R2 Resource Consultants, Inc.

15250 NE 95th Street
Redmond, WA 98052-2518
Phone: (425) 556-1288
Fax: (425) 556-1290
e-mail: mail@R2usa.com

Technical Memorandum

Date: March 2, 2015 Project Number: 2050.02/MM103

To: Craig Garric, King County River and Floodplain Management Section
cc: Andy Loch City of Bothell

From: Paul DeVries, Ph.D., P.E.

Subject: Sammamish River Off-Channel Thermal Refuge Rearing Habitat Restoration Project: Evaluation of Design in Context of Avoiding Adverse Effects to the Integrity of the US Army Corps of Engineers' Sammamish River Channel Improvement Project.

Overview of Proposed Restoration Project

The City of Bothell (COB) Public Works Department desires to reconnect and restore ~1,100 ft of an old remnant channel and adjoining floodplain of the Sammamish River within the city limits. R2 Resource Consultants (R2) has been retained to assist the COB with planning, design, and permitting of a project that meets the City's goals (COB Project). The resulting proposed action was identified as a key project of the 2002 Sammamish River Corridor Action Plan and responds directly to the 2005 WRIA 08 Chinook Recovery Plan which identified the need to increase off-channel rearing habitat for salmonids throughout the river basin (King County Department of Natural Resources 2005). An assessment prepared by R2/PGG (2013) for the COB concluded that a feasible restoration project could be designed that provides critical cool water refuge for juvenile salmonids during summer months when water temperatures in the Sammamish River exceed water quality criteria. The COB has obtained funding from the Washington State Salmon Recovery Funding board (SRFB) to prepare 100% designs and permit applications for a preferred alternative that was selected based on the results of the feasibility assessment. R2 has been tasked with that work (R2 2014).

The proposed COB Project site is located between River Mile 3 and River Mile 4 from Lake Washington and within a reach of the Sammamish River where there are cold water springs (Figure 1; R2/PGG 2013). A key goal is to hydraulically connect constructed off-channel habitat at both ends to the Sammamish River to make the COB Project accessible as rearing and thermal refuge habitat for salmonids, with an emphasis on Chinook (*Oncorhynchus tshawytscha*) and coho (*O. kisutch*) salmon.

