City of Lacey, Washington
Utilities Committee Agenda

Refer to bottom of the agenda for instructions on attendance.

Monday, July 3, 2023	12:00 PM	Council Chambers and Online

1. **Roll Call**
2. **Agenda Items**
   A. **Draham Road Annexation**
   Ryan Andrews, Planning Manager
3. **Adjourn**

Attend Remote or In Person

The public may attend the meeting in person, or you may view or listen to the meeting using one of the following platforms:

In Person:	Council Chambers at Lacey City Hall, 420 College Street SE, Lacey, WA 98503
Via Zoom:	https://us02web.zoom.us/j/81422459484
City Website:	https://cityoflacey.org/upcoming-meetings/
Facebook:	https://www.facebook.com/cityoflacey
YouTube:	https://www.youtube.com/watch?v=YSpDCqEO964
By Phone:	(888) 788-0099 or (877) 853-5247 (Webinar ID 814 2245 9484)

UTILITIES COMMITTEE
July 3, 2023

SUBJECT:	**Draham Road Annexation. Project no. 23-160.**
RECOMMENDATION:	**Motion: Recommend to the full council that a resolution be approved to proceed with the proposed Draham Road Annexation proposal utilizing the unincorporated island method (RCW 35A.14.295). Additional staff analysis will be provided at the full council meeting.**
STAFF CONTACT:	Rick Walk, Interim City Manager RW Grant Beck, Planning and Development Services Manager Ryan Andrews, Planning Manager RA
ORIGINATED BY:	Community and Economic Development Department
ATTACHMENTS:	1. Notice of Intent to Commence Annexation 2. Map of Notice of Intention Parcels 3. Map of Expanded Area 4. Existing Zoning 5. Aerial Photo 6. Existing Sewer Lines 7. Existing Water Lines and Service Areas 8. Agency Comments
FISCAL NOTE:	See background.
WORK PLAN GOAL AND STRATEGY:	Coordinated and Collaborative Planning - (A)(3&4)
PRIOR REVIEW:	None.

BACKGROUND:

The City has received a notice of intent to commence annexation proceedings filed by Three's Company LLC. The filing of the notice is the first step in the annexation process under the petition method (RCW 35A.14.120), which requires a petition filed by property owners representing a minimum of 10% of the valuation of the area proposed for annexation. The City has verified that the ownership does comprise a minimum of more than 10% of the assessed valuation for general taxation purposes of the properties for which annexation is requested.

As a result of the petition, the Utilities Committee will review the annexation proposal to verify that the City can effectively provide utility service to the proposed annexation area and identify any significant costs to the City associated with the application.

Additionally, the Committee will review the boundaries of the annexation area for any recommended modifications. Because the proposed annexation would create an unincorporated island to the east, staff is recommending that the City lead the annexation utilizing the Unincorporated Island Method (RCW 35A.14.295) as the area contains residential property and at least 80 percent of the annexation boundary is contiguous to the city limits boundary.

The City Council does have the option to move forward with the annexation of the parcels in the Notice of Intent using the petition method (RCW 35A.14.120), however, it is anticipated that the Boundary Review Board for Thurston County would assert jurisdiction over the annexation. This would likely require the City to annex the remaining unincorporated island. The most efficient method of annexation is the Unincorporated Island Method.

Proposed Annexation Area

The area proposed for annexation is primarily located within the Pleasant Glade Planning Area and within the Lacey Urban Growth Area west of Judd Street SE, north of 15th Avenue NE/Draham Road NE, south of the existing Cuoio Park boundary and west of the existing city limits boundary. The area includes 189 tax parcels totaling approximately 210 acres. The properties contain a mixture of single-family residential uses on larger lots. The area also includes critical areas and their buffers primarily associated with Woodland and Eagle Creek. The 2022-2023 assessed value of the proposed annexation area is $55,927,000.

The annexation contains a variety of residential zoning including Low Density 0-4 and Low Density 3-6 which would be converted to the Lacey designation of Low Density Residential upon annexation. Other zones include Moderate and High Density Residential and Agriculture which will all be retained upon annexation as required by an annexation agreement with Thurston County. There are several known critical areas including Woodland Creek which will be designated with an Urban Conservancy shoreline environment as well as Eagle Creek which will receive an Open Space Institutional designation for protection consistent with the City of Lacey requirements for habitat conservation areas protection (LMC 14.33).

The annexation area contains two projects with vested land use approvals. Ventura Crossing is located on 15th Avenue NE west of Judd Street NE and is a 69-unit single-family subdivision. Williams Crossing is located to the east of Ventura Crossing and is a 216-unit multi-family apartment complex. Upon annexation, the land use approvals for these projects would be transferred to the City of Lacey and final design, permits, and construction would occur in the city.

Annexation Boundary

The area proposed for annexation is a logical extension of the city limits and would not create any islands or illogical boundaries. With the submittal of the 10% petition, the area proposed for annexation would create an unincorporated island. Therefore, staff is recommending that the City Council modify the boundary to eliminate the island and utilize the unincorporated island method of annexation.

Utilities

The properties are located primarily within the City of Lacey's water service area. There is one small private water system at the northern portion of the Woodland Creek Estates subdivision known as the Covington 212 Water Service Area. Water service is provided by an existing 12-inch waterline located in 15th Avenue NE/Draham Road NE. The line is adequate to serve the existing and future development of the properties within the area, however, this could change if any significant rezoning was to occur in the area. There is limited water service within the Carpenter Road NE area of the annexation.

City of Lacey sewer service in the area is relatively limited. A small 4-inch force main serves the STEP system within Woodland Creek Estates. With the installation of a sewer lift station on the south side of 15th Avenue NE associated with the Modera Apartments, additional sewer service can be better served in this area.

The area is also served by private utilities including Puget Sound Energy and Comcast. No issues are expected concerning provision of these utilities to the area.

Taxes, Fees, and Services

Since 2015, the City of Lacey has annexed a total of 1,522 acres (2.4 square miles) adding nearly 15% to the geographical area of the city and serving an additional 2,863 residents. It is important to recognize the cumulative impact of these recent annexations, and while city services have been extended to these areas, no additional staff have been directly added as a result. The following identifies the recent annexations since 2015:

Property owner-initiated:

2015	Hill-Betti	150 acres	193 residents
2017	NTPS Marvin Rd.	72 acres	
2017	Martin Way East	7 acres	
2018	Barr	10 acres	
2020	Mullen Road	67 acres	3 residents
2021	Serenity Carpenter Rd.	3 acres	
2021	Mosure 54th Ave.	10 acres	
2021	Steilacoom/Marvin	410 acres	1,589 residents
Total		**729 acres**	**1,785 residents**

City-initiated:

2017	Cuoio Park	330 acres	
2017	Gateway Div. 2	80 acres	
2021	Capitol City/Chambers Estates	288 acres	978 residents
2022	Lake Lois	95 acres	100 residents
Total		**793 acres**	**1,078 residents**

The annexation area will generate property tax revenue for the City of Lacey associated with approximately $56 million in assessed value for a total estimate of $38,000 in property tax per year. Additionally, revenue will be generated through utility and sales tax revenue. It is anticipated that providing City services to the area will exceed the revenue associated with the annexation.

Comments on the proposed annexation were received from several departments. The Lacey Police Department has stated that the calls for service from the annexation area have historically been very low. However, the Department did have general concerns with serving the area given the additional demands that will be needed to serve new development on a street network that has not yet been developed to its full capacity (particularly 15th/Draham). Lacey Police are already utilizing these existing streets and these issues will occur whether or not annexation occurs.

The Lacey Public Works Department commented on the transportation infrastructure needed in the area. Both 15th Avenue NE/Draham Road NE and Carpenter Road NE are planned to be constructed to a 4 or 5-lane section including the full suite of multi-modal improvements. Overall, the existing pavement condition in the area, except for two sections of Draham and 15th, which need to be repaved within 1-3 years. The culvert crossing Draham Road at Woodland Creek is in need of replacement as well. All of these projects would have significant long-term costs associated with them and a broad estimate of the total project would be around $60 million.

Comments on stormwater maintenance were also provided. The main concern is maintenance of existing facilities (catch basins, swales, and vegetation). Additionally, an existing culvert on Carpenter Road NE for the Eagle Creek crossing is overgrown with vegetation and a make-shift grate was constructed to prevent debris from entering the culvert made out of sign posts. Staff indicates that vegetation will need to be removed and a proper debris grate installed in this location.

Lacey Fire District 3 provides services to all but one property in the annexation area which is provided by Fire District 8 (South Bay). According to RCW 52.04.091, any future annexations into a city that has annexed into a fire district shall also be annexed into that fire district. Since Lacey annexed into Fire District 3 several years ago, any future annexations not currently within Fire District 3 are also annexed into Fire District 3.

Process

The applicant has submitted a notice of intent to commence annexation using the petition method of annexation (RCW 35A.14.120). Using the petition method, property owners representing a minimum of 10 percent of the assessed valuation of the property proposed for annexation are required to submit the notice. After filing the petition, the City Council must pass a motion notifying the petitioners of its approval, rejection, or modification of the annexation area's geographical boundaries. Because the proposed annexation would create an unincorporated island to the east, staff is recommending that the City lead the annexation utilizing the Unincorporated Island Method (RCW 35A.14.295) as the area contains residential property and at least 80 percent of the annexation boundary is contiguous to the city limits boundary. The Utilities Committee is requested to recommend to the full council that a resolution be approved to proceed with the proposed Draham Road Annexation proposal utilizing the unincorporated island method (RCW 35A.14.295).

ADVANTAGES:

1. Annexation of the area will eliminate a potential unincorporated island and will create more logical city limit boundaries.

2. Annexation of the area is consistent with City Council priorities for annexation.

DISADVANTAGES:

1. The additional city services provided to the area will generally cost more than the revenue generated. When coupled with other recent annexations, there is a cumulative impact to the level of city services that can be provided unless staffing levels increase.

2. While the short-term costs associated with services and not substantial, the long-term costs primarily associated with the transportation infrastructure needs of the area are significant.

NOTICE OF INTENT TO COMMENCE ANNEXATION PROCEEDINGS

The following owners of land do hereby certify that we are the owners of not less than 10% in value, according to assessed valuation for general taxation, of the following described property (as generally described on the attached exhibit and legal description) which is contiguous to the City of Lacey and hereby provide notice to the City Council of the City of Lacey of the landowners intent to commence annexation proceeding pursuant to Ordinance 510. Pursuant to Section 35A.14.120 of the Revised Code of Washington, the landowners request the Council to set a public meeting at which time this annexation proposal may be considered.

Exhibit and Legal Description (see attached)

Warning: Every person who signs this notice with any other that his or her true name, or who knowingly signs more than one of these petitions, or signs a petition seeking an election when he or she is not a legal voter, or signs a petition when he or she is otherwise not qualified to sign, or who makes herein any false statement, shall be guilty of a misdemeanor.

Property Owner	Signature	Date	Address	Acreage	Parcel No.
Three's Company, LLC	[signature] Managing Member	6/3/2023	5216 NE 15th Av	4.92	11809310100
Three's Company, LLC	[signature] Managing Member	6/3/2023	5228 NE 15th Av	9.15	11809310600
Three's Company, LLC	[signature] Managing Member	6/3/2023	5224 NE 15th Av	4.63	11809310700

I hereby certify that I have examined the above petition as well as the Assessor's rolls for the area described and I have determined that the petitioners are the owners of not less than 10% in value, according to the assessed valuation for general taxation, of the described area to be annexed.

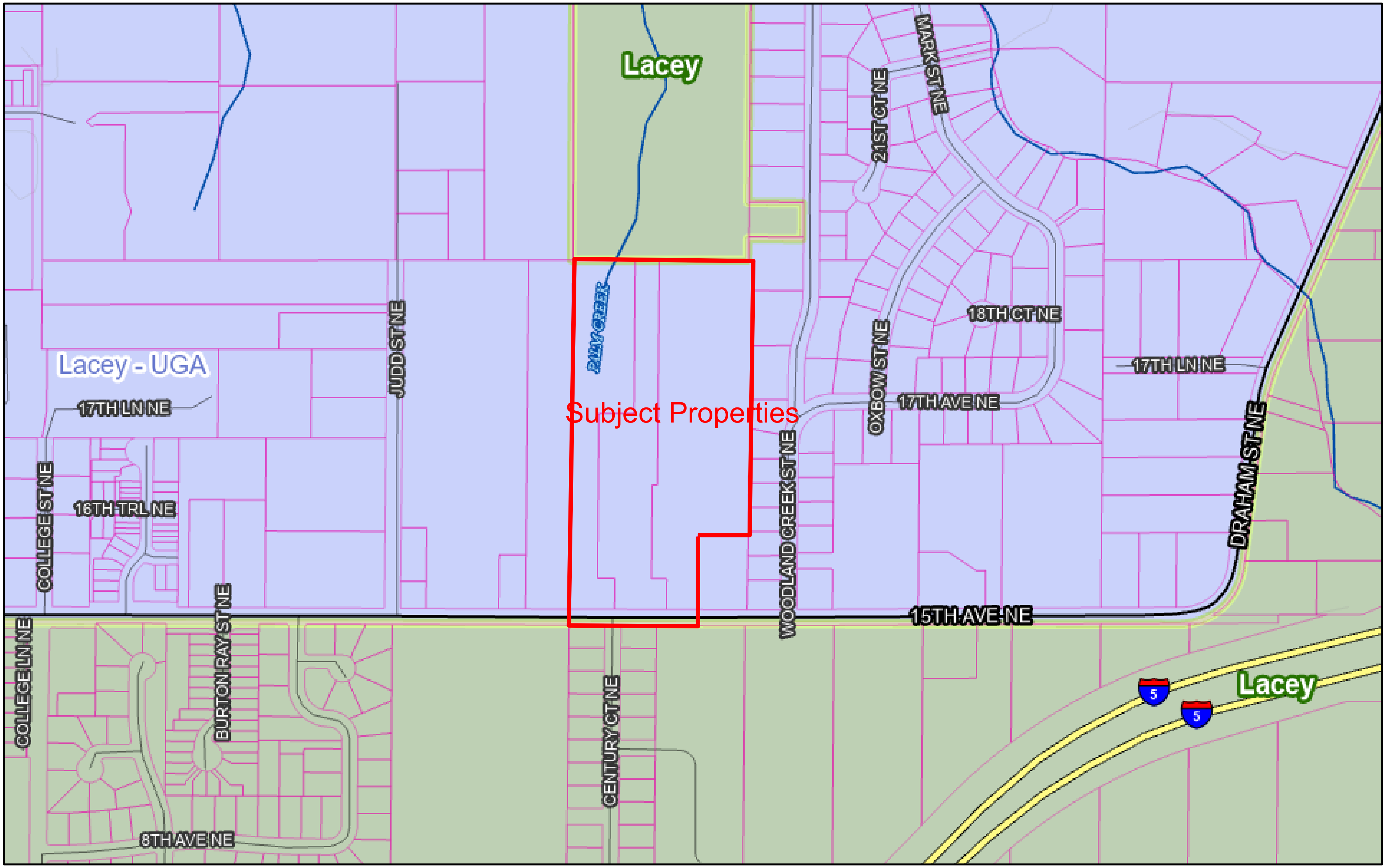
In determining whether this petition contains the signatures of owners of not less than 10% in value according to the assessed valuation for general taxation purposes I have used the same method that the Thurston County Assessor would use to define assessed valuation for general taxation purposes as the date affixed below.

Signed this ____________ day of ____________, 20__

____

Director, Community & Economic Development Department

Draham Road Annexation 10% Notice of Intention



6/8/2023, 10:00:05 AM

UGA
City Limits
Stream
Lacey Streets
Interstate 5
Major Roads
Minor Roads
Unnamed
Lacey Area Parcels

1:9,028

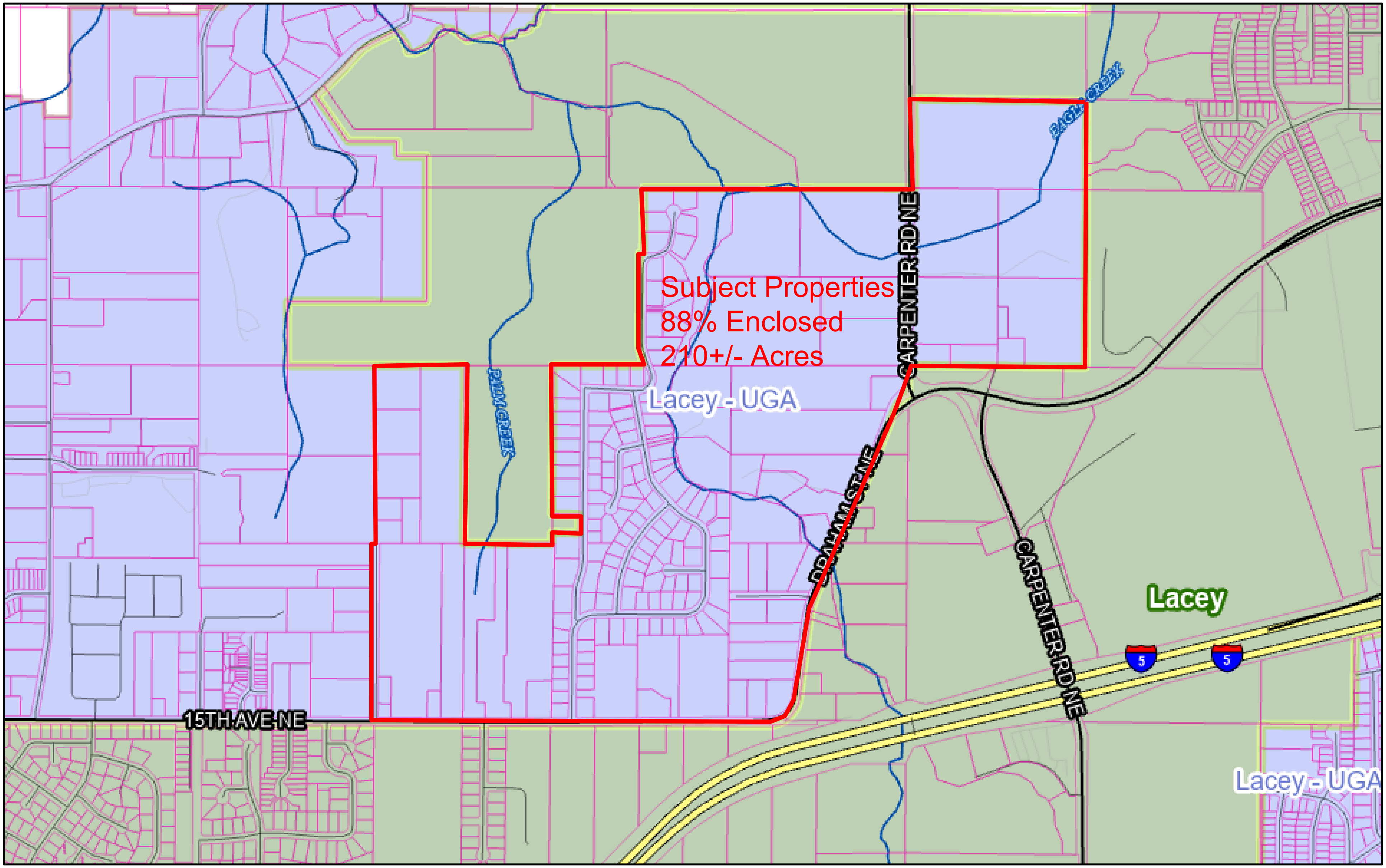
0 0.05 0.1 0.2 mi

0 0.07 0.15 0.3 km

GIS Coordinator, City of Lacey

Lacey C&ED

Draham Road Annexation of Unincorporated Island Alternative



6/8/2023, 9:20:09 AM

UGA
City Limits
Stream
Lacey Streets
Interstate 5
Major Roads
Minor Roads
Unnamed
Lacey Area Parcels

1:18,056

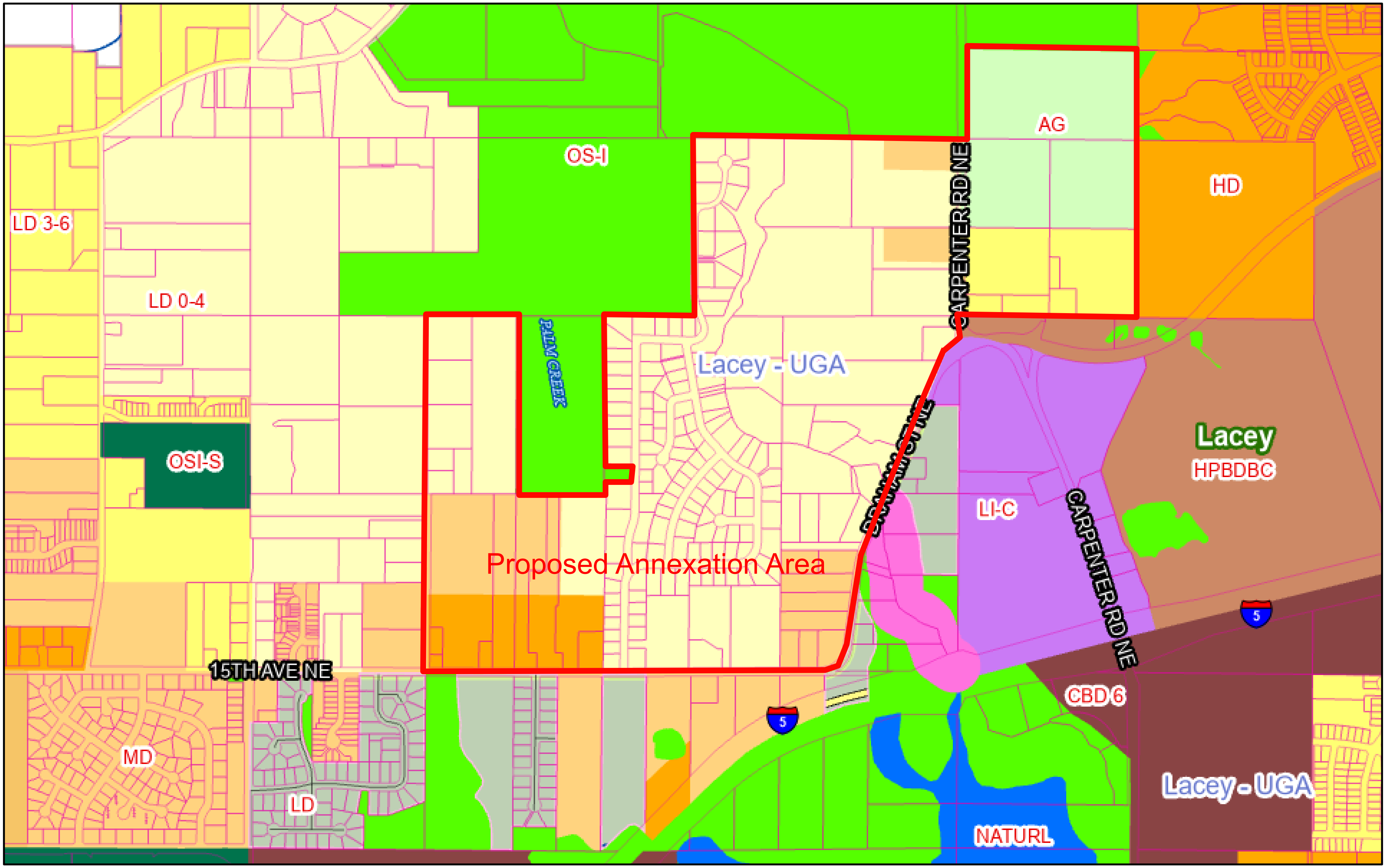
0 0.1 0.2 0.4 mi

0 0.15 0.3 0.6 km

GIS Coordinator, City of Lacey

Lacey C&ED

Draham Road Annexation Zoning



6/20/2023, 8:50:38 AM

Lacey Zoning

- LD 0-4 Low Density Residential
- LD 3-6 Low Density Residential
- MD Moderate Density Residential
- HD High Density Residential
- MMDC Mixed Use Moderate Density Corridor
- HPBD-BC Hawks Prairie Business District (Business/Comm.)

1:18,056

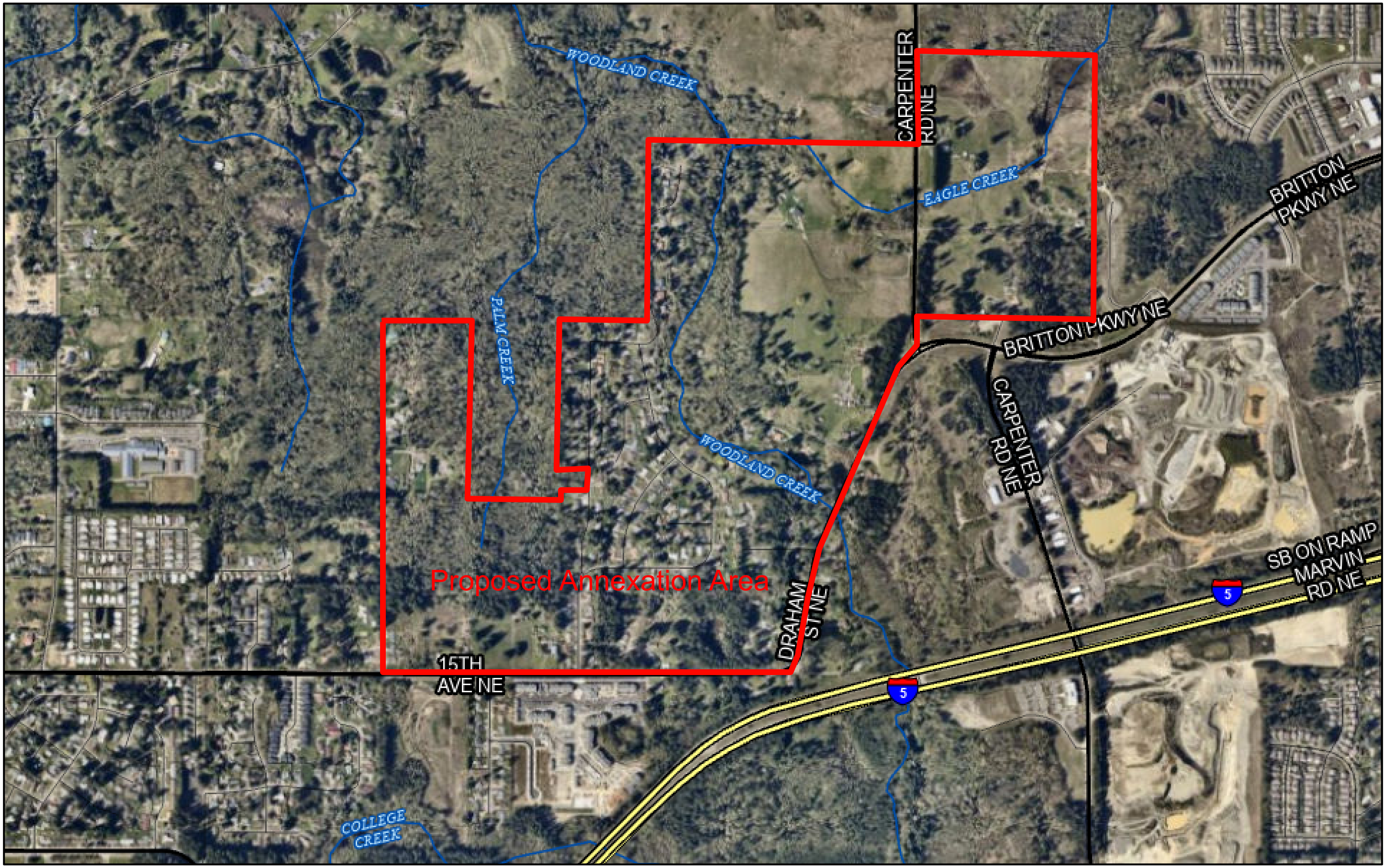
0 0.1 0.2 0.4 mi

0 0.15 0.3 0.6 km

GIS Coordinator, City of Lacey

Lacey C&ED

Draham Road Annexation Aerial Photo



6/20/2023, 9:01:35 AM

Stream
Lacey Streets
Interstate 5
Major Roads
Minor Roads
Unnamed
Major Roads
Interstate 5
Major Roads

1:18,056

0 0.1 0.2 0.4 mi

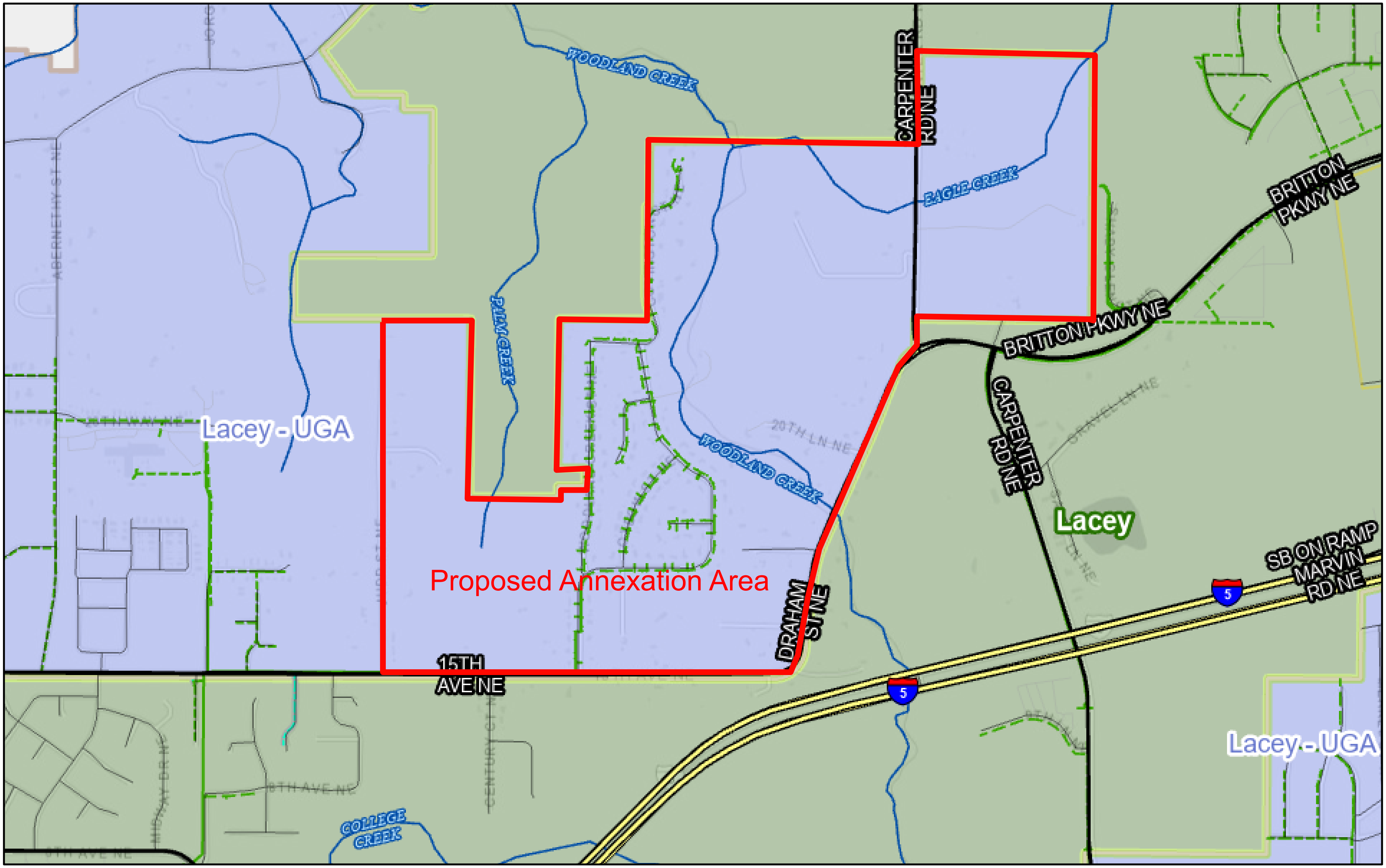
0 0.15 0.3 0.6 km

Bureau of Land Management, Esri, HERE, Garmin, GeoTechnologies, Inc., USGS, EPA, GIS Coordinator, City of Lacey

ArcGIS Web AppBuilder

Bureau of Land Management, Esri, HERE, Garmin, GeoTechnologies, Inc., USGS, EPA | GIS Coordinator, City of Lacey |

Draham Road Annexation Sewer Lines



6/20/2023, 8:58:00 AM

Sewer Main
- Force Main, COL
- Gravity Main, COL
- STEP Main, COL
- Force Main, PVT/Other
- <all other values>
- UGA
- City Limits
- Stream

Lacey Streets
- Interstate 5
- Major Roads
- Minor Roads
- Unnamed

Major Roads
- Interstate 5
- Major Roads

1:18,056

0 | 0.1 | 0.2 | 0.4 mi

0 | 0.15 | 0.3 | 0.6 km

Bureau of Land Management, Esri, HERE, Garmin, GeoTechnologies, Inc., USGS, EPA, GIS Coordinator, City of Lacey

ArcGIS Web AppBuilder

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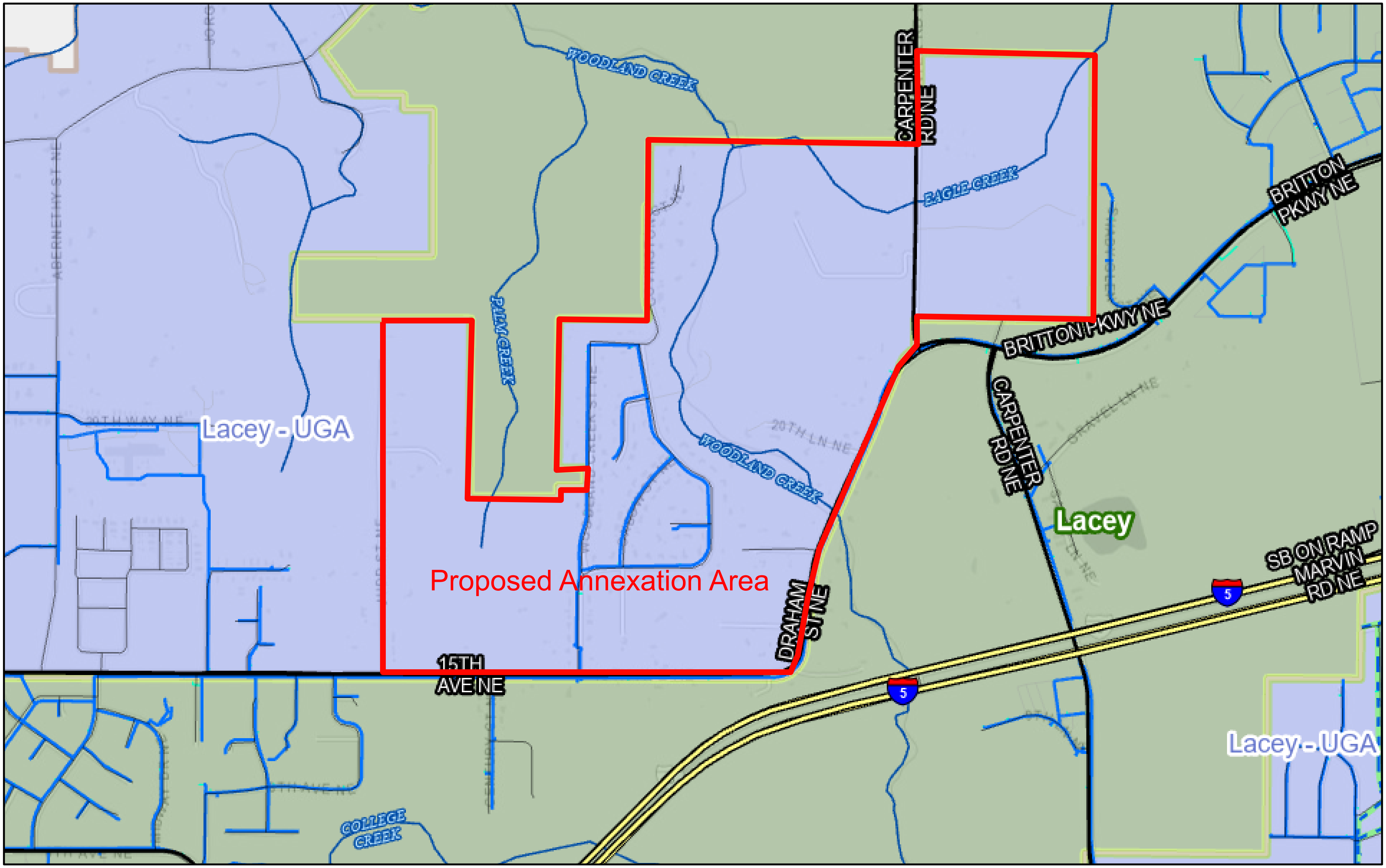
Draham Road Annexation Water Lines



6/20/2023, 8:59:11 AM

1:18,056

0 0.1 0.2 0.4 mi

0 0.15 0.3 0.6 km

Water Mains
- WS, COL
- WS, PVT/OTHER
- WM, COL
- Private Water System
- UGA
- City Limits
- Stream

Lacey Streets
- Interstate 5
- Major Roads
- Minor Roads
- Unnamed

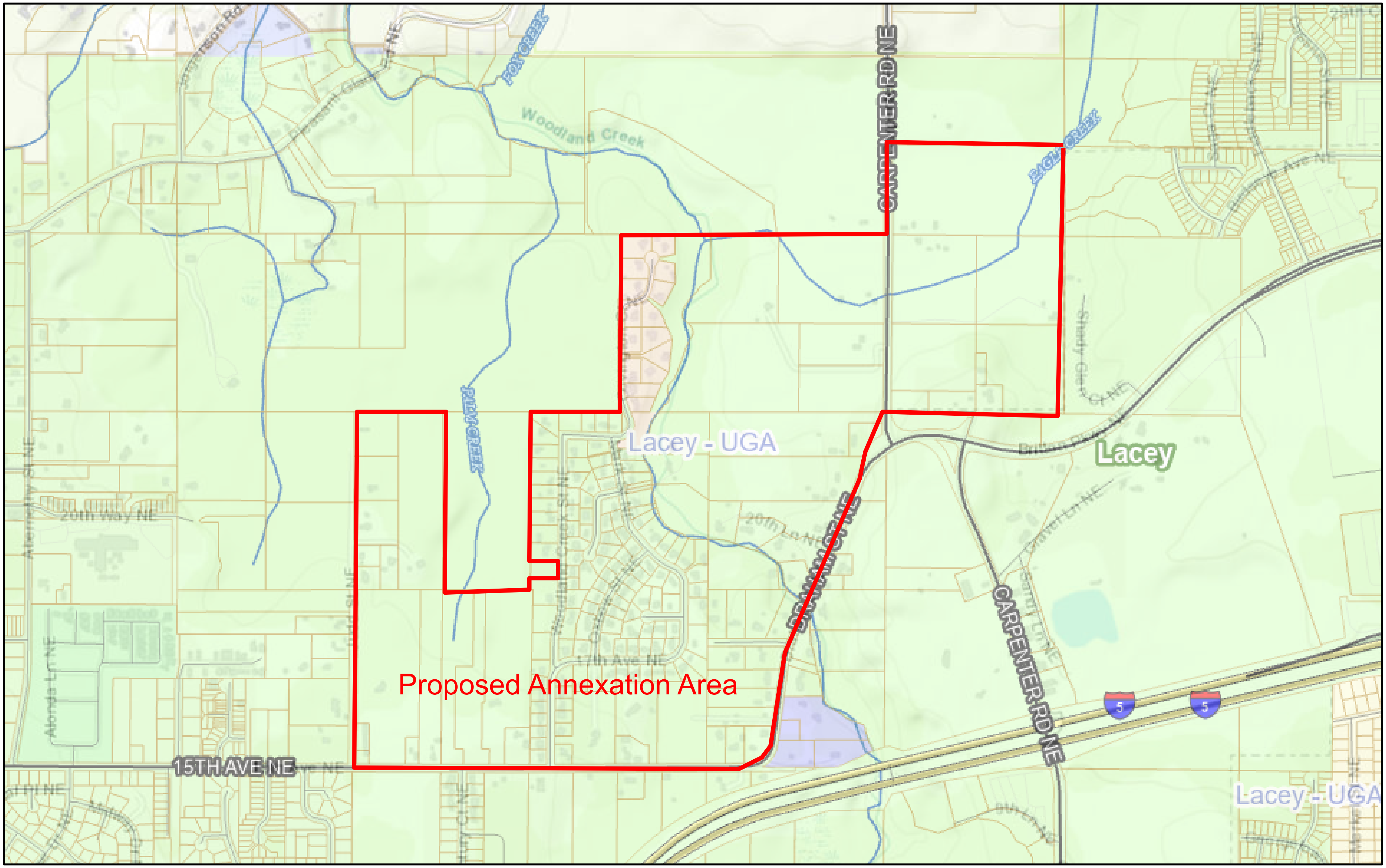
Major Roads
- Interstate 5
- Major Roads

Bureau of Land Management, Esri, HERE, Garmin, GeoTechnologies, Inc., USGS, EPA, GIS Coordinator, City of Lacey

ArcGIS Web AppBuilder

Bureau of Land Management, Esri, HERE, Garmin, GeoTechnologies, Inc., USGS, EPA | GIS Coordinator, City of Lacey |

Draham Road Annexation Water Service Areas



6/20/2023, 9:12:29 AM

Lacey Area Parcels

Water Service Areas

ALONDA VILLA

CAMPBELL, THOMAS

COVINGTON 212

LACEY

TANGLEWILDE #600

UGA

City Limits

Stream

Lacey Streets

Interstate 5

Major Roads

Minor Roads

Unnamed

1:18,056

0 0.1 0.2 0.4 mi

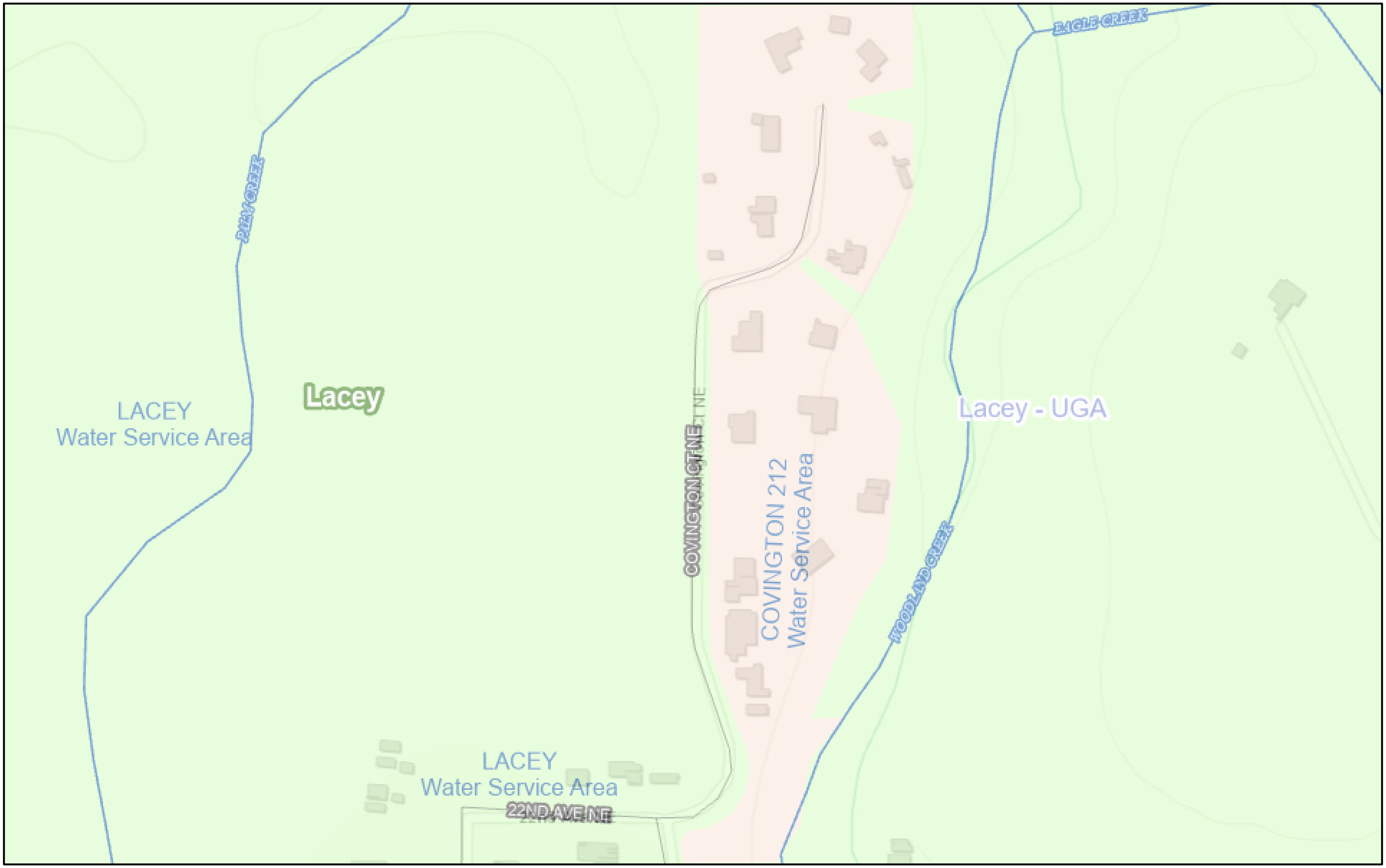
0 0.15 0.3 0.6 km

Bureau of Land Management, Esri Canada, Esri, HERE, Garmin, INCREMENT P, USGS, METI/NASA, EPA, USDA, GIS Coordinator

ArcGIS Web AppBuilder

Bureau of Land Management, Esri Canada, Esri, HERE, Garmin, INCREMENT P, USGS, METI/NASA, EPA, USDA | GIS Coordinator |

Covington 212 Water Service Area



6/20/2023, 9:06:55 AM

Water Service Areas
COVINGTON 212
LACEY
UGA
City Limits
Stream
Lacey Streets
Minor Roads
Unnamed

1:4,514

0 | 0.03 | 0.05 | 0.1 mi

0 | 0.04 | 0.08 | 0.16 km

GIS Coordinator, Bureau of Land Management, Esri Canada, Esri, HERE, Garmin, INCREMENT P, USGS, EPA, USDA

ArcGIS Web AppBuilder

Bureau of Land Management, Esri Canada, Esri, HERE, Garmin, INCREMENT P, USGS, EPA, USDA | GIS Coordinator |

From:	Marcus Hoch
To:	Ryan Andrews
Subject:	RE: Draham Road Annexation PW Comments
Date:	Thursday, June 22, 2023 12:06:06 PM
Attachments:	Draham Road Annexation.pdf

Ryan,

Here is the information I have with the Draham Road Annexation.

Pavement- Overall in good condition with the PCI on the 80's, except for 2 sections (part of Draham and part of 15 Ave NE) that would need our attention in 1-3 years at a cost of approx. $404,000. Draham & 15th would require realigning the curve, widen to 4/5 lane, median, bicycle lane, curb/gutter, planter strip, sidewalks, street lighting, and storm water improvements, and replacing the culvert. Thurston Co did a replacement analysis in the culvert/bridge, which indicates that work should start in 2024 at a cost of $5.3 million. Carpenter would be widen to 4/5 lane from Martin to Britton, with a roundabout added to Britton/Carpenter. The College Phase 3, Double Carpenter, Bridge/Culvert, cost are estimate at $60,000,000. Other items to be considered are converting signs and markings to city standards, signs would cost about $2,100 and street markings cost are around $40,000.

There could be considerable costs in utilities if the zoning is changed from low density to med or high density. According to Brandon, a well site may need to be added near Carpenter Rd NE and adding a pressure zone, Wastewater may require Step or grinder systems, and possibly up to 3 pumpstations. Currently, utilities are limited in the area as much of the parcels have wells and septic system. Stormwater would assume 23 catch basins to the departments maintenance load, and Woodland Creek and Eagle Creek culverts. While Woodland Creek has been evaluated by the County, Eagle Creek culvert has not been maintained and was difficult to assess. The culvert is overgrown with vegetation and make shift grate was created out of sign poles. Stormwater indicates that lack of maintenance, some sections of sidewalks would have to be repaired, vegetation mowed, and some areas they were not able to access to be evaluated. Street trees would have to be trimmed, some streets have not been sealed. No sidewalks on Judd St, with a question about being private or not.

Let me know if you need more information.

Marcus

From: Ryan Andrews <Randrews@ci.lacey.wa.us>
Sent: Thursday, June 8, 2023 10:49 AM
To: 1 Executive Team <Directors@ci.lacey.wa.us>
Subject: Draham Road Annexation

Good morning Executive Team. I wanted to make you aware that we have received a notice to commence annexation proceedings for property located off of 15th Avenue NE north of Century Court (we're calling this the Draham Road Annexation). By annexing this area, it would leave a large unincorporated island so we are moving forward with analyzing the island for impacts to services if it was potentially annexed. At this point, I am in need of some high level information on the area prior to a City Council Utilities Committee on July 3rd. Attached are three maps: one showing the three parcels that we received the notice to commence and two options for the unincorporated island. Please provide this to your affected staff for review and to return any high level comments back to me on potential annexation of the two incorporated island options by **Friday, June 23rd**. I will likely need more detailed information if the council does decide to move forward with the annexation.

Below are some additional details that I am interested in. Thank you so much for your assistance. Please don't hesitate to reach out if you have any questions.

