Sammamish Transition Zone
Sediment Removal Feasibility Study

September 2012

King County
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Sediment Removal Feasibility Study

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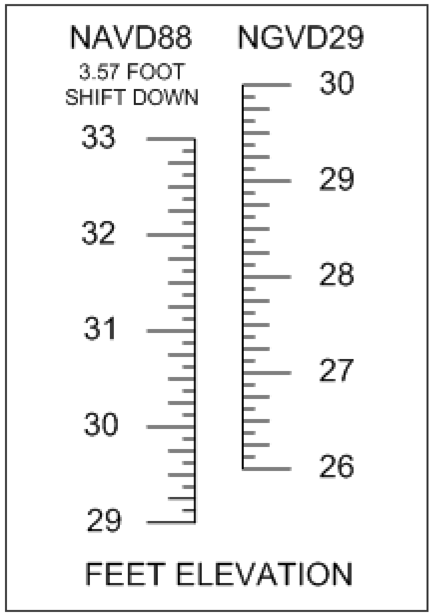
Special Note

Two different elevation datums have been referenced in design and as-built plans and in surveys conducted for the Sammamish Transition Zone. Please observe, where elevations are indicated, whether the elevation datum referenced is the National Geodetic Vertical Datum of 1929 (NGVD29) or the North American Vertical Datum of 1988 (NAVD88). In the area of the transition zone, the datum shift is 3.57 vertical feet:

$$NAVD88_{local} = NGVD29_{local} + 3.57 \text{ feet}$$



1 Introduction and Summary

In 1964, U.S. Army Corps of Engineers (USACE) completed a flood control project referred to as the Sammamish River Flood Control Project that lowered, widened, and straightened the Sammamish River. King County signed a maintenance agreement with USACE for the project area, including the area known as the Sammamish River Transition Zone. In recent years, community members with property along the shoreline of Lake Sammamish have expressed concern that the outlet capacity of the lake has been diminishing over the last decade. The assertion had been that as a result of insufficient maintenance, lake levels are higher, at a given flow, for longer durations. A review of hydrologic data confirmed a trend of higher lake levels in recent years. Higher lake levels are of concern because of the direct impacts inundation can have on private property, such as damage to decks and waterfront yards.

In response to community concerns over lake levels, in April 2011 King County produced the King County DNRP Lake Sammamish Flood Reduction Plan (Appendix 1). The plan, which is a list of eight action items, acknowledges that flooding may be caused by many factors, some of which are outside the control of King County. The plan affirms that the County is committed to taking actions, consistent with USACE agreements, to reduce flooding that are within its authority and in compliance with applicable laws. Eight such action items are identified and timelines are ascribed to each.

This report addresses action item 4 of the plan, "Sediment and debris removal evaluation." The evaluation consists of determining:

(1) Whether sediment and debris removal from the Sammamish River transition zone, including any flow obstructions, would be beneficial in terms of reducing lake flooding (Section 3)
(2) Environmental impacts (preliminary review) (Section 4)
(3) Permit requirements (Section 5)
(4) Costs associated with proposed project (Section 6)

King County Water and Land Resources Division held a public meeting on January 31, 2012, where stakeholders had opportunity to state their concerns and opinions about the proposed sediment removal maintenance project. Stakeholders and interested parties included landowners, cities, regulatory agencies, Muckleshoot Tribe, and environmental groups. A list of stakeholders identified for this project are listed in Appendix 2 and full notes from the public meeting are presented in Appendix 3. Some of the main concerns and viewpoints brought up at the public meeting are as follows:

- Washington Sensible Shorelines and some Lake Sammamish property owners are concerned regarding damage to docks, shoreline erosion, and potential "takings" due to a higher ordinary high water mark and encroachment of the lake onto their property.
- The Muckleshoot Tribe representative asserted that this project must be consistent with the WRIA 8 Recovery Plan for a large restoration project at this same site.

- Save Lake Sammamish is concerned regarding community pressure taking precedence over scientific analysis.
- Members of the Issaquah Environmental Council are opposed to sediment and debris removal.

The purpose of this study is to evaluate the benefits and impacts of a proposed maintenance project to remove accumulated sediment and debris from the Sammamish River Transition Zone. The work, which is described in more detail in Section 6, would remove material from the outside edge of the willow retention buffer on the low-flow channel to the toe of the slope of the high flow channel banks. Material would be removed down to the constructed rock-lined channel (see Appendix 4). The project represents an area of approximately 60 to 80 foot widths on either side of the willow- retention buffer. The timing and techniques used will be developed to minimize impacts to water quality and the stream resources.

The Sammamish River project, built in 1964, was designed primarily for the purpose of agricultural flood control in the Sammamish Valley with a secondary role in controlling both the seasonal low and high levels of Lake Sammamish. Influences on the lake level today include changing management objectives resulting from the higher complexity of ESA listed salmon species and water quality laws that were not in place in 1964. The transition zone is an important corridor for federally threatened salmon, such as Chinook, that migrate through this channel. These competing objectives resulted in many discussions with USACE, King County and National Marine Fisheries Service beginning in the 1990s. Subsequently, letters of agreement between King County and the Corps resulted in agreements on managing the vegetation in the Transition Zone. Example letters from 2003 and 2001 are shown in Appendix 12 that reflect these differences. In addition, development in the last nearly 50 years has resulted in increased stormwater runoff in the Sammamish watershed, including Bear Creek, which influences the outflow from Lake Sammamish. Consequently more attention is needed manage the lake level and address environmental conditions in the Sammamish River.

2 Existing Conditions of Sammamish River Transition Zone

In 1964, the U.S. Army Corps of Engineers (USACE) completed a flood control project referred to as the Sammamish River Flood Control Project that lowered, widened, and straightened the Sammamish River. The project also included a low-water elevation control facility at the upstream end of the river, referred to herein as the weir, and a transition reach, referred to as the transition zone, downstream of the weir. As the local sponsor for the federal flood control project, King County assumed responsibility for maintenance and operation of the Sammamish River following the 1963 USACE dredging and realignment project (for additional information, see USACE 1965). The transition zone is important because it acts as the primary control for the lake outlet, with the weir limiting the low summer lake level.

The Sammamish River transition zone is located entirely within Marymoor Park, a 642-acre King County multi-use park in Redmond, Washington (Figure 1). A highly developed and heavily used recreational area lies on the northeast side of the transition zone. Park facilities immediately adjacent to the transition zone include a heavily used off-leash dog area, a parking lot, a mowed lawn area, and a covered picnic shelter. The park area to the southwest

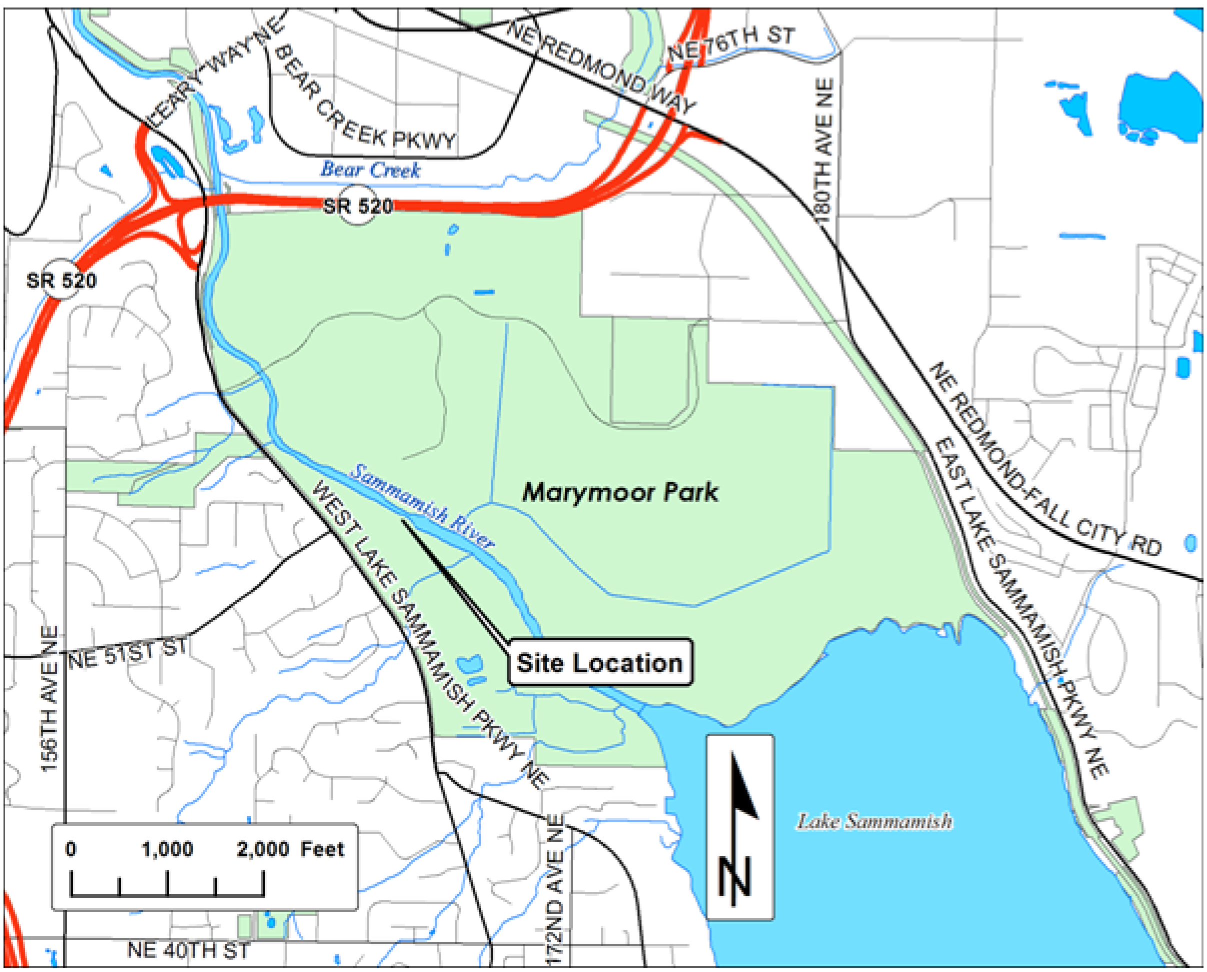


Figure 1. Site Location.

of the transition zone is undeveloped and used primarily for passive recreation. Much of this left-bank area is wetland that is heavily infested with invasive reed canarygrass. West Lake Sammamish Parkway is located 200 to 600 feet southwest of the transition zone. The study area is located in Sections 11, 13, and 14, in Township 25 North, Range 5 East, Willamette Meridian.

The transition zone is 1,432 feet long, designed with a 12-foot wide low-flow channel and a 200-foot wide high-flow channel (Figure 2). It is located between river mile (RM) 12.5 and RM 13.0.

The transition zone has a relatively steep gradient of about 0.47 percent, falling 6.75 feet in 1,432 feet. The Sammamish River downstream from the north end of the transition zone to the mouth at Lake Washington, has an average bed slope of 0.019 percent, falling 12.7 feet in 13.25 miles. Between the upstream end of the transition zone and the outlet of Lake Sammamish, approximately 3,000 feet, the channel is essentially flat and has been over excavated 5 feet to minimize head loss.

The 1964 design criteria of the weir and transition zone were to provide an outlet from Lake Sammamish into the improved river channel that would pass the spring design flood of about 1,500 cfs (including Bear Creek, Redmond discharge) after March 1st without exceeding a lake elevation of 29.0 feet NGVD29 (or NGVD88 equivalent of 32.57 feet) (USACE 1962 as cited in Chin et al. 2003).

In July 1998, the USACE replaced the 1964 weir with a new weir structure that included a higher elevation sill and a lower elevation low-flow notch (Figure 2; also see Appendix 8). The purpose of the project (known as "1135 project, a Project Modification for the Improvement of the Environment") was to facilitate passage of spawning salmon during periods of summer low flow.

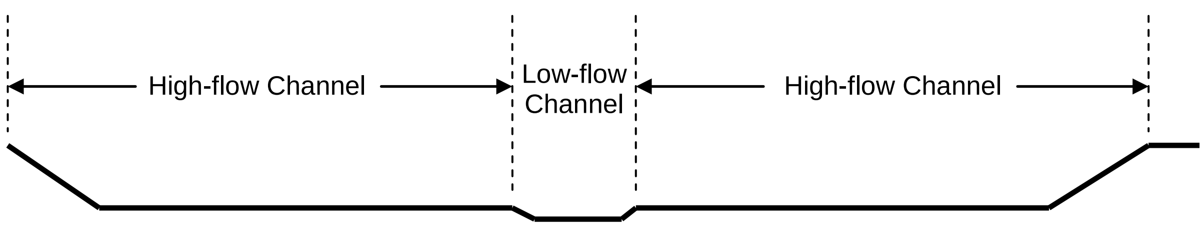


Figure 2. Typical transition zone design cross-section.

2.1 Channel Design and Sediment Accumulation

The USACE's "as built" channel improvement drawings, dated May 10, 1965, show that quarry spalls were placed across the entire floor of the transition zone on a gravel liner and up the side slopes to 28.0 feet elevation NGVD 29. The original design had called for a gravel surface on the outer 50 feet of the high flow channel. Grout was included with the quarry spalls at the weir. The as-built drawings do not record finished elevations.

During August 2011, a sediment accumulation study (Timm 2011; see Appendix 5) was undertaken in the channel and floodplain of the Sammamish River transition zone as the first step to evaluate the feasibility and effects of sediment removal. Sediments on established cross-sections were probed to obtain the elevation of the quarry spall surface below the sediments. Eight cross-sections, ranging in length from approximately 175 feet, on cross-section 1, to more than 250 feet, on cross-section 8, were surveyed during the study (Figure 3). Cross-sections 3 through 8 were downstream from the weir and were accessed by wading. A Trimble survey-grade real time kinematic global positioning system was used to reoccupy positions from the flood insurance study (NHC 2010) and to measure ground surface elevations to sub-centimeter accuracy.

Through most of the transition zone, the quarry spall (small-sized rock) surface is likely a very good representation of the true “as built” elevations. It is a more irregular surface than planned in the design drawings, and slopes and elevations differ from the design drawings.

Illustrations of the design and surveyed cross-sections are in Appendix 6.

Sediment accumulation depths were measured in 2011 as close as possible to where previous bed surface elevation measurements had been made for the flood insurance study (NHC 2010). Sediment depths were measured by driving a 3/8-inch diameter steel rod through sediments at each location until the underlying hard surface positively stopped the rod. Depths of sediment were measured to the nearest half inch and recorded.

The mean depth of sediment on the high flow channel outside of the low flow channel buffer between cross-section 3 and cross-section 8 is estimated to be approximately 8 to 9 inches. This range was calculated by linearly interpolating the depths measured on the established cross-sections across the area between the cross-sections (Appendix 5).

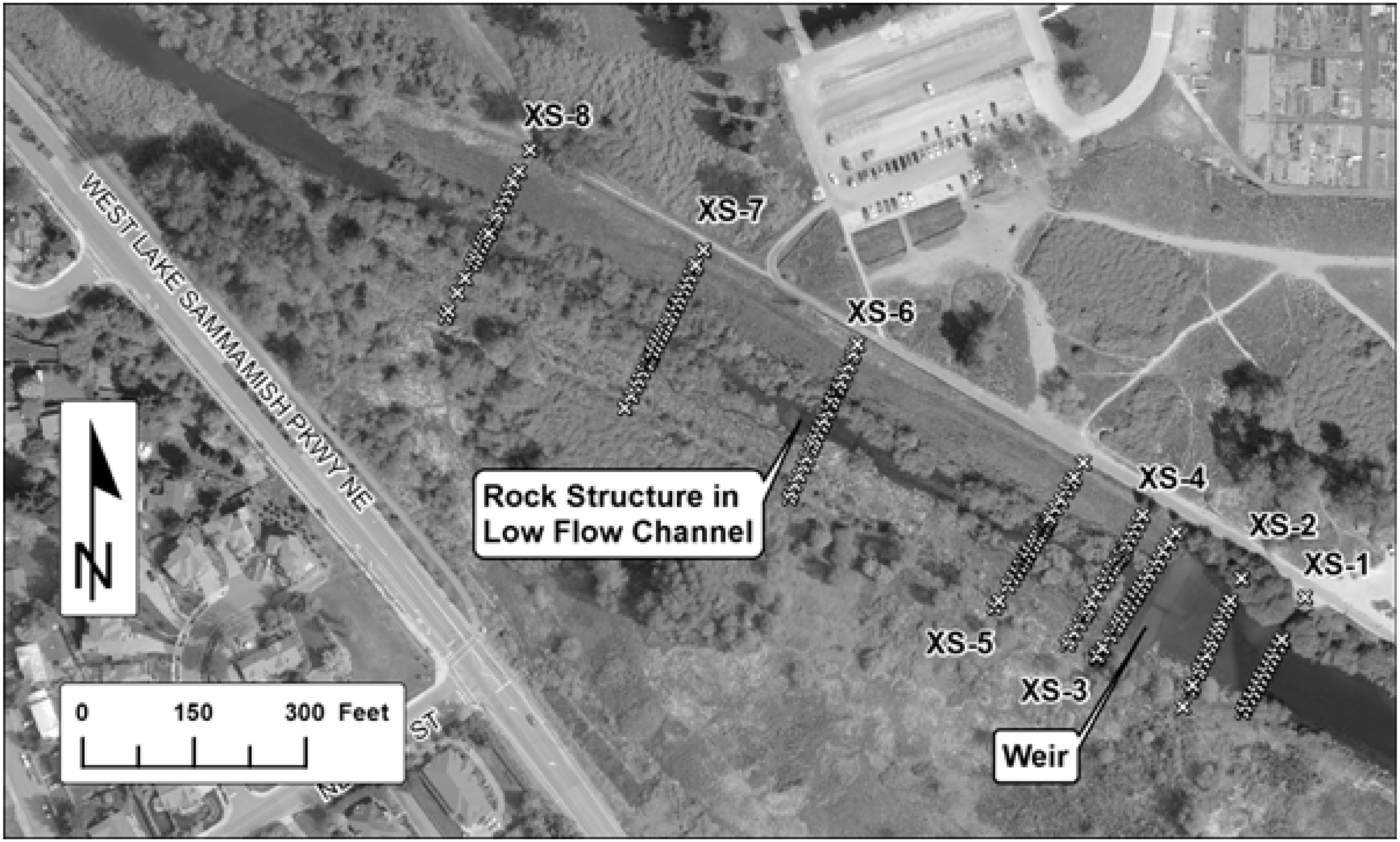


Figure 3. Positions reoccupied during sediment survey plus other points of interest.

2.2 Hydrology

King County reviewed previous studies on the Sammamish River (USACE 1974; Northwest Hydraulic Consultants 1991; USACE 1997; USACE 2001; West Consultants 2004, all as cited in Chin et al. 2003). Some highlights from the earlier work are applicable to the current analysis:

- The Sammamish River is a backwater system, which means that features downstream in the river can affect water levels upstream in the river.
- During higher flows, the lake levels are largely affected by flows in Bear Creek, Redmond.
- Transition zone vegetation can provide a resistance to flow and consequently affect lake elevations during lower flows.

2.2.1 Obstructions in the Low Flow Channel

During the 2011 survey of the transition zone (Appendix 5), a rock structure was found in the low flow channel immediately downstream from NHC cross-section 6. The structure is built of rock and anonymously constructed about 550 feet downstream of the weir. It is close to 2 feet tall at the center, 50 feet wide across the low flow channel and 10 feet wide in the direction of flow. The structure was likely constructed informally by local citizens or youths.

2.2.2 Sammamish Weir 1135 Project – 1998

The weir was altered in 1998 by the USACE. The record drawings for the weir alteration can be found in Appendix 8. The 1998 modified weir is the existing condition used in the Hydraulic Model. See Section 3 for discussion of the hydraulic model.

The weir reconfiguration narrows the area through which low flows pass; therefore, it may take more time to pass a given volume of water at low flows.

2.3 Natural Resources

This section provides a brief summary of the natural resources in the transition zone of the Sammamish River (WRIA No 08.0057, Type S water). It is a first-level evaluation of resources necessary to assess potential temporary and permanent construction impacts and related mitigation options and permit requirements.

2.3.1 Aquatic Resources

There is approximately 0.4 acre of stream surface area at low flow in the transition zone. This surface area includes 79 percent riffles and 20 percent glide habitat (Chin et al 2003). The entire project area is a constructed USACE facility that now contains fish habitat features not found elsewhere in the 13-mile length of the Sammamish River. The forested riparian area is only 10 feet wide on each side of the low-flow channel, and the only trees or shrubs present are willows. The proposed project site, which is limited to the high-flow channel, has flow from approximately 9 - 10 months of the year to year-round, depending on the specific location. When these areas are flowing in the fall, winter, and spring, they offer a network of side channels and back-water channels through the reed canarygrass and willow roots that function as off-channel fish rearing and refuge area for juvenile salmonids (Figure

4). During high-flow events the high-flow channels likely offer adult salmonids holding and refuge habitat. This type of off-channel habitat is rare in the Sammamish River, as the rest of the length of the river is largely confined to a constructed trapezoidal single-thread channel.

Figure 4. Weir (showing low-flow notch) as well as channels through willows and reed canarygrass (2009 aerial imagery).

The transition zone's off-channel habitat within the vegetative buffer and several side channels adjacent to the buffer is protected from the high velocities of the center low-flow channel and may provide hydraulic refuge for fish. The high-flow areas are likely to offer forage opportunities for juvenile salmonids as well. Floodplain wetland habitats (even intermittently inundated) in the western U. S. have been shown to be utilized by salmonids and to enhance salmonid growth and survival (Baker 2008; Henning 2004; Henning et al. 2006; Henning et al. 2007; Sommer et al. 2001a; Sommer et al. 2001b; Sommer et al. 2005). The quality and fish use of the off-channel areas in the transition zone likely decreases with increasing distance from the low flow channel. The highest quality fish habitat lies within and at the edge of the willows along the low flow channel edge (Appendix 5). Conditions on the site were recently modified (increased mowing and some willow cutting; mitigation willow planting in the transition zone) after the 2011 survey was done.

In addition to the river, three small tributaries to the Sammamish River are located on or within the immediate vicinity of the proposed project site. Tributary 0141 (Type F water; Figure 5) discharges from the left bank of the river upstream of the concrete weir. Two small unclassified, seep-fed perennial streams (marked 1 and 2 in Figure 5) discharge underneath West Lake Sammamish Parkway into the wetland marked A in Figure 5. These two streams flow into Wetland A and emerge across the left riverbank high flow channel within the project site, and appear to join to flow into the river near the downstream end of the transition zone.

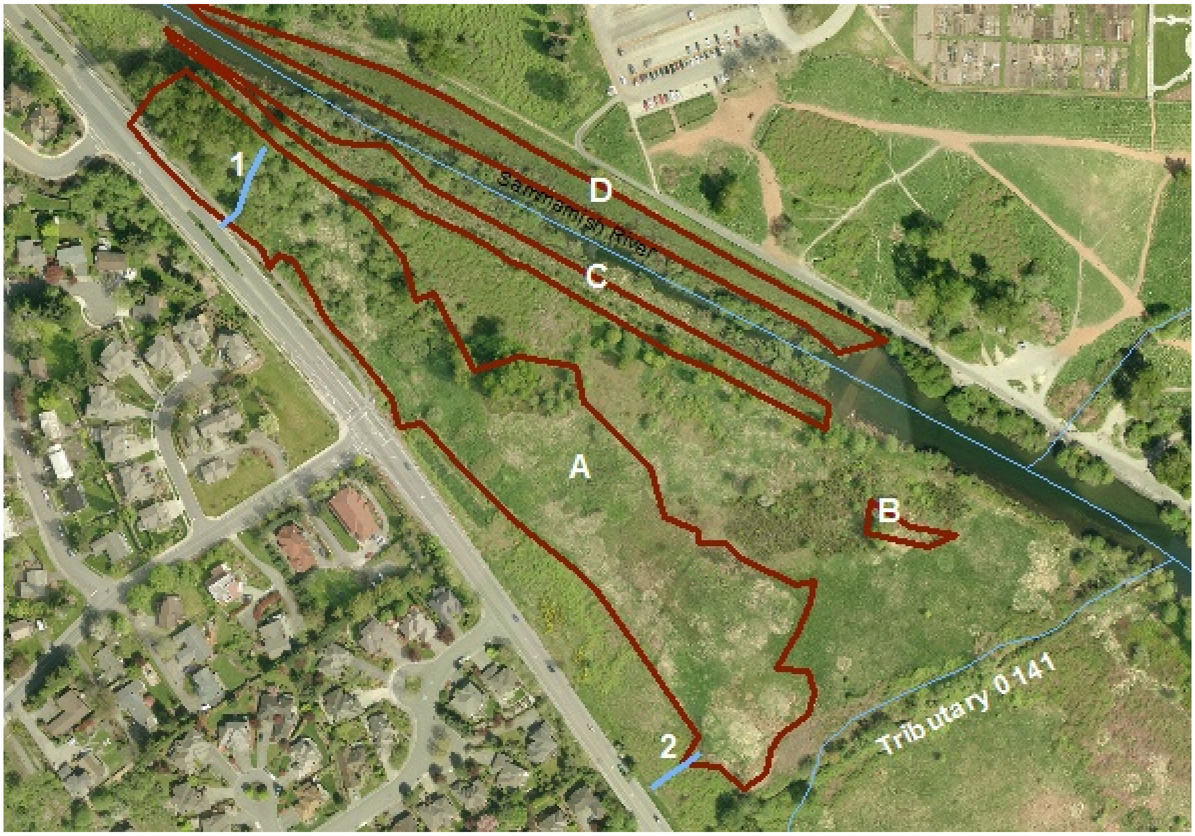


Figure 5. Streams and wetlands in the project site area (based on Chin et al. 2003). Streams are blue lines and wetlands are outlined in red.

2.3.2 Wetlands

Two of four wetlands are located in the project site (Figure 5; also see Appendix D in Chin et al. 2003). Two wetlands, labeled C and D in Figure 5, parallel the river in a narrow band along each bank in the high flow channel and are underlain by quarry spall liner as defined components of the USACE Transition Zone Facility. These wetlands are palustrine scrub-shrub/emergent wetlands. They are riverine flow-through wetlands under the HGM system, are 0.83 acres and 0.83 acres in size, respectively, and are WDOE Category 1 and King County Class 1 wetlands (Chin et al. 2003). To date, these wetlands have not been categorized or rated with the current Critical Areas Ordinance system.

The wetlands labeled A and B are outside the proposed project area and outside the transition zone facility foot print.

2.3.3 Channel Vegetation and Willow-retention Buffer

Vegetation in the high-flow channel of the transition zone is dominantly either reed canarygrass or willow shrubs. The reed canarygrass is distributed throughout the high-flow channel and is generally landward of the willow shrubs, which are prevalent adjacent to the low-flow channel.

The willow-retention buffer was created in consultation with USACE with the goal of retaining a10 foot swath of willow stems on both sides of the low flow channel. In fact, because of the natural variance in willow survival and growth structure and the dynamic meander pattern of the river bank, the willow buffer meanders and is not always exactly 10 feet from the edge of the low-flow channel. In some cases the buffer begins immediately adjacent to the low-flow channel, whereas in some places it starts several feet landward of the channel. The buffer is sometimes divided by a side channel within which willows do not grow; this sort of division results in a buffer zone split on either side of a side channel and therefore possessing a wider horizontal distance than 10 feet stem-to-stem. Additionally there is an overhead canopy approximately 30 feet wide associated with the 10 foot swath of willow stems. Because of all these factors, the buffer may appear significantly greater than 10 feet wide in some areas. However, the buffer is carefully measured each summer before trimming to ensure the stem-to-stem distance of the buffer remains as close to 10 feet as possible.

An existing maintenance access road that runs parallel to the left bank has not been used in many years and is overgrown with shrubs and some trees (Appendix 4, map 2).

2.3.4 Fish and Wildlife

Several species of salmonids use the Sammamish River for migration or spawning, including Chinook, coho, sockeye, and kokanee. Puget Sound Chinook are listed as threatened under the Endangered Species Act (ESA). Puget Sound steelhead trout, listed as threatened under the ESA, historically utilized the Sammamish River Basin, including Issaquah Creek upstream of the project site. Steelhead trout juveniles rear for 2 years in freshwater prior to ocean migration. However, steelhead trout have not been documented in the upper Sammamish River basin since spring 2000 in Issaquah Creek by professional surveyors (Berge, H., pers. comm.).

Several large pools located just downstream of the transition zone were identified by Houck et al. (1988). Large pools are uncommon in the Sammamish River but are important habitat for Chinook salmon. One pool, “Upper Marymoor,” was measured to be 8.4 feet deep, 50 feet wide, and 98 feet long, and another pool, “Lower Marymoor,” was measured to be 8.4 feet deep, 40 feet wide, and 305 feet long. On September 16, 1998, 200 adult chinook were observed holding in the Upper Marymoor pool, and 30 chinook were observed holding in the Lower Marymoor pool (Chin et al. 2003).

Use of the project area wetlands and stream corridor by birds is high. The forested wetland and upland areas near the transition zone provide cover, forage, nesting, and rearing habitat for many species of birds (Chin et al. 2003). Michael Hobbs, a Master Birder with Seattle Audubon Society, has logged over 300 hours birding in Marymoor Park, including along the transition zone, over the past 18 years. He provided information on what bird species use the transition zone year-round; a sampling of the most common birds present in the summer are noted here.

