Appendix E
Revised Bank Assessment of Non-Point Source Consequences of Sediment at Siltronic Corporation Memorandum (January 27, 2022)

MAUL FOSTER ALONGI

MEMORANDUM

To: File

Date: January 27, 2022

From: Michael R. Murray, RG, PE
Jesse Hall, GIT

Project: 8128.02.04

RE: Revised Bank Assessment of Non-point Source Consequences of Sediment at Siltronic Corporation

This memorandum presents the results of an erosion potential assessment, conducted by Maul Foster & Alongi, Inc. (MFA), of the Willamette River bank adjacent to the Siltronic Corporation (Siltronic) property in Portland, Oregon. MFA used the Bank Assessment for Non-point Source Consequences of Sediment (BANCS) model to predict the erosion potential and channel stability of the riverbank. The BANCS model uses the quantitative assessment of the Bank Erosion Hazard Index (BEHI), developed by David L. Rosgen of Wildland Hydrology, Inc. (Rosgen, 2001). The BEHI is a procedure for assessing streambank erosion condition and potential. The U.S. Fish and Wildlife Service and the Oregon Department of Environmental Quality use the BEHI in the Portland Harbor to evaluate bank erosion potential. This assessment was originally finalized on August 29, 2016 and has been revised based on feedback provided by CDM Smith on behalf of the United States Environmental Protection Agency via electronic mail (CDM Smith, 2021). The results of this revised BANCS assessment are essentially the same as the results of the 2016 BANCS assessment both of which determined BEHI erosion potential adjective ratings of "very low" or "low" for all transects along the Siltronic riverbank.

ASSESSMENT METHODS

On May 5, 2016, personnel from MFA conducted a survey of the riverbank along the Siltronic property adjacent to the Willamette River to obtain the site-specific data of the current bank conditions necessary for completing the erosion assessment. The riverbank survey was conducted both on foot along the top of riverbank and in other accessible areas, as well as by boat to access the riverbank from the Willamette River.

The BEHI was assessed along 12 transects spaced at 200-foot intervals along the riverbank. Figure 1 shows the location of the 12 transects. The elevation profiles of transects 1 through 4, 5 through 8, and 9 through 12 are presented in Figures 2, 3, and 4, respectively. Representative photographs of the bank conditions are provided in Attachment 1.

To evaluate the BEHI, MFA conducted a visual inspection of the riverbank transects at high and low tide by boat to measure the following characteristics:

- Bank height
- Bankfull height
- Root density and depth
- Type of surface protection (e.g., boulders, cobbles, sand, gravel, silt/clay)
- Vegetation
- Bank angle
- Condition of bank materials

A complete BEHI field sheet with ratings for each transect is provided in Attachment 2. The measured stream bank characteristics were converted to a risk rating system, to find the applied BEHI value for each bank characteristic (Rosgen, 2014). The assessment of the BEHI assigns point values to the following six characteristics:

1. Ratio of bank height to bankfull height
2. Ratio of root depth to bank height
3. Weighted root density
4. Bank angle
5. Surface protection
6. Bank material composition

The methods for determining each of these characteristics are described in the following subsections.

Ratio of Study Bank Height to Bankfull Height

The ratio of study bank height to bankfull height requires the identification of the top of bank elevation, toe of slope elevation, bankfull stage elevation, and mean high water (MHW) level. Study bank height is defined as the top of bank elevation minus the toe of slope elevation. Bankfull height is defined as the bankfull stage elevation minus the toe of slope elevation. The toe of slope is defined as the first significant change in slope below the OHW but above the MHW level. If there is no geomorphic feature demonstrating a change in slope below the OHW but above the MHW, then the MHW from the Portland, Oregon Morrison Street Bridge gage was used as the toe of the slope for the BANCS model evaluation. Bankfull stage is defined as 'an established gage height at a given location along a river or stream, above which a rise in water surface will cause the river or stream to overflow the lowest natural stream bank somewhere in the corresponding reach' [1]. The opposite

[1] National Weather Service Manual 10-950, Definitions and General Terminology. November 26, 2019. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service. https://www.nws.noaa.gov/directives/

river bank from the BANCS transect area is a large bluff of greater elevation, and as such this evaluation will use top of bank elevation as the bankfull stage at each transect location.

Root Depth Ratio and Weighted Root Density

Root depth is the ratio of average plant root depth to the bank height, expressed as a percent (e.g., roots extending 10 feet into a 20-foot-tall bank = 0.50). Because of a lack of exposed roots, the root depth was estimated based on reference values for the rooting depth of the plant species present along the bank.

Root density is the proportion of the streambank surface covered by plant roots, expressed as a percent. Rooting density was estimated with the percentage of vegetation on bank. Weighted root density was found by multiplying root depth ratio and root density.

Bank Angle

Bank angle is the angle of the bank from the top of bank elevation to the toe of slope elevation. Bank angle was calculated at each transect using the elevation profile of the bank (Figures 2 through 4).

Surface Protection

Surface protection is the amount of stream bank covered by plant roots, logs, branches, rocks, etc. expressed as a percent. This was visually estimated for each transect.

Bank Material Composition

Elements of the bank material composition assessed in the field included the grain size distribution of the bank material and the presence of stratification. The bank along the entire shoreline of the Siltronic property is covered with riprap; no stratified materials are exposed in the bank. Due to the relatively uniform coverage of riprap along the bank, grain size distribution for the bank materials was measured by choosing an area (about 1 meter square) representative of the 200-foot-long bank segments between transects.

The following Bank Material Adjustment was applied in the BEHI calculation:

- Bedrock (overall very low BEHI)
- Boulders: >10 inches (overall very low BEHI)
- Cobble: 2.5 inches to 10.1 inches (subtract 10 points of uniform medium to large cobble)
- Gravel or Composite Matrix (add 5 to 10 points, depending on percentage of bank material that is composed of sand)
- Sand: 0.04 inch to 0.2 inch (add 10 points)
- Silt/Clay: 0.0002 inch to 0.04 inch (no adjustment)

BEHI RATING METHODS

The sum of the six bank characteristics (ratio of bank height to bankfull height, ratio of root depth to bank height, weighted root density, bank angle, surface protection, and bank material composition adjustment) was applied to the BEHI scale (Attachment 2) to determine the rating for each transect. All transects and corresponding BEHI ratings are summarized in Table 1.

The total BEHI value of each transect can be correlated with the BEHI adjective ratings on the following table:

Total BEHI	BEHI adjective rating
5–9.5	Very Low
10–19.5	Low
20–29.5	Moderate
30–39.5	High
40–45	Very High
46–50	Extreme

CHANNEL STABILITY

The channel stability characteristics were also recorded at each transect and used to assign a channel stability rating for each transect (Rosgen, 2001). The channel stability assessment categories and criteria for assigning channel stability ratings are shown in Table 2. The channel stability ratings for each transect are summarized in Table 3.

The following 15 channel stability characteristics were assessed at each transect:

1. Landform slope
2. Mass erosion
3. Debris jam potential
4. Vegetative bank protection
5. Channel capacity
6. Bank rock content
7. Obstructions to flow
8. Cutting
9. Deposition
10. Rock angularity
11. Brightness
12. Consolidation of particles
13. Bottom size distribution
14. Scouring and deposition
15. Aquatic vegetation

RESULTS

BEHI Ratings

Overall, the physical characteristics (bank material, surface protection, slope, root density, bankfull ratios, etc.) of the Siltronic bank were generally uniform at all 12 transects. BEHI results from each transect are provided in Table 1 and summarized below:

- The study bank height to bankfull height ratio was uniform with a corresponding risk rating of "very low" (1.0 BEHI).
- Root depth to study bank height ratio BEHI risk ratings were "moderate" to "high," depending on placement of mature trees along the top of bank (4.2 to 7.0 BEHI).
- Because of lack of vegetation along the bank, weighted root density was rated as "moderate/high" to "extreme" (5.9 to 9.5 BEHI).
- The bank angles (slopes) of all transects ranged between 22 and 25.7 degrees as measured from the top of bank to toe of slope, and scored a BEHI risk rating of "low."
- Surface protection was uniform along the entire bank, with approximately 95 percent coverage and a BEHI risk rating of "very low." The approximate 5 percent of unprotected surface consists of localized sediment deposits along the OLW.
- Bank material along all transects was found to be cobbles to boulders. The presence of uniform cobbles and boulders along the entire bank resulted in a bank material adjustment of -10 points for the total BEHI score for each transect.

The total BEHI model scores for all transects ranged between 3.8 and 10.2 with adjective ratings of "very low" to "low". See Table 1 for BEHI transect summary.

Channel Stability

The channel stability characteristics were found to be generally uniform in all transects surveyed and resulted in overall channel stability scores of 42 to 48, corresponding to an overall channel stability rating of "good and stable" for all transects. See Table 3 for the channel stability summary.

REFERENCES

CDM Smith. 2021. Electronic mail (re: Request for Clarification - EPA Comment #36 on Gasco Sediments Site Combined BOD-PDR) from L. Peterson, CDM Smith to R. Barth, Anchor QEA. December 21.

National Weather Service Manual 10-950, Definitions and General Terminology. November 26, 2019. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service. Available at: https://www.nws.noaa.gov/directives/

Rosgen, D. L. 2001. A practical method of computing streambank erosion rate. Vol. 2, pp. 9-15. Proceedings of the 7th Federal Interagency Sedimentation Conference, March 25, Reno, Nevada.

Rosgen, D. L. 2014. River stability field guide. 2d ed. Wildland Hydrology.

ATTACHMENTS

Figures

1 Riverbank Transect Locations
2 Riverbank Transects 1–4
3 Riverbank Transects 5–8
4 Riverbank Transects 9–12

Tables

1 BEHI Transect Summary
2 Channel Stability Ratings
3 Channel Stability Summary

Attachment 1 Photographs
Attachment 2 BEHI Field Data Sheets
Attachment 3 NOAA Datums for 9439221 (Portland, Oregon, Morrison St. Bridge)

