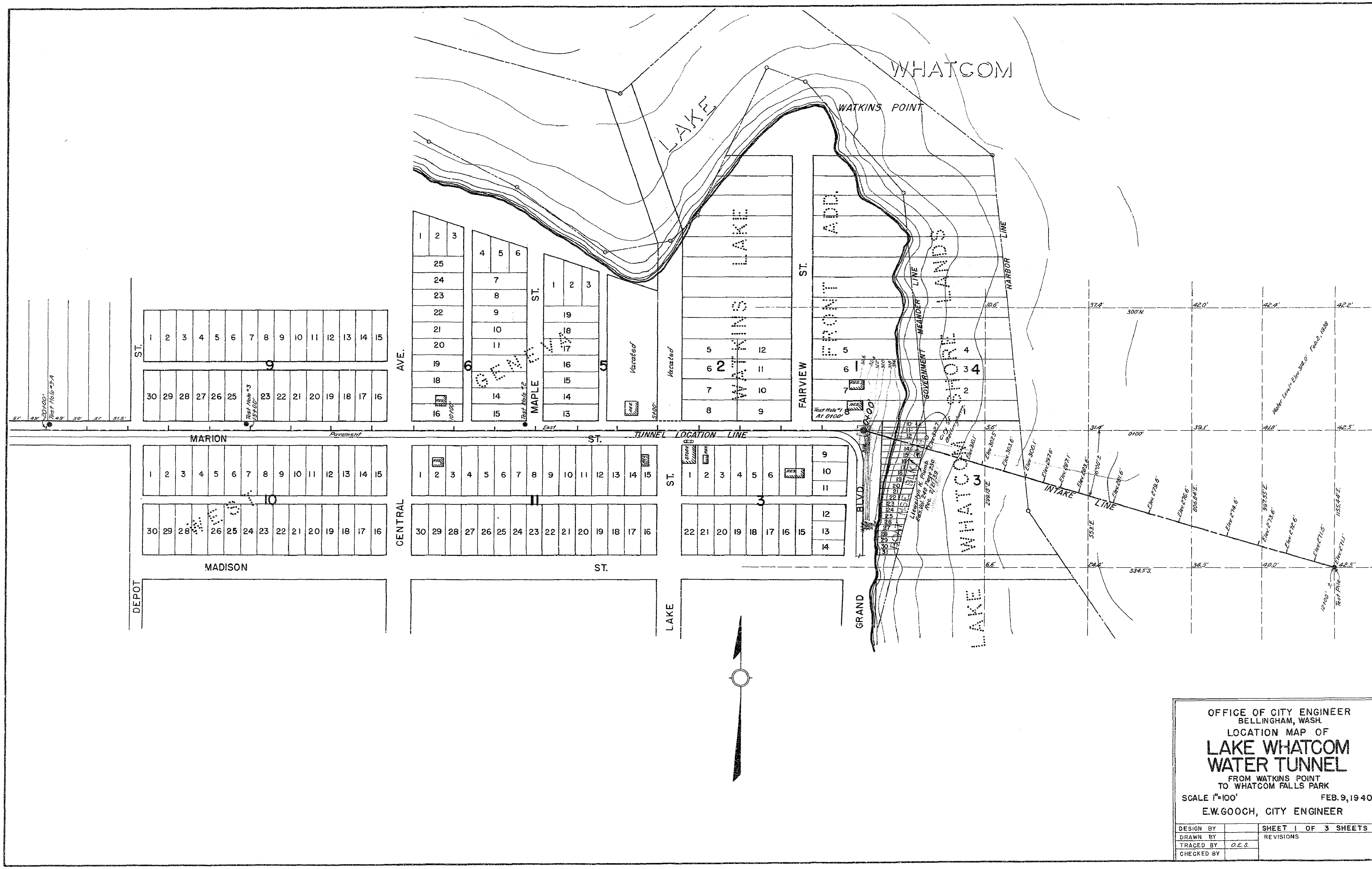
CITY OF BELLINGHAM, WN.
WATERWORKS IMPROVEMENT

TUNNEL SECTIONS

SCALES:- AS NOTED

DESIGN BY	F.S.Z.	DATE: NOV. 8, 38	NO. 3 OF 4
DRAWN BY	F.S.Z.	REVISIONS	FILE NO.
TRACED BY	F.S.Z.		379-A-5
CHECKED BY			1402

WA - 40



OFFICE OF CITY ENGINEER
BELLINGHAM, WASH.
LOCATION MAP OF

LAKE WHATCOM WATER TUNNEL

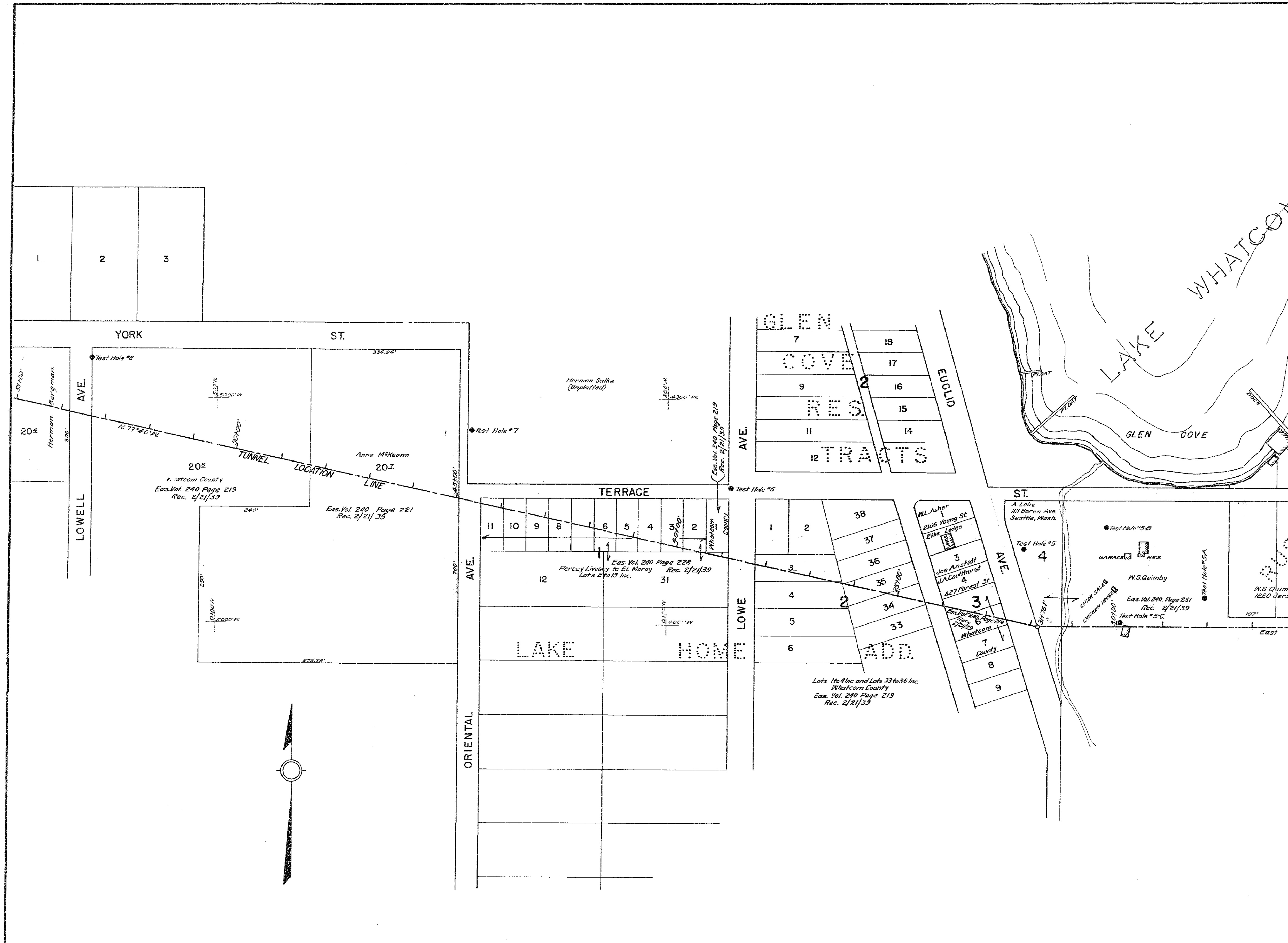
FROM WATKINS POINT
TO WHATCOM FALLS PARK

SCALE 1"=100' FEB. 9, 1940

E.W. GOOCH, CITY ENGINEER

DESIGN BY		SHEET 1 OF 3 SHEETS
DRAWN BY		REVISIONS
TRACED BY	O.E.S.	
CHECKED BY		

WA-54



OFFICE OF CITY ENGINEER
BELLINGHAM, WASH.
LOCATION MAP OF

LAKE WHATCOM WATER TUNNEL

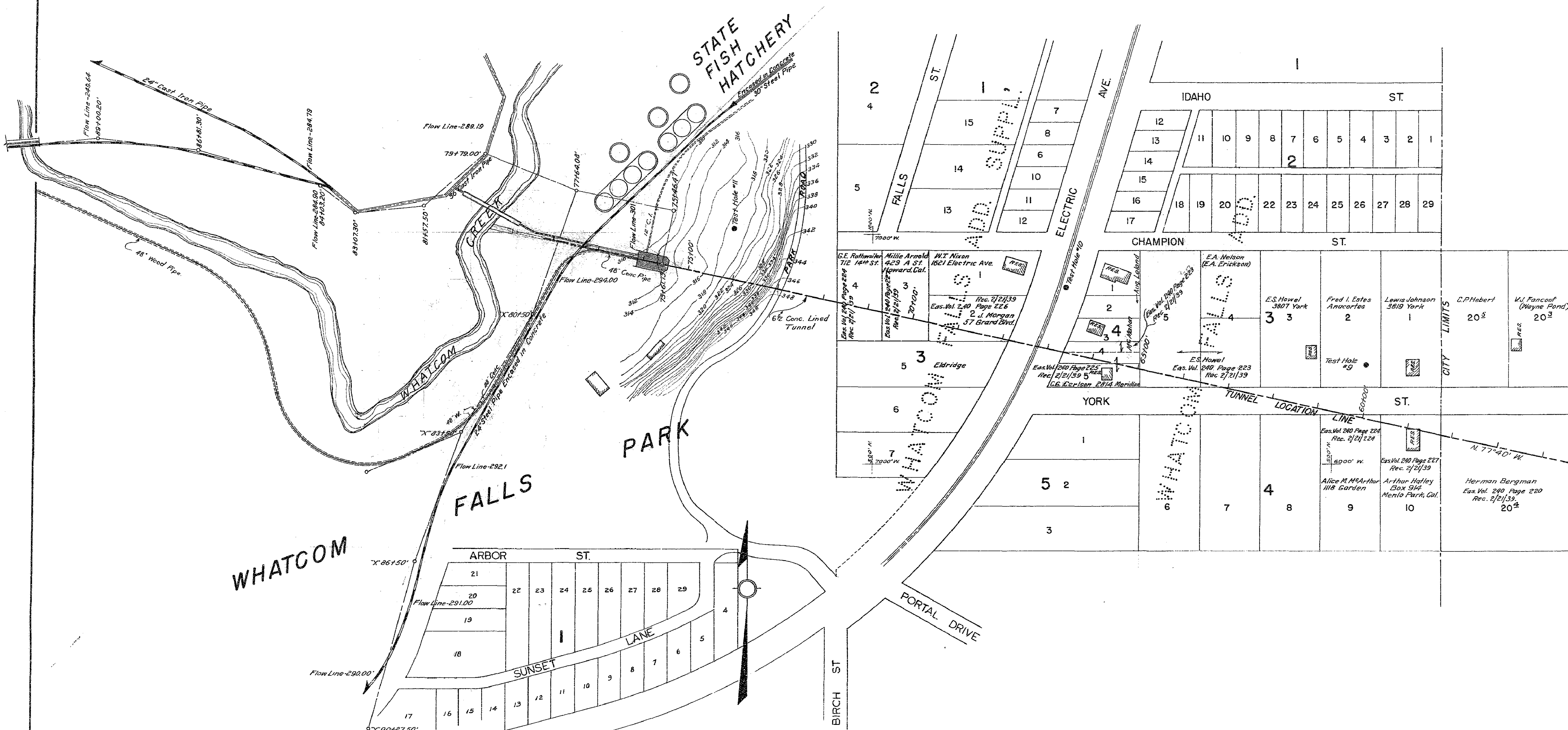
FROM WATKINS POINT
TO WHATCOM FALLS PARK