-Ryan

Public Works:

General infrastructure availability and any major deficiencies
Pavement condition

Finance:

Projected revenue—property tax, utility tax and any others

Police:

Potential service issues within the area
Historic call volume

Ryan Andrews, Planning Manager
Lacey Community & Economic Development Department
360.412.3190
randrews@ci.lacey.wa.us

Pavement Analysis

Section #	Street	Length Ft	Width Ft	Area SF	PCI	Cost $
1	Woodland Creek St NE	2475	28	69300	80	270,000
2	22nd Ave NE	350	28	9800	85	39,000
3	Mark St NE	1820	28	50960	81	199,000
4	21st Ct NE	610	28	17080	81	67,000
5	Oxbow St NE	940	28	26320	74	103,000
6	18th Ct NE	290	28	8120	85	32,000
7	17th Ave NE	930	28	26040	85	102,000
TOT		7415		207620		812,000

Woodland Creek Neighborhood – The sight lines exiting Woodland Creek St NE onto 15th are very poor and would need some maintenance. The road has a few potential soft spots, minor surface irregularities and some poor cross slope in spots but the water looks to be draining. There are signs of wheelpath base failure on Oxbow St NE. The area has wedge curb and catch basins, the paved lanes look newer than the wedge curbing, and the base material is assumed to be minimal rock on native.

Timeline: 10+ Years. Oxford needs some base repair on a different timeline.

Section #	Street	Length Ft	Width Ft	Area SF	PCI	Cost $
8	Covington Ct NE	1575	22	34650	88	135,000

Covington Neighborhood – The road is in great condition. The only concern, although minimal, is the shade keeping the road damp longer after rains and the potential for elevated loss of fines down the road.

Timeline: 20+ Years.

Section #	Street	Length Ft	Width Ft	Area SF	PCI	Cost $
9	15th Ave NE 1	960	24	23040	55	180,000
10	15th Ave NE 2	1100	44	48400	85	377,000
11	15th Ave NE 3	960	24	23040	98	180,000
TOT		3020		94480		737,000[1]

[1] This is the cost for the entire pavement section including the recent developer repaired portions. The cost omitting the new pavement in sections 1 and 2 would be ~$140,000 for 17,520 sq. ft. of pavement.

15th Ave NE – The area the developer repaved and the roadway near the curve is in excellent condition. The rest of the road, however, has minimal service life remaining with high levels of cracking, extreme weathering, and spots of missing pavement.

Timeline: Section 1, 1-3 Years for the older pavement in the eastbound lane. Section 2, 1-3 Years for the older pavement in the westbound lane. Section 3, 15+ Years.

Section #	Street	Length Ft	Width Ft	Area SF	PCI	Cost $
12	Draham St NE 1	1040	24	24960	98	195,000
13	Draham St NE 2	1200	24	28800	57	224,000
TOT		2240		53760		419,000

Draham St NE – The area around the curve to the seam just south of Woodland Creek is in excellent condition. The area north of the seam has markings for digouts to repair what looks to be a base failure and is in fair to poor shape exhibiting signs of wheelpath base failure, elevated alligator cracking, and missing pavement both in the road and the shoulder.

Timeline: Section 1, 15+ years. Section 2, with base repair 8-10 years, without base repair 3-5 years.

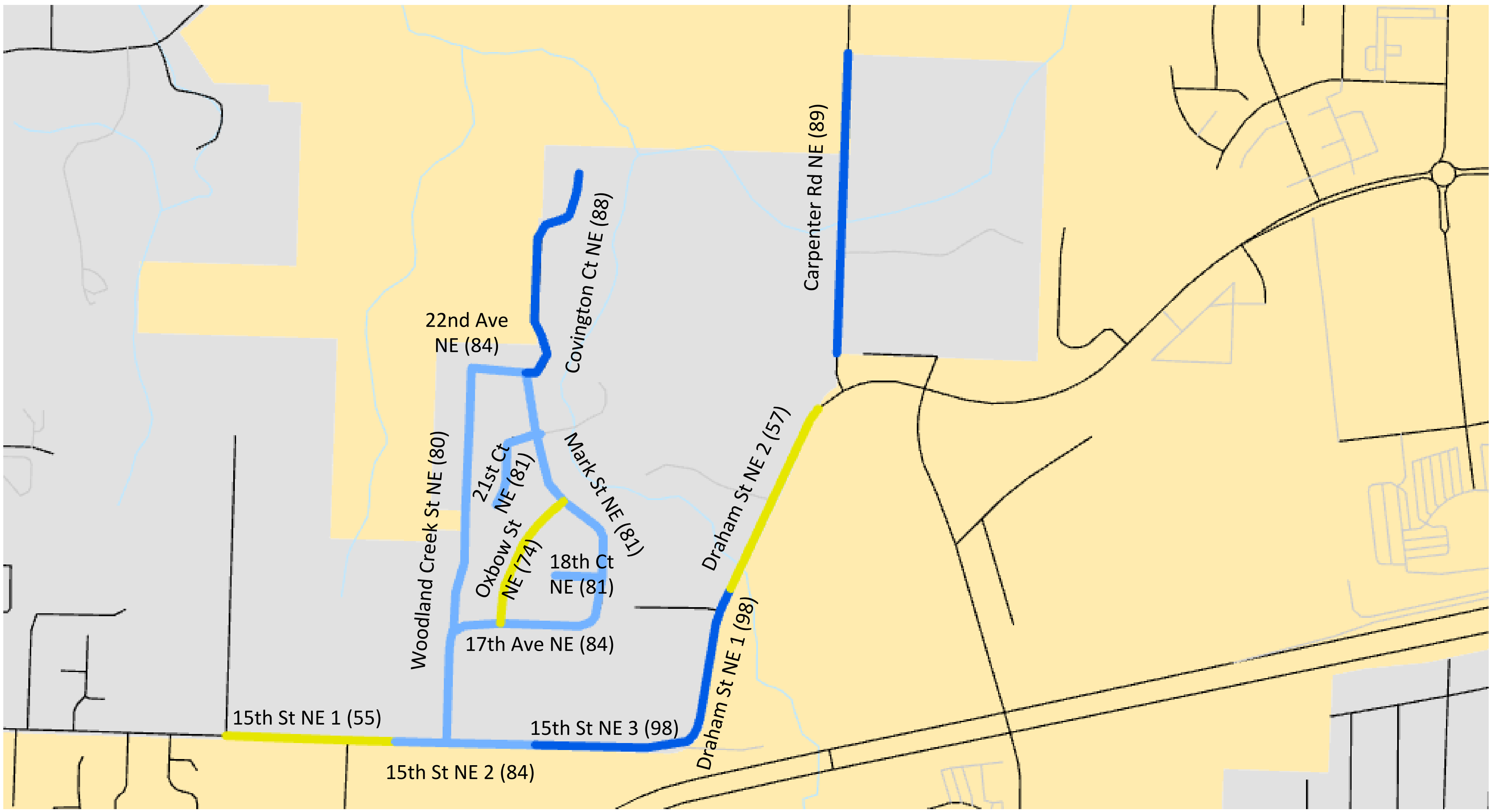
Section #	Street	Length Ft	Width Ft	Area SF	PCI	Cost $
14	Carpenter Rd NE	1330	24	31920	89	249,000

Carpenter Rd NE – The surface is a chipseal with what looks to be a healthy base section. The surface is weathered but in good condition with typical signs of reflective cracking.

Timeline: 10+ Years depending on how the chip holds up.

Section #	Street	Length Ft	Width Ft	Area SF	PCI	Cost $
N/A	TOTAL	15,580	--	422,430	--	2,352,000

Draham Annexation Streets & PCI



Marcus Hoch

From: Chris Stolberg
Sent: Tuesday, June 20, 2023 4:39 PM
To: Marcus Hoch
Cc: Aubrey Collier; Martin Hoppe; Scott Egger
Subject: RE: 15th & Draham

Hi Marcus,

Please see my responses below in red. Please let me know if you need any additional information or clarification of anything.

Best,

Chris Stolberg, EIT
Transportation Engineer
City of Lacey
Office: (360) 438-2640
Mobile: (360) 972-5763
cstolber@ci.lacey.wa.us

From: Scott Egger <SEgger@ci.lacey.wa.us>
Sent: Monday, June 19, 2023 2:57 PM
To: Chris Stolberg <CStolber@ci.lacey.wa.us>
Cc: Aubrey Collier <acollier@ci.lacey.wa.us>; Martin Hoppe <MHOPPE@ci.lacey.wa.us>; Marcus Hoch <mhoch@ci.lacey.wa.us>
Subject: RE: 15th & Draham

Hi Chris,
Will you provide a brief summary of the following information to Marcus regarding the 15th & Draham long term upgrades…

- Project Limits & distance
  The complete project will extend from Sleater Kinney Road NE to Carpenter Road NE (approximately 10,000 feet). Approximately 1,900 feet on the south side of 15th has already been widened by developer-constructed frontage improvements. There were plans for Olympia to extend 15th from Sleater Kinney to Lilly Road, however based on development in the area it now looks like any connection between the two would need to be further south.
- Brief Scope of improvements… number of lanes, curb, gutter, sidewalk, landscape strips, sidewalks, street lighting
  The project would widen Draham and 15th to a 4/5 lane section with arterial street standards. This includes medians, bicycle lanes, curb and gutter, planter strips, sidewalks, street lighting, and necessary stormwater infrastructure. The curve at the transition between Draham and 15th would be realigned to have a larger radius. In addition, the existing culvert under Draham would be replaced by either a bridge or buried structure.
- Brief description of bridge project
  There is an existing culvert for Woodland Creek underneath Draham Road. The culvert has been identified as a fish passage barrier and needs to be replaced. Thurston County has conducted an alternatives analysis that was completed in February 2023. The two alternatives identified were replacement with a bridge, or replacement

with a buried structure. Both alternatives had an estimated cost of $5.3 million. The actual cost would likely be higher, because their assumption was a three-lane section not four or five.

- Brief description of ultimate intersection improvements at 15th & Sleater-kinney.
  A traffic signal is planned for this intersection and construction will likely begin this summer as part of the Sleater Landing Project. The western half of the intersection is in Olympia and the city of Olympia has agreed to maintain the signal. The intersection will be revised in the future to accommodate road widening. There is potential to eventually convert the signal to a roundabout. Conversion to a roundabout would require coordination between the Cities of Olympia and Lacey (Olympia has the intersection identified in their comprehensive plan as a signal or roundabout), and may be difficult depending on surrounding development and the location of any future connection between Sleater Kinney and Lilly.
- Any other significant improvements that are needed.
  As mentioned above, the project would include realigning the curve at 15th and Draham. The existing curve has a small radius and road widening would create an even smaller radius for the westbound curb lane. In order to realign the curve, several parcels would be impacted.

Thanks,
Scott

From: Scott Egger
Sent: Friday, June 16, 2023 4:48 PM
To: Chris Stolberg <CStolber@ci.lacey.wa.us>
Cc: Aubrey Collier <acollier@ci.lacey.wa.us>; Martin Hoppe <MHOPPE@ci.lacey.wa.us>; Marcus Hoch <mhoch@ci.lacey.wa.us>
Subject: RE: 15th & Draham

Thank Chris!!

From: Chris Stolberg <CStolber@ci.lacey.wa.us>
Sent: Friday, June 16, 2023 4:43 PM
To: Scott Egger <SEgger@ci.lacey.wa.us>
Cc: Aubrey Collier <acollier@ci.lacey.wa.us>; Martin Hoppe <MHOPPE@ci.lacey.wa.us>; Marcus Hoch <mhoch@ci.lacey.wa.us>
Subject: FW: 15th & Draham

Hi Scott,

I reached out to the County earlier this week and this was their response.

Best,

Chris Stolberg, EIT
Transportation Engineer
City of Lacey
Office: (360) 438-2640
Mobile: (360) 972-5763
cstolber@ci.lacey.wa.us

From: Sam Bloom <sam.bloom@co.thurston.wa.us>
Sent: Tuesday, June 13, 2023 3:56 PM
To: Chris Stolberg <CStolber@ci.lacey.wa.us>
Subject: 15th & Draham

Chris,

I confirmed with Matt that we do not have any studies, preliminary plans, or estimates for road widening on 15th and Draham. We do have the $8M figure that we have been collecting Traffic Impact Fees for, but I think that number was just thrown in there. I have attached the study for the Draham Culvert study, but that is all we have.

Sam Bloom, EIT
Associate Civil Traffic Engineer
Thurston County Public Works
Office: 360-867-2367
Email: sam.bloom@co.thurston.wa.us

THURSTON COUNTY
WASHINGTON
SINCE 1852

Draham Street Culvert Replacement Alternatives Analysis Report

Thurston County Fish Passage Enhancement Program

Olympia, WA

Prepared By: *HDR, Inc.*
Jessica Soward, *Sargent Engineers*
Annabel Irwin, *Landau*

Date: February 15, 2023

Contents

Appendices

Tables

Figures

1. Introduction

Thurston County is proposing to improve fish passage at Woodland Creek crossing at Draham Street (St) Northeast (NE) by replacing the existing fish passage barrier with a fish passable structure (WDFW Site ID 340709). The crossing is located approximately 2.6 miles west of Exit 111 on Southbound I-5, at the city limits of Lacey, WA.

This report documents the existing site conditions and the hydraulic analysis of existing and proposed conditions based on Washington Department of Fish and Wildlife's (WDFW) 2013 *Water Crossing Design Guidelines* (WCDG) (Barnard et al. 2013). This document also summarizes the structural alternatives considered for this crossing. A 30 percent conceptual plan set and planning level Engineer's Opinion of Probable Construction Cost (OPCC) are included within the appendices as part of this deliverable.

The objectives of the report are the following:

- Document existing site conditions
- Summarize preliminary hydrologic and hydraulic analysis
- Size minimum hydraulic opening to meet fish passage requirements
- Summarize roadway section
- Summarize structural alternative analysis
- Develop preliminary OPCC
- Develop preliminary 30 percent conceptual plan set

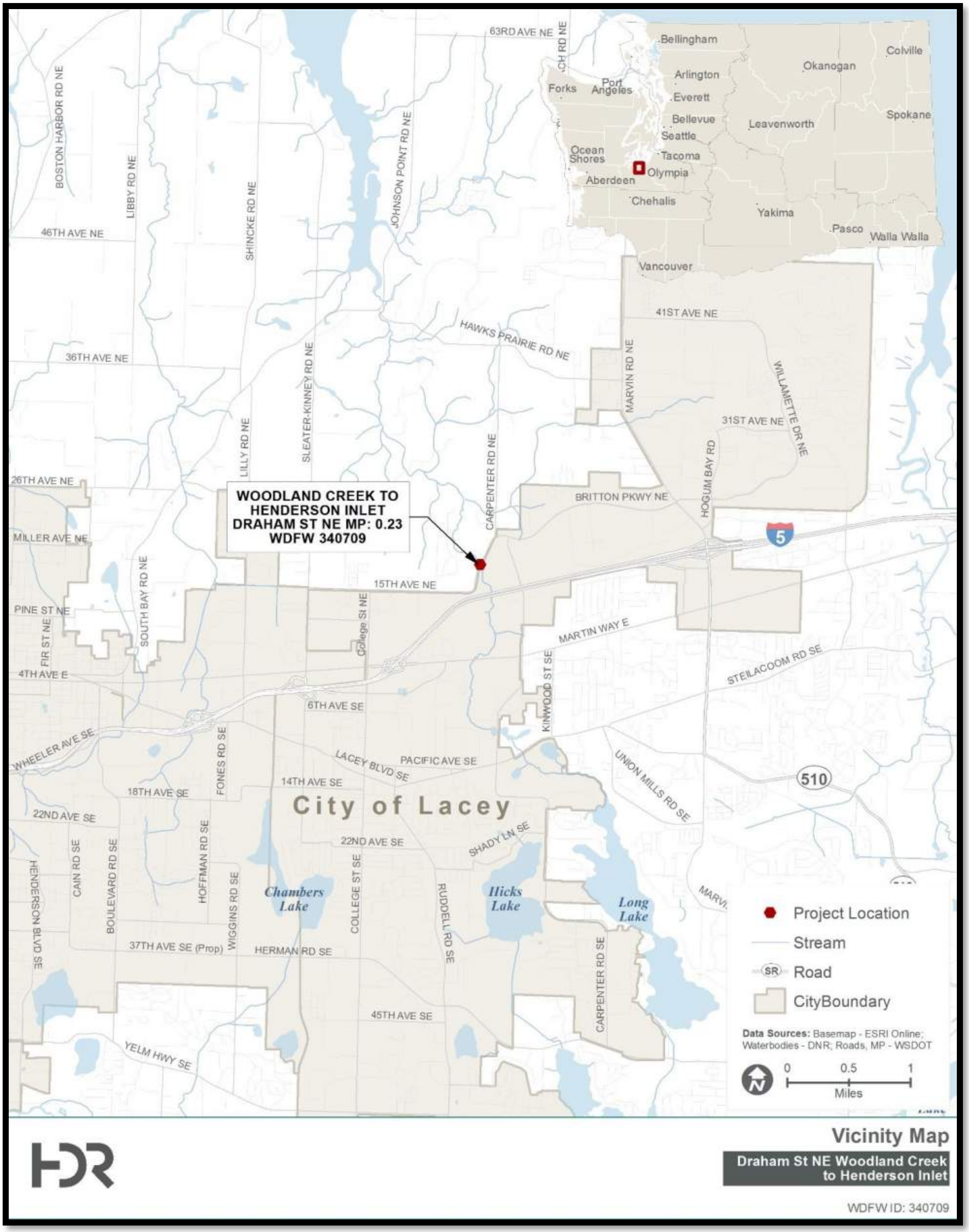


Figure 1: Vicinity map

2. Existing Conditions

HDR Engineering, Inc. (HDR) performed a site visit on July 27, 2021 to gather information to support the fish passage design. Information collected included bankfull width (BFW) measurements, pebble counts, Large Woody Material (LWM), site photos, and other observations. During this site visit, a reference reach was identified for use as the basis for the stream design. The reference reach is a selected section of channel that is outside the influence of the existing culvert crossings, intended to represent a natural portion of the stream with minimal anthropogenic influences. Identification of a reference reach is an important step when using the geomorphic approach to fish passage design because characteristics such as BFW, channel slope, and channel substrate size within the reference reach are used to design the proposed structure, channel shape, and streambed material. The reference reach is located approximately 80 feet downstream of the Woodland Creek crossing with Draham St NE. Figure 17 provides the locations of the field measurements and observations.

2.1. Site Observations

Woodland Creek generally flows south to north and is conveyed underneath Draham St NE in a 10-foot-wide, 7-foot-high open bottom corrugated steel culvert with concrete abutments (Figure 2 and 8). The existing crossing has been classified as 67% percent passable in 2015 due to excessive velocity by Washington State Department of Fish and Wildlife (WDFW) in their Fish Passage and Diversion Screening Inventory Database (WDFW 2015). A detailed topographic survey extending approximately 350 feet upstream and 300 feet downstream of the crossing was provided by Thurston County in January of 2022. Per the survey, the existing culvert is approximately 61 feet long and has a zero percent slope.

Figure 2: Crossing inlet

Figure 3: Crossing outlet

2.1.1. Upstream Reach

Site observations begin approximately 450 feet upstream of the crossing. The channel meanders through high terraces approximately 8 to 12 feet in height. There are houses located near the edge of the terrace at several locations. A pedestrian bridge is located approximately

490 feet upstream of the culvert crossing at Draham St NE (Figure 4). There are multiple channel spanning logs in the channel, indicating a healthy supply of woody material to the stream as depicted in Figure 5. Riparian vegetation consists of primarily deciduous trees, with some conifers and smaller plants. The LWM within the stream is mostly larger trees that have likely been recruited from the sides of the channel. Grass is abundant in the upstream channel as depicted in Figure 6.

Figure 4: Pedestrian bridge approximately 490 feet upstream of the culvert inlet

Figure 5: Channel crossing log approximately 400 feet upstream of the culvert inlet

Figure 6: Woody debris and grass in the channel approximately 200 feet upstream of the culvert inlet

Geomorphology of the upstream reach primarily consists of pools and riffles, with large woody material forming these geomorphological elements. Streambed sediment primarily consists of fines with some gravels (Figure 7); sand and gravel deposits are present intermittently throughout. A pebble count was taken approximately 400 feet upstream of the culvert inlet (Figure 8). Three BFWs were measured in the upstream reach (Section 2.2). The locations of pebble counts and BFWs are shown in the field map in Figure 17. Overall, the upstream reach is confined.

Figure 7: Sand substrate upstream of the culvert inlet

Figure 8: Pebble count 1 location, approximately 400 feet upstream of the culvert inlet

There is a cluster of concrete debris and in-channel vegetation obstructing the channel approximately 50 feet upstream of the culvert inlet as shown in Figure 9. The concrete debris seems to consist of remnants of an old weir that has failed and never been removed from the channel; this abandoned weir is not noted in the WDFW inventory. The debris is causing the flow to split in this area. The stream meanders left upstream of the culvert inlet before flowing into the culvert. The culvert is a 61-foot-long, 10-foot-wide, 7-foot-tall open bottom arch culvert with concrete abutments as shown in Figure 10. Signs of failure were observed on one of the concrete footings of the culvert. Manmade riprap is present near the inlet of culvert and within the culvert itself.

Figure 9: Concrete debris from abandoned weir forming obstruction in the channel approximately 50 feet upstream of the culvert inlet

Figure 10: Culvert inlet at Draham St NE, facing downstream

2.1.2. Downstream Reach

Downstream of the culvert outlet, quarry spall riprap is present as shown in Figure 11. Surrounding vegetation consists of mixed deciduous and coniferous trees as well as ferns and smaller bushes. A total of six BFW measurements were taken within the downstream reach (Section 2.2).

Figure 11: Culvert outlet at Draham St NE, facing upstream, approximately 25 feet downstream of the culvert outlet

Sediment composition in the downstream reach mainly consists of fine sediments, sand, and gravel. Gravel deposits are observed intermittently along banks in the downstream reach, in combination with occasional cobbles. Overall, the substrate is slightly larger than was observed in the upstream reach   A pebble count was taken approximately 150 feet downstream of the culvert outlet (Figure 12). LWM present in the channel shows the healthy supply of wood into the stream and increases channel complexity by creating pools (Figure 13 and Figure 14). The morphology of the downstream reach is pool-riffle, similar to the upstream reach.

A reference reach was identified extending from approximately 80 feet to 160 feet downstream of the culvert outlet. This location was chosen because the pool-riffle morphology is consistent with both the upstream and downstream reach morphology, and because the substrate is consistent with other locations as well. The reference reach is located outside of the influence of the culvert, downstream and upstream weir remnants, and not adjacent to significantly manipulated banks within residential yards.

Figure 12: Pebble count 2 location, approximately 150 feet downstream of the culvert outlet

Figure 13: Large woody material accumulation approximately 160 feet downstream of the culvert outlet

Figure 14: Channel crossing log and associated pool approximately 260 feet downstream of the culvert outlet

Overall, the downstream reach is confined, though there are areas of occasional accessible floodplains alternating between the right and left banks.

Starting at approximately 175 feet downstream of the culvert outlet, the right bank appears to have been previously graded and the right floodplain maintained for residential use. Between 260 and 350 feet downstream of the culvert outlet, the channel changes to a plane bed morphology and anthropogenic influences further increase. Bank modifications were observed on the right bank approximately 250 feet downstream of the culvert outlet, consisting of a manmade stone wall. A weir was present approximately 350 feet downstream of the culvert outlet, shown in Figure 15 (WDFW Site ID 998506). This weir was identified as a full spanning rock dam with 33 percent passability due to a water surface drop in the WDFW Fish Passage and Diversion Screening Inventory Database, and it appears to have been modified since its last assessment by WDFW in 2006 (WDFW 2006). The downstream end of the site reconnaissance was a private bridge located approximately 400 feet downstream of the culvert outlet (Figure 16).

Figure 15: Weir approximately 350 feet downstream of culvert outlet, looking upstream

Figure 16: Existing private bridge approximately 400 feet downstream of the culvert outlet, looking downstream

2.2. Bankfull Width

BFW measurements were taken by HDR at a total of nine locations (three measurements upstream and six measurements downstream of the culvert crossing) using the guidelines in Appendix H of WDFW's 2013 *Water Crossing Design Guidelines* (WCDG). Figure 17 shows the locations of these bankfull width measurements. BFW values ranged from 29 feet to 54 feet (Table 1). BFW 3 was not included in the design average width of 43 feet because of the altered banks observed on site.

Table 1: Bankfull width summary

BFW	U/S or D/S	Distance from culvert (measured from inlet or outlet)	Bankfull Width (ft)	Included in Average?
1	D/S	300	30	Y
2	D/S	250	37	Y
3	D/S	200	29	N
4	D/S	150	48	Y
5	D/S	100	54	Y
6	D/S	50	50	Y
7	U/S	100	45	Y
8	U/S	150	32	Y
9	U/S	250	48	Y
Design Average			**43**	

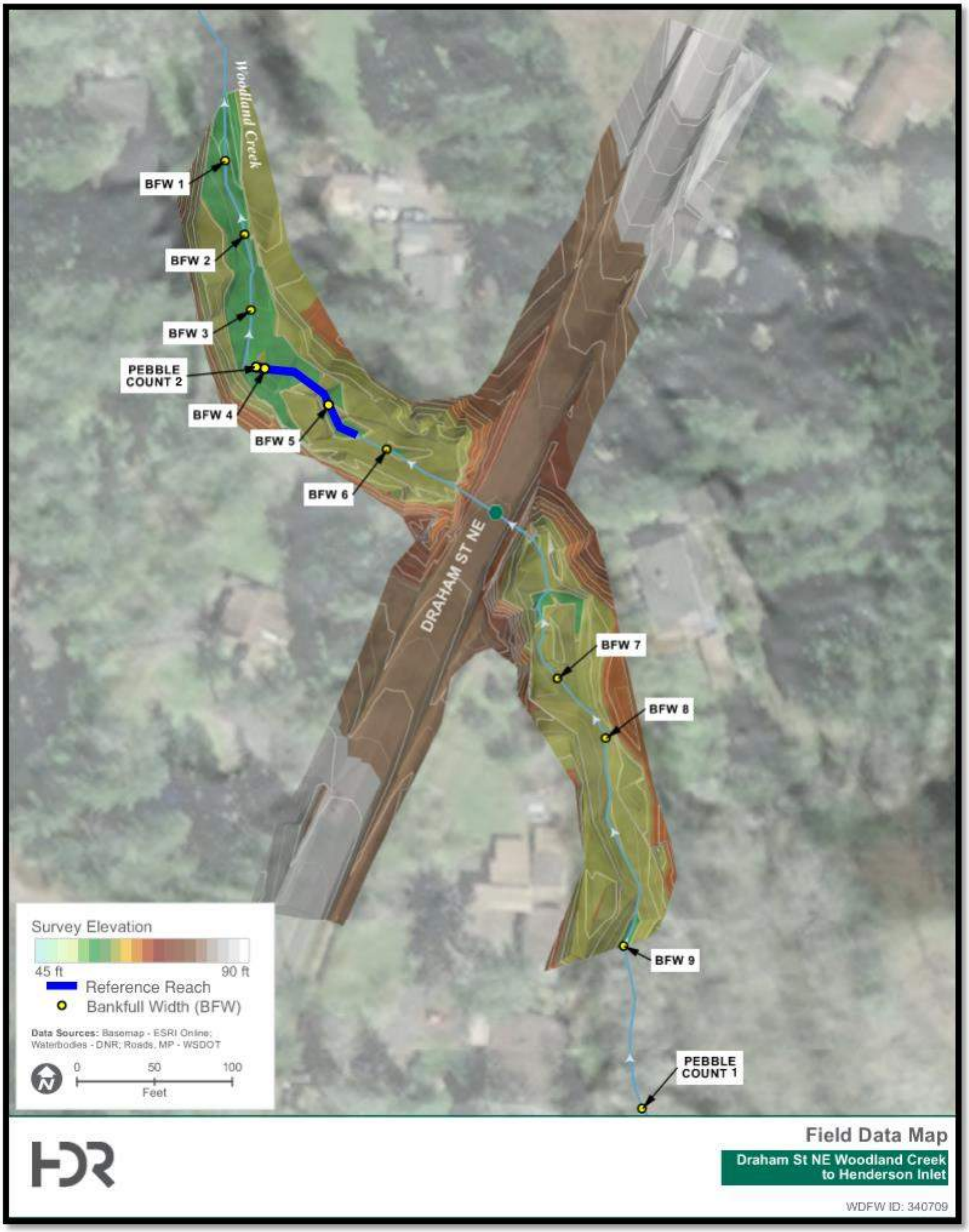


Figure 17: Field measurement locations

2.3. Channel Gradient

The long profile of Woodland Creek is displayed in Figure 18 using LiDAR obtained from the Department of Natural Resources (DNR) (USGS and Quantum Spatial 2017). The LiDAR was lowered by 3.41 feet per the conversion between NAVD88 and NGVD29 datums in order to match the NGVD29 datum used by the survey. Based on the long profile, the project reach has an average gradient of about 0.5 percent starting approximately 500 feet upstream of the culvert crossing at Draham St NE and continuing downstream for over 8,000 feet. The average slope through I-5 is 0.3 percent and continuing upstream the stream becomes steeper with gradients of 1.5, 2.7 and 1.4 percent as shown in Figure 18.

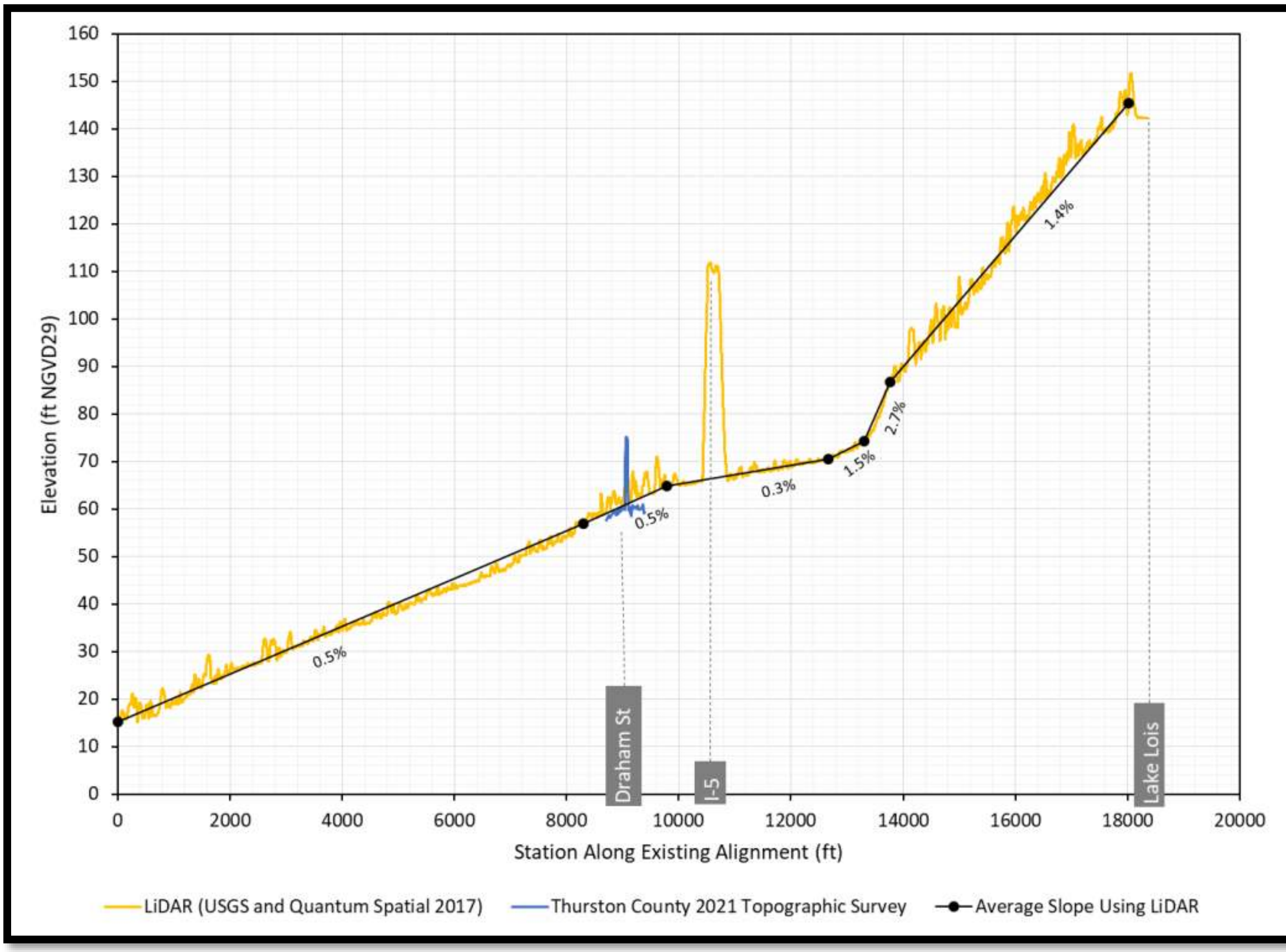


Figure 18: Woodland Creek long profile

The survey profile is shown in Figure 19. The average channel gradient is 0.7 percent downstream and 0.2 percent through the crossing and upstream based on the site survey; the average slope through the site as a whole is 0.39 percent.

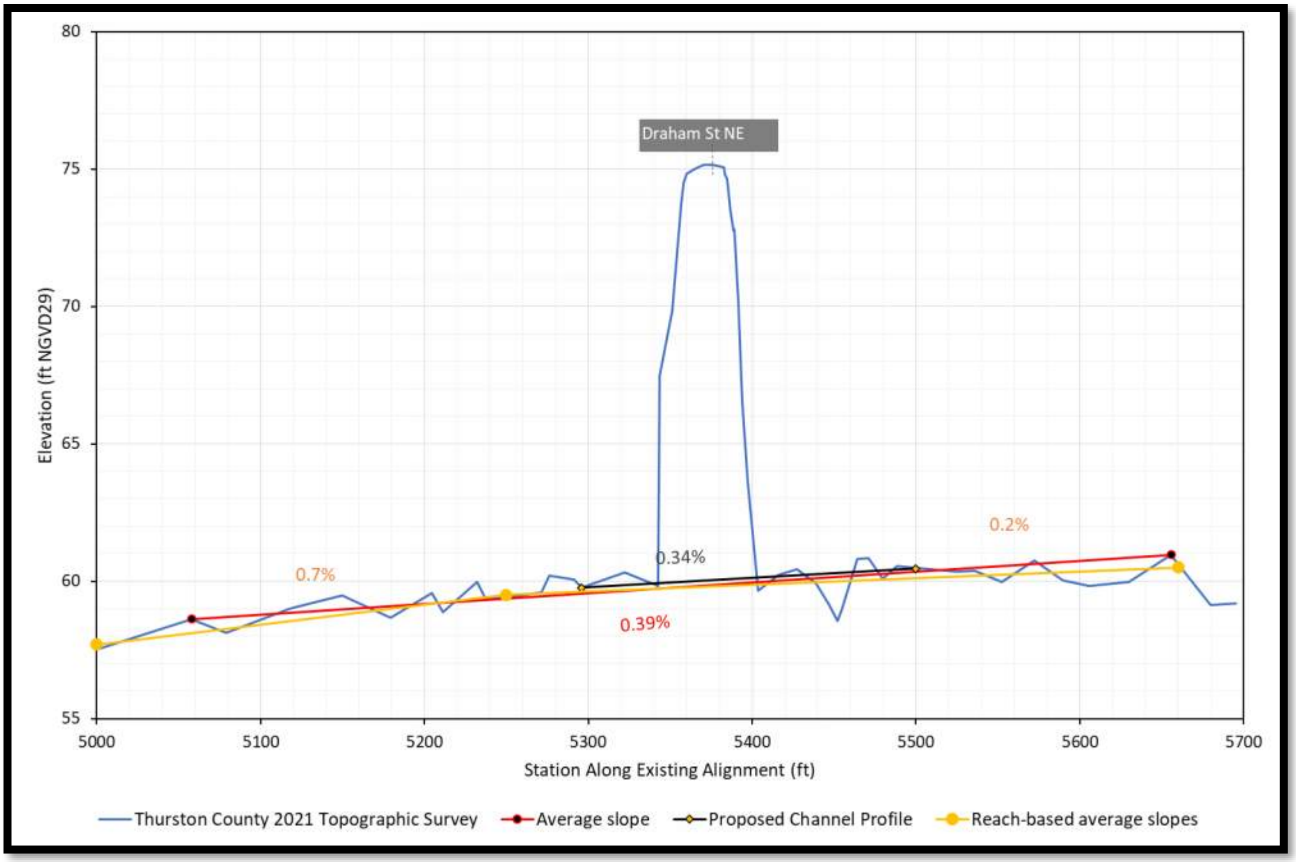


Figure 19: Woodland Creek survey profile

2.4. Streambed Material

Two pebble counts were conducted (one upstream and one downstream of the crossing) at locations displayed on Figure 17. Pebble count 1 was taken approximately 400 feet upstream of the culvert inlet (Figure 20). The streambed material consisted of sand and gravel with some fines at this location. Pebble count 2 was taken approximately 150 feet downstream of culvert outlet within the reference reach, where streambed composition was extremely similar to upstream, consisting of sands and gravels. The median pebble size was 0.4 inches (Table 2). Throughout the site visit, the largest particle observed on site was a cobble measured as 6 inches (Figure 22).

Figure 20: Pebble count 1 location approximately 400 feet upstream of culvert inlet

Figure 21: Pebble count 2 location and streambed sediment composition approximately 150 feet downstream of culvert outlet

Figure 22: Largest cobble observed on site, 6 inches

Table 2: Channel substrate gradation

	Pebble count 1 (400 feet upstream of inlet)	Pebble count 2 (150 feet downstream of outlet)	Cumulative
Particle	Diameter (in)	Diameter (in)	Diameter (in)
D16	0.2	0.2	0.2
D50	0.3	0.6	0.4
D84	0.6	1.1	0.9
D95	1.1	1.5	1.4

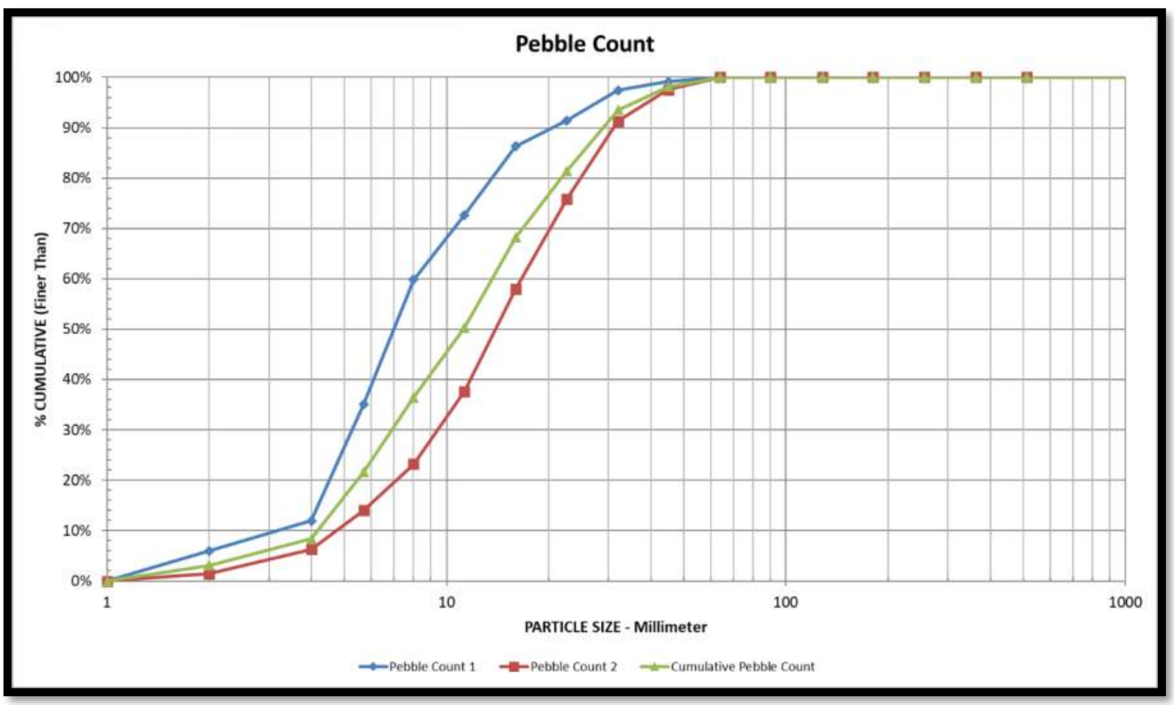


Figure 23: Channel substrate gradation at pebble count 1 and pebble count 2 locations

2.5. Large Woody Material

During the site visit, LWM was observed upstream and downstream of the culvert crossing at Draham St NE as described in Section 2.1. The majority of the LWM consisted of channel spanning logs that appeared to have been recruited from the channel banks and appeared to be relatively stable due to the size of the logs. LWM created a relatively deep pool in the reference reach (Figure 24). Numerous smaller woody material was present in the channel and downed trees were also common along the banks.

Figure 24: LWM creating a pool in the reference reach, approximately 80 feet downstream of the culvert outlet

3. Hydrology

There are no stream gages on Woodland Creek at the Draham St Crossing. USGS stream gage 12081000 was historically operated on Woodland Creek at Pleasant Glade Rd approximately 2 miles downstream, which has historic daily flow rate data available from 1949 to 1969 (USGS 2022). Currently, Thurston County Department of Public Works operates a stream gage at this same location on Woodland Creek at Pleasant Glade Rd. 15-minute flow rate data for this gage from 2007 to 2022 was provided by Thurston County (Thurston County 2022).

HDR utilized a combination of these two data sets to create a 35-year long record and calculate peak flow rates at Pleasant Glade Rd based on the United States Geological Survey (USGS) Bulletin 17C method (USGS 2019). US Army Corps of Engineers' Hydrologic Engineering Center's (HEC) Statistical Software Package (HEC-SSP) was used to conduct the Bulletin 17C analysis. Peak flow rates resulting from the Bulletin 17C analysis for Pleasant Glade Rd were then scaled for the drainage area at Draham St, based on methods outlined in Mastin et al 2016. The USGS regression equation uses mean annual precipitation (MAP) and drainage basin area to estimate peak flows. Mean annual precipitation for the Woodland Creek basin is

47.4 inches based on the 30-year normals PRISM dataset produced by Oregon State University (PRISM 2015). The estimates of flood magnitudes at ungaged sites near gaged sites are intended to be used when the drainage area of the ungaged basin is between 50 percent and 150 percent of the drainage area of the gaged basin; in this analysis the basin area for Pleasant Glade Rd is 24.6 square miles, while the basin size for the Draham St crossing is 19.0 square miles, falling within the acceptable range.

Another method to calculate peak flow rates was based on information from the FEMA Flood Insurance Study (FIS) for Thurston County and Incorporated areas (FEMA 2020). This study includes a peak flow analysis and modeled water surface elevations for Woodland Creek downstream of the Draham St crossing.

The third method to estimate peak flow rates at the project location was to utilize USGS regression equations for region 3 based on the methodology outlined in Mastin et al 2016. The regression equations are not intended to be used in urban areas where greater than 5 percent of the basin consists of impervious surface; therefore, the USGS regression equations are not an appropriate method to estimate peak flow rates at Draham St due to presence of three lakes and extensive stormwater systems upstream of the site near I-5.

Based on the results of the three methods outline above, the peak flow rates scaled for Draham St NE based on the Bulletin 17C method were selected for the hydraulic analysis of the crossing. This method was used because gage data is the most accurate method to estimate hydrology between each of the different analyses performed. The results of analysis are provided in Table 3.

Table 3: Summary of peak flow rates

Method	Drainage Area (mi^2)	2-year (cfs)	10-year (cfs)	25-year (cfs)	50-year (cfs)	100-year (cfs)	500-year (cfs)
Woodland Creek @ Pleasant Glade Rd Bulletin 17C	24.6	10.4	231	NA	435	561	984
Woodland Creek @ Draham St NE (scaled from Pleasant Glade Rd) Bulletin 17C	**19.0**	**82**	**183**	**NA**	**345**	**445**	**780**
USGS Regression Equation for Woodland Creek @ Draham St NE	19.0	355	696	880	1020	1170	1530
FEMA FIS Peak flow rates for Woodland Creek @ Draham St NE	19.0		94	NA	127	142	176

At the time of the writing of this report, it is not required to accommodate the 2080 100-year flow event in hydraulic design; however, this information was obtained for context and in case this requirement changes in the future. The 2080 100-year flow rate was estimated by using the WDFW Future Projections for Climate-Adapted Culvert Design program (Wilhere et al. 2017).

The tool indicated that the projected mean percent change in 100-year flood is 34.6 percent, corresponding to a flow rate of 599 cfs.

4. Fish Passage Design

4.1. Proposed Design

The following sections describe the various design components of the recommended stream design. The proposed design was based on requirements listed in the 2013 WDFW WCDG and WAC 220-660-190 (Barnard et al. 2013; WAC 2015). Although two different structural alternatives will be considered within Section 7, the proposed stream design presented here can apply to each alternative.

Stationing in this report begins at 50+00 for existing conditions at the downstream survey extents and is renumbered as 0+00 at the downstream survey extents for the proposed conditions. Different stationing is used for existing and proposed due to a slight realignment of the channel centerline.

4.1.1. Design Approach

For BFWs greater than 15 feet, a bridge design approach is recommended in the WCDG (Barnard et al. 2013). The specific bridge design methodology depends on whether the crossing is located in a confined or unconfined reach. To assess this criterion, the floodplain utilization ratio (FUR) was calculated by dividing the flood-prone width (FPW) during the 100-year event by the average BFW. A ratio under 3.0 is considered a confined channel, and a ratio above 3.0 is considered an unconfined channel. Table 4 contains a summary of the FUR calculations for the Draham St crossing. FPW and FUR values were estimated from the proposed hydraulic model results in order to remove the impacts of the existing culverts and associated backwater on determination of the FUR. The average FUR is 1.1 and the channel is confined within both the upstream and downstream reaches.

Table 4: Floodplain utilization ratio summary – 100-year event

Cross Section	FPW (ft)	FUR
51+00 (DS)	53.9	1.3
52+20 (DS)	46.9	1.1
53+00 (DS)	48.3	1.1
54+90 (US)	44.6	1.0
56+20 (US)	44.1	1.0

The crossing will follow the confined bridge design approach based on BFW measurements and the stream's confined nature (Section 4.1.2); the stream simulation equation will be used to size the Minimum Hydraulic Opening (MHO).

4.1.2. Stream Alignment and Profile

The proposed design includes 204 linear feet of grading. From the upstream grading limits to the downstream grading limits, the channel has a proposed slope of 0.34 percent.

Slope ratios are the comparison of slope of the existing stream channel to the proposed stream channel to determine that the slope won't produce an unnecessary headcut or degradation. The stream simulation design methodology requires the ratio of proposed channel slope to existing channel slope be less than or equal to 1.25. However, confined bridge design methodology does not require meeting slope ratio.

The proposed stream grading is approximately 204 feet in length. The proposed stream slope is 0.34 percent; this was compared to the overall survey profile average slope of 0.39 percent. When compared to the overall existing channel slope of 0.39 percent, the slope ratio is 0.87 which is lower than 1.25 and therefore falls in an acceptable range. Figure 25 shows the proposed stream profile.

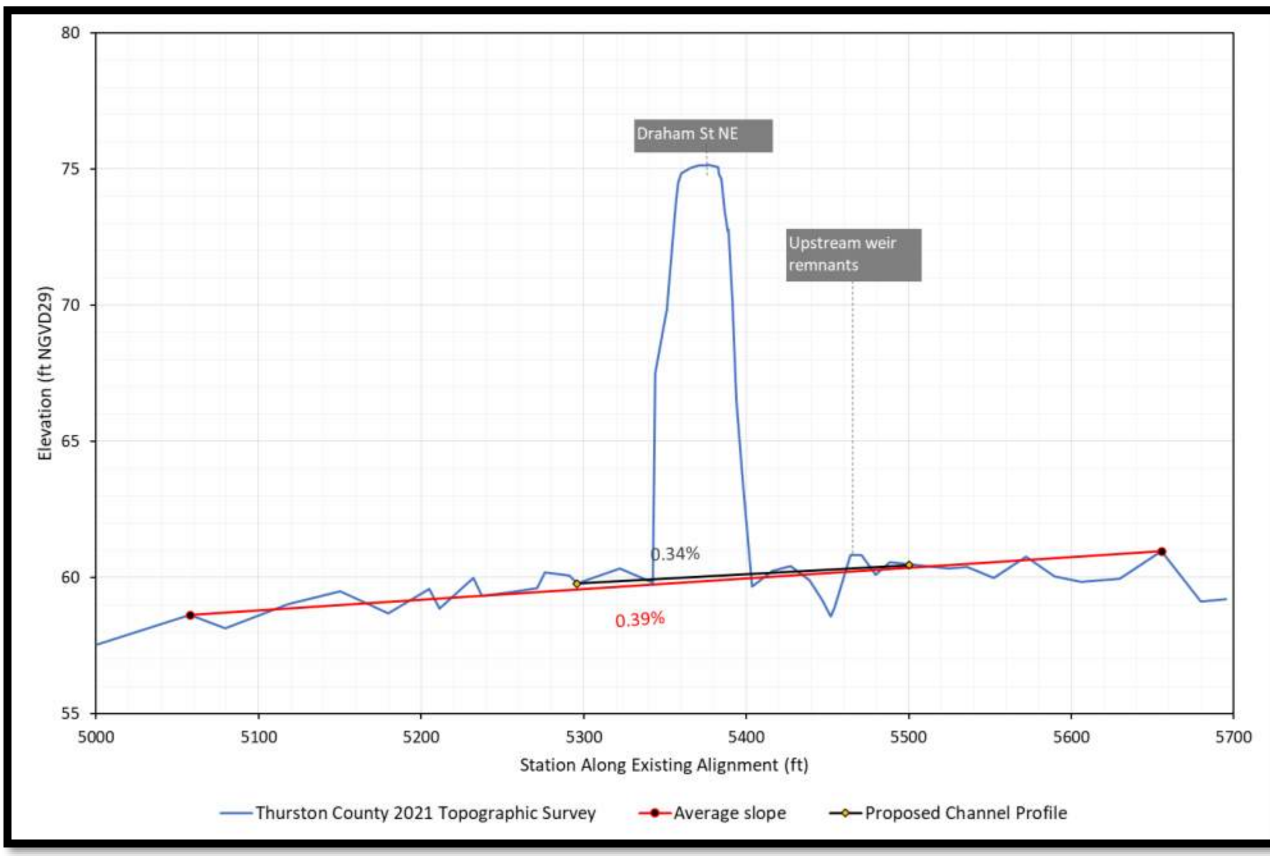


Figure 25: Proposed stream profile and project slope meeting slope ratio

The stream alignment was slightly shifted from its existing alignment to soften the bends in the vicinity of the structure. As design progresses, the alignment may be refined slightly to limit impacts to ravine slopes and infrastructure along the sides of the ravine. The current proposed grading limits are shown in Figure 26. It is anticipated that where the proposed grading conflicts with the remnants of the old weir in the upstream channel (shown in Figure 9 and noted in

Figure 26), those remnants will be removed. At lower flows, the stream is forced to split upstream of the culvert inlet; by removing the weir remnants, the stream will return to its natural, unobstructed alignment and conditions. Removal of the remnants will also eliminate the possibility of the weir acting as a grade control and will allow the stream to reach an equilibrium slope as the profile adjusts following removal of both the undersized culvert and the weir remnants. A view of the topography in the upstream reach showing the elevations of the weir remnants is located in Figure 27.

