# Priddis River Hazard Study

Channel Stability Investigation Report



July 31, 2019

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# Executive Summary

Alberta Environment and Parks (AEP) commissioned Stantec Consulting Ltd. (Stantec) in August 2017 to undertake the Priddis River Hazard Study. The primary purpose of the study is to identify and assess river and flood hazards along Priddis Creek and Fish Creek.

This study is being conducted under the provincial Flood Hazard Identification Program (FHIP), the goals of which include enhancement of public safety and reduction of future flood damages through the identification of river and flood hazards. Project stakeholders include the Government of Alberta, local authorities and the public. Key municipal stakeholders include the Municipal District of Foothills No. 31, including the Hamlets of Priddis and Priddis Greens.

The Priddis River Hazard Study includes multiple components and deliverables. This report documents the channel stability assessment for both Fish Creek and Priddis Creek for use in the hazard study. The primary tasks, services, and deliverables of this component include:

- Historical Aerial Photography Preparation
- Channel Bank Delineation and Comparison
- Channel Section and Thalweg Comparison
- Rating Curve Comparison

The study area includes approximately 30 km of Fish Creek, between Range Road 40 (288 St W) and Tsuut'ina Nation; and approximately 20 km of Priddis Creek, between its confluence with Fish Creek and Tsuut'ina Nation. The study area is divided into 23 reaches based on geomorphic characteristics, including 13 along Fish Creek and three along Priddis Creek.

Historical aerial photographs from 1949, 1966, 1974, 1987, 1998, and 2008 were used in the analysis. The Alberta Environment and Parks (AEP) provided the air photo images. The images were processed for three-dimensional viewing and digitization by IGI Consulting Ltd. Details of the processing are described in the memo titled "Priddis River Hazard Study - Aerial Photograph Preparation Memorandum" (IGI 2019).

The channel banks were delineated for both Priddis Creek and Fish Creek for each of the years of air photos identified above. Changes in bank positioning were analyzed and are described in the context of geomorphic processes, including lateral movement (lateral migration, avulsion, and channel widening) and vertical movement (aggradation and degradation).

Channel sections and thalweg positions from the 2018 survey conducted by Stantec as described in the Priddis River Hazard Study - Survey and Base Data Collection Report (Stantec 2019) are compared to available sections from the "Priddis Flood Risk Mapping Study" completed in 2004 (AMEC 2004). Bankfull geometry (channel width and depth), cross-sectional area (scour and fill), and longitudinal profiles are assessed in terms of geomorphic processes and knowledge of flood history in the channels.

Water flow and level data accessed for the hydrometric station within the study reach (05BK001, Fish Creek Near Priddis) from the Water Survey of Canada (WSC) are presented in the form of rating curves. These data are combined with cross-section and thalweg information to assess geomorphic changes that have occurred at the station.

This report presents the methodology and results of the channel stability assessment, including qualitative and limited quantitative descriptions of indicators of general channel stability throughout the study area.

A summary description of channel reaches is presented in Table i.

**Table i. River reaches and summary descriptions of stability parameters.**

| Reach | River | Sinuosity (2018) | Description |
|---|---|---|---|
| 1 | Lower Fish Creek | 1.5 | • Unconfined<br>• Single-thread channel<br>• Low-amplitude, regularly meandering planform<br>• Incised<br>• Progressive in-channel bar growth, large volume of sediment stored<br>• Numerous oxbows and meander scars in the floodplain, particularly left floodplain |
| 2 | | 1.8 | • Unconfined<br>• Single-thread channel<br>• Irregularly meandering planform<br>• Stabilization of lateral bars by vegetation resulting in channel narrowing<br>• Channel migration along bends throughout reach<br>• Oxbows and meander scars in the floodplain<br>• Evidence of beaver activity exerting minimal local control |
| 3 | | 1.1 | • Partially confined<br>• Single-thread channel<br>• Straight planform<br>• Channel planform relatively stable throughout aerial imagery record<br>• No evidence of beaver activity<br>• Stabilization of lateral bars by vegetation causing channel narrowing |
| 4 | Upper Fish Creek | 1.7 | • Unconfined<br>• Incised<br>• Single-thread channel<br>• High amplitude, regularly meandering planform<br>• Channel planform relatively stable throughout aerial imagery record<br>• Moderate beaver activity exerting local flow control<br>• Limited presence of lateral bars<br>• Recent bank protection placed along outer banks in lower reach |
| 5 | | 2.3 | • Unconfined<br>• Single-thread channel<br>• Highly sinuous, irregularly meandering planform<br>• Channel planform relatively stable from 1966 to present<br>• Presence of channel bars and small stable vegetated islands |

| Reach | River | Sinuosity (2018) | Description |
|---|---|---|---|
| | | | • Numerous oxbows and meander scars in the floodplain |
| 6 | | 2.2 | • Partially confined<br>• Single-thread channel<br>• Highly sinuous, irregularly meandering planform<br>• Incised<br>• Floodplain largely covered in dense mature forest<br>• Minor channel migration along outer bends<br>• Presence of lateral bars<br>• Oxbows and meander scars in the floodplain |
| 7 | | 1.6 | • Partially confined<br>• Single-thread channel<br>• Tight, moderately regularly meandering planform<br>• Incised<br>• Floodplain largely covered in dense mature forest<br>• Minor channel migration along outer bends over time<br>• Presence of lateral bars |
| 8 | | 1.2 | • Unconfined<br>• Single-thread channel<br>• Low-sinuosity meandering planform<br>• Floodplain largely covered in dense mature forest<br>• No substantial change to channel planform observed after 1974<br>• Presence of bars in lower half of reach<br>• Meander scars in floodplain |
| 9 | | 2.0 | • Partially confined<br>• Single-thread channel<br>• Irregularly meandering planform<br>• Incised<br>• No substantial change to channel planform observed after 1966<br>• Presence of lateral bars<br>• Meander scars in the floodplain |
| 10 | Priddis Creek | 2.2 | • Unconfined<br>• Single-thread channel<br>• Irregularly meandering planform<br>• Channel straightening through meander cutoff over aerial imagery record<br>• Presence of lateral and medial bars<br>• Evidence of beaver activity exerting minimal local control |
| 11 | | 1.7 | • Unconfined<br>• Single-thread channel<br>• Irregularly meandering planform<br>• Active channel splitting throughout aerial imagery record<br>• Evidence of beaver activity exerting moderate local control<br>• Presence of large lateral bars |
| 12 | | 1.6 | • Partially confined<br>• Single-thread channel<br>• Irregularly meandering planform<br>• Heavily vegetated floodplain<br>• Channel largely stable throughout aerial imagery record |

| Reach | River | Sinuosity (2018) | Description |
|---|---|---|---|
| | | | • Limited presence of lateral bars<br>• Evidence of beaver activity exerting moderate local control |
| 13 | | 1.7 | • Unconfined<br>• Single-thread channel<br>• Irregularly meandering planform<br>• Incised<br>• Stabilization of lateral bars into floodplain resulting in channel narrowing<br>• Numerous vegetated meander scars in the surrounding floodplain |
| 14 | | 1.0 | • Confined<br>• Single-thread channel<br>• Straight reach<br>• Limited connection between channel and floodplain<br>• No substantial change to channel position observed |
| 15 | | 1.5 | • Unconfined<br>• Anabranched channel<br>• Irregularly meandering channel planform<br>• Numerous meander loop cutoffs occurred since 1949 imagery<br>• Upper reach is morphologically controlled by beaver dams (presently and historically)<br>• Lower section of reach is incised |
| 16 | | 1.5 | • Unconfined<br>• Predominantly single-thread channel with split flow around some stable island<br>• Irregularly meandering channel planform<br>• Morphology controlled by beaver dams throughout reach (presently and historically) |

## Acknowledgements

The Priddis River Hazard Study was managed on behalf of AEP by Muhammad Durrani, M.Eng., P.Eng., with support from Kurt Morrison, M.Eng., P.Eng., and Jane Eaket, M SC. P. Eng., of the River Engineering and Technical Services Section, both of whom provided project direction and review of this document.

The following personnel from Stantec contributed to this component of the study:

- Matt Wood, P. Eng., CPESC – Project Manager, Lead Project Engineer
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- Catalina Tandara, CET – CAD Lead
- Dave Merrick, B.Sc. – GIS Technician

The project team acknowledges assistance provided by personal of the following agencies and their consultants:

- Ian Grady, IGI Consulting Ltd
- Informatics Branch, AEP
- Hamlet of Priddis
- Hamlet of Priddis Greens
- Robert Miller, Foothills County
- Water Survey of Canada

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# 1.0 INTRODUCTION

The Priddis River Hazard Study was conducted by Stantec Consulting Ltd. (Stantec) on behalf of the Government of Alberta, in accordance with the study-specific terms of reference and applicable project guidelines.

## 1.1 STUDY BACKGROUND

Alberta Environment and Parks (AEP) commissioned Stantec in August 2017 to undertake the Priddis River Hazard Study. The study is being conducted under the provincial Flood Hazard Identification Program (FHIP), the goals of which include enhancement of public safety and reduction of future flood damages through the identification of river and flood hazards (Alberta Environment, 2011). Project stakeholders include the Government of Alberta, local authorities and the public.

## 1.2 STUDY OBJECTIVES

The primary purpose of the Priddis River Hazard Study is to identify and assess river and flood hazards along Fish Creek and Priddis Creek. The study includes multiple components and deliverables.

This report documents the channel stability assessment for both Fish Creek and Priddis Creek for use in the Priddis River Hazard Study. The channel stability analysis is designed to provide a qualitative description about the general stability of the channel bed and banks within the study reach, supported by limited quantitative information where appropriate.

The primary tasks, services, and deliverables of the channel stability assessment component include:

- Historical Aerial Photography Preparation,
- Channel Bank Delineation and Comparison,
- Channel Section and Thalweg Comparison, and
- Rating Curve Comparison.

## 1.3 STUDY AREA AND REACHES

Priddis Creek and Fish Creek are the two main channels in the Fish Creek Watershed, located in the Southern Foothills of the Rocky Mountains. Priddis Creek is a tributary of Fish Creek. The creeks join near the town of Priddis, Alberta, where the channel flows east to join the Bow River in South Calgary. The Fish Creek Watershed comprises a mix of Subalpine, Montane, and Foothills Parkland natural sub-regions (Downing & Pettapiece, 2006). The floodplain is largely composed of till deposits, fluvial deposits, and occasionally highly calcareous wind deposits. Cretaceous and Tertiary sedimentary rocks underlie the surficial deposits of the Montane Natural Subregion; bedrock exposures occur within the Fish Creek watershed. Land use in the watershed ranges from urban in Calgary, to agricultural lands in parts of the foothills, and forest in the remainder of the foothills.

The study area includes approximately 30 km of Fish Creek between Range Road 40 (288 St W) and Tsuut'ina Nation, and approximately 20 km of the Priddis Creek between the Tsuut'ina Nation and its confluence with Fish Creek (Figure 1). For the purpose of the channel stability analysis, the study area is divided into 16 reaches based on geomorphic characteristics, including 3 along Lower Fish Creek, 6 along Upper Fish Creek, and 7 along Priddis Creek (Table 1). These reaches are assessed for changes in channel planform, geometry, and features for the channel change analysis.

