# Memorandum

**Date:** May 24, 2018

**To:** Department of Community Development

**From:** Tawni Dalziel, P.E., Sr. Stormwater Program Manager

**Subject:** **Zackuse Creek Fish Passage and Stream Restoration Project – FINAL TIR**

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## Project

The City of Sammamish Public Works Department proposes to construct the Zackuse Creek Fish Passage and Stream Restoration Project to improve salmon spawning habitat in the Lake Sammamish watershed. The project includes replacing an undersized pipe culvert that completely blocks migrating salmon with a fish passable 12-ft span x 6-ft rise concrete box culvert. The culvert being replaced are located under East Lake Sammamish Parkway (ELSP) in the City of Sammamish. Additionally, approximately 400 linear feet of Zackuse Creek will be restored and reestablished to improve salmon spawning habitat upstream of ELSP.

The project includes work on both private property and public right of way. The culvert replacement is planned in the following location: East Lake Sammamish Parkway, approximately 900 ft south of its intersection with Louis Thompson Road. Additional private property work will be completed on Tax Parcels 3225069021 (Pereyra) for the stream restoration portion of the work.

Owner: Wally Pereyra
Parcel No.: 3225069021
Address: 202 East Lake Sammamish Parkway NE
Legal Description:
LOT B SAMMAMISH BLA# BLA2013-00180 REC# 20140307900003 SD BLA BEING POR OF SE 1/4 OF NW 1/4 SD STR LY ELY OF E LK SAMMAMISH PKWY NE

The project is vested to the 2016 King County Surface Water Design Manual and the Sammamish Addendum. The limited scope of work allows exemptions from the core requirements as described below.

**Core Requirement No. 1 - Discharge at Natural Location**
The project will maintain discharge to Lake Sammamish through improvements to the culvert and restoration of the Zackuse stream channel.

**Core Requirement No. 2 – Offsite Analysis**
Zackuse Creek flows into Lake Sammamish along the eastern shoreline of the lake, approximately 900 feet south of Louis Thompson Road in the City of Sammamish. The creek flows down a west-facing slope in a steep-sided ravine east of the East Lake Sammamish Parkway (ELSP) before reaching a forested wetland adjacent to the Parkway, at an approximate elevation of 40 feet. The creek then turns into three braided channels before flowing into a 30-inch diameter concrete pipe beneath East Lake Sammamish Parkway. Zackuse Creek continues under East Lake Sammamish Trail in a 36-inch diameter concrete pipe (partial fish passage barrier). Once more, the creek passes under East Lake Shore Lane Drive through a concrete box culvert three feet high and one foot wide (partial fish passage barrier). Downstream of Shore Lane, in 2009, the City of Sammamish daylighted Zackuse Creek and installed two fish passable metal arch pipe culverts. The mouth of Zackuse Creek is located to the south of the residential home located at 205 East Lake Sammamish Shore Lane.

The existing stream alignment along East Lake Sammamish Parkway causes embankment erosion. Erosion in this area has produced road failures. The current stream alignment possesses a low slope grade, which causes the creek to disperse from one channel to several braided channels. These braided channels allow vegetation to thrive and creates a barrier for aquatic life.

See Figure 1 – Offsite Analysis Map
See Figure 2 – Environmentally Critical Areas Map

**Core Requirement No. 3 – Flow Control**
The project will add less than 5,000 SF of new impervious surface and less than ¾ acre of pervious surface. Therefore, the project meets the basic exemption from formal flow control. New impervious added will include three additional feet of road shoulder on each side. This will accommodate a new guard rail over culvert headwalls on East Lake Sammamish Parkway.

**Core Requirement No. 4 – Conveyance System**
The proposed culvert was designed consistent with Washington Department of Fish and Wildlife standards for fish passage culverts, including passage of the 100-year storm event. The culvert will be 12-ft in span with a 6-ft rise. Western Washington Hydrology Model was used to calculate low and high flows through the restored channel and culverts. Please see Appendix A for more information on the design of the fish passage culvert and stream channel.

**Core Requirement No. 5 – Construction Stormwater Pollution Prevention**
A construction stormwater pollution prevention plan is separately provided within the permit package.

**Core Requirement No. 6 – Maintenance and Operations**
Public Works will provide maintenance and operations of the new culvert under East Lake Sammamish Parkway. The culvert is designed with two access hatches over ELSP that will assist in maintenance of larger debris in the culvert. Permitting requirements from the Army Corps and the Washington State Department of Fish and Wildlife require a 5 year monitoring plan for the culvert and stream restoration. See Appendix B for details.

Long term culvert maintenance will be consistent with NPDES permit requirements as shown in the 2016 King County Surface Water Design Manual.

**Core Requirement No. 7 – Financial Guarantees and Liability**
The project is a public project and financial guarantees will be required from the City's contractor consistent with WSDOT Standard Specifications.

**Core Requirement No. 8 – Water Quality**
The project will add less than 5,000 SF of new pollution generating impervious surface and less than ¾ acre of pollution generating pervious surface. Therefore, the project meets the surface area exemption from formal water quality treatment. New pollution generating impervious added will include three additional feet of road shoulder on each side. This will accommodate a new guard rail over culvert headwalls on East Lake Sammamish Parkway. No further new pollution generating pervious surface will be added.

**Core Requirement No. 9 – Flow Control BMPs**
Under TARGET SURFACE Section of the 2016 KCSWDM, page 1-83, projects whose land disturbing activity is greater than 7000 SF but where new plus replaced impervious surface is less than 2000 SF may consider basic dispersion as a second order of flow control best management practices after consideration of full dispersion. Full dispersion is infeasible for the project site due to the limit of vegetated flow path from the natural discharge location to the stream or wetland. The project uses sheet flow as a basic dispersion FCBMP for all target surfaces.