Some bird species are present year-round and are known as resident species. Great Blue Heron are residents and are commonly found along the edges of the main channel feeding as well as wading through puddles and channels in the mowed areas and in the willows. Black-capped Chickadee, Bushtit, Bewick’s Wren, Golden-crowned Kinglet, Ruby-crowned

Kinglet, American Robin, Song Sparrow, Dark-eyed Junco and Red-winged Blackbird are commonly seen in the willow strip. Marsh Wren breeds in the cattails along the willow strip edge and remain there all year.

Birds present in the transition zone willows during only the summer breeding season include Cedar Waxwing, Common Yellowthroat, and Yellow Warbler. Willow Flycatcher is a late-arrival for breeding and can be found in the willows. Barn and Cliff Swallows may be mixed in with the Tree and Violet-green Swallows foraging above the willows in the summertime. Vaux's Swift, a state candidate species, are also present in small numbers (1-5) just about any time swallows are present.

Use by small mammals, reptiles, amphibians, and invertebrates has not been surveyed but is expected to be moderate to high.

2.4 Archaeological Resources

Archaeological investigations in the Marymoor area suggest that the area around the outlet of Lake Sammamish has a long history of occupation by native peoples, dating back as much as 6,000 years. At the time of European settlement in the Puget Lowland, the area around the Lake Sammamish Area was occupied by the Sammamish band of the Duwamish Tribe.

Productive archaeological digs have been conducted in the immediate vicinity of the Sammamish River transition zone in Marymoor Park. These digs have revealed several thousand Native American artifacts, including numerous worked stone points and tools. The Marymoor site was placed on the National Register of Historic Places in 1970, because of its significance as an archaeological resource (Chin et al. 2003). However, the entire proposed project area has likely been previously disturbed, with the native soils graded, then covered with non-native soils (a gravel layer topped with a quarry spall layer). No excavation is proposed below the USACE-placed quarry spall liner in the transition zone.

3 Hydraulic Effectiveness of Sediment Removal Study

The proposed project consists of sediment and debris removal from the transition zone outside an established willow-retention buffer and removal of the small rock structure located in the low-flow channel 550 feet downstream from the weir. Hydraulic modeling was conducted to evaluate the effectiveness of the proposed maintenance. A full report on this modeling work can be found in Appendix 9. This recent modeling uses the NAVD88 vertical datum, whereas the original USACE project used the NGVD29 datum. See Special Note on page iii.

3.1 Existing Conditions Hydraulic Model Development

Northwest Hydraulic Consultants (NHC) conducted the Sammamish River Flood Insurance Study (FIS) and authored their Floodplain Mapping Study for the Sammamish River (see NHC 2010). In order to calculate and map the flood areas for the mapping study, NHC built a model, a Hydraulic Engineering Center - River Analysis System (HEC-RAS) model. The hydrology and most of the hydraulics from the NHC's 2010 HEC-RAS model was used to hydraulically model the effects of the proposed maintenance project on the Sammamish Lake water surface elevations.

NHC's work included modeling the hydrologic inputs to the Sammamish Basin using Hydrologic Simulation Program – Fortran (HSPF) models for catchments in the Sammamish Basin. Flow hydrographs[1] of the catchments derived from the HSPF models were then routed[2] to the Sammamish River using an unsteady flow HEC-RAS model to derive the amount of flow in the Sammamish River. NHC used results of the models to determine quantile flows for the river (i.e., 10-, 50-, 100-, 500-year exceedance period flows). NHC applied these flows to floodplain mapping, again using HEC-RAS (but this time, a steady-state HEC-RES model was used for each quantile).

The 2010 NHC HEC-RAS steady state model was updated with 2011 survey data acquired for this report (Appendix 5) from within the transition zone, and the model was recalibrated using new, observed stage-discharge readings at the weir. The 2011 survey included the informal rock structure in the low flow channel about 550 feet downstream of the weir. The rock structure is close to 2 feet tall at the center, 50 feet wide across the low flow channel and 10 feet wide in the direction of flow. Two new cross-sections were added at the structure.

Other than the two new cross-sections, the 2011 survey occupied the same cross-section points used in the 2010 NHC HEC-RAS model (Figure 3), and the identical cross-sections incorporated the addition of the underlying quarry spall layer surface elevations to the model. Sammamish River roughness values, bank station locations, and boundary conditions established for the NHC model were retained in the current study.

Scenarios were employed in the model to represent two proposed maintenance components, removal of the small rock structure in the low flow channel, and sediment and debris removal

[1] A flow hydrograph is a graph depicting the rate of flow over a period of time past a specific point in a stream or river.

[2] "Routed" means the translation of the hydrograph from one point to another – in this case, it is the translation of the hydrograph from a catchment's discharge point to the Sammamish River.

outside the willow-retention buffer. These components were each modeled individually in order to evaluate the hydraulic effect of each component and then combined. The scenarios modeled were:

1. Removal of small rock structure in the low flow channel.
2. Sediment and debris removal outside the willow-retention buffer.
3. Removal of small rock structure in the low flow channel and sediment and debris removal outside the willow-retention buffer.

3.2 Model Calibration

Calibration of the model was targeted on the transition zone to match modeled flows to observed flows associated with stage measured at the Sammamish River transition zone gage at the weir (King County gage 51m, Figure 6). Measurements of low flow were taken at the transition zone weir, and measurements of high flows were taken at the downstream bridge.

The calibration method used a HEC-RAS *Vertical Variation in Manning's Roughness Values* table for the 10 cross-sections in the transition zone. This calibration method was selected because it was the same method used in a 2004 hydraulic study of the transition zone and applied to the 2010 FIS, and because it is an industry standard. This method was also chosen because it replicates the site physical condition in which the mid-channel willows apply greater resistance to flow above an elevation of 24.5 feet NAVD88.

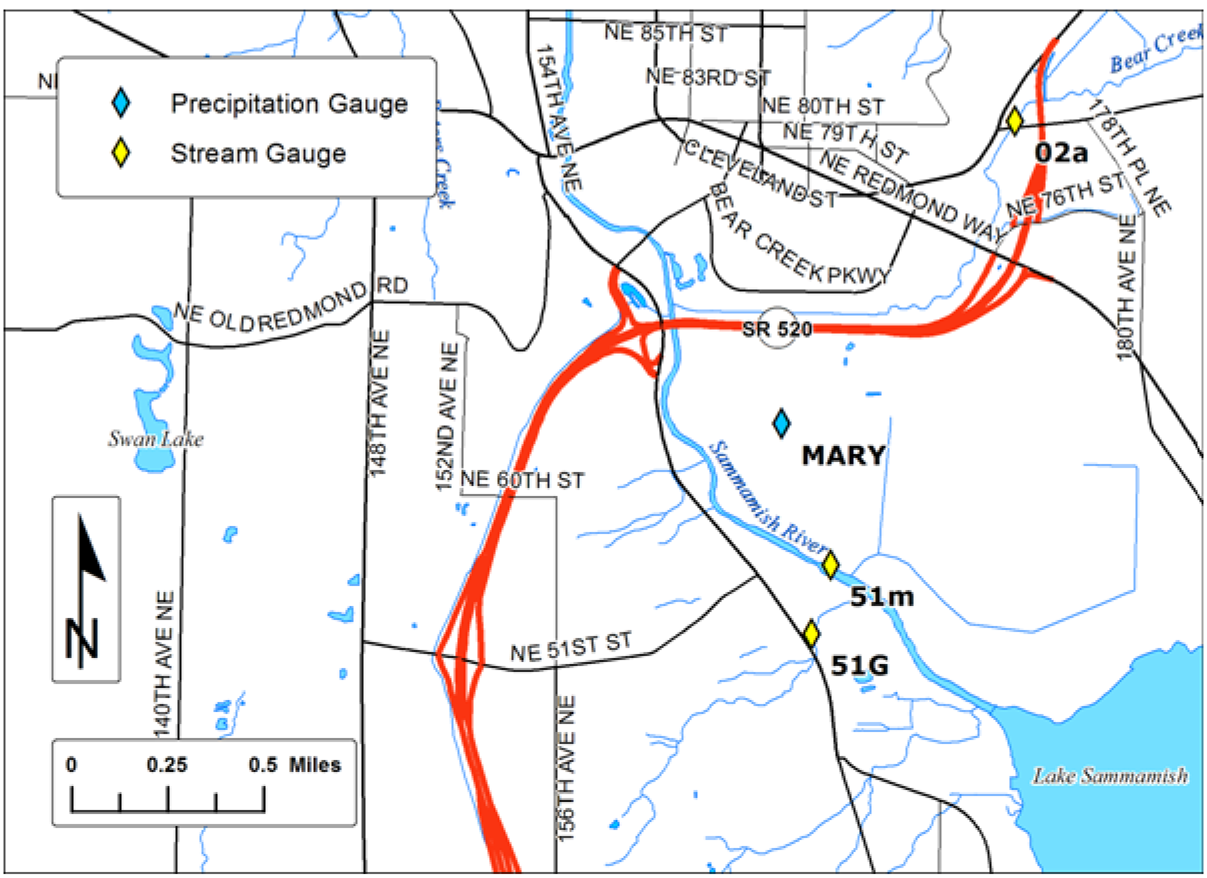


Figure 6. Gage locations. Note: MARY is Marymoor Park I&I Rain Gage.

The NHC calibration of the HEC-RAS model was the starting point for the updated model calibration. Table 1 shows a typical NHC vertical roughness table for the transition zone used in the HEC-RAS model. The two bold-numbered cells in Table 1 represent the mid-channel roughness due to willows above 24.5 feet NAVD88.

Table 1. Typical NHC transition zone vertical roughness table for transition zone.

	Left Floodplain		Channel	Right Floodplain	
Elevation (NAVD88)	Station 404-565	Station 565-595	Station 595-662	Station 662-690	Station 690-800
24	0.09	0.2	0.03	0.2	0.095
24.5	0.09	0.2	**0.09**	0.2	0.095
29	0.09	0.2	**0.09**	0.2	0.095

Our calibration method modeled transition zone hydraulics using recent observed flow rates, and iteratively adjusted the mid-channel willow roughness values to match model water surface elevations to observed water surface elevations at the gage located by the weir. The sum of model error[3] was reduced to zero in two steps of iteration. The mid-channel roughness above 24.5 feet NAVD88 was 0.09 from the NHC model. The first step of iteration increased mid-channel roughness above 24.5 feet NAVD88 from 0.09 to 0.13. The second step of iteration reduced the mid-channel roughness above 24.5 feet NAVD88 from 0.13 to 0.11. See Appendix 9 for more details on the iterative process.

Once the existing (baseline) conditions model was prepared, the information from the existing model was used as a comparison to evaluate the maintenance scenarios. There was also interest in comparing the hydraulic properties resulting from the 1964 construction of the transition zone. A "1964" HEC-RAS model was created using the 1964 weir as-built plans and also using the 2011 survey of the quarry spall elevations along the transition zone. The 1964 model does not include the existing rock structure near cross section 6 (about 550 feet downstream of the sill) or the existing willow stands. It was assumed that the 1964 project site would inevitably grow a thick reed canarygrass stand, so the 1964 model used the reed canarygrass roughness factor for the overbank area.

The model calibration modifications were limited to change in roughness coefficients, which are used to differentiate the channel roughness, the willow roughness and the reed canary grass roughness. The 1964 model uses the same 0.03 channel roughness as the existing conditions model, but replaces the willow stand roughness of 0.20 to 0.09 as the 0.09 value is used to model reed canarygrass. The roughness values used in the model were based on work by NHC (2010) and West Consultants (2004).

[3] The difference between the measured water surface elevation and the modeled water surface elevation.

3.3 Proposed Maintenance Scenarios Hydraulic Model Development

The HEC-RAS models for the proposed maintenance scenario were developed from the calibrated existing-conditions model. The scenarios modeled were:

1. Removal of small rock structure in the low-flow channel.
2. Sediment and debris removal outside the willow-retention buffer.
3. Combined removal of small rock structure in the low flow channel and sediment and debris removal outside the willow-retention buffer.

To evaluate the hydraulic effect of removing the rock dam from the low-flow channel, the cross-section of the crest of the rock dam (RM69353.95) was modified such that the channel bed was the same as the next downstream cross-section (RM69348.35), at the elevation of the toe of the rock (Scenario 1).

To represent excavation of sediments down to the quarry spall layer outside the willow-retention buffer, surveyed elevations of the quarry spalls were substituted into the calibrated model (Scenario 2). Roughness values were kept the same under the assumption that reed canarygrass would grow back and establishing the same hydraulic roughness as in the existing conditions model.

Cross-section surveys are shown in Appendix 6, with the existing topography at a generally higher elevation and the rock spall topography generally at a lower elevation outside the buffer. See Appendix 6 for complete topography and depths of sediments measured at each section.

3.4 Hydraulic Effects of Sediment Removal: Model Study Results

Results of both the steady-state and the continuous-flow models are presented in this section. The steady-state model was used for most model runs because it can provide quick comparisons of flow characteristics under different conditions such as different flow rates or cross-sectional area with sediment removal. Once this work was completed, a continuous (or unsteady flow) model was run for one water year (2009) to represent how the lake level might be affected over the entire year.

3.4.1 Steady-state Model

Table 2 displays the steady-state model results for the hydraulic effects that the maintenance scenarios will have versus the existing conditions. The results show a reduction in lake levels varying from less than a tenth of a foot (0.05 ft) to less than 3-tenths (0.27 ft). Note that the greatest change in surface elevation occurs at the moderate flow rate of about 750 cfs as opposed to the highest or lowest. At this flow rate, the overbank area is inundated by a few inches, therefore resulting in proportionally greater increase in flow area as the sediments are removed. Similarly, at low-flow conditions, most of the flow is concentrated in the low-flow channel and sediment removal will have very little effect on the channel flow area. At higher flow rates, the overbank area is occupied, but the area of sediment removal is a relatively smaller percentage of the overbank flow area.

Table 2. Summary of lake water surface elevation changes.

	Lake water surface elevation NAVD 88	change in water surface elevation	Lake water surface elevation NAVD 88	change in water surface elevation	Lake water surface elevation NAVD 88	change in water surface elevation
Flow rate, cfs (quantile)	**1,649**	(100-yr)	**1,530**	(50-yr)	**1,233**	(10-yr)
Existing	36.20		35.72		34.53	
Scenario 1: Existing without rock dam near XS-6	36.20	0.00	35.71	-0.01	34.53	0.00
Scenario 2: Sediment removed from outside buffer	36.15	-0.05	35.64	-0.08	34.43	-0.10
Scenario 3: Combined maintenance scenarios	36.15	-0.05	35.64	-0.08	34.43	-0.10
Flow rate, cfs	**1,000**		**750**		**300**	
Existing	32.93		32.17		31.01	
Scenario 1: Existing without rock dam near XS-6	32.93	0.00	32.16	-0.01	31.01	0.00
Scenario 2: Sediment removed from outside buffer	32.67	-0.26	31.91	-0.26	30.81	-0.20
Scenario 3: Combined maintenance scenarios	32.67	-0.26	31.90	-0.27	30.81	-0.20

3.4.2 Continuous-flow Model

The continuous-flow model was run by taking the existing conditions model and running it for a continuous period of time during 2009 using the HEC-RAS Unsteady Flow Analysis routine, which is a 1-D model that allows for time-step calculation of flows. Unlike the steady-state model, the time-step calculation model allows for the addition of storage and temporal routing of flows. The two most important differences of the continuous model is it can calculate the stormwater detention effect of Lake Sammamish as it stores then releases flows to the Sammamish River. The second important difference is the continuous-flow model can import previously recorded inflows from tributaries such as Bear Creek for gaged periods of record; in this case the 2009 water year was chosen because the gage data is available, because it was a moderately wet winter, and because most of the residents can recall the weather conditions.

The purpose of the unsteady model was to run the complete, available historical flow and rainfall data to re-create the complex interaction of Lake Sammamish and Bear Creek flows. The Sammamish River hydraulic conditions generated from the interaction of known hydraulic and hydrologic components such as the backwater created by the Lake Sammamish tributary inflows, the available Lake Sammamish storage volumes, and all the tributary inflows. This model will provide a good comparative estimate of the difference between the existing conditions versus the proposed maintenance scenario.

Figure 7 shows the continuous model output for the existing and maintenance scenarios. The model shows the peak lake elevation for the 2009 water year would be reduced by 0.2 feet, but the difference in the lake elevation reduction would diminish into the spring as the rainfall events subsided. The results of the continuous model are similar to those of the steady-state model, with the continuous model showing a slightly lower reduction in lake surface level. However, given the different nature of the model with input flows varying with time, this difference is reasonably close.

Figure 8 shows the actual lake elevations from the USGS Lake Sammamish gage #12122000 for water year 2009. Note the elevations in this figure are based on the NGVD29 datum, which is 3.6 feet lower than the NAVD88 datum used in the model; the peak lake elevation from the gage would then be just over 33.6 feet NAVD88 and the above output from the model shows it to be close to 32 feet. The difference between the continuous simulation model shown in Figure 7 and the gage data shown in Figure 8 reflects the fact that the model was not calibrated for lake levels. The original intent of the model for the FIS was as a tool to develop flow rates entering the Sammamish River, not to determine lake levels. However, as a tool for this study, the continuous simulation was used to show the effects of sediment removal over an entire water year. The results are consistent with the steady state results as a measure of the changes resulting from the maintenance work.

Model output can also be compared to the measured lake elevations at King County gage #51m, which is located at the transition zone sill. The sill is considered to be the outlet control boundary of the lake, but it can vary in elevation relative to the lake from 0.1 to 0.3 feet depending on flow conditions. On average the difference is about 0.2 feet. In other words, the gage accurately represents lake levels at the weir, but at other locations the lake level may vary slightly.

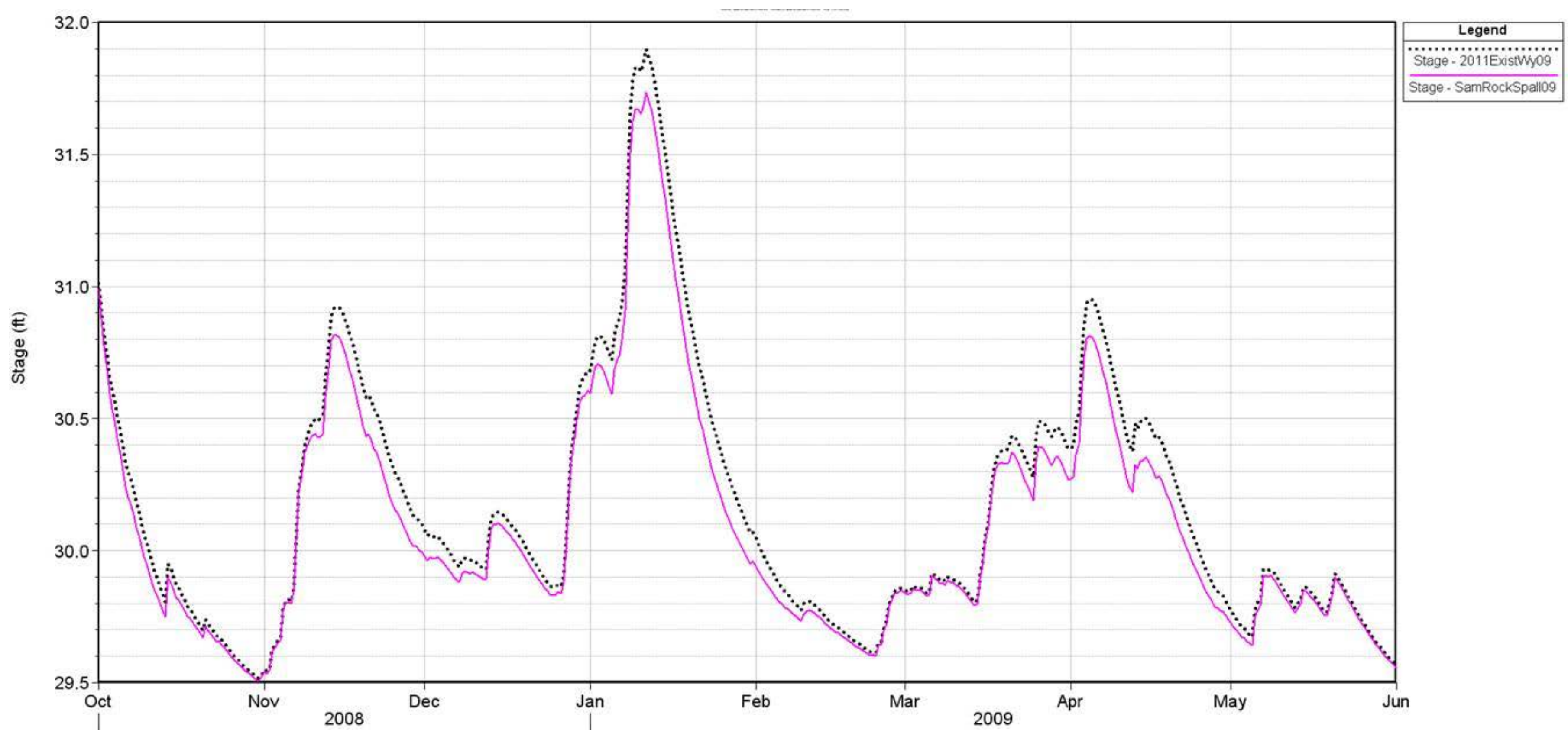


Figure 7. Lake Sammamish continuous model hydrographs.

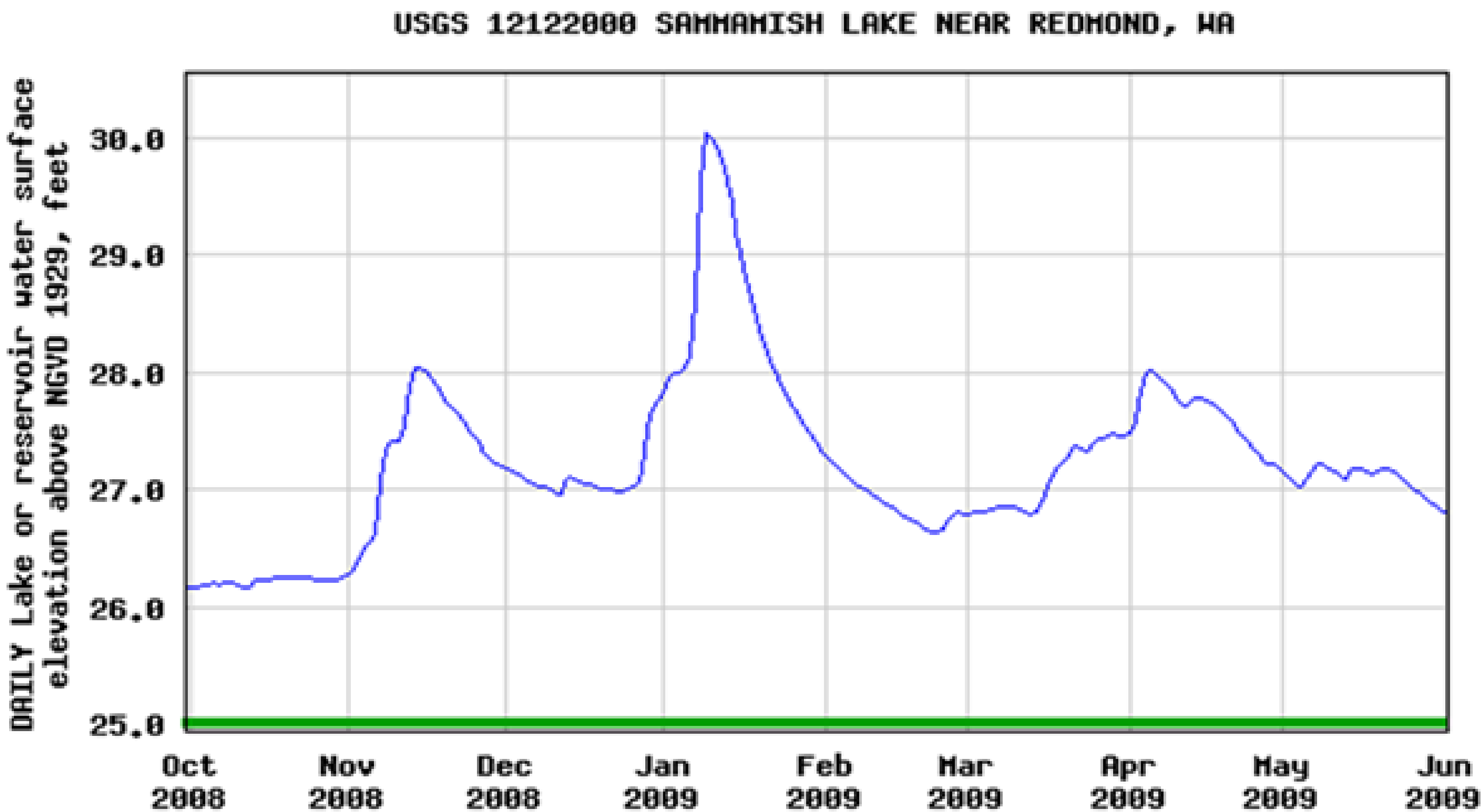


Figure 8. Observed Lake Sammamish stage measurements for water year 2009 (based on the NGVD29 datum; for NAVD88 datum, add 3.57 feet).

4 Environmental Effects Analysis of Sediment Removal Project

The total disturbed area within King County Critical Areas would be approximately 3.15 acres and would include the Sammamish River and riparian areas, tributaries, and wetlands. Potential impacts to aquatic habitat, wetlands, vegetation, and fish and wildlife are examined in this section.

Note that these impacts would potentially require mitigation, preferably onsite. If an off-site location were used for mitigation and the fall 2012 willow trimming and reed canarygrass mowing mitigation ratios apply to this action, then the mitigation area would be calculated as twice that of the area of project-induced disturbance (see King County Critical Areas Ordinance, 21A.24.380.E).

4.1 Aquatic Habitat

The existing seasonal off-channel and side channel areas on the left and right banks will be graded and flattened by the proposed project. Grading of these areas, which are inundated from 9 - 10 months of the year to year-round, will reduce their complexity.

Additionally, the rock structure constructed within the low-flow channel has backed up river flow and created a series of side channels that flow year-round on the left high-flow bank. These channels provide valuable and rare low-flow off-channel rearing habitat (Appendix 5). The entire length of these channels (estimated to be approximately 800 ft cumulatively) will likely be eliminated during the proposed sediment removal operation and would likely need to be mitigated.

During his field survey in August 2011, Ray Timm, Fisheries Scientist in the King County Water and Land Resource Division – Scientific and Technical Support Section, observed evidence of upwelling near the downstream-most cross-section (8) in the low-flow channel. The upwelling could provide valuable thermal refuge particularly during parts of the year when high temperatures are a known problem in the Sammamish system. To the extent that the proposed project area may provide groundwater flow supplying this upwelling, the temperature and quantity of the cool hyporheic flow could be negatively affected by excavation. Additionally, when inundated with flowing water, the freshly disturbed area could potentially release sediment and turbidity downstream into the Sammamish River.

The beaver activity in the transition zone (see the Fish and Wildlife section below) has likely had a negligible impact to overall hydraulics. No beaver dams exist in the area. Transportation of some willow branches by beavers has altered hydraulics at a very fine scale and locally caused flows to move around the willows to create and maintain small side channels outside of the engineered low-flow channel (R. Timm, pers. comm.).

4.2 Wetlands

Wetlands outside the constructed channel will likely not be impacted by the project.

The two wetlands in the constructed channel (labeled C and D in Figure 5) would have their vegetation scraped from them. It is assumed that all impacts of removing reed canarygrass would be temporary, as the invasive species would grow back. In the interim, summer temperatures would increase in any wetted remaining in the project areas, as reed canarygrass is effective in shading. Because most of the project area is expected to be dry during implementation, little to no impacts to water temperatures in the wetlands would be expected. Additionally, a potential reduction in filtering of nutrients and toxins, metals, and other pollutants may occur with the removal of the reed canarygrass.

4.3 Vegetation

The reed canarygrass that would be removed would presumably grow back, as it is an invasive species that is essentially impossible to eradicate without very aggressive and deliberative removal actions. Willows will be left intact.

The over-grown access road would need to be put back into service to implement the sediments removal project from the left-bank high-flow area. Re-commissioning the road would require clearing of scattered existing voluntary native vegetation (shrubs and trees), and this vegetation removal would require additional mitigation for impacts within the regulated buffer.

4.4 Fish and Wildlife

If the sediment removal area is lowered to a level that creates surface flow during the warm months of summer, increased water temperatures may result that could exacerbate already near-lethal temperatures in the Sammamish River during adult Chinook salmon upstream migration. In the Sammamish River, water temperature is the most significant limiting factor to salmon species: water temperature affects the reproductive health and survival of all adult salmonids entering the basin and affecting smolt migration and habitat suitability for juvenile rearing (Martz et al. 1999). Any potential temperature impacts of the proposed project could directly impact adult fish headed to spawning grounds and temporarily holding in these large pools. Additionally, the willows are productive fish habitat for juvenile salmon across a broad range of flows because they provide refuge and the salmonids are better able to feed, hide, and migrate upstream and downstream.

Impacts to birds should be minor, assuming any mowing and sediment removal would take place during August/September, after nesting is complete. Most bird use of the area should be in the willows, but birds using the reed canarygrass should be mobile and finished with nesting before work is done to avoid potential impacts to ground-nesting birds.

As with birds, amphibians would be finished breeding by August/September, so any eggs would already be hatched and therefore should not be impacted. It is possible some adult amphibians might be killed as a result of the proposed project.