FIGURES

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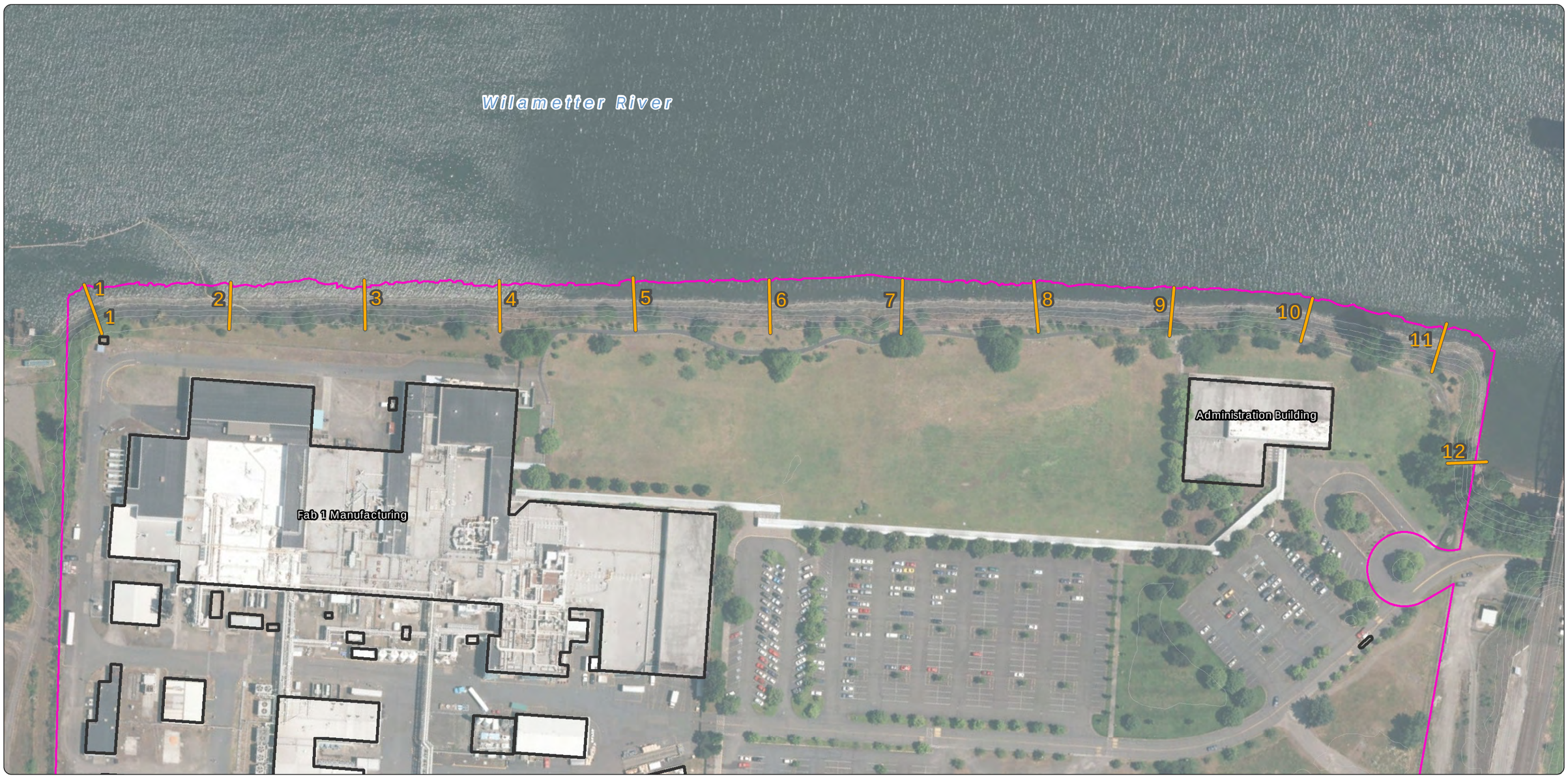
Print Date: 1/21/2022

Reviewed By:

Produced By: aguse

Project:



NOTE:
NAVD88 = North Americal Vertical Datum of 1988.

Source: Aerial photograph (2012) obtained from City of Portland; elevations obtained from 2005 Columbia River dataset, Puget Sound LiDAR Consortium.

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Legend

- Riverbank Transect (with Transect ID)
- Elevation (NAVD88, feet)
- Site Boundary

Figure 1
Riverbank Transect Locations

Siltronic Corporation
Portland, Oregon

0 75 150
Feet

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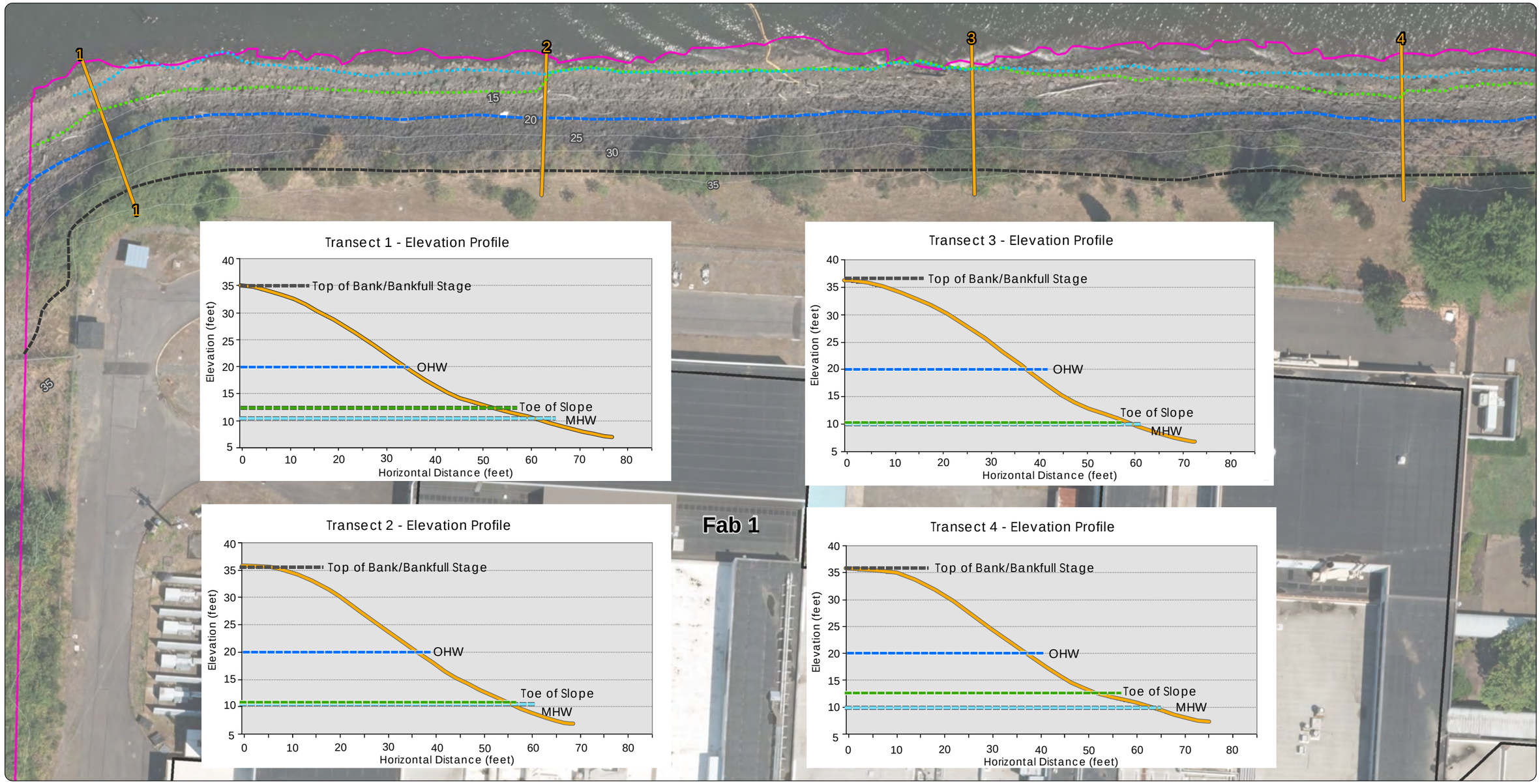

Source: Aerial photograph (2012) obtained from City of Portland; National Flood Hazard dataset obtained from FEMA; elevations obtained from 2005 Columbia River dataset, Puget Sound LiDAR Consortium; Ordinary High Water and Ordinary Low Water data obtained from Oregon Department of State Lands.

Legend

- Riverbank Transect (with Transect ID)
- MHW (Mean High Waterline)
- Toe of Slope
- Top of Bank
- Ordinary High Water
- Elevation (NAVD88, feet)
- Site Building / Structure
- Site Boundary

Figure 2
Riverbank Transects 1 - 4
Siltronic Corporation
Portland, Oregon

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Note: NAVD88 = North American Vertical Datum of 1988.

0 20 40
Feet

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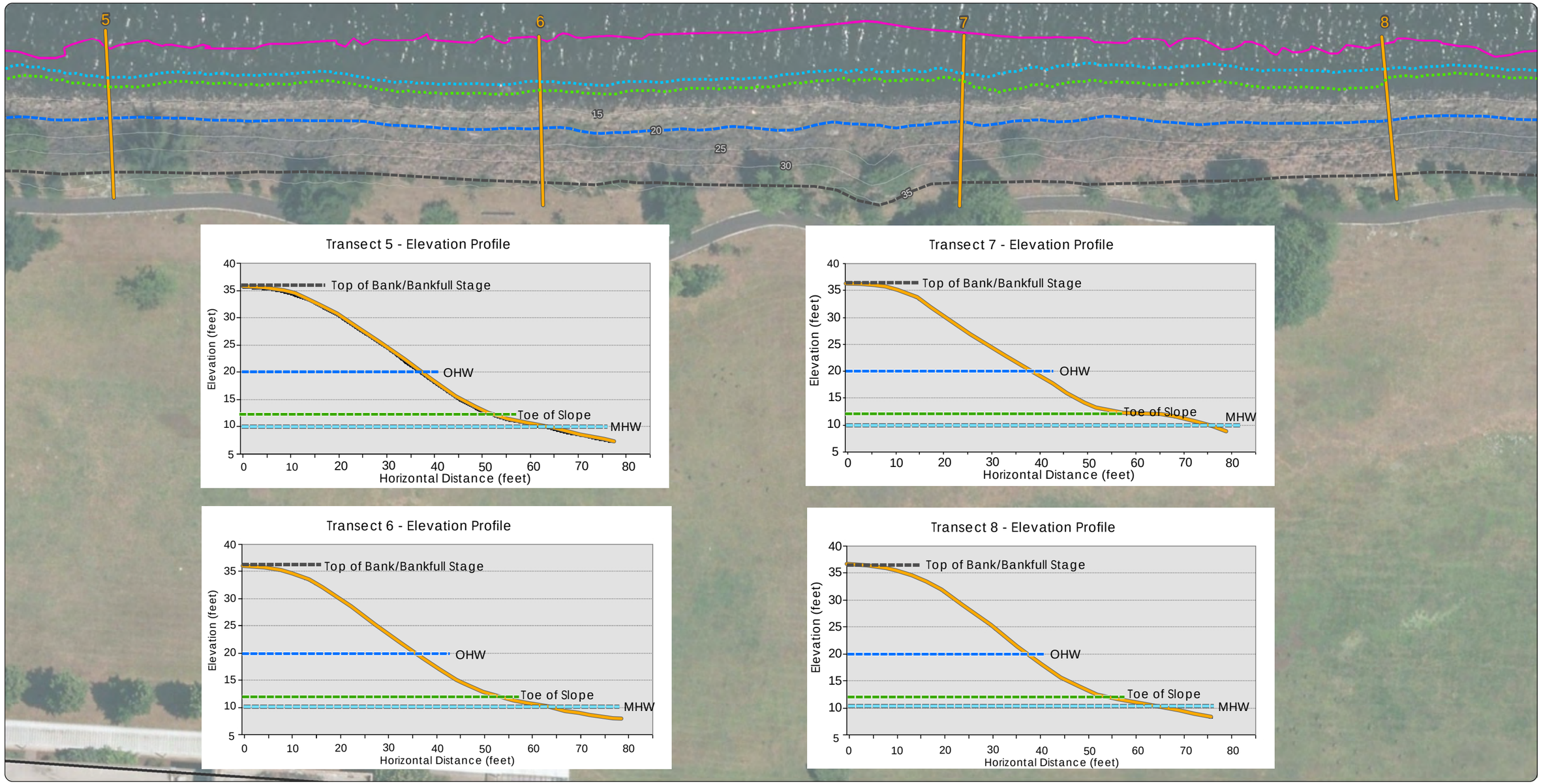

Source: Aerial photograph (2012) obtained from City of Portland; National Flood Hazard dataset obtained from FEMA; elevations obtained from 2005 Columbia River dataset, Puget Sound LiDAR Consortium; Ordinary High Water and Ordinary Low Water data obtained from Oregon Department of State Lands.

Legend

- Riverbank Transect (with Transect ID)
- MHW (Mean High Waterline)
- Toe of Slope
- Top of Bank
- Ordinary High Water
- Elevation (NAVD88, feet)
- Photo
- Site Building / Structure
- Site Boundary

Note: NAVD88 = North American Vertical Datum of 1988.