SCALE 1"=100' FEB. 9, 1940

E.W. GOOCH, CITY ENGINEER

DESIGN BY		SHEET 2 OF 3 SHEETS
DRAWN BY		REVISIONS
TRACED BY	G.E.S.	
CHECKED BY		

WA-55



OFFICE OF CITY ENGINEER
BELLINGHAM, WASH.
LOCATION MAP OF

LAKE WHATCOM WATER TUNNEL

FROM WATKINS POINT TO WHATCOM FALLS PARK

SCALE 1"=100' FEB. 9, 1940

E.W. GOOCH, CITY ENGINEER

DESIGN BY		SHEET 3 OF 3 SHEETS
DRAWN BY		
TRACED BY	O.E.S.	
CHECKED BY		

WA-56

A-5-8-13

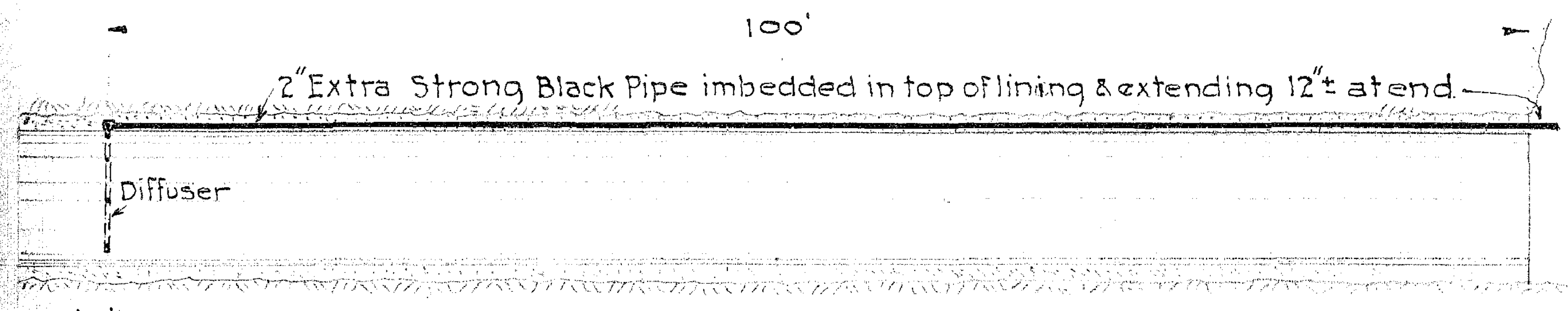
No.	Item	Amount	R.G. Clifford, San Francisco — 360 days, $27,000 — Unit Price	Total	Morrison-Knudson Co., Boise, Idaho — 430 days, $30,000 — Unit Price	Total	L. Romano, Seattle, Wash. — No time set, $30,000 — Unit Price	Total
1	Clearing at Portals & Dumps	2 Acres	200.00	400.00	400.00	800.00	500.00	1,000.00
2	Shaft excavation	350 Cu. yds.	9.00	3,150.00	12.00	4,200.00	40.00	14,000.00
3	Shaft Timbering	20 MBM.	60.00	1,200.00	100.00	2,000.00	150.00	3,000.00
4	Portal trench excavation	2,200 Cu. yds.	2.00	4,400.00	1.25	2,750.00	10.00	22,000.00
5	Portal trench timbering	23 MBM.	50.00	1,150.00	75.00	1,725.00	50.00	1,150.00
6	Drainage trench exca. & backfill	500 Cu. yds.	2.00	1,000.00	5.00	2,500.00	10.00	5,000.00
7	18" Sewer pipe drain	360 lin. ft.	2.25	810.00	2.10	756.00	5.00	1,800.00
8	21" Sewer pipe drain (Alternate)	360 lin. ft.	3.00	1,080.00	3.00	1,080.00	6.00	2,160.00
9	24" Sewer pipe drain (Alternate)	360 lin. ft.	4.00	1,440.00	3.60	1,296.00	7.00	2,520.00
10	Lumber in Bridge	4 MBM.	150.00	600.00	100.00	400.00	50.00	200.00
11	Tunnel Section "A"	1400 lin. ft.	30.75	43,050.00	30.00	42,000.00	40.00	56,000.00
12	Temporary timbering Sec. "A"	15 MBM.	30.00	450.00	60.00	900.00	200.00	3,000.00
13	Tunnel Section "B"	6,160 lin. ft.	30.75	189,420.00	35.00	215,600.00	40.00	246,400.00
14	Steel Sets Section "B"	216,000 lbs.	.06	12,960.00	.10	21,600.00	.10	21,600.00
15	Lagging etc. Section "B"	245 MBM.	30.00	7,350.00	60.00	14,700.00	100.00	24,500.00
16	Tunnel Section "C" (Alternate)	6,160 lin. ft.	30.75	189,420.00	36.00	221,760.00	40.00	246,400.00
17	Timbering Section "C" (Alternate)	385 MBM.	50.00	19,250.00	80.00	30,800.00	125.00	48,125.00
18	Tunnel Section "D" (Alternate)	6,160 lin. ft.	30.75	189,420.00	36.00	221,760.00	40.00	246,400.00
19	Timbering Section "D" (Alternate)	445 MBM.	35.00	15,575.00	80.00	35,600.00	150.00	66,750.00
20	Tunnel Section "E" Alternate	400 lin. ft.	30.75	12,300.00	36.00	14,400.00	40.00	16,000.00
21	Liner Plates (1/8") for Sec. "C" (Alt.)	400 lin. ft.	15.00	6,000.00	12.00	4,800.00	10.00	4,000.00
22	Extra thickness of liners for Sec. "C" (Alt.)	60,000 lbs.	.08	4,800.00	.065	3,900.00	.10	6,000.00
23	Drain 8" complete	1800 lin. ft.	1.20	2,160.00	3.00	5,400.00	3.00	5,400.00
24	Drain 12" complete	1,900 lin. ft.	2.00	3,800.00	4.00	7,600.00	3.00	5,700.00
25	Drain 15" complete	1900 lin. ft.	2.80	5,320.00	4.50	8,550.00	3.50	6,650.00
26	Drain 18" complete	2,000 lin. ft.	3.50	7,000.00	5.00	10,000.00	4.00	8,000.00
27	Overhaul for additional distance	20,000 Cu. yds.	.02	400.00	.03	600.00	.05	1,000.00
28	Concrete tunnel lining in place	6,500 Cu. yds.	19.00	123,500.00	26.00	169,000.00	20.00	130,000.00
29	Concrete Shaft lining in place	50 Cu. yds.	19.00	950.00	50.00	2,500.00	40.00	2,000.00
30	Copper water stops	3000 lin. ft.	1.00	3,000.00	.70	2,100.00	1.50	4,500.00
31	Drain or Grout pipe	400 Units	3.00	1,200.00	2.00	800.00	2.00	800.00
32	Pressure Grouting	100 Cu. yds.	35.00	3,500.00	35.00	3,500.00	40.00	4,000.00
33	Tunnel reinforcing Steel in place	75,000 lbs.	.05	3,750.00	.055	4,125.00	.10	7,500.00
34	Shaft structure reinforcing in place	4000 lbs.	.06	240.00	.06	240.00	.10	400.00
35	Superstructure Lake Whatcom shaft	L.S.	3,000.00	3,000.00	1,000.00	1,000.00	2,000.00	2,000.00
36	Ladder & Manhole cover Euclid Ave. shaft	L.S.	500.00	500.00	50.00	50.00	100.00	100.00
37	Checkered plate channels and Ladder Lake Whatcom shaft	L.S.	500.00	500.00	150.00	150.00	200.00	200.00
38	Setting Gate	8,000 lbs.	.10	800.00	.04	320.00	.15	1,200.00
				425,560.00		525,866.00		579,100.00

No.	Item	Wilder, Bellingham, Wash. — 450 days, $18,500 — Unit Price	Total	Macri Bros., Seattle, Wash. — 450 days, $22,000 — Unit Price	Total	B.H. Sheldon — 365 days, $17,000 — Unit Price	Total
1	Clearing at Portals & Dumps	300.00	600.00	500.00	1,000.00	100.00	200.00
2	Shaft excavation	8.00	2,800.00	10.00	3,500.00	6.00	2,100.00
3	Shaft Timbering	50.00	1,000.00	50.00	1,000.00	50.00	1,000.00
4	Portal trench excavation	1.25	2,750.00	2.50	5,500.00	1.00	2,200.00
5	Portal trench timbering	50.00	1,150.00	40.00	920.00	50.00	1,150.00
6	Drainage trench exca. & backfill	5.00	2,500.00	3.00	1,500.00	8.00	4,000.00
7	18" Sewer pipe drain	2.00	720.00	2.50	900.00	2.25	810.00
8	21" Sewer pipe drain (Alternate)	2.60	936.00	3.00	1,080.00	2.50	900.00
9	24" Sewer pipe drain (Alternate)	3.25	1,170.00	4.00	1,440.00	3.00	1,080.00
10	Lumber in Bridge	50.00	200.00	65.00	260.00	50.00	200.00
11	Tunnel Section "A"	25.00	35,000.00	27.00	37,800.00	21.00	29,400.00
12	Temporary timbering Sec. "A"	50.00	750.00	45.00	675.00	50.00	750.00
13	Tunnel Section "B"	25.00	154,000.00	27.00	166,320.00	16.00	98,560.00
14	Steel Sets Section "B"	.10	21,600.00	.10	21,600.00	.08	17,280.00
15	Lagging etc. Section "B"	50.00	12,250.00	45.00	11,025.00	50.00	12,250.00
16	Tunnel Section "C" (Alternate)	25.00	154,000.00	28.00	172,480.00	17.00	104,720.00
17	Timbering Section "C" (Alternate)	50.00	19,250.00	55.00	21,175.00	50.00	19,250.00
18	Tunnel Section "D" (Alternate)	30.00	184,800.00	28.00	172,480.00	17.00	104,720.00
19	Timbering Section "D" (Alternate)	70.00	31,150.00	45.00	20,025.00	50.00	22,250.00
20	Tunnel Section "E" Alternate	30.00	12,000.00	29.00	11,600.00	16.00	6,400.00
21	Liner Plates (1/8") for Sec. "C" (Alt.)	12.00	4,800.00	13.00	5,200.00	10.00	4,000.00
22	Extra thickness of liners for Sec. "C" (Alt.)	.08	4,800.00	.10	6,000.00	.07	4,200.00
23	Drain 8" complete	.65	1,170.00	1.50	2,700.00	.75	1,350.00
24	Drain 12" complete	1.00	1,900.00	2.00	3,800.00	1.25	2,375.00
25	Drain 15" complete	1.50	2,850.00	2.50	4,750.00	1.75	3,325.00
26	Drain 18" complete	2.00	4,000.00	3.00	6,000.00	2.50	5,000.00
27	Overhaul for additional distance	.01	20[illegible].00	.03	600.00	.002	40.00
28	Concrete tunnel lining in place	15.00	97,500.00	20.00	130,000.00	20.00	130,000.00
29	Concrete Shaft lining in place	30.00	1,500.00	35.00	1,750.00	20.00	1,000.00
30	Copper water stops	.40	1,200.00	.65	1,950.00	.50	1,500.00
31	Drain or Grout pipe	1.00	400.00	2.00	800.00	1.00	400.00
32	Pressure Grouting	40.00	4,000.00	60.00	6,000.00	35.00	3,500.00
33	Tunnel reinforcing Steel in place	.10	7,500.00	.10	7,500.00	.07	5,250.00
34	Shaft structure reinforcing in place	.08	320.00	.10	400.00	.07	280.00
35	Superstructure Lake Whatcom shaft	1,200.00	1,200.00	2,200.00	2,200.00	1,000.00	1,000.00
36	Ladder & Manhole cover Euclid Ave. shaft	75.00	75.00	300.00	300.00	100.00	100.00
37	Checkered plate channels and Ladder Lake Whatcom shaft	70.00	70.00	500.00	500.00	200.00	200.00
38	Setting Gate	.04	320.00	.15	1,200.00	.02	160.00
			359,525.00		422,450.00		325,380.00

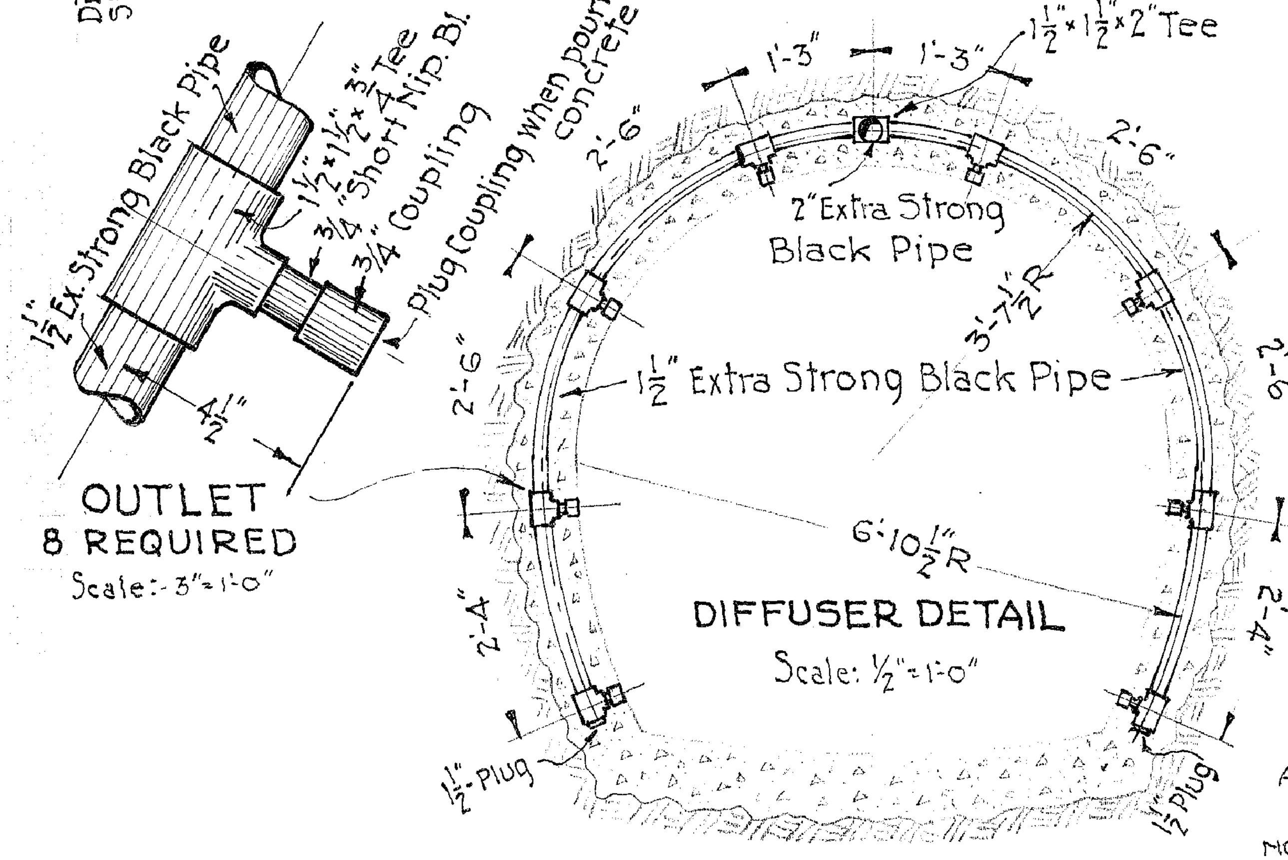
No.	Item	Sam Orino, Portland, Oregon — 540 days, $25,000 — Unit Price	Total	Utah Const. Co., San Francisco — 450 days, $35,000 — Unit Price	Total	Croy & Litch Co., Bellingham, Wash. — 540 days, $19,500 — Unit Price	Total
1	Clearing at Portals & Dumps	400.00	800.00	175.00	350.00	200.00	400.00
2	Shaft excavation	12.00	4,200.00	17.25	6,037.50	8.00	2,800.00
3	Shaft Timbering	90.00	1,800.00	80.00	1,600.00	50.00	1,000.00
4	Portal trench excavation	1.00	2,200.00	3.50	7,700.00	3.00	6,600.00
5	Portal trench timbering	90.00	2,070.00	57.50	1,322.50	40.00	920.00
6	Drainage trench exca. & backfill	1.50	750.00	3.50	1,750.00	2.00	1,000.00
7	18" Sewer pipe drain	3.00	1,080.00	1.75	630.00	2.35	846.00
8	21" Sewer pipe drain (Alternate)	4.00	1,440.00	2.30	828.00	3.50	1,260.00
9	24" Sewer pipe drain (Alternate)	5.00	1,800.00	3.00	1,080.00	3.95	1,422.00
10	Lumber in Bridge	90.00	360.00	115.00	460.00	50.00	200.00
11	Tunnel Section "A"	25.00	35,000.00	40.70	56,980.00	20.00	28,000.00
12	Temporary timbering Sec. "A"	90.00	1,350.00	80.00	1,200.00	60.00	900.00
13	Tunnel Section "B"	25.00	154,000.00	44.85	276,276.00	18.00	110,880.00
14	Steel Sets Section "B"	.10	21,600.00	.115	24,840.00	.10	21,600.00
15	Lagging etc. Section "B"	90.00	22,050.00	104.00	25,480.00	60.00	14,700.00
16	Tunnel Section "C" (Alternate)	25.00	154,000.00	48.30	297,528.00	21.00	129,360.00
17	Timbering Section "C" (Alternate)	90.00	34,650.00	92.00	35,420.00	65.00	25,025.00
18	Tunnel Section "D" (Alternate)	25.00	154,000.00	50.60	311,696.00	22.00	135,520.00
19	Timbering Section "D" (Alternate)	90.00	40,050.00	92.00	40,940.00	60.00	26,700.00
20	Tunnel Section "E" Alternate	25.00	10,000.00	57.50	23,000.00	25.00	10,000.00
21	Liner Plates (1/8") for Sec. "C" (Alt.)	15.00	6,000.00	28.75	11,500.00	15.00	6,000.00
22	Extra thickness of liners for Sec. "C" (Alt.)	.10	6,000.00	.115	6,900.00	.12	7,200.00
23	Drain 8" complete	2.00	3,600.00	2.30	4,140.00	1.10	1,980.00
24	Drain 12" complete	2.25	4,275.00	2.60	4,940.00	2.00	3,800.00
25	Drain 15" complete	2.75	5,225.00	2.85	5,415.00	3.50	6,650.00
26	Drain 18" complete	3.25	6,500.00	3.15	6,300.00	4.60	9,200.00
27	Overhaul for additional distance	.05	1,000.00	.03	600.00	.02	400.00
28	Concrete tunnel lining in place	28.00	182,000.00	21.85	142,025.00	20.00	130,000.00
29	Concrete Shaft lining in place	28.00	1,400.00	24.75	1,237.50	35.00	1,750.00
30	Copper water stops	.16	480.00	.57	1,710.00	1.00	3,000.00
31	Drain or Grout pipe	2.00	800.00	2.30	920.00	2.00	800.00
32	Pressure Grouting	50.00	5,000.00	31.00	3,100.00	40.00	4,000.00
33	Tunnel reinforcing Steel in place	.06	4,500.00	.09	6,750.00	.10	7,500.00
34	Shaft structure reinforcing in place	.06	240.00	.11	440.00	.10	400.00
35	Superstructure Lake Whatcom shaft	1,500.00	1,500.00	1,725.00	1,725.00	2,000.00	2,000.00
36	Ladder & Manhole cover Euclid Ave. shaft	50.00	50.00	175.00	175.00	150.00	150.00
37	Checkered plate channels and Ladder Lake Whatcom shaft	50.00	50.00	175.00	175.00	500.00	500.00
38	Setting Gate	.05	400.00	.07	560.00	.05	400.00
			464,280.00		584,838.50		362,376.00