**Table 1: River reaches within the study area. Lengths based on 2018 imagery.**

| Geomorphic Reach Number | River | Length (m) | Marker Posts (m) |
|---|---|---|---|
| 1 | Lower Fish Creek | 3,848 | 0 – 3,848 |
| 2 | | 4,247 | 3,848 – 8,095 |
| 3 | | 1,189 | 8,095 – 9,284 |
| 4 | Upper Fish Creek | 2,697 | 9,284 – 11,980 |
| 5 | | 5,561 | 11,980 – 17,541 |
| 6 | | 5,426 | 17,541 – 22,967 |
| 7 | | 2,795 | 22,967 – 25,762 |
| 8 | | 3,651 | 25,762 – 29,413 |
| 9 | | 4,117 | 29,413 – 33,531 |
| 10 | Priddis Creek | 3,145 | 33,531 – 36,675 |
| 11 | | 4,870 | 36,675 – 41,545 |
| 12 | | 2,822 | 41,545 – 44,367 |
| 13 | | 1,793 | 44,367 – 46,160 |
| 14 | | 623 | 46,160 – 46,783 |
| 15 | | 2,775 | 46,783 – 49,558 |
| 16 | | 2,391 | 49,558 – 51,949 |

# 2.0 AVAILABLE DATA

## 2.1 AERIAL IMAGERY

Stantec identified seven years of historical air photos suitable for the channel stability assessment. The years were chosen based on adequate coverage of the study area, temporal spacing (roughly one set per decade), and appropriate scale for the purpose of channel feature delineation. Scanned air photos were provided by AEP. Table 2 provides a summary of the air photos obtained for the channel stability analysis.

The air photos were prepared for digital analysis by IGI Consulting Ltd. Details of the air photo preparation are provided in “Priddis River Hazard Study - Aerial Photograph Preparation Memorandum” (IGI, 2019).

### Table 2: Summary Table of New and Historical Aerial Imagery

| Date(s) of Collection | Scale | Source | Accuracy |
|---|---|---|---|
| 2018-07-13<br>2018-08-01 | 1:1 | AEP (OGL Engineering) | 1 m at 95% confidence |
| 2008-09-28 | 20,000 | AEP Photo Library | ± 5 m |
| 1998-07-17 | 20,000 | | |
| 1987-09-08 | 65,000 | | |
| 1974-06-13 | 31,680 | | |
| 1966-07-14<br>1966-08-09 | 31,680 | | |
| 1950-05-05[1]<br>1951-06-14[1] | 40,000 | | |

[1] AEP Photo Library has labelled these images as 1949. For the purposes of this report, these images will be herein referred to as 1949.



## 2.2 CROSS-SECTION DATA

Historical cross-section data were provided to Stantec for both Priddis Creek and Fish Creek from the 2004 study completed by AMEC. Stantec conducted surveys of cross-sections in both Priddis Creek and Fish Creek in 2018 as part of the current study. Details of Stantec’s 2018 survey data collection can be found in “Priddis River Hazard Study - Survey and Base Data Collection Report” (Stantec, 2019). Summary details of the data are provided in Table 3.

The project footprint of the 2004 study is smaller than the current study and therefore, comparisons were made only where available cross-sections overlap. The cross-sections lie within Geomorphic Reaches 2, 3, and 4 on Fish Creek and Reach 10 on Priddis Creek. Cross-section locations for both 2004 and 2018 data are shown in Appendix A along with delineation of the relevant Geomorphic Reach boundaries.

**Table 3: Summary Table of Cross-Section Data**

| | Dates(s) of Collection | Scale | Source | Accuracy |
|---|---|---|---|---|
| 2004 Model | DEM created by Geodesy Digital Mapping Ltd. on May 24, 2003, and survey data collected by Raymac Surveys Ltd. In 2002 (specific dates unknown). | 1:5000 (DEM)<br>Unknown (survey) | AEP (AMEC) | Unknown |
| 2018 Survey | Fall 2018 | - | Stantec 2019 | ±0.05 m, at 95% confidence interval |
| 2018 LiDAR | 2018-07-13<br>2018-08-01 | 1:1 | AEP | Horizontal: 0.824 m<br>Vertical: 0.935 m |

## 2.3 THALWEG PROFILE DATA

Historical thalweg data from the 2004 study completed by AMEC for both Priddis Creek and Fish Creek were provided to Stantec. Stantec conducted surveys of thalweg location and elevation in both Priddis Creek and Fish Creek in 2018 as part of the current study. Details of Stantec's 2018 survey data collection can be found in Priddis River Hazard Study - Survey and Base Data Collection Report (Stantec 2019). Summary details of the data are provided in Table 4.

The project footprint of the 2004 study is smaller than the current study and therefore, comparisons were made only where available cross-sections overlap. The thalweg data collection locations lie within Geomorphic Reaches 2, 3, and 4 on Fish Creek and Reach 10 on Priddis Creek.

**Table 4: Summary Table of Thalweg Profile Data**

| | Dates of Collection | Scale | Source | Accuracy |
|---|---|---|---|---|
| 2004 Model | DEM created by Geodesy Digital Mapping Ltd. on May 24, 2003, and survey data collected by Raymac Surveys Ltd. In 2002 (specific dates unknown). | 1:5000 (DEM)<br>Unknown (survey) | AEP (AMEC) | Unknown |
| 2018 Survey | Fall 2018 | - | Stantec 2019 | ±0.05 m, at 95% confidence interval |
| 2018 LiDAR | 2018-07-13<br>2018-08-01 | 1:1 | AEP | Horizontal: 0.824 m<br>Vertical: 0.935 m |

## 2.4 RATING CURVE DATA

The Water Survey of Canada (WSC) operates one hydrometric station within the study area boundary (Fish Creek near Priddis, 05BK001). This station is located on Fish Creek at approximately 135 m downstream of the confluence with Priddis Creek within Geomorphic Reach 3 (Section 54 of the 2018 HEC-RAS model). Hydrometric station details are presented in Table 5. From communications with the WSC, we understand that the high-water measurement location for the station is the Priddis Valley Road W (Range Road 32) bridge downstream of the gauge.

Rating curve data (discharge and stage) for 05BK001 from a number of different years were provided by the WSC. Interpretation of the rating curve data requires reference to channel geometry data. For this reason, rating curve data from years closest to the historical and recent cross-section and thalweg data (refer to Sections 2.2 and 2.3) were used in this analysis. These years include 2005 and 2013.

**Table 5: Summary Table of Water Survey of Canada Station Information**

| Station Number | Station Name | Years of Available Data | | Drainage Area (km$^2$) | Latitude | Longitude |
|---|---|---|---|---|---|---|
| | | Flow | Level | | | |
| 05BK001 | Fish Creek near Priddis | 1908-2016 | 2012 - 2016 | 261 | 50.88547° | -114.3268° |

# 3.0 METHODS AND RESULTS

## 3.1 CHANNEL BANK COMPARISON

### 3.1.1 Channel Bankline Delineation Methods

The channel bank delineation and comparison were conducted using digitized orthorectified and georeferenced airphotos imported into the PurView$^{TM}$ 3D stereoscopy extension in ArcMap (refer to aerial imagery details provided in Section 2.1).

Channel banks and other river features relevant to channel stability were delineated from the historical (1949, 1966, 1974, 1987, 1998, and 2008) and recent (2018) imagery. Other relevant features include anabranching and other active side channels and islands.

The ability to accurately identify channel banks was limited by a number of factors, including the quality of the air photos, flow level at the time of air photo acquisition, and the presence of bank-obscuring features within the image (e.g. overhanging vegetation). Factors affecting air photo quality include relative scale, resolution, type of scanner used to digitize the image and dpi settings of the scan. Further details about imagery quality are discussed in “Priddis River Hazard Study - Aerial Photograph Preparation Memorandum” (IGI, 2019).

To account for relative submergence of channel features due to differences in flow volume between successive photo capture dates, historical daily peak discharge values were obtained from the WSC gauge station on Fish Creek (05BK001) for the dates the aerial imagery was taken (Table 6). Note that discharge data were not recorded between 1917 and 1955, inclusive, and at the time of writing this report, 2018 discharge data were not available from the WSC website.

**Table 6: Daily instantaneous peak discharge data at WSC 05BK001 on dates of aerial image capture.**

| Year | Date flown | Discharge ($m^3/s$) |
|---|---|---|
| 2018 | July 13/August 1 | N/A |
| 2008 | Sept 28 | 0.409 |
| 1998 | July 17 | 3.37 |
| 1987 | Sept 8 | 0.44 |
| 1974 | June 13 | 1.74 |
| 1966 | July 14/August 9 | 1.75/1.03 |
| 1950/1951 | May 5/June 14 | N/A |

Where banks were obscured by floodplain features such as overhanging vegetation, the bank line was interpolated by upstream and downstream bank positioning. The interpolated bank was assessed for reasonableness based on relative width and typical cross section expected based on local channel planform.

Using the 2018 imagery, the study area was divided into reaches, where a reach is considered a length of homogeneous channel with respect to channel characteristics such as planform, riparian vegetation, channel confinement, presence of a confluence, and/or changes in sediment supply (BC MoE, 1996). Each delineated reach was compared between successive air photos to identify changes in channel characteristics relating to stability.

Once the features within the study area were delineated for each year of available air photos, the digital margins were exported into an ArcGIS 10.2 (ArcMap) database with the geospatial attributes. The bankline positions from each year were subsequently compared to identify indications of instability within the study area.

Sinuosity was calculated for each reach, for each year of available data to quantify planform changes over time. The method of Brice (1964) was employed in this analysis to account for the complex meandering of the channel throughout the study area.

The channel stability assessment is derived from the analysis described above combined with information collected from site photos and observations made during channel surveying in Fall 2018, as well as 2018 aerial imagery. This provides a summary of current stability of the channel reaches in the study area.

### 3.1.2 Channel Bank Delineation Results

Fish Creek flows as a single-thread meandering channel throughout the study area. Priddis Creek is mainly a single-thread meandering channel, with some sections of anabranching. Both Creeks have channel beds composed of predominantly cobble-sized material, with some variability in grain-size distribution where bank erosion or bedrock slope failure has contributed sediment to the channel, or where beaver activity has altered the sediment transport regime. Bed morphology is typically riffle-pool throughout the study area, with the exception of sections where beaver activity has formed ponding.

Observed bank material is typically coarse loose soils where the channel flows through wide, flat floodplain, and is bedrock or soil-mantled bedrock in the steeper, narrower floodplain sections.

Detailed reach-by-reach descriptions of the existing channel conditions and the results of the channel bank delineation are presented in the following subsections. Figures showing representative reach conditions are shown in Appendix B.

#### 3.1.2.1 Lower Fish Creek

##### Reach 1

Reach 1 displays a relatively regular meandering planform of low amplitude. The channel is largely unconfined and incised. The floodplain varies from flat agricultural areas with numerous oxbows and meander scars to steep slopes composed of fine material, showing evidence of erosion. Bank protection measures were observed in several locations where residential properties border the channel. A large volume of sediment is stored in lateral bars throughout the reach.

Channel realignment was observed between 1949 and 1966. Limited evidence of channel shifting suggests the realignment was sudden, possibly an avulsion. Localized straightening of the channel was observed between 1966 and 1974 by the cutoff of a meander loop. During this same time period, lateral bars were degraded. The channel showed an overall widening trend over time, particularly in the lower portions of the reach between 1998 and 2018.

