

Technical Memorandum



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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

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

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 206th 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 bankfull 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		
13		
Above 90 degree bends		
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 10⁰% 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.