

CITY COUNCIL AGENDA ITEM
CITY OF SHORELINE, WASHINGTON

AGENDA TITLE:	Hidden Lake Dam Removal and Boeing Creek Restoration Projects Update
DEPARTMENT:	Public Works
PRESENTED BY:	John Featherstone, Engineer II – Surface Water
ACTION:	<input type="checkbox"/> Ordinance <input type="checkbox"/> Resolution <input type="checkbox"/> Motion <input checked="" type="checkbox"/> Discussion <input type="checkbox"/> Public Hearing

PROBLEM/ISSUE STATEMENT:

On May 23, 2016, the City Council discussed the results of the Hidden Lake Dam Removal alternatives analysis and authorized staff to further develop Alternative 4, representing an expanded project vision extending restoration efforts downstream along Boeing Creek in addition to Hidden Lake-area dam removal and creek restoration. The Boeing Creek Restoration Project was created as a separate but related project to the Hidden Lake Dam Removal Project to encompass the additional areas downstream of Hidden Lake proposed for restoration under this approach.

In the 16 months since Council authorization, this approach has been furthered by a number of efforts, including implementing Boeing Creek streamflow gaging and Hidden Lake sedimentation monitoring programs; completing a Boeing Creek-Puget Sound nearshore habitat gains analysis and follow-up with WRIA 8; and pursuing grants – including a successful application to secure \$300,000 from the King County Flood Control District for design of Hidden Lake dam removal and the replacement of the culvert under NW Innis Arden Way.

Additionally, specific to the Boeing Creek Restoration Project, the project consultant (Herrera) completed a memorandum for Concept Design Evaluation of Fish Passage Improvements in Lower Boeing Creek (Attachment A). Results indicate that implementation of improvements would be difficult as a City-lead project (with high costs and risk levels) for the purpose of enhancing the fish passage benefits in Boeing Creek and increasing funding opportunities for the Hidden Lake Dam Removal Project.

Both projects were also evaluated as part of the CIP project prioritization effort under ongoing Surface Water Master Plan Update.

RESOURCE/FINANCIAL IMPACT:

Updated expenditures from prior years, estimated 2017 expenditures through end-of-year, and estimated future expenditures as programmed in the draft 2018-2023 CIP for both Hidden Lake Dam Removal Project and Boeing Creek Restoration Project are as follows:

Year		Project Expenditures	
		Hidden Lake Dam Removal	Boeing Creek Restoration
Prior Years		\$177,023	\$20,406
2017 (Est.)		\$76,100	\$32,916
2018-2023 CIP	2018	\$267,800	\$0
	2019	\$275,834	\$0
	2020	\$1,657,667	\$0
	2021	\$22,510	\$56,275
	2022	\$23,185	\$0
	2023	\$23,881	\$0
Total		\$2,524,000	\$109,597

A \$300,000 King County Flood Control District Flood Reduction Grant for design of Hidden Lake dam removal and NW Innis Arden Way culvert replacement was recently obtained. This grant is expected to fund 47% of total staff and consultant costs for design from initiation through final (expected to be completed by end of 2019); total costs are estimated at \$643,240, the City matching portion is \$343,240.

RECOMMENDATION

No action is required from Council at this time. Staff is looking for feedback and concurrence on two key staff recommendations:

1. Proceed with Hidden Lake Dam Removal Project as planned, including completion of pre-design by the end of 2017, design to begin in 2018, and construction to occur in 2020. Replacement of NW Innis Arden Way culverts will be included in the Hidden Lake Dam Removal pre-design and design, and may be replaced during construction of Hidden Lake Dam Removal improvements if feasible. This recommended approach mostly closely resembles Alternative 3 from the prior alternatives analysis.
2. Discontinue further City development of the Boeing Creek Restoration Project concepts downstream of NW Innis Arden Way. Results of analysis done to date will be used to inform design for Hidden Lake dam removal and NW Innis Arden Way culvert replacement. City staff will share results of analysis with downstream property owners and provide guidance for any potential future Lower Boeing Creek restoration efforts led by others.

Approved By: City Manager **DT** City Attorney **JT-A**

BACKGROUND

Hidden Lake is a man-made lake located east of the intersection of NW Innis Arden Way and 10th Avenue NW, partially within Shoreview Park. The lake originated in the early 20th Century when Boeing Creek was dammed to create a fishing pond and small hatchery near William Boeing's estate. Archived aerial photos and other sources establish that Hidden Lake was completely sediment-filled by 1970 and overgrown with mature vegetation by 1995. King County constructed the present dam and re-established Hidden Lake in 1996 as an environmental enhancement in relation to impacts of the West Point Sewage Treatment Plant expansion, effectively creating a stormwater management facility because the County's design included a maintainable sediment trap in the upstream end of the lake. Ownership of Hidden Lake is shared between the City of Shoreline (as part of Shoreview Park) and four private property owners to the north and west.

The existing lake configuration traps sediment that would otherwise be carried downstream to replenish sediment-starved downstream reaches of Boeing Creek and near-shore habitat within the Puget Sound at Innis Arden Beach. Sediment deposition within the lake occurs at a high rate and, as a result, the City's Surface Water Utility had been required to remove large volumes of sediment to maintain the lake as an open water feature. From 2002 to 2013, the Surface Water Utility spent over \$600,000 to implement seven separate dredging projects which removed a total of nearly 13,000 cubic yards of material. The actual volume of removed material was about six times greater than the deposition volume estimated by King County in developing the lake re-establishment design in the mid-1990s.

On September 8, 2014, the City Council discussed this issue as presented in the Hidden Lake Management Plan Feasibility Study and authorized staff to cease dredging the lake and begin a phased approach to remove Hidden Lake Dam and re-establish Boeing Creek at Hidden Lake. This decision followed the Hidden Lake Management Plan Feasibility Study and a July 24, 2014 recommendation from the Parks, Recreation and Cultural Services (PRCS)/Tree Board. No sediment removal has occurred since the summer of 2013. The staff report for the September 8, 2014 City Council discussion can be found at the following link:

<http://cosweb.ci.shoreline.wa.us/uploads/attachments/cck/council/staffreports/2014/staffreport090814-8a.pdf>.

In 2015, the Hidden Lake Dam Removal Project team (consisting of City staff and a consultant team led by Herrera Environmental Consultants) developed design alternatives for alteration or removal of Hidden Lake Dam. Each alternative would modify the existing lake and its associated outflow configuration to safely convey flood flows and manage sediments that will continue to be transported into the existing lake area in Boeing Creek during storm events in the basin. Conceptual alternatives in development were presented to the PRCS/Tree Board on October 22, 2015, and in a Public Meeting at Shoreview Park on October 24, 2015. Comments received were used to further refine the alternatives. A summary of the Alternatives Analysis results and a preliminary staff recommendation favoring Alternative 3 were presented to and received approval from the PRCS/Tree Board on January 28, 2016.