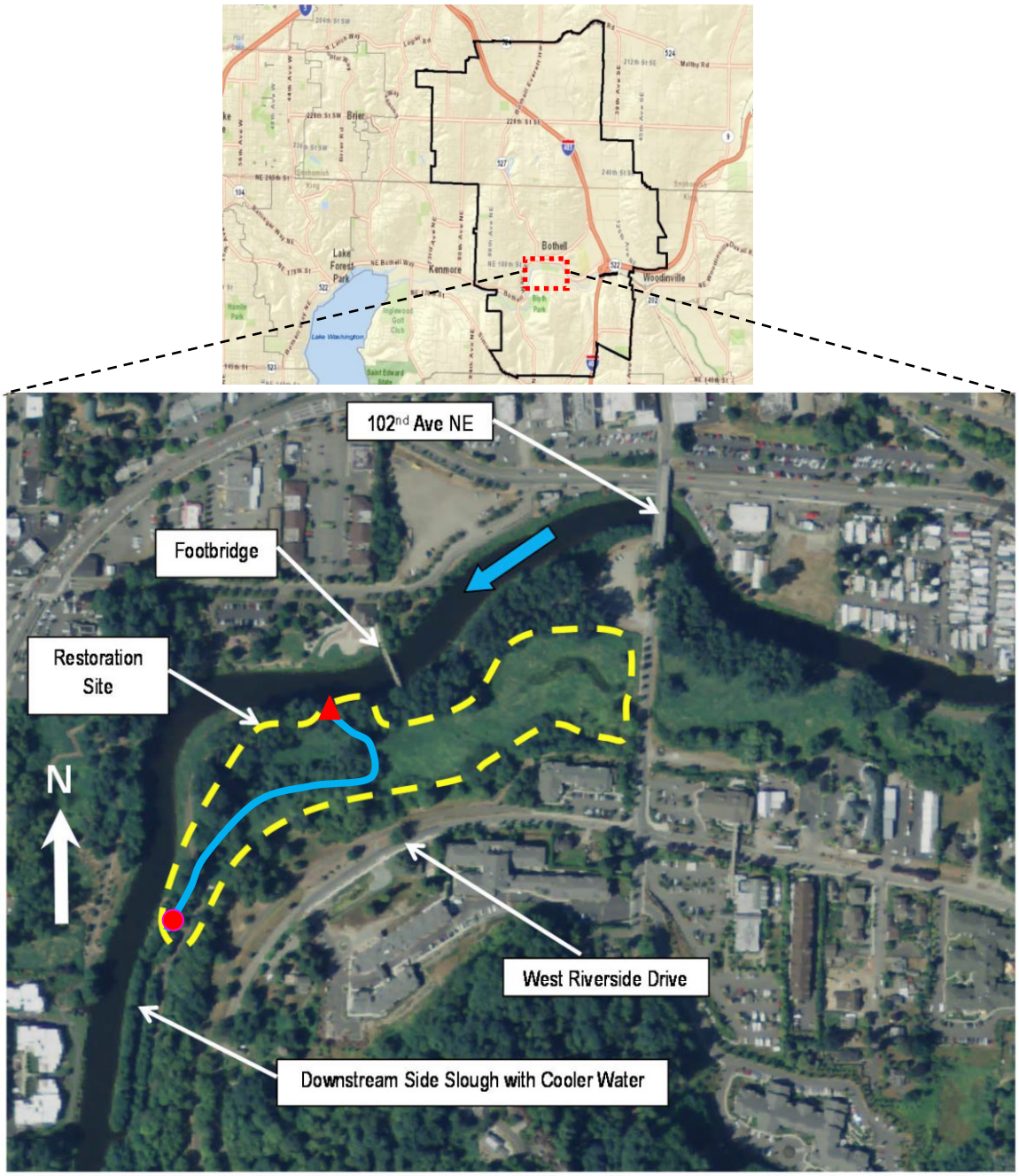

Figure 1. Location of Sammamish River Off-Channel Habitat Restoration Project site, approximate disturbance limits for construction (yellow dashed line), and relevant landmarks. The proposed side channel is outlined by the blue line; the inlet and outlet culvert locations are indicated by the red triangle and dot, respectively.

The COB Project entails excavation of a narrow, deep channel that is permanently inundated and that is connected to the Sammamish River via two fish-passable culverts. The culverts have been designed to prevent inflow at the upstream end during summer months when Lake Washington and the Sammamish River water levels are elevated, and remain open for unrestrained fish passage at the downstream end. The culverts have also been designed to allow inundation of the floodplain, which will be restored with native vegetation.

The COB Project has been planned such that there will be no fill placed on the floodplain within the boundaries of the 100 year flood extent depicted on FEMA's (2005) Flood Insurance Rate Map (FIRM; Figure 2). Wetlands have been mapped, and a restoration plan has been developed that will replace current reed canarygrass and Himalayan blackberry infested areas with native vegetation. While the project will result in changing the functional characterization of the floodplain by constructing a channel and changing certain elevations, the project was designed with the goal of not significantly changing the extent of the 100 year flood. Related to this, another goal of the design has been to not significantly alter the structural integrity or crest elevations of the left bank levee constructed by the US Army Corps of Engineers (USACE) in 1964 as part of the Sammamish River Channel Improvement Project ("USACE Project").

This memorandum documents an evaluation of the structural changes proposed as part of the COB Project, in the context of ensuring the integrity and function of the USACE Project are maintained. The evaluation identifies relevant aspects of the design, reviews hydraulic modeling performed in support of Flood Hazard certification by King County's River and Floodplain Management Section of the Department of Natural Resources and Parks, and also references geotechnical engineering analyses performed by a subcontractor that were used to inform the design; copies of two relevant reports accompany this memorandum. The evaluation concludes that there are no elements of the design that might adversely impact the structural integrity and hydraulic functions of the USACE Project.