Figure 3
Riverbank Transects 5 - 8
Siltronic Corporation
Portland, Oregon

0 20 40
Feet

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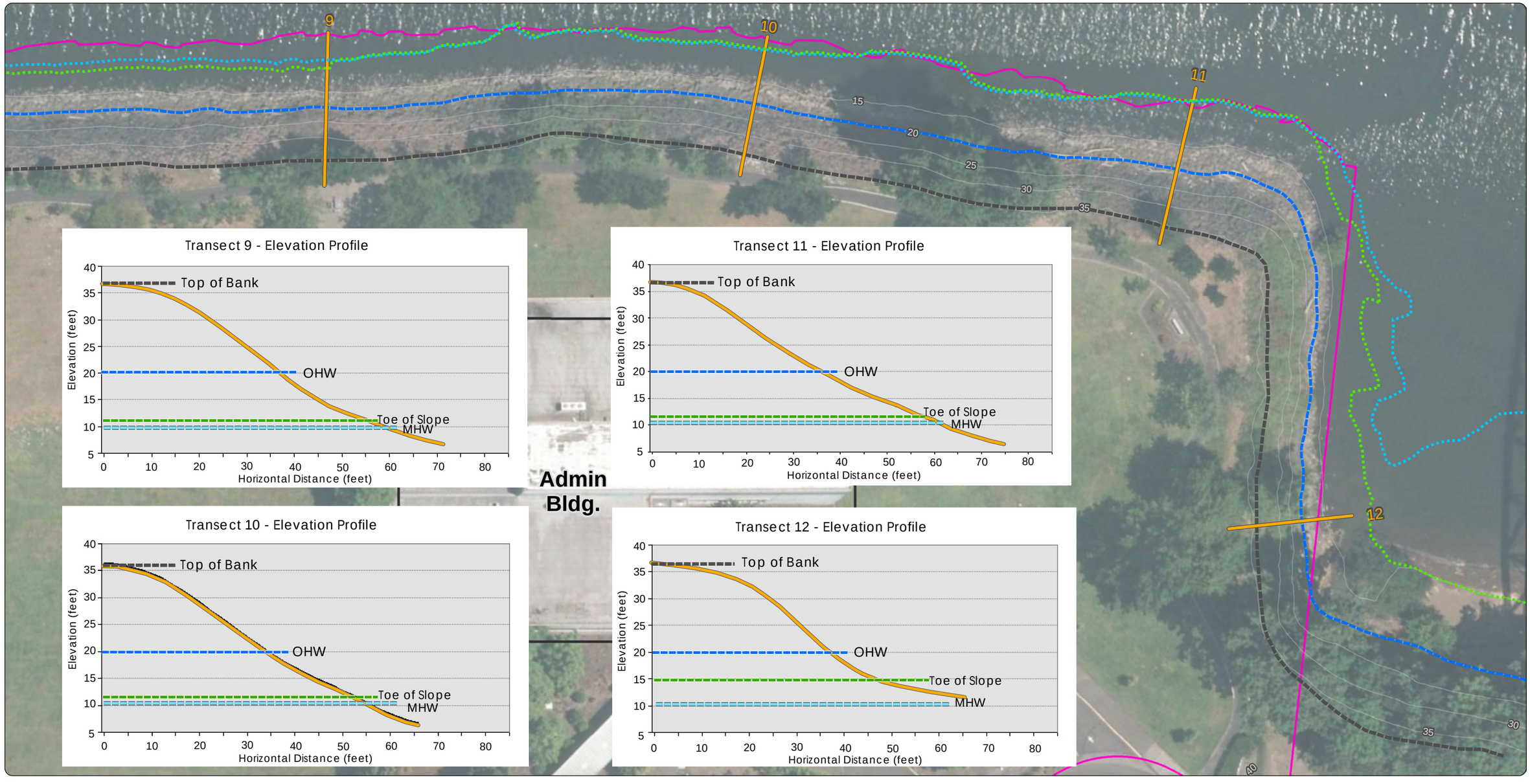

Source: Aerial photograph (2012) obtained from City of Portland; National Flood Hazard dataset obtained from FEMA; elevations obtained from 2005 Columbia River dataset, Puget Sound LiDAR Consortium; Ordinary High Water and Ordinary Low Water data obtained from Oregon Department of State Lands.

Legend

- Riverbank Transect (with Transect ID)
- MHW (Mean High Waterline)
- Toe of Slope
- Top of Bank
- Ordinary High Water
- Elevation (NAVD88, feet)
- Site Building / Structure
- Site Boundary

Figure 4
Riverbank Transects 9 - 12
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Portland, Oregon

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Note: NAVD88 = North American Vertical Datum of 1988.

0 20 40
Feet

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TABLES

Table 1
BEHI Transect Summary
Siltronic
Portland, Oregon

	Transect 1	Transect 2	Transect 3	Transect 4	Transect 5	Transect 6	Transect 7	Transect 8	Transect 9	Transect 10	Transect 11	Transect 12
Study bank height to bankfull height ratio	1	1	1	1	1	1	1	1	1	1	1	1
BEHI	1	1	1	1	1	1	1	1	1	1	1	1
Root depth to study bank height ratio	0.22	0.19	0.19	0.21	0.21	0.19	0.42	0.2	0.37	0.19	0.19	0.45
BEHI	6.9	7	7	7	7	7	4.2	7	5	7	7	4.2
Weighted root density	10.94	4.83	9.48	5.32	10.42	4.84	20.83	10	18.62	4.66	9.31	31.82
BEHI	9	9.5	8.8	9.3	8.5	9.5	7	8.6	7.8	9.5	8.5	5.9
Bank angle	24.5	25.2	24.7	25.2	23.9	22	22.8	25.7	24.9	25.6	24.1	25.1
BEHI	2.1	2.2	2.1	2.2	2.2	2.1	2.1	2.1	2.2	2.2	2.2	2.2
Surface protection	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%	95%
BEHI	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Total BEHI Score	19.5	20.2	19.4	20	19.2	20.1	14.8	19.2	16.5	20.2	19.2	13.8
Bank material adjustment (Cobbles -10)	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10
Total BEHI with adjustment	9.5	10.2	9.4	10	9.2	10.1	4.8	9.2	6.5	10.2	9.2	3.8
BEHI adjective rating	Very Low	Low	Very Low	Low	Very Low	Low	Very Low	Very Low	Very Low	Low	Very Low	Very Low

NOTE:

BEHI = bank erosion hazard index.

Table 2
Channel Stability Ratings
Siltronic
Portland, Oregon

Stream:	Willamette River		Location: Portland, Oregon		Valley Type:		Observers: Justin Pounds		Date:	
Loca-tion	Key	Category	Excellent		Good		Fair		Poor	
			Description	Rating	Description	Rating	Description	Rating	Description	Rating
Upper banks	1	Landform slope	Bank slope gradient <30%.	2	Bank slope gradient 30–40%.	4	Bank slope gradient 40–60%.	6	Bank slope gradient > 60%.	8
	2	Mass erosion	No evidence of past or future mass erosion.	3	Infrequent. Mostly healed over. Low future potential.	6	Frequent or large, causing sediment nearly yearlong.	9	Frequent or large, causing sediment nearly yearlong OR imminent danger of same.	12
	3	Debris jam potential	Essentially absent from immediate channel area.	2	Present, but mostly small twigs and limbs.	4	Moderate to heavy amounts, mostly larger sizes.	6	Moderate to heavy amounts, predominantly larger sizes.	8
	4	Vegetative bank protection	> 90% plant density. Vigor and variety suggest a deep, dense, soil-binding root mass.	3	70–90% density. Fewer species or less vigor suggest less dense or deep root mass.	6	50–70% density. Lower vigor and fewer species from a shallow, discontinuous root mass.	9	<50% density plus fewer species and less vigor indicating poor, discontinuous, and shallow root mass.	12
Lower banks	5	Channel capacity	Bank heights sufficient to contain the bankfull stage. Width/depth ratio departure from reference width/depth ratio = 1.0. Bank-Height Ratio (BHR) = 1.0.	1	Bankfull stage is contained within banks. Width/depth ratio departure from reference width/depth ratio = 1.0–1.2. Bank-Height Ratio (BHR) = 1.0–1.1.	2	Bankfull stage is not contained. Width/depth ratio departure from reference width/depth ratio = 1.2–1.4. Bank-Height Ratio (BHR) = 1.1–1.3.	3	Bankfull stage is not contained; over-bank flows are common with flows less than bankfull. Width/depth ratio departure from reference width/depth ratio > 1.4. Bank-Height Ratio (BHR) > 1.3.	4
	6	Bank rock content	> 65% with large angular boulders. 12"+ common.	2	40–65%. Mostly boulders and small cobbles 6–12".	4	20–40%. Most in the 3–6" diameter class.	6	<20% rock fragments of gravel sizes, 1–3" or less.	8
	7	Obstructions to flow	Rocks and logs firmly imbedded. Flow pattern w/o cutting or deposition. Stable bed.	2	Some present causing erosive cross currents and minor pool filling. Obstructions fewer and less firm.	4	Moderately frequent, unstable obstructions move with high flows causing bank cutting and pool filling.	6	Frequent obstructions and deflectors cause bank erosion yearlong. Sediment traps full, channel migration occurring.	8
	8	Cutting	Little or none. Infrequent raw banks <6".	4	Some, intermittently at outcurves and constrictions. Raw banks may be up to 12".	6	Significant. Cuts 12–24" high. Root mat overhangs and sloughing evident.	12	Almost continuous cuts, some over 24" high. Failure of overhangs frequent.	16
	9	Deposition	Little or no enlargement of channel or point bars.	4	Some new bar increase, mostly from coarse gravel.	8	Moderate depostion of new gravel and coarse sand on old and some new bars.	12	Extensive deposit of predominantly fine particles. Accelerated bar development.	16
Bottom	10	Rock angularity	Sharp edges and corners. Plane surfaces rough.	1	Rounded corners and edges. Surfaces smooth and flat.	2	Corners and edges well-rounded in two dimensions.	3	Well-rounded in all dimensions, surfaces smooth.	4
	11	Brightness	Surfaces dull, dark, or stained. Generally not bright.	1	Mostly dull, but may have <35% bright surfaces.	2	Mixture dull and bright, i.e., 35–65% mixture range.	3	Predominantly bright, > 65%, exposed or scoured surfaces.	4
	12	Consolidation of particles	Assorted sizes tightly packed or overlapping.	2	Moderately packed with some overlapping.	4	Mostly loose assortment with no apparent overlap.	6	No packing evident. Loose assortment, easily moved.	8
	13	Bottom size distribution	No size change evident. Stable material 80–100%.	4	Distribution shift light. Stable material 50–80%.	8	Moderate change in sizes. Stable materials 20–50%.	12	Marked distribution change. Stable materials 0–20%.	16
	14	Scouring and deposition	<5% of bottom affected by scour or deposition.	6	5–30% affected. Scour at constrictions and where grades steepen. Some deposition in pools.	12	30–50% affected. Deposits and scour at obstructions, constrictions, and bends. Some filling of pools.	18	More than 50% of the bottom in a state of flux or change nearly yearlong.	24
	15	Aquatic vegetation	Abundant growth moss-like, dark green perennial. In swift water too.	1	Common. Algae forms in low velocity and pool areas. Moss here too.	2	Present but spotty, mostly in backwater. Seasonal algae growth makes rocks slick.	3	Perennial types scarce or absent. Yellow-green, short-term bloom may be present.	4
				Excellent Total =		Good Total =		Fair Total =		Poor Total =