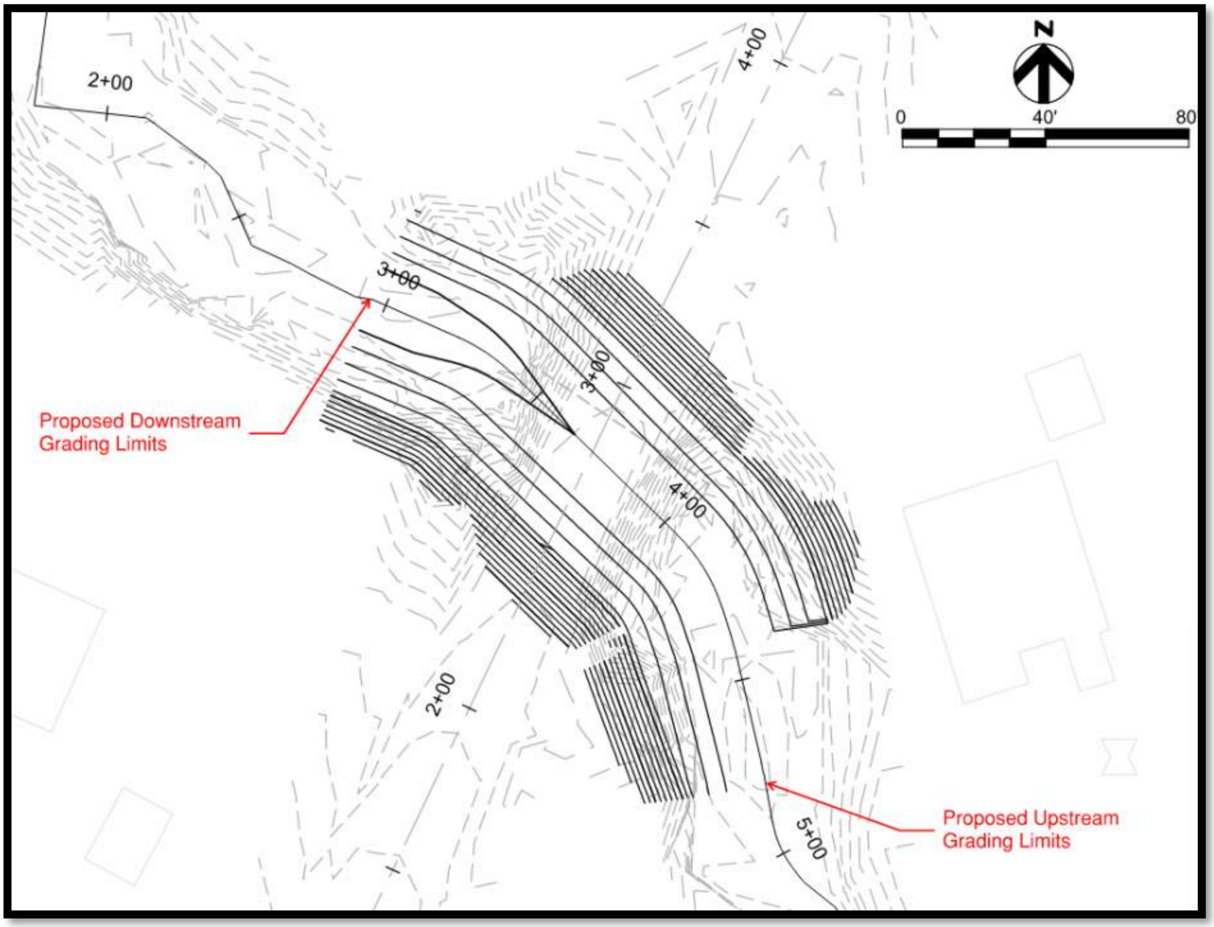


Figure 26: Proposed stream alignment and grading limits

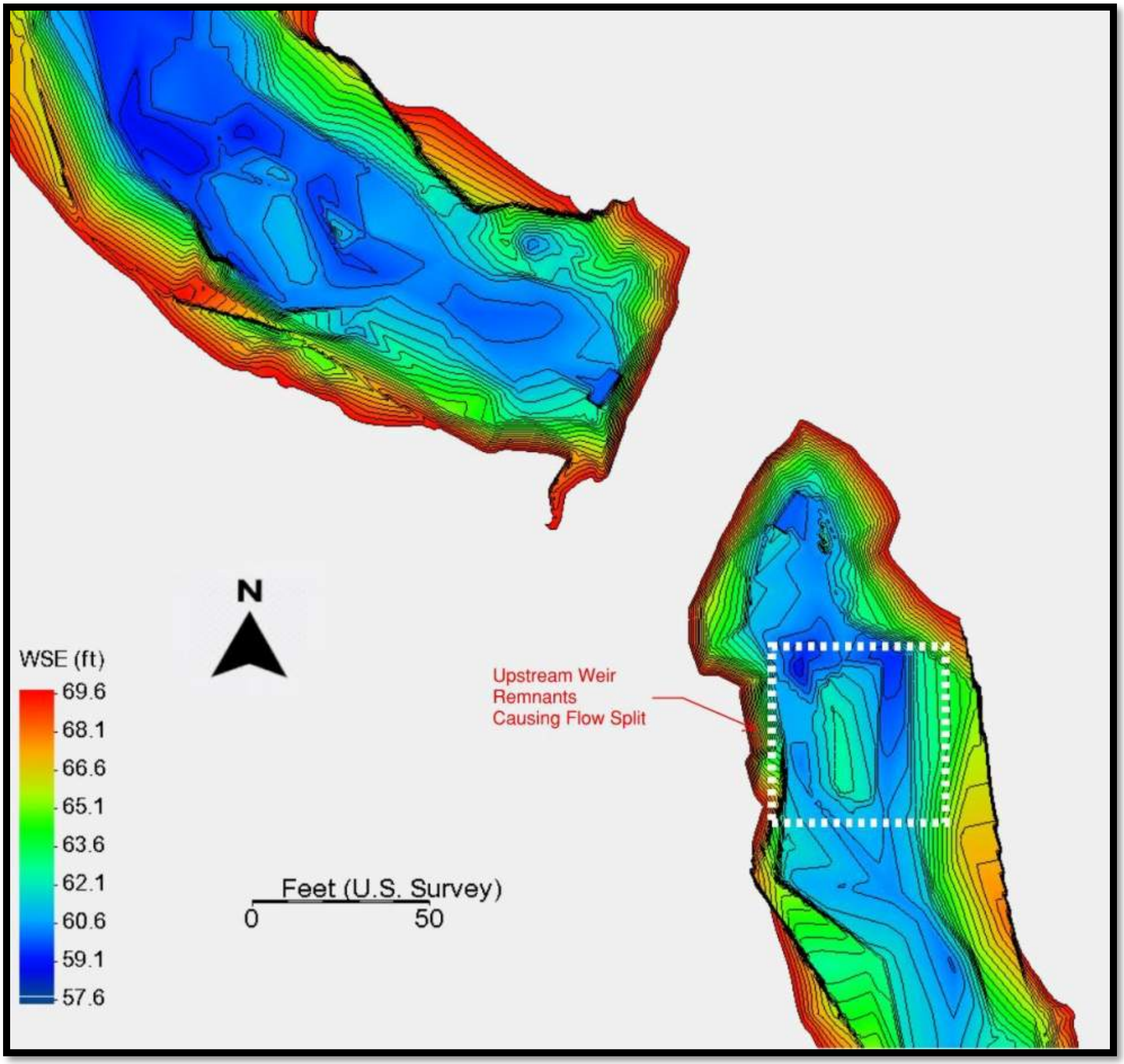


Figure 27: Topographical view of weir remnants

4.1.3. Stream Cross Section

A proposed stream cross section was sized based on the reference reach channel shape as shown in Figure 28. The proposed channel width is 54 feet. From the channel bottom, 2 percent toe slopes extend nine feet in each direction to create a low flow channel with a toe width of 18 feet. Banks are formed with 5:1 slopes to create the 54-foot top width. The bank heights approximately match the reference reach. At the top of the banks 1.5:1 daylight slopes are used to connect back to the existing grade.

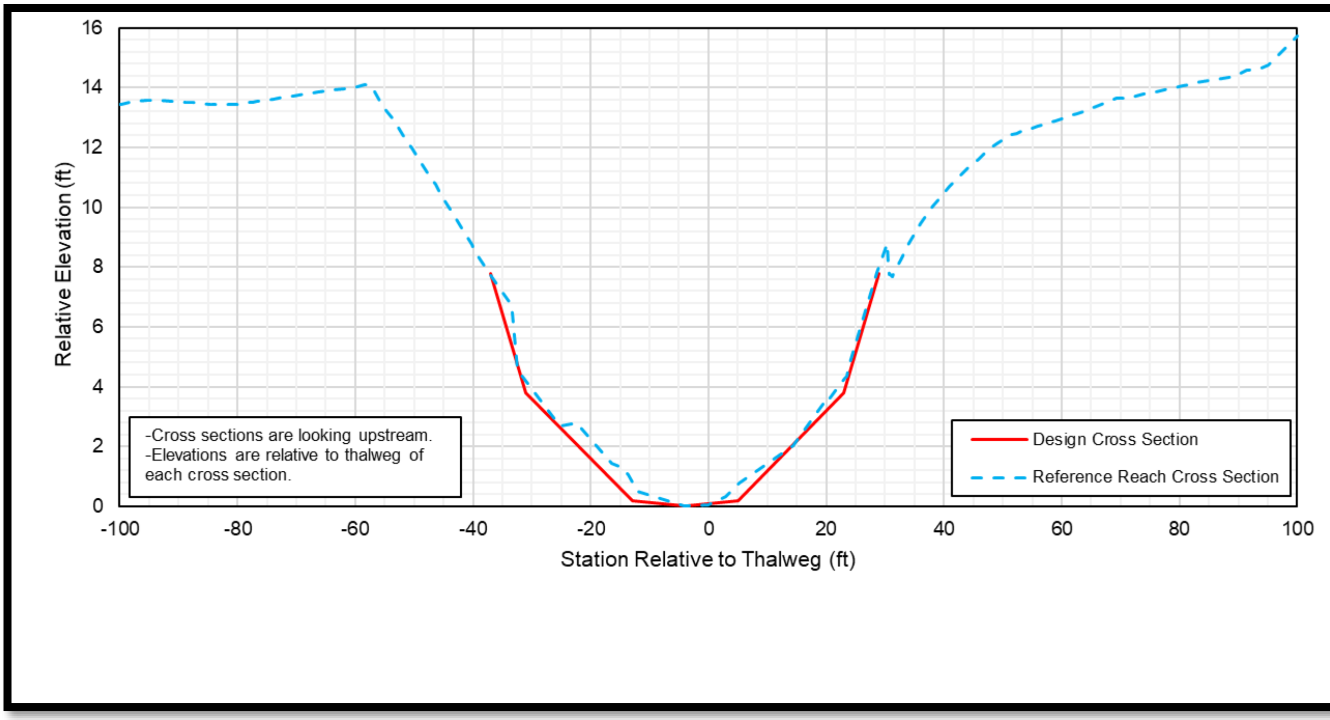


Figure 28: Proposed cross section shape

4.1.4. Minimum Hydraulic Opening Width and Height

The WCDG recommends providing sufficient freeboard to prevent excessive backwater rise and increased main channel velocities during floods that might lead to scour of the streambed and coarsening of the stream substrate, to allow the free passage of debris expected to be encountered, and generally suggests a minimum 3-foot freeboard above the 100-year WSEL for streams with a BFW larger than 15 feet (Barnard et al. 2013). The modeled 100-year water depth is 3.8 feet at the upstream face of the structure. Adding the freeboard requirement of 3 feet above the water surface, a minimum structure height of 6.8 feet above the thalweg is required to meet the minimum freeboard requirements for the 100-year event.

Though not a design requirement, the 2080 100-year flow event was modeled so that if future guidelines require structures to be designed with consideration for climate change flows, the information is readily available. The modeled 2080 100-year depth is 4.4 feet at the upstream face of the structure; if it later becomes a requirement to accommodate 3 feet of freeboard above the 2080 100-year water surface, a minimum structure height of 7.4 feet above the thalweg would be required.

The WCDG recommends starting with the stream simulation equation for sizing water crossing structures. The equation is:

*1.2*BFW + 2 = Minimum Hydraulic Width*

The stream simulation equation dictates a minimum hydraulic width of 53.6 feet using the design BFW of 43 feet. Therefore, a minimum hydraulic width of 54 feet is recommended for this crossing. The structure or its foundation should be countersunk a minimum of 4 feet to account for the estimated scour depth (See Section 6 for scour calculations). Total scour will continue to be refined as the design progresses.

4.1.5. Streambed Material

The proposed streambed material is composed of WSDOT Standard Specifications Streambed Aggregates, consisting of 100 percent streambed sediment (WSDOT Standard Specification 9-03.11(1)). The proposed streambed material closely matches the existing material on site based on pebble count data and stream observations (Section 2.4), consisting of sands and gravels. The crossing is not a sediment starved streambed based on site observations and is anticipated to have a supply of sediment upstream that continually moves downstream. A sediment mobility analysis was conducted on the existing and proposed streambed material. The analysis indicates that both existing and proposed material are stable during the 2-year and 10-year flow events, and begin to mobilize during the 100-year and 500-year flow events. This lines up with the results of the scour analysis performed (Section 6). See Appendix A for detailed mobility calculations. A comparison with the existing streambed material is shown in Table 5.

Table 5: Proposed and existing streambed material

Particle	Observed Material (in)	Proposed Material (in)
D15	0.2	0.02
D50	0.4	0.8
D84	0.9	2.1
D95	1.4	2.4

4.1.6. Habitat Complexity Design

The proposed channel is designed to mimic existing conditions as much as possible by following natural bends and disturbing only the area necessary to adequately tie into the existing ground. To promote channel complexity LWM placement is recommended to offer channel-forming features, bank stability, and complexity to enhance fish habitat. The LWM installations will provide structures conducive to creating stream complexity and facilitate geomorphic functions in segments that will have low natural LWM delivery rates while new and impacted riparian areas recover from construction activities related to installation of the new crossings and regrading of the stream channel.

LWM, in conjunction with bank-side bioengineering, will also help protect newly constructed banks and will promote long-term bed stability by creating pools, sinuosity, hard points, and channel roughness. Bank-side bioengineering is recommended immediately after construction for bank stability and will require further coordination with the landscape architect during future phases of design.

The 50th percentile targets, based upon Fox and Bolton (2007) for 204 feet of stream length, are 1 key piece and 32 total LWM pieces. A conceptual LWM layout was developed for this project area. Figure 29 and Figure 30 show the layouts for the bridge and buried structure alternatives, respectively. Both concepts assume LWM cannot be placed within the structure footprint. During future phases of design, channel complexity within the structure should be further considered. LWM is typically the preferred method, however if it is deemed unacceptable to place LWM within the structure other complexity features could include meander bars, boulder clusters, or other rock structures.

The conceptual layout for both the bridge and buried structure alternatives propose 1 key piece 3 feet in diameter and 40 feet in length; and 21 additional LWM pieces 1 to 2 feet in diameter and 25 to 30 feet in length.

The LWM layout is conceptual and will be further refined as design progresses. Stability of LWM has not been assessed at this point in design, though it is recommended that at a minimum key piece LWM should be stable at the 100-year flow event.

LWM structures placed in the stream will serve as habitat features for fish. The LWM layout for the proposed channel provides habitat complexity; sediment sorting; flow refuge; and pools that allow fish to rest, feed, and protect themselves, especially during high flows. Preformed pools are recommended at rootwads interacting with flow. Risk for fish stranding during summer flow conditions is minimal because proposed grading directs flow back to the main channel and does not promote standing pools. Additionally, a low-flow channel will be constructed and directed in the field by the engineer to help minimize stranding during low flows by providing connectivity between the habitat complexity features.

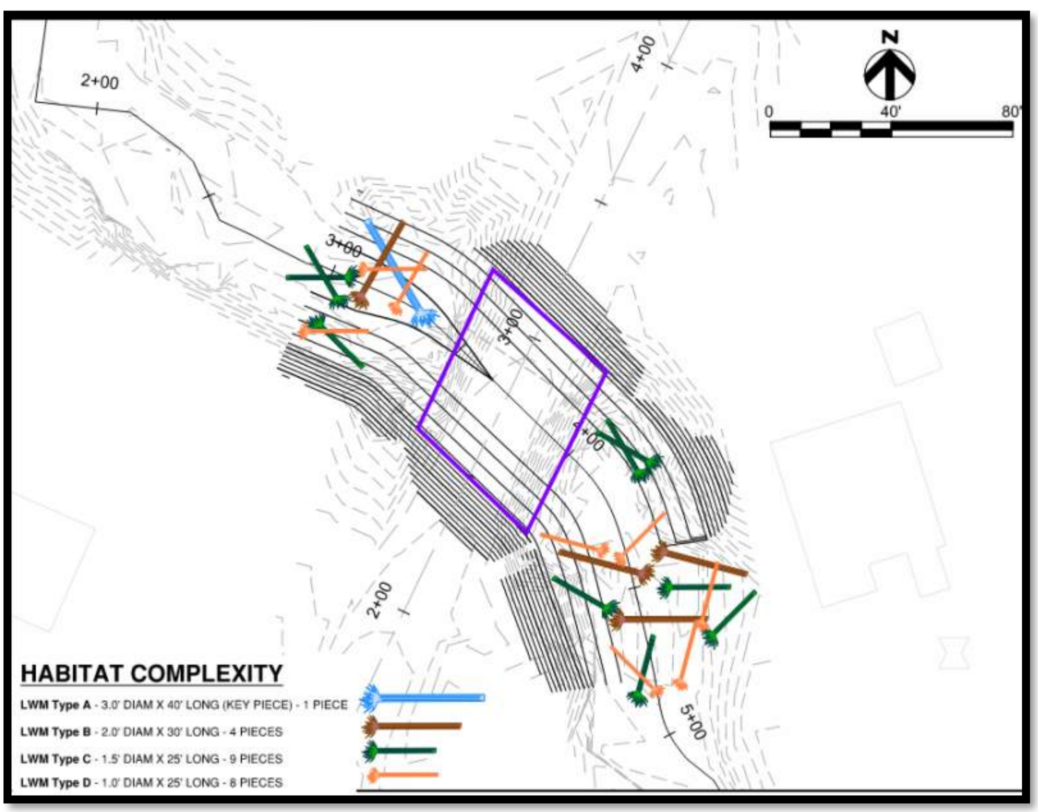


Figure 29: Conceptual LWM layout, bridge structure

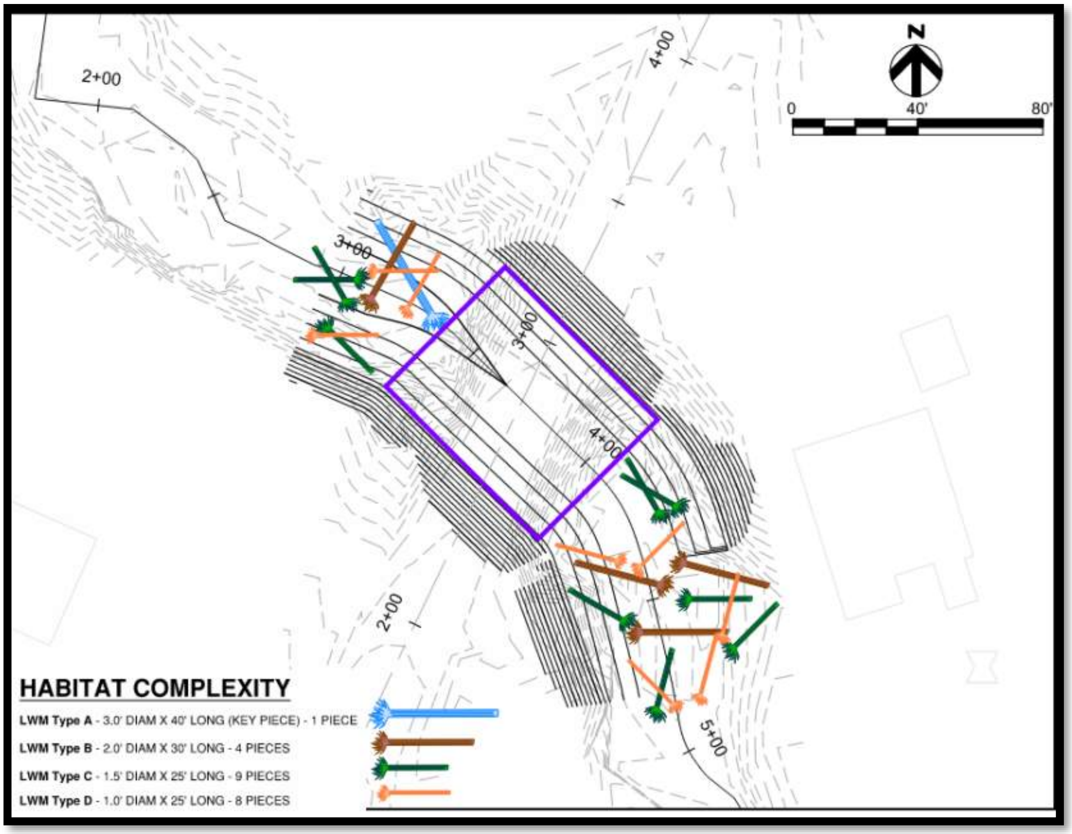


Figure 30: Conceptual LWM layout, buried structure

5. Hydraulics

The hydraulic analysis of the existing and proposed Woodland Creek crossing was performed using Bureau of Reclamation's SRH-2D Version 3.3.1 (USBR 2017) computer program, a two-dimensional hydraulic and sediment transport model. The software was selected for its ability to model dynamic interactions between the stream channel and overbanks, roadway overtopping, culverts, and the influence of bridge decks on bridge backwater (pressure flow). Pre- and post-processing of the model was completed using SMS Version 13.1.22 (Aquaveo, 2022).

Two scenarios were analyzed for determining stream characteristics for Woodland Creek with the SRH-2D models: 1) existing conditions and 2) future conditions with the proposed 54-foot hydraulic opening.

5.1. Model Development

The following sections describe the development of the SRH-2D including model inputs and assumptions.

5.1.6. Topography

Detailed channel geometry data in the model was obtained from the survey files, which were developed from topographic surveys performed by Thurston County. Additional topography in the floodplains was supplemented with LiDAR data from the 2011 Thurston County LiDAR dataset hosted by Washington Department of Natural Resources (DNR). Proposed channel geometry was developed from the proposed grading surface created by HDR. All elevations are referenced using the NGVD 1929 vertical datum (feet). The horizontal datum used for the model was NAD 1983 HARN Washington South (feet).

5.1.7. Model Extent and Computational Mesh

The hydraulic model upstream extents are consistent with the detailed survey boundary. The left and right overbanks were supplemented with LiDAR data to capture the full extents of floodplain over the range of modeled flows (Figure 31 and Figure 32). The model downstream extents are consistent with the downstream survey extents. The computational mesh elements were a combination of patched (quadrilateral) and paved (triangular) elements, with finer resolution in the channel and larger elements in the floodplain. The total number of mesh elements for the existing and proposed models was approximately 26,000.

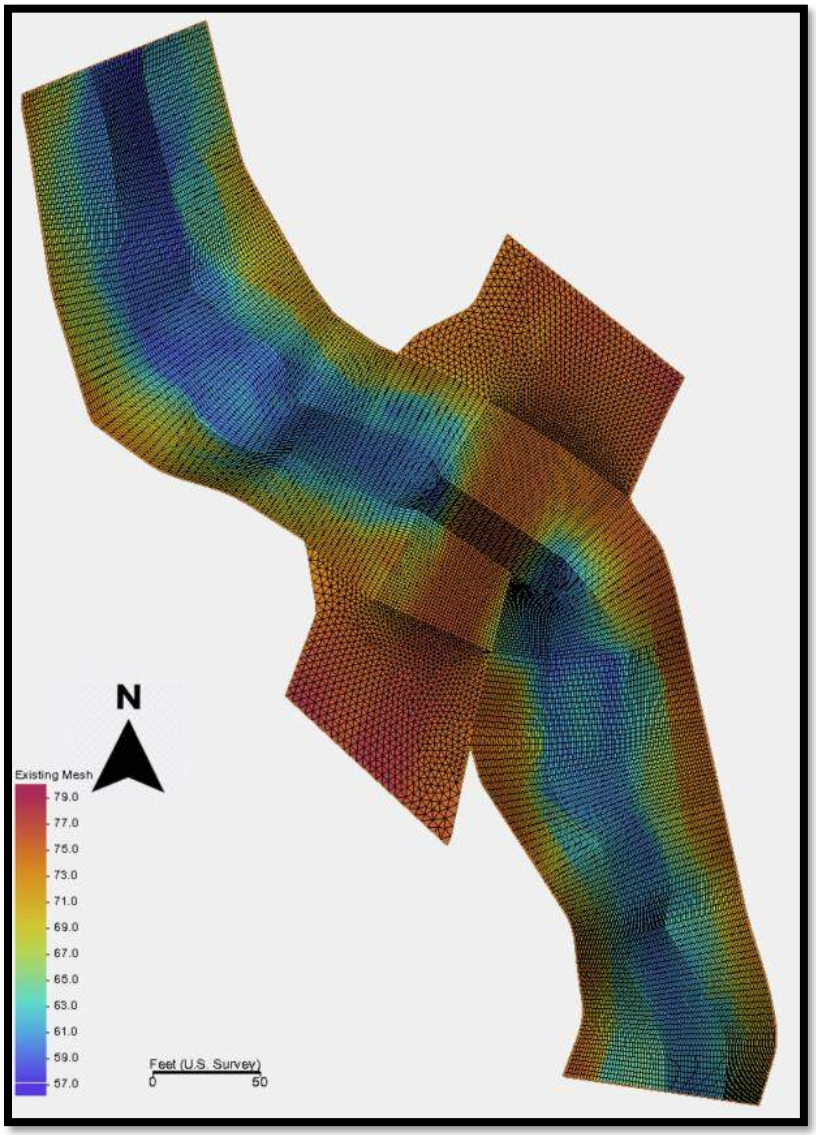


Figure 31: Existing computational mesh with underlying terrain

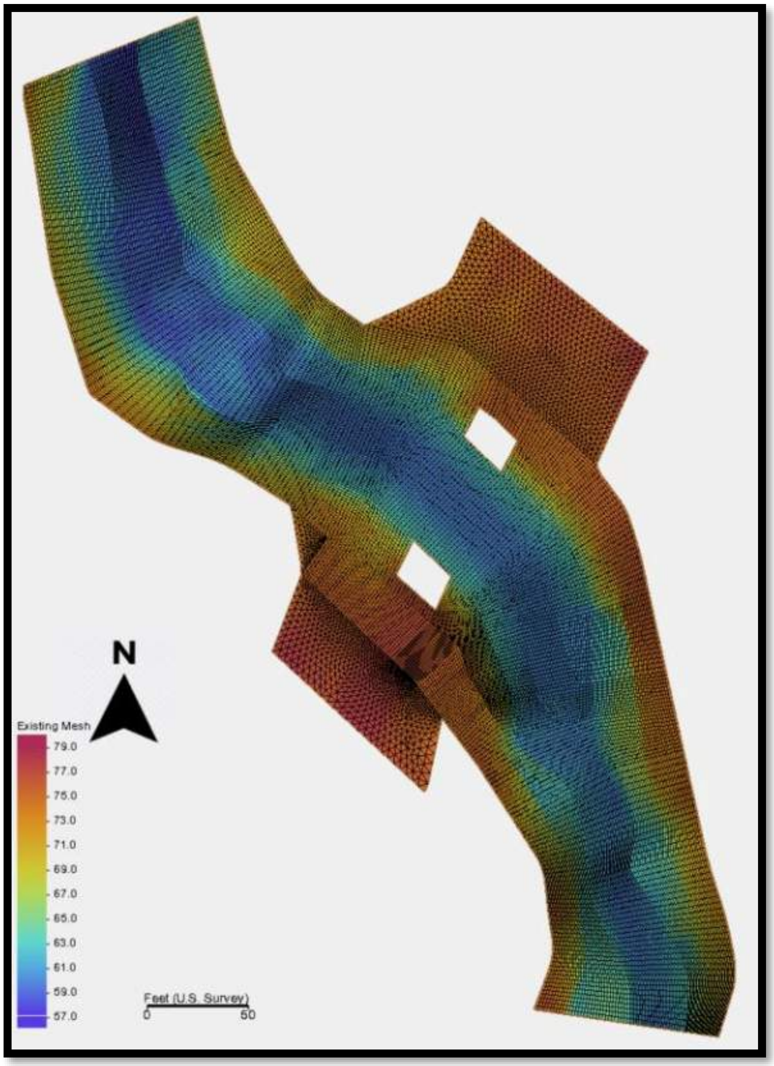


Figure 32: Proposed computational mesh with underlying terrain

5.1.8. Roughness

Manning's n values were estimated based off site observations, aerial photography and standard engineering values (Chow, 1959) and are summarized below (Table 6). Roughness in the overbanks represents dense vegetation and undergrowth associated with the grasses, shrubs and trees in the riparian areas.

Table 6: Summary of roughness coefficients

Land Cover	Manning's Roughness Coefficient
Existing Channel	0.05
Overbank	0.09
Road	0.025
Existing Culvert	0.024
Proposed Channel	0.05

5.1.9. Boundary Conditions

Model simulations were performed using multiple steady state discharges ranging from the 2-year to 500-year peak flow events as described in Section 3.0. External boundary conditions were applied at the upstream and downstream extents of the model and remained the same between the existing and proposed conditions runs. A constant flow rate was specified at the upstream external boundary condition, while multiple normal depth rating curves were specified at the downstream boundary. The downstream normal depth boundary condition rating curves were developed within SMS using the existing terrain. Multiple rating curves were used at the downstream boundary to capture the varying elevations in the floodplain. The crossing is located within a FEMA regulatory Zone AE floodplain (Figure 33). Consideration was given to using the FEMA 100-Year Base Flood Elevation for the Woodland Creek as the downstream boundary condition for the project hydraulic model. However, when compared to the normal depth boundary condition, the BFE was lower than the normal depth at the boundary, and therefore it was more conservative to use the normal depth boundary.

A HY-8 internal boundary condition was specified in the existing conditions model to represent the existing culvert. HY-8 is a culvert analysis software developed by the Federal Highway Administration. The existing culvert was modeled as a 10-ft diameter circular pipe with 3 feet of sediment at the bottom to represent the open bottom arch culvert. Inverts elevations were determined from the survey information. The existing culvert was modeled with zero longitudinal slope.

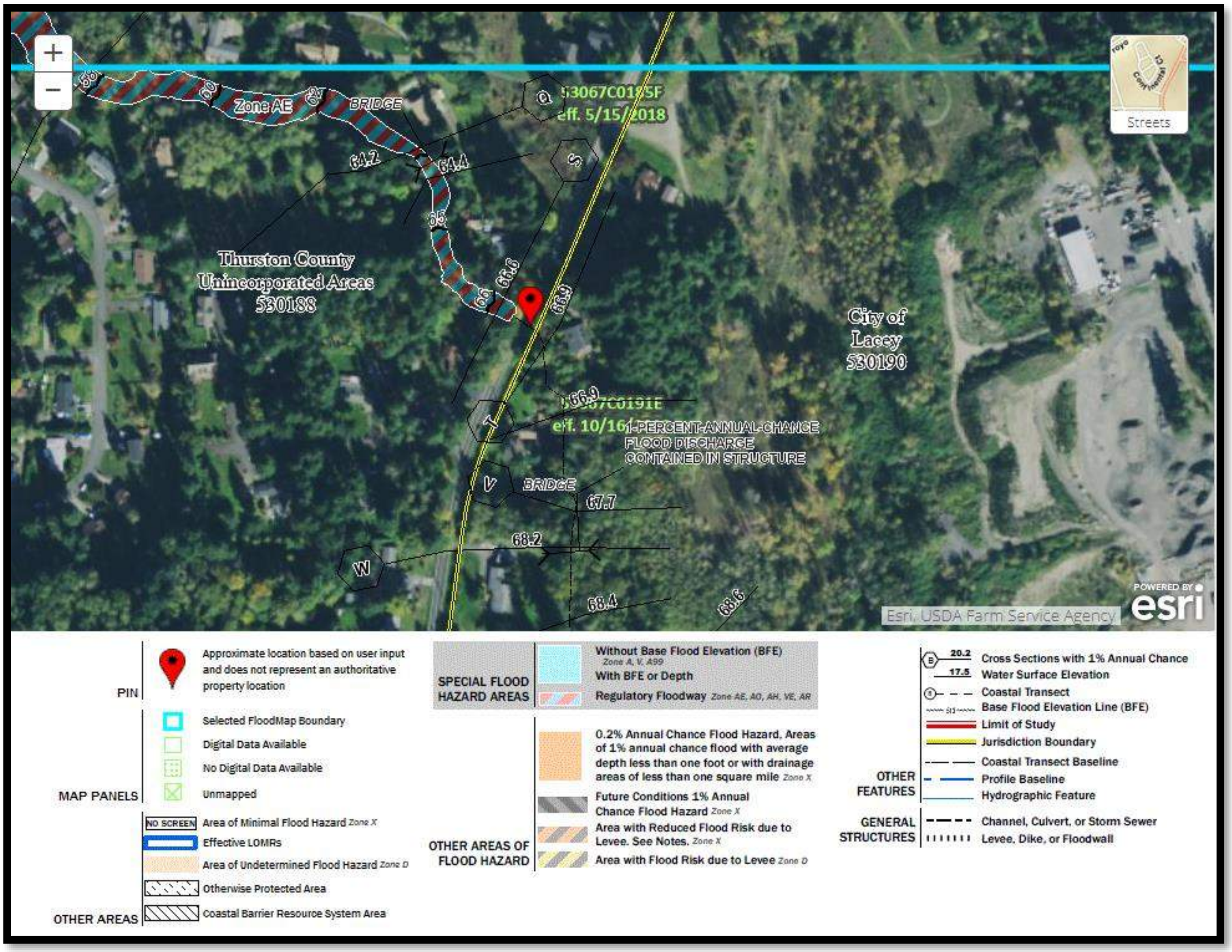


Figure 33: FEMA Floodplain map

5.1.10. Model Geometries

Two geometries were developed for simulation with SRH-2D, representing existing and proposed conditions. The existing conditions includes the existing culvert under Draham St. The proposed conditions geometry was created by modifying the existing condition geometry to remove the existing culverts and associated internal boundary conditions. Additionally, the terrain was updated to reflect the proposed grading and 54-foot span hydraulic opening. The walls of the proposed structure were modeled as voids in the computational mesh. Model geometry outside of the proposed improvements are the same for the proposed conditions as the existing condition.

5.1.11. Model Controls

The SRH-2D model controls were kept consistent between existing- and proposed-conditions models. The model began at time zero and ended at 4 hours with a 1-second time step. The initial condition was dry, and the default flow module was used.

5.2. Hydraulic Results

The following sections provide a summary of the hydraulic modeling results for existing and proposed conditions. Additional hydraulic results can be found in Appendix B.

5.2.6. Existing-Conditions Model Results

Simulated results from the hydraulic model of the Draham St crossing indicate that the existing culvert creates a backwater impact. The model results showed that the culvert is overtopped during the 500-year event and results in approximately 0.3 feet of water on the road surface northeast of the culvert crossing. Channel velocities in the existing model generally range from 1 ft/sec to 12 ft/sec for the 100-year event. In general, velocities are lower upstream of the culvert as they are impacted by backwater from the existing culvert. There is a high velocity area at the outlet of the culvert, most likely due to low capacity of the culvert and some high points in the topography of the channel immediately downstream of the culvert outlet. The largest velocities occur at the culvert outlet. Hydraulic results from the existing model within the main channel are shown in Table 7.

Figure 34 and Figure 35 show the plan view existing conditions of the 100-year water surface elevation and velocity, respectively. Figure 36 shows the horizontal profile of water surface elevations for all storm events run. Figure 37 shows the reference reach cross section for all storm events run.

Table 7: Existing-conditions main channel hydraulic results

Hydraulic Parameter	Cross Section	Station	2-yr	10-yr	100-yr	500-yr
Average Water Surface Elevation (ft)	A	51+55	60.8	61.7	63.1	64.7
	B	52+87	61.5	62.1	63.3	64.6
	C	54+81	62.9	64.5	68.4	75.2
	D	55+84	63.0	64.6	68.4	75.2
Max Depth (ft)	A	51+55	1.6	2.5	3.9	5.5
	B	52+87	1.4	2.0	3.2	4.5
	C	54+81	2.8	4.5	8.3	15.2
	D	55+84	2.7	4.3	8.1	14.9
Average Velocity (ft/s)	A	51+55	1.6	2.1	2.9	3.4
	B	52+87	2.5	3.5	4.8	6.0
	C	54+81	1.0	1.3	1.4	1.0
	D	55+84	1.6	1.9	1.7	1.2
Average Shear (ft/s)	A	51+55	0.2	0.3	0.5	0.6
	B	52+87	0.5	0.9	1.5	2.2
	C	54+81	0.1	0.1	0.1	<0.1
	D	55+84	0.2	0.2	0.2	<0.1

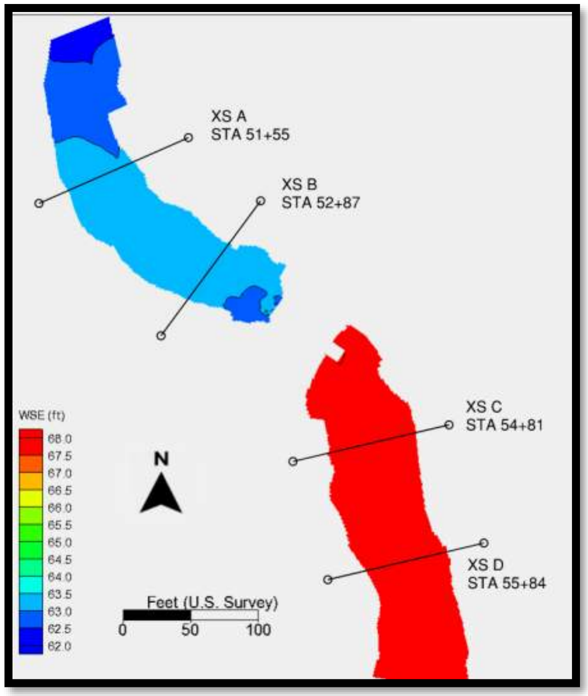


Figure 34: Existing-conditions 100-year water surface elevations with cross section locations

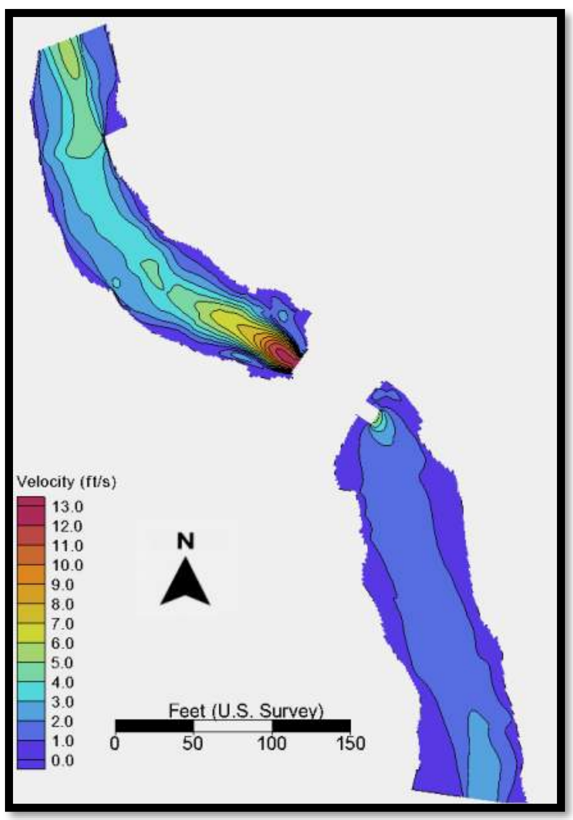


Figure 35: Existing-conditions 100-year velocity

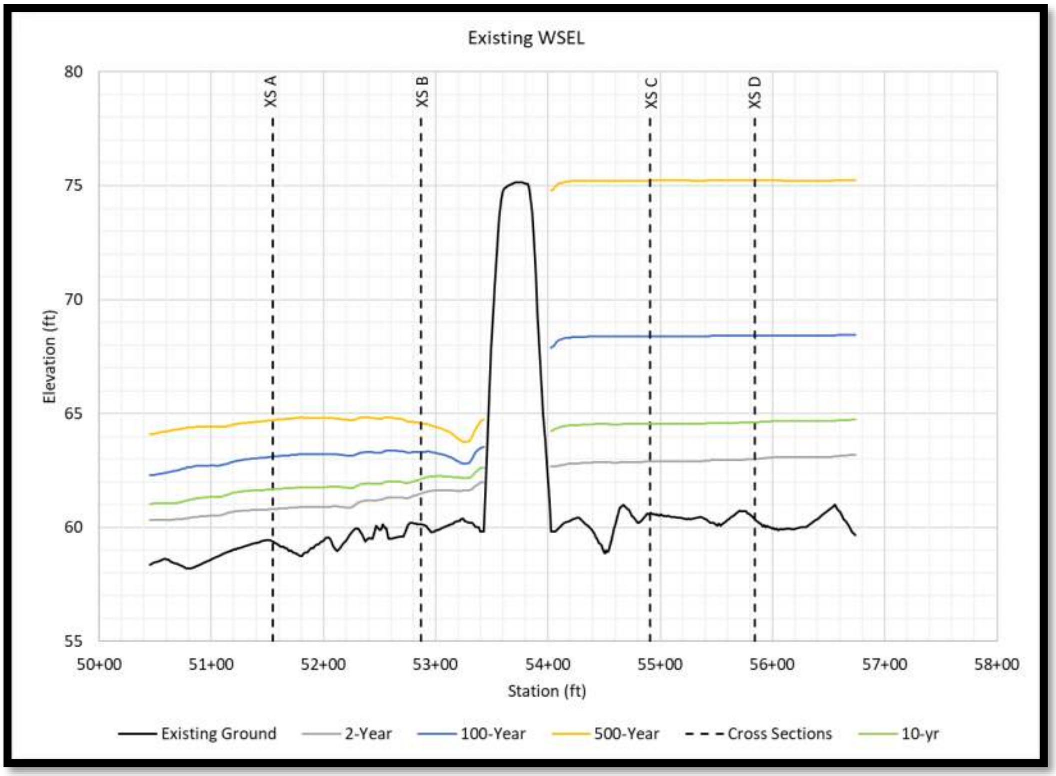


Figure 36: Existing-conditions water surface elevation profile

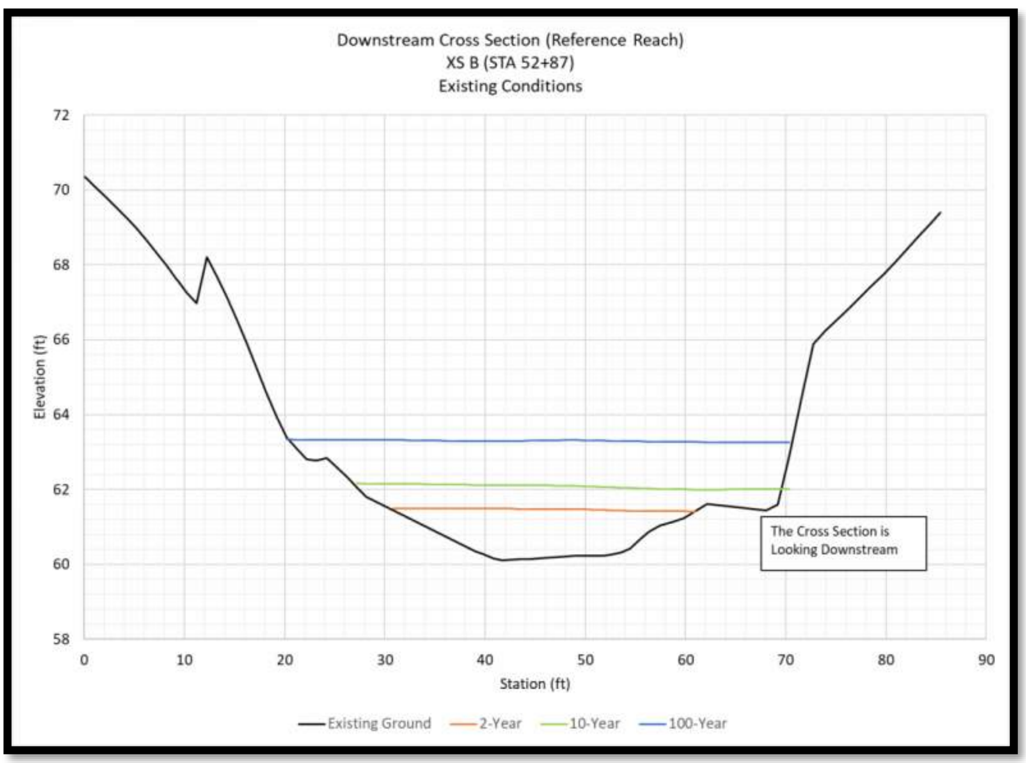


Figure 37: Existing-conditions reference reach, XS 52+87

5.2.7. Proposed-Conditions Model Results

The proposed design follows the natural progression of the stream alignment with a slight 15-degree skew with respect to the road. For proposed conditions, channel velocities range from 2.9 ft/sec to 4.7 ft/sec during the 100-year event. Proposed channel velocities upstream of the crossing increase because the backwater effect has been reduced due to the larger opening.

Under proposed conditions, the upstream water surface at the inlet of the proposed culvert decreases by approximately 4.5 feet when compared to the existing conditions 100-year scenario. A localized WSE increase of approximately 0.9 foot occurs at the 100-year occurs at the existing culvert outlet. This increase in WSE is caused by the change in flow regime from supercritical to subcritical at the culvert outlet.

Hydraulic results from the proposed model within the channel are shown in Table 8 for the average water surface elevation, maximum channel depth, average velocity, and average shear stress. Figure 38 shows a plan view of the cross sections and the water surface elevations used for the quantitative output. Figure 39 shows the plan view proposed-conditions of the 100-year velocity. Figure 40 shows the proposed alignment of the vertical profile of water surface elevations for all storm events run. Figure 41 shows the reference reach cross section and Figure 42 shows the proposed structure cross section for all storm events run.

