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Technical Memorandum

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cc. Andy Loch City of Bothell

From: Paul DeVries, Ph.D., P.E.; Chiming Huang, Ph.D., P.E.; Glen Anderson, P.E.

Subject: Design Revision, Sammamish River Off-Channel and Floodplain Habitat Restoration Project – Changes to Channel and Downstream Culvert Elevations/ Dimensions

1. OVERVIEW

The City of Bothell (COB) Public Works Department (PWD) desires to reconnect and restore ~1,100 ft of an old remnant channel and floodplain of the Sammamish River within the City of Bothell limits. Funding has been obtained via SRFB grant #13-1133, and thus the project is subject to SRFB Manual 18 requirements. Project goals include: increasing juvenile salmon habitat quantity and quality in a critical reach of the Sammamish River; restoring floodplain plant community diversity and structure; restoring floodplain and channel connectivity and function; and developing opportunities for public involvement and education. The site is located within a reach of the Sammamish where there are cold water springs, and a feasibility study prepared by R2/PGG (2013) for the COB concluded that a feasible restoration project could be designed that provides critical cool water refuge during summer months, while minimizing access by predatory fish during the warmest summer months.

R2 Resource Consultants Inc, (R2) is assisting the COB with preparing final designs and permit applications. A preliminary design and report was prepared per SRFB grant requirements (R2 2014). The preliminary design was distributed to stakeholders, and was subsequently presented and discussed in a meeting with the local WRIA 8 technical committee on November 5, 2014, and again onsite with WDFW staff on December 22, 2014. Two key issues were identified by WDFW that have been considered, and as a result have led to substantial changes to the design:

1. There was a concern that sedimentation and leaf fall and other organic debris could shorten the lifespan of the project through gradually filling of the constructed channel; and

2. WDFW wanted the downstream culvert invert and downstream excavated channel elevations lowered so that juveniles could move in and out of the channel at any time of the year.

This Technical Memorandum documents the resulting design considerations and changes. The reader is referred to the preliminary design report for background material and explanation behind specific project elements. This memorandum was prepared as a supplement to that report.

2. CHANGES ASSOCIATED WITH SEDIMENTATION CONSIDERATIONS

2.1 Analyses

Order of magnitude analyses during development of the preliminary design indicated that velocities during high water would generally be sufficient to transport silt sized particles as suspended load. It was suggested during the WRIA 8 meeting that R2 evaluate the potential for sediment and organic detritus buildup further in two ways, by (i) surveying the existing downstream channel to provide empirical data as a reference condition related to long term bed elevation change, and (ii) performing more detailed hydraulic analyses. The specific data & analyses pertinent to each are presented respectively below.

2.1.1 Empirical Data/Survey of Existing Channel

The existing downstream channel was a relic of channel straightening actions completed by the US Army Corps of Engineers in 1964. The channel is located where the historic river channel flowed, and was left as a disconnected pond after straightening. A review through COB records found an as-built plan for a mitigation project constructed ca. 2001 where the upstream and downstream ends of the relic water body were reconnected to the river. The downstream end was excavated as a relatively deep connection, and the upstream inlet was excavated as a perched inlet with inlet control elevation currently equal to 19.75 ft NAVD88. Three cross-sections were surveyed for as-built documentation and their locations (upstream, middle, and downstream) drawn on an as-built plan sheet. We were able to relocate all three transects based on horizontal distances from the inlet, to within a judged +/- 5 ft from the actual location. Given the streamwise bed elevation slope is relatively small and the channel generally prismatic in nature, differences between our survey and the as-built should be primarily reflective of changes in the bed elevation, and not due to difference in survey location.

Figure 1 depicts the comparison in cross-section profiles at middle and upstream locations; despite wearing chest waders, we were unable to survey the downstream cross-section owing to it being too deep there. The figure shows that the bed elevation has remained effectively unchanged over the past 13 years. Given that the design channel will flow more frequently because its inlet control elevation is 1.25 ft lower than the invert of the inlet to the existing channel, it is reasonable to expect that flushing in the design channel would be sufficient to minimize sedimentation and detrital buildup for a much longer period than 13 years.