Relevant sheets from the 90% plan set detailing structural changes associated with the COB Project are provided in Appendix A of this document.

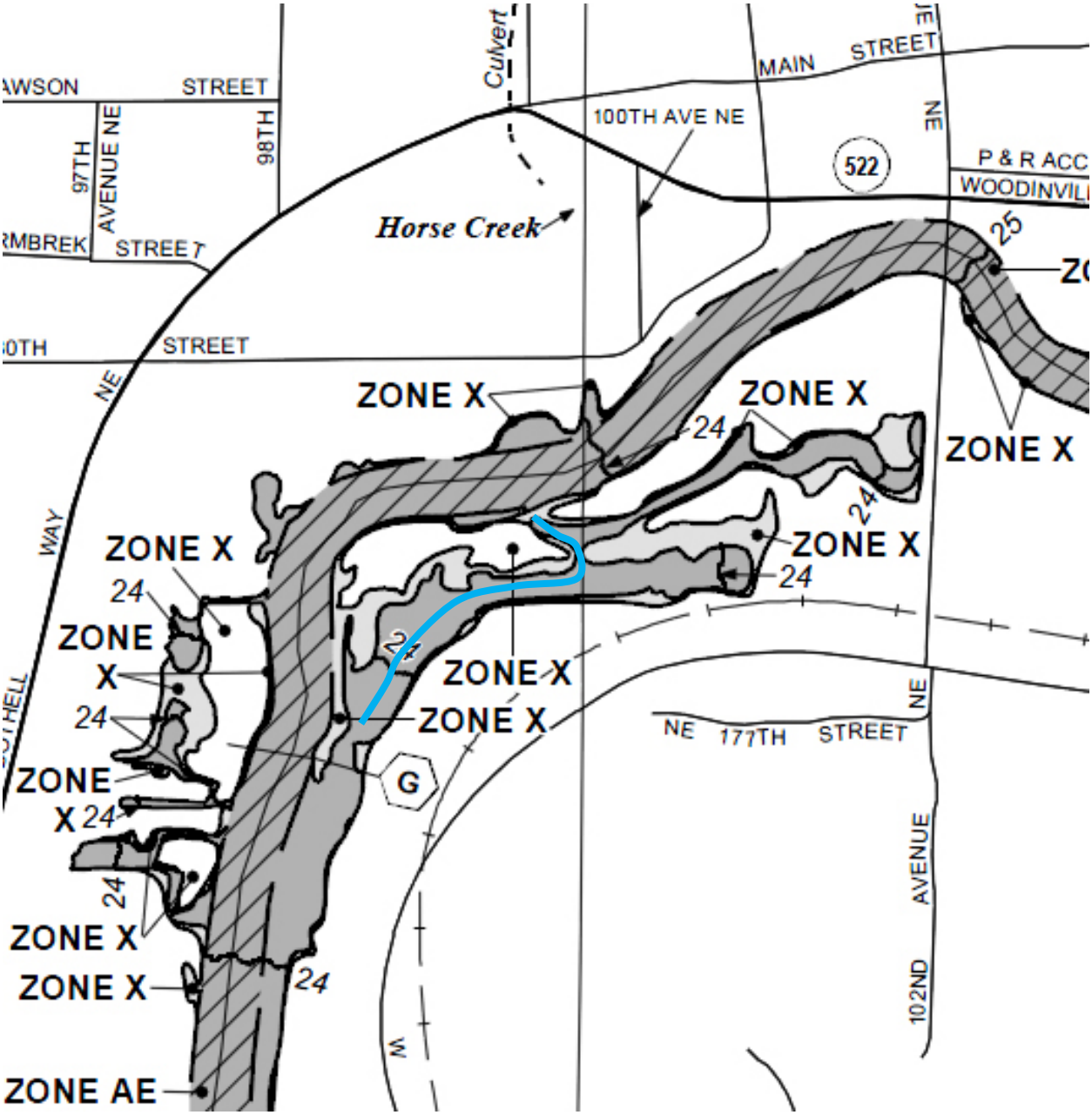

Figure 2. FEMA Flood Insurance Rate Map (FIRM) for the area in the vicinity of the proposed off-channel site. The side channel location is depicted by the thick blue line. The map indicates the 100-year flood level with shaded areas. Surrounding the shaded areas is Zone X, indicated on the map as areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

Description of COB Project Site

The proposed side channel generally lies along a relic channel depression on the floodplain. The inlet of the side channel is located about 1,100 ft downstream of the 102nd Ave NE Bridge, and 200 ft downstream of the pedestrian foot bridge (Figure 1). It is likely the river flowed through the side channel location at some point prior to lowering of Lake Washington ca. 1916 and straightening of the river ca. 1964 by the USACE. The presently undeveloped project site is owned by the COB and is zoned Public Park Open Space on land located to the west of 102nd Ave NE. Inspection of King County's Critical Areas web-based mapping indicates that the project site is classified as a sensitive area with respect to Chinook salmon distribution and 100 year floodplain extent. The site is classified as having a 'Low' CAO Basin Condition and its Shoreline Management Designation is mapped as "Rural" away from the Sammamish River trail. No other Critical Area Designations are indicated on King County's website.

The locations of the proposed channel and culverts lie within the mapped boundaries of the 100 year flood as depicted on the FIRM (Figure 2). There is a small CMP culvert running presently under the Sammamish River trail at the proposed upstream culvert location that drains the floodplain presently when the river is low, and can become engaged when flows are below the 10- year flood level depending on Lake Washington elevation (invert control elevation =21.2 ft NAVD88; see modeling results below). The culvert is partially blocked, however, and has limited conveyance capacity.