Stream type	A1	A2	A3	A4	A5	A6	B1	B2	B3	B4	B5	B6	C1	C2	C3	C4	C5	C6	D3	D4	D5	D6
Good (Stable)	38-43	38-43	54-90	60-95	60-95	50-80	38-45	38-45	40-60	40-64	48-68	40-60	38-50	38-50	60-85	70-90	70-90	60-85	85-107	85-107	85-107	67-98
Fair (Mod. unstable)	44-47	44-47	91-129	96-132	96-142	81-110	46-58	46-58	61-78	65-84	69-88	61-78	51-61	51-61	86-105	91-110	91-110	86-105	108-132	108-132	108-132	99-125
Poor (Unstable)	48+	48+	130+	133+	143+	111+	59+	59+	79+	85+	89+	79+	62+	62+	106+	111+	111+	106+	133+	133+	133+	126+
Stream type	**DA3**	**DA4**	**DA5**	**DA6**	**E3**	**E4**	**E5**	**E6**	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**G1**	**G2**	**G3**	**G4**	**G5**	**G6**		
Good (Stable)	40-63	40-63	40-63	40-63	40-63	50-75	50-75	40-63	60-85	60-85	85-110	85-110	90-115	80-95	40-60	40-60	85-107	85-107	90-112	85-107		
Fair (Mod. unstable)	64-86	64-86	64-86	64-86	64-86	76-96	76-96	64-86	86-105	86-105	111-125	111-125	116-130	96-110	61-78	61-78	108-120	108-120	113-125	108-120		
Poor (Unstable)	87+	87+	87+	87+	87+	97+	97+	87+	106+	106+	126+	126+	131+	111+	79+	79+	121+	121+	126+	121+		

Grand Total =	
Existing Stream Type =	
*Potential Stream Type =	
Modified channel stability rating =	

***Rating is adjusted to *potential* stream type, not existing stream type**

Worksheet 3-10. Pfankuch (1975) channel stability rating procedure, as modified by Rosgen (1996, 2006b). *River Stability Field Guide* pages 3-46 to 3-47

Table 3
Channel Stability Summary
Siltronic
Portland, Oregon

Transect No.	Upper Banks				Lower Banks					Bottom							
	Landform slope	Mass erosion	Debris jam potential	Vegetative bank protection	Channel capacity	Bank rock content	Obstructions to flow	Cutting	Deposition	Rock angularity	Brightness	Consolidation of particles	Bottom size distribution	Scouring and deposition	Aquatic vegetation	Total	Channel Stability Rating
1	2	3	2	9	1	2	2	4	4	1	1	2	4	6	2	45	Good (Stable)
2	2	3	2	12	1	2	2	4	4	1	1	2	4	6	2	48	Good (Stable)
3	2	3	2	9	1	2	2	4	4	1	1	2	4	6	2	45	Good (Stable)
4	2	3	2	12	1	2	2	4	4	1	1	2	4	6	2	48	Good (Stable)
5	2	3	2	9	1	2	2	4	4	1	1	2	4	6	2	45	Good (Stable)
6	2	3	2	12	1	2	2	4	4	1	1	2	4	6	2	48	Good (Stable)
7	2	3	2	9	1	2	2	4	4	1	1	2	4	6	2	45	Good (Stable)
8	2	3	2	9	1	2	2	4	4	1	1	2	4	6	2	45	Good (Stable)
9	2	3	2	9	1	2	2	4	4	1	1	2	4	6	2	45	Good (Stable)
10	2	3	2	12	1	2	2	4	4	1	1	2	4	6	2	48	Good (Stable)
11	2	3	2	9	1	2	2	4	4	1	1	2	4	6	2	45	Good (Stable)
12	2	3	2	6	1	2	2	4	4	1	1	2	4	6	2	42	Good (Stable)

ATTACHMENT 1
PHOTOGRAPHS

MAUL FOSTER ALONGI

PHOTOGRAPHS

Project Name: Siltronic Bank Survey
Project Number: 8128.02.03
Location: 7200 Northwest Front Avenue
Portland, Oregon

Photo No.
1

Description
Looking southeast on top of bank near Transect #9.

Photo No.
2

Description
Looking northeast on top of bank near Transect #4.

PHOTOGRAPHS

Project Name: Siltronic Bank Survey
Project Number: 8128.02.03
Location: 7200 Northwest Front Avenue
Portland, Oregon

Photo No.
3

Description
Looking northwest from water of Transect #10.

Photo No.
4

Description
Trees on top of bank, looking west at Transect #10 from water.

PHOTOGRAPHS

Project Name: Siltronic Bank Survey
Project Number: 8128.02.03
Location: 7200 Northwest Front Avenue
Portland, Oregon

Photo No.
5

Description
Panoramic view of bank.

PHOTOGRAPHS

Project Name: Siltronic Bank Survey
Project Number: 8128.02.03
Location: 7200 Northwest Front Avenue
Portland, Oregon

Photo No.
6

Description
Looking west at Transect #3 from water.

Photo No.
7

Description
Looking west at Transect #5 from water.

PHOTOGRAPHS

Project Name: Siltronic Bank Survey
Project Number: 8128.02.03
Location: 7200 Northwest Front Avenue
Portland, Oregon

Photo No.
8

Description
Looking west at Transect #9 from water.

Photo No.
9

Description
Looking west at Transect #11 from water.

PHOTOGRAPHS

Project Name: Siltronic Bank Survey
Project Number: 8128.02.03
Location: 7200 Northwest Front Avenue
Portland, Oregon

Photo No.
10

Description
Looking west at Transect #12 from water.

ATTACHMENT 2

BEHI FIELD DATA SHEETS

Worksheet 3-11. Form to calculate an overall Bank Erosion Hazard Index (BEHI) rating. Use **Figure 3-7** to determine individual BEHI scores.

Stream:	**Willamette River**	Location:	**Portland, Oregon**
Station:	**Transect 1**	Observers:	**Justin Pounds**
Date:	**7/26/2016**	Stream Type: **C2**	Valley Type:

						BEHI Score (Fig. 3-7)
Study Bank Height to Bankfull Height (C)						
Study Bank Height (ft) =	**22.86 (A)**	**Bankfull Height** (ft) =	**22.86 (B)**	(A) / (B) =	**1.00 (C)**	**1.0**
Root Depth to Study Bank Height (E)						
Root Depth (ft) =	**5.00 (D)**	**Study Bank Height** (ft) =	**22.86 (A)**	(D) / (A) =	**0.22 (E)**	**6.9**
Weighted Root Density (G)						
Root Density as **%** =		**50.00 (F)**		(F) x (E) =	**10.94 (G)**	**9.0**
Bank Angle (H)						
Bank Angle as *Degrees* =		**24.5 (H)**				**2.1**
Surface Protection (I)						
Surface Protection as **%** =		**95% (I)**				**0.5**

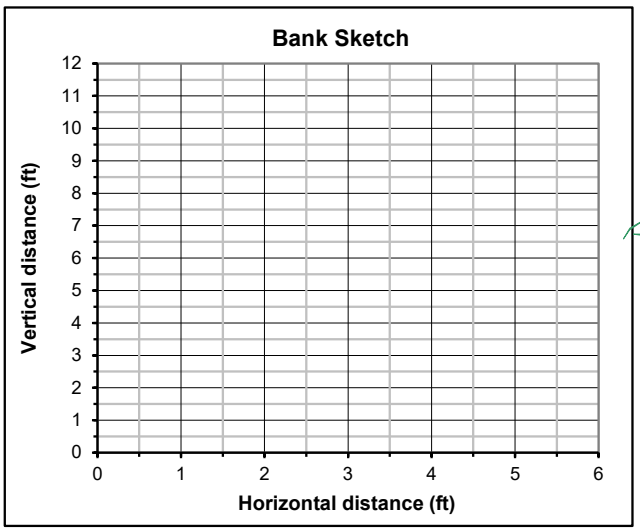
Bank Material Adjustment:

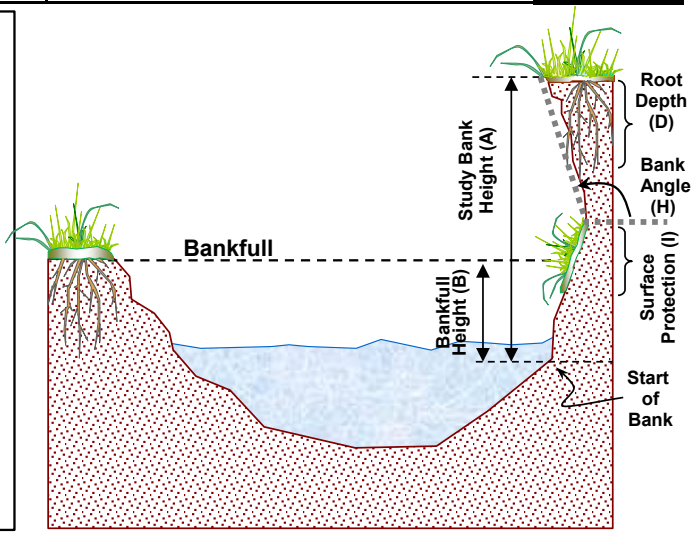
Bedrock (Overall *Very Low* BEHI)
Boulders (Overall *Low* BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment unless primarily clay, then subtract 20 points)

Bank Material Adjustment **-10**

Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage: **0**

Very Low	*Low*	*Moderate*	*High*	*Very High*	*Extreme*	**Adjective Rating** and **Total Score**	**Very Low**
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		**9.5**





Worksheet 3-11. Form to calculate an overall Bank Erosion Hazard Index (BEHI) rating. Use **Figure 3-7** to determine individual BEHI scores.

Stream:	**Willamette River**	Location:	**Portland, Oregon**
Station:	**Transect 2**	Observers:	**Justin Pounds**
Date:	**7/26/2016**	Stream Type: **C2**	Valley Type:

						BEHI Score (Fig. 3-7)
Study Bank Height to Bankfull Height (C)						
Study Bank Height (ft) =	25.90 (A)	Bankfull Height (ft) =	25.90 (B)	(A) / (B) =	1.00 (C)	1.0
Root Depth to Study Bank Height (E)						
Root Depth (ft) =	5.00 (D)	Study Bank Height (ft) =	25.90 (A)	(D) / (A) =	0.19 (E)	7.0
Weighted Root Density (G)						
Root Density as % =	25.00 (F)			(F) x (E) =	4.83 (G)	9.5
Bank Angle (H)						
Bank Angle as *Degrees* =	25.2 (H)					2.2
Surface Protection (I)						
Surface Protection as % =	95% (I)					0.5

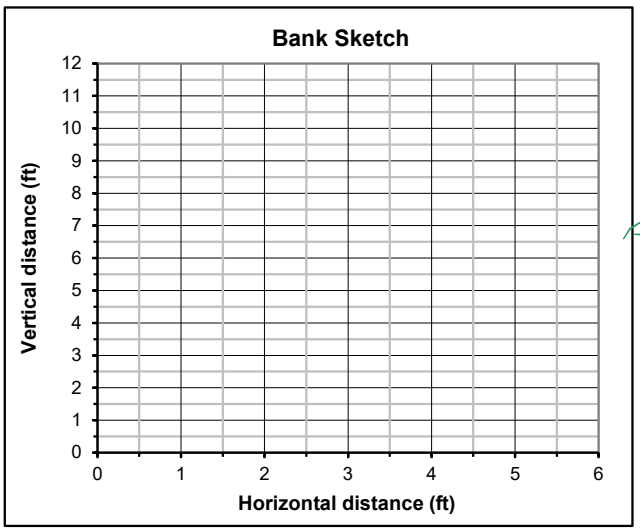
Bank Material Adjustment:

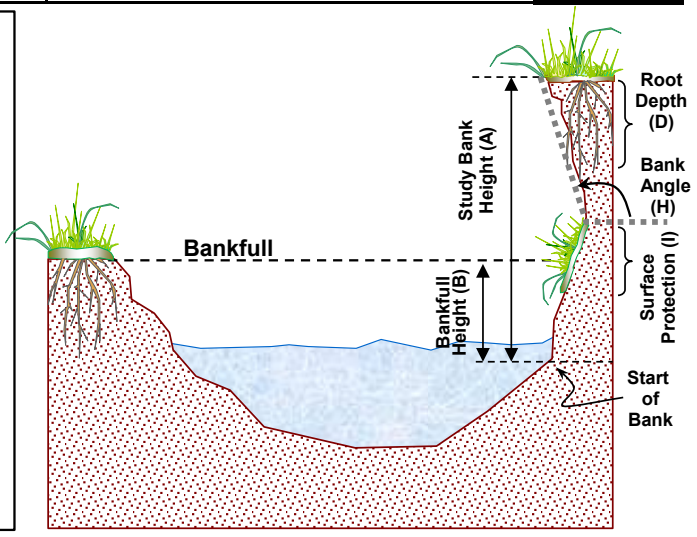
Bedrock (Overall *Very Low* BEHI)
Boulders (Overall *Low* BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment unless primarily clay, then subtract 20 points)

Bank Material Adjustment: -10

Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage: 0

Very Low	*Low*	*Moderate*	*High*	*Very High*	*Extreme*	Adjective Rating and Total Score
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50	Low / 10.2





GASCO0066811

Worksheet 3-11. Form to calculate an overall Bank Erosion Hazard Index (BEHI) rating. Use **Figure 3-7** to determine individual BEHI scores.

