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Vedder River Hydraulic Profile Update 2020

Final Report
June 4, 2020
KWL Project No. 607.028-300

Prepared for:
City of Chilliwack

CITY OF CHILLIWACK

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Executive Summary

Kerr Wood Leidal (KWL) was retained by the City of Chilliwack on behalf of the Vedder River Technical Committee (VRTC) to carry out a hydraulic analysis on the Vedder River and the Vedder Canal to update the 200-year flood profile and to estimate sediment deposition over the past two years (2018-2020). The study area includes the 12 km reach from the Vedder Crossing Bridge to the Highway 1 Bridge. This reach has a long history of sediment removal activities dating back to 1979.

The channel survey was conducted by CRA Canada Surveys Inc. in February 2020. The survey includes 23 cross sections in the Vedder Canal and 53 cross sections in the Vedder River. The 200-year design flood of 1,470 m^3/s was routed through the surveyed channel geometry using the HEC-RAS hydraulic model. A starting water level of 7.4 m was utilized as the boundary condition at the Highway 1 Bridge. The channel Manning roughness coefficients were 0.030 for the Vedder Canal and ranged from 0.034 to 0.036 for the Vedder River. Overbank roughness was 0.03 for the Canal managed overbank and was 0.150 across the brush and treed overbank area. The roughness values remained the same as the 2018 study due to the lack of high flow event for model calibration. The computed 200-year flood profile was compared to the crest elevation of the setback dikes to determine freeboard. In the Vedder Canal, the dike freeboard exceeded the 0.75 m freeboard requirement on both sides, except at XSC36 where the freeboard on the right dike is 0.70 m. In the Vedder River, the setback dike freeboard deficiency of below 0.75 m was noted on the right (north) dike from XS8 to XS13 and XS3. In 2020, the freeboard deficiency is higher than in 2018 due to an increase (0.08 m – 0.13 m) in the water level. The lowest freeboard was found to be 0.40 m at XS9. Detailed water level changes for individual reaches are included as Appendix B of this report.

Natural deposition in the Vedder River and the Vedder Canal was calculated as the sum of the surveyed bed surface changes (2018-2020). The Vedder River and Canal have been in a minor state of sediment degradation over the past 4 years. The 2016 to 2018 period resulted in 27,200 m^3/year degradation in the canal section and 25,800 m^3/year deposition in the river section. The 2018 to 2020 period resulted in a deposition of 16,600 m^3/year in the Vedder Canal section and a degradation of 24,700 m^3/ year in the Vedder River section. Based on the 2020 survey data review, sediment migrated from the Vedder River to the Vedder Canal which resulted in an increased water level in the lower reach of the Vedder River and in the Vedder Canal. This change in bed profile resulted in a reduction of available freeboard across the Vedder Canal and the lower reaches of the Vedder River including the freeboard limited reach (Cross-Sections XS8-XS13). The average quantity of deposition in the Vedder River and Vedder Canal was calculated to be -8,100 m^3/y (i.e., net degradation) for the past two years (2018-2020) and is -4,800 m^3/y for the past four years (2016-2020). Though a net degradation has been observed in the recent past it is important to note the localized aggradation within specific reaches of the Vedder River and the Canal have impacted freeboard. Since 2008, the annual deposition rate has fallen below the long-term average level, primarily due to lower peak flows. The peak flows from 2013 to 2020 have been 1:2 year events with 2015 being a 1:5 year event at 600 m^3/s. This compares to peak flows of 1140 m^3/s in 2003 and 1040 m^3/s in 2006.

The discharge record for the Vedder Crossing hydrometric station (08MH001) was reviewed for the recent flood event that occurred in January 2020. Flood frequency analysis indicates that a peak discharge of 307 m^3/s is close to the mean annual flood, which is associated with a return period of about 2 years. It is important to recognize that larger peak flow events could potentially result in a significantly large sediment migration and deposition.

The Vedder River Management Area Committee is responsible for overseeing the implementation of the Vedder River Management Area Plan, including the removal of sediment to maintain the flow capacity of the Vedder River and Canal over the long-term so that the level of flood protection provided by the dike system is not diminished. Sediment removal is intended to maintain the existing standard of flood protection (1 in 200-year design flood), through improving the available freeboard.

KWL has analyzed the effect of removing a volume of sediment identified by Nova Pacific and found it to produce significant benefits in terms of flood control. In practice, a volume less than the amount modelled can likely be removed for accessibility and other reasons. Furthermore, the Vedder River Management Area Plan (updated December 2015), Section 2.4, identifies the current approach for sediment removal volumes as removing material biennially at a rate equal to the long-term average deposition rate, or at approximately 10% below this rate in years of low gravel recruitment. The amount of sediment removed will respect this guideline. Choices regarding the selection of gravel bars targeted for excavation will be based on any practical constraints and the effectiveness factor, as shown in Table 9 of this report, which represents water level reduction and the length of reach influenced, relative to the volume of each excavation.

In accordance with the recommendations of the Vedder River Management Area Plan, and demonstrated through the hydraulic modeling included in this report, removals should be focused on the Vedder Canal and lower reach of the Vedder River to achieve flood protection benefits by reducing the flood water level in the area with a dike freeboard deficiency.

1. Introduction

Kerr Wood Leidal (KWL) was engaged by the City of Chilliwack (the City) to undertake a flood profile and sediment management study of the Vedder Canal and Vedder River. This is one of a series of reports that have been prepared every two years as part of the flood control program to reduce the effects of gravel deposition in the Vedder River and Vedder Canal. In this report 'gravel' and 'sediment' are used interchangeably. This project is jointly funded by the City of Chilliwack, BC FLNRORD, and the City of Abbotsford as members of the Vedder River Management Area Committee.

The study area includes the 12 km river and canal reach from Vedder Crossing Bridge to the Highway 1 Bridge. The Vedder River and Canal flood profile was last established in 2018 by KWL. The scope of this study was to carry out an updated hydraulic analysis using the 2020 channel survey to update the flood profile and to quantify sediment deposition over the past two years.

2. River Surveys

The 2020 channel geometry survey was conducted by CRA Canada Survey Inc. in February 2020. The river channel was surveyed from bank to bank with additional points on the top of the setback dikes where applicable. Additional cross sections XSC7, XSC8 and XSC9 were surveyed in the Vedder Canal from the Highway 1 Bridge to the mouth. Overbank areas were not surveyed and were assumed to remain the same as the 2004 overbank survey. Paired distance-elevation survey data were provided in .XLS format oriented looking downstream. Historical cross sections for 2018 and 1991/1996 were also supplied in .DWG plan format for volume calculations. Survey plans of the Vedder Canal and Vedder River are provided in Figure 1 and Figure 2.

3. Thalweg Profile

The thalweg is a line connecting the lowest points along the length of the river bed to define its deepest channel.

3.1 Vedder Canal

The Vedder Canal thalweg profiles for 1991, 2016, 2018 and 2020 are provided in Figure 3. The 2020 Canal thalweg has increased by an average of 0.13 m when compared to the 2018 thalweg from XSC29 to XSC36. This is different to past years when the Canal had a lower thalweg. Relative to 1991, a considerable lowering of the Canal bed level also occurred.

3.2 Vedder River

The Vedder River thalweg profiles for 1996, 2016, 2018 and 2020 are shown in Figures 4 to 6. Examination of the profiles shows greatest degradation at XS10, XS12, XS20,and XS31 where the channel bed lowered by 1.74 m, 2.58 m, 1.74 m, and 2.12 m, respectively, since 1996. The greatest thalweg increase was found in the upper reach from XS41, with an increase of 2.5 m.

Compared with the 2018 condition, the Vedder River mean thalweg profile elevation decreased by 0.7 m, 0.6 m and 0.4 m for the lower, middle and upper reach, respectively. However, an increase in the thalweg ranging between 0.3 m and 0.5 m has occurred in the lower reach at XS1, XS11, and XS14.

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City of Chilliwack

Vedder River Hydraulic Profile Update 2020

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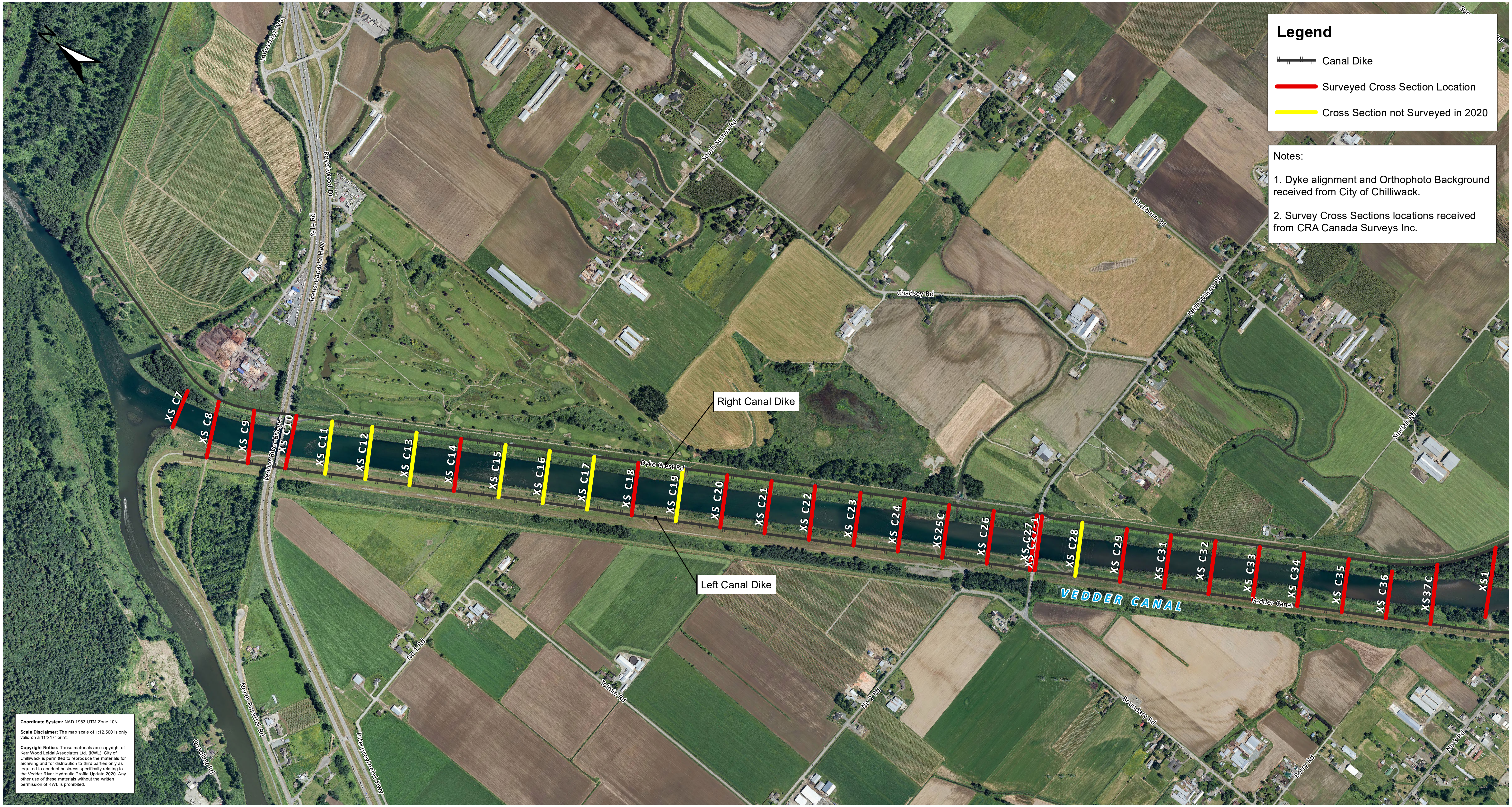

Project No. 607.028

Date May 2020

Scale 1:12,500

Vedder River Cross Section Locations - Vedder Canal

Figure 1

City of Chilliwack

Vedder River Hydraulic Profile Update 2020

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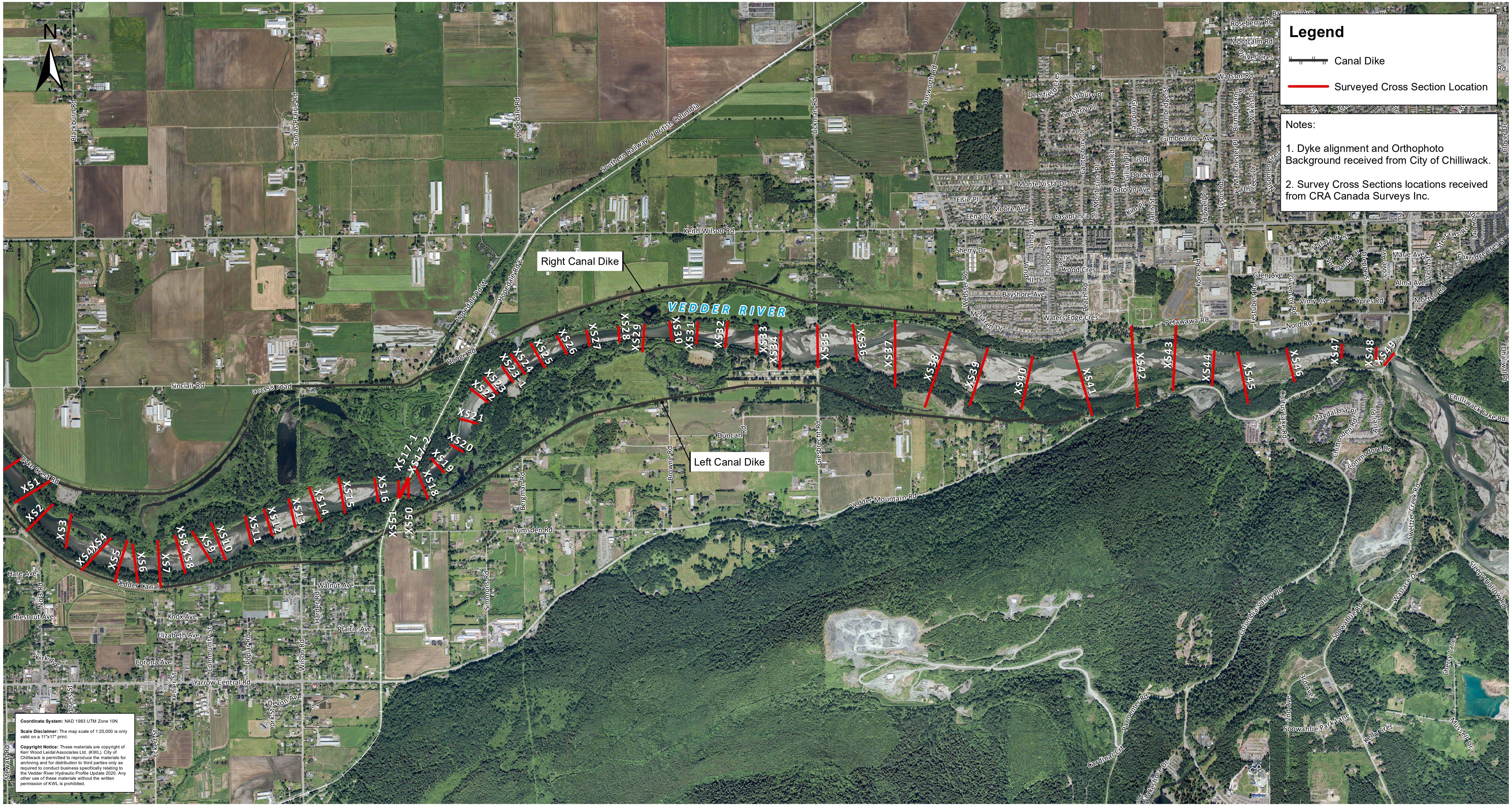

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:20,000 is only valid on a 11"x17" print.

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Vedder River Cross Section Locations - Vedder River

Figure 2

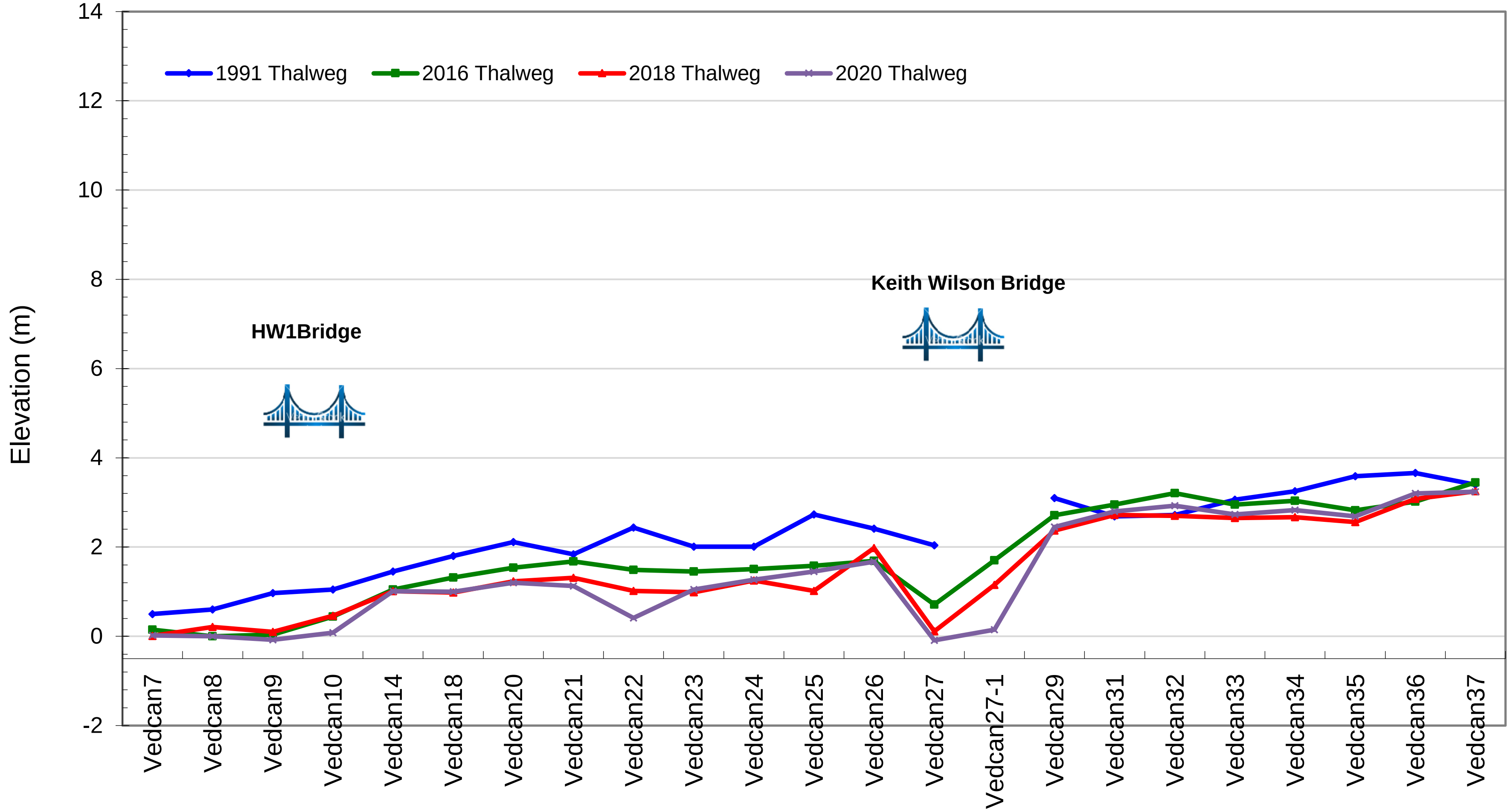

Figure 3: Vedder Canal Thalweg Profile

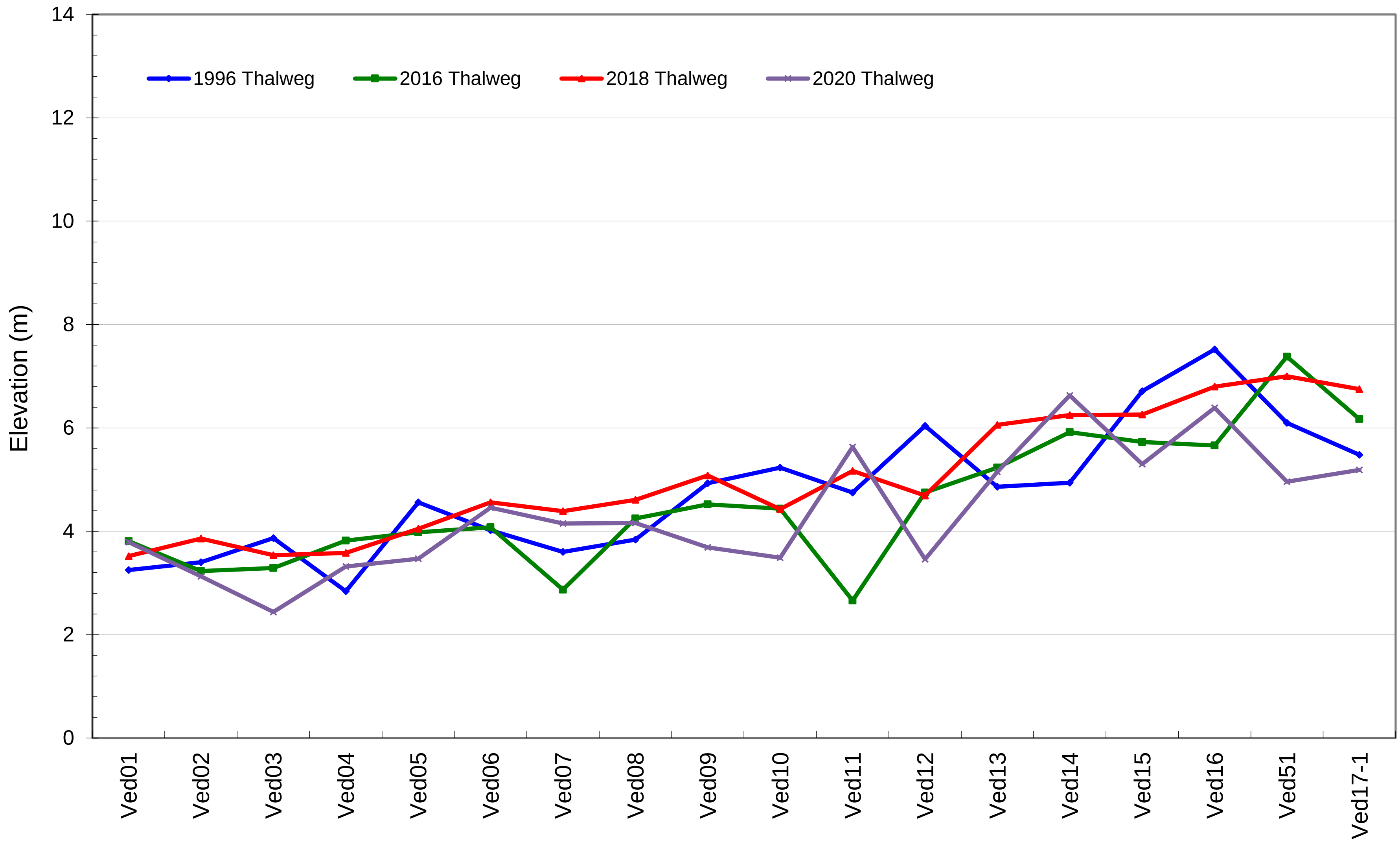

Figure 4: Vedder River Thalweg Profile Lower Reach

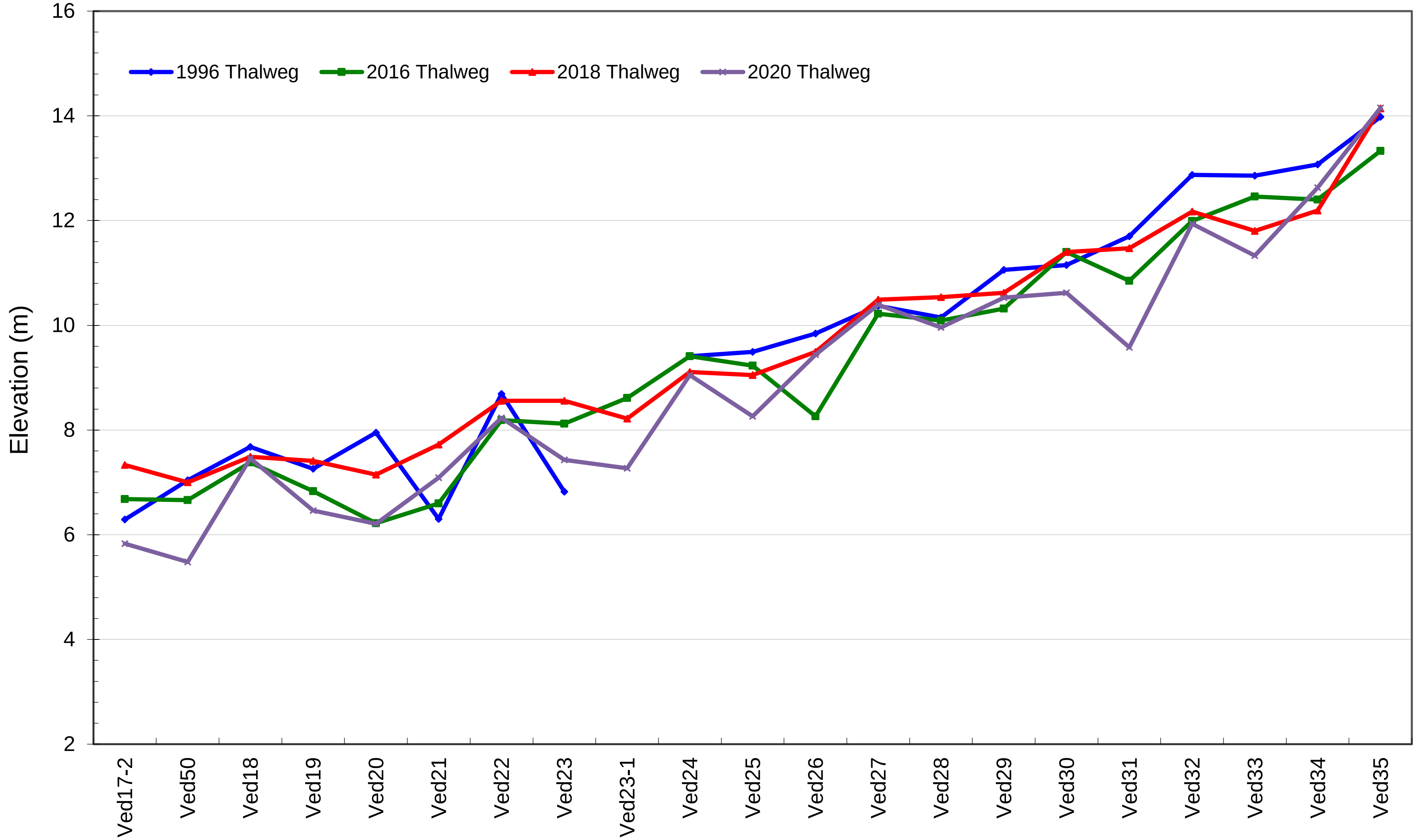

Figure 5: Vedder River Thalweg Profile Middle Reach

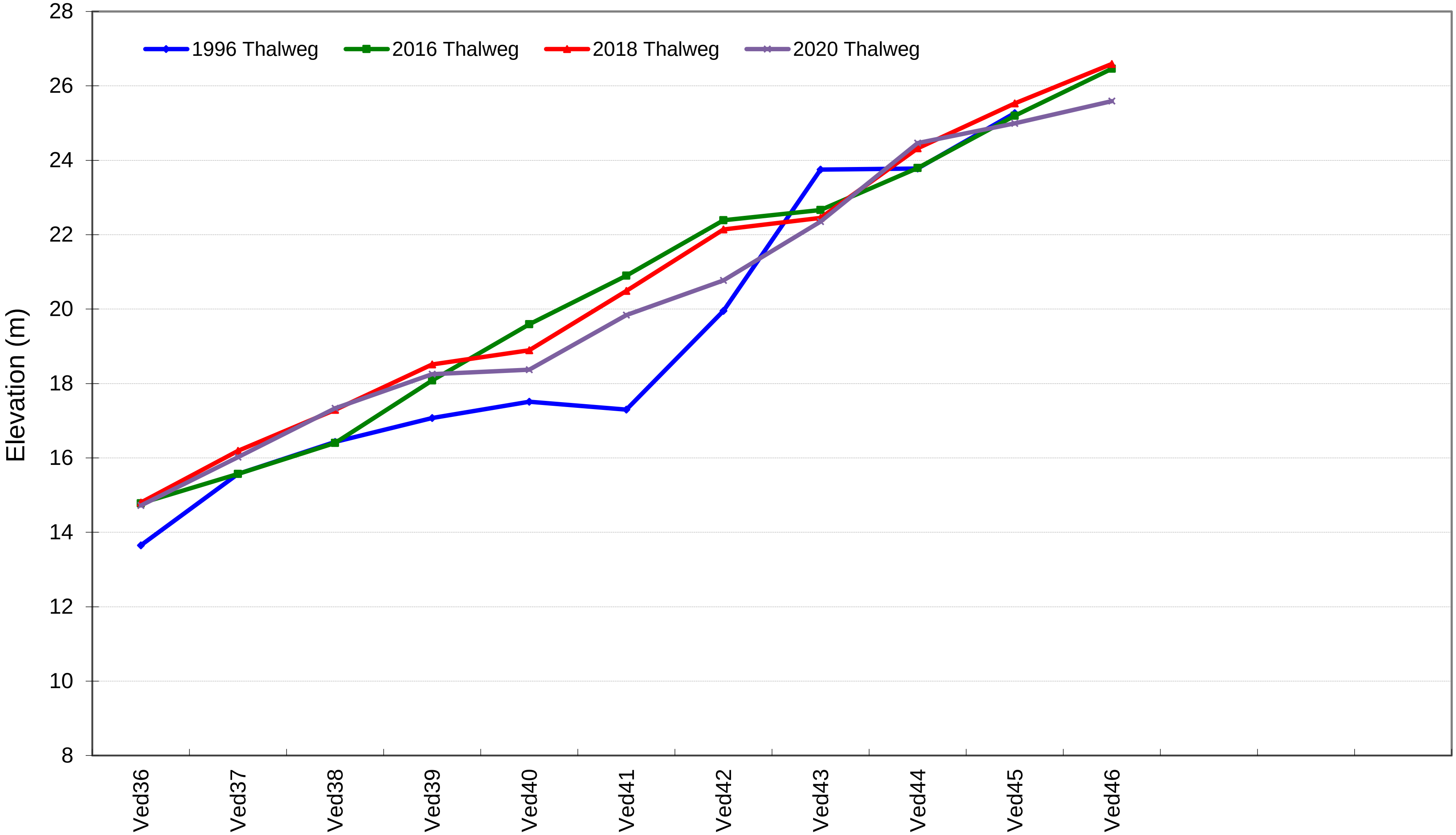

Figure 6: Vedder River Thalweg Profile Upper Reach

4. Bed Material Quantity Calculations

Sediment aggradation and degradation volumes in the Vedder Canal and Vedder River were calculated using the average end area method. No sediment was removed in 2018. Sediment excavation quantities for 2016 were obtained from the City. Natural bed material deposition was calculated as the difference between surveyed bed material change and bed material excavation. Calculated changes in channel sediment quantities are shown in Table 1 and 2 for the past years including (2018-2020) and (2016-2020). Negative aggradation indicates degradation.

