KERR WOOD LEIDAL
consulting engineers

Greater Vancouver
200 - 4185A Still Creek Drive
Burnaby, BC V5C 6G9
T 604 294 2088
F 604 294 2090

Technical Memorandum

DATE: March 2, 2020

TO: Tareq Islam
Fraser Valley Regional District

FROM: Erica Ellis, M.Sc., P.Geo.

RE: **CHILLIWACK RIVER SLESSE PARK**
Erosion Setback Line Update
Our File 2080.040-300

1. Introduction

1.1 Purpose of Project

Chilliwack River is an active gravel-bed river that has historically seen dramatic changes in channel position during large flood events. In the 1990s, the Fraser Valley Regional District (FVRD) commissioned the Chilliwack River Hazard Management Study. From this study, and related work, two erosion-related setback lines were developed:

1. The 100-year erosion limit line.
2. The erosion setback line.

The FVRD's Official Community Plan for Electoral Area E defines the 100-year erosion limit line as "the estimated limit of erosion over 100 years", and the erosion setback line as "the possible extent of erosion during a single major erosion event". Both lines are used by the FVRD to manage development adjacent to the Chilliwack River as presented in the FVRD's Hazard Acceptability Thresholds for Development Approvals guide (FVRD, 2017)[1].

FVRD has retained Kerr Wood Leidal Associates Ltd. (KWL) to update the 1990s erosion setback line for the Slesse Park area.

1.2 Project Team

The KWL project team and roles for this study are as follows:

- Erica Ellis, M.Sc., P.Geo. – Project Manager and Professional of Record;
- Mike Currie, M.Eng., P.Eng., FEC – Technical Reviewer and Professional of Record;
- Dylan Chernick, GradTech – Water Resources Technologist;
- Deanna Shrimpton – Junior Geomorphologist; and
- Jack Lau – GIS.

[1] Fraser Valley Regional District. (2017, June). *Hazard Acceptability Thresholds for Development Approvals.*

1.3 Study Area

The project is located on the Chilliwack River in the region of Slesse Park, approximately 20 km south-east of the City of Chilliwack. The study area, shown in Figure 1, extends approximately 4 km along the north side of the Chilliwack River, with an upstream limit near the large river bend adjacent to the Allison Pool Campground and a downstream limit at the Chilliwack Lake Road bridge.

2. Background

2.1 Previous Reports

FVRD provided the two previous studies that yielded the 100-year erosion limit line and the erosion setback line.

In July 1992, Hay & Company Consultants Inc. completed the “Chilliwack River Hazard Management Study” report. The study focused on the area between Slesse Park and Baker Trails (near Vedder Crossing). The purpose of the report was to provide guidance to protect development within the study reach from flooding, erosion, and landslides (Hay & Co et. al, 1992)[2]. The report contains a detailed analysis of flood history, geomorphology, geotechnical hazards, flood frequency, and flood mapping. The report provides an estimate of the 200-year return period flood limits as well as an estimate of cumulative erosion over 100 years.

In January 1993, Hay & Company produced a letter report titled “Erosion setback line – Chilliwack River Valley” (Hay & Co., 1993)[3]. The erosion setback line described in the report is the estimate of erosion potential during a single major event (greater than 50-year return period). Minimum setbacks included in the development of the line are 15 m for sections with bank protection works and 20 m for unprotected sections.

2.2 Hydrology

The nearest Water Survey of Canada (WSC) hydrometric station (08MH001 – Chilliwack River at Vedder Crossing) is located approximately 10 km downstream of the study area at the Vedder Road crossing. For the purpose of this study, hydrometric data was used from this station as no other significant confluences enter the Chilliwack River between the study area and the station.

The catchment area at station 08MH001 is 1230 km^2. Regionally, historic flooding tends to occur on the Chilliwack River during two periods: during freshet in the months of April to July, and during fall/winter storms during the months of October to February. Highest peak flows have historically occurred during fall and winter storm events (1-3 days), while longer duration (1-2 weeks) lower peak flow events occur during the snowmelt freshet.

Data for hydrometric station 08MH001 was obtained from Water Survey of Canada. Peak flow data between 1911 and 2017 is available; however, some years were missing data and there is a large gap in monitoring between 1930 and 1950. Some of the data gaps occur in years when large floods are known to have occurred (e.g., 1989, 1990).

