

# **Appendix O: Lateral Migration Rapid Assessment**

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# Lateral Migration Rapid Assessment

I-405 MP 21.94 Juanita Creek (WDFW ID): 998602 Preliminary Hydraulic Design Report

## Background

The Washington State Department of Transportation (WSDOT) is proposing a project to provide fish passage at the Interstate 405 (I-405) crossing of Juanita Creek at milepost (MP) 21.94. The existing culvert has been identified as a fish barrier and will be replaced by a 30-foot-wide bottomless culvert designed using the Stream Simulation methodology.

## Purpose

The objective of this assessment is to provide a quantitative measure of Juanita Creek's potential for lateral migration.

## Data Available

The following is a list of data/references used to prepare this calculation:

- Stream Stability at Highway Structures (FHWA, 2012),
- Field observations,
- WSDOT preliminary streambed profile and geometry (2021).

## Methodology

The rapid assessment method was used from the Hydraulic Engineering Circular No. 20 (HEC-20) – Tables 5.5 through 5.8 – to rate the migration potential of Juanita Creek.

## Results

The results of the rapid assessment indicate that Juanita Creek has low potential for lateral or vertical migration.

## References

Lagasse, P.F., Zevenbergen, L.W., Spitz, W.J., and Arneson, L.A. (2012). *Stream Stability at Highway Structures, Fourth Edition*. Federal Highway Administration (FHWA) Publication No. FHWA-HIF-12-004. Hydraulic Engineering Circular No. 20.

WSDOT. 2021. *I-405 MP 26.87, SR 527 2.78 Queensborough Creek: Preliminary Hydraulic Design Report*.

## Attachments

Attachment A – Rapid Assessment for Juanita Creek

**Attachment A – Rapid Assessment for Juanita Creek**

A rapid stability assessment method should have the following characteristics: (1) it should be brief such that it can be completed quickly; (2) it should be simple in that extensive training is not required (although some training will be required); (3) it should be based on sound indicators as discussed in Section 5.3.3; and (4) it should be based on the needs of the bridge engineering community.

One way to assure that all aspects of channel stability are included is to start at the watershed or regional level and focus in on vertical and lateral aspects of the channel, following the concepts of Thorne (1998) (see Appendix C) and Montgomery and MacDonald (2002). Thus, at the broader level, watershed and floodplain activities and characteristics, flow habit, channel pattern and type, and entrenchment are selected as appropriate indicators. At the channel level, indicators such as bed material consolidation and armoring, bar development, and obstructions are used. Indicators of bank stability include bank material, angle, bank and riparian vegetation, bank (fluvial) cutting, and mass wasting (geotechnical failure). Finally, the position of the bridge relative to the channel can be indicated by meander impact point and alignment.

#### **5.4.2 Rapid Assessment Method**

The rapid channel stability assessment method uses a set of indicators, as determined from the literature and field observations. For each indicator, a rating is selected, the ratings are summed for a total score, and the score compared to stability definitions. In order to provide an appropriate level of sensitivity, the stability is based on stream type. Given that the Montgomery–Buffington classification method (Table 5.3) is based on processes as well as physical characteristics, this scheme was used to provide additional sensitivity to the method.

There are several assumptions implicit in this method of obtaining an overall rank. First, all indicators are weighted equally. This assumption was tested by assigning weights to each of the indicators and creating a weighted score for every bridge where observations were made. The results showed that the weighted indicators yielded the same results as the equally weighted indicators. Thus, there was no advantage in using weights. Second, this method implies that each indicator is independent of all others. While it is possible that some correlation exists between several of the indicators, an attempt was made to select indicators that independently describe various aspects of channel stability; thus, correlation effects were judged to be insignificant. Third, the summing of the ratings implies a linear scheme. The impact of this is not precisely known; however, given that weighted ratings provided no change in the overall results (Johnson 2005; FHWA 2006), it can be assumed that the linearity will also not affect the results significantly.

In collecting the data and observations for this method, it is desirable for the engineer or other inspector to view aerial photos of the bridge crossing and surrounding area and to walk some distance upstream and downstream from the bridge, rather than making all observations of the channel from the bridge itself. The appropriate distance, however, depends on several factors, such as uniformity of stream conditions; magnitude of disturbances along the banks, in the floodplain, or in the watershed; time available; and accessibility. Ideally, the observer should walk at least 10 channel widths upstream and downstream of the bridge. Although it is possible to establish stability conditions in a lesser distance, the more of the stream that is observed, the better the observer will understand the causes, processes, and rates of change, assuming that such observations are repeated at different times. Roads and bridges often divide property and sometimes divide geomorphic features or regions. Thus, conditions upstream and downstream of the bridge may be significantly different. In this case, it may be necessary to conduct separate analyses upstream and downstream.