Table 1: Channel Sediment Quantities 2018-2020

Location	Bed Change	Excavation	Total Natural Deposition	
	(m^3)	(m^3)	(m^3)	(m^3/y)
Vedder Canal				
XSC10 – XS1	33,155	0	33,155	16,600
Vedder Canal Sub-total	33,155	0	33,155	16,600
Vedder River				
XS1 – SRBC	-20,816	0	-20,816	-10,400
SRBC – XS35	-11,478	0	-11,478	-5,700
XS35 – XS45	-17,135	0	-17,135	-8,600
Vedder River Sub-total	-49,430	0	-49,430	-24,700
Vedder Canal and Vedder River Total Annual Natural Deposition (m^3/y)				**-8,100**
Note: A positive value means river bed aggradation, a negative value means degradation.				

Table 2: Channel Sediment Quantities 2016-2020

Location	Bed Change	Excavation	Total Natural Deposition	
	(m^3)	(m^3)	(m^3)	(m^3/y)
Vedder Canal				
XSC10 – XS1	-38,419	-16,944	-21,475	-5,400
Vedder Canal Sub-total	-38,419	-16,944	-21,475	-5,400
Vedder River				
XS1 – SRBC	9,408	-16,566	25,974	6,500
SRBC – XS35	-21,387	-18,593	-2,794	-700
XS35 – XS45	-61,310	-40,382	-20,928	-5,200
Vedder River Sub-total	-73,289	-75,541	2,252	600
Vedder Canal and Vedder River Total Annual Natural Deposition (m^3/y)				**-4,800**
Note: A positive value means river bed aggradation, a negative value means degradation.				

Table 1 shows that Vedder Canal aggraded at a rate of 16,600 m^3/y in the last two years. This is contrary to the long-term trend (1981-2020) of aggradation at an average rate of 3,300 m^3/y and the most recent short term trend (2016-2018) of degradation at a rate of 27,200 m^3/y. The Vedder River lost bed material in the middle and upper reach due to natural degradation. The Vedder River lower reach degraded by about 10,400 m^3/yr since 2018 and aggraded by about 6,500 m^3/yr since 2016. Overall, the Vedder River degraded by 24,700 m^3/y from 2018 to 2020. This is contrary to the long-term (1981-2020) annual deposition rate of 36,300 m^3/yr in the Vedder River.

The discharge record in the Vedder River was obtained from the real-time gauge at the Vedder Crossing hydrometric station (08MH001). A review of the discharge record available for the study period identified a maximum instantaneous discharge of 307 m^3/s (January 2020). Flood frequency analysis indicates that a peak discharge of 307 m^3/s is close to the mean annual flood, which is associated with a return period of about 2 years. The lack of significant flood events since 2006 is likely the cause of reduced sedimentation in the Vedder River and Vedder Canal in recent years.

4.1 Vedder Canal

Sediment bed aggradation or degradation volumes in the Vedder Canal were calculated using two pairs of survey data:

- April 1991 and February 2018; and
- February 2018 and February 2020.

Details on volume changes at each cross section are listed in Table 3.

Compared with the 1991 conditions, the 2020 survey shows channel degradation at all Canal cross sections. The total volume of bed material lost in the Canal from 1991 to 2020 is 152,200 m^3 with about 62% of the loss from the lower Canal reach downstream of the Keith Wilson Bridge and the remaining 38% from the upper Canal reach. Compared with the 2018 conditions, the 2020 channel survey shows a deposition of 33,200 m^3. This results from 24,000 m^3 of bed material gain downstream of the Keith Wilson Bridge and 9,200 m^3 gain upstream of the bridge.

The Canal sediment quantity changes over the long term, from 1991-2020 and from 1981 to 2020, are summarized in Table A-1 and Table A-2, Appendix A. The 1981-2020 (39 years) sediment quantities were updated by adding the calculated volume changes for the period 2018-2020. Sediment quantities prior to 2010 were obtained from the Tetra Tech EBA (2014) Report.

The sediment quantity changes computed for each Canal cross section are listed in Table 3.

Table 3: Vedder Canal Sediment Quantities

Cross Section	Distance to D/S XS	Volume Change 1991 to 2018	Volume Change 2018 to 2020	Volume Change 1991 to 2020
	(m)	(m^3)	(m^3)	(m^3)
Vedder River XS1 to Keith Wilson Bridge				
XS1	185.93	-6,308	1,452	-4,855
C37	151.48	-7,674	1,204	-6,471
C36	152.07	-8,612	1,794	-6,818
C35	152.34	-7,634	1,614	-6,021
C34	152.36	-6,054	1,472	-4,582
C33	152.34	-4,839	1,373	-3,466
C32	152.30	-4,315	1,190	-3,125
C31	152.39	-4,292	767	-3,525
C29	292.16	-17,972	-1,482	-19,454
C27-1	15.98	-	-190	-
C27				
Total		**-67,701**	**9,195**	**-58,316**
Keith Wilson Bridge to Highway 1 Bridge				
C27	148.98	-9,043	-1,023	-10,066
C26	152.36	-9,586	4,056	-5,530
C25	152.36	-10,474	4,613	-5,861
C24	152.38	-6,844	1,064	-5,781
C23	154.14	-5,738	652	-5,086
C22	150.56	-6,328	837	-5,491
C21	152.35	-7,221	741	-6,480
C20	304.71	-13,862	1,781	-12,080
C18	609.41	-27,182	6,921	-20,261
C14	572.00	-21,609	4,318	-17,291
C10				
Total		**-117,887**	**23,960**	**-93,927**
Total for Canal		**-185,588**	**33,155**	**-152,243**

Notes:
1. Quantity calculations are between the section and the next section downstream.
2. Negative numbers represent degradation. Positive numbers represent aggradation.
3. All surveys were prior to the year's excavation.
4. Cross section C27-1 was surveyed in 2016, 2018, and 2020 but not in 1991. The volume for C27-1 is included in the 2018 to 2020 total volume calculations, but not included in the 1991-2018 and 1991-2020 total volume calculation.

4.2 Vedder River

Similarly, sediment volume changes for the Vedder River were calculated using two pairs of survey data:

- October 1996 and February 2018; and
- February 2018 and February 2020.

The Vedder River sediment volumes are summarized in three sub-reaches, namely the lower reach from XS1 to SRBC, the middle reach from SRBC to XS35 and the upper reach from XS35 to XS49. Details of the volume changes at each cross section are listed in Table 4.

Relative to 1996, the Vedder River has degraded through the lower reach and the middle reach. The total losses from 1996 to 2020 amount to 139,100 m^3 and 127,000 m^3, respectively. In the Vedder River upper reach, sediment deposition outweighed sediment loss by 43,100 m^3. Most of the deposition occurred from XS38 to XS42 with the refill and growth of the Giesbrecht Bar near Peach Road. Relative to 2018, the lower reach degraded by 20,800 m^3. The middle reach and upper reach also degraded by 11,500 m^3 and 17,100 m^3.

The River channel sediment quantity changes over the longer term, from 1981-2020 and from 1996-2020, are also summarized in Table A-1 and Table A-2 in Appendix A. The sediment quantities were established in the same manner as stated at the beginning of Section 4.

The sediment quantity changes computed for each Vedder River cross section are listed in Table 4.

Table 4: Vedder River Sediment Quantities

Cross Section	Distance to D/S XS	Volume Change 1996 to 2018	Volume Change 2018 to 2020	Volume Change 1996 to 2020
	(m)	(m^3)	(m^3)	(m^3)
SRBC to XS1 (Lower Reach)				
SRBC	27.32	-1,042	-1,448	-2,490
XS51	120.45	-7,520	-2,581	-10,101
XS16	190.13	-15,242	-806	-16,047
XS15	154.57	-4,750	-13	-4,763
XS14	132.73	2,537	-945	1,592
XS13	139.15	-2,452	-997	-3,449
XS12	116.94	-7,909	852	-7,058
XS11	175.51	-15,521	-1,541	-17,062
XS10	94.66	-5,567	-3,746	-9,313
XS9	126.44	-8,975	-3,995	-12,970
XS8	118.42	-12,046	-860	-12,906
XS7	131.03	-4,912	-156	-5,069
XS6	71.08	269	-397	-128
XS5	125.46	-4,168	-627	-4,796
XS4	201.70	-19,557	-935	-20,492
XS3	163.68	-9,437	-2,252	-11,689
XS2	136.11	-2,006	-369	-2,375
Total		**-118,299**	**-20,816**	**-139,115**
XS35 to SRBC (Middle Reach)				
XS35	204.85	-22,916	954	-21,962
XS34	142.69	-9,885	-34	-9,919
XS33	165.19	-12,296	-960	-13,256
XS32	159.56	-7,914	-4,890	-12,804
XS31	143.30	-6,059	-1,700	-7,759
XS30	146.78	-7,704	1,005	-6,699
XS29	135.43	-4,661	82	-4,579
XS28	169.52	-4,769	827	-3,942
XS27	147.59	-4,089	44	-4,045
XS26	143.62	-3,338	-1,429	-4,766
XS25	116.34	-4,184	-458	-4,642
XS24	78.46	-5,271	1,336	-3,934

Cross Section	Distance to D/S XS	Volume Change 1996 to 2018	Volume Change 2018 to 2020	Volume Change 1996 to 2020
	(m)	(m³)	(m³)	(m³)
XS23-1	112.29		751	
XS23	80.84	-956	1,459	502
XS22	150.55	-4,399	1,739	-2,660
XS21	160.14	-6,256	678	-5,578
XS20	140.85	-5,576	219	-5,357
XS19	126.63	-2,418	-4,051	-6,469
XS18	78.16	-1,876	-4,853	-6,729
XS50	27.32	-1,042	-1,448	-2,490
SRBC				
Total		**-115,609**	**-11,478**	**-127,087**
XS45 to XS35 (Upper Reach)				
XS45	169.62	-25,740	-748	-26,489
XS44	212.92	-36,275	2,889	-33,386
XS43	221.05	91	-1,192	-1,101
XS42	289.75	78,312	-9,375	68,937
XS41	303.19	57,817	-7,078	50,740
XS40	264.43	24,805	-6,471	18,335
XS39	225.47	18,605	-2,334	16,271
XS38	251.80	-4,169	4,390	221
XS37	230.76	-24,071	1,200	-22,872
XS36	204.57	-29,172	1,584	-27,588
XS35				
Total		**60,203**	**-17,135**	**43,068**

Notes:

1. Quantity calculations are between the section and the next section downstream.
2. Negative numbers represent degradation. Positive numbers represent aggradation.
3. All surveys were prior to the year's excavation.
4. Quantity SRBC-XS51 assumed equal to 50% of quantity XS51-XS50.
5. XS23-1 was not surveyed in 1996 and is not included in totals.
6. XS49 was not surveyed in 2008 or 2010.
7. Volume changes from XS 46 to XS 49 were not included in the total calculation to be consistent with the 2010-2014 EBA studies and the previous Bland Engineering studies.

4.3 Long Term Annual Deposition Comparison

A comparison of the annual degradation and aggradation rates from 1991/96 to 2016, 2018, and 2020 is given below in Table 5. This represents the natural degradation or aggradation in the channel at an overall and sub-reach level over various periods of time, as a long term average annual deposition rate in m^3/year. Negative numbers signify degradation and positive numbers mean aggradation. The recent canal surveys are compared to the 1991 survey, while the river values are compared to the 1996 river survey. The bed change column is the difference between surveyed cross-sections, and it includes the effects of past excavations. This figure has no meaning on its own, as it is a function of the cumulative natural deposition and excavation volumes. The excavation column is shown as negative values as it represents sediment removed from the channel. The annual deposition represents the natural aggradation in the channel and is the combination of the bed change and the sediment excavated for the estimation period. For example, in the first line of Table 5, a bed change of -114,300 m3 (apparent loss of material) minus -99,900 m3 (actual material lost to excavation) = -114,300 - (-99,000) = -15,300 m3 (actual degradation because negative). This number divided by the number of years in the period (taken as 25 in this case) = approximately -600 m3/y (annual degradation).Together, the river and canal received annual deposits of 45,400 m^3/yr, 41,500 m^3/yr, and 37,000 m^3/yr as of 2016, 2018, and 2020. The combined annual deposition rate has slightly decreased in the Vedder River and Vedder Canal in recent years, due to the lack of significant flood events since 2006. A single major flood event could reverse this trend.

Table 5: Long Term Sediment Quantities

Location	Bed Change (m^3)	Excavation (m^3)	Annual Deposition (m^3/yr)
1991/6 – 2016 Comparison			
XSC10 to XS1 (Canal)	-114,300	-99,900	-600
XS1 to SRBC (Lower)	-148,500	-411,200	13,200
SRBC to XS35 (Middle)	-105,600	-237,800	6,700
XS35 to XS45 (Upper)	104,400	-415,900	26,100
Total	**-264,000**	**-1,164,800**	**45,400**
1991/6 – 2018 Comparison			
XSC10 to XS1 (Canal)	-186,000	-117,800	-2,500
XS1 to SRBC (Lower)	-118,000	-428,000	14,100
SRBC to XS35 (Middle)	-116,000	-256,000	6,400
XS35 to XS45 (Upper)	60,000	-456,000	23,500
Total	**-359,000**	**-1,257,000**	**41,500**
1991/6 – 2020 Comparison			
XSC10 to XS1 (Canal)	-152,500	-117,800	-1,200
XS1 to SRBC (Lower)	-139,100	-428,000	12,000
SRBC to XS35 (Middle)	-127,100	-256,000	5,400
XS35 to XS45 (Upper)	43,100	-456,000	20,800
Total	**-375,700**	**-1,257,000**	**37,000**

5. Hydraulic Analysis

The HEC-RAS water surface profile model, Version 5.0.7, developed by the Hydrologic Engineering Center, Davis, California was used for the hydraulic analysis of the River and Canal reach.

5.1 Flood Profile Analysis

In the 2020 hydraulic model, the design flood of 1,470 m^3/s was applied to the surveyed river channel in a steady flow condition. A starting water surface elevation of 7.4 m was utilized as the boundary condition at the Highway 1 Bridge. This starting water level is a best estimate of the downstream water level, based on regression analysis of peak levels recorded downstream at Barrowtown Pump Station corresponding to the peak flows recorded at the WSC gauge Chilliwack River at Vedder Crossing (BC FLNRO, 2010).

The setback dikes were constructed in the early 1980s based on a flood flow of 1,250 m^3/s and a dike freeboard of 0.75 m. During 1998-2000, the setback dike was upgraded by raising critical sections about 0.4 m above the 1984 as-built profile to provide 0.6 m freeboard over the 1996 flood profile (1,330 m^3/s). The left setback dike was further raised in 2010 corresponding to the increased design flood of 1,470 m^3/s and to meet the provincial standard for Fraser River flood protection, based on the 2008 NHC Fraser River Hydraulic Model. The raised sections are between Keith Wilson Bridge on the Vedder Canal and XS14 in the Vedder River on the left (south) side.

The upgraded dike crest elevations were obtained from the 2014 report (Tetra Tech EBA, 2014). Bland's assumption on flow split upstream of the railway bridge was adopted in this study. It was assumed that 200 m^3/s leaves the main channel on the right bank between XS21 and XS22 and 150 m^3/s leaves just downstream of XS18 on the left bank under the design flood conditions. Overbank flow travels through the left bank trestle structure and the right bank relief opening through the railway embankment. The split flows were assumed to rejoin the river at XS13.

The 2020 flood profile was calculated and compared to the setback dike crest elevations. Sub-critical flow conditions were assumed in the HEC-RAS model, which provides conservative results for the flood level. The resultant left and right dike freeboards are as listed in Table 6 for the Vedder Canal and in Table 7 for the Vedder River. The freeboard on the right bank (Rotary Trail) from XS40 to XS49 is also included.

Table 6: 2020 Flood Profile and Dike Freeboard for the Vedder Canal

Cross Section	Dike Crest Elevation (m)		Calculated W.L. (m)	Dike Freeboard (m)	
	Left	Right	Starting at 7.4 m	Left	Right
C37	*11.28*	10.55	9.61	1.67	0.94
C36	*11.18*	10.21	9.51	1.67	0.70
C35	*11.26*	10.39	9.45	1.81	0.94
C34	*11.19*	10.28	9.33	1.86	0.95
C33	*11.28*	10.36	9.26	2.02	1.10
C32	*11.27*	10.68	9.20	2.07	1.48
C31	*11.34*	10.77	9.11	2.23	1.66
C29	*11.20*	10.77	9.03	2.17	1.74
C27.1	11.51	11.78	8.76	2.75	3.02
KW					
C27	11.41	11.74	8.74	2.67	3.00
C26	*11.27*	10.21	8.65	2.62	1.56
C25	10.93	10.17	8.60	2.33	1.57
C24	10.95	10.18	8.53	2.42	1.65
C23	10.93	10.49	8.49	2.44	2.00
C22	10.99	10.37	8.39	2.60	1.98
C21	10.92	10.25	8.32	2.60	1.93
C20	10.95	10.18	8.26	2.69	1.92
C18	10.83	10.25	8.13	2.70	2.12
C14	10.93	10.25	7.76	3.17	2.49
C10	10.98	10.30	7.40	3.58	2.90

Note: The italic numbers show the dike crest elevation after the raising in 2010. The red numbers show the dike freeboard that does not meet the required 0.75 m.

Table 7: 2020 Flood Profile and Bank/Dike Freeboard for the Vedder River

Cross Section	Bank Elevation (m)		Calculated W.L. (m)	Bank Freeboard (m)	
	Left	Right	Starting at 7.4 m	Left	Right
49	37.92	38.26	36.56	--	1.70
48	32.80	33.96	34.71	--	-0.75*
47	31.21	33.22	32.66	--	0.56
46	29.83	31.95	30.91	--	1.04
45	28.48	30.08	29.22	--	0.86
44	29.22	29.89	28.34	--	1.55
43	29.96	29.09	27.06	--	2.03
42	25.26	26.58	25.35	--	1.23
41	23.50	24.67	23.58	--	1.09
40	24.33	23.33	22.25	--	1.08
39	--	21.92	21.37	--	0.55

Cross Section	Dike Crest Elevation (m)		Calculated W.L. (m)	Dike Freeboard (m)	
	Left	Right	Starting at 7.4 m	Left	Right
39	22.70	--	21.37	1.33	--
38	21.79	22.20	20.50	1.29	1.70
37	21.00	21.00	19.35	1.65	1.65
36	20.50	20.50	18.57	1.93	1.93
35	19.57	19.40	17.82	1.75	1.58
34	18.67	18.81	17.39	1.28	1.42
33	18.20	18.30	16.72	1.48	1.58
32	17.44	17.80	16.03	1.41	1.77
31	17.12	17.30	15.9	1.22	1.40
30	16.92	16.95	15.6	1.32	1.35
29	16.55	16.60	15.42	1.13	1.18
28	16.24	16.00	15.13	1.11	0.87
27	15.52	15.40	14.45	1.07	0.95
26	15.48	15.05	14.18	1.30	0.87
25	14.88	14.90	13.79	1.09	1.11
24	14.79	14.75	13.57	1.22	1.18
23.1	14.61	14.50	13.24	1.37	1.26
23	14.40	14.18	12.99	1.41	1.19

Cross Section	Dike Crest Elevation (m)		Calculated W.L. (m)	Dike Freeboard (m)	
	Left	Right	Starting at 7.4 m	Left	Right
22	14.35	--	12.78	1.57	--
21	14.14	--	12.63	1.51	--
20	13.79	--	12.45	1.34	--
19	13.54	--	12.23	1.31	--
18	13.42	--	11.81	1.61	--
50	13.25	12.98	11.73	1.52	1.25
17.2	--	--	11.32	--	--

Cross Section	Dike Crest Elevation (m)		Calculated W.L. (m)	Bank Freeboard (m)	
	Left	Right	Starting at 7.4 m	Left	Right
SRBC	--	--		--	--
17.1	--	--	11.13	--	--
51	13.12	12.80	11.09	2.03	1.71
16	12.00	12.31	10.81	1.19	1.50
15	11.67	11.80	10.69	0.98	1.11
14	*11.51*	11.40	10.56	0.95	0.84
13	*11.28*	11.10	10.52	0.76	**0.58**
12	*11.36*	11.00	10.41	0.95	**0.59**
11	*11.28*	10.90	10.4	0.88	**0.50**
10	*11.30*	10.80	10.34	0.96	**0.46**
9	*11.28*	10.70	10.3	0.98	**0.40**
8	*11.38*	10.80	10.29	1.09	**0.51**
7	*11.31*	11.10	10.25	1.06	0.85
6	*11.32*	11.25	10.1	1.22	1.15
5	*11.31*	11.30	10.08	1.23	1.22
4	*11.28*	11.10	10.06	1.22	1.04
3	*11.30*	10.70	9.97	1.33	**0.73**
2	*11.30*	10.65	9.86	1.44	0.79
1	*11.27*	10.65	9.69	1.58	0.96

Note: The italic numbers show the elevation of the dike crest after the raising in 2010.

The red numbers show the dike freeboard that does not meet the required 0.75 m.

Dike elevations and freeboards were not listed for XS22 to XS18, as the flow on the right bank is obstructed by the railway before reaching the setback dike. The right bank flow leaves the main channel between cross section XS21 and XS22 and forms a side channel through the right bank relief opening. This complex situation at the railway bridge makes freeboard assessment difficult.

*Flow leaving the right bank at XS48 will re-join the river at a lower location upstream of the critical reach.

In the Vedder Canal, the dike freeboard exceeds 0.75 m on both sides, except at XSC36 where the freeboard on the right dike is 0.70 m. The Canal dike was designed for the Fraser River freshet flood water levels, which exceed the water levels during the Vedder River winter design flood event of 1,470 m^3/s. In the Vedder River, the setback dike freeboard exceeds 0.75 m except at Vedder River XS8 to XS13 and XS3 on the right (north) side. The minimum freeboard is determined to be 0.40 m at XS9. The computed flood profiles, in comparison to the dike crest elevations for the Vedder Canal and Vedder River, are shown in Figures 7 to and 8.

The differences between the 2020 water surface profile and the historical profiles (1996, 2014, 2016 and 2018) are listed in Appendix B. Compared with the 2018 water surface profile, the 2020 profile is on average 0.16 m higher in the Vedder Canal and 0.003 m lower in the Vedder River. However, the lower reach of the Vedder River generally has an increase in water level compared to 2018, while the middle and upper reaches have a decreased water level. This is consistent with the surveyed bed change, which identified overall aggradation in the Vedder Canal and degradation in the Vedder River (see Table 1).

The 2020 HEC-RAS cross section plots, showing the updated water surface elevations, are provided in Appendix C.

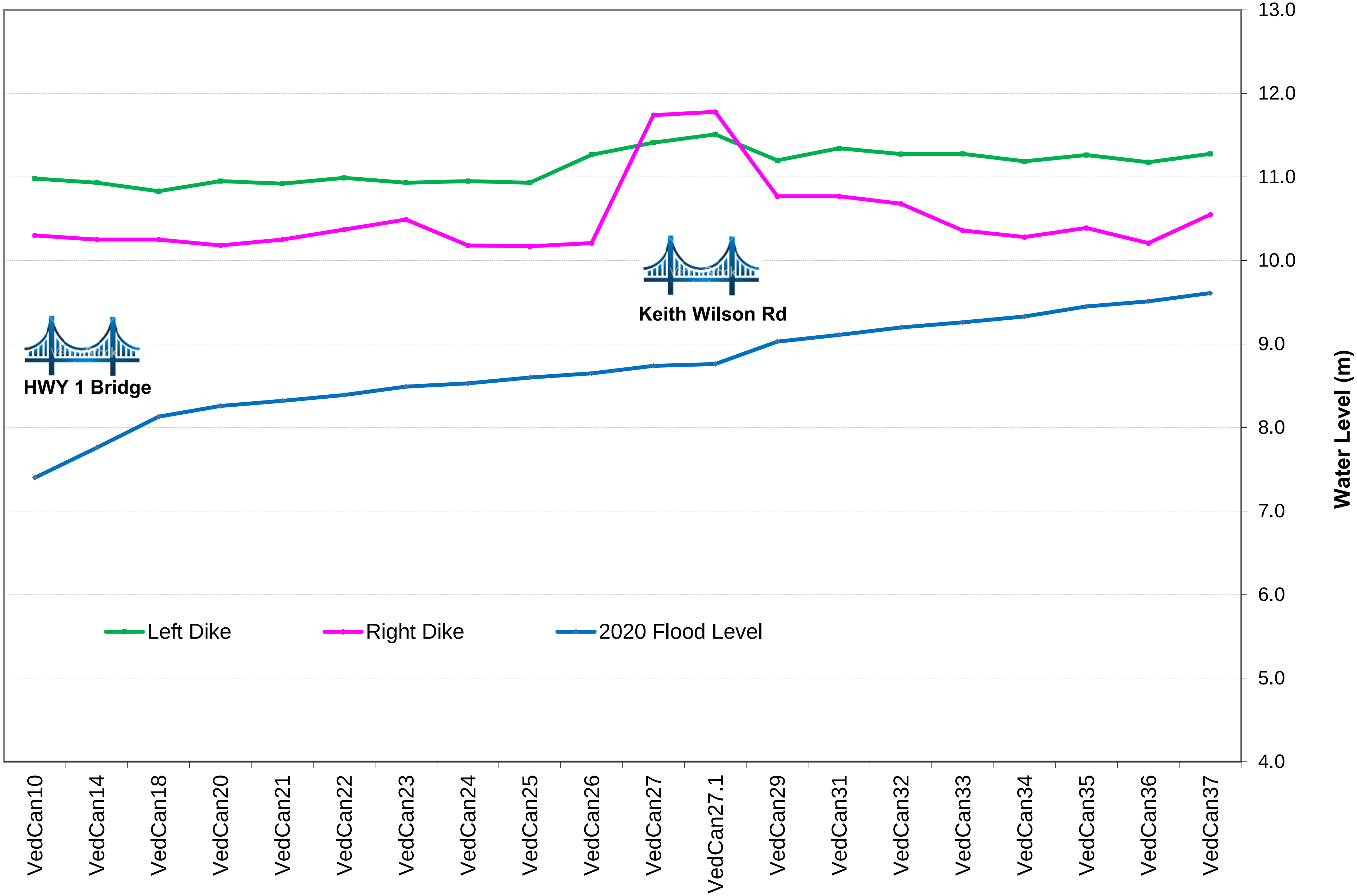

Figure 7: Vedder Canal Flood and Setback Dike Profiles

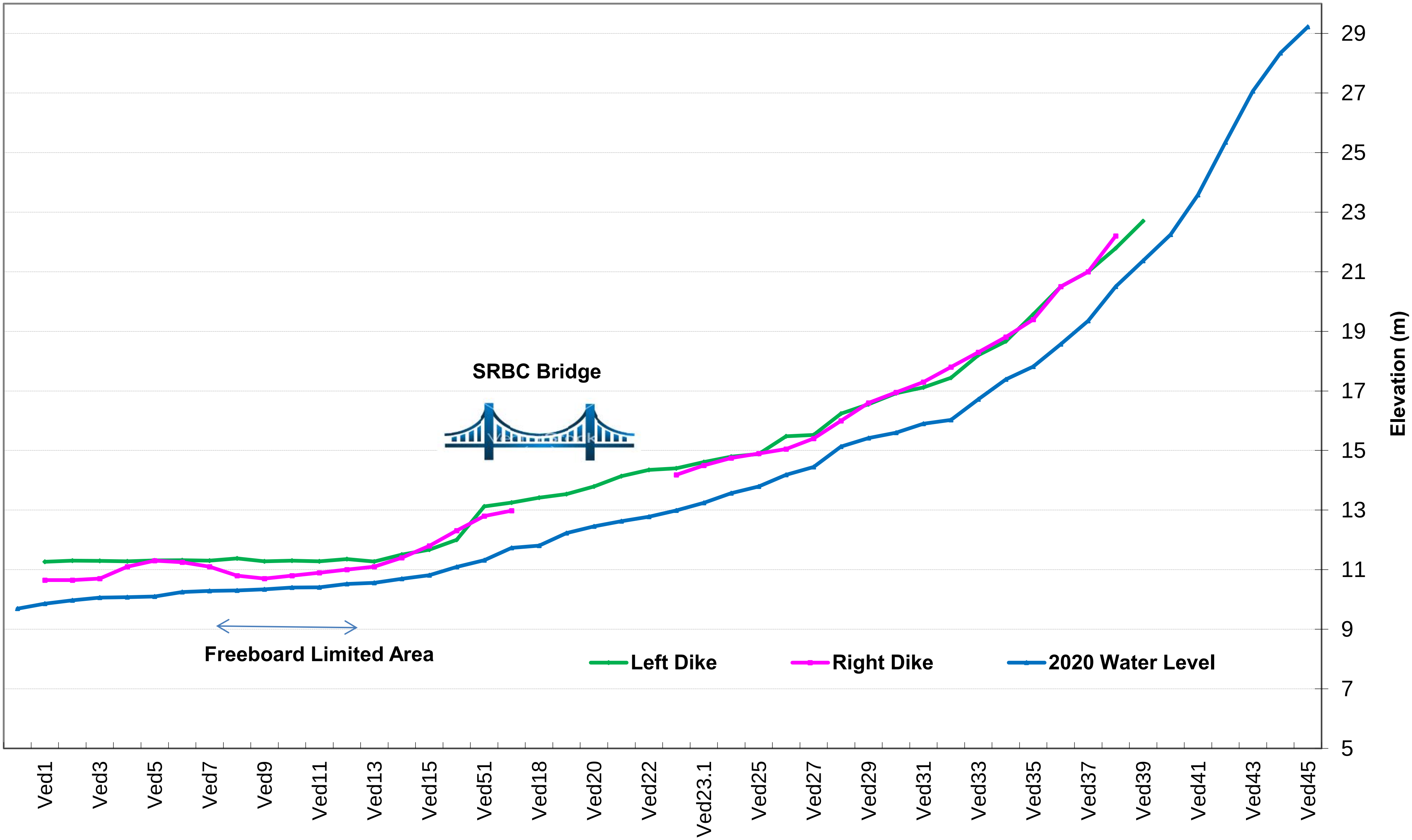

Figure 8: Vedder River Flood and Setback Dike Profiles

6. Channel Improvement Options

6.1 Sediment Removal

Nova Pacific Environmental originally identified eight potential gravel removal sites for consideration by the Vedder River Technical Committee (VRTC). A copy of the 2020 Sediment Removal Planning Report is provided in Appendix D. All eight sites were modelled to determine the effectiveness of the proposed gravel extraction. The hydraulic benefit determined for each site was presented to the VRTC and VRMAC (refer to Section 6.2). The proposed sediment removal plan for 2020 is summarized in Table 8.