Stream:	**Willamette River**	Location:	**Portland, Oregon**
Station:	**Transect 3**	Observers:	**Justin Pounds**
Date:	**7/26/2016**	Stream Type: **C2**	Valley Type:

						BEHI Score (Fig. 3-7)
Study Bank Height to Bankfull Height (C)						
Study Bank Height (ft) =	**26.36 (A)**	**Bankfull Height** (ft) =	**26.36 (B)**	(A) / (B) =	**1.00 (C)**	**1.0**
Root Depth to Study Bank Height (E)						
Root Depth (ft) =	**5.00 (D)**	**Study Bank Height** (ft) =	**26.36 (A)**	(D) / (A) =	**0.19 (E)**	**7.0**
Weighted Root Density (G)						
Root Density as % =	**50.00 (F)**	(F) x (E) =	**9.48 (G)**			**8.8**
Bank Angle (H)						
Bank Angle as *Degrees* =	**24.7 (H)**					**2.1**
Surface Protection (I)						
Surface Protection as % =	**95% (I)**					**0.5**

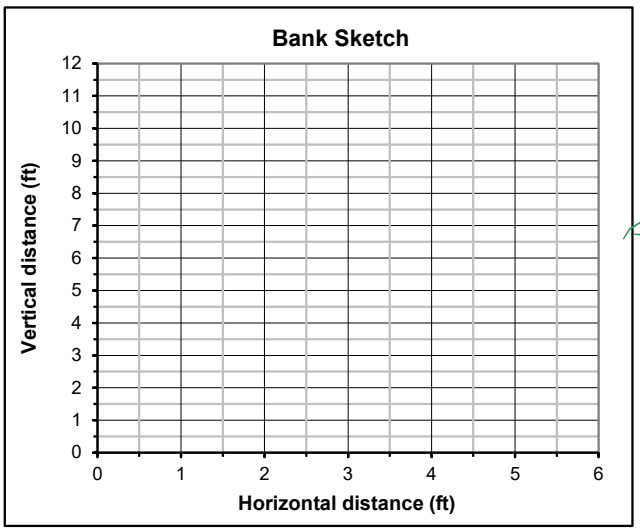
Bank Material Adjustment:

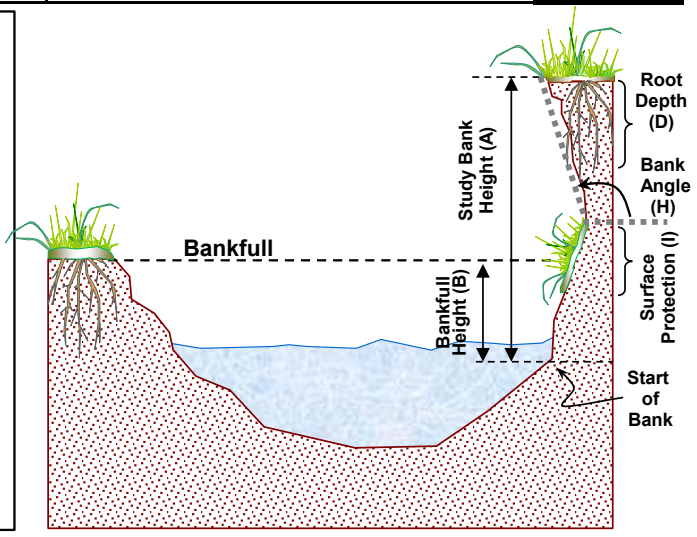
Bedrock (Overall *Very Low* BEHI)
Boulders (Overall *Low* BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment unless primarily clay, then subtract 20 points)

Bank Material Adjustment: **-10**

Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage: **0**

Very Low	*Low*	*Moderate*	*High*	*Very High*	*Extreme*	**Adjective Rating** and **Total Score**	**Very Low**
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		**9.4**





Worksheet 3-11. Form to calculate an overall Bank Erosion Hazard Index (BEHI) rating. Use **Figure 3-7** to determine individual BEHI scores.

Stream:	**Willamette River**	Location:	**Portland, Oregon**
Station:	**Transect 4**	Observers:	**Justin Pounds**
Date:	**7/26/2016**	Stream Type: **C2**	Valley Type:

						BEHI Score (Fig. 3-7)
Study Bank Height to Bankfull Height (C)						
Study Bank Height (ft) =	23.50 (A)	Bankfull Height (ft) =	23.50 (B)	(A) / (B) =	1.00 (C)	1.0
Root Depth to Study Bank Height (E)						
Root Depth (ft) =	5.00 (D)	Study Bank Height (ft) =	23.50 (A)	(D) / (A) =	0.21 (E)	7.0
Weighted Root Density (G)						
Root Density as % =	25.00 (F)			(F) x (E) =	5.32 (G)	9.3
Bank Angle (H)						
Bank Angle as *Degrees* =	25.2 (H)					2.2
Surface Protection (I)						
Surface Protection as % =	95% (I)					0.5

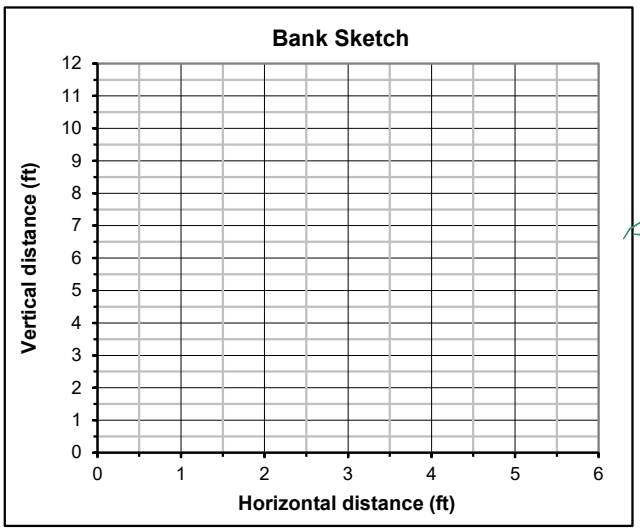
Bank Material Adjustment:

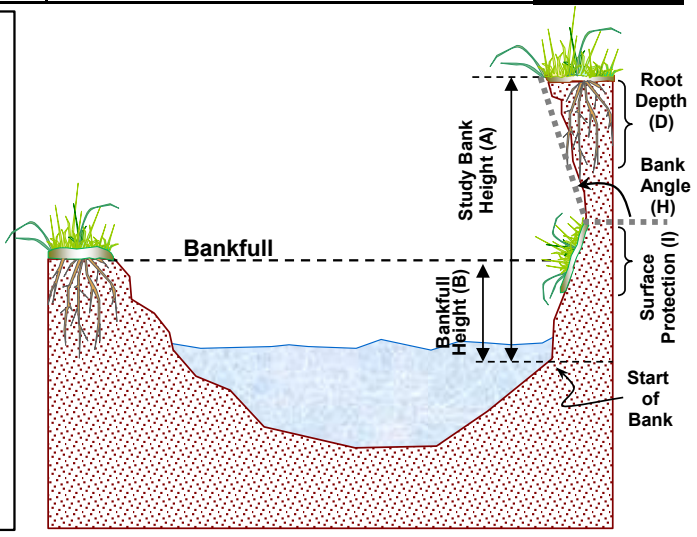
Bedrock (Overall *Very Low* BEHI)
Boulders (Overall *Low* BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment unless primarily clay, then subtract 20 points)

Bank Material Adjustment: -10

Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage: 0

Very Low	*Low*	*Moderate*	*High*	*Very High*	*Extreme*	Adjective Rating and Total Score
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50	Low / 10.0





GASCO0066813

Worksheet 3-11. Form to calculate an overall Bank Erosion Hazard Index (BEHI) rating. Use **Figure 3-7** to determine individual BEHI scores.

Stream:	**Willamette River**	Location:	**Portland, Oregon**
Station:	**Transect 5**	Observers:	**Justin Pounds**
Date:	**7/26/2016**	Stream Type: **C2**	Valley Type:

						BEHI Score (Fig. 3-7)
Study Bank Height to Bankfull Height (C)						
Study Bank Height (ft) =	24.00 (A)	Bankfull Height (ft) =	24.00 (B)	(A) / (B) =	1.00 (C)	1.0
Root Depth to Study Bank Height (E)						
Root Depth (ft) =	5.00 (D)	Study Bank Height (ft) =	24.00 (A)	(D) / (A) =	0.21 (E)	7.0
Weighted Root Density (G)						
Root Density as % =	50.00 (F)			(F) x (E) =	10.42 (G)	8.5
Bank Angle (H)						
Bank Angle as *Degrees* =	23.9 (H)					2.2
Surface Protection (I)						
Surface Protection as % =	95% (I)					0.5

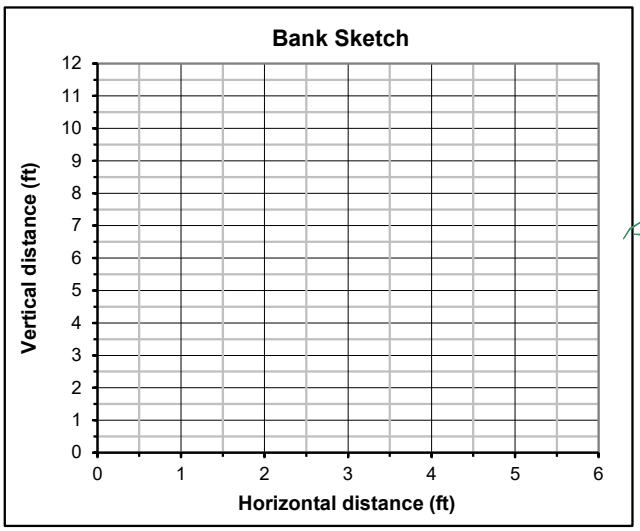
Bank Material Adjustment:

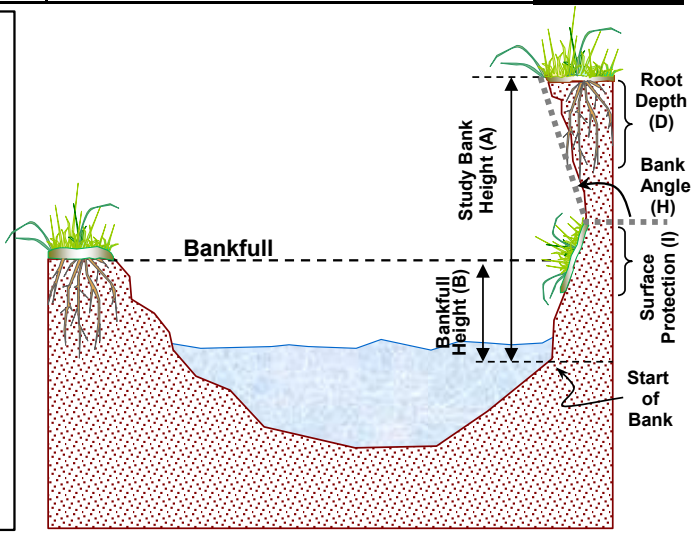
Bedrock (Overall *Very Low* BEHI)
Boulders (Overall *Low* BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment unless primarily clay, then subtract 20 points)

Bank Material Adjustment: -10

Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage: 0

Very Low	*Low*	*Moderate*	*High*	*Very High*	*Extreme*	Adjective Rating and Total Score
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50	Very Low / 9.2





GASCO0066814

Worksheet 3-11. Form to calculate an overall Bank Erosion Hazard Index (BEHI) rating. Use **Figure 3-7** to determine individual BEHI scores.