### **5.4.3 Stability Indicators**

The 13 indicators identified for this study are listed in Table 5.5 (FHWA 2006). For each indicator, a rating of poor, fair, good, or excellent can be assigned based on descriptors listed in the table. After a rating is assigned for each of the indicators, an overall score is obtained by summing the 13 ratings. This total score provides the overall relative stability of the channel. Table 5.6 provides the range of scores for Excellent, Good, Fair, and Poor ratings of stability for each of the three divisions of stream channels. The simplified data collection sheets of Appendix E assist in obtaining information necessary to score the stability indicators.

Occasionally, rating of each of the thirteen factors for a particular bridge will result in one factor which stands out as being much higher (worse) than the others. This situation is worth noting and making additional observations during future inspections.

### **5.4.4. Lateral and Vertical Stability**

The indicators in Table 5.5 can be divided into those that indicate vertical stability and those that indicate lateral stability; vertical stability is described by indicators 4–6, while lateral stability is indicated by indicators 8 –13. Each of the lateral and vertical stability scores, based on summing the appropriate ratings, were normalized by the total number of points possible in each category so that they could be represented as a fraction and more readily compared. If the lateral fraction is greater than the vertical fraction, then it can be expected that channel instability is expressed primarily in the lateral direction. Lateral and vertical processes may be ongoing simultaneously or they may be occurring differentially; this is not indicated by the assessment method. If both fractions are relatively low, this suggests minimal instability in either direction.

As an example, if the lateral score is significantly higher than the vertical score (say for example, 0.93 versus 0.67), indicating that lateral instability is dominant. If, on the other hand, the vertical score fraction is greater than the lateral, then bed degradation is the dominant source of instability. If both scores are high, then the channel is unstable due to both lateral and vertical processes. For example, if a channel has lateral and vertical fractions of 0.86 and 0.92, this indicates that the channel is both degrading and widening.