Table 8: Proposed-conditions main channel hydraulic results

Hydraulic Parameter	Cross Section	Station	2-yr	10-yr	100-yr	500-yr
Average Water Surface Elevation (ft)	A	1+55	60.8	61.7	63.1	64.1
	B	2+87	61.5	62.1	63.4	64.6
	G	3+55	61.8	62.5	63.8	64.9
	F	3+69	61.8	62.5	63.8	64.9
	E	3+83	61.8	62.6	63.9	65.0
	C	4+70	62.1	62.8	64.1	65.2
	D	5+69	62.6	63.4	64.8	66.0
Max Depth (ft)	A	1+55	1.6	2.5	3.9	5.0
	B	2+87	1.4	2.0	3.3	4.4
	G	3+55	1.8	2.5	3.8	4.9
	F	3+69	1.8	2.5	3.8	4.9
	E	3+83	1.8	2.5	3.8	4.9
	C	4+70	1.7	2.5	3.8	4.8
	D	5+69	2.2	3.0	4.4	5.6
Average Velocity (ft/s)	A	1+55	1.5	2.1	2.9	3.8
	B	2+87	2.5	3.6	4.4	5.1
	G	3+55	1.7	2.6	3.6	4.4
	F	3+69	1.8	2.6	3.6	4.4
	E	3+83	1.8	2.6	3.6	4.4
	C	4+70	1.6	2.3	3.5	4.5
	D	5+69	2.5	3.6	4.7	5.5
Average Shear (ft/s)	A	1+55	0.2	0.3	0.5	0.8
	B	2+87	0.6	0.9	1.2	1.5
	G	3+55	0.2	0.4	0.6	0.8
	F	3+69	0.2	0.4	0.6	0.8
	E	3+83	0.2	0.4	0.6	0.8
	C	4+70	0.2	0.3	0.6	0.9
	D	5+69	0.4	0.7	1.0	1.3

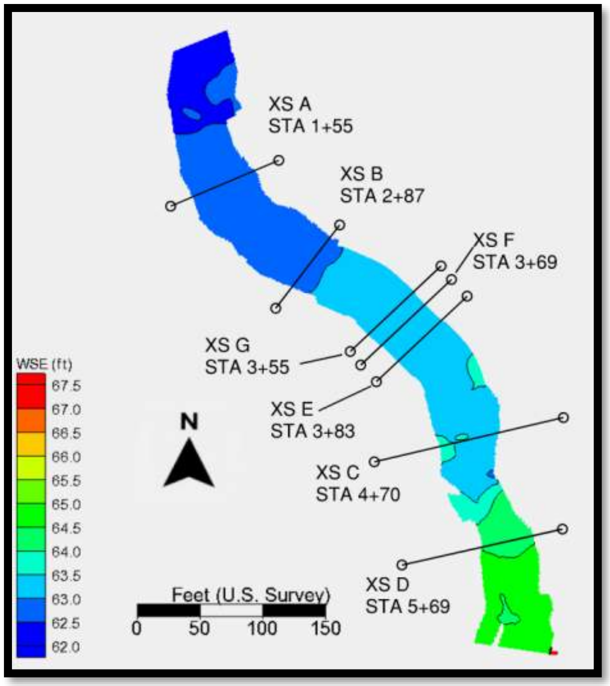


Figure 38: Proposed-conditions 100-year water surface elevations with cross section locations

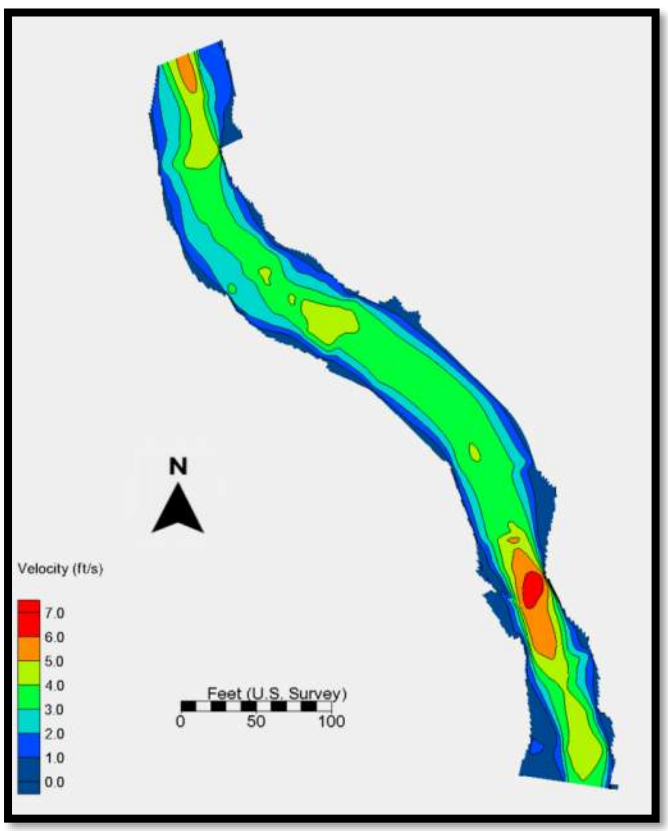


Figure 39: Proposed-conditions 100-year velocity

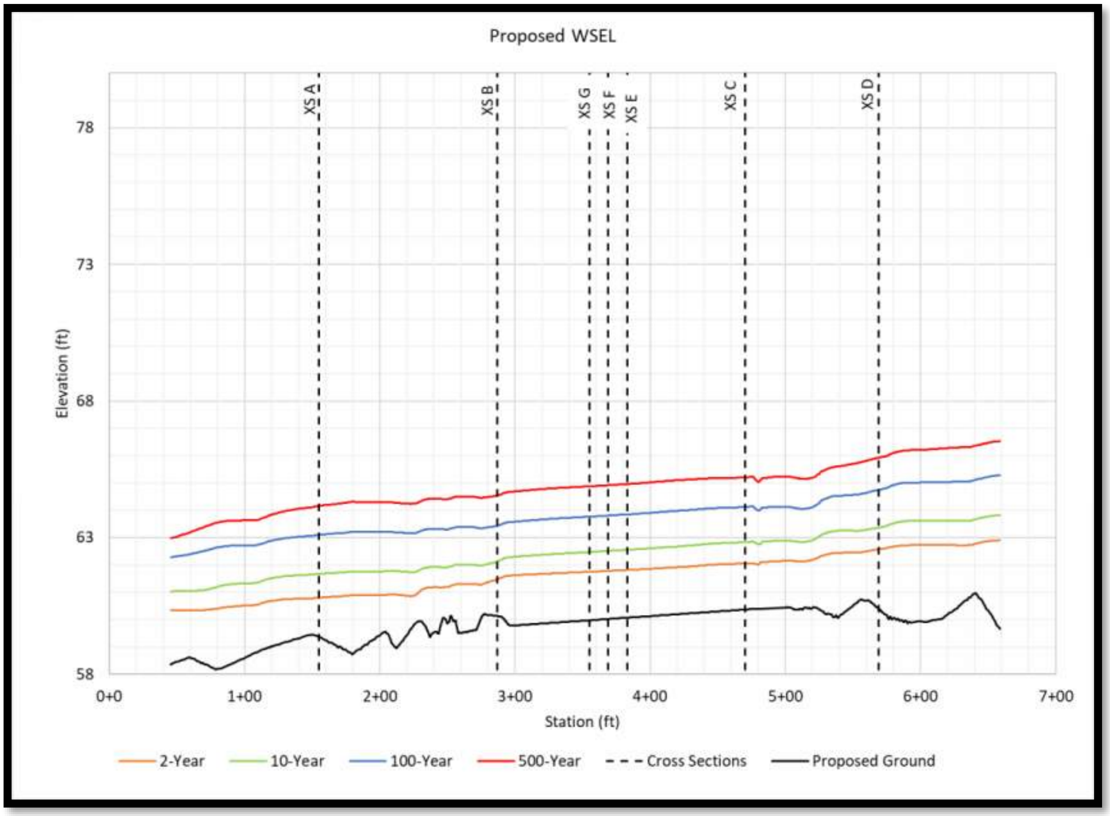


Figure 40: Proposed water surface elevation profile

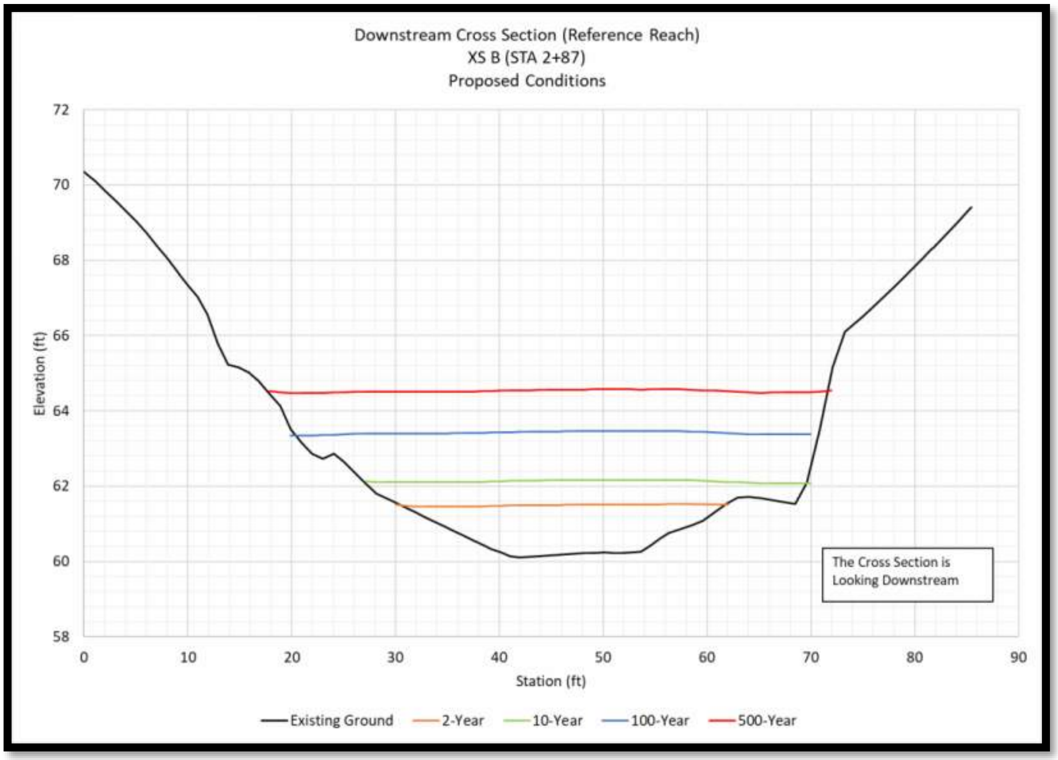


Figure 41: Proposed-conditions reference reach cross section, XS 2+87

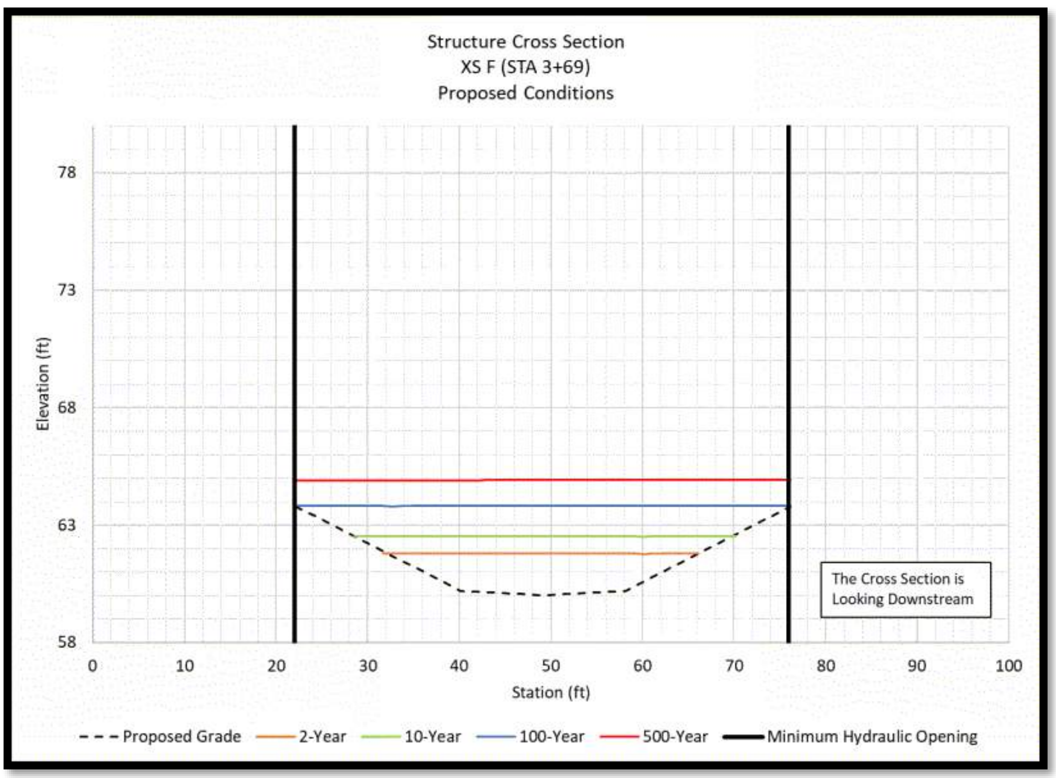


Figure 42: Proposed structure cross section, XS 3+69

Installation of the proposed structure would eliminate the backwater impacts just upstream of the existing culvert, resulting in a reduction in water surface elevation upstream. The water surface elevation is reduced by as much as 4.5 feet at the inlet of the proposed culvert at the 100-year event. As seen in Figure 43, the pool remains intact and slightly backwaters the downstream end of the proposed structure. Downstream of the private access road, which has been graded through in the proposed conditions, the proposed water surface elevations are approximately 0.5 feet higher than the existing water surface elevations. This is due to proposed grading eliminating a pool and small terrain bump at the outlet of the existing culvert. Approximately 70 feet downstream, at station 2+80, the existing and proposed water surface elevations converge; therefore, it is expected no major floodplain changes will occur downstream.

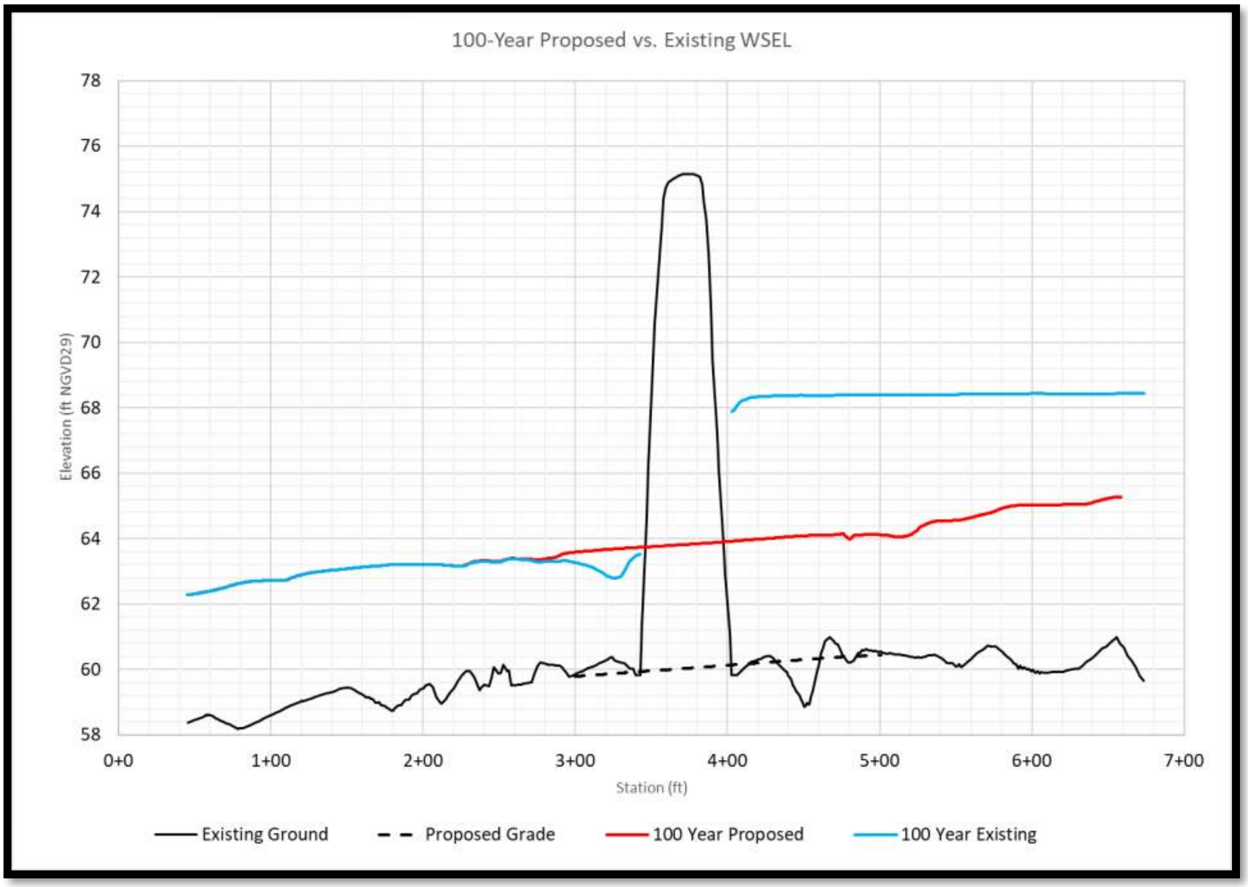


Figure 43: Comparison of existing and proposed 100-year water surface elevations

5.3. Model Assumptions and Limitations

The model results and recommendations in this report are based on the conditions of the project site and the associated watershed at the time of this study. Any modifications to the site, man-made or natural, could alter the analysis, findings, and recommendations contained herein and could invalidate the analysis, findings, and recommendations. Site conditions, completion of upstream or downstream projects, upstream or downstream land use changes, climate changes, vegetation changes, maintenance practice changes, or other factors may change over time. Additional analysis or updates may be required in the future as a result of these changes or as the stream design is progressed.

6. Estimated Scour

Preliminary scour calculations were completed to assist in the structure alternative analysis in identifying a preliminary required countersink or footing depth of the structure. See Appendix C for detailed scour calculations.

6.1. Assumptions

The following assumptions were made during the preliminary scour analysis:

- Scour input variables were extracted from the SRH-2D hydraulic model
- The pebble count conducted during the site visit was used to characterize the streambed material, specifically the median particle size (D_{50})
- Scour was not quantified at habitat features such as LWM or meander bars
- Bedrock or other competent rock is not present to limit scour depth

6.2. Long-term Degradation

Long-term elevation changes to streambed elevations associated with man-made or natural causes are considered long-term aggradation and degradation. Aggradation is the deposition of material upstream of a crossing caused by erosion of the channel and/or upstream watershed. Aggradation is not a component of total scour. Conversely, degradation is the lowering or scouring of the channel bed across long reaches of channel caused by a decrease in the sediment supply from upstream. Degradation is a component of total scour.

It was anticipated that a minor amount of long term degradation will occur throughout the crossing; based on the long profile (Figure 18), the average slope upstream, downstream, and through the crossing is 0.5 percent. Locally, based on the survey profile, the slope downstream of the culvert is approximately 0.7 percent; after a grade break, the slope decreases to 0.2 percent through the crossing and upstream of the culvert. With the removal of the Draham St culvert, the stream may regrade slightly to eliminate the grade break and achieve a constant slope throughout the upstream and downstream reaches. Long-term degradation was estimated by visually projecting a constant slope through the crossing at 0.4 percent beginning at an assumed base control point of the downstream dam. The exact location of the dam is not in the survey data and needs to be confirmed during later stages of design. It was visually estimated that 0.8 foot of long-term degradation is possible if the Woodland Creek channel vertically adjusts to a slope more consistent with the slope of the long profile and without a disconnect between the downstream and upstream slopes.

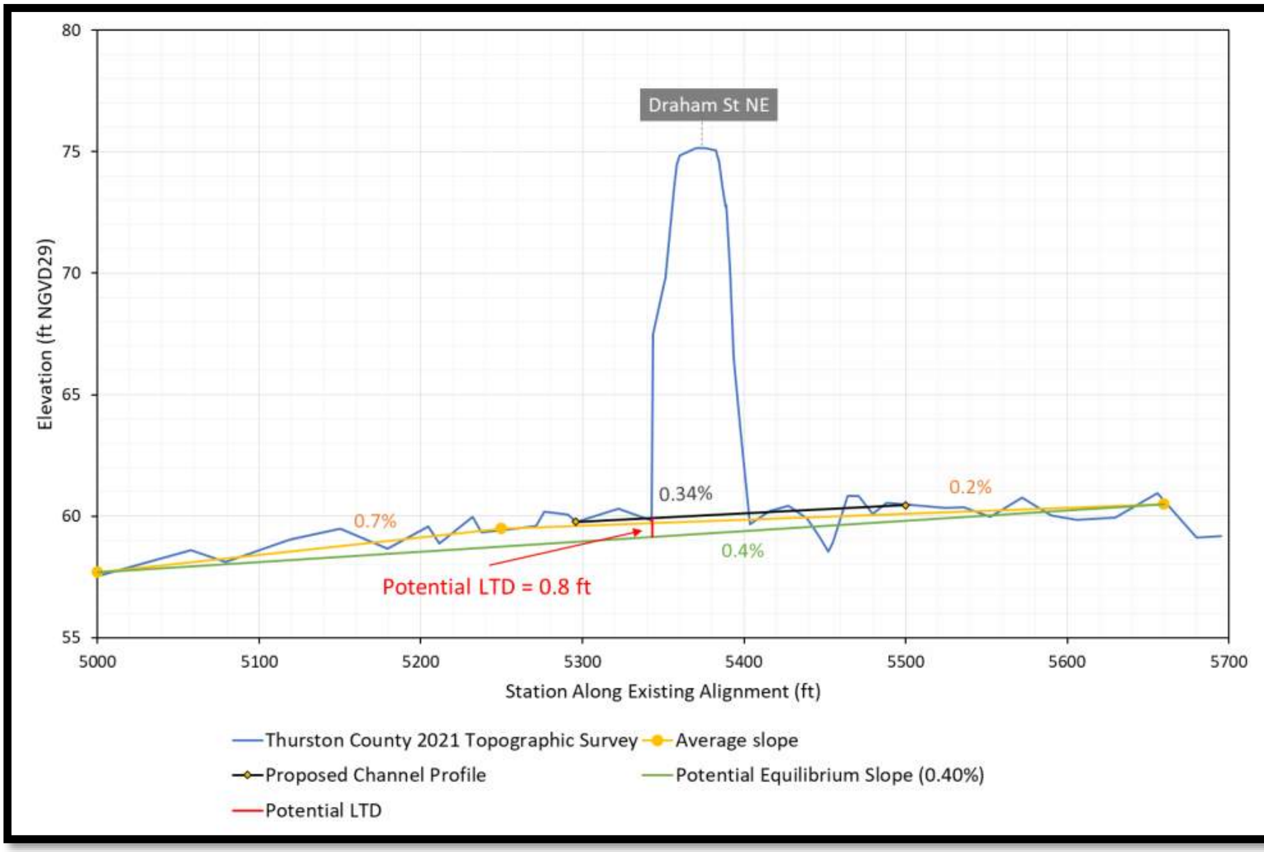


Figure 44: Potential long-term degradation

6.3. Contraction Scour

Contraction scour is the lowering of the streambed elevation associated with a constriction of flow through a culvert or bridge. Estimates of contraction scour were calculated following the methodology outlined in Chapter 6 of HEC-18 (Arneson et al. 2012) for non-cohesive materials. Contraction scour condition can be classified as live-bed or clear-water scour. The scour condition is dependent on the transport of bed material flow upstream of the bridge. Clear-water scour occurs when there is no material of bed transport, while live-bed scour occurs when there is transport of bed material from an upstream reach into the crossing. Scour condition determination is made by calculating the critical velocity of the D50 and comparing it to the mean velocity upstream of the bridge opening.

The scour analysis indicates that the clear-water scour condition exists at the lower 2-year, 10-year, and 100-year flow events, while the live-bed scour condition exists at the 500-year event. As a result, both live-bed and clear water contraction scour depths were estimated. The results indicate 0.0 feet of scour at the 2-year, 10-year, and 100-year events; and 0.2 foot of scour at the 500-year event.

6.4. Local Scour

Local scour includes scour as acceleration of flow and resulting vortices induced by specific features such as piers, spurs, and embankments. Abutments and piers are not present in the proposed design and as a result it was not necessary to quantify scour for these features.

Bend scour was calculated following the methodology outlined in HEC-23 (Lagasse et al. 2012). Depth of bend scour was estimated using Maynord's method and applied to the 2-year and 10-year flows. It is recommended that the estimation only be applied to flow conditions with an overbank depth less than 20 percent of the main channel depth. The 500-year and 100-year flow exceed this percentage and therefore are not accounted for in bend scour estimation. It is estimated there will be approximately 0.9 foot of scour for the 2-year event and 1.7 feet of scour for the 10-year event. The 10-year estimate of 1.7 feet of scour was used for the 100-year and 500-year events as well as it is the most conservative value.

6.5. Total Scour

Total scour includes the three components previously discussed: long-term degradation, contraction scour, and local scour. These three components are added to obtain the total scour. It is assumed that each component occurs independent of the other and adding them together likely adds some conservatism to the design. Calculated preliminary total scour depths are provided in Table 9 to be accounted for in the design.

Table 9: Estimated total scour depth

Scour Type	2-Year	10-Year	100-Year (ft)	500-Year (ft)
Contraction	0.0	0.0	0.0	0.2
Local - Bend	0.9	1.7	1.7	1.7
Long-Term	0.8	0.8	0.8	0.8
Total	**1.7**	**2.5**	**2.5**	**2.7**

To account for anticipated scour within the proposed structure, the structure will be placed a minimum of 4 feet below the finished grade, approximately 1.3 feet below the maximum estimated total scour depth. See Appendix C for detailed scour calculations. These results are preliminary and further scour calculations will be completed in the future as the design is progressed.

If climate change flows are a required design consideration in the future, the results from this scour analysis will remain applicable. The 500-year flow event controls the scour depth and is greater than the 2080 100-year flow (Section 3), thereby showing that a structure accommodating the 500-year flow event scour depth of 2.7 feet will also accommodate the 2080 100-year flow event scour depth.

7. Roadway Section

The City of Lacey intends to widen Draham St through this corridor, adding sidewalks and a center lane turn pocket. To accommodate these future corridor improvements, Thurston County is implementing a widened road condition throughout the Project extents and a bridge span that can be restriped for future corridor conditions.

The roadway section will be a total of 59 feet wide, consisting of two 6-foot sidewalks, two 0.5-foot curb and gutters, two 11-foot shoulders, and two 12-foot lanes (Figure 45). Under future conditions, the road will be restriped to include a 12-foot turn pocket, reducing each shoulder to 5 feet wide (Figure 46).

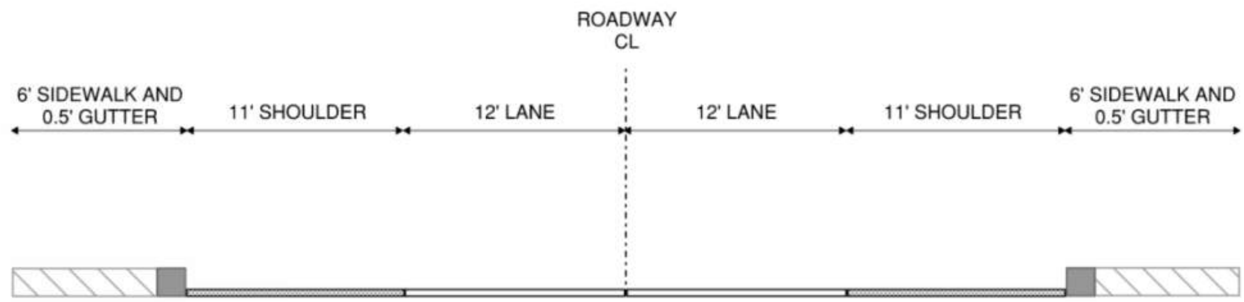


Figure 45: Proposed roadway section, current conditions striping plan

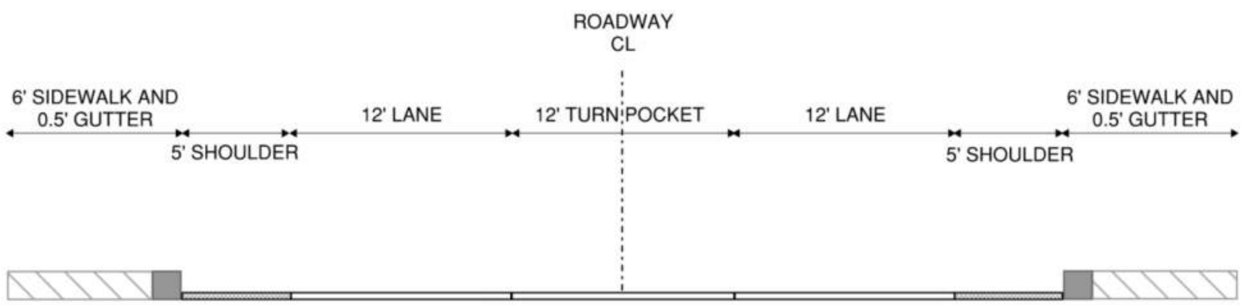


Figure 46: Proposed roadway section, future conditions striping plan

7.1. Maintenance of Traffic (MOT)

A temporary bypass road will be constructed in order to maintain traffic on Draham St during construction. A traffic detour route is not recommended because Draham St is a busy and widely used thoroughfare. The temporary bypass road will likely be placed downstream of the current roadway to avoid impacts to driveways and to cross the stream at the straightest part of its alignment. Further analysis should be performed at later stages of design to determine if the temporary bypass should be a two-lane or an alternating single-lane .

8. Structure Alternative Analysis

The two alternatives considered for structure design utilize the previously identified hydraulic design parameters including a minimum hydraulic opening of 54 feet; a required clearance above the stream thalweg of 6.8 feet; and a design scour depth of 2.7 feet. As previously described, the crossing needs to provide a 59-foot wide corridor (46-foot wide roadway, two 0.5-

foot curbs and gutter, and two 6-foot sidewalks) to accommodate future development plans for the corridor. The channel is skewed approximately 18-degrees to the roadway. The site is underlain by liquefiable soils, so drilled shafts are recommended for foundation support with either alternative. During concept development, two alternatives were considered for the crossing structure:

1. Bridge Structure
2. Buried Structure

8.1. Alternative 1: Bridge Structure

This alternative would utilize an 80-foot span constructed of 30-inch prestressed voided slab girders. A cast-in-place topping slab would be placed over the voided slabs to provide a more durable wearing surface and increased weather protection. The prestressed girders can be cast with skewed ends, and the topping slab would correct any differential camber in the girders for a smooth finished roadway. The bridge would be supported on drilled shaft foundations, estimated to be 5-foot in diameter. This alternative is shown in Figure 47, and further details shown in the drawings in Appendix D. A temporary bridge adjacent to the existing crossing will be utilized for maintenance of traffic during construction.

A modular steel girder superstructure was also considered for the bridge crossing alternative, but was determined to not meet the needs of the site well. Modular steel bridges are typically supplied with bridge rails meeting Test Level 2 design standard, which is only suitable for low-speed local routes with a limited number of heavy trucks. Additionally, County development standards call for new bridges to be of concrete construction unless otherwise approved. Draham Street is currently a busy roadway with significant increases projected for the future. For these reasons, a prestressed concrete superstructure will perform better over the lifespan of the structure.

The bridge structure low chord of 15 feet above the thalweg accommodates the required 6.8 feet clearance required, and if future guidelines require climate change flows to be considered within design, the structure also accommodates the 7.4 feet clearance that would be required (Section 4.1.4).

The estimated construction cost for the Alternative 1 bridge structure is $2,190,000 (inclusive of approach slab and temporary bypass road costs).

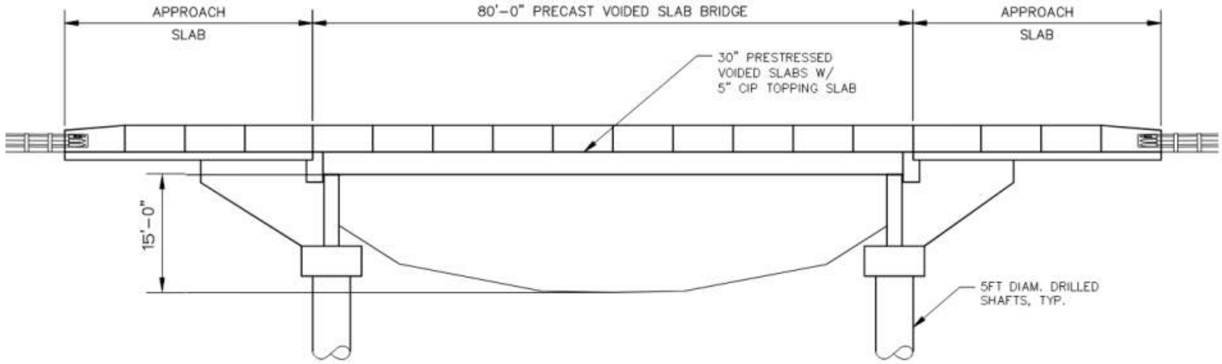


Figure 47: Bridge structure

8.2. Alternative 2: Buried Structure

This alternative would utilize a 60-foot span, 14-foot rise precast concrete arch to span the stream channel, supporting approximately 7-feet of roadway embankment over the crown. Precast arches cannot be constructed with skewed ends, so the ends of the structure would extend beyond the edges of the roadway and the roadway grading would be adjusted to apply even soil pressure. Headwalls and/or wingwalls would be needed to minimize the culvert length and retain the roadway embankment from spilling into the stream channel. The arch would be supported on drilled shaft foundations, estimated to be 5-foot in diameter. This alternative is shown in Figure 48, and further details shown in the drawings in Appendix D. A temporary bridge adjacent to the existing crossing will be utilized for maintenance of traffic during construction.

The buried structure low chord of 10 feet above the thalweg accommodates the required 6.8 feet clearance required, and if future guidelines require climate change flows to be considered within design, the structure also accommodates the 7.4 feet clearance that would be required (Section 4.1.4).

The estimated construction cost for the Alternative 2 arch structure is $2,210,000 (exclusive of earthwork costs and inclusive of temporary bypass road costs).

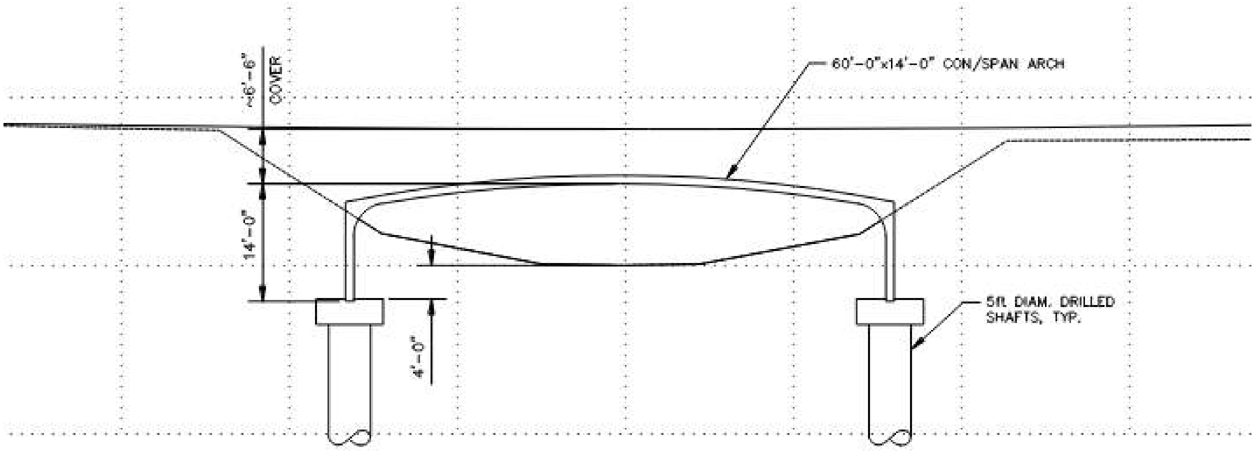


Figure 48: Buried structure

8.3. Cost Estimate

The preliminary costs for each alternative are summarized in Table 10; the buried structure has a slightly higher cost due to the additional grading and headwalls required for structure construction. Detailed OPCCs can be found in Appendix E.

Table 10: Summary of costs for Alternatives

Item Description	Bridge Cost	Buried Structure Cost
Preparation	$69,288	$67,983
Grading	$24,591	$90,085
Drainage	$341,848	$288,612
Storm Sewer	$20,000	$20,000
Structure	$2,190,000	$2,210,000
Surfacing	$59,858	$55,441
Hot Mix Asphalt	$80,099	$81,383
Erosion Control and Roadside Planting	$24,500	$24,500
Traffic	$75,669	$77,539
Other Items	$60,453	$61,503
Subtotal Construction	**$2,946,305**	**$2,977,045**
Contingency @ 25%	$736,576	$744,261
Total Construction	**$3,682,881**	**$3,721,306**
Preliminary Engineering (PE) @ 12%	$441,946	$446,557
Construction Management (CM) @ 3.8%	$139,949	$141,410
Miscellaneous Costs @ 16.6% (includes inflation)	$611,358	$617,737
Right of Way Costs	$400,000	$400,000
Project total	**$5,276,135**	**$5,327,009**

9. Conclusions and Recommendations

The bridge structure and the buried structure alternatives are each feasible at the project site. Both alternatives will require drilled shaft foundations, so foundation type is not a differentiating factor. The bridge is estimated to be less expensive to construct, but only marginally, so cost is not a differentiating factor either.

The prestressed concrete girder bridge is the recommended alternative for the crossing structure due to the fact that the bridge structure is easier to configure to fit the site geometry. Because of the 18 degree skew of the stream along the roadway, the headwall of the buried structure extends further into the stream corridor than the bridge structure. As a result, the bridge structure requires less earthwork during construction.

Another reason the buried structure is not the recommended alternative is because the hydraulic design and modeling were performed under the assumption that the roadway section were to remain as it is currently under existing conditions, rather than being widened to accommodate the future 59-foot wide corridor. If the buried structure alternative is advanced, the headwalls of the structure extend far enough upstream and downstream that the alignment of the stream would need to be shifted and therefore remodeled to keep alignment curve elements outside the limits of the structure. These issues are not associated with the bridge alternative, where the alignment curve elements are located outside of the limits of the structure under the future 59-foot wide corridor.

10. Next Steps

This alternatives analysis report summarizes the findings of preliminary design of two different alternatives from the perspective of various disciplines and recommends an alternative for further development. The next steps include selection of the preferred alternative and to advance the alternative to the next level of design.

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Appendix A Streambed Mobility Analysis

Summary - Stream Simulation Bed Material Design

Project:	**Draham St NE Woodland Creek**
By:	**Farnaz Aslkhodapasand**

Observed Gradation:						***Design Gradation:***					
Location:	Cumulative Pebble Count					**Location:**	Streambed Design				
	D_{100}	**D_{95}**	**D_{84}**	**D_{50}**	**D_{16}**		**D_{100}**	**D_{95}**	**D_{84}**	**D_{50}**	**D_{16}**
ft	**0.5**	**0.1**	**0.1**	**0.0**	**0.0**	ft	**0.21**	**0.20**	**0.17**	**0.06**	**0.00**
in	**6.0**	**1.4**	**0.9**	**0.4**	**0.2**	in	**2.5**	**2.4**	**2.1**	**0.8**	**0.0**
mm	**152**	**36**	**24**	**11.2**	**4.8**	mm	**64**	**60**	**53**	**19.1**	**0.4**

Determining Aggregate Proportions

Per WSDOT Standard Specifications 9-03.11

Rock Size		**Streambed**	**Streambed Cobbles**					**Streambed Boulders**			
[in]	**[mm]**	**Sediment**	**4"**	**6"**	**8"**	**10"**	**12"**	**12"-18"**	**18"-28"**	**28"-36"**	**D_{size}**
36.0	**914**									**100**	**100.0**
32.0	**813**									50	**100.0**
28.0	**711**								**100**		**100.0**
23.0	**584**								50		**100.0**
18.0	**457**							**100**			**100.0**
15.0	**381**							50			**100.0**
12.0	**305**						**100**				**100.0**
10.0	**254**					**100**	**80**				**100.0**
8.0	**203**				**100**	**80**	68				**100.0**
6.0	**152**			**100**	**80**	68	57				**100.0**
5.0	**127**			**80**	68	57	**45**				**100.0**
4.0	**102**		**100**	71	57	**45**	39				**100.0**
3.0	**76.2**		**80**	63	**45**	38	34				**100.0**
2.5	**63.5**	**100**	65	54	37	32	28				**100.0**
2.0	**50.8**	**80**	50	**45**	29	25	22				**80.0**
1.5	**38.1**	73	**35**	32	21	18	16				**72.5**
1.0	**25.4**	**65**	20	18	13	12	11				**65.0**
0.75	**19.1**	50	**5**	**5**	**5**	**5**	**5**				**50.0**
0.187	**4.75**	**35**									**35.0**
No. 40 =	**0.425**	**16**									**16.0**
No. 200 =	**0.0750**	**7**									**7.0**
% per category		**100**	**0**		**0**	**0**	**0**	**0**	**0**	**0**	*--> 100%*

Streambed Mobility/Stability Analysis

Modified Shields Approach

References:

Stream Simulation: An Ecological Approach to Providing Passage for Aquatic Organizms at Road-Stream Crossings

Appendix E--Methods for Streambed Mobility/Stability Analysis

Limitations:

D_{84} must be between 0.40 in and 10 in

uniform bed material (Di < 20-30 times D50)

Slopes less than 5%

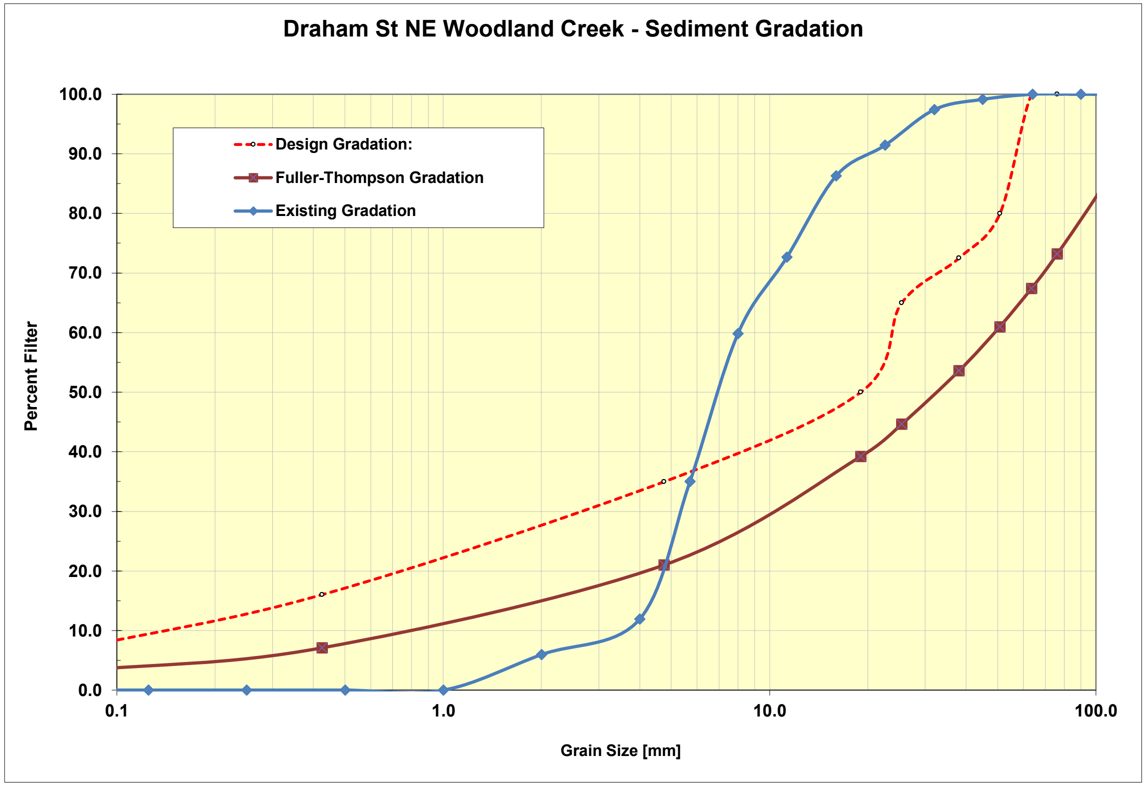
Sand/gravel streams with high relative submergence

γ_s	165	specific weight of sediment particle (lb/ft^3)
γ	62.4	specific weight of water (1b/ft^3)
τ_{D50}	0.047	dimensionless Shields parameter for D50

Flow	2-YR (82 cfs)	10-YR (183 cfs)	100-YR (445 cfs)	500-YR (780 cfs)
Average Modeled Shear Stress (lb/ft^2)	0.1	0.2	0.4	0.6
τ_{ci}				
0.96	No Motion	No Motion	No Motion	No Motion
0.93	No Motion	No Motion	No Motion	No Motion
0.89	No Motion	No Motion	No Motion	No Motion
0.84	No Motion	No Motion	No Motion	No Motion
0.78	No Motion	No Motion	No Motion	No Motion
0.74	No Motion	No Motion	No Motion	No Motion
0.69	No Motion	No Motion	No Motion	No Motion
0.66	No Motion	No Motion	No Motion	No Motion
0.61	No Motion	No Motion	No Motion	No Motion
0.56	No Motion	No Motion	No Motion	Motion
0.53	No Motion	No Motion	No Motion	Motion
0.50	No Motion	No Motion	No Motion	Motion
0.46	No Motion	No Motion	No Motion	Motion
0.43	No Motion	No Motion	No Motion	Motion
0.40	No Motion	No Motion	No Motion	Motion
0.37	No Motion	No Motion	Motion	Motion
0.33	No Motion	No Motion	Motion	Motion
0.30	No Motion	No Motion	Motion	Motion
0.20	No Motion	Motion	Motion	Motion

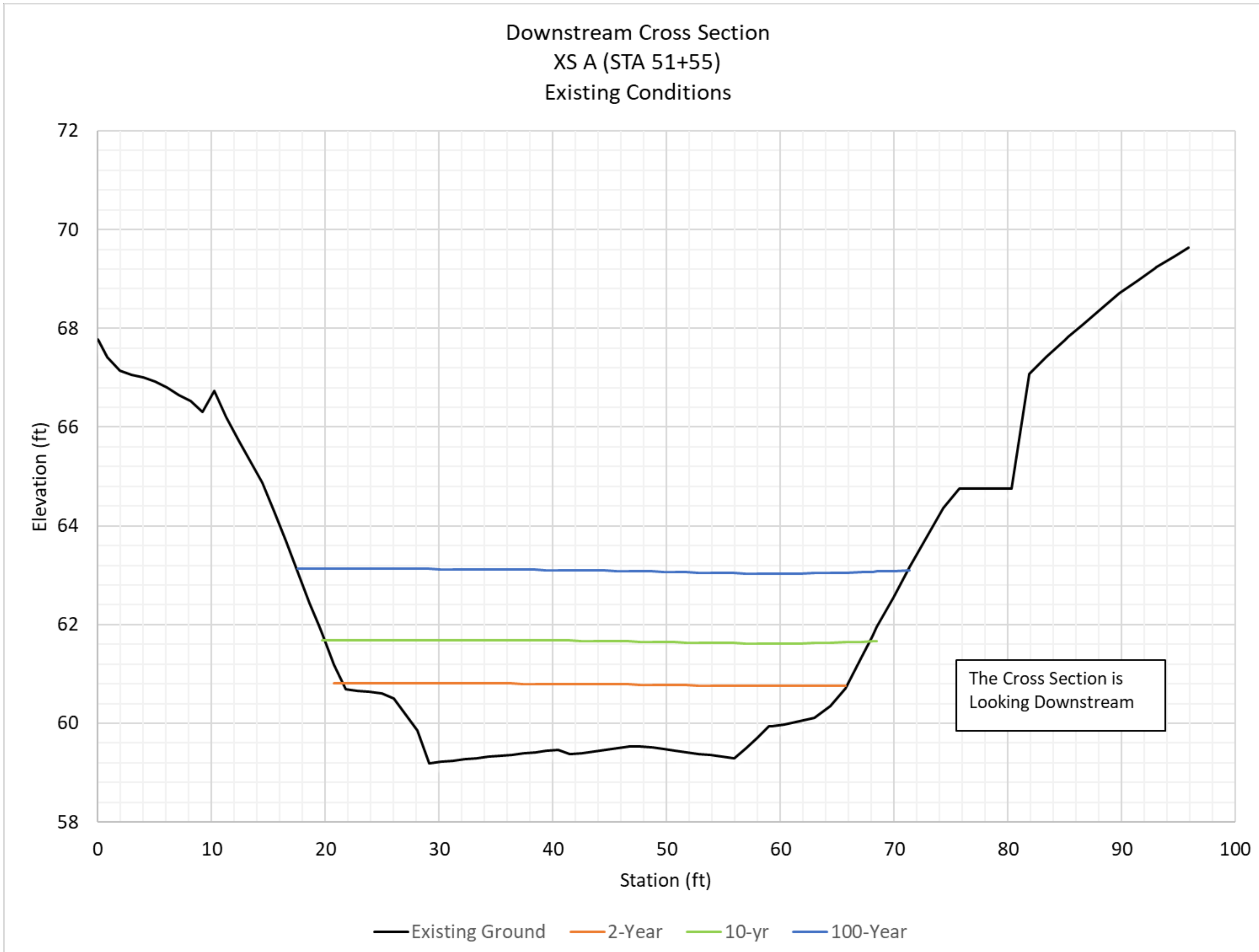
	D95	**D84**	**D50**	**D35**	**D16**
Mix Size Interpolation	95	84	50	35	16
(mm)	**60**	**53**	**19**	**5**	**0**
(inches)	**2.36**	**2.09**	**0.75**	**0.19**	**0.02**
(feet)	**0.20**	**0.17**	**0.06**	**0.02**	**0.00**