There was evidence that beaver are present in the Sammamish River transition zone and had been cutting down some of the willows along the channel margins and had moved some of the branches into places where they trapped debris, other cuttings, and organic material (R.Timm, pers. comm.). Because the willows will not be removed, beavers are not likely to be impacted.

4.5 Archaeological Resources

Because the entire proposed project area has likely been previously disturbed, no impacts to archaeological or cultural resources are anticipated.

5 Permit Requirements

The following permits and other environmental reviews are likely to be required for the proposed sediment and debris removal project in the transition zone high flow channel (which encompasses waters of the U.S.). Exemptions to permits or environmental review processes are also noted.

- King County Parks Special Use Permit.
- King County DDES Clearing and Grading Permit. This project is exempt as “maintenance or repair of flood protection facility” under KC Clearing and Grading Code 16.82.
- King County DDES Shoreline Exemption per direction of KC DDES.
- King County Flood Hazard Certification.
- King County Critical Areas Alteration Exception. This permit is not required per direction of KC DDES because the Sammamish transition zone was determined to be an “existing structure’ that qualifies as an allowed alteration for maintenance of “flood protection facility” per KCC 21A.24.045.
- Washington State SEPA Process with Public Notice.
- Washington State Department of Fish and Wildlife Hydraulic Project Approval.
- WDOE NPDES Construction Stormwater General Permit, including a Stormwater Pollution Prevention Plan.
- Army Corps of Engineers Clean Water Act (CWA) Section 404 Nationwide Permit 3 or 31.
- Army Corps of Engineers CWA Section 404 Individual Permit with Public Notice. The Corps Regulatory staff informed County staff that because of the project’s location within Section 10 jurisdiction, the project does not qualify for a maintenance exemption, and King County must obtain either a Nationwide or Individual Corps Section 404 Permit.
- Army Corps of Engineers River and Harbors Act Section 10 Permit. Corps staff and website documents the entire length of the Sammamish River (including the project area) as navigable, triggering this permit requirement.
- National Historic Preservation Act Section 106 Consultation with the Corp of Engineers, Washington State Office of Historic Preservation, and affected Tribes (likely Muckleshoot, Tulalip, Suquamish, and Snoqualmie).
- King County Landmarks Certificate of Appropriateness.
- Section 6(f) Land and Water Conservation Fund Act (LWCFA) Permit. Whether this permit is required depends on impacts to LWCFA properties.
- ESA Section 7 Consultation with U.S. Fish and Wildlife Service and National Marine Fisheries Service. Includes consultation with NMFS on Essential Fish Habitat under the Magnuson-Stevens Fishery Conservation and Management Act.

- Migratory Bird Treaty Act Approval; U.S. Fish and Wildlife Service.
- Bald and Golden Eagle Protection Act Approval; U.S. Fish and Wildlife Service.
- Washington State Dept of Ecology 401 Water Quality Certification Coordination with Muckleshoot Tribal Fisheries Division, Washington State Department of Natural Resources (WSDNR) Aquatic Lands Easement. This certification does not appear to be required at this time; however, this question may need to be revisited if this project proceeds. Cyrilla Cook, WSDNR Aquatic Lands Manager in Olympia informed County staff in February 2012 that an Aquatic Lands Easement would not be needed for this project. The design plans of the Corps of Engineers channel improvement project, dated April 30, 1963, show a segment of the pre-project Sammamish River channel alignment falling within the current proposal. According to WSDNR Aquatic Lands Managers, the location of the riverbed at statehood generally defines the jurisdiction of the WSDNR. This permit may only be needed for the small area on the left bank at the downstream end of the proposed sediment removal project.

6 Sediment Removal and Implementation Costs

In order to implement this sediment removal project, a track hoe and a Case 850 dozer would remove and stage sediments and debris within the toes of slope on the high flow channel. A long-reach track hoe and dump trucks would operate above the tops of bank to lift staged sediments and debris, and haul it. Paved trails would be protected from damage from tracks. Unimproved trails and roads would be lined with hog fuel, to create temporary construction access roads.

Super sacks or other temporary devices would be placed across the head of the work area to reduce the likelihood river flows would enter the work area in order to keep sediment disturbed during the project from moving downstream.

No equipment would be operated in or disturb the buffer or the low flow channel. The proposed maintenance is expected to take 3 to 4 weeks, to take place during summer low flows to minimize potential for sediments to impact the river.

Permission for access on the site would be needed from King County Parks and from the City of Redmond for use of their bike path easement on the left bank. Proper permits will be needed from applicable agencies (see Section 5).

Estimated total costs for sediment and debris removal range from $394,000 to $480,000 (Table 3).

Table 3. Cost estimates for sediment and debris removal.

Construction	Permitting	Total
$225,000	$169,000 to $255,000*	$394,000 to $480,000

* depending on Individual vs NW Corps permit; Substantial Shoreline Development Permit vs Shoreline Exemption; and Clearing and Grading Permit vs C & G Maintenance Exemption.

For a detailed construction cost spreadsheet, see Appendix 11.

Table 4 presents a brief summary of the estimated ranges of permit costs given the mixture of permits potentially required for this project, broken down into Low End (Complex) and High End (Very Complex). The low-end scenario could also be viewed as the best case permitting scenario, and the high-end scenario would be the worst case scenario. A very detailed breakdown of each permit for labor, environmental study costs, and estimated schedules can be found in Appendix 12[4]. These numbers represent an estimate only and made with the limitations of the current state of knowledge. Permit complexity and costs could be much higher given the uncertainties with the public notification for SEPA and Individual Corps permits.

[4] These estimates were assembled by Peter Drakos, Environmental Engineer II, and Tina Morehead and Howard Haemmerle, Senior Environmental Engineers, in coordination with environmental staff in the King County Roads Services Environmental Unit and Don Finney, Senior Ecologist in the Capital Services Unit.

Table 4. Estimated permit cost ranges.

Low End, Complex Permitting Scenario		High End, Very Complex Permitting Scenario	
County Labor-Permits/Approvals:	$83K	County Labor-Permits/Approvals:	$146K
Required Technical Reports Estimate:	$86K	Required Technical Reports Estimate:	$109K
Permitting Total Cost:	**$169K**	**Permitting Total**	**$255K**

The estimated total costs do not include cost estimate of on-site or off-site mitigation. These costs can include site acquisition, easements, permits, site preparation, plants and planting labor, and multi-year monitoring and maintenance of mitigation site(s). Depending upon regulatory agency requirements, total mitigation costs are expected to be between $50K and $150K.

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Appendices

Appendix 1. Lake Sammamish Flood Reduction Plan, April 2011

King County
Department of
Natural Resources and Parks
Director's Office
King Street Center
201 S Jackson St, Suite 700
Seattle, WA 98104-3855

King County DNRP Lake Sammamish Flood Reduction Plan
April, 2011

This documents actions that King County DNRP is committed to taking to address Lake Sammamish flooding. Many factors contribute to the flooding along Lake Sammamish. Although many of the factors that contribute to the flooding are beyond King County's control, the County is fully committed to taking actions within its authority that will to reduce flooding, consistent with environmental protection and in compliance with applicable laws.

The County's scientific modeling indicates that the actions identified below will materially reduce high-water levels. Although actual outcomes could differ from the models, the County is committed to monitoring the success of the work and modifying it to ensure optimal results.

To address the flooding occurring along Lake Sammamish, King County DNRP is committed to taking the following actions:

1. **Four-fold increase in mowing.** King County will **mow both sides of the transition zone every year.** This is a four-fold increase in mowing frequency, compared to the prior schedule.
   Timing: Permit application: April 2011; Mowing: Fall 2011, the time when it will be most effective.

2. **Cutting buffer vegetation.** King County will cut back willows and other vegetation on the buffer to a maximum of ten feet adjacent to the low flow channel.
   Timing: Permit applications: April 2011; Cutting: Fall 2011, the time when it will be most effective.

3. **Removal of cuttings and clippings.** King County will remove cuttings and clippings after each cutting or mowing.
   Timing: Immediately following each cutting or mowing.

4. **Sediment and debris removal evaluation.** King County will retain a consultant to evaluate sediment and debris removal in the transition zone to determine areas in which sediment removal will be most beneficial and areas in which debris may be causing flow obstructions, along with related impacts and permitting requirements.
   Timing: Consultant identified: June 2011; Report complete: Summer 2012 or sooner; Follow up actions: Fall 2012

5. **Downstream Aquatic Weeds Removal.** King County will continue with a recently-started project to remove a large infestation of noxious aquatic weeds downstream of the transition zone. Weed removal is designed to improve water quality and flow.

Timing: Planning in progress; Weed removal: 2013 or sooner.

6. **Transition Zone Flood Reduction Capital Improvement Project.** King County will reallocate funds to match the City of Redmond's $130,000 commitment to the initial phases (e.g., scoping and feasibility) of a project to modify the transition zone to reduce flooding.
   Timing: Seek budget authorization: Spring 2011; Start of project scoping and feasibility (if budget authorization approved): Fall 2011

7. **Restoration of Navigability of Center ("Low Flow") Channel.** Center channel of transition zone will be restored to be navigable by small non-motorized watercraft.
   Timing: In conjunction with each cutting.

8. **Monitor Plan Effectiveness.** King County will monitor the effectiveness of actions in the Lake Sammamish Flood Reduction Plan. King County will monitor and report at appropriate milestones to the King County Flood Control District Lake Sammamish water levels and discharge at the weir in order to facilitate monitoring to achieve optimal results. Original designed functionality was a discharge of, at a minimum, 1,500 CFS
   9. at 29 feet NGVD.
   Timing: Current calculation: Spring 2011; Monitoring: Ongoing.

Mark Isaacson
Director, King County WLRD

Bob Burns
Deputy Director, King County DNRP

Jane Hague
King County Councilmember

Kathy Lambert
King County Councilmember

We the undersigned have been privy to discussions and contributed to developing this plan and agree this plan will move in the necessary direction to mitigate lake flooding and does not create any legal or financial obligations to the Lake Sammamish citizens.

Marty Nizelk
Lake Sammamish Resident

Gil Pauley
Lake Sammamish Resident

Dwight Martin
Lake Sammamish Resident

Appendix 2. List of Identified Stakeholders

- King County Water and Land Resources Division
- King County Citizens
- King County Office of Risk Management
- King County Emergency Operation Center
- King County Department of Development and Environmental Services
- King County Department Of Transportation
- King County Council Member Kathy Lambert
- King County Council Member Jane Hague
- City of Sammamish
- City of Issaquah
- City of Bellevue
- City of Redmond
- Washington State Department of Fish and Wildlife
- Washington State Department of Ecology
- Washington State Dam Safety Office
- Community Members and Groups
- Washington Sensible Shorelines
- Save Lake Sammamish
- Issaquah Environmental Council
- Tribes
- WRIA 8 Salmon Recovery Council
- Army Corps of Engineers
- National Oceanic and Atmospheric Administration

Appendix 3. Public Meeting Notes – January 31, 2012

Attendees:

John Engel, King County Water and Land Resources Division (KC WLRD), Rivers, Supervising Engineer
Don Althauser, KC WLRD, Stormwater Services, Managing Engineer
Claire Jonson, KC WLRD, Stormwater Services, Project Manager
Kate Akyuz, KC WLRD, Rivers, Senior Ecologist
Don Finney, KC WLRD, Stormwater Services, Senior Ecologist
Tim Kelly, KC WLRD, Stormwater Services, Senior Engineer
Scott Miller, KC WLRD, Stormwater Services, Project Engineer
Jon Spangler, City of Redmond, Engineering Manager
Hank Myers, City of Redmond, Councilmember
Steve Bottheim, King County Department of Development and Environmental Services (KC DDES), Supervisor
Laura Casey, KC DDES, Environmental Scientist III
Karen Walter, Muckleshoot Tribe, Watersheds and Land Use Team Leader
Erik Stockdale, Washington Department of Ecology (WDOE), Northwest Region, Wetlands/401 Unit Supervisor
Rebekah Padgett, WDOE, Northwest Region, Shorelands & Environmental Assistance
David Radabaugh, WDOE, Northwest Region, Shorelands & Environmental Assistance
Patrick McGraner, WDOE, Northwest Region, Shorelands & Environmental Assistance
Jamie Bails, Washington Department of Fish and Wildlife (WDFW), Habitat Biologist
Jonathan Smith, United States Army Corps of Engineers (USACE), Project Manager, Regulatory Branch
Catherine Desjardin, USACE, Civil Engineer
Dwight Martin, Homeowners of Lake Sammamish
Martin Nizlek, Homeowners of Lake Sammamish
Gil Pauley, Homeowners of Lake Sammamish
Rory Crispin, Homeowners of Lake Sammamish
Connie Marsh, Issaquah Environmental Council
Jean White, WRIA 8 Watershed Coordinator
Christine Jensen, King County Council, Legislative Aide - District 3
Kimberly Nuber, King County Council, Legislative Aide - District 6
Ed McCarthy, Hydrologist
Charlie Klinge, Groen Stephens & Klinge LLP
Jonathan Frodge, Save Lake Sammamish
Erica Tiliacos, Save Lake Sammamish
John Reinke, Save Lake Sammamish
Vic Bishop, West Lake Sammamish Association

Notes:

-John Engel, King County Supervising Engineer, Cedar River Basin, opened the meeting, introduced himself and the project, and all attendees introduced themselves.

-John Engel gave history and background of the Sammamish Transition Zone

-Dwight Martin and Martin Nizlek, Homeowners of Lake Sammamish, gave a presentation of the Property Owners concerns.

-Kate Akyuz, King County Senior Ecologist, gave a presentation of the Vegetation Maintenance that King County performed in the fall of 2011.

-Don Althauser, King County Managing Engineer, presented the sediment and debris removal evaluation project's recent field survey results.

-Tim Kelly, King County Senior Engineer presented the preliminary hydraulic model of the Transition Zone.

- Don Finney, King County Senior Ecologist, opened up the discussion for feedback on Regulatory and Tribal Perspective and Permit Recommendations.

Public Comments:

Note that these are comments of some of the people who spoke, not all.

-Dwight Martin, Homeowner of Lake Sammamish: 1. Record high water events of 2009, and 2010 caused us to review Sammamish River flow rates. We found that the rates were reduced to 40% of expected flow rates. At first county employees were not accepting our concerns as being valid, but later they agreed that we had identified a problem. The County has accepted and re-affirmed its' obligation to maintain flows at the outlet to Lake Sammamish (1,500 cfs at elevation 29.00). 2. Environmental improvements to the Sammamish River are good, but the design and implementation of these restoration and improvements must not increase flood hazard by reducing flow rates. 3. This is not an "either or proposition", but a "both and". This is a great opportunity to improve the habitat functions of the Sammamish River and restore flow rates to levels that provide flood protection. However, habitat improvements must not reduce flow rates. 4. Minor work (removing root balls and logjams,) immediately below the weir could provide significant improvements to flow and would be easier to permit than a quarter mile long sediment removal project. Please focus on flow improvements immediately below the weir, as these should be easier to permit and to be done in a timely fashion. Long-term improvements would be great, but there is deferred maintenance work that can be done now.

-Martin Nizlek, Lake Sammamish Resident and board member of WA Sensible Shorelines Association: 1) Residents have shown the County and Corps, as early as Sept. 2010, that flows have been reduced through the weir-transition zone area as maintenance has been reduced. 2) This has resulted in artificially raised lake water levels. As early as 2004, a City of Bellevue study showed this to be true. The result has been encroachment on property by 10, 15, and even 20 feet. 3) Since the Shoreline Management Program (SMP) will regulate from the OHWM, this is not acceptable (and possibly is a taking), especially when combined with property damage and sediments and pollutants being pulled into the lake. 4) The deferred maintenance program in the transition zone has resulted in predator fish habitat, which needs to be considered, and now an illegal rock obstruction has been uncovered, only increasing the need for quick action. Knowing of the obstruction, and given recent out-of-court settlements for similar "man-made" conditions, risk managers should provide input regarding the need for immediate action. 5) Additionally, residents have provided "post-cutting" input on channel restrictions, which still remain. 6) Residents recommend active Corps of Engineers involvement going forward.

-Jonathan Smith, USACE, Regulatory Branch: Need a Nationwide Permit 3 (Maintenance), or possibly, instead an individual permit, depending on what the actual project consists of. These permits would cover the County's obligation to obtain permits under the Federal Clean Water Act and the navigation-focused 1899 Rivers & Harbors Act. The County should allow 6 to 12 months to obtain the nationwide permit, and 12 months for an individual permit. For both kinds of permits, the Corps will need to do ESA Consultations, and the County will need to obtain a Section 401 Water Quality Certification from Ecology. Compensatory mitigation probably would not be required by the Corps to maintain the project as originally approved/constructed, but additional measures to protect species and critical habitat listed under the ESA could be required. Only a limited Section 106 Historic Properties review might be necessary if the maintenance work would not deviate from the originally authorized project footprint.

-Catherine Desjardin, USACE, Civil Engineer: Encourages the County to do maintenance on the Transition Zone.

-Rebekah Padgett, WDOE: Concerned about water quality, turbidity, temperature, hydrology, beneficial uses. Interested in alternatives. Would like to see Hydrology and Modeling. The Nationwide permit is currently in flux, expiring in March 2012, and new Nationwide permit should be coming out soon. Individual –Section 401 Water Quality Certification and Coastal Zone Management Consistency Determination may be needed. Joint public notice would be done with the Corps. Assuming a good application, timing is 6 to 12 months. Mitigation will be needed. Are there options to start with something smaller like removing the rock weir to keep permitting needs more manageable? New Shoreline Master Program for King County coming soon. Flood hazard permitting may be necessary.

-Jamie Bails, WDFW: Hydraulic Project Approval is straightforward. Fish Timing will be specified to a certain window of time. How much material will be moved? When? Demonstrate that project will work. Sponsor would have to define scope of project. Fish removal will likely be needed.

-Jon Spangler, City of Redmond: Do not maintain a problem, fix the problem long term. We can make this a river again and maintain flood capacity. City has put in some money for the Transition Zone Flood Reduction Capital Improvement Project (i.e. Willowmoor Project). Would like to see the Transition Zone as not a flood control facility if Army Corps of Engineers allows. The City is doing work downstream of Transition Zone to enhance the River.

-Jean White, WRIA 8 Watershed Coordinator, clarified that the project area is Tier 1 salmon habitat in the Chinook Recovery Plan. She explained that WRIA8 Funding for the salmon conservation plan is provided by 27 local governments in the watershed.

-Homeowners of Lake Sammamish: Ordinary high water mark has been raised a foot higher and residents have to live with it. They have pushed for this meeting. Maintenance has been deferred for 20+ years. Go ahead and spend the money that was not spent on the maintenance. Citizens ask that County implement maintenance agreement with Army Corps of Engineers. Landowners gave a history reflecting on the reduced flows as a consequence of lack of maintenance. Representing “Washington Sensible Shorelines”. Concerns include damage to docks and shoreline erosion.

-Karen Walter, Muckleshoot Tribe: This project cannot be done in a vacuum. Want to see hydraulic analysis, fish monitoring. Tired of seeing separate projects and not showing how they connect. Kate Akyuz will complete answers to Karen’s 20 questions list for the Vegetation Maintenance that King County performed in the fall of 2011. Has also not received temperature and other monitoring info promised to her. This project must be consistent with the WRIA 8 Recovery Plan for a large restoration project at this same site.

-Jonathan Frodge, Save Lake Sammamish: This was a political decision with no scientific analysis. The willows that were planted in the transition zone were mitigations for other projects.

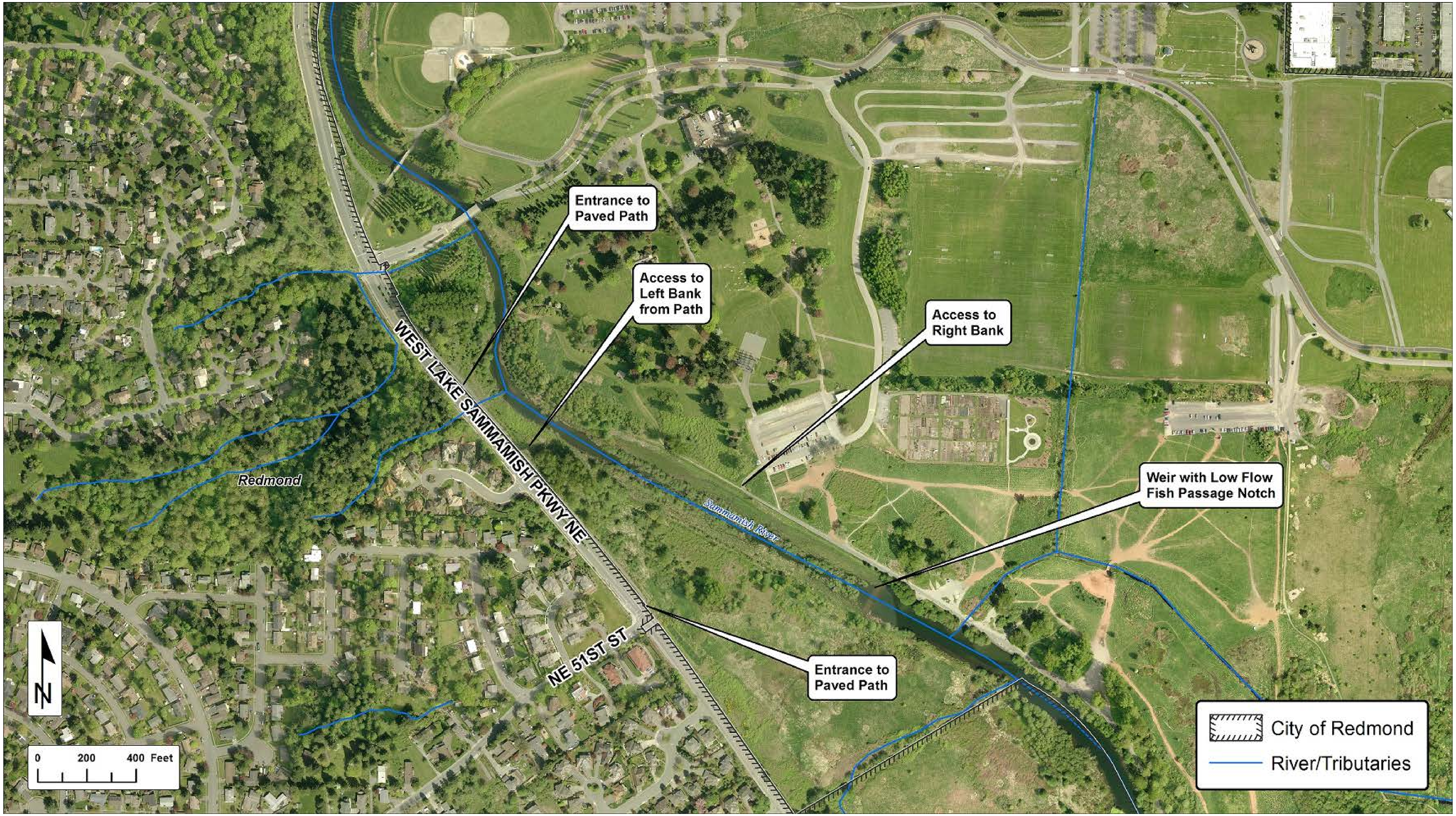
-Erica Tiliacos, Save Lake Sammamish: Look at inputs to Lake Sammamish. Development and impervious surface has increased. The 1960s design of the Transition Zone did not have as much development around it as it does now.

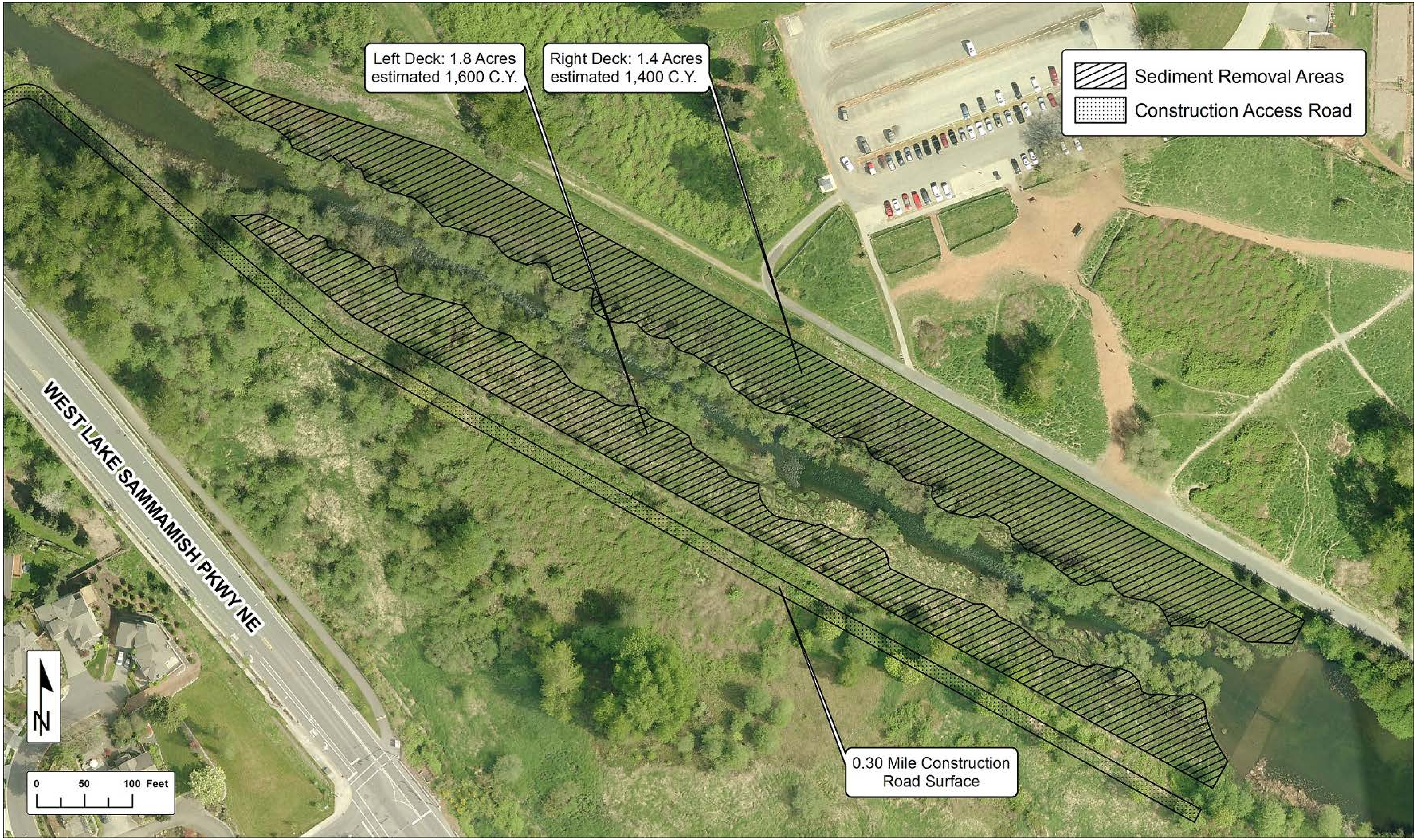
-Connie Marsh, Issaquah Environmental Council: wants to remove the Receiving Body designation for the lake, as more and more storm water is planned to be tightlined into it from neighboring cities and developers. Lake cannot handle any more.

-Laura Casey, King County Department of Development and Environmental Services: This project area is within Shoreline jurisdiction. The area is an aquatic area, and a wetland (different distinctions in the CAO). At minimum, needs a clearing and grading permit. Definition of Maintenance in King County Code 21A.06 will have to be reviewed. This sediment and debris removal has not been done before per King County staff knowledge for at least 20 years. Flood Hazard Permit may be needed.

-John Engel closed the meeting and invited attendees to the field meeting at the Transition Zone immediately following this meeting.

Appendix 4. Maintenance Site Overview




Left Deck: 1.8 Acres
estimated 1,600 C.Y.
Right Deck: 1.4 Acres
estimated 1,400 C.Y.
Sediment Removal Areas
Construction Access Road
WEST LAKE SAMMAMISH PKWY NE
0.30 Mile Construction
Road Surface
N
0 50 100 Feet

Appendix 5. Sediment Accumulation Study

Citation:

Timm, R. 2011. DRAFT Sammamish River Channel and Floodplain Sediment Accumulation Study in the Transition Zone. King County Water and Land Resources Division, Seattle, WA.

Sammamish River Channel and Floodplain Sediment Accumulation Study in the Transition Zone, August, 2011.

Introduction

The Sammamish River is the connecting waterway between Lake Sammamish and Lake Washington in King County, Washington. It has a long history of management activities that have included draining riparian wetlands, dredging, bank hardening, and major channel realignments (Chin et al., 2003). The transition zone of the river (Figure 1) is a completely artificial channel that was constructed by the US Army Corps of Engineers (ACOE) in 1963 (Chin et al., 2003). At the upstream end of the transition zone, a weir was installed in 1998 to maintain Lake Sammamish water levels, repair damage to the channel, and improve fish passage (NHC 2010). Channel gradients in the transition zone are very high (0.46%) relative to the rest of the Sammamish River (0.019%) as the channel loses 6.75 feet over 1452 feet of channel length (Chin et al., 2003).