Table 8: Proposed Sediment Removal Plan 2020

Site	Location	Nearest XS	Excavation Volume (m^3)
Chadsey	1,900 m downstream of Keith Wilson Bridge	XSC16	25,000
Boundary	800 m downstream of Keith Wilson Bridge	XSC22	19,000
Powerline	200 m upstream of Keith Wilson Bridge	XSC29	8,000
Salad (A)	Adjacent (downstream) to Greendale Stockpile	XSC37	6,000
Greendale	Adjacent (upstream) to Greendale Stockpile	XS4	6,000
Yarrow	North foot of Wilson Road	XS13	7,000
Railway	Approx. 180 m upstream of the railway bridge	XS19	4,000
Bergman	Adjacent to Bergman Bar Stockpile	XS23	20,000
Total Expected Sediment Yield Volume			**95,000**

6.2 Hydraulic Effects on Flood Profile

The configurations of the proposed sediment excavation were obtained from Nova Pacific Environmental (Appendix D). The surveyed channel geometry was modified in the HEC-RAS model to represent the post-excavation conditions. Additional hydraulic simulations were carried out for each individual bar to identify the influenced river reach that shows water level reduction. For comparison purposes, an effectiveness factor was developed for each selected site which represents water level reduction and the length of reach influenced, relative to the excavation volume. As listed in Table 9, sediment removal is more effective in the Vedder Canal due to the narrow channel geometry and longer influence reach than in the Vedder River upper reach due to the higher river gradient.

Table 9: Hydraulic Effects on the Flood Profile

Site	Excavation Volume	Influence Reach	Reach Length (km)	Average W.L. Reduction	Effectiveness Factor
	m^3			(cm)	$(cm*km/m^3) \times 10^4$
Chadsey	25,000	XSC18-XS16	5.6	4.4	9.9
Boundary	19,000	XSC23-XS16	4.4	1.4	3.2
Powerline	8,000	XSC31-XS16	3.3	1.8	7.4
Salad (A)	6,000	XS1-XS16	2.3	0.9	3.5
Greendale	6,000	XS4-XS16	1.8	1.0	3.0
Yarrow	7,000	XS14-XS16	0.5	1.0	0.7
Railway	4,000	XS19-XS25	1.0	1.6	3.9
Bergman	20,000	XS22-XS28	1.0	9.6	4.8

Note:
The effectiveness factor = (Average W.L. Reduction for the XS) * (Influence Reach Length) / (Excavation Volume/10,000)

7. Freeboard Assessment with the Proposed Gravel Removal

Gravel removal from all bars downstream of Yarrow Bar provides direct flood reduction benefits to the freeboard limited area (XS8-XS13). Yarrow Bar touches on XS14, but mostly falls outside of the critical zone. The combined effect of all removal sites would reduce the water level in the critical reach by 0.05 to 0.07 m. Table 10 lists the Vedder River right dike freeboard for XS8 to XS13 under the pre- and post-excavation conditions with all gravel bars excavated. A table comparing the pre- and post-excavation water levels for all cross-sections is located in Appendix E.

Table 10: Updated Freeboard Resulting from the Proposed 2020 Gravel Excavations

Cross Section	R. Dike Elev. (m)	2020 W.L. (m)		R. Dike Freeboard (m)	
		(pre-excavation)	(post-excavation)	(pre-excavation)	(post-excavation)
13	11.1	10.52	10.47	0.58	0.63
12	11.0	10.41	10.35	0.59	0.65
11	10.9	10.40	10.34	0.50	0.56
10	10.8	10.34	10.28	0.46	0.52
9	10.7	10.30	10.23	0.40	0.47
8	10.8	10.29	10.22	0.51	0.58

Note: this table only includes cross sections in the freeboard limited area.

For the rest of the sites located upstream of the freeboard limited area, gravel removal leads to indirect hydraulic benefits by providing sediment traps. As concluded in the Vedder River Management Area Plan Update (Tetra Tech, 2015), and based on a review of past gravel removals, excavation pits in the lower to middle reach of Vedder River, including Yarrow, Railway D/S bridge and Railway Bars, have shown a consistent pattern of refilling. Gravel removal at these locations, therefore, creates an effective buffer zone intercepting the material moving towards the critical reach. Besides the water level reduction and gravel trapping benefits, gravel removal may also serve erosion protection purposes if designed properly.

8. Conclusions and Recommendations

8.1 Conclusions

The average quantity of gravel deposition in the Vedder River and Vedder Canal was calculated to be -8,100 m^3/y (i.e. net degradation) for the past two years (2018-2020) and is -4,800 m^3/y for the past four years (2016-2020).

Though a net degradation has been observed in the recent past it is important to note the localized aggradation within specific reaches of the Vedder River and the Canal, which negatively impacts the water levels and freeboard. The Vedder Canal has significant aggradation when compared to 2018.

Since 2008, the annual deposition rate has fallen below the long-term average level. The peak flows from 2013 to 2020 have been mostly 1:2 year events with 2015 being a 1:5 year event at 600 m^3/s. This compares to a peak flow of 1,140 m^3/s in 2003 and 1,040 m^3/s in 2006. Therefore, it is important to recognize that larger peak flow events could result in significant gravel migration and deposition, which would reverse the recent degradation trend.

8.2 Recommendations

KWL has analyzed the effect of removing a volume of sediment identified by Nova Pacific and found it to produce significant benefits in terms of flood control. In practice, a volume less than the amount modelled can likely be removed for accessibility and other reasons. Furthermore, the Vedder River Management Area Plan (updated December 2015), Section 2.4, identifies the current approach for sediment removal volumes as removing material biennially at a rate equal to the long-term average deposition rate, or at approximately 10% below this rate in years of low gravel recruitment. The amount of sediment removed will respect this guideline. Choices regarding the selection of gravel bars targeted for excavation will be based on any practical constraints and the effectiveness factor, as shown in Table 9 of this report, which represents water level reduction and the length of reach influenced, relative to the volume of each excavation.

KWL also recommends that the current Vedder River hydraulic model be recalibrated for high flow conditions. The magnitude of the calibration flow should ideally be above the 5-year flood of 612 m3/s. This will require close monitoring of the daily flow conditions and surveying high water marks shortly following a flood event.

Report Submission

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Statement of Limitations

This document has been prepared by Kerr Wood Leidal Associates Ltd. (KWL) for the exclusive use and benefit of City of Chilliwack for the Vedder River Hydraulic Profile Update 2020. No other party is entitled to rely on any of the conclusions, data, opinions, or any other information contained in this document.

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Revision History

Revision #	Date	Status	Revision	Author
0	June 4, 2020	Final	Issued as final for client copy.	PB/LF

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Appendix A

Channel Sediment Quantities

Table A-1: Channel Gravel Quantities 1981-2020

Location	Bed Change	Excavation	Total natural deposition	
	1981-2020 m^3	1981-2020 m^3	m^3	m^3/yr
XSC10 to XS1	-745	-127,023	126,278	3,300
XS1 to SRBC	2,581	-601,601	604,182	15,500
SRBC to XS35	-33,708	-897,062	863,354	22,200
XS35 to XS45	-552,132	-495,302	-56,830	-1,400
			Total natural deposition m^3/yr	39,600

Table A-2: Channel Gravel Quantities 1991/6-2020

Location	Bed Change	Excavation	Total natural deposition	
	1991/6-2020 m^3	1991/6-2020 m^3	m^3	m^3/yr
XSC10 to XS1	-152,243	-116,883	-35,659	-1,200
XS1 to SRBC	-139,116	-427,737	288,621	12,000
SRBC to XS35	-127,086	-256,349	129,263	5,400
XS35 to XS45	43,067	-456,318	499,385	20,800
			Total natural deposition m^3/yr	37,000

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Appendix B

Vedder Canal and River Historical Water Surface Profile

Table B-1 Vedder Canal Historical Water Surface Profile

Cross Section	River Stn	2020 W.L. (7.4m)	2018 W.L. (7.4m)	2016 W.L. (7.4m)	2014 W.L. (7.4m)	1996 W.L. (5.5m)	2020-2018 W.L. (m)	2018-2016 W.L. (m)	2016-2014 W.L. (m)	2020-1996 W.L. (m)	2018-1996 W.L. (m)	2016-1996 W.L. (m)	2014-1996 W.L. (m)
VedCan37	15	9.61	9.49	9.58	9.59	9.12	0.12	-0.09	-0.01	0.49	0.37	0.46	0.47
VedCan36	14	9.51	9.39	9.45	9.49	8.97	0.12	-0.06	-0.04	0.54	0.42	0.48	0.52
VedCan35	13	9.45	9.31	9.36	9.41	8.91	0.14	-0.05	-0.05	0.54	0.40	0.45	0.50
VedCan34	12	9.33	9.18	9.23	9.27	8.75	0.15	-0.05	-0.04	0.58	0.43	0.48	0.52
VedCan33	11	9.26	9.11	9.15	9.18	8.63	0.15	-0.04	-0.03	0.63	0.48	0.52	0.55
VedCan32	10	9.20	9.05	9.07	9.11	8.54	0.15	-0.02	-0.04	0.66	0.51	0.53	0.57
VedCan31	9	9.11	8.93	9	9.04	8.44	0.18	-0.07	-0.04	0.67	0.49	0.56	0.60
VedCan29	8	9.03	8.89	8.93	8.94	8.32	0.14	-0.04	-0.01	0.71	0.57	0.61	0.62
VedCan27.1	7	8.76	8.59	8.65	8.68		0.17	-0.06	-0.03				
VedCan27	6	8.74	8.56	8.62	8.66		0.18	-0.06	-0.04				
VedCan26	5	8.65	8.47	8.51	8.55	8.02	0.18	-0.04	-0.04	0.63	0.45	0.49	0.53
VedCan25	4.3	8.60	8.44	8.43	8.46		0.16	0.01	-0.03				
VedCan24	4.2	8.53	8.34	8.36	8.4		0.19	-0.02	-0.04				
VedCan23	4.1	8.49	8.29	8.3	8.31		0.20	-0.01	-0.01				
VedCan22	4	8.39	8.17	8.25	8.25	7.59	0.22	-0.08	0.00	0.80	0.58	0.66	0.66
VedCan21	3.2	8.32	8.13	8.14	8.15		0.19	-0.01	-0.01				
VedCan20	3.1	8.26	8.04	8.06	8.09		0.22	-0.02	-0.03				
VedCan18	3	8.13	7.93	7.96	7.95	7.19	0.20	-0.03	0.01	0.94	0.74	0.77	0.76
VedCan14	2	7.76	7.66	7.67	7.64	6.55	0.10	-0.01	0.03	1.21	1.11	1.12	1.09
VedCan10	1	7.40	7.40	7.4	7.4	5.5	0.00	0.00	0.00	1.90	1.90	1.90	1.90

Note:
1. 2010-2020 water surface profiles computed using starting water level at 7.4 m. 1996 water surface profile computed using starting water level at 5.5 m.
2. Design flood of 1330 m^3/s was used to calculate the 1996 water surface profile; Design flood of 1470 m^3/s was used to calculate the 2010-2018 water surface profiles.

Table B-2 Vedder River Historical Water Surface Profile

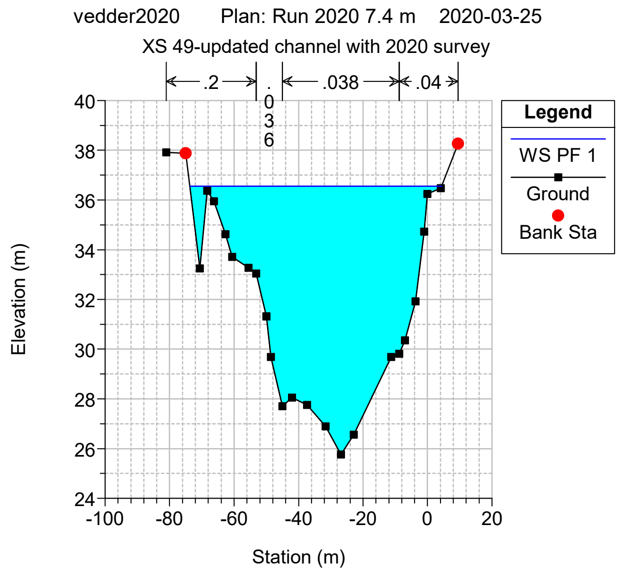
Cross Section	River Stn	2020 W.L. (7.4m)	2018 W.L. (7.4m)	2016 W.L. (7.4m)	2014 W.L. (7.4m)	1996 W.L. (5.5m)	2020-2018 W.L. (m)	2018-2016 W.L. (m)	2016-2014 W.L. (m)	2020-1996 W.L. (m)	2018-1996 W.L. (m)	2016-1996 W.L. (m)	2014-1996 W.L. (m)
Ved45	71	29.22	29.15	29.14	29.17	29.14	0.07	0.01	-0.03	0.08	0.01	0.00	0.03
Ved44	70	28.34	28.28	28.34	28.32	28.22	0.06	-0.06	0.02	0.12	0.06	0.12	0.10
Ved43	69	27.06	27.08	27.25	27.09	26.79	-0.02	-0.17	0.16	0.27	0.29	0.46	0.30
Ved42	68	25.35	25.51	25.72	25.5	22.94	-0.16	-0.21	0.22	2.41*	2.57*	2.78*	2.56*
Ved41	67	23.58	23.65	23.66	23.7	22.82	-0.07	-0.01	-0.04	0.76	0.83	0.84	0.88
Ved40	66	22.25	22.36	22.43	22.22	21.91	-0.11	-0.07	0.21	0.34	0.45	0.52	0.31
Ved39	65	21.37	21.4	21.49	21.32	21.18	-0.03	-0.09	0.17	0.19	0.22	0.31	0.14
Ved38	64	20.5	20.46	20.46	20.41	20.32	0.04	0.00	0.05	0.18	0.14	0.14	0.09
Ved37	63	19.35	19.37	19.38	19.58	19.98	-0.02	-0.01	-0.20	-0.63	-0.61	-0.60	-0.40
Ved36	62	18.57	18.5	18.63	19.04	18.89	0.07	-0.13	-0.41	-0.32	-0.39	-0.26	0.15
Ved35	61	17.82	17.84	18.05	18.26	17.9	-0.02	-0.21	-0.21	-0.08	-0.06	0.15	0.36
Ved34	60	17.39	17.37	17.47	17.41	17.47	0.02	-0.10	0.06	-0.08	-0.10	0.00	-0.06
Ved33	59	16.72	16.8	16.8	16.73	16.97	-0.08	0.00	0.07	-0.25	-0.17	-0.17	-0.24
Ved32	57	16.03	16.13	16.13	16.18	16.5	-0.1	0.00	-0.05	-0.47	-0.37	-0.37	-0.32
Ved31	55	15.9	15.91	15.91	16.01	16.07	-0.01	0.00	-0.10	-0.17	-0.16	-0.16	-0.06
Ved30	54	15.6	15.59	15.57	15.67	15.77	0.01	0.02	-0.10	-0.17	-0.18	-0.20	-0.10
Ved29	53	15.42	15.42	15.4	15.51	15.59	0	0.02	-0.11	-0.17	-0.17	-0.19	-0.08
Ved28	52	15.13	15.13	15.1	15.31	15.13	0	0.03	-0.21	0.00	0.00	-0.03	0.18
Ved27	51	14.45	14.44	14.46	14.52	14.53	0.01	-0.02	-0.06	-0.08	-0.09	-0.07	-0.01
Ved26	50	14.18	14.22	14.29	14.31	14.19	-0.04	-0.07	-0.02	-0.01	0.03	0.10	0.12
Ved25	48	13.79	13.79	13.88	13.92	14	0	-0.09	-0.04	-0.21	-0.21	-0.12	-0.08
Ved24	47	13.57	13.58	13.66	13.74	13.93	-0.01	-0.08	-0.08	-0.36	-0.35	-0.27	-0.19
Ved23.1	46	13.24	13.24	13.3	13.5		0	-0.06	-0.20				
Ved23	45	12.99	13.07	13.07	13.25	13.69	-0.08	0.00	-0.18	-0.70	-0.62	-0.62	-0.44
Ved22	44	12.78	12.93	12.93	13.12	13.54	-0.15	0.00	-0.19	-0.76	-0.61	-0.61	-0.42
Ved21	42	12.63	12.82	12.79	12.99	13.3	-0.19	0.03	-0.20	-0.67	-0.48	-0.51	-0.31
Ved20	41	12.45	12.68	12.51	12.74	12.98	-0.23	0.17	-0.23	-0.53	-0.30	-0.47	-0.24
Ved19	40	12.23	12.51	12.32	12.58	12.96	-0.28	0.19	-0.26	-0.73	-0.45	-0.64	-0.38
Ved18	38	11.81	11.94	11.91	12.08	12.8	-0.13	0.03	-0.17	-0.99	-0.86	-0.89	-0.72
Ved50	37	11.73	11.74	11.53	11.68		-0.01	0.21	-0.15				
Ved17.2	36	11.32	11.57	11.5	11.73	11.55	-0.25	0.07	-0.23	-0.23	0.02	-0.05	0.18
SRBC	35.5												
Ved17.1	35	11.13	11.44	11.41	11.57		-0.31	0.03	-0.16				
Ved51	34	11.09	11.06	10.89	11.1		0.03	0.17	-0.21				
Ved16	33	10.81	10.74	10.73	10.93		0.07	0.01	-0.20				
Ved15	32	10.69	10.61	10.63	10.69	10.71	0.08	-0.02	-0.06	-0.02	-0.10	-0.08	-0.02
Ved14	31	10.56	10.48	10.53	10.55	10.66	0.08	-0.05	-0.02	-0.10	-0.18	-0.13	-0.11
Ved13	29	10.52	10.44	10.49	10.52	10.47	0.08	-0.05	-0.03	0.05	-0.03	0.02	0.05
Ved12	27	10.41	10.3	10.38	10.4	10.31	0.11	-0.08	-0.02	0.10	-0.01	0.07	0.09
Ved11	26	10.4	10.3	10.38	10.4	10.27	0.1	-0.08	-0.02	0.13	0.03	0.11	0.13
Ved10	25	10.34	10.23	10.31	10.31	10.13	0.11	-0.08	0.00	0.21	0.10	0.18	0.18
Ved9	24	10.3	10.18	10.26	10.27	10.08	0.12	-0.08	-0.01	0.22	0.10	0.18	0.19
Ved8	23	10.29	10.16	10.24	10.25	10.02	0.13	-0.08	-0.01	0.27	0.14	0.22	0.23
Ved7	22	10.25	10.1	10.18	10.19	9.94	0.15	-0.08	-0.01	0.31	0.16	0.24	0.25
Ved6	21	10.1	9.97	10.07	10.07	9.88	0.13	-0.10	0.00	0.22	0.09	0.19	0.19
Ved5	20	10.08	9.95	10.05	10.06	9.85	0.13	-0.10	-0.01	0.23	0.10	0.20	0.21
Ved4	19	10.06	9.93	10.03	10.04	9.79	0.13	-0.10	-0.01	0.27	0.14	0.24	0.25
Ved3	18	9.97	9.84	9.95	9.94	9.63	0.13	-0.11	0.01	0.34	0.21	0.32	0.31
Ved2	17	9.86	9.67	9.8	9.8	9.4	0.19	-0.13	0.00	0.46	0.27	0.40	0.40
Ved1	16	9.69	9.57	9.67	9.66	9.34	0.12	-0.10	0.01	0.35	0.23	0.33	0.32

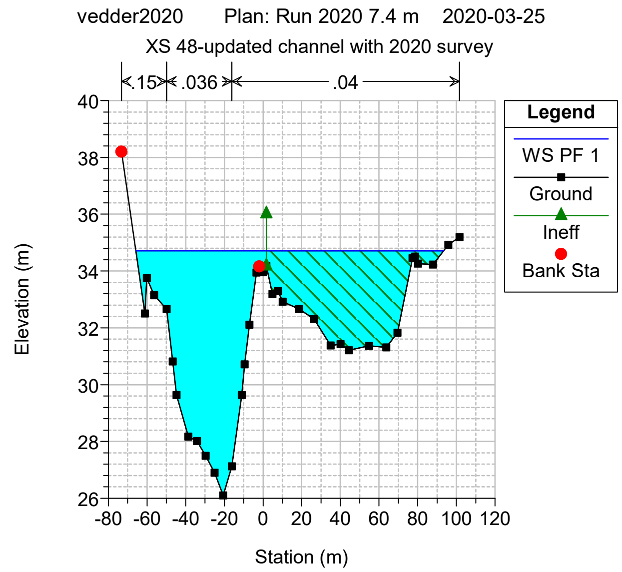
Note:
1. 2010-2020 water surface profiles computed using starting water level at 7.4 m. 1996 water surface profile computed using starting water level at 5.5 m.
2. Design flood of 1330 m^3/s was used to calculate the 1996 water surface profile; Design flood of 1470 m^3/s was used to calculate the 2010-2018 water surface profiles.
* Appears inconsistent with other data.

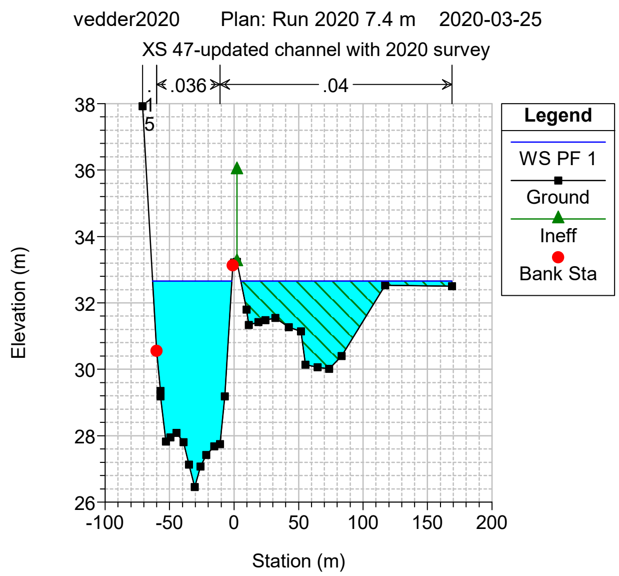
KERR WOOD LEIDAL
consulting engineers

Appendix C

2020 HEC-RAS Water Surface Elevations


vedder2020 Plan: Run 2020 7.4 m 2020-03-25
XS 49-updated channel with 2020 survey
.2
.036
.038
.04
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)


vedder2020 Plan: Run 2020 7.4 m 2020-03-25
XS 48-updated channel with 2020 survey
.15
.036
.04
Legend
WS PF 1
Ground
Ineff
Bank Sta
Elevation (m)
Station (m)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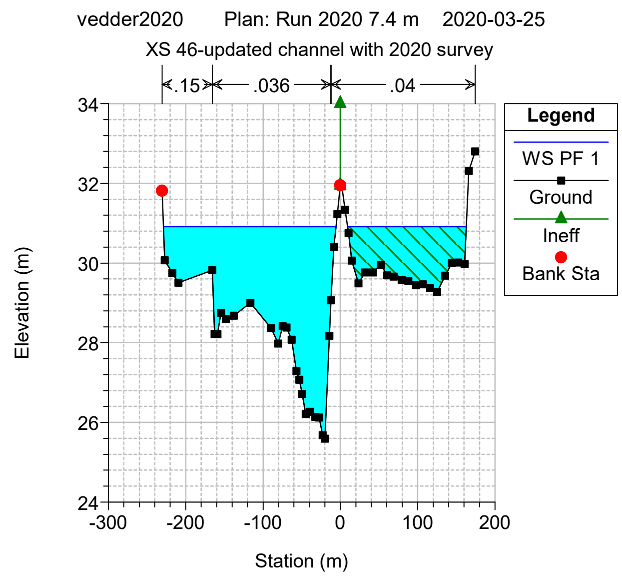
XS 47-updated channel with 2020 survey
.15
.036
.04
Legend
WS PF 1
Ground
Ineff
Bank Sta
Elevation (m)
Station (m)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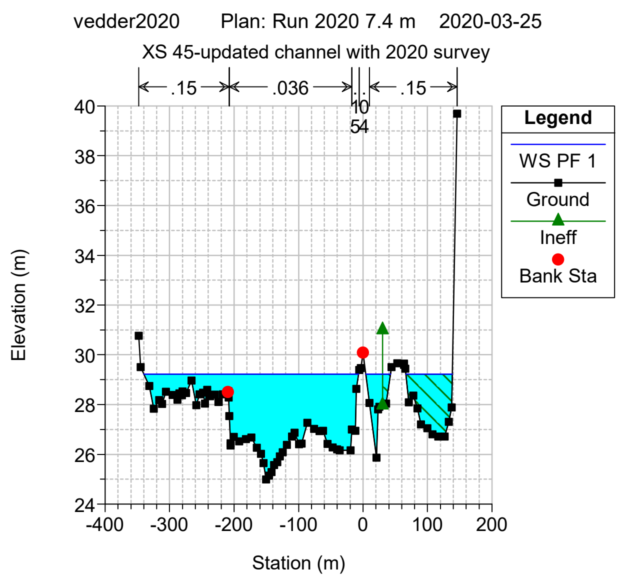
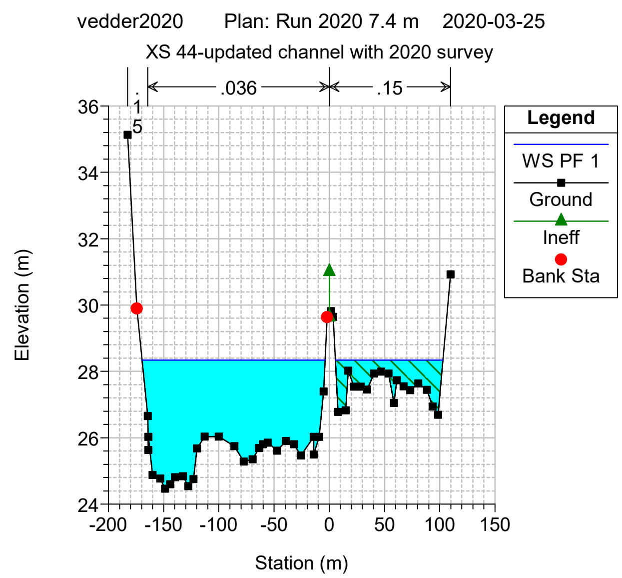
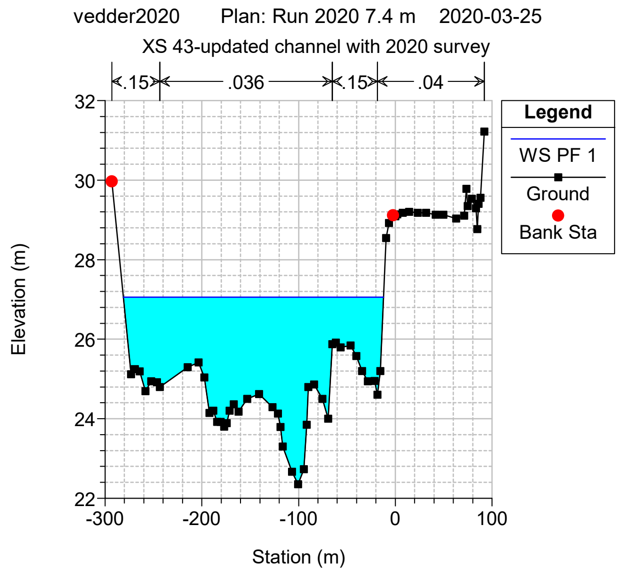
XS 46-updated channel with 2020 survey
.15
.036
.04
Legend
WS PF 1
Ground
Ineff
Bank Sta
Elevation (m)
Station (m)