Otto Gershon, gershoo@wsdot.wa.gov ; 9/2007
modified by Kevin Lautz, P.E. 6/2010

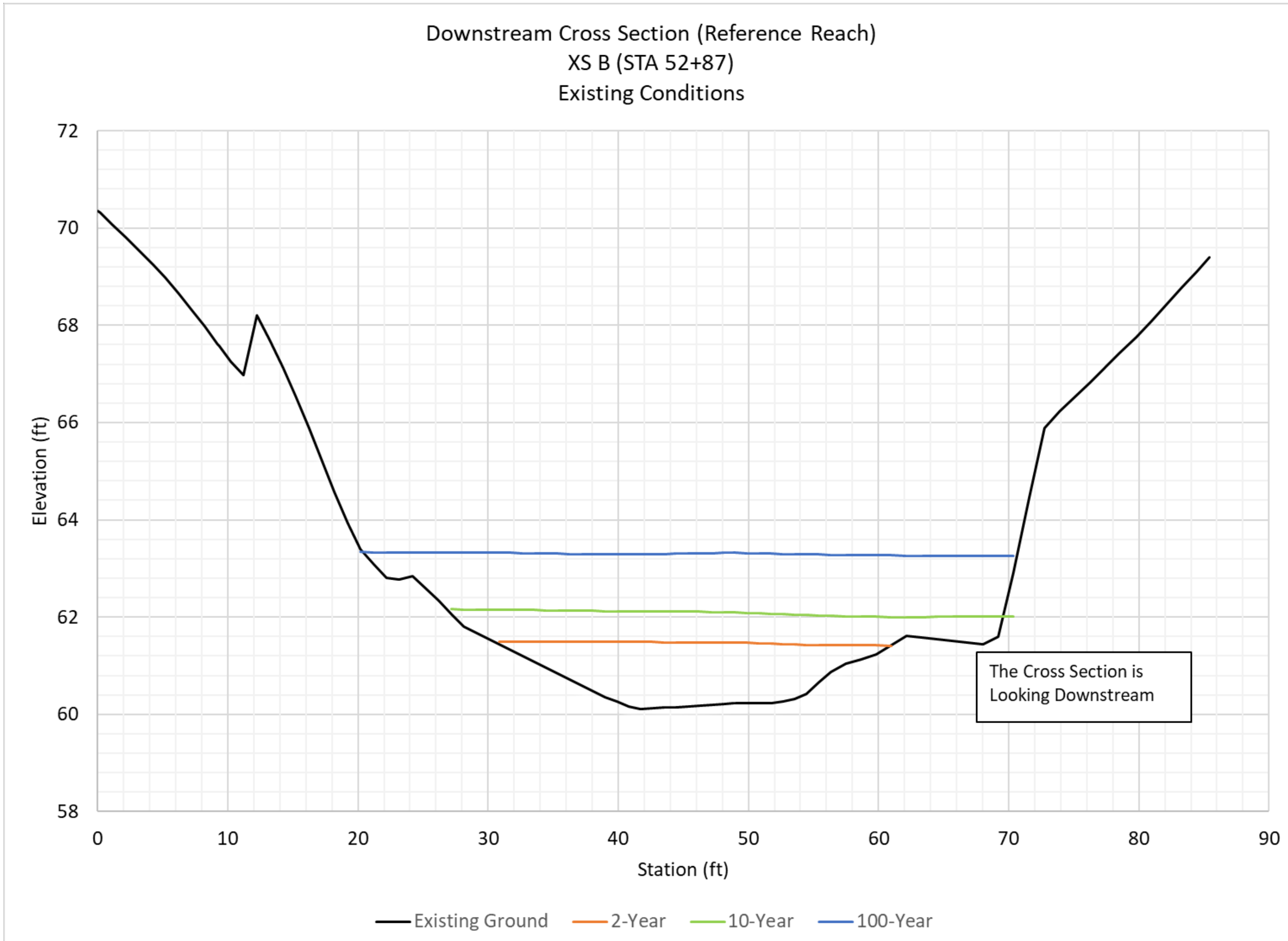


Otto Gershon, gershoo@wsdot.wa.gov ; 9/2007
modified by Kevin Lautz, P.E. 6/2010

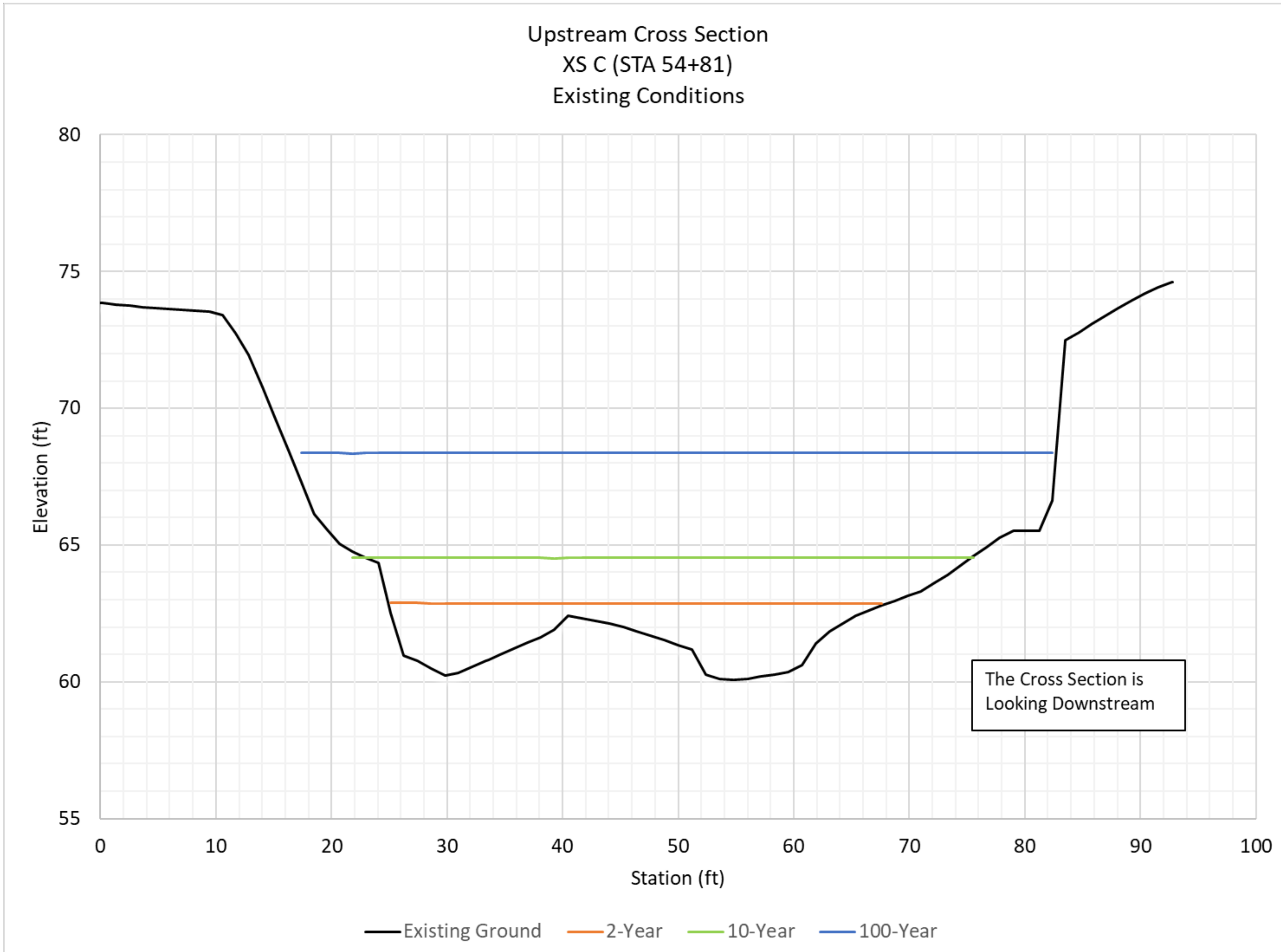
Appendix B Hydraulic Results



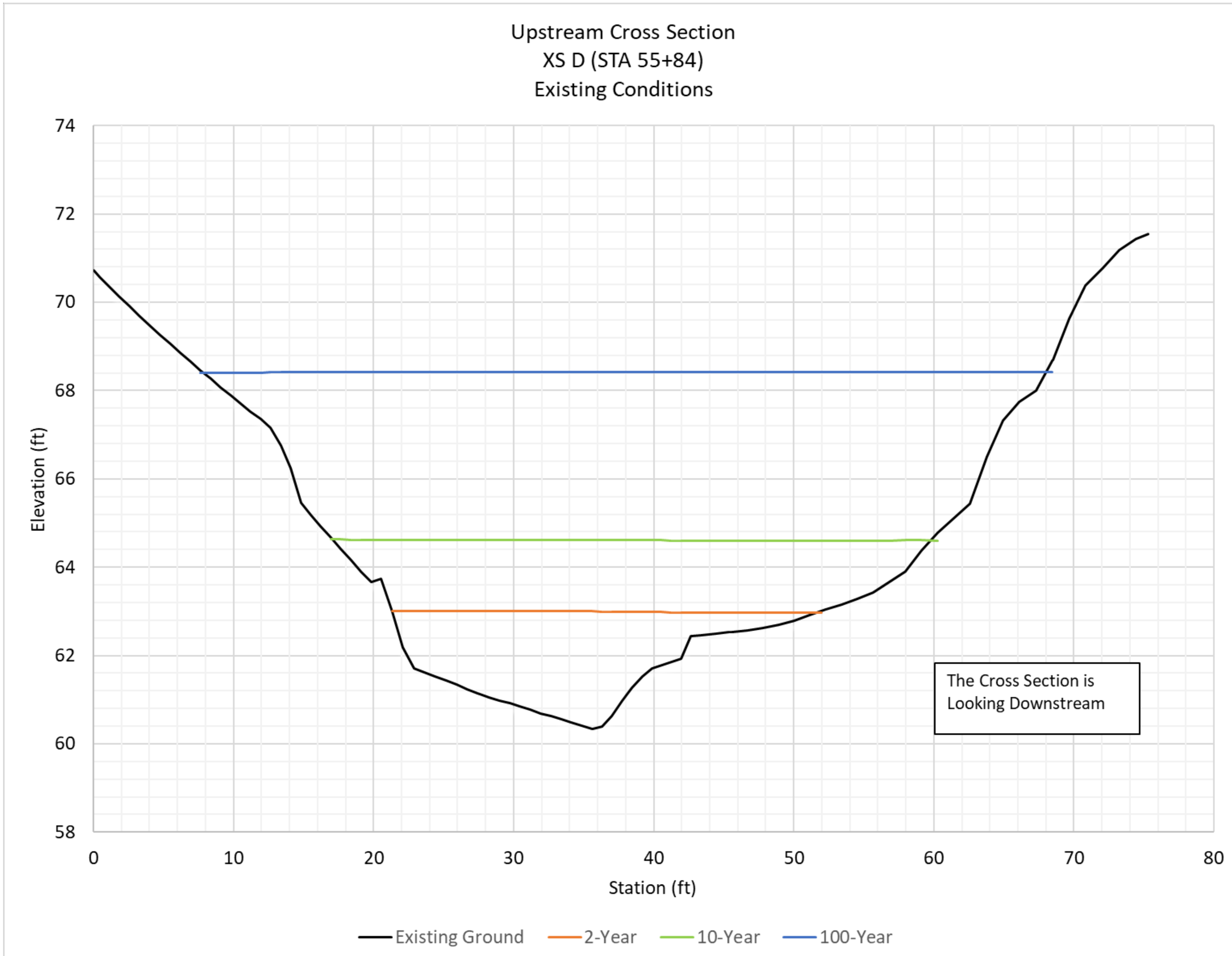
Downstream Cross Section
XS A (STA 51+55)
Existing Conditions
Elevation (ft)
72
70
68
66
64
62
60
58
0
10
20
30
40
50
60
70
80
90
100
Station (ft)
The Cross Section is Looking Downstream
Existing Ground
2-Year
10-yr
100-Year

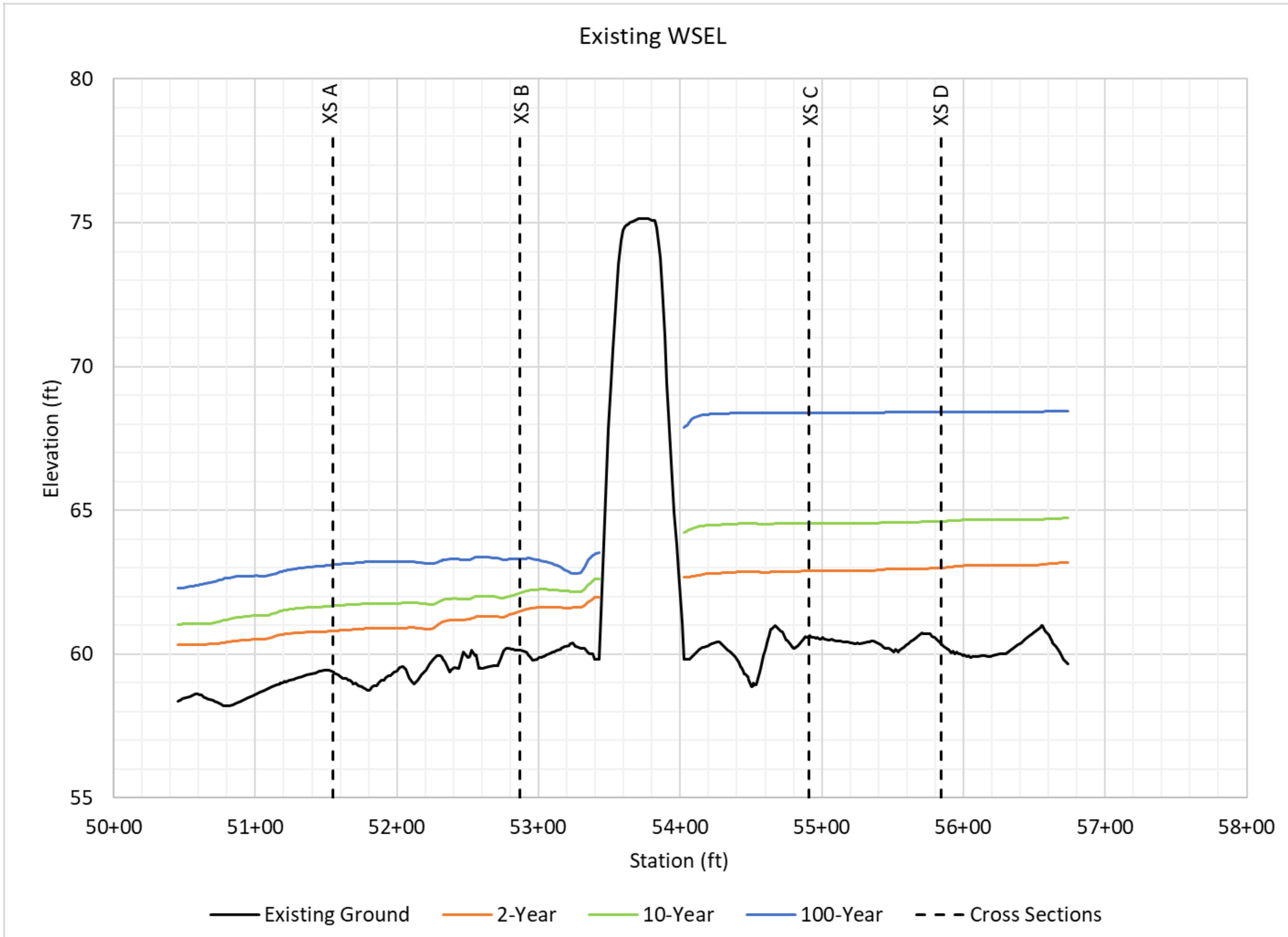


Downstream Cross Section (Reference Reach)
XS B (STA 52+87)
Existing Conditions
Elevation (ft)
72
70
68
66
64
62
60
58
0
10
20
30
40
50
60
70
80
90
Station (ft)
The Cross Section is Looking Downstream
Existing Ground
2-Year
10-Year
100-Year

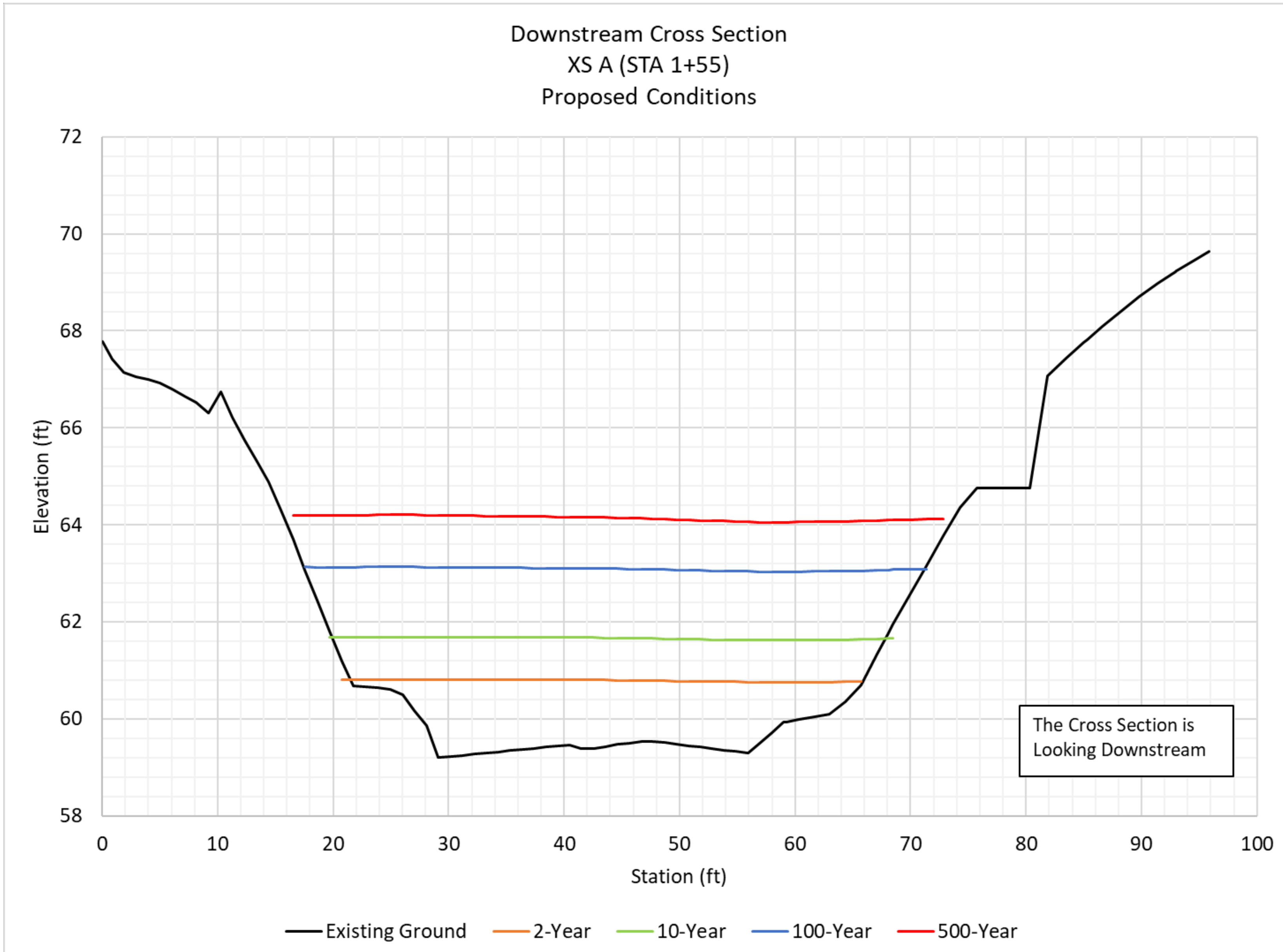


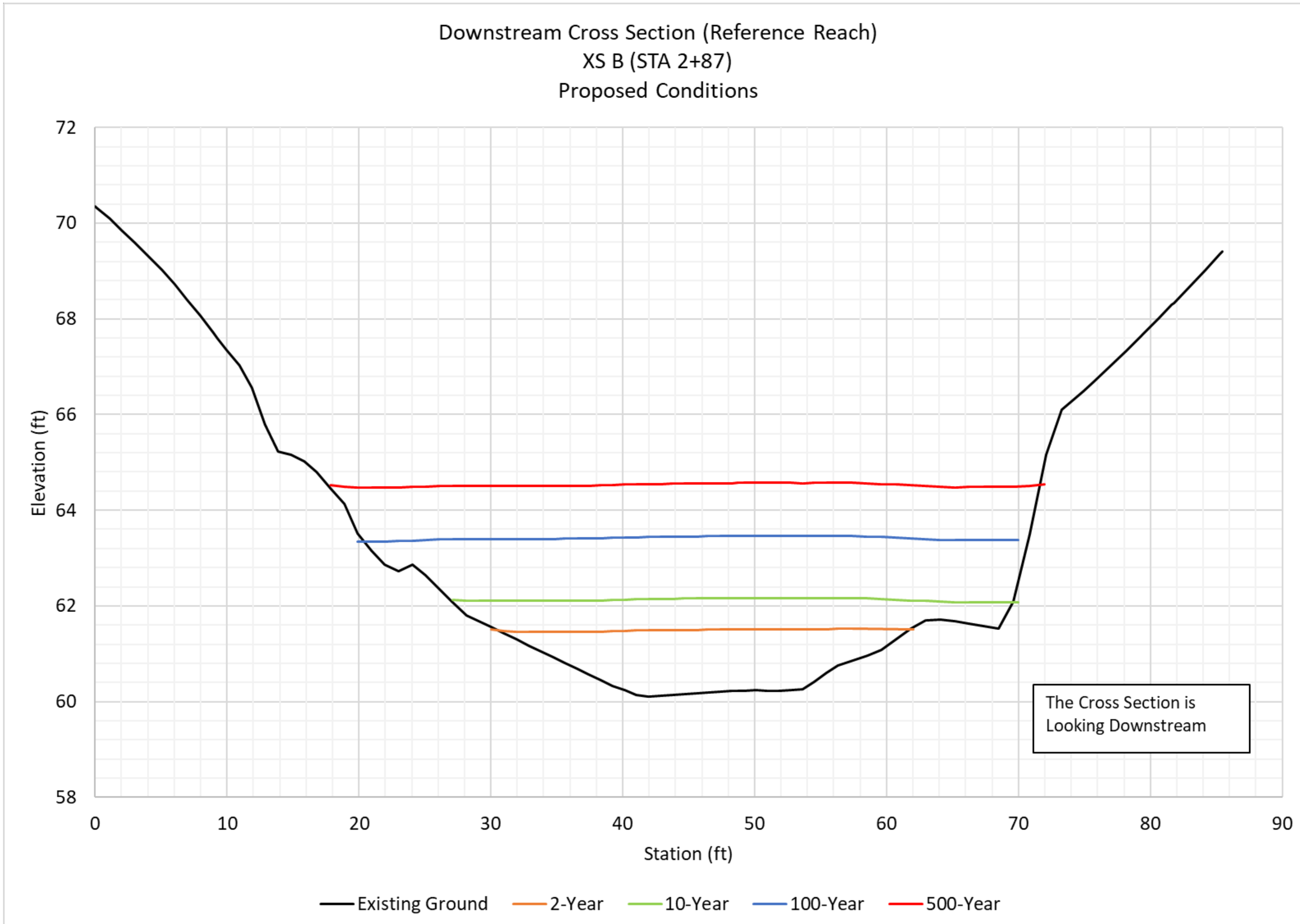
Upstream Cross Section
XS C (STA 54+81)
Existing Conditions
Elevation (ft)
80
75
70
65
60
55
0
10
20
30
40
50
60
70
80
90
100
Station (ft)
The Cross Section is Looking Downstream
Existing Ground
2-Year
10-Year
100-Year

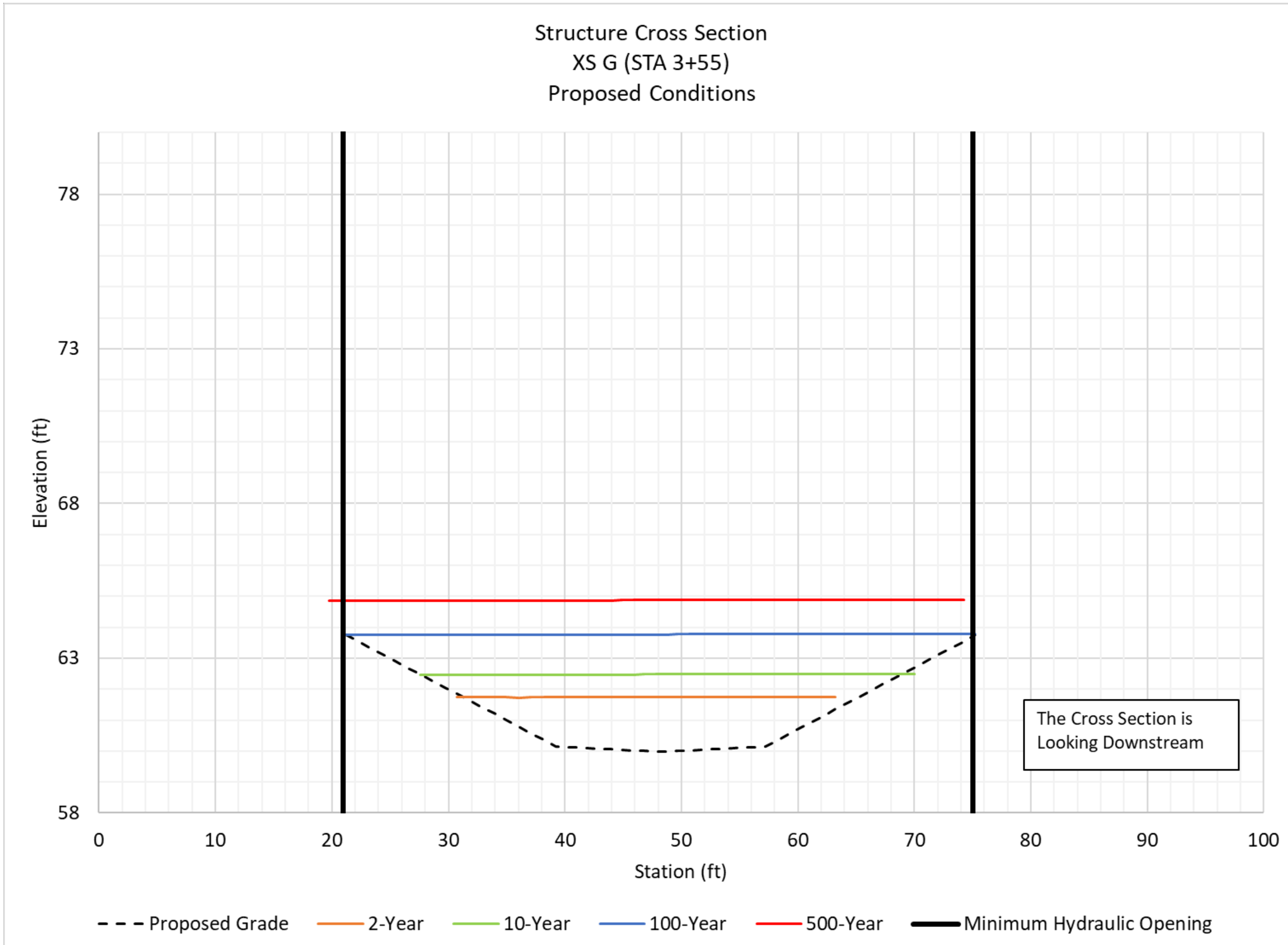

Upstream Cross Section
XS D (STA 55+84)
Existing Conditions
74
72
70
68
66
64
62
60
58
Elevation (ft)
0
10
20
30
40
50
60
70
80
Station (ft)
The Cross Section is Looking Downstream
Existing Ground
2-Year
10-Year
100-Year



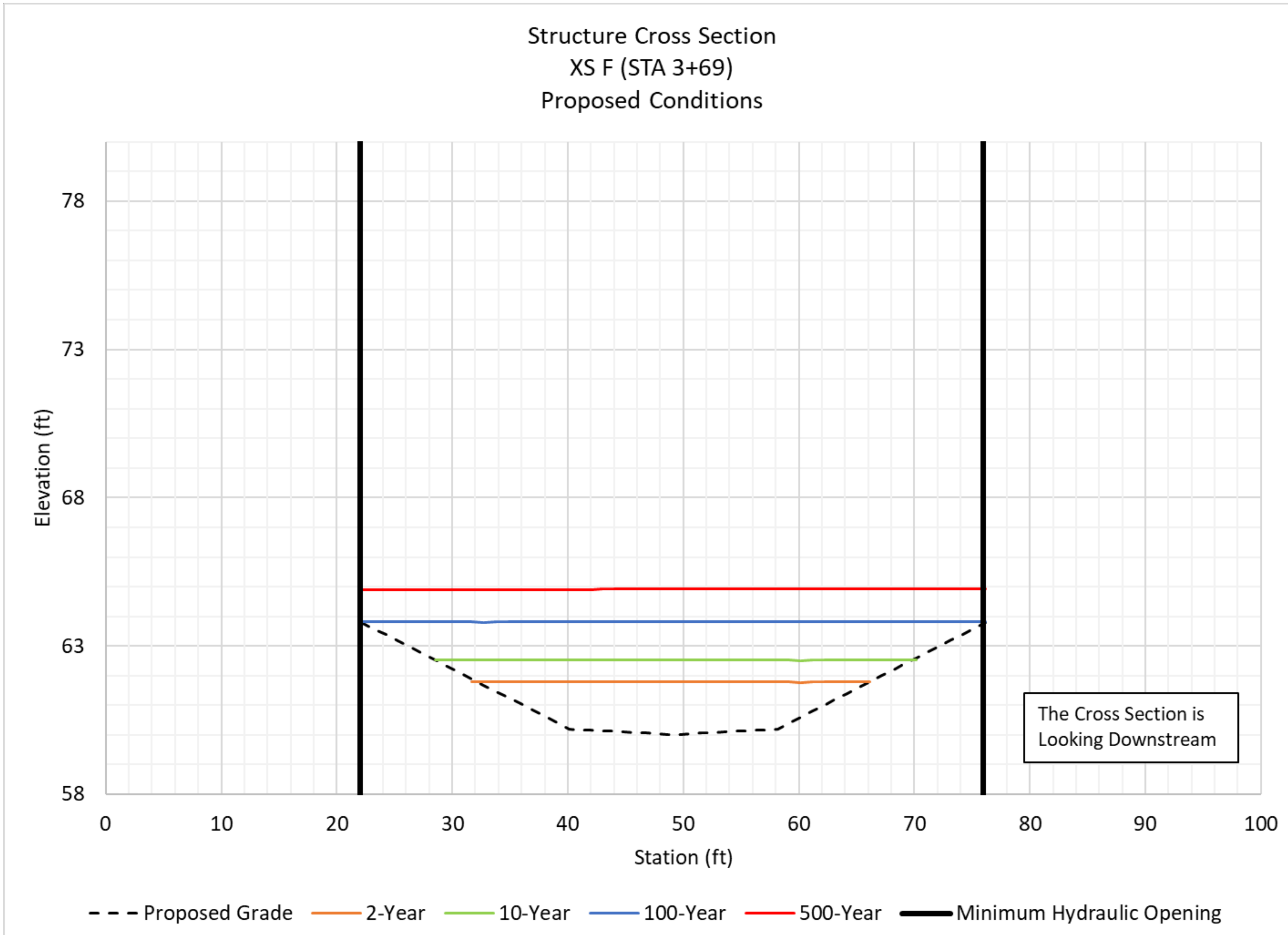
Existing WSEL
Elevation (ft)
80
75
70
65
60
55
XS A
XS B
XS C
XS D
50+00
51+00
52+00
53+00
54+00
55+00
56+00
57+00
58+00
Station (ft)
Existing Ground
2-Year
10-Year
100-Year
Cross Sections


Downstream Cross Section
XS A (STA 1+55)
Proposed Conditions
Elevation (ft)
72
70
68
66
64
62
60
58
0
10
20
30
40
50
60
70
80
90
100
Station (ft)
The Cross Section is Looking Downstream
Existing Ground
2-Year
10-Year
100-Year
500-Year

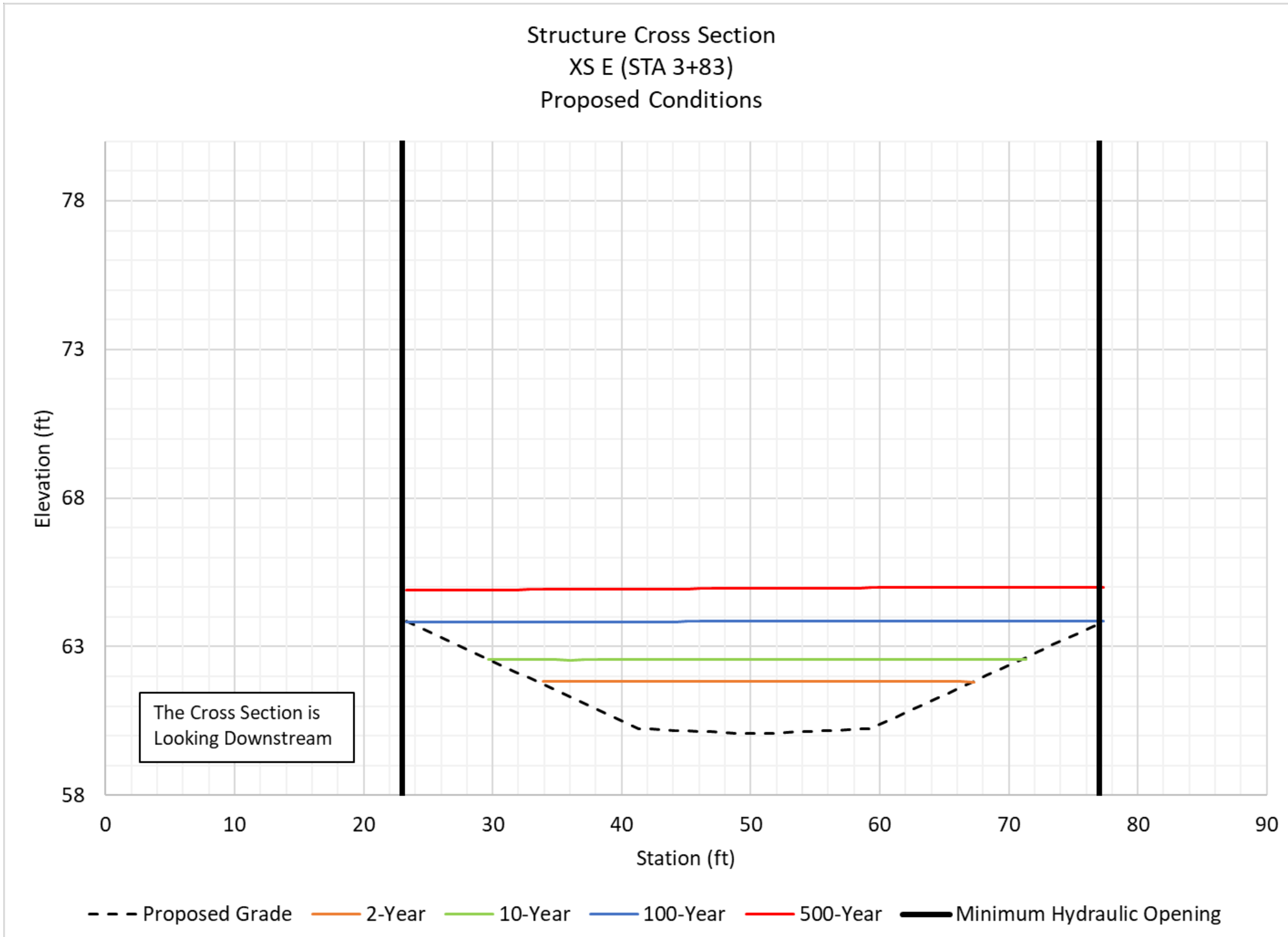

Downstream Cross Section (Reference Reach)
XS B (STA 2+87)
Proposed Conditions
Elevation (ft)
72
70
68
66
64
62
60
58
0
10
20
30
40
50
60
70
80
90
Station (ft)
The Cross Section is Looking Downstream
Existing Ground
2-Year
10-Year
100-Year
500-Year



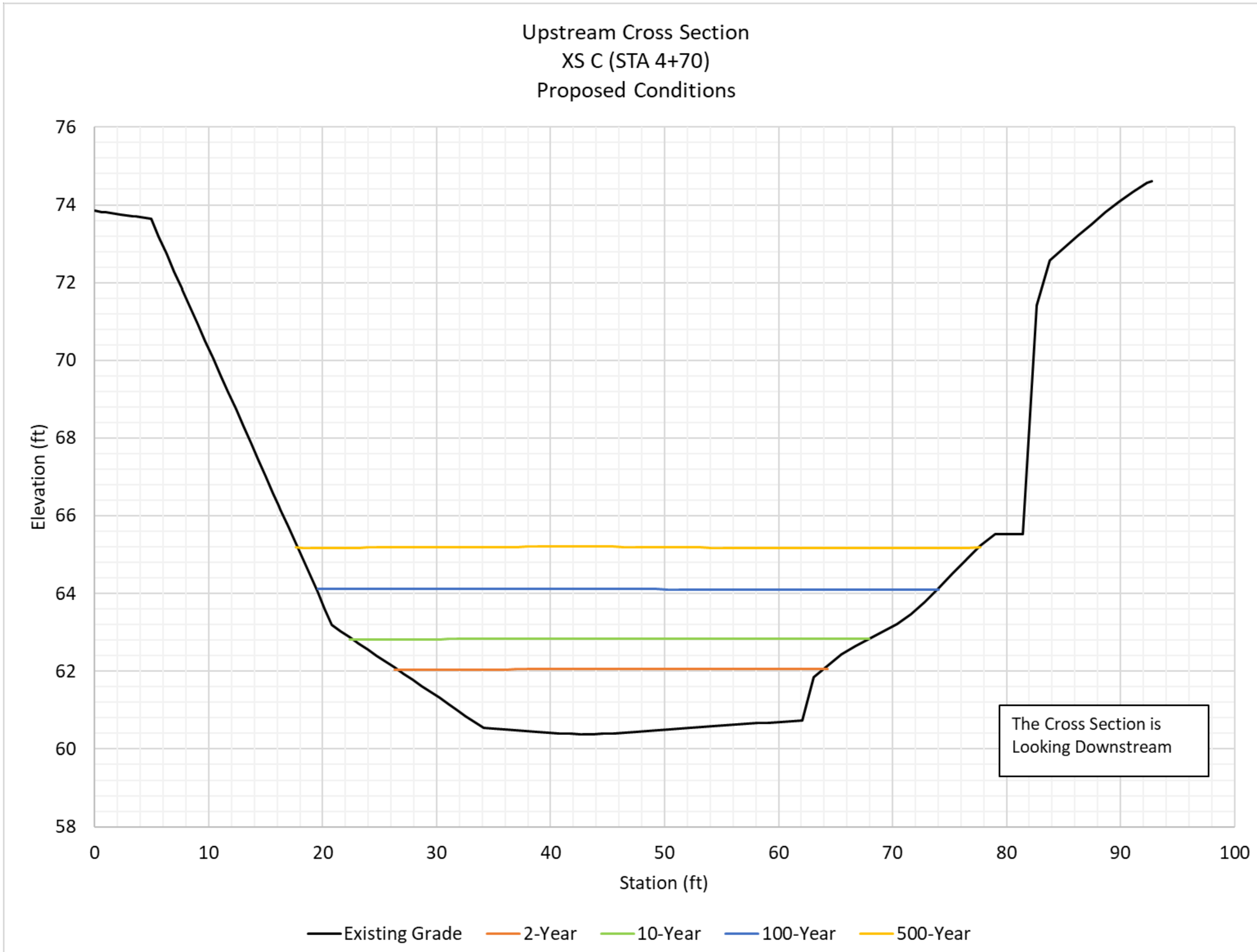
Structure Cross Section
XS G (STA 3+55)
Proposed Conditions
Elevation (ft)
78
73
68
63
58
0
10
20
30
40
50
60
70
80
90
100
Station (ft)
The Cross Section is Looking Downstream
Proposed Grade
2-Year
10-Year
100-Year
500-Year
Minimum Hydraulic Opening



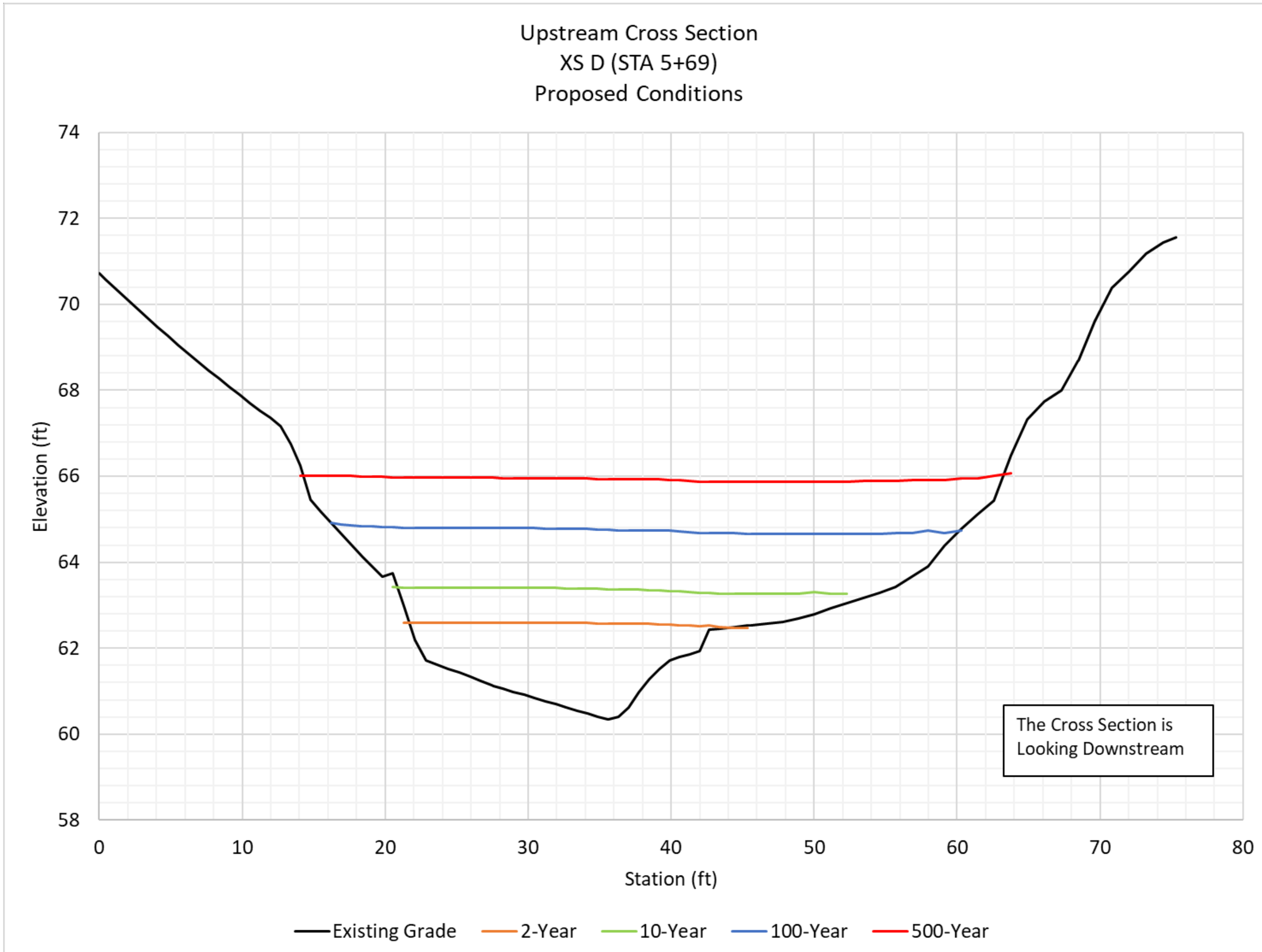
Structure Cross Section
XS F (STA 3+69)
Proposed Conditions
Elevation (ft)
78
73
68
63
58
0
10
20
30
40
50
60
70
80
90
100
Station (ft)
The Cross Section is Looking Downstream
Proposed Grade
2-Year
10-Year
100-Year
500-Year
Minimum Hydraulic Opening



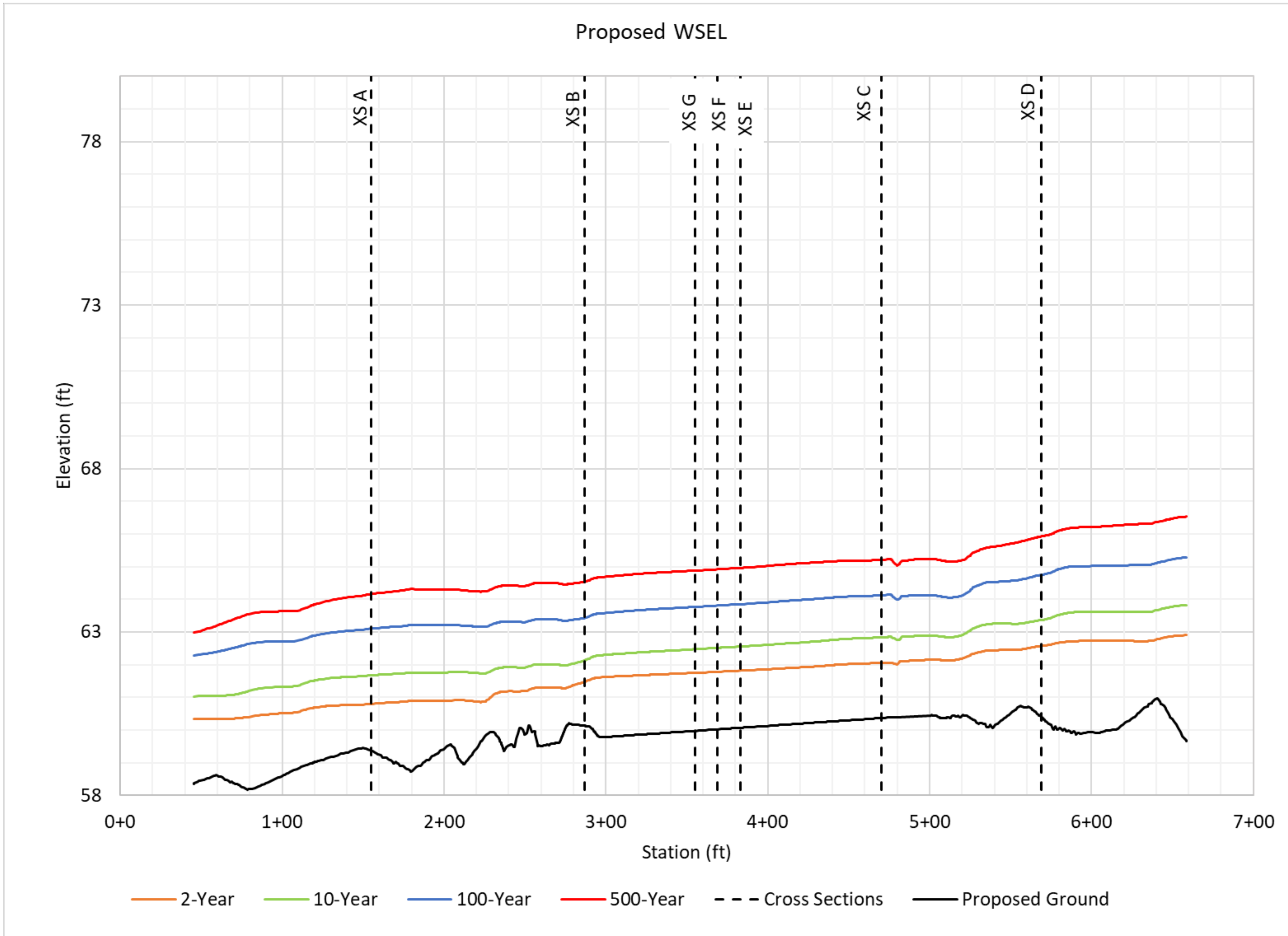
Structure Cross Section
XS E (STA 3+83)
Proposed Conditions
Elevation (ft)
78
73
68
63
58
0
10
20
30
40
50
60
70
80
90
Station (ft)
The Cross Section is Looking Downstream
Proposed Grade
2-Year
10-Year
100-Year
500-Year
Minimum Hydraulic Opening



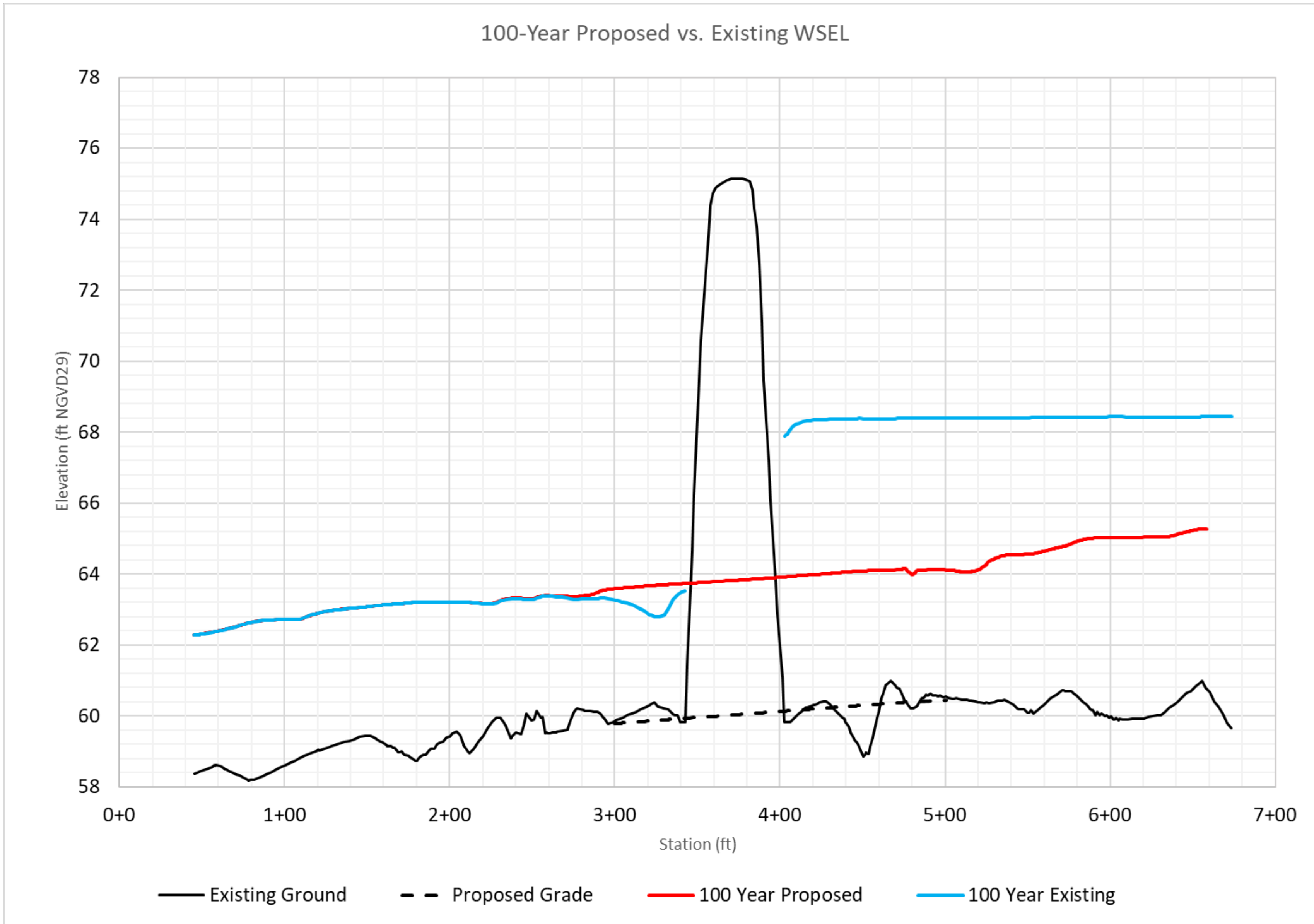
Upstream Cross Section
XS C (STA 4+70)
Proposed Conditions
Elevation (ft)
76
74
72
70
68
66
64
62
60
58
0
10
20
30
40
50
60
70
80
90
100
Station (ft)
The Cross Section is Looking Downstream
Existing Grade
2-Year
10-Year
100-Year
500-Year