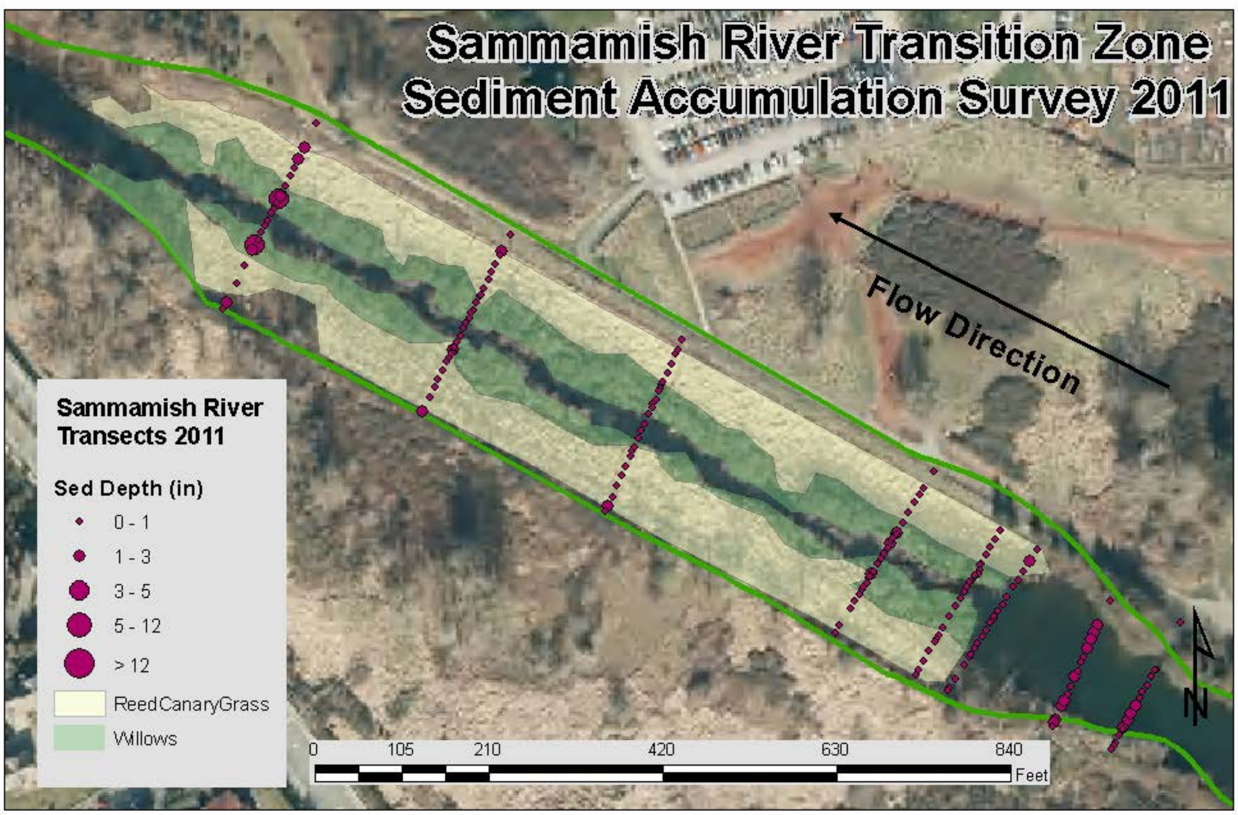


Figure 1. Transition zone of the Sammamish River. Flow direction in the photo is from bottom right to top left. Sediment depths measurements reoccupied points along cross-sections established for a flood study performed during 2009. Cross-sections are numbered 1 – 8 from upstream to downstream. The flow control weir is located along cross-section 3.

Survey Methods

During August 2011, a sediment accumulation study was undertaken in the channel and floodplain of the Sammamish River transition zone as part of a larger feasibility study for flood hazard reduction activities. Sediment accumulation depths were measured as near as possible to previous bed surface elevations measured for a flood modeling exercise (NHC, 2010). Eight cross-sections, ranging in length from approximately 175 feet (cross-section 1) to more than 250 feet (cross-section 8) were measured during the study with an average of 23 points on each cross-section. Cross-sections 3 – 8 were in wadeable sections of the stream below the weir that defines the upstream extent of the transition zone (Figure 1). We used a Trimble survey-grade real time kinematic global positioning systems (rtkGPS) to reoccupy the locations from the earlier study (NHC 2010) and measure ground surface elevations to sub-centimeter accuracy.

Sediment depths were measured by inserting a 3/8-inch diameter steel rod at each location until the underlying hard surface positively stopped the rod. Depths of sediment were then measured to the nearest 0.5 inches and recorded. Vegetation in the transition zone floodplain is dominated by two vegetation zones; reed canary grass, and willow shrubs. The reed canary grass is distributed throughout the floodplain and is generally landward of the willow shrubs which are more dominant in direct proximity to the low flow channel edge (Figure 1).

Sediment Accumulations

Much of the sediment that has accumulated in the reed canary grass zone of the floodplain appears to be the product of decaying plant matter in the reed canary grass rhizome mat. During our surveys, the river had very little suspended load. Upstream of the transition zone there is nearly zero current which is typical of the outlets of stage-controlled lakes (Chin et al., 2003). In the absence of current, water quickly drops all of the material that it is carrying. In the low flow channel of the transition zone, there are no measurable accumulations of sediment to speak of at any of the previously measured cross-sections, except near cross-sections 7 and 8 where some sediment accumulations were found associated with willow root masses. In addition, the relatively high stream power associated with this high gradient section of the river effectively maintains the engineered channel geomorphology. In general, the channel has competency to remove all the material smaller than the quarry spalls that were used in its construction. These findings are consistent with those reported by Chin et al. (2003).

Accumulated sediment depths tended to be greatest along the levee toes for all cross-sections except for cross-section 8. Cross-sectional graphs showing bed surface elevations and sediment accumulation elevations are presented for all cross-sections in Appendix 1. Presumably, these mostly mineral soils were eroded from the levees themselves because there is no evidence of flow along the toe of the facilities that would suggest alluvial deposition. On average, cross-sections 2 and 8 had the highest average sediment accumulations that exceeded twelve inches and were quite variable. Cross-section 2, upstream of the weir has substantial submersed aquatic macrophyte beds that create and trap fine organic material (Rooney et al., 2003) upstream of the transition zone. Other cross-sections had considerably less accumulated material, with depths ranging from an average of 3.1 inches to 7.3 inches

(Figure 2). In addition, when evaluated by major vegetation type, the floodplain reed canary grass exhibited the highest sediment accumulations and the low flow channel the least, while the floodplain willows were the most variable (Figure 3).

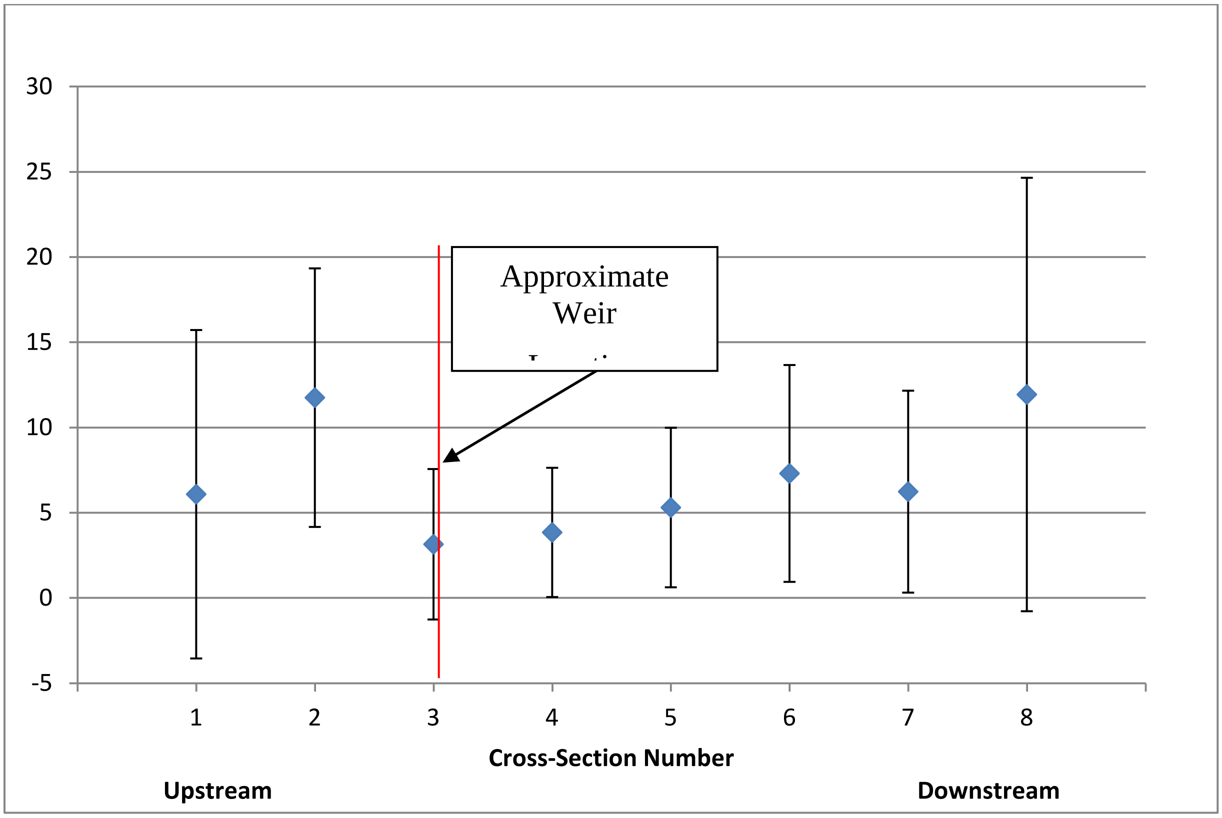


Figure 2. Average Depth (in) of sediment accumulations in the Sammamish River Transition Zone, August 2011. Error bars represent +- 1 standard deviation for each cross-section.

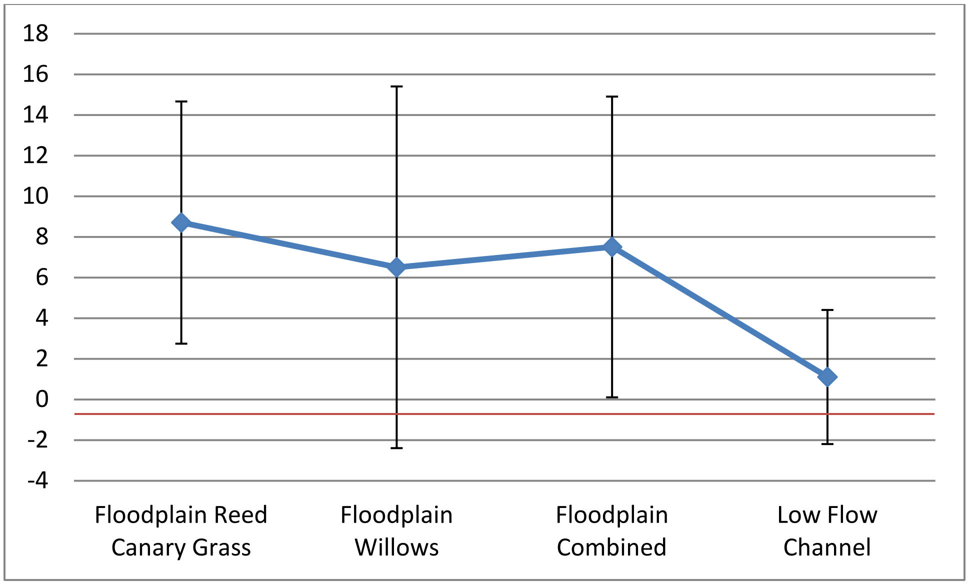


Figure 3. Average sediment depth (in) by floodplain vegetative zone. Overall sediment accumulations in the transition zone averaged slightly less than 6 inches with lowest accumulations in the low flow channel.

Ecology of the Transition Zone

Along the riparian edge of the low flow channel, the geomorphology can be quite hummocky where willow shrubs dominate the vegetation. The willows have added considerable edge diversity to the engineered low flow channel partly because beaver activity in the transition zone has caused the flow to move around willow clumps in many locations. The willows in proximity to the low flow channel provide shading and invertebrate food for aquatic fauna. In many locations throughout the transition zone, the willows provide a fully closed canopy over the main low flow channel as well as the numerous smaller side channels (Figure 4).

Figure 4. Upper left plate shows extent of closed canopy over low flow channel. Upper right plate shows beaver activity in willow zone. Lower left plate shows complexity of the edge in the willow zone. Lower right plate shows near monoculture in reed canary zone of the Sammamish River transition zone.

In short, the transition zone of the Sammamish River seems to be functioning quite well from an ecological perspective despite the major anthropogenic influences that are governing it to a large extent. The underlying geology is fixed to the engineered surface built in 1963 or thereabouts. The floodplain is dominated by invasive weeds. And yet, the fish habitat value of the low flow channel, is extremely high. In part, its value is because of its rareness. Most of the Sammamish River is devoid of ecologically functional riparian habitat (Chin et al., 2003). The willows along the downstream extent of the low flow channel have provided a place for some alder to recruit down near cross-sections 6,7, and 8. This indicates that the riparian zone, while still in the early stages of succession, is maturing as expected (Naiman et al., 2005).

During the 2-day field survey, we observed numerous belted kingfishers, several great blue herons, and an osprey. In addition, more than 100 juvenile salmonids were observed during the survey of this reach, along with adult trout, salmon, and whitefish. Adult whitefish feed on invertebrates that live within and on the channel bed, and adult trout were observed feeding on invertebrates in the drift and on the surface of the low flow channel in the transition zone. A single adult salmon was observed swimming through the reach despite the early timing. Other non-salmonid fish observed using this section of river were primarily unidentified species of sculpin.

Conclusions

The reed canary grass zone of the floodplain has sediment accumulation that appears to be the product of natural rhizome mat decay. We infer this because in general, the sediment depths above the 1963 engineered surface are fairly consistent, averaging approximately 8.7 inches. In addition, the variability around this average is small relative to the willow zone, indicating that the willow zone is a more dynamic place in terms of sediment accumulations. The willow zone also has a more modest average sediment accumulation, but with more variability. This is consistent with the higher energies associated with water moving through the low flow channel and the willow's proximity to the channel.

The low flow channel itself has almost no sediment accumulations. Due to the hydrologic consistency associated with being a lake outlet, the low flow conditions represent a dominant discharge that is a direct function of the constructed channel geomorphology. The low flow discharge is competent to handle all of the sediment load received from the lake upstream, which is nearly zero (Chin et al., 2003).

Sources of roughness in the channel/ floodplain of the transition zone of the Sammamish River are mostly derived from the vegetation and not from sediment. Standing, high density reed canary grass can create substantial drag on water moving through floodplains. King County (2008) has reported Manning's n coefficients as high as 1.9 for reed canary grass in agricultural ditches. Roughness that high can have a dramatic effect on flood conveyance. In addition, the thick shrub zone in direct proximity to the low flow channel would similarly impede flows that exceed the low flow channel's capacity. Manning's n values for riparian willow shrubs have been reported in the literature from 0.25 to 1.00 (Wissmar 1996). Again, roughness numbers this high can have a substantial drag on flow, decreasing flood conveyance dramatically.

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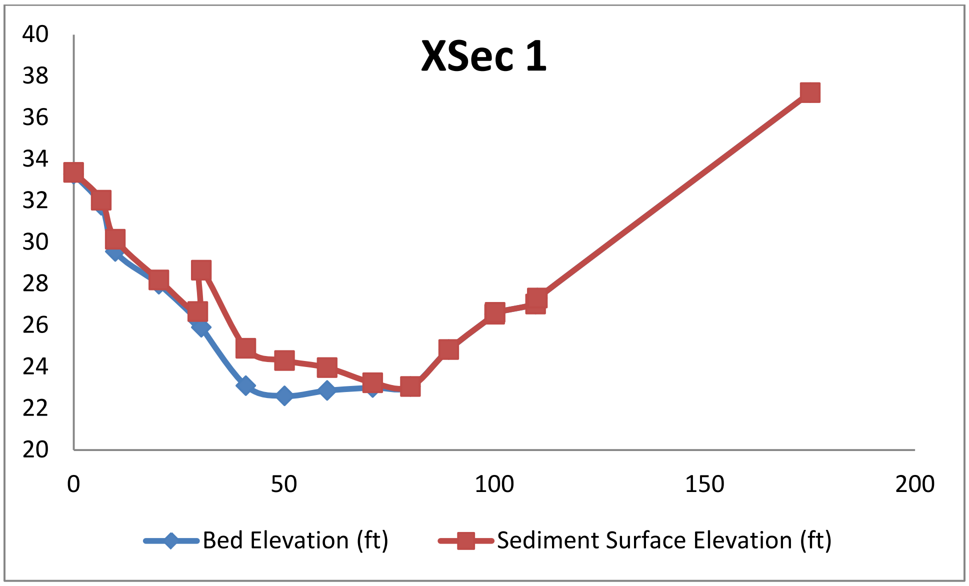
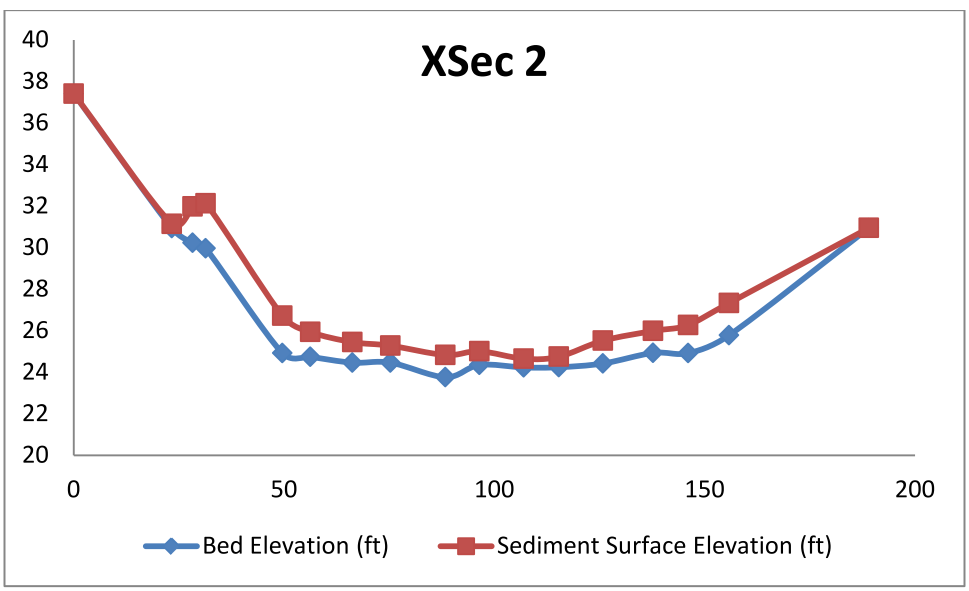
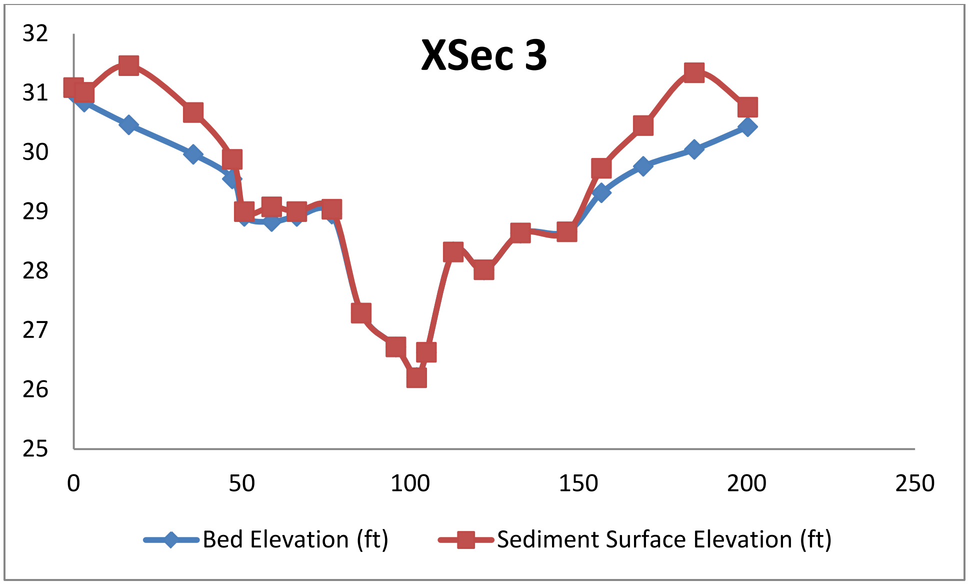
Appendix 1. Bed surface and sediment accumulation elevations in the Sammamish River Transition Zone for eight cross-sections surveyed during August 2011. Refer to Figure 1 in the main text for cross-section locations. Values on the Y axis represent elevations in feet, while values on the X axis represent distance (feet) from the first point on each cross-section beginning from the left top of bank measurement.






XSec 3
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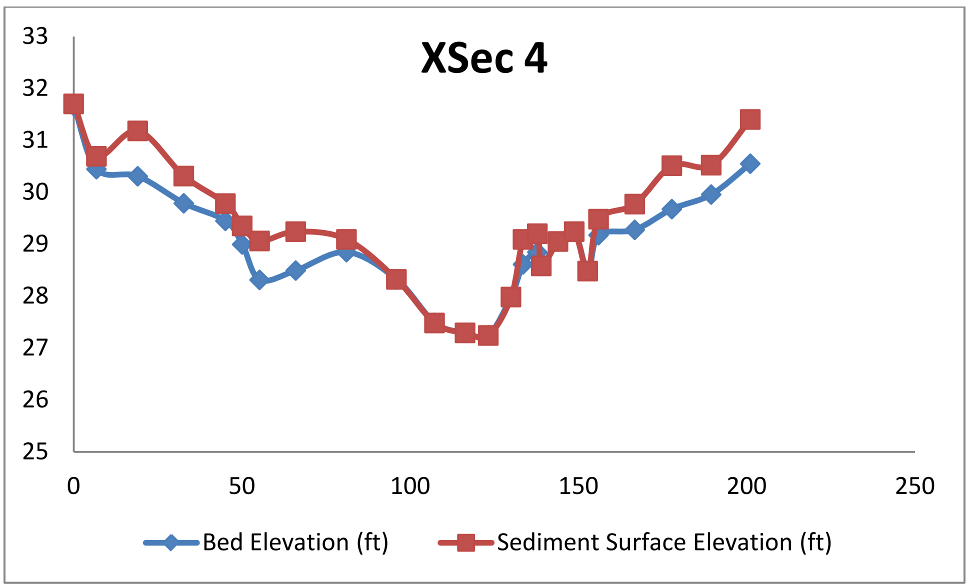
Bed Elevation (ft)
Sediment Surface Elevation (ft)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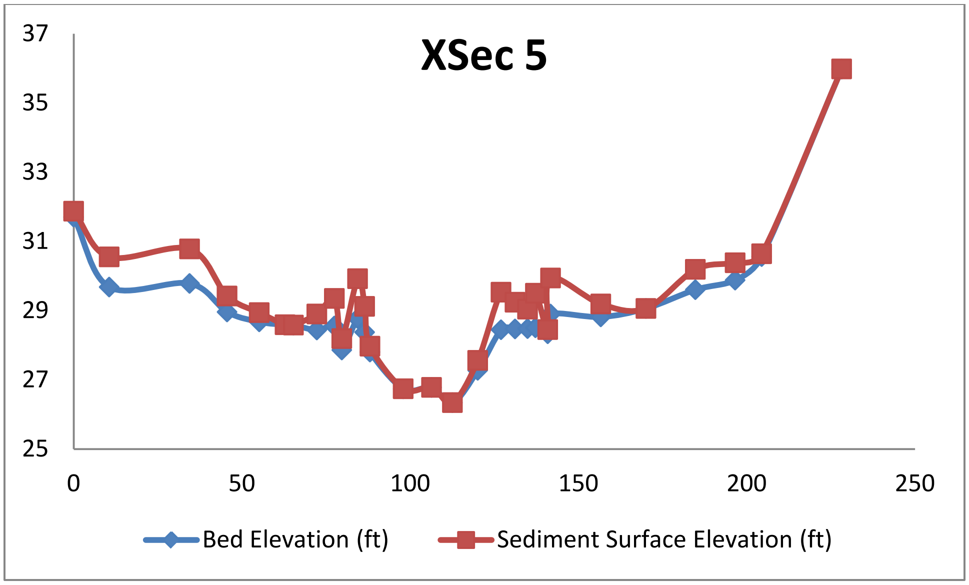
Bed Elevation (ft)
Sediment Surface Elevation (ft)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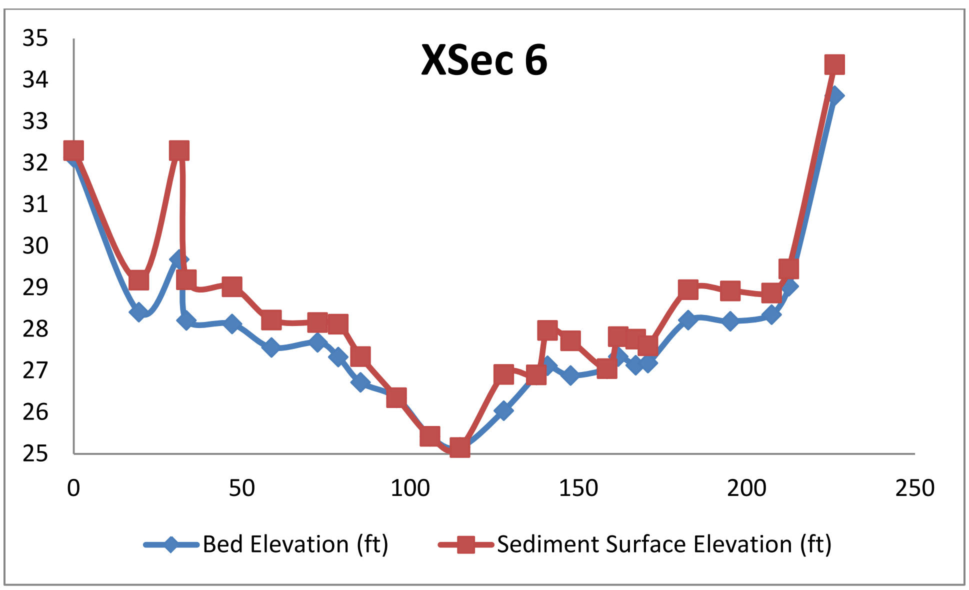
Bed Elevation (ft)
Sediment Surface Elevation (ft)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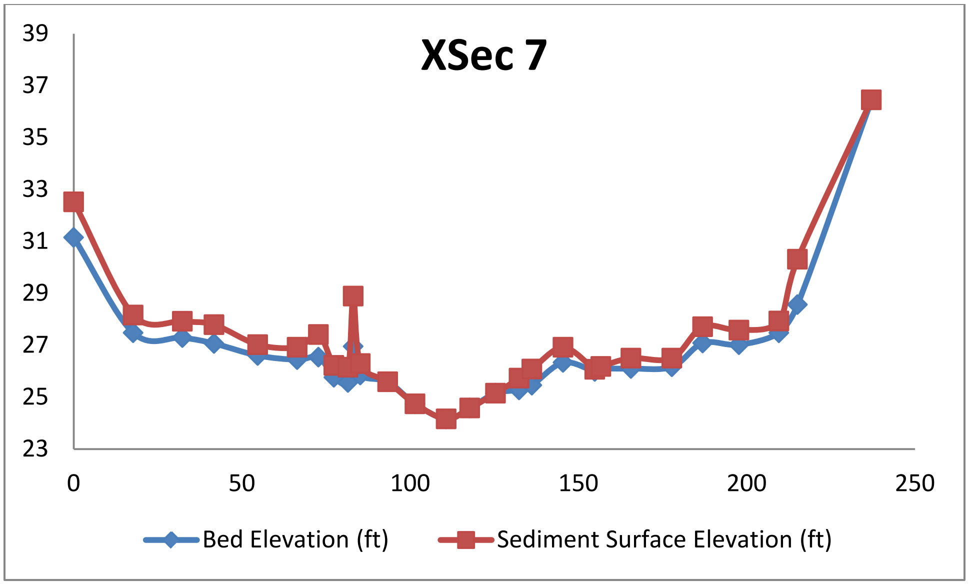
Sediment Surface Elevation (ft)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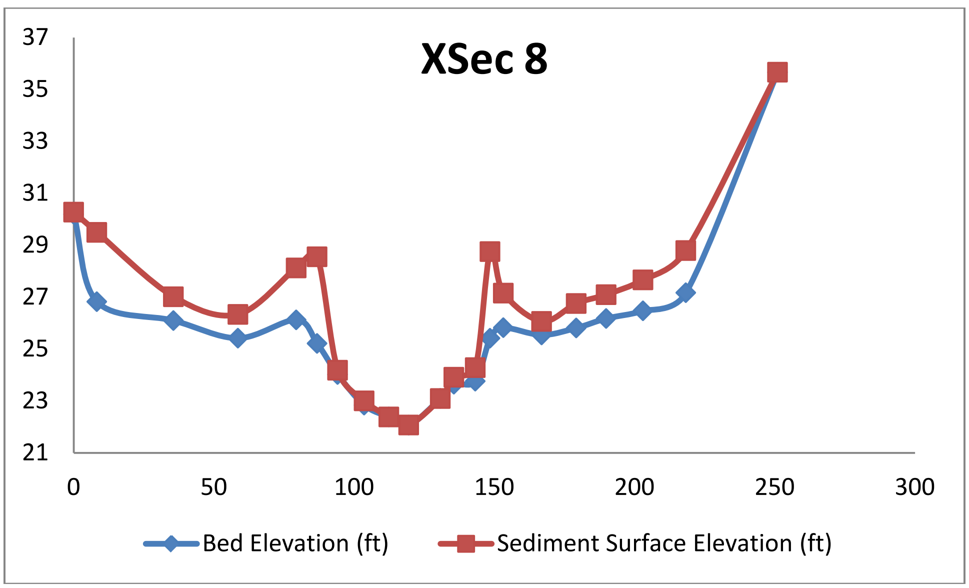
Bed Elevation (ft)
Sediment Surface Elevation (ft)


XSec 8
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100
150
200
250
300
Bed Elevation (ft)
Sediment Surface Elevation (ft)

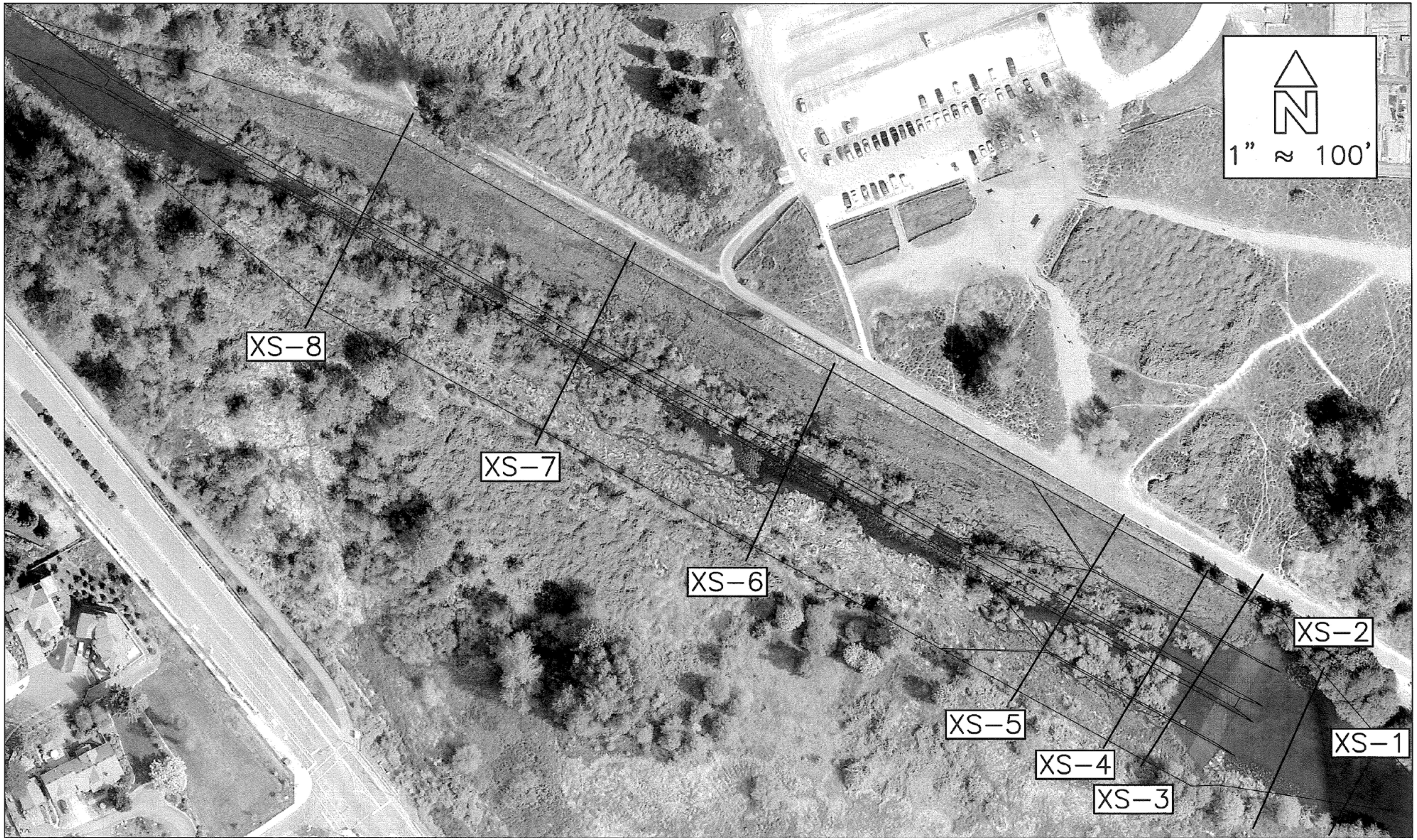
Appendix 6. Bed surface and sediment accumulation elevations in the Sammamish River Transition Zone for eight cross-sections surveyed during August 2011

Map 1 shows the locations of the NHC cross-sections reoccupied for this survey.