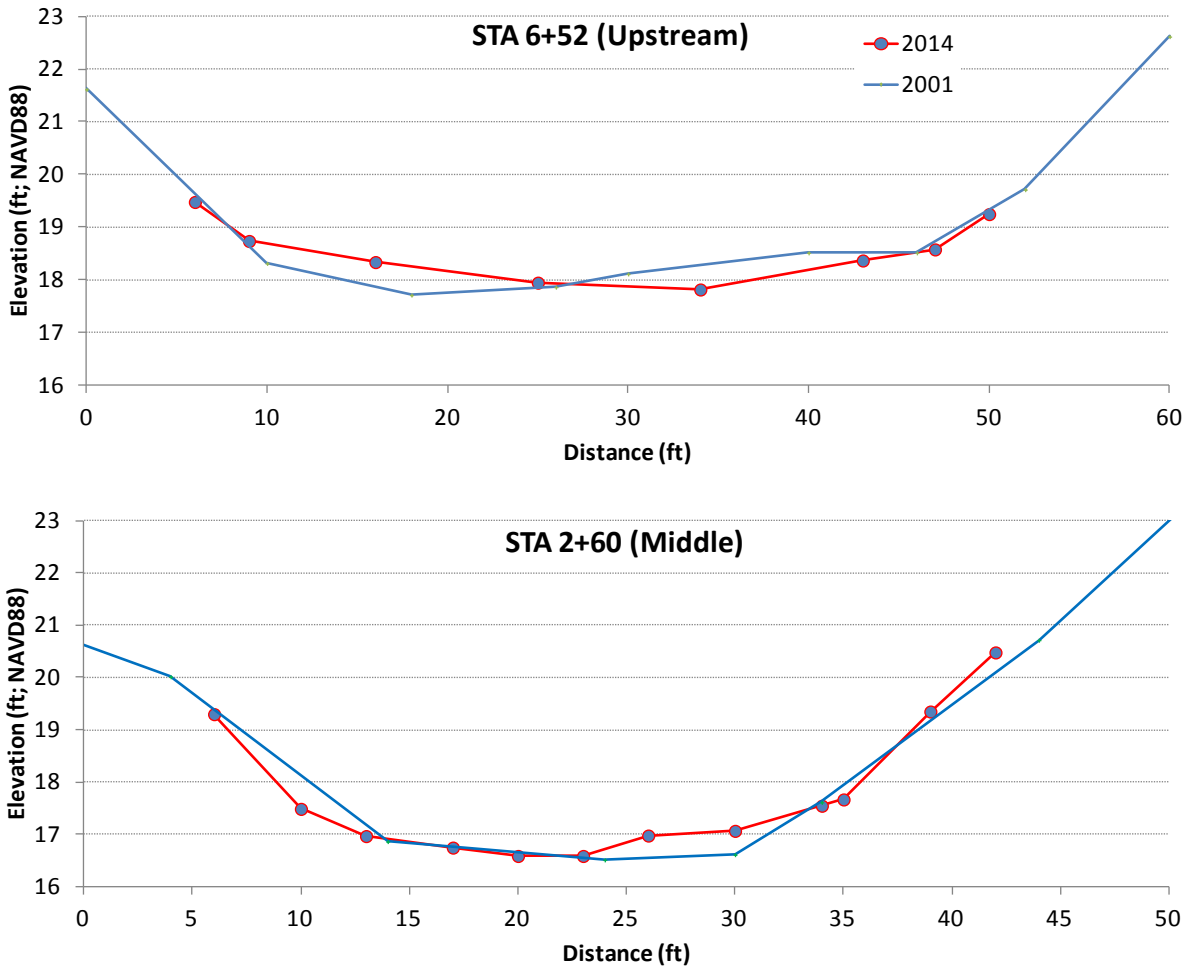

Figure 1. Comparison of cross-section profiles in the existing downstream channel, as surveyed in 2001 and 2014.