As a refresher, summaries of Alternatives 3 and 4 from the Alternatives Analysis, are presented below. The complete Hidden Lake Dam Removal Project Alternatives Analysis and Alternative Selection Memorandum can be found at the following link: <http://www.shorelinewa.gov/home/showdocument?id=26499>

Alternative 3

To provide both a high degree of restoration of natural conditions and removal of multiple fish passage barriers, Alternative 3 would: remove the dam and the outlet piping; excavate a single new creek channel through the existing lake bed; replace the NW Innis Arden Way culverts with a large box culvert or small bridge; and modify the creek channel for a distance of about 150 feet downstream of NW Innis Arden Way to enable fish passage and improve habitat. Channel excavation within the Hidden Lake area would be exclusively on City-owned land. In total, Alternative 3 would create or improve approximately 1,000 feet of creek channel from upstream of the lake to downstream of the road. Work would also include planting areas surrounding the new channel in the existing lake area and along the modified channel extents downstream of the road, which would mostly be forested vegetation. Post-construction vegetation monitoring and management would be necessary in much of the existing lake footprint. A distinct benefit of Alternative 3 from an operations and maintenance perspective is that it would eliminate risks associated with road embankment washout due to flood-borne debris clogging the existing culverts, and eliminate the need for a future costly project to remove and replace the culverts when they reach the end of their service life, which is expected to occur by 2040.

Alternative 4

After drafting the Alternatives Analysis report, staff considered a variation of Alternative 3 that used a phased approach to maximize grant funding opportunities and minimize flood hazard risks:

- Phase 1 (Hidden Lake Dam Removal Project) would first implement the elements of Alternative 3 located within Shoreview Park, including dam removal and channel excavation/restoration. Improvements in this phase will address the risks to roadway infrastructure and related flooding due to sediment loading in a timely fashion and can be built upon in Phase 2 to fully implement a final condition as described in Alternative 3.
- Phase 2 (Boeing Creek Restoration Project) will involve completing design and construction of Alternative 3 elements – including replacing the NW Innis Arden Way culverts and restoring the downstream riprap cascade. To increase grant funding appeal and the overall habitat benefits of the project, Phase 2 scope may be modified to include removal of the downstream Seattle Golf Club dam and associated stream improvements. This will require additional planning and design as well as significant grant funding for this work. Likelihood of obtaining grant funding is difficult to predict, and it could take a lengthy amount of time (10 years or longer) to secure funding and implement improvements.

On May 23, 2016, City Council discussed the results of the Hidden Lake Dam Removal alternatives analysis and authorized staff to further develop Alternative 4, representing an expanded project vision extending restoration efforts downstream along Boeing Creek in addition to Hidden Lake-area dam removal and creek restoration. The Boeing

Creek Restoration Project was created (as a separate but related project to the Hidden Lake Dam Removal Project) to encompass the additional areas downstream of Hidden Lake proposed for restoration under this approach. The staff report for the May 23, 2016 City Council discussion can be found at the following link:

<http://cosweb.ci.shoreline.wa.us/uploads/attachments/cck/council/staffreports/2016/staffreport052316-8a.pdf>

DISCUSSION – PROJECT UPDATES

In the 16 months following Council's May 2016 authorization, the approach has been furthered by a number of efforts:

- **Boeing Creek streamflow gaging:** A streamflow meter was installed within Boeing Creek upstream of Hidden Lake in October 2016 and has been continuously gathering streamflow data since then. These data will be invaluable for design of Hidden Lake Dam Removal improvements, and as general reference for future use.
- **Hidden Lake Sediment Monitoring Plan** ([link to document](#)) was created and implemented in October 2016 to monitor ongoing sediment accumulation in Hidden Lake. The first sediment measuring update was completed in July 2017. While no significant measurable sedimentation was observed along the lake midline bottom, a relatively small shelf of sediment near the Boeing Creek delta at the upstream end of the lake appears to be growing slowly and will be measured annually. Observed overall sedimentation rate to date appears to indicate several years remain until in-filling of lake with sediment is imminent.
- **Nearshore Habitat Gains Analysis** ([link to document](#)) was completed (February 2017) and immediately shared with WRIA 8 representatives. In March 2017 the Hidden Lake Dam Removal Project elements which will provide nearshore habitat benefits by means of restoring sediment transport to downstream areas were proposed to be added to the WRIA 8 Chinook Salmon Conservation Plan Project List - Nearshore. Confirmation of the project's WRIA listing will occur in November 2017; Hidden Lake Dam Removal nearshore beneficial elements are proposed under the following project name: "Boeing Creek Mouth and Delta Restoration."
- **Grant Opportunities:**
 - **Recreation Conservation Office (RCO) Land and Water Conservation Fund (LWCF):** On August 30, 2016, the City's "Shoreview Park Trail and Creek Improvement Project" (a recreation-centric "spin" on the Hidden Lake Dam Removal Project) was presented to the LWCF evaluation panel with a request for \$448,000 in funding. Grant funding is unlikely as the panel ranked the City's application 16th out of 22 total projects, with funding typically only available for up to ten projects.
 - **King County Flood Control District:** On August 22, 2017, King County awarded the City a \$300,000 Flood Reduction Grant for design of Hidden Lake dam removal and NW Innis Arden Way culvert replacement. This

grant is expected to fund 47% of total staff and consultant costs for design from initiation through design; total costs are estimated at \$643,240; City matching portion is \$343,240.

- Concept Design Evaluation of Fish Passage Improvements in Lower Boeing Creek (Attachment A), completed on July 18, 2017: To develop and evaluate concepts for potential improvements, the project team conducted a stream walk for the entire length of Boeing Creek between Puget Sound and NW Innis Arden Way, completed topographic survey of the Boeing Creek ravine between the Seattle Golf Club Dam and NW Innis Arden Way, and met with Washington Department of Fish and Wildlife (WDFW) representatives. Information obtained from these efforts was used to develop a plan and profile with associated costs for a fish passage restoration concept design, as presented in Attachment A. The resulting implications for the portions of the Boeing Creek Restoration Project downstream of NW Innis Arden Way are described below.
- Surface Water Master Plan project prioritization: Both the Hidden Lake Dam Removal Project and Boeing Creek Restoration Project were evaluated as part of the CIP project prioritization effort under the ongoing Surface Water Master Plan Update: the Hidden Lake Dam Removal Project received a score of 480, ranking 5th out of the 40 City projects evaluated; the Boeing Creek Restoration Project received a score of 180, ranking 22nd of the 40 projects. The main difference in scoring between the two projects was due to the flood risk reduction aspect of the Hidden Lake Dam Removal Project, which the Boeing Creek Restoration Project does not share.
- 2018-2023 CIP scope, budget, and schedule updates:
 - Pre-design efforts for both the Hidden Lake Dam Removal Project and Boeing Creek Restoration Project are expected to conclude by the end of 2017. The 2018-2023 CIP includes funding for complete design, permitting, construction, and permit-driven initial maintenance for the Hidden Lake Dam Removal Project. NW Innis Arden Way culvert replacement is included under the design phase of the Hidden Lake Dam Removal Project; however, the construction budget currently includes only Hidden Lake dam removal and associated restoration costs and does not include NW Innis Arden Way culvert replacement. Construction costs for potential replacement of NW Innis Arden Way culvert concurrent with Hidden Lake Dam removal will be evaluated further as pre-design is finalized and design is developed.
 - The 2018-2023 CIP includes \$56,275 in funding for the Boeing Creek Restoration Project for any additional coordination as needed in coming years, but the project is not expected to advance beyond pre-design during that time.