A-5-8-13

A-5-8-14



LONGITUDINAL TUNNEL SECTION
SHOWING LOCATION OF DIFFUSER
Scale:- 1/8" = 1'-0"



OUTLET
8 REQUIRED
Scale:- 3" = 1'-0"

DIFFUSER DETAIL
Scale: ½" = 1'-0"

CITY OF BELLINGHAM, WASHINGTON

DETAIL OF

AMMONIA DIFFUSER

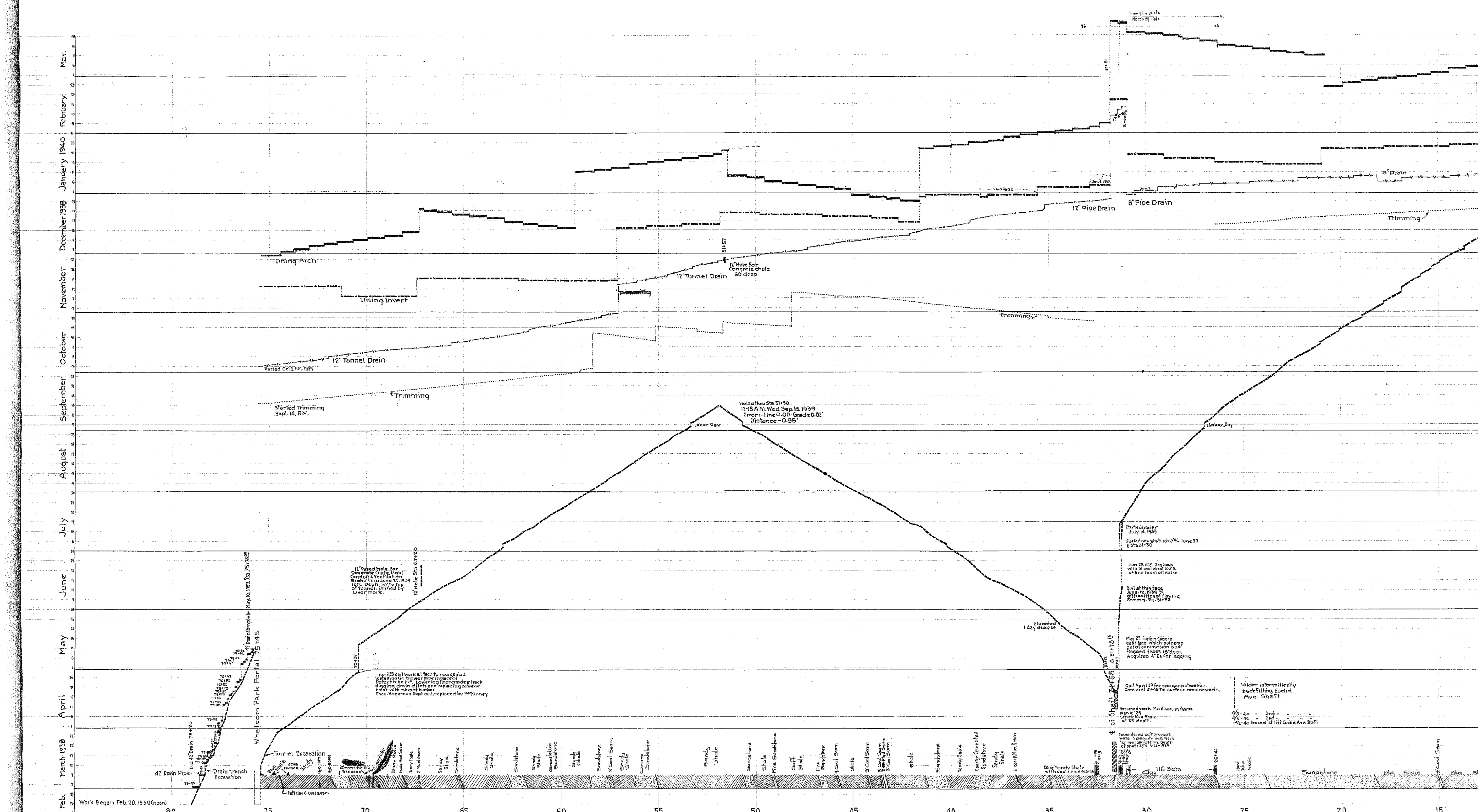
AT WHATCOM PARK TUNNEL PORTAL

NOV. 1, 1939

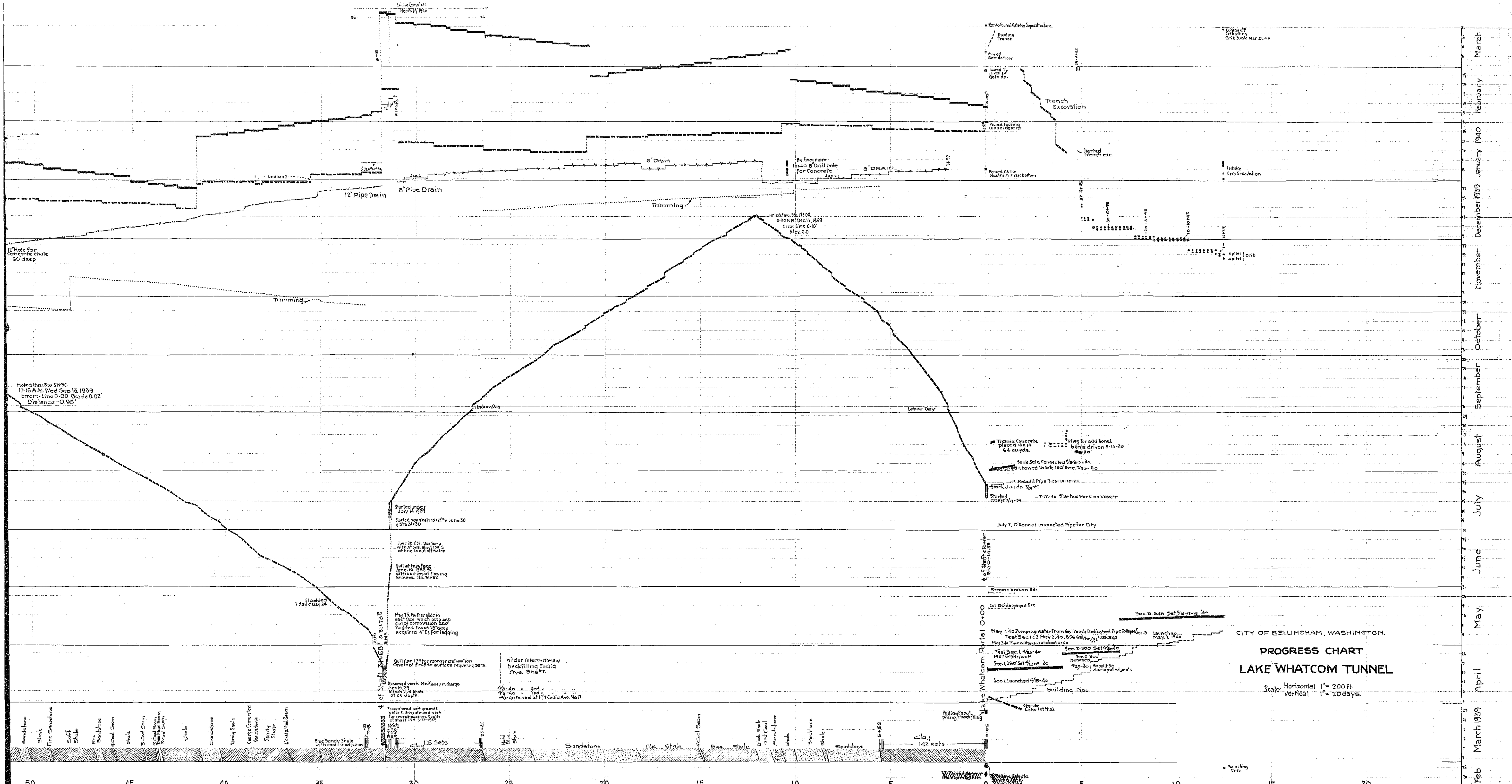
BAAR AND CUNNINGHAM

A-5-8-14

379-L-12
1463

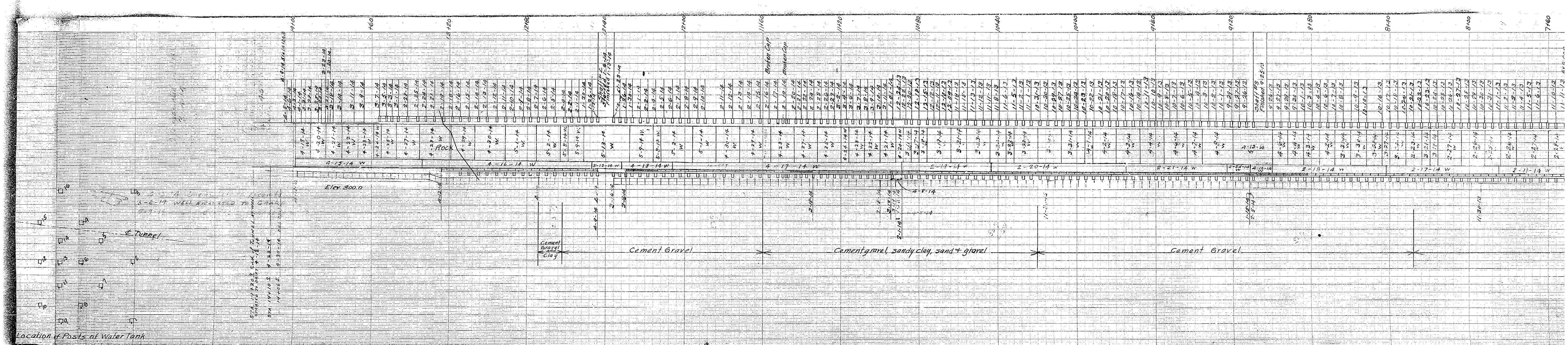

Mar.
February
January 1940
December 1939
November
October
September
August
July
June
May
April
March 1939
Feb.
Work Began Feb. 20, 1939 (noon)
Lining Arch
Lining Invert
12" Tunnel Drain
Started Oct. 3, P.M. 1939
Trimming
Started Trimming Sept. 14, P.M.
12" Hole for Concrete chute 60 deep
12" Pipe Drain
8" Pipe Drain
8" Drain
Holed thru Sta 51+90
12-15 A.M. Wed Sep. 13, 1939
Error:- Line 0-00 Grade 0.02'
Distance -0.95'
Labor Day
Whatcom Park Portal 75+45
Tunnel Excavation
42" Drain Pipe
Drain Trench Excavation
70+57
April 29 quit work at face to reorganize. Installing G.I. blower pipe in place of Dupont tube 10". Lowering floor grade & track digging drain ditch and replacing conveyor hoist with skip et bunker.
Chas. Hageman Supt. quit, replaced by MacKinney.
Flooded 1 day delay
Started under July 14, 1939
Started new shaft 10x12' c/c June 30 ℄ Sta 31+30
June 28, 1939. Dug Sump with Shovel about 100' S. of line to cut off water.
Quit at this face June 12, 1939 % difficulties of flowing Ground. Sta. 31+32
May 23. Further slide in east face which put pump out of commission and flooded faces 18" deep. Acquired 4" Es for lagging
℄ of Shaft 31+68
Δ 31+78.13
Quit April 29 for reorganization. Cave in at 31+45 to surface requiring sets.
Resumed work MacKinney in charge. Apr. 10, '39
Struck blue Shale at 25' depth.
Encountered soft ground & water & discontinued work for reorganization. Depth of shaft 25'± 3-22-1939
116 Sets
Clay
Sandy Shale
Sandstone
Shale
Soft Shale
Coal Seam
Blue Sandy Shale with coal & mud seams
80
75
70
65
60
55
50
45
40
35
30
25
20
15

24 F1

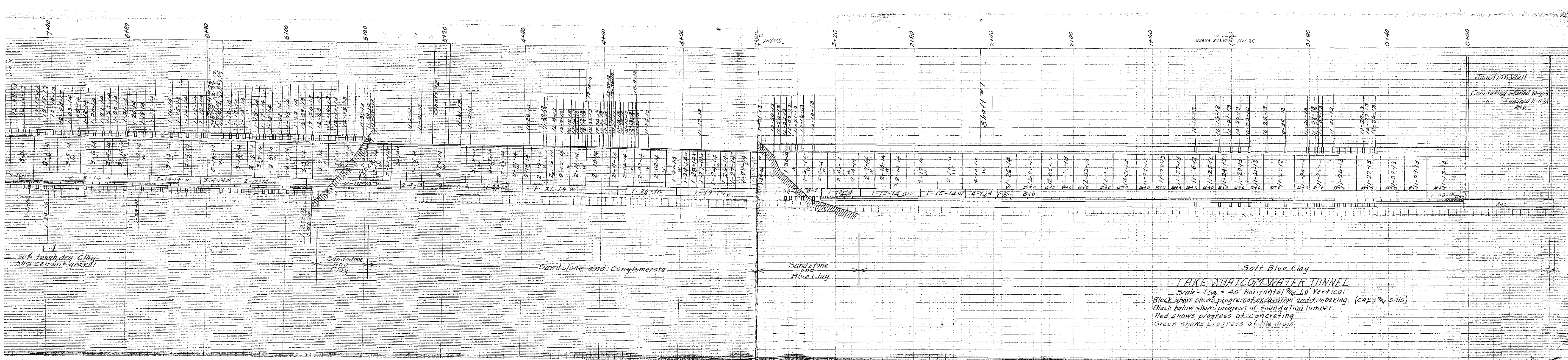


CITY OF BELLINGHAM, WASHINGTON.
PROGRESS CHART
LAKE WHATCOM TUNNEL
Scale: Horizontal 1" = 200 Ft. Vertical 1" = 20 days.
March
February
January 1940
December 1939
November
October
September
August
July
June
May
April
March 1939
Feb
Trench Excavation
12" Pipe Drain
8" Pipe Drain
8" Drain
8" DRAIN
Trimming
Labor Day
Lake Whatcom Portal 0+00
Building Pipe
Sandstone
Blue Shale
115 Sets
142 sets
50
45
40
35
30
25
20
15
10
5
0
5
10
15
20

24 F2


Location of Posts of Water Tank
E Tunnel
Elev. 300.0
Rock
Cement Gravel and Clay
Cement Gravel
Cementgravel, sandy clay, sand + gravel
Cement Gravel

30 F 1


Junction Well
Shaft #1
Shaft #2
50% tough dry Clay
50% cement gravel
Sandstone and Clay
Sandstone and Conglomerate
Sandstone and Blue Clay
Soft Blue Clay
LAKE WHATCOM WATER TUNNEL
Scale - 1 sq. = 4.0' horizontal and 1.0' Vertical
Black above shows progress of excavation and timbering. (caps and sills)
Black below shows progress of foundation lumber.
Red shows progress of concreting
Green shows progress of tile drain

30 F 2

Attachment B
Defect Coding, Scoring, and Rehabilitation Priority

Appendix B

Defect Coding, Scoring, and Rehabilitation Priority

Presented herein is a discussion of some of the key tunnel liner defect coding definitions relative to the defects encountered in the Lake Whatcom tunnel. Also included is a discussion of defect coding, an example calculation of how segments of the tunnel lining were rated, and a discussion of liner rehabilitation priority. At the end of this appendix is a table listing the defect codes and their relative scoring or weighting.

