Technical Memorandum

To:	Cory Nau, City of Shoreline
From:	Dave Stewart, PE Gwyn Perry, PE Kevin O'Brien, PhD
Copies:	Tyson Hounsel, PE
Date:	May 29, 2019
Subject:	South Branch of Boeing Creek Near M-1 Dam Channel Study and Recommendations
Project No.:	32713.C21

Introduction

The M-1 Dam is located on the South Branch of Boeing Creek within the City of Shoreline, Washington (Figure 1). The South Branch of Boeing Creek upstream of the M1 Dam is a drainage channel that was heavily modified in the 1970s by filling the channel bed and constructing rock weir grade control structures. The M1 Dam was then constructed in the early 1980s (King County, 1983). The channel is armored with angular riprap (approx. 4-12″ diam.), cobbles and gravels for nearly the entire reach from the M1 dam to the upstream culvert at Greenwood Avenue N (the project area) (Figure 2). Shrub vegetation is growing along the side slopes and top of the channel banks, and trees are established on the ravine side slopes. Large wood from fallen trees, as well as brush are present in some segments of the channel bed.

During a routine inspection of the M-1 Dam in January 2017, City maintenance crews observed a fallen tree on the left bank of the channel, laying across the access road and in the bed of the channel upstream of the dam. A scour hole has formed in the left bank that has eroded the maintenance access road under the location of the fallen tree. The scour has made the access road leading up to the debris rack and sediment basin impassable for the City's maintenance vehicles. The erosion failure has occurred approximately 140 feet upstream of the dam which falls within the dam storage zone. The City requested that Otak evaluate repairs to restore access for maintenance and evaluate the channel system for potential erosion and scour issues that may affect the City's access to the dam.

The purpose of this memo is to summarize our assessment of the channel conditions and provide recommendations for proposed repairs and maintenance of the channel.

Project Basin Characteristics

The drainage basin upstream of the dam is approximately 700 acres in size, and consists of developed residential area, part of Boeing Creek Park, Shoreline Community College property, and a section of Aurora Avenue N The majority of the drainage basin flows into the project area from the storm drain outfall under Greenwood Avenue to the east. Another storm drain outfall along the middle of the project reach outfalls from Carlyle Hall Road on the northside. A third storm drain outfall enters the creek just upstream of the dam from the southwest from the Shoreline Community College.

11241 Willows Road NE, Suite 200 Redmond, WA 98052 ▪ Phone (425)822-4446 Fax (425)827-9577 **otak.com**

The project is located within both an erosion hazard and landslide hazard area, delineated by King County (King County iMap). The project area is not within a FEMA mapped floodplain. There is a FEMA-mapped Special Flood Hazard Area (SFHA) on the South Fork of Boeing Creek about 1,000 feet downstream of the M1 Dam (FIRM Map Number 53033C0040F, May 16, 1995).

Boeing Creek is mapped in the project area as a perennial stream, excluding a 0.07-mile section just upstream of the M1 Dam that is mapped as an artificial flow path (Ecology 2010). Based on information presented in the Washington State Department of Natural Resources Forest Practices Mapping application, the South Fork of Boeing Creek is considered a non-fish bearing stream (DNR, 2005). The Washington State Department of Ecology (Ecology) Clean Water Act Section 303(d) list of polluted waters does not indicate any listings on Boeing Creek within 1 miles of the project site.

Existing Conditions Field Assessment

The hydrology of the reach is seasonal, with precipitation and groundwater-derived flow during the winter and spring months based on observations during the site visit. A field assessment was performed in February 2019, and documented in an existing conditions memo provided in Appendix A.

Downstream of the culvert crossing under Greenwood Avenue N, the maintenance access road approaches and abuts the left channel bank. The maintenance access road width varies from about 10′-12′ for the length of the project area, and trees have fallen across the channel and access road at some locations along the length of the channel.

In the middle of the project area, the riprap channel is entrenched with a bottom width of about 5′, and an average depth of 2′ from the top of bank. Rock weirs control the grade of the channel through the reach, with drop heights of about 2′. Some large rocks (18-24″) from the rock weirs have been undermined and fallen into the channel below.

In the downstream reach, a scour hole has formed in the maintenance access road where a tree has fallen into the channel. The material of the eroded bank was observed to consist of silt interspersed with cobbles about 1″-4″ in diameter. Immediately downstream of the scour hole, there is a bend in the low flow channel, and the total channel width increases to approximately 40 feet. An 18″ corrugated metal pipe (CMP) enters from the left bank within this wider section of channel. The 18″ CMP was observed to be crushed and broken, with erosion occurring around where the pipe emerges from the bank. The pipe connects to a catch basin on the south side of the access road, that connects to a storm drain pipe within the steep ravine slope. Erosion and rilling was also evident along the steep ravine slope in this area, including erosion around the roots of trees on the slope.

The channel then enters a grouted riprap drop structure with a riprap apron downstream at the entrance to the sediment basin at the M1 Dam. The sediment basin is located immediately upstream of the M1 dam and is maintained by the City when significant sediment accumulates.

The M1 Dam consists of a low flow pipe outlet with a sluice gate, and a large overflow structure that engages before water levels reach the crest of the emergency spillway of the dam. When water levels reach the top of the overflow structure at the dam, the channel, access road, and surrounding floodplain are submerged.

Offsite Drainage

Stormwater runoff from Shoreline Community College property enters the channel via two paths: sheet flow runoff from the gravel parking lot, and direct discharge from pipe SP-9289 (see Figure 2). Runoff from the Shoreline Community College gravel parking at the top of the slope is directed towards the south ravine slope that is within

the dam inundation zone. City staff has observed sheet flow running down the slope and there is evidence of concentrated flow paths forming.

The catch basin collects stormwater runoff from Shoreline Community College buildings and parking area is labeled as CB-551 in the City's GIS data. Discharge from pipe SP-9289 is expected to originate from catch basin CB-551 (see Figure 2), although GIS data does not show where pipe SP-9289 originates from. Through field reconnaissance, Otak staff observed an 8-inch diameter pipe exiting CB-551 to the north. Although not observed in the field, there is likely an additional junction structure between CB-551 and CB-1208 that reconciles the pipe size difference and significant elevation drop between the College property and the outfall to the channel.

Hydrologic Analysis

A hydrologic model for the entire Boeing Creek Basin was previously developed in HSPF for the Boeing Creek Basin Plan (City of Shoreline 2013). However, the model was calibrated to a stream gauge downstream of M1 Dam and may not provide representative hydrology for the project site. Therefore, a project-specific model was developed for the basin upstream of M1 Dam.

Subbasins upstream of M1 Dam were delineated based on City of Shoreline topographic and stormwater asset GIS data, and labeled according to the convention used in the Boeing Creek Basin Plan (City of Shoreline 2013) (See Appendix B). WWHM-SWMM was used to simulate runoff through the subbasins and conveyance system upstream of M1 Dam. WWHM-SWMM is a stormwater modeling tool that combines the Western Washington Hydrology Model (WWHM), as continuous rainfall hydrologic computer model, with the open source version of the Storm Water Management Model (SWMM 5) for hydraulic modeling. Rainfall data were taken from the SeaTac gage for water years 1949 – 1989, with precipitation factor of 0.833 applied by WWHM-SWMM for the project location. For water years 1990 – 2009, rainfall data were taken from a King County operated gage at the M1 Dam (KC Hydrologic Information Center, 2019). The existing conditions land use for each subbasin are summarized in Table 1. The existing conditions peak discharge rates for the total basin upstream of M1 Dam are summarized in Table 2.

Table 1—Existing Conditions Land Use

Drainage Basin	Pervious Area (ac)	Impervious Area (ac)	Total Basin Area (ac)
Basin Total	515.3	155.5	670.8

Table 4.2—Existing Conditions Basin Hydrology

Drainage Basin	2-yr (cfs)	5-yr (cfs)	10-yr (cfs)	25-yr (cfs)	50-yr (cfs)	100-yr (cfs)
Basin Total	49.0	69.6	85.9	109.8	130.2	153.0

Preliminary Hydraulic Calculations

A simple Manning's equation calculation was used to confirm the channel dimensions required for conveyance capacity of about a 2-year event (Appendix C). The average channel slope was determined to be about 2.0%, and therefore a channel bottom width of about 7 feet, with a 1′ depth, and 2H:1V side slopes was found to be required for conveyance of 49 cfs within the bankfull channel.

To determine the preliminary bed material, a threshold channel calculation was performed to determine the bed material size that would resist motion during the 100-year flow. The median particle size (d_{50}) that would be stable at the 100-year flow was found to be 4-inches in diameter. The WSDOT 10″ streambed cobbles gradation in

Section 9-03.11(2) of the WSDOT Standard Specifications has a d_{50} of about 4-inches, and therefore, the 10″ streambed cobbles gradation is recommended for the channel bed material based on preliminary calculations.

Conceptual Design of Repairs

The City needs to restore and maintain access along the road to the dam for sediment removal and has asked us to consider addressing potential future channel instability issues that could require future repairs to the access road, channel, or ravine embankment. The following sections describe the repairs or improvements anticipated for final design.

Scour Hole Repair and Stabilization of Access Road

The fallen tree that is approximately 200 feet upstream of the dam will need to be removed and the scour hole within the maintenance access road will need to be repaired to restore access. The fallen tree is decomposing and unsuitable for use as the proposed deflector log. All vegetation and woody debris removed from the channel can be placed within the ravine, outside of the dam inundation zone.

The concept exhibits provided in Appendix D show the proposed repairs. The area of the road should have the surface material stripped, and the embankment re-built following the requirements of WSDOT Standard Specifications Section 2-03 for embankment construction, using gravel borrow material to restore the road prism at the scour location. Near the area of the scour location, the channel is confined, and a steeper road embankment slope of 1H:1V is required to maintain the bottom width of the channel. In the next phase of design, geotechnical recommendations and further stability analysis will confirm the final extents of embankment grading. Larger material for steep channel side slopes or regrading of the channel to allow for less steep side slopes may be required. Geotextile fabric should be placed to separate the gravel borrow embankment material from the surface material that will be placed above it. Quarry spalls should be placed on the roadway embankment side slope to prevent erosion of the embankment material from channel flow. Quarry spalls are also recommended for surfacing the repaired roadway to resist flotation within the dam inundation zone.

Downstream of the scour location, the channel meanders away from the access road, and there is an overbank area between the access road and low flow channel. Therefore, the road embankment can be constructed with a slope of 1.5H:1V can be constructed downstream of the scour hole location. Geotextile fabric, and quarry spalls should also be placed on the side slope and top of access road. The quarry spalls on the access road sideslope should be covered with topsoil in this location. The topsoil should be amended with compost, hydroseeded, and covered with erosion control blankets (coir fabric).

The 18″ CMP pipe downstream of the scour hole location is crushed, and erosion is occurring around the pipe outlet. The road should be excavated to replace the pipe and catchbasin, and the road embankment re-built.

Stabilization of Ravine Slope above Access Road

The steep ravine slope on the south side, above the access road, show signs of instability and erosion. Trees roots are exposed, and trees have fallen from the slope across the access road and channel, such as the tree that caused the scour hole to be repaired. This slope is within the dam storage inundation zone, which causes the slope to become saturated during high flow events, and erosion likely increases as the water levels drawdown as water is released from the dam. Bank sloughing is evident on the slope, with undermining occurring around several trees. The City has also observed water flowing down the steep slopes from the area above following rain events, which is evident from the rill erosion occurring along the slope.

In order to stabilize the slope and reduce on-going maintenance from clearing fallen trees and repairing the damaged roadway, it is recommended that the trees and vegetation is cleared and grubbed from the unstable area of the slope. The slope should be excavated into benches, and gravel borrow material compacted to

construct the restored embankment slope. A layer of topsoil at least 18″ thick should be placed above the gravel borrow, and then a compost layer mixed in, erosion control blanket installed, and live stakes installed to revegetate the slope. The area of slope to be stabilized is considered to be approximately 200 feet in length along the access road based on preliminary evaluations.

Off-site Drainage from Shoreline Community College Parking Lot

The parking area above the eroding ravine side slope drains towards the top of slope, is slowed by a berm near the edge of the parking area, and eventually drains around the berm and over the slope. It is recommended that coordination occur with the Community College to review the drainage pattern and maintenance of their parking area, and that an improvement is made to safely convey the runoff to the bottom of the slope to reduce impacts to the City's property and facility. The improvement could consist of installing a new catchbasin with grate inlet near the low point of the edge of the gravel parking area, with the catchbasin connecting to the existing pipe that discharges into the creek near the access road repair.

Monitoring and Maintenance

Maintenance records show that the City performs routine inspection of the M1 Dam, upstream channel and access road approximately once per year. Following the results of these inspections, the City performs vegetation maintenance, including tree removal from the channel and/or access road, approximately once per year. The City also performs sediment removal/dredging from the M1 Dam sediment bay approximately once every two years.

The trees established along the ravine slopes along the length of the access road and channel upstream of the M1 Dam will fall over time due to erosion of the steep slopes. The previously described repairs are aimed at stabilizing the downstream reach to reduce maintenance over the long-term due to fallen trees in the area near the M1 Dam. The frequency of monitoring and maintenance of the access road for fallen trees and debris should also be evaluated for areas outside of the proposed repairs. The monitoring and maintenance will identify blockages within the channel so they can be removed shortly after they occur, to avoid failure of the access road at other locations due to scour.

Implementing a more frequent monitoring and maintenance plan could be an alternative to avoid clearing the trees and re-constructing the ravine slope near the M1 Dam. However, due to the eroded conditions of the south slope within and near the M1 Dam inundation zone, trees are at enhanced risk of falling within this area and stabilization improvements are recommended as described above. Regular practices for operating the dam should include more frequent monitoring and maintenance of the entire ravine to identify and clear any fallen trees to avoid future damage to the access road, particularly after significant storm or wind events.

Environmental / Permitting

The characterization of the project channel and associated riparian habitat is detailed in the existing conditions memo provided in Appendix A. The project channel displays significant modifications in order to accommodate stormwater conveyance and functioning of the M-1 Dam.

The project channel is mapped as an untyped stream by City of Shoreline, and City GIS data provides an estimate for the project channel stream buffer that extends upslope of the project area to the Community College parking lot. The Washington State Department of Natural Resources (DNR) maps the project channel as a non-fish bearing stream, and Washington Department of Fish and Wildlife (WDFW) also maps the project channel as a stream with no salmonid presence. WDFW will consider the project channel as a water of the state. The project channel drains to Boeing Creek, and is highly likely to be considered by the U.S. Army Corps of Engineers (USACE) to be a water of the U.S. as a result of its surface water connectivity to Boeing Creek. Modifications of the project channel and clearing and grubbing of the nearby riparian corridor will trigger City of Shoreline critical areas compliance.

The project channel and the surrounding land will be subject to a number of permitting and regulatory compliance requirements, based on the current proposed project design and activities.