The river currently backwaters onto the floodplain over the trail at the proposed downstream culvert location by overflowing the trail when the river is at the 100-year flood stage; there is no hydraulic connection there at the 10 year flood level, thus water that enters via the existing CMP culvert ponds within depressions on the floodplain during that event.

Description of Relevant USACE Project Attributes

According to the USACE (1962) General Design Memorandum, the USACE Project was constructed over native soils composed of clayey silt, sandy silt, and silty fine sand, with some of this material used to construct levees. Borings within the COB Project location indicated the presence of poorly graded sand and gravel below the water level, with pieces of wood present. The channel was straightened in the vicinity of the COB Project site to accommodate future construction of SR 522, with a design bottom width of 50 feet (constructed width ~56 ft; USACE 1964) and side slopes generally at 3H:1V (constructed = 2.5H:1V; USACE 1964) for stability and safety. In several locations, the USACE Project design called for steeper side slopes

between 2H:1V and 1.5H:1V to reduce or avoid alterations to bridges, with a wider channel bottom and a 1 ft thick layer of quarry spalls extending up the bank ~14 ft (constructed ~7-15 ft; USACE 1964) above the channel bottom for stability. In the COB Project reach, the side slopes above the water surface of the design flood (~11 ft above the channel bottom), the design called for 2H:1V side slopes that were to be seeded to prevent gullying, seepage and erosion damage by flows greater than the design flood. At locations where fill was to be placed (e.g., at the two locations in the COB Project site where the river channel was straightened), the design called for fill protection by a blanket of sand and gravel extending up to 14 ft above the channel bottom. Rock riprap and gravel blanketing necessary for channel slope and invert protection at various locations were imported from quarries near Duvall and a gravel pit in Redmond (USACE 1962).