Upstream Cross Section
XS D (STA 5+69)
Proposed Conditions
Elevation (ft)
74
72
70
68
66
64
62
60
58
0
10
20
30
40
50
60
70
80
Station (ft)
The Cross Section is Looking Downstream
Existing Grade
2-Year
10-Year
100-Year
500-Year



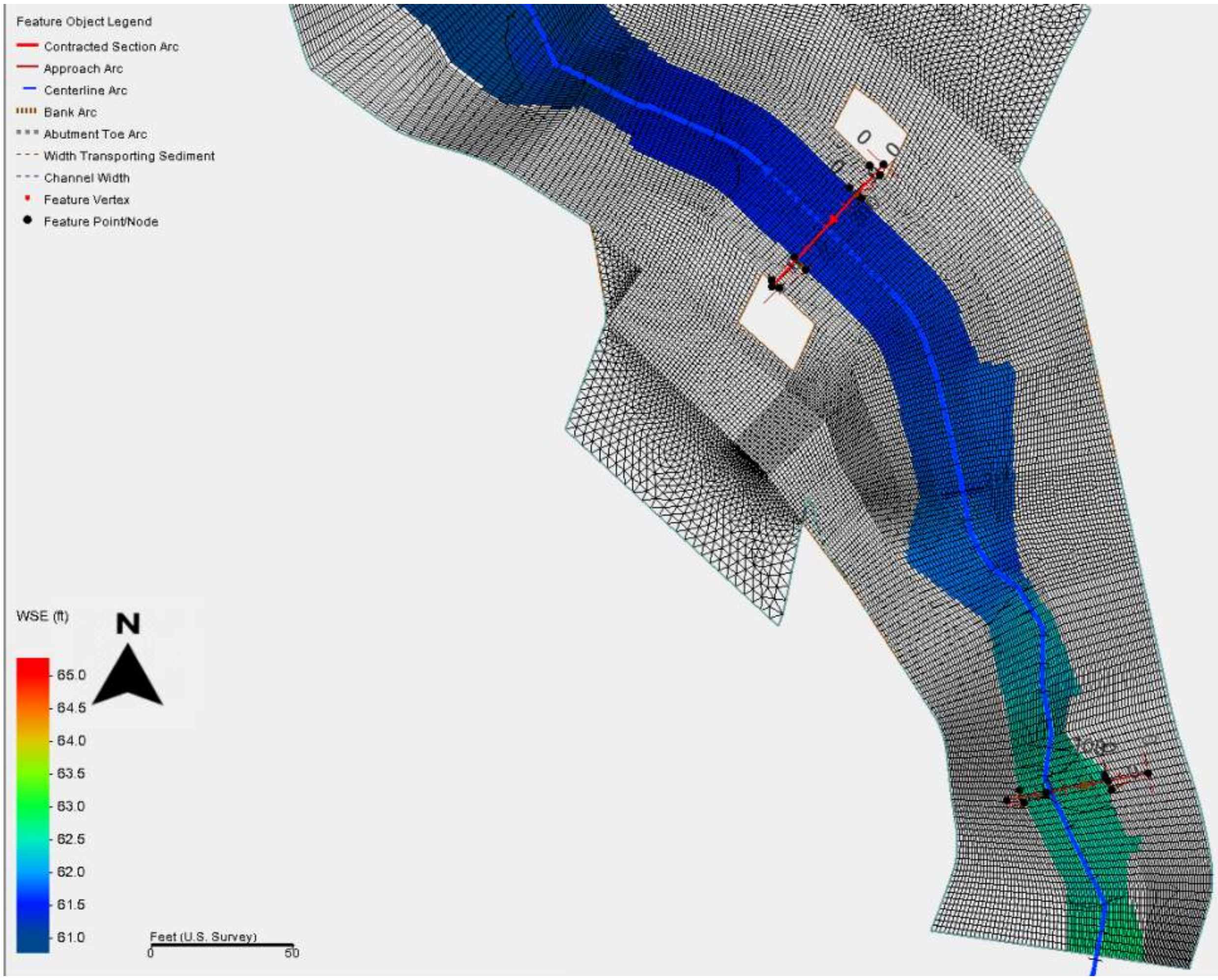
Proposed WSEL
Elevation (ft)
78
73
68
63
58
0+0
1+00
2+00
3+00
4+00
5+00
6+00
7+00
Station (ft)
XS A
XS B
XS G
XS F
XS E
XS C
XS D
2-Year
10-Year
100-Year
500-Year
Cross Sections
Proposed Ground


100-Year Proposed vs. Existing WSEL
Elevation (ft NGVD29)
78
76
74
72
70
68
66
64
62
60
58
0+0
1+00
2+00
3+00
4+00
5+00
6+00
7+00
Station (ft)
Existing Ground
Proposed Grade
100 Year Proposed
100 Year Existing

Appendix C Scour Calculations

500-year Flood Event Hydraulic Toolbox Contraction Scour Computation		
Parameter	value	Units
Input Parameters		
Average Depth Upstream of Contraction	5.37	ft
D50	10.06	mm
Average Velocity Upstream	4.34	ft/s
Results of Scour Condition		
Critical velocity above which bed material of size D and smaller will be transported	4.74	ft/s
Contraction Scour Condition	Live Bed	
Live Bed & Clear Water Input Parameters		
Temperature of Water	60	F
Slope of Energy Grade Line at Approach Section	0.005668	ft/ft
Discharge in Contracted Section	623.55	cfs
Discharge Upstream that is Transporting Sediment	712.66	cfs
Width in Contracted Section	31.41	ft
Width Upstream that is Transporting Sediment	30.61	ft
Depth Prior to Scour in Contracted Section	4.48	ft
Unit Weight of Water	62.4	lb/ft^3
Unit Weight of Sediment	165	lb/ft^3
Results of Live Bed Method		
k1	0.64	
Shear Velocity	0.99	ft/s
Fall Velocity	1.44	ft/s
Average Depth in Contracted Section after Scour	4.71	ft
Scour Depth	0.22	ft
Shear Applied to Bed by Live-Bed Scour	0.3122	lb/ft^3
Shear Required for Movement of D50 Particle	0.132	lb/ft^3
Recommendations		
Recommended Scour Depth	0.22	ft

Bank arcs were defined as the extents of the 2-year flow event.



Project:	Draham St NE	Computed:	RIA	Date:	11/15/2022
Subject:	Scour Analysis	Checked:	SB	Date:	11/17/2022
Task:	Bend Scour	Page:	1	of:	1
Job #:		No:			

Computation of Bend Scour

Variables and Equations

References: ***FHWA. 2009. Hydraulic Engineering Circular No. 23 Third Edition, Volume 1 Chapter 4***
NRCS. 2007. National Engineering Handbook Part 654. TS 14B. Scour Calculations.

Maynord's method for estimating scour depth at bend:

$$\frac{D_{mxb}}{D_{mnc}} = 1.8 - 0.051\left(\frac{R_c}{W}\right) + 0.0084\left(\frac{W}{D_{mnc}}\right) \quad (4.5)$$

R_c	ft	Centerline radius of the bend
W	ft	Width upstream of bend
D_{mxb}	ft	Maximum water depth in the bend
D_{mnc}	ft	Average water depth in the crossing upstream of the bend. Cross sectional area/width
y_s	ft	Scour depth below proposed thalweg
y_0	ft	Thalweg depth at bend prior to bend scour occurring

$y_s = D_{mxb} - y_0$ ft

Per HEC-23, for channels with $R_c/W < 1.5$ or $W/D_{mnc} < 20$, the scour depth calculations should use $R_c/W = 1.5$ and $W/D_{mnc} = 20$, respectively. Equation only valid when no to minimal overbank flow.

Computation of Bend Scour

	2-year	10-year	100-year	500-year	
Rc	50.0	50.0	NA	NA	ft
W	38.1	38.1	NA	NA	ft
Dmnc	1.4	2.2	NA	NA	ft
y_0	1.7	2.5	NA	NA	ft
R_c/W =	1.3	1.3	NA	NA	
W/Dmnc =	27.2	17.3	NA	NA	

Notes (results pulled from main channel only)

Approach section main channel width measured in SMS
Avg water depth taken US at approach section
Bend section main channel max depth
No data points taken at fringe nodes of cross sections

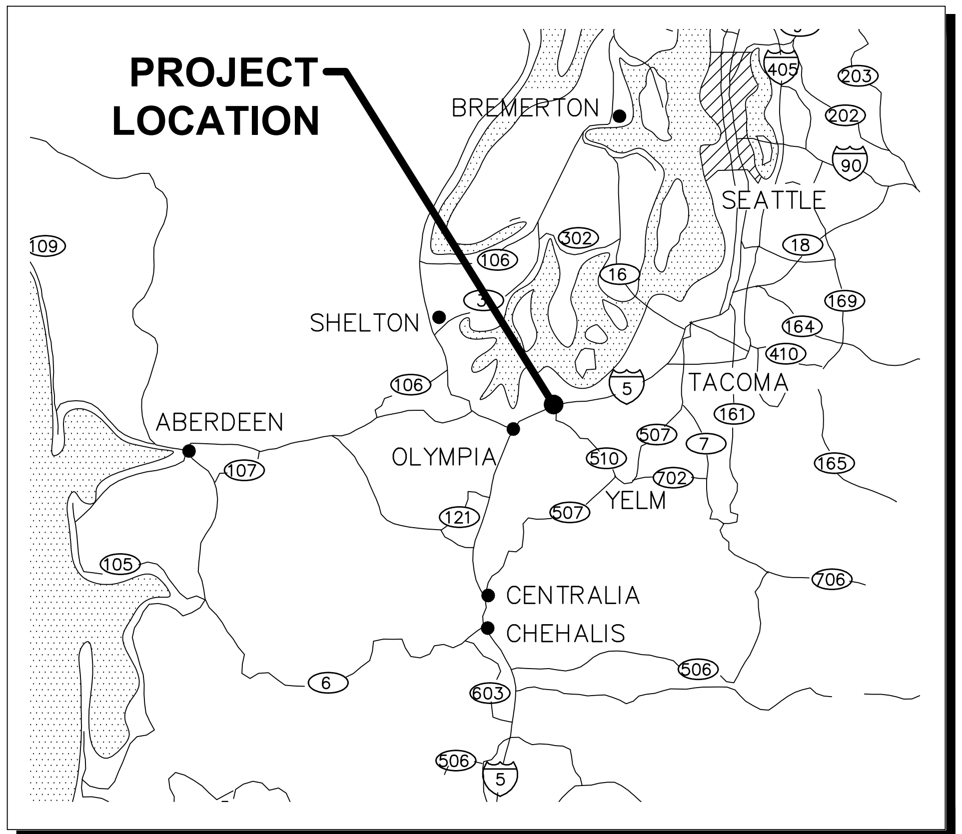
If R_c/W is less than 1.5/ greater than 10 or width to depth ratio is less than 20/ greater than 125, the scour depth for Rc/W=1.5 and W/Dmnc=20 should be used.

	2-year	10-year	100-year	500-year	
R_c/W =	1.5	1.5	NA	NA	
W/Dmnc =	20.0	20.0	NA	NA	
Dmxb =	2.6	4.2	NA	NA	ft
y_s =	**0.9**	**1.7**	**NA**	**NA**	**ft**

Appendix D Drawings

DRAHAM ST NE CULVERT REPLACEMENT

THURSTON COUNTY
WASHINGTON
SINCE 1852



VICINITY MAP
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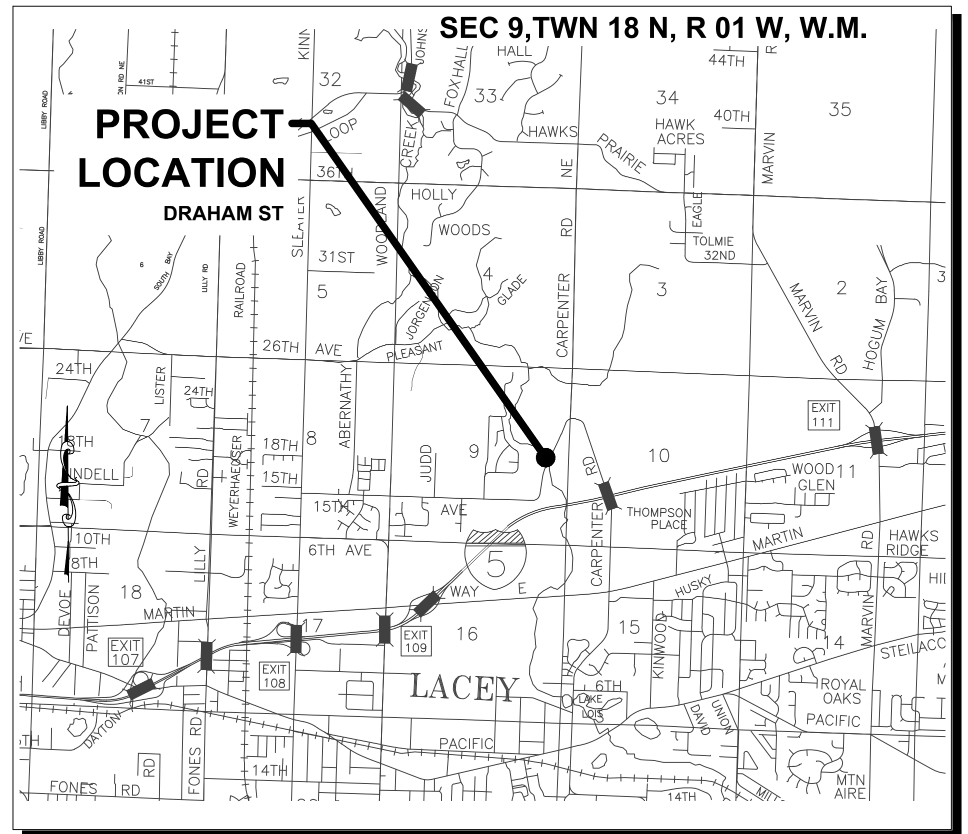

VICINITY MAP
NO SCALE

THURSTON COUNTY

CP-63016

APPROVED BY:

THURSTON COUNTY ENGINEER

DATE

INDEX OF SHEETS	
SHEET #	SHEET TITLE
1	COVER SHEET
2	EXISTING SITE PLAN
3	TYPICAL STREAM SECTIONS
4	TYPICAL STREAM SECTIONS
5	TYPICAL ROADWAY SECTIONS
6	PLAN AND PROFILE STREAM
7	PLAN AND PROFILE DRAHAM ST BRIDGE
8	PLAN AND PROFILE BRIDGE STRUCTURE
9	PLAN AND PROFILE DRAHAM ST BURIED
10	PLAN AND PROFILE BURIED STRUCTURE

PREPARED BY:

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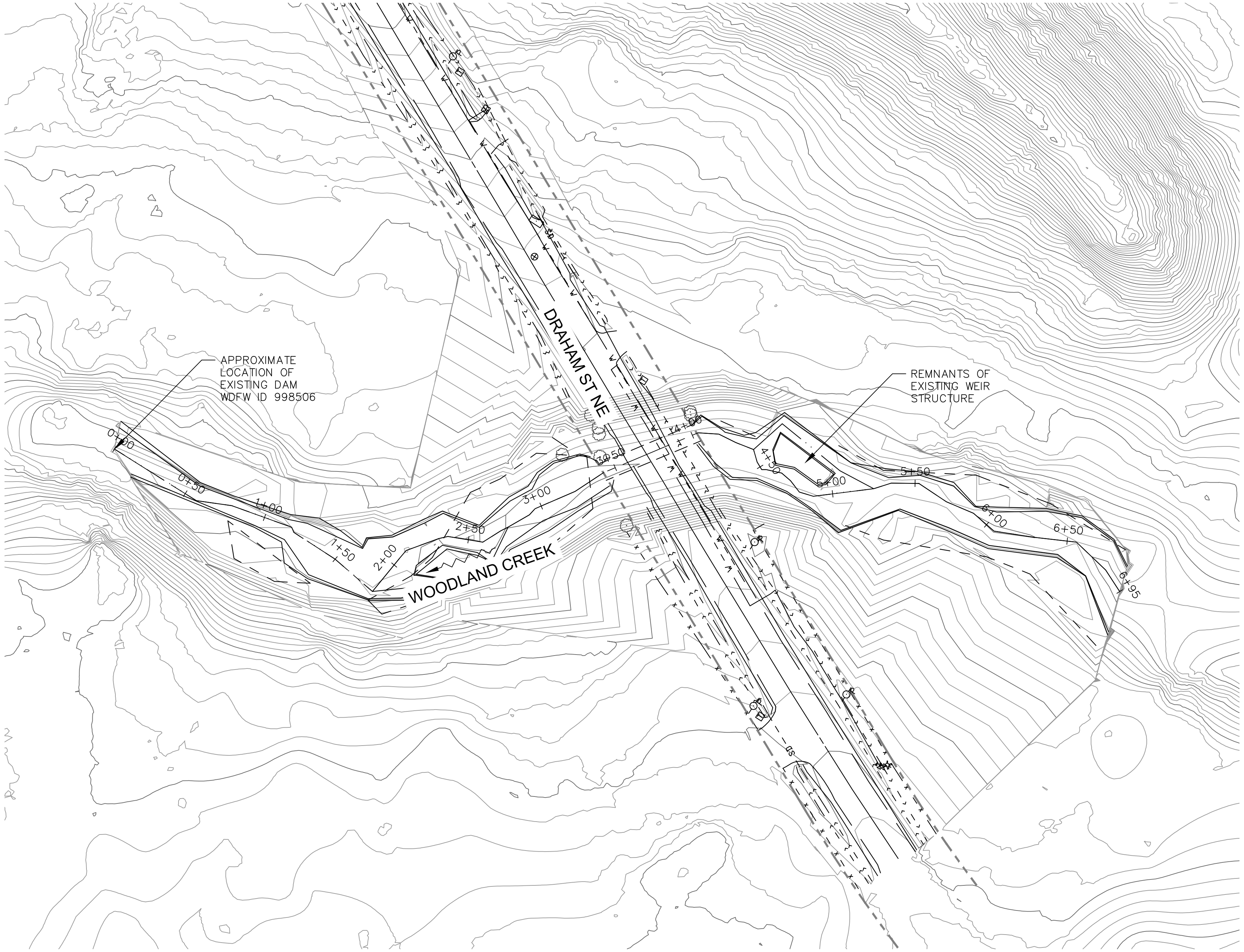
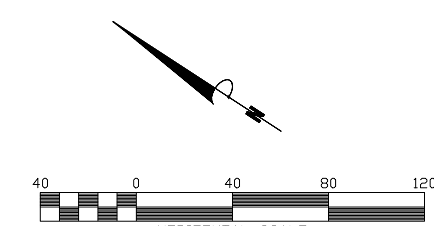
(360) 867-2300



LEGEND

- EXISTING ROW LINE
- EXISTING MAJOR CONTOUR
- EXISTING MINOR CONTOUR
- EXISTING EDGE OF PAVEMENT
- EXISTING CULVERT
- EXISTING TREES



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DRAHAM ST NE CULVERT REPLACEMENT

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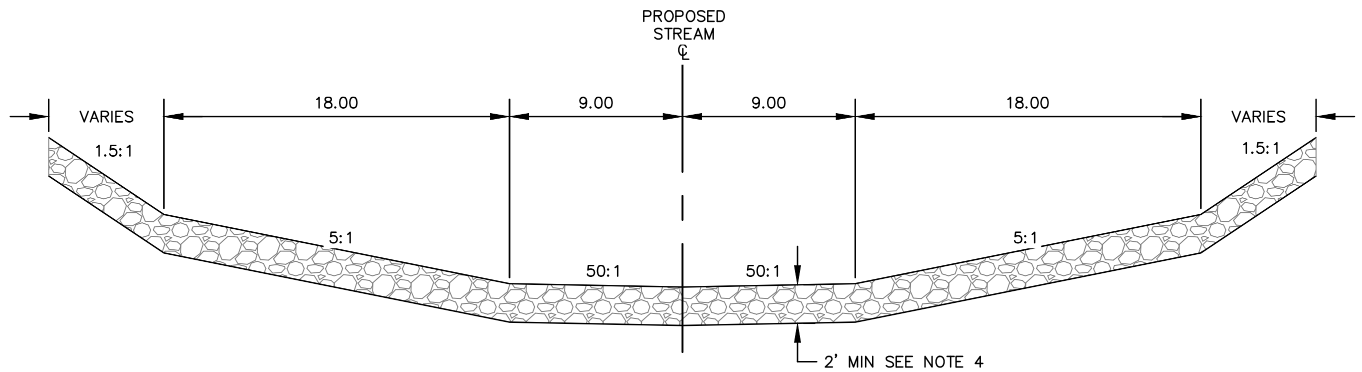
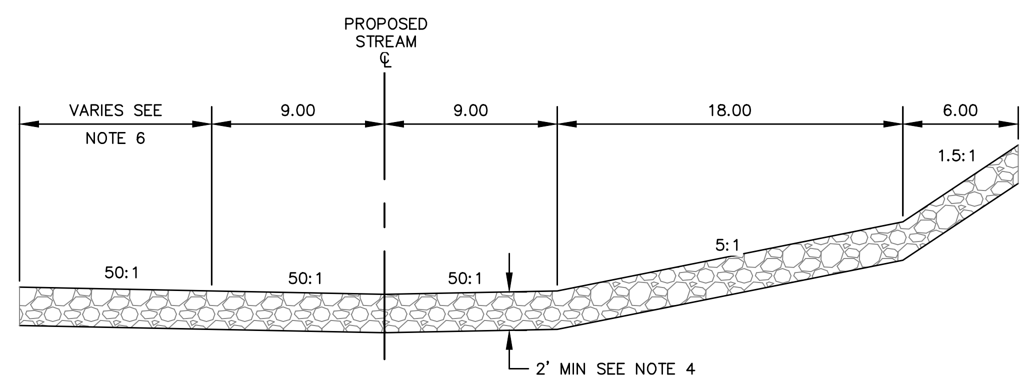
EXISTING SITE PLAN



STA 2+96 TO STA 3+45
STA 3+98 TO STA 4+40

CHANNEL SECTION - TYPICAL SECTION (A)
SCALE: NTS SEE NOTE 2



STA 4+40 TO STA 5+00

CHANNEL SECTION - TYPICAL SECTION (B)
SCALE: NTS SEE NOTE 3

GENERAL NOTES

1. ALL SECTIONS ARE FACING UPSTREAM.
2. FROM STA 2+96 TO 3+10 TRANSITION FROM EXISTING TO SECTION A.
3. FROM STA 4+79 TO 5+00 TRANSITION FROM SECTION B TO EXISTING.
4. STREAMBED MATERIAL 100% STREAMBED SEDIMENT PER WSDOT STD. SPEC 9-03.11.
5. CATCH SLOPES ARE ESTIMATED TO DEPICT ESTIMATED AREA OF POTENTIAL IMPACT. FINAL CATCH SLOPES AND AREAS OF IMPACT TO BE DETERMINED PENDING GEOTECHNICAL AND STRUCTURAL INVESTIGATION AND STRUCTURE TYPE.
6. LENGTH VARIES TO MATCH EXISTING CHANNEL BOTTOM OF BANK.

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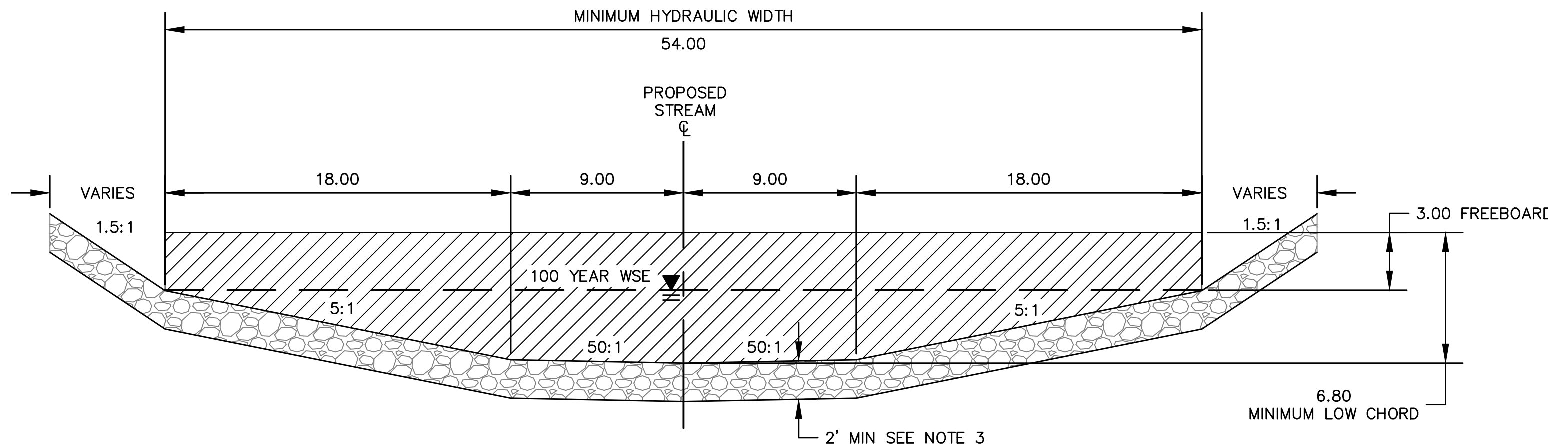
DRAHAM ST NE CULVERT REPLACEMENT
C.R.P. No. 63016 F.A. No. N/A

TYPICAL STREAM SECTIONS

GENERAL NOTES

1. ALL SECTIONS ARE FACING UPSTREAM.
2. RECOMMENDED BRIDGE ALTERNATIVE SHOWN FOR ILLUSTRATIVE PURPOSES. IF A BRIDGE STRUCTURE IS NOT ADVANCED, STRUCTURE STATIONING WILL NEED TO BE ADJUSTED.
3. STREAMBED MATERIAL 100% STREAMBED SEDIMENT PER WSDOT STD. SPEC 9-03.11.
4. CATCH SLOPES ARE ESTIMATED TO DEPICT ESTIMATED AREA OF POTENTIAL IMPACT. FINAL CATCH SLOPES AND AREAS OF IMPACT TO BE DETERMINED PENDING GEOTECHNICAL AND STRUCTURAL INVESTIGATION AND STRUCTURE TYPE.
5. LENGTH VARIES TO MATCH EXISTING CHANNEL BOTTOM OF BANK.



STA 3+45 TO STA 3+98

CHANNEL SECTION - TYPICAL SECTION (C / - | -)
SCALE: NTS SEE NOTE 2

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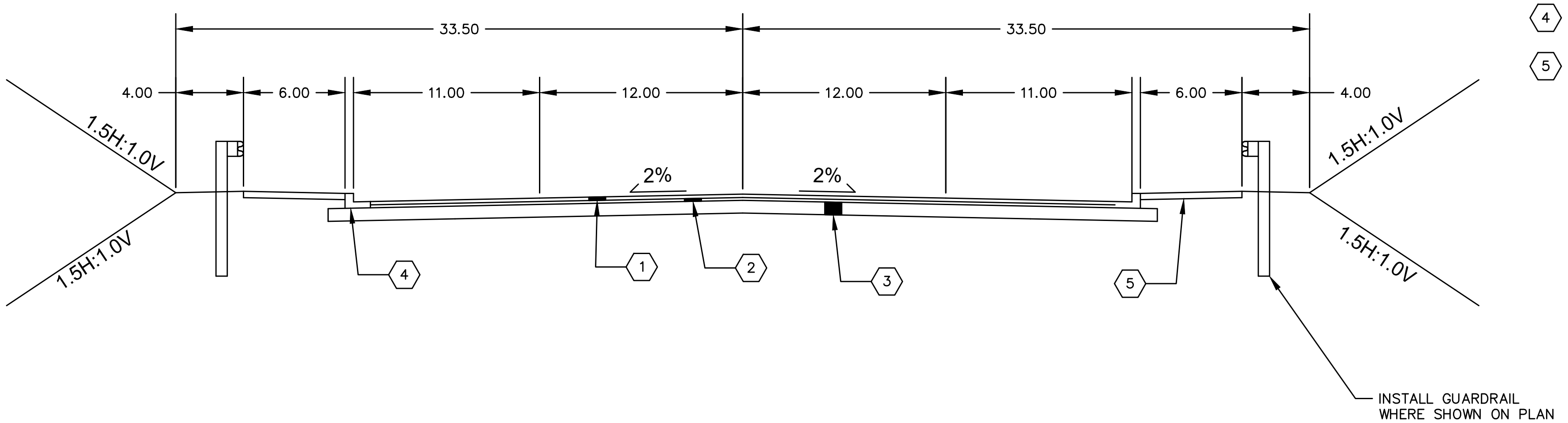
TYPICAL STREAM SECTIONS

Sheet 4 of 10

KEY NOTES

1. 0.33' HOT MIX ASPHALT CLASS 1/2 IN. PG 58H-22
2. 0.17' CRUSHED SURFACING TOP COURSE
3. 0.75' CRUSHED SURFACING BASE COURSE
4. CEMENT CONCRETE CURB AND GUTTER
5. CEMENT CONCRETE SIDEWALK



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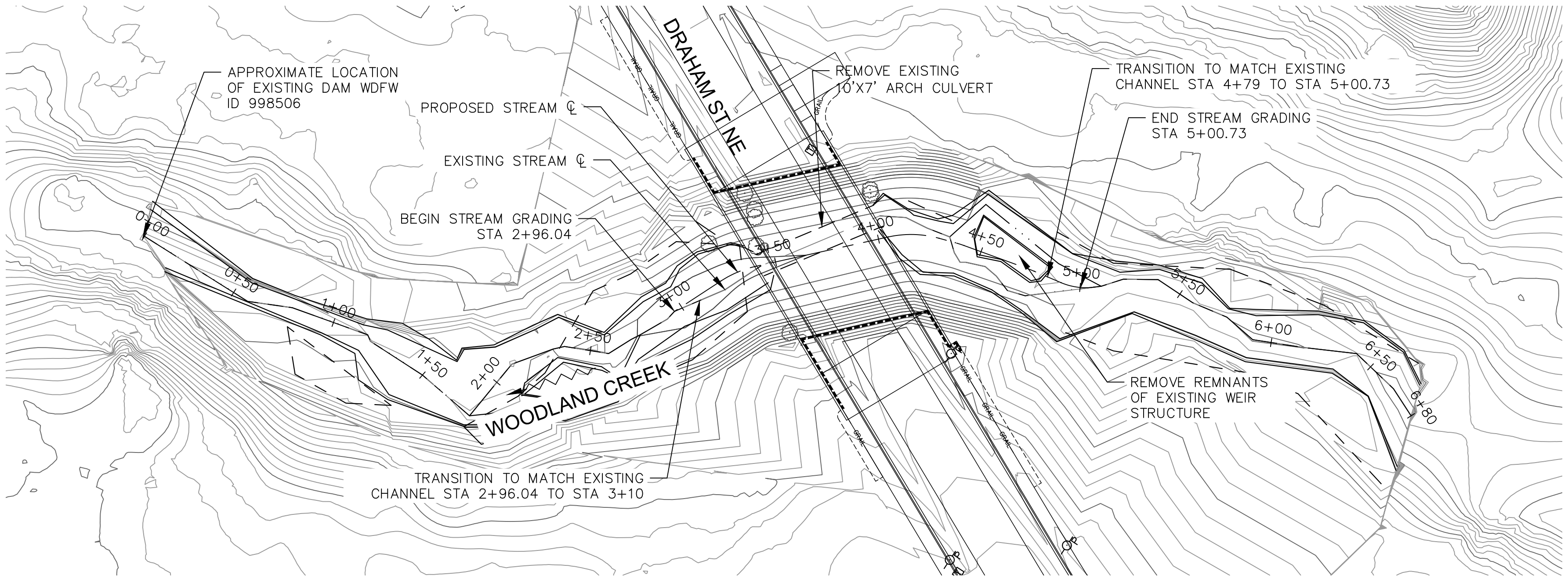
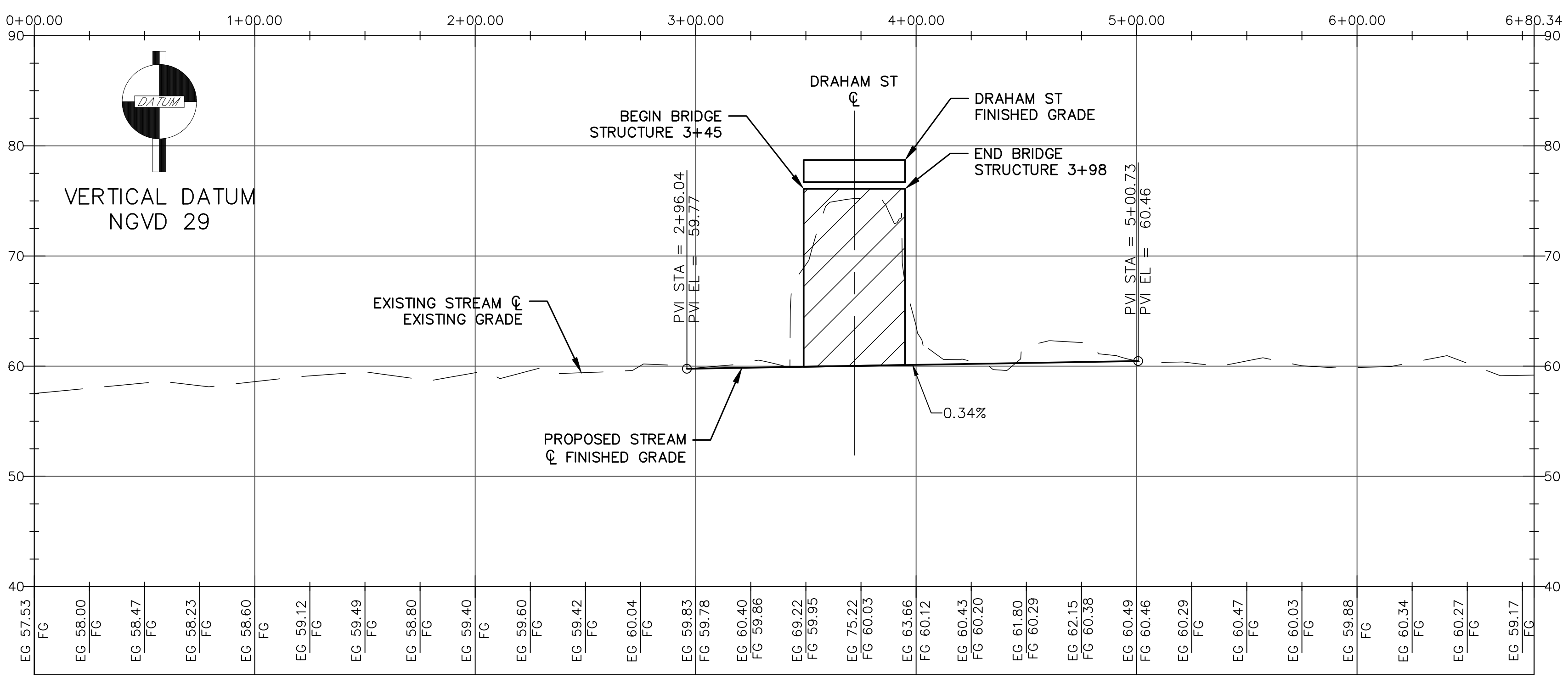
DRAHAM ST NE CULVERT REPLACEMENT

C.R.P. No. 63016 F.A. No. N/A

TYPICAL ROADWAY SECTIONS





NOTES

1. CATCH SLOPES ARE ESTIMATED TO DEPICT ESTIMATED AREA OF POTENTIAL IMPACT. FINAL CATCH SLOPES AND AREAS OF IMPACT TO BE DETERMINED PENDING GEOTECHNICAL AND STRUCTURAL INVESTIGATION AND STRUCTURE TYPE.
2. GRADING LIMITS SHOWN ARE FOR ILLUSTRATIVE PURPOSES ONLY. FINAL LIMITS TO BE DETERMINED BASED ON FINAL ALTERNATIVE TYPE.
3. RECOMMENDED BRIDGE ALTERNATIVE SHOWN FOR ILLUSTRATIVE PURPOSES. IF A BRIDGE STRUCTURE IS NOT ADVANCED, STRUCTURE STATIONING WILL NEED TO BE ADJUSTED.

LEGEND

- PROPOSED STREAM CENTERLINE
- EXISTING ROW LINE
- EXISTING MAJOR CONTOUR
- EXISTING MINOR CONTOUR
- PROPOSED MAJOR CONTOUR
- PROPOSED MINOR CONTOUR
- EXISTING EDGE OF PAVEMENT
- EXISTING CULVERT
- EXISTING TREE

40 0 40 80 120
HORIZONTAL SCALE

8 0 8 16 24
VERTICAL SCALE

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DRAHAM ST NE CULVERT REPLACEMENT
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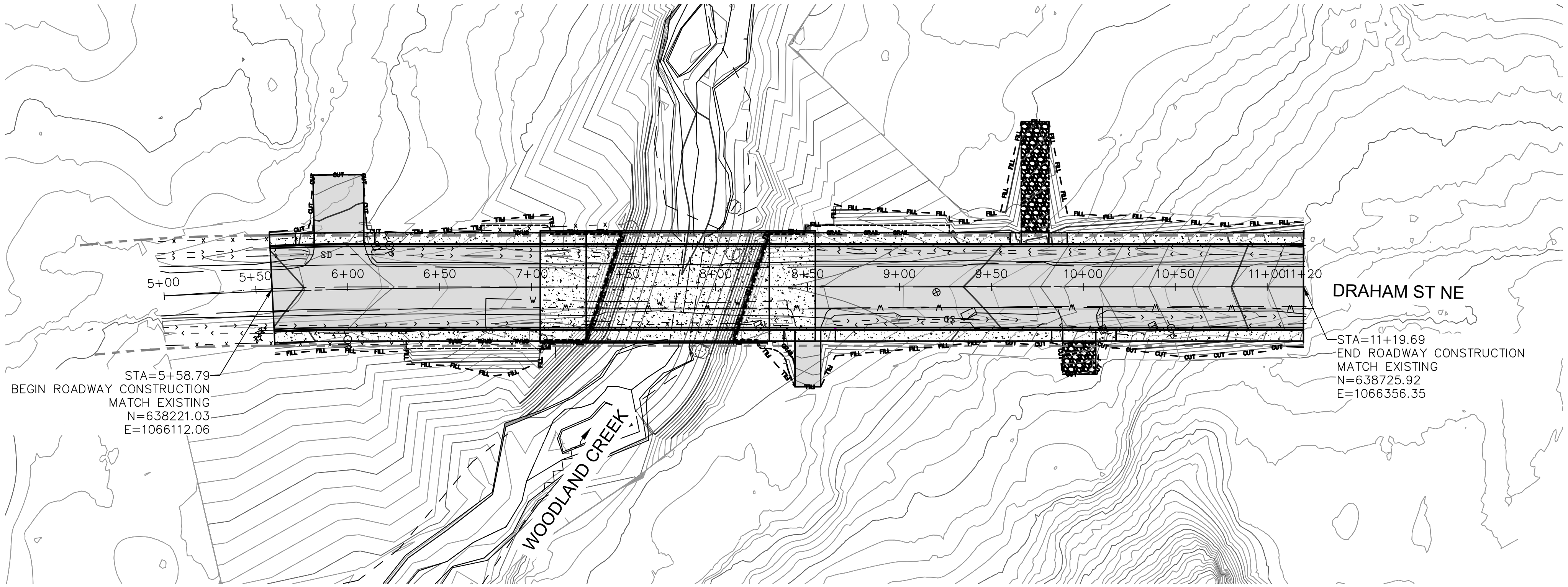
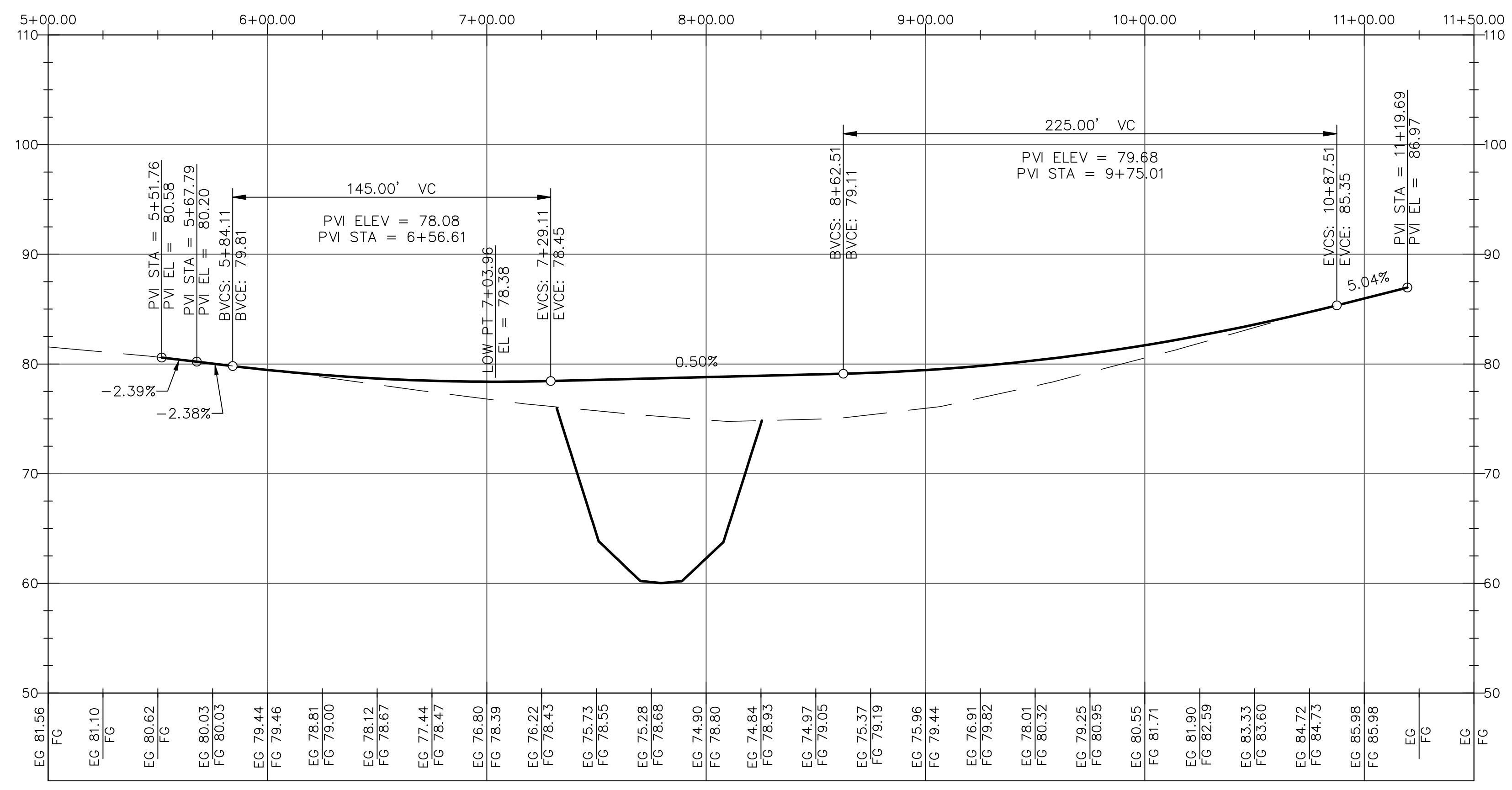
PLAN AND PROFILE STREAM



LEGEND

- EXISTING MAJOR CONTOUR
- EXISTING MINOR CONTOUR
- PROPOSED MAJOR CONTOUR
- PROPOSED MINOR CONTOUR
- EXISTING EDGE OF PAVEMENT
- EXISTING CULVERT
- EXISTING TREE
- GRADING LINES
- PROPOSED GUARDRAIL
- PROPOSED DITCH



VERTICAL DATUM
NGVD 29

HORIZONTAL SCALE: 40 0 40 80 120

VERTICAL SCALE: 8 0 8 16 24

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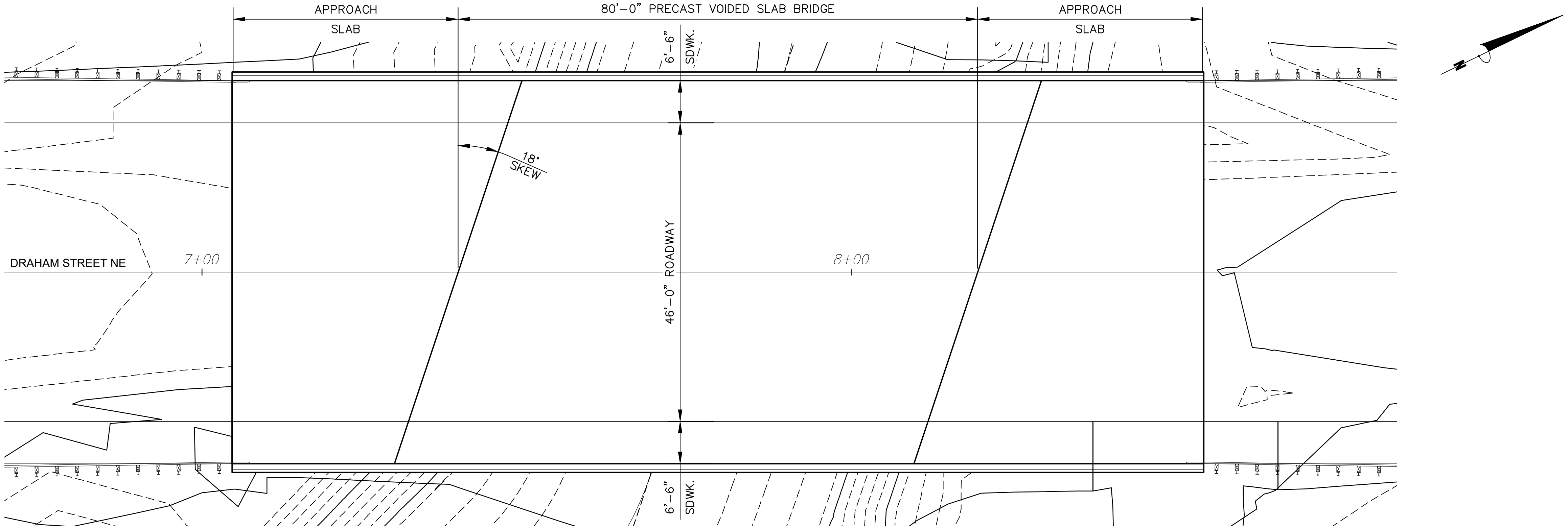
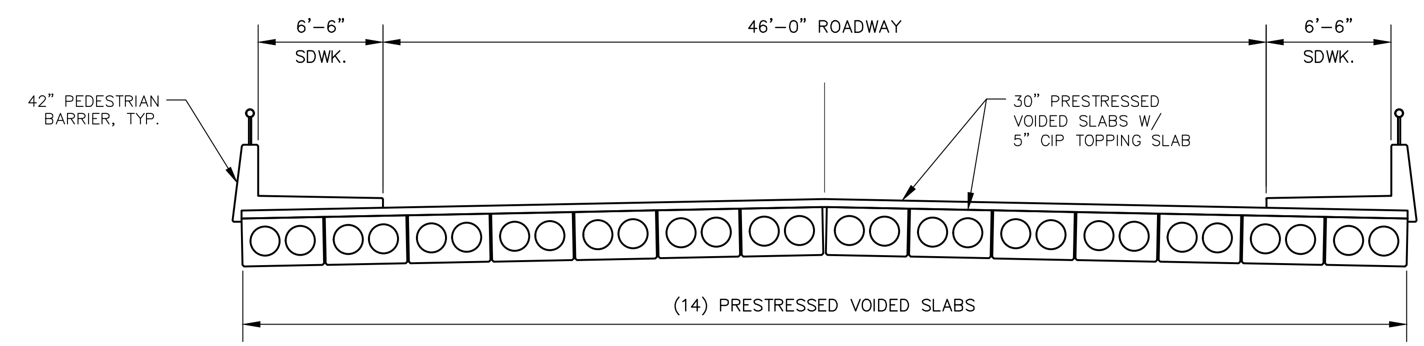
PLAN AND PROFILE DRAHAM ST BRIDGE