- USACE Clean Water Act (CWA) Section 404 permit
  - Triggered by permanent impacts to waters of the U.S.
  - Will likely be covered by an existing Nationwide Permit (NWP) but will require a Joint Aquatic Permit Application (JARPA) for the project
  - Triggers additional regulatory requirements due to federal nature of the permit (see below)
- Endangered Species Act (ESA) and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) compliance
  - Triggered due to Section 404 permit
  - Will result in a No Effects determination, based on the site location and nature of the proposed work
  - Will result in No Adverse Effect to EFH
  - Will require submittal of a Letter of No Effects or a Biological Evaluation to the USACE for concurrence
- National Historic Preservation Act (NHPA) compliance
  - Triggered due to Section 404 permit
  - Will likely result in a No Adverse Effect determination, based on the site location and nature of the proposed work
  - Will require documentation to be submitted to the USACE
- CWA Section 401 compliance
  - Triggered by the in-water work and need for a USACE Section 404 permit
  - Will be covered by issuance of the letter of verification for the USACE NWP
  - May require monitoring for turbidity during construction
- Coastal Zone Management consistency
  - Triggered by the in-water work and need for a USACE Section 404 permit
  - Will be covered by issuance of the letter of verification for the USACE NWP
- WDFW Hydraulic Project Approval (HPA)
  - Triggered by in-water work and work in the nearby riparian zone
  - Will require upload of project design, environmental support documentation to the WDFW APPS site
- Executive Order 05-05 compliance
  - Compliance is associated with Revised Code of Washington (RCW) sections 27.44 and 27.53 for
  - Required for any project that is funded by state capital construction funds
  - If required, this will be covered by documentation for NHPA Section 106 as noted above
- State Environmental Policy Act (SEPA) compliance
  - RCW 43.21 C requires all governmental agencies to consider the environmental impacts of a proposal before making decisions
  - For the proposed work, impacts are anticipated to be appropriately mitigated, and the SEPA threshold determination will be a Determination of Non-Significance (DNS).
  - City of Shoreline will review and issue SEPA determination
- City of Shoreline Critical Areas Regulations
  - Land uses, development activity, and all structures and facilities within the City of Shoreline are subject to City of Shoreline critical areas ordinance requirements per Shoreline Municipal Code (SMP) 20.80. Per SMP 20.80.030, the proposed project is unlikely to meet the exemption criteria.
    - Clearing and grubbing of the slope adjacent to the project channel extends project impacts beyond the existing access road and will likely not meet the exemption criteria per SMP 20.80.030(C) for Roadway Operation, Maintenance, Repair, or Replacement

  - Proposed alteration of the watercourse will likely not meet the exemption criteria per SMP 20.80.030(C).
- The proposed project is likely to require compensatory mitigation to the City-identified buffer of the project channel (noted as a buffer estimate in the City's database)
  - Based on field data collected, Otak recommends a typing of the project channel as a non-fish bearing seasonal system (Type Ns), with a SMC buffer for Fish and Wildlife Habitat Conservation Area (FWHCA) per SMC 20.80.280(C) of 45 feet as measured from the ordinary high-water mark
  - Compensatory mitigation for buffer impacts may include removal of non-native vegetation and/or installation of native vegetative species to enhance riparian ecological function within the established FWHCA buffer
  - Appropriate critical areas documentation per SMP 20.80 as well as appropriate mitigation sequencing will be required for the proposed project

Preliminary Estimate of Construction Cost

A preliminary estimate of construction cost has been prepared for the recommended repairs. The construction cost estimate is included in Appendix D. Appendix E

Recommendations for Additional Steps

This technical memo presents preliminary recommendations for repairs to stabilize the channel and access road near the location of the scour hole in the road embankment. When the repairs are progressed to preliminary and final design, the design work should include the following tasks:

- Topographic survey – Topographic surveying of the area will be required to provide a detailed topography for designing the repairs.
- Geotechnical Investigation and Repairs – a geotechnical investigations should be performed for the access road, channel, and ravine slope soils. Geotechnical recommendations should include recommendations for stabilizing or re-constructing the ravine slope near the scour area, as well as recommendations for repairing the access road.
- Field Meeting with Permit Agencies – to advance permit applications, meetings should be held with permitting agencies to discuss the proposed design and the need for the proposed repairs.
- Hydraulic design of the proposed channel – based on collected topographic survey, more detailed hydraulic calculations should be performed to design the channel section, channel bed materials, and erosion protection for the access road.
- Coordination with Shoreline Community College for the parking area drainage – Meetings should be held with the Community College to discuss the current drainage issues on the City's property. Drainage improvements could be designed for the parking area to reduce erosion on the slopes above the access road.

References

King County, Interactive Mapping Tool (iMap). https://gismaps.kingcounty.gov/iMap/. Accessed March 2019.

King County Hydrologic Information Center. Site Codes 04u and 04d. https://green2.kingcounty.gov/hydrology/GaugeMap.aspx. Accessed April 2019.

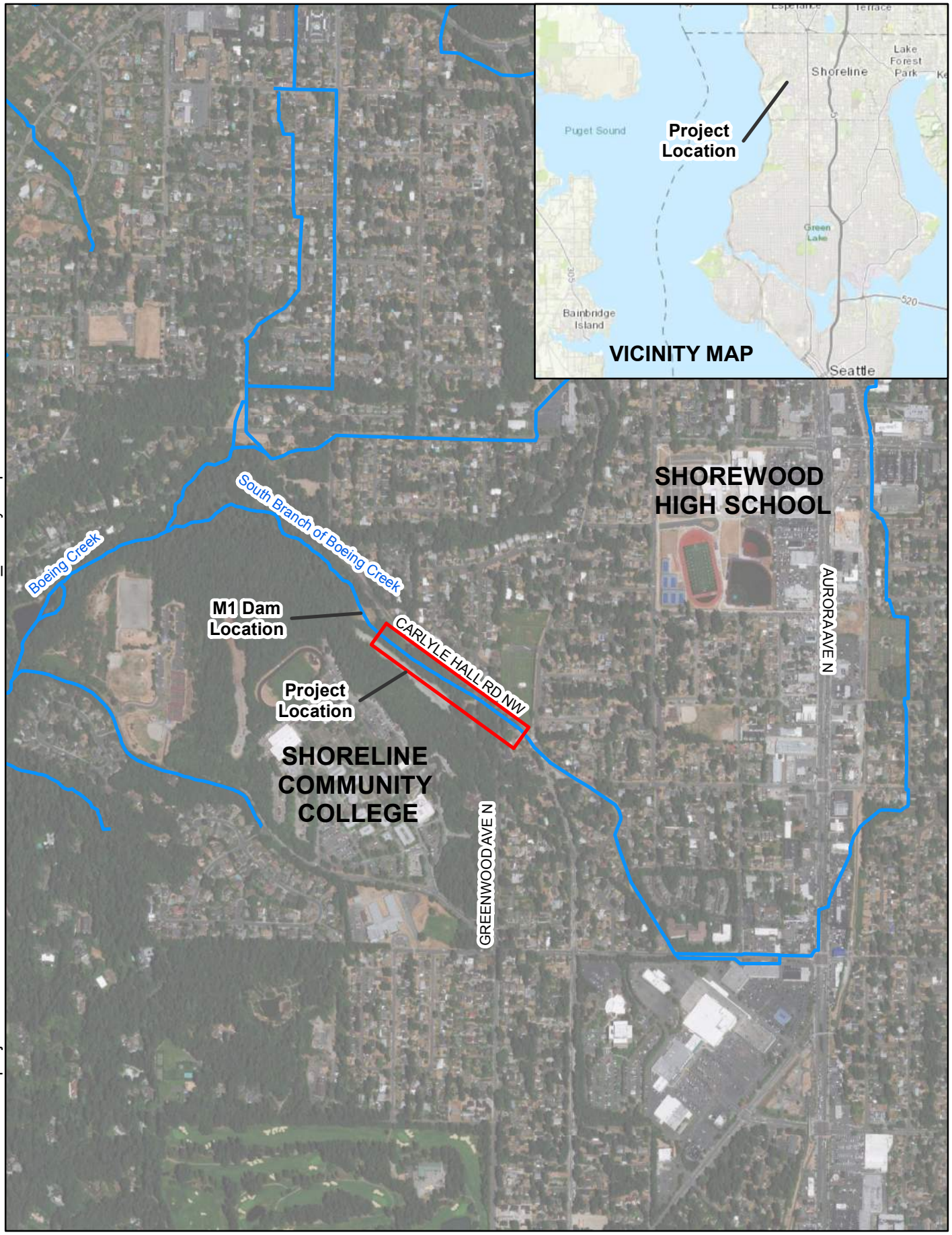
Washington State Department of Ecology, The National Hydrography Dataset in Washington State. 2010. https://waecy.maps.arcgis.com/apps/Cascade/index.html?appid=4505430ad1f947a5a255001080f6d359. Accessed March 2019.

Washington State Department of Natural Resources, Forest Practices Water Typing. 2005. Forest Practices Application Mapping Tool. https://fpamt.dnr.wa.gov/default.aspx. Accessed March 2019.

Attachments

Figure 1: Project Location
Figure 2: Existing Channel Conditions Overview

Appendix A: Existing Conditions Memo
Appendix B: Hydrologic Model Subbasins
Appendix C: Manning's Calculations
Appendix D: Conceptual Repair Exhibits
Appendix E: Preliminary Cost Estimate



Document Path: K:\project\32700\32713C21\CADD\GIS\MXDs\Deliverable\Task21_Vicinity Map.mxd

Figure 1: Project Location
South Branch of Boeing Creek from Greenwood Ave. to M1 Dam
Date: 3/27/2019

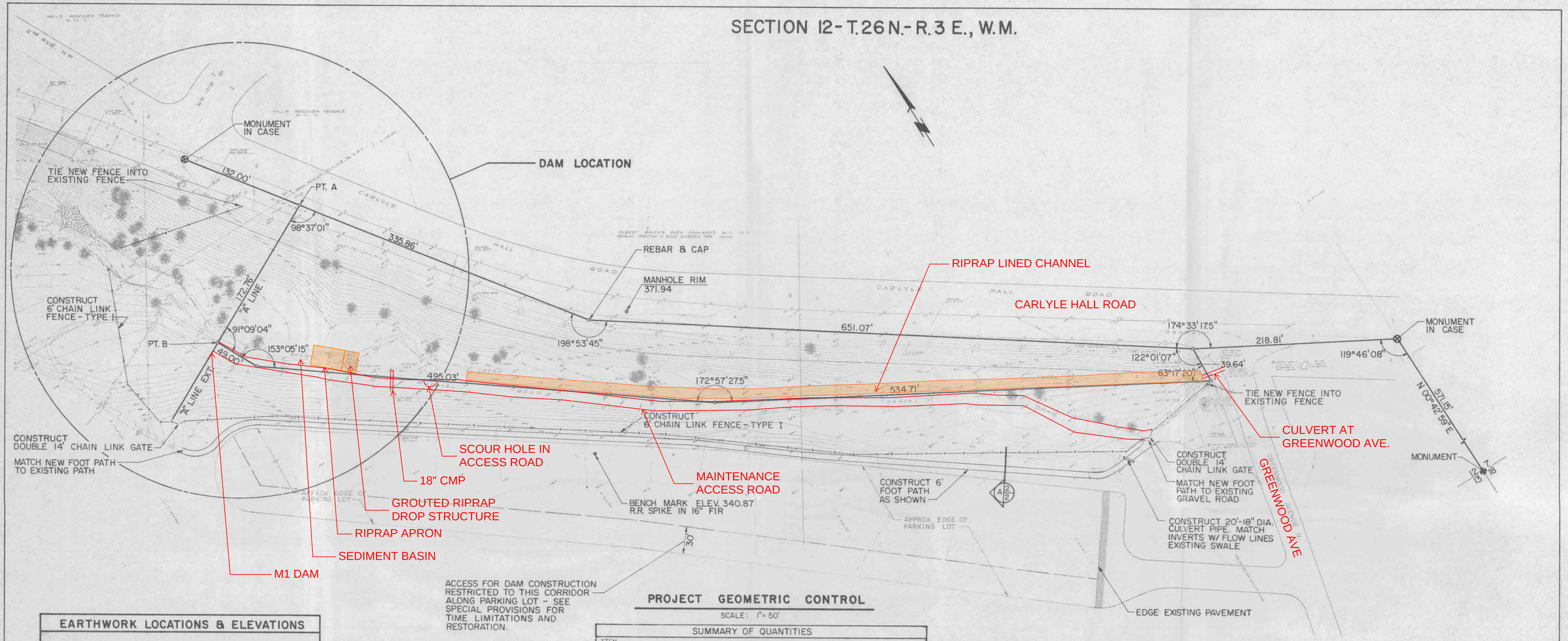
1 inch = 1,000 feet

0 500 1,000 Feet

N

Otak

SECTION 12 - T. 26 N. - R. 3 E., W.M.