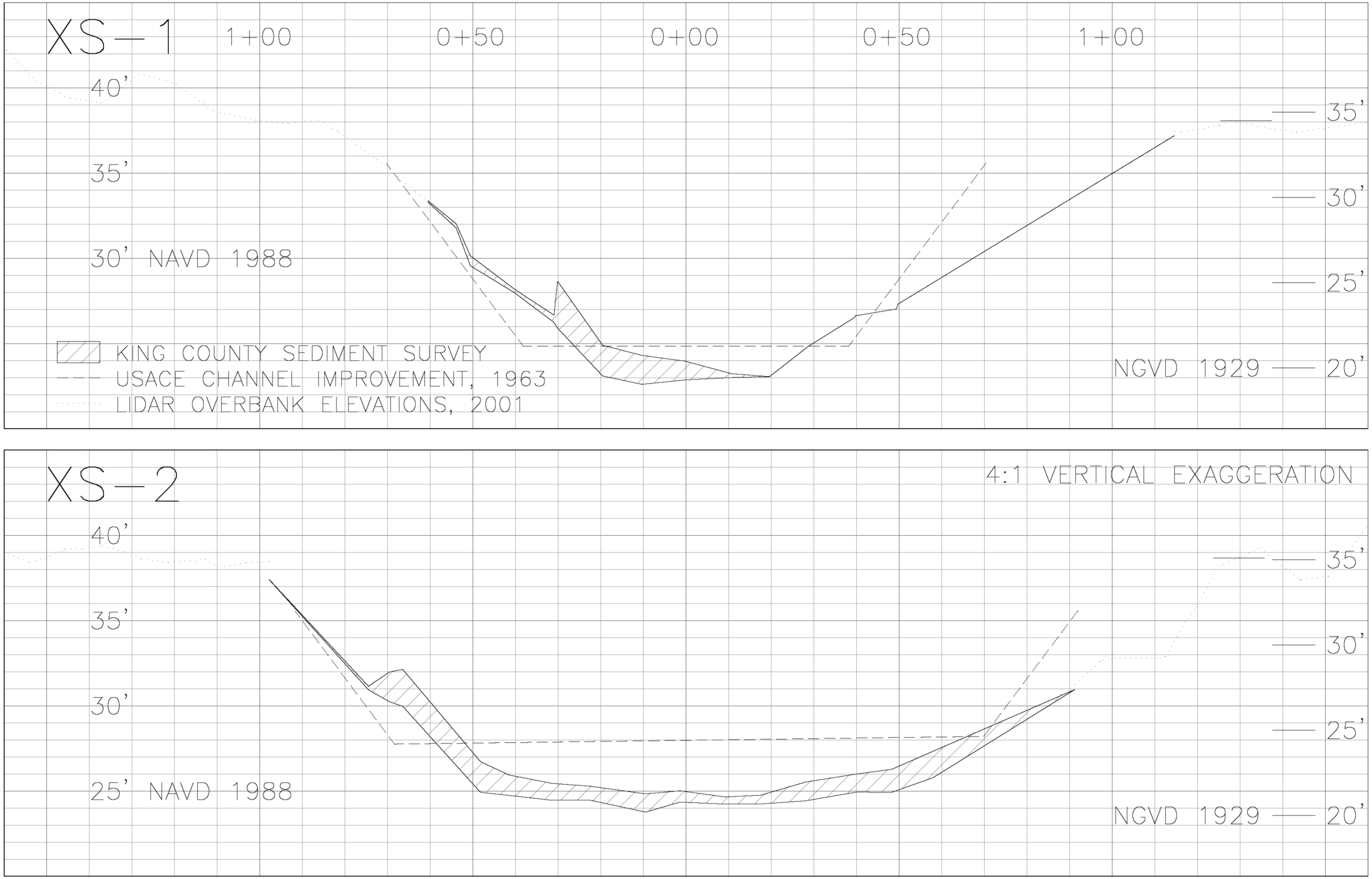
Maps 2 through 5 show the cross-sectional elevations of the bed surface and sediment depths with a 4:1 vertical exaggeration.

The bottom of the crosshatched areas represents the quarry spall surface, and the top of the crosshatched areas represents the top of sediments. The dashed line represents the U.S. Army Corps of Engineers design elevations.

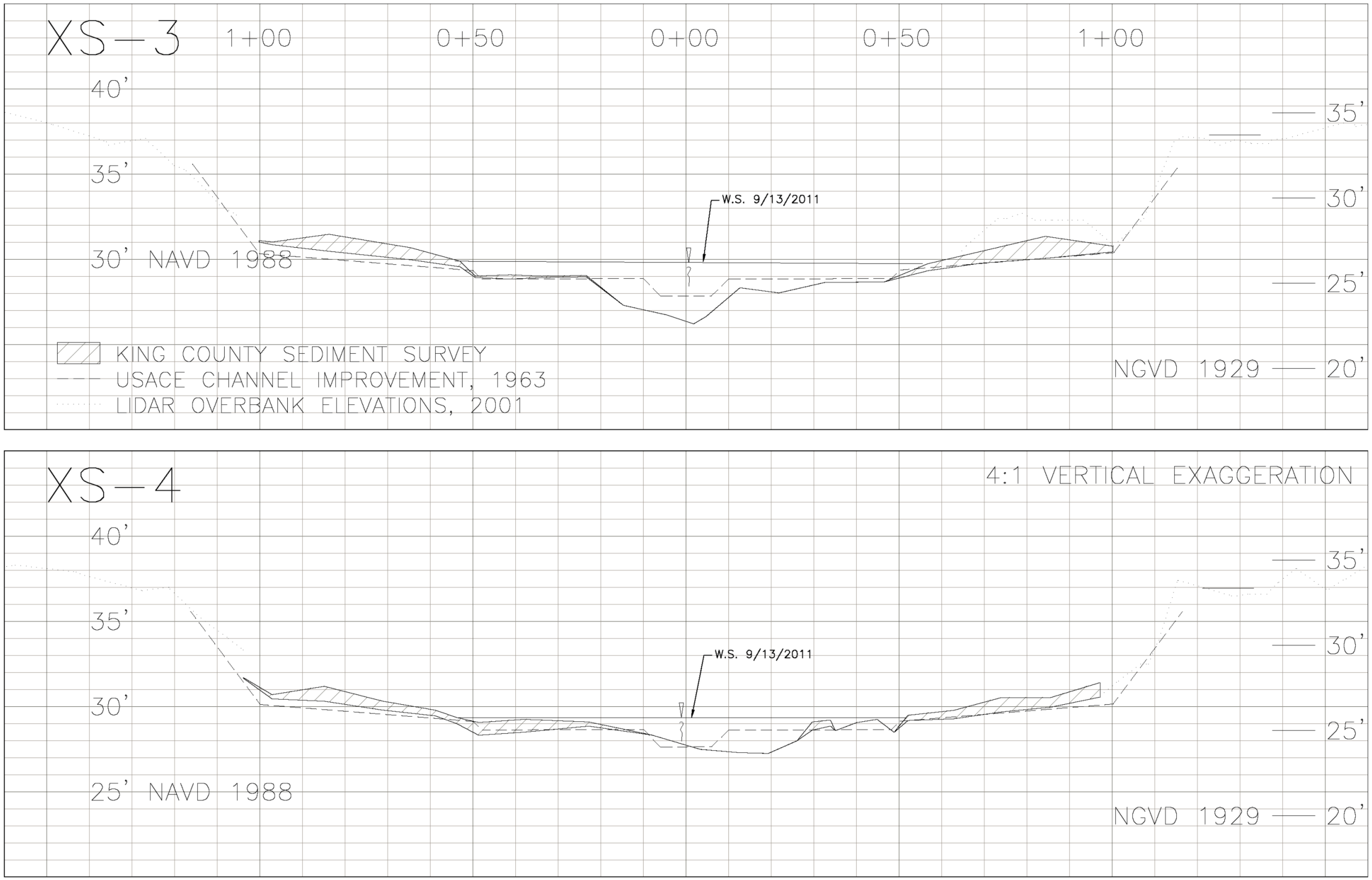
Map 6 shows survey conducted by Dwight Martin and Rory Crispin, who own homes on Lake Sammamish.



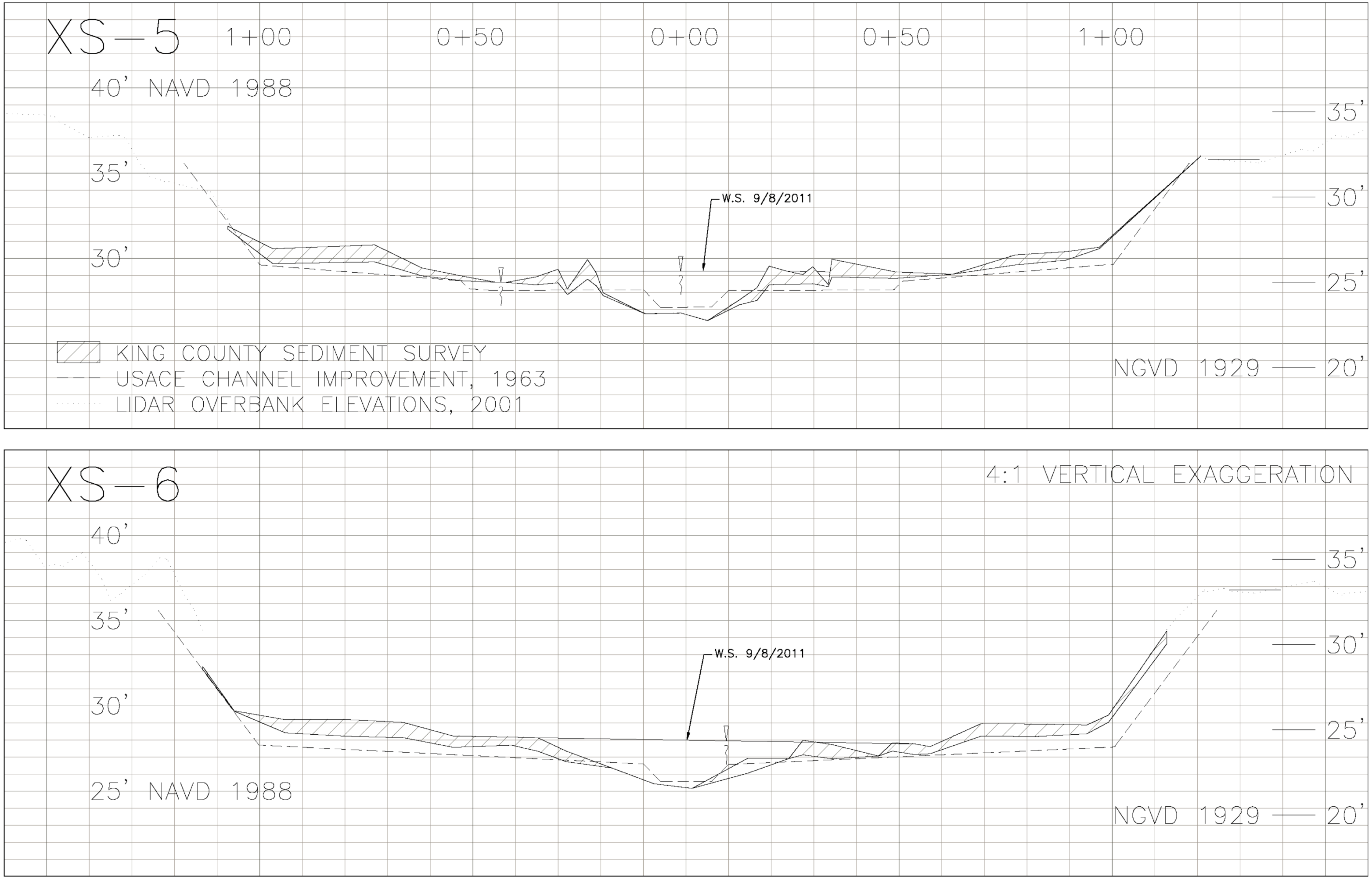
Locations of NHC Cross-sections, Occupied for Sediment Survey.



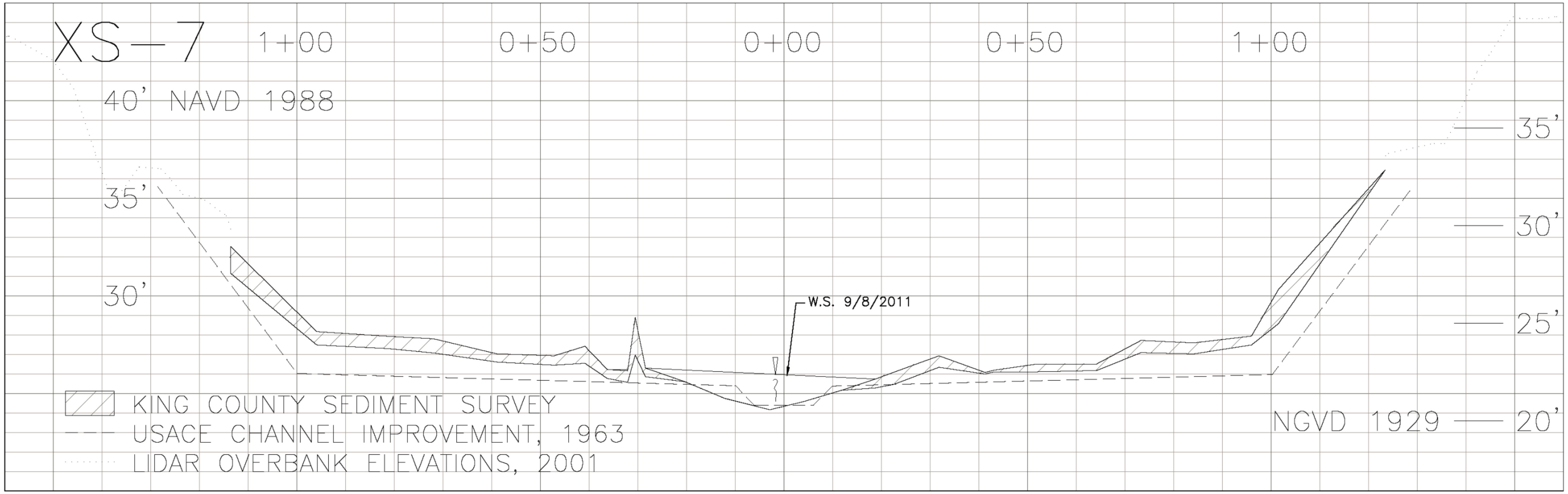
Sediment Survey Cross-sections 1 & 2.

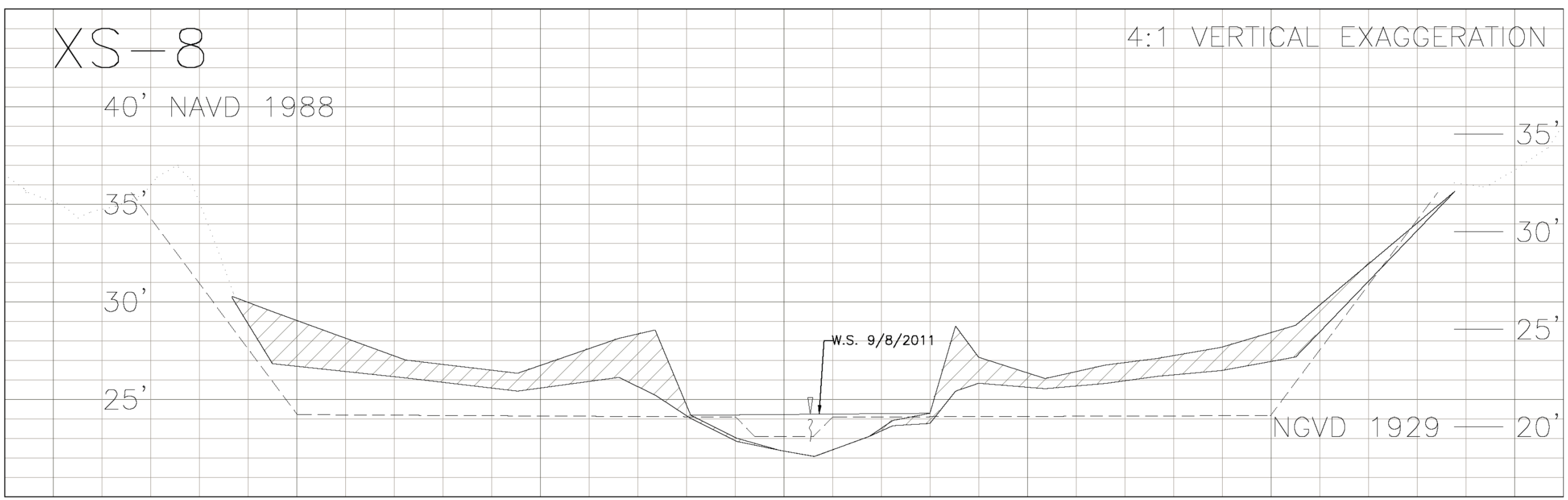


Sediment Survey Cross-sections 3 & 4.

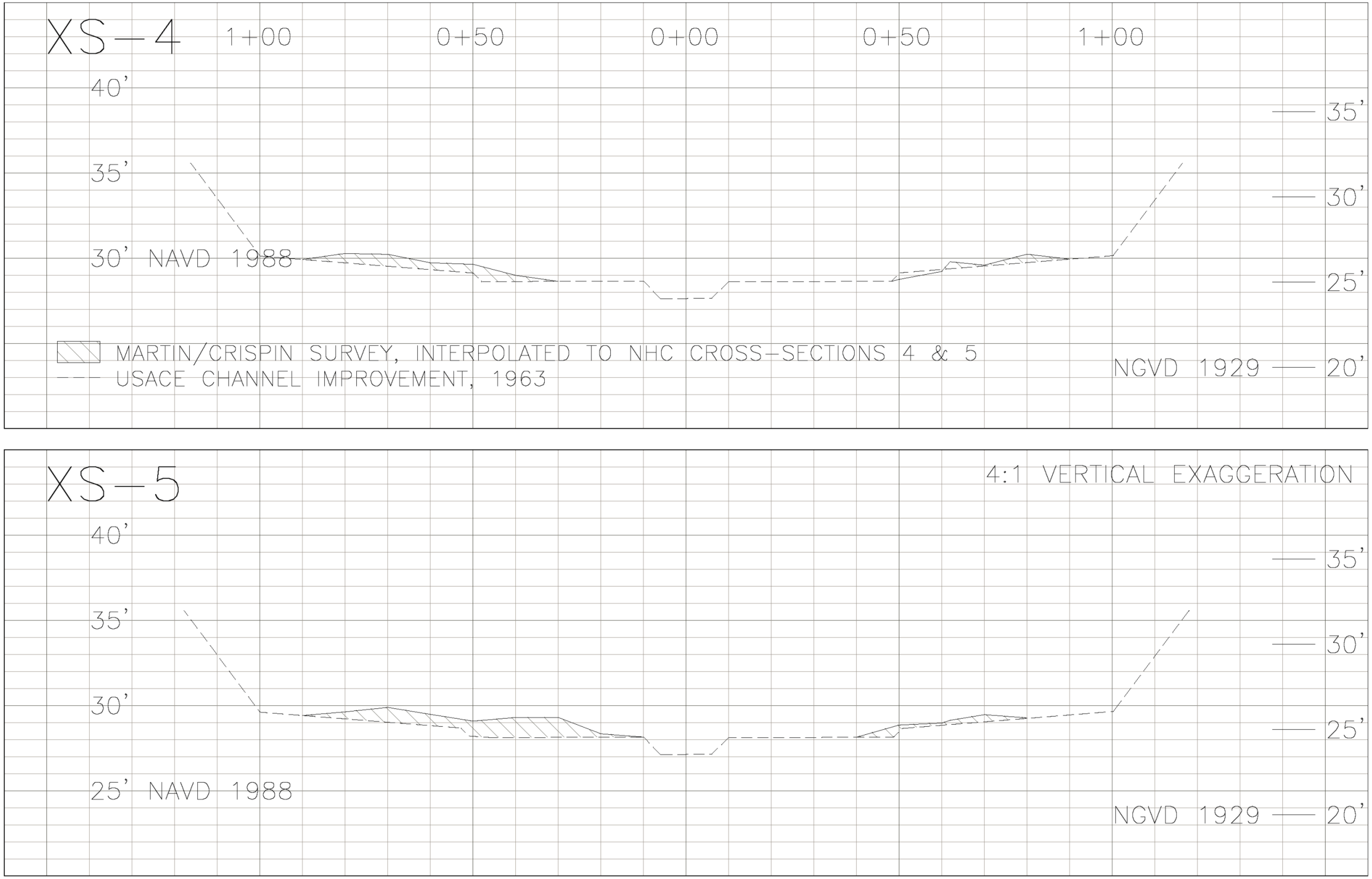


Sediment Survey Cross-sections 5 & 6.





Sediment Survey Cross-sections 7 & 8.



Martin/Crispin Survey, interpolated to NHC cross-sections 4 & 5.

Appendix 7. Estimated Volume of Sediments

Volume of sediments between the weir and cross-section eight was calculated from surveyed depths. Depths ranging from the low flow channel buffer to the toe of slope at 100 feet from center were used to calculate the cross-sectional areas of sediments for each surveyed cross-section. The average of the sediment areas between two adjacent cross-sections was multiplied by the distance between those cross-sections to obtain an estimate of volume between cross-sections. These volumes were summed to obtain an estimate of the volume of sediments in the reach. Sediment depth was not extrapolate downstream of cross-section eight, at the beginning of the transition zone contraction.

DISTANCE BETWEEN CROSS-SECTIONS:

xs	dist. (ft)	
3	25	-- distance in feet from weir to cross-section 3
4	45	
5	107	
6	330	
7	245	
8	272	
	1024	-- total distance in feet from weir to contraction

AMOUNT OF AREA DISTURBED BY TREATMENT:

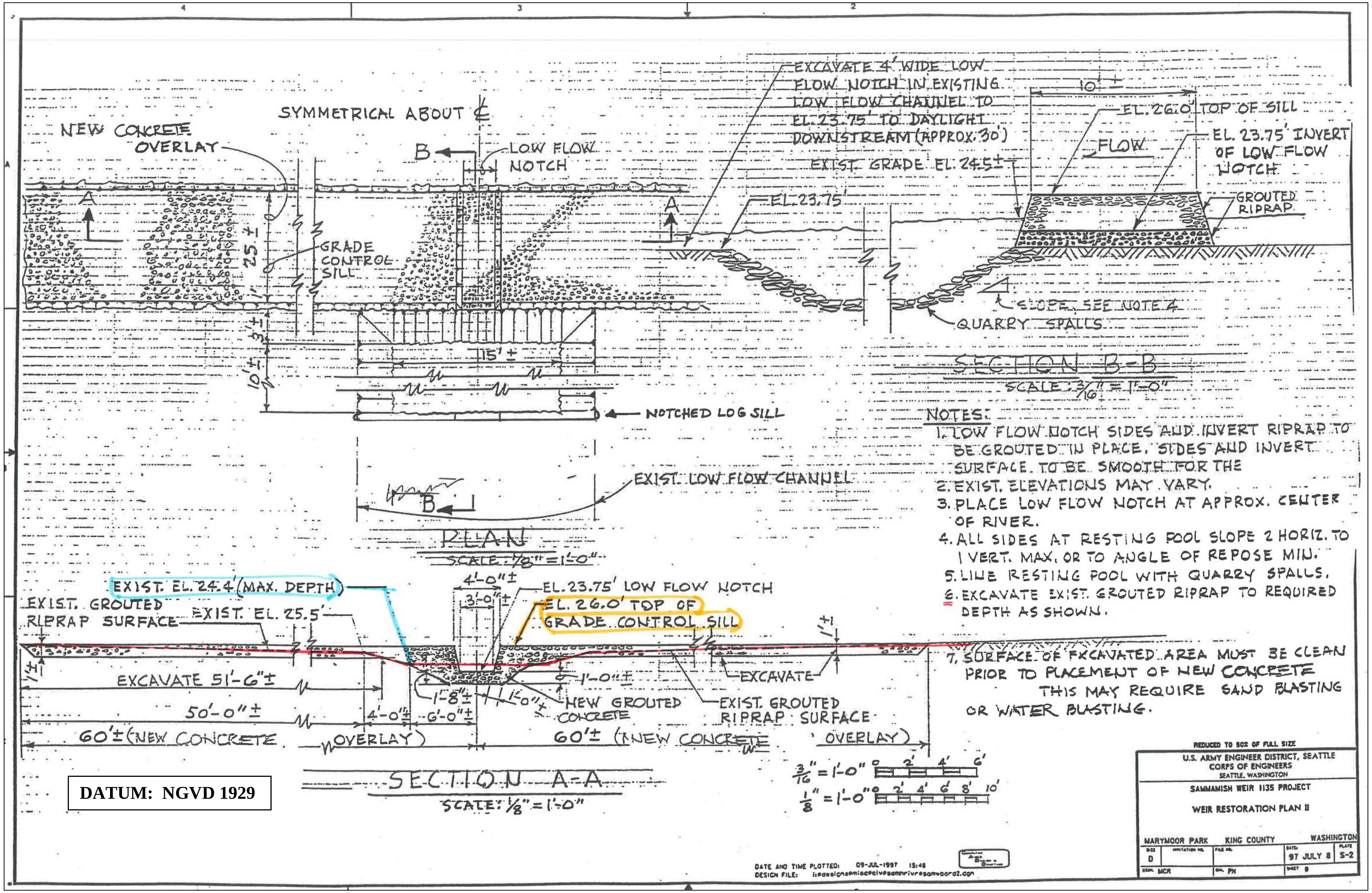
	Left Deck	Right Deck
sq.ft.	59,465	77,681
acres	1.37	1.78
total area both decks* (ac.):		3.15

*outside of low flow channel and buffer of willows

SEDIMENT VOLUMES:

	Left Deck sed. area	Left Deck reach vol.	Right Deck sed. area	Right Deck reach vol.
	34.55	863.75	34.52	863.00
	42.38	1730.93	26.37	1370.03
	37.12	4253.25	23.50	2668.05
	36.46	12140.70	32.22	9193.80
	33.00	8508.85	27.56	7323.05
	114.09	20004.24	48.20	10303.36
cu.ft.		47,501.7		31,721.3
cu.yd.		1,759.3		1,174.9
sediment volume both decks (cu.yd.):				2,934.2

Appendix 8. Sammamish Weir 1135 Project - Sill modification detail, 1998



Appendix 9. Sammamish River Transition Zone Hydraulic Study

SAMMAMISH RIVER
Transition Zone Hydraulic Study

KING COUNTY DEPARTMENT OF NATURAL RESOURCES AND PARKS

August 2012

SUBMITTED BY: TIM KELLY, SR. ENGINEER

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Report Goals, Background and Methods

The goal of this report is to hydraulically model the impacts of various maintenance scenarios along the Sammamish River transition zone on the Sammamish Lake water surface elevations. The impacts of the maintenance are measured relative to the existing (baseline) condition in contrast to various maintenance scenarios including sediment removal and removal of a small existing rock dam located 550 feet downstream of the weir.