The USACE (1964) Project Operations and Maintenance (O&M) Manual requires in section 3.7 that any improvements or alterations affecting the flood protective works shall require prior approval by the USACE. Maintenance requirements in Section 4 include raising any part of the levee top that has experienced settling back to required grade, and checking culverts draining into the river to see that they are functioning properly. Where repairs are required due to erosion of the levee and/or bank, the use of quarry spalls or coarse gravel was recommended to prevent further damage. Furthermore, inspections are needed to ensure encroachments are not being made on the levee right-of-way that might adversely affect levee structure and channel conveyance.

In the remainder of this memorandum, these attributes of the USACE Project are assessed relative to the proposed COB Project design.

Changes to USACE Project Conveyance (Dimensions of Channel and Levee Cross-Section)

All excavation will be at elevations above the invert of the Sammamish River, and will not involve disturbance of the toe of the levee. The proposed downstream culvert is located away from the channel, and the proposed upstream culvert will be effectively retrofitted into an existing recess in the levee bank, and will thus not involve protrusion into the river channel cross-section profile. Hence, the existing bottom and top widths and thus flood conveyance capacity of the Project channel will be maintained. In addition, the project will not change the elevation of the Sammamish River trail, thus the bankfull elevation will remain the same. However, there will be some reduction in flood flows in the river between the two culvert locations where some of the water is diverted over the restored floodplain instead.

Changes to Levee Structural Fill & Stability of Toe

The upstream culvert is located where the river flowed prior to 1964, and the downstream culvert is located adjacent to the pre-straightening location, well away from the current river's edge (Figure 3). Fill material was placed at both locations to form the levee and trail during channel straightening. Test borings were performed by R2's geotechnical engineering subcontractor (Zipper Geo Associates 2014a). The blow count data in the boring logs indicate that the fill material appears to extend down to roughly 10+ ft below the surface of the Sammamish River trail at both locations. The trail constitutes the crest of the levee. The fill material is composed of various layers of sand, silt and trace gravel and organic materials. Underneath, the native substrate is a harder silt/clay/sand/gravel mix. Most of the relatively fine fill material from 1964 will be replaced with structural fill, quarry spalls, and the proposed culverts, all of which will provide increased structural strength to the levee. The trail surface will be returned to its existing elevation to avoid creating sudden changes in elevation that could affect bicyclist safety.