PROJECT GEOMETRIC CONTROL

SCALE: 1"= 50'

EARTHWORK LOCATIONS & ELEVATIONS

POINT	A-LINE STATION	OFFSET	EX. ELEV.	BOTTOM SUBGRADE EXCAVATION	BOTTOM DRAINAGE BLANKET	FINISH ELEVATION
A	0+00	0.	-	-	-	-
B	1+72.76	0.	-	-	-	-
C	0+53	11.0 LT	348.0	-	-	348.0
D	0+56	7.5 RT	348.0	-	-	348.0
E	0+66	35.0 LT	339.0	-	-	339.0
F	0+86	123.0 LT	331.0	-	-	331.0
G	0+82	32.5 RT	337.0	-	334.0	340.0
H	1+13	82.0 LT	328.5	-	-	328.0
	1+00	32.5 RT	327.0	-	325.0	340.0
		57.0 RT	329.0	-	325.0	331.5
	1+20	32.5 RT	323.5	-	321.0	340.0
		83.0 RT	322.5	-	317.0	324.0
I	1+22	85.0 RT	322.0	-	317.0	323.5
J	1+26	72.0 LT	327.0	322.5	-	328.0
K	1+25	90.0 RT	322.0	314.5	319.5	334.0
	1+40	7.5 RT	323.0	315.0	-	345.0
		32.5 RT	322.0	311.0	317.0	337.0
		50.0 RT	320.5	315.0	315.0	331.0
		85.0 RT	313.0	-	314.0	320.0
	1+60	7.5 RT	319.0	308.0	-	345.0
X	1+60	32.5 RT	317.0	307.0	318.0	337.0
		50.0 RT	318.0	317.0	317.0	331.0
		85.0 RT	318.5	-	315.0	320.0
L	1+56	123.0 LT	333.0	-	-	333.0
M	1+72	85.0 RT	321.0	-	318.0	323.0
N	1+71	72.0 LT	328.0	327.5	-	328.0
O	1+76	90.0 RT	322.0	320.0	320.0	334.0
P	1+59	82.0 LT	326.0	-	-	327.0
	1+80	7.5 RT	323.0	321.0	-	348.0
		32.5 RT	322.5	322.0	322.0	340.0
		76.5 RT	324.0	-	322.5	325.0
Q	1+93	62.0 RT	327.0	-	324.5	330.0
	2+00	32.5 RT	328.5	-	325.0	340.0
		61.0 RT	328.5	-	325.0	330.0
		72.0 LT	342.0	-	-	342.0
	2+20	32.5 RT	330.5	-	329.0	340.0
		57.0 RT	329.5	-	329.0	331.5
	2+40	32.5 RT	334.0	-	333.5	340.0
		55.0 RT	331.0	-	330.5	332.0
R	2+48	54.0 RT	332.0	-	331.5	332.0
S	2+54	32.5 RT	338.0	-	337.0	340.0
T	2+64	4.0 RT	390.0	-	-	350.0
U	1+35	0.	323.5	-	-	345.0
V	1+85	0.	324.0	-	-	348.0
W	1+60	0.	320.0	309.0	-	345.0

SUMMARY OF QUANTITIES

ITEM NO.	ITEM	QUANTITY	UNIT
1.	Mobilization	Lump Sum	L.S.
2.	Clearing and Grubbing	Lump Sum	L.S.
3.	Grading for Foot Path	Lump Sum	L.S.
4.	Subgrade Excavation	1500	cu. yds
5.	Structure Excavation Class B, Inc. Haul	705	cu. yds
6.	Embankment Fill Material Including Haul	9000	cu. yds
7.	Shoring and Cribbing or Extra Excavation Class B at a fixed price of $1.50/sq. ft.	4000	sq. ft.
8.	Impervious Blanket Material in Place	3700	cu. yds
9.	Drainage Blanket Filter Material in Place	660	cu. yds
10.	Drainage Blanket Core Material in Place	660	cu. yds
11.	Crushed Surfacing Base Course	200	Tons
12.	Crushed Surfacing Top Course	145	Tons
13.	Gravel Base Class B	125	Tons
14.	Light Loose Riprap	350	Tons
15.	Heavy Loose Riprap	775	Tons
16.	Gravel Filter for Riprap	540	cu. yds
17.	Channel Rock	200	Tons
18.	Schedule A Culvert Pipe - 12-inch Diameter	182	lin. ft.
19.	Schedule A Culvert Pipe - 18-inch Diameter	20	lin. ft.
20.	Underdrain Pipe - 12-inch Diameter	56	lin. ft.
21.	Ductile Iron Pipe Class 52 - 20-inch Diameter Including Bedding and Cutoff Collars	35	lin. ft.
22.	Class V Reinforced Concrete Pipe - 60-inch Diameter Including Concrete Bedding and Cutoff Collars	143	lin. ft.
23.	Catch Basin Type II - 48-inch Diameter	2	Only
24.	Manhole Type I - 48-inch Diameter	2	Only
25.	Inlet Structure in Place	Lump Sum	L.S.
26.	Control Structure in Place	Lump Sum	L.S.
27.	Outlet Structure in Place	Lump Sum	L.S.
28.	Cement Concrete, Class A	71	cu. yds
29.	Filter Fabric for Drainage	1650	sq. yds
30.	Filter Fabric Fence	730	lin. ft.
31.	Seeding, Fertilizing, Mulching	Lump Sum	L.S.
32.	Clear Plastic Covering	2700	sq. yds
33.	Topsoil Type A	590	cu. yds
34.	Chain Link Fence - Type 1	1465	lin. ft.
35.	Double 14-foot Chain Link Gate	2	Only
36.	Metal Handrail	77	lin. ft.
37.	Traffic Control & Restoration of Parking Lot	Lump Sum	L.S.

NOTES:

1. ALIGNMENT SHOWN FOR FENCE & FOOTPATH IS APPROXIMATE. ACTUAL ALIGNMENT WILL BE STAKED BY ENGINEER.
2. PROVIDE WEED INHIBITOR UNDER FOOTPATH, CASARON G4 OR EQUAL, 6-7 LBS./1000 SQ.FT. COST INCIDENTAL TO "CRUSHED SURFACING TOP COURSE PER TON."

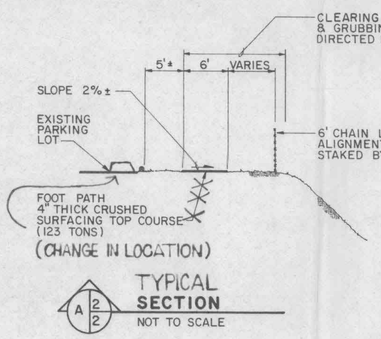


FIGURE 2.
EXISTING CHANNEL CONDITIONS OVERVIEW

JOHN E. NEWBY — STATE OF WASHINGTON — REGISTERED PROFESSIONAL ENGINEER

WALTER G. RAMSEY — STATE OF WASHINGTON — REGISTERED PROFESSIONAL ENGINEER

KING COUNTY DEPARTMENT OF PUBLIC WORKS
DONALD J. LaBELLE, DIRECTOR
DIVISION OF SURFACE WATER MANAGEMENT

BOEING CREEK PROJECT

RECOMMENDED Donald E. Wood

APPROVED _____ DATE _____
Larry Gibbons, Section Manager

LARRY R. GIBBONS — STATE OF WASHINGTON — 12550 — REGISTERED PROFESSIONAL ENGINEER

SCALE: AS SHOWN SURVEY NO. 12-26-3-60 SHEET 2 OF 7

305-56A

Appendix A

Existing Conditions Memo

11241 Willows Road NE, Suite 200 Redmond, WA 98052 ▪ Phone (425)822-4446 Fax (425)827-9577 **otak.com**

Technical Memorandum

To:	Cory Nau, City of Shoreline
From:	Dave Stewart, PE, Brian Clarke, PhD, Kevin O'Brien, PhD,
Copies:	Tyson Hounsel, PE, Gwyn Perry, EIT
Date:	May 7, 2019
Subject:	Existing Conditions Observations for the South Branch of Boeing Creek Near M1 Dam
Project No.:	32713.C21

Introduction

The M1 Dam is located on the South Branch of Boeing Creek within the City of Shoreline, Washington (Figure 1). During a routine inspection of the M1 Dam in December 2017, City maintenance crews observed a fallen tree on the South bank of the channel, laying across the access road and in the bed of the channel upstream of the dam. A scour hole has formed in the South bank that has eroded the maintenance access road under the location of the fallen tree. The scour has made the access road leading up to the debris rack and sediment basin impassible for the City's maintenance vehicles. The erosion failure has occurred approximately 140 feet upstream of the dam, which falls within the dam storage zone. The City requested that Otak evaluate repairs to restore access for maintenance, and evaluate the channel system for potential erosion and scour issues that may affect the City's access to the dam.

The purpose of this memo is to document preliminary existing conditions observations of the South Branch of Boeing Creek related to the scour along the maintenance road near the M1 Dam, as well as the upstream and immediately downstream reaches, to assess for channel instabilities. This assessment of existing conditions will inform recommendations for the extent of proposed repairs and improvements. The following information summarizes qualitative field observations and desktop review of available City data and does not provide technical analysis for basis of final design.

Greenwood Ave N. to M1 Dam Reach

Existing Channel Conditions

A site visit was performed on February 28, 2019 to document existing conditions. The South Branch of Boeing Creek upstream of the M1 Dam is a drainage channel that was heavily modified in the 1970's by filling the channel bed, and constructing rock weir grade control structures. The channel is armored with angular riprap (approx. 4-12" diam.), cobbles and gravels for nearly the entire reach from the M1 dam to the upstream culvert at Greenwood Ave N (the project area) (Figure 2). Shrub vegetation is growing along the side slopes and top of the channel banks, and trees are established on the ravine side slopes. Large wood from fallen trees, as well as brush are present in some segments of the channel bed.

The hydrology of the reach is seasonal, with precipitation and groundwater-derived flow during the winter and spring months based on observations during the site visit. A small amount water was flowing from the 48" culvert outlet at the Greenwood Ave N road crossing into the riprap channel in the upstream reach of the

project area (Photo 1). The flow was observed to gradually seep through the porous channel substrate and become subsurface near the middle of the project reach. No surface flow was evident for the reach from approximately 500 feet upstream of the M1 Dam to the dam. Snow had accumulated to a depth of 20" approximately two weeks prior to the site visit and had melted into groundwater by the time of the site visit. Otherwise, no significant precipitation had occurred in at least the two weeks preceding the site visit.

Downstream of the culvert crossing under Greenwood Ave N., the maintenance access road approaches and abuts the left channel bank. An 18" CMP is exposed on the ravine slope north of the channel and is the outlet from a catch basin within Carlyle Hall Rd. at the top of slope. The maintenance access road width varies from about 10' – 12' for the length of the project area, and trees have fallen across the channel and access road at some locations along the length of the channel (Photo 2).

In the middle of the project area, the riprap channel is entrenched with a bottom width of about 5', a top width of about 6', and an average depth of 2' from the top of bank. Rock weirs control the grade of the channel through the reach, with drop heights of about 2' (Photo 3). Some large rocks (18 – 24") from the rock weirs have been undermined and fallen into the channel below. The typical riprap gradation of the channel bed in this reach is shown in Photo 4.

In the downstream reach, the scour hole in the maintenance access road with the fallen tree in the channel was measured as about 12 feet into the width of the access road and left bank of the channel, and about 9 feet in length along the access road (Figures 3 and 4, and Photo 5). The height of the drop from the top of the access road to the bed surface was measured as 5.5 feet. The material of the eroded bank was observed to consist of silt interspersed with cobbles about 1" – 4" in diameter. The typical riprap and gravel gradation within the channel bed near the scour location are shown in Photo 6.

Immediately downstream of the scour hole, there is a bend in the low flow channel, and the total channel width increases to approximately 40 feet (Photo 7). An 18" corrugated metal pipe (CMP) enters from the left bank within this wider section of channel. The 18" CMP was observed to be crushed and broken, with erosion occurring around where the pipe emerges from the bank (Photo 8). The pipe connects to a catch basin on the south side of the access road, that connects to a storm drain pipe within the steep ravine slope. Erosion and rilling was also evident along the steep ravine slope in this area, including erosion around the roots of trees on the slope.

The channel then enters a grouted riprap drop structure with a riprap apron downstream at the entrance to the sediment basin at the M1 Dam. The grouted riprap pad was measured as approximately 17 feet in length and 12 feet in width, with a drop height of about 2 feet to the 10-foot long riprap apron downstream (Photo 9).

The M1 Dam consists of a low flow pipe outlet with a sluice gate, and a large overflow structure that engages before water levels reach the crest of the emergency spillway of the dam (Photos 10 and 11). When water levels reach the top of the overflow structure at the dam, the channel, access road, and surrounding floodplain are submerged for approximately 500 feet upstream of the dam based on the M1 Dam design plans (King County, 1983). A sediment basin is located immediately upstream of the M1 dam that is maintained by the City when significant sediment accumulates. A depth of sediment and debris of approximately 1 – 2 feet was observed at the time of the site visit. The area of deposition was measured as approximately 35 feet in length, and 25 feet wide, with the top of the sediment averaging a depth of 3 feet below the adjacent top of banks.

Geomorphic Observations

Sediment continuity is disrupted in the project reach by the culverts and development upstream. Sediment input is limited into the system from the culverts under Greenwood Ave., leading to degradation and clear water scour issues at downstream channels where the banks are earthen. The riprap lined channel also accelerates flow and leads to higher velocities and increasing erosion downstream.

Geomorphic responses within the project site are also related to degradation of rock grade control structures and scour associated with large woody material within the channel, both of which have led to bank instabilities. The most immediate issue of concern is the large scour hole that has cut into the access road making it impassable. The tree that has fallen into the channel has forced stream flow into the left bank and caused a local scour issue. The banks are unstable, as they are vertical and about 5.5 feet in height. If not addressed, the banks will continue to erode and expand the area of damage to the access road.

Upstream of the scour hole the channel is riprap lined with a series of rock weir grade control structures composed of 18-24" rocks. Several of the grade control structures have been undermined. In the area immediately upstream of the scour hole, the first drop structure has been completely undermined and the large rocks have toppled into the channel. The degree of degradation is less pronounced moving upstream. The extent of incision and entrenchment of the channel follows a similar pattern. Directly upstream of the scour hole, the channel is entrenched about 3' in depth, whereas in the upper portion of the reach the channel is entrenched about 1-2' in depth. The rock weir grade control structures are currently limiting the depth of channel incision and limiting erosion headcutting from progressing upstream.

Habitat and Environmental Observations

Drainage and riparian habitat in the Greenwood Ave N. to M1 Dam Reach is significantly disturbed, impacted by the access road and a parking area to the southwest of the reach, and by Carlyle Hall Road North to the northeast. Land use in the vicinity consists of single-family residential development, activity associated with the campus of Shoreline Community College, and passive recreational use in Boeing Park.

Habitat conditions for the reach are significantly impacted by in-channel conditions and the M1 dam. Fish passage is completely precluded by the presence of the dam and its discharge structures, and habitat for invertebrates as a contributing element to the downstream food web dynamics are very limited by the substrate and hydrologic regime of the reach. Anadromous salmonid species are not present nor have the potential to be present due to downstream passage blockages and in-stream flow conditions, and resident species presence is likewise precluded due to lack of flow and access to downstream refugia/reintroduction sites. Habitat functions for aquatic biota afforded by the reach would be considered very limited due to modifications of the drainage substrate, channel, hydrologic regime, and the physical barrier imposed by the dam.

The riparian corridor associated with the Greenwood Ave N. to M1 Dam Reach has been impacted by nearby development and the presence of roadways and parking lots in the reach vicinity. Invasive species that are correlated with disturbed habitat, such as Himalayan blackberry (Rubus armeniacus), English ivy (Hedera helix), and reed canary grass (Phalaris arundinacea) are abundant in the riparian corridor associated with the reach. Native species include a tree layer consisting of deciduous species such as black cottonwood (Populus trichocarpa), big leaf maple (Acer macrophylla), and red alder (Alnus rubra). Coniferous species in the riparian corridor consisted of western red cedar (Thuja plicata) and Douglas fir (Pseudotsuga menziesii).

Native riparian woody shrub vegetation included salmonberry (Rubus spectabalis) and vine maple (Acer circinatum), while the herbaceous community consisted largely of sword fern (Polystichum munitum) along the slopes. Riparian wetlands were absent, as the incised and armored nature of the stream banks resulted in

a spatially short transition from aquatic to upland habitat moving laterally from the ordinary high-water mark.