Sheet 7 of 10

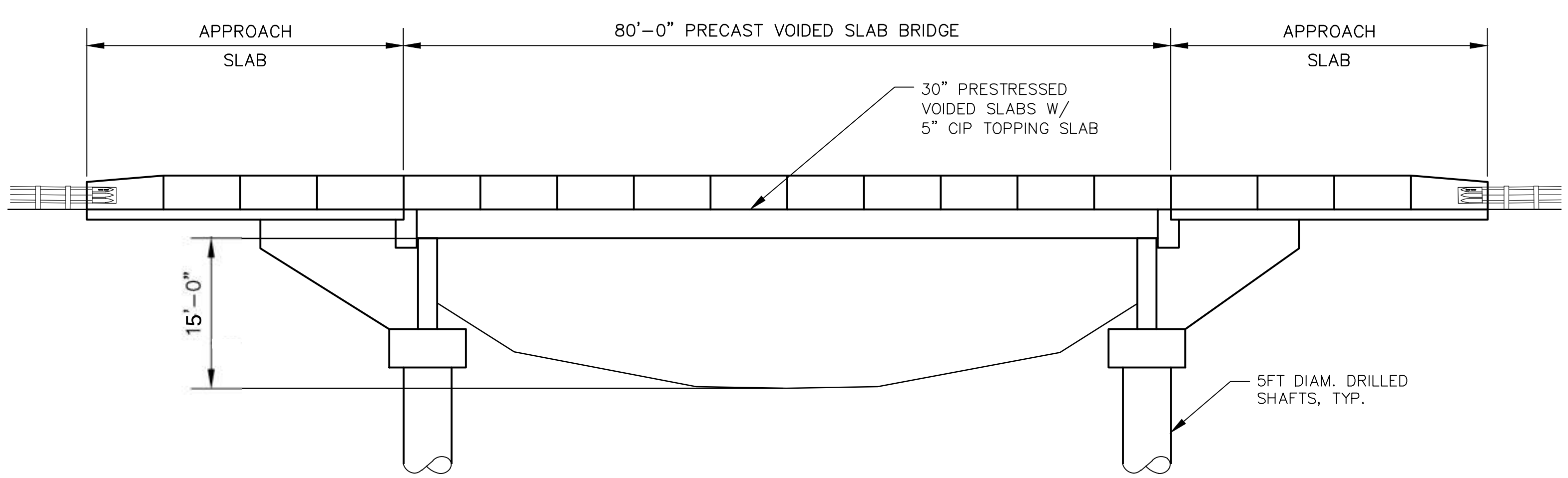


PLAN

SCALE: 1"=10'-0"



SECTION



ELEVATION

SCALE: 1"=10'-0"

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JESSICA S SOWARD, STATE OF WASHINGTON, 45272, PROFESSIONAL ENGINEER

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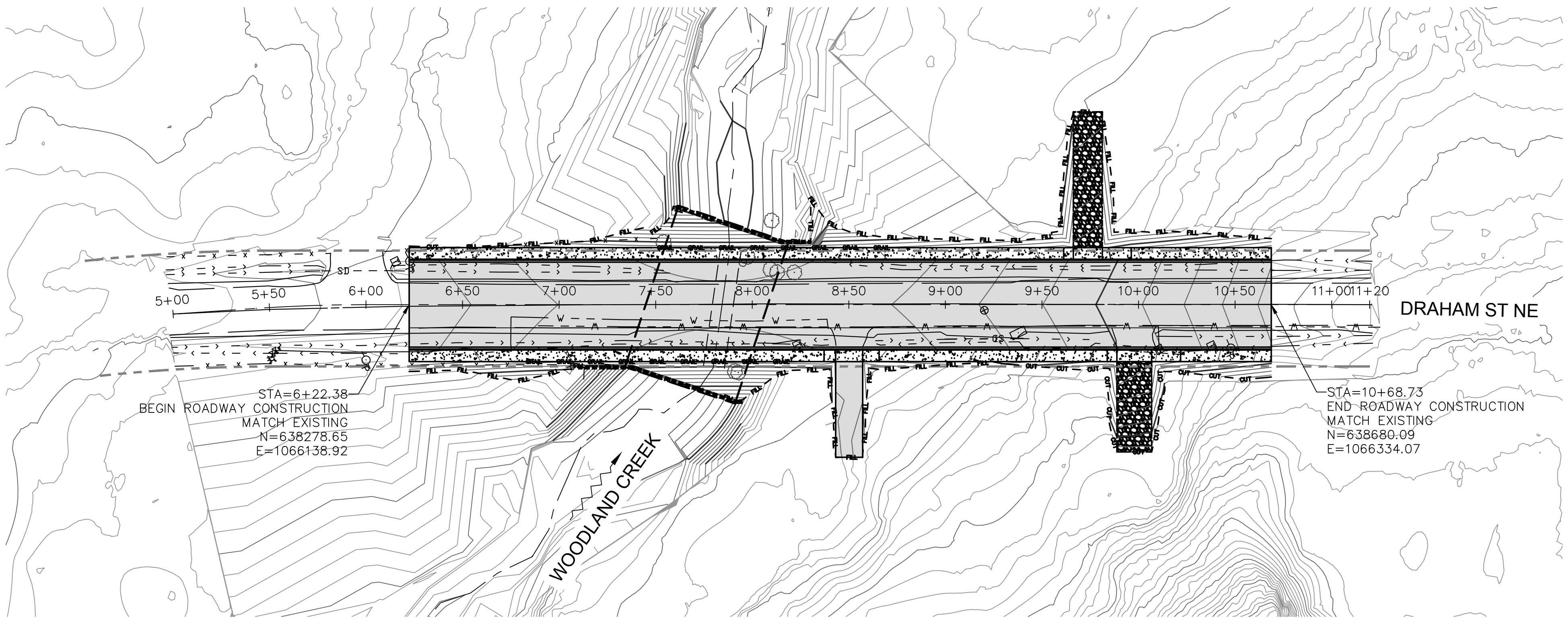
CULVERT REPLACEMENT

C.R.P. No. 63016 F.A. No. N/A

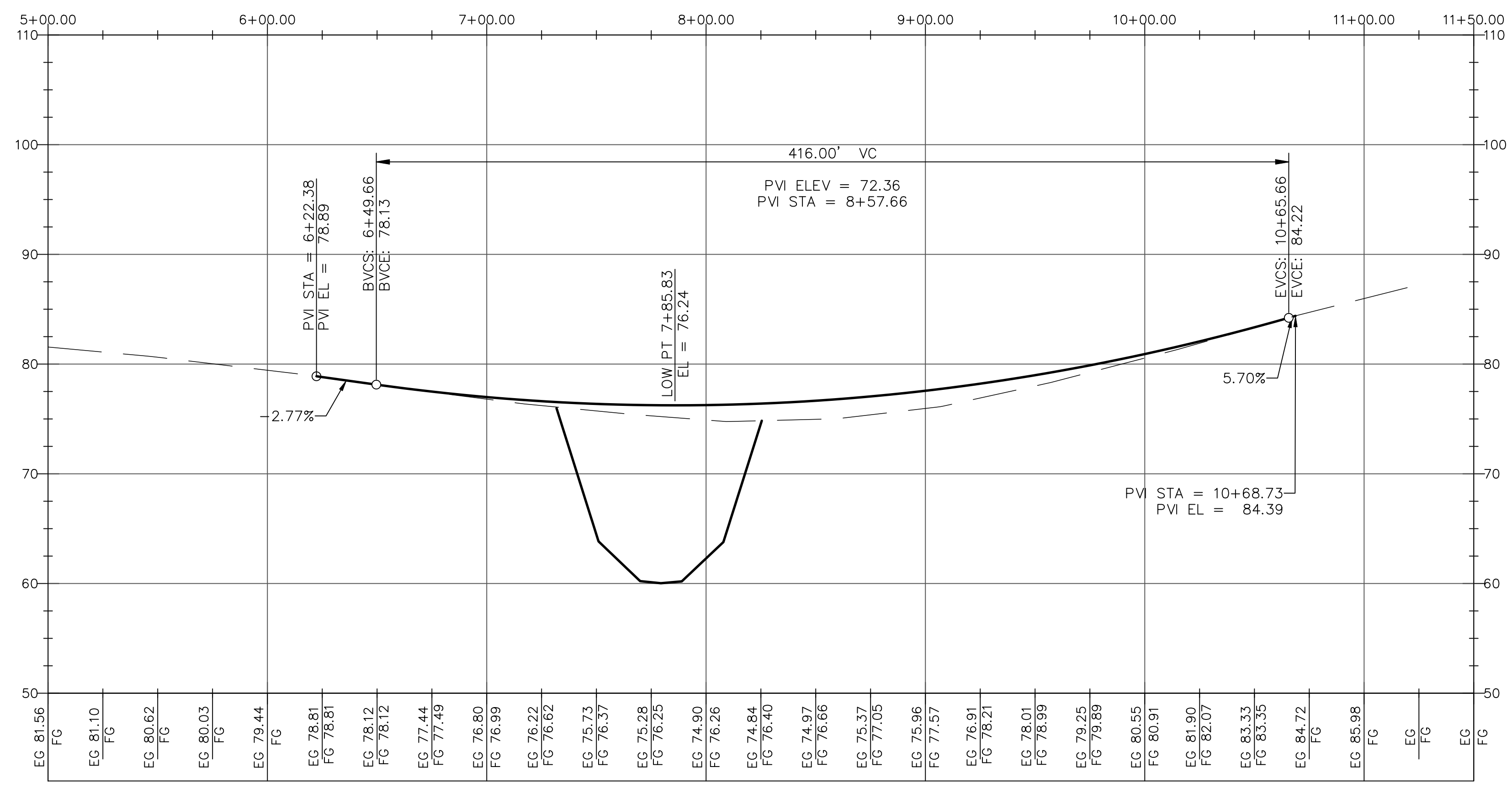
PLAN & PROFILE
BRIDGE STRUCTURE

Sheet 8 of 10



LEGEND

- EXISTING MAJOR CONTOUR
- EXISTING MINOR CONTOUR
- PROPOSED MAJOR CONTOUR
- PROPOSED MINOR CONTOUR
- EXISTING EDGE OF PAVEMENT
- EXISTING CULVERT
- EXISTING TREE
- GRADING LINES
- PROPOSED GUARDRAIL
- PROPOSED DITCH



VERTICAL DATUM
NGVD 29

HORIZONTAL SCALE 40 0 40 80 120

VERTICAL SCALE 8 0 8 16 24

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DRAHAM ST NE CULVERT REPLACEMENT

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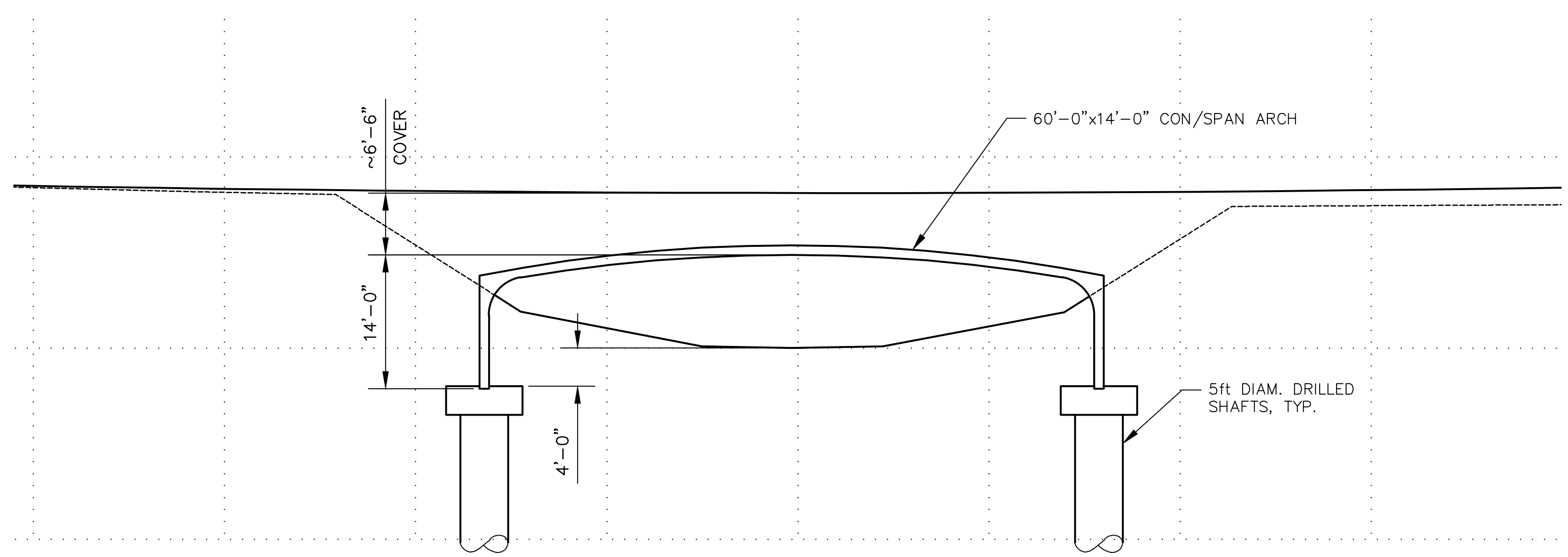
PLAN AND PROFILE DRAHAM ST BURIED

Sheet 9 of 10

PLAN
SCALE: 1"=10'-0"



ELEVATION
SCALE: 1"=10'-0"

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CULVERT REPLACEMENT
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PLAN & PROFILE
BURIED STRUCTURE

Sheet
10 of 10

Appendix E Geotechnical Memorandum

Technical Memorandum

TO: Ms. Rachel Ainslie, PE, Water Resources Engineer, HDR Engineering, Inc. and
Mr. Ty Johnson, PE, Senior Project Manager, HDR Engineering, Inc.

FROM: Annabel Irwin, PE, and Calvin McCaughan, PE

DATE: February 8, 2023

RE: **Summary of Geotechnical Engineering Services**
Draham Street Northeast Culvert Replacement
Alternatives Analysis
Olympia, Washington
Project No. 0122057.010.013

Introduction

This memorandum summarizes the results of geotechnical engineering services provided by Landau Associates, Inc. (Landau) in support of the Draham Street Northeast (NE) Culvert Replacement Alternatives Analysis project in Olympia, Washington (site; Figure 1). Services were provided in accordance with the scope outlined in the subconsultant agreement between Landau and HDR Engineering, Inc. (HDR, project civil engineer), authorized July 8, 2021.

This memorandum has been prepared with information provided by HDR and Thurston County Public Works (County, project owner) and with data collected during Landau's geotechnical field exploration and laboratory testing programs.

Project Understanding

The County proposes to replace a culvert beneath Draham Street NE to improve fish passage where the street crosses Woodland Creek. The existing culvert consists of an approximately 10-foot (ft)-diameter corrugated metal pipe. Landau understands that the culvert will be replaced with a bridge that will be constructed in, or around, 2024. The bankfull width of Woodland Creek is approximately 54 ft. Landau assumes that the replacement structure will be installed 4 ft below finished grade and approximately 1.3 ft below the estimated maximum scour depth.

Surface Conditions

The site is developed with a two-lane, asphalt road (Draham Street NE), built on an embankment at the existing culvert crossing. The embankment has a maximum fill height of approximately 15 ft. The bank of Woodland Creek is forested with coniferous and deciduous trees with an understory of vegetation common to the area. The site is located at a local low point, and elevations to the northeast and southwest increase at an approximately 3 percent grade.

Geologic Conditions

Geologic information for the site and the surrounding area was obtained from the *Geologic Map of the Lacey 7.5-minute Quadrangle, Thurston County, Washington* (Logan et al. 2003). Surficial deposits in the vicinity of the site are mapped as Vashon Stade recessional sand and minor silt (Qgos). This unit consists of well-sorted, fine- to medium-grained sand with minor silt content, deposited in and around the boundaries of glacial lakes.

The subsurface conditions observed in Landau's July 2021 explorations were generally consistent with the mapped geology. Embankment fill also was observed in Landau's explorations.

Subsurface Conditions

Site subsurface conditions were explored on July 22, 2021 by advancing two hollow-stem auger borings (B-1 and B-2) at the approximate locations shown on Figure 2. Boring B-1 was advanced 101.5 ft below ground surface (bgs), and boring B-2 was advanced 26.5 ft bgs.

Landau personnel coordinated and monitored the field explorations, collected representative soil samples, and maintained a detailed record of the subsurface soil and groundwater conditions observed. Subsurface conditions were described using the soil classification system shown on Figure 3, in general accordance with ASTM International (ASTM) standard D2488, *Standard Practice for Description and Identification of Soils (Visual-Manual Procedures).* Summary boring logs are presented on Figures 4 and 5.

Soil Conditions

The soils observed underlying existing surface conditions (i.e., asphalt pavement) were categorized into two general units:

- **Fill:** Fill was observed in both borings and consisted of sand with variable gravel, silt, and organic content or of silt with sand and organics. The fill was in a very loose to loose/soft, damp to moist condition and extended approximately 9.0 to 9.5 ft bgs.
- **Recessional glacial outwash:** Recessional glacial outwash was observed beneath the fill in both borings and consisted of silt with variable sand content or of sand with variable silt content. The recessional outwash was in a medium stiff to very stiff/loose to dense, moist to wet condition. Both borings were terminated in the recessional outwash unit.

Groundwater Conditions

During Landau's July 2021 field investigation, groundwater was observed at 17.0 ft bgs in boring B-1 and at 16.0 ft bgs in boring B-2. Groundwater conditions will vary depending on local subsurface conditions, weather conditions, and other factors. Furthermore, site groundwater levels are expected to fluctuate seasonally, with maximum groundwater levels occurring during late winter and early spring. Site groundwater levels are anticipated to approximate the surface water elevation of nearby Woodland Creek.

Geotechnical Laboratory Testing

Soil samples were transported to Landau's geotechnical laboratory for further examination and testing. Field log descriptions were checked against the laboratory samples. Where appropriate, the descriptions were updated in accordance with ASTM standard D2487, *Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System).*

Natural moisture content tests were performed on select soil samples in accordance with ASTM standard test method D2216, *Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass.* The natural moisture content is shown as "W = xx" (i.e., percent of dry weight) in the "Test Data" column on Figures 4 and 5.

Grain size analyses were performed in accordance with ASTM standard test method D6913, *Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis.* Grain size analysis was also performed on a sediment sample collected from the Woodland Creek streambed. Results of the grain size analyses are presented on Figures 6 and 7.

U.S. standard No. 200 washes were performed in accordance with ASTM standard test method D1140, *Standard Test Methods for Determining the Amount of Material Finer than 75-µm (No. 200) Sieve in Soils by Washing.* Results are shown as "-200 = xx" in the "Test Data" column on Figures 4 and 5.

Conclusions and Recommendations

Based on the subsurface conditions observed in Landau's July 2021 explorations, a bridge structure would be a suitable replacement for the existing culvert, provided the recommendations contained herein are incorporated into the project design. The following key points should be considered when developing project plans and specifications:

- Site soil predominantly consists of medium dense sand that is saturated below the surface water elevation of Woodland Creek. This soil is susceptible to liquefaction during a design-level earthquake, and 10 to 16 inches of liquefaction-induced settlement could occur. The Washington State Department of Transportation (WSDOT) considers the maximum potential depth of soil liquefaction to be 80 ft bgs (2021a).
- This maximum potential soil liquefaction depth is greater than that of other culvert replacement projects in Thurston County. It precludes the use of driven piles to support

the proposed bridge foundation, as pile refusal likely would be encountered before achieving an embedment depth that satisfies seismic design criteria.

- Landau considered two foundation-support alternatives for the proposed bridge structure:
  - **Drilled shafts:** Two 5-ft-diameter drilled shafts, installed at each bridge abutment, should provide adequate foundation support. To satisfy seismic design criteria, the drilled shafts should extend approximately 110 ft below the roadway. Landau assumes that Sargent Engineers (project structural engineer) will provide rough-order-of-magnitude (ROM) cost estimates for design and installation of a drilled shaft foundation system.
  - **Shallow foundations and ground improvement:** Shallow foundations established on a prism of improved soil should provide adequate support for the proposed bridge. Based on preliminary discussions with ground improvement contractors, rammed aggregate piers (RAPs), 24 to 36 inches in diameter, are likely the most cost-effective ground improvement method, given the shallow groundwater table and anticipated depth of ground improvement. ROM costs for RAPs are approximately $550,000 (2021 cost index). Estimated costs are based on a replacement ratio of 10 to 20 percent.
- Granular portions of the roadway embankment fill ("SW-SM" or "SP-SM" on Figures 4 and 5) are well suited for reuse as structural fill. Soils designated as "SM" or "ML" on Figures 4 and 5 are fine-grained and have an above-optimum *in situ* moisture content. These soils should not be reused as structural fill.

Bridge Structure

Landau evaluated two foundation-support alternatives for the proposed bridge structure: drilled shafts and shallow foundations with ground improvement.

Drilled Shafts

Landau anticipates that drilled shafts will be the most cost-effective method of deep foundation support. In Landau's experience, two 5-ft-diameter drilled shafts, installed at each bridge abutment, should provide adequate foundation support. To satisfy seismic design criteria, drilled shafts should be embedded approximately 110 ft below the roadway. Drilled shaft elements would be filled with lean-mix concrete (minimum compressive strength of 1,000 pounds per square inch). Landau recommends using a temporary casing to mitigate soil caving. Sargent Engineers can prepare ROM cost estimates for design and installation of a drilled shaft foundation system.

Diagram 1 depicts the various loads that would be exerted on the drilled shaft foundation system.

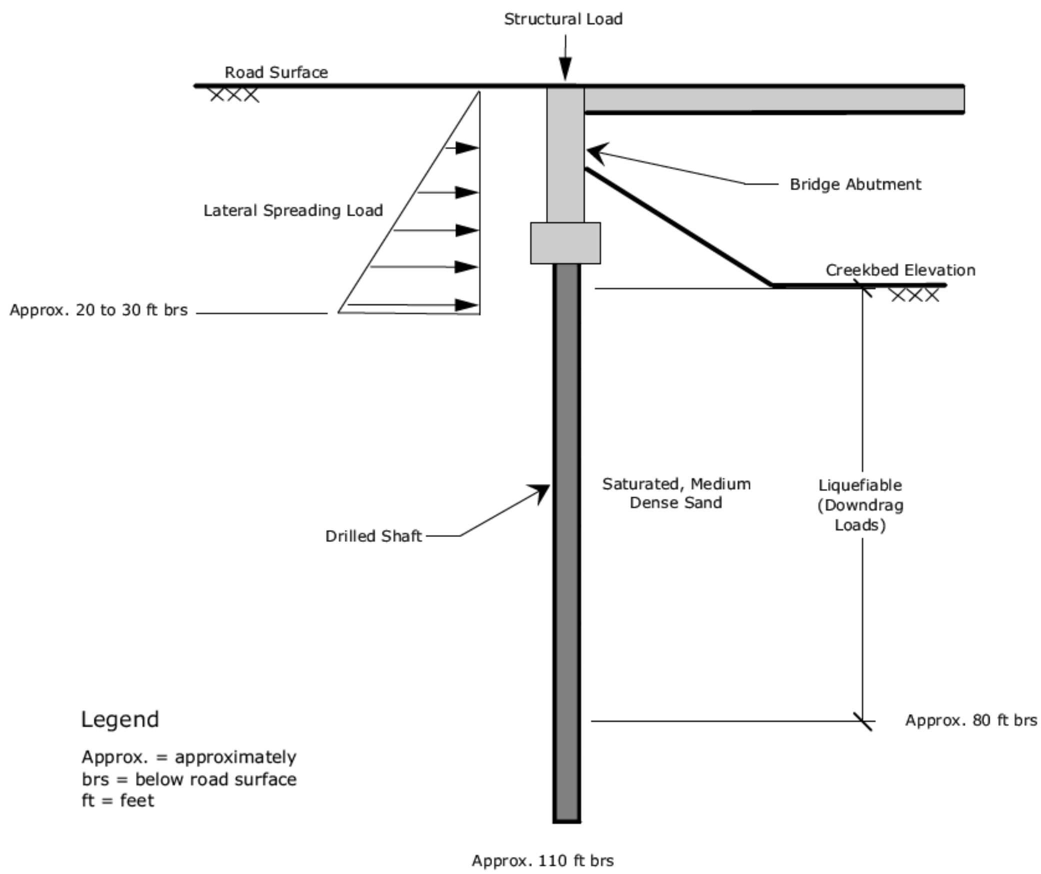

Diagram 1. Drilled Shaft Foundation Loads

Shallow Foundations and Ground Improvement

Shallow foundations established on a prism of improved soil should provide adequate foundation support for the proposed bridge. The improved soil zone (ISZ) would form a non-liquefiable crust, essentially "capping" the saturated, liquefiable recessional outwash soil and limiting the occurrence of seismically induced liquefaction at ground surface. Given the presence of a shallow groundwater table and the depth of ground improvement needed to establish the non-liquefiable crust, RAPs are the most feasible ground improvement method.

The ISZ would measure approximately 6,265 square feet, and RAPs would be installed on a grid with 6-ft by 6-ft spacing (i.e., a replacement ratio of 10 to 20 percent). The RAPs would be installed in 24- to 36-inch-diameter boreholes extending approximately 35 ft below the creek bed elevation. The boreholes would be backfilled with lifts of compacted aggregate, increasing the lateral stress in the surrounding soil and densifying the ISZ. The ROM cost for RAP design, installation, and load testing is $550,000. (These services would be completed by a specialty ground improvement contractor).

Retaining Wall Design Parameters

Retaining walls or bridge abutment walls may be used to contain embankment soils. Retaining walls should be evaluated for global stability during final design. For planning purposes, the heels of wing walls should be assumed to equal 80 percent of the wall height. The parameters in Table 1 can be used to design retaining walls; passive resistance should not be included, given the potential for scour at the face of retaining walls.

Table 1. Retaining Wall Design Parameters

Parameter	Value	
	Level Backslope	3H:1V Backslope
Backfill soil unit weight (pcf)	125	
Backfill soil submerged unit weight (pcf)	63	
Backfill soil internal angle of friction (degrees)	36	
Foundation soil internal angle of friction (degrees)	30	
Active earth pressure coefficient (K_a)	0.26	0.32
At-rest earth pressure coefficient (K_0)	0.41	0.50
Seismic earth pressure coefficient – Unrestrained (K_{ae})	0.37	0.51
Seismic earth pressure coefficient – Restrained (K_{ae})	0.67	N/A[(a)]
Ultimate coefficient of sliding	Cast-in-place: 0.57 Precast: 0.46	

Note: Landau assumes that retaining walls will be unrestrained and free to rotate.
(a) Upon request, Landau will develop a limit equilibrium model to obtain this coefficient.
H:V = horizontal to vertical
N/A = not applicable
pcf = pounds per cubic foot

When developing the design parameters in Table 1, Landau assumed that backfill within the structural excavation zone would consist of Gravel Borrow, conforming to the requirements in Section 9-03.14(1) of WSDOT's 2022 *Standard Specifications for Road, Bridge, and Municipal Construction* (2021b; *2022 WSDOT Standard Specifications*). Landau also assumed that the Gravel Borrow would be compacted to at least 95 percent of its maximum dry density.

Seismic Design

The seismic design parameters in Table 2 were developed in accordance with the American Association of State Highway and Transportation Officials' (AASHTO) *LRFD* (Load and Resistance Factor Design) *Bridge Design Specifications* (2017). AASHTO recommends using a "7 percent probability of exceedance in 75 years" (nominal 1,000-year earthquake) event to develop a design spectrum for structures (2017).

Table 2. Seismic Design Parameters

Site Class	M	PGA (g)	A_s (g)	S_s (g)	S_1 (g)	F_a	F_v	F_{PGA}
E	8.96	0.394	0.362	0.860	0.310	1.068	2.761	0.918

A_s = site-adjusted peak ground acceleration
F_a, F_v = acceleration (0.2-second period) and velocity (1.0-second period) site coefficients, respectively
F_{PGA} = peak ground acceleration coefficient
g = acceleration due to gravity
M = design earthquake moment magnitude
PGA = peak ground acceleration
S_s, S_1 = 0.2-second and 1.0-second period spectral accelerations, respectively

Given the distance between the site and the nearest known active crustal fault, the risk of ground rupture due to surface faulting is low.

Construction Considerations

The following key points should be considered when developing project plans and specifications:

- **Reuse of site soil:** Portions of the roadway embankment fill ("SW-SM" or "SP-SM" on Figures 4 and 5) are granular and well suited for reuse as structural fill. Fine-grained site soils, designated as "SM" or "ML" on Figures 4 and 5, have an above-optimum *in situ* moisture content. These soils should not be reused as structural fill.
- **Structural fill:** Gravel Borrow, as described in Section 9-03.14(1) of the *2022 WSDOT Standard Specifications,* is a suitable source of structural fill. During periods of wet weather, the fines content should not exceed 5 percent, based on the minus ¾-inch fraction. Structural fill should be used as backfill within the limits of the structural excavation.
- **Temporary excavations:** Temporary excavations should be completed in accordance with Section 2-09 of the *2022 WSDOT Standard Specifications.* The contractor should be responsible for actual excavation configurations and the maintenance of safe working conditions, including temporary excavation stability. Temporary excavations in excess of 4 ft should be shored or sloped in accordance with the requirements in Safety Standards for Construction Work, Part N (Chapter 296-155 Washington Administrative Code). The soil likely to be exposed in excavation sidewalls should be considered Type C. The maximum allowable excavation inclination in Type C soils is 1.5 horizontal to 1 vertical (1.5H:1V). The parameters in Table 3 can be used to design engineered shoring systems.

Table 3. Recommended Soil Parameters for Design of Temporary Shoring

Soil Unit	Moist Unit Weight (pcf)	Submerged Unit Weight (pcf)	Cohesion (psf)	Internal Angle of Friction (degrees)
Fill	115	53	0	28
Recessional Outwash	120	58	0	30

pcf = pounds per cubic foot
psf = pounds per square foot

- **Dewatering/bypass:** Soils at the anticipated retaining wall foundation depth may readily transmit groundwater. If excavations extend below the streambed, the use of conventional sumps and pumps may not be adequate to provide a dry, stable work area.

  The contractor should anticipate the need for stream bypass, installation of shallow cofferdams, and/or extensive pumping with trash pumps. Completing construction during the dry period between summer and early fall will reduce dewatering needs. The contractor should be responsible for the design and implementation of the dewatering system(s).
- **Roadway embankment:** Embankments should be constructed with 2H:1V slopes or flatter, in accordance with the requirements in Section 2-03 of the *2022 WSDOT Standard Specifications.*
- **Oversized material:** Cobbles and boulders are often found in glacial deposits and may be encountered during earthwork construction. The contractor should be prepared to manage such oversized material.

Use of This Technical Memorandum

Landau Associates has prepared this technical memorandum for the exclusive use of HDR Engineering, Inc. and Thurston County Public Works for specific application to the Draham Street Northeast Culvert Replacement Alternatives Analysis project in Olympia, Washington. No other party is entitled to rely on the information, conclusions, and recommendations included in this document without the express written consent of Landau Associates. Reuse of the information, conclusions, and recommendations provided herein for extensions of the project or for any other project, without review and authorization by Landau Associates, shall be at the user’s sole risk.

Landau Associates warrants that, within the limitations of scope, schedule, and budget, its services have been provided in a manner consistent with that level of skill and care ordinarily exercised by members of the profession currently practicing in the same locality, under similar conditions as this project. Landau Associates makes no other warranty, either express or implied.

Closing

We trust that this memorandum provides you with sufficient information to proceed with the project. If you have questions or comments, or if we can be of further service, please contact Annabel Irwin at 360.628.5112 or at airwin@landauinc.com.

LANDAU ASSOCIATES, INC.

Annabel Irwin, PE
Senior Project Engineer

Calvin McCaughan, PE
Principal

AMI/CAM/mcs
[Y:\0122\057.010\R\FINAL\DRAHAM STREET NE CULVERT REPLACEMENT TECHNICAL MEMORANDUM 2.8.2023.DOCX]

Attachments: Figure 1. Vicinity Map
Figure 2. Site and Exploration Plan
Figure 3. Soil Classification System and Key
Figure 4. Log of Boring B-1
Figure 5. Log of Boring B-2
Figures 6 and 7. Grain Size Distribution

References

AASHTO. 2017. *LRFD Bridge Design Specifications, Customary U.S. Units.* 8th Edition. American Association of State Highway and Transportation Officials. September.

ASTM. 2003. D420-D5876: Annual Book of Standards. In: *Soil and Rock (I).* ASTM International. West Conshohocken, PA.

LNI. 2020. Construction Work. Chapter 296-155 WAC; Part N. Excavation, Trenching, and Shoring. Washington State Department of Labor and Industries. June 2.

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WSDOT. 2021a. *M 46-03: Geotechnical Design Manual.* Washington State Department of Transportation. June 1.

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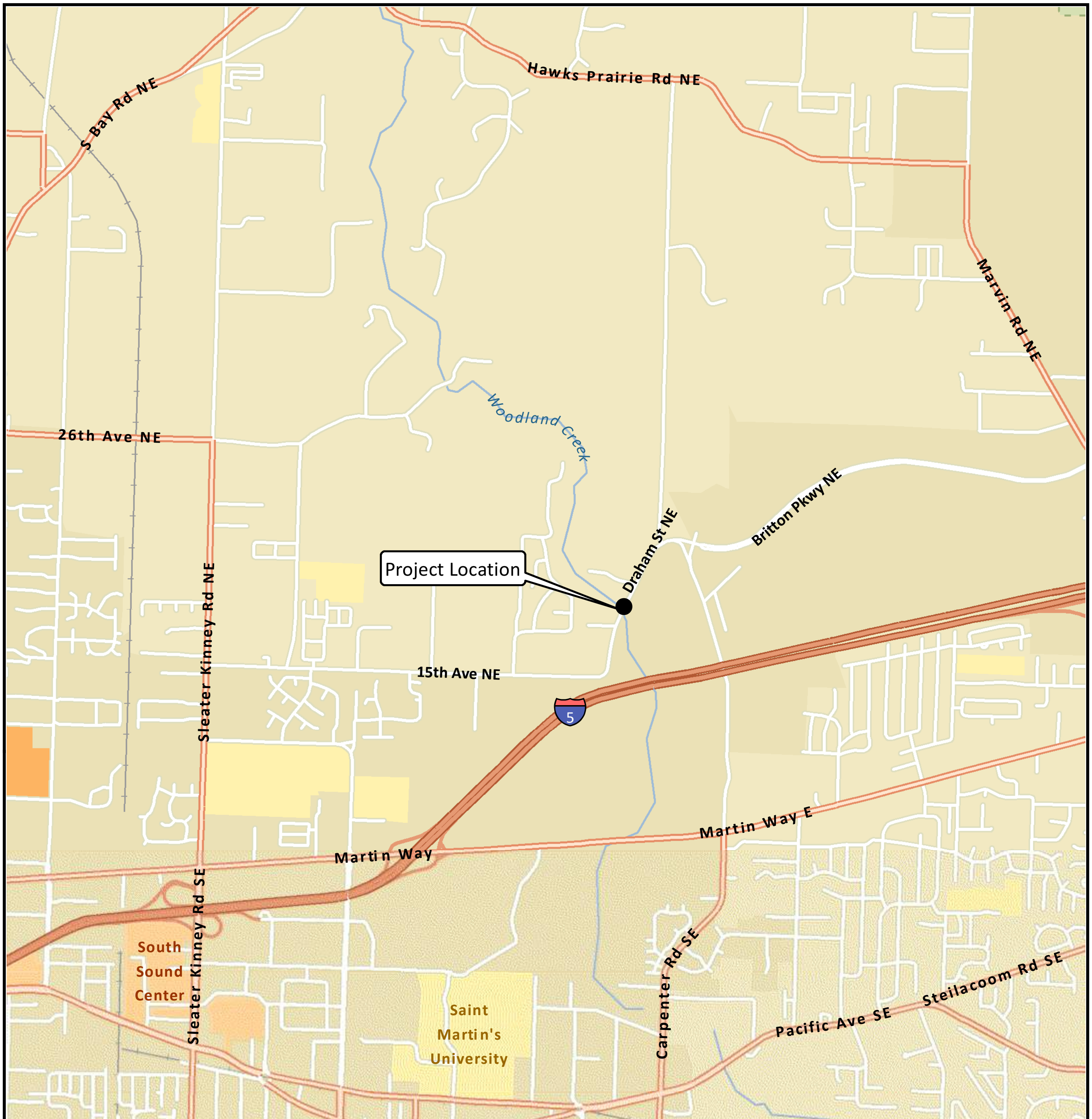

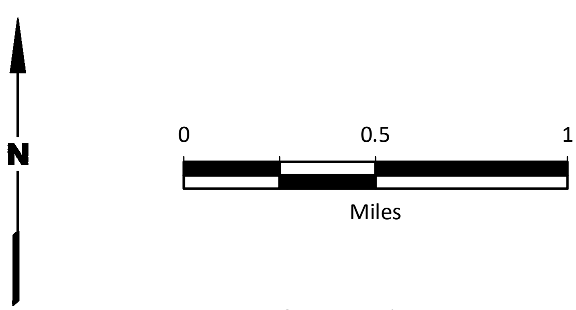

Data Source: Esri.

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Draham Street NE Culvert Replacement Olympia, Washington	**Vicinity Map**	Figure 1

Legend

B-1 ⊕ Approximate Boring Location and Designation

0 150 300

Scale in Feet

Note

1. Black and white reproduction of this color original may reduce its effectiveness and lead to incorrect interpretation.

Source: Google Earth 2018

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LANDAU ASSOCIATES

Draham Street NE Culvert Replacement Olympia, Washington	**Site and Exploration Plan**	Figure 2

Soil Classification System

MAJOR DIVISIONS			GRAPHIC SYMBOL	USCS LETTER SYMBOL[1]	TYPICAL DESCRIPTIONS [2][3]
COARSE-GRAINED SOIL (More than 50% of material is larger than No. 200 sieve size)	GRAVEL AND GRAVELLY SOIL (More than 50% of coarse fraction retained on No. 4 sieve)	CLEAN GRAVEL (Little or no fines)		**GW**	Well-graded gravel; gravel/sand mixture(s); little or no fines
				GP	Poorly graded gravel; gravel/sand mixture(s); little or no fines
		GRAVEL WITH FINES (Appreciable amount of fines)		**GM**	Silty gravel; gravel/sand/silt mixture(s)
				GC	Clayey gravel; gravel/sand/clay mixture(s)
	SAND AND SANDY SOIL (More than 50% of coarse fraction passed through No. 4 sieve)	CLEAN SAND (Little or no fines)		**SW**	Well-graded sand; gravelly sand; little or no fines
				SP	Poorly graded sand; gravelly sand; little or no fines
		SAND WITH FINES (Appreciable amount of fines)		**SM**	Silty sand; sand/silt mixture(s)
				SC	Clayey sand; sand/clay mixture(s)
FINE-GRAINED SOIL (More than 50% of material is smaller than No. 200 sieve size)	SILT AND CLAY (Liquid limit less than 50)			**ML**	Inorganic silt and very fine sand; rock flour; silty or clayey fine sand or clayey silt with low plasticity
				CL	Inorganic clay of low to medium plasticity; gravelly clay; sandy clay; silty clay; lean clay
				OL	Organic silt; organic, silty clay of low plasticity
	SILT AND CLAY (Liquid limit greater than 50)			**MH**	Inorganic silt; micaceous or diatomaceous fine sand; elastic silt
				CH	Inorganic clay of high plasticity; fat clay
				OH	Organic clay of medium to high plasticity; organic silt
	HIGHLY ORGANIC SOIL			**PT**	Peat; humus; swamp soil with high organic content

OTHER MATERIALS	GRAPHIC SYMBOL	LETTER SYMBOL	TYPICAL DESCRIPTIONS
PAVEMENT		**AC** or **PC**	Asphalt concrete pavement or Portland cement pavement
ROCK		**RK**	Rock (See Rock Classification)
WOOD		**WD**	Wood, lumber, wood chips
DEBRIS		**DB**	Construction debris, garbage

Notes:
1. USCS letter symbols correspond to symbols used by the Unified Soil Classification System and ASTM classification methods. Dual letter symbols (e.g., SP-SM for sand or gravel) indicate soil with an estimated 5-15% fines. Multiple letter symbols (e.g., ML/CL) indicate borderline or multiple soil classifications.
2. Soil descriptions are based on the general approach presented in the Standard Practice for Description and Identification of Soils (Visual-Manual Procedure), outlined in ASTM D 2488. Where laboratory index testing has been conducted, soil classifications are based on the Standard Test Method for Classification of Soils for Engineering Purposes, as outlined in ASTM D 2487.
3. Soil description terminology is based on visual estimates (in the absence of laboratory test data) of the percentages of each soil type and is defined as follows:

Primary Constituent:	> 50%	- "GRAVEL," "SAND," "SILT," "CLAY," etc.
Secondary Constituents:	> 30% and ≤ 50%	- "very gravelly," "very sandy," "very silty," etc.
	> 15% and ≤ 30%	- "gravelly," "sandy," "silty," etc.
Additional Constituents:	> 5% and ≤ 15%	- "with gravel," "with sand," "with silt," etc.
	≤ 5%	- "with trace gravel," "with trace sand," "with trace silt," etc., or not noted.

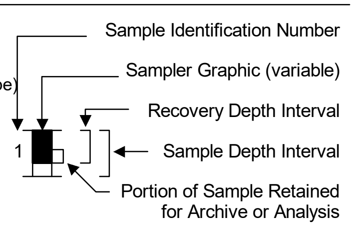
4. Soil density or consistency descriptions are based on judgement using a combination of sampler penetration blow counts, drilling or excavating conditions, field tests, and laboratory tests, as appropriate.

Drilling and Sampling Key

SAMPLER TYPE & METHOD

Graphic	Code	Description
	a	3.25-in OD, 2.42-in ID Split Spoon
	b	2.00-in OD, 1.50-in ID Split Spoon
	c	Thin-Wall Sampler (aka Shelby Tube)
	d	Grab Sample
	e	Single-Tube Core Barrel
	f	Double-Tube Core Barrel
	g	2.50-in OD, 2.00-in ID WSDOT
	h	3.00-in OD, 2.37-in ID Mod. Calif.
	i	Other - See text if applicable
	1	300-lb Hammer, 30-inch Drop
	2	140-lb Hammer, 30-inch Drop
	3	Pushed Sample
	4	Vibrocore (Rotosonic/Geoprobe)
	5	Other - See text if applicable
	6	Piston Extraction

SAMPLE NUMBER & INTERVAL



Groundwater

- ∇ Approximate water level at time of drilling (ATD)
- ▼ Approximate water level at time after drilling/excavation/well

Field and Lab Test Data

Code	Description
WOR	Weight of Rod
WOH	Weight of Hammer
PP = 1.0	Pocket Penetrometer, tsf
TV = 0.5	Torvane, tsf
PID = 100	Photoionization Detector VOC screening, ppm
W = 10	Moisture Content, %
D = 120	Dry Density, pcf
-200 = 60	Material smaller than No. 200 sieve, %
GS	Grain Size - See separate figure for data
AL	Atterberg Limits - See separate figure for data
UU	Triaxial Unconsolidated Undrained (UU) Strength
CU	Triaxial Consolidated Undrained (CU) Strength
Consol	1-D Consolidation Test
Perm	Permeability Test
CA	Chemical Analysis

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Draham Street NE
Culvert Replacement
Olympia, Washington

Soil Classification System and Key

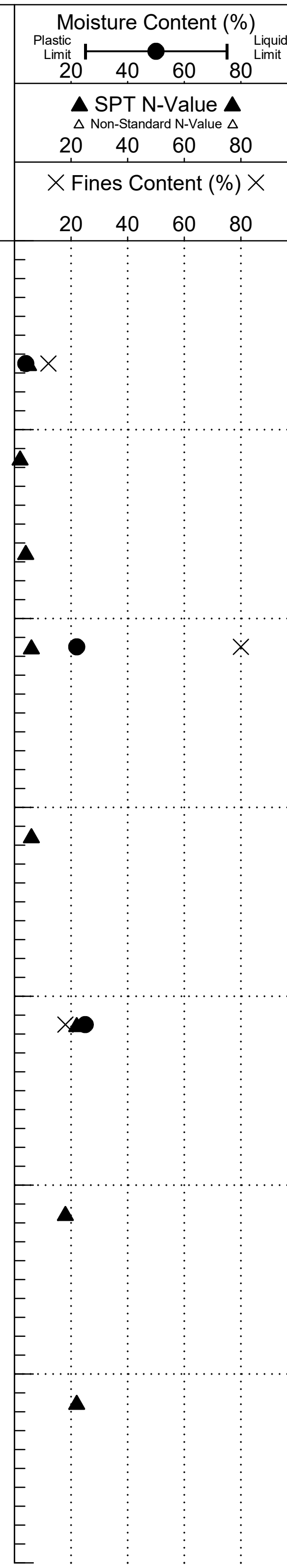
Figure 3

B-1

LAI Project No: 0122057.010

Drilling Method: Hollow-Stem Auger
Ground Elevation (ft): Not Measured
Drilled By: Holocene Drilling Inc.
Logged By: BP Date: 07/22/21

Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	USCS Symbol	Material Description	Groundwater
0					AC	9 inches of asphalt over 12 inches of crushed surfacing base course **(ASPHALT)**	
	S-1	b2	5	W = 4 GS	SW-SM	Brown, very gravelly, well-graded, fine to coarse SAND with silt (loose, damp) **(FILL)**	
5	S-2	b2	2		SM	Brown, very silty, fine to coarse SAND (very loose, damp)	
	S-3	b2	4		SP-SM	Brown, fine to coarse SAND with silt, gravel, and trace organics (very loose, moist)	
10	S-4	b2	6	W = 22 -200 = 80	ML	Gray, iron-stained, sandy SILT with trace organics (medium stiff, moist) **(RECESSIONAL GLACIAL OUTWASH)**	
					SM	Brown, iron-stained, very silty, fine to medium SAND (loose, moist)	
15	S-5	b2	6			-Grades to gray-brown and moist to wet	17.0 ft ATD
20	S-6	b2	22	W = 25 GS		-Grades to silty, wet, and medium dense -Drillers began adding bentonite slurry to mitigate heave	
					SP-SM	Gray, fine to coarse SAND with silt (medium dense, wet)	
25	S-7	b2	18				
30	S-8	b2	22				
35							



Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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Draham Street NE Culvert Replacement Olympia, Washington

Log of Boring B-1

B-1

LAI Project No: 0122057.010

Drilling Method: Hollow-Stem Auger

Ground Elevation (ft): Not Measured

Drilled By: Holocene Drilling Inc.

Logged By: BP Date: 07/22/21

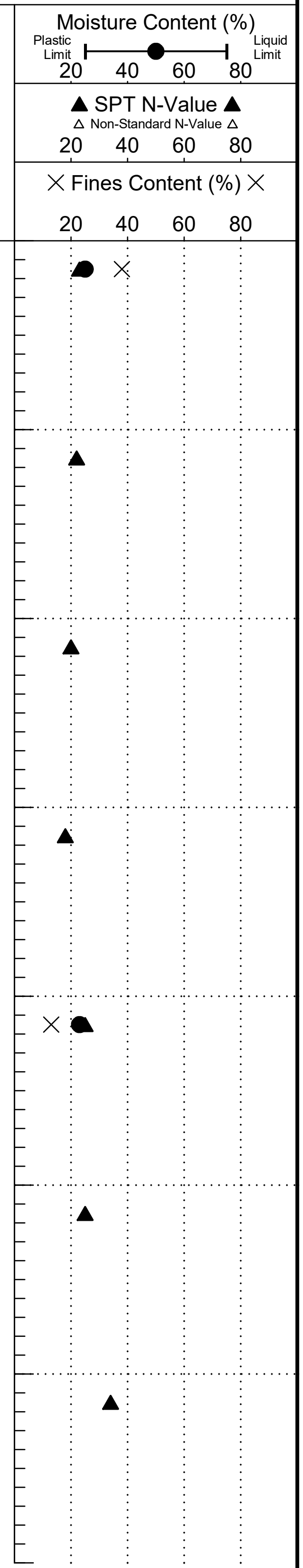
SAMPLE DATA

Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data
35		S-9	b2	23	W = 25 GS
40		S-10	b2	22	
45		S-11	b2	20	
50		S-12	b2	18	
55		S-13	b2	25	W = 23 GS
60		S-14	b2	25	
65		S-15	b2	34	
70					

SOIL PROFILE

USCS Symbol	Description
SP-SM	Gray, fine to coarse SAND with silt (medium dense, wet) **(RECESSIONAL GLACIAL OUTWASH)** -Lens of very silty sand
ML	Gray, sandy SILT (very stiff, wet)
SP-SM	Gray, fine to medium SAND with silt (medium dense, wet) -Switched to mud-rotary drilling -Grades to dense
SM	Gray, very silty, fine to medium SAND (medium dense, wet)

Groundwater



Notes: 1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

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Draham Street NE
Culvert Replacement
Olympia, Washington

Log of Boring B-1

Figure 4

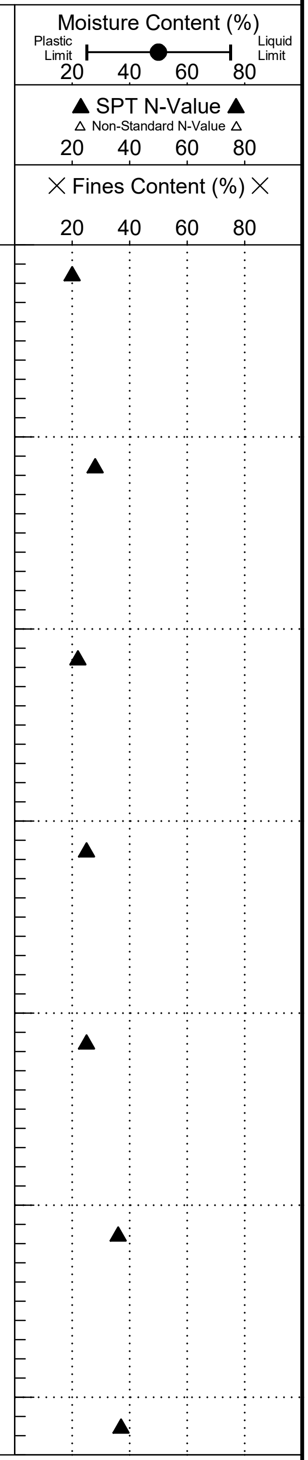
B-1

LAI Project No: 0122057.010

SAMPLE DATA | **SOIL PROFILE**

Drilling Method: Hollow-Stem Auger
Ground Elevation (ft): Not Measured
Drilled By: Holocene Drilling Inc.
Logged By: BP Date: 07/22/21

Depth (ft)	Elevation (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data	USCS Symbol	Description	Groundwater
70		S-16	b2	20		SM	Gray, very silty, fine to medium SAND (medium dense, wet) **(RECESSIONAL GLACIAL OUTWASH)**	
						SP	Gray, fine to coarse SAND (medium dense, wet)	
75		S-17	b2	28				
80		S-18	b2	22				
85		S-19	b2	25				
90		S-20	b2	25				
95		S-21	b2	36			-Grades to dense	
100		S-22	b2	37				
105								



Boring Completed 07/22/21
Total Depth of Boring = 101.5 ft.