Stability Indicator	Ratings				
	Excellent (1-3)	Good (4-6)	Fair (7-9)	Poor (10-12)	
1. Watershed and floodplain activity and characteristics	Stable, forested, undisturbed watershed.	Occasional minor disturbances in the watershed, including cattle activity (grazing and/or access to stream), construction, logging, or other minor deforestation. Limited agricultural activities.	Frequent disturbances in the watershed, including cattle activity, landsliding, channel sand or gravel mining, logging, farming, or construction of buildings, roads, or other infrastructure. Urbanization over significant portion of watershed. <b>9</b>	Continual disturbances in the watershed. Significant cattle activity, landsliding, channel sand or gravel mining, logging, farming, or construction of buildings, roads, or other infrastructure. Highly urbanized or rapidly urbanizing watershed.	36% impervious per PHD
2. Flow habit	Perennial stream with no flashy behavior <b>3</b>	Perennial stream or ephemeral 1 <sup>st</sup> order stream with slightly increased rate of flooding	Perennial or intermittent stream with flashy behavior	Extremely flashy; flash floods prevalent mode of discharge; ephemeral stream other than 1 <sup>st</sup> order stream	
3. Channel pattern	Straight to meandering with low radius of curvature; primarily suspended load	Meandering, moderate radius of curvature; mix of suspended and bed loads; well maintained engineered channel <b>4</b>	Meandering with some braiding; tortuous meandering; primarily bed load; poorly maintained engineered channel.	Braided; primarily bed load; unmaintained engineered channel.	
4. Entrenchment / channel confinement	Active floodplain exists at top of banks; no sign of undercutting infrastructure; no levees	Active floodplain abandoned, but is currently rebuilding; minimal channel confinement; infrastructure not exposed; levees are low and set well back from the river	Moderate confinement in valley or channel walls; some exposure of infrastructure; terraces exist; floodplain abandoned; levees are moderate in size and have minimal setback from the river. <b>7</b>	Knickpoints visible downstream; exposed water lines or other infrastructure; channel width to top of banks ratio small; deeply confined; no active floodplain; levees are high and along the channel edge.	The bankfull width measurements reflect a moderately confined channel in a forest reach of a highly urbanized basin.
5. Bed material Fs = approximate portion of sand in the bed	Assorted sizes tightly packed, overlapping, and possibly imbricated. Most material > 4 mm. Fs < 20%	Moderately packed with some overlapping. Very small amounts of material < 4 mm. <b>5</b> 20 < Fs < 50%	Loose assortment with no apparent overlap. Small to medium amounts of material < 4 mm. 50 < Fs < 70%	Very loose assortment with no packing. Large amounts of material < 4 mm. Fs > 70%	Observed sediment included a wide distribution of gravels mixed with a smaller distribution of fines and cobbles.
6. Bar development S = Slope W/Y = Width to Depth ratio	For S < 0.02 and W/Y > 12, bars are mature, narrow relative to stream width at low flow, well vegetated, and composed of coarse gravel to cobbles. For S > 0.02 and W/Y < 12, no bars are evident.	For S < 0.02 and W/Y > 12, bars may have vegetation and/or be composed of coarse gravel to cobbles, but minimal recent growth of bar evident by lack of vegetation on portion of the bar. For S > 0.02 and W/Y < 12, no bars are evident. <b>5</b>	For S < 0.02 and W/Y > 12, bar widths tend to be wide and composed of newly deposited coarse sand to small cobbles and/or may be sparsely vegetated. Bars forming for S > 0.02 and W/Y < 12.	Bar widths are generally greater than 1/2 the stream width at low flow. Bars are composed of extensive deposits of fine particles up to coarse gravel with little to no vegetation. No bars for S < 0.02 and W/Y > 12.	W/Y > 12 (12.08/1.25 = 9.664) S=2%. Some small sand/gravel bars.
7. Obstructions, including bedrock outcrops, armor layer, large woody debris jams, grade control, bridge bed paving, revetments, dikes or vanes, riprap	Rare or not present.	Occasional, causing cross currents and minor bank and bottom erosion. <b>5</b>	Moderately frequent and occasionally unstable obstructions, cause noticeable erosion of the channel. Considerable sediment accumulation behind obstructions.	Frequent and often unstable causing a continual shift of sediment and flow. Traps are easily filled causing channel to migrate and/or widen.	Lots of down trees in the wetlands upstream. Channel complexity, floodplain connectivity, and riparian condition and function are heavily degraded due to bank armoring.

Table 5.5. Stability indicators, descriptions, and ratings. Range of values in ratings columns provide possible rating values for each factor.				
Stability Indicator	Ratings			
	Excellent (1-3)	Good (4-6)	Fair (7-9)	Poor (10-12)
8. Bank soil texture and coherence	Clay and silty clay; cohesive material	Clay loam to sandy clay loam; minor amounts of noncohesive or unconsolidated mixtures; layers may exist, but are cohesive materials.	Sandy clay to sandy loam; unconsolidated mixtures of glacial or other materials; small layers and lenses of noncohesive or unconsolidated mixtures <b>8</b>	Loamy sand to sand; noncohesive material; unconsolidated mixtures of glacial or other materials; layers or lenses that include noncohesive sands and gravels
9. Average bank slope angle (where 90° is a vertical bank) V = Vertical H = Horizontal	Bank slopes < 3H:1V (18°) for noncohesive or unconsolidated materials to < 1:1 (45°) in clays on both sides <b>3</b>	Bank slopes up to 2H:1V (27°) in noncohesive or unconsolidated materials to 0.8:1 (50°) in clays on one or occasionally both banks	Bank slopes to 1H:1V (45°) in noncohesive or unconsolidated materials to 0.6:1 (60°) in clays common on one or both banks.	Bank slopes over 45° in noncohesive or unconsolidated materials or over (60°) in clays common on one or both banks
10. Vegetative or engineered bank protection	Wide band of woody vegetation with at least 90% density and cover. Primarily hard wood, leafy, deciduous trees with mature, healthy, and diverse vegetation located on the bank. Woody vegetation oriented vertically. In absence of vegetation, both banks are lined or heavily armored.	Medium band of woody vegetation with 70-90% plant density and cover. A majority of hard wood, leafy, deciduous trees with maturing, diverse vegetation located on the bank. Woody vegetation oriented 80-90° from horizontal with minimal root exposure. Partial lining or armoring of one or both banks. <b>4</b>	Small band of woody vegetation with 50-70% plant density and cover. A majority of soft wood, piney, coniferous trees with young or old vegetation lacking in diversity located on or near the top of bank. Woody vegetation oriented at 70-80° from horizontal often with evident root exposure. No lining of banks, but some armoring may be in place on one bank.	Woody vegetation band may vary depending on age and health with less than 50% plant density and cover. Primarily soft wood, piney, coniferous trees with very young, old and dying, and/or monostand vegetation located off of the bank. Woody vegetation oriented at less than 70° from horizontal with extensive root exposure. No lining or armoring of banks.
11. Bank Cutting	Little or none evident. Infrequent raw banks, insignificant percentage of total bank.	Some intermittently along channel bends and at prominent constrictions. Raw banks comprises minor portion of bank in vertical direction. <b>5</b>	Significant and frequent on both banks. Raw banks comprise large portion of bank in vertical direction. Root mat overhangs.	Almost continuous cuts on both banks, some extending over most of the banks. Undercutting and sod-root overhangs.
12. Mass wasting or bank failure	No or little evidence of potential or very small amounts of mass wasting. Uniform channel width over the entire reach.	Evidence of infrequent and/or minor mass wasting. Mostly healed over with vegetation. Relatively constant channel width and minimal scalloping of banks. <b>4</b>	Evidence of frequent and/or significant occurrences of mass wasting that can be aggravated by higher flows, which may cause undercutting and mass wasting of unstable banks. Channel width quite irregular and scalloping of banks is evident.	Frequent and extensive mass wasting. The potential for bank failure, as evidenced by tension cracks, massive undercuttings, and bank slumping, is considerable. Channel width is highly irregular and banks are scalloped.
13. Upstream distance to bridge from meander impact point and alignment	More than 115 ft (35 m); bridge is well aligned with river flow	66-115 ft (20 - 35 m); bridge is aligned with flow	33 - 66 ft (10 - 20 m); bridge is skewed to flow or flow alignment is otherwise not centered beneath bridge <b>7</b>	Less than 33 ft (10 m); bridge is poorly aligned with flow