The collective results of these efforts indicate that the Hidden Lake Dam Removal Project should generally continue as planned; no new information substantively alters the previously understood scope or schedule for the project. However, new information obtained on the Boeing Creek Restoration Project (from the Concept Design Evaluation

of Fish Passage Improvements in Lower Boeing Creek – Attachment A) reveals that the previous understanding of the project concepts underestimated challenges while overestimating benefits. Analyses described in Attachment A indicate that while the concept for restoring fish passage downstream of NW Innis Arden Way may be technically constructible (and potentially acceptable for at least the WDFW permitting process), it would require constructing a roughened channel of an unprecedented scale (at least within Washington State), and could only be done at a high cost (about twice as much as previously thought -- approximately \$6,000,000 -- excluding any property acquisition), with high impacts to existing critical areas and very challenging access completely within properties with no existing City ownership or easements. Which fish species would benefit from this major restoration effort is somewhat unclear, although the Chinook salmon, which are highly targeted for regional fish recovery efforts, would not likely see significant benefits. Due to the high degree of expected costs, challenges, and uncertainties, restoring fish passage along lower Boeing Creek between the Seattle Golf Club Dam and NW Innis Arden Way would not appear to rate well for current grant programs, or for any other kind of “leverage” to benefit the upstream Hidden Lake Dam Removal effort which was the original intent behind the staff recommendation of Alternative 4 and subsequent creation of the Boeing Creek Restoration Project.

Accordingly, staff recommends the updated approach for moving forward for these City projects should take account for the following:

1. Difficulties, costs, risks, and uncertain benefits associated with potential fish passage restoration improvements along Boeing Creek downstream of NW Innis Arden Way.
2. Continued need to remove Hidden Lake Dam within approximately three years.
3. Need to replace NW Innis Arden Way Boeing Creek culverts within longer-term timeframe (approximately 20 years), and benefits of combining culvert replacement with Hidden Lake dam removal for design and possibly construction efforts.
4. Resource availability and limitations:
 - a. Surface Water Master Plan Update highly prioritized Hidden Lake Dam Removal Project and programmed funding for 2020 construction. King County Flood Reduction Grant provides funding for almost half of the design costs for Hidden Lake dam removal and NW Innis Arden Way culvert replacement.
 - b. Surface Water Master Plan Update did not highly rank Boeing Creek Restoration Project and did not program any funding for design or construction.

The staff recommendation was developed considering all of the above information.

RESOURCE/FINANCIAL IMPACT

Updated expenditures from prior years, estimated 2017 expenditures through end-of-year, and estimated future expenditures as programmed in the draft 2018-2023 CIP for both Hidden Lake Dam Removal Project and Boeing Creek Restoration Project are as follows:

Year		Project Expenditures	
		Hidden Lake Dam Removal	Boeing Creek Restoration
Prior Years		\$177,023	\$20,406
2017 (Est.)		\$76,100	\$32,916
2018-2023 CIP	2018	\$267,800	\$0
	2019	\$275,834	\$0
	2020	\$1,657,667	\$0
	2021	\$22,510	\$56,275
	2022	\$23,185	\$0
	2023	\$23,881	\$0
Total		\$2,524,000	\$109,597

A \$300,000 King County Flood Control District Flood Reduction Grant for design of Hidden Lake dam removal and NW Innis Arden Way culvert replacement was recently obtained. This grant is expected to fund 47% of total staff and consultant costs for design from initiation through final (expected to be completed by end of 2019); total costs are estimated at \$643,240, the City matching portion is \$343,240.

RECOMMENDATION

No action is required from Council at this time. Staff is looking for feedback and concurrence on two key Staff recommendations:

1. Proceed with Hidden Lake Dam Removal Project as planned, including completion of pre-design by the end of 2017, design to begin in 2018, and construction to occur in 2020. Replacement of NW Innis Arden Way culverts will be included in the Hidden Lake Dam Removal pre-design and design, and may be replaced during construction of Hidden Lake Dam Removal improvements if feasible. This recommended approach mostly closely resembles Alternative 3 from the prior alternatives analysis.
2. Discontinue further City development of the Boeing Creek Restoration Project concepts downstream of NW Innis Arden Way. Results of analysis done to date will be used to inform design for Hidden Lake dam removal and NW Innis Arden Way culvert replacement. City staff will share results of analysis with downstream property owners and provide guidance for any potential future Lower Boeing Creek restoration efforts led by others.

ATTACHMENT

Attachment A – Concept Design Evaluation of Fish Passage Improvements in Lower Boeing Creek



TECHNICAL MEMORANDUM

Date: July 18, 2017
To: John Featherstone, City of Shoreline
From: Ian Mostrenko and Mark Ewbank
Subject: Concept Design Evaluation of Fish Passage Improvements in Lower Boeing Creek

CONTENTS

Introduction.....	3
Existing Conditions in Lower Boeing Creek.....	3
Design Concept for Fish Passage Upstream to Northwest Innis Arden Way.....	7
Design Approach.....	8
Channel Profile and Typical Cross Sections Analysis.....	9
Cost Estimates for Construction and Long-term Inspections and Maintenance.....	10
Construction Cost.....	11
Long-term Inspection and Maintenance Costs.....	11
Discussion.....	12
Implications for Hidden Lake Dam Removal Project.....	13
References.....	14

APPENDICES

- Appendix A Lower Boeing Creek Roughened Channel Plan and Profile Design Concept
Appendix B Lower Boeing Creek Roughened Channel Conceptual Cost Estimate



TABLES

Table 1. Boeing Creek Flow Rates Used for Fish Passage Concept Design Analysis
Downstream of Hidden Lake..... 7

FIGURES

Figure 1. Lower Boeing Creek Reach..... 5
Figure 2. Looking Upstream at Steep Rock Cascade Between Northwest Innis Arden
Way and Seattle Golf Club Diversion Dam..... 6
Figure 3. Looking Upstream at Seattle Golf Club Diversion Dam. 6
Figure 4. Roughened Channel Section in Coal Creek, Bellevue, Washington..... 9

INTRODUCTION

Potential upstream fish passage for salmonids is blocked by several features in the reach of Boeing Creek between Hidden Lake and the Puget Sound shoreline. In May 2016, Shoreline City Council authorized staff to pursue a Hidden Lake Dam Removal Project approach including assessment of potential fish passage improvements downstream of Hidden Lake to best serve the long-term overall health of Boeing Creek, and also to enhance competitiveness for fish passage-related grant funding for these planned improvements. Accomplishing fish passage restoration from Puget Sound to a point upstream of Hidden Lake will require restoring fish passage in three general areas: 1) the lower reach of Boeing Creek downstream of Northwest Innis Arden Way, 2) the creek crossing of Northwest Innis Arden Way, and 3) the lake area upstream of Northwest Innis Arden Way.

This memorandum documents analyses of a conceptual approach for restoring fish passage in the lower reach of the creek from Puget Sound to the downstream side of the Northwest Innis Arden Way crossing, and implications of fish passage improvements downstream of the roadway on the Hidden Lake Dam Removal Project and eventual replacement of existing creek culverts beneath Northwest Innis Arden Way. Figure 1 shows the extents of the creek that are the subject of this memorandum, which coincide with the “Innis Arden Reach” and “Lower Reach” as documented in the Boeing Creek Basin Plan (Windward et al. 2013).