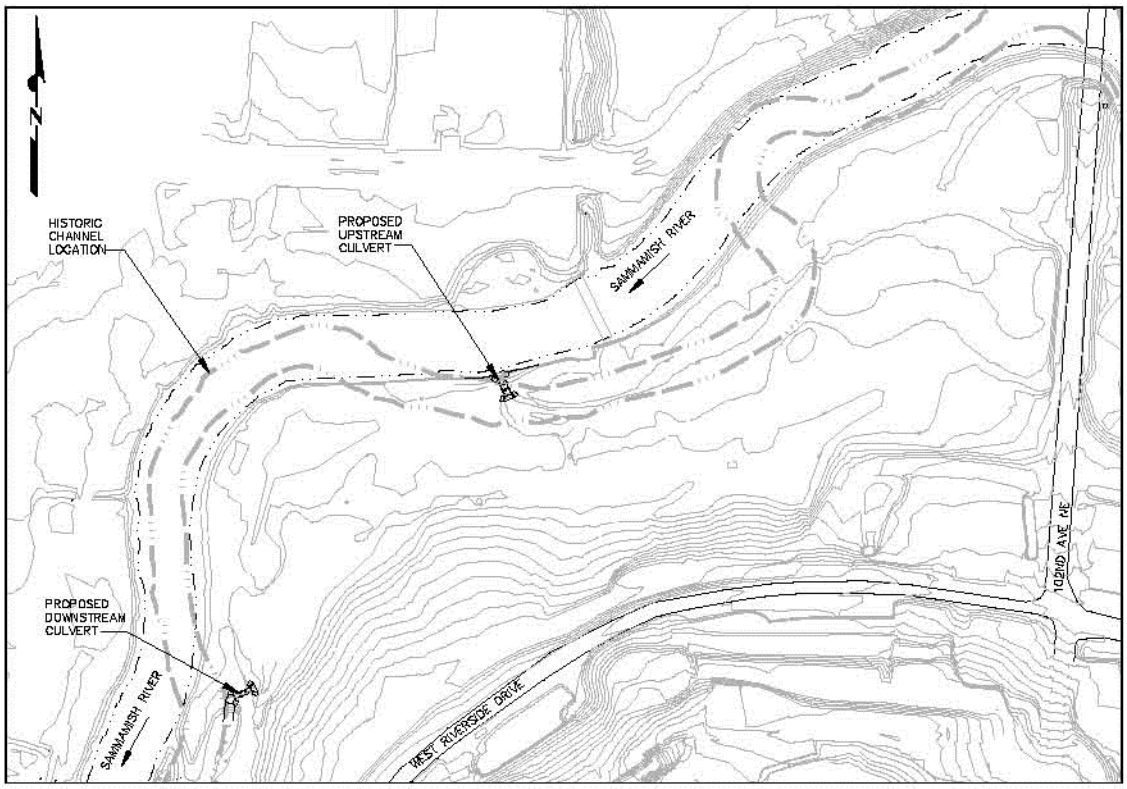

Figure 3. Locations of proposed culverts relative to pre-straightening and current Sammamish River Channel.

A design constraint of the COB Project involved minimizing water management during construction of the upstream culvert by minimizing the depth of excavation required, and by setting the culvert as far back from the river bank edge as practical while maintaining a suitable width of level ground on the river-side of the Sammamish River trail for pedestrians to avoid bicyclists. R2 engaged the geotechnical engineering subcontractor to develop recommendations for alternative foundation construction approaches, and selected the simplest solution involving placement of a suitable base composed of quarry spalls (Zipper Geo Associates 2014b).

Water management at the upstream culvert site will be accomplished by installing sandbags with plastic sheeting (or approved alternative proposed by the contractor) riverward of the excavation and pumping the work area. Pumping will occur continuously as excavation proceeds, and during placement of quarry spalls and crushed surfacing base course, and installation of the culvert. As part of this, an accompanying design constraint was that the upstream culvert excavation should not disturb the river-side toe of the levee so that additional bank protection work would not be required. The proposed depth of excavation is 8 ft and 9 ft at the upstream and downstream culvert locations, respectively (see 90% design drawings, sheet 8). The proposed upstream culvert opening is recessed approximately 5' into the bank from the river's edge at an existing alcove, with wing walls that taper down to existing bank elevation, and a gravel apron placed on the bottom riverward side of the culvert opening between the wing walls to transition to the existing riverbed surface (see 90% design drawings, sheet 7). The wing walls will have cantilevered footings extending back into the levee, and will site on the same layer of quarry spalls and crushed surfacing base course as the culvert sections.

Velocities entering the culvert were predicted using the HEC-RAS model (Figure 4). Based on predicted water surface elevation and discharge into the culvert, velocities will not exceed 1.6 ft/s. Consistent with O&M manual recommendations (USACE 1964), a coarse gravel apron will be placed between the wing walls in front of the culvert opening for stability. The material will meet WSDOT specification 9-03.11(2) for 4" cobble, which is stable at velocities less than about 3 ft/s (cf. Plate B-28, USACE 1991). The corresponding stability safety factor is therefore nearly equal to 2.

In sum, excavation will not disturb the toe of the levee, ands all replacement material will be structurally sounder than the material removed and meet stability requirements. These design features are consistent with the USACE (1964) O&M manual requirements identified above related to maintaining structural integrity and stability of the levee, which will be maintained or improved as a result of the COB Project.