---

[2] Hay & Company, Golder Associates, D.B. Lister and Associates, Urban Systems, R. Laird, K. Moore (1992). *Chilliwack River Hazard Management Study Interim Report*. Report produced for Fraser Cheam Regional District. 116 pp + tables, figures & appendices.

[3] Hay & Company (1993). Erosion setback line - Chilliwack River Valley. Letter report prepared for the Regional District of Fraser-Cheam. 7 pp. + maps.

Daily and Instantaneous peak flows between 1911 and 2017 are shown in Figure 2. Based on the available WSC data, three large (greater than 50-year return period) peak instantaneous flow events occurred during 1917, 2003 and 2006. Although WSC does not publish peak flows for 1989 and 1990, Hay & Co. et al. (1992) estimates each of these events to have had a daily average flow of about 700 m^3/s, and at the time these events were estimated to have a return period of about 40 years.

2.3 Geomorphology

Slesse Park is located about 9 km downstream of the Slesse Creek tributary, which contributes flow and sediment load to the Chilliwack River. The Slesse Park reach is currently characterized by large meander bends, with a generally single-thread channel and gravel bars on the inside of bends. Historically, the channel in this reach has displayed low-order braiding with mid-channel bars and islands. The bed material ranges from boulders to cobbles, while banks are composed of glaciolacustrine silt and clay. This reach has historically displayed channel instability, including a notable change in alignment during the 1990s (discussed later).

2.4 Historical Channel Changes

Historical air photographs were loaned from the Geographic Information Centre at the University of British Columbia. Historical air photos were reviewed using a stereoscope to asses changes in the channel morphology within the study reach. More recent (2016) orthophotos and LiDAR (2015) were also reviewed. To demonstrate channel changes, selected air photographs were scanned and georeferenced using ArcGIS and 2016 orthophotos.

Table 1 summarizes the most significant changes in the study reach of the Chilliwack River by decade since historical images were available in the 1940's.

Table 1: Summary of Historical Changes of the Slesse Park Reach by Decade

1940's	• Slesse Road is present but very little development on the floodplain. • Downstream end of study reach: more meandering than current alignment. Single-thread channel with point-bars, and the occasional mid-channel bar. • Upstream end of reach, just downstream of Slesse Slide, the right-bank meander bend has a prominent side channel. Side channel appears to have been active historically but is beginning to vegetate.
1950's	• Development on floodplain. Chilliwack Lake Road (and bridge crossing) constructed. • General morphology similar to 1940's although meanders are more pronounced. In the meander upstream of Slesse Slide (near Allison Pools), a sharp bend has formed. • Formerly bare gravel bars now generally heavily vegetated (very little exposed bar). The abandoned right-bank side channel is mostly vegetated.
1960's	• More development on floodplain observed, including some houses. Some indication that Obyrne Road may have been eroded by the river at one location and then later widened and repaired. • More gravel bars observed to be exposed along entire length of river.
1970's	• Additional residential development on the floodplain. Obyrne Road appears to have been eroded again. Additional bank protection placed along Obyrne Road. • Minor changes in morphology. Meander bend upstream of Slesse Slide (near Allison Pool) is cut-off.
1980's	• Slesse Park community well-established. • Side channel in meander bend downstream of Slesse Slide has been partially re-activated. • Unvegetated gravel bars more prominent, some shifting of bars.
1990's	• Most significant shift in gross morphology during the period of observed record: downstream portion of study reach has straightened through erosion of two meanders. • Large areas of bare gravel bar in straightened reach.
2000's	• Gravel bars have largely revegetated. • Channel is generally single-thread channel with few meanders. • Upstream of Slesse Slide meander (near Allison Pool), the channel is still braided and continues to exhibit instability.

As indicated in Table 1, the largest morphologic change captured in the historical air photo record occurred in the 1990s: Hay & Co. et al. (1992) indicate that this change occurred during the November 1990 flood. Figure 3 shows a comparison of the Slesse Park reach from before (1986) and after (1993) the November 1990 event. As shown, there was a notable change in alignment (rather than progressive erosion at the outside of existing bends), as part of which two meander bends were cut off, resulting in a much straighter channel alignment.

Figure 3 illustrates the dynamic nature of the Chilliwack River and the potential for change within the study reach in a single, large flood event. In addition, the air photo review indicates that there are old channels in now-vegetated areas that could become activated in a flood (these are also visible in the LiDAR topography).

3. Methodology

3.1 Development of Updated Erosion Setback Line

The general approach taken in updating the erosion setback line is summarized below.