**Figure 1. Offsite Analysis Map**

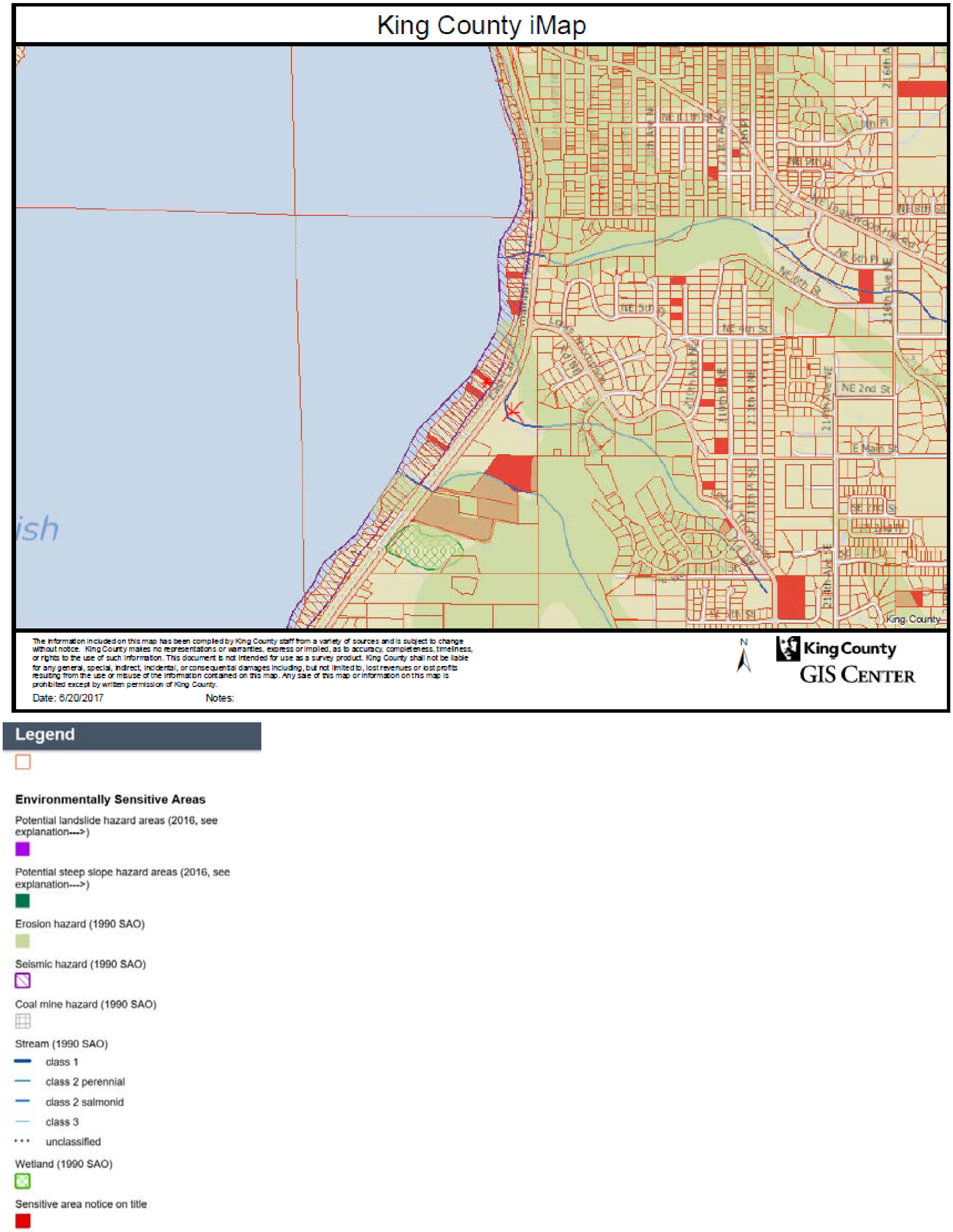


Figure 2 – Environmentally Critical Areas Map

# Technical Memorandum

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**To:** Tawni Dalziel

**From:** Courtney Moore

**Copies:** Greg Laird, file

**Date:** 10/20/2017

**Subject:** Culvert Sizing Recommendations

**Project No.:** 32794

Culvert Sizing Summary

A critical path to fish habitat improvement on Zackuse Creek is the replacement of fish passage barrier culverts. To address this portion of the project, Otak, Inc. performed a stream survey to quantify channel characteristics needed to assess the replacement culvert. For preliminary design purposes, Otak used the information and stream simulation design criteria from WDFW's Water Crossing Design Guidelines (2013), which provide guidance on appropriately sizing culvert width for a natural channel. Otak performed this analysis as a follow-up to the work done previously in 2012 by R2 Resources consultants.

Revised Stream Assessment Information

Within the project area, Zackuse Creek can be divided into four reaches: an upstream, slightly steeper reach above an eroding but apparently stabilized headcut; an upper middle reach that has experienced recent incision, and where the channel configuration has been historically altered by straightening and altering of channel planforms; a lower middle reach that flows through the upstream section of a low-gradient alluvial floodplain; and a downstream reach where the stream continues through the alluvial floodplain and wetland area, and is impounded by the East Lake Sammamish Parkway roadbed. Ordinary high water mark (OHWM) designation through all four of these reaches was performed by Otak scientists.

Selection of WDFW design criteria

WDFW presents three different options for culvert design: the Stream Simulation Option, the Hydraulic Design Option, and the No Slope Option. Both the Stream Simulation and Hydraulic option are presented below. The No Slope Option is no longer preferred by WDFW and therefore was not evaluated.

The Stream Simulation Option is designed for allowing a natural channel through the proposed culvert. This option is heavily dependent upon identifying the bankfull width within a representative reach of the stream in question. A preliminary estimate of channel width and associated culvert width was performed using the regional regression analysis information provided in the WDFW Water Crossing Design Guidelines. The results from this regression for Zackuse Creek suggest a culvert width of approximately 10 ft. WDFW Design Criteria Guidelines stream simulation design requirements for culverts are as follows:

*The minimum width of the bed in any type of culvert, $W_{culvert\ bed}$, in feet, should be determined by*

$W_{culvert\ bed} = 1.2W_{ch} + 2$ *(in feet).*

Assessment of the previously identified R2 Resources reference reach and resulting bankfull width is not possible, as the reach location was not specifically identified and may no longer be representative due to channel migration and other geomorphic disturbances (e.g. incision, headcut migration, etc.) in the intervening time period (five years). Zackuse Creek, both upstream and downstream of the intended culvert replacement, has been significantly impacted by infrastructure (such as the roadway embankment) and land use changes. Due to these changes, identifying an appropriate reference reach similar in both channel gradient and desired substrate to the culvert replacement reach for the Stream Simulation Option is difficult. Additionally, the instabilities along the length of Zackuse Creek (such as bank incision, headcuts and upstream slope failure) make the associated identification of a bankfull flow using field indicators problematic and ultimately not defensible. These constraints were discussed with representatives from local and state agencies, as well as the tribes during a project field meeting on 3/2/2017. Representatives from these agencies agreed with the assessment of a lack of representative reach from which to determine an appropriate bankfull width.

Although a clear representative reach is difficult to determine, as described above, bankfull measurements taken by Otak were still used as a check on proposed design. Two sets of measurements were taken along Zackuse Creek, focusing in the area in and upstream of the culvert replacement. The first set of measurements was based on sections of the stream where the ordinary high water mark also well represents bankfull width. Two reference areas shown in Exhibit A (a reach downstream of the proposed culvert tie in point and a reach downstream of 206$^{th}$ Ave NE) were chosen for bankfull comparison. The difference in average bankfull width between these two reference reaches is illustrated in Table 1 and reflects the difference in channel type and bedform. Parametrix took stream measurements in April 2016, and the average bankfull width (BFW) was found to be 8.1 feet. Although specific locations were never recorded, Parametrix channel measurements were reportedly taken at the upper end of what Otak characterized as their Lower Middle Reference Reach (King County Technical Memo, Feb. 2017).