Slope instability was observed in two sections of trees on the south ravine side slopes (see Figure 2 and Photo 14). Each section is approximately 30' long. The instability is likely due to a combination of slope erosion and periodic soil inundation when the dam is storing water. The upper section of the slope contains the location where the alder tree fell into the stream and caused the scour hole. This area also contains two western red cedar trees along with a red alder tree. The roots of the two western red cedar trees are exposed due to surface erosion. The trees in this area are approximately 60' to 80' tall.

The second section of slope instability is about 60' downstream of the first section. This area has a western red cedar and alder trees too. They range between 50' and 80' tall. A focused area of surface erosion has incised about a 1' to 1.5' deep channel down the slope to the southeast of the western red cedar tree, through salmonberry (Photo 15). This area is within the staging area of the dam and occasionally is inundated with water up to the trunk of the western red cedar. Signs of mountain beavers (*Aplodontia rufa)* burrows are in this second area, which could exacerbate the soil saturation during times of inundation.

The Greenwood Ave N. to M1 Dam Reach is an untyped stream by City of Shoreline above the M1 dam, and typed as fish habitat by the City below the dam. The DNR maps the Greenwood Ave N. to M1 Dam Reach and approximately 0.28 miles below dam as non-fish bearing. WDFW maps the stream as providing resident cutthroat habitat upstream to the M1 dam.

The presence of a mapped stream system on the City of Shoreline GIS database, and WDFW and DRN mapping databases strongly suggests that the Greenwood Ave N. to M1 Dam Reach will be regulated as a Water of the State and likely as a Water of the U.S., in spite of the extensive modifications to the drainage channel. In addition, the Greenwood Ave N. to M1 Dam Reach system drains to fish-bearing waters below the dam. As such, work within the Greenwood Ave N. to M1 Dam Reach is likely subject to regulatory compliance requirements form the City of Shoreline with respect to critical areas; to HPA requirements from WDFW, and potentially to Army Corps of Engineer requirements for Section 404 permits.

Ravine Slopes

The north ravine side slope above the drainage channel, from the dam to Greenwood Ave. N., appears stable with no apparent active sloughing or erosion being caused by concentrated flow from the roadway at the top of slope. The south ravine side slope is heavily vegetated with trees, shrubs, and blackberry and surface conditions vary. From Greenwood Ave. N to the upstream end of the dam inundation zone, within the first 540 linear feet of the channel reach, there are no clear signs of active sloughing or erosion due to surface runoff. However, two fallen trees, from the south slope within this zone, were observed across the maintenance road and this is a regular occurrence according to the City maintenance staff.

Within the dam inundation zone, which extends approximately 360 linear feet upstream from the dam, the south ravine side slope has signs of significant surface erosion that is leading to sloughing and exposing the root systems of the trees on this slope. It is likely that the slope instability led to the failure of the tree that fell across the maintenance road and led to the scour and erosion failure of the road embankment. Based on a review of the GIS contours and field observation, it appears that the runoff from the Shoreline Community College gravel parking at the top of the slope is directed towards the south ravine slope that is within the dam inundation zone. The slope within the dam inundation zone becomes saturated and more susceptible to erosion when concentrated runoff from the parking lot drains down the slope. Significant surface flow on the slope has been observed by City maintenance staff and there does not appear to be a collection system in the parking lot to manage the stormwater at the top of the steep slope.

The trees in this zone have grown to a height that increases the risk for more tree failures due to slope

instability and weakened anchorage caused by erosion from surface runoff and cycles of saturation within the dam storage zone during large storm events (Photos 16 and 17). Tree failures on the south ravine slope outside of the dam inundation zone may also be indications of erosion issues caused by surface runoff from the Community College parking lot, although, the ravine slopes in this area are not as steep and instabilities are not as evident.

Reach Downstream of the M1 Dam

Downstream Channel Conditions and Geomorphic Observations

The reach downstream of the M1 Dam is armored with riprap, cobbles, and gravels, with constructed rock weir grade control structures similar to the channel upstream of the M1 Dam. The M1 Dam and associated sediment basin disrupts sediment continuity and prevents sediment from moving from upstream to downstream. As a result, the channel downstream of the dam has degraded and the channel has become entrenched with eroded side slopes based on observations approximately 500 feet downstream of the dam (Photo 12). The channel overbanks consist of some shrubs and trees. Bank failure was observed in a few locations where the channel abuts steep ravine slopes, and the banks and trees have fallen into the channel (Photo 13). The rock weir drop structures downstream of the dam were also observed to have been undermined, with some rocks having fallen into the downstream channel bed. However, there does not appear to be significant downcutting of the armored channel bed, or severe headcutting migrating upstream that would impact the stability of the dam. As a result, there does not appear to be a need for immediate repairs to the downstream channel based on the observations from the site visit.

Downstream Habitat and Environmental Observations

Stream substrate and channel conditions downstream of the M1 dam also show armored channel, substrate, and bank conditions. Substrate conditions gradually changed moving downstream, with more rounded cobble and gravel replacing the angular and subangular armoring material. Significant incision has occurred in these reaches, bank erosion and some evidence of localized slope failure in the ravine walls was apparent during the site visit. Habitat downstream of the M1 dam consists of fish-bearing stream habitat per WDFW, primarily cutthroat trout (*Oncorhnchus clarkii)* based on priority species habitat data. The observed flow regime includes additional input from groundwater, resulting in a perennially flowing system moving further downstream. Boeing Park provides a larger, more robust and more functional riparian habitat for the downstream reaches, including input of significantly-sized trees for large woody debris.

Offsite Drainage

North Side of Ravine

Carlyle Hall Rd NW runs along the top of the north ravine slope. The majority of runoff from the road surface and hillside to the north collects in swales along the north side of the road and the swales are eventually collected in catch basins and pipes that drain through pipe outfalls into the channel both upstream and downstream of the dam. There does not appear to be significant surface erosion caused by concentrated roadway runoff draining down the north ravine slope between Greenwood Ave. N. and the dam.

South Side of Ravine

Stormwater runoff from the Shoreline Community College property along the south side of the ravine enters the channel via two paths: sheet flow runoff from the gravel parking lot, and direct discharge from pipe SP-9289 (see Figure 2). During a site visit for inspection of trees within the ravine, the gravel parking lot was closed, and it appears as if it was undergoing maintenance activities included grading and compaction of the

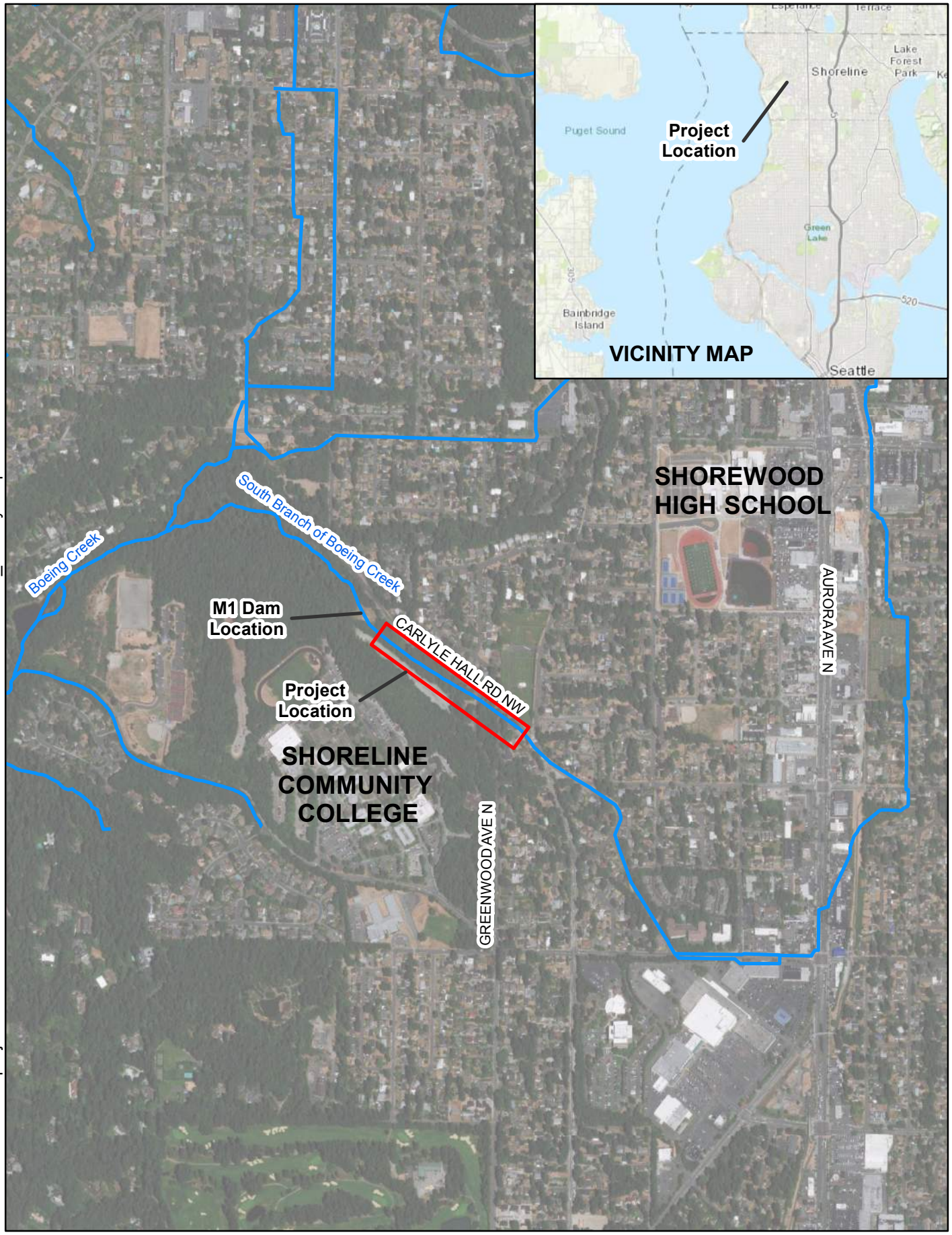
gravel surfacing. According to GIS level contour information and field observations, it appears that runoff form the parking lot generally sheet flows north toward the top of the south ravine slope. There is a low gravel berm along the northeast edge of the parking lot and it is not clear whether this has been intentionally graded or is an artifact of maintenance activities for the gravel surfacing. There are some concrete wheel stops along the northeast edge of the parking lot, but they are scattered and do not follow a consistent alignment or spacing pattern (Photo 18). Runoff from the gravel parking lot concentrates along this berm edge and then flows down the south ravine slope within the dam inundation zone of the channel and near the location of the fallen tree and scour hole in the dam maintenance road. City staff have observed sheet flow running down the slope during rain events and there is clear surface erosion and exposure of tree roots.

The outfall pipe SP-9289 is labeled as a 12-inch diameter pipe in City GIS data, but was observed be an 18-inch diameter pipe in the field. Discharge from SP-9289 most likely originates from catch basin CB-551 (see Figure 2), which collects stormwater runoff from Shoreline Community College buildings and paved parking area which is uphill from the gravel parking lot. During a site inspection, Otak staff observed an 8-inch diameter pipe exiting CB-551 to the north. The continuation of this pipe and connection to SP-9289 is not available in GIS and further indications of the pipe alignment such as junction structures were not found. Although not located in the field, there are likely junction structures between CB-551 and CB-1208 that provide transition in horizontal and vertical alignment and in pipe size. Based on the available GIS data, parking lot runoff contributing to this system currently discharges to the channel untreated and unattenuated.

Observed Issues to be Addressed

The City wants to restore and maintain access along the road to the dam for sediment removal, and has asked us to consider addressing potential future channel instability issues that could require future repairs to the access road, channel, or ravine embankment. The following issues were observed during the field assessment and we recommend that they be addressed as part of the project design:

- The fallen tree that is approximately 200 feet upstream of the dam will need to be removed and the scour hole within the maintenance access road will need to be repaired to restore access.
- The road prism where the scour hole occurred will need to be stabilized for a length upstream and downstream where the bank has not been armored to prevent additional erosion from occurring.
- The 18” CMP pipe outfall (SP-9289) just upstream of the dam is crushed, and erosion is occurring around the outlet. The existing catch basin (CB-1208) is also in poor condition. The pipe and catch basin should be replaced and the bank stabilized. In addition, TV inspection of the upstream system draining into this catch basin should be performed to assess condition of steep slope pipe buried under the ravine slope. Discussions with Shoreline Community College maintenance staff may also identify other upstream junction structures for this system that are missing from GIS data. Identification of these structures would help to confirm the contributing area for this pipe outfall.
- Rill erosion is occurring on the south ravine side slope that is likely accelerating the rate of trees falling into the channel, which causes or contributes to the bank erosion issues. The erosion of the ravine side slope is likely caused by inundation from the dam storage zone, as well as contributed to by overland runoff from the Community College parking lot. The design of improvements should include options to stabilize the ravine side slope and establishment of vegetation including trees with a shorter mature height. In order to maintain the stability of the restored slope, the design should also consider coordination with Shoreline Community College to understand the gravel parking lot drainage patterns and concentration of storm runoff. Improvements on the Community College site may be necessary to protect against future destabilization of the south ravine slope.
- Trees will continue to fall across the access road and channel over time due to the steep ravine side slopes. A monitoring and maintenance plan should be evaluated or expanded for removal of trees to minimize potential for scour and erosion.