- A desktop review of 2016 orthophotos and 2015 LiDAR was conducted to identify high banks, terraces, and historic channels. Locations of bedrock outcrops and log jams were also noted.
- The 'estimated natural boundary' was digitized based on 2016 orthophotos, and a corresponding elevation profile was extracted from 2015 LiDAR.
- The 'estimated natural boundary' profile was extrapolated in GIS to create a surface representing an area where floodwaters could regularly reach (i.e., an estimate of the active floodway).
- A draft erosion setback line was produced by considering the active river corridor in conjunction with topographical features that would have the potential to reduce erosion (e.g., high banks and bank protection works).
- A field inspection was conducted along the draft erosion setback line to identify any features not immediately obvious in orthophotos imagery or LiDAR, and to verify the locations of the features identified. Adequacy and erosion potential of the various features along the reach was also considered (e.g. existing banks and bank protection works).

The FVRD approach for building and subdivision applications was also considered in the development of the erosion setback line. A significant point arising from this consideration is that building permit applications that are on the riverside of the erosion setback line require a supportive engineering report, while those on the land side of the erosion line do not. Therefore, establishment of the new erosion setback line endeavoured to provide an appropriate delineation between these two situations in view of the erosion hazard.

3.2 Additional Detail on the Erosion Setback Line Update Work.

Desktop Analysis

Desktop analysis of orthophotos and LiDAR was conducted using ArcGIS 10.6.1. LiDAR was interpreted both in terms of derived 1 m contours, as well as a hillshade digital elevation model (DEM). As noted previously, orthophotos are from 2016 and LiDAR is from 2015: as such, more recent changes to the morphology of the river may not be captured.

Using GIS, KWL visually mapped the 'estimated natural boundary' for the river-right (north) bank of the study reach. The estimated natural boundary was defined as the transition from bare sediment to vegetation. The purpose of estimating the natural boundary line was to establish the active river floodway where the ground is low and subject to relatively frequent flood inundation, regardless of distance from the current active river channel.

The following assumptions were used in the development of the estimated natural boundary line:

- In locations with dense canopy, the estimated natural boundary line was drawn at the assumed centre of the obscuring tree trunk.
- The estimated natural boundary line was drawn at the top of the bank in areas with obvious (reasonable quality) riprap bank protection.
- Log jams were assumed to be transient features and were not identified as bank protection.
- Sporadic vegetation growing on the bank and on gravel bars were ignored due to minimal erosion protection.

The completed estimated natural boundary line was assigned elevations using the 2015 LiDAR. The resulting elevation profile is shown in Figure 4. The profile displays an overall consistent trend through the study reach. Local variations were examined and appear to result from mapping inaccuracies, which captured areas of locally-high riverbanks (for example), or areas that are generally lower (for example, a vegetating gravel bar). An envelope curve was established which captures the general trend of highest points along the banks (while ignoring the smaller areas of high outliers).

The envelope curve was then spatially extrapolated into the adjacent floodplain areas to delineate areas that might be expected to become regularly wetted during a flood (i.e., an estimate of the active floodway). The rationale for this assumption is that the reason there is a transition from bare sediment to vegetation along river channels is that inundation occurs regularly enough to prevent vegetation from establishing. When compared with mapped historical channels, the active floodway encompassed these channels, which supports the notion that the active floodway is an area that could be inundated during a flood.

A draft erosion setback line was produced by considering the mapped active river floodway (to the estimated natural boundary line) in conjunction with topographical features that would have the potential to reduce erosion (e.g., high banks and bank protection works). The position of the draft erosion setback line was established using professional judgement and by considering local topographic features and channel characteristics. In some locations, particularly those with existing bank protection, the position of the erosion setback line was determined by projecting a 3H:1V slope from the observable bank toe to the top of bank and adding a 5 m setback from this point.

Field Visit

A site visit was completed on November 12, 2019 to visually assess the draft erosion setback line from the desktop analysis. Erosion-resistant features such as escarpments and bank protection identified in the orthophotos and LiDAR were confirmed in the field and reflected in the position of the erosion setback line. Consideration was also given to recent changes to the morphology of the river, updated bank protection works and residential development.

Table 2 describes features identified within the study reach that were considered in establishing the updated erosion setback line. Within this table, the study reach has been broken into sub-sections (identified by letters): these breaks and sub-section identifiers are also shown on Figure 5.