vedder2020 Plan: Run 2020 7.4 m 2020-03-25
XS 45-updated channel with 2020 survey
.15
.036
.15
Legend
WS PF 1
Ground
Ineff
Bank Sta
Elevation (m)
Station (m)


vedder2020 Plan: Run 2020 7.4 m 2020-03-25
XS 44-updated channel with 2020 survey
.15
.036
.15
Legend
WS PF 1
Ground
Ineff
Bank Sta
Elevation (m)
Station (m)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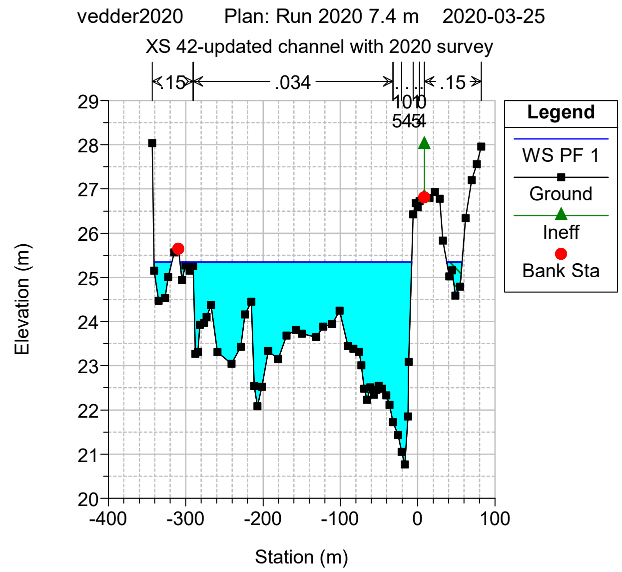
XS 43-updated channel with 2020 survey
.15
.036
.15
.04
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)
32
30
28
26
24
22
-300
-200
-100
0
100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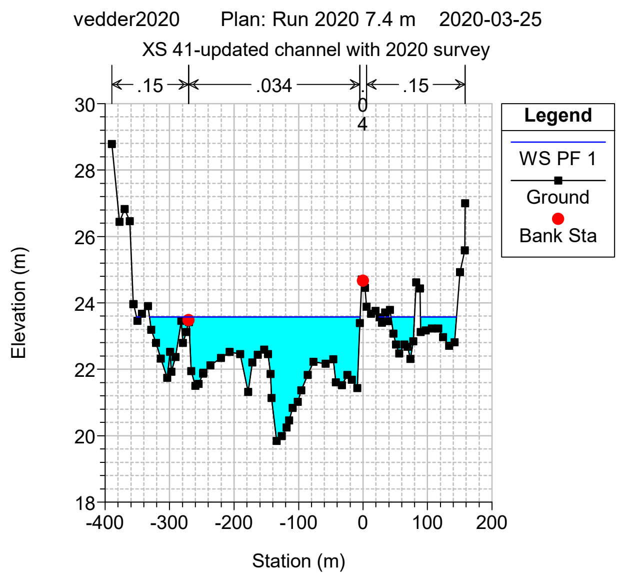
XS 42-updated channel with 2020 survey
.15
.034
.15
Legend
WS PF 1
Ground
Ineff
Bank Sta
Elevation (m)
Station (m)
29
28
27
26
25
24
23
22
21
20
-400
-300
-200
-100
0
100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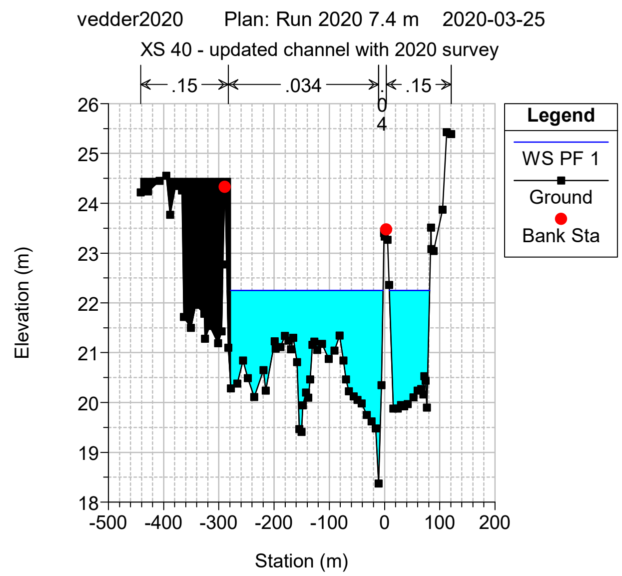
XS 41-updated channel with 2020 survey
.15
.034
.15
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)
30
28
26
24
22
20
18
-400
-300
-200
-100
0
100
200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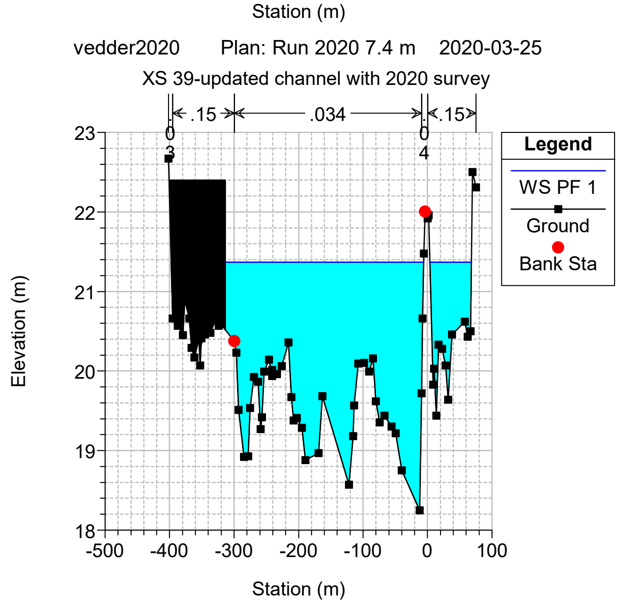
XS 40 - updated channel with 2020 survey
.15
.034
.15
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)
26
25
24
23
22
21
20
19
18
-500
-400
-300
-200
-100
0
100
200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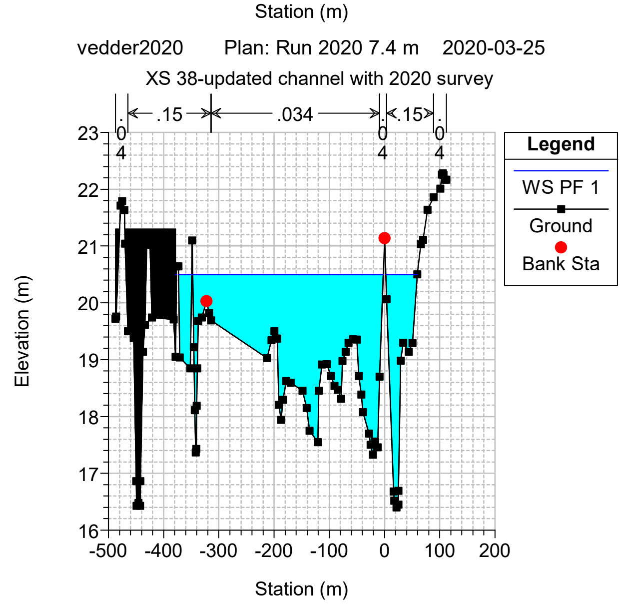
XS 39-updated channel with 2020 survey
.15
.034
.15
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)
23
22
21
20
19
18
-500
-400
-300
-200
-100
0
100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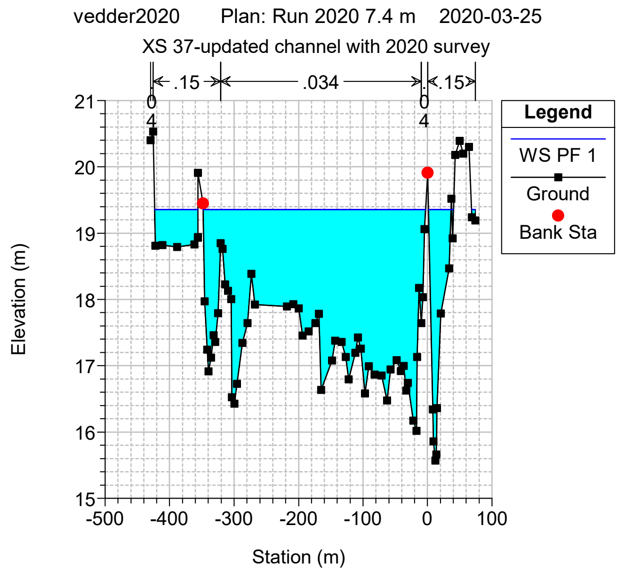
XS 38-updated channel with 2020 survey
.15
.034
.15
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)
23
22
21
20
19
18
17
16
-500
-400
-300
-200
-100
0
100
200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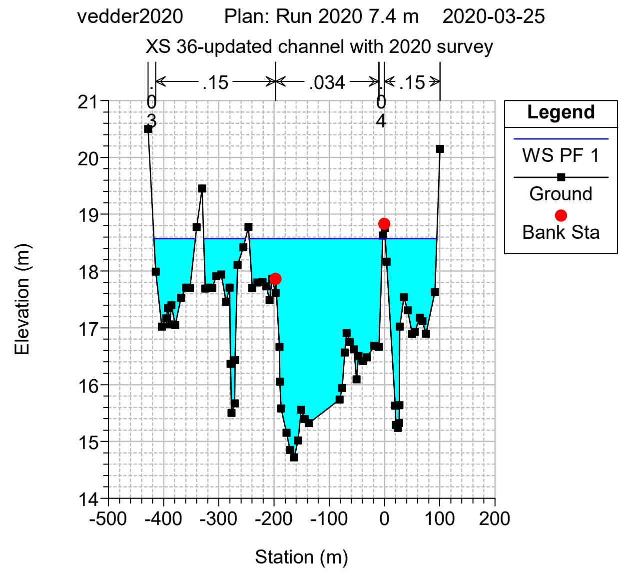
XS 37-updated channel with 2020 survey
.15
.034
.15
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)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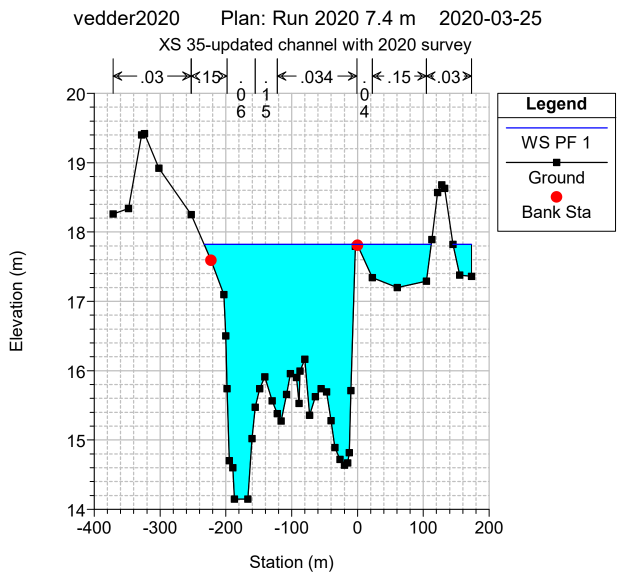
XS 36-updated channel with 2020 survey
.15
.034
.15
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)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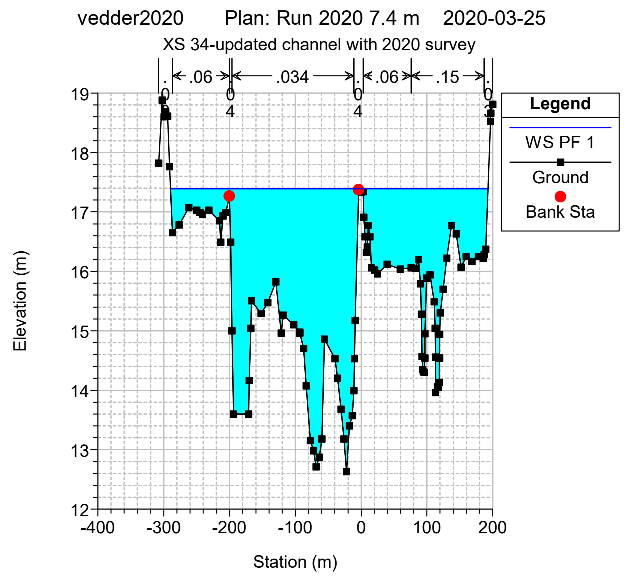
XS 35-updated channel with 2020 survey
.03
.15
.034
.15
.03
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)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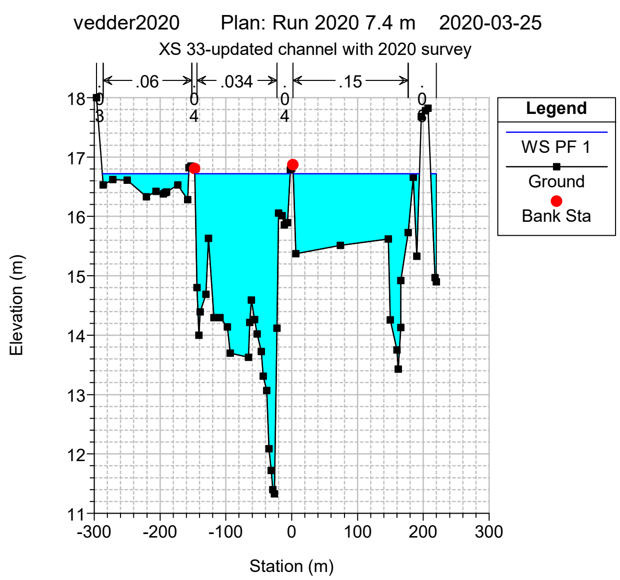
XS 34-updated channel with 2020 survey
.06
.034
.06
.15
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)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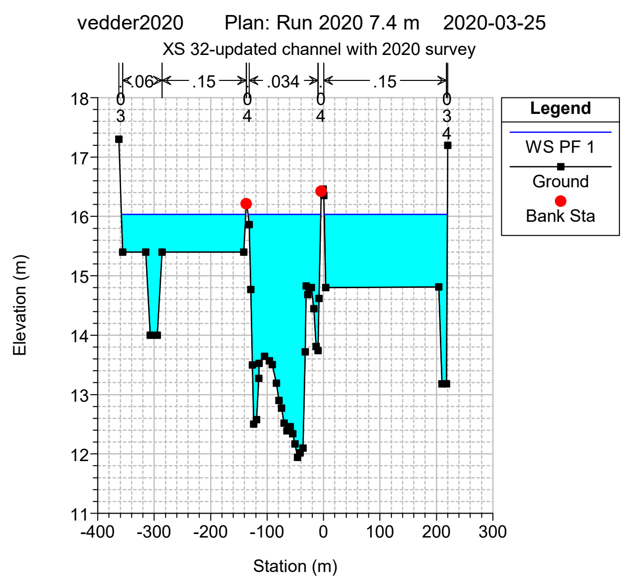
XS 33-updated channel with 2020 survey
.06
.034
.15
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)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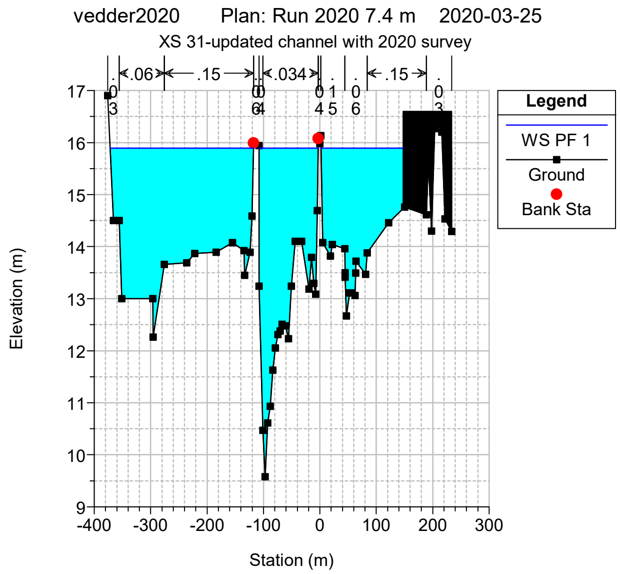
XS 32-updated channel with 2020 survey
.06
.15
.034
.15
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)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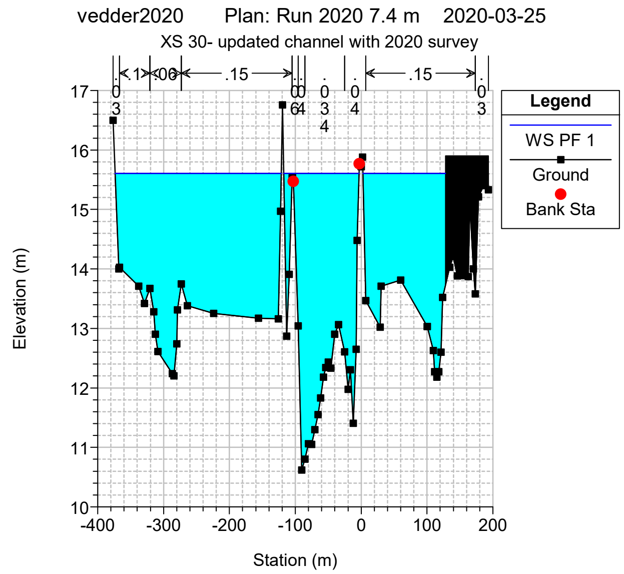
XS 31-updated channel with 2020 survey
.06
.15
.034
.15
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)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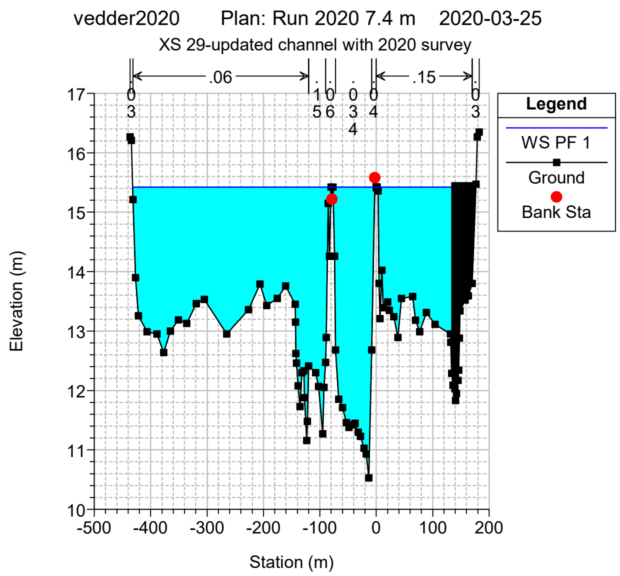
XS 30- updated channel with 2020 survey
.15
.15
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)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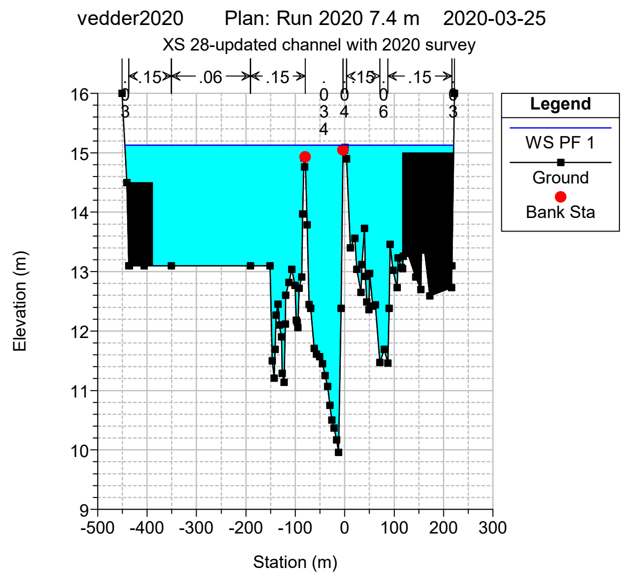
XS 29-updated channel with 2020 survey
.06
.15
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)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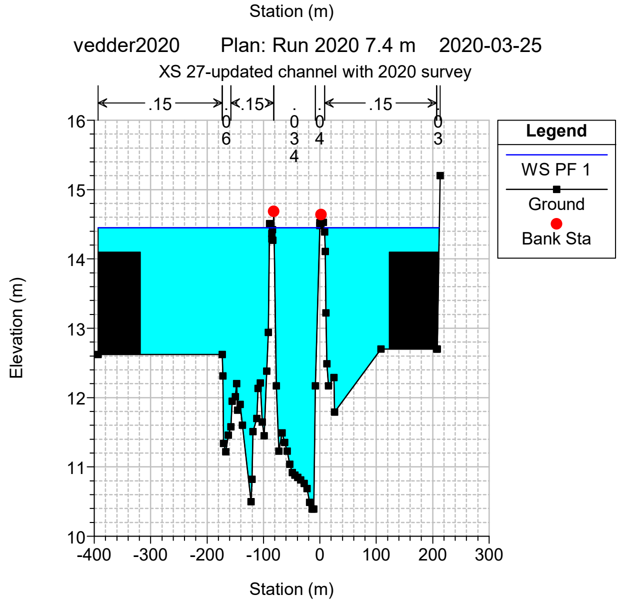
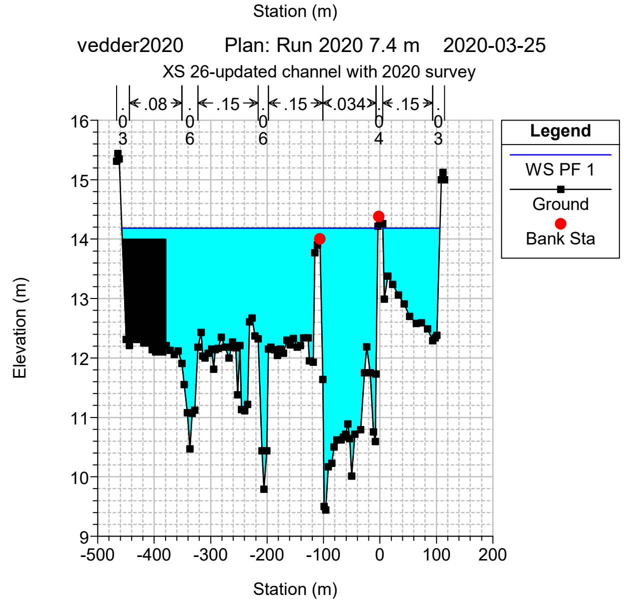
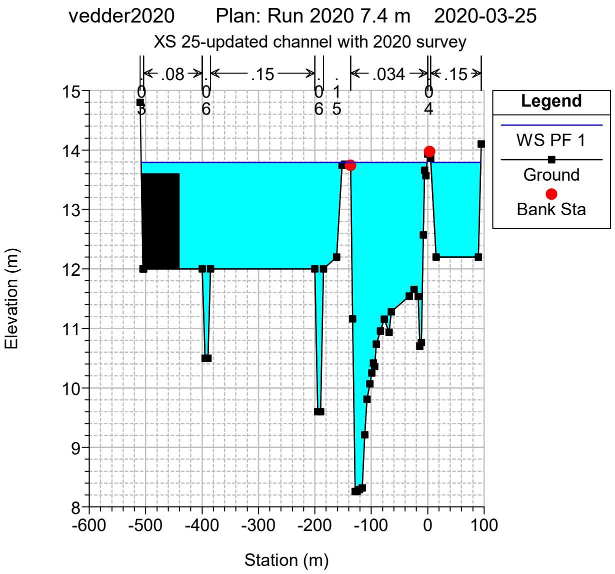
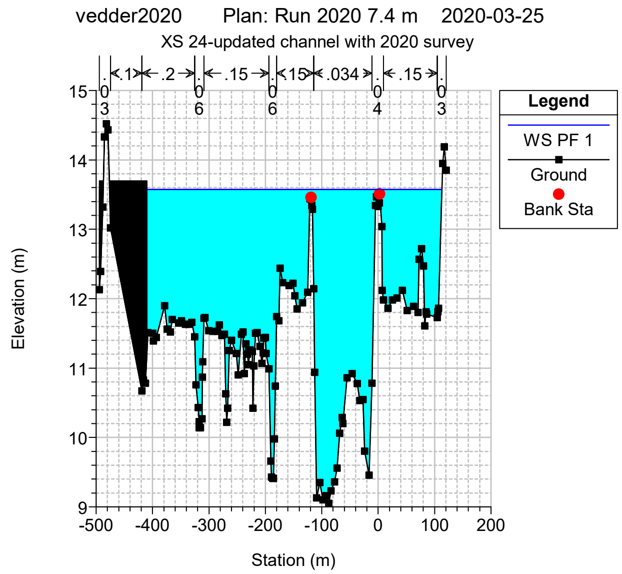
XS 28-updated channel with 2020 survey
.15
.06
.15
.15
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)


vedder2020 Plan: Run 2020 7.4 m 2020-03-25
XS 27-updated channel with 2020 survey
.15
.15
.15
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)


vedder2020 Plan: Run 2020 7.4 m 2020-03-25
XS 26-updated channel with 2020 survey
.08
.15
.15
.034
.15
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)


vedder2020 Plan: Run 2020 7.4 m 2020-03-25
XS 25-updated channel with 2020 survey
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)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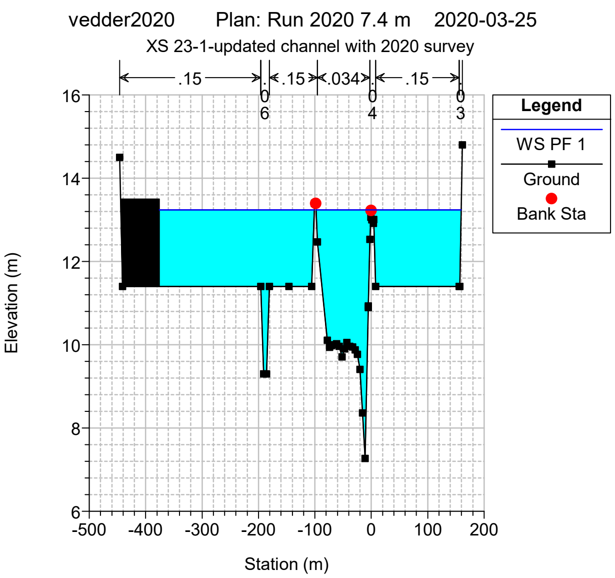
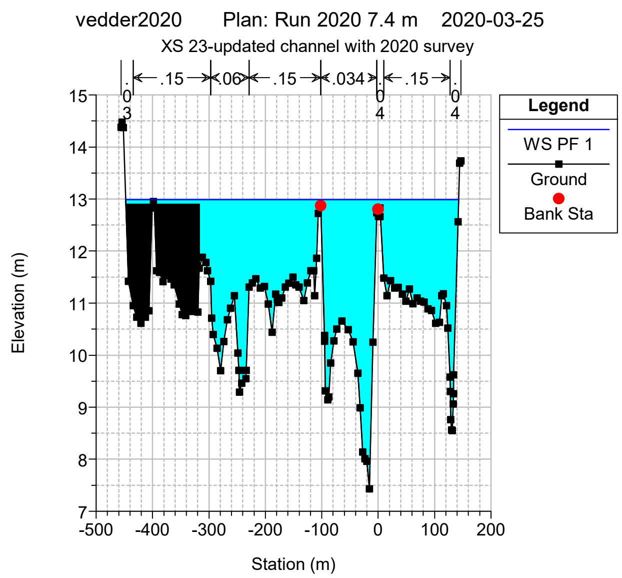
XS 24-updated channel with 2020 survey
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)