The large average bankful width in the lower reference reach illustrates the alluvial, sediment laden stream described previously. As described above the lower reach being is not representative of the appropriate design condition the upstream reference reach combined with the measurements taken up and downstream of the 90 degree bends.

Table 1 Otak Bankfull Width Measurements (see attached map for location)

| Bankfull Width (ft) | Resulting Average StreamSim Width (1.2 x BFW + 2 feet) | Approx. Location |
|---|---|---|
| Full Reach Measurements | | |
| 4.4 | | |
| 9 | | |
| 6 | | Above 90 degree bends |
| 13 | | Below grade break/incision |
| Upstream Measurements | | |
| 10.5 | | |
| 13.2 | | |
| 16.6 | | |
| 14.3 | | |
| Downstream Measurements | | |
| 10.12 | | |
| 9.3 | | |
| 6.26 | | |
| 8.74 | | |

The proposed channel cross section and profile is designed in order to accommodate design flows and maintain channel sediment appropriate for spawning Kokanee. This channel cross section is proposed at a top/bankfull width of 8 feet along the channel realignment and through the proposed culvert. This bankfull width agrees with top widths in the 6-8 foot range, noted in locations along Zackuse Creek that are representative of more stable reaches. An 8 foot channel top width results in a proposed Stream Simulation culvert width of 11.6 feet, rounded to 12 feet, which falls right at the average of measurements presented above. The final four measurements were taken at the downstream to cover all areas of the stream however they were deemed not representative of either the undisturbed system or the proposed restored condition.

The Hydraulic Design Option sets maximum velocities for fish passage based on fish species and culvert length. This velocity criterion of 4ft/s for culverts less than 60 feet in length, and 3ft/s for culverts less than 100 feet in length, and is based on species and 10% exceedance flow for the month of migration (identified as November for kokanee). The channel and proposed 12 foot width culvert were modeled that show compliance with this criterion for a culvert less than 60 feet.

Otak, Inc. Recommendation for Culvert Span Size
This strategy of meeting both the hydraulic and stream simulation design guidelines allows a conservative and empirically derived estimate of needed bed width through the proposed culvert. In light of the above analysis, Otak recommends that a bed inside the chosen culvert be 12 feet wide per WDFW stream simulation sizing and hydraulic design. This is derived from both field measurements presented above and the proposed bankfull width measurements for a stable channel design. This channel geometry design has also been modeling with a HEC-RAS model which shows that it also meets hydraulic option velocity requirements through the proposed culvert.


# Zackuse Creek
# WDFW Culvert Sizing Bankfull Width Locations

**DRAFT**

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Date: 1/9/2017

# Technical Memorandum

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**To:** Greg Laird, Courtney Moore

**From:** Kevin Pilgrim and Travis Stroth

**Copies:** [Electronic submittal]

**Date:** 10/19/2017

**Subject:** Zackuse Creek Bed Material Stability

**Project No.:** 032794

The purpose of this memo is to summarize hydraulic model results and stability calculations, specifically focusing on the evaluation of the proposed channel profile for Reach 2A. These results illustrate and guide the appropriate choice of proposed material and channel geometry. This memo builds on the previous Otak geomorphic memo which described and detailed existing conditions and proposed alternatives.

**Proposed Channel Design Profile and Dimensions**

The current selected profile is a step-pool-run sequence. The average gradient of the reach is 3.78%. The gradient of the run was 1.6% based on previous equilibrium analyses when using a gravel mix gradation appropriate for kokanee spawning with a length of 20 ft and a step height of 0.8 ft, and a pool length of 8 ft and depth of 0.4 ft. The proposed profile for a step-pool-run sequence was created using Civil 3D grading tools.

Table 1. Proposed Channel Geometry

| | Proposed Geometry |
|---|---|
| Bankfull Width (ft) | 8.0 |
| Bed Width (ft) | 5.0 |
| Bankfull Depth (ft) | 0.75 |
| Channel Side Slope (1:Z) | 3.0 |
| Run Length (ft) | 20 |
| Run bed slope (%) | 1.6 |
| Pool depth (ft) | 0.4 |
| Pool Length (ft) | 7 |
| Step height (ft) | 0.8 |

**Hydraulic Analysis**

A 1-D hydraulic analysis of Zackuse Creek in the project vicinity was performed using the USACE HEC-RAS v5.0 computer software (USACE, 2016). Results of the hydraulic modeling were used to provide hydraulic input to hydraulic design calculations and provide input to sediment transport and channel stability calculations. Manning's roughness value was based on existing conditions upstream of the proposed reach and would reflect post restoration conditions with the vegetation fully restored to natural conditions. A constant n value of 0.1 was used for floodplain for both overbanks to represent average conditions and a value of 0.045 was used for the channel. The downstream boundary condition is a rating curve from the proposed hydraulic model for reach 1 with the preferred culvert option. Hydrology was based on results from a WWHM model. For simplicity of comparison of stability data it was assumed that the discharge remained constant throughout the proposed reach.

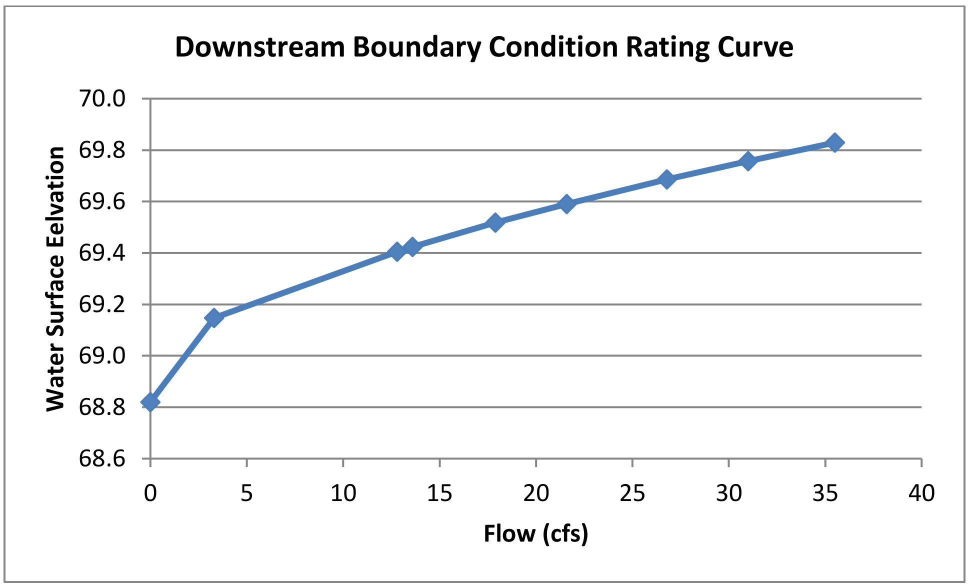


Figure 1. Boundary Condition Rating Curve

**Hydraulic Model results**

Table 2 presents the reach average hydraulic values for the entire reach 2 and for the proposed channel reach 2A and existing channel reach 2B upstream of the project area at the 2-year flow (12.8 cfs). Generally, reach average values for width ($W_2$), shear stress ($\tau_2$), energy slope ($S_{e,2}$) and velocity ($v_2$) decrease from reach 2B to reach 2A while depth and hydraulic radius ($R_2$) increases.