Table 2: Features Considered in Erosion Setback Line Update

Sub-Section	Summary
A	• Undeveloped area with alluvial fan present on right (north) bank, which provides higher ground to reduce erosion. Upstream end of updated line ties into existing higher ground. *The updated erosion setback line is on the land side of the 100-year erosion limit line, in places.*
B	• Area of lower-lying floodplain with multiple dwellings situated within 150 m of the current riverbank. River morphology indicates this is an area of historical channel instability, with much higher ground on the left (south) bank. During the site visit, signs of recent erosion were observed along the right bank including the undermining of large trees. The erosion setback line was established based on topographic features with allowance for potential channel change during a flood. *The updated erosion setback line is on the land side of the 100-year erosion limit line, in places.*
C	• Slesse Slide located on right (north) bank. Bank currently built up at an estimated 1.5H:1V slope and protected with riprap. Erosion setback line was determined by projecting a 3H:1V slope from the observable bank toe to the top of bank and adding a 5 m setback from this point.
D	• Area includes some residential development. Low-lying area with historic non-standard dikes (berms), old river channels and a creek fan. Updated erosion setback line follows the toe of valley wall and then transitions to an escarpment in the low-lying region behind the old berms. The setback line follows an escarpment in front of developed properties. *The updated erosion setback line is on the land side of the 100-year erosion limit line, in places.*
E	• Area of residential development. Sub-section of study reach with riprap on right (north) bank. Erosion setback line was determined by projecting a 3H:1V slope from the observable bank toe to the top of bank and adding a 5 m setback from this point.
F	• Area of residential development with variable river-side topography. Updated erosion setback line follows the north side of Obyrne Road. The position of the updated line was established considering topography, and potential risk to existing development.
G	• Area of residential development fronted by a steep embankment leading to an old river channel and vegetated floodplain. The position of the updated line was established considering topography, and potential risk to existing development. Erosion setback line was determined by projecting a 3H:1V slope from the observable bank toe to the top of bank and adding a 5 m setback from this point.
H	• Area of residential development with variable river-side topography. The position of the updated line was established considering topography, and potential risk to existing development.
I	• Area of undeveloped land where floodplain meets steep valley wall. The updated erosion setback line in this reach follows the natural valley wall until it meets Chilliwack Lake Road at the end of the study reach. *The updated erosion setback line is on the land side of the 100-year erosion limit line, in places.*

4. Conclusions and Recommendations

The updated erosion setback line for Slesse Park is presented in Figure 5.

In general, the location of the updated line does not differ greatly from the previous erosion setback line established by Hay & Co et al. (1992). Given the observed ability of Chilliwack River to dramatically change its alignment within a single large flood event, the erosion setback line must necessarily consider the potential for avulsion into older channels (including the reactivation of vegetated floodplain). As noted in Table 2, in a few locations the updated erosion setback line is now on the landside of the 100-year erosion limit line.

Based on the results of this study, it is recommended that:

1. FVRD consider updating the 100-year erosion limit line to be consistent with the updated erosion setback line.
2. FVRD consider integrating the updated erosion setback line to the existing downstream erosion setback line (or some other appropriate end point).
3. The erosion setback line be assessed (and updated if required) after future major events. A major event could be classified as an event with a peak flow greater than a 50-year return period or an event that causes a significant change in the river alignment in the study area.

KERR WOOD LEIDAL ASSOCIATES LTD.

Prepared by:

PROFESSIONAL PROVINCE OF E. R. ELLIS #32982 BRITISH COLUMBIA GEOSCIENTIST

March 2, 2020

Erica Ellis, P.Geo.
Project Geomorphologist

Reviewed by:

PROFESSIONAL PROVINCE OF M. V. CURRIE BRITISH COLUMBIA ENGINEER

March 2, 2020

Mike V. Currie, M.Eng., P.Eng., FEC
Technical Reviewer

DAC/EE

Statement of Limitations

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

This document represents KWL's best professional judgement based on the information available at the time of its completion and as appropriate for the project scope of work. Services performed in developing the content of this document have been conducted in a manner consistent with that level and skill ordinarily exercised by members of the engineering profession currently practising under similar conditions. No warranty, express or implied, is made.