vedder2020 Plan: Run 2020 7.4 m 2020-03-25
XS 23-1-updated channel with 2020 survey
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)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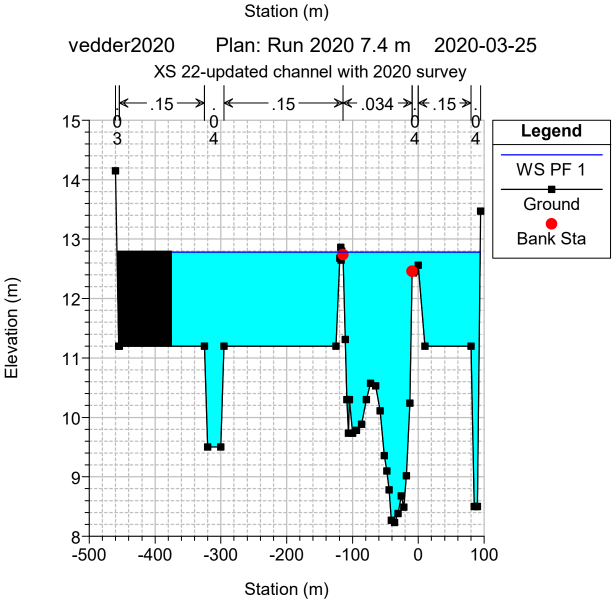
XS 23-updated channel with 2020 survey
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)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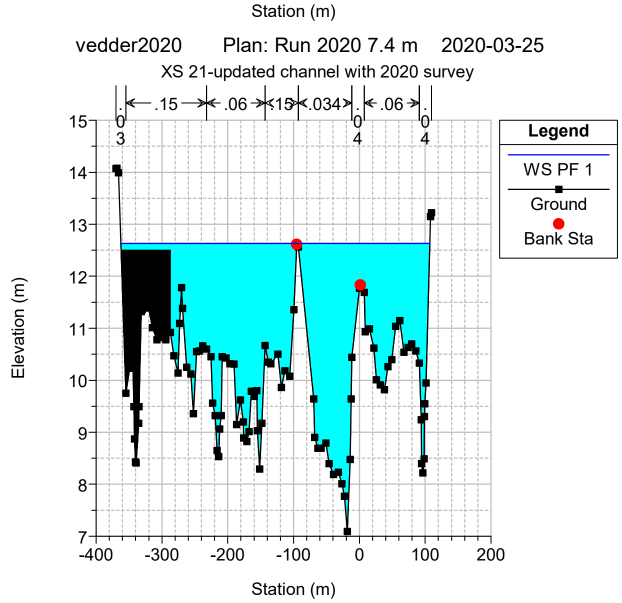
XS 22-updated channel with 2020 survey
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)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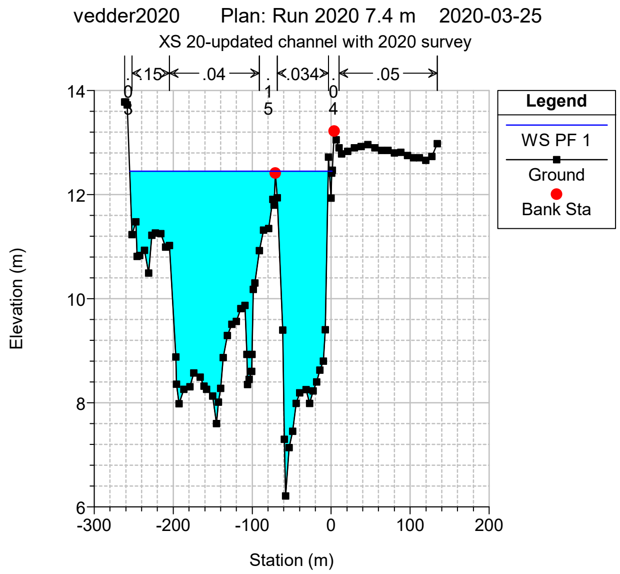
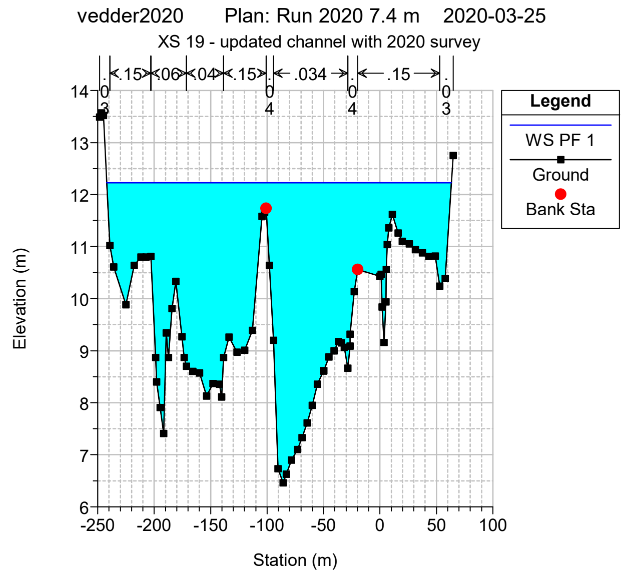
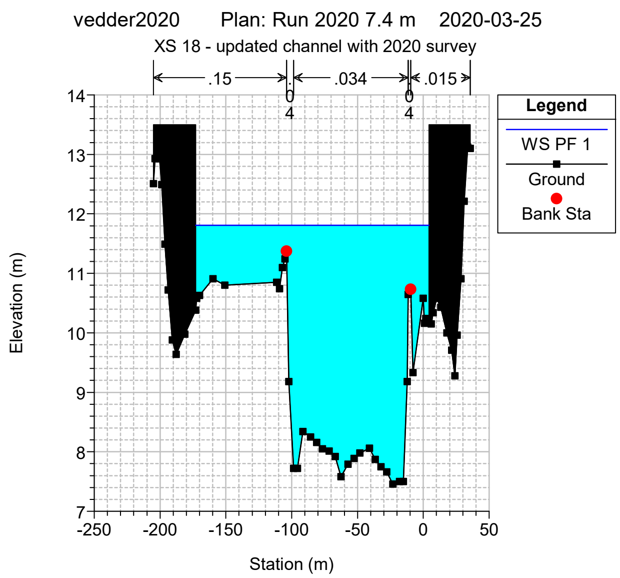
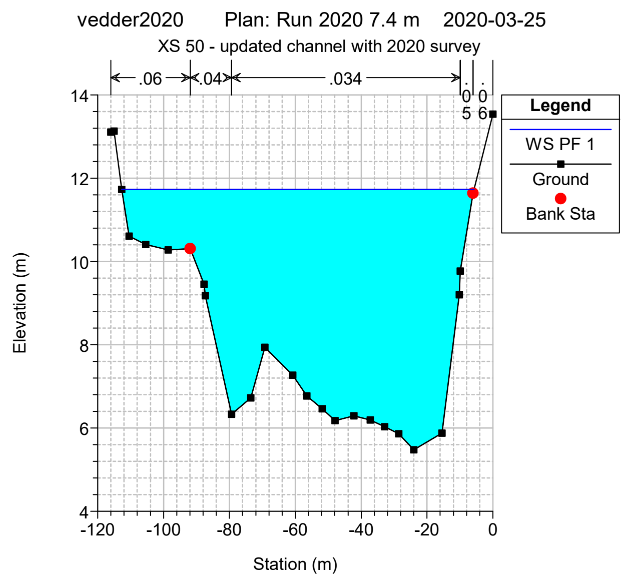
XS 21-updated channel with 2020 survey
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)


vedder2020 Plan: Run 2020 7.4 m 2020-03-25
XS 20-updated channel with 2020 survey
.15
.04
.034
.05
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)


vedder2020 Plan: Run 2020 7.4 m 2020-03-25
XS 19 - updated channel with 2020 survey
.15
.06
.04
.15
.034
.15
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)


vedder2020 Plan: Run 2020 7.4 m 2020-03-25
XS 18 - updated channel with 2020 survey
.15
.034
.015
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)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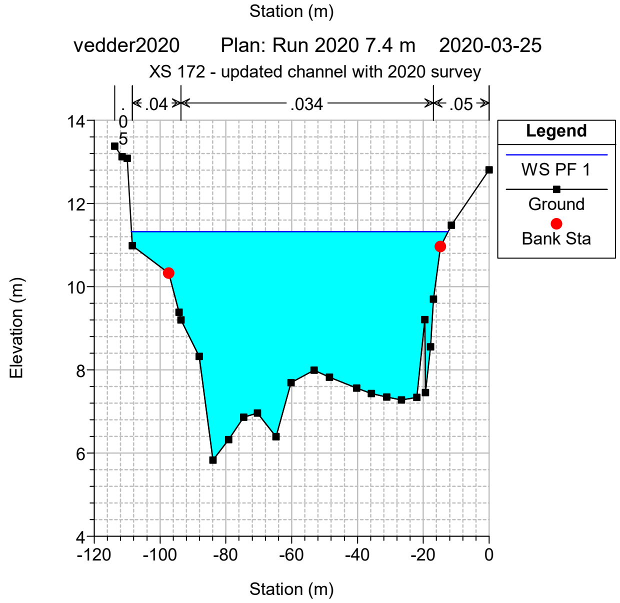
Ground
Bank Sta
Elevation (m)
Station (m)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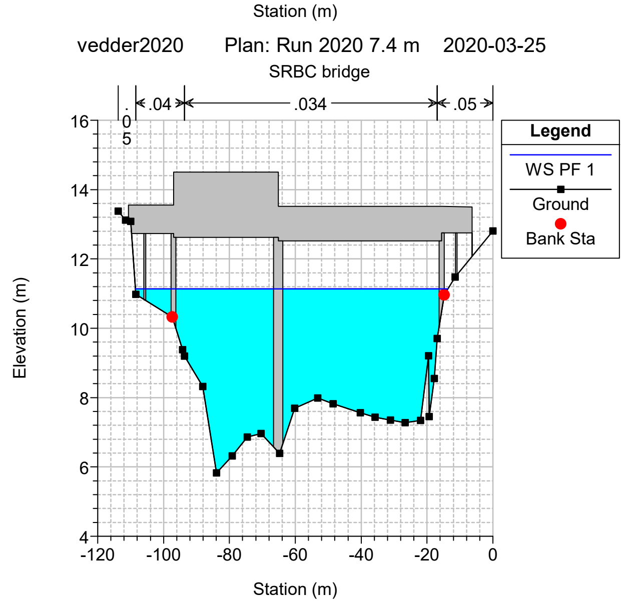
Bank Sta
Elevation (m)
Station (m)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SRBC bridge
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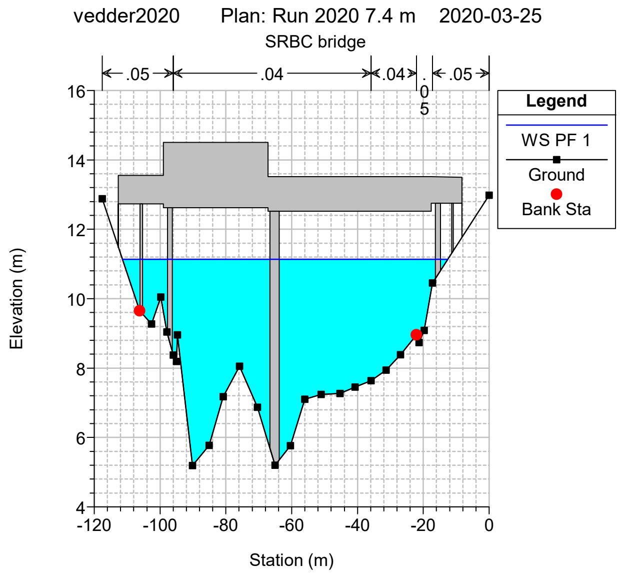
Bank Sta
Elevation (m)
Station (m)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SRBC bridge
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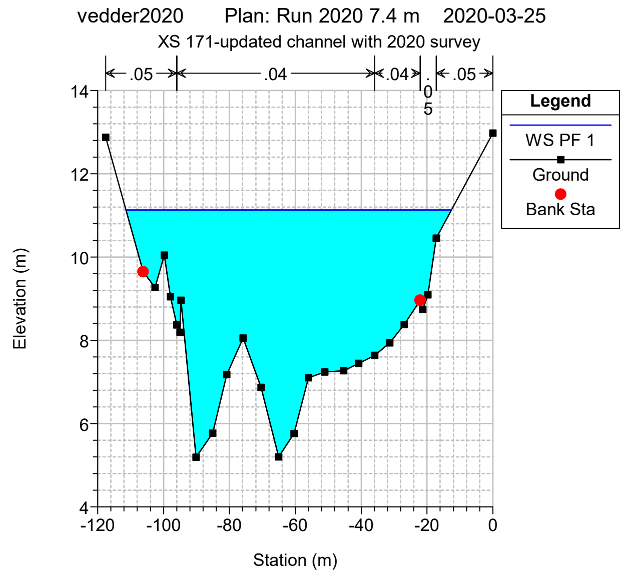
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)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Legend
WS PF 1
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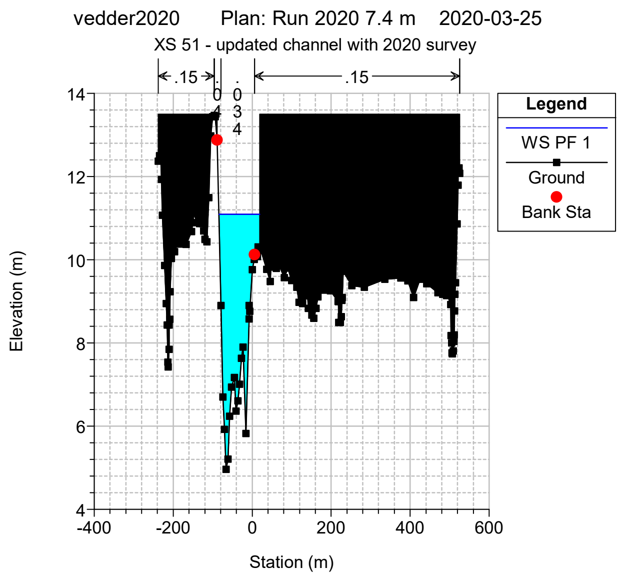
Bank Sta
Elevation (m)
Station (m)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Legend
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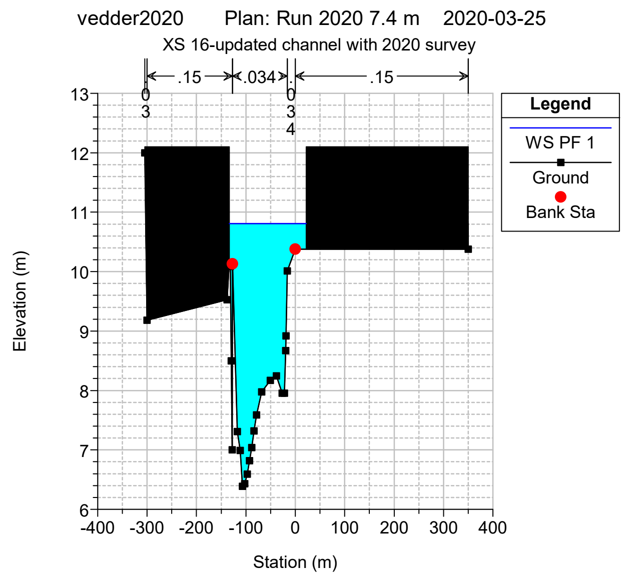
Ground
Bank Sta
Elevation (m)
Station (m)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Legend
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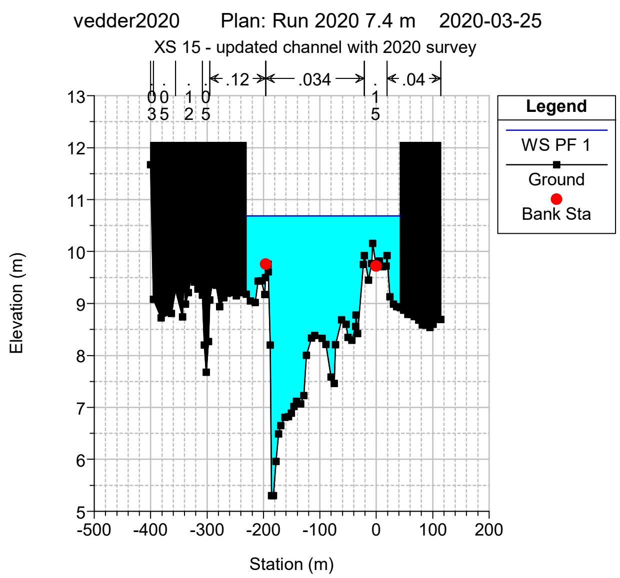
Ground
Bank Sta
Elevation (m)
Station (m)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Legend
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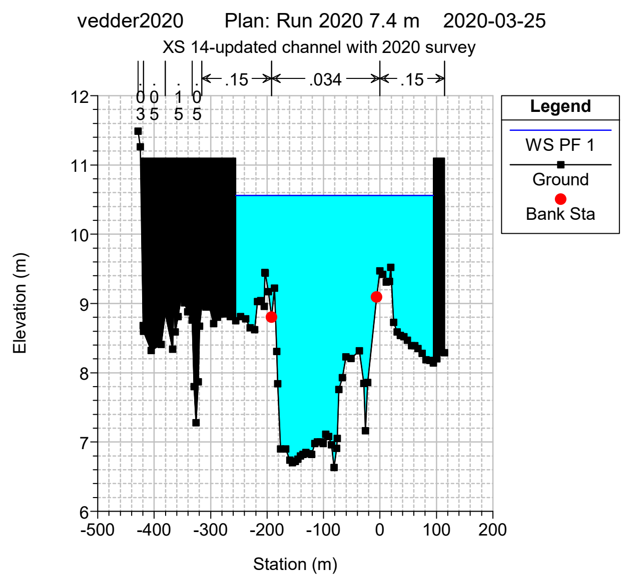
Ground
Bank Sta
Elevation (m)
Station (m)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XS 14-updated channel with 2020 survey
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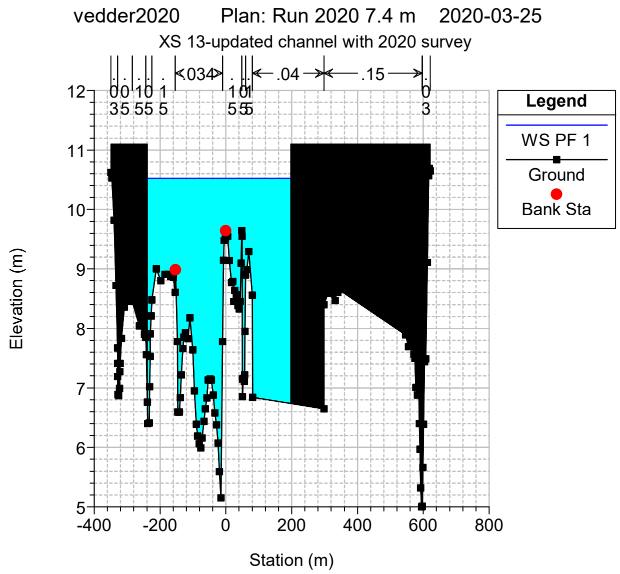
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)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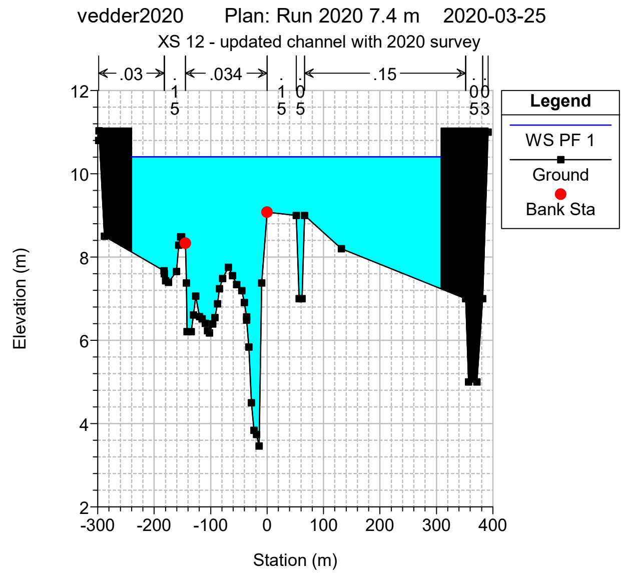
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)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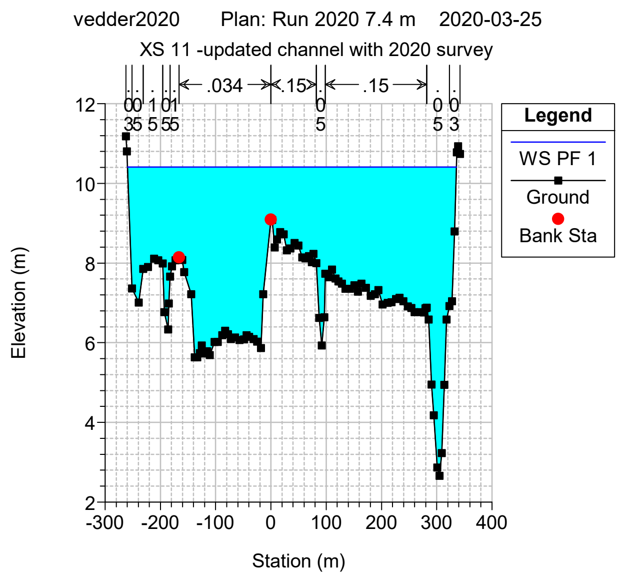
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)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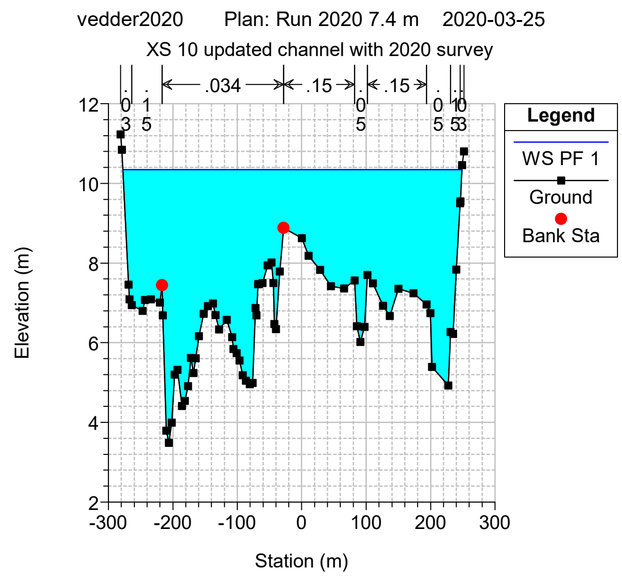
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)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XS 10 updated channel with 2020 survey
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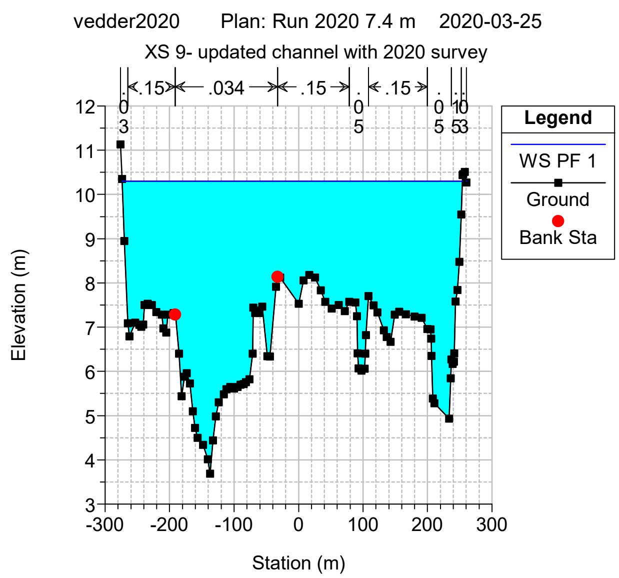
.15
.15
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)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XS 9- updated channel with 2020 survey
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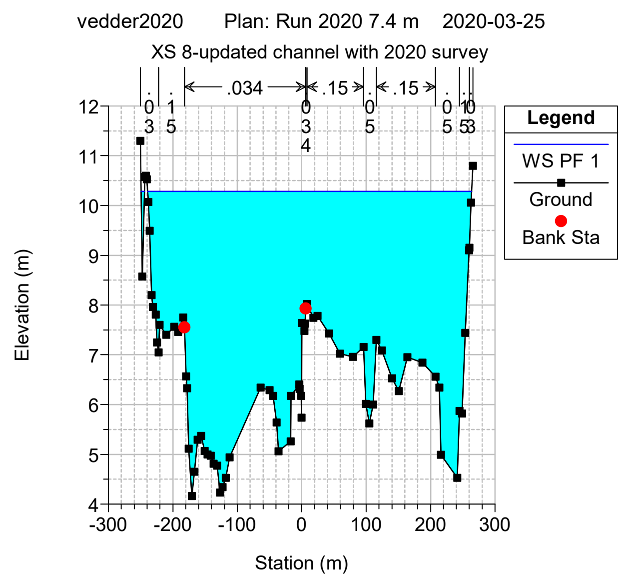
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)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XS 8-updated channel with 2020 survey
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Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

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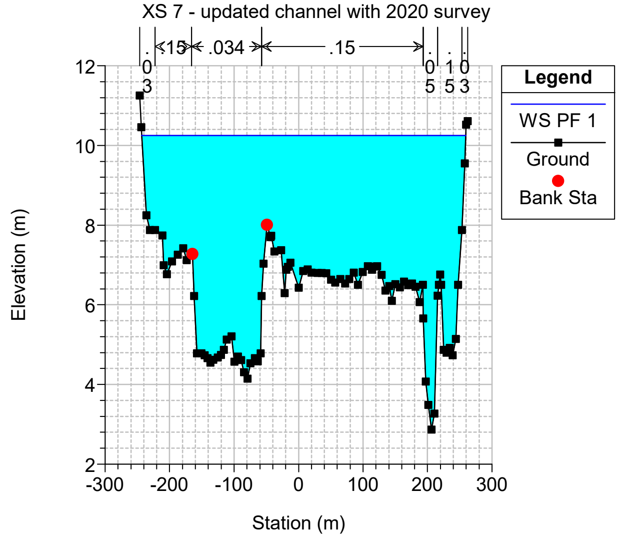
XS 7 - updated channel with 2020 survey



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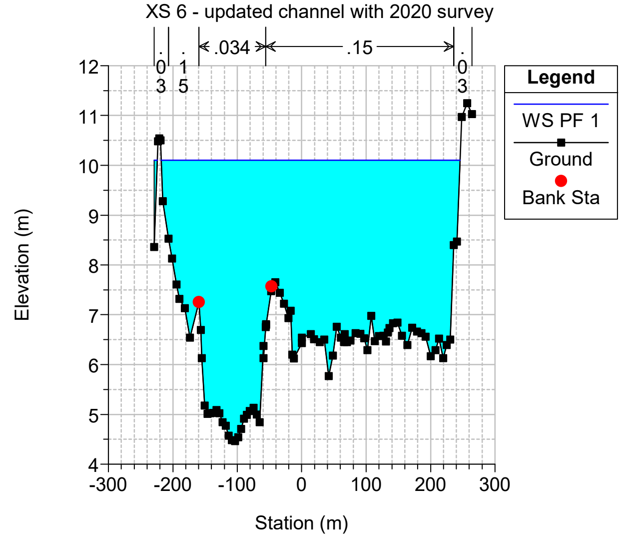

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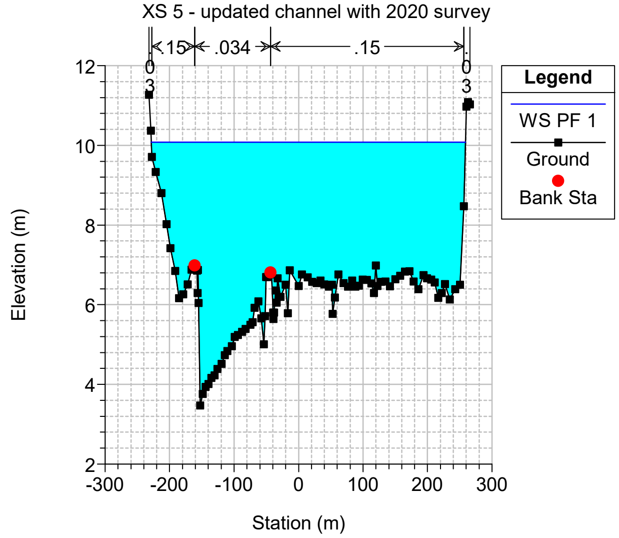
XS 5 - updated channel with 2020 survey