Table 2. Reach Average Values for $Q_2$

| Variable | Units | Reach Average Value | Reach 2A | Reach 2B |
|---|---|---|---|---|
| $Q_2$ | cfs | | 12.8 | 11.7 |
| $W_2$ | ft | 7.7 | 7.3 | 9.8 |
| $R_2$ | ft | 0.6 | 0.631 | 0.428 |
| $\tau_2$ | lb/ft$^2$ | 0.764 | 0.736 | 0.899 |
| $S_{e,2}$ | ft/ft | 0.0247 | 0.0225 | 0.0355 |
| $y_2$ | ft | 0.83 | 0.87 | 0.64 |
| $v_2$ | ft/s | 2.85 | 2.82 | 3.02 |

The upstream average bed slope is 3.58% which is slightly less than the proposed reach bed slope (3.78%). The reduction in velocity and shear stress and increase in depth is due to the proposed bed form and lower gradient run sections included in the proposed design.

**Sediment Data**

Sediment data collected during previous field visits (described in the previous Otak geomorphic memo) was used for the stability analysis. In order to understand the downstream change in sediment gradation, a total of four pebble counts were conducted along Zackuse creek, with at least one pebble count per geomorphic reach. Two pebble counts were conducted in the alluvial fan reach ("Reach 2"), one downstream (Reach 2a between Sta. 8+75 to 9+25) and one upstream near the ditch line (Reach 2b, between Sta. 11+25 to 11+75), based on observations that the grain sizes increased from downstream to upstream within the reach. The Reach 3 pebble count was conducted from approximately Sta. 16+30 to 17+00, below a grade break immediately downstream of the previous stream restoration work and upstream of the wooden footbridge. The Reach 5 pebble count was conducted from approximately Sta. 19+25 to 20+00, above the 206$^{th}$ Street culvert. The results of the pebble count are summarized in 2 below.

Table 3. Pebble Count Data

| | Reach 2a | | Reach 2b | | Reach 3 | | Reach 5 | |
|---|---|---|---|---|---|---|---|---|
| Percentile | Dia (mm) | Dia (in) | Dia (mm) | Dia (in) | Dia (mm) | Dia (in) | Dia (mm) | Dia (in) |
| DMIN | 2 | 0.1 | 2 | 0.1 | 2 | 0.1 | 2 | 0.1 |
| D10 | 6.6 | 0.3 | 11.0 | 0.4 | 8.9 | 0.4 | 11.9 | 0.5 |
| D16 | 8.2 | 0.3 | 14.1 | 0.6 | 13.0 | 0.5 | 14.0 | 0.6 |
| D25 | 10.2 | 0.4 | 18.2 | 0.7 | 17.4 | 0.7 | 17.4 | 0.7 |
| D50 | 16.0 | 0.6 | 29.0 | 1.1 | 27.1 | 1.1 | 28.3 | 1.1 |
| D75 | 22.0 | 0.9 | 41.5 | 1.6 | 43.0 | 1.7 | 45.0 | 1.8 |
| D84 | 26.6 | 1.0 | 48.1 | 1.9 | 57.6 | 2.3 | 57.4 | 2.3 |
| D90 | 30.5 | 1.2 | 54.9 | 2.2 | 74.1 | 2.9 | 80.3 | 3.2 |
| DMAX | 64 | 2.5 | 128 | 5.0 | 180 | 7.1 | Bedrock | Bedrock |
| **Class** | **% Total** | | **% Total** | | **% Total** | | **% Total** | |
| Sand | 5% | | 1% | | 3% | | 1% | |
| Fine Gravel | 10% | | 5% | | 6% | | 4% | |
| Coarse Gravel | 85% | | 91% | | 78% | | 83% | |
| Cobble | 0% | | 3% | | 13% | | 11% | |
| Boulder | 0% | | 0% | | 0% | | 0% | |
| Bedrock | 0% | | 0% | | 0% | | 1% | |

Equilibrium Bed Slope Calculations

Equilibrium bed slope calculations (NRCS, 2007) were performed for Reach 2A proposed conditions using hydraulic data from HEC-RAS and the Reach 2A pebble count data. The results indicate that for the existing hydraulics, the required stable D50 particle may be higher than existing (0.15 ft compared to existing 0.09 ft from the pebble count). Using the Manning and Shields equation, the calculated equilibrium bed slope is 1.3%. For the purposes of this preliminary analysis, a critical shear stress of 0.047 was assumed, after Gessler, 1971.

The equilibrium bed slope calculations were performed based on hydraulic results for the cross sections representing the run profile within the reach. This was done to eliminate the variability of the hydraulics due to the step and pool sequence and evaluate the stability of the run using a proposed gradation for spawning gravel.

A mix similar to the WDOT 4” streambed cobble mix is proposed (Table 4). Note that the WSDOT 4” mix is similar to the gradations required for adult kokanee spawning. The WSDOT 4” mix is also similar to the pebble count data from Reach 3 and upstream Reach 2 (Reach 2B), which may represent future sediment supply.

The results for the analysis using just the run cross sections indicate that for the existing hydraulics the required stable D50 particle is very close to the proposed 1.6 inches compared to the proposed gradation of 1.4 inches. Using the Manning and Shields equation, the calculated equilibrium bed slope is 1.7%. This indicates the reach will be slightly degradational and the bed material may coarsen over time. Given the fear that the reach will be depositional in nature due to the upstream sediment supply and the uncertainty involved with these calculations it is a favorable result.