Copyright Notice

Revision History

Revision #	Date	Status	Revision Description	Author
0	March 2, 2020	Final		DAC / EE
A	November 22, 2019	Draft	For client review.	DAC / EE

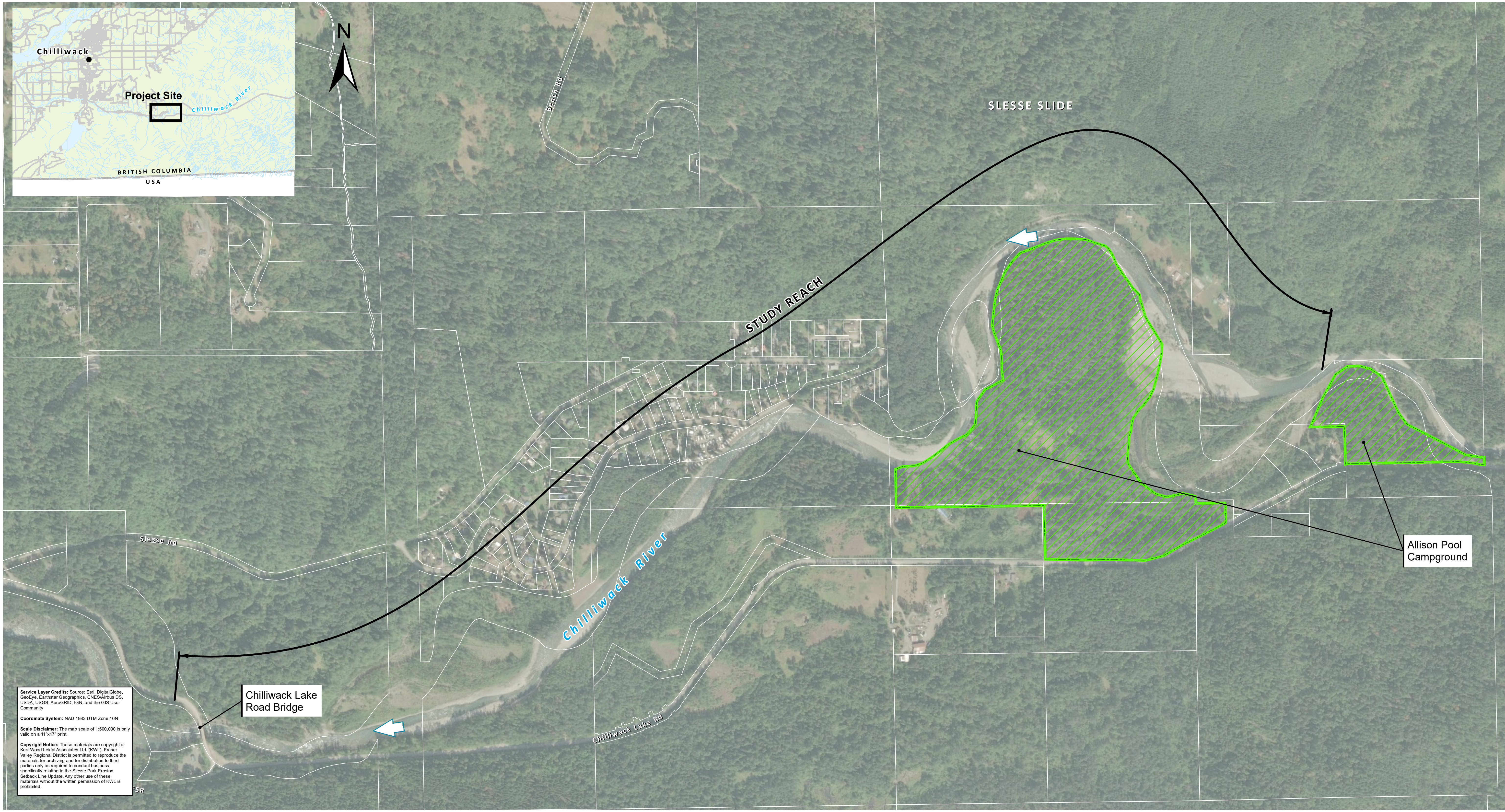
OQM CERTIFIED

Path: \\kwl.ca\bby\2000-2999\2000-2099\2080-040\430-GIS\MXD-Rp\2080040_Fig1_Overview.mxd Date Saved: 2019-11-22 1:11:35 PM | Author: GOConnell

Fraser Valley Regional District

Slesse Park Erosion Setback Line Update

KERR WOOD LEIDAL consulting engineers



Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:500,000 is only valid on a 11"x17" print.