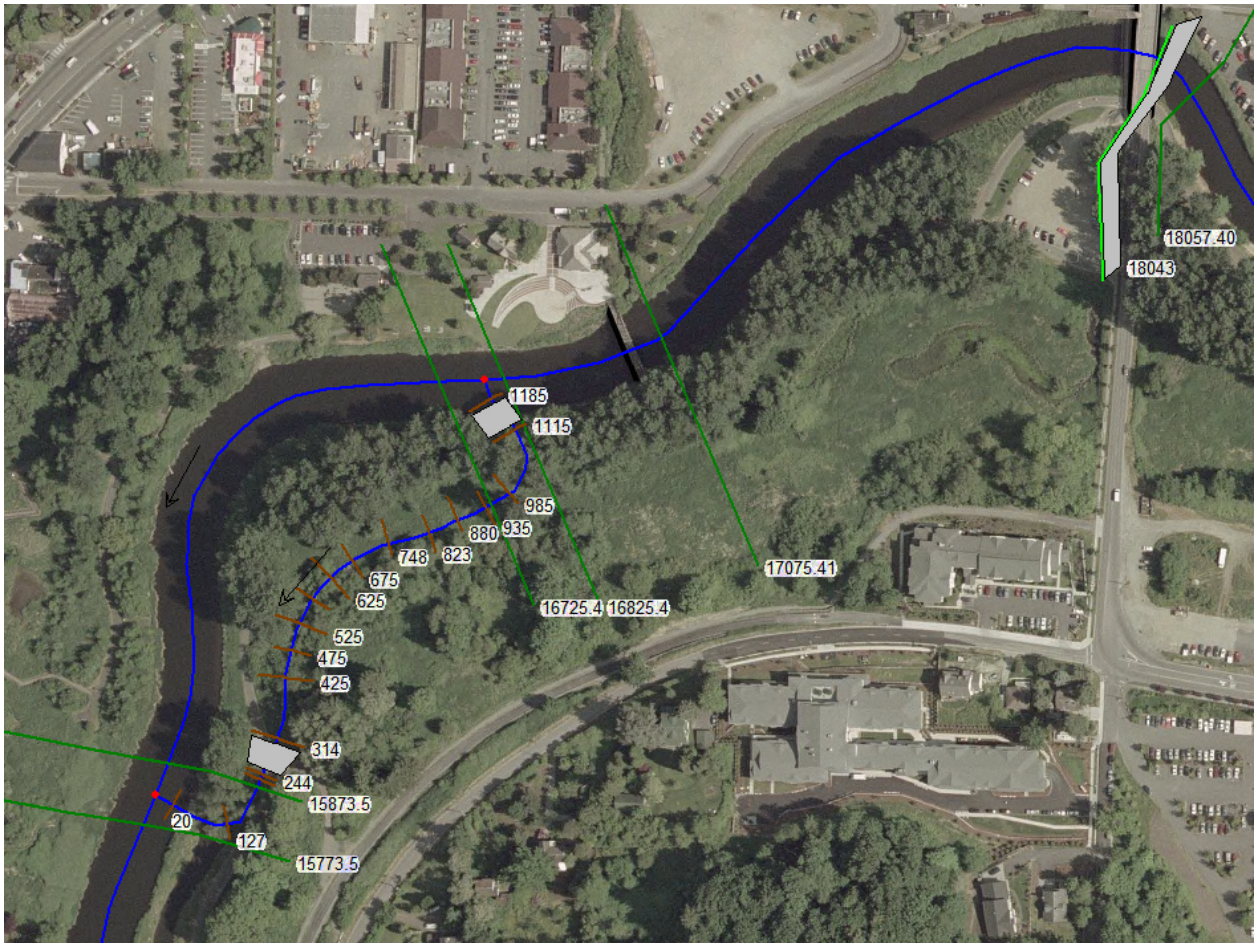

Figure 4. HEC-RAS model representation of the proposed side channel and Sammamish River, with cross-sections and culverts identified.