Table 4. Initial Proposed Sediment Mix

| Percentile | Dia (inches) |
|---|---|
| D10 | 0.7 |
| D16 | 0.8 |
| D25 | 0.9 |
| D50 | 1.4 |
| D75 | 1.9 |
| D84 | 2.4 |
| D90 | 3 |
| DMAX | 4 |

**Incipient motion Analysis**

The relationship between the driving forces of water flow and resisting forces of gravity and friction are summarized in the Shields dimensionless shear stress parameter ($\tau^*$). Values of this parameter, which scales with bed grain size and shear stress at a given discharge, can be compared to standard values of critical dimensionless shear stress which tend to range from 0.03 to 0.07 (Buffington and Montgomery 1997). The Shields parameter represents a ratio of the shear stress acting on the bed to the weight of the grain, and is calculated as follows:

$$\tau^* = \frac{\tau_0}{(\rho_s - \rho)gD}$$

Where:
$\tau^*$ = Shields shear stress
$\tau_0$ = boundary shear stress ($N/m^2$)
$\rho_s$ = density of sediment (2650 $kg/m^3$)
$\rho$ = density of water (1000 $kg/m^3$)
$g$ = gravity (9.81 $m/s^2$)
$D$ = diameter of sediment (m)

The boundary shear stress, obtained from HEC-RAS, is averaged for a given cross section, but considering only a portion of this shear stress acts directly on the stream bed to initiate sediment movement, shear stress partitioning is more appropriate to estimate grain size mobility. Shear stress available to mobilize bed grains was calculated following Pitlick, et al. (2009), and replaces $\tau_0$ in the above equation with τ', defined as follows:

$$\tau' = \rho g (0.013)^{1.5} (SD)^{0.25} U^{1.5}$$

Where:
$\tau'$= Bed grain shear stress (N/m2)
S = Friction slope
U = flow velocity (m/s)
D = grain size, $D_{90}$ (mm)

Particle mobility was determined for each bed sediment size class by comparing $\tau^*$ against a critical dimensionless shear stress value ($\tau_c^*$). When $\tau^* > \tau_c^*$, the particle is considered mobile at the representative critical dimensionless shear and associated discharge value. Values of $\tau_c^*$=0.03 and 0.047 were used to characterize mobility at each cross section. The 2 and 25-year return flows were evaluated for stability. For final design the full range of flows could be evaluated to determine crest rock sizes. Table 5 shows the results for incipient motion at the step crest, the pool and run cross sections. These are the predicted size of rock that could mobilize for the given flow and design sizes should be increased for a safety of factor and stability.

| Critical Sediment Size (inches) | | | | |
|---|---|---|---|---|
| | $Q_2$ | | $Q_{25}$ | |
| | t*c= 0.03 | t*c= 0.047 | t*c= 0.03 | t*c= 0.047 |
| Step Crest | 5.6 | 3.6 | 7.2 | 4.6 |
| Pool | 0.9 | 0.6 | 0.9 | 1.26 |
| Run | 2.0 | 1.3 | 2.0 | 2.20 |

**Alternative Alignment and Bedform Analysis**

A constant equilibrium bed slope of 1.6% without bedforms or grade breaks would require a very long proposed channel (>900 feet) to connect the proposed tie-in elevations at the East Lake Sammamish Parkway culvert. This length of channel would necessitate an alternative upstream tie in on private land much farther upstream or an unnaturally meandering channel to achieve the needed length. However, since the equilibrium bed slope applies only to the channel gradient between the top of a downstream grade control and the base of an upstream grade control (e.g., step, riffle), using grade control structures means that the proposed shorter channel reach within the project boundaries can be achieved. The crests of the grade breaks will maintain higher velocities and the pools will scour and fill depending on flows.

The proposed tie in point for the channel which dictates the elevation drop was designed to meet multiple project constraints. The proposed tie in point takes advantage of an existing overflow path in the floodplain that currently has flow at wet times of year. This alignment also stays within the project boundaries (property rights, budget and scope) and maintains existing appropriate spawning habitat described in Otak's initial geomorphic memo.

A repeating pattern of rock chutes or log drops and pools were considered to provide bedform complexity and habitat with spawning habitat provided in the runs and pool tailouts. Grade control structures in both the form of boulder bands or rock chutes were evaluated and for this project site boulder bands were the chosen alternative. Due to the amount of elevation needed along the proposed channel rock chutes would need to be long or steep, resulting in sections of channel > 10% or longer lower gradient sections that reduce the length of spawning habitat. The grain size distribution for these proposed rock chutes would also be higher than the grain size distribution required for adult kokanee spawning. Boulder bands were chosen as the step form for the grade control design and are designed to meet applicable stability and fish passage requirements. They maximize equilibrium slope sections as well as have the ability to make up grade within the project limitations and provide habitat features for returning fish. Log features are incorporated for these structures as well.

**Conclusions and Future Work**

Both the proposed channel geometry (equilibrium run lengths and channel cross section) and bed material were evaluated for design suitability and stability. Slopes and bed material for the proposed channel realignment seem to be appropriately sized for the purpose of stability and spawning habitat. Within the range of uncertainty of current analysis, the proposed reach may have the energy and transport capacity to become slightly degradational. This, however, does not take into account velocity variability due to step-pool structures and added large wood structures designed to provide added roughness and habitat diversity. These design elements will reduce velocities in the vicinity of the structures and therefore also reduce scour and transport potential. Additionally, the amount of sediment supply delivered to the reach is currently unquantified. The slopes and bed material gradations will likely fluctuate over time depending on the variable nature of sediment supply.

Instabilities exist above the project reach where upstream of the realignment channel is a steep incised/unstable channel. The two 90 degree bends upstream of the project site, in particular, have very steep non-cohesive banks that are likely a large source of sediment for downstream. One option for additional work at the ditch line is grading back the steep banks or making the bends less severe. A second option is extending the proposed channel grading upstream further to connect above the ditch line bypassing the bends entirely. However, since neither of these options addresses the channel instabilities upstream of the two 90 degree bends the stream those instabilities will remain and the stream is likely to continue to headcut. An alternative consideration for work at the 90 degree bends is adding wood structures into the channel or adding roughness to increase stability temporarily. While this may help the situation in the short term the tradeoff is an increased likelihood of avulsion at this location.

References:

1. Gessler, J., Beginning and ceasing of sediment motion, in *River Mechanics,* edited by H.W. Shen, pp.7:1-7:22, H.W. Shen, Fort Collins, Colo., 1971.
2. NRCS (Natural Resources Conservation Service). 2007. National Engineering Handbook 654 Technical Supplement 14B. Scour Calculations. 210-VI-NEH. August 2007.

# City of Sammamish
# Zackuse Creek Fish Passage Project

# Culvert and Stream Monitoring Plan

Submitted to:
U.S. Army Corps of Engineers, Seattle Headquarters
Washington Fish and Wildlife Department

Prepared by for the City of Sammamish by:
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Otak Project No. 32794

February 16, 2018

# Table of Contents

# Section 1— Background

## Background

City of Sammamish (City) has contracted with Otak, Inc. (Otak) to carry out the design for the Zackuse Creek Fish Passage project. The project intends to improve fish passage and spawning habitat for native kokanee salmon in Zackuse Creek. As part of the project, three existing concrete culverts imposing partial fish passage blockages will be removed and replaced with fish passable box culverts. Other improvements involve stream restoration of portions of the upstream reaches of Zackuse Creek in order to create enhanced stream channel morphology that is better suited for kokanee spawning and rearing habitat. Upstream restoration involves installation of pool-riffle sequences, appropriate channel meandering, and installation of appropriately-sized spawning gravels and large woody debris. Installation of native plant species in riparian and wetland habitats is also a component of the proposed project.