Document Path: K:\project\32700\32713C21\CADD\GIS\MXDs\Deliverable\Task21_Vicinity Map.mxd

Figure 1: Project Location
South Branch of Boeing Creek from Greenwood Ave. to M1 Dam
Date: 3/27/2019

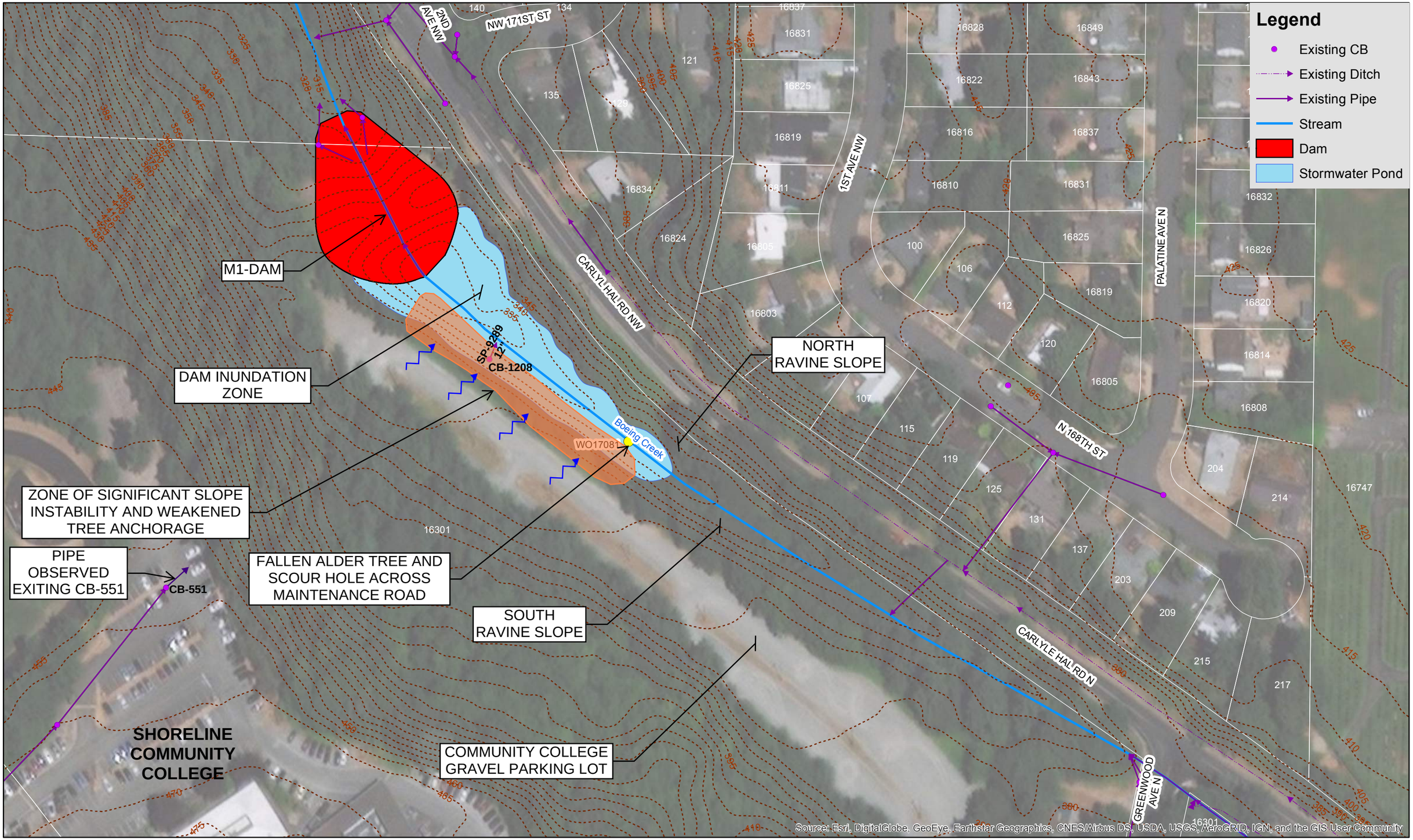
1 inch = 1,000 feet

0 500 1,000 Feet

N

Otak

This page intentionally left blank



Document Path: K:\project\32700\32713C21\CADD\GIS\MXDs\Working\Task20_working_landscape.mxd

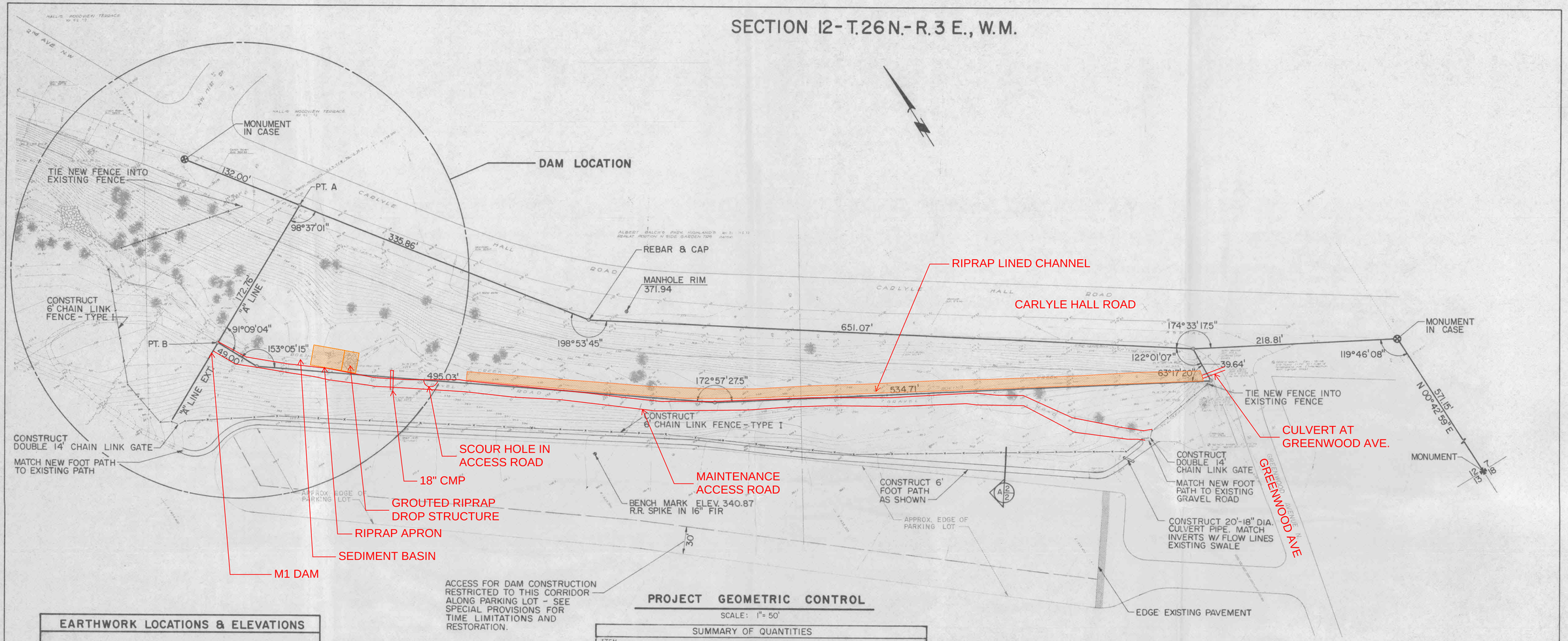
Figure 2 - Existing Site Conditions

Date: 4/15/2019

1 inch = 100 feet

100 50 0 100 Feet

SECTION 12 - T. 26 N. - R. 3 E., W.M.



PROJECT GEOMETRIC CONTROL

SCALE: 1"= 50'

EARTHWORK LOCATIONS & ELEVATIONS

POINT	A-LINE STATION	OFFSET	EX. ELEV.	BOTTOM SUBGRADE EXCAVATION	BOTTOM DRAINAGE BLANKET	FINISH ELEVATION
A	0+00	0.	-	-	-	-
B	1+72.76	0.	-	-	-	-
C	0+93	11.0 LT	348.0	-	-	348.0
D	0+56	7.5 RT	348.0	-	-	348.0
E	0+66	35.0 LT	339.0	-	-	339.0
F	0+86	123.0 LT	331.0	-	-	331.0
G	0+82	32.5 RT	337.0	-	334.0	340.0
H	1+13	82.0 LT	328.5	-	-	328.0
	1+00	32.5 RT	327.0	-	325.0	340.0
		57.0 RT	329.0	-	325.0	331.5
	1+20	32.5 RT	323.5	-	321.0	340.0
		83.0 RT	322.5	-	317.0	324.0
I	1+22	85.0 RT	322.0	-	317.0	323.5
J	1+36	72.0 LT	327.0	322.5	-	328.0
K	1+25	90.0 RT	322.0	314.5	319.5	334.0
	1+40	7.5 RT	323.0	315.0	-	345.0
		32.5 RT	322.0	311.0	317.0	337.0
		50.0 RT	320.5	315.0	315.0	331.0
		85.0 RT	313.0	-	314.0	320.0
	1+60	7.5 RT	319.0	308.0	-	345.0
X	1+60	32.5 RT	317.0	307.0	318.0	337.0
		50.0 RT	318.0	317.0	317.0	331.0
		85.0 RT	318.5	-	315.0	320.0
L	1+56	123.0 LT	333.0	-	-	333.0
M	1+72	85.0 RT	321.0	-	318.0	323.0
N	1+71	72.0 LT	328.0	327.5	-	328.0
O	1+76	90.0 RT	322.0	320.0	320.0	334.0
P	1+59	82.0 LT	326.0	-	-	327.0
	1+80	7.5 RT	323.0	321.0	-	348.0
		32.5 RT	322.5	322.0	322.0	340.0
		76.5 RT	324.0	-	322.5	325.0
Q	1+93	62.0 RT	327.0	-	324.5	330.0
	2+00	32.5 RT	328.5	-	325.0	340.0
		61.0 RT	328.5	-	325.0	330.0
		72.0 LT	342.0	-	-	342.0
	2+20	32.5 RT	330.5	-	329.0	340.0
		57.0 RT	329.5	-	329.0	331.5
	2+40	32.5 RT	334.0	-	333.5	340.0
		55.0 RT	331.0	-	330.5	332.0
R	2+48	54.0 RT	332.0	-	331.5	332.0
S	2+54	32.5 RT	338.0	-	337.0	340.0
T	2+64	4.0 RT	390.0	-	-	350.0
U	1+35	0.	323.5	-	-	345.0
V	1+85	0.	324.0	-	-	348.0
W	1+60	0.	320.0	309.0	-	345.0

SUMMARY OF QUANTITIES

ITEM NO.	ITEM	QUANTITY	UNIT
1.	Mobilization	Lump Sum	L.S.
2.	Clearing and Grubbing	Lump Sum	L.S.
3.	Grading for Foot Path	Lump Sum	L.S.
4.	Subgrade Excavation	1500	cu. yds
5.	Structure Excavation Class B, Inc. Haul	705	cu. yds
6.	Embankment Fill Material Including Haul	9000	cu. yds
7.	Shoring and Cribbing or Extra Excavation Class B at a fixed price of $1.50/sq. ft.	4000	sq. ft.
8.	Impervious Blanket Material in Place	3700	cu. yds
9.	Drainage Blanket Filter Material in Place	660	cu. yds
10.	Drainage Blanket Core Material in Place	660	cu. yds
11.	Crushed Surfacing Base Course	200	Tons
12.	Crushed Surfacing Top Course	145	Tons
13.	Gravel Base Class B	125	Tons
14.	Light Loose Riprap	350	Tons
15.	Heavy Loose Riprap	775	Tons
16.	Gravel Filter for Riprap	540	cu. yds
17.	Channel Rock	200	Tons
18.	Schedule A Culvert Pipe - 12-inch Diameter	182	lin. ft.
19.	Schedule A Culvert Pipe - 18-inch Diameter	20	lin. ft.
20.	Underdrain Pipe - 12-inch Diameter	56	lin. ft.
21.	Ductile Iron Pipe Class 52 - 20-inch Diameter Including Bedding and Cutoff Collars	35	lin. ft.
22.	Class V Reinforced Concrete Pipe - 60-inch Diameter Including Concrete Bedding and Cutoff Collars	143	lin. ft.
23.	Catch Basin Type II - 48-inch Diameter	2	Only
24.	Manhole Type I - 48-inch Diameter	2	Only
25.	Inlet Structure in Place	Lump Sum	L.S.
26.	Control Structure in Place	Lump Sum	L.S.
27.	Outlet Structure in Place	Lump Sum	L.S.
28.	Cement Concrete, Class A	71	cu. yds
29.	Filter Fabric for Drainage	1650	sq. yds
30.	Filter Fabric Fence	730	lin. ft.
31.	Seeding, Fertilizing, Mulching	Lump Sum	L.S.
32.	Clear Plastic Covering	2700	sq. yds
33.	Topsoil Type A	590	cu. yds
34.	Chain Link Fence - Type 1	1465	lin. ft.
35.	Double 14-foot Chain Link Gate	2	Only
36.	Metal Handrail	77	lin. ft.
37.	Traffic Control & Restoration of Parking Lot	Lump Sum	L.S.

NOTES:

1. ALIGNMENT SHOWN FOR FENCE & FOOTPATH IS APPROXIMATE. ACTUAL ALIGNMENT WILL BE STAKED BY ENGINEER.
2. PROVIDE WEED INHIBITOR UNDER FOOTPATH, CASARON G4 OR EQUAL, 6-7 LBS./1000 SQ.FT. COST INCIDENTAL TO "CRUSHED SURFACING TOP COURSE PER TON."