As a brief background of the hydraulic importance of the transition zone; the transition zone has been frequently studied using hydraulic models and has also been field monitored with gage and flow measurement data both at the weir and for flows from Bear Creek. The site is a primary hydraulic control for impoundment of water in Lake Sammamish. The hydraulic control is due to the grade change at this location as this is the start of a positive slope from the lake to the river as can be seen on the *Transition Zone Profile and Slope* Figure 3. The upper end of the transition zone has an engineered sill that is often called a weir; but for other than very low flows the structure is either submerged or backwatered such that it does not function as a weir. The upstream 1/3 of the transition zone, about 200 feet in length, is flat run of the river, that along with the sill becomes the significant influence on the lake elevation. The lower, downstream 2/3's of the transition zone was designed at a slope of 0.0048 per the US Army Corps of Engineers (USACE) as-built plans and the most recent survey shows this has a slope of 0.0050, which is an adequate grade allowing a riffle type flow during typical winter flow. During significant rainfall events Bear Creek flows will combine with the lake outfall flows and create a backwater condition starting 4,900 feet downstream of the transition zone sill. The additional flow from Bear Creek will then backwater the transition zone and influence the lake elevation. Additional historical and technical information relevant to the transition zone, including the USACE project as-built plans are identified in the appendices of this document.

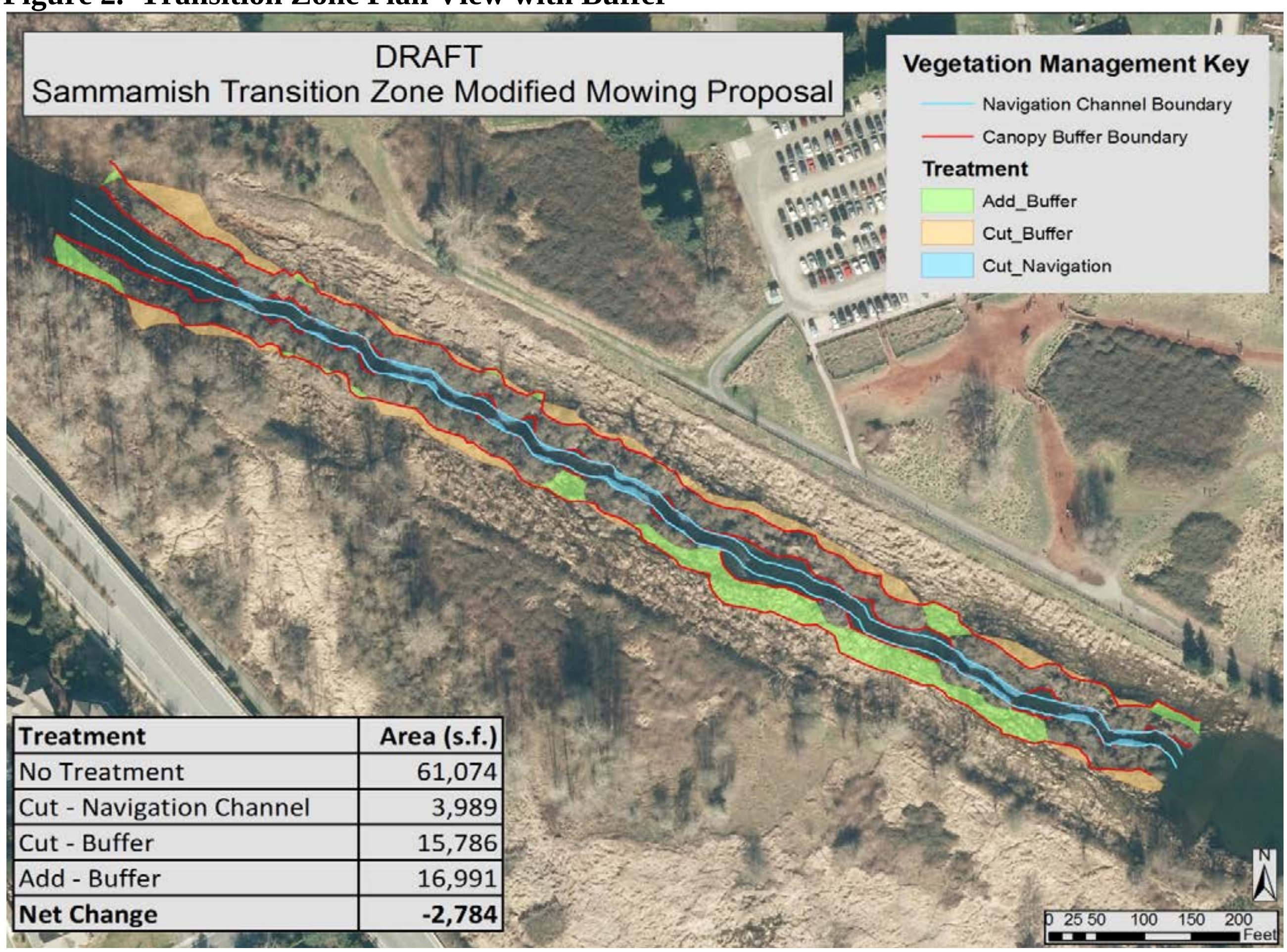
This report will utilize both the hydrology and most of the hydraulics from the Floodplain Mapping Study for the Sammamish River, which was completed by Northwest Hydraulic Consultants (NHC dated February 5, 2010) as part of the Sammamish River Flood Insurance Study (FIS). This work is referred to as the 2010 NHC Hec-Ras model in this study. This study updated the 2010 NHC model with new 2011 survey data at the transition zone and then re-calibrated the model using recently collected gage data. The re-calibration was included to model the hydraulic roughness impacts caused by the 2011 King County vegetation cutting and removal project.

Once an existing Hec-Ras model was prepared and calibrated the proposed maintenance scenarios was then compiled. The maintenance proposal is the combination of two separate actions, scenario #1 is the removal of the rock impoundment located 550 feet downstream of the weir and scenario #2 is the removal of sediment built up outside of the canopy buffer. The two components of the maintenance scenario were modeled individually for the purpose of measuring the anticipated impacts of each scenario. The combined maintenance operation is listed as scenario #3 in this report.

The key elements of the maintenance work can be observed in the following two figures. The riffle created by the small existing rock dam is located 550 feet downstream of the weir, and is observable in Figure 1. The change in vegetative cover shown in both ortho-photo Figures 1 and 2 gives a good indication of the location of the 3:1 side slopes at the landward side of the flood bench. Figure 2 shows the boundary line (in red) of the canopy buffer that limits the extents of the maintenance work.

Figure 1. Transition Zone Plan View

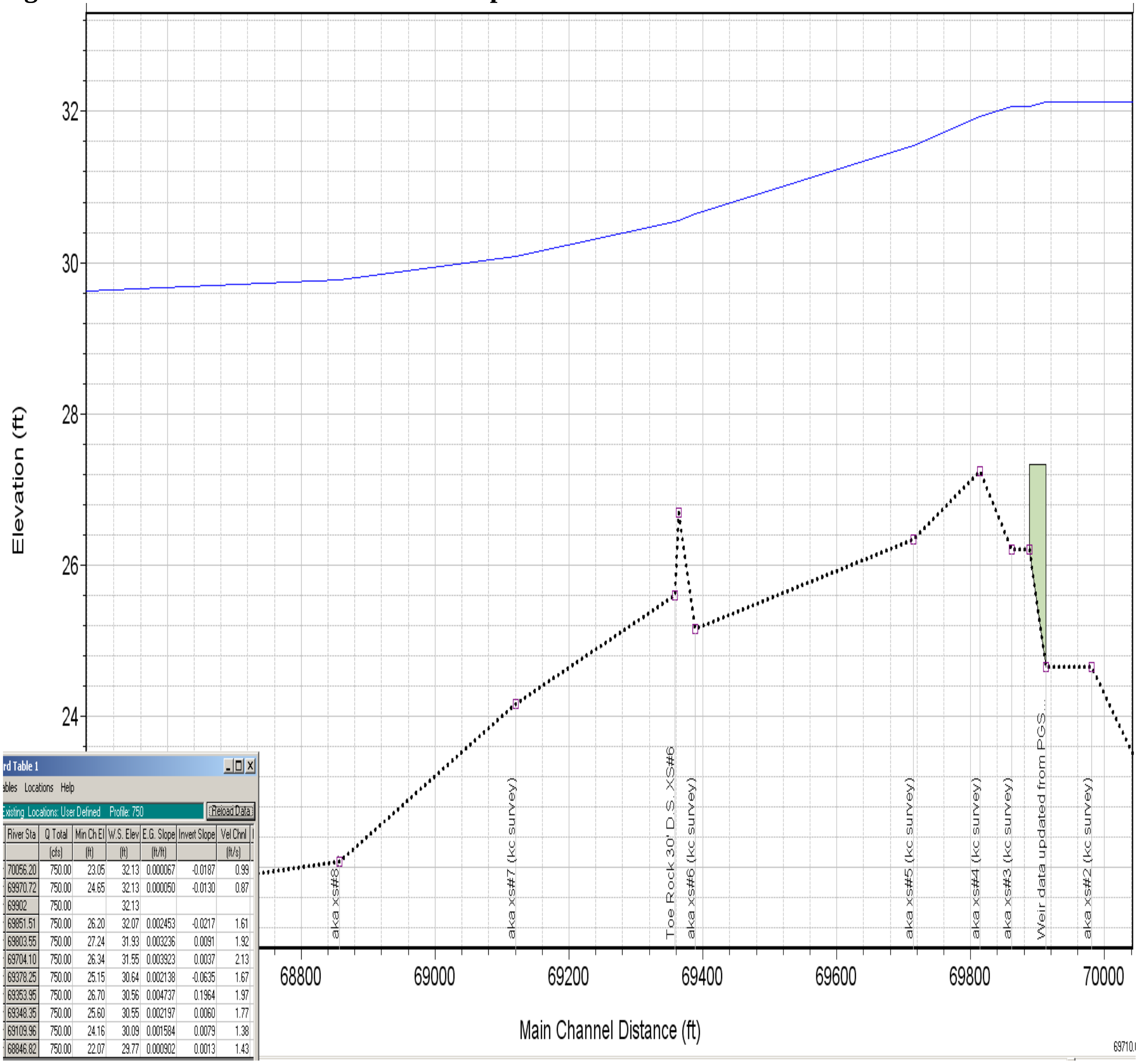
Figure 2. Transition Zone Plan View with Buffer



Treatment	Area (s.f.)
No Treatment	61,074
Cut - Navigation Channel	3,989
Cut - Buffer	15,786
Add - Buffer	16,991
Net Change	**-2,784**

The following Figure 3 shows the water surface profile through the transition zone (in blue) for 750 cfs, which is a typical high flow for any given water year. The sill is shown in green towards the right near station 69900 and the small rock dam is shown in the center near station 69400 with flow going from right to left. The lake would be approximately 4000 feet to the right of the figure limits. The channel thalweg is shown as the black dotted line. The thalweg profile clearly shows the influence of the sill and the portion of the channel just downstream of the sill on the lake elevation as this establishes the high point in the thalweg. The thalweg remains lower than the shown thalweg in the vicinity of station 69900as it extends right past the limits of the figure to the lake. The Hec-Ras output data appended to the lower left hand corner of the figure gives hydraulic properties at the shown river stations along the profile.

Figure 3. Transition Zone Profile and Slopes



River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	E.G. Slope (ft/ft)	Invert Slope	Vel Chnl (ft/s)
70056.20	750.00	23.05	32.13	0.000067	-0.0187	0.99
69970.72	750.00	24.65	32.13	0.000050	-0.0130	0.87
69902	750.00		32.13			
69851.51	750.00	26.20	32.07	0.002453	-0.0217	1.61
69803.55	750.00	27.24	31.93	0.003236	0.0091	1.92
69704.10	750.00	26.34	31.55	0.003923	0.0037	2.13
69378.25	750.00	25.15	30.64	0.002138	-0.0635	1.67
69353.95	750.00	26.70	30.56	0.004737	0.1964	1.97
69348.35	750.00	25.60	30.55	0.002197	0.0060	1.77
69109.96	750.00	24.16	30.09	0.001584	0.0079	1.38
68846.82	750.00	22.07	29.77	0.000902	0.0013	1.43

Existing (2011) Baseline Condition Hydraulic Scenario

The baseline Hec-Ras scenario assembled for this study used the 2010 NHC Steady State Hec-Ras model; the model was then updated with recent survey information to create a 2011 existing conditions scenario of the transition zone area. The recent information used to update the model includes recent 2011 survey of the transition zone and uses recent observed stage-discharge readings at the weir to calibrate the model. A discussion of the recent work is included in the chronology section of this report in Appendix B. For the sake of brevity a summary of the NHC hydraulics and hydrology work is appended to this section, but for detailed information the reader should obtain the NHC publication.

The 2011 work included new survey of the same cross section points used in the 2010 NHC Hec-Ras model. The 2011 survey also included new survey of the top and toe of a small rock dam that was anonymously constructed about 550 feet downstream of the weir. The rock dam cross sections used in this study were not included in the 2010 NHC model. The small rock impoundment dam is close to 2 feet tall at the center, 50 feet wide across the channel and 10 feet in length. The best guess is that a group of ambitious kids stacked the rocks. The existing (2011) conditions scenario updated all eight of the transition zone sections with the new survey and added two new sections at the rock impoundment, which is near cross section #6 (aka RM69353.95) as shown in the following Figure 4.

Figure 4. 2011 Transition Zone Survey

Once the existing topology was created, the recent observed stage-discharge information was used to re-calibrate the model; the calibration process is discussed in the following section. The Existing Condition Scenario was used as baseline that other maintenance scenarios could be compared against. The data from this scenario is reported in the *Model Output and Summary Findings* section of this report.

Existing Hydraulic Scenario Calibration

King County completed a significant maintenance effort at the transition zone in the summer of 2011. After the work was completed King County monitored the site to evaluate the project performance. The monitoring effort included field measurements of the observed stage-discharge readings at the transition zone sill (also known as weir). The monitoring data was then compared with pre-project readings of similar flow events. This analysis showed that the maintenance effort had a measurable impact on the stage-discharge relationship at the sill. The change in the stage-discharge relationship required a re-calibration of the portion of the model affected by the recent 2011 maintenance work.

Calibration of the model was targeted only for the transition zone, and in particular it was calibrated to match observed flows at the transition zone with the observed weir stage. The calibration method used a Hec-Ras V*ertical Variation in Manning's Roughness Values* table for the 10 cross-sections along the transition zone. Information regarding the roughness values table can be found in the Hec-Ras Version 4.1.0 Users Manual.

The modification of the vertical variation in roughness method for calibration of the model was selected because it was the same method used in a 2004 *Sammamish River Transition Zone Hydrologic and Hydraulic Investigation* study of the transition zone by West Consultants (see Appendix B for a reference). The method was also utilized because it is a known industry standard and because it closely replicates the physical constraints at the site where the mid-channel overhanging mass of willows starts to impede flow at an elevation of 24.5'.

The results from the 2004 calibration were used in the Flood Insurance Study (FIS study) and they were also used as the starting point for the calibration used in this study. The goal of the calibration was to run the model using the observed flow rates, then modify the vertical roughness value so that the model output Water Surface Elevation (WSEL) at the gage matched the observed gage height.

The following *Typical NHC Vertical Roughness* Table 1, was used in the 2010 NHC Hec-Ras model, the table shows the typical final calibrated values used in the 2010 flood insurance study. The *Transition Zone Calibration Summary* Table 2 shows the calibration input flows and the measured gage elevations followed by the Hec-Ras model results for the existing scenario and output from two calibration efforts. The Run#2 results from the table show a summed model output of 0.00, which is the optimum target result. The roughness values used in the Run#2 scenario were then selected for use in the existing condition baseline scenario Hec-Ras model.

Table 1. 2011 Transition Zone Survey

Typical NHC Transition Zone Vertical Roughness Table

	Left Floodplain		Channel	Right Floodplain	
	Station	Station	Station	Station	Station
Elevation	404-565	565-595	595-662	662-690	690-800
24	0.09	0.2	0.03	0.2	0.095
24.5	0.09	0.2	**0.09[n]**	0.2	0.095
29	0.09	0.2	**0.09[n]**	0.2	0.095

[n] Two highlighted cells are the mid channel roughness (due to willows above 24.5') and were modified to calibrate model.

Transition Zone Calibration Summary Table

Date	Q Weir	Q Bear	Q Sam@Bear	Gage[n] Measured	WSEL Measured	Ex HecRas Model[1]	Ex HecRas Error[4]	Run #1 Model[2]	Run #1 Error	Run #2 Model[3]	Run #2 Error
12/15/2011	158.17	40.00	198.17	3.64	30.35	29.91	-0.44	30.10	-0.25	29.96	-0.39
2/15/2012	309.38	70.00	379.38	4.10	30.81	30.54	-0.27	30.91	0.10	30.74	-0.07
11/28/2011	377.56	173.00	550.56	4.34	31.05	30.81	-0.24	31.18	0.13	31.02	-0.03
1/23/2012	411.00	250.00	661.00	4.35	31.06	30.93	-0.13	31.30	0.24	31.13	0.07
2/24/2012	458.28	183.00	641.28	4.53	31.24	31.09	-0.15	31.46	0.22	31.30	0.06
1/31/2012	704.72	218.00	922.72	4.93	31.64	31.80	0.16	32.17	0.53	32.00	0.36
						Σ=	**-0.18**		**0.16**		**0.00**

[n]Note: Gage (Measured) + 26.71=NAVD88 WSEL

[1] Used vertical roughness (above 24.5') of 0.09 from NHC model, see table above

[2]Increased channel vertical roughness (above 24.5') from 0.09 to 0.13

[3]Reduced channel vertical roughness (above 24.5') from 0.13 to 0.11

[4] The Error columns show the difference in WSEL Measured and the HecRas WSEL. The column summation should be 0 to calibrate.

Note: Bear Creek (Q Bear above) backwaters the weir gage, and therefore needs to be included in the Hec-Ras model.

The above calibration table is based on recent observed (field measured) events at the Sammamish River Transition Zone gage at the weir (King County gage 51m - Sammamish River @ Marymoor). The measurements for low flow are taken at the transition zone weir while the high flows are measured at the downstream bridge (for safety reasons). The Q Bear column shown in the table is needed to establish a tailwater that may influence the gage reading at the weir. The Q Bear flow rates were measured at King County gage number 02a, which is the Bear Creek @ Union Hill road gage.

1964 Conditions Scenario

There was interest in comparing the hydraulic properties resulting from the 1964 construction of the transition zone prior to sediment built-up and willow growth. The 1964 Hec-Ras scenario was created using the 1964 weir as-built plans and also using the 2011 survey of the quarry spall elevations along the transition zone. The 1964 scenario excludes the existing rock impoundment near cross section #6 (about 550 feet downstream of the sill) and excludes the existing willow stands. It was assumed that the 1964 project site would inevitably grow a thick reed canary grass stand, so the 1964 scenario used the reed canary grass roughness factor for the overbank area.

The 1964 scenario was created by replacing the existing conditions transition zone elevations with recent 2011 survey by King County of probes taken down to the 1964 constructed rock spall layer. The 2011 survey is the most accurate data available to generate the elevations. The removal of the existing rock wedge at cross section RM69353.95 (the rock top) was modified such that the channel bed was copied from the rock toe cross section (RM69348.35), which is 5 feet downstream of the rock top section. The 1964 scenario also includes the modification of the existing sill, which was re-constructed in 1998. The 1964 sill has just over 50 square feet of additional flow area than the 1998 sill. The last modification was the change in roughness coefficients which is used to differentiate the channel roughness, the willow roughness and the reed canary grass roughness. The 1964 scenario uses the same 0.03 channel roughness as the existing scenario, but replaces the willow stand roughness of 0.20 to 0.09 as the 0.09 value is used to model reed canary grass. The roughness values used in the model were based on work by NHC and West Consultants for preparation of the FIS.

The Hec-Ras output showed 1964 scenario was 0.40 feet lower than the existing baseline condition for 100 year flood event. The 1964 scenario showed a significant decrease in water surface elevations for events that have less of an impact from Bear Creek backwater; for example the typical medium winter flow, which was 750 cfs had a Bear Creek flow of 212 cfs (the 100 year event had a Bear Creek flow of 942 cfs). The results from the typical medium winter flow analysis showed the 1964 scenario would reduce the lake level by just over one foot relative to the existing baseline.

Proposed Maintenance Scenarios

The Hec-Ras model assembled for three maintenance scenarios used the existing conditions scenario (calibrated as discussed in the previous section), then the model was modified using relevant topographic and hydraulic information that best models the proposed maintenance scenario. The three maintenance scenarios include:

1. *Rock Impoundment Removal* scenario – This models the removal an existing wedge of rocks located about 25 feet downstream of cross-section #6.
2. *Excavate Down to the Rock Spall Layer* – This models excavation of the existing sediment down to the rock spall layer that was constructed by the USACE in 1964.
3. Combined Scenario - Utilized both the *Excavate down to the Rock Spall Layer* scenario the *Rock Impoundment Removal* scenario.

Scenario #1

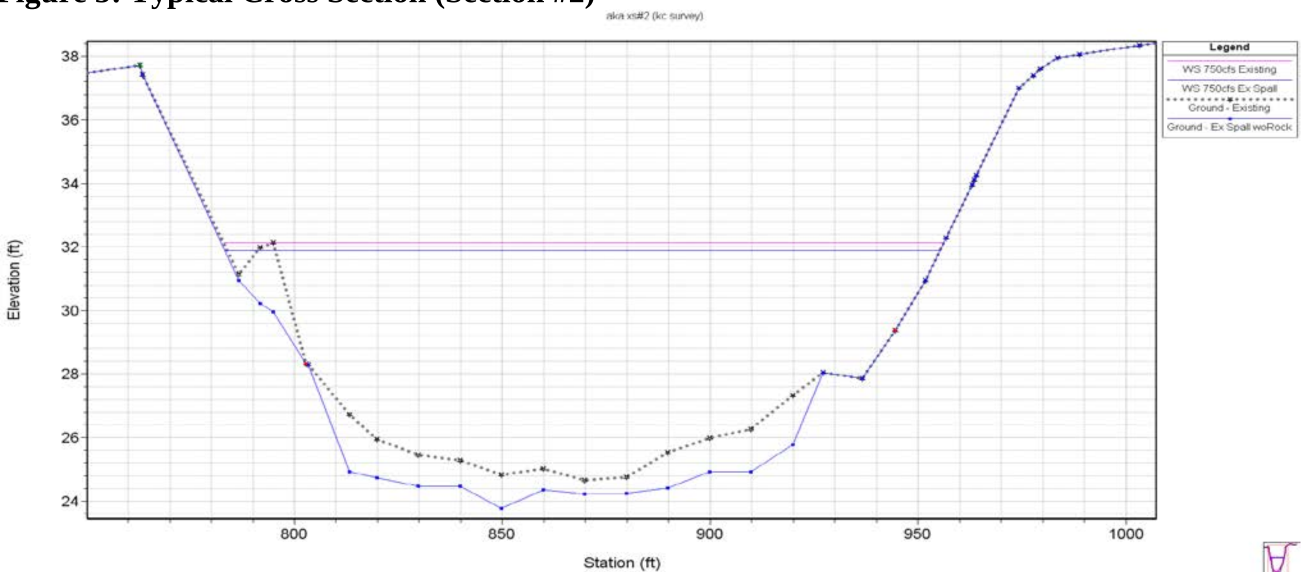
The first maintenance scenario, the *Rock Impoundment Removal* scenario, modeled the hydraulic effect of removing an existing wedge of rocks located about 25 feet downstream of cross-section #6 (aka RM69376.25), which is about 550 feet downstream of the sill. The wedge of rocks is about 50 feet across the channel 10 feet in length and close to 2 feet high at the center. The rock wedge was surveyed by King County and the two new cross-sections that represent this feature were added to the model. The two sections include the rock top and the downstream toe of the rock which is about 5 feet downstream of the top. The *Rock Impoundment Removal* scenario was identical to the existing conditions scenario, but the cross section of the rock top (River Sta. 69353.95) was modified such that the channel bed was the same as the next downstream cross section (River Sta. 69348.35), which is the rock toe section. The channel roughness parameter was left the same since there would be no change in the texture of the channel.

Scenario #2

The second maintenance scenario, the *Excavate Down to the Rock Spall Layer* scenario shows excavation of the existing sediment down to the rock spall layer that was constructed by the USACE in 1964. The *Excavate Down to the Rock Spall Layer* models the sediment removal of two strips of land along the right and left floodplain benches. The area is bounded by the Canopy Buffer Boundary (as seen as the red line in Figure 3) on one side and the toe of the side slope of the flood bench on the other. The buffer boundary was recently (2011) established through communications and agreements between King County and the USACE (personal communication with Kate Akyuz from King County).

The creation of this scenario used the recent 2011 spall layer survey by King County (as discussed in the Chronology Section, Appendix B of this document). This scenario used the elevations established from the probed test holes, using only the spall elevations taken outside the buffer area discussed in the previous paragraph. The following Figure 5 was taken at King County cross-section #2 and is also listed as cross section RS69970.72 in the Hec-Ras model. The section shown in Figure 5 is also a typical cross section found along the transition zone. The dotted line is the existing (2011) ground surface and the blue line is the top of the 1964 constructed spall layer.

Figure 5: Typical Cross Section (Section #2)



The proposed maintenance scenario hydraulic roughness parameter was left the same as the existing condition scenario. The rational for not altering the hydraulic roughness parameter is that after maintenance work is complete the reed canary grass mat will grow back, reestablishing the same hydraulic roughness used in the existing conditions scenario.

Scenario #3

A third scenario combined the *Excavate down to the Rock Spall Layer* scenario #1 with the *Rock Impoundment Removal* scenario #2. The resultant model depicts the transition zone with the removal of the rock wedge 550 downstream from the weir and removal of the sediment outside the buffer zone down to the 1964 spall layer.

Steady State Flow Data

Each of the scenarios was modeled using various flow regimes including the 100 year, 50 year, 10 year recurrence interval, the 1964 COE Design flow and three additional typical flow events. The 100 year, 50 year and 10 year flow values for the Sammamish River and Bear Creek were generated in the 2010 Flood Insurance Study that was discussed previous. The 1964 COE design flow used for the transition zone design was 1500 cfs. The 1964 hydraulics did not establish a Bear Creek flow and most likely did not consider the backwater impacts from this tributary. This study used 1,500 cfs flow with 0 cfs at Bear Creek as the design flows. The final three events used in the Hec-Ras model are based on a historical gage record representation of a typical high, medium and low winter flow event. The selection of the event also includes the Bear Creek flow (from K.C. gage 02a) that was associated with the event. The flow values that influence the hydraulics at the transition zone, including Sammamish River at the weir, Bear Creek confluence and Sammamish River downstream of Bear Creek are shown in Table 2. The Bear Creek flows shown in Table 2 were copied from the 2010 Flood Insurance Study, in the case of the typical flow events shown in the table, the flow in Bear Creek used an average value recorded at the Bear Creek gage for the relevant Sammamish River flow.

Output and Summary Findings

The following table shows relevant Hec-Ras model output information for the baseline condition and the three scenarios discussed in the previous section. The table also provides a summary of the change in the existing conditions lake water surface elevation versus the 3 plans discussed in the hydraulic modeling section.