##### Reach 2

The channel in Reach 2 displays an irregularly meandering planform. The channel is largely unconfined, flowing through mature forested floodplain. Steep outer banks along the channel are composed of coarse, loose soils. Intermittent bank protection was observed through the reach during the 2018 survey work. The presence of oxbows and meander scars in the floodplain suggest a history of substantial lateral channel activity.

Existing beaver dams have created localized ponding and are exerting limited control on morphology. This activity was observed in the field, but not in air photos and it is unclear if beaver activity has had an effect on channel morphology historically.

Moderate channel migration was observed throughout the photo record. Shifting of the meanders was observed over time through erosion of outer bends and stabilization of lateral bars by establishment of vegetation along the inner bends. The stabilization has also resulted in an overall narrowing of the channel.

##### Reach 3

The upstream limit of Reach 3 marks the confluence of Priddis Creek and Fish Creek. It flows along an approximately straight path through a partially confined floodplain. The right floodplain is a steep slope covered in dense mature forest, with bedrock outcrops. The left floodplain is flatter, covered mostly in grasses and shrubs.

A shift in the channel position occurred at the HWY 22 bridge crossing between 1949 and 1987. The process appeared to be a result of splitting of flow by the formation of a new side channel, and the eventual cutoff and filling of the former main channel.

The channel planform has remained relatively stable over the photo record. Overall, the channel has narrowed since 1998; bar size increased between 1998 and 2008, then stabilized with the establishment of vegetation.

#### 3.1.2.2 Upper Fish Creek

Reach 4

The meander bends in Reach 4 are high amplitude, and of relatively consistent in size and spacing. The incised channel is bound by high banks and a moderately flat floodplain. The channel is not naturally confined; however, bank protection is present along the majority of the outer bends of the meanders within the reach, providing protection against bank erosion. Evidence of beaver activity was observed; however, the effects are localized and minimal to overall stability.

Comparison of the channel banks through the air photo record indicates that the channel planform has remained relatively stable since 1949.

#### 3.1.2.3 Reach 5

Reach 5 has a high sinuosity, irregularly meandering planform. The channel is unconfined, flowing through a flat floodplain covered with dense grass and intermittent mature tree stands. Numerous oxbows and meander scars exist in the floodplain. Lateral channel bars and small stable vegetated islands occur throughout the reach.

Minor bank erosion was observed during the 2018 field visit, with the erosion rate was estimated at less than 20 cm/year. Evidence of beaver activity was observed, with dams creating small ponds throughout the reach. These ponds appear to have a minor, local influence on the channel morphology.

Channel shortening via meander cutoff occurred at two locations within the reach between 1949 and 1966. From 1966 to 2018, the planform showed minimal change in position.

#### 3.1.2.4 Reach 6

The channel is highly sinuous, irregularly meandering through Reach 6. The channel is incised, and partially confined by steep slopes and bedrock outcrops. The floodplain is covered in dense, mature forest. Oxbows and meander scars exist in the floodplain. The channel bed is predominantly coarse gravel-sized material. Consistent alternating lateral bars exist throughout the reach. Evidence of small-scale beaver activity was observed resulting in localized ponding of flow.

Channel migration at outer bends was observed over time in the air photo record. Evidence of slow to moderate bank erosion (erosion rates estimated at 20 to 50 cm/year), and resulting downed trees observed during the 2018 field visit suggest that this migration is ongoing. Between 1987 and 1988, the channel widened, and the number of in-channel bars increased.

#### 3.1.2.5 Reach 7

The channel flowing through Reach 7 has relatively regularly sized and spaced, tight meanders. It is incised, flowing through a flat floodplain covered in dense, mature forest. The bed material has a higher percentage of gravel and coarse sand compared to bounding reaches. Alternating lateral bars are present.

Lateral channel migration is evident in the air photo record over time through the expansion of outer meander bends. Observation of eroded and undercut banks in this reach suggest this migration is on-going.

#### 3.1.2.6 Reach 8

Reach 8 is a low-sinuosity meandering channel. The flat, densely forested floodplain displays meander scars. Riffle-pools composed of cobble- and boulder-sized material dominate the bed. Lateral bars occur in the lower half of the reach.

Evidence of slow to moderate bank erosion was observed in the field.

Channel straightening via meander cutoff occurred in lower reach between 1949 and 1974. No substantial change to channel planform was observed after 1974.

#### 3.1.2.7 Reach 9

Reach 9 marks the upper limit of the study area on Fish Creek. In this reach the channel meanders irregularly through partially confining steep slopes covered in mature forest. Bank erosion and slope failure was observed along the banks of the channel. Meander scars occur in the wider floodplain. Small-scale beaver activity was observed, having minimal local effects on channel stability.

Channel straightening via meander cutoff occurred within the reach between 1949 and 1966, however, no substantial change to channel planform observed after 1966.

#### 3.1.2.8 Reach 10

Reach 10 is the downstream-most reach on Priddis Creek. The channel meanders irregularly through gently sloping banks covered in grasses and shrubs. Lateral and medial bars are common in this reach. The bed material is mostly coarse cobble and fine boulder. Isolated bank erosion and slope failure was observed, and rip rap protection has been placed on the banks bordering residential properties in the reach. Ponding from beaver dams was observed, exerting localized control on flow.

Limited channel migration was observed over the air photo record. Channel straightening through meander cutoff was observed between 1949 and 1974. The channel split to form an island in the lower reach between 1998 and 2008.

### 3.1.2.9 Reach 11

Reach 11 is an irregularly meandering channel. The channel flows unconfined through a flat floodplain covered predominantly in dense, mature forest. Large quantities of sediment are stored in medial and lateral bars in the upstream portion of reach, while stable, vegetated islands split flow in the downstream portion of reach. Widespread bank undercutting has downed mature trees into the channel. Moderate beaver activity was noted in the reach. The channel bed is composed of coarse cobble, with some sections of bed material covered in algae, typically upstream of beaver dams.

The reach planform was predominantly anabranching from 1949 to 1987. The positions of the anabranched channels were highly dynamic during this time. It does not appear that new channels were created, rather old channels were being reoccupied then abandoned. By 1998, the number of stable islands had reduced, and the channel was largely single-thread. Channel widening and exposure of bank material was observed between 1998 and 2008, and re-establishment of vegetation had begun in these exposed sections by 2018.

### 3.1.2.10 Reach 12

Reach 12 is an irregularly meandering channel. Flow is partially confined in some sections by steep valley walls covered in mature forest. In other sections the floodplain is flat and covered in dense grass. Few bars are present in the channel. Isolated slope instability was observed within the reach as evident by downed and pistol-butted trees, as well as discrete slope failures contributing sediment to channel. Beaver dams are present in the channel in the open-floodplain sections, resulting in localized ponding.

Minor channel shifting occurred in the reach over the air photo record. Larger, discrete channel change events include a meander cutoff that occurred between 1998 and 2008, and smaller-scale shifting of meander bends between 2008 and 2018; however, overall, the channel was largely stable.

### 3.1.2.11 Reach 13

Reach 13 has an irregularly meandering planform. The channel is unconfined and incised within a flat floodplain covered in grass. Numerous vegetated meander scars exist in the floodplain. Moderate bank erosion was observed during 2018 field work, including undercutting and bank slumping. The bed material is largely cobble-sized, arranged in riffle-pool morphology with alternating lateral bars throughout the reach. Evidence of beaver activity exerting localized ponding on flow, however the effects to channel stability are minimal.

Stable, vegetated islands emerged prior to 1966, as flow split and the channel adopted a more anabranched planform. Anabranching, and the number of islands, increased number up to 1998. A meander cutoff occurred in upper reach between 1987 and 1998, shortening the channel. An overall channel widening of a main channel and emergence of alternating lateral bars within this channel occurred between 1998 and 2008. By 2018, no islands remained, and the channel planform became single-thread.

#### 3.1.2.12 Reach 14

Reach 14 is a stable single-thread channel with a straight planform. The channel is confined by steep bedrock slopes on either side of the channel covered in dense mature forest.

No substantial change to channel position was observed between 1949 and 2018.

#### 3.1.2.13 Reach 15

Reach 15 displays an irregularly meandering planform with anabranching sections. The channel flows unconfined through a wide, flat floodplain covered in dense grass. Intermittent bank erosion was observed, with estimated erosion rates less than 20 cm per year. Numerous beaver dams are present in the upper half of reach, facilitating raised water levels and overbank flooding. Bed material is covered in algae in the beaver ponds. No beaver dams were observed in the lower section of the reach.

Stable, vegetated islands emerged in the upper reach prior to 1966, as flow split and the channel adopted a more anabranched planform. Anabranching, and the number of islands, increased in number up to 1987. Channel straightening via meander loop cutoff dominated the reach between 1974 and 1998. Between 1998 and 2008, the channel in the lower reach widened, and alternating lateral bars emerged in the channel. Between 2008 and 2018, smaller anabranch channels were cut off and the number of islands reduced.

#### 3.1.2.14 Reach 16

Reach 16 is a predominantly single-thread channel-thread with split flow around some stable islands. The channel displays an irregularly meandering planform. The stream is connected to the floodplain and overland flooding of low-lying floodplain is common (e.g. in abandoned channels and meander scars present throughout the surrounding floodplain). The morphology of the channel is controlled by beaver dams throughout reach (both presently and historically). The presence of the dams has resulted in raised water-levels and decreased flow velocities. The cobble channel beds are covered in thick algae as a result.

In 1949, the channel was mainly single-thread, with a few small islands splitting flow in the centre of the reach. The reach became partially anabranched as flow splitting increased through to 1974 and large islands separated the channel. From 1974 to 2018, an increase water stored in side channels and ponds was observed.

### 3.1.3 Channel Stability Commentary

Changes to a channel's shape and planform are a result of the interactions between flowing water and the material that makes up the channel and floodplain. The processes of erosion and deposition are the mechanisms that alter the channel over time. Channel stability, thus, represents the ability of the channel to resist the variable forces of flow. Additional factors affecting the channel's ability to resist change include applied factors such as anthropogenic bank protection, erosion due to livestock, or beaver activity.

The channel bed material is relatively consistent in size distribution and bed pattern throughout the study area. Bank and floodplain material alternate between coarse, loose till and fluvial deposits covering wide, relatively flat or gently undulating floodplains, and steep-sided, narrow slopes composed of bedrock, either as exposed outcrops or sediment-mantled. These steep bedrock reaches tend to be covered in dense mature vegetation, providing added stability. Analysis of the channel bank positions over time revealed that in these sections, channel migration was typically less prevalent. In the wide, flat, sediment-covered floodplains, the ability of channel to migrate is large. Floodplain vegetation does provide some protection against migration; however, the air photo record shows that these reaches have seen the most channel migration, and evidence of historic changes are evident in the form of meander scars, avulsions and oxbows in the broader floodplain.

The wide, flat floodplain sections were observed to be favoured locations for beaver dams. Anabranching was commonly observed in areas of high beaver dam density. It is surmised that the dams contribute to diversion of a portion of the main flow into previously abandoned side channels and floodplain ponds, creating an anabranched system. The lifecycle of a beaver dam is typically 10 years (Remillard, Gruendling, & Bogucki, 1987). Observed seemingly avulsing shifts of anabranched channels between successive air photo images, which were roughly a decade apart, could be related to the abandonment of old beaver dams and construction of new ones. The effects of beaver dams on river channels has been well-documented (citations). Channel-spanning beaver dams create in-channel ponds that raise water levels upstream, reduce flow velocities and stream energies (Naiman, Melilo, & Hobbie, 1986). Lower stream energy results in less erosion of the bed and banks and reduces bed degradation and changes to channel planform shape.

## 3.2 CROSS-SECTION COMPARISON

### 3.2.1 Cross-Section Comparison Methods

Cross-sections from Stantec's 2018 HEC-RAS model were compared to available cross-sections from the 2004 hydraulic model (AMEC, 2004) to characterize patterns of lateral and vertical change in both Priddis Creek and Fish Creek. Available 2004 cross-sections were reviewed for location relative to the 2018 cross-sections. Cross-section pairs were omitted where the distance was greater than 10 m or the alignment was inconsistent. As a result of this review, a total of 15 cross-sections from Lower Fish Creek, 10 cross-sections from Upper Fish Creek, and two cross-sections from Priddis Creek were deemed suitable for comparison.

Qualitative and quantitative analyses of the suitable cross-sections were carried out. The qualitative analysis included review and documentation of cross-section characteristics, including handedness (relative position of the thalweg within the cross-section as left, centered, or right), symmetry (whether the cross-section leans to the left, right, or is uniform), planform description (single- or multiple-thread), and evidence of bed and bank aggradation or degradation.

Quantitative parameters of each suitable cross-section were obtained from the 2004 and 2018 HEC-RAS models. The results of the model simulations for the 2-year flow were used as a proxy for bankfull conditions. The parameters included cross-sectional area, maximum bankfull depth, average bankfull depth, and bankfull width.

### 3.2.2 Cross-Section Comparison Results

Detailed quantitative and qualitative descriptions for the cross-section comparisons are presented in Table 7. Figures showing the cross-sections are presented in Appendix C.

**Table 7: Summary of cross-section parameters compared between 2018 (Stantec) and 2004 (AMEC) datasets.**

| Reach | Geomorphic Reach ID | Reach ID (2018/2004) | Average Bankfull Width (m) | | Maximum Bankfull Depth (m) | | Average Bankfull Depth (m) | | Cross-Sectional Area ($m^2$) | | Description |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 2004 | 2018 | 2004 | 2018 | 2004 | 2018 | 2004 | 2018 | |
| Lower Fish Creek | 2 | 32/102 | 10.8 | 9.7 | 1.2 | 1.6 | 0.9 | 1.1 | 11.5 | 37.1 | • single-thread planform<br>• centered thalweg<br>• left-skewed in 2004, uniform symmetry by 2018 |
| | | 34/104 | 16.5 | 20.0 | 1.0 | 0.8 | 0.7 | 0.6 | 11.3 | 14.1 | • single-thread planform, abandoned channel in the left floodplain<br>• left-handed<br>• left-skewed |
| | 3 | 38/106 | 14.3 | 19.7 | 0.9 | 1.4 | 0.7 | 1.1 | 10.3 | 22.2 | • single-thread channel<br>• right-handed<br>• right-skewed |
| | | 39/107 | 15.5 | 19.4 | 1.0 | 2.4 | 0.7 | 1.8 | 11.4 | 35.7 | • single-thread channel<br>• centred thalweg<br>• left-skewed in 2004, uniform symmetry by 2018 |
| | | 40/107.1 | 16.4 | 18.0 | 1.1 | 4.0 | 0.8 | 2.9 | 12.3 | 51.5 | • single-thread channel<br>• right-handed<br>• right-skewed |
| | | 41/108 | 15.7 | 18.3 | 1.2 | 2.3 | 0.8 | 1.4 | 11.9 | 26.4 | • single-thread channel |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | • abandoned former main channel within right floodplain in 2004, completely infilled by 2018 |
| | | 42/109 | 19.6 | 20.2 | 0.7 | 0.7 | 0.5 | 0.6 | 10.6 | 20.2 | • single-thread channel<br>• right-handed in 2004, centered by 2018<br>• slightly right-skewed in 2004, uniform symmetry by 2018 |
| | | 44/110 | 18.9 | 17.6 | 1.1 | 1.4 | 0.8 | 1.1 | 14.6 | 17.6 | • single-thread channel<br>• thalweg centered in 2004, left-handed by 2018<br>• skewness shifted from uniform in 2004 to left-skewed by 2018 |
| | | 45/111 | 15.1 | 10.1 | 1.0 | 1.3 | 0.6 | 1.0 | 8.4 | 11.3 | • single-thread channel<br>• right-handed<br>• right-skewed |
| | | 46/112 | 12.8 | 12.8 | 1.3 | 0.9 | 0.7 | 0.6 | 9.6 | 9.9 | • single-thread channel<br>• side channel forming in left floodplain<br>• right-handed in 2004, left-handed by 2018<br>• right-skewed in 2004, left-skewed by 2018 |
| | | 47/112.1 | 11.3 | 17.5 | 1.1 | 1.0 | 0.6 | 0.7 | 7.2 | 12.4 | • single-thread channel<br>• slight right-handed in 2004, centered by 2018 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | • slight right-skewed in 2004, slight left-skewed by 2018 |
| | | 49/113 | 18.7 | 16.2 | 1.0 | 1.7 | 0.7 | 1.2 | 13.0 | 16.2 | • single-thread channel<br>• thalweg centered in 2004, right-handed by 2018<br>• right-skewed |
| | | 53/115 | 10.0 | 15.2 | 0.9 | 1.3 | 0.6 | 0.8 | 6.1 | 13.3 | • single-thread channel<br>• abandoned channel in the left floodplain cutoff from main channel flow and is completely revegetated<br>• slight right-handedness in 2004, right-handed by 2018<br>• slight right-skewed in 2004 to right-skewed by 2018 |
| | | 54/116 | 10.0 | 12.2 | 0.9 | 1.3 | 0.8 | 0.9 | 7.5 | 12.2 | • single-thread channel<br>• right-handed in 2004, centered by 2018<br>• right-skewed in 2004, slight right-skewed by 2018 |
| | | 55/116.1 | 15.5 | 13.3 | 1.0 | 0.8 | 0.7 | 0.6 | 11.5 | 8.2 | • single-thread channel<br>• left-handed<br>• left-skewed |
| Upper Fish Creek | 4 | 58/117 | 11.3 | 10.5 | 0.6 | 1.0 | 0.6 | 0.7 | 6.2 | 10.5 | • single-thread channel<br>• slight right-handedness in 2004, left-handed by 2018<br>• right-skewed in 2004, left-skewed by 2018 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 59/117.04 | 11.4 | 9.7 | 0.6 | 0.8 | 0.6 | 0.5 | 6.7 | 4.6 | • single-thread channel<br>• slight right-handedness in 2004, increased right-handedness by 2018<br>• slight right-skewed in 2004, right-skewed in 2018 |
| | | 62/118 | 9.9 | 9.0 | 1.0 | 1.0 | 0.7 | 0.8 | 7.1 | 9.0 | • single-thread channel<br>• right-handed<br>• right-skewed |
| | | 64/119 | 7.4 | 7.0 | 0.8 | 1.3 | 0.6 | 0.9 | 4.0 | 7.0 | • single-thread channel<br>• left-handed<br>• left-skewed |
| | | 65/119.1 | 11.1 | 8.7 | 1.2 | 1.1 | 0.8 | 0.9 | 9.3 | 62.1 | • single-thread channel<br>• right-handed in 2004, left-handed by 2018<br>• slight right-skewed in 2004 shifted to left-skewed by 2018 |
| | | 67/120 | 10.4 | 12.2 | 1.3 | 1.1 | 0.9 | 0.6 | 10.3 | 12.2 | • single-thread channel<br>• left-handed<br>• left-skewed |
| | | 73/121.1 | 15.1 | 12.6 | 1.0 | 1.0 | 0.5 | 0.6 | 7.0 | 7.1 | • single-thread channel<br>• right-handed in 2004, centered position by 2018<br>• right-skewed in 2004 shifted to uniform symmetry by 2018 |
| | | 74/122 | 4.0 | 10.2 | 1.0 | 1.0 | 0.8 | 0.8 | 3.2 | 7.7 | • Single-thread channel<br>• abandoned channel in left floodplain |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | • centered thalweg<br>• centered skew in 2004 shifted to slight right-skew by 2018 |
| | | 76/123 | 8.8 | 11.0 | 1.7 | 1.1 | 1.2 | 0.8 | 10.6 | 34.5 | • single-thread meander<br>• abandoned channel in left floodplain evident in 2004, largely filled and vegetated by 2018<br>• right-handed in 2004, left-handed by 2018<br>• right-skewed in 2004, shifted to left-skewed by 2018 |
| | | 78/124 | 9.8 | 14.1 | 1.3 | 1.3 | 0.9 | 1.1 | 9.1 | 55.3 | • single-thread channel<br>• abandoned meander cutoff in left floodplain evident in 2004, largely filled and vegetated by 2018<br>• right-handed in 2004, slight left-handedness by 2018<br>• right-skewed in 2004 shifted to slightly left-skewed by 2018 |
| Priddis Creek | 10 | 2/202 | 7.9 | 10.3 | 1.1 | 0.9 | 0.6 | 0.7 | 5.3 | 7.1 | • single-thread channel<br>• left-handed in 2004, centered position by 2018 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | • left-skewed in 2004 shifted to uniform symmetry by 2018 |
| | | 5/203.1 | 7.2 | 7.8 | 1.1 | 1.2 | 0.7 | 0.7 | 4.8 | 5.2 | • Single-thread channel<br>• Abandoned meander cutoff in left floodplain evident in 2004 and had filled by 2018<br>• centered thalweg<br>• uniform thalweg symmetry in 2004, slight right-skewed by 2018 |

### 3.2.3 Cross-Section Comparison Commentary

The channel has maintained a consistent single-thread planform throughout the limited study area encompassing the 2004 and 2018 cross-section data. No typical patterns of channel migration were observed through the analyzed reaches (i.e. channel migration at the outer bend of a meander and buildup of the inner bend by sedimentation). Summary descriptions of the cross-sections are provided below.

#### 3.2.3.1 Lower Fish Creek

Cross-section 32 maintains channel width and position but experiences a shift in the thalweg position both to the right and into the bed, resulting in a deeper and more symmetric channel. From observation of available air photos, the bank vegetation has remained consistent and the left bank has been protected and stabilized by the placement of riprap between 2008 and 2018. Cross-section 34 has shifted approximately 5 m to the right but experienced minimal change to the overall channel shape. A depression has developed to the left of the main channel; but based on aerial photos, appears to be an isolated water body rather than a developing side channel.

Cross-sections 38 through 41 lie within 20 m downstream or upstream of the HWY 22W road crossing. A substantial increase in cross-sectional area was noted at each of these four sites, but was accommodated differently by the individual cross-sections. The downstream-most cross-section (XS 38) has shifted to the left and widened approximately 2 m, and the bed has aggraded. The banks of the cross-sections directly downstream (XS 39) and upstream (XS 40) of the bridge have not shifted between 2004 and 2018, however, scouring of the bed has occurred at both cross-sections. The upstream cross-section (XS 41) shifted to the right and narrowed by approximately 2 m and the bed degraded. The depression left by the former main channel to the right of the existing main channel at XS 41 was observed in the 2004 data, but was filled in the 2018 data.

Cross-sections 42 through 49 fall between the HWY 22W bridge cross-sections downstream and the Priddis Valley Road W bridge upstream. Cross-sections 42 through 46 lie within an approximately straight stretch of the river, and show lateral shifting of the channel of 3 m or less with no appreciable change to channel width. Bed degradation of between 0.3 and 0.7 m was observed at XS 42, 44, and 46, while no change in bed elevation was noted at XS 44. Cross-sections 46 to 49 lie along a gentle bend in the channel. The channel widens and shifts to the left at both cross-sections 46 and 47 and the bed elevation increases, indicating aggradation. Cross-section 49 widens by 8 m through erosion of the left bank, and the bed degrades by almost 1 m between 2004 and 2018.

Cross-sections 53 through 55 lie downstream of the confluence of Fish Creek with Priddis Creek. XS 53 and 54 both increase in width and depth between 2004 and 2018, while XS 55 narrows by 3 m along the left bank.

#### 3.2.3.2 Upper Fish Creek

Modest increases are seen in cross-sectional area for cross-sections 58 to 64, except for XS 59, which decreases slightly. Bed degradation is observed at all four cross-sections, ranging from 0.2 to 0.6 m of elevation loss. The 186 Avenue W Bridge is bound by cross-sections 58 and 59. XS 58 (downstream) widens and shifts to the left, with XS 59 maintains a consistent width but also shifts to the left.

Cross-sections 62 to 78 lie along a series of relatively high-amplitude meander bends within the reach. Cross-sections 62 to 73 all show slight narrowing of channel widths. Cross-sections 62 and 64 maintain relatively consistent bank positions with narrowing of 0.5 to 1 m. Bed elevations at the crossings decreased 0.4 to 0.6 m. Cross-sections 64 and 65 both shifted to the right by 4 to 5.5 m, while cross-section 67 shifts to the left 4 m. The upper four cross-sections experienced bed aggradation of between 0.2 and 1 m between 2004 and 2018. Cross-section 73 narrows by 5 m, accommodated largely by growth of the right bank. Cross-sections 74 and 76 both widen between 2004 and 2018, however, the bed elevation at XS 74 decreases by approximately 0.1 m, while the bed at XS 74 aggrades by 1 m. Cross-section 78 shifts to the right and widens, but no appreciable change in bed elevation is observed.

#### 3.2.3.3 Priddis Creek

Both cross-sections 2 and 5 on Priddis Creek migrated to the right. XS 2 narrowed through the build-up of the left bank, and deepened by approximately 1.2 m. XS 5 widened by 1.5 m on the right bank, and deepened 0.3 m.

## 3.3 THALWEG PROFILE COMPARISON

### 3.3.1 Thalweg Profile Comparison Methods

Thalweg profiles from the 2004 and 2018 hydraulic models were compared to identify changes in the vertical position of the deepest part of the channel cross-section. A decrease in thalweg elevation indicates bed degradation or scour, while an increase in thalweg position indicates bed aggradation through sedimentation. Elevation changes were calculated for each cross-section and a net change profile was developed, where zero indicates no net change in bed elevation, a positive value indicates sedimentation, and a negative value indicates scour.

Horizontal shifts in thalweg position were calculated from the cross-section profiles (refer to Section 3.2.2) and compared to channel planform information to identify areas of lateral channel migration.

### 3.3.2 Thalweg Profile Results

The comparison graphs of Fish Creek from 2004 and 2018 are shown in Figure 2, and comparison for Priddis Creek are shown in Figure 4. A thalweg profile in equilibrium typically displays a concave-upward profile, chiefly a result of a decrease in channel slope with distance downstream.

The thalweg profiles from the 2018 data in Reaches 4 and 2 of Fish Creek both show a concave down profile, while the profile in Reach 3 is largely concave up. The profiles are quite similar in general shape to the profiles derived from the 2004 data, however, Reach 3 data from 2018 shows greater changes in elevation between data points compared to 2004.

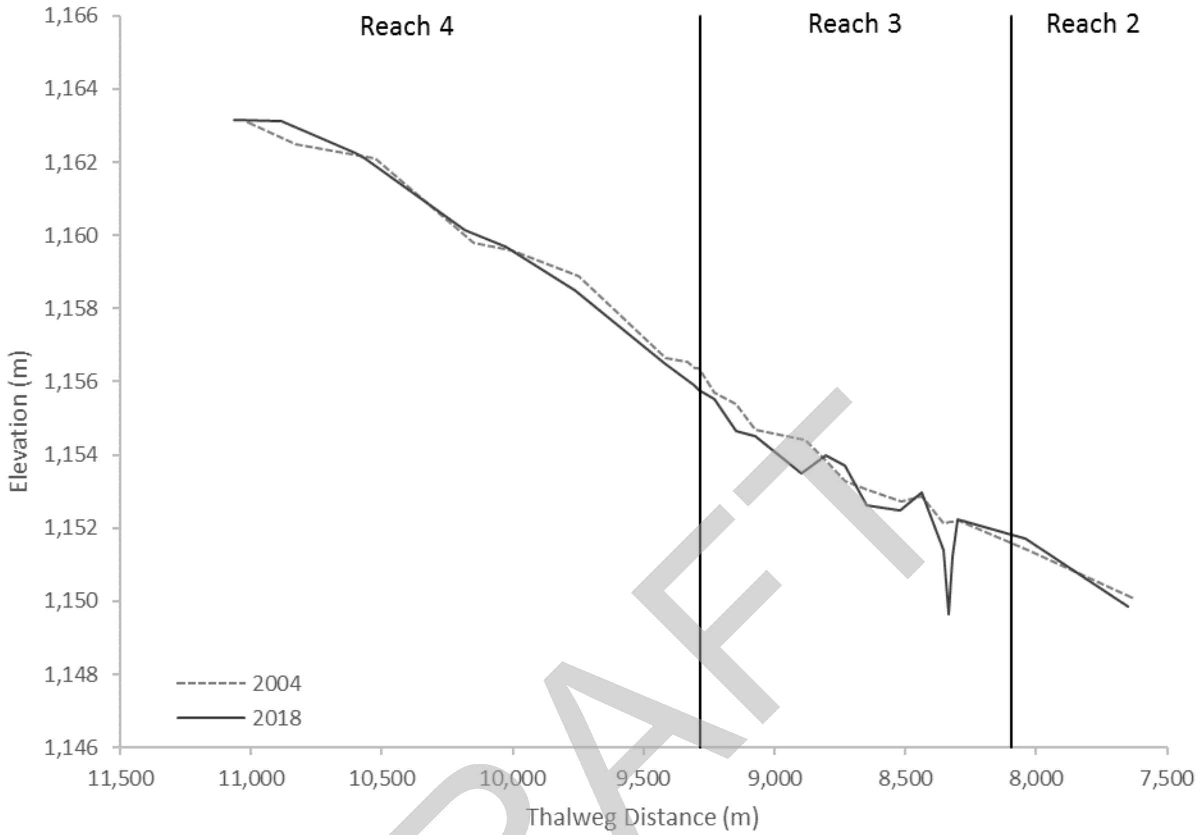


**Figure 2. Fish Creek thalweg profile comparison.**

To consider the differences in the thalweg profiles between 2004 and 2018 in more detail, a graph displaying the elevation differences are presented in Figure 3. The bed experienced aggradation from cross-sections 78 to 65, and degradation between cross-sections 64 to 49. The change in bed elevation fluctuated for the remainder of the channel, including a large scour hole developed at XS 40.

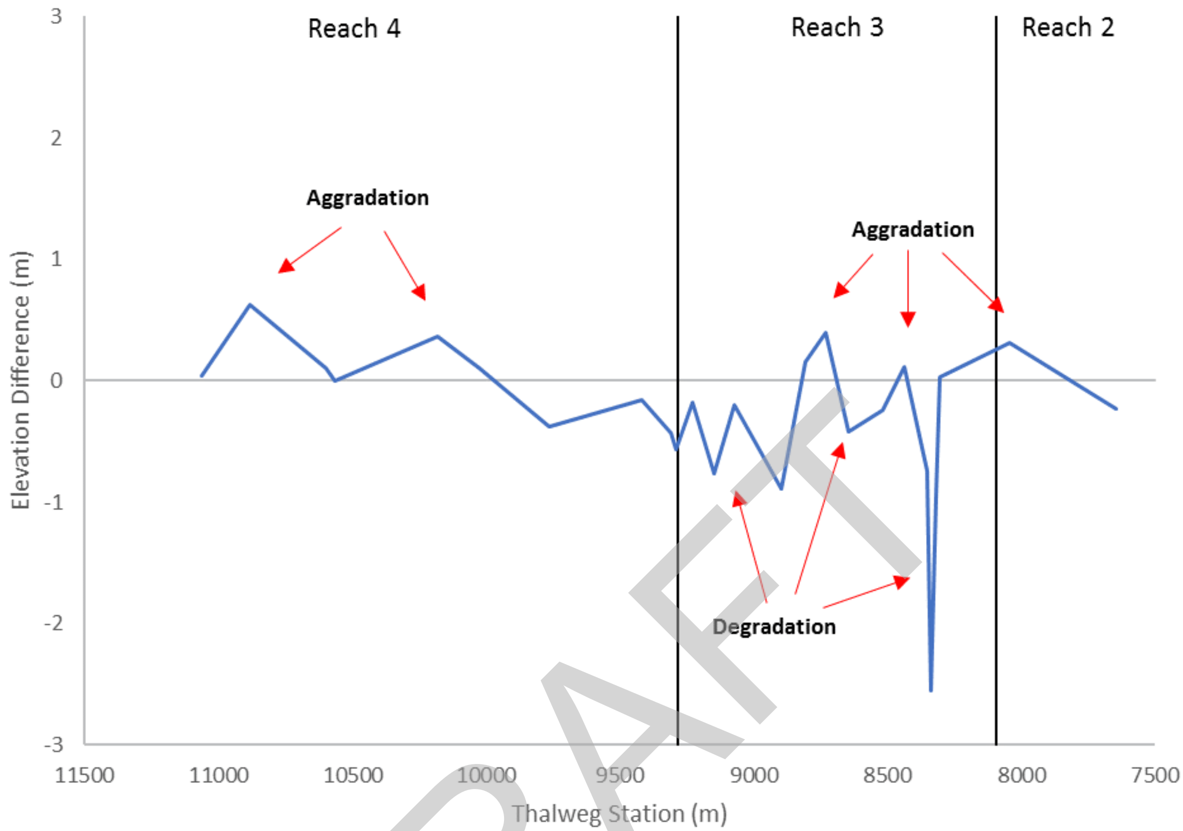


**Figure 3. Fish Creek thalweg elevation difference comparing 2004 data to 2018 data.**

The Priddis Creek thalweg profile from 2018 shows a general concave-up profile in contrast to the concave-down profile developed from the 2004 data (Figure 4). The change in profile concavity can be explained by the results of the elevation difference profile (Figure 5), which shows degradation throughout the assessed section of Priddis Creek.

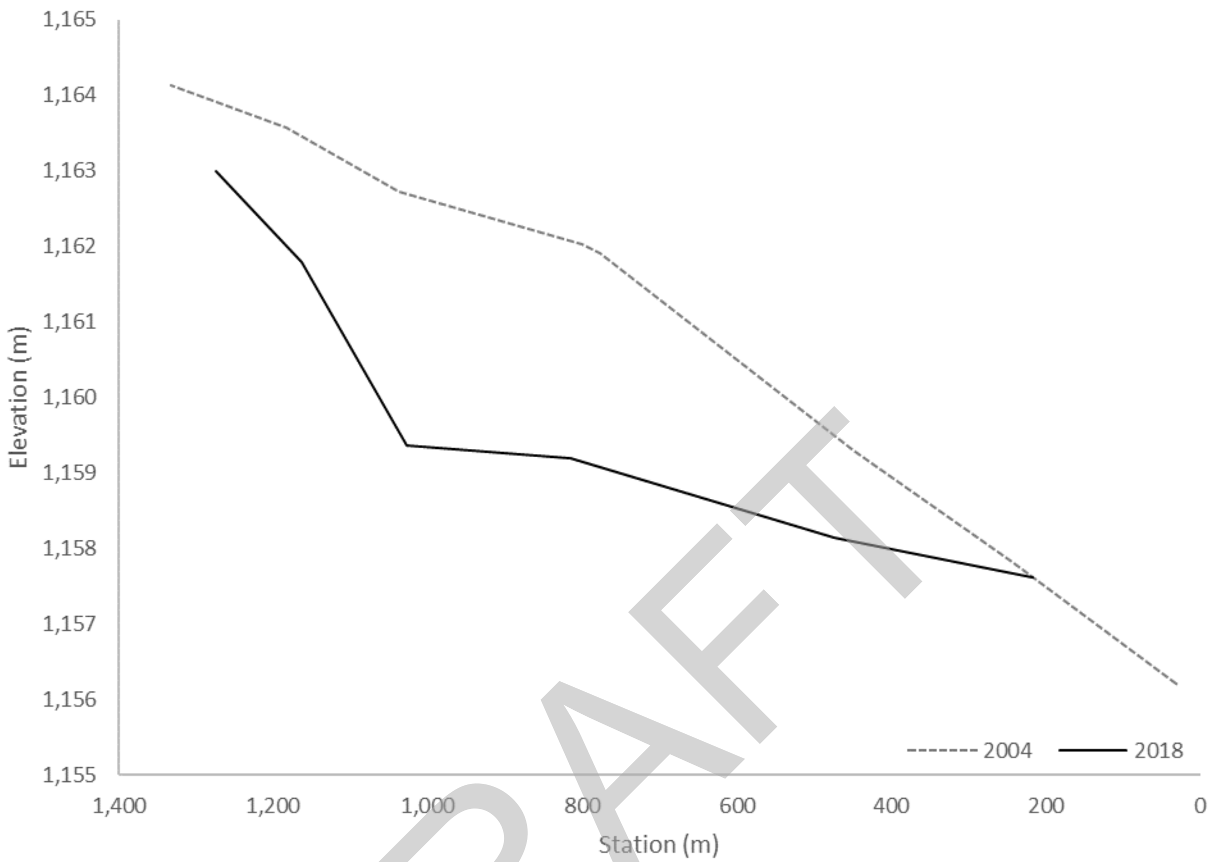


**Figure 4: Priddis Creek thalweg profile comparison.**

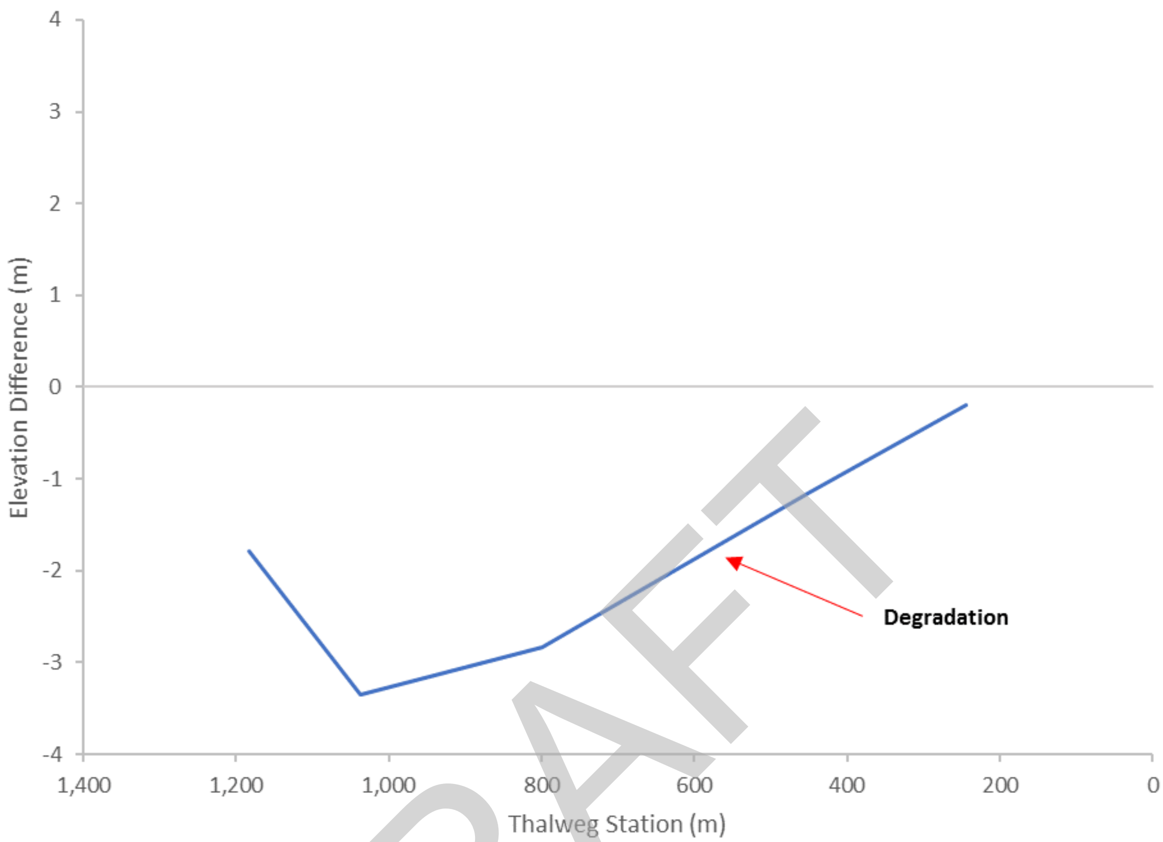


**Figure 5: Priddis Creek thalweg elevation difference, 2004 compared to 2018.**

## 3.4 RATING CURVE COMPARISON

### 3.4.1 Rating Curve Comparison Methods

The rating curve provides the relation between flow stage and discharge at a given location on a river. As such, the curve can provide an indication of changes to channel geometry due to bed mobility as a response to variable flow conditions.

The historical (2005) and most recent (2013) rating curves developed from WSC gauge data were assessed and related to the changes observed in the channel cross-section and thalweg data of the nearest cross-sections. The data collected from the comparison of river geometry (channel delineation, cross-section and thalweg) were used to inform interpretations of changes observed in the rating curves.

### 3.4.2 Rating Curve Comparison Results

The results of the rating curve comparison for WSC station 05BK001 are presented in Figure 6.

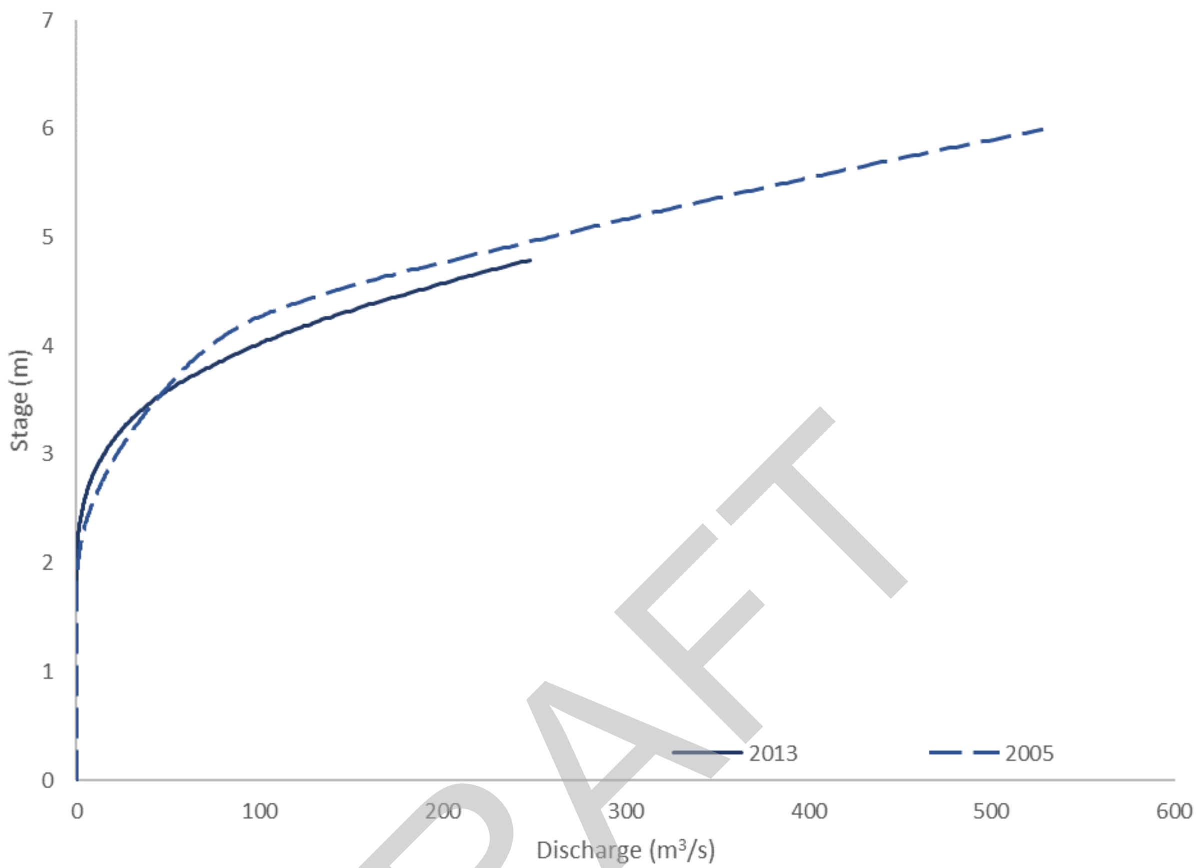


**Figure 6. Historical rating curve comparison for WSC 05BK001.**

The hydrometric station is located within Geomorphic Reach 3 and is roughly located at the 2018 Stantec cross-section 54.

When comparing the 2005 curve to the 2013 curve, the water levels were higher in 2013 for discharges up to 48 $m^3$/s when compared to 2005. The rating curve lines then cross at 48 $m^3$/s and the water levels at flood-stages were lower for a given discharge in 2013 compared to 2005.

The crossing of the curves can be explained by looking at the profiles of cross-section 54 for 2004 and 2018. The 2004 channel is roughly trapezoidal in shape, with a large width-to-depth ratio. The 2018 channel cross-section shows a low-flow channel that has eroded into the trapezoidal channel bed, which is narrower with respect to the width-to-depth ratio as compared to the 2004 channel. For a channel bed with comparable thalweg elevations, the 2018 channel would have a higher water level for a given discharge compared to the 2005 channel, up to the banks of the low flow channel, where the substantial increase in width would result in a decrease in water level relative to discharge.

The cross-section does present conflicting evidence to the rating curve analysis in that the bed elevation of the 2005 profile is at a higher elevation to the 2018, which would yield a rating curve that is consistently higher in 2005 compared to 2018. Reasons for the differences between the cross-sections and the rating curves may be due to lack of consistent measuring location for water levels (at the stations for lower flows and at the bridge for higher flows), or subtle differences in channel profile between the location of the cross-section data collection and the location of the gauge station.

# 4.0 CONCLUSIONS

## 4.1 LOWER FISH CREEK

The reaches assessed in Lower Fish Creek are largely unconfined and flow through wide floodplains that show evidence of widespread channel migration in the past. The reach has generally experienced a narrowing of the channel, paired with increased vegetation along the bank line. This is indicative of channel stabilization; however, the floodplain is composed of predominantly loose, coarse, and easily erodible material. Since the vegetation growth is predominantly grass and small shrub, it provides only limited protection, and could be susceptible to erosion under high flow conditions. Based on cross-sectional data available in Lower Fish Creek, the channel bed has been downcutting throughout most of the reach. Downcutting can increase the bank slopes and leave the banks vulnerable to failure.

## 4.2 UPPER FISH CREEK

The reaches assessed in Upper Fish Creek range from unconfined to partially confined. The unconfined reaches are similar to those in Lower Fish Creek, where the banks and wide unconfined floodplain are susceptible to channel migration and have experienced channel activity throughout the floodplain based on oxbows and meander scars in the floodplain. Where the channel is partially confined, erosion is limited by steep bedrock slopes and are considered stable. The high sinuosity of the channel in most bends may lead to meander cutoffs.

## 4.3 PRIDDIS CREEK

The lower reaches of Priddis Creek (10 – 14) are predominantly single-thread channels flowing through mostly unconfined floodplains similar to those described in Fish Creek. Low to moderate channel migration was observed in these reaches, however, changes noted to the channel over time were largely attributed to meander cutoff. The erodible nature of the low, flat floodplains are susceptible to future erosion. The upper two reaches are largely controlled by the presence of widespread beaver damming. This provides stability to the channel by reducing flow velocities and stream energies. Ponds that form upstream of beaver dams typically aggrade over time as transport sediment is deposited. As beaver dams age and are abandoned they may become susceptible to breach, which could increase downstream erosion with increase flow velocities, and destabilize accumulated sediment stored in beaver ponds.

## Table 8. Summary of qualitative reach characteristics.

| Reach | River | Sinuosity (2018) | Description |
|---|---|---|---|
| 1 | Lower Fish Creek | 1.5 | • Unconfined<br>• Single-thread channel<br>• Low-amplitude, regularly meandering planform<br>• Incised<br>• Progressive in-channel bar growth, large volume of sediment stored<br>• Numerous oxbows and meander scars in the floodplain, particularly left floodplain |
| 2 | | 1.8 | • Unconfined<br>• Single-thread channel<br>• Irregularly meandering planform<br>• Stabilization of lateral bars by vegetation resulting in channel narrowing<br>• Channel migration along bends throughout reach<br>• Oxbows and meander scars in the floodplain<br>• Evidence of beaver activity exerting minimal local control |
| 3 | | 1.1 | • Partially confined<br>• Single-thread channel<br>• Straight planform<br>• Channel planform relatively stable throughout aerial imagery record<br>• No evidence of beaver activity<br>• Stabilization of lateral bars by vegetation causing channel narrowing |
| 4 | Upper Fish Creek | 1.7 | • Unconfined<br>• Incised<br>• Single-thread channel<br>• High amplitude, regularly meandering planform<br>• Channel planform relatively stable throughout aerial imagery record<br>• Moderate beaver activity exerting local flow control<br>• Limited presence of lateral bars<br>• Recent bank protection placed along outer banks in lower reach |
| 5 | | 2.3 | • Unconfined<br>• Single-thread channel<br>• Highly sinuous, irregularly meandering planform<br>• Channel planform relatively stable from 1966 to present<br>• Presence of channel bars and small stable vegetated islands<br>• Numerous oxbows and meander scars in the floodplain |
| 6 | | 2.2 | • Partially confined<br>• Single-thread channel<br>• Highly sinuous, irregularly meandering planform<br>• Incised<br>• Floodplain largely covered in dense mature forest<br>• Minor channel migration along outer bends<br>• Presence of lateral bars<br>• Oxbows and meander scars in the floodplain |
| 7 | | 1.6 | • Partially confined<br>• Single-thread channel<br>• Tight, moderately regularly meandering planform |

| Reach | River | Sinuosity (2018) | Description |
|---|---|---|---|
| | | | • Incised<br>• Floodplain largely covered in dense mature forest<br>• Minor channel migration along outer bends over time<br>• Presence of lateral bars |
| 8 | | 1.2 | • Unconfined<br>• Single-thread channel<br>• Low-sinuosity meandering planform<br>• Floodplain largely covered in dense mature forest<br>• No substantial change to channel planform observed after 1974<br>• Presence of bars in lower half of reach<br>• Meander scars in floodplain |
| 9 | | 2.0 | • Partially confined<br>• Single-thread channel<br>• Irregularly meandering planform<br>• Incised<br>• No substantial change to channel planform observed after 1966<br>• Presence of lateral bars<br>• Meander scars in the floodplain |
| 10 | Priddis Creek | 2.2 | • Unconfined<br>• Single-thread channel<br>• Irregularly meandering planform<br>• Channel straightening through meander cutoff over aerial imagery record<br>• Presence of lateral and medial bars<br>• Evidence of beaver activity exerting minimal local control |
| 11 | | 1.7 | • Unconfined<br>• Single-thread channel<br>• Irregularly meandering planform<br>• Active channel splitting throughout aerial imagery record<br>• Evidence of beaver activity exerting moderate local control<br>• Presence of large lateral bars |
| 12 | | 1.6 | • Partially confined<br>• Single-thread channel<br>• Irregularly meandering planform<br>• Heavily vegetated floodplain<br>• Channel largely stable throughout aerial imagery record<br>• Limited presence of lateral bars<br>• Evidence of beaver activity exerting moderate local control |
| 13 | | 1.7 | • Unconfined<br>• Single-thread channel<br>• Irregularly meandering planform<br>• Incised<br>• Stabilization of lateral bars into floodplain resulting in channel narrowing<br>• Numerous vegetated meander scars in the surrounding floodplain |
| 14 | | 1.0 | • Confined<br>• Single-thread channel<br>• Straight reach<br>• Limited connection between channel and floodplain |

| Reach | River | Sinuosity (2018) | Description |
|---|---|---|---|
| | | | • No substantial change to channel position observed |
| 15 | | 1.5 | • Unconfined<br>• Anabranched channel<br>• Irregularly meandering channel planform<br>• Numerous meander loop cutoffs occurred since 1949 imagery<br>• Upper reach is morphologically controlled by beaver dams (presently and historically)<br>• Lower section of reach is incised |
| 16 | | 1.5 | • Unconfined<br>• Predominantly single-thread channel with split flow around some stable island<br>• Irregularly meandering channel planform<br>• Morphology controlled by beaver dams throughout reach (presently and historically) |

# 5.0 REFERENCES

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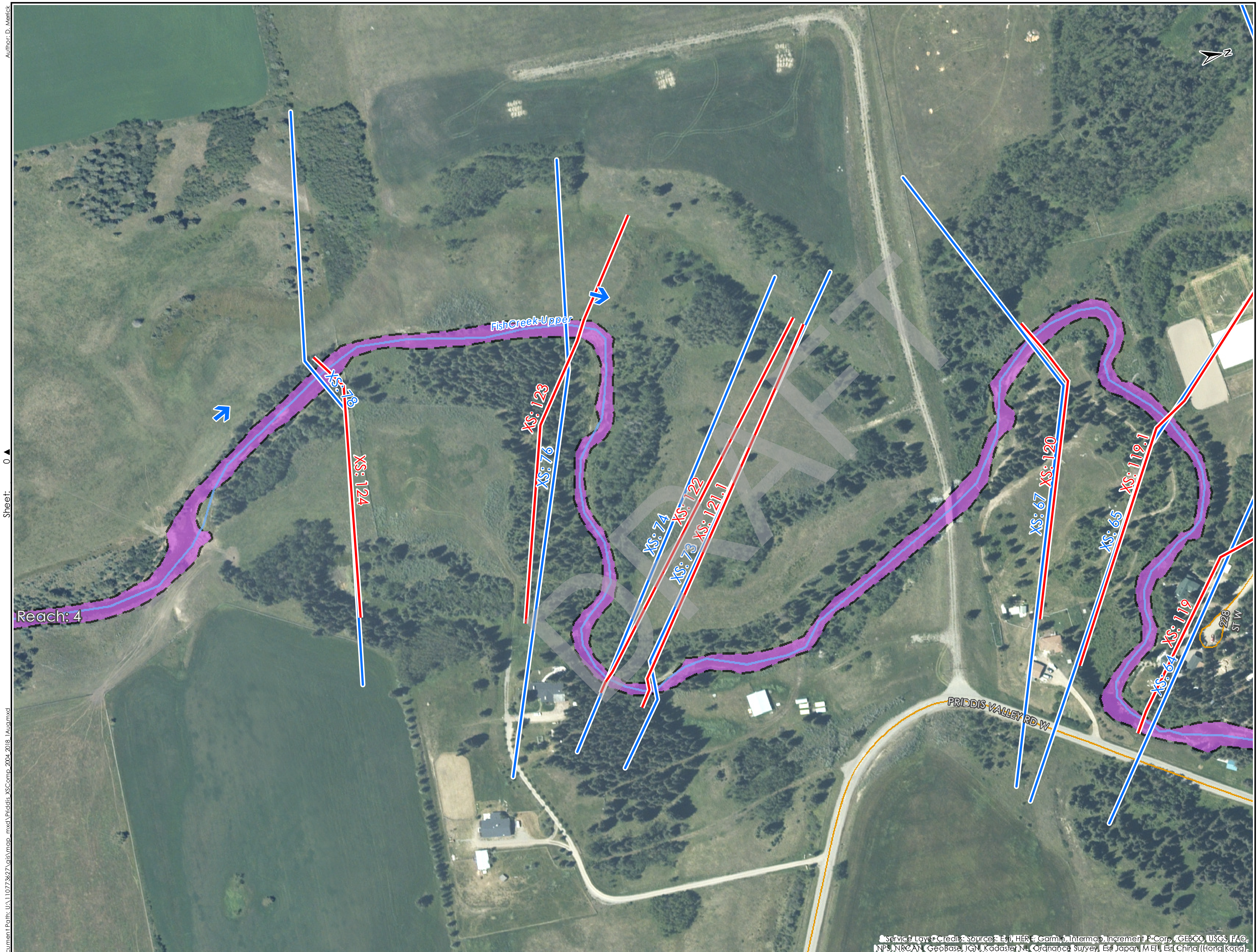
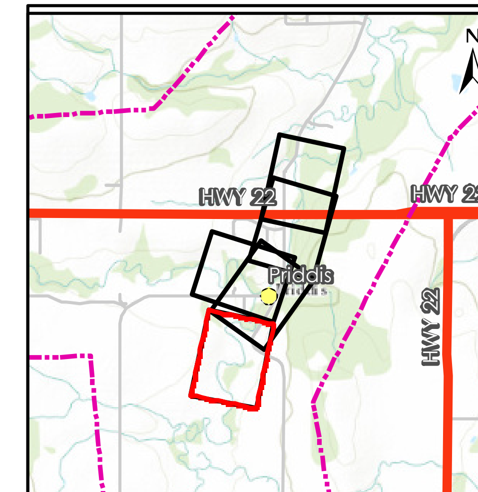
# APPENDIX A

## Cross-Section Locations




Alberta Government

Stantec

2018 Cross Sections

2004 Cross Sections

Banks - 2018

Reach 4

Local Road

Creek

Flow Direction

50 25 0 50 Meters Scale 1:2,500

Priddis River Hazard Study

Cross Section Locations: 2004 - 2018

| GIS: | QA/QC: | Approved: |
|---|---|---|
| DM | MA | MW |

Spatial Ref: NAD 1983 CSRS 3TM 114

Sheet: 1 of 5

| Project No. | REV. | Date: |
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| 110773627 | A | 31 Jul 2019 |

Author: D. Merrick

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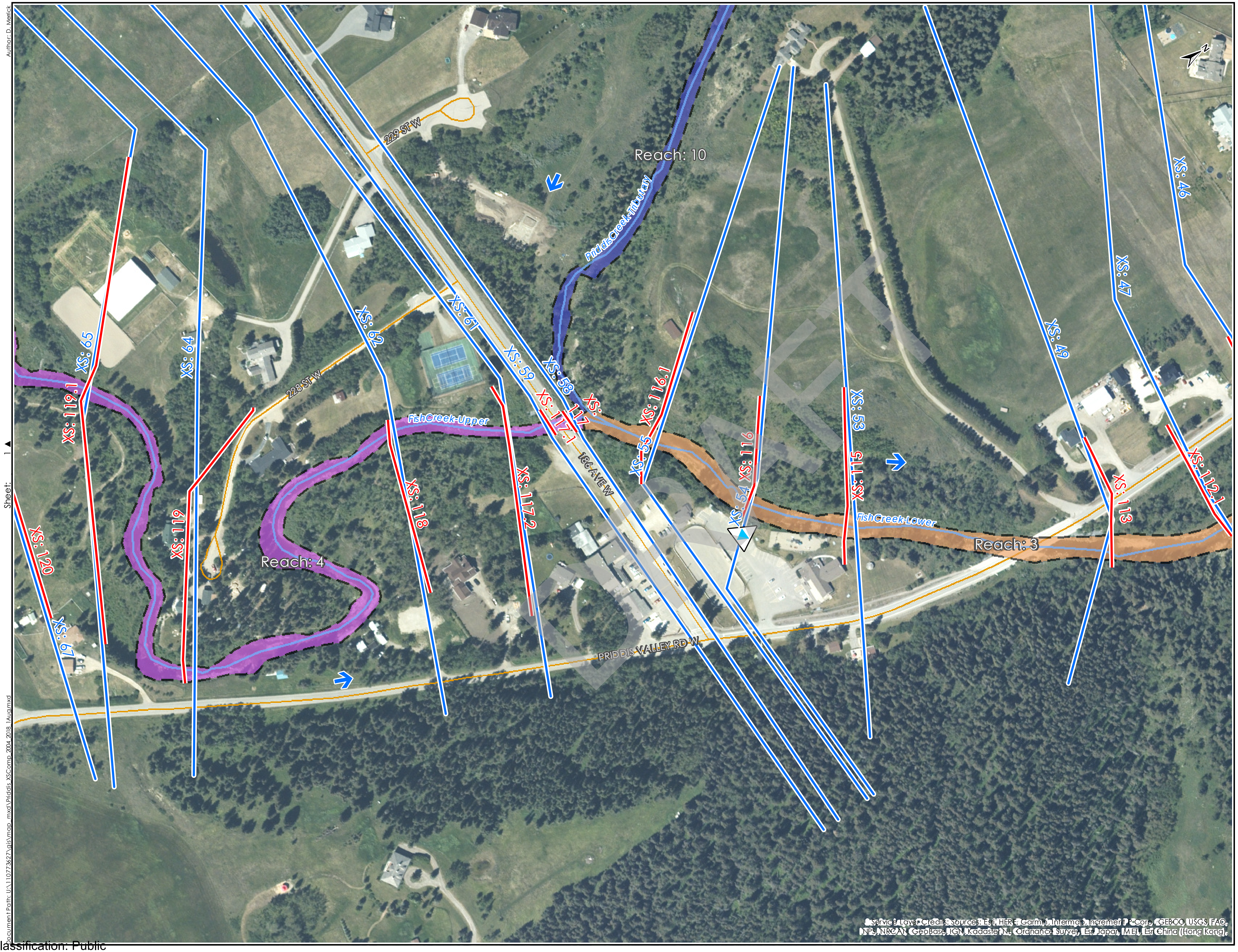


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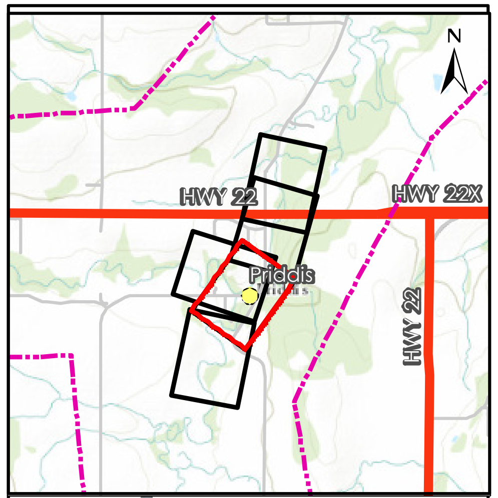


Alberta Government

Stantec

WSC Gauge Station
2018 Cross Sections
2004 Cross Sections

Banks - 2018

Reach 3
Reach 4
Reach 10
Local Road
Creek
Flow Direction

50 25 0 50 Meters
Scale 1:2,500

Priddis River Hazard Study
Cross Section Locations: 2004 - 2018

| GIS: | QA/QC: | Approved: |
|---|---|---|
| DM | MA | MW |

| Spatial Ref: | Sheet: |
|---|---|
| NAD 1983 CSRS 3TM 114 | 2 of 5 |

| Project No. | REV. | Date: |
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| 110773627 | A | 31 Jul 2019 |

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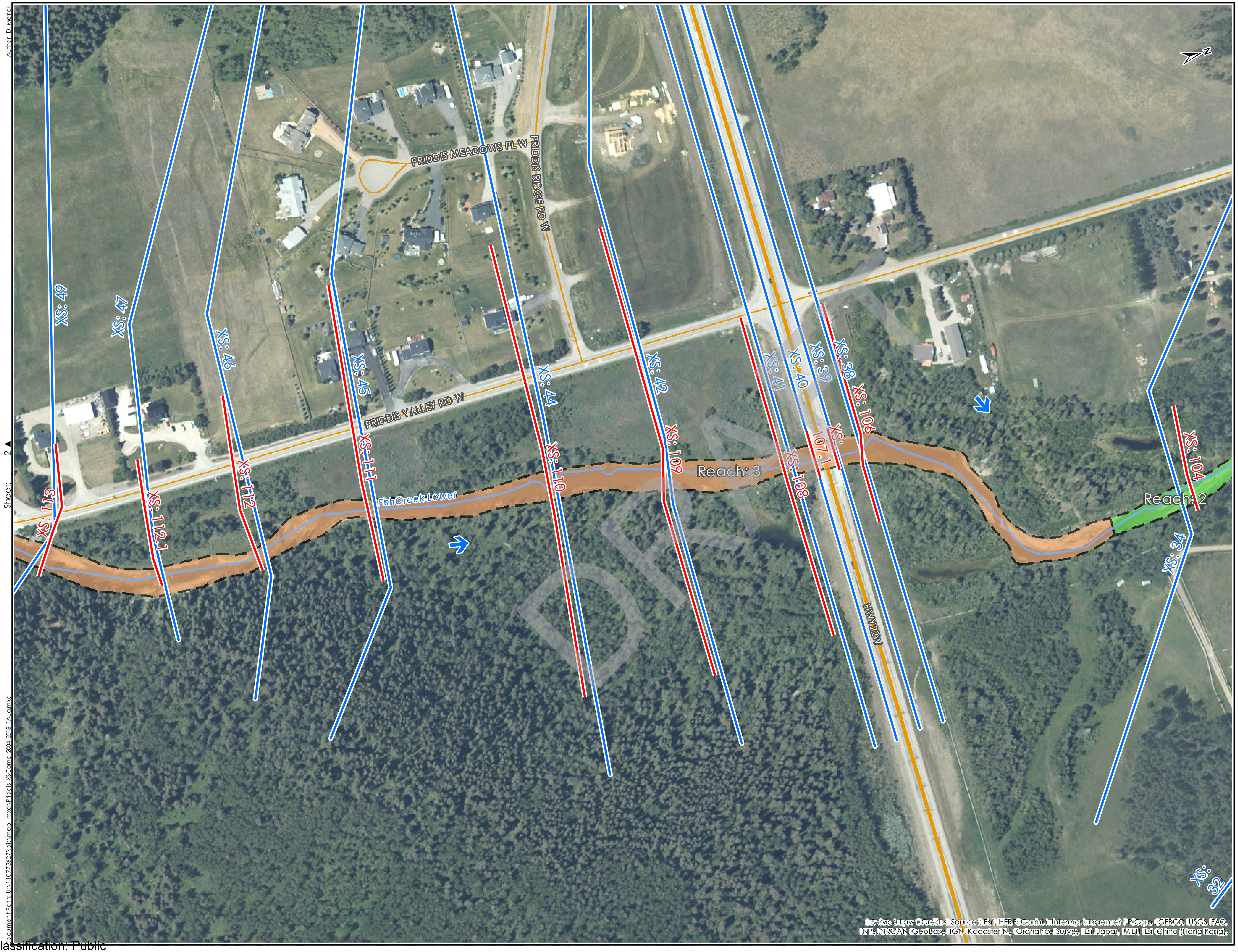


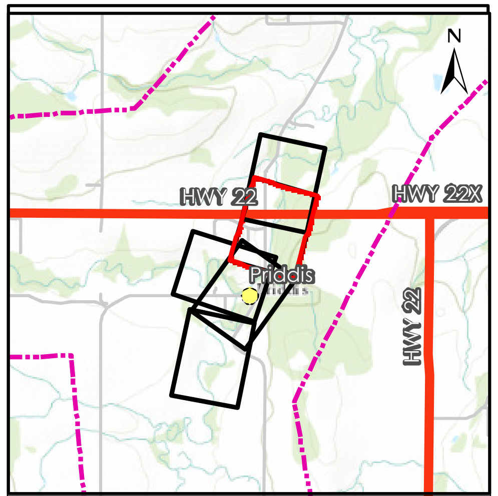


Alberta Government

Stantec

2018 Cross Sections
2004 Cross Sections

Banks - 2018

Reach 2
Reach 3
Major Road
Local Road
Creek
Flow Direction

50 25 0 50 Meters
Scale 1:2,500

Priddis River Hazard Study
Cross Section Locations:
2004 - 2018

| GIS: | QA/QC: | Approved: |
|---|---|---|
| DM | MA | MW |

Spatial Ref: NAD 1983 CSRS 3TM 114
Sheet: 3 of 5

| Project No. | REV. | Date: |
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| 110773627 | A | 31 Jul 2019 |

Author: D. Merrick

Sheet: 2

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