Zackuse Creek transitions from steep slopes to a lower gradient in a palustrine forested wetland where the channel loses definition. The stream then flows through a culvert under East Lake Sammamish Parkway and two more culverts (East Lake Sammamish Trail and East Lake Sammamish Shore Lane) before discharging into Lake Sammamish. The Washington Department of Fish and Wildlife lists these three culverts as partial fish passage barriers. Zackuse Creek is classified as a Type F stream by the City of Sammamish, and has a 150-foot buffer per SMC Chapter 21A.50.330. Zackuse Creek is classified as a relatively permanent water under the Clean Water Act, and regulated by the US Army Corps of Engineers.

Several sensitive fish species are known or presumed to occur in Zackuse Creek including: sockeye/kokanee salmon (*Oncorhynchus nerka*), coho salmon *(O. kisutch*), and resident cutthroat (*O. clarki*).

The proposed culverts are designed to convey 100-year peak flows and provide fish passage for all life stages. The design of the culverts is based on accepted Washington Department of Fish and Wildlife (WDFW) stream simulation and hydraulic design criteria as outlined in the *2013 Water Crossing Guidelines* to provide appropriate fish passage. The existing culverts will be replaced with 12-foot wide concrete box culverts. A minimum depth of two feet of streambed gravels will be placed inside the culvert for scour protection. Monitoring will be performed to verify that the culverts do not become a partial or total barrier to fish passage.

In addition to the culvert replacements, a portion of Zackuse Creek will be realigned to provide for improved fish passage, spawning and rearing habitat, and improved in-stream habitat complexity. Monitoring will be performed to verify that the channel functions as designed and does not become a partial or total barrier to fish passage.

# Section 1—
## Continued

The purpose of this plan is to document the monitoring procedures to assure that the culverts and the realigned stream reach continue to provide fish passage for all life stages. Monitoring is necessary to identify as-needed repairs, cleaning of the culverts, and/or channel modifications to ensure fish passage functionality.

Monitoring and documenting culvert and channel conditions will be used to create an annual monitoring report. Monitoring reports will be used to assess trends to ensure the culverts and channel remain fish-passable and that stream simulation design parameters were appropriate for the system, and that the culverts and channel are functioning as intended. Annual monitoring results will be documented in reports prepared and submitted to the permitting agencies and interested stakeholders. Adaptive management may be developed depending upon monitoring results and culvert/channel condition and any potential pattern of changes in associated physical stream channel or culvert parameters.

# Section 2— Monitoring Procedures

## Monitoring Procedures

*Monitoring Locations and Frequency*

Monitoring is proposed for the three culverts, the restored/realigned stream channel, and the native vegetation installation. The culverts are located under East Lake Sammamish Shore Lane, East Lake Sammamish Trail, and Lake Sammamish Parkway NE. Figures 2A and 2B illustrate anticipated monitoring areas for the project.

The project is scheduled to begin construction in May 2018 and is anticipated to be completed in November 2018. Monitoring will begin in the spring of 2019.

Fish passage barriers that occur at high stream flows may not be observable during low or normal stream flows. Therefore, culverts should be analyzed at both low and high flows to properly assess fish-passage barriers (WDFW 2003). Monitoring will occur twice per year in years 1, 3, and 5 (2019, 2021, 2023) and will occur in the late summer during the dry season (late August or early September) and in spring following the wet season (late March or early April).

Rebar will be installed to mark representative riffle locations outside the influence of the culverts. The location of the rebar can be either upstream or downstream of the culverts depending on which is most representative of the stream reach.

Concurrent with culvert and channel monitoring, vegetative monitoring will be conducted for installed vegetation in the riparian and wetland habitats. Sampling plots and photo points will be established in representative portions of the areas proposed for installation of vegetation.

*Culvert Barrier Monitoring Protocol*

Protocol for monitoring will follow the stream simulation culvert guidelines from the Water Crossing Design Guidelines (WDFW 2013). Culvert data collection will include photographs of the inlet and outlet of both culverts and the surrounding banks, qualitative descriptive information and the following physical measurements will be recorded.

1. Culvert span: Culvert span will be measured with a fiberglass tape from the point where the bed meets the culvert wall on one side to a similar point on the other. This measurement is taken at the inlet and outlet of the culvert.

# Section 2—
Continued

2. Slope ratio: The water surface slope of the culvert will be compared with the prevailing slope upstream of the culvert. Often the area within a 100 feet or more of a recently replaced culvert will be in transition, adjusting to the new culvert and its hydraulic and sediment transport control. Measurements will be taken sufficiently upstream of the culverts and the realigned channel reach to effectively measure this parameter for purposes of monitoring.

2. Bed material: Bed material data will be collected using the Wolman pebble count methodology (Wolman 1954) upstream and downstream of the culverts.

4. Countersink: The stream simulation criterion for countersink at the culvert inlet and outlet is greater than 30% and less than 50% of culvert rise. This is determined by subtracting the nominal culvert rise divided by measured bed-to-crown distance from 1.

5. Cross section: Determine an upstream reach of the stream outside of the influence of the culverts and the realigned stream channel. Install rebar (either bank) at this location for future measurements. Measure the bankful depth. Per WDFW *Water Crossing* Design Guidelines (2013), measure the difference between the minimum and maximum elevation in several culvert cross sections—for this monitoring plan, two cross sections per culvert. Compare the bankful depth at the location outside the influence of the culverts and realigned stream channel to the difference between the minimum and maximum depth in the culverts and to the bankful width of the realigned stream channel.

*Realigned Stream Channel Monitoring Protocol*

Protocol for monitoring the realigned stream channel for Zakcuse Creek will involve the following elements.

1. Hydraulic breaks: During low flow conditions (late summer) measure differences in water surface elevations associated with the culverts and along the realigned stream channel. Measurements will be conducted at culvert upstream and downstream inverts, and at each proposed boulder band.

2. Large wood: Installed and recruited large wood (>2 meters in length, >15 cm in diameter) will be counted along the realigned stream channel.

# Section 2—
Continued

3. Bed material: Bed material data will be collected using the Wolman pebble count methodology (Wolman 1954) at two points within the realigned stream channel. Install rebar at the two locations for future measurements.

*Performance Standards and Thresholds*

Culvert span: The culvert bed width should be equal to or greater than 1.2Wch + 2ft, unless the culvert is located in an unconfined channel and the width has been increased to accommodate overbank flow.

Slope ratio: The culvert bed slope should be less than 1.25 times average upstream channel slope.

Bed material: The median particle size in the culverts and realigned stream channel reach should be within 18% of median particle size in the natural stream.

Countersink: The stream simulation criterion for countersink at the culvert inlet and outlet is greater than 30% and less than 50% of culvert rise.

Cross section: Culverts will have a maximum depth of no less than 50% of the bankfull depth.

Hydrualic Breaks: Hydraulic breaks associated with the culverts and with the realigned stream channel reach will be no greater than 0.5 foot.