Stream:	**Willamette River**	Location:	**Portland, Oregon**
Station:	**Transect 6**	Observers:	**Justin Pounds**
Date:	**7/26/2016**	Stream Type: **C2**	Valley Type:

						BEHI Score (Fig. 3-7)
Study Bank Height to Bankfull Height (C)						
Study Bank Height (ft) =	**25.84 (A)**	**Bankfull Height** (ft) =	**25.84 (B)**	(A) / (B) =	**1.00 (C)**	**1.0**
Root Depth to Study Bank Height (E)						
Root Depth (ft) =	**5.00 (D)**	**Study Bank Height** (ft) =	**25.84 (A)**	(D) / (A) =	**0.19 (E)**	**7.0**
Weighted Root Density (G)						
Root Density as % =	**25.00 (F)**	(F) x (E) =	**4.84 (G)**			**9.5**
Bank Angle (H)						
Bank Angle as *Degrees* =	**22 (H)**					**2.1**
Surface Protection (I)						
Surface Protection as % =	**95% (I)**					**0.5**

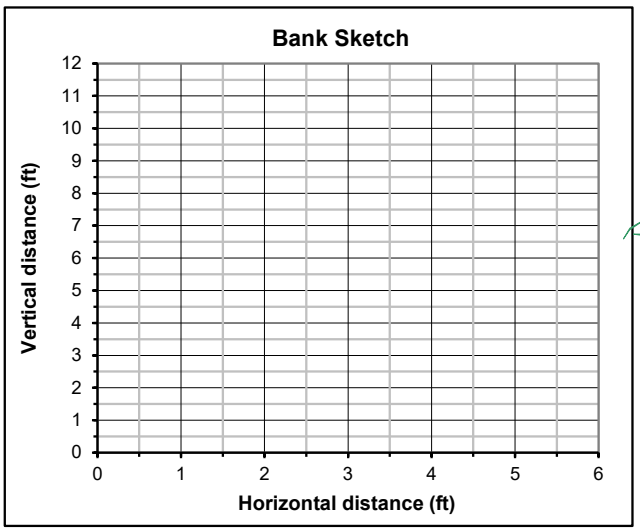
Bank Material Adjustment:

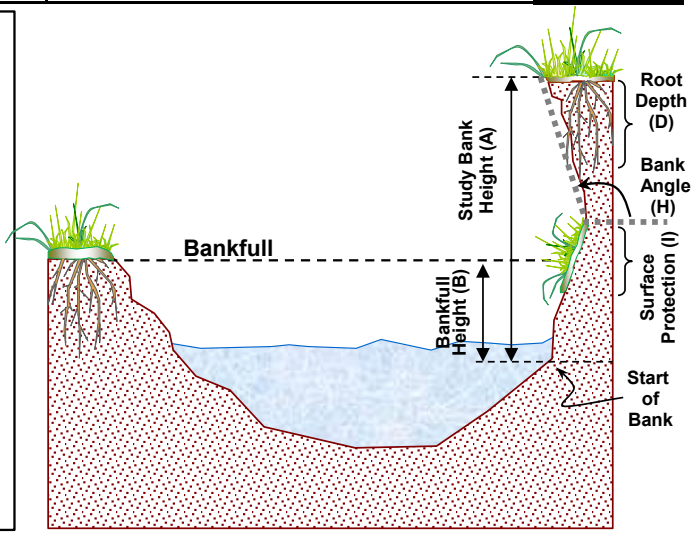
Bedrock (Overall *Very Low* BEHI)
Boulders (Overall *Low* BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment unless primarily clay, then subtract 20 points)

Bank Material Adjustment: **-10**

Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage: **0**

Very Low	*Low*	*Moderate*	*High*	*Very High*	*Extreme*	**Adjective Rating** and **Total Score**	**Low** / **10.1**
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		





Worksheet 3-11. Form to calculate an overall Bank Erosion Hazard Index (BEHI) rating. Use **Figure 3-7** to determine individual BEHI scores.

Stream:	**Willamette River**	Location: **Portland, Oregon**	
Station:	**Transect 7**	Observers: **Justin Pounds**	
Date:	**7/26/2016**	Stream Type: **C2**	Valley Type:

						BEHI Score (Fig. 3-7)
Study Bank Height (C)						
Study Bank Height (ft) =	24.00 (A)	Bankfull Height (ft) =	24.00 (B)	(A) / (B) =	1.00 (C)	1.0
Root Depth to Study Bank Height (E)						
Root Depth (ft) =	10.00 (D)	Study Bank Height (ft) =	24.00 (A)	(D) / (A) =	0.42 (E)	4.2
Weighted Root Density (G)						
Root Density as % =	50.00 (F)			(F) x (E) =	20.83 (G)	7.0
Bank Angle (H)						
Bank Angle as *Degrees* =	22.8 (H)					2.1
Surface Protection (I)						
Surface Protection as % =	95% (I)					0.5

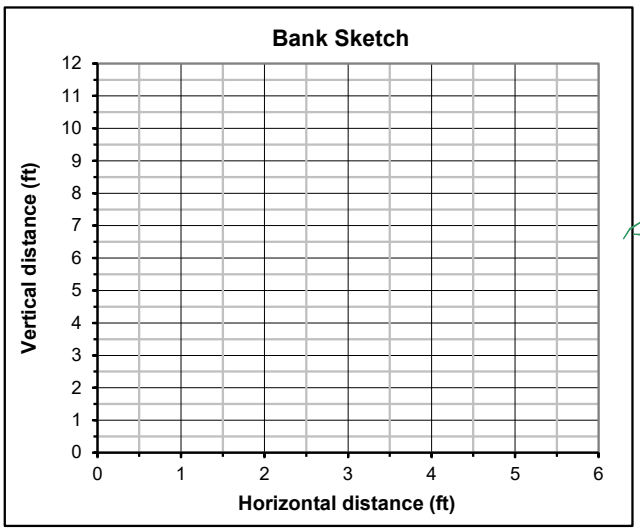
Bank Material Adjustment:

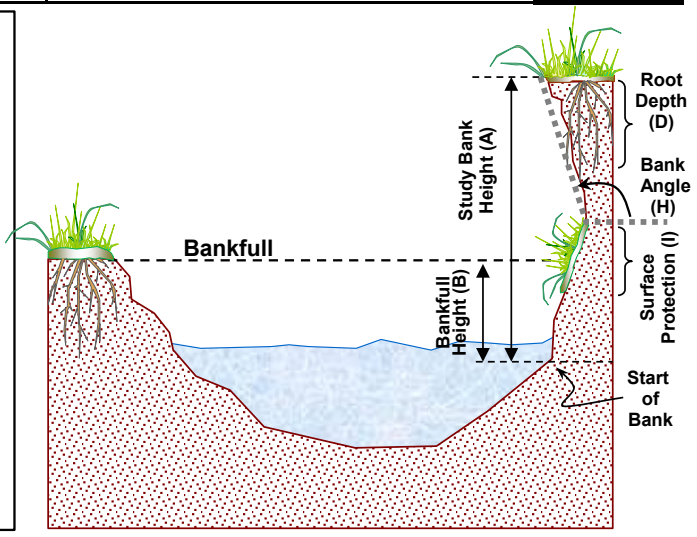
Bedrock (Overall *Very Low* BEHI)
Boulders (Overall *Low* BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment unless primarily clay, then subtract 20 points)

Bank Material Adjustment: -10

Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage: 0

Very Low	*Low*	*Moderate*	*High*	*Very High*	*Extreme*	Adjective Rating and Total Score
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50	Very Low 4.8





Worksheet 3-11. Form to calculate an overall Bank Erosion Hazard Index (BEHI) rating. Use **Figure 3-7** to determine individual BEHI scores.

Stream:	**Willamette River**	Location:	**Portland, Oregon**
Station:	**Transect 8**	Observers:	**Justin Pounds**
Date:	**7/26/2016**	Stream Type: **C2**	Valley Type:

						BEHI Score (Fig. 3-7)
Study Bank Height to Bankfull Height (C)						
Study Bank Height (ft) =	25.00 (A)	Bankfull Height (ft) =	25.00 (B)	(A) / (B) =	1.00 (C)	1.0
Root Depth to Study Bank Height (E)						
Root Depth (ft) =	5.00 (D)	Study Bank Height (ft) =	25.00 (A)	(D) / (A) =	0.20 (E)	7.0
Weighted Root Density (G)						
Root Density as % =	50.00 (F)			(F) x (E) =	10 (G)	8.6
Bank Angle (H)						
Bank Angle as *Degrees* =	25.7 (H)					2.1
Surface Protection (I)						
Surface Protection as % =	95% (I)					0.5

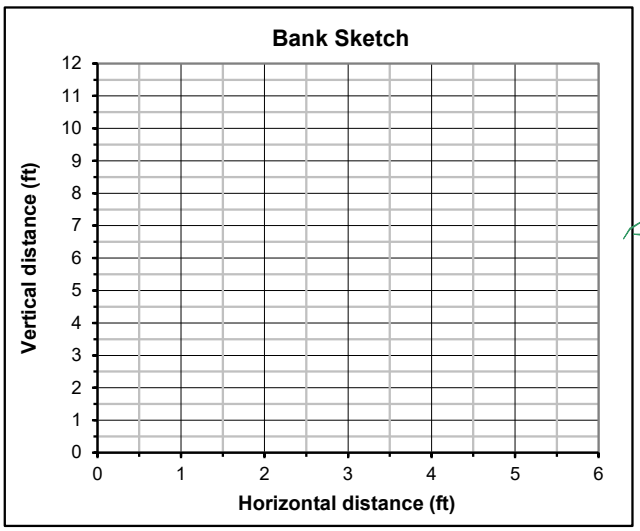
Bank Material Adjustment:

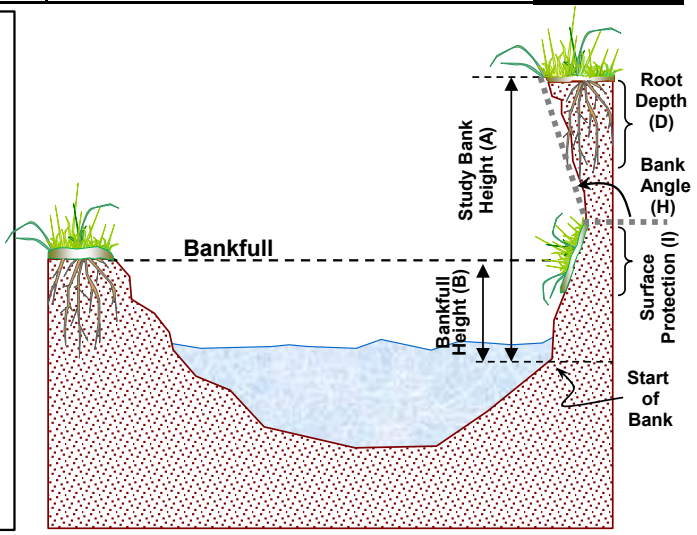
Bedrock (Overall *Very Low* BEHI)
Boulders (Overall *Low* BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment unless primarily clay, then subtract 20 points)

Bank Material Adjustment: -10

Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage: 0

Very Low	*Low*	*Moderate*	*High*	*Very High*	*Extreme*	Adjective Rating and Total Score
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50	Very Low / 9.2





Worksheet 3-11. Form to calculate an overall Bank Erosion Hazard Index (BEHI) rating. Use **Figure 3-7** to determine individual BEHI scores.