EXISTING CONDITIONS IN LOWER BOEING CREEK

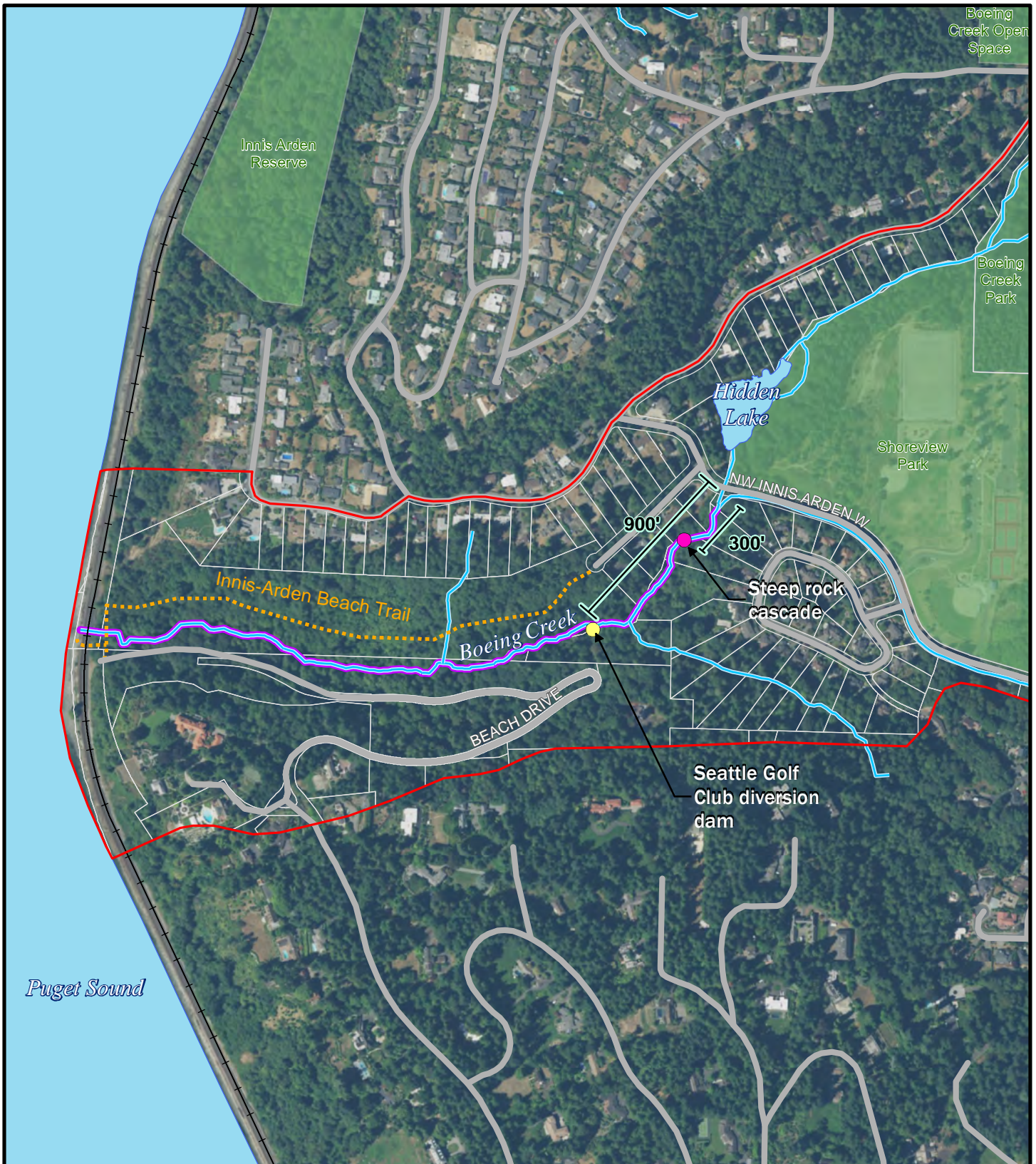
Between Northwest Innis Arden Way and the Puget Sound shoreline, Boeing Creek flows through a natural channel amid a forested ravine area. While those are generally favorable characteristics for good quality fish habitat, potential upstream fish passage is completely prevented by constructed impoundments in two places: 1) a steep rock cascade approximately 300 feet downstream of the road (Figure 2), and 2) a dam made of sheet pile approximately 900 feet downstream of the road, that formerly served to divert water for the Seattle Golf Club (Figure 3). Both of these features create an abrupt drop in the channel elevation of approximately 12 to 13 feet. A third major fish passage barrier is a more gently sloped but longer rock cascade extending from the outlet of twin Boeing Creek culverts beneath Northwest Innis Arden Way. If fish migrating upstream could make it to the outlet of the twin culverts beneath the road, the culverts themselves would pose a significant barrier to upstream passage because they create shallow and high-velocity flow conditions most of the time. The dam impounding Hidden Lake represents a fifth major fish passage barrier in the system. Additionally, due to extensive development in the watershed upstream of Hidden Lake, the creek’s natural hydrology has been altered and resultant high flows during larger storm events have eroded the channel in several places, creating smaller obstacles to fish passage, degrading habitat quality, and inducing hillslope instability on several private properties downstream of Hidden Lake.

For fish to be able to pass unimpeded from Puget Sound upstream through the Hidden Lake area each of these major barriers would have to be removed and a gradually sloped channel would need to be reconstructed for most of that stream channel length. As described later in this memorandum, restoring fish passage for that much stream length is a considerable challenge. This is partly because the land through which the creek flows downstream of Northwest Innis Arden Way is all privately owned, and vehicular access to the creek is currently provided in only one location amid that land at the Seattle Golf Club diversion dam site. The ravine slopes adjacent to the channel are relatively steep for most of the lower creek reach, with minor landsliding evident in several locations.

Anadromous salmonids that historically used and currently use the creek include coho, chum, and Chinook salmon, and cutthroat trout (Windward et al. 2013). Several reaches surveyed in the fall of 2016 contained average gradients of 4 to 5 percent that appeared to be fish passable, but those areas contained tight clusters of at least three to four fallen trees in excess of 48 inches in diameter that have formed complex grade control features. Several adult coho carcasses were observed approximately 700 feet upstream of the creek mouth during a site reconnaissance by Herrera staff on October 27, 2016, so it is apparent that woody debris inducing local channel gradients between 4 to 5 percent are currently not precluding coho passage.

The historical average gradient in the sub-reach of Boeing Creek from the current Seattle Golf Club diversion dam area to the Northwest Innis Arden Way crossing was likely closer to 7 to 8 percent. Based on that channel gradient and the underlying geology, historical fish passage upstream of the diversion dam area was likely intermittent and enabled by complex grade-control features created by dense clustering of very large woody debris. Furthermore, it is likely that the intermittent nature of fish passage in that reach of the creek was also species-dependent. Chinook and chum salmon have been found close to the mouth of the creek (TetraTech/KCM 2004), but recent references/documentation of either of those species in lower Boeing Creek are unknown or unavailable. Altered hydrology, sediment delivery, channel incision, and channel straightening have likely shaped the lower Boeing Creek current channel geometry to be incompatible with these larger salmonid species. With increasing prevalence of pink salmon in Puget Sound, it is possible that pink salmon will use Boeing Creek in the future whereas they have not been documented in the creek in the past.

Taking into account all available information, past and present, the salmonid species that would most likely benefit from fish passage barrier removals as described in this memorandum are coho salmon and sea-run cutthroat trout, and possibly pink salmon as well (if introduced to the creek). Over time, the larger species (Chinook and chum) may reoccupy Boeing Creek after the removal of the Hidden Lake Dam that has impeded downstream sediment delivery and altered channel morphology, but future passage for larger salmonids is uncertain and difficult to predict due to the highly altered hydrology of the basin.

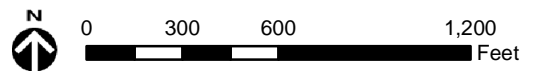


Legend

- Project area
- Tax parcel
- Open water
- Park
- Railroad
- Trail
- Street
- Stream
- Lower Boeing Creek Reach
- Steep rock cascade
- Seattle Golf Club diversion dam

Figure 1.
Lower Boeing Creek Reach.