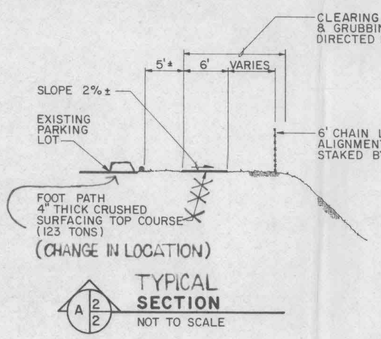


FIGURE 3.
EXISTING CHANNEL CONDITIONS OVERVIEW

JOHN E. NEWBY — STATE OF WASHINGTON — REGISTERED PROFESSIONAL ENGINEER

WALTER G. RAMSEY — STATE OF WASHINGTON — REGISTERED PROFESSIONAL ENGINEER

KING COUNTY DEPARTMENT OF PUBLIC WORKS
DONALD J. LaBELLE, DIRECTOR
DIVISION OF SURFACE WATER MANAGEMENT

BOEING CREEK PROJECT

RECOMMENDED Donald E. Wood

APPROVED _____ DATE _____
Larry Gibbons, Section Manager

LARRY R. GIBBONS — STATE OF WASHINGTON — 12550 — REGISTERED PROFESSIONAL ENGINEER

SCALE: AS SHOWN SURVEY NO. 12-26-3-60 SHEET 2 OF 7

305-56A

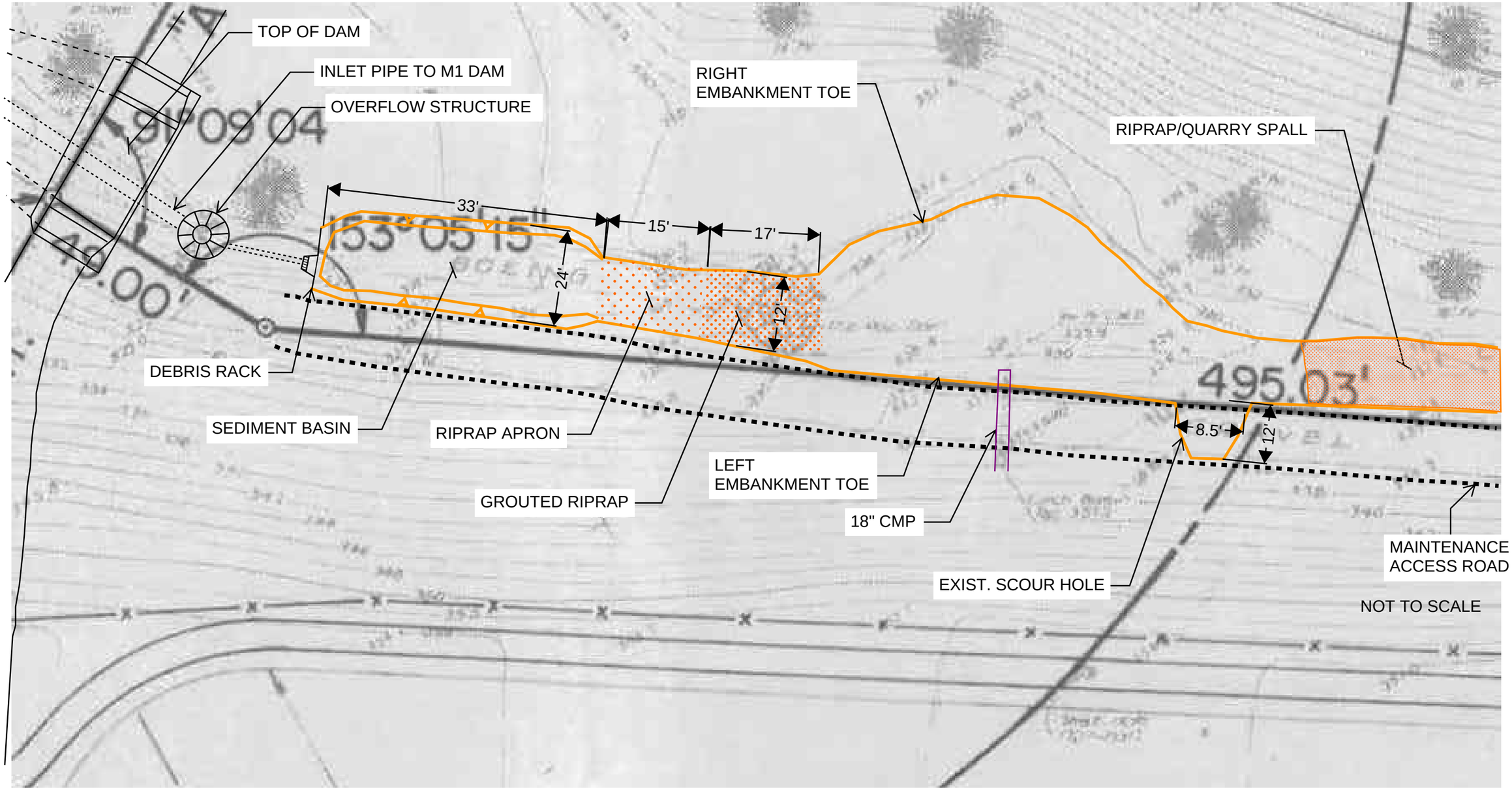


FIGURE 4. ENLARGED PLAN VIEW AT SCOUR HOLE LOCATION

This page intentionally left blank

Photo 1. Upstream reach of the South fork of Boeing Creek with riprap armoring, with above ground flow, looking upstream towards the culvert outlet under Greenwood Ave N.

Photo 2. Looking upstream, the maintenance access road abuts the channel on the right side, the exposed 18" CMP is on the left side, and tree have fallen across the access road and channel in the foreground.

Photo 3. Entrenched channel with rock drop structure near the middle of the project area.

Photo 4. Typical riprap gradation within the entrenched channel reach, near the middle of the project area.

Photo 5. Scour in the left bank of the channel and access road, beneath the tree fallen into the channel.

Photo 6. Typical riprap, cobble, and gravel gradation of the channel bed, near the scour hole location.

Photo 7. Looking upstream at the bend in the channel, downstream of the scour hole location.

Photo 8. Crushed 18" CMP and bank erosion on the left bank at the bend in the channel.

Photo 9. Looking upstream at the grouted riprap grade control structure, upstream of the sediment basin for the M1 Dam.

Photo 10. Looking downstream, at the grouted riprap grade control structure, and the M1 dam.

Photo 11. Sluice gate at the outlet pipe of the M1 Dam.

Photo 12. Looking upstream, at a rock weir grade control structure and eroded channel several hundred feet downstream of the M1 Dam.

Photo 13. Looking downstream, at the eroded channel, eroded ravine slopes and fallen trees downstream of the M1 Dam.

Photo 14: areas of tree instability one (upstream) and two (downstream) indicated with white arrows

Photo 15: drainage caused ~1 to 1.5' channel on left bank slope in area two of tree instability

Photos 16 and 17: Soil erosion around tree root zones on south ravine slope within dam inundation zone

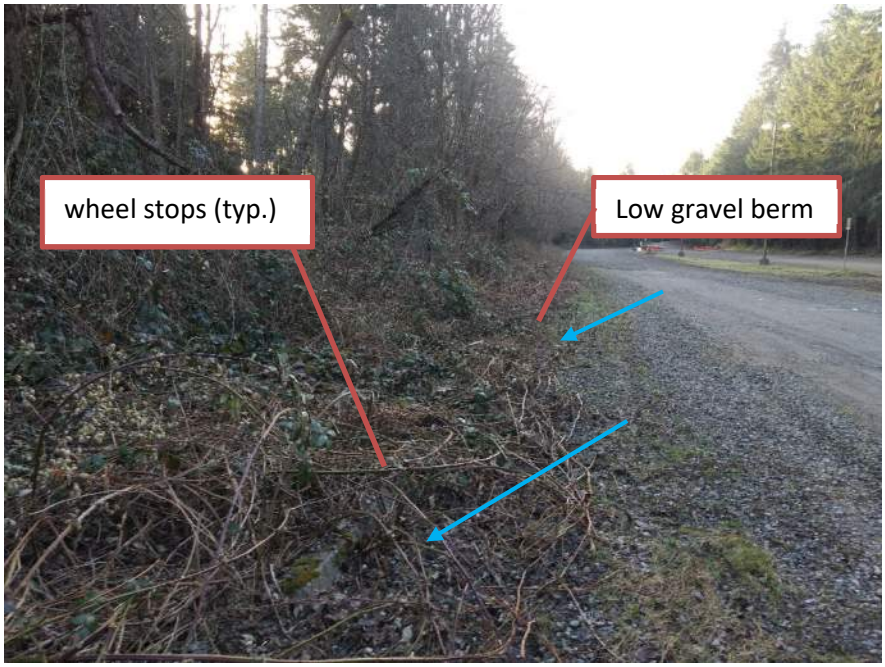


Photo 18: Northeast edge of gravel parking lot (facing southeast)

References

- King County Department of Public Works Division of Surface Water Management, Boeing Creek Project / M1 Dam Design Plans, 1983.

- City of Shoreline, Online Interactive GIS Maps. http://www.shorelinewa.gov/our-city/maps-gis/online-interactive-maps. Accessed 3/13/2019.

Appendix B

Hydrologic Model Subbasins

The following Figure B-1 shows the delineation of the eight (8) subbasins contributing to the South Branch of Bowing Creek upstream of M1 Dam. The land use inputs used to model these basins in WWHM-SWMM are provided in Table B-1 below. Resulting Peak flows for each basin are provided in Table B-2 below.

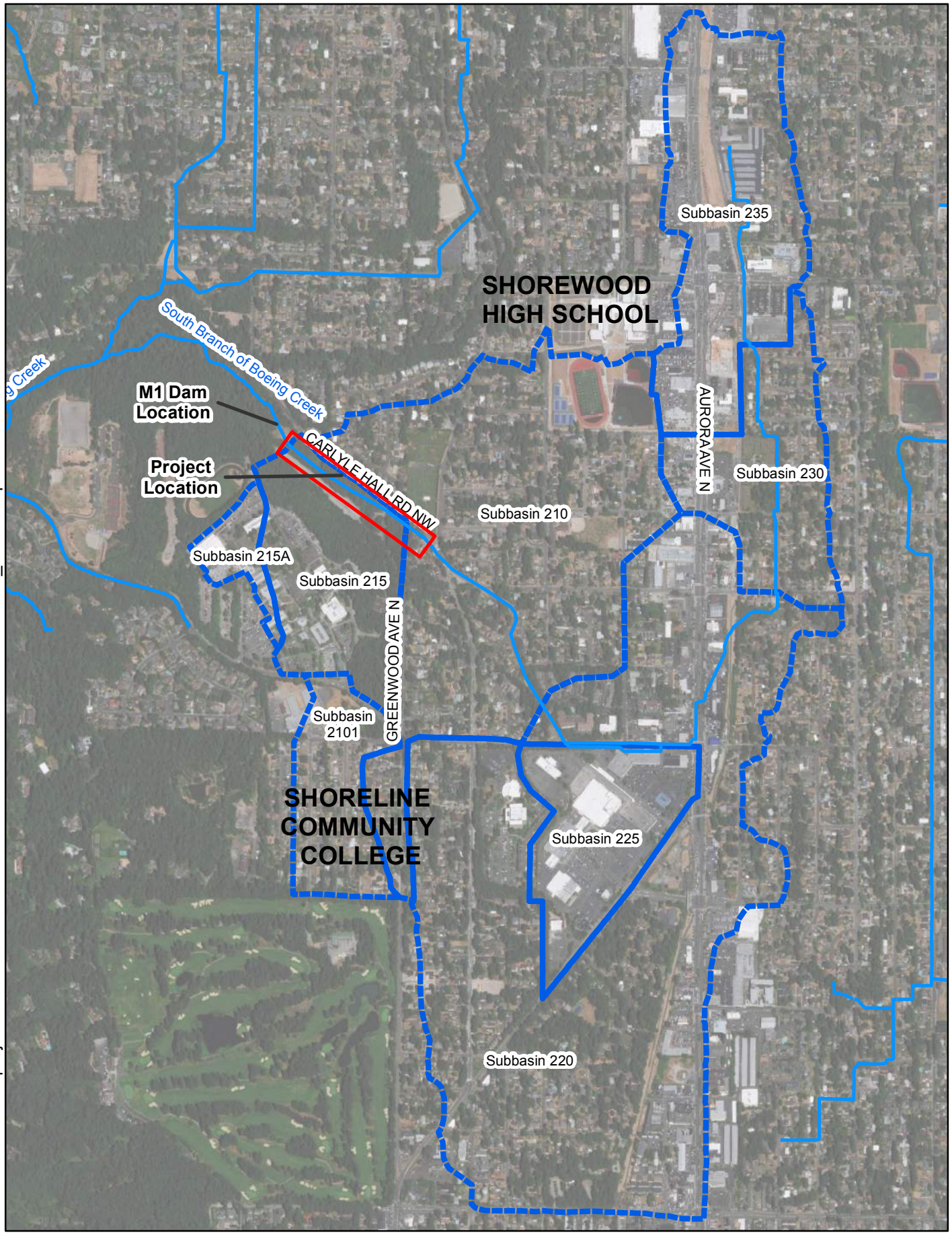
Table B-1—Existing Conditions Land Use

Drainage Basin	Pervious Area (ac)	Impervious Area (ac)	Total Basin Area (ac)
Subbasin 210	139.3	20.8	160.1
Subbasin 2101	24.8	4.1	28.9
Subbasin 215	40.7	5.9	46.6
Subbasin 215A	1.3	7.7	9.0
Subbasin 220	205.3	53.1	258.4
Subbasin 225	23.7	19.0	42.7
Subbasin 230	38.9	9.6	48.5
Subbasin 235	41.3	35.3	76.6
Basin Total	*515.3*	*155.5*	*670.8*

Table B-2—Existing Conditions Basin Hydrology

Drainage Basin	2-yr (cfs)	5-yr (cfs)	10-yr (cfs)	25-yr (cfs)	50-yr (cfs)	100-yr (cfs)
Subbasin 210	2.0	3.1	4.1	5.6	6.9	8.5
Subbasin 2101	0.4	0.7	0.9	1.2	1.4	1.8
Subbasin 215	0.5	0.8	1.0	1.3	1.6	1.9
Subbasin 215A	0.4	0.6	0.7	0.8	1.0	1.1
Subbasin 220	4.5	6.6	8.4	11.1	13.5	16.3
Subbasin 225	1.2	1.7	2.0	2.6	3.0	6.5
Subbasin 230	0.8	1.3	1.6	2.1	2.6	3.1
Subbasin 235	2.3	3.1	3.8	4.7	5.5	6.4
Basin Total	*49.0*	*69.6*	*85.9*	*109.8*	*130.2*	*153.0*

2731 Wetmore Avenue, Suite 300 Everett, WA 98201 ▪ Phone (425)493-5221 otak.com



Document Path: K:\project\32700\32713C21\CADD\GIS\MXDs\DeliverableTask21_Basin Map.mxd

Figure 5: Basin Map

1 inch = 1,100 feet

0 550 1,100 Feet

Date: 5/10/2019

Appendix C

Manning's Calculations

Channel Report

Hydraflow Express Extension for Autodesk® AutoCAD® Civil 3D® by Autodesk, Inc. Tuesday, May 7 2019

<Name>

Trapezoidal

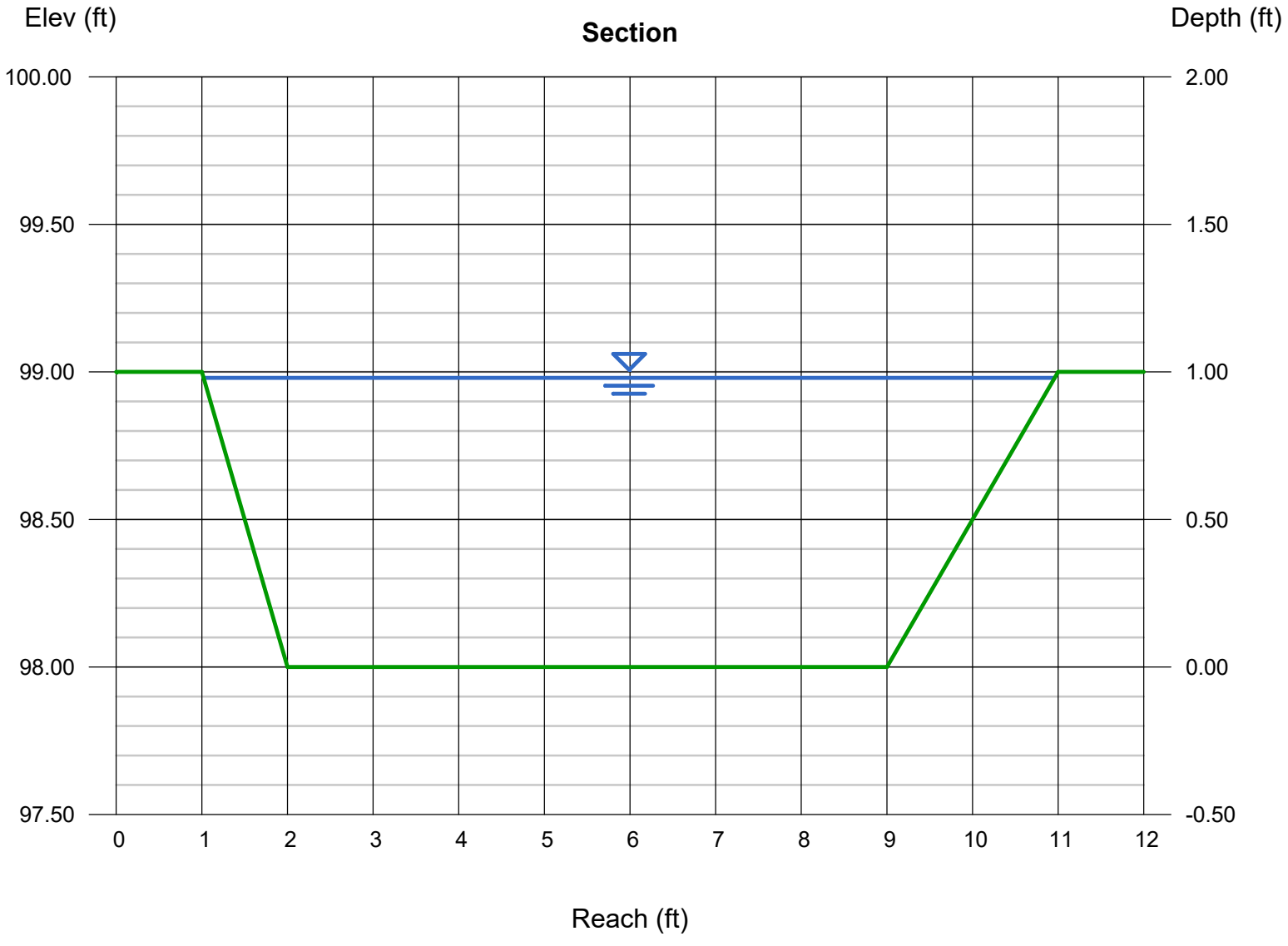
Bottom Width (ft)	= 7.00
Side Slopes (z:1)	= 1.00, 2.00
Total Depth (ft)	= 1.00
Invert Elev (ft)	= 98.00
Slope (%)	= 2.00
N-Value	= 0.030