C.1 Tunnel Liner Defect Coding

The NASSCO PACP method consists of structural and operational type defects that are weighted and then are scored. The types of defects used in this inspection are discussed below.

C.1.1 Structural Defect Coding Definitions

There are two categories of defects: structural and operational. Structural defects generally result in rehabilitation of the liner result in maintenance of the liner. Key structural defects are defined below.

C.1.1.1 Fractures

A fracture is a crack that is open more than 0.015 inch wide and is sometimes accompanied by deformation or evidence of infiltration. It is challenging to differentiate a crack on the interior of the liner from fractures when the fractures are closed. If inspection methods are used that are suited for only above the flow line, fractures below the flow line may not be detected unless the pipe is fully dewatered. There are several types of typical fractures. Fractures observed in the Lake Whatcom tunnel include: longitudinal, circumferential, and diagonal.

C.1.1.2 Cracks

A crack is a defect in the liner that is closed at the surface. The distinction between cracks and fractures is necessary so that consecutive inspection data can be used to determine the progress of deterioration. There are several types of cracks that are typically observed. Fractures in the Lake Whatcom tunnel include: longitudinal, circumferential, and diagonal.

C.1.1.3 Hole

The classification of a hole is used if the defect in the liner wall is less than 12 inches in diameter or if it is rectangular in shape less than 12-inch by 12-inches or equivalent area. A hole in a liner generally warrants repair, particularly if there is evidence of infiltration or migration of fines from behind the line.

C.1.1.4 Surface Damage

Surface damage to a liner occurs on the inner portion of the liner and is caused by chemical attack, biological attack or wear. For a concrete tunnel liner, surface damage includes spalling of the material, and or exposure and corrosion of the reinforcement.

C.1.2 Operational Defect Coding Definitions

Operational defects generally result in the maintenance of the liner. The primary operational defects identified as part of the investigation are defined below.

C.1.2.1 Debris

Debris is a deposit of soils, rock, or other materials that may disrupt flow. If debris consists of construction-related materials, it may be an indication that a more severe condition may exist upstream. A reduction in tunnel or pipe diameter is used to determine severity. This was not an issue in the Lake Whatcom tunnel.

C.1.2.2 Infiltration

Infiltration is the ingress of groundwater into a tunnel or pipe through a defect. Mineral deposits on the liner often indicate infiltration. Infiltration can disrupt the stability of the mass behind the liner.

C.2 Defect Scoring or "Weighting"

NASSCO PACP identifies the scoring of the liner as a rating system and uses a numerical grading system to define the severity of each pipe defect. Defect severity grades for structural defects and operation and maintenance (O&M) defects are assigned by NASSCO PACP based on the risk of further deterioration or failure. The numerical scores or "weights" rank defects on a scale of 1 to 5, with 1 being best (least risk) and 5 being worst (highest risk). A table summary of these scores are presented at the end of this appendix**.**

C.3 Example Calculation for Liner Rating

PACP uses several methods for scoring the condition of the liner: segment grade scoring, overall pipe rating, structural pipe rating, O&M pipe rating, structural pipe rating index, O&M pipe rating index, and overall pipe rating index. All methods offer their own unique approach for characterizing the condition of the liner. The overall pipe rating index was used for representing the condition of the Lake Whatcom tunnel liner on a per-100-foot segment basis.

The overall pipe rating index is an expression of the defect severity found in the pipe over a 100-foot segment of the tunnel. The index is calculated scoring each defect then adding up the total score. The total is then divided by the number of defects encountered in a defined 100-foot segment. As an example, a pipe segment from Stations 1+00 to 2+00 contains the following defects and associated scores:

1. 5 circumferential cracks = 5 (PACP assigns a score of 1 to each circumferential crack)
2. 2 circumferential fractures = 6 (PACP assigns a score of 3 to each circumferential fracture)
3. 3 longitudinal cracks = 6 (PACP assigns a score of 2 to each longitudinal crack)
4. The sum of defects between Stations 1+00 to 2+00 = 17, calculated by adding 5 + 6 + 6
5. The total number of defects in the 100 foot segment = 10, calculated by adding 5 + 2 + 3

Therefore, in this example the overall pipe rating index for the liner between Stations 1+00 and 2+00 is 2, which is calculated by dividing 17 by 10 and rounding up to 2.

C.4 Rehabilitation Priority

The scores calculated for each 100-foot tunnel segment, as described in the example above, are a rehabilitation priority. NASSCO has established a priority for rehabilitation efforts based on calculated scoring for each segment of the liner. The rehabilitation ranges from "immediate" where the liner has failed, to "not required" where the tunnel is in good or excellent condition. Timelines associated with the rehabilitation priority range from immediate to more than 10 years, depending on the defect(s). Rehabilitation efforts may include everything from replacing the liner to simply monitoring observed defects over time. Rehabilitation priority and timing is presented in the below.

Rehabilitation Priority from NASSCO PACP

Condition Rating	Implication	Rehabilitation Priority	Recommended Timing
5	Failed or failure imminent	Immediate	—
4	• Very poor condition • High structural risk	High	1 year
3	• Poor condition • Moderate structural risk	Medium	5 years

Rehabilitation Priority from NASSCO PACP

Condition Rating	Implication	Rehabilitation Priority	Recommended Timing
2	• Fair condition • Minimal structural risk	Low	5 to 10 years
1 or 0	Good or excellent condition	not required	>10 years

Defect Code Summary Table

Defect Group Name	Defect Group Code	Defect Weight	Group
Access Point Blind Shaft	ABS	1	Operational
Access Point Cleanout	ACO	1	Operational
Access Point Discharge Point	ADP	1	Operational
Access Point Drift Tunnel	ADT	1	Operational
Access Point Junction Box	AJB	1	Operational
Access Point Meter	AM	1	Operational
Access Point Manhole	AMH	1	Operational
Access Point Other Special Chamber	AOC	1	Operational
Access Point Drill Hole (< 3')	APDH	1	Operational
Access Point Shaft Hole (3' or >)	APSH	1	Operational
Access Point Tee Connection	ATC	1	Operational
Access Point WW Access Device	AWA	1	Operational
Access Point Wet Well	AWW	1	Operational
Pipe Failure Broken	B	5	Structural
Brickwork Displaced	BDB	5	Structural
Brickwork Dropped Invert	BDI	5	Structural
Brickwork Missing	BMB	4	Structural
Brickwork Missing Mortar	BMM	3	Structural
Broken Soil Visible	BSV	5	Structural
Broken Void Visible	BVV	5	Structural
Crack	C	1	Structural
Crack Angular	CA	2	Structural
Crack Circumferential	CC	1	Structural
Crack Longitudinal	CL	2	Structural
Crack Multiple	CM	3	Structural
Crack Spiral	CS	2	Structural
Deposits Attached Encrustation	DAE	1	Operational
Deposits Attached Grease	DAGS	1	Operational
Deposits Attached Ragging	DAR	1	Operational
Deposits Attached Other	DAZ	1	Operational
Deformed Brick	DB	5	Structural
Deposits Ingress Fines Silt/Sand	DNF	1	Operational
Deposits Ingress Gravel	DNGV	1	Operational
Deposits Ingress Other	DNZ	1	Operational
Deformed Pipe	DP	5	Structural
Deposits Settled Hard/Compacted	DSC	1	Operational
Deposits Settled Fine	DSF	1	Operational
Deposits Settled Gravel	DSGV	1	Operational
Deposits Settled Other	DSZ	1	Operational
Fracture	F	3	Structural
Fracture Angular	FA	3	Structural
Fracture Circumferential	FC	3	Structural
Fracture Longitudinal	FL	4	Structural
Fracture Multiple	FM	4	Structural
Fracture Spiral	FS	4	Structural
Geologic Feature	GF	1	Other

Defect Group Name	Defect Group Code	Defect Weight	Group
Pipe Failure Hole	H	2	Structural
Hole Soil Visible	HSV	4	Structural
Hole Void Visible	HVV	4	Structural
Infiltration Dripper	ID	1	Operational
Infiltration Gusher	IG	1	Operational
Infiltration Runner	IR	1	Operational
Intruding Seal Material Grout	ISGT	1	Operational
Intruding Seal Material Sealing Ring	ISSR	1	Operational
Intruding Seal Material Other	ISZ	1	Operational
Infiltration Weeper	IW	1	Operational
Joint Angular	JA	2	Structural
Joint Offset	JO	3	Structural
Joint Separated	JS	4	Structural
Line Down	LD	1	Other
Lining Failure Abandoned Connection	LFAC	1	Other
Lining Failure Blistered	LFB	1	Other
Lining Failure Buckled	LFBK	1	Other
Lining Failure Service Cut Shifted	LFCS	1	Other
Lining Failure Detached	LFD	1	Other
Lining Failure Defective End	LFDE	1	Other
Lining Failure Overcut Service	LFOC	1	Other
Lining Failure Undercut Service	LFUC	1	Other
Lining Failure Wrinkled	LFW	1	Other
Lining Failure Other	LFZ	1	Other
Line Left	LL	1	Other
Line Left/Down	LLD	1	Other
Line Left/Up	LLU	1	Other
Line Right	LR	1	Other
Line Right/Down	LRD	1	Other
Line Right/Up	LRU	1	Other
Line Up	LU	1	Other
Miscellaneous Camera Underwater	MCU	1	Other
Miscellaneous Direction Change	MDC	1	Other
Miscellaneous General Observation	MGO	1	Other
Miscellaneous General Photograph	MGP	1	Other
Miscellaneous Joint Length Change	MJL	1	Other
Miscellaneous Lining Change	MLC	1	Other
Miscellaneous Material Change	MMC	1	Other
Miscellaneous Repair Recommendation	MRR	1	Other
Miscellaneous Survey Abandoned	MSA	1	Other
Miscellaneous Dimension/Diam/Shape Change	MSC	1	Other
Miscellaneous Survey End	MSE	1	Other
Miscellaneous Survey Start	MSS	1	Other
Miscellaneous Tunnel Condition - Fair	MTC	1	Other
Miscellaneous Tunnel Condition - Good	MTG	1	Other

Defect Group Name	Defect Group Code	Defect Weight	Group
Miscellaneous Tunnel Condition - Poor	MTP	1	Other
Miscellaneous Water Level	MWL	1	Other
Miscellaneous Water Mark	MWM	1	Other
Miscellaneous Dye Test	MY	1	Other
Obstacles/Obstructions Brick or Masonry	OBB	1	Operational
Obstacles/Obstructions Object Thru Connection	OBC	1	Operational
Obstacles/Obstructions Object Protruding Thru Wall	OBI	1	Operational
Obstacles/Obstructions Object Wedged in Joint	OBJ	1	Operational
Obstacles/Obstructions Pipe Material in Invert	OBM	1	Operational
Obstacles/Obstructions Construction Debris	OBN	1	Operational
Obstacles/Obstructions External Pipe/Cable In Sewr	OBP	1	Operational
Obstacles/Obstructions Rocks	OBR	1	Operational
Obstacles/Obstructions Built Into Structure	OBS	1	Operational
Obstacles/Obstructions Other Objects	OBZ	1	Operational
Obstacles/Obstructions Drop Pipe	ODP	1	Operational
Roots Ball	RB	1	Operational
Roots Fine	RF	1	Operational
Roots Medium	RM	1	Operational
Point Repair Localized Lining	RPL	1	Other
Point Repair Patch Repair	RPP	1	Other
Point Repair Pipe Replaced	RPR	1	Other
Point Repair Other	RPZ	1	Other
Roots Tap	RT	1	Operational
Settlement	S	1	Structural
Surface Damage Aggregate Missing	SAM	4	Operational
Surface Damage Aggregate Projecting	SAP	3	Operational
Surface Damage Aggregate Visible	SAV	3	Operational
Surface Damage (Metal Pipes) Corrosion	SCP	3	Operational
Surface Damage Missing Wall	SMW	5	Operational
Surface Damage Reinforcement Corroded	SRC	5	Operational
Surface Damage Roughness Increased	SRI	1	Operational
Surface Damage Reinforcement Visible	SRV	5	Operational
Surface Damage Surface Spalling	SSS	2	Operational
Surface Damage Other	SZ	1	Operational
Tap Break-In/Hammer	TB	1	Other
Tap Factory Made	TF	1	Other
Tap Saddle	TS	1	Other
Vermin Cockroach	VC	1	Other
Vermin Rat	VR	1	Other
Vermin Other	VZ	1	Other

Defect Group Name	Defect Group Code	Defect Weight	Group
Weld Failure Circumferential	WFC	4	Structural
Weld Failure Longitudinal	WFL	5	Structural
Weld Failure Multiple	WFM	5	Structural
Weld Failure Spiral	WFS	5	Structural
Collapse Brick	XB	5	Structural
Collapse Pipe	XP	5	Structural

Attachment C
Inspection Plan

Inspection Plan for Lake Whatcom Screenhouse, Tunnel and Gatehouse

Date: February 16, 2024

Project name: Raw Water Intake - Condition Assessment and Inter-Tie Design

Author: Jacobs Inspection Team

1. Introduction

The purpose of this memorandum is to present the inspection plan for the City of Bellingham's Lake Whatcom Screenhouse, Tunnel and Gatehouse (above-grade portion) facilities. This inspection is a key element in assessing the condition of the raw water supply system. The 72-inch diameter wood-stave intake pipeline upstream of the Gatehouse, in Lake Whatcom, was inspected in December 2023.

The inspection of the Tunnel, Screenhouse, and Gatehouse is planned for March 20, 2024, beginning at 7am and will continue over the course of the day for up to and estimated 11 hours. The results of the inspection will be documented in subsequent reporting that will identify and describe defects and present approaches and estimated costs for rehabilitation.

In support of the inspection effort, the City of Bellingham (City) will close and lock out the slide gate at the Gatehouse at the upstream end of the tunnel in the late evening/early morning prior to the inspection. Shutting the water off will leave the tunnel free of water and available for the inspection team. The City will also lock out the traveling screens within the Screenhouse to provide safe access and avoid any mechanical movement for the Screenhouse assessment team. Once the Screenhouse inspection has been completed and the inspection team is out of the tunnel, the City will open the slide gate at the Gatehouse to re-establish supply to its downstream water treatment plant. The total duration the City estimates it can discontinue water supply is approximately 24 hours.