Large wood: Large wood, installed or recruited, will constitute 90% or more of the number of pieces indicated in the approved design drawings in the realigned stream channel reach.

Vegetation: Performance standards for riparian and wetland vegetation will consist of:

- Year 1: 100% survival of all installed vegetation; <30% cover of non-native invasive vegetative species;
- Year 3: 80% survival of installed tree species; 30% aerial coverage of native woody species, to include native volunteer species; <20% cover of non-native invasive vegetative species;

# Section 2—
Continued

- Year 5: 80% survival of installed tree species; 75% aerial coverage of native woody species, to include native volunteer species; <20% cover of non-native invasive vegetative species.

# Section 3—Reporting

## Reporting

Monitoring data should be recorded and documented in a spring memo and a fall annual report. The annual report should be prepared during the fall for five years following the year of construction and will include the spring memo as well as the additional monitoring data collected during the year for reporting to regulatory agencies. The following information should be documented in each of the spring memos and the fall annual report:

- The date the monitoring was performed.
- Culvert span compared to active channel width measured at representative riffle location.
- Slope ratio.
- Bed material size results.
- Counter sink results.
- Cross section results and comparison.
- Measurement of water surface drop.
- A field sketch documenting the location of any bank erosion or significant deposition and locations of any other notable conditions of the channel.
- Inspection for any potential fish passage barriers (debris, culvert failure, hydraulic drops greater than 0.5 foot, etc.).
- Riparian and wetland vegetation assessment
- Qualitative description of notable site features

The annual monitoring report should evaluate the monitoring data collected and provide a summary of the project effectiveness in ensuring fish passage. The annual reports will be submitted to the permitting agencies and interested stakeholders for comment by December 30 of each monitoring year.

# Section 4— Conclusions

## Conclusions

The project is designed to improve fish passage for kokanee salmon, provide spawning and rearing habitat, and improve instream habitat complexity. The successful monitoring of the three culverts and the realigned stream channel reach will allow for an evaluation of the stability of the channel and culverts, assess potential aggredation of excess sediment and ultimately provide fish passage for kokanee salmon at all life stages within Zackuse Creek. Monitoring of installed and recruited vegetation will allow for an evaluation of nearby habitat that interacts with and influences in-stream and kokanee salmon habitat. The monitoring protocols established with this document are meant to help guide the management options that will be available to the City after construction of the culverts and the realigned channel.

Monitoring and documenting the changes to the stream with these protocols will provide the City with precise data—gravel composition, channel geometry, channel slope, riparian/wetland habitat—to implement appropriate adaptive management strategies if concerns/needs arise.

# Section 5—References

## REFERENCES

Washington State Department of Fish and Wildlife. 2003. Design of Road Culverts for Fish Passage.

Washington State Department of Fish and Wildlife. 2013. Water Crossing Design Guidelines.

Wolman, M.G. 1954. A Method of Sampling Coarse River-bed Material. Transactions, American Geophysical Union 35(6):951-956.


**Figure 1**
**Vicinity Map**

Zackuse Creek Fish Passage Project
City of Sammamish, WA

**Legend**

Project Area
Roads

1 inch = 1,000 feet

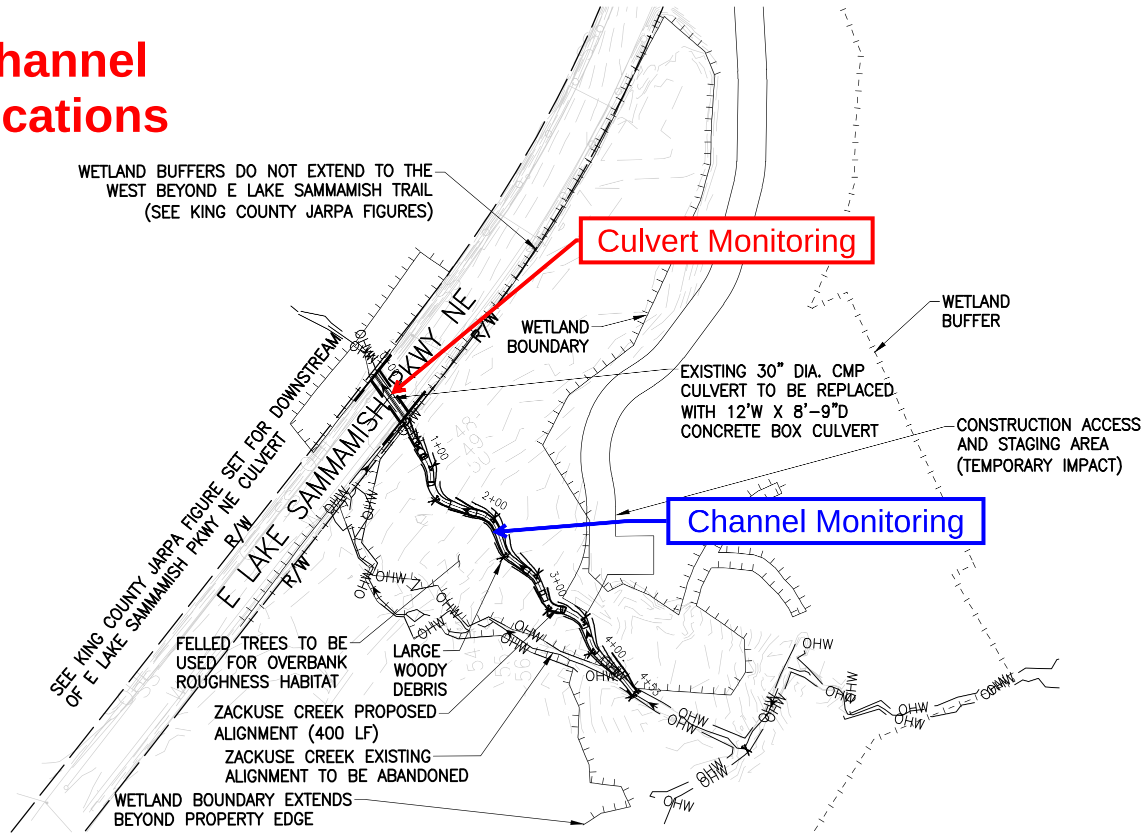
0 1,000 Feet

K:\project\32700\32794\CADD\GIS\MXDs\Wetlands_Archive\Fig01_VicinityMap.mxd

Date: 1/18/2017

A

# Figure 2A
# Culvert and Channel Monitoring Locations




## LEGEND

WETLAND BOUNDARY

WETLAND BUFFER

200' 0' 200' 400'