Stream:	**Willamette River**	Location: **Portland, Oregon**	
Station:	**Transect 9**	Observers: **Justin Pounds**	
Date:	**7/26/2016**	Stream Type: **C2**	Valley Type:

						BEHI Score (Fig. 3-7)
Study Bank Height to Bankfull Height (C)						
Study Bank Height (ft) =	26.86 (A)	Bankfull Height (ft) =	26.86 (B)	(A) / (B) =	1.00 (C)	1.0
Root Depth to Study Bank Height (E)						
Root Depth (ft) =	10.00 (D)	Study Bank Height (ft) =	26.86 (A)	(D) / (A) =	0.37 (E)	5.0
Weighted Root Density (G)						
Root Density as % =	50.00 (F)			(F) x (E) =	18.62 (G)	7.8
Bank Angle (H)						
Bank Angle as *Degrees* =	24.9 (H)					2.2
Surface Protection (I)						
Surface Protection as % =	95% (I)					0.5

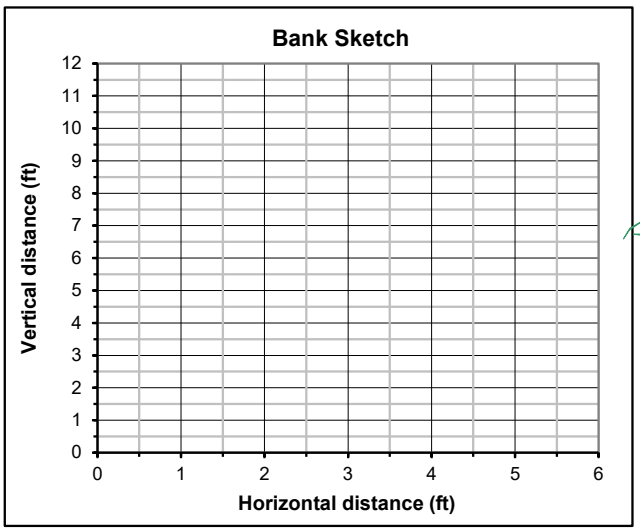
Bank Material Adjustment:

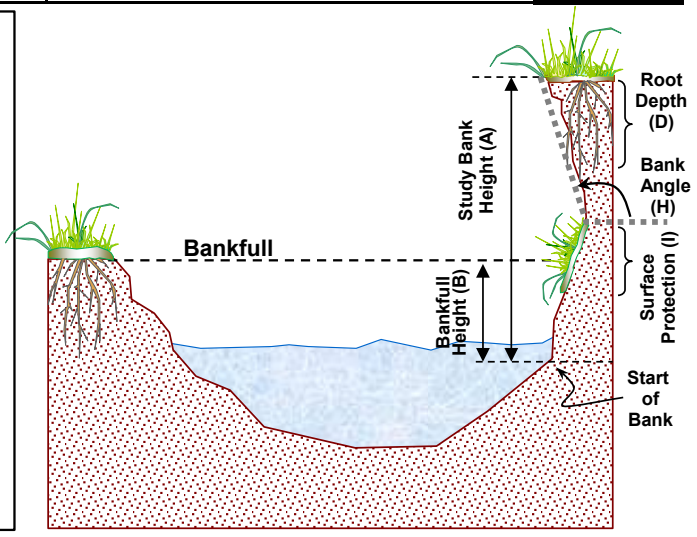
Bedrock (Overall *Very Low* BEHI)
Boulders (Overall *Low* BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment unless primarily clay, then subtract 20 points)

Bank Material Adjustment: -10

Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage: 0

Very Low	*Low*	*Moderate*	*High*	*Very High*	*Extreme*	Adjective Rating and Total Score
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50	Very Low 6.5





Worksheet 3-11. Form to calculate an overall Bank Erosion Hazard Index (BEHI) rating. Use **Figure 3-7** to determine individual BEHI scores.

Stream:	**Willamette River**	Location: **Portland, Oregon**	
Station:	**Transect 10**	Observers: **Justin Pounds**	
Date:	**7/26/2016**	Stream Type: **C2**	Valley Type:

						BEHI Score (Fig. 3-7)
Study Bank Height to Bankfull Height (C)						
Study Bank Height (ft) =	26.84 (A)	Bankfull Height (ft) =	26.84 (B)	(A) / (B) =	1.00 (C)	1.0
Root Depth to Study Bank Height (E)						
Root Depth (ft) =	5.00 (D)	Study Bank Height (ft) =	26.84 (A)	(D) / (A) =	0.19 (E)	7.0
Weighted Root Density (G)						
Root Density as % =	25.00 (F)			(F) x (E) =	4.66 (G)	9.5
Bank Angle (H)						
Bank Angle as *Degrees* =	25.6 (H)					2.2
Surface Protection (I)						
Surface Protection as % =	95% (I)					0.5

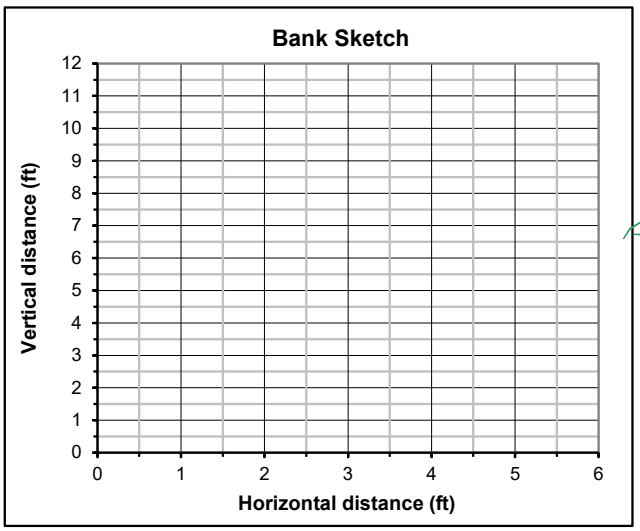
Bank Material Adjustment:

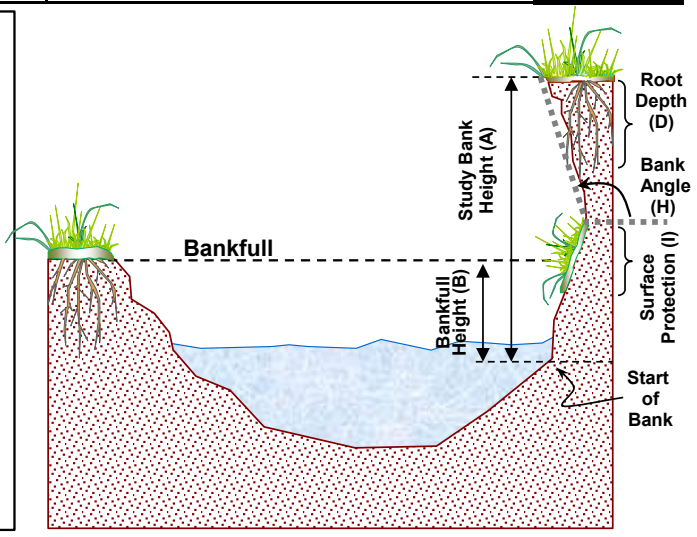
Bedrock (Overall *Very Low* BEHI)
Boulders (Overall *Low* BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment unless primarily clay, then subtract 20 points)

Bank Material Adjustment → **-10**

Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage → **0**

Very Low	*Low*	*Moderate*	*High*	*Very High*	*Extreme*	**Adjective Rating** and **Total Score**	**Low**
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		**10.2**





GASCO0066819

Worksheet 3-11. Form to calculate an overall Bank Erosion Hazard Index (BEHI) rating. Use **Figure 3-7** to determine individual BEHI scores.

Stream:	**Willamette River**	Location: **Portland, Oregon**	
Station:	**Transect 11**	Observers: **Justin Pounds**	
Date:	**7/26/2016**	Stream Type: **C2**	Valley Type:

						BEHI Score (Fig. 3-7)
Study Bank Height to Bankfull Height (C)						
Study Bank Height (ft) =	26.84 (A)	Bankfull Height (ft) =	26.84 (B)	(A) / (B) =	1.00 (C)	1.0
Root Depth to Study Bank Height (E)						
Root Depth (ft) =	5.00 (D)	Study Bank Height (ft) =	26.84 (A)	(D) / (A) =	0.19 (E)	7.0
Weighted Root Density (G)						
Root Density as % =	50.00 (F)			(F) x (E) =	9.31 (G)	8.5
Bank Angle (H)						
Bank Angle as *Degrees* =	24.1 (H)					2.2
Surface Protection (I)						
Surface Protection as % =	95% (I)					0.5

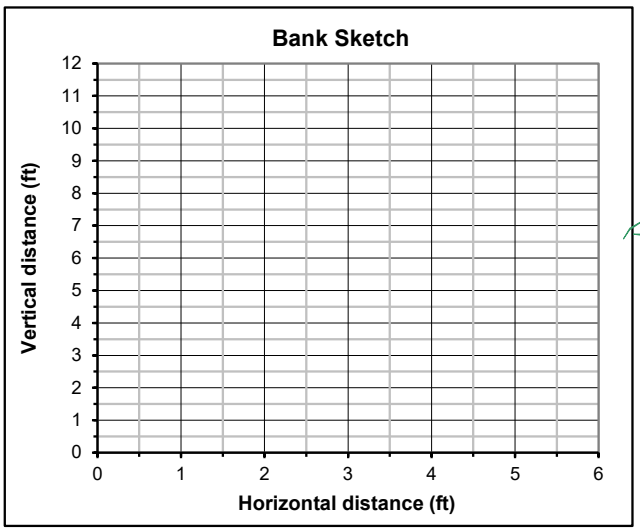
Bank Material Adjustment:

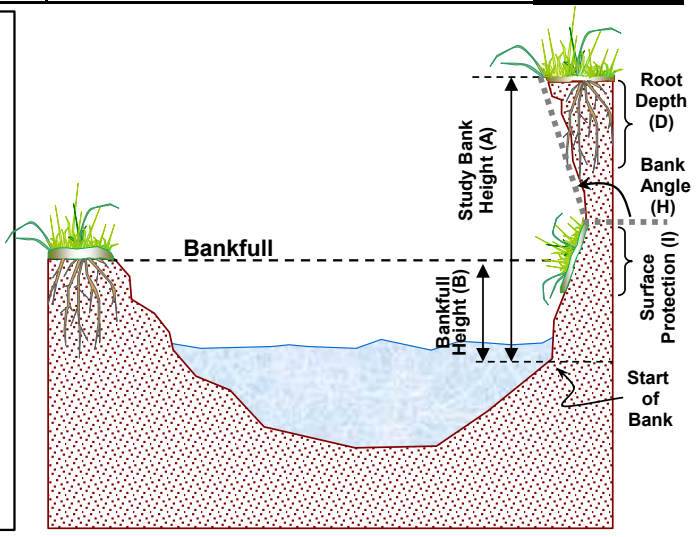
Bedrock (Overall *Very Low* BEHI)
Boulders (Overall *Low* BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment unless primarily clay, then subtract 20 points)

Bank Material Adjustment: -10

Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage: 0

Very Low	*Low*	*Moderate*	*High*	*Very High*	*Extreme*	Adjective Rating and Total Score
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50	Very Low 9.2





GASCO0066820

Worksheet 3-11. Form to calculate an overall Bank Erosion Hazard Index (BEHI) rating. Use **Figure 3-7** to determine individual BEHI scores.