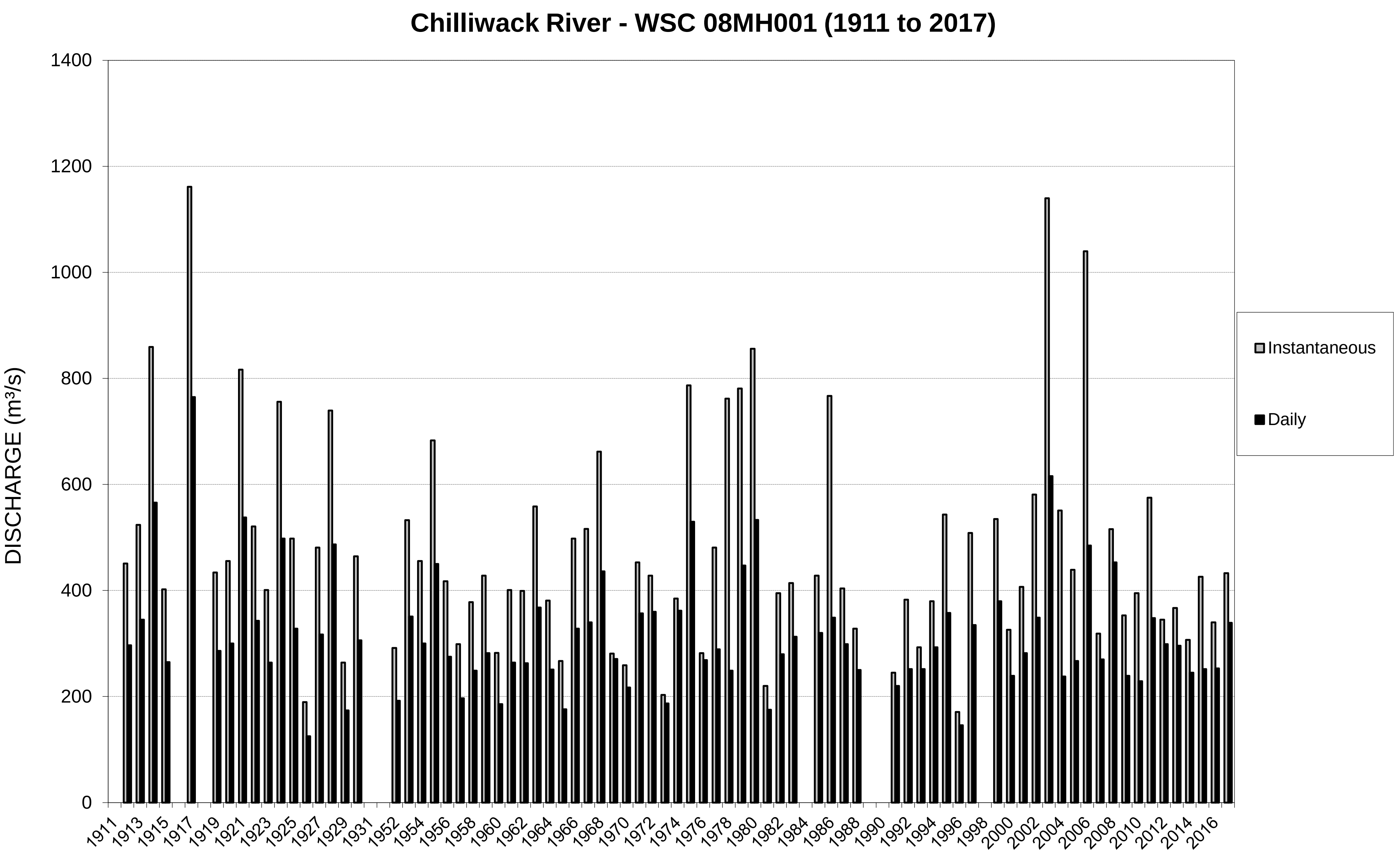
Project No. 2080.040

Date March 2020

Scale 0 50 100 200 (m)
1:10,000

Study Location

Figure 1



KERR WOOD LEIDAL
consulting engineers

Z:\2000-2999\2000-2099\2080-040\400-Work\Hydrology\08MH001_20191106_HYFRAN_Results_DAC.xls / peaks

Figure 2

Fraser Valley Regional District

Slesse Park Erosion Setback Line Update

KERR WOOD LEIDAL
consulting engineers

1986 (30BCC 453 #43)

1993 (30BCB93026 #133)

Coordinate System: NAD 1983 UTM Zone 10N

Scale Disclaimer: The map scale of 1:12,500 is only valid on a 8.5"x11" print.