- **Baseline**: Sam Ex 2011 – Sammamish River Transition Zone Existing (2011) Calibrated scenario which is the baseline condition. Also referred to as Baseline in the output tables.
- **Scenario #1**: Ex wRemoved Rock – Same as the baseline scenario (Sam Ex 2011), but the small rock impoundment is removed. Also referred to as Scenario #1 in the output tables.
- **Scenario #2**: Spal Lyr wRoc@6 – Scenario showing excavation down to the 1964 spall layer, but the rock impoundment still in place. Also referred to as Scenario #2 in the output tables.
- **Scenario #2**: Spal Lyr WORock – Combines Scenario 1&2 which is the same as the Spal Lry wRoc@6 scenario (scenario #1) without the rock impoundment near XS#6 (scenario #2). Also referred to as Scenario #3.

The *Comment* heading shown on the following Table 2 illustrates the various flow regimes that were used when running the Hec-Ras model. The three columns under *Flow* give the flows that were used in the steady state Hec-Ras model. The model utilized these flows at three locations, the Sammamish River weir (sill), Bear Creek flow at the confluence and Sammamish River flow just downstream of Bear Creek confluence.

The Baseline, Scenario #1, Scenario #2 and the Scenario #3 show the Hec-Ras lake-level results and the adjacent column (Δ*Water Surface vs. Existing* column) shows the difference in the lake water surface versus the baseline condition.

Table 2: Output Summary

	Flow			Baseline	Scenario #1		Scenario #2		Scenario #3	
Comment	Lake Flow to Sam R.	Bear Cr Inflow Sam R.	Sam R. @ Bear Cr	Sam Ex 2011	Ex wRemoved Rock	ΔWater Surface vs Exist.	Spal Lyr wRoc@6	ΔWater Surface vs Exist.	Spal Lyr WORock	ΔWater Surface vs Exist.
100 Yr Flow	1649	942	2591	36.10	36.10	0.00	36.04	0.06	36.04	0.06
50 Yr Flow	1530	889	2419	35.58	35.58	0.00	35.52	0.06	35.52	0.06
10 Yr Flow	1233	750	1983	33.87	33.87	0.00	33.68	0.19	33.69	0.18
1964 COE Design Flow	1500	0	1500	34.37	34.37	0.00	34.29	0.08	34.29	0.08
Typ. Winter High Flow	1000	329	1329	32.89	32.88	0.01	32.70	0.19	32.69	0.20
Typ. Winter Mid Flow	750	212	962	32.13	32.13	0.00	31.89	0.24	31.88	0.25
Typ. Winter Low Flow	350	51	401	30.71	30.71	0.00	30.57	0.14	30.58	0.13
		WSEL are from RS 69970.72, which is just upstream of the sill. Elevations or NAVD88.								

The variation shown in the Δ*Water Surface vs Exist* column in Table 2 is most likely due to the variation in Bear Creek flows. As the Bear Creek flows increase relative to Sammamish River flows, the backwater both slows down flows through the transition zone and increases the river depth. The impact of channel roughness on flow is related to the square of the velocity. This would mean that as Bear Creek slows flows it would exponentially decrease the impacts of the reduction in roughness as a result of the maintenance work. The second significant impact to the results would be due to flood depth in the transition zone. The maintenance work through out the transition zone is modeled as a reduction in roughness (relative to the existing condition) of the homogeneous horizontal flood bench. The effects of the maintenance would become optimal as the area defined by the wetted perimeter across this layer is first submerged. Flow below the level defined by the maintenance would have no relative impact on values in the Δ*Water Surface vs Exist* column shown in Table 2. Flood depths that exceed the optimum depth would benefit from the decreased roughness defined in the maintenance area, but the benefit will be reduced with increased depth.

The following Table 3 illustrates the model results for a typical Sammamish River high flow event (750 cfs with 212 cfs flow from Bear Creek). The “River Sta” column shown in the table (shown as 73736.02 and 69970.72 thru 68846.82) are the river stations along the transition zone with the top most river station (73736.02) being the furthest upstream station in the model which depicts Lake Sammamish conditions. The transition zone stations can be seen in Figure 3. The remaining columns show the selected Hec-Ras model results.

Table 3: Hec-Ras Output

Reach	River Sta	Plan	Q Total	Min Ch El	W.S. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width
			(cfs)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)
Sammamish River	73736.02	Existing	750.00	23.87	32.35	0.000001	0.14	7051.34	3758.50
Sammamish River	73736.02	Exist wo Rock@6	750.00	23.87	32.34	0.000001	0.14	7044.20	3758.08
Sammamish River	73736.02	Ex Spall Buf w6	750.00	23.87	32.13	0.000001	0.15	6599.84	3732.18
Sammamish River	73736.02	Ex Spall woRock	750.00	23.87	32.12	0.000001	0.15	6590.04	3731.60
Sammamish River	69970.72	Existing	750.00	24.65	32.13	0.000050	0.87	892.00	173.18
Sammamish River	69970.72	Exist wo Rock@6	750.00	24.65	32.13	0.000050	0.87	891.32	173.06
Sammamish River	69970.72	Ex Spall Buf w6	750.00	23.76	31.89	0.000037	0.79	989.05	172.02
Sammamish River	69970.72	Ex Spall woRock	750.00	23.76	31.88	0.000037	0.79	988.10	171.98
Sammamish River	69902		Inl Struct						
Sammamish River	69851.51	Existing	750.00	26.20	32.07	0.002453	1.61	556.14	211.43
Sammamish River	69851.51	Exist wo Rock@6	750.00	26.20	32.07	0.002463	1.61	555.31	211.41
Sammamish River	69851.51	Ex Spall Buf w6	750.00	26.20	31.83	0.002634	1.62	556.54	210.07
Sammamish River	69851.51	Ex Spall woRock	750.00	26.20	31.82	0.002651	1.62	555.37	210.04
Sammamish River	69803.55	Existing	750.00	27.24	31.93	0.003236	1.92	531.44	211.74
Sammamish River	69803.55	Exist wo Rock@6	750.00	27.24	31.92	0.003254	1.93	530.45	211.72
Sammamish River	69803.55	Ex Spall Buf w6	750.00	27.24	31.69	0.003211	1.88	546.76	211.00
Sammamish River	69803.55	Ex Spall woRock	750.00	27.24	31.68	0.003260	1.82	545.32	210.98
Sammamish River	69704.10	Existing	750.00	26.34	31.55	0.003923	2.13	496.60	205.25
Sammamish River	69704.10	Exist wo Rock@6	750.00	26.34	31.55	0.003959	2.14	495.06	205.16
Sammamish River	69704.10	Ex Spall Buf w6	750.00	26.34	31.33	0.003514	1.99	519.69	205.18
Sammamish River	69704.10	Ex Spall woRock	750.00	26.34	31.32	0.003562	2.00	517.41	205.07
Sammamish River	69378.25	Existing	750.00	25.15	30.64	0.002138	1.67	599.92	210.87
Sammamish River	69378.25	Exist wo Rock@6	750.00	25.15	30.61	0.002206	1.69	593.57	210.71
Sammamish River	69378.25	Ex Spall Buf w6	750.00	25.15	30.50	0.001969	1.56	622.52	211.73
Sammamish River	69378.25	Ex Spall woRock	750.00	25.15	30.46	0.002038	1.58	615.53	211.53
Sammamish River	69353.95	Existing	750.00	26.70	30.56	0.004737	1.97	493.84	211.62
Sammamish River	69353.95	Exist wo Rock@6	750.00	25.60	30.56	0.002168	1.76	594.72	211.62
Sammamish River	69353.95	Ex Spall Buf w6	750.00	26.70	30.40	0.005923	2.13	460.73	210.74
Sammamish River	69353.95	Ex Spall woRock	750.00	25.60	30.40	0.002529	1.86	564.90	210.74
Sammamish River	69348.35	Existing	750.00	25.60	30.55	0.002197	1.77	592.07	211.55
Sammamish River	69348.35	Exist wo Rock@6	750.00	25.60	30.55	0.002197	1.77	592.07	211.55
Sammamish River	69348.35	Ex Spall Buf w6	750.00	25.60	30.39	0.002611	1.89	558.13	210.65
Sammamish River	69348.35	Ex Spall woRock	750.00	25.60	30.39	0.002611	1.89	558.13	210.65
Sammamish River	69109.96	Existing	750.00	24.16	30.09	0.001584	1.38	676.38	207.58
Sammamish River	69109.96	Exist wo Rock@6	750.00	24.16	30.09	0.001584	1.38	676.38	207.58
Sammamish River	69109.96	Ex Spall Buf w6	750.00	24.16	29.97	0.001210	1.27	734.96	212.29
Sammamish River	69109.96	Ex Spall woRock	750.00	24.16	29.97	0.001210	1.27	734.96	212.29
Sammamish River	68846.82	Existing	750.00	22.07	29.77	0.000902	1.43	753.04	217.77
Sammamish River	68846.82	Exist wo Rock@6	750.00	22.07	29.77	0.000902	1.43	753.04	217.77
Sammamish River	68846.82	Ex Spall Buf w6	750.00	22.07	29.76	0.000559	1.13	895.61	227.26
Sammamish River	68846.82	Ex Spall woRock	750.00	22.07	29.76	0.000559	1.13	895.61	227.26

Continuous (Un-Steady State) Model of Existing and Proposed Maintenance Scenario

The purpose of including a continuous un-steady state model run of the existing condition and the maintenance condition was to address the concern that the maintenance work would have a synergistic effect on lake elevations that the steady state model would not calculate. The hydrologists working on this project have considered that a small maintenance project with a minor conveyance improvement will allow for continuous improved flows from the lake that will be additive over time. As the lake releases the additional water associated with the maintenance work, the volume of flow accumulating over time would not be addressed by the steady state model that was used in the previous sections. The impact of using the un-steady state model versus the steady state model was not intuitive so this section was added to better understand the dynamics of the maintenance work on the lake elevation.

The existing (2011) conditions scenario was run using the HecRas Unsteady Flow Analysis routine, which is a 1-D model that allows for time-step calculation of flows. Unlike the steady-state model, the time-step calculation allows for the addition of storage and temporal routing of flows. The two most important advantages of the continuous model is it can calculate the stormwater detention effect of Lake Sammamish as it stores, then releases flows to the Sammamish River. The second important advantage is the model can import previously recorded time-series inflows from tributaries such as Bear Creek for gauged periods of record. The time-series hydrograph inflow has a distinct advantage over the steady state model as it can allow for the off-set of peak flows from the tributaries. Typically the smaller developed basins will discharge both the peak flow and a significant portion of the total volume of stormwater before the larger main-stem will convey the peak flow; this is especially true when a large storage area like Lake Sammamish is involved. The steady state model, which is used in the previous sections of this report, allows for a snap-shot of the hydraulic impacts of the transition zone for the given flow entered at the inlet to the Sammamish River and from the backwater effect of the flow at Bear Creek. This means the Hec-Ras software will run the flow rate until an equilibrium is calculated. Normally for river flows this is an acceptable practice, but the large storage in a lake can have a significant impact on the calculation of steady-state equilibrium.

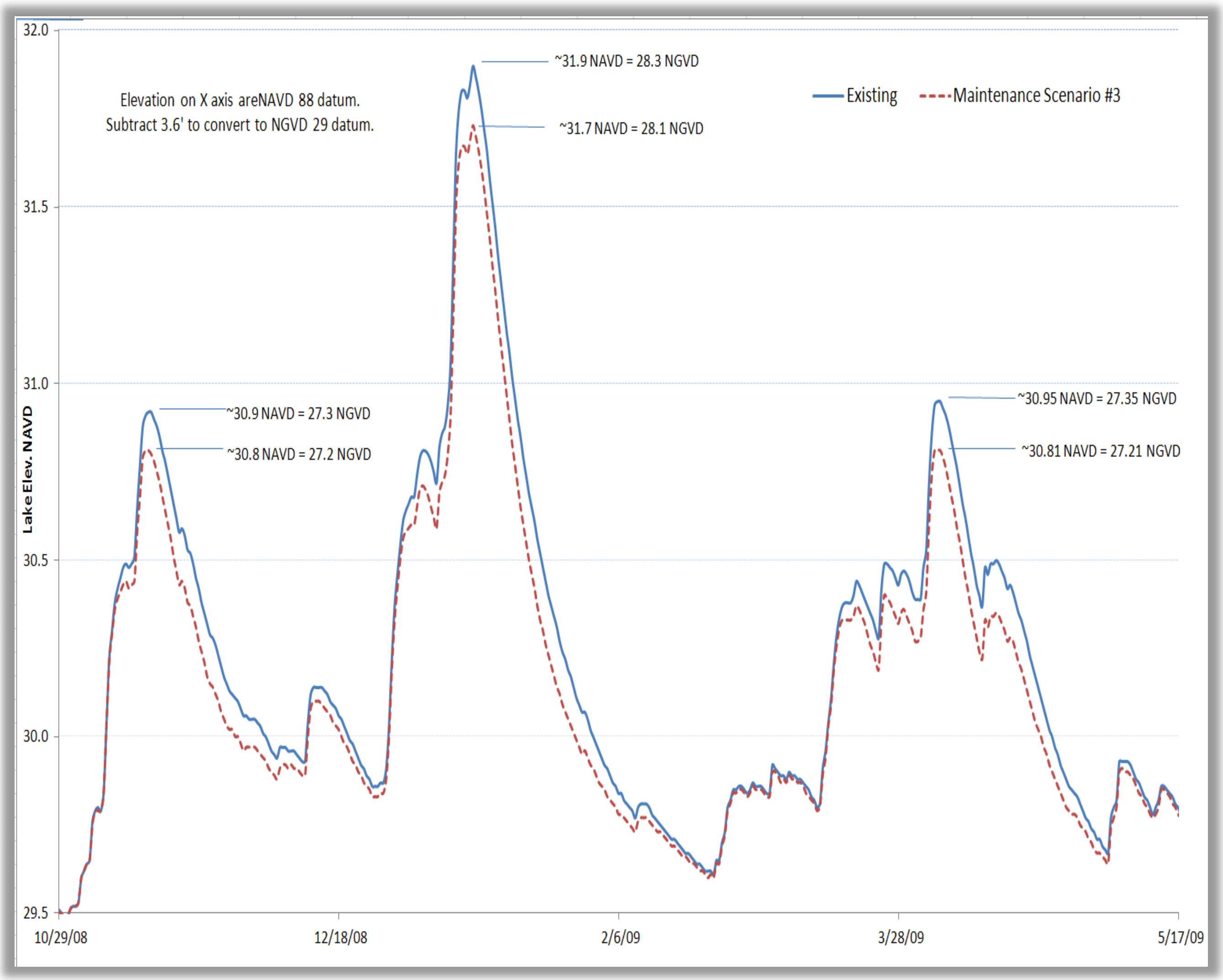
The 2009 water year was chosen as the time-series for this study because the gage data is available, because it was a moderately wet winter and because most of the residents can recall the weather and lake conditions.

The unsteady flow model was prepared by West Consultants and was used as part of the 2010 FIS study discussed previously. The unsteady model used both the available historical gage flow and rainfall data as input to re-create the complex real-time interaction of all the Sammamish River basin tributary flows. The Sammamish River flows were generated from the interaction of known hydraulic and hydrologic components such as the backwater created by Lake Washington, the Lake Sammamish tributary inflows, the planimetered Lake Sammamish stage-storage relationship and all the tributary flows that feed the Sammamish River. The reader should be aware that the stage-storage curve created for Lake Sammamish (the one used in this Hec-Ras model) is only accurate up to the intent of original model, which was to establish flow-frequency tables for the Sammamish River. The Lake Sammamish storage node used in the model does not take complex hydrology into account such as lake infiltration, exfiltration, evaporation or detailed topography at the lake boundary. With that said, the model is not calibrated such that it would calculate accurate lake elevations (as shown in the following figure); but, the model is very useful because it will give a good estimate of the difference between two scenarios, in this case the existing baseline scenario versus a proposed maintenance scenario. West Consultants provided the continuous model channel roughness values. These values were not re-calibrated as was performed to the steady-state model (as discussed previous in this report).

The proposed maintenance scenario is the same geometry file as the one used as scenario #3 in the steady state model that was described in the previously in the report. Scenario #3 includes excavation down to the 1964 rock spall layer (as disgust in the previous section this is only for areas outside the existing buffer), and also includes the removal of the small rock impoundment located about 550 feet downstream of the sill. The existing scenario used for the continuous model is the same geometry file as the steady-state model; the existing scenario models the 2011 surveyed conditions.

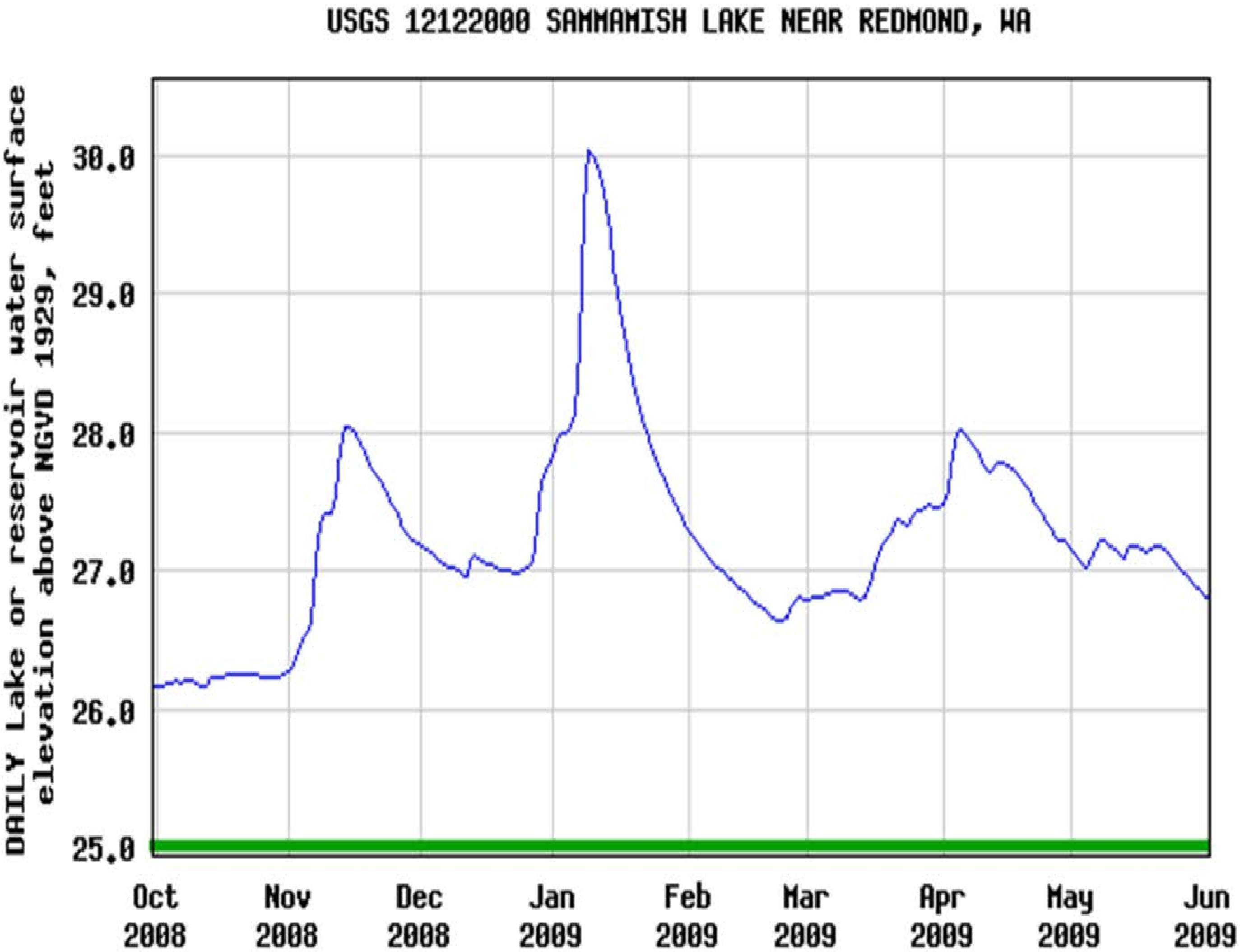
The following figure shows the continuous model output for the existing and the maintenance scenario. The model shows the January 14th peak lake elevation for the 2009 water year would be reduced by 0.2 feet as a result of the maintenance work. The figure also shows the effects of the maintenance work (shown as the reduction in the lake elevation) would diminish into the spring as the rainfall events subsided. The peak modeled January 14th flow rate shown on the figure was 800 cfs and the two peak flows for the November 14th and April 4th peaks were 510 cfs and 515 cfs. The reader can also compare results from the steady-state model for the existing versus maintenance scenario #3, the results are shown in Table 2 and they show the effects of the maintenance work for each of the modeled flow rates. The reader should be aware that the Bear Creek flows, which are not shown, will also impact the results. The results show the steady-state and the un-steady state modeling methods give similar deviation in results when comparing existing and the proposed maintenance impacts on the lake level.

Figure 6. Lake Sam W.S. Elev. for Existing and Maintenance Scenarios – Unsteady State Model



The following figure shows the actual lake elevations from the USGS Lake Sammamish gage #12122000 for the same 2009 water year. Note the elevations in this figure are based on the NGVD datum, which is 3.6 feet lower than the NAVD datum used in the model and as shown in the figure above; the peak lake elevation from the gage would then be just over 33.6 feet NAVD and the above output from the model shows it to be close to 32 feet.

Figure 7. Observed Lk Sammamish Stage Measurements for W.Y. 2009



As a check of the model output results, the 2009 modeled output (Figure 6) should be similar to the actual recorded lake elevations (Figure 7). Observation of the two figures shows similar correlation between the two hydrographs. The reader should note two items from the graphs:

- The lake elevation difference calculated by the model for the water year is ~2.4' and the actual (gauged) difference as shown in Figure 7 is ~3.9'.
- The modeled existing peak flow is 31.9 NAVD and the actual (gauged) is 33.6 NAVD (conversion is 30.0 NGVD+3.6).

Both of these differences are most likely related to the simplified hydrologic assumptions used to model the lake (these assumptions are discussed previously in this section). The second item would not affect the outcome of this study because the study is looking at the relative difference in the lake water surface elevations. The first item indicates the continuous (unsteady-state) model should be calibrated to the known lake elevation. The calibration would be helpful to better model lake elevations for various design scenarios. Because this study used the results from the steady state model run, the calibration of the continuous model was not needed.

A second check of the continuous model output is by comparison of the King County measured lake elevations as shown in the following Table 4. Table 4 shows the observed stage elevations at King County gage #51m, which is located at the transition zone sill, for the 2009 water year. The sill is considered to be the outlet control boundary of the lake, but it can vary in elevation relative to the lake from 0.1 to 0.3 feet depending on flow conditions, lake elevation, Bear Creek flows and because of its proximity to the lake, which is about 4,000 feet downstream of the summer lake perimeter. On average the difference is about 0.2 feet, so the adjusted stage shown in the following table reflects an approximation of the lake elevation for both NGVD and NAVD datums. The table below shows good correlation with the Lake Sammamish gage and fair correlation with the modeled results.

Table 4. Observed K.C. Gage #51 Stage Measurements for W.Y. 2009

	Observed @ Gage #51					Hec-Ras Output	
Measurement Date	Stage Observed	Stage NAVD[n]	Stage NGVD[n]	Adj Stage NAVD[n]	Adj Stage NGVD[n]	Hec-Ras NAVD[n]	Hec-Ras NGVD[n]
8/13/2008	3	29.71	26.11	29.91	26.31	NA	NA
10/1/2008	3.06	29.77	26.17	29.97	26.37	29.87	26.27
12/9/2008	3.88	30.59	26.99	30.79	27.19	29.96	26.36
1/8/2009	6.28	32.99	29.39	33.19	29.59	31.78	28.18
2/12/2009	3.77	30.48	26.88	30.68	27.08	29.77	26.17
4/30/2009	4.03	30.74	27.14	30.94	27.34	29.79	26.19
6/25/2009	3.18	29.89	26.29	30.09	26.49	NA	NA

[n]Gage (Measured) – 26.71=NAVD88 WSEL
[n]Gage (Measured) – 23.11=NGVD WSEL
[n]Adj Stage - Added 0.2' which is typical difference in water surface from Tzone sill to the Lake

Summary of Results

The unsteady-state model run shows that using the steady state model gives adequate results when comparing various scenarios. Both the unsteady-state model and the steady state model are inaccurate with respect to calculation of an absolute lake elevation. In the event the model is up-graded to calculate absolute lake water surface elevations the lake stage-storage tables would need better resolution, additional hydrologic properties affecting storage in the lake would need to be added to the model including (but not limited to) exfiltration, infiltration and evaporation. The model would also need to be calibrated to known lake levels.

The scope of the report was to show the relative effect of various maintenance operations on the lake elevation. The model correlates with measured data, which indicates the model gives accurate results. The model shows:

- For high flows, Bear Creek has a significant impact on the lake water surface elevation.
- The water surface of the lake can be drawn down slightly less than 0.3’ under optimal conditions for the modeled maintenance scenario #3.
- Through the late spring and summer the lake elevation will recede to a depth controlled by the sill.

The scope of the project was limited to the scenarios shown in this report. It is apparent that the control of the lake is sensitive to modifications to the sill and to the floodplain area approximately 200 feet downstream of the sill. This assertion is based on engineering judgment and review of the transition zone profile, survey information, modeling results and visual observations at the site. Increased conveyance and lowering the lake elevation would most likely benefit from targeted maintenance in this area.

Appendix Index

A. Summary of 2010 NHC Hydrologic and Hydraulic Routing Study
B. Chronology of Events Relevant to Hydraulics at the Transition Zone

A. Summary of 2010 NHC Hydrologic and Hydraulic Routing Study

As discussed previous, the 2010 NHC (Northwest Hydraulic Consultants) flood study was a utilized for a large portion of this study, and for that reason the following section was added to give the reader a background on the information used to create this study.

The hydrologic study for the model was completed as part of the February 5th, 2010 Floodplain Mapping Study for the Sammamish River. The study explains in detail the methodology for creating the time-series that were used in the hydraulic model.

The most significant challenge in developing a flow-frequency distribution is determining how flow hydrographs from the various tributary basins coincide in time to produce a given peak flow quantiles on the Sammamish River. Tributaries to Lake Sammamish comprise less than half of the Sammamish River basin area and outflow from the lake is significantly attenuated; consequently, local runoff and tributary inflows downstream of Lake Sammamish are likely to peak much earlier than lake outflows. The downstream sub-basins, namely Bear Creek, Little Bear Creek, North Creek, and Swamp Creek, may also peak at different times from each other due to differences in precipitation patterns, land-use conditions (including level of urbanization) and basin storage characteristics. The hydrologic analysis must specifically account for these differences, or Sammamish River flows could be overestimated and result in an overly conservative floodplain analysis. To address these timing issues, NHC generated long-time series of flows at multiple points along the Sammamish River (including the weir) under current watershed conditions. These time series were generated using a combination of two models; Hydrologic Simulation Program -FORTRAN (HSPF), to simulate flow inputs from the tributary basins, and Hydrologic Engineering Center River Analysis System (HEC-RAS), to route these inflows down the Sammamish River. Frequency analysis was then performed on the simulated peak flows to determine flows for use in a steady state HEC-RAS model for floodplain analysis. The use of continuous hydrologic modeling (HSPF) precludes the need to make judgments regarding the temporal correlation between tributary hydrographs and Sammamish River peak flows. It also allowed NHC to define flood frequency quantiles based on simulation of actual hydrologic response (with the most recently available land use and weir conditions). NHC obtained and used existing King County and Snohomish County HSPF models of basins tributary to Lake Sammamish and to the Sammamish River to produce a 60-year time series of flows for each basin (water year 1949 to 2009). King County developed and calibrated HSPF models for all basins in the Sammamish River watershed as part of its Sammamish-Washington Analysis and Modeling Program (SWAMP). These models included Issaquah and Tibbetts Creeks, East Lake Sammamish Tributaries, West Lake Sammamish Tributaries, Bear Creek (including Evans Creek), Little Bear Creek, North Creek, Swamp Creek, and local drainage to the Sammamish River. Land-use conditions represented in these models are from 1995. In more recent work for Snohomish County, NHC has developed and/or updated and calibrated HSPF models for the Swamp, North, and Little Bear Creek basins. These models use land-use data current to the time of this flood study analysis.

The initial simulation periods for the models provided by King County were limited to the period of record of the local precipitation gages used as input (approximately water years 1990 through 2003). To produce long-term simulations, precipitation records were extended back to October 1948 by transposing SeaTac precipitation data to each of the local gage locations. A multiplier on SeaTac precipitation was determined for each gage using the ratio of local to SeaTac mean annual precipitation from overlapping periods of record. Local gage precipitation records used in the provided Snohomish County models had already been extended by similar methods. NHC also extended the simulation period forward to 2009 to capture some recent large storm events. As needed, data gaps were filled by transposing data from nearby gages. The time-series created from the hydrology study were then used in the hydraulic model.

The hydraulic characteristics for the NHC 2010 study used a Hec-Ras (Version 4.0) steady and unsteady state computer model. An unsteady state-condition was used to route flow through the Sammamish River for the hydrologic analysis and determining peak flows along the river as discussed in the Hydrology summary. A steady-state condition was then used to compute water surface profiles corresponding to the 2 thru 500 year frequency quintiles typically reported in FIS studies.

This study utilized both the Steady State and Unsteady HEC-RAS Model from the February 5th, 2010 NHC Floodplain Mapping Study for the Sammamish River; then updated these files using the recent 2011 survey. The new survey includes the same 8 cross sections used in the FIS through the transition zone. The new survey points were shot at the same locations as the original Flood Plain Mapping Study (FIS). The procedure to accomplish this was done by loading the horizontal coordinates in the GIS data-logger (need this from Bob), then using the staking program to re-occupy the points. The new survey also included measure-down elevations of the top of the rock spall layer. This was done by steel probe measurement or test pit excavation and measurement. NHC used the HSPF-simulated time series from each tributary as input to an unsteady Hec-Ras model (development of the Hec-Ras model geometry and model calibration is discussed in Section 3.2). The unsteady Hec-Ras model was used to route flows through Lake Sammamish and the Sammamish River.