2.1.2 Hydraulic Analysis

The HEC-RAS model used for the preliminary design was modified to assess mean velocities in the new design channel for a range of inlet culvert widths (preliminary design value of 5 ft vs. an alternative 10 ft), channel widths (preliminary design value of 8 ft vs. an alternative 6 ft), and downstream culvert invert elevations (preliminary design value of 18.5 ft vs. alternatives 17.5 ft and 16.5 ft). The model geometry was modified to include the design channel as a side channel with upstream and downstream junctions in the mainstem, and with two culverts and various cross-sections defining the design pools and intervening sections in the side channel.

The model was run for a range of flood flows spanning the 1.5-year to the 100-year events. In general, the model predicted highest velocities in the design channel around the 1.5- and 2-year events. Accordingly, transport of suspended sediment and detritus should be greatest at those flows. From a channel maintenance perspective, this result is ideal because it is consistent with the concept that these flows approximate the dominant discharge associated with maximum cumulative sediment transport in alluvial systems. Peak velocities were around 1 ft/s or less depending on alternative configuration. This is generally within acceptable limits for vegetated bank stability (cf. Chow 1959), and within the suitable range for juvenile salmonids (e.g., Bovee 1978). Hence, the model predictions appear to be consistent with the empirical observation of negligible fine sediment and detritus buildup in the existing channel, and the design channel should have a relatively long functional (for habitat) life span (judged to be >30 years).

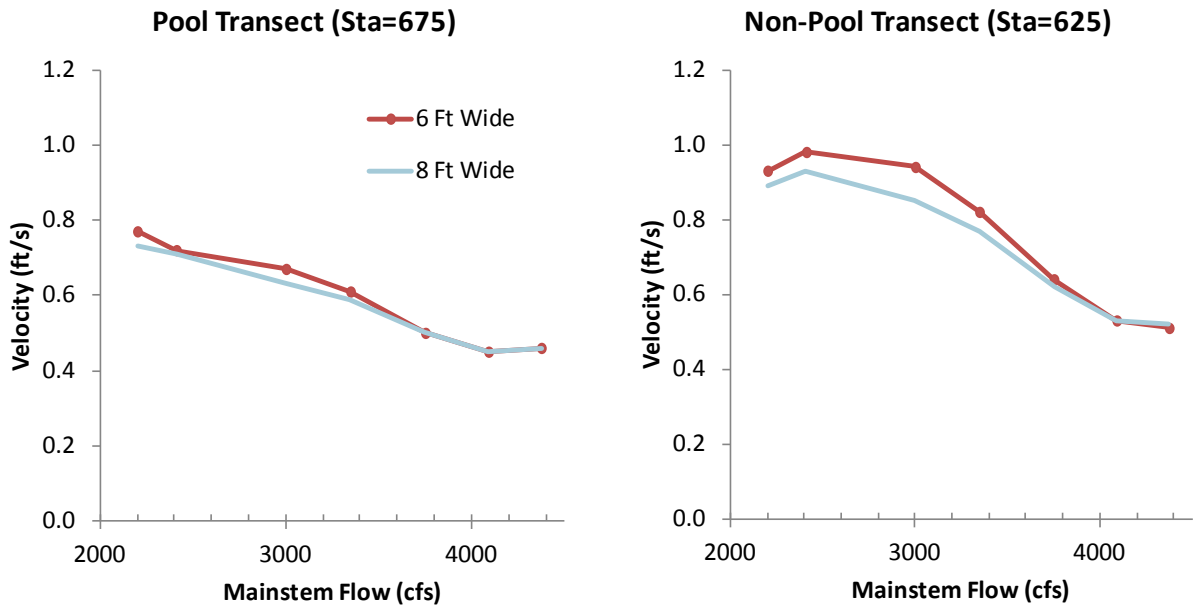

Figure 2. Comparison of predicted velocities in the design channel depending on channel width and river flow, where the inlet culvert is 10 ft wide, and the outlet culvert is 6 ft wide and its invert elevation is 17.5 ft. Similar results are observed for other outlet culvert invert elevations.