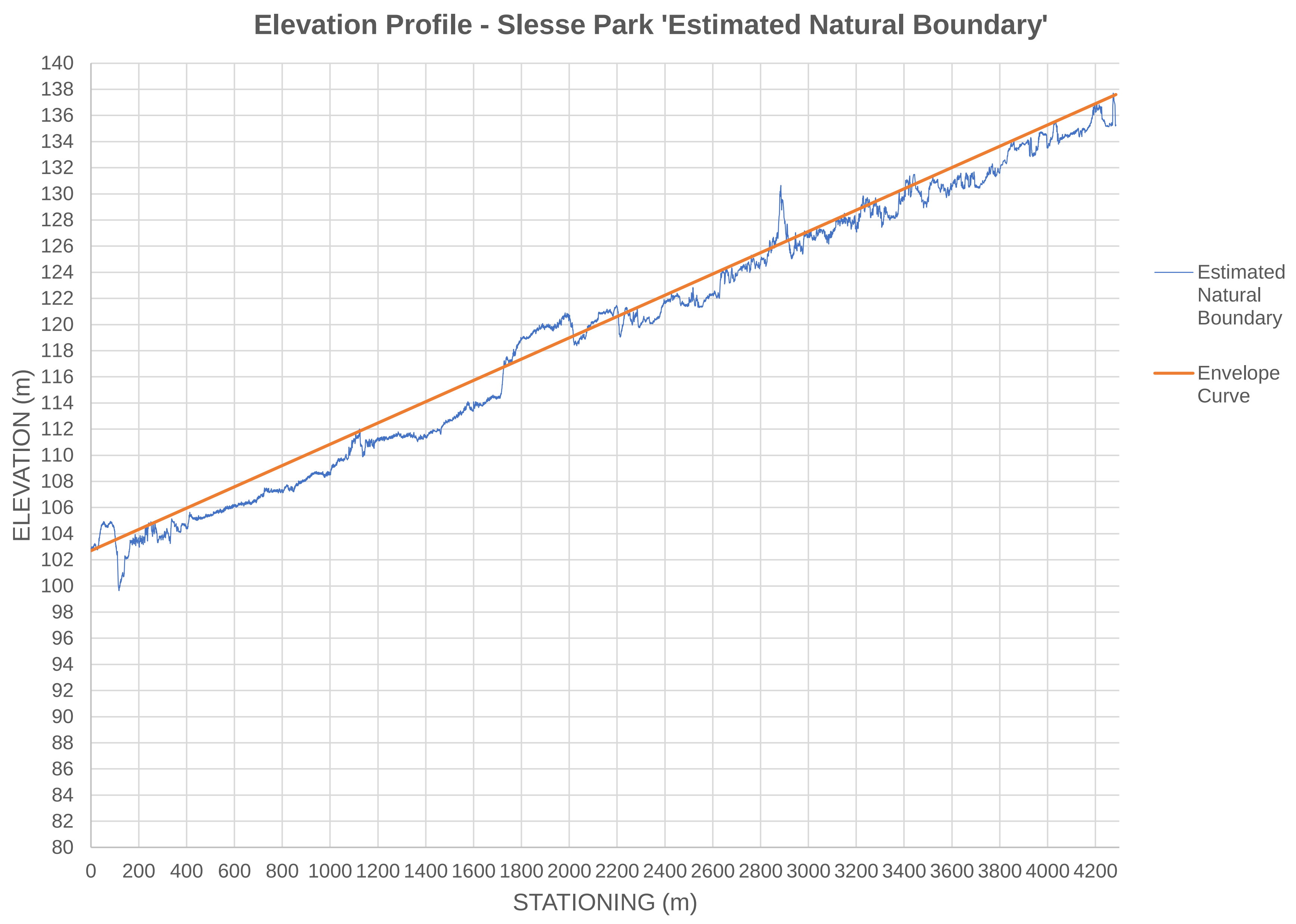
Project No. 2080.040

Date March 2020

Scale 1:12,500 — 0 50 100 200 (m)

Slesse Park: 1986 vs 1993 Georeferenced Air Photos

Figure 3



KERR WOOD LEIDAL
consulting engineers

Z:\2000-2999\2000-2099\2080-040\400-Work\Natural_Erosion_Boundary\20191122_Elevation Profile_Natural Erosion Boundary.xlsx / Elevation_Profile