Changes to Hydrostatic Pressure Forces on Levee

In general, the project is predicted to have either no effect or result in negligible change (±0.01 ft) in flood levels in the Sammamish River during the 10- and 100- year flood events. The project will likely increase floodplain compensatory storage, however, by increasing floodplain connectivity via the two culverts. The larger upstream culvert will replace a small diameter CMP that connects the floodplain with the Sammamish River. The associated increased floodplain connectivity may cause a slightly higher 100 year flood stage on portions of the wetland floodplain to the west of 102nd Ave NE. This is because the existing CMP has limited conveyance such that the floodplain is effectively connected hydraulically to the Sammamish River at the downstream junction under existing without-project conditions. Peak 100 year

floodplain water levels to the east (=up-valley) therefore currently reflect backwater from downstream, and effectively equal the level at the downstream connection with the river. At the time the flood crests, water will still be flowing through the partially obstructed CMP culvert with a maximum head difference of about 0.25 ft and estimated maximum flow rate less than 1 cfs. This inflow rate is negligible, with limited influence on floodplain water surface elevation at the time the 100 year flood peaks. This phenomenon is essentially reflected in the constant FIRM water level of 24' across the floodplain area. With the restoration project, therefore flood levels shall be more similar on both sides of the levee, thus reducing hydrostatic pressure differences across the levee and trail during flooding, which should act to reduce seepage through, and increase stability of, the levee.

The increased floodplain storage volume would also serve to attenuate flood flows in the Sammamish River, which would help reduce potential for flood damage.

Summary and Conclusion

Based on the information presented above, the following key points and conclusions are noted:

- The downstream culvert will be placed at location that is not directly part of the levee prism constructed by the USACE in 1964.
- The upstream culvert will be placed in the levee prism, at a location that was filled previously by the USACE using local native material during channel straightening in 1964. In addition to concrete box culverts and associated wingwalls, the non-cohesive materials replacing the former fill material will be larger sized and more stable, and therefore maintain or improve the structural integrity of the levee overall.
- Quarry spalls will be used as a foundation base for the culverts. This material was approved for use in the O&M manual for repairs, and is thus also suitable for burial in the levee.
- Coarse gravel will protect the riverbed at the upstream culvert inlet, consistent with material approved in the O&M manual for repairs.
- The toe of the levee will not be disturbed by excavation activity.
- The project will not result in a change in channel cross-section profile and thus flood conveyance in the Sammamish River at the project site.

- Overall, the proposed COB project is not expected to adversely affect the integrity or function of the USACE Project, and will provide ecological benefits.

References

FEMA. 2005. King County Flood Insurance Study, King County, Washington and Incorporated Areas, Volume 1 to Volume 4, Federal Emergency Management Agency, Flood Insurance Study Number 53033CV001B,

King County Department of Natural Resources. 2005. Final Lake Washington/Cedar /Sammamish Watershed (WRIA 8) Chinook Salmon Conservation Plan. July.

R2 Resource Consultants, Inc. 2014. Sammamish River Off-Channel Thermal Refuge Rearing Habitat Restoration. Preliminary Design Report prepared for City of Bothell, Washington.

R2 Resource Consultants, Inc. and Pacific Groundwater Group (R2/PGG). 2013. On the Feasibility of Constructing Suitable Juvenile Salmonid Off-Channel Habitat on the Sammamish River, City of Bothell. Final report prepared for City of Bothell, WA. May.

U.S. Army Corps of Engineers (USACE). 1962. Channel improvement, Sammamish River, Washington: General design memorandum. Seattle District.

U.S. Army Corps of Engineers (USACE). 1964. Flood control improvements, Sammamish River, Washington: Operation and maintenance manual, Volume I. Seattle District.

U.S. Army Corps of Engineers (USACE). 1991. Hydraulic design of flood control channels. Engineer Manual EM 1110-2-1601.

Zipper Geo Associates. 2014a. Geotechnical engineering report, Sammamish River side channel restoration project, Sammamish River trail culverts, Bothell Washington. Technical report prepared for R2. September 19.

Zipper Geo Associates. 2014b. Supplemental geotechnical engineering services, Sammamish River side channel restoration project, Sammamish River trail upstream box culvert, Bothell Washington. Technical memorandum to P. DeVries, R2. December 19.

Appendix A

CAD Sheets, 90% Design