2.2 Resulting Change to Design

The model run predictions are summarized in Table 1. In general, velocities in the design channel are maximized with a wider inlet culvert width and narrower channel. These conditions act to allow more flow in and out of the site, and reduce the flow cross-section area in the design channel. These attributes physically cause the velocity to increase in the design channel compared with the preliminary design. Based on these results, the inlet (upstream) culvert width was changed in the design to 10 ft, and the design channel width was changed to 6 ft; accordingly, the outlet culvert width was set to match the channel width (a wider downstream culvert would not affect the outflow rate or velocities since the resulting hydraulics reflect primarily upstream channel control).

3. CHANGES ASSOCIATED WITH FISH PASSAGE CONSIDERATIONS

3.1 Analyses

Design of the invert elevation for the outlet (downstream) culvert is not as straightforward as the design described above for improved channel maintenance. There are two conflicting goals that are not easily resolved at the same time:

1. Allowing uninhibited movement of juvenile salmonids;

   vs.

2. Restricting movement of predators, with emphasis on smallmouth bass (*Micropterus dolomieui*) which, in addition to adult cutthroat trout (*Oncorhynchus clarki*) are a primary piscine predator found in the Sammamish River (Jeanes and Hilgert 2002).

The preliminary design opted for a compromise between achieving the two goals, where movement of juveniles was restricted so that bass could not enter the channel during their prime feeding times of the year when water temperatures are elevated. In addition, the preliminary design opted for similar inlet and outlet control elevations so that beaver would not be induced to build dams (i.e., there would be negligible head drop in the design channel from upstream to downstream except during flood flows), which could interfere with juvenile movement as well.

During the WRIA 8 meeting, it was recommended that R2 evaluate alternative invert elevations for the downstream culvert. The HEC-RAS model run results in Table 1, which does not involve any excavation of the existing slough channel, indicate that there is not much difference in through-flow and velocities in the design channel between the two culverts when the downstream culvert invert elevation is below about 17.5 ft NAVD88. This is because the existing slough channel downstream has an invert elevation between ~17.2-17.5 ft in the vicinity of it upstream end, which controls the flow. This portion of the channel is above water during December and January primarily. Without excavating any of the existing channel, it would not make any difference hydraulically to construct a lower culvert invert elevation, and thus an initial design change to 17.5 ft invert elevation was selected in preparation for the site visit with WDFW.

Upon review of this proposal during the site visit, however, it was indicated by WDFW that the design must be modified to allow passage of coho salmon (*O. kisutch*) juveniles at all times

throughout the winter. Based on the Lake Washington elevation plots presented in the preliminary design report (R2 2014), this means that the outlet elevation would have to be lowered to about 16.9 ft NAVD 88 to provide about 0.1 ft of depth minimum in the excavated channel downstream of the culvert during December and January. This would also entail additional excavation in the existing channel.

If the invert elevation were reduced to 16.9 ft NAVD88, then the channel depth during the summer months would be between 1 ft and 2 ft for most of the summer, in most years. This would not preclude access to the design channel by smallmouth bass during their prime feeding season, but in discussions with WDFW, it was concluded that the need to avoid trapping fish outweighed the need to minimize entry by predators. A review of smallmouth bass habitat requirements indicated that the width, depth, and summer temperature characteristics of the proposed channel are relatively unsuitable compared with the wider, deeper, warmer mainstem for both adults and juveniles (Edwards et al. 1983). Therefore, the risk of predation associated with keeping the channel accessible year round may be low. Monitoring should be performed to evaluate this hypothesis.

3.2 Resulting Change to Design

Accordingly, the design was changed to reflect the required reduction in downstream culvert elevation, down to 16.9 ft. In addition, the downstream excavation was extended farther to the west to connect with the side slough bottom at elevation 16.9 ft NAVD88. As an adaptive management modification, the design also will include installation of angle iron brackets for future insertion of temporary 4"x8" stop logs should monitoring indicate the need to reduce bass access during the summer. Summer snorkeling and/or electrofishing within the constructed channel is recommended to evaluate the potential impact of bass. If large individuals are caught, then stomach sampling is recommended.

4. REFERENCES

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