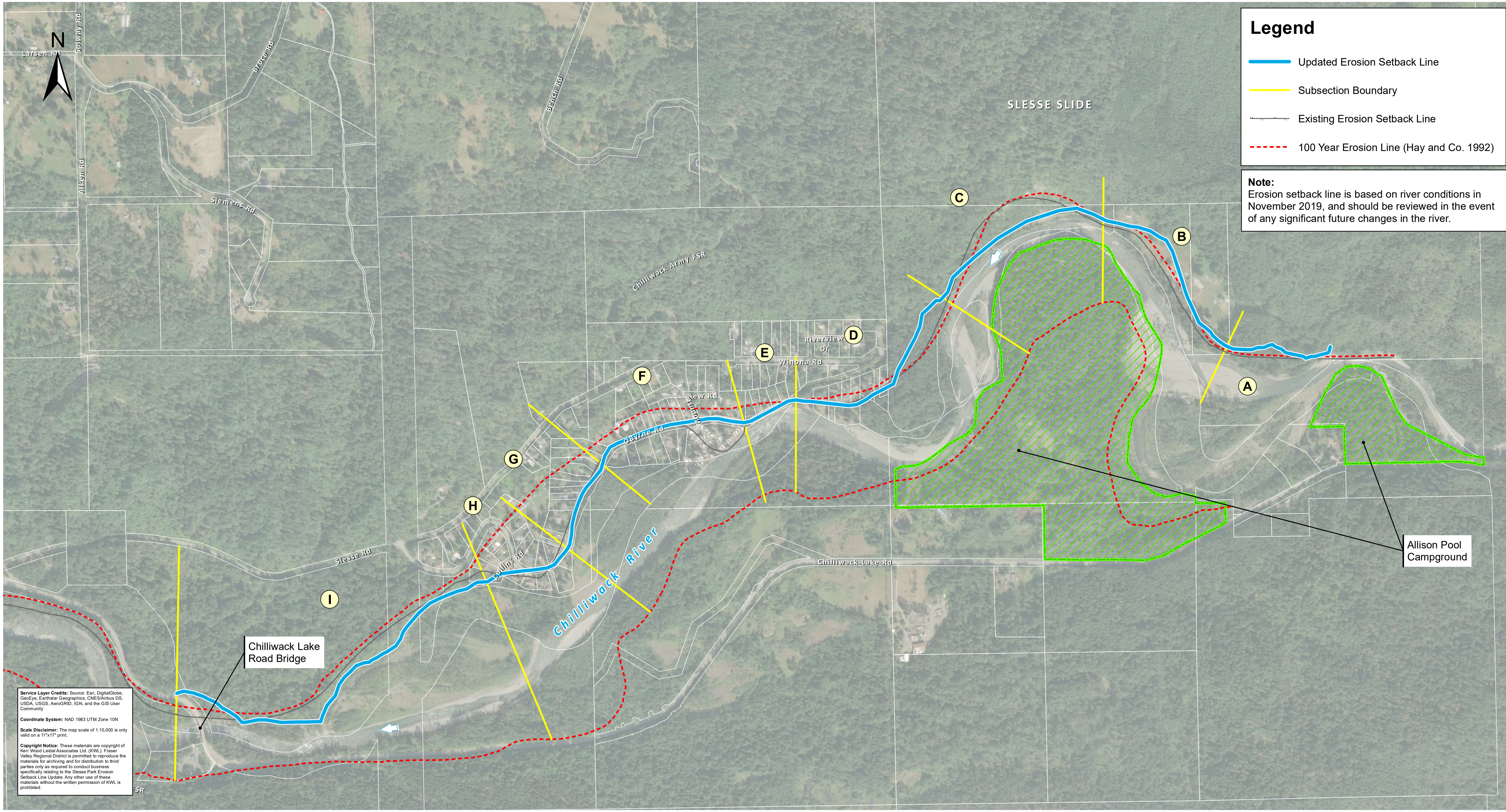
Figure 4

Path: \\kwl.ca\bby\2000-2999\2000-2099\2080-040\430-GIS\MXD-Rp\2080040_Fig5_ErosionSetback.mxd Date Saved: 2020-03-12 3:23:09 PM | Author: GOConnell

Fraser Valley Regional District

Slesse Park Erosion Setback Line Update

KERR WOOD LEIDAL consulting engineers



Project No. 2080.040

Date March 2020

Scale 1:10,000 0 50 100 200 (m)

Updated Erosion Setback Line

Figure 5