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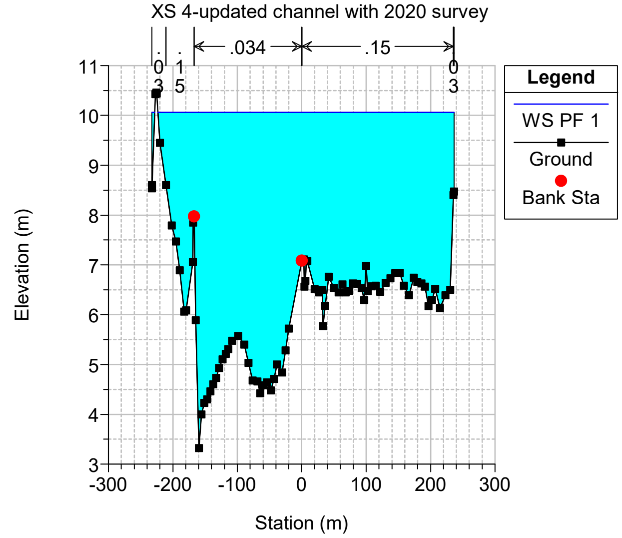
XS 4-updated channel with 2020 survey



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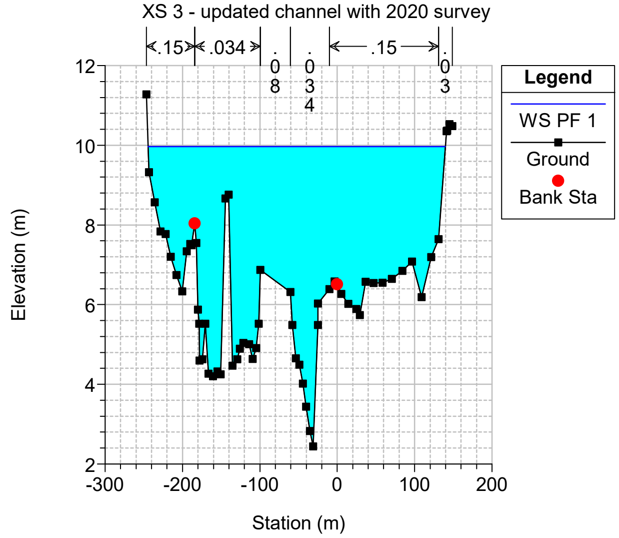
XS 3 - updated channel with 2020 survey



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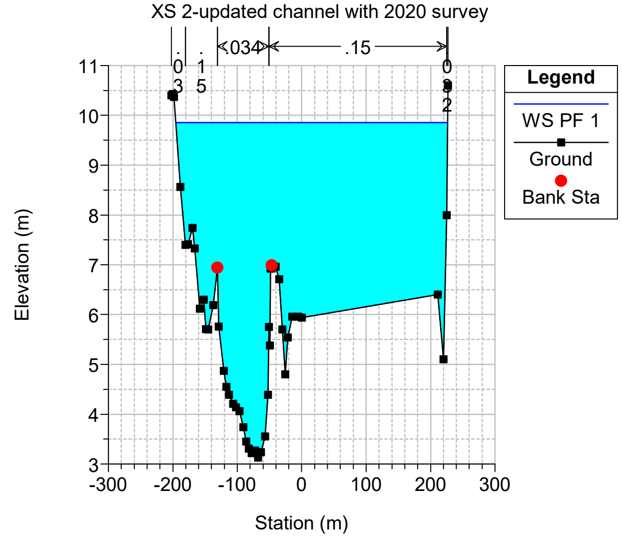
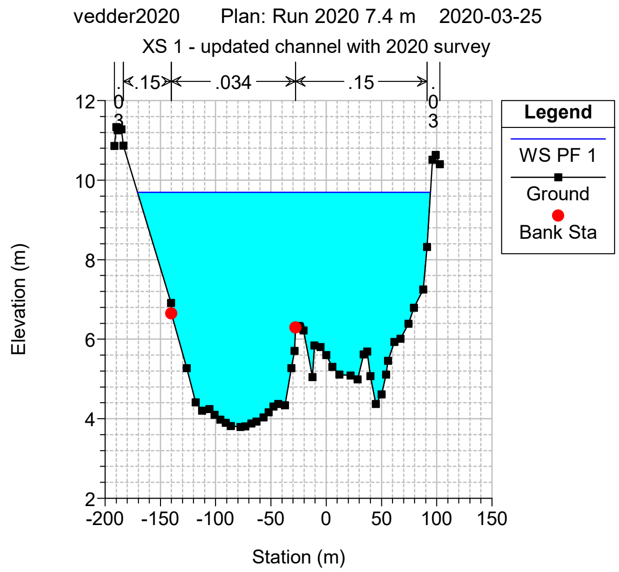
XS 2-updated channel with 2020 survey

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XS 1 - updated channel with 2020 survey
.15
.034
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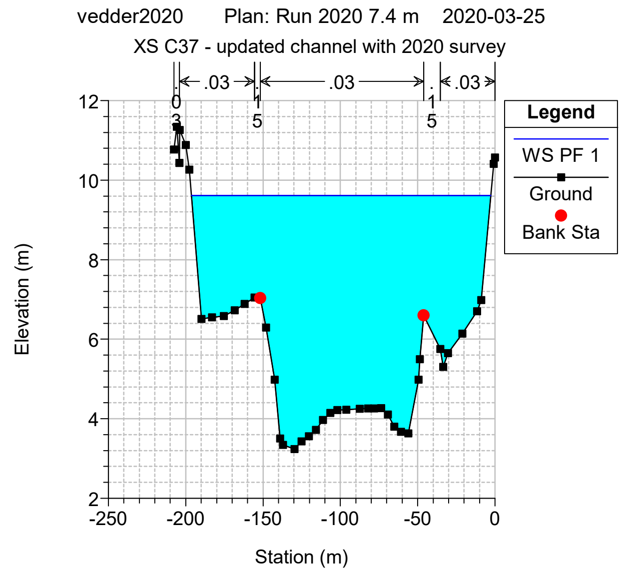
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)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.03
.03
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Legend
WS PF 1
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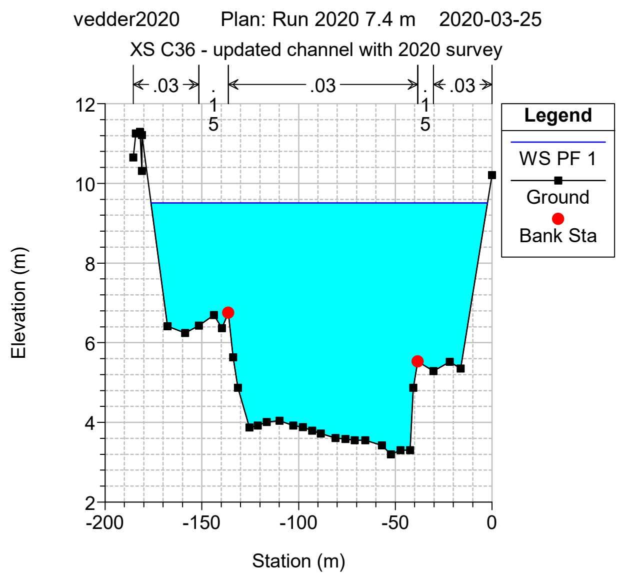
Bank Sta
Elevation (m)
Station (m)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.03
.03
Legend
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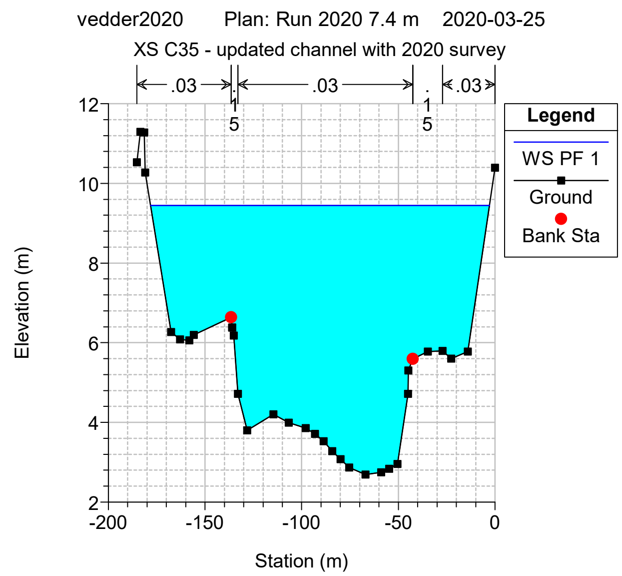
Bank Sta
Elevation (m)
Station (m)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.03
.03
.03
Legend
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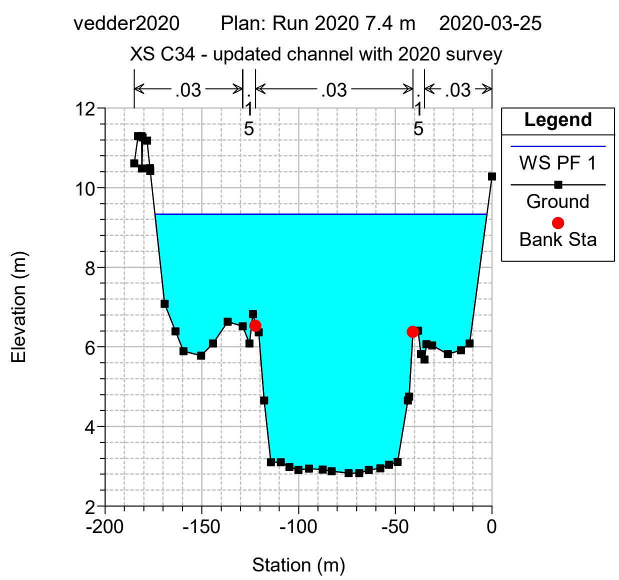
Bank Sta
Elevation (m)
Station (m)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.03
.03
.03
Legend
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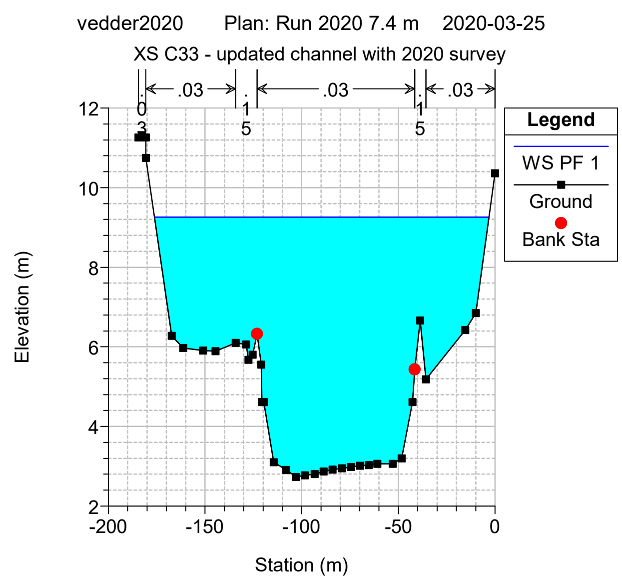
Bank Sta
Elevation (m)
Station (m)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.03
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.03
Legend
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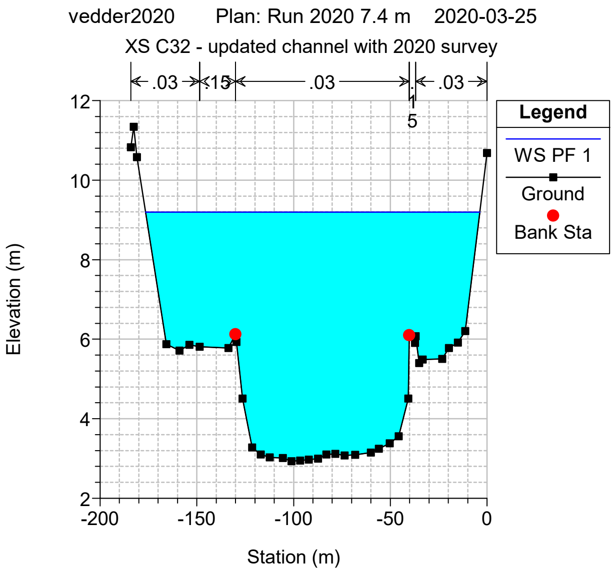
Bank Sta
Elevation (m)
Station (m)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Bank Sta
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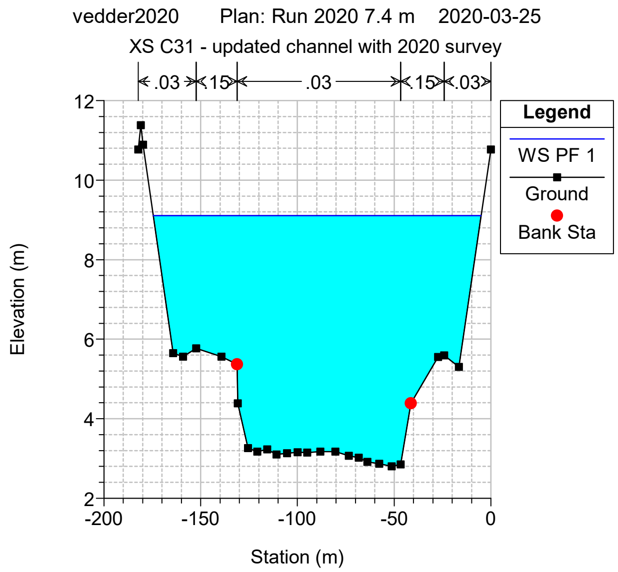
Station (m)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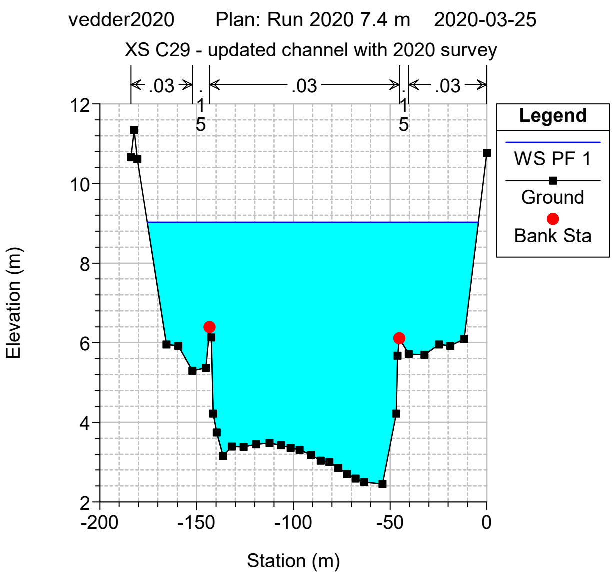
Bank Sta
Elevation (m)
Station (m)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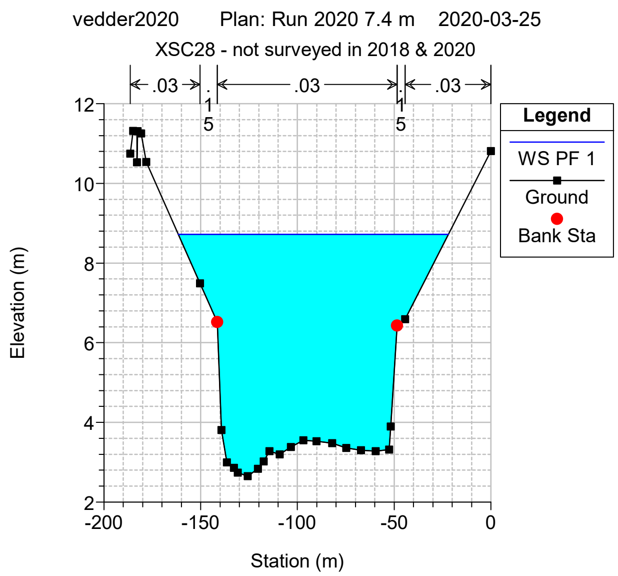
Bank Sta
Elevation (m)
Station (m)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XSC28 - not surveyed in 2018 & 2020
Legend
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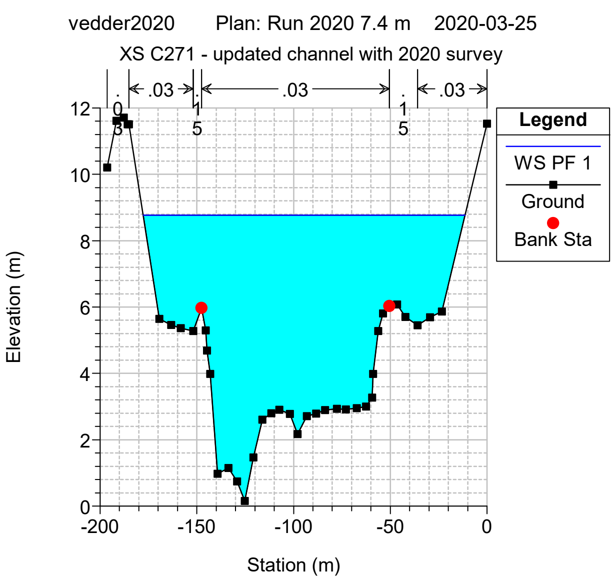
Ground
Bank Sta
Elevation (m)
Station (m)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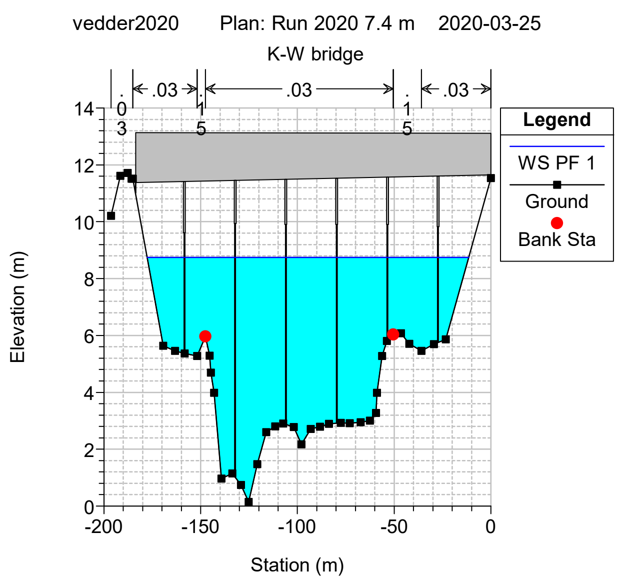
Ground
Bank Sta
Elevation (m)
Station (m)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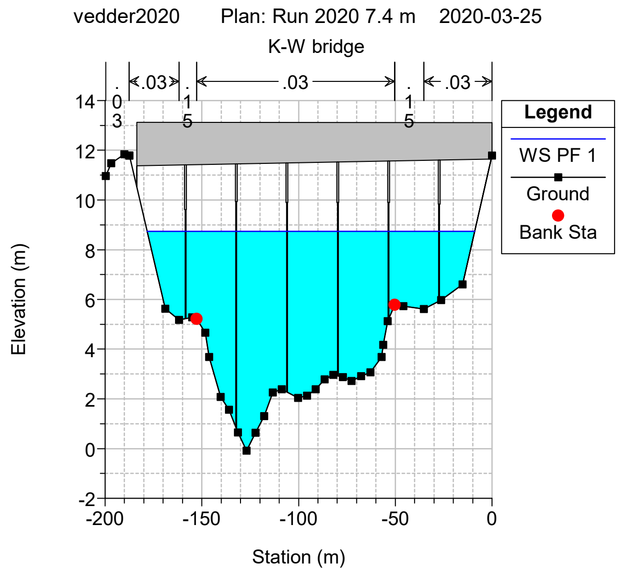
K-W bridge
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)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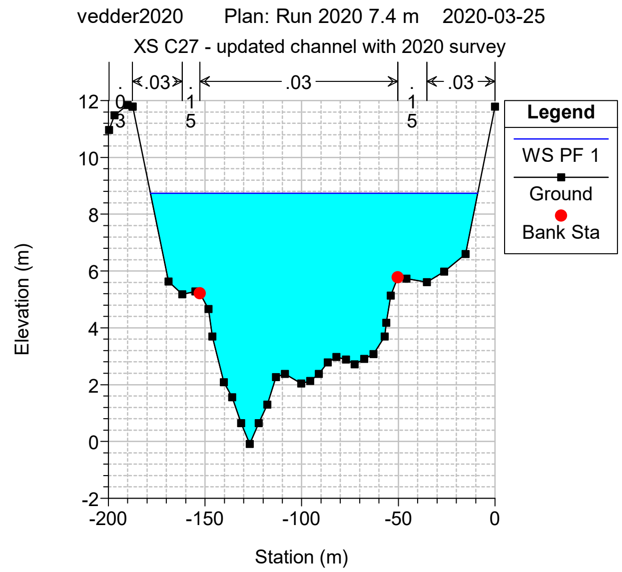
K-W bridge
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)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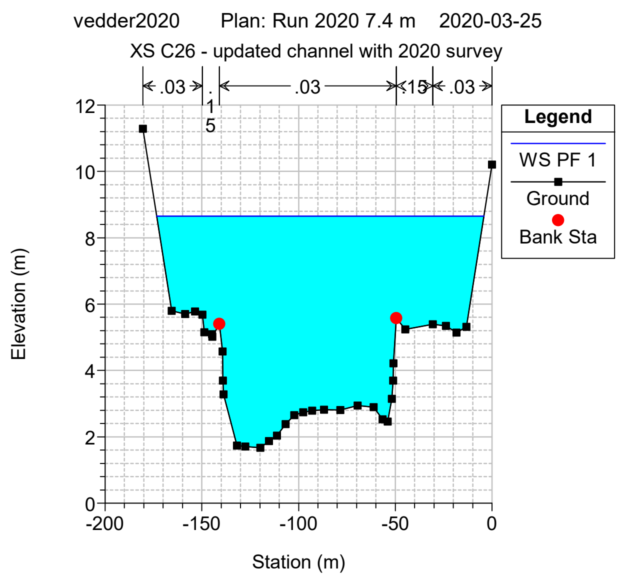
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)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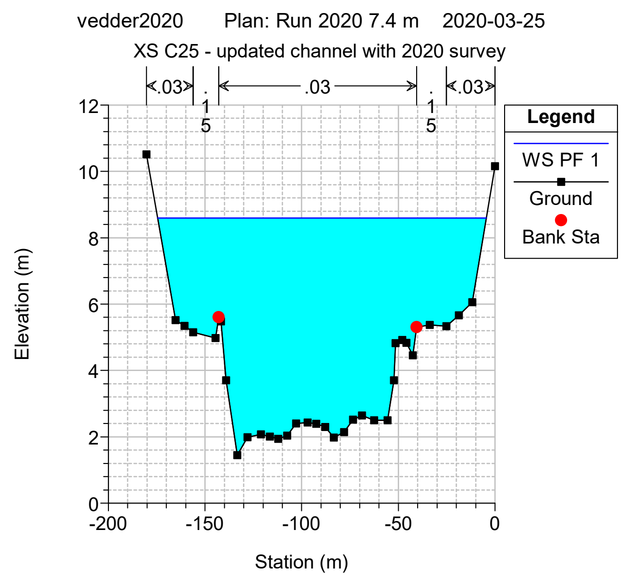
Ground
Bank Sta
Elevation (m)
Station (m)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Legend
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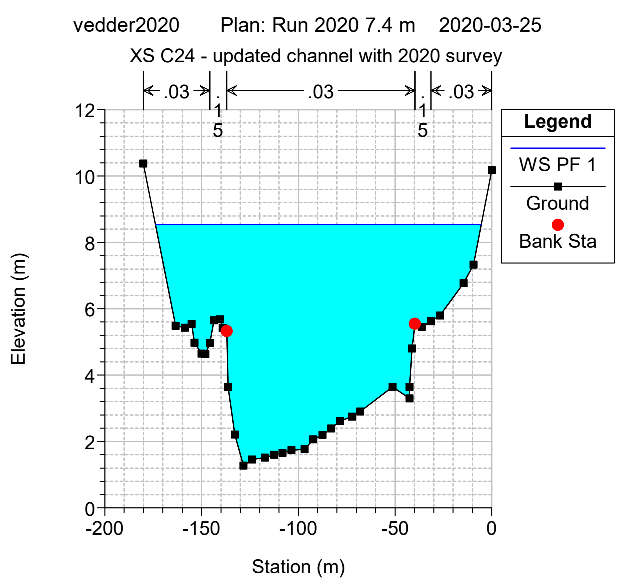
Ground
Bank Sta
Elevation (m)
Station (m)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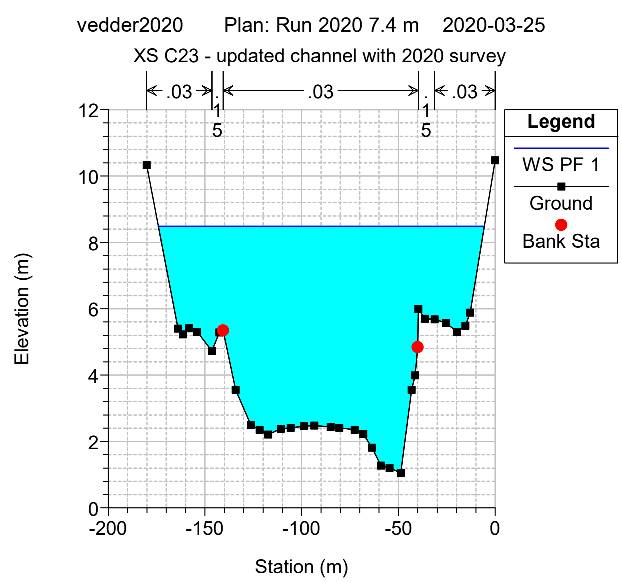
Bank Sta
Elevation (m)
Station (m)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Legend
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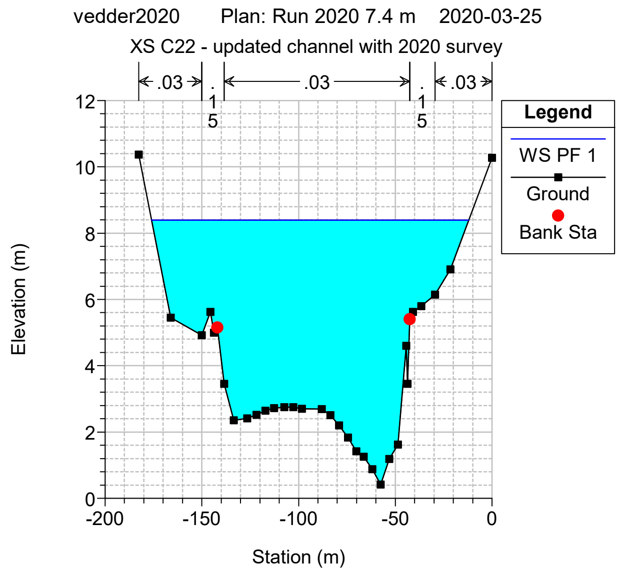
Bank Sta
Elevation (m)
Station (m)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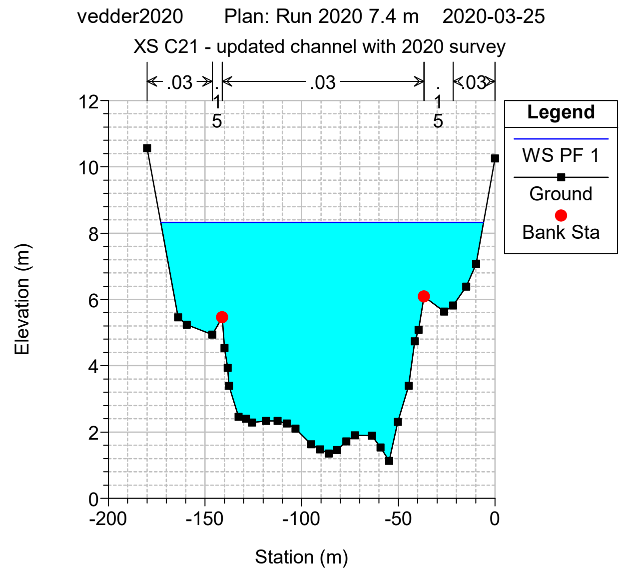
Ground
Bank Sta
Elevation (m)
Station (m)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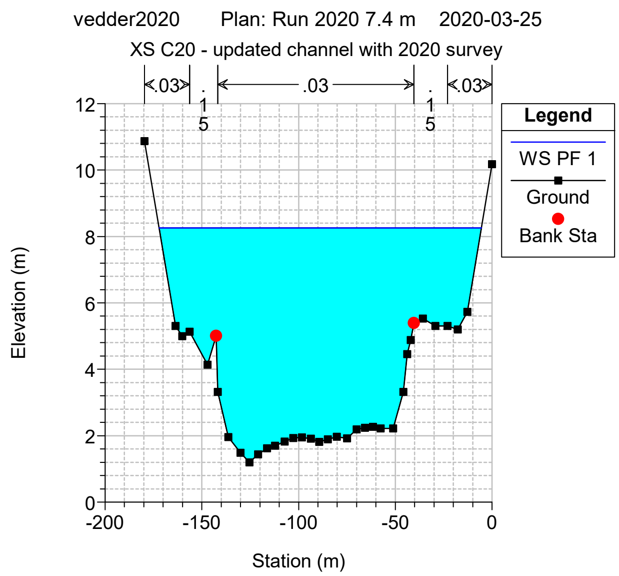
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)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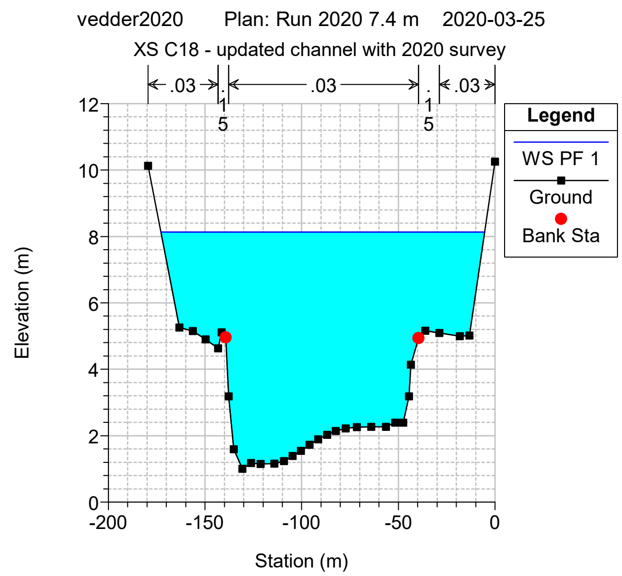
XS C20 - updated channel with 2020 survey
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)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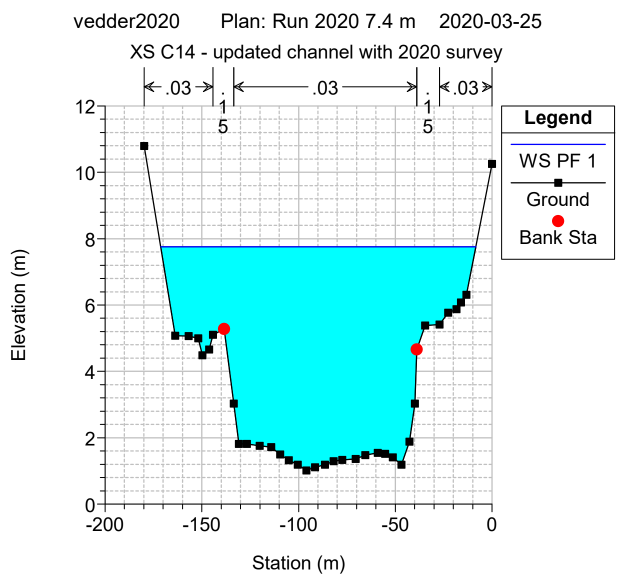
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)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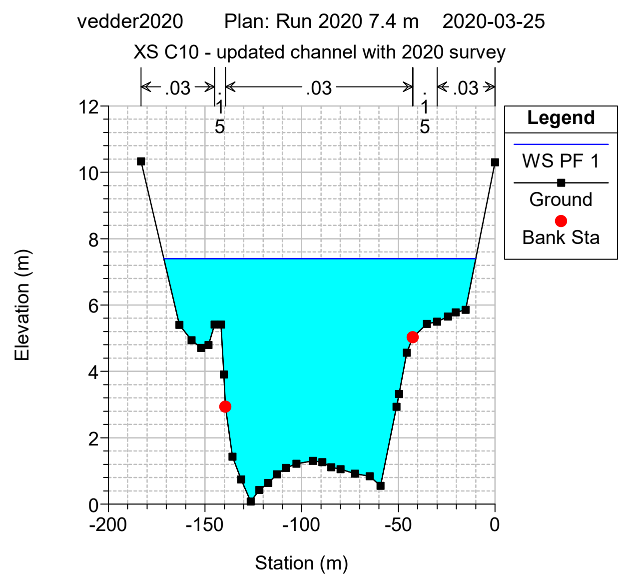
XS C14 - updated channel with 2020 survey
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)


vedder2020 Plan: Run 2020 7.4 m 2020-03-25
XS C10 - updated channel with 2020 survey
Legend
WS PF 1
Ground
Bank Sta
Elevation (m)
Station (m)

KERR WOOD LEIDAL
consulting engineers

Appendix D

Nova Pacific Proposed 2020 Vedder River Sediment Removal Plan

Preliminary
Vedder River Gravel Excavation Sites for 2020
Notes and Excavation Layouts

Vedder River Management Area Committee
Draft - April 28, 2020

Prepared by

Bruce Wright
Tatiana Kozlova
Stefanie Schoenberger
Michael Richard

Nova Pacific Environmental, Ltd.