Soil type can be confirmed by geotech - Gray silty sand.

Bank slope angles vary by location. An average of 14.5 degrees

Bank erosion was encountered in various locations along Juanita. On the downstream side scour was evident below the outlet of the culvert and lateral scour further downstream into a resident yard.

infrequent evidence of mass wasting, "undercut banks slumping into channel"

Juanita most consistent with Pool-Riffle from Table 3.5

Table 5.6. Overall Scores for Three Classifications of Channels.

Category	Score, R		
	Pool-Riffle, Plane-Bed, Dune-Ripple, and Engineered Channels	Cascade and Step-Pool Channels	Braided Channels
Excellent	R < 49	R < 41	N/A
Good	49 ≤ R < 85	41 ≤ R < 70	R < 94
Fair	85 ≤ R < 120	70 ≤ R < 98	94 ≤ R < 129
Poor	120 ≤ R	98 ≤ R	129 ≤ R

1st score = 69  
 Revised score = ?  
 Result: **Good** for Pool-Riffle, **Good** for Step-Pool

Table 5.7. Stability Ratings for Streams in Figures 5.11 – 5.14.

Stream	Indicator													Total	Rating Based on Table 5.5
	1	2	3	4	5	6	7	8	9	10	11	12	13		
Figure 5.11	12	4	6	12	11	10	10	12	12	11	12	12	3	127	Poor
Figure 5.12	9	12	10	7	11	8	3	11	8	10	6	7	8	110	Fair
Figure 5.13	8	2	4	5	3	5	5	8	5	2	2	2	6	57	Good
Figure 5.14	3	2	3	3	4	3	3	4	5	4	4	1	5	44	Excellent

Table 5.8. Lateral and Vertical Stability for Streams in Figures 5.11 – 5.14.

Stream	Lateral	Vertical	Lateral Fraction	Vertical Fraction
Figure 5.11	62	33	0.86	0.92
Figure 5.12	50	26	0.69	0.72
Figure 5.13	25	13	0.35	0.36
Figure 5.14	23	10	0.32	0.28

Lateral Fraction =  $\text{sum}[4:6] = 7+5+5 = 17/36 = 0.47$   
 Vertical Fraction =  $\text{sum}[8:13] = 8+3+4+5+4+7 = 31/72 = 0.43$   
 Channel has equal (albeit low) potential for both vertical and lateral migration.  
 See 5.4.4