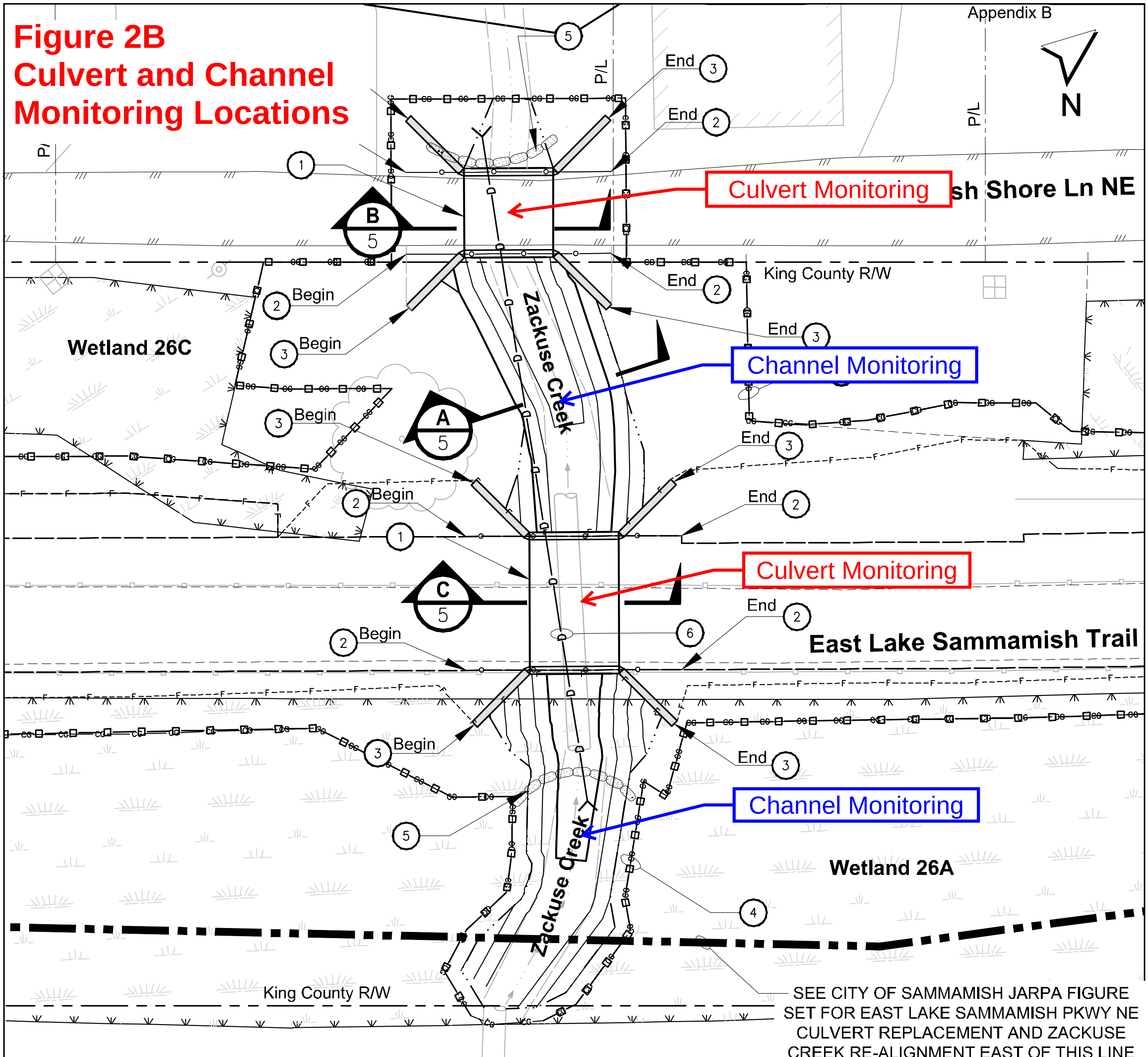
HORZ SCALE IN FEET

DATE: MAY 2017

| | | |
|---|---|---|
| APPLICANT: CITY OF SAMMAMISH<br><br>REFERENCE #:<br><br>ADJACENT PROPERTY OWNERS:<br>SEE JARPA ATTACHMENT C | PURPOSE: ENVIRONMENTAL ENHANCEMENT<br><br>LAT/LONG: 47.6100N / 122.0703W<br><br>SITE LOCATION ADDRESS:<br>PORTIONS OF SECTION 32, TOWNSHIP 25N, RANGE 06E | PROPOSED PROJECT:<br>ZACKUSE CREEK FISH PASSAGE PROJECT<br><br>WATER BODY: LAKE SAMMAMISH/ZACKUSE CREEK<br>NEAR: SAMMAMISH<br>COUNTY: KING STATE: WA |

# Figure 2B
# Culvert and Channel Monitoring Locations






## LEGEND:

- EXISTING WETLAND BOUNDARY
- EXISTING WETLAND BUFFER
- EXISTING DITCH
- EXISTING RIGHT OF WAY
- PROPOSED FILL LIMIT
- PROPOSED CUT LIMIT
- PROPOSED CLEARING/GRUBBING LIMIT
- EXISTING TREES

## NOTES:

1. FISH EXCLUSION TO BE PERFORMED AT UPSTREAM AND DOWNSTREAM ENDS OF STREAM CONSTRUCTION AREA BEFORE CONSTRUCTION WORK MAY BEGIN.

## CONSTRUCTION NOTES:

1. INSTALL FISH PASSABLE BOX CULVERT. SEE SHEETS 3-5 FOR DETAILS.
2. INSTALL COATED CHAIN LINK FENCE TYPE 6.
3. INSTALL WING WALL.

## TESC NOTES:

4. INSTALL HIGH VISIBILITY SILT FENCE.
5. GRAVEL BAG DAM. DEWATER CONSTRUCTION AREA DURING CULVERT WORK.
6. INSTALL TEMPORARY BYPASS TO DIVERT WATER AROUND WORK ZONE. PROTECT DISCHARGE AREA FROM EROSION WITH PLASTIC SHEETING.

**PROPOSED PROJECT:** ZACKUSE CREEK CULVERT REPLACEMENT AND FISH HABITAT IMPROVEMENT PROJECT

REPLACE DEFICIENT CULVERTS W/ FISH PASSABLE BOX CULVERTS AT EAST LAKE SAMMAMISH TRAIL AND EAST LAKE SAMMAMISH SHORE LN NE. INCLUDES TEMPORARY ACCESS ROUTE FOR RESIDENTS, CONSTRUCTION EQUIPMENT, AND EMERGENCY VEHICLES.

**ADJACENT PROPERTY OWNERS:** SEE JARPA ATTACHMENT C

**REFERENCE NUMBER:**

## SITE PLAN

0 20

SCALE 1" = 20'

**APPLICANT:** CITY OF SAMMAMISH

**DATUM:** VERT: NAVD 88
HORIZ: NAD 83 (CORPS.)

**BASIN:** EAST LAKE SAMMAMISH

**LOCATION:** SAMMAMISH, KING COUNTY WASHINGTON
S 8, 32, T 25N, R 6E, W.M.
LATITUDE: 47.6100N
LONGITUDE: 122.0703W

**B**

**DATE:** MAY 2017

**SHEET:** 2 of 14