Stream:	**Willamette River**	Location: **Portland, Oregon**	
Station:	**Transect 12**	Observers: **Justin Pounds**	
Date:	**7/26/2016**	Stream Type: **C2**	Valley Type:

						BEHI Score (Fig. 3-7)
Study Bank Height to Bankfull Height (C)						
Study Bank Height (ft) =	22.00 (A)	Bankfull Height (ft) =	22.00 (B)	(A) / (B) =	1.00 (C)	1.0
Root Depth to Study Bank Height (E)						
Root Depth (ft) =	10.00 (D)	Study Bank Height (ft) =	22.00 (A)	(D) / (A) =	0.45 (E)	4.2
Weighted Root Density (G)						
Root Density as % =	70.00 (F)			(F) x (E) =	31.82 (G)	5.9
Bank Angle (H)						
Bank Angle as *Degrees* =	25.1 (H)					2.2
Surface Protection (I)						
Surface Protection as % =	95% (I)					0.5

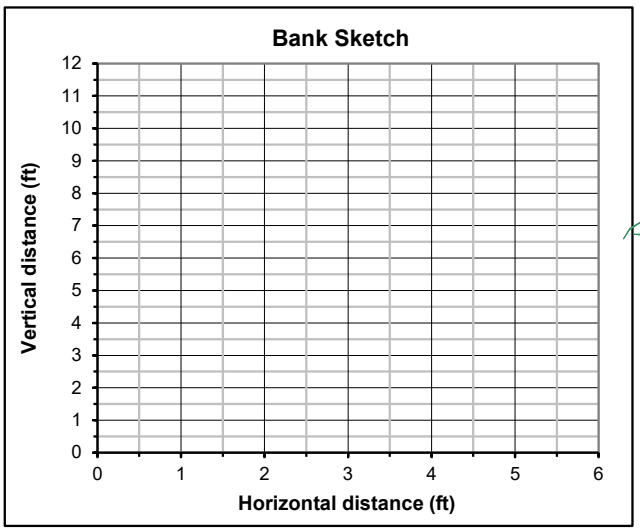
Bank Material Adjustment:

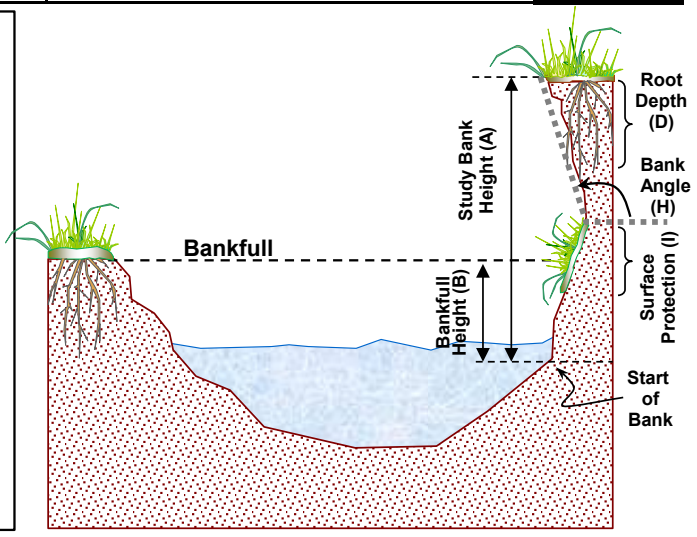
Bedrock (Overall *Very Low* BEHI)
Boulders (Overall *Low* BEHI)
Cobble (Subtract 10 points if uniform medium to large cobble)
Gravel or Composite Matrix (Add 5–10 points depending on percentage of bank material that is composed of sand)
Sand (Add 10 points)
Silt/Clay (no adjustment unless primarily clay, then subtract 20 points)

Bank Material Adjustment → **-10**

Stratification Adjustment
Add 5–10 points, depending on position of unstable layers in relation to bankfull stage → **0**

Very Low	*Low*	*Moderate*	*High*	*Very High*	*Extreme*	Adjective Rating and Total Score	Very Low
5 – 9.5	10 – 19.5	20 – 29.5	30 – 39.5	40 – 45	46 – 50		3.8





ATTACHMENT 3

NOAA DATUMS FOR 9439221
(PORTLAND, OREGON MORRISON ST. BRIDGE)

Datums for 9439221, Portland Morrison Street Bridge OR

NOTICE: All data values are relative to the NAVD88.

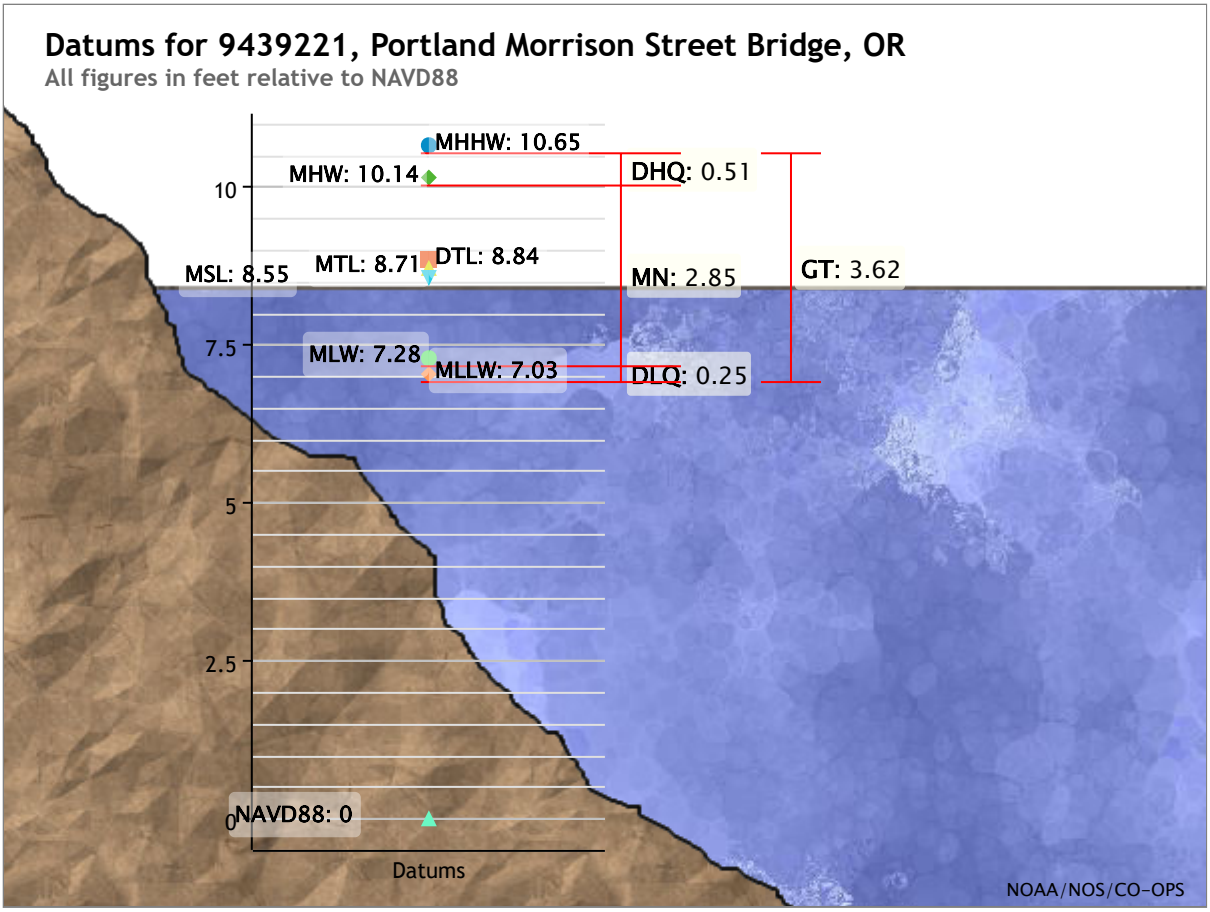
Elevations on NAVD88

Station: 9439221, Portland Morrison Street Bridge, OR
Status: Accepted (Feb 2 2012)
Units: Feet
Control Station: 9439040 Astoria, OR
T.M.: 120
Epoch: (/datum_options.html#NTDE) 1983-2001
Datum: NAVD88

Datum	Value	Description
MHHW (/datum_options.html#MHHW)	10.65	Mean Higher-High Water
MHW (/datum_options.html#MHW)	10.14	Mean High Water
MTL (/datum_options.html#MTL)	8.71	Mean Tide Level
MSL (/datum_options.html#MSL)	8.55	Mean Sea Level
DTL (/datum_options.html#DTL)	8.84	Mean Diurnal Tide Level
MLW (/datum_options.html#MLW)	7.28	Mean Low Water
MLLW (/datum_options.html#MLLW)	7.03	Mean Lower-Low Water
NAVD88 (/datum_options.html)	0.00	North American Vertical Datum of 1988
STND (/datum_options.html#STND)	5.38	Station Datum
GT (/datum_options.html#GT)	3.62	Great Diurnal Range
MN (/datum_options.html#MN)	2.85	Mean Range of Tide
DHQ (/datum_options.html#DHQ)	0.51	Mean Diurnal High Water Inequality

Datum	Value	Description
DLQ (/datum_options.html#DLQ)	0.25	Mean Diurnal Low Water Inequality
HWI (/datum_options.html#HWI)	1.10	Greenwich High Water Interval (in hours)
LWI (/datum_options.html#LWI)	9.51	Greenwich Low Water Interval (in hours)
Max Tide (/datum_options.html#MAXTIDE)		Highest Observed Tide
Max Tide Date & Time (/datum_options.html#MAXTIDEDT)		Highest Observed Tide Date & Time
Min Tide (/datum_options.html#MINTIDE)		Lowest Observed Tide
Min Tide Date & Time (/datum_options.html#MINTIDEDT)		Lowest Observed Tide Date & Time
HAT (/datum_options.html#HAT)	13.63	Highest Astronomical Tide
HAT Date & Time	05/25/1994 12:18	HAT Date and Time
LAT (/datum_options.html#LAT)	4.94	Lowest Astronomical Tide
LAT Date & Time	09/09/2000 18:24	LAT Date and Time

Tidal Datum Analysis Periods
09/01/2002 - 10/31/2002
08/01/2005 - 10/31/2005



Showing datums for

9439221 Portland Morrison S…

Datum

NAVD88

Data Units
- (•) Feet
- ( ) Meters

Epoch
- (•) Present (1983-2001)
- ( ) Superseded (1960-1978)

Submit

Show nearby stations

GASCO0066825

Products available at 9439221 Portland Morrison Street Bridge, OR

TIDES/WATER LEVELS

Water Levels

NOAA Tide Predictions (/noaatidepredictions.html?id=9439221)

Harmonic Constituents (/harcon.html?id=9439221)

Sea Level Trends

Datums (/datums.html?id=9439221)

Bench Mark Sheets (/benchmarks.html?id=9439221)

Extreme Water Levels (/est/est_station.shtml?stnid=9439221)

Reports (/reports.html?id=9439221)

METEOROLOGICAL/OTHER

Meteorological Observations
Water Temp/Conductivity

PORTS®

This station is not a member of PORTS®

OPERATIONAL FORECAST SYSTEMS

Columbia River Estuary (/ofs/creofs/creofs.html)

OFS product page for Portland Morrison Street Bridge

INFORMATION

Station Home Page (/stationhome.html?id=9439221)

Data Inventory (/inventory.html?id=9439221)

Measurement Specifications (/measure.html)

Website Owner: Center for Operational Oceanographic Products and Services

National Oceanic and Atmospheric Administration (http://www.noaa.gov)
National Ocean Service (http://oceanservice.noaa.gov)
Privacy Policy (/privacy.html)
Disclaimer (/disclaimers.html)
Take Our Survey (/survey.html)
Freedom of Information Act (https://www.noaa.gov/foia-freedom-of-information-act)
Contact Us (/contact.html)