This inspection plan addresses the following key topics:

- Background Description of Screenhouse, Tunnel and Gatehouse
- Inspection Methods and Approach
- Key Inspection Activities and Chronology
- Inspection and Safety Team
- Equipment Requirements
- Safety Concerns

2. Background Description of Screenhouse, Tunnel and Gatehouse

The Lake Whatcom Gatehouse, Tunnel, and Screenhouse are part of the City's raw water infrastructure that convey water from Lake Whatcom to the City's Whatcom Falls Water Treatment Plant. Each was constructed circa 1939. Upstream of these three infrastructure elements is the 72-inch diameter wood stave intake pipeline (Raw Water Intake) in Lake Whatcom. Downstream of the Screenhouse are large-diameter pipelines that convey raw water to the Water Treatment Plant. This supply system operates continuously and is very infrequently shutdown, for short durations, for inspection, repair, or regular maintenance.

Screenhouse. The function of the Screenhouse facility has changed over time. At the time of construction, in 1939, the facility served as the primary treatment facility for all municipal water consisting of screening (two traveling screens) and chemical dosing. Following construction of the City's Whatcom Falls Water Treatment Plant in 1966, , the Screenhouse continued to serve the important function of debris-screening. It also served up until the early 2000s as a chlorine injection point. Chlorine injection has since been decommissioned.

Lake Whatcom Tunnel. The tunnel has a design capacity of 98 mgd, is approximately 7,560 feet long, and is constructed through sedimentary rock consisting primarily of shale. Record drawings indicate the tunnel was constructed using drill and blast methods forming a 6.5 foot horseshoe shape and has a cast-in-place concrete lining. The upstream invert elevation of the intake pipe is at 298.5 feet above sea level, and the downstream invert at the screening plant is at 290.94. The tunnel slopes at a uniform rate of 0.1%.

The function of the tunnel is to convey raw water from the Gatehouse at Watkins Point on the West shore of Lake Whatcom near the intersection of Lakeway Drive and Lake Whatcom Boulevard, westward 1.5 miles to the Screenhouse in Whatcom Falls Park on Silver Beach Road. The tunnel entrances at the east and west end will be used in the field inspection and they will provide emergency access. An intermediate access point at Euclid Park, on Euclid Road, will be used as an access point for emergency rescue services, as needed, as well as a lunch break point for the tunnel inspection team.

Gatehouse. The Gatehouse consists of am above grade structure above a wet well caisson. The primary function of the Gatehouse is connecting the 72-inch diameter wood-stave intake pipeline in Lake Whatcom to the Lake Whatcom tunnel with a slide gate for isolation between the two. The Slide gate is integral to the wet well caisson below the Gatehouse. The above grade consists of an empty room, a sampling well and access to the caisson.

3. Project Health and Safety Approach

The inspection for the Screenhouse, Tunnel and Gatehouse will be performed in conformance with the overall Project Health, Safety and Environment (HSE) Plan developed for this project. These planning elements conform with Jacobs' standard safety protocols for confined space entry (CSE), which conform to applicable federal, state, and local requirements. These standard safety protocols, which form the backbone of the safety planning for this work are presented as Attachment A. Also developed for this specific CSE inspection event on March 20, 2024, is an activity-specific safe systems of work (SSOW) plan describing the activities, tools, risks and mitigation measures specific to confined space entry, as well as the Jacobs CSE permit to be used. This SSOW is presented in Attachment B.

4. Inspection Methods and Approach

Two concurrent inspection teams shall be deployed with one inspection team assessing the Screenhouse and above grade portion of the Gatehouse facility and the other, the tunnel inspection team, assessing the tunnel. Both teams will begin their inspection from the Screenhouse facility and perform their respective assessments, as described in the subsections below. The tunnel inspection will begin at the downstream end of the tunnel (Screenhouse) and proceed to the upstream end of the tunnel (Gatehouse). A full list of assessment equipment, including responsible party, is included below in Section 7.

4.1 Screenhouse Inspection

The Screenhouse inspection will include an evaluation of the overall structure (visual) and key components of the facility with particular emphasis placed on condition of the contents within the wet well caisson of the Screenhouse and three 48" outlet pipes from this wet well caisson. The inspection team will include the following subject matter focus areas and individuals performing the inspection:

- Structural Engineer – Bin Ge
- Corrosion Engineer – Cody Nelson
- Slide gates and traveling screens – Aaron George
- Pipe Condition Assessment – Kenny Moffat

In addition to the subject matter experts, additional team member on site will include:

- Phil Martinez (Jacobs, Project Manager) will provide overall project context to the team and will support the inspection.
- Robert Martin and Reece Kurre will be part of the tunnel inspection team with Kenny Moffat.
- Mike Sinon (Jacobs, Health and Safety Manager) will act as the overall confined space supervisor for the inspection effort.
- Life Rescue Inc. will act in the role as on-site standby confined space rescue personnel and will provide harnesses, fall arrest systems, tripods and other confined space entry PPE as appropriate.

The inspection of the screen well, outlet well and the 48" discharge pipes will be conducted via confined space entry. To facilitate the confined space entry, a segmented ladder will be rented and assembled to avoid reliance on the existing, original wall-installed ladder rungs. An image of the ladder segments to be assembled is provided in **Figure 1**.

Prior to beginning entry, the City will lockout-tagout (LOTO) the traveling screens and supplemental dewatering will be completed, as needed, to provide for safe access for the inspection teams.

Figure 1: Segmented Ladder to Support Confined Space Entry

4.2 Tunnel Inspection

The tunnel assessment will be comprised of visual and non-destructive inspection methods. Tunnel defects will be documented using a combination of paper notes and electronic forms capable of generated PDF reports. Photographs will also be taken to document conditions in the tunnel. The alignment of the tunnel and the access portals are as shown below in Figure 2. Note that all access portals will require confined space entry protocols to be in place.

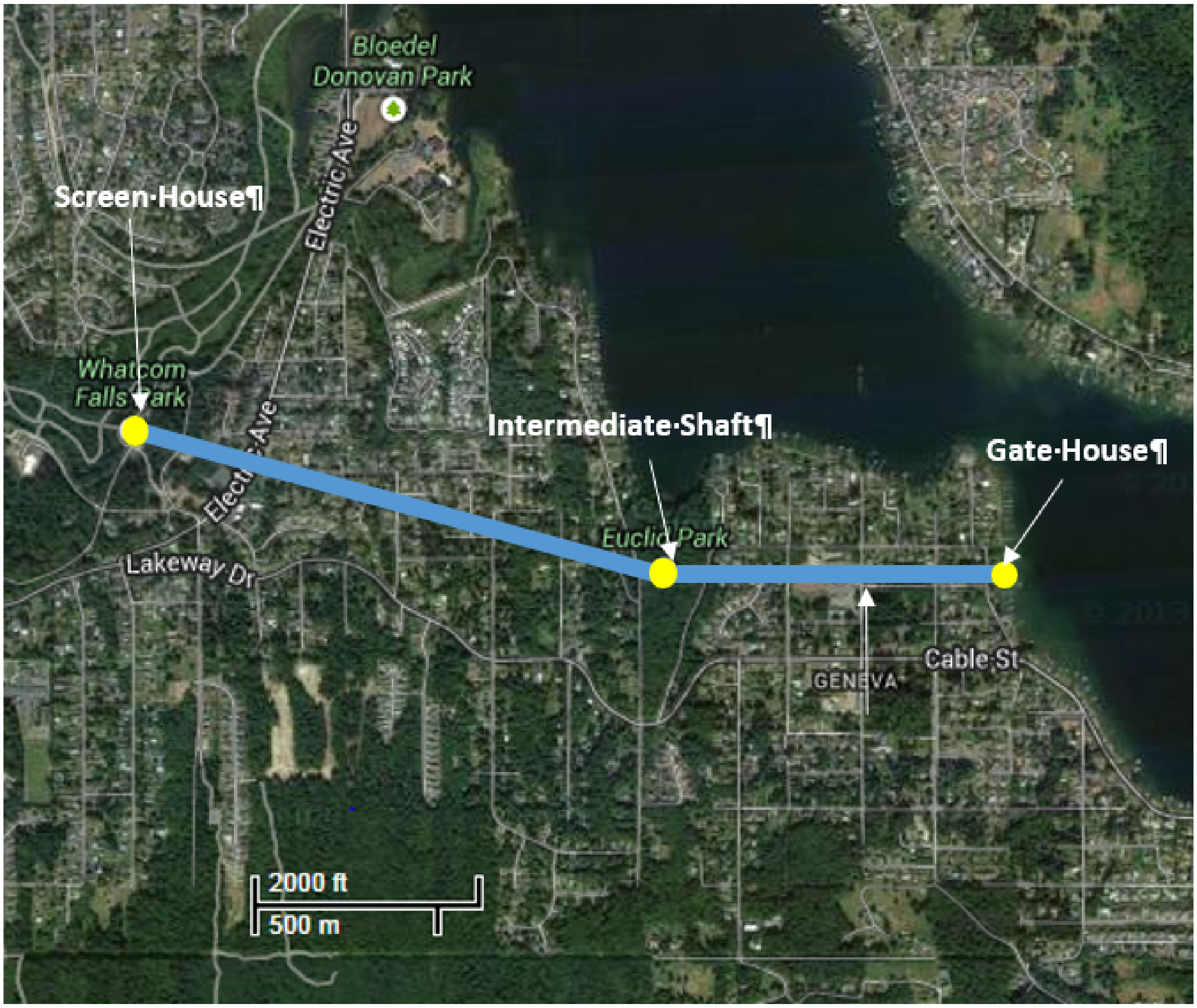


Figure 2: Raw Water Intake Tunnel Alignment and Access Points

The inspection will generally follow industry accepted practices and standards defined by the National Association of Sewer Service Companies (NASSCO) for documenting defects. This inspection will duplicate the inspection work completed in 2015 by CH2M HILL and specific attention will be given to defects identified during the 2015 inspection. As part of the 2015 inspection, stationing anchors were installed at 100 ft intervals to support the orientation of inspection and repair teams during subsequent entries. This inspection will make use of these stationing anchors and observe their condition. In addition to visually identifying and documenting, the inspection will include the following specific tasks:

- Identify changes in the tunnel lining material and/or geometry, if any, from that observed during the 2015 inspection.
- Perform hammer sounding of lining to determine void or separation from rock in locations where visual indications suggest this may be occurring.
- Identify locations of water infiltration either through weep holes constructed for that purpose (if any) or through defects in the lining.
- If observed, document location and extents of previous injection grouting efforts and any other point repairs observed.

The inspection team will make continuous measurement of distance from the tunnel entrance at the Screen House by use of walking-wheel and markings applied by lumber crayon or chalk on the tunnel wall. The inspection team is comprised of the following individuals and roles.

- Lead Tunnel Engineer – Robert Martin
- Support Tunnel Engineer – Reece Kurre
- Pipe Condition Assessment and Rehab– Kenny Moffat

4.3 Gatehouse Inspection

As part of the plant shutdown to allow for the Screenhouse and tunnel inspections, the City will begin by lowering the manual gate in the Gatehouse. Prior to beginning the tunnel or screenhouse inspections, the entrants will lock a chain around the manual gate operator as part of the LOTO procedure.

The Gatehouse inspection will commence following completion of the Screenhouse and will be performed by the individuals identified in the preceding section. This portion of the Gatehouse inspection will be focused on the superstructure and not include the wet well caisson, which was inspected as part of the Raw Water Intake in December 2023. This portion of the inspection is anticipated to be completed during the early afternoon of March 20 and will focus primarily on structural observation.

The tunnel inspection team, upon completion of the tunnel inspection, will exit through the access hatch on the downstream side of the Gatehouse isolation slide gate. The setup for the confined space use of the access hatch is shown in Figure 3 below. This team will document notable observations, as appropriate, on the downstream side of the caisson. The tunnel inspection team is anticipated to be completed in the late afternoon/early evening. Following safe extraction of the tunnel inspection team and equipment, the City will be notified, and the tunnel team locks on the isolation gate will be removed allowing for the gate to be lifted and the treatment plant to go back into service.

Figure 3: Confined Space Entry at Gatehouse

5. Key Inspection Activities and Chronology

The Screenhouse, Tunnel and Gatehouse inspections will be conducted on Wednesday, March 20th, 2024. The key activities associated with the inspections are presented below:

1. January 25, 2024 – Conducted a preliminary safety meeting to outline roles and responsibilities for safety and for inspection with representatives from Jacobs, the City, and Life Rescue.
2. March 5, 2024 – City of Bellingham to conduct dry-run of tunnel gate closure and tunnel drain down with the intent of understanding presence of leaks and drawdown needs in advance of the March inspection.
3. Week of March 11th, 2024 – Segmented ladder sections to be delivered by Brand Safway to the Screenhouse, received by City, and hoisted into the above-grade traveling screen room where the two access hatches are located. Ladders to be assembled on-site, in the two access hatches by Life Rescue, morning of March 20th to facilitate confined space entry.
4. March 14, 2024 – Pre-Inspection meeting between Jacobs, City, and Life Rescue Inc. to share any last-minute information and confirm all needs are in place prior to inspection team arriving on-site.
5. March 20, 2024 (~12 AM until Completion of Tunnel Inspection) – City to close manual slide gate at Gatehouse and take water treatment plant offline. City to open Gatehouse and Screenhouse hatches and turn on fans at both locations to support ventilation of tunnel. City personnel are to maintain a presence at the Gatehouse until the completion of the Tunnel Inspection to observe the gate is functioning as intended and continuous ventilation is directed into the tunnel.
6. March 20, 2024 (6 AM) – Jacobs and Life Rescue personnel arrive on-site to Screenhouse, with City provided access, to begin assembly of segmented ladder to support confined space entry (CSE) within Screenhouse.
7. March 20, 2024 (7 AM) – Full inspection team and safety personnel meet outside in front Screenhouse for 30-minute safety meeting before entry to Screenhouse and beginning inspections.
8. March 20, 2024 (~7:30 AM) – Final tie off ladders at Screenhouse and assemble tripods to support CSE at Screenhouse. Insert gas monitors to begin taking readings and confirm safe environment for entry.
9. March 20, 2024 (~8 AM) – Locks to be placed at traveling screens and at Gatehouse. Once LOTO has been completed, CSE equipment is in place, and confined space entry supervisor (Mike Sinon) has confirmed spaces are safe to enter, the Screenhouse and Tunnel inspections will commence.
10. March 20, 2024 (~12 PM) – Anticipated end of Screenhouse inspection. Locks to be removed from traveling screens. Ladder to be removed from the downstream portion of the Screenhouse wet well caisson (downstream of the traveling screens). Following removal of ladder, to be relocated by the City of Bellingham and assembled at Euclid Park for use by Tunnel Inspection Team. Inspection team to head to Gatehouse to complete Gatehouse inspection. At completion of Screenhouse inspection team confined space activity, the Screenhouse inspection team lock at the Gatehouse may be removed; the tunnel inspection team lock is to remain in place.