The following notes and accompanying drawings are intended to provide a forum for discussion of potential sites for sediment removal in Summer 2020. The excavations generally follow program criteria for site selection and design.

Within limits, site selections and designs can be revised to address sediment removal targets identified for each reach or sub-reach. The focus for this set of excavations is on the freeboard limited area and Canal excavations that can influence the backwater curve. As well, two excavations immediately upstream of the sediment deposition area are included to help limit downstream movement of sediment into the freeboard limited area.

Estimated quantities have been calculated to take sloped edges into account. Specific LWD placements have not been shown although it is expected that most excavations will include some LWD features, depending on availability of material and opportunities at each site. Habitat excavations have been indicated where these are appropriate.

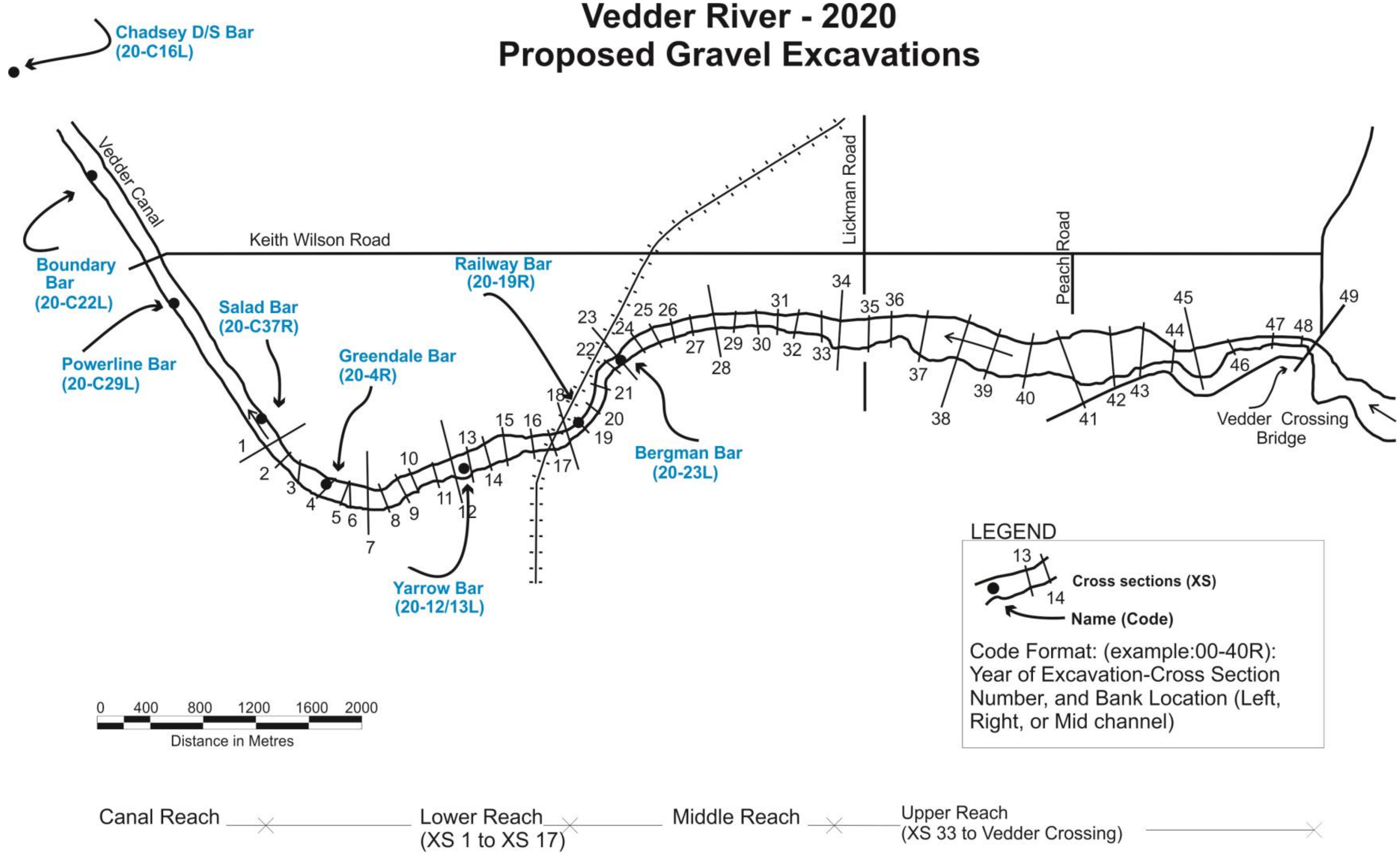
Designs and commentary provided are preliminary. Additional material including: agency permit applications and support documents, site specific mitigation plans, construction drawings and an evaluation of anticipated net habitat changes will be prepared, for sites that are selected for excavation in 2020. The current freshet may also change conditions significantly and accordingly final excavations will be field fit to address specific conditions at the time of excavation.

All excavation designs incorporate slopes to maintain the integrity of the channel in the excavation areas and to ensure that anticipated changes yield optimal habitat outcomes. Low slopes are intended to limit risk of headcutting and spawning activity within the excavations. Steep slopes are generally intended to collapse into the pit to restore normal channel configurations with increased freeboard and minimal river impacts. Wide openings will be excavated to prevent trapping of fish by water fluctuations as the pit fills.

Table 1: Bars Considered and Anticipated Yield from Eight Proposed Candidate Sites

#	Bar Name	Plan Developed	VRTC 1 comments	Yield (m^3)	Comment
1	Bergman	Y		20,000	
2	Railway	Y		4,000	
3	Yarrow	Y		7,000	
4	Greendale	Y		6,000	
5	Salad (A)	Y		6,000	
6	Powerline	Y		8,000	
7	Boundary	Y		19,000	
8	Chadsey	Y		25,000	
	Total			**95,000**	

Vedder River - 2020
Proposed Gravel Excavations



Site Name: Bergman **Site Number:** 1
Identifier: 20-23L
Location: Adjacent to Bergman Stockpile, near the north end of Bergman Rd.

Previous Excavations: 1994, 1998, 2000, 2002, 2006, 2010, 2014, & 2016 (approximate location by XS identifier)

Stockpile: Bergman Stockpile

Length: 154 m
Avg. Width: 42 m
Depth: 4 m
Expected Gravel Yield: 20,000 m³

Bar Access:
North on Bergman Road, past setback dyke to Bergman Stockpile. Upstream end of bar can be accessed with a constructed ramp from top of armoured bank. Culvert probably not required this year.

Objectives and Effectiveness:
The main purpose of this excavation would be to intercept gravel upstream of the area of freeboard limitation. The bar is estimated to have approximately 1m in height above low water levels

Mitigation Plans:
Mitigation measures described on the first page of this document apply at this location. The proposed outlet includes a connection to both the mainstem and the lower portion of the habitat channel. The downstream habitat is being maintained but due to the rapid aggradation upstream the upstream habitat component will likely be omitted. Excavation of these channels is straightforward and will contribute additional gravel with limited extra cost.

Habitat Considerations:
Maintaining the downstream low flow channel through the bar would increase habitat complexity at this location. The excavation extends to the left bank so that as the bar refills, more of the left bank habitat channel is likely to reform with water provided by sub-gravel flow. The habitat channel can be enhanced with LWD as has been done in past cycles.

Anticipated Outcome:
It is expected this excavation would refill quickly. However, a low flow channel through the middle of the bar may persist as occurred in 2016. This would be a large excavation that would allow for a significant amount of new material to be trapped.

Comments:

2020 Construction Drawing: Bergman Bar

Plan Date: April 24, 2020 Photo: April 9, 2020

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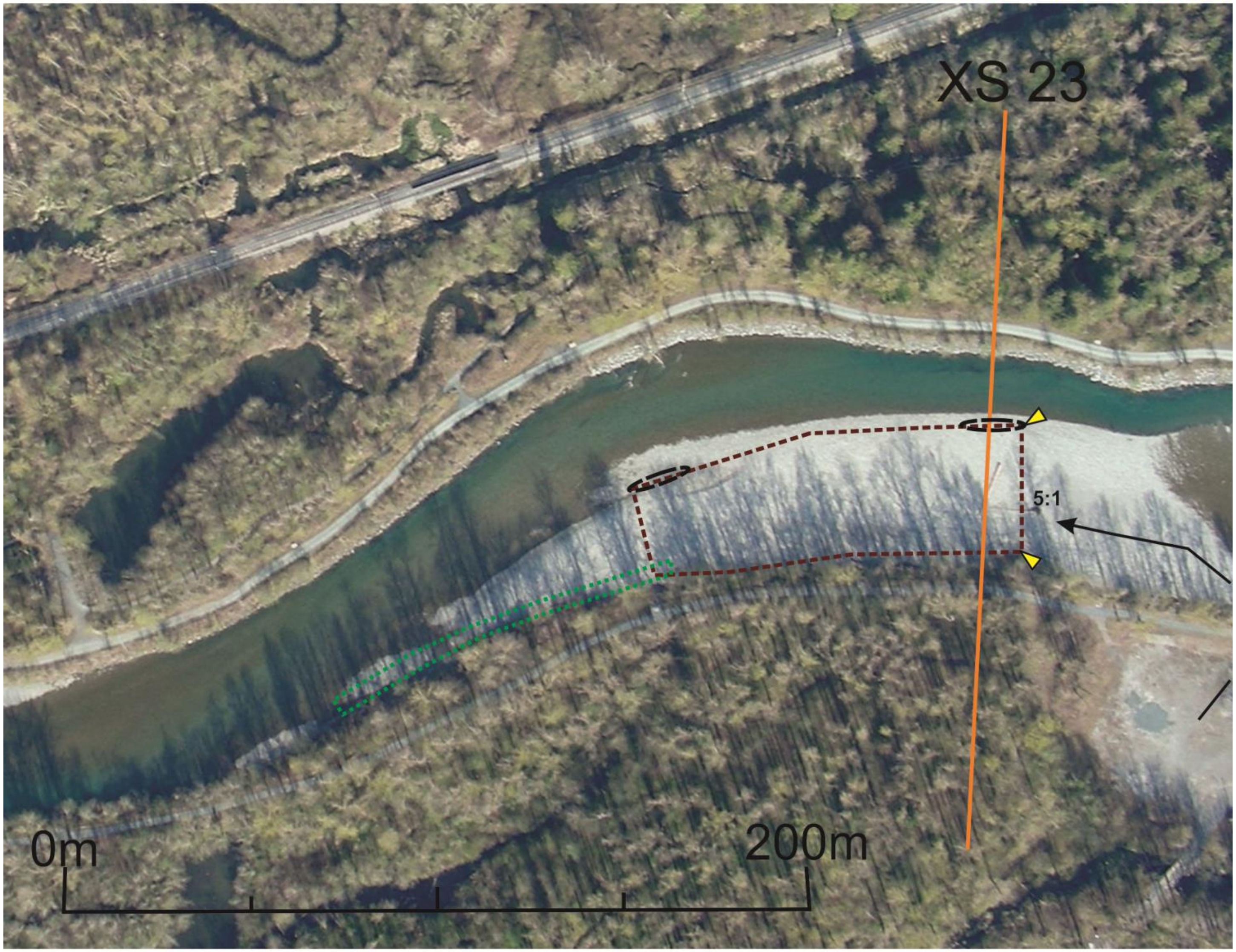

Culvert Crossing
Perimeter of proposed excavation
Habitat excavation

Slope change point
Pit openings
Access Route
Pit Slopes are 1.5:1 unless otherwise shown

Volume = 20,000 m^3

Avg. Length = 154m
Width = 42m
Depth = 4m

Site Name: Railway Bar **Site Number:** 2
Identifier: 20-19R
Location: Approximately 180m upstream from the railway bridge

Previous Excavations: 1994, 1998, 2004, 2006, 2008, 2010, 2014, & 2016 (approximate location by XS identifier)

Stockpile: Hooge Stockpile

Length: 140 m
Avg. Width: 7 m
Depth: 3 m
Expected Gravel Yield: 4,000 m^3

Bar Access:
From Keith Wilson, south on Sinclair Rd., then east along the setback dyke to parking area and stockpile location. Proceed west along the trail following the existing bank protection works.

Objectives and Effectiveness:
Small excavation but should refill and reduce the amount of gravel moving downstream into the freeboard limited reach.

Mitigation Plans:
In addition to the mitigation measures described on the first page of this document, the excavation will avoid the riprap at the new culvert outlet to ensure that it does not slump into the pit.

Habitat Considerations:
Significant chum salmon spawning has been noted in the channel along the right bank at the downstream portion of the bar and this has been maintained concurrently with this excavation in the past. This work may continue but with the recent habitat works, a prior discussion with DFO is needed. Abundant pink salmon spawning has also been recorded between the downstream end of the bar and the railway bridge. Maintenance of these habitats is a critical concern in the design of this excavation.

Anticipated Outcome:
It is expected this excavation pit will refill quickly and the general configuration of the river at this location will be maintained.

Comments:

2020 Proposed Excavations: Railway Bar (20-19R)

Plan Date: April 24, 2020 Photo: April 9, 2020

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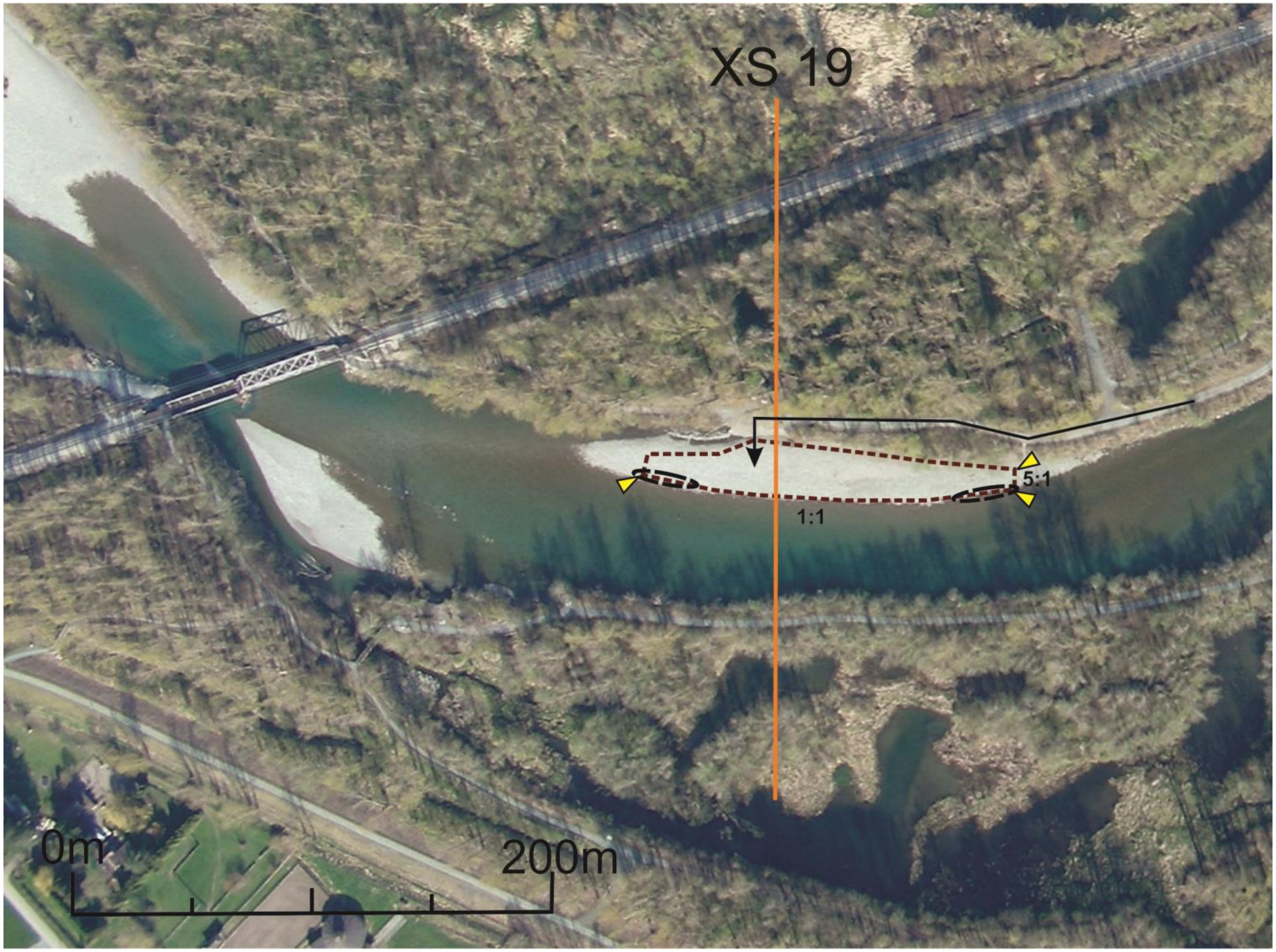

Culvert Crossing

Perimeter of proposed excavation

Habitat excavation

Slope change point

Pit openings

Access Route

Pit Slopes are 1.5:1 unless otherwise shown

Volume = 4,000m^3

Avg. Length = 140m

Width = 7m

Depth = 3m

Site Name: Yarrow Bar **Site Number:** 3
Identifier: 20-12/13L
Location: North end of Wilson Road

Previous Excavations: 1994, 1995, 1996, 1998, 2000, 2004, 2006, 2008, 2010, 2012, 2014, & 2016 (approximate location by XS identifier)

Stockpile: Wilson Road Stockpile (or restored stockpile located along setback dyke near the railway)

	PIT	SCALP
Length:	98 m	93 m
Avg. Width:	18 m	20 m
Depth:	3.5 m	0.5 m
Expected Gravel Yield:	6,000 m^3	1,000 m^3

Bar Access:
From north end of Wilson Road, around the perimeter of the stockpile site to avoid wells. A culvert will likely be required.

Objectives and Effectiveness:
This excavation is at the upstream end of freeboard limited zone and is expected to contribute to increased floodway capacity. In addition to the excavation a scalp is being proposed to encourage flow toward the left bank across the main bar and increase riffle habitat in this area.

Mitigation Plans:
The mitigation measures described on the first page of this document will be followed. Measures including “stand-by” silt fencing, sediment traps and strict maintenance would be incorporated to prevent input of sediment into the river or habitat channel related to any culverts that are required.

Habitat Considerations:
LWD features, will be incorporated where suitable. The proposed scalp will also provide new riffle habitat across the bar and enhance the pool habitat remaining from the prior excavation. Minor excavations to improve low flow connectivity to left bank microchannel is proposed. be protected as well as eddy pool near the upstream end of the excavation

Anticipated Outcome:
This excavation would be expected to refill while potentially providing additional braided low flow channels which would further additional habitat at this location.

Comments:

2020 Proposed Excavations: Yarrow Bar (20-12/13L)

Plan Date: April 24, 2020 Photo: April 9, 2020

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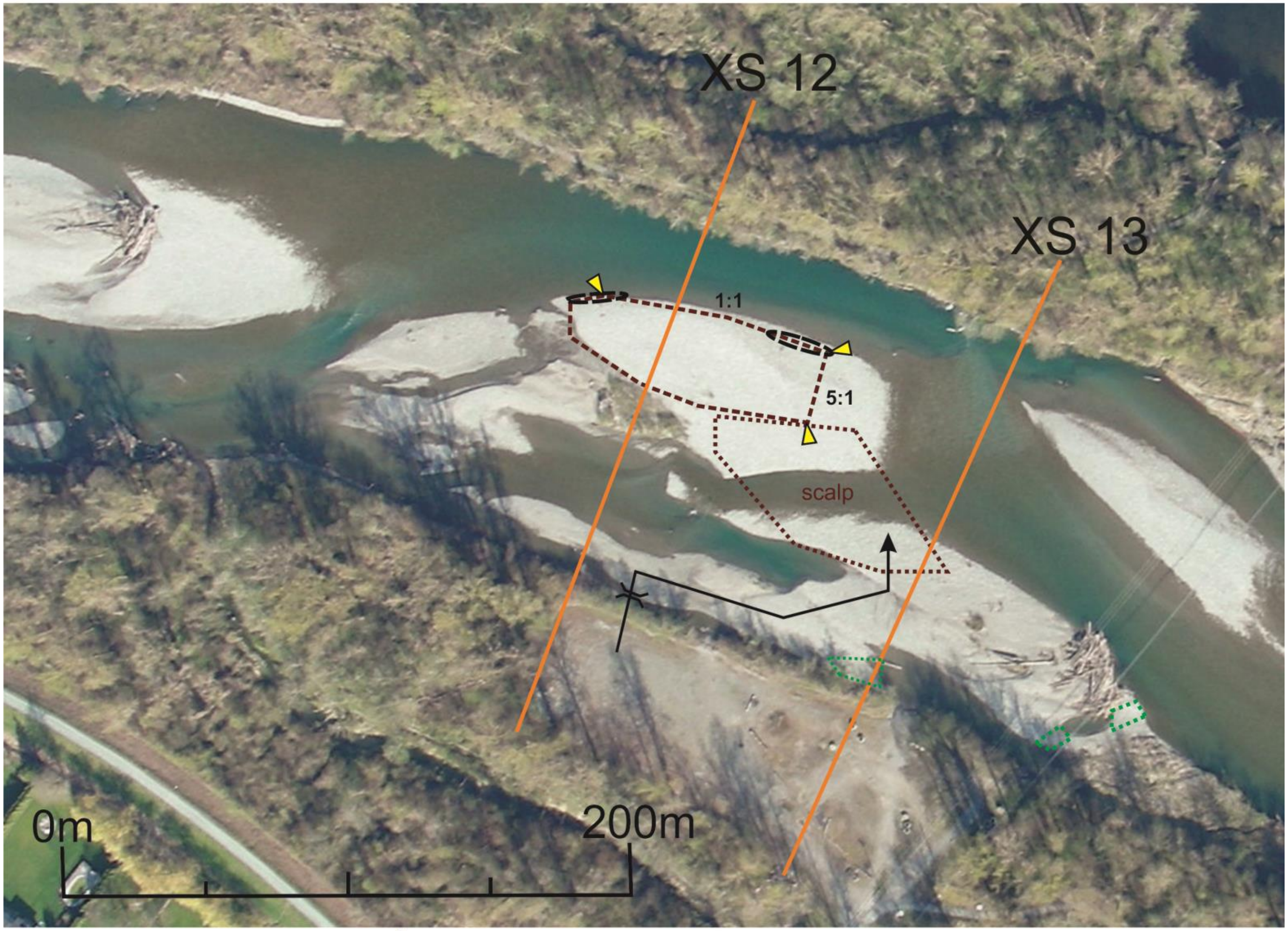

Culvert Crossing

Perimeter of proposed excavation

Habitat excavation

Slope change point

Pit openings

Access Route

Pit Slopes are 1.5:1 unless otherwise shown

Volume (pit) = 6,000m^3

Avg. Length = 98m

Width = 18m

Depth = 3.5m

Volume (scalp) = 1,000m^3

Avg. Length = 93m

Width = 20m

Depth = 0.5m

Site Name: Greendale Bar **Site Number:** 4
Identifier: 20-4R
Location: Adjacent (upstream) to Greendale Stockpile

Previous Excavations: 1994, 1998, 2000, 2004, 2006, 2008, 2010, & 2012 (approximate location by XS identifier)

Stockpile: Greendale Stockpile

	PIT (Downstream)	PIT (Upstream)
Length:	86 m	36 m
Avg. Width:	21 m	27 m
Depth:	3 m	2.5 m
Expected Gravel Yield:	5,000 m^3	1,000 m^3

Bar Access:
Along north dike access road from east end of Keith Wilson Bridge to parking area at Greendale Stockpile. Thence along the Rotary Trail to existing access point Two culverts would be required to reach the D/S bar area on the vegetated island.

Objectives and Effectiveness:
Improve channel capacity in the freeboard limited section of the river. May help to reduce erosional energy against the left bank at this location. A smaller pit is also being proposed at the upstream end of Greendale Bar to encourage flow through the channel between the vegetated island and the right bank.

Mitigation Plans:
The mitigation measures described on the first page of this document will be followed. Culverts or possibly a bridge would be required to excavate the pit on the island and measures would be incorporated to reduce input of sediment into the river.

Habitat Considerations:
The opening to the secondary channel along the right bank will be re-excavated and enhanced in an effort to improve flow and habitat along the right bank. This excavation is relatively risky from the habitat perspective as it is proximal to existing high habitat values located around the vegetated island.

Anticipated Outcome:
It is expected that the upstream excavation will refill quickly with the downstream excavation potentially delayed.