Scale: 1" = 600'



K:\Projects\Y2015\15-05984-000\Project\Report\lower_boeing_creek_reach.mxd (7/6/2017)



Figure 2. Looking Upstream at Steep Rock Cascade Between Northwest Innis Arden Way and Seattle Golf Club Diversion Dam.



Figure 3. Looking Upstream at Seattle Golf Club Diversion Dam.

Fish passage analysis and design requires a reasonably accurate understanding of both high flood flow magnitudes for channel stability and low flows for fish passage. Flow estimates were obtained from several sources. Flood flow estimates were obtained from the Boeing Creek Basin Plan (Windward et al. 2013). Smaller flows such as the 10 percent exceedance and average

annual flow required for assessing maximum permissible velocities for fish passage were estimated by Herrera using gage data collected in 1992 and 1993 by King County (King County Hydrologic Information Center) and data collected by Herrera in 2016 and 2017 at a flow gaging site upstream of Hidden Lake. Table 1 lists flow rates for various frequencies used in the analyses documented in this memo.

Frequency	Flow Rate (cfs)	Design Importance
100-year	227.3	Channel Stability
25-year	160.5	Channel Geometry and Stability
2-year	72.1	Channel Geometry (Stage 2)
10 Percent Exceedance	5.4	Fish Passage
Average Annual	3.7	Channel Geometry (Stage 1)/Fish Passage

cfs – cubic feet per second

DESIGN CONCEPT FOR FISH PASSAGE UPSTREAM TO NORTHWEST INNIS ARDEN WAY

Based on recent reconnaissance of the entire length of Boeing Creek downstream of Northwest Innis Arden Way, it appears that the best, sustainable instream habitat conditions (with pools, suitable spawning substrate, no channel downcutting or otherwise significantly unstable banks, and woody debris retention) coincide with sections of the channel having a longitudinal slope of about 2 percent or less. Therefore, a concept for restoring fish passage throughout the lower reach of the creek should seek to preserve as much of the channel length as possible with a slope of 2 percent maximum. By doing that, accomplishing a “smoothing out” of the currently disjointed longitudinal profile would require creation of some steeper sections interspersed with flatter (2 percent maximum slope) sections. The overall elevation drop from the entrance to the culverts on the north (Hidden Lake) side of Northwest Innis Arden Way to the Puget Sound shoreline is 160 feet over a total distance of approximately 3,300 feet, equating to an average channel slope of 4.8 percent in the study reach for fish passage improvements downstream of Hidden Lake. However, a large portion of the elevation change (85 feet) occurs in the 900 feet of stream length between Northwest Innis Arden Way and the downstream side of the Seattle Golf Club diversion dam, with an average slope of 9.5 percent in that sub-reach.

Analysis of the creek valley topography from upstream of Hidden Lake to Puget Sound shows that the average slope over that length is (and likely historically was) about 5.4 percent, without accounting for local variations in the natural channel alignment that would have effectively flattened the gradient for native fish passage. That slope is not too steep, yet is fairly challenging, for naturally passable conditions for coho salmon and sea-run cutthroat, particularly for returning spawners and juveniles that have yet to outmigrate to Puget Sound. Furthermore, the historical channel gradient was most likely flatter in the lower reach

approaching Puget Sound and steeper than 5.4 percent from present-day Northwest Innis Arden Way to the Seattle Golf Club diversion dam area (as described previously), meaning that upstream salmonid passage was intermittent and sometimes blocked or impeded by steeper conditions as the channel adjusted to large floods, sediment delivery, and downed trees in the channel. Restoring fish passage in Boeing Creek should have these types of historical channel characteristics in mind.

Design Approach

There are many design options that could be used to create fish-passable conditions in lower Boeing Creek, all of which would require some form of fixed channel grade control (such as via a series of weirs, a hardened bed, and/or porous dams that emulate small beaver dams) to maintain the necessary water surface depth and velocity for swimmable conditions under a wide range of flows. Given the considerable length of Boeing Creek that would need to be modified to create continuous fish passage from near the mouth of the creek to Northwest Innis Arden Way, and the associated high cost of those modifications, it is preferable to use a design approach that is durable, inherently redundant to be able to “self heal” when shifting of the channel bed inevitably occurs over time, and not prone to failing if one or more step-pool elevation drops (such as a weir) were to blow out or be undermined.

The historical channel was probably dominated by large wood clusters that would “self heal” over time with respect to channel gradient, but those adjustments would be slow and would create intermittent fish passage barriers that could persist over many years. As such, restoration of historical conditions would not provide continuous passage. Furthermore, re-creating historical conditions is unrealistic because importing hundreds of trees/logs more than 4 feet in diameter is not feasible. The use of smaller-sized logs to create a gradual channel gradient would require hundreds of small grade-control step structures, which have been found to be prone to failure, especially in steeper gradient systems, and they typically cannot “self heal” due to the size of available wood. To avoid necessitating a continuous sequence of over 100 engineered small step-pool drops through the length of lower Boeing Creek, the concept design described herein follows the roughened channel design approach presented in the Washington Department of Fish and Wildlife’s (WDFW’s) Water Crossing Design Guidelines (Barnard et al. 2013).

Roughened channels use large rock (e.g., boulders or riprap) mixed with smaller cobbles, gravel, and sediment to create hardened substrate that resists deformation under high-flow conditions while creating numerous micro-scale pathways for flow conveyance and fish passage under low-flow conditions and also providing substrate suitable for spawning in many locations. Figure 4 shows an example of a recently constructed roughened channel in Coal Creek in the city of Bellevue, Washington. That project created over 400 feet length of roughened channel extending from a new roadway culvert through a section of channel where there were previously a series of weirs that impeded upstream fish passage. The average slope of the roughened channel segments in Coal Creek is 5 percent, and those are interspersed with 1.4 percent slope

segments. The 1.4 percent riffle segments emulate the natural channel gradient in Coal Creek to support formation of pools and riffles that are vital for fish resting. The average gradient in the entire restored Coal Creek reach is approximately 3.8 percent, which is flatter than the reach of Boeing Creek described herein.



Figure 4. Roughened Channel Section in Coal Creek, Bellevue, Washington.

Channel Profile and Typical Cross Sections Analysis

Topographic survey was collected in fall 2016 throughout lower Boeing Creek to support this analysis. Greater topographic resolution was obtained in the vicinity of the Seattle Golf Club diversion dam. Representative cross-sections were obtained at intervals between Northwest Innis Arden Way and the diversion dam area, and from downstream of the diversion dam to near the BNSF Railway crossing. Numerous channel bed elevation points were obtained to enable creating an accurate thalweg elevation profile for the entire reach downstream of Hidden Lake.

As stated above, the topographic data indicate an average slope of 9.5 percent in the 900 feet of Boeing Creek length extending through the two major fish passage barriers (steep rock cascade and the Seattle Golf Club diversion dam) downstream of the Northwest Innis Arden Way culverts. A continuous slope of 9.5 percent is steeper than historical conditions in this reach of Boeing Creek and is approaching the upper limit for a roughened channel (personal communication with Channing Syms [e-mail], WDFW, March 24, 2017) in a fish passage culvert context. Thus, fish passage would not be achievable with a continuous slope of 9.5 percent over much of the 900 feet of length due to fish exhaustion without the benefit of pools for resting.

Therefore, a “stair-step” profile approach would be necessary to provide periodic resting areas and possibly even areas that would support spawning. The natural gradient segments in a stepped streambed profile would be constructed at 2 percent grade to mimic the natural and sustainable gradient of the pool-riffle areas observed in the creek downstream of the Seattle Golf Club diversion dam.