Calculations

Compute by:	Known Q
Known Q (cfs)	= 49.00

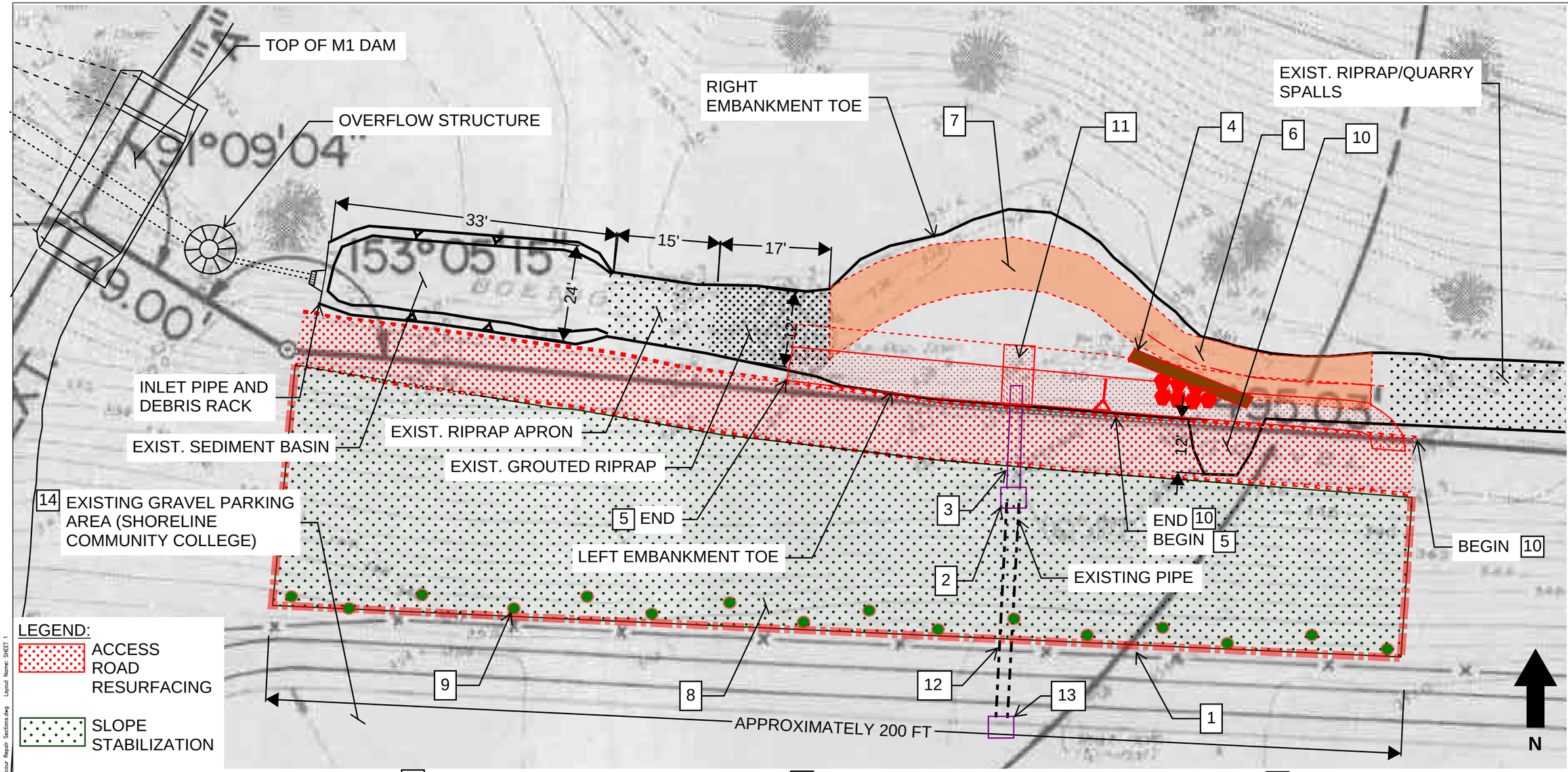
Highlighted

Depth (ft)	= 0.98
Q (cfs)	= 49.00
Area (sqft)	= 8.30
Velocity (ft/s)	= 5.90
Wetted Perim (ft)	= 10.58
Crit Depth, Yc (ft)	= 1.00
Top Width (ft)	= 9.94
EGL (ft)	= 1.52



Appendix D

Conceptual Repair Exhibits



CONSTRUCTION NOTES:

1 CLEARING AND GRUBBING LIMITS.

2 REPLACE CATCHBASIN WITH NEW TYPE 1 CB.

3 REPLACE PIPE WITH NEW 18" CPEP WITH DEBRIS RACK OUTLET.

4 INSTALL DEFLECTOR LOG, SEE SHEET 4.

5 CONSTRUCT ACCESS ROAD REPAIR TYPE 1. SEE TYPICAL SECTION DETAIL ON SHEET 2.

6 REMOVE FALLEN TREES AND BRUSH.

7 CONSTRUCT CHANNEL REPAIR, SEE DETAIL ON SHEET 2.

8 CONSTRUCT SLOPE STABILIZATION, SEE DETAIL ON SHEET 3.

9 PLANT NEW TREES AT LEAST 3' UPLAND FROM INUNDATION ZONE (TYP.)

10 CONSTRUCT ACCESS ROAD REPAIR TYPE 2, INCLUDING BACKFILLING SCOUR HOLE, SEE TYPICAL SECTION ON SHEET 2.

11 CONSTRUCT QUARRY SPALL OUTLET PROTECTION.

12 TV PIPE CONDITION AND REPLACE PIPE IF NECESSARY.

13 INSTALL TYPE 1 CB ON EXISTING PIPE.

14 COORDINATE WITH SHORELINE COMMUNITY COLLEGE TO ADDRESS PARKING LOT STORMWATER RUNOFF, INCLUDING DIRECTING FLOW TO PROPOSED CB.

M-1 DAM CHANNEL STUDY - PROPOSED CONCEPT IMPROVEMENTS SITE PLAN

NOT TO SCALE

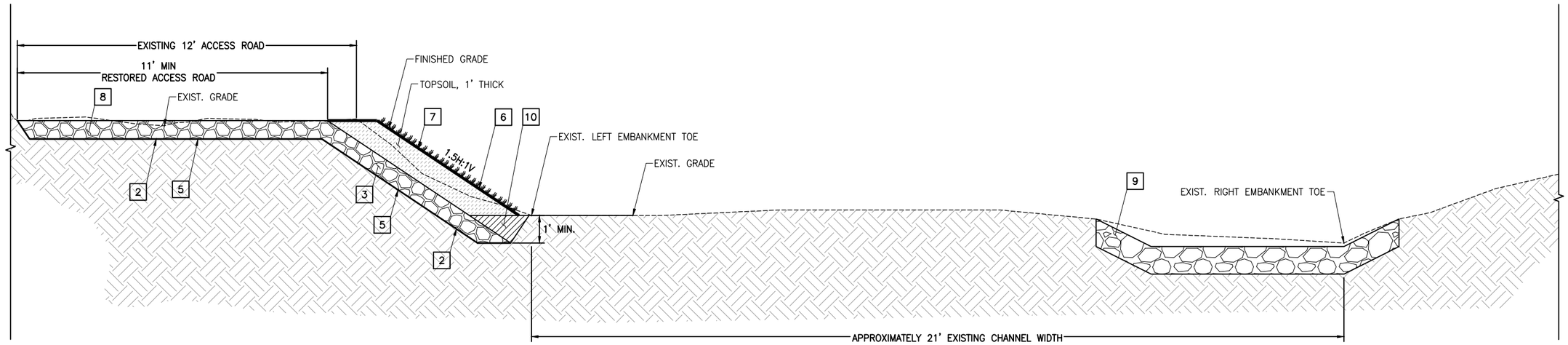
CONCEPTUAL PLAN - NOT FOR CONSTRUCTION

Otak
11241 Willows Road NE, Suite 200
Redmond, WA 98052
425.822.4446
www.otak.com

CITY OF SHORELINE
M-1 DAM ACCESS ROAD RESTORATION
CONCEPT

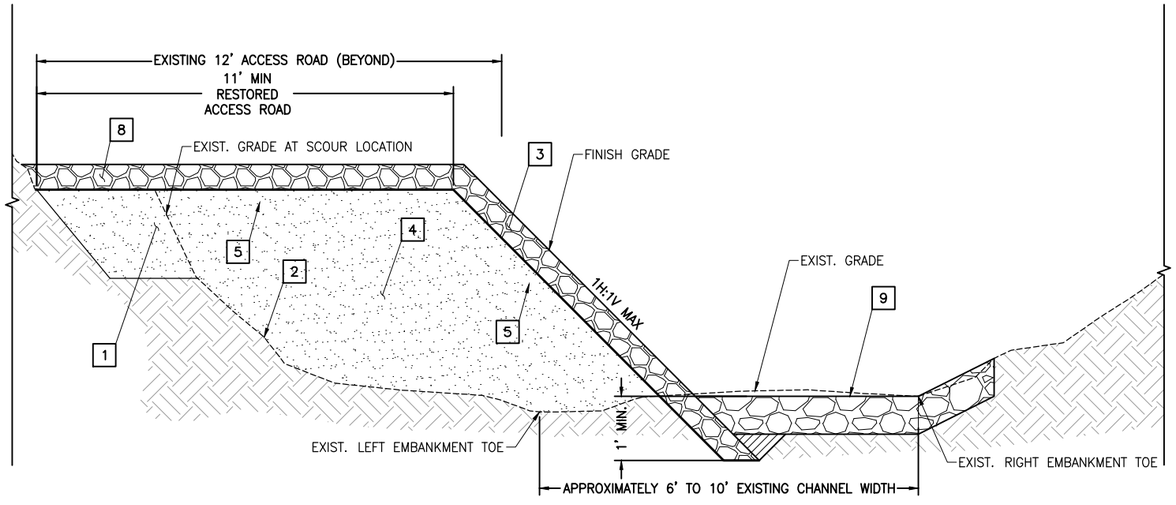
Date 5/29/2019

Job No. 32713.C21



ACCESS ROAD REPAIR: TYPE 1 TYPICAL SECTION

NOT TO SCALE



ACCESS ROAD REPAIR: TYPE 2 TYPICAL SECTION

NOT TO SCALE

GENERAL NOTES

1. INSTALL TEMPORARY BYPASS SYSTEM FOR CHANNEL FLOW PRIOR TO CONSTRUCTION.
2. INSTALL NECESSARY TEMPORARY EROSION CONTROL MEASURES TO PREVENT SEDIMENT FROM ENTERING DOWNSTREAM CHANNEL SYSTEM.

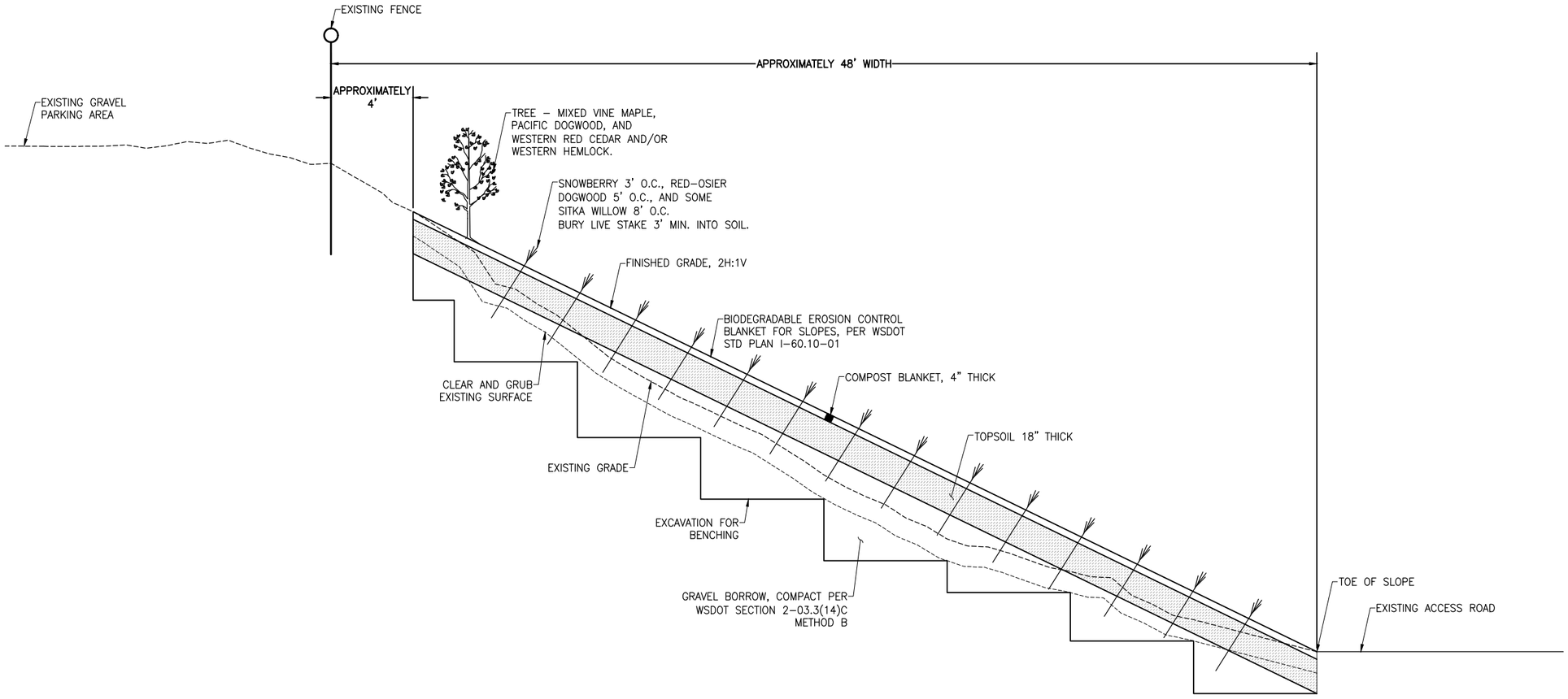
CONSTRUCTION NOTES

1. EXCAVATE EMBANKMENT AND COMPACT SUBGRADE.
2. CLEAR AND GRUB EXISTING EMBANKMENT.
3. INSTALL QUARRY SPALLS PER WSDOT STD SPEC 9-13.1(5), 8" THICK.
4. CONSTRUCT EMBANKMENT WITH GRAVEL BORROW PER WSDOT STD SPEC 9-13.1 COMPACT BY METHOD B PER WSDOT STD SPEC 2-03.3(14)C.
5. INSTALL NON-WOVEN GEOTEXTILE FOR UNDERGROUND DRAINAGE.
6. INSTALL BIODEGRADABLE EROSION CONTROL BLANKET FOR DITCHES PER WSDOT STD 9-14.5(2)D WITH 1"x2"x12" WOOD STAKES.
7. SEEDING, FERTILIZING AND MULCHING.
8. EXCAVATE 1' DEPTH AND RESURFACE ROAD WITH QUARRY SPALLS PER WSDOT STD SPEC 9-13.1(5), 8" THICK.
9. CHANNEL STABILIZATION, SEE TYPICAL SECTION ON SHEET 4.
10. BACKFILL WITH EXCAVATED NATIVE MATERIAL.