Initial channel and overbank roughness factors (Manning's "n" values) used in the hydraulic model were selected based on field observations, orthophotos, published data, values used in the previous flood studies, and engineering judgment. The model was calibrated to high water marks along the length of the river and stage and flow hydrographs, when available, at the Willows Run gage and at the weir for three observed flood events (March 1991, December 2001, and January 2009). The Willows Run gage (King County gage 51t/USGS gage 12125200) has observed data from 1965 to 2009, and the weir (King County gage 51m) from 2001 to 2009. High water marks were generally matched to within 0.25 feet, but all values were within 0.5 feet. Manning's "n" values were varied for these events to reflect the increase in bank vegetation growth over time. The January 2009 calibration, representing current conditions, was used for the 60-year simulation and final analysis of the 10%-, 2%-, 1%-and 0.2%-annual-chance events and floodway.

B. Chronology of Events Relevant to Hydraulics at the Transition Zone

Feb 12, 1951 Flood of Record Lake Sammamish Elevation 33.60 MSL (37.20 NAVD88) 1,520 "second-feet" documented at Redmond (this should be cfs), assumed ~2000+ cfs at Bothell (no gage at that time).

May, 1962 General Design Memorandum Report by the USACE – The reports document design criteria (see page 11), the following are key points relevant to the Transition Zone:

- Set 1,500 cfs from the lake without overbank flooding as design criteria; also designed to keep the lake below 29.00 MSL (32.60 NAVD). Report does not mention Bear Creek flows or tailwater effects. The report does not show or discuss analysis to support design goals. The engineers at the time did not have the ability to calculate event related time-series flows and most like hand calculated manning's normal flows and possibly did level pool routing calculations. The normal flow calculations would be marginally adequate to design the facility to meet the overbank flooding goal for 1,500 cfs, but it is unlikely the lake elevation goal of 29.00 MSL could be calculated.
- Page 12 of the report: "The design will over-excavate 6" to provide for initial sedimentation immediately following construction." Recent (2011) survey of the transition zone has shown that the site has not filled in past the 6" designed safety factor.

July 1963 to Nov. 1964 - USACE Trans Zone Construction moved channel to new location.

1965 Operations and Maintenance Manual Volume 1 – O&M for the facility includes obligations:

- 2 Annual Reports
- Minimum of 4 Yearly Inspections
- Transition Zone to be kept clear of undergrowth and formation of shoals.

1978 FEMA FIS Study – This document has been superseded by the 2010 FEMA FIS.

December 16, 1993 Letter RE: *Vegetation Management on the Sammamish River* from Jerry Creek to the Corps defining a 10 foot buffer strip along the side of the transition zone channel. This has since been either updated or appended with information found in: 1998 Sammamish River Transition Zone Vegetation Management Plan, the May 20, 2003 Letter to Diane Parks at USACE, the July 7, 2003 HPA Application Cover Letter, the January 7, 2008 Vegetation Management SEPA and the August 22, 2011 JARPA Application for Sammamish River Transition Zone Vegetation Maintenance. The following is a summary of findings from these documents and conversations with Nancy Faegenburg and Kate Akyuz from King County WLRD, both excellent sources on this topic.

- Willows are naturally occurring, not part of a planting effort
- K.C. and USACE agreed that they could stay given maintenance is completed every 4 years (rotate 2 years each side) a 10 foot swath adjacent to the banks can stay while the others are removed; and a limit of 6" diameter for willows.
-

1998 Sammamish Weir 1135 Project and As-Built plans - Weir was modified for fish passage; key points:

- ~100' of weir raised 0.5' to el. 26.0' MSL (29.6 NAVD 88)

- A new 3' wide notch was added dropped the pre-project 12' wide notch from 24.5' to 23.75'.
- The project reduced the conveyance area by 54.5 sq. ft. from the pre-project condition.
- Did not find a design report but there was some cryptic spreadsheets showing lake impacts for various scenarios.

August, 1999 Survey - Kathryn Neal from King County initiated a survey for either a project or alternatives study (this may have been for the early Marymoor Park river meandering project); King County Surveyed the Transition Zone where points numbered 1000 to 1388 represent field data gathered in April, 1999; points numbered 1500 to 1618 represent soundings and ground spot elevations gathered points numbered above 8731 represent data gathered in early march, during august, 1999.

2004 *Sammamish River Transition Zone Hydrologic and Hydraulic Investigation* report - Completed by West Consultants, the study was completed to assist in design of the Marymoor Park river meandering project. The study updated hydrologic and hydraulic Sammamish Basin data and created a robust unsteady state Hec-Ras model of the Sammamish River. This study was also used in development of the 2010 NHC FEMA Flood Insurance Study (FIS) update.

April 2009 Pacific Geometric Services Inc. surveyed Sammamish River in-channel area for the FIS.

March 2009 3Di-West did the upper floodplain (flood-bench) survey for FIS using photogrammetric data that tied in with the Pacific Geometrics work.

Feb 5, 2010 *Floodplain Mapping Study for the Sammamish River* Report by NHC. This report is the most recent FIS.

June, 2011 KC DNRP *Lake Sammamish Flood Reduction Plan* - Monitoring Phase I.
Report quote on how to increase capacity, "Specifically, less vegetation and sediment accumulation within the transition zone low flow channel, and in the River within approximately 1.7 miles downstream of the transition zone, can improve the Lake's outlet capacity". Includes 8 action items includes, cutting, mowing, sediment evaluation and monitoring.

December 14, 2010 KC Draft Report on Lake Sammamish Preliminary Findings

August 2011 King County WLRD (Larry Goulet and Meredith Radella) Survey of transition zone cross sections. This survey re-located exact coordinates from NHC study and re-shot these points to show the sediment accumulation; the work also included survey of the small rock dam (aka impoundment) that is located about 550 feet downstream of the weir. This survey was used in the hydraulic model (in this report) to establish existing conditions.

August 2011, King County WLRD (Meredith Radella, Cody Toal and Ray Timm) excavate or probed test holes down to rock spall layer and surveyed this depth. This survey re-located exact coordinates from NHC study and re-shot these points to show the as-built elevation of the rock spall bench. This survey was used in the hydraulic model (in this report) to establish the "rock spall layer" condition. The "rock spall layer" will be the as-built elevation of the transition zone; it is also the depth that the maintenance operation will excavate to and is one of the scenarios in this report.

August, 2011. *Sammamish River Channel and Floodplain Sediment Accumulation Study in the Transition Zone*, report by Ray Timm with King County, WLRD. The report details measurement methods and results for the sediment survey conducted along the transition zone. In summary, very little sediment, mostly root mass averaging 8.7 inches.

August 2011 Cut Willows and September 2011 Mowed Reed Canary Grass; King County Maintenance Operation at the Transition Zone. King County WLRD (Supervised by Kate Akyuz) completed extensive vegetation removal along the transition zone. The work was followed up with a monitoring effort and report to gage the effectiveness of the work.

November 29, 2011, *Comparing Existing Conditions to Design As-Built Drawings* report by Dwight Martin. Note: this report used the 1964 as-built as existing conditions, not the 1998 sill reconstruction as-built drawings.

December 5, 2011 Action Item 8 - *Monitoring Plan Effectiveness* Memo from King County Carolyn Butchart. This has pre and post vegetation maintenance flow measurements at the weir; this is an on-going program and has most likely been updated.

Appendix 9. Sammamish River Transition Zone Hydraulic Study

Appendix 10. Sediment and Debris Removal Construction Cost Estimate

DATE	3/22/2012
PROGRAM	
SITE	Sammamish TZ left & right deck
PROJ#	
TASK#	
LABOR	$99,106.90
ERR	$31,512.80
VENDOR	$12,000.00
MATERIALS	$82,040.00
DAILY TOTAL	$224,659.70
PREVIOUS JOB TOTAL	
JOB TOTAL	$224,659.70
B3/Indirect Overhead	$33,201

DESCRIPTION AND ROCK TALLY FOR THE JOB

This estimate is for removing approx. 3953 cy's of vegetation/sediment from the left and right decks of the Sammamish TZ. This estimate includes labor, equipment, and material/disposal costs.

***Please note this estimate does not include any permitting requirements, they are unknown at this time.**

MATERIAL	TONS		PREVIOUS	TOTAL
3/4" Minus	0			0
Pipe Backfill	0			0
1 1/2" Minus	0			0
2 1/2" Minus	0			0
Boulders	0			0
2-4"	0			0
4-8"	0			0
Wash pea-1 1/2"	0			0
StrBed Armor	0			0
LLRR	0			0
HLRR	0			0
2 Man	0			0
3-4 Man	0			0
Common Borrow	0			0
Top Soil	0			0
WASTE OUT	2940			2940

LABOR	*HOURS*	*OT*	*TOTAL*
Operator	240		$17,330.40
TD II	480		$34,660.80
TD III			$0.00
Utility	480		$28,670.40
Supervisor	60		$6,483.60
Crew Chief	130		$10,822.50
Admin. Spec. II	20		$1,139.20
EQUIPMENT		*TOTAL*	
Dump Truck 10-12cy	480	$19,828.80	
Tractor /Tub		$0.00	
Slope Mower		$0.00	
Pick Up	430	$3,440.00	
Vactor		$0.00	
Loader		$0.00	
Sweeper	12	$1,284.00	
Backhoe		$0.00	
Hydroseeding - SY		$0.00	
Equip. Trailer	120	$1,560.00	
Trackhoe	120	$3,240.00	
Case 850 Dozer	120	$2,160.00	
RENTALS			
Traf. Display Trailer		$0.00	
PC 120		$0.00	
CAT 330		$0.00	
PC 200 Long Reach	120	$12,000.00	
D6 LGP w/13' blade		$0.00	
Mis Rent		$0.00	
Honey Bucket		$0.00	
Vendor Truck		$0.00	

MATERIALS		*TOTAL*
Misc mat	1600	$1,600.00
	Tons	
3/4" Minus		$0.00
Pipe Backfill		$0.00
1 1/2" Minus		$0.00
2 1/2" Minus		$0.00
Boulders		$0.00
2-4"		$0.00
4-8"		$0.00
Wash pea-1 1/2"		$0.00
StrBed Armor		$0.00
LLRR		$0.00
HLRR		$0.00
2 Man		$0.00
3-4 Man		$0.00
Str Boldr/cobble		$0.00
Common Borrow		$0.00
	L F	*TOTAL*
12" HDPE		$0.00
18" HDPE		$0.00
12" Ductile Iron		$0.00
12" CMP		$0.00
18" CMP		$0.00
12" ADS		$0.00
18" ADS		$0.00
12" CP		$0.00
18" CP		$0.00
Swamp Pad		$0.00

	EACH	*TOTAL*
Type 15 CB		$0.00
Type 16 CB		$0.00
48" MH		$0.00
54" MH		$0.00
72" MH		$0.00
18 X 24 Lid		$0.00
Fabrics		
Coir 900		$0.00
Coir 400		$0.00
Coir Logs 16"		$0.00
Coir 700		$0.00
FISH HABITAT& BIOSTABILIZATION		
Logs		$0.00
Logs w/ Roots		$0.00
EROSION CONTROL		
Eco. Blocks		$0.00
BMP'S (Each)		$0.00
Safety Fence- L.F.		$0.00
Straw/ bale		$0.00
Silt Fence-L.F		$0.00
Straw Wattle		$0.00
WASTE- PER CY		
Clean Dry Fill		$0.00
Dry w/sod		$0.00
Wet / Mud		$0.00
Vegetation/Wet Mud/PTS	2940	$76,440.00
Unsorted/unscreen		$0.00
Top Soil		$0.00
Hog Fuel		200	$4,000.00

UNIT COSTS

LABOR		
Operator	$72.21	$89.50
TD II	$72.21	$89.50
TD III	$73.94	$91.65
Utility	$59.73	$74.04
Supervisor	$108.06	
Crew Chief	$83.25	$103.19
Admin. Spec. II	$56.96	$70.61
ERR		
Dump Truck 10-12cy	$41.31	
Tractor/Tub	$70.00	
Slope Mower	$128.00	
Pick Up	$8.00	
Vactor	$95.20	
Loader	$35.00	
Sweeper	$107.00	
Backhoe	$44.10	
Hydroseeding - SY (1200 +/-)	$3.00	
Equip. Trailer	$13.00	
Trackhoe	$27.00	
Case 850 Dozer	$18.00	
Traffic Display Trailer	$51.70	
PC 120	$35.00	
Cat 330	$87.00	
PC 200 Long Reach	$100.00	
D6 LGP w/13' blade	$66.00	
Mis Rent	$1.00	
Honey Bucket	$70.00	
Vendor Truck	$100.00	
TYPE 15 CB	$174.25	
TYPE 16 CB	$223.31	
48" MH	1,082.00	
54" MH	1,309.00	
72" MH - W/O KNOCK OUT	1,721.00	
18 X 24 LID	100.00	
12" HDPE	$5.92	
18" HDPE	$11.06	
12" CMP	$14.00	
12" Ductile Iron	$27.00	
18" CMP	$15.00	
12" ADS	$8.00	
18" ADS	$12.00	
12" CP	$10.00	
18" CP-- EACH 4FT SECT.	$15.00	
Swamp Pad	$1,100.00	

MATERIALS	
Misc mat	$1.00
ROCK & GRAVEL	
3/4" minus	$11.00
Pipe Backfill Gravel	$12.50
1 1/2" minus	$12.00
2 1/2" Minus:	$13.00
Boulder	$48.00
2"- 4"	$15.00
4"- 8":	$16.00
Washed Pea & 3/4"- 1 1/2"	$15.00
Streambed Armor Gravel:	$18.00
Lite Loose Rip Rap:	$13.00
Heavy Loose Rip Rap:	$20.00
2 Man:	$36.25
3-4 Man:	$36.25
Streambed boulder cobble mix	$40.00
Common Borrow-Unscreened pitrun	$6.00
TOPSOIL	
Hog Fuel	$20.00
Top Soil	$16.75
FABRICS	
Coir 900	$880.00
Coir 400	$285.00
Coir Log 20' -16"	$180.00
Coir 700	$260.28
FISH HABITAT & BIOSTABILIZATION	
Logs	$400.00
Logs w/ Roots	$850.00
EROSION CONTROL	
Eco. Blocks	$37.00
BMP'S (Each)	$1.00
Saftey Fence 3' X L.F.	$0.48
Straw per Bale:	$30.00
Silt Fence 3' X L.F. w/post	$18.00
Straw Wattle	$29.88
WASTE- CY	
Clean Dry Fill	$10.00
Dry w/sod	$32.00
Wet / Mud	$26.00
Vegetation/Mixed Mud PTS	$26.00
Unsorted/unscreen	$31.00

Appendix 11. Labor, Environmental Study Costs, and Estimated Schedules for Permits

TASK NAME	Estimated Time to Prepare Studies and Permits	Estimated Processing Time	Estimated Hours Low End Estimate						Estimated Hours High End Estimate				
			EI	EII	EIII	EIV	Total Hours		Estimated Hours	EII	EIII	EIV	Total Hours
Permits/Approvals													
Project Management					120		120				120		120
NEPA													
SEPA													
Documentation	60 - 120 Days			80	10		90			80	10		90
Administration		30 - 60 Days	40	10			50		40	10			50
Cultural Resources													
Section 106	30 - 90 Days	Unknown			40		40				50		50
KC Landmarks - Certificate of Appropriateness	31 - 90 Days	30 - 60 Days			40		40				50		50
Section 6(f) Land and Water Conservation Fund Act	30 -90 Days						0			80	40		120
ESA Section 7 Consultation (NOAA and USFWS)	30 Days	90 - 210 Days	10	40	60		110		10	100	80		190
Army Corps of Engineers													
Section 404 - CWA Nationwide or Individual	90 Days	90 - 360 Days		30	10		40			120	40		160
Section 10 - Rivers and Harbors Act 1899*	90 -120 Days			20	5		25			20	5		25
U.S. Fish and Wildlife													
Migratory Bird Treaty Act	30 Days	30 Days		40	20		60			40	20		60
Bald and Golden Eagle Protection Act	30 Days	30 Days		40	20		60			40	20		60
WA Department of Ecology													
Section 401 - Water Quality Certification	30 Days	30 - 60 Days					0			80	20		100
Coastal Zone Management Act CZM	5 Days	30 - 60 Days					0			10	2		12
NPDES	30 Days	60 - 90 Days		60	5		65			60	5		65
WA Department of Fish and Wildlife													
HPA - Hydraulic Project Approval	30 - 90 Days	45 Days		40	10		50			40	10		50
WA Department of Natural Resources													
Aquatic Lands Easement	30 Days	180 Days		40	10		50			40	10		50
KC DDES													
Clearing and Grading	30 - 60 Days	90 -180 Days					0			40	20		60
Critical Areas Alteration Exception	30 - 60 Days	120 - 180 Days					0			80	20		100
Shoreline Exemption	30 - 60 Days	180 Days		20		5	25			20	5		25
Flood Hazard Certification	30 - 60 Days	90 -180 Days					0			20	10		30
			50	420	350	5	825		50	880	537	0	1467
Cost/HR			$84.94	$95.73	$107.67	$121.23			$84.94	$95.73	$107.67	$121.23	
Estimated Cost for KC Employees			$4,247.00	$40,206.60	$37,684.50	$606.15	$82,744.25		$4,247.00	$84,242.40	$57,818.79	$0.00	$146,308.19

TASK NAME	Estimated Time to Prepare Studies and Permits	Estimated Processing Time	Estimated Hours						Estimated Hours				
			Low End Estimate						High End Estimate				
			EI	EII	EIII	EIV	Total Hours		Estimated Hours	EII	EIII	EIV	Total Hours
Technical Reports													
Stream Report	60 - 90 Days		10	60	80		150		10	60	80		150
Wetland Report	60 - 90 Days		10	80	40		130		10	80	40		130
Mitigation Report	90 - 120 Days		10	120	80		210		10	120	80		210
Geomorphic Study	Various						0			40			40
Wildlife Report	60 - 90 Days		10	60	30		100		10	100	60		170
ESA Section 7 - Biological Evaluation	160 - 180 Days		10	100	80		190		10	100	80		190
Archaeological Report	Unknown				80		80				190		190
ENVIRONMENTAL REPORT/STUDY TOTAL			50	420	390	0	860		50	500	530	0	1080
Cost including Burden Rate			$84.94	$95.73	$107.67	$121.23			$84.94	$95.73	$107.67	$121.23	
Estimated Cost for KC Employees			$4,247.00	$40,206.60	$41,991.30	$0.00	$86,444.90		$4,247.00	$47,865.00	$57,065.10	$0.00	$109,177.10
Total Cost							**$169,189.15**						**$255,485.29**

Assumptions associated with Labor, Environmental Study Costs, and Estimated Schedules for Permits.

TASK NAME	ASSUMPTIONS
Permits/Approvals	
SEPA	
Documentation	SEPA necessary applicable to both low and high end estimates
Section 6(f) Land and Water Conservation Fund Act	Dependent upon impacts to LWCFA properties
ESA Section 7 Consultation (NOAA and USFWS)	Assumes that ESA Consultation required due to Corps Permit and assumes a May Affect, NLAA Determination for High End and NE for low end
Army Corps of Engineers	
Section 404 - CWA Nationwide or Individual	Preparation time is based on a Individual Permit for High End Estimate and Nationwide Permit required for Low End Estimate
Section 10 - Rivers and Harbors Act 1899*	Assumes Sec 10 Permit is required
U.S. Fish and Wildlife	
Migratory Bird Treaty Act	Assumes baseline work will be completed with Wildlife Report. Time listed here required for drafting, submitting and obtaining approval of monitoring plans
Bald and Golden Eagle Protection Act	
WA Department of Ecology	
Section 401 - Water Quality Certification	Low End Estimate assumes these two approvals are not required. High end estimates includes hours to obtain these approvals
Coastal Zone Management Act CZM	
NPDES	Assumes an NDPES approval is required
WA Department of Fish and Wildlife	
HPA - Hydraulic Project Approval	Assumes HPA approval is required
WA Department of Natural Resources	
Aquatic Lands Easement	Assumes an Aquatic Lands Easement approval is required
KC DDES	
Shoreline Exemption	Estimate based on information provided by DDES
Flood Hazard Certification	Assumes no local permits are required for Low End Estimate
Technical Reports	
Stream Report	Assumes a Level 2 Stream Report
Wetland Report	Assumes new delineation and rating using new ACOE requirements
Mitigation Report	Dependent upon level of impacts and amount of mitigation required
Geomorphic Study	Review time is for geologic and sediment issues applies to High End Estimate
Wildlife Report	Low End Estimate based upon assessing two vegetative communities and a 10-foot buffer width - High End Estimate assumes 3 vegetative communities and a 50-foot buffer width
Archaeological Report	Low End Estimate assumes use of previously prepared reports

Appendix 12. Recent Maintenance Letters of Agreements with the U.S. Army Corps of Engineers

King County
Water and Land Resources Division
Department of Natural Resources and Parks
King Street Center
201 South Jackson Street, Suite 600
Seattle, WA 98104-3855
206-296-6519 206-296-0192 Fax

May 20, 2003

Dianne Parks
Chief, Operations Division
4735 East Marginal Way South
Seattle, WA 98124-2255

Dear Ms. Parks:

The King County Water and Land Resources Division (WLRD) and the US Army Corps of Engineers (Corps) worked together over the last several months to resolve issues related to maintenance of the Sammamish River Channel Improvement Project. It was a pleasure working with your staff and I would like to thank the Corps for allowing the use of a third-party mediator to resolve some long-standing issues.

The maintenance issues revolve primarily around the lack of adequate vegetation cutting performed by King County in recent years per the 1993 Maintenance Agreement. Presently, stands of native vegetation have been allowed to grow for habitat enhancement along the banks of the river in a number of reaches. Installations of large woody debris and other channel modifications have also occurred in several locations, which are beneficial to aquatic habitat, and are in direct conflict with the maintenance standards outlined in the 1967 Operations and Maintenance Manual. Some of these modifications were built by the Corps and have been approved. Of particular concern is the stand of willows growing in the Transition Section, which the Corps believes needs to be substantially cut to ensure adequate conveyance for the flood control project. At the same time, recent hydraulic modeling efforts have shown that some (but not all) of these environmental enhancement features can be accommodated without jeopardizing the function of the project, although the extent and locations where that can occur have not been fully defined. Lastly, Puget Sound Chinook salmon and bull trout were listed as threatened under the Endangered Species Act (ESA) in 1998, restricting all subsequent actions on this river that would harm these species.

The commitments of our meeting on April 15, 2003 are outlined below:

- King County will perform maintenance in the Transition Section, in accordance with the 1993 Maintenance Agreement, provided such action would not constitute a "take" in consideration of comments from the Services and Tribes per the mandates of the ESA. To that end, King County will convene a meeting that will include representatives from federal, state, and local resource agencies and the Tribes; the County and the Corps will describe the proposed maintenance work; and the agencies and the Tribes will be asked for comments on the proposed work. The meeting will be targeted for late May 2003; a preparatory (dry run) meeting will be scheduled for early May. If the proposed maintenance work is deemed acceptable, the County will cut one side by 10/31/03 and will cut the opposite bank by 4/30/04 -- a 10-foot wide windrow on either side of the low flow channel will remain uncut. Results of this cutting will be monitored; how and by whom to be determined during or subsequent to the meeting. If the agencies or the Tribe do not concur with the proposed maintenance plan, and if the County elects not to proceed with the maintenance, the County will document their decision in a letter to the Corps. The County understands the Corps will then declare the Sammamish Flood Control Project ineligible for future PL84-99 repair.

- The Corps will complete the programmatic Biological Assessment (BA) for their regional vegetation management program and specifically, include the 1993 Maintenance Agreement for the Sammamish River. The Corps will work with the County in developing the BA to ensure that relevant concerns of the County are addressed. The Corps will actively pursue the agencies' concurrence of the completed BA.

- King County will work with the Corps towards design and construction of a project modification in the Transition Section that will protect and enhance valuable habitat while maintaining the necessary flood conveyance. One objective will be a design for the Transition Section that requires no vegetation cutting once it is constructed. The County and the Corps will consider partnering to design and construct this project under Section 1135 project authority.

- The Corps will work with the County to develop an updated O&M Manual that recognizes approved environmental improvements and modifications and establishes new maintenance standards to accommodate them. The catalyst for the revisions will be the Transition Section modification project.

- The Corps and King County will endeavor to evaluate the potential to implement additional habitat improvements downstream from the Transition Section. Specific improvements to be considered include the recommendations in the Sammamish River Corridor Action Plan recently completed in a joint effort by the Corps and the County under Section 216 authority, as well as various plans and projects proposed by the local jurisdictions lining the river. This longer-term effort may involve two components. First is a consideration of flood conveyance based on hydraulic modeling results.

Second is a re-evaluation of the extent to which the authorization of the original project is relevant, and a possible refinement of the project purpose.

- King County will send out an informational letter to cities and other agencies involved in projects and/or management of lands along the Sammamish River. The letter will describe the flood protection project and its maintenance obligations, and will outline a process for obtaining review by the County and the Corps for any project that would modify the flood control works. The County will send the letter to the Corps for review prior to distribution.

Thanks again for all the contributions from your team on this important project. We look forward to working with you on these vital next steps.

Sincerely,

Mark Isaacson
Assistant Division Director

cc: Daryl Grigsby, Division Director, Water and Land Resources Division (WLRD), Department of Natural Resources and Parks (DNRP)
Dave Clark, Flood Hazard Reduction Section, WLRD, DNRP
Nancy Faegenburg, Flood Hazard Reduction Section, WLRD, DNRP
Charles Ifft, US Army Corps of Engineers
Paul Komorosky, US Army Corps of Engineers
Lester Soule, US Army Corps of Engineers
Michael Walsh, Mediator & Program Manager, Alternative Dispute Resolution Program

DEPARTMENT OF THE ARMY
SEATTLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 3755
SEATTLE, WASHINGTON 98124-3755

REPLY TO
ATTENTION OF

Emergency Management Branch

MAR 15 2001

Mr. Dave Clark
Director, Surface Water Management
201 South Jackson Street, Suite 600
Seattle, Washington 98104-3855

Subject: Local Maintenance for the Sammamish River Authorized Project

Dear Mr. Clark:

We conducted a review of the Sammamish River Flood Control Project on January 22, 2001 to determine the serviceability of the project. It was found that the transition area at the upper end of the project currently is out of compliance with the established Corps of Engineers standards. The work done by King County crews last fall was helpful, but not adequate to meet the engineering requirements of flood flow passage. Our informal agreement on May 9, 2000 was that the transition area would be maintained according to the National Marine Fisheries Service recommendations of 1998. We agreed that the following would take place in October 2000:

1998 Sammamish River Transition Zone Vegetation Management Plan

No-Cut Zone	*Leave a 20-foot wide "No Cut" zone along both sides of the low flow channel.*
Cutting Zone	*Cut one-third of all woody stems equal to or greater than one-half inch in diameter to 6 inches above the ground between the landward edge of the "No Cut" zone and the top of the bank.*
Non-Native Plant Removal	*Remove all non-native woody species within the cutting zone e.g., blackberries, Scot's Broom, etc. Avoid disturbing Purple loosestrife unless seed-bearing flowering tops have been removed. If loosestrife is removed, it should be immediately bagged and disposed of in a sanitary landfill.*

"Steve Landino – NMFS 1998"

There was evidence of some cutting of willows as indicated by cut stock left on the side slope. However, the current state of the transition zone consists of willows with an average height of 15 feet and stem diameters averaging 3 inches. The density of the stems across the floor of the transition zone is high enough to significantly impact the flow characteristics of the structure.

Maintenance of vegetation along the Sammamish Flood Control Project has been an issue for some time. We have been flexible and progressive in allowing more vegetation to grow along the river to benefit fish and wildlife. The Corps has constructed two environmental enhancement projects along the river that allow for wildlife benefits while still maintaining the functionality of the original project. Additional vegetation can be allowed without jeopardizing the functionality of the project if the additional plantings are placed in accordance with an engineered plan and properly maintained. Without an effective maintenance program, the vegetation will become too thick to pass the design flows and thereby fail to meet the Congressionally Authorized intent of the project.

We agreed in 1993 to allow a buffer along the low flow channel in the transition area for the benefit of wildlife. It was determined that this would slightly reduce conveyance, but effective flood control would be maintained. King County maintained the transition area according to this agreement for approximately 3 years, but has not done so since.

Also, we request that any future work done to the Project, either by King County or the local entities, be coordinated with our District.

A risk assessment (attached) has shown that the continued lack of maintenance has increased the risk of flooding in the Project area. With this finding the Sammamish Flood Control Project has been identified as a Category 3 Project. (Reference ER 1130-2-530, Appendix D). To review the Corps policy governing Federal Flood Control Projects refer to "http://www.usace.army.mil/inet/usace-docs/eng-regs/er1130-2-530/toc.htm".

You are requested to respond with your intent for Project maintenance by April 16, 2001. If no further maintenance is planned, we would request a meeting be arranged between the King County Executive's Office and our District Engineer to discuss a mutually agreeable solution. If you have any questions please call Charles Ifft at (206) 764-3406.

Sincerely,

Arill Berg

Arill Berg, P.E.
Chief, Emergency Management Branch