Notes: 1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

122057.01 2/6/23 Y:\0122\057.010\T\0122057.010.GPJ SOIL BORING LOG WITH GRAPH

B-2

LAI Project No: 0122057.010

SAMPLE DATA / **SOIL PROFILE**

Drilling Method: Hollow-Stem Auger

Ground Elevation (ft): Not Measured

Drilled By: Holocene Drilling Inc.

Logged By: BP Date: 07/22/21

Moisture Content (%) — Plastic Limit / Liquid Limit: 20 40 60 80

▲ SPT N-Value ▲ (△ Non-Standard N-Value △): 20 40 60 80

× Fines Content (%) ×: 20 40 60 80

Depth (ft)	Sample Number & Interval	Sampler Type	Blows/Foot	Test Data
5	S-1	b2	3	W = 288 -200 = 68
10	S-2	b2	15	W = 10 GS
15	S-3	b2	19	
20	S-4	b2	12	
25	S-5	b2	15	

Depth (ft)	USCS Symbol	Description
0	AC	9 inches of asphalt over 24 inches of crushed surfacing base course **(ASPHALT)**
	ML	Brown, very sandy SILT with organics (soft, moist) **(FILL)** -Grades to gray-brown and iron-stained -Seam of organics observed
	SW-SM	Brown, well-graded, fine to coarse SAND with silt and gravel (medium dense, moist to wet) **(RECESSIONAL GLACIAL OUTWASH)** -Grades to gray-brown
	ML	Gray-brown, iron-stained SILT with sand (stiff, wet)
	SP	Gray-brown, fine to coarse SAND (medium dense, wet)

Groundwater: 16.0 ft ATD

288

Boring Completed 07/22/21
Total Depth of Boring = 26.5 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

122057.01 2/6/23 Y:\0122\057.010\T\0122057.010.GPJ SOIL BORING LOG WITH GRAPH

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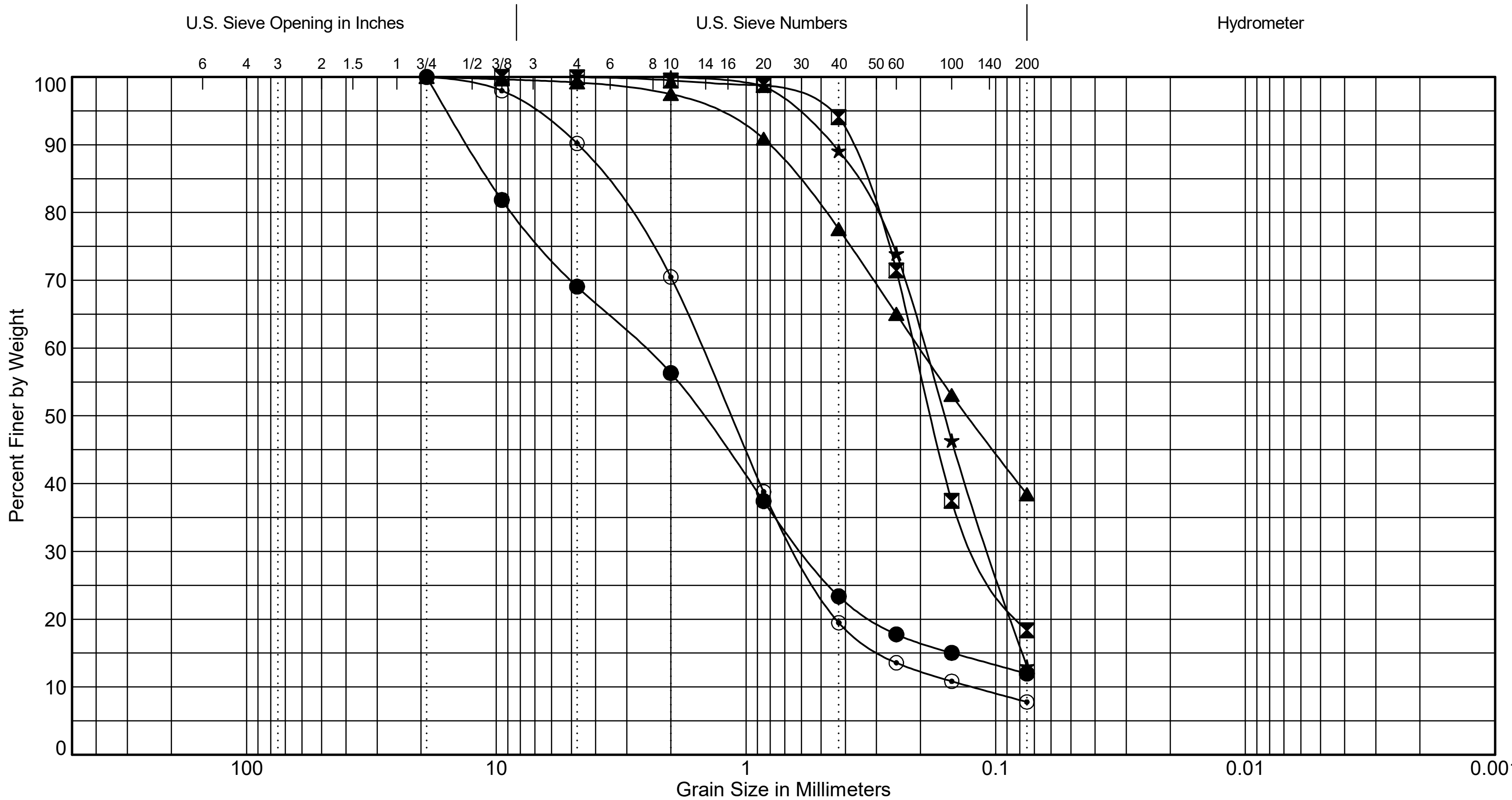
Draham Street NE Culvert Replacement
Olympia, Washington

Log of Boring B-2

Figure 5



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Exploration Number	Sample Number	Depth (ft)	Natural Moisture (%)	Soil Description	Unified Soil Classification
●	B-1	S-1	2.5	4	Very gravelly, well-graded, fine to coarse SAND with silt	SW-SM
⧗	B-1	S-6	20.0	25	Silty, fine to medium SAND	SM
▲	B-1	S-9	35.0	25	Very silty, fine to medium SAND	SM
★	B-1	S-13	55.0	23	Fine to medium SAND with silt	SP-SM
⊙	B-2	S-2	10.0	10	Well-graded, fine to coarse SAND with silt and gravel	SW-SM

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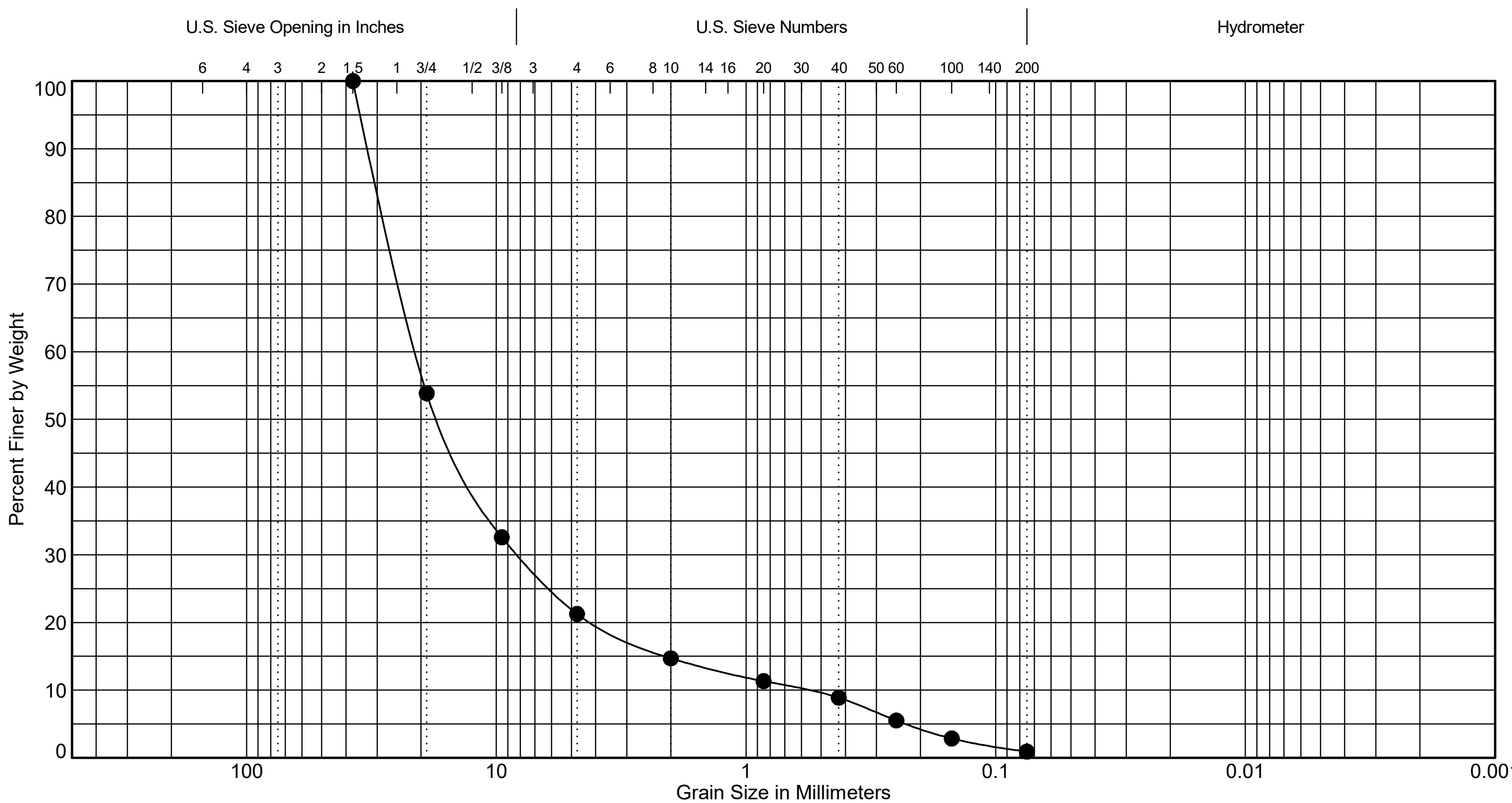
Draham Street NE Culvert Replacement Olympia, Washington	Grain Size Distribution	Figure 6



Cobbles	Gravel		Sand			Silt or Clay
	Coarse	Fine	Coarse	Medium	Fine	

Symbol	Exploration Number	Sample Number	Depth (ft)	Natural Moisture (%)	Soil Description	Unified Soil Classification
●	Stream bed	Stream bed	0.1	7	Sandy, fine to coarse GRAVEL	GP

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Draham Street NE Culvert Replacement Olympia, Washington	Grain Size Distribution	Figure 7

Appendix F OPCC

Project Name: Draham Street NE Culvert Replacement - Bridge

Client Name: Thurston County

HDR Project No.: 10310387.00

Estimate Level: 30% Design

Date: 11/10/2022

BID ITEM NO.	WSDOT STD ITEM NO.	ITEM DESCRIPTION	UNIT	UNIT PRICE	TOTAL QUANTITY	Schedule A Buried Structure	TOTAL
		PREPARATION					
1	0001	MOBILIZATION	L.S.	$ 54,542.00	1.0	1.0	$ 54,542
2	0025	CLEARING AND GRUBBING	ACRE	$ 18,432.00	0.8	0.8	$ 14,746
					Subtotal:	**$69,288**	**$ 69,288**
		GRADING					
3	0310	ROADWAY EXCAVATION INCL. HAUL	C.Y.	$ 66.00	162.0	162.0	$ 10,692
4	0431	GRAVEL BORROW INCL. HAUL	TON	$ -	0.0	0.0	$ -
5	0470	EMBANKMENT COMPACTION	C.Y.	$ 8.00	1737.3	1737.3	$ 13,899
					Subtotal:	**$24,591**	**$ 24,591**
		DRAINAGE					
6	1040	CHANNEL EXCAVATION INCL. HAUL	C.Y.	$ 26.00	2908.0	2908.0	$ 75,608
7	1095	STREAMBED SEDIMENT	C.Y.	$ 85.00	984.0	984.0	$ 83,640
8	3075	TEMPORARY STREAM DIVERSION	L.S.	$ 130,000.00	1.0	1.0	$ 130,000
9	NS-216	LARGE WOODY MATERIAL - KEY PIECE (3' DIAM., 40' LONG)	EACH	$ 4,000.00	1.0	1.0	$ 4,000
10	NS-217	LARGE WOODY MATERIAL - OTHER (2' DIAM., 40' LONG)	EACH	$ 1,600.00	21.0	21.0	$ 33,600
11	NS-218	STREAM FINISH GRADING	L.S.	$ 15,000.00	1.0	1.0	$ 15,000
					Subtotal:	**$341,848**	**$ 341,848**
		STORM SEWER					
12	NS-277	WATER QUALITY/QUANTITY SYSTEM	L.S.	$ 20,000.00	1.0	1.0	$ 20,000
					Subtotal:	**$20,000**	**$ 20,000**
		STRUCTURE					
13	NS-452	BRIDGE, PIERS & ABUTMENTS	L.S.	$ 2,190,000.00	1.0	1.0	$ 2,190,000
					Subtotal:	**$2,190,000**	**$ 2,190,000**
		SURFACING					
14	5100	CRUSHED SURFACING BASE COURSE	TON	$ 41.00	1203.2	1203.2	$ 49,332
15	5120	CRUSHED SURFACING TOP COURSE	TON	$ 44.00	239.2	239.2	$ 10,526
					Subtotal:	**$59,858**	**$ 59,858**
		HOT MIX ASPHALT					
16	5767	HMA CL. 1/2 IN. PG 58H-22	TON	$ 160.00	453.4	453.4	$ 72,548
17	5873	HMA FOR APPROACH CL. 1/2 IN. PG 58H-22	TON	$ 249.00	30.3	30.3	$ 7,551
					Subtotal:	**$80,099**	**$ 80,099**
		EROSION CONTROL AND ROADSIDE PLANTING					
18	6403	ESC LEAD	DAY	$ 75.00	60.0	60.0	$ 4,500
19	6488	EROSION CONTROL AND WATER POLLUTION PREVENTION	L.S.	$ 20,000.00	1.0	1.0	$ 20,000
					Subtotal:	**$24,500**	**$ 24,500**
		TRAFFIC					
20	6700	CEMENT CONC. TRAFFIC CURB AND GUTTER	L.F.	$ 51.13	824.0	824.0	$ 42,135
21	6760	BEAM GUARDRAIL TRANSITION SECTION TYPE 24	EACH	$ 2,500.00	4.0	4.0	$ 10,000
22	6719	BEAM GUARDRAIL TYPE 31 NON-FLARED TERMINAL	EACH	$ 3,763.00	2.0	2.0	$ 7,526
23	6786	BEAM GUARDERAIL ANCHOR TYPE 11	EACH	$ 1,413.00	2.0	2.0	$ 2,826
24	6806	PAINT LINE	L.F.	$ 3.00	894.0	894.0	$ 2,682
25	6890	PERMANENT SIGNING	L.S.	$ 500.00	1.0	1.0	$ 500
26	6971	PROJECT TEMPORARY TRAFFIC CONTROL	L.S.	$ 10,000.00	1.0	1.0	$ 10,000
					Subtotal:	**$75,669**	**$ 75,669**
		OTHER ITEMS					
27	7038	ROADWAY SURVEYING	L.S.	$ 7,500.00	1.0	1.0	$ 7,500
28	7055	CEMENT CONC. SIDEWALK	S.Y.	$ 91.94	468.4	468.4	$ 43,063
29	7059	CEMENT CONC. DRIVEWAY ENTRANCE TYPE 1	S.Y.	$ 111.11	80.0	80.0	$ 8,890
30	7736	SPCC PLAN	L.S.	$ 1,000.00	1.0	1.0	$ 1,000
					Subtotal:	**$60,453**	**$ 60,453**

Subtotal Construction:	**$2,946,305**	**$ 2,946,305**
Contingency @ 25%	**$736,576**	**$ 736,576**
TOTAL CONSTRUCTION:	**$3,682,881**	**$ 3,682,881**
Preliminary Engineering (PE) @ 12%	**$441,946**	**$ 441,946**
Construction Management (CM) @ 3.8%	**$139,949**	**$ 139,949**
Miscellaneous Costs @ 16.6%	**$611,358**	**$ 611,358**
Right of Way Costs	**$400,000**	**$ 400,000**
SCHEDULE COST TOTALS:	**$5,276,135**	**$ 5,276,135**

TOTAL PROJECT COST: $ 5,276,135

Project Name: Draham Street NE Culvert Replacement - Buried Structure

Client Name: Thurston County

HDR Project No.: 10310387.00

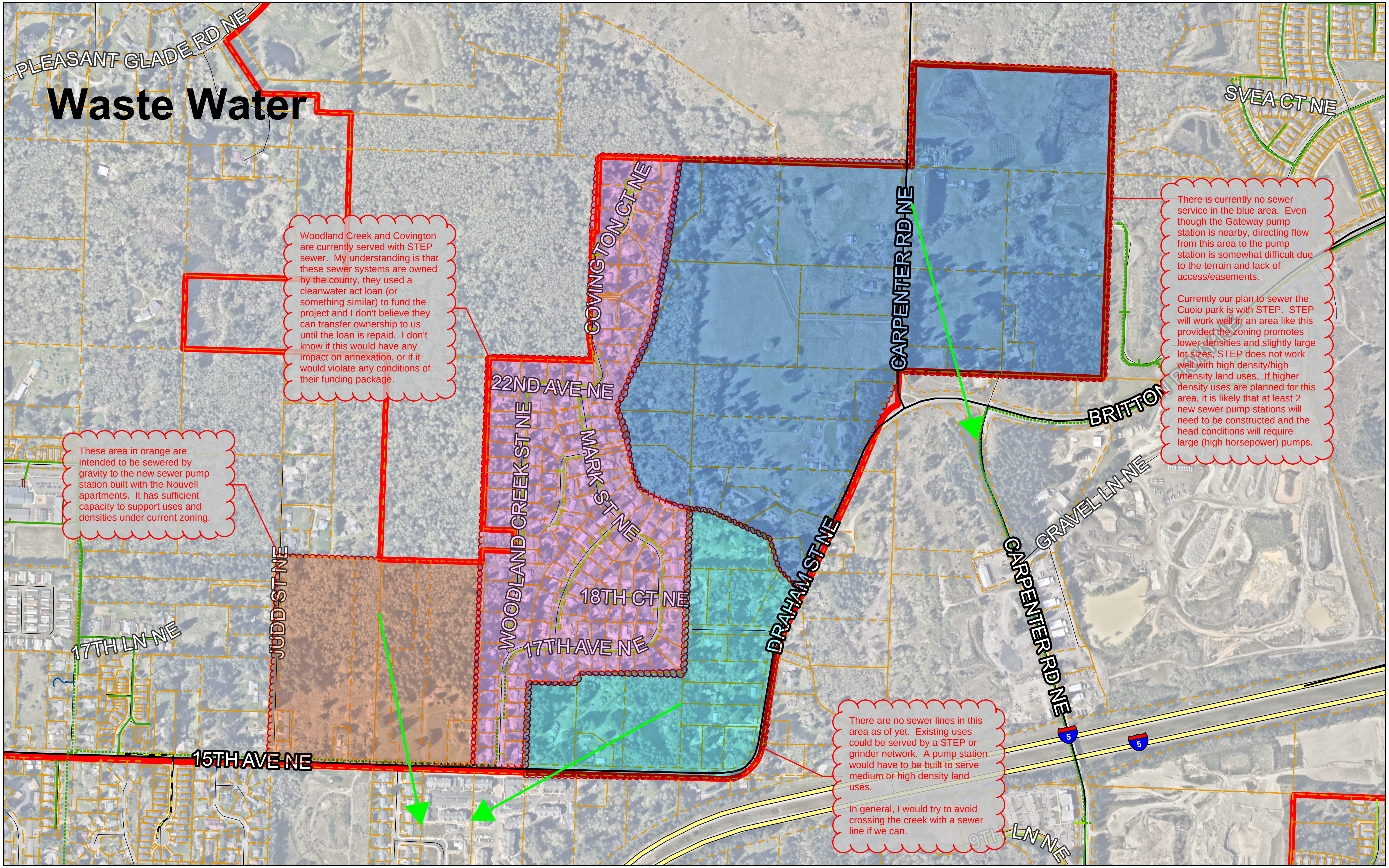
Estimate Level: 30% Design

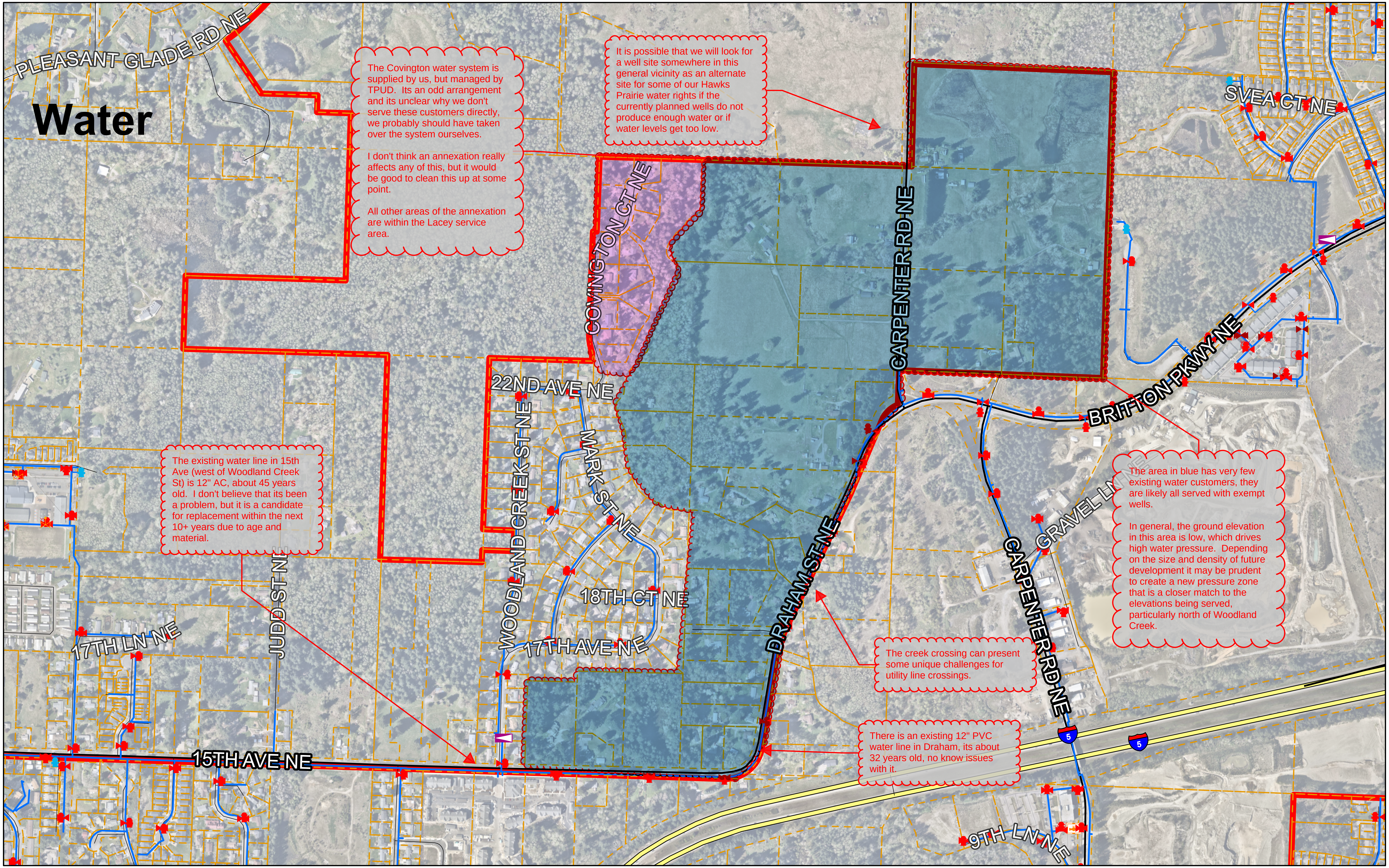
Date: 11/10/2022

BID ITEM NO.	WSDOT STD ITEM NO.	ITEM DESCRIPTION	UNIT	UNIT PRICE	TOTAL QUANTITY	Schedule A Buried Structure	TOTAL
		PREPARATION					
1	0001	MOBILIZATION	L.S.	$ 55,336.65	1.0	1.0	$ 55,337
2	0025	CLEARING AND GRUBBING	ACRE	$ 19,767.00	0.6	0.6	$ 12,647
					Subtotal:	**$67,983**	**$ 67,983**
		GRADING					
3	0310	ROADWAY EXCAVATION INCL. HAUL	C.Y.	$ 63.00	179.0	179.0	$ 11,277
4	0431	GRAVEL BORROW INCL. HAUL	TON	$ 24.00	2293.3	2293.3	$ 55,039
5	0470	EMBANKMENT COMPACTION	C.Y.	$ 7.00	3395.6	3395.6	$ 23,769
					Subtotal:	**$90,085**	**$ 90,085**
		DRAINAGE					
6	1040	CHANNEL EXCAVATION INCL. HAUL	C.Y.	$ 28.00	1924.0	1924.0	$ 53,872
7	1095	STREAMBED SEDIMENT	C.Y.	$ 85.00	984.0	984.0	$ 83,640
8	3075	TEMPORARY STREAM DIVERSION	L.S.	$ 130,000.00	1.0	1.0	$ 130,000
9	NS-216	LARGE WOODY MATERIAL - KEY PIECE (3' DIAM., 40' LONG)	EACH	$ 4,000.00	1.0	1.0	$ 4,000
10	NS-217	LARGE WOODY MATERIAL - OTHER (2' DIAM., 40' LONG)	EACH	$ 100.00	21.0	21.0	$ 2,100
11	NS-218	STREAM FINISH GRADING	L.S.	$ 15,000.00	1.0	1.0	$ 15,000
					Subtotal:	**$288,612**	**$ 288,612**
		STORM SEWER					
12	NS-277	WATER QUALITY/QUANTITY SYSTEM	L.S.	$ 20,000.00	1.0	1.0	$ 20,000
					Subtotal:	**$20,000**	**$ 20,000**
		STRUCTURE					
13	NS-451	CONCRETE ARCH & HEADWALLS	L.S.	$ 2,210,000.00	1.0	1.0	$ 2,210,000
					Subtotal:	**$2,210,000**	**$ 2,210,000**
		SURFACING					
14	5100	CRUSHED SURFACING BASE COURSE	TON	$ 41.00	1106.7	1106.7	$ 45,375
15	5120	CRUSHED SURFACING TOP COURSE	TON	$ 44.00	228.8	228.8	$ 10,066
					Subtotal:	**$55,441**	**$ 55,441**
		HOT MIX ASPHALT					
16	5767	HMA CL. 1/2 IN. PG 58H-22	TON	$ 155.00	492.1	492.1	$ 76,273
17	5873	HMA FOR APPROACH CL. 1/2 IN. PG 58H-22	TON	$ 294.00	17.4	17.4	$ 5,110
					Subtotal:	**$81,383**	**$ 81,383**
		EROSION CONTROL AND ROADSIDE PLANTING					
18	6403	ESC LEAD	DAY	$ 75.00	60.0	60.0	$ 4,500
19	6488	EROSION CONTROL AND WATER POLLUTION PREVENTION	L.S.	$ 20,000.00	1.0	1.0	$ 20,000
					Subtotal:	**$24,500**	**$ 24,500**
		TRAFFIC					
20	6700	CEMENT CONC. TRAFFIC CURB AND GUTTER	L.F.	$ 49.50	894.0	894.0	$ 44,255
21	6712	BEAM GUARDRAIL TYPE 31 - 9 FT. LONG POST	L.F.	$ 50.00	195.0	195.0	$ 9,750
22	6719	BEAM GUARDRAIL TYPE 31 NON-FLARED TERMINAL	EACH	$ 3,763.00	2.0	2.0	$ 7,526
23	6786	BEAM GUARDERAIL ANCHOR TYPE 11	EACH	$ 1,413.00	2.0	2.0	$ 2,826
24	6806	PAINT LINE	L.F.	$ 3.00	894.0	894.0	$ 2,682
25	6890	PERMANENT SIGNING	L.S.	$ 500.00	1.0	1.0	$ 500
26	6971	PROJECT TEMPORARY TRAFFIC CONTROL	L.S.	$ 10,000.00	1.0	1.0	$ 10,000
					Subtotal:	**$77,539**	**$ 77,539**
		OTHER ITEMS					
27	7038	ROADWAY SURVEYING	L.S.	$ 7,500.00	1.0	1.0	$ 7,500
28	7055	CEMENT CONC. SIDEWALK	S.Y.	$ 86.99	527.5	527.5	$ 45,887
29	7059	CEMENT CONC. DRIVEWAY ENTRANCE TYPE 1	S.Y.	$ 105.16	67.7	67.7	$ 7,116
30	7736	SPCC PLAN	L.S.	$ 1,000.00	1.0	1.0	$ 1,000
					Subtotal:	**$61,503**	**$ 61,503**

Subtotal Construction:	**$2,977,045**	**$ 2,977,045**
Contingency @ 25%	**$744,261**	**$ 744,261**
TOTAL CONSTRUCTION:	**$3,721,306**	**$ 3,721,306**
Preliminary Engineering (PE) @ 12%	**$446,557**	**$ 446,557**
Construction Management (CM) @ 3.8%	**$141,410**	**$ 141,410**
Miscellaneous Costs @ 16.6%	**$617,737**	**$ 617,737**
Right of Way Costs	**$400,000**	**$ 400,000**
SCHEDULE COST TOTALS:	**$5,327,009**	**$ 5,327,009**

TOTAL PROJECT COST: $ 5,327,009


Waste Water
PLEASANT GLADE RD NE
SVEA CT NE
COVINGTON CT NE
CARPENTER RD NE
22ND AVE NE
WOODLAND CREEK ST NE
MARK ST NE
18TH CT NE
17TH AVE NE
JUDD ST NE
17TH LN NE
15TH AVE NE
DRAHAM ST NE
BRITTON
GRAVEL LN NE
9TH LN NE
Woodland Creek and Covington are currently served with STEP sewer. My understanding is that these sewer systems are owned by the county, they used a cleanwater act loan (or something similar) to fund the project and I don't believe they can transfer ownership to us until the loan is repaid. I don't know if this would have any impact on annexation, or if it would violate any conditions of their funding package.
There is currently no sewer service in the blue area. Even though the Gateway pump station is nearby, directing flow from this area to the pump station is somewhat difficult due to the terrain and lack of access/easements.
Currently our plan to sewer the Cuoio park is with STEP. STEP will work well in an area like this provided the zoning promotes lower densities and slightly large lot sizes, STEP does not work well with high density/high intensity land uses. If higher density uses are planned for this area, it is likely that at least 2 new sewer pump stations will need to be constructed and the head conditions will require large (high horsepower) pumps.
These area in orange are intended to be sewered by gravity to the new sewer pump station built with the Nouvell apartments. It has sufficient capacity to support uses and densities under current zoning.
There are no sewer lines in this area as of yet. Existing uses could be served by a STEP or grinder network. A pump station would have to be built to serve medium or high density land uses.
In general, I would try to avoid crossing the creek with a sewer line if we can.



Water
PLEASANT GLADE RD NE
The Covington water system is supplied by us, but managed by TPUD. Its an odd arrangement and its unclear why we don't serve these customers directly, we probably should have taken over the system ourselves.
I don't think an annexation really affects any of this, but it would be good to clean this up at some point.
All other areas of the annexation are within the Lacey service area.
It is possible that we will look for a well site somewhere in this general vicinity as an alternate site for some of our Hawks Prairie water rights if the currently planned wells do not produce enough water or if water levels get too low.
SVEA CT NE
COVINGTON CT NE
CARPENTER RD NE
22ND AVE NE
BRITTON PKWY NE
WOODLAND CREEK ST NE
MARK ST NE
The existing water line in 15th Ave (west of Woodland Creek St) is 12" AC, about 45 years old. I don't believe that its been a problem, but it is a candidate for replacement within the next 10+ years due to age and material.
The area in blue has very few existing water customers, they are likely all served with exempt wells.
In general, the ground elevation in this area is low, which drives high water pressure. Depending on the size and density of future development it may be prudent to create a new pressure zone that is a closer match to the elevations being served, particularly north of Woodland Creek.
GRAVEL LN
DRAHAM ST NE
18TH CT NE
JUDD ST NE
17TH LN NE
17TH AVE NE
The creek crossing can present some unique challenges for utility line crossings.
There is an existing 12" PVC water line in Draham, its about 32 years old, no know issues with it.
15TH AVE NE
9TH LN NE

Draham Road Annexation

Transportation and Stormwater Maintenance Evaluation

Subject Properties

The initial area (subject properties) have little influence that we can see on either transportation or stormwater issue, as all areas will be new except for the following, approximately 500' of roadside vegetation that would be slope mowed, 435' of sidewalk maintenance and a section of 15th Ave NE on the South side of the road that is in very poor condition (it was not completed with the sewer upgrade). We could not access the area to the North with Palm Creek to be able to evaluate that area of the site.

Both extended options

Electrical:

There are 8 wood pole streetlights with PSE grid numbers on them in the Woodland Creek neighborhood, of these, two appear to be private but unable to verify. Currently no other electrical responsibilities were noticed.

Stormwater:

One of the main concerns here is the two creek crossings, one on Draham with Woodland Creek and the other is Eagle Creek crossing Carpenter Road. It is public knowledge that the Woodland Creek culvert crossing Draham has been evaluated for replacement and has a cost for either option around 5.3 million dollars. This evaluation was completed 2/15/2023 for the Thurston County Fish Passage Enhancement Program. The Eagle Creek culvert has not been maintained very well and is so overgrown it is hard to make a clear assessment. It looks as if they pounded sign poles into the front intake side to keep debris out and the outlet side is completely overgrown with vegetation. Woodland Creek neighborhood will add 23 catch basins to our maintenance load and 3 large filter systems (this system does drain through the filter systems straight into Woodland Creek).

Figure 1Eagle Creek Inlet

Figure 2Eagle Creek Outlet

Draham Street Culvert Replacement Alternatives Analysis Report

Thurston County Fish Passage Enhancement Program

Olympia, WA

Prepared By: *HDR, Inc.*
Jessica Soward, *Sargent Engineers*
Annabel Irwin, *Landau*

Date: February 15, 2023

Project Name: Graham Street NE Culvert Replacement - Bridge
Client Name: Thurston County
HDR Project No.: 10210367.00
Estimate Level: 30% Design
Date: 11/10/2022

HDR

[illegible]	[illegible]	ITEM DESCRIPTION	UNIT	UNIT PRICE	TOTAL QUANTITY	[illegible]		TOTAL
		PREPARATION						
1	0001	MOBILIZATION	L.S.	$ 54,542.00	1.0	1.0	$	54,542
2	0025	CLEARING AND GRUBBING	ACRE	$ 18,422.00	0.8	0.8	$	14,740
					Subtotal	$69,280	$	69,280
		GRADING						
3	0310	ROADWAY EXCAVATION INCL. HAUL	C.Y.	$ 66.00	162.0	162.0	$	10,692
4	0431	GRAVEL BORROW INCL. HAUL	TON	$ -	0.0	0.0	$	-
5	0470	EMBANKMENT COMPACTION	C.Y.	$ 8.00	1737.3	1737.3	$	13,899
					Subtotal	$24,591	$	24,591
		DRAINAGE						
6	1040	CHANNEL EXCAVATION INCL. HAUL	C.Y.	$ 26.00	2908.0	2908.0	$	75,608
7	1080	STREAMBED SEDIMENT	C.Y.	$ 85.00	984.0	984.0	$	83,640
8	3075	TEMPORARY STREAM DIVERSION	L.S.	$ 130,000.00	1.0	1.0	$	130,000
9	NS-216	LARGE WOODY MATERIAL - KEY PIECE (2' DIAM. 40' LONG)	EACH	$ 4,000.00	1.0	1.0	$	4,000
10	NS-217	LARGE WOODY MATERIAL - OTHER (2' DIAM. 40' LONG)	EACH	$ 1,600.00	21.0	21.0	$	33,600
11	NS-218	STREAM FINISH GRADING	L.S.	$ 15,000.00	1.0	1.0	$	15,000
					Subtotal	$341,848	$	341,848
		STORM SEWER						
12	NS-277	WATER QUALITY/QUANTITY SYSTEM	L.S.	$ 20,000.00	1.0	1.0	$	20,000
					Subtotal	$20,000	$	20,000
		STRUCTURE						
13	NS-452	BRIDGE, PIERS & ABUTMENTS	L.S.	$ 2,190,000.00	1.0	1.0	$	2,190,000
					Subtotal	$2,190,000	$	2,190,000
		SURFACING						
14	5100	CRUSHED SURFACING BASE COURSE	TON	$ 41.00	1203.2	1203.2	$	49,332
15	5120	CRUSHED SURFACING TOP COURSE	TON	$ 44.00	236.2	236.2	$	10,526
					Subtotal	$59,858	$	59,858
		HOT MIX ASPHALT						
16	5767	HMA CL. 1/2 IN. PG 58H-22	TON	$ 165.00	433.4	433.4	$	71,549
17	5873	HMA FOR APPROACH CL. 1/2 IN. PG 58H-22	TON	$ 245.00	30.3	30.3	$	7,551
					Subtotal	$80,099	$	80,099
		EROSION CONTROL AND ROADSIDE PLANTING						
18	6403	ESC LEAD	DAY	$ 75.00	60.0	60.0	$	4,500
19	6490	EROSION CONTROL AND WATER POLLUTION PREVENTION	L.S.	$ 20,000.00	1.0	1.0	$	20,000
					Subtotal	$24,500	$	24,500
		TRAFFIC						
20	6700	CEMENT CONC. TRAFFIC CURB AND GUTTER	L.F.	$ 51.12	824.0	824.0	$	42,135
21	6760	BEAM GUARDRAIL TRANSITION SECTION TYPE 24	EACH	$ 2,500.00	4.0	4.0	$	10,000
22	6716	BEAM GUARDRAIL TYPE 31 NON-FLARED TERMINAL	EACH	$ 3,763.00	2.0	2.0	$	7,526
23	6786	BEAM GUARDRAIL ANCHOR TYPE 11	EACH	$ 1,413.00	2.0	2.0	$	2,826
24	6806	PAINT LINE	L.F.	$ 3.00	894.0	894.0	$	2,682
25	6890	PERMANENT SIGNING	L.S.	$ 500.00	1.0	1.0	$	500
26	6971	PROJECT TEMPORARY TRAFFIC CONTROL	L.S.	$ 10,000.00	1.0	1.0	$	10,000
					Subtotal	$75,669	$	75,669
		OTHER ITEMS						
27	7030	ROADWAY SURVEYING	L.S.	$ 7,500.00	1.0	1.0	$	7,500
28	7055	CEMENT CONC. SIDEWALK	S.Y.	$ 91.94	468.4	468.4	$	43,063
29	7059	CEMENT CONC. DRIVEWAY ENTRANCE TYPE 1	S.Y.	$ 111.11	80.0	80.0	$	8,890
30	7736	SPCC PLAN	L.S.	$ 1,000.00	1.0	1.0	$	1,000
					Subtotal	$60,453	$	60,453

Subtotal Construction:	$2,946,305	$	2,946,305
Contingency @ 25%	$736,576	$	736,576
TOTAL CONSTRUCTION:	$3,682,881	$	3,682,881
Preliminary Engineering (PE) @ 12%	$441,946	$	441,946
Construction Management (CM) @ 3.8%	$139,949	$	139,949
Miscellaneous Costs @ 16.6%	$611,358	$	611,358
Right of Way Costs	$400,000	$	400,000
SCHEDULE COST TOTALS:	$5,276,135	$	5,276,135

TOTAL PROJECT COST: $ 5,276,135

Project Name:	**Graham Street NE Culvert Replacement - Buried Structure**
Client Name:	**Thurston County**
HDR Project No.:	**10310387.00**
Estimate Level:	**30% Design**
Date:	**11/10/2022**

HDR

BID ITEM NO.	WSDOT STD. ITEM NO.	ITEM DESCRIPTION	UNIT	UNIT PRICE	TOTAL QUANTITY	Schedule A Buried Structure	TOTAL
		PREPARATION					
1	0001	MOBILIZATION	L.S.	$ [illegible]	1.0	1.0	$ 49,335
2	0025	CLEARING AND GRUBBING	ACRE	$ 14,787.00	0.9	0.9	$ 12,647
					Subtotal:	**$61,982**	**$ 61,982**
		GRADING					
3	0310	ROADWAY EXCAVATION INCL. HAUL	C.Y.	$ 63.00	179.0	179.0	$ 11,277
4	0421	GRAVEL BORROW INCL. HAUL	TON	$ 24.00	2293.3	2293.3	$ 55,039
5	0470	EMBANKMENT COMPACTION	C.Y.	$ 7.00	3395.6	3395.6	$ 23,769
					Subtotal:	**$90,085**	**$ 90,085**
		DRAINAGE					
6	1040	CHANNEL EXCAVATION INCL. HAUL	C.Y.	$ 28.00	1924.0	1924.0	$ 53,872
7	1095	STREAMBED SEDIMENT	C.Y.	$ 85.00	984.0	984.0	$ 83,640
8	3075	TEMPORARY STREAM DIVERSION	L.S.	$ 136,000.00	1.0	1.0	$ 136,000
9	NS-216	LARGE WOODY MATERIAL - KEY PIECE (3' DIAM., 40' LONG)	EACH	$ 4,000.00	1.0	1.0	$ 4,000
10	NS-217	LARGE WOODY MATERIAL - OTHER (2' DIAM., 40' LONG)	EACH	$ 100.00	21.0	21.0	$ 2,100
11	NS-218	STREAM FINISH GRADING	L.S.	$ 15,000.00	1.0	1.0	$ 15,000
					Subtotal:	**$294,612**	**$ 294,612**
		STORM SEWER					
12	NS-277	WATER QUALITY/QUANTITY SYSTEM	L.S.	$ 20,000.00	1.0	1.0	$ 20,000
					Subtotal:	**$20,000**	**$ 20,000**
		STRUCTURE					
13	NS-451	CONCRETE ARCH & HEADWALLS	L.S.	$ 2,210,000.00	1.0	1.0	$ 2,210,000
					Subtotal:	**$2,210,000**	**$ 2,210,000**
		SURFACING					
14	5100	CRUSHED SURFACING BASE COURSE	TON	$ 41.00	1106.7	1106.7	$ 45,375
15	5120	CRUSHED SURFACING TOP COURSE	TON	$ 44.00	228.8	228.8	$ 10,066
					Subtotal:	**$55,441**	**$ 55,441**
		HOT MIX ASPHALT					
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		TRAFFIC					
20	6700	CEMENT CONC. TRAFFIC CURB AND GUTTER	L.F.	$ 49.50	894.0	894.0	$ 44,255
21	6712	BEAM GUARDRAIL TYPE 31 - 9 FT. LONG POST	L.F.	$ 50.00	195.0	195.0	$ 9,750
22	6719	BEAM GUARDRAIL TYPE 31 NON-FLARED TERMINAL	EACH	$ 3,763.00	2.0	2.0	$ 7,526
23	6780	BEAM GUARDERAIL ANCHOR TYPE 11	EACH	$ 1,413.00	2.0	2.0	$ 2,826
24	6806	PAINT LINE	L.F.	$ 3.00	894.0	894.0	$ 2,682
25	6890	PERMANENT SIGNING	L.S.	$ 500.00	1.0	1.0	$ 500
26	6971	PROJECT TEMPORARY TRAFFIC CONTROL	L.S.	$ 10,000.00	1.0	1.0	$ 10,000
					Subtotal:	**$77,539**	**$ 77,539**
		OTHER ITEMS					
27	7038	ROADWAY SURVEYING	L.S.	$ 7,500.00	1.0	1.0	$ 7,500
28	7055	CEMENT CONC. SIDEWALK	S.Y.	$ 86.99	527.5	527.5	$ 45,887
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30	7736	SPCC PLAN	L.S.	$ 1,000.00	1.0	1.0	$ 1,000
					Subtotal:	**$61,503**	**$ 61,503**

Subtotal Construction:	**$2,977,045**	**$ 2,977,045**
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Right of Way Costs	**$400,000**	**$ 400,000**
SCHEDULE COST TOTALS:	**$5,327,009**	**$ 5,327,009**

TOTAL PROJECT COST: $ 5,327,009

Streets:

The three-parcel annexation would have approximately 500’ of roadside vegetation that would be slope mowed, 435’ of sidewalk maintenance and a section of 15th Ave NE on the South side of the road that is in very poor condition (it was not completed with the sewer upgrade).

Scenario without Judd St: 15th, Draham, and Carpenter: 2.74 lane miles of slope mowing and tree clearance trimming, 15th/Draham/Carpenter: road condition is terrible. 1,268’ of sidewalk maintenance on 15th. Would also have 15th, Draham and Carpenter added to the snow and ice priority list for treatment and plowing. Woodland Creek has roads in decent shape that haven’t been sealed and streets have some cracking with rolled curbing and no sidewalks. There arte a few parcels we would be responding to for brush growth into the street.

The scenario with Judd St included would be the same as above. Would Judd St NE be private? If not, the road is very narrow and turns to gravel. There is .50 lane miles in addition to slope mow/tree clearance. No sidewalks on Judd St., but about 500’ is prepped for sidewalk on 15th Ave. It would add an additional .24 lane miles to road maintenance on 15th to equal 2.98 lane miles to maintain.

Signs and Markings:

Signs

Judd St NE

Speed Limit 25; upgrade to our pole & hardware
Stop, 15th Ave NE; Judd St NE, Dead End; upgrade to our pole & hardware, street name signs & Dead End

Woodland Creek St NE
Stop, Woodland Creek St NE, 15th Ave NE, No Outlet; upgrade to our pole & hardware, street name signs, No Outlet
Speed Limit 25; upgrade to our pole & hardware
Yield, 17th Ave NE, Woodland Creek St NE; upgrade to our pole & hardware, street name signs

Mark St NE
Stop, Mark St SE, 22nd Ave SE>, <Covington Ct SE; upgrade to our pole & hardware, street name signs

Draham St NE
Speed Limit 35; upgrade to our pole & hardware
Right Turn sign, 20mph; upgrade to our pole & hardware
Large Arrow sign, 15th Ave NE; upgrade to our pole & hardware, street name sign
Large Arrow sign, Large Arrow sign, Draham St NE; upgrade to our pole & hardware, street name sign
School Bus Stop Ahead, upgrade to our pole & hardware

Left Turn sign,20 mph; upgrade to our pole & hardware
Speed limit 35; upgrade to our pole & hardware

Carpenter Rd NE
Speed Limit 50; upgrade to our pole & hardware

17th Ave NE
Mark St NE, 17th Ave NE; upgrade to our pole and hardware, street name signs

18th Ct NE
Stop, 18th Ct NE; upgrade to our pole & hardware, street name signs

Oxbow St NE
Stop, Marks St NE, Oxbow St NE; upgrade to our pole and hardware, street name signs
Stop, 17th Ave NE, Oxbow St NE; upgrade to our pole & hardware, street name signs

21st Ave NE
Stop, 21st Ct NE; upgrade to our pole & hardware, street name sign

22nd Ave NE
Woodland Creek St NE, 22nd Ave NE; upgrade to our pole & hardware, street name signs

Total cost of upgrading to our sign poles/hardware and fabricating/installing new street name signs

$2,100 not including 75 hours of labor or tax

Markings

Woodland Creek St NE
1-Stop bar 15th @ Woodland Creek St

15th Ave NE - ***Judd to Draham***
Double Yellow Centerline 2,870'
8" Thermo Edge Line 2,460'
4" Painted Edge line 4815'
2 Right Arrows @ Modera Apartments

Draham St NE - ***15th to current City Limit***
Double Yellow Centerline 2,040'
4" Painted Edge Line 4,080'

Carpenter Rd NE – ***Current City Limit to North border of Cuio Park on E. side.***

Double Yellow Centerline 1,144’
Centerline skip 1,515’
4” Painted Edge Line 5615’
Single Lane Passing Centerline 570’
Stop Ahead Marking

Convert Painted Edge Lines to Thermoplastic $26,843*+tax, contracted out*
Convert Painted Centerline to Raised Pavement Markers $12,624*+tax, contracted out*
Stop bar & Only Markings $410 ***not including 4 hours of Labor or tax***
Total Cost of Markings to our standard $39,877, not including tax or 4 hours of labor