Comments:

2020 Proposed Excavations: Greendale Bar (20-4R)

Plan Date: April 24, 2020 Photo: April 9, 2020

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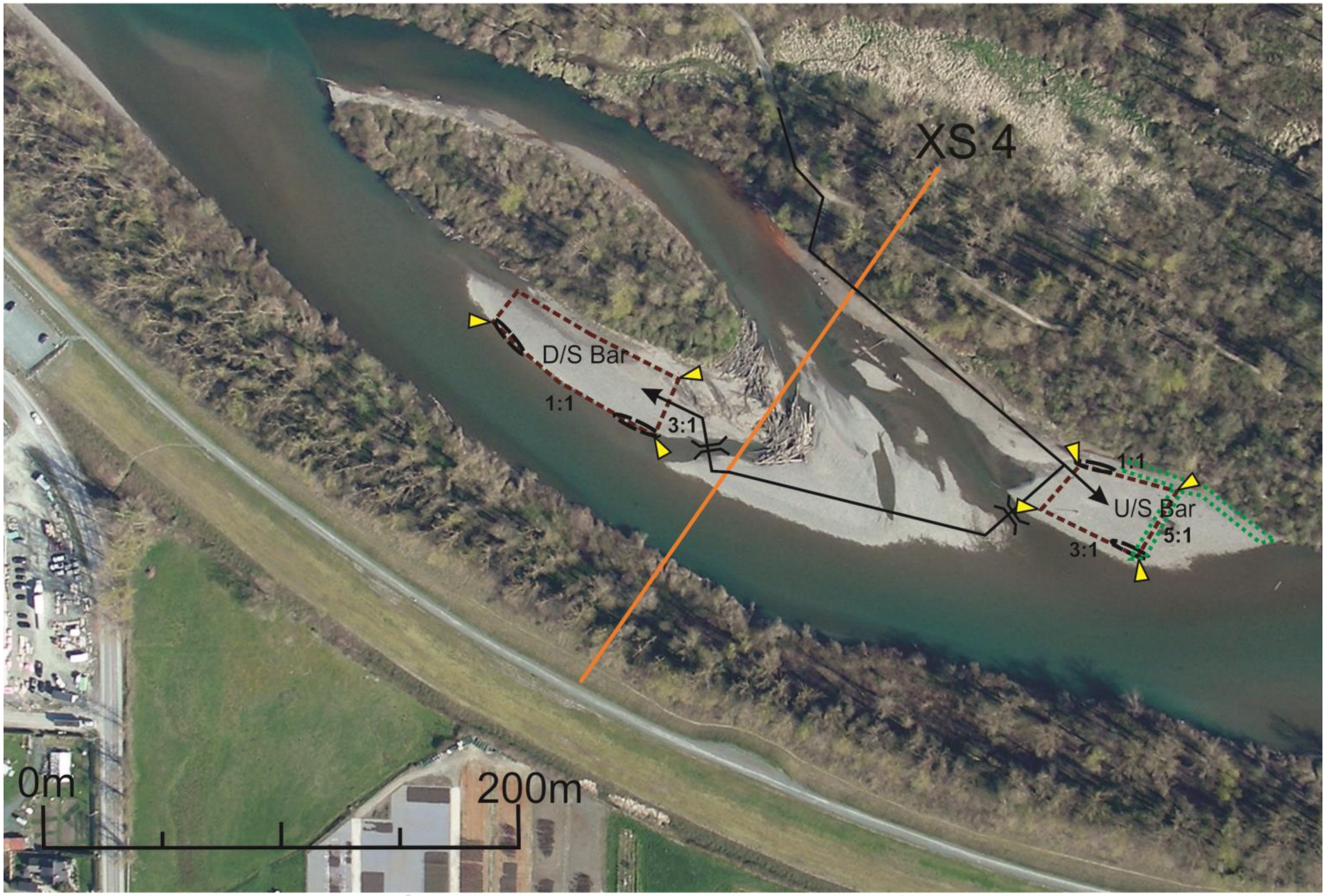


Culvert Crossing

Perimeter of proposed excavation

Habitat excavation

Slope change point

Pit openings

Access Route

Pit Slopes are 1.5:1 unless otherwise shown

Volume (d/s) = 5,000m^3

Avg. Length = 86m
Width = 21m
Depth = 3m

Volume (u/s) = 1,000m^3

Avg. Length = 36m
Width = 27m
Depth = 2.5m

Site Name: Salad Bar A **Site Number:** 5
Identifier: 20-Canal 37R
Location: Adjacent (downstream) to Greendale Stockpile

Previous Excavations: 1994, 2004, 2006, 2008, & 2014 (approximate location by XS identifier)

Stockpile: Greendale Stockpile

Length:	118 m
Avg. Width:	26 m
Depth:	2.5 m
Expected Gravel Yield:	6,000 m^3

Bar Access:
East along Dyke Crest Rd. from east end of Keith Wilson Bridge to blocked access road approximately 100m west of the parking area at the Greendale Stockpile site. The access road would need to be unblocked and at least two culverts would be required to reach the bar.

Objectives and Effectiveness:
Lower water levels in the freeboard limited area through backwater curve reduction

Mitigation Plans:
The mitigation measures described on the first page of this document will be followed. A culvert would be required, and measures would be incorporated to reduce input of sediment into the river.

Habitat Considerations:
The excavation design is intended to preserve the existing right bank secondary channel and the adjacent glide tail and riffles. This is key as this feature contributes to the key pink salmon spawning habitat at this location.

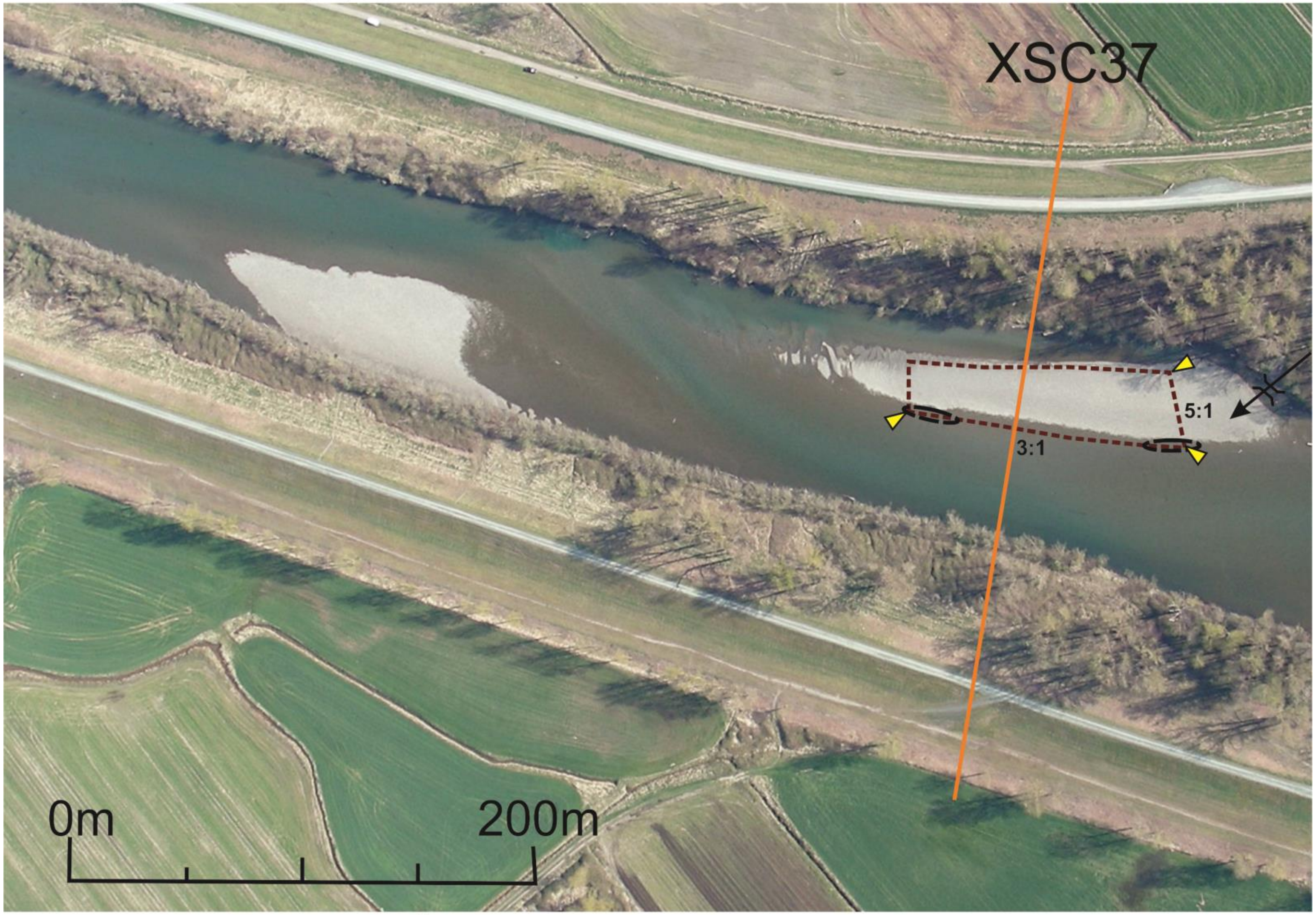
Anticipated Outcome:
It is anticipated that this excavation will return to its original configuration.

Comments:

2020 Proposed Excavations: Salad Bar A (20-C 37)

Plan Date: April 24, 2020 Photo: April 9, 2020

Nova Pacific Environmental



Culvert Crossing

Perimeter of proposed excavation

Habitat excavation

Slope change point

Pit openings

Access Route

Pit Slopes are 1.5:1 unless otherwise shown

Volume = 6,000m^3

Avg. Length = 118m
Width = 26m
Depth = 2.5m

Site Name: Powerline Bar **Site Number:** 6
Identifier: 20-Canal 29L
Location: 200 m upstream of Keith Wilson Bridge

Previous Excavations: 1994 & 2004 (approximate location by XS identifier)

Stockpile: Boundary Road Stockpile

Length: 121 m
Avg. Width: 23 m
Depth: 3 m
Expected Gravel Yield: 8,000 m^3

Bar Access:
North along the left bank dike road from the Fisherman's Corner parking lot to Keith Wilson Bridge. The existing ramp down from the dyke road allows trucks to travel under the bridge and thence upstream to the bar access point. A ramp down to the bar will need to be constructed and at least one culvert would be required.

Objectives and Effectiveness:
Lower water levels in the freeboard limited area through backwater curve reduction

Mitigation Plans:
General mitigation measures as outlined on the first page of this document.

Habitat Considerations:
Protection of the secondary channel along the left bank is required. The lateral riffle downstream of the bar will be enhanced by scalping the downstream end of Powerline Bar.

Anticipated Outcome:
It is expected this excavation will provide additional riffle habitat as it slowly refills.

Comments:
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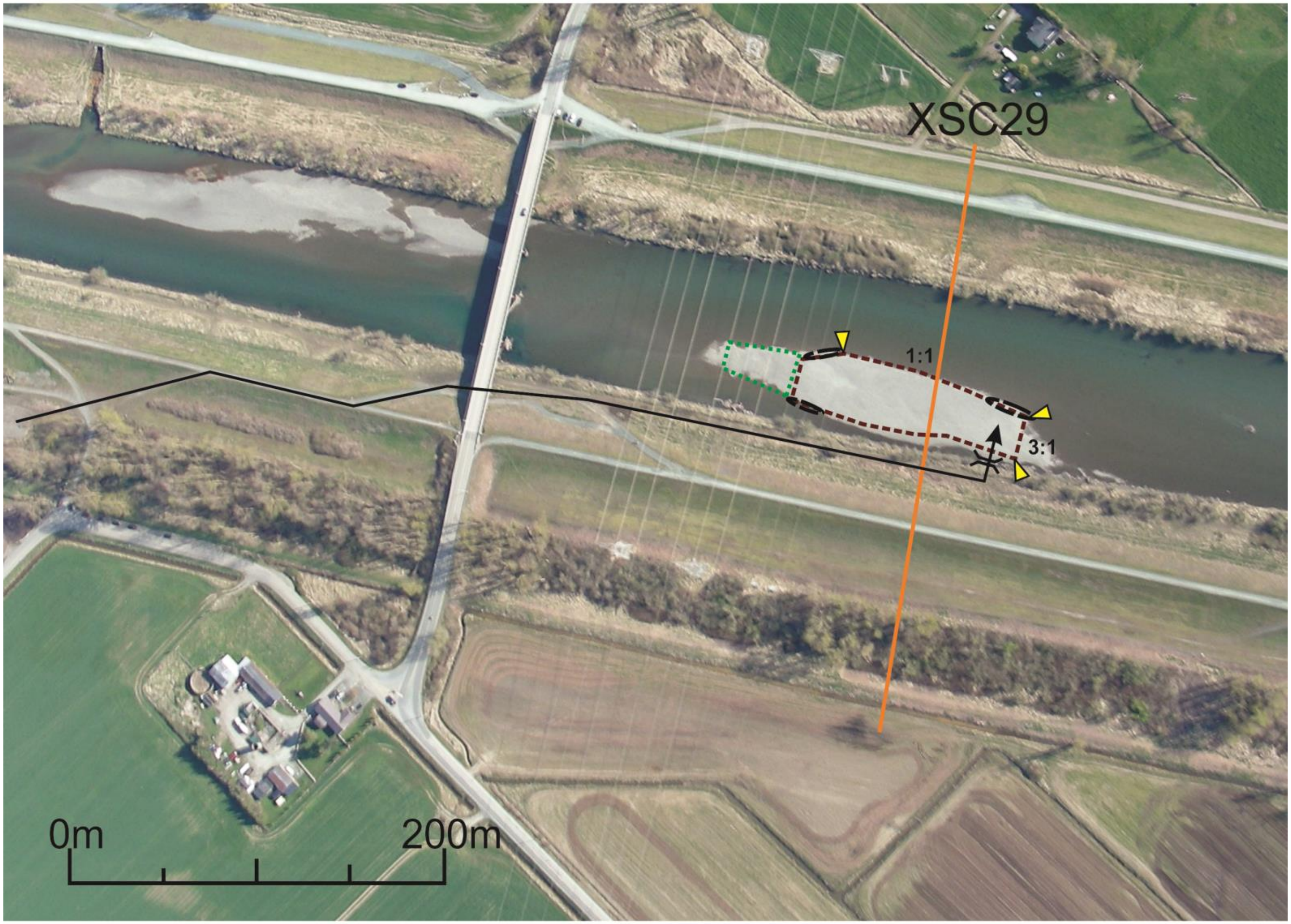
2020 Proposed Excavations: Powerline Bar (20-C 29L)

Plan Date: April 24, 2020   Photo: April 9, 2020

Nova Pacific Environmental



Culvert Crossing

Perimeter of proposed excavation

Habitat excavation

Slope change point

Pit openings

Access Route

Pit Slopes are 1.5:1 unless otherwise shown

Volume = 8,000m^3

Avg. Length = 121m
Width = 23m
Depth = 3m

Site Name: Boundary Bar **Site Number:** 7
Identifier: 20-Canal 22L
Location: 800 meters downstream of Keith Wilson Bridge

Previous Excavations: 2002 & 2014 (approximate location by XS identifier)

Stockpile: Boundary Road Stockpile

Length: 185 m
Avg. Width: 57 m
Depth: 2.5 m
Expected Gravel Yield: 19,000 m^3

Bar Access:
Northwest along the left bank dike road from the Fisherman's Corner parking lot. A ramp down from the dyke top to the low bank and then a second ramp down to the bar would be required. A culvert is not likely to be needed.

Objectives and Effectiveness:
To improve backwater curve reducing risk of dyke overtopping upstream in the freeboard limited section of the Vedder River.

Mitigation Plans:
General mitigation measures are outlined on the first page of this document. Excavation will extend to the bank with a buffer of approximately 5m to protect bank integrity.

Habitat Considerations:
The excavation will be constructed with habitat channels at the upstream and downstream ends of the bar against the left bank. Previously a habitat channel was provided along the full length but proved to be too shallow. Accordingly, excavation to the bank is proposed.

Anticipated Outcome:
Presence of fines and woody debris may limit the excavation depth. It is expected this excavation will remove a significant amount of sediment from the canal section of the Vedder River with no net impact to fish habitat values.

Comments:

2020 Proposed Excavations: Boundary Bar (20-C 22L)

Plan Date: April 24, 2020 Photo: April 9, 2020

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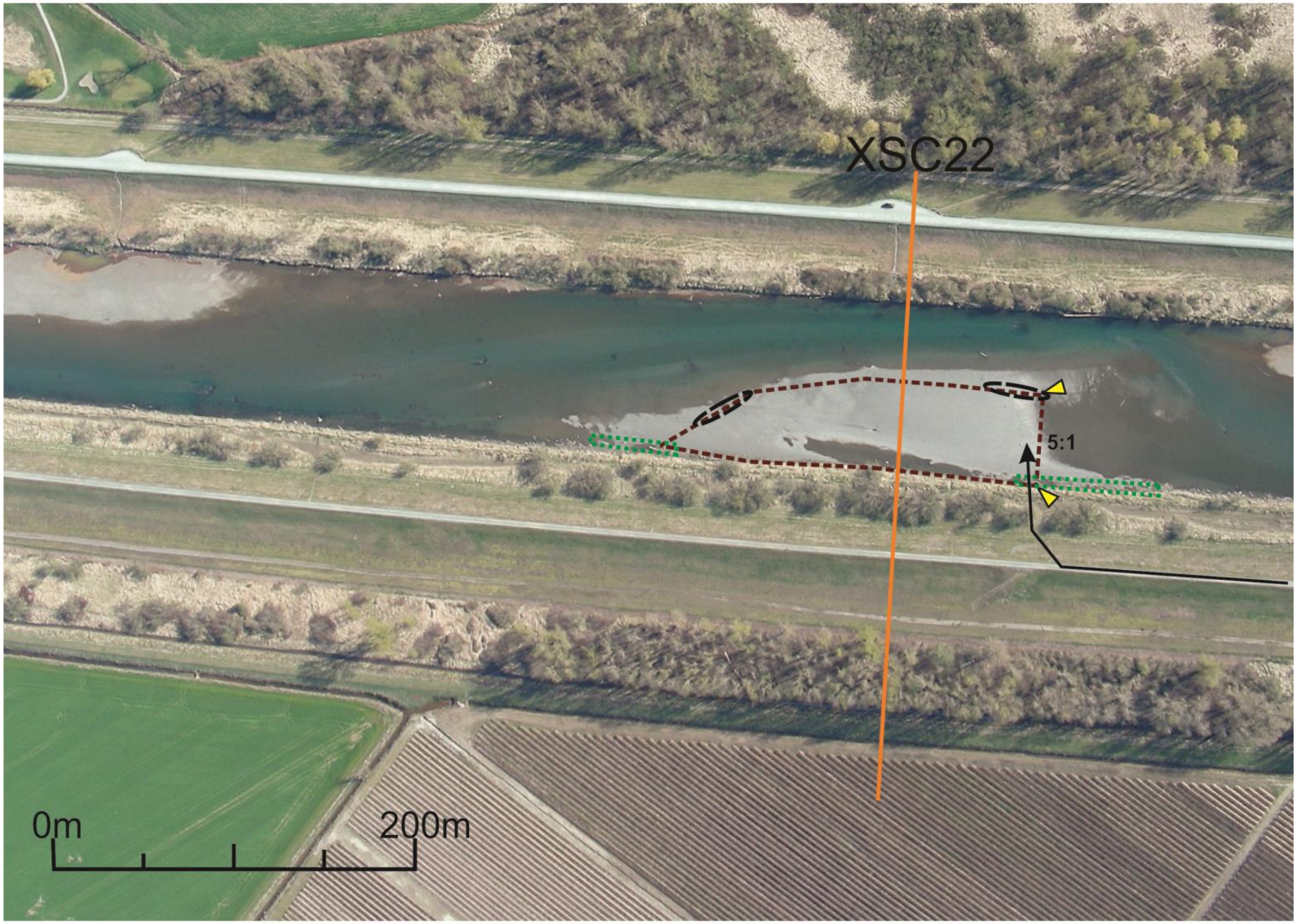


Culvert Crossing

Perimeter of proposed excavation

Habitat excavation

Slope change point

Pit openings

Access Route

Pit Slopes are 1.5:1 unless otherwise shown

Volume = 19,000m^3

Avg. Length = 185m
Width = 57m
Depth = 2.5m

Site Name: Chadsey D/S **Site Number:** 8
Identifier: 20-Canal 16L
Location: 1,900 meters downstream of Keith Wilson Bridge

Previous Excavations: n/a

Stockpile: Boundary Road Stockpile

Length:	248 m
Avg. Width:	44 m
Depth:	2.5 m
Expected Gravel Yield:	25,000 m³

Bar Access:
Northwest along the left bank dike road from the Fisherman's Corner parking lot. A ramp down from the dyke top to the low bank and then a second ramp down to the bar would be required. A culvert is not likely to be needed.

Objectives and Effectiveness:
This bar has not been previously excavated and it extends across approximately 2/3 of the channel. In addition to potential backwater benefit to the freeboard limited section of the river, this excavation should alleviate the erosion occurring on the right bank which appears to be new and related to the recent formation of this bar.

Mitigation Plans:
General mitigation measures are outlined on the first page of this document.

Habitat Considerations:
In addition to increasing wetted habitat in the lower canal area, the excavation will be constructed with habitat channels at the upstream and downstream ends of the bar against the left bank.

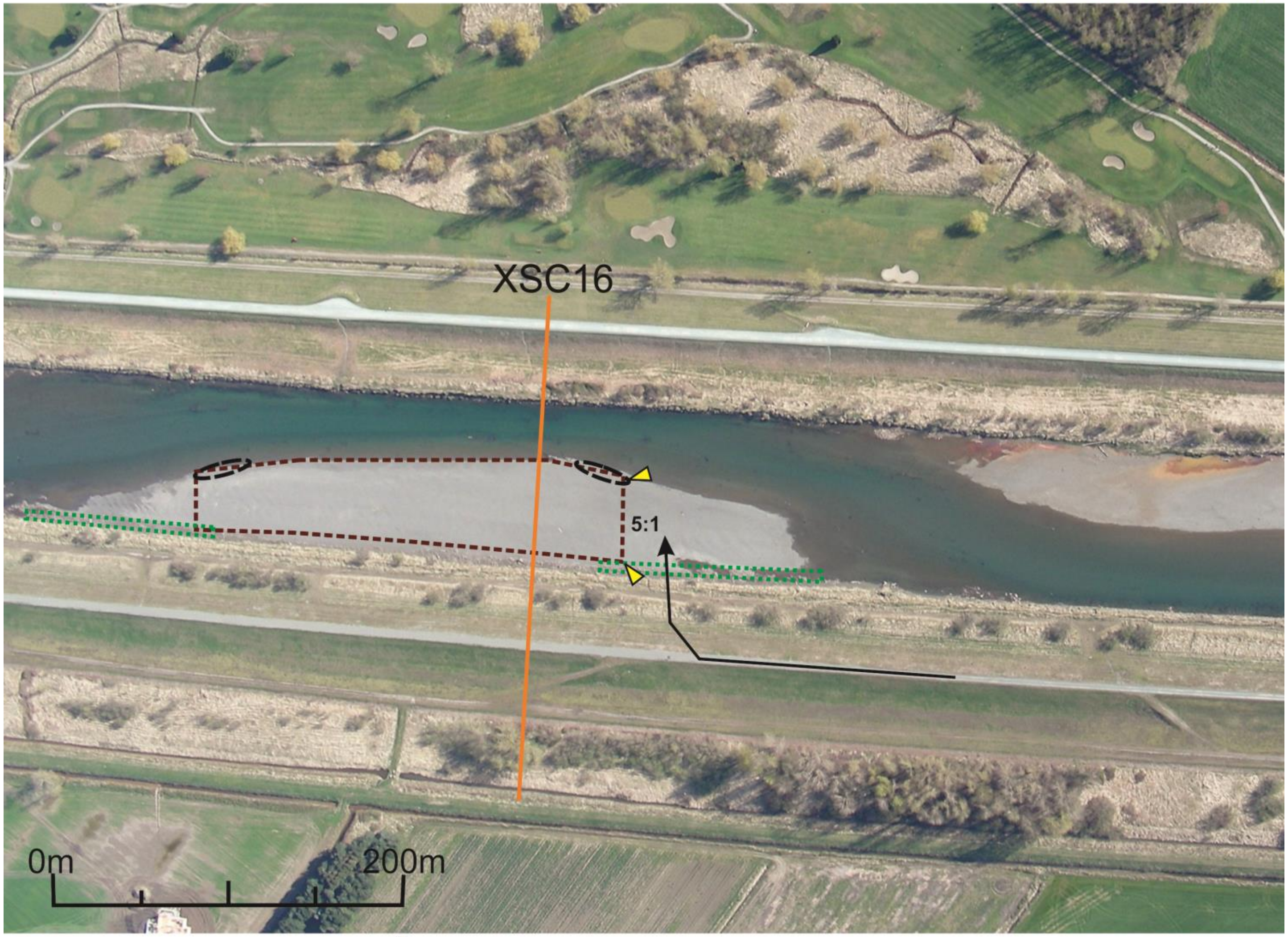
Anticipated Outcome:
This excavation will result in the largest sediment yield of all proposed excavations for the 2020 program. It is expected this excavation will remove a significant amount of sediment from the canal section of the Vedder River with minimal impact to fish habitat values while mitigating erosion on the right bank at this location.

Comments:

2020 Proposed Excavations: Chadsey D/S Bar (20-C 16L)

Plan Date: April 24, 2020 Photo: April 9, 2020

Nova Pacific Environmental



Culvert Crossing

Perimeter of proposed excavation

Habitat excavation

Slope change point

Pit openings

Access Route

Pit Slopes are 1.5:1 unless otherwise shown

Volume = 25,000m^3

Avg. Length = 248m
Width = 44m
Depth = 2.5m


View of eroding right bank across from Chadsey Bar

KERR WOOD LEIDAL
consulting engineers

Appendix E

Detailed Water Level Change for All Bars Removed

Detailed Water Level Change for All Bars Removed

Cross Section	2020 Water Level Change with Gravel Removal (m)	Pre-Gravel Removal		Post-Gravel Removal	
		L Dike F.B. (m)	R Dike F.B. (m)	L Dike F.B. (m)	R Dike F.B. (m)
XS49	0.00	-	-	-	-
XS48	0.00	-	-	-	-
XS47	0.00	-	-	-	-
XS46	0.00	-	-	-	-
XS45	0.00	-	-	-	-
XS44	0.00	-	-	-	-
XS43	0.00	-	-	-	-
XS42	0.00	-	-	-	-
XS41	0.00	-	-	-	-
XS40	0.00	-	-	-	-
XS39	0.00	1.33	-	1.33	-
XS38	0.00	1.29	1.70	1.29	1.70
XS37	0.00	1.65	1.65	1.65	1.65
XS36	0.00	1.93	1.93	1.93	1.93
XS35	0.00	1.75	1.58	1.75	1.58
XS34	0.00	1.28	1.42	1.28	1.42
XS33	0.00	1.48	1.58	1.48	1.58
XS32	0.00	1.41	1.77	1.41	1.77
XS31	-0.01	1.22	1.40	1.23	1.41
XS30	0.00	1.32	1.35	1.32	1.35
XS29	0.00	1.13	1.18	1.13	1.18
XS28	-0.01	1.11	0.87	1.12	0.88
XS27	-0.03	1.07	0.95	1.10	0.98
XS26	-0.04	1.30	0.87	1.34	0.91
XS25	-0.10	1.09	1.11	1.19	1.21
XS24	-0.13	1.22	1.18	1.35	1.31
XS23.1	-0.38	1.37	1.26	1.75	1.64
XS23	-0.13	1.41	1.19	1.54	1.32
XS22	-0.04	1.57	-	1.61	-
XS21	-0.03	1.51	-	1.54	-
XS20	-0.04	1.34	-	1.38	-
XS19	-0.02	1.31	-	1.33	-
XS18	-0.01	1.61	-	1.62	-
XS50	-0.01	1.52	1.25	1.53	1.26
XS17.2					
SRBC					
XS17.1					
XS51	-0.02	2.03	1.71	2.05	1.73
XS16	-0.04	1.19	1.50	1.23	1.54
XS15	-0.05	0.98	1.11	1.03	1.16
XS14	-0.06	0.95	0.84	1.01	0.90
XS13	-0.05	0.76	0.58	0.81	0.63
XS12	-0.06	0.95	0.59	1.01	0.65
XS11	-0.06	0.88	0.50	0.94	0.56
XS10	-0.06	0.96	0.46	1.02	0.52
XS9	-0.07	0.98	0.40	1.05	0.47
XS8	-0.07	1.09	0.51	1.16	0.58
XS7	-0.07	1.06	0.85	1.13	0.92
XS6	-0.08	1.22	1.15	1.30	1.23
XS5	-0.08	1.23	1.22	1.31	1.30
XS4	-0.07	1.22	1.04	1.29	1.11
XS3	-0.07	1.33	0.73	1.40	0.80
XS2	-0.08	1.44	0.79	1.52	0.87
XS1	-0.08	1.58	0.96	1.66	1.04
XSC37	-0.06	1.67	0.94	1.73	1.00
XSC36	-0.08	1.67	0.70	1.75	0.78
XSC35	-0.09	1.81	0.94	1.90	1.03
XSC34	-0.09	1.86	0.95	1.95	1.04
XSC33	-0.10	2.02	1.10	2.12	1.20
XSC32	-0.10	2.07	1.48	2.17	1.58
XSC31	-0.11	2.23	1.66	2.34	1.77
CXSC29	-0.07	2.17	1.74	2.24	1.81
XSC27.1	-0.09	2.75	3.02	2.84	3.11
XSC27	-0.09	2.67	3.00	2.76	3.09
XSC26	-0.09	2.62	1.56	2.71	1.65
XSC25	-0.10	2.33	1.57	2.43	1.67
XSC24	-0.10	2.42	1.65	2.52	1.75
XSC23	-0.12	2.44	2.00	2.56	2.12
XSC22	-0.03	2.60	1.98	2.63	2.01
XSC21	-0.09	2.60	1.93	2.69	2.02
XSC20	-0.09	2.69	1.92	2.78	2.01
XSC18	-0.10	2.70	2.12	2.80	2.22
XSC14	0.00	3.17	2.49	3.17	2.49
XSC10	0.00	3.58	2.90	3.58	2.90