Otak
11241 Willows Road NE, Suite 200
Redmond, WA 98052
425.822.4446
www.otak.com

CITY OF SHORELINE
M-1 DAM ACCESS ROAD RESTORATION
CONCEPT

Date 5/29/2019
Job No. 32713.C21



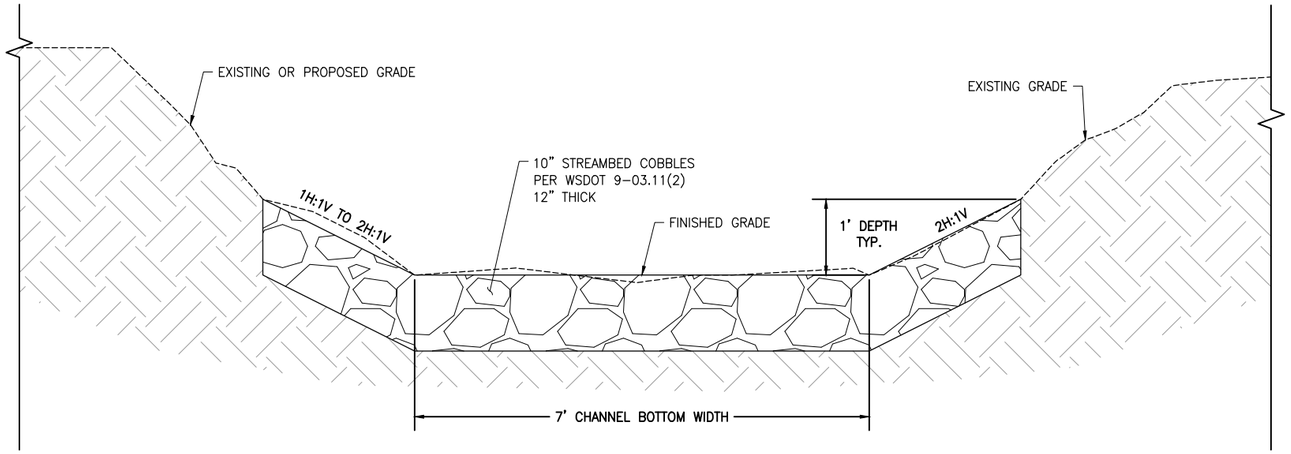
SLOPE STABILIZATION TYPICAL SECTION

NOT TO SCALE

Otak
11241 Willows Road NE, Suite 200
Redmond, WA 98052
425.822.4446
www.otak.com

CITY OF SHORELINE
M-1 DAM ACCESS ROAD RESTORATION
CONCEPT

Date 5/29/2019
Job No. 32713.C21

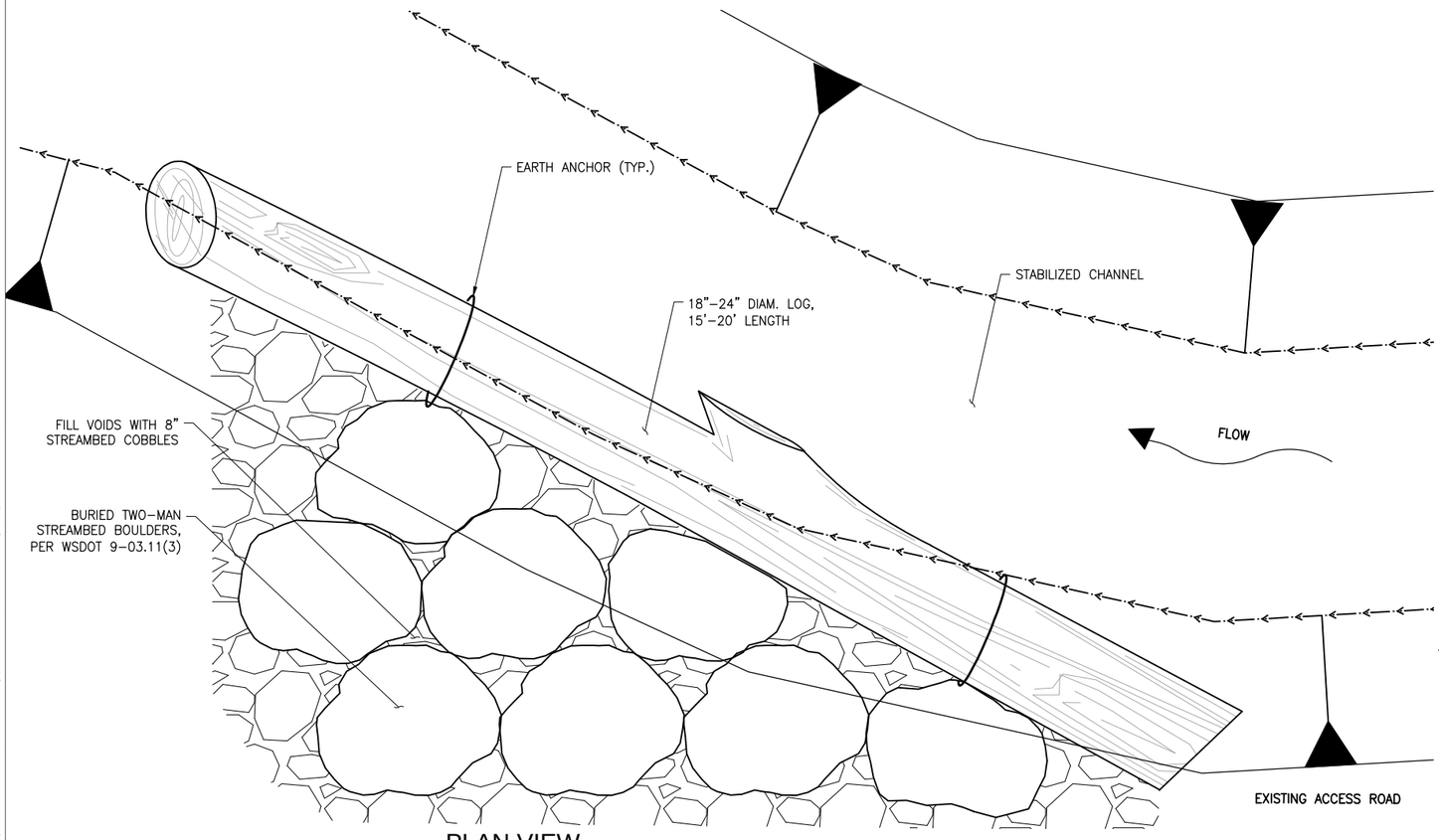


CHANNEL STABILIZATION TYPICAL SECTION

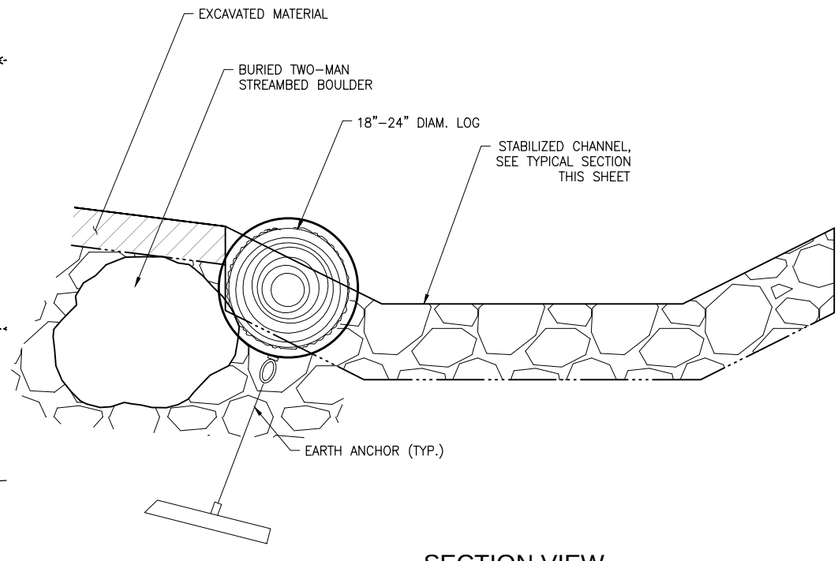
NOT TO SCALE

GENERAL NOTES

1. INSTALL TEMPORARY BYPASS SYSTEM FOR CHANNEL FLOW PRIOR TO CONSTRUCTION.
2. INSTALL NECESSARY TEMPORARY EROSION CONTROL MEASURES TO PREVENT SEDIMENT FROM ENTERING DOWNSTREAM CHANNEL SYSTEM.



PLAN VIEW



SECTION VIEW

DEFLECTOR LOG WITH BURIED BOULDERS

NOT TO SCALE

Otak
11241 Willows Road NE, Suite 200
Redmond, WA 98052
425.822.4446
www.otak.com

CITY OF SHORELINE
M-1 DAM ACCESS ROAD RESTORATION
CONCEPT

SHEET 4 OF 4
Date 5/29/2019
Job No. 32713.C21

Appendix E

Preliminary Cost Estimate

City of Shoreline

Channel Study of M1 Dam - Recommended Repair Improvements

Construction Cost Estimate - Planning Level

Last Updated: 5/29/2019

Item No.	Spec. Section	Description	Unit	Total Quantity	Unit Price	Total Amount
		DIVISION 1 - GENERAL REQUIREMENTS				
1	1-09	Mobilization (10%)	LS	1	$ 41,861.00	$ 41,861.00
2	1-10	Project Temporary Traffic Control	LS	1	$ 10,000.00	$ 10,000.00
		DIVISION 2 - EARTHWORK				
3	2-01	Clearing and Grubbing	LS	1	$ 25,000.00	$ 25,000.00
4	2-02	Removal of Structure and Obstruction	LS	1	$ 2,000.00	$ 2,000.00
5	2-03	Channel Excavation Incl. Haul	CY	710	$ 40.00	$ 28,400.00
6	2-03	Gravel Borrow Incl. Haul	TN	1,150	$ 35.00	$ 40,250.00
7	2-09	Shoring or Extra Excavation Class B	LS	1	$ 10,000.00	$ 10,000.00
		DIVISION 4 - BASES				
		DIVISION 7 - DRAINAGE STRUCTURES, STORM SEWERS, SANITARY SEWERS, WATER MAINS, AND CONDUITS				
8	7-04	Corrugated Polyethylene Storm Sewer Pipe 18-In. Diam.	LF	58	$ 200.00	$ 11,600.00
9	7-05	Catch Basin Type 1	EA	2	$ 2,000.00	$ 4,000.00
10	7-05	Debris Rack	EA	1	$ 1,000.00	$ 1,000.00
11	7-05	Connection to Drainage Structure	EA	1	$ 1,000.00	$ 1,000.00
		DIVISION 8 - MISCELLANEOUS CONSTRUCTION				
12	8-01	Erosion Control and Water Pollution Prevention	LS	1	$ 10,000.00	$ 10,000.00
13	8-01	Biodegradable Erosion Control Blanket	SY	980	$ 5.00	$ 4,900.00
14	8-01	Seeding, Fertilizing, and Mulching	LS	1	$ 2,000.00	$ 2,000.00
15	8-02	Topsoil Type A	CY	480	$ 40.00	$ 19,200.00
16	8-02	Compost Blanket	SY	890	$ 5.00	$ 4,450.00
17	8-02	Live Stake Row	EA	880	$ 10.00	$ 8,800.00
18	8-02	Revegetation- Ravine Slope	SY	890	$ 25.00	$ 22,250.00
19	8-02	PSIPE (tree)	EA	16	$ 300.00	$ 4,800.00
20	8-27	Temporary Stream Diversion	LS	1	$ 10,000.00	$ 10,000.00
21	8-28	Streambed Cobbles 10 in.	TN	110	$ 70.00	$ 7,700.00
22	8-28	Streambed Boulder Two Man	EA	8	$ 300.00	$ 2,400.00
23	8-28	Deflector Log Structure	EA	1	$ 5,000.00	$ 5,000.00
24	8-30	Quarry Spalls	TN	270	$ 50.00	$ 13,500.00
25	8-30	Non-woven Geotextile	SY	400	$ 5.00	$ 2,000.00
		Subtotal Construction Cost				**$ 292,111.00**
		Design Contingency		***30%***		**$ 87,700.00**
		Sales Tax		***10.2%***		**$ 38,800.00**
		Construction Cost				**$ 418,611.00**
		Engineering/Legal/Admin		***30%***		**$ 125,600.00**
		Permitting		***15%***		**$ 62,800.00**
		Construction Management		***20%***		**$ 83,800.00**
		Total				**$ 691,000.00**

NOTES

1 The above cost opinion is in 2019 dollars and does not include future escalation, financing, or O&M costs.

2 The order-of-magnitude cost opinion has been prepared for guidance in project evaluation from the information available at the time of preparation and for the assumptions stated. The final costs of the project will depend on actual labor and material.