Using the topographic survey data, an alternating sequence of 100-foot-long steeper cascade segments and 50-foot-long 2 percent pool-riffle segments was iteratively laid out to assess extents of bank excavation and channel fill that would be required, while attempting to yield a channel bed elevation at the Northwest Innis Arden Way crossing that would be compatible with tying into a fish-passage channel through the Hidden Lake area. After laying out several iterations, it was determined that using a 10 percent slope in the steeper cascade segments of the roughened channel could accomplish fish-passable conditions for the length of creek under consideration while minimizing disturbance of good quality habitat that extends to the creek mouth from a point about 325 feet downstream of the Seattle Golf Club diversion dam. The creek profile and cross-sections in Appendix A reflect an alternating 10 percent/2 percent grade for cascade and pool-riffle segments, respectively, along approximately 1,050 linear feet of rebuilt channel. Within that 1,050 feet of length, a total of 700 feet length would be comprised of a roughened channel at 10 percent slope and a total of 350 feet length would be comprised of a natural (non-roughened) channel with 2 percent slope.

Cost Estimates for Construction and Long-term Inspections and Maintenance

The elevation profile and cross-sections in Appendix A were used to create a three-dimensional surface in CAD with which to compare to a three-dimensional surface of the existing channel bed and banks to yield estimates of the total excavation volume and fill volume that would be required. The construction cost estimate covers the length of channel from the downstream end of the conceptual design to approximately Station 11+20 (see the plan and profile drawings in Appendix A), which is the approximate location where channel modifications associated with eventual culvert replacements for the Northwest Innis Arden Way crossing would tie into the channel bed and banks downstream of the road. The Washington Department of Fish and Wildlife (WDFW) roughened channel design guidance (Barnard et al. 2013) includes sizing of the mix of boulders, cobbles, gravel, and sediment needed to remain stable while promoting fish passage under low-flow conditions given the prevailing flow regime of a stream system. The flow data presented in Table 1 were applied to that design guidance to derive estimated sizes of the larger boulders on down to the smaller substrate that would be required in each of the 10 percent and 2 percent sections of the channel, and thus to enable deriving quantity estimates for different size classes of streambed material that would have to be imported for channel construction. (An important point to note is that the existing Boeing Creek channel contains very few larger boulders and cobbles, in part because the creek’s natural development did not cut through geology creating such material.)

Construction Cost

The quantity estimates for channel excavation, channel fill (using excavated material), and imported streambed rock form the backbone of the planning-level construction cost estimate presented in Appendix B. In addition to the earthwork and streambed material import, the cost estimate includes other major items of work that could be expected for successful construction and to facilitate long-term inspections and maintenance (and required to satisfy anticipated permit conditions, described in more detail below). Suitable access for construction amid privately owned properties represents a significant challenge for ultimately implementing the fish passage improvements described herein, and triggers a corresponding high cost. The construction cost estimate in Appendix B includes creating the permanent access roadway(s), but does not include any costs associated with property easements or acquisitions.

It is anticipated that a condition of obtaining a Hydraulic Project Approval permit for the project from WDFW would be providing and maintaining suitable access for the life of the project (e.g., decades) to enable inspections and repairs as necessary to ensure fish passability (personal communication with Larry Fisher [e-mail], WDFW, April 6, 2017). If a section of the channel deforms considerably and compromises fish passage, repair would most likely have to be done with heavy equipment, necessitating a small roadway(s) for permanent access.,

A contingency of 50 percent is added to the estimate to account for unforeseen cost issues, which is typical for concept design development. Additionally, the cost estimate in Appendix B includes permitting and design costs.

Long-term Inspection and Maintenance Costs

For planning purposes, it is assumed that annual inspections would be performed in the dry season via the permanent access road along the creek. These inspections would be done to determine if there are any local areas along the modified creek length that are not suitable for fish passage due to creek bed or bank erosion in the preceding wet season, and if so to outline the extent of repair needed (including any repairs that may be needed to the access road to enable equipment and vehicles to complete the channel repairs). This type of inspection work, including documentation and coordination of it, is estimated to cost \$500 per year (2017 dollars) on average.

It is difficult to accurately estimate long-term maintenance costs to assure sufficient fish passage conditions along the length of modified creek channel. Thus, some simplifying assumptions are necessary, as follows:

- Repair work would be needed every 3 to 5 years

- The repair would not require importing streambed/bank rock, but would require shifting rock in the channel, and repositioning one or more downed trees, using heavy equipment to restore original “as-built” channel conditions
- Minor access road clearing and maintenance/upkeep would coincide with mobilizing to complete creek channel repairs
- Repair work would require a crew of two laborers, a small truck, and an excavator, for one week. This crew cost equates to about \$25,000 per repair effort (in 2017 dollars), including a modest contingency for unforeseen issues. In addition, repair work would require technical and administrative oversight to assure it is done adequately and documented clearly; these oversight and administration costs are estimated to be \$5,000 per repair cycle (in 2017 dollars).

Assuming a project design life of 75 years, the cumulative maintenance and repair costs could thus be on the order of \$500,000 to \$700,000 (2017 dollars), including the costs of routine annual inspections and oversight and administration of periodic repair work.

DISCUSSION

Based upon discussions with Larry Fisher and Channing Syms of WDFW, the overall length and relatively steep slope of the roughened channel concept described above is beyond WDFW’s experience in past fish passage projects, and thus represents an unprecedented approach in Washington State that could indicate an inherent risk to long-term success. If a large tree falls into the roughened channel, or other debris forms a local flow blockage, turbulent flow deflected into erodible soil above the rock lining the channel bed and lower bank could readily induce an abrupt elevation drop that is not passable for fish, triggering a need for maintenance action to restore the channel area that outflanked the rock lining. Given the forested land use surrounding the creek, it would be nearly impossible to prevent treefall from partially obstructing the engineered channel. The risks of maintaining “as-constructed” conditions is the reason for anticipating permanent inspection and maintenance access as a condition of the HPA permit.

In addition to technical design challenges and high costs, establishing construction access and long-term access thereafter would likely require acquiring portions of several private properties or negotiating permanent easements on those properties. Currently, downstream of Northwest Innis Arden Way, Boeing Creek flows along the boundaries of eight individually owned parcels, then along the boundaries of three larger parcels owned by the Seattle Golf Club, Innis Arden Club, and the Highlands, Inc., before crossing the BNSF railroad right-of-way and entering the Puget Sound (Figure 1). The City of Shoreline does not own or have easements for any of this reach of Boeing Creek downstream of Northwest Innis Arden Way. It is probably unrealistic to expect that this group of private property owners could collectively manage the long-term inspection and maintenance role and capably fulfill that role to ensure long-term fish-passage

success. A key question for the City of Shoreline is, without any ownership of land along the lower stream corridor, whether project construction and/or long-term inspections and maintenance are consistent with the City's overall responsibilities, authority, and resources to pursue.

One consideration that can encourage private property owner willingness to collaborate in large-scale channel improvements for fish passage relates to existing erosion concerns on many of those properties. The roughened channel design approach would provide a stable toe for the creek banks through most of those properties, reducing potential for future bank erosion that can lead to larger-scale slope instability extending inland from the creek. A more predictable creek bank is likely of interest to most of the property owners who would be affected by construction of a long section of roughened channel.

Given that most grant programs targeting removal of fish passage barriers in the Puget Sound region are currently focused on endangered species (e.g., Chinook and steelhead) that would possibly have only marginal benefits from removing fish passage barriers in lower Boeing Creek, the relatively small size of this creek, and the estimated high costs and degree of challenges in implementation and maintenance of a large-scale roughened channel project, the prospects for obtaining grant funding in the near term for the project as described in this memorandum are low. However, there are several relevant grant programs to consider pursuing, and the focus of stream restoration grant programs evolves over time. There is increasing focus on removing fish passage barriers at roadway crossings in Washington State that will lead to large sums of grant money being allocated in the years ahead for fish passage improvement projects. That funding climate for fish passage could improve the chances of grant funds being viable for fish passage improvements in Boeing Creek.

IMPLICATIONS FOR HIDDEN LAKE DAM REMOVAL PROJECT

The City of Shoreline intends to proceed with modifications to Hidden Lake and the dam impounding it, and to eventually replace the Boeing Creek culverts crossing Northwest Innis Arden Way, in ways that could be compatible with fish-passage improvements in the lower creek. Thus, the roughened-channel design plan and profile design concept presented in Appendix A would seamlessly tie into the modified creek channel on the downstream (south) side of Northwest Innis Arden Way once the existing culverts are replaced. If future efforts eventually lead to fish passage restoration improvements being implemented in lower Boeing Creek, the City's work at and upstream of Northwest Innis Arden Way would allow for fish passage in Boeing Creek from Puget Sound to upstream of the current Hidden Lake configuration.

REFERENCES

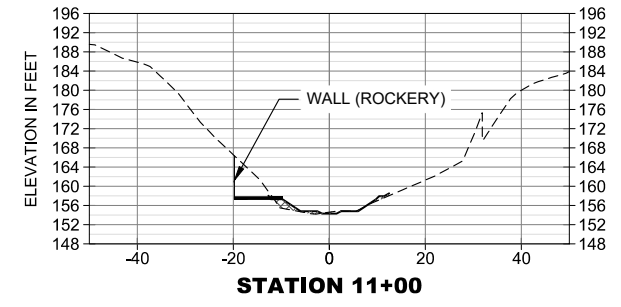
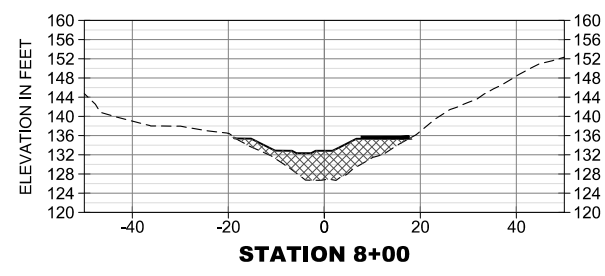
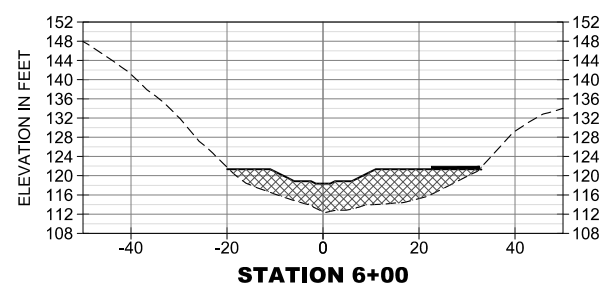
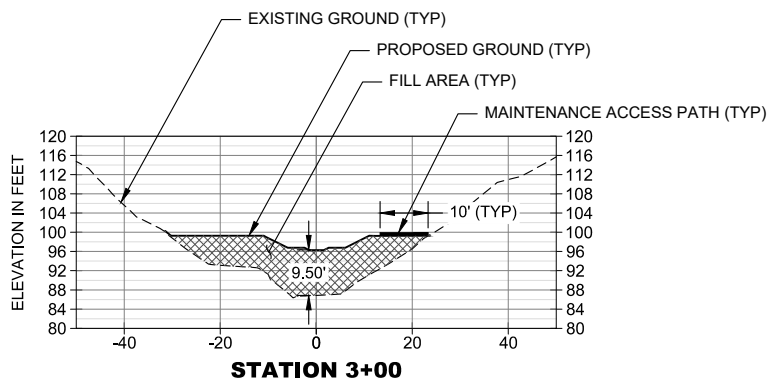
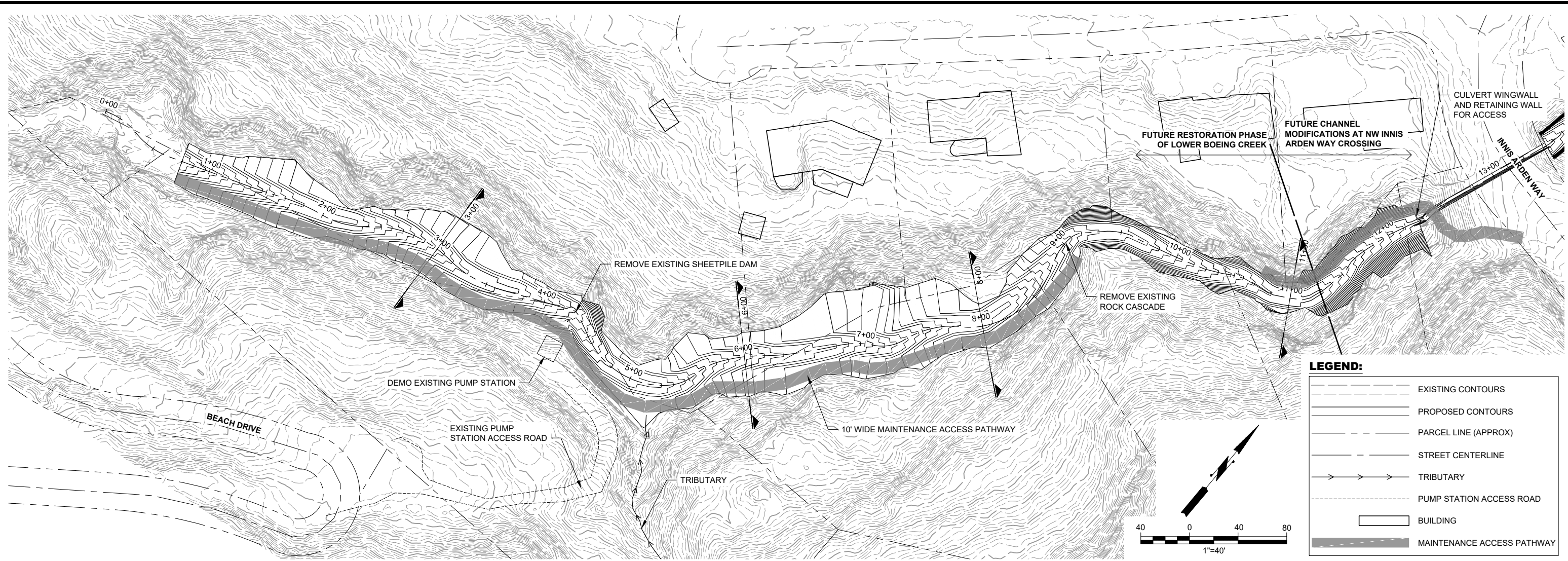
Barnard, R.J., J. Johnson, P. Brooks, K.M. Bates, B. Heiner, J.P. Klavas, D.C. Ponder, P.D. Smith, and P.D. Powers. 2013. Water Crossing Design Guidelines. Washington Department of Fish and Wildlife, Olympia, Washington.

TetraTech/KCM. 2004. Boeing Creek Basin Characterization Report. Prepared for City of Shoreline by TetraTech/KCM, Inc., Seattle, Washington.

Windward Environmental, Osborn Consulting, and The Watershed Company. 2013. Boeing Creek Basin Plan. Prepared for City of Shoreline.

APPENDIX A

Lower Boeing Creek Fish Passage Restoration Plan and Profile Design Concept

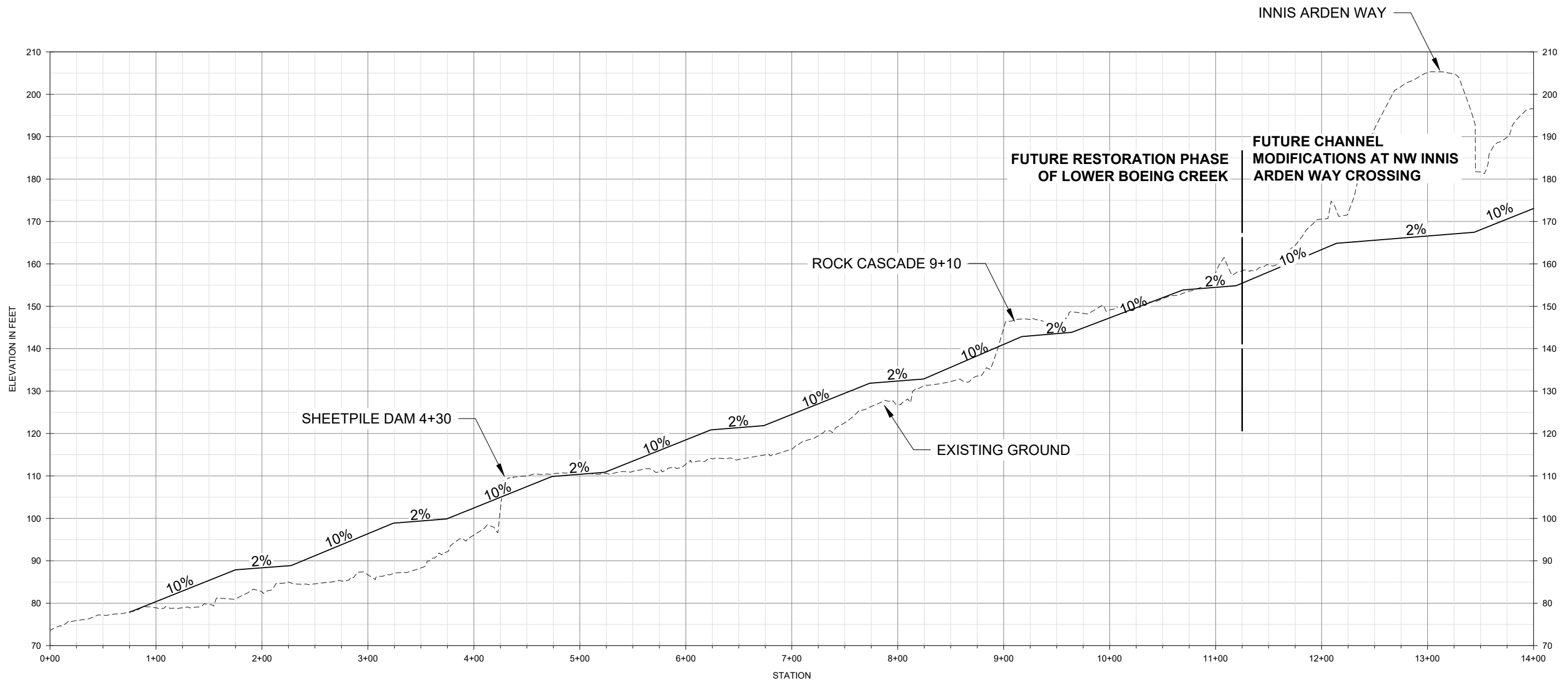


CROSS SECTIONS
 HORIZ. SCALE: 1"=20'
 VERT. SCALE: 1"=20'

C:\proj\2015\15-05984-000\CA\DDwg\Lower Boeig Conceptual design components.dwg | 7/18/2017 5:53 PM | Todd Prescott

© 2017 Herrera Environmental Consultants, Inc. All rights reserved.

	LOWER BOEIG CREEK	DATE: JULY 2017
	CONCEPTUAL DESIGN COMPONENTS	DRAWING:
		SHEET: OF



PROFILE
 HORIZ. SCALE: 1"=80'
 VERT. SCALE: 1"=20'



8b-27



LOWER BOEING CREEK
 CONCEPTUAL DESIGN PROFILE

DATE:	JULY 2017
DRAWING:	
SHEET:	OF

C:\proj\2015\15-05984-000\CA\DDwg\Profile.dwg | 7/18/2017 6:08 PM | Todd Prescott

© 2017 Herrera Environmental Consultants, Inc. All rights reserved.

APPENDIX B

Lower Boeing Creek Fish Passage Restoration Conceptual Cost Estimate

Planning-Level Cost Estimate for Fish Passage Restoration in Lower Boeing Creek

Project: Hidden Lake Dam Removal
 Herrera Project 15-05984-000
 Client: City of Shoreline

Date Modified: 7/19/2017
 Spreadsheet by: I. Mostrenko
 Checked by: M. Ewbank
 Latest Date Checked: 7/19/2017

Cost Item #	Spec Section	Item Description	Quantity	Unit	Unit Cost	Price	Total Price	Comments
1		Mobilization	1	LS	\$ 212,500.00		\$ 212,500.00	8% of construction subtotal (Div 2 - Div 8 work items)
2		Temporary Erosion and Sediment	1	LS	\$ 120,300.00		\$ 120,300.00	Assumes 5% of all other items except water management
3		Water Management	1	LS	\$ 130,000.00		\$ 130,000.00	Use Coal Creek bid cost, assume 2 phases, like coal creek total
4		Clearing	1.0	AC	\$ 19,445.00		\$ 19,104.44	WSDOT unit bid analysis, NW Region 2016
5		Removal/staging of LWD	1	LS	\$ 42,000.00		\$ 42,000.00	See support calcs
6		Access Construction	1950	LF	\$ 64.90		\$ 126,555.00	See support calcs
7		Access Road Retaining Wall	1	LS	\$ 60,000.00		\$ 60,000.00	upper 200 feet reach to minimize large cut slope
8		Channel Excavation	2470	CY	\$ 40.00		\$ 98,800.00	See support calcs, unit assumes double handling and staging
9		Import Alluvial Fill (pit run)	590	CY	\$ 60.00		\$ 35,400.00	See support calcs, increase unit cost due to access/stage space
10		Import Boulders	3820	CY	\$ 150.00		\$ 573,000.00	See support calcs / add 25% to unit est due to access/staging
11		Import Sediment Gravel/Cobble Material	1910	CY	\$ 112.50		\$ 214,900.00	See support calcs / add 25% to unit est due to access/staging
12		Channel Construction	5740	CY	\$ 190.00		\$ 1,090,600.00	See support calcs
13		LWD Placement	14	EA	\$ 6,800.00		\$ 95,200.00	See support calcs
14		Riparian Restoration	1	AC	\$ 50,000.00		\$ 50,000.00	
Construction Subtotal							\$ 2,868,359	
Sales Tax (10.0%)							\$ 286,900	
Construction Total (roundup to 1000's)							\$ 3,156,000	
Contingency (50%)							\$ 1,578,000	
Construction Total with Contingency							\$ 4,734,000	
Permitting							\$ 100,000	based on past project experience, high end due to WDFW
Design							\$ 225,000	based on past project experience, channel design
Construction Management & Administration (20% of Construction Cost)							\$ 946,800	
GRAND TOTAL							\$ 6,010,000	

July 2017
 C-1