11. March 20, 2024 (~12:30 PM to 1:30 PM) – Tunnel Inspection team anticipated to arrive at Euclid Park intermediate access portal for lunch break. Two Life Rescue staff shall be available at that time at that location. One City staff person will also need to be at this location at this time.
12. March 20, 2024 (~3PM) – Gatehouse inspection team completes assessment. Life Rescue CSE support team will remains in place and awaits arrival of tunnel inspection team.
13. March 20, 2024 (~5PM) – Tunnel inspection team arrives at Gatehouse and exits tunnel, terminating inspection activities.
14. March 20, 2024 (~5:05PM) – Once communication from Gatehouse confirming the tunnel inspection team is out of the tunnel, Life Rescue Inc. removes fan and lighting. Then, Life Rescue removes remaining segmented ladder from upstream side of the wet well caisson at the Screenhouse following end of tunnel inspection. At least two persons from Life Rescue need to be at this location for this activity and at least one person from the City. Life Rescue to move the segmented ladder to the first floor of Screenhouse.
15. March 20, 2024 (~5:05PM) – At intermediate access portal location in Eclipse Park, once communication from Gatehouse confirming the tunnel inspection team is out of the tunnel, Life Rescue Inc. removes remaining segmented ladder access portal shaft. Two Life Rescue team members need to be at this location for this activity and at least one person from the City. Life Rescue returns segmented ladder to first level at Screenhouse.
16. March 20, 2024 (~5:30PM, or as determined by City) – Lock for Tunnel inspection team to be removed from gate stem at Gatehouse and City of Bellingham staff to opens gate and commences activities to restart water treatment plant.
17. Week of March 25th, 2024 – City to provide access to Brand Safway at Screenhouse for pickup of segmented ladder.

6. Inspection Team

The technical inspection team will be comprised of representatives from Jacobs. Life Rescue Inc. will support the technical inspection team with confined-space entry support. Jacobs' regional safety manager shall serve as the Confined Space Supervisor. Roles and designations are shown below in Table 1. For a complete discussion of safety activities planned for this inspection, refer to the project health and safety plan in Attachment 1. Topics included in the health and safety plan include the safety equipment list, confined space entry procedures, activity hazard analysis, and safe systems of work (SSOW).

Table 1: Inspection Team

Role (Organization)	Name (Contact)
City Site Contact (City of Bellingham)	Steve Day (360 778 7944)
Project Manager and Site Lead (Jacobs)	Phil Martinez (425 736 8861)
Condition Assessment and Rehabilitation Lead (Jacobs)	Kenny Moffat (360-319-1535)
Confined Space Supervisor, Site Field and Safety Lead (Jacobs)	Mike Sinon (406 559 0891)
Corrosion Assessment (Jacobs)	Cody Nelson

Structural Engineer (Jacobs)	Bin Ge (425.283.7055)
Senior Tunnel Engineer (Jacobs)	Robert Martin (414 379 0808)
Tunnel Engineer (Jacobs)	Reece Kurre
Slide Gate and Traveling Screen (Jacobs)	Aaron George (206 -247 -9814)
Standby Rescue Services Lead (Life Rescue)	Kyle Dungan (360-969-7274)

7. Equipment Requirements

Equipment and instrument requirements for inspection activities can generally be characterized as facilitating (access, lighting, LOTO, and safety) equipment and inspection equipment.

Facilitating equipment includes items that are necessary to allow the inspection team to safely perform their inspections. A list of facilitating equipment (and the anticipated quantity), as well as the responsible party, is provided below in Table 2.

Table 2: Facilitating Equipment and Responsible Party

Equipment	*Responsible Party*
Confined Space Entry	
Tripods with Self-Retracting Lifeline (3)	Life Rescue Inc.
Calibrated 4-/5-Gas Monitors (5)	Life Rescue Inc.
Segmented Ladder (80 ft)	Brand Safway (Coordinated by Jacobs)
Full Body Harness (8)	Life Rescue Inc.
Ventilation Fans (2, one each at SH & GH)	City of Bellingham
Lockout-Tagout	
Equipment Chains/Decommissioning	City of Bellingham
Locks	Jacobs
Supplemental Access Support	
Lights at Screenhouse	City of Bellingham
PPE (All Staff)	
High Visibility Vests	Jacobs/Life Rescue
Hard Hats	Jacobs/Life Rescue
Safety Glasses	Jacobs/Life Rescue
Gloves	Jacobs/Life Rescue
Tyvek Suits (Optional)	Jacobs
Hearing Protection (Tunnel Inspection Team)	Jacobs
First Aid Kit (1 per Inspection Team)	Jacobs
Safety Toed Boots	Jacobs/Life Rescue

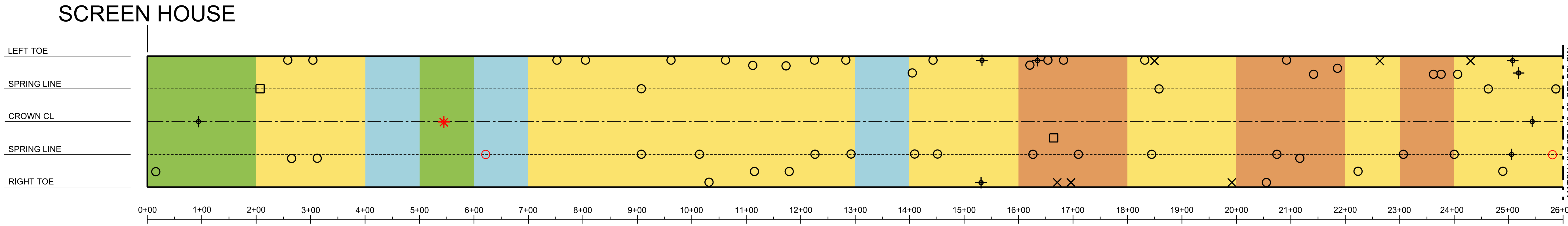
Inspection equipment includes items for carrying out the assessment of the City assets. A list of Inspection equipment and the responsible party is provided below in Table 3.

Table 3: Inspection Equipment and Responsible Party

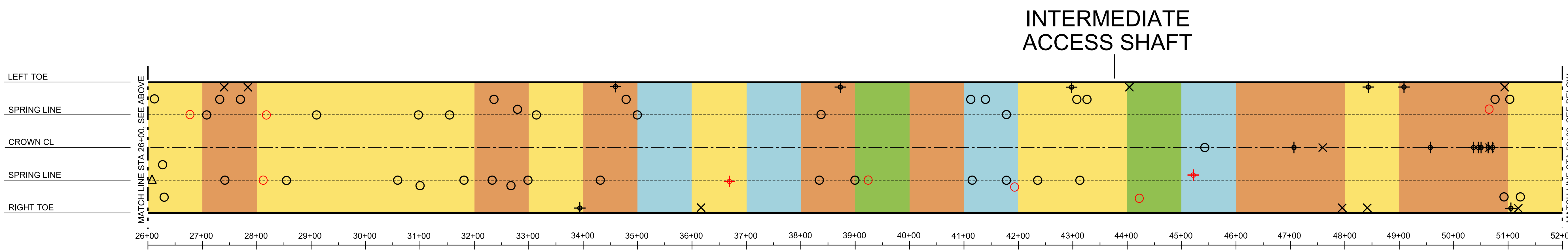
Equipment	*Responsible Party*
Screenhouse Assessment	

Ultrasonic thickness Gauge	Jacobs
Copy of 2014 Screenhouse Assessment and plan Drawings	Jacobs
Pit Depth Gauge	Jacobs
Tape Measure	Jacobs
Chalk	Jacobs
Rock Hammer	Jacobs
Note Taking Materials	Jacobs
Plastic Bag and Permanent Marker	Jacobs
Camera	Jacobs
Tunnel Assessment	
Sounding Hammer	Jacobs
Headlamps	Jacobs
Chalk	Jacobs
Radio	Jacobs/Life-Rescue
Rock Hammer	Jacobs
Tape Measure/Walking Wheel	Jacobs
Lunch/Water	Jacobs
Note Taking Materials	Jacobs
Plastic Bag and Permanent Marker	Jacobs
Camera	Jacobs
Gatehouse Assessment	
Rock Hammer	Jacobs
Note Taking Materials	Jacobs
Camera	Jacobs

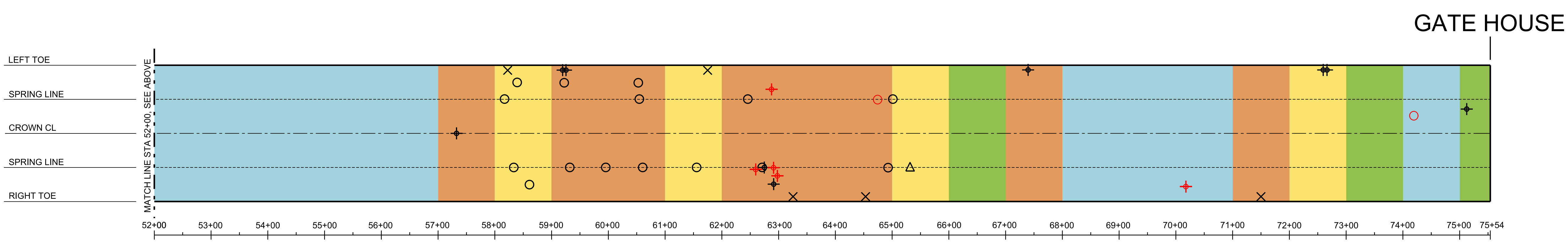
Attachment D
Lake Whatcom Tunnel Defect Distribution



PLAN - STA 0+00 TO STA 26+00



PLAN - STA 26+00 TO STA 52+00



PLAN - STA 53+00 TO STA 75+54

LEGEND

REHABILITATION PRIORITY

- IMMEDIATE
- HIGH
- MEDIUM
- LOW
- NOT REQUIRED

DEFECT SYMBOLS

(NEW DEFECTS IDETIFIED DURING THE 2024 CONDITIONS ASSESSMENT ARE SHOWN IN RED)

- ○ FRACTURE LONGITUDINAL
- △ FRACTURE MULTIPLE
- □ FRACTURE SPIRAL
- × HOLE SOIL VISIBLE
- + HOLE VOID VISIBLE

(UPDATED MARCH 2024)

LAKE WHATCOM TUNNEL DEFECT DISTRIBUTION

STA 0+00 TO STA 75+54

JACOBS

488508

<u>Attachment E</u>
Summary of Locations of Holes and Voids Contributing to High Priority Rating

Attachment E

Summary of Location of Holes and Voids Contributing to High Priority Rating

The specific locations of hole defects within the 100-foot segments contributing to the "high" rehabilitation priority are presented in in the table below. Highlighted in purple are the new locations where holes were observed during the March 2024 inspection.

Station Start	Station End	Hole Defect Observed	Newly Observed in March 2024
0+96	0+96	Hole Void Visible	
5+47	5+49	Hole Soil Visible	X
15+32	15+33	Hole Void Visible	
15+39	15+40	Hole Void Visible	
16+28	16+28	Hole Void Visible	
16+72	16+74	Hole Soil Visible	
16+97	16+98	Hole Soil Visible	
18+50	18+50	Hole Soil Visible	
19+95	19+98	Hole Soil Visible	
22+60	22+61	Hole Soil Visible	
24+32	24+34	Hole Soil Visible	
25+04	25+15	Hole Void Visible	
25+05	25+05	Hole Void Visible	
25+05	25+05	Hole Void Visible	X
27+40	27+43	Hole Soil Visible	
27+82	27+82	Hole Void Visible	
32+92	32+97	Hole Soil Visible	X
33+90	33+96	Hole Void Visible	
34+56	34+57	Hole Void Visible	
36+18	36+21	Hole Soil Visible	
36+84	36+84	Hole Void Visible	X
38+68	38+68	Hole Void Visible	
42+96	43+02	Hole Void Visible	
44+00	44+05	Hole Soil Visible	
45+12	45+12	Hole Void Visible	
47+59	47+59	Hole Soil Visible	
47+96	47+96	Hole Soil Visible	
48+21	48+22	Hole Soil Visible	
48+23	48+23	Hole Void Visible	
49+09	49+09	Hole Void Visible	
49+09	49+09	Hole Void Visible	X
49+60	49+60	Hole Void Visible	
50+40	50+40	Hole Void Visible	
50+47	50+47	Hole Void Visible	
50+50	50+50	Hole Void Visible	
50+60	50+60	Hole Void Visible	
50+61	50+61	Hole Soil Visible	

Station Start	Station End	Hole Defect Observed	Newly Observed in March 2024
50+67	50+67	Hole Void Visible	
50+97	50+97	Hole Soil Visible	
51+06	51+10	Hole Void Visible	
57+32	57+32	Hole Void Visible	
58+20	58+20	Hole Soil Visible	
59+17	59+17	Hole Void Visible	
59+23	59+23	Hole Void Visible	
61+73	61+75	Hole Soil Visible	
62+75	62+75	Hole Void Visible	
62+78	62+78	Hole Void Visible	X
62+87	62+87	Hole Void Visible	X
62+96	62+96	Hole Void Visible	
63+25	63+25	Hole Soil Visible	
64+52	64+53	Hole Soil Visible	
67+38	67+44	Hole Void Visible	X
70+11	70+11	Hole Void Visible	X
72+59	72+60	Hole Void Visible	
72+64	72+64	Hole Void Visible	
75+11	75+14	Hole Void Visible	

Jacobs

Technical Memorandum

1100 – 112th Ave NE, Suite 500
Bellevue, WA 98004
425.453.5000

Attachment F
Tunnel Inspection Reports

JACOBS

1610 North 2nd Street, Suite 201
Milwaukee, WI 53212

RECORD COPY

Inspection Date:	**03/20/2024**
Start Time:	**0900**
End Time:	**1630**
Report Number:	**1**
Tunnel Number:	**1**
Inspector Name:	**Robert Martin**

Tunnel Inspection Report For: Lake Whatcom Tunnel

Inspection Station Start	Inspection Station End	Code		Value				Circumferential Location		Image Referance	Remarks
		Descriptor	Modifier	Feet							
				D	H	W	L	At/From	To		
0	0	Miscellaneous Survey Start									Survey start at 9:05
0	0	Miscellaneous Lining Change									Cast in place concrete
0	0	Miscellaneous Dimension/Diam/Shape Change			6.5	6.4					Modified Horseshoe
0	0	Access Point Other Special Chamber									Screen House
0	0	Deposits Settled Other				12					Sand and gravel at invert.
0	0	Surface Damage Aggregate Visible	Surface Damage Mechanical Aggregate Visible					6	6		In trough at invert
14	14	Obstacles/Obstructions Built Into Structure						6		New	Plug in invert
16	17	Infiltration Dripper						4	4		
16	17	Fracture Longitudinal				0.3		4	4		
17	17	Fracture Circumferential				.2		11	5	New	
17	17	Fracture Angular				.3		11	5		
22	22	Obstacles/Obstructions Built Into Structure						6		New	Plug in invert
35	35	Obstacles/Obstructions Built Into Structure		4				66			Plug in Invert
43	47	Fracture Angular				.3		8	7		
45	45	Obstacles/Obstructions Built Into Structure		4				8	8		Plug
46	49	Fracture Angular				.3		8	7		
46	46	Obstacles/Obstructions Built Into Structure		4				7	7		Plug
55	55	Fracture Angular				.2		7	9		
56	58	Fracture Angular				.2		3	6		
78	84	Fracture Angular				.3		3	5		
80	80	Obstacles/Obstructions Built Into Structure		4				3	3		Plug
96	103	Fracture Angular				.3		3	4		
96	96	Infiltration Dripper						12	12		
96	96	Hole Void Visible		1				12	12		Hole
100	122	Fracture Angular				.1		3		New	
100	102	Fracture Angular				.25		9	11	New	
101	101	Obstacles/Obstructions Built Into Structure		4				3	3	New	Plug

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Tunnel Inspection Report For: Lake Whatcom Tunnel

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Inspector Name:	**Robert Martin**

Inspection Station Start	Inspection Station End	Code		Value				Circumferential Location		Image Referance	Remarks
		Descriptor	Modifier	Feet							
				D	H	W	L	At/From	To		
101	101	Obstacles/Obstructions Built Into Structure		4				3			Plug
125	125	Obstacles/Obstructions Built Into Structure		4				5	5		Plug
125	125	Obstacles/Obstructions Built Into Structure		4				12	12		Plug
138	138	stacles/Obstructions Object Protruding Thru W		.75			3	12	12		Steel Pipe
140	149	Fracture Angular				.3		9	7	2	
146	146	Infiltration Runner						9	7	New	
202	208	Fracture Spiral				.2		9	4		
206	209	Fracture Angular				.125		9	6		
209	220	Fracture Angular				.2		3	6		
235	270	Fracture Longitudinal				.3		7	7		
240	241	Infiltration Runner						3			0.25 gpm.
240	241	Lining Failure Other						3	3		Honeycomb
245	290	Fracture Longitudinal				.3		3	4		
250	250	Infiltration Weeper						7	7		
260	260	Infiltration Dripper						12	12		
263	263	Infiltration Dripper						12	12		
325	355	Infiltration Weeper						7		New	
325	355	Fracture Longitudinal				.2		7	7		
325	328	Fracture Angular				.1		10	7		
327	370	Infiltration Weeper						3	4		
327	370	Fracture Longitudinal				.2		3	4		
338	339	Infiltration Weeper						7	7		
360	368	Fracture Circumferential				.1		1	6		
501	501	Infiltration Gusher						4	4		0.25 gpm
508	509	Lining Failure Other						5	5		Honeycomb
508	509	Infiltration Weeper						5	5		From honeycomb
547	549	Hole Soil Visible				6	24	12	12	New	g. vis, soft conc.; liner missi

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Tunnel Inspection Report For: Lake Whatcom Tunnel

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		Descriptor	Modifier	Feet							
				D	H	W	L	At/From	To		
580	580	Infiltration Weeper						5	5		
598	603	Fracture Angular				.25		6	9		
598	598	Fracture Circumferential				.2		3	9	New	
603	603	Infiltration Weeper						3		New	
603	607	Fracture Longitudinal				.1		3		New	
730	730	Infiltration Weeper						1	5		Along cold joint
749	760	Fracture Longitudinal				.1		7	7		
760	760	Fracture Circumferential				.2		7	10		
760	760	Infiltration Weeper						7	10		
785	820	Fracture Longitudinal				.3		7	7		
785	820	Infiltration Weeper						7	7		
830	830	Fracture Circumferential				.1		7	5		
843	850	Fracture Angular				.1		8	7		
864	864	Infiltration Dripper						11	1		
864	864	Fracture Circumferential				.1		11	5		
899	915	Fracture Longitudinal				.1		9	9		
899	915	Infiltration Weeper						9	9		
899	915	Fracture Longitudinal				.1		3	3		
900	900	Miscellaneous General Photograph								5	
946	946	Fracture Circumferential				.1		7	9		
947	1089	Fracture Longitudinal				.2		3	3		
947	1089	Infiltration Weeper						3	3		
947	948	Fracture Angular				.1		1	3		
950	970	Fracture Longitudinal				.3		7	7		
1028	1041	Fracture Longitudinal				.1		5	5		
1028	1028	Fracture Circumferential				.1		11	5		
1028	1028	Infiltration Weeper						9	3	New	

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Tunnel Inspection Report For: Lake Whatcom Tunnel

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		Descriptor	Modifier	Feet							
				D	H	W	L	At/From	To		
1055	1066	Fracture Longitudinal				.1		7	7		
1060	1060	Infiltration Weeper						7	8		
1060	1060	Fracture Circumferential				.1		7	10		
1061	1066	Fracture Angular				.1		3	5		
1082	1092	Fracture Angular				.1		7	9		
1091	1103	Fracture Angular				.2		1	4		
1091	1127	Infiltration Weeper						7	8		
1091	1127	Fracture Longitudinal				.3		7	8		
1098	1127	Fracture Longitudinal				.2		3	5		
1103	1103	Infiltration Weeper						4	4		
1114	1114	Fracture Circumferential				.2		7	5		
1114	1114	Infiltration Runner						7	5		
1140	1202	Infiltration Weeper						7	8		
1140	1202	Fracture Longitudinal				0.3		7	8		
1151	1200	Fracture Longitudinal				0.3		3	5		
1167	1167	Fracture Circumferential				0.1		11	2		
1167	1167	Infiltration Weeper						11	2		
1202	1247	Infiltration Weeper						7	7		
1202	1247	Fracture Longitudinal				0.1		7	7		
1204	1258	Infiltration Weeper						3	3		
1204	1258	Fracture Longitudinal				0.2		3	3		
1218	1218	Fracture Circumferential						3	9	New	
1261	1297	Fracture Longitudinal				0.2		7	9		
1261	1297	Infiltration Weeper						7	7		
1270	1270	Fracture Circumferential						6	3	New	
1280	1301	Fracture Longitudinal				0.3		3	3		
1280	1301	Infiltration Weeper						3	3		

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Inspection Station Start	Inspection Station End	Code		Value				Circumferential Location		Image Referance	Remarks
		Descriptor	Modifier	Feet							
				D	H	W	L	At/From	To		
1283	1284	Fracture Angular				0.2		3	5		
1285	1285	Fracture Circumferential						3	9	New	
1396	1398	Fracture Angular				0.2		3	5		
1396	1427	Fracture Longitudinal				0.1		3	3		
1397	1418	Fracture Longitudinal				0.1		7	9		
1397	1418	Infiltration Weeper						7	9		
1428	1458	Fracture Longitudinal				0.3		7	7		
1430	1471	Fracture Longitudinal				0.3		3	3		
1444	1449	Fracture Angular				0.1		2	3		
1447	1447	Fracture Circumferential				0.1		6	2		
1447	1447	Infiltration Runner						11	2		
1470	1470	Infiltration Runner						9		New	
1506	1506	Infiltration Dripper						11	2		
1532	1533	Hole Void Visible				12	12	5		New	Hole
1539	1540	Hole Void Visible				4	6	7	7		Hole
1539	1540	Infiltration Gusher						7	7		1 gpm
1558	1558	Infiltration Dripper						11	11		
1603	1636	Infiltration Weeper						7	8		
1606	1636	Fracture Longitudinal				0.2		7	8		
1609	1609	Infiltration Weeper						7	5		
1609	1641	Fracture Longitudinal					0.1	3	3		
1609	1609	Fracture Circumferential				0.1		7	5		
1628	1628	Hole Void Visible			3	4	12	7			Hole
1651	1656	Fracture Longitudinal				0.1		7	7		
1653	1655	Fracture Circumferential				0.1		8	5		
1655	1706	Fracture Longitudinal				0.3		7	7		
1658	1663	Fracture Spiral				0.1		9	5		

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		Descriptor	Modifier	Feet							
				D	H	W	L	At/From	To		
1672	1674	Hole Soil Visible	Changed from 6" to 10"		4	10	24	5	5	7	Hole soil visible
1675	1690	Fracture Angular				0.1		3	5		
1691	1691	Fracture Circumferential				0.1		7	5		
1697	1698	Hole Soil Visible			2	8		5	5		Soil visible
1698	1704	Fracture Angular				0.1		3	5		
1703	1707	Fracture Angular				0.1		5	12	New	
1704	1726	Fracture Longitudinal				0.1		3	3		
1818	1875	Fracture Longitudinal				0.3		3	3		
1818	1875	Infiltration Weeper						3	3		
1822	1840	Fracture Longitudinal				0.2		7	7		
1825	1825	Fracture Circumferential				0.2		7	5		
1830	1831	Fracture Angular				0.1		3	5	New	
1848	1851	Point Repair Patch Repair						7	7	8	
1849	1853	Fracture Angular				0.2		7	10		
1850	1850	Hole Soil Visible			8	7		7	7		Hole soil visible
1852	1857	Fracture Longitudinal				0.2		9	9		
1852	1857	Infiltration Weeper						9	9		
1897	1907	Fracture Angular				0.1		3	5		
1897	1907	Fracture Angular				0.1		7	10		
1950	1966	Infiltration Dripper						7	2		
1950	1966	Fracture Circumferential				0.05		7	2		
1995	1998	Hole Soil Visible			2	3		5	5		Hole soil visible
1997	1997	Fracture Circumferential			0.1			7	5		
1997	1997	Infiltration Weeper						12	2		
2047	2135	Fracture Longitudinal				0.3		7	9		
2054	2058	Fracture Longitudinal				0.2		5	5		
2054	2093	Fracture Longitudinal				0.2		3	3		

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Inspection Station Start	Inspection Station End	Code		Value				Circumferential Location		Image Referance	Remarks
		Descriptor	Modifier	Feet							
				D	H	W	L	At/From	To		
2054	2055	Fracture Angular				0.2		3	5		
2062	2064	Fracture Angular				0.2		3	5		
2096	2103	Fracture Angular				0.1		7	9	New	
2106	2106	Fracture Circumferential				0.1		3	9	New	
2106	2112	Fracture Angular				0.1		3	5		
2110	2135	Fracture Longitudinal				0.3		3	4		
2139	2153	Fracture Longitudinal				0.2		8	8		
2152	2158	Fracture Angular				0.1		7	8		
2157	2222	Fracture Longitudinal				0.2		7	8		
2200	2202	Fracture Angular				0.5		7	8		
2203	2203	Fracture Circumferential						3	8	New	
2215	2235	Fracture Longitudinal				0.1		3	5		
2260	2261	Infiltration Weeper						7	7		
2260	2261	Hole Soil Visible			1	3		7	7		Void moving soil
2305	2315	Fracture Longitudinal				0.1		3	3		
2305	2305	Infiltration Dripper						10	4		
2305	2305	Fracture Circumferential				0.1		7	5		
2350	2365	Fracture Longitudinal				0.2		8	8		
2358	2365	Fracture Angular				0.1		4	5		
2360	2361	Fracture Angular				0.2			7	8	
2365	2385	Fracture Longitudinal				0.2		8	8		
2370	2375	Fracture Angular				0.3		4	5		
2376	2376	Fracture Circumferential				0.2		11	4		
2380	2420	Fracture Longitudinal				0.2		3	3		
2398	2410	Fracture Longitudinal				0.2		8	8		
2430	2480	Fracture Angular				0.3		3	5		
2432	2434	Point Repair Patch Repair			6			7	7		

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Milwaukee, WI 53212

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Tunnel Inspection Report For: Lake Whatcom Tunnel

Inspection Date:	**03/20/2024**
Start Time:	**0900**
End Time:	**1630**
Report Number:	**1**
Tunnel Number:	**1**
Inspector Name:	**Robert Martin**

Inspection Station Start	Inspection Station End	Code		Value				Circumferential Location		Image Referance	Remarks
		Descriptor	Modifier	Feet							
				D	H	W	L	At/From	To		
2432	2434	Hole Soil Visible			2	5	8	7			Hole soil visible
2450	2450	Infiltration Dripper						11	12		
2450	2450	Fracture Circumferential				0.1		7	5		
2451	2475	Fracture Longitudinal				0.4		9	9		
2485	2502	Fracture Longitudinal				0.2		4	4		
2504	2515	Hole Void Visible			1.5	3		7	7		Hole
2505	2505	Lining Failure Other			9	9		9	9		honeycomb, 7" deep
2505	2505	Infiltration Runner						12	12		
2505	2505	Hole Void Visible			6	3		4			Hole
2505	2505	Lining Failure Other			8	5		8	8		3" honeycomb
2505	2505	Hole Void Visible			4	4		3			Hole
2507	2510	Lining Failure Other			15	7	24	7	8	8	p, honeycomb, multiple fra
2512	2514	Pipe Failure Hole						6	6		invert missing; soil vis
2512	2512	Miscellaneous General Observation									ssurized water spurts at inv
2518	2519	Lining Failure Other			3	3		8	8		
2555	2565	Infiltration Runner						12	12		0.1 gpm
2563	2600	Fracture Longitudinal				0.1		3		New	
2564	2606	Fracture Longitudinal				0.2		9	9		
2570	2598	Fracture Circumferential				0.1		3	5		
2598	2608	Infiltration Weeper						3	3		
2598	2608	Fracture Multiple				0.2		3	3		
2600	2615	Infiltration Weeper						8	8		
2600	2615	Fracture Longitudinal				0.2		8	8		
2604	2670	Fracture Longitudinal				0.3		3	5		
2604	2604	Fracture Angular				0.2		3	3	New	
2618	2618	Infiltration Gusher						11	1		0.2 gpm
2622	2622	Fracture Circumferential				0.1		7	5		

1610 North 2nd Street, Suite 201
Milwaukee, WI 53212

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		Descriptor	Modifier	Feet							
				D	H	W	L	At/From	To		
2622	2635	Fracture Longitudinal				0.1		4	4		
2672	2690	Fracture Longitudinal				0.1		9		New	
2696	2725	Fracture Longitudinal				0.1		9	9		
2699	2699	Infiltration Runner						12	12		0.1 gpm
2699	2793	Fracture Longitudinal				0.2		3	3		
2703	2706	Fracture Angular				0.2		3	5		
2732	2740	Fracture Longitudinal				0.1		8	8		
2740	2743	Hole Soil Visible			1	3		7	7		Migrating fines
2747	2754	Fracture Angular				0.1		7	8		
2758	2782	Fracture Longitudinal				0.2		8	8		
2770	2776	Fracture Angular				0.1		8	9		
2782	2782	Infiltration Gusher						7	7		0.3 gpm migrating fines
2782	2782	Hole Void Visible			3	4	4	7			Hole
2824	2830	Fracture Longitudinal				0.1		9		New	
2824	2824	Fracture Circumferential				0.2		7	5	New	
2824	2830	Fracture Longitudinal				0.1		3		New	
2842	2844	Fracture Angular				0.2		7	2		
2846	2860	Fracture Longitudinal				0.2		3	3		
2861	2861	Infiltration Gusher						12	12		0.5 gpm
2878	2878	Infiltration Dripper						11	11		
2880	2880	Infiltration Gusher						1	1		0.3 gpm
2890	2890	Infiltration Weeper						11	5		
2890	2890	Fracture Circumferential				0.1		11	5		
2905	2920	Fracture Longitudinal	Change from 0.1 tp 0.2			0.2		9	9		
2951	2952	Lining Failure Other						9	10		honeycomb
2951	2952	Infiltration Dripper						9	10		0.1gpm
2953	2954	Lining Failure Other						1	2		honeycomb

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1610 North 2nd Street, Suite 201
Milwaukee, WI 53212

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		Descriptor	Modifier	Feet							
				D	H	W	L	At/From	To		
2953	2954	Infiltration Gusher						1	2		
2954	3161	Fracture Longitudinal				0.3		3	3		
2976	3001	Fracture Angular				0.3		7	8		
2980	2982	Fracture Angular				0.1		8	1		
2999	3002	Fracture Angular				0.1		7	9		
3003	3011	Fracture Angular				0.1		7	9		
3011	3051	Fracture Angular				0.3		8	9		
3045	3045	Lining Failure Other			9	7	9	3	3	9	Thin liner, exposed shale
3058	3080	Fracture Angular	Change from 0.1 tp 0.2			0.2		8	9		
3060	3085	Fracture Angular	Change from 0.1 tp 0.2			0.2		2	4		
3082	3109	Fracture Longitudinal				0.2		9	9		
3085	3115	Fracture Longitudinal				0.2		3	4		
3109	3202	Fracture Longitudinal				0.2		9	9		
3132	3132	Infiltration Runner						11	12		0.2 gpm
3144	3152	Fracture Angular				0.2		1	3		
3150	3154	Fracture Angular				0.2		5	5		
3153	3203	Fracture Longitudinal				0.3		3	3		
3214	3259	Fracture Longitudinal				0.3		8	8		Offset 1/8"
3215	3255	Fracture Longitudinal				0.3		3	3		Offset 1/8"
3246	3247	Fracture Angular				0.1		7	8		
3250	3250	Fracture Circumferential				0.1		9	3		
3250	3250	Infiltration Dripper						9	3		
3251	3254	Fracture Angular				0.2		7	8		
3256	3282	Fracture Longitudinal				0.1		3	4		
3262	3296	Fracture Longitudinal				0.1		8	9		Offset 1/16"
3292	3297	Hole Soil Visible	Change from 5" to 10"		2	10	36	5	5		Hole in invert, soil visible
3297	3297	Fracture Circumferential				0.1		10	5		

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		Descriptor	Modifier	Feet							
				D	H	W	L	At/From	To		
3297	3301	Fracture Longitudinal				0.1		3	3		
3301	3302	Lining Failure Other				4		1	1		soft concrete area
3304	3310	Fracture Angular				0.1		7	8		
3306	3307	Lining Failure Other				7	12	10	11		Thin liner area at crown
3306	3306	Lining Failure Other					5	2	2		Honeycomb 3/4"
3311	3321	Fracture Longitudinal				0.1		9	9		
3323	3325	Fracture Angular				0.1		7	9		
3390	3396	Hole Void Visible			1	1		5	5		Invert hole
3411	3419	Fracture Angular	Change from 0.1 tp 0.2			0.2		7	9		
3425	3440	Fracture Longitudinal				0.1		3	3		
3440	3440	Fracture Circumferential				0.2		7	5		
3440	3440	Infiltration Dripper						7	5		
3456	3457	Hole Void Visible			2	1		7	7		Invert hole
3462	3497	Fracture Longitudinal				0.2		8	8		
3497	3497	Fracture Circumferential				0.2		7	5		
3497	3503	Fracture Longitudinal				0.1		9	9		
3618	3621	Hole Soil Visible	Change from 6" to 10"		6	10	36	5	5		Shale fragments, void inver
3646	3646	Infiltration Gusher						12	12		0.3 gpm
~~3646~~	~~3646~~	~~Miscellaneous General Observation~~									~~current time 15:07~~
3684	3684	Hole Void Visible			6	4	10	3		New	Hole
3684	3684	Fracture Circumferential				0.1		12	3	New	
3735	3735	Infiltration Gusher						12			
3735	3735	Lining Failure Other				2		8	3		cold joint with honeycomb
3815	3819	Fracture Angular				0.2		3	5		
3819	3862	Fracture Longitudinal				0.2		9	9		
3819	3862	Infiltration Weeper						9	9		
3819	3857	Fracture Longitudinal				0.3		3	3		

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Milwaukee, WI 53212

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Inspection Station Start	Inspection Station End	Code		Value				Circumferential Location		Image Referance	Remarks
		Descriptor	Modifier	Feet							
				D	H	W	L	At/From	To		
3845	3845	Fracture Circumferential						4	8	New	
3868	3868	Hole Void Visible			2	5	6	7	7		Invert hole
3882	3882	Fracture Circumferential						5	7	New	
3897	3903	Fracture Longitudinal				0.1		3	3		
3903	3903	Infiltration Runner						10	1		0.05 gpm
3905	3922	Fracture Longitudinal				0.1		3		New	
3952	3952	Fracture Circumferential				0.1		7	3		
3952	3952	Infiltration Dripper						7	1		
4101	4122	Fracture Longitudinal				0.2		3	3		
4105	4116	Fracture Longitudinal				0.1		8	8		
4106	4106	Fracture Circumferential				0.2		12	5		
4132	4151	Fracture Longitudinal				0.1		8	8		
4161	4161	Fracture Circumferential				0.1		7	5		
4161	4194	Fracture Longitudinal				0.1		9	9		
4163	4194	Fracture Longitudinal				0.2		3	3		
4163	4192	Infiltration Weeper						3	3		
4197	4205	Fracture Longitudinal				0.1		3	4	New	
4218	4260	Fracture Longitudinal				0.2		3	3		
4247	4250	Fracture Angular				0.1		8	9		
4267	4267	Infiltration Gusher						2	2		0.2 gpm
4267	4267	Lining Failure Other				1		7	5		cold joint with honeycomb
4267	4267	Infiltration Gusher						10	10		0.2 gpm
4296	4302	Hole Void Visible			3	2		7	7		Invert hole
4303	4325	Fracture Longitudinal				0.1		3	3		
4303	4325	Infiltration Weeper						3	3		
4303	4309	Fracture Longitudinal				0.1		8	8		
4307	4313	Fracture Longitudinal				0.1		8	8		

1610 North 2nd Street, Suite 201
Milwaukee, WI 53212

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Tunnel Inspection Report For: Lake Whatcom Tunnel

Inspection Station Start	Inspection Station End	Code		Value				Circumferential Location		Image Referance	Remarks
		Descriptor	Modifier	Feet							
				D	H	W	L	At/From	To		
4313	4330	Fracture Angular						7	9	New	
4313	4313	Fracture Circumferential						5	7	New	
4315	4315	Obstacles/Obstructions Built Into Structure		4				8	8	New	plug
4315	4315	Obstacles/Obstructions Built Into Structure						5		New	plug
4335	4335	Obstacles/Obstructions Built Into Structure						6		New	plug
4345	4345	Obstacles/Obstructions Built Into Structure						9			plug
4345	4345	Obstacles/Obstructions Built Into Structure		4				3	3	2	plug
4345	4345	Obstacles/Obstructions Built Into Structure						6			plug
4359	4370	Point Repair Other					7	5	10		urethane grout
4359	4359	Line Left								2	
4375	4375	Access Point Shaft Hole (3' or >)		36							Re-entered tunnel at 15:32
4382	4382	Fracture Circumferential				0.2		7	3		
4396	4396	Fracture Longitudinal						5	7		
4398	4398	Fracture Circumferential				0.2		7	5		
4400	4405	Hole Soil Visible			2	2		7	7		Invert hole, migrating fines
4402	4402	Obstacles/Obstructions Built Into Structure		4				4	4		plug
4402	4402	Obstacles/Obstructions Built Into Structure		4				8	8		plug
4403	4403	Point Repair Other						7	7		chem grout
4404	4404	Obstacles/Obstructions Built Into Structure						9		New	Wood plug
4405	4405	Infiltration Gusher						7	7	11	r carrying fines, sand and g
4408	4408	Infiltration Gusher						7	7	12 video	0.75 gpm
4412	4412	Fracture Longitudinal						12	5	New	
4449	4449	Infiltration Runner						5		New	soils vis
4449	4449	Point Repair Other						3	5		chem grout
4453	4453	Obstacles/Obstructions Built Into Structure						3			plug
4453	4453	Obstacles/Obstructions Built Into Structure						5			plug
4512	4512	Hole Void Visible			3	2	3	2		New	Hole

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1610 North 2nd Street, Suite 201
Milwaukee, WI 53212

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Inspection Station Start	Inspection Station End	Code: Descriptor	Code: Modifier	Value (Feet): D	Value (Feet): H	Value (Feet): W	Value (Feet): L	Circumferential Location: At/From	Circumferential Location: To	Image Referance	Remarks
4535	4535	Fracture Circumferential				0.2		7	5		
4535	4549	Fracture Longitudinal				0.1		12	12		
4535	4535	Infiltration Weeper						1	5		
4535	4549	Infiltration Weeper						12	12		
4639	4639	Fracture Circumferential				0.2		7	5		
4759	4759	Hole Soil Visible			3	3	4	5	5		hole, piping fines sands and
4771	4771	Fracture Circumferential				0.2		7	5		
4796	4796	Hole Soil Visible			2	1	6	5			hole, piping fine sand and
4821	4822	Hole Soil Visible			2	3	12	5			vert hole, piping sand grav
4823	4823	Hole Void Visible			2	1	9	7			Invert hole
4830	4830	Fracture Circumferential				0.2		7	5		
4830	4830	Infiltration Weeper						5			0.3 gpm
4896	4896	Fracture Circumferential				0.2		7	5	New	
4909	4909	Hole Void Visible			2	2	9	7			Invert hole
4909	4909	Hole Void Visible			2	1	2				Hole
4960	4960	Hole Void Visible		4	1	4	1	6			Invert hole; exfiltration
5040	5040	Hole Void Visible		1		5		6			Invert hole
5047	5047	Hole Void Visible		2			6				vert hole, extends under sla
5050	5050	Fracture Circumferential				0.2		1	5		
5050	5050	Hole Void Visible		2				6		12	vert hole, extends under sla
5050	5056	Fracture Angular				0.2		7	9		
5056	5094	Fracture Longitudinal				0.3		7	9		
5060	5060	Hole Void Visible		2		4		6			Invert hole
5061	5077	Fracture Angular				0.2		7	9		
5061	5061	Fracture Longitudinal						5	8	New	
5061	5114	Fracture Longitudinal				0.2		3	5		
5061	5061	Infiltration Runner						5	8	New	

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1610 North 2nd Street, Suite 201
Milwaukee, WI 53212

RECORD COPY

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		Descriptor	Modifier	Feet							
				D	H	W	L	At/From	To		
5061	5061	Hole Soil Visible		2				6			vert hole pipe sand and grav
5067	5067	Hole Void Visible		2		3		6			Invert hole
5094	5109	Fracture Longitudinal				0.3		8	8		
5097	5097	Hole Soil Visible			2		4	7			ert hole piping sand and gra
5106	5110	Hole Void Visible			10	6	12	5			Invert hole
5109	5112	Fracture Angular				0.3		4	5		
5115	5125	Fracture Longitudinal				0.2		4	4		
5153	5153	Infiltration Dripper						10	1		
5175	5175	Infiltration Runner						10	12		0.1 gpm
5175	5175	Fracture Circumferential				0.1		10	12		
5732	5732	Hole Void Visible			2	1		6			invert hole
5796	5832	Fracture Longitudinal				0.2		9	9		
5801	5801	Fracture Circumferential				0.1		7	5		
5801	5801	Infiltration Dripper						11	1		
5808	5857	Fracture Longitudinal				0.3		3	3		
5820	5820	Fracture Circumferential				0.1		7	3		
5820	5859	Fracture Longitudinal				0.2		8	8		
5820	5820	Hole Soil Visible			4	10	9	7			nvert hole piping sand grave
5853	5864	Fracture Longitudinal				0.2		4	4		
5862	5867	Fracture Angular				0.1		3	4		
5900	5900	Miscellaneous General Observation									current time 17:03
5914	5924	Fracture Longitudinal				0.1		8	8		
5917	5917	Fracture Circumferential				0.1		7	5		
5917	5917	Hole Void Visible	Change from 2" to 9"		2	9	10	7			Invert hole
5922	5942	Fracture Longitudinal				0.1		3	3		
5923	5923	Hole Void Visible			5	6		7			5" deep void
5980	6010	Fracture Longitudinal				0.2		3	3		

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1610 North 2nd Street, Suite 201
Milwaukee, WI 53212

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		Descriptor	Modifier	Feet							
				D	H	W	L	At/From	To		
6000	6000	Fracture Circumferential				0.1		7	5		
6000	6000	Infiltration Dripper						12	2		
6008	6133	Fracture Longitudinal				0.3		3	3		
6050	6065	Fracture Longitudinal				0.2		9	9		
6064	6090	Fracture Longitudinal				0.2		8			
6094	6100	Fracture Angular				0.1		7	8		
6115	6115	Fracture Circumferential						4	7	New	
6146	6162	Infiltration Weeper						3	3		
6146	6162	Fracture Longitudinal				0.2		3	5		
6146	6146	Fracture Circumferential				0.2		3	5		
6146	6146	Infiltration Weeper						3	5		
6173	6175	Hole Soil Visible			2	2		7			Hole piping sand
6192	6192	Fracture Circumferential				0.2		7	5		
6211	6284	Fracture Longitudinal				0.3		9	9		Offset 1/16"
6212	6214	Fracture Angular				0.1		12	1	New	
6214	6328	Fracture Longitudinal				0.3		3			Offset 3/16"
6250	6250	Surface Damage Aggregate Visible	Surface Damage Chemical Aggregate Projecting		3	8		3			spalled
6275	6275	Hole Void Visible			4	3		3		3	Hole
6278	6278	Fracture Circumferential						5	9	New	
6278	6278	Hole Void Visible			3	3	4	3		New	Hole
6280	6324	Fracture Angular				0.2		7	9	New	
6287	6287	Hole Void Visible			10	7	10	7		New	Hole
6296	6296	Fracture Circumferential				0.1		8	4		
6296	6296	Hole Void Visible			2	2	5	4		New	Hole
6325	6325	Hole Soil Visible			2		9	5			Hole piping sand gravel shal
6452	6453	Hole Soil Visible	Changed from 5" to 7"		2	7		5	5		Hole pipe sand and gravel
6485	6485	Infiltration Dripper						10	12		

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1610 North 2nd Street, Suite 201
Milwaukee, WI 53212

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Inspection Date:	03/20/2024
Start Time:	0900
End Time:	1630
Report Number:	1
Tunnel Number:	1
Inspector Name:	Robert Martin

Tunnel Inspection Report For: Lake Whatcom Tunnel

Inspection Station Start	Inspection Station End	Code		Value				Circumferential Location		Image Referance	Remarks
		Descriptor	Modifier	Feet							
				D	H	W	L	At/From	To		
6485	6485	Fracture Circumferential				0.1		8	4		
6485	6490	Fracture Angular						12	3	New	
6485	6490	Fracture Longitudinal						9		New	
6490	6532	Fracture Longitudinal				0.1		3	3		
6490	6490	Fracture Circumferential						5	9	New	
6490	6507	Fracture Longitudinal				0.2		8	8		
6547	6547	Infiltration Dripper						12			
6649	6649	Fracture Circumferential				0.1		7	5		
6649	6649	Infiltration Runner						7	5		0.1 gpm
6730	6770	Fracture Circumferential						5	7	New	
6738	6744	Hole Void Visible			1	1		7	5		Hole
7011	7011	Hole Void Visible			1	3	2	5		New	Hole
7021	7021	Fracture Circumferential				0.1		7	5	New	
7106	7106	Fracture Circumferential				0.1		7	5	New	
7150	7150	Hole Void Visible			1	1	1	5	5		
7259	7260	Hole Void Visible			1	2		7			Hole
7264	7264	Hole Void Visible			3	4		7			2" deep hole
7266	7266	Infiltration Dripper						1			
7356	7356	Infiltration Dripper						12	1		
7415	7415	Infiltration Runner						5	10	New	
7415	7415	Fracture Longitudinal						5	10	New	
7511	7511	Point Repair Patch Repair									rec repair
7511	7514	Hole Void Visible					3	11			7" deep hole, hollow
7511	7511	Fracture Circumferential				0.1		5	7		
7545	7545	Miscellaneous Dimension/Diam/Shape Change			65						flare out to gate house
7553	7553	Access Point Shaft Hole (3' or >)		30							Gate house
7554	7554	Miscellaneous Survey End									current time 18:00

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Tunnel Inspection Report For: Lake Whatcom Tunnel

Inspection Station Start	Inspection Station End	Code		Value				Circumferential Location		Image Referance	Remarks
		Descriptor	Modifier	Feet							
				D	H	W	L	At/From	To		
7554	7554	Access Point WW Access Device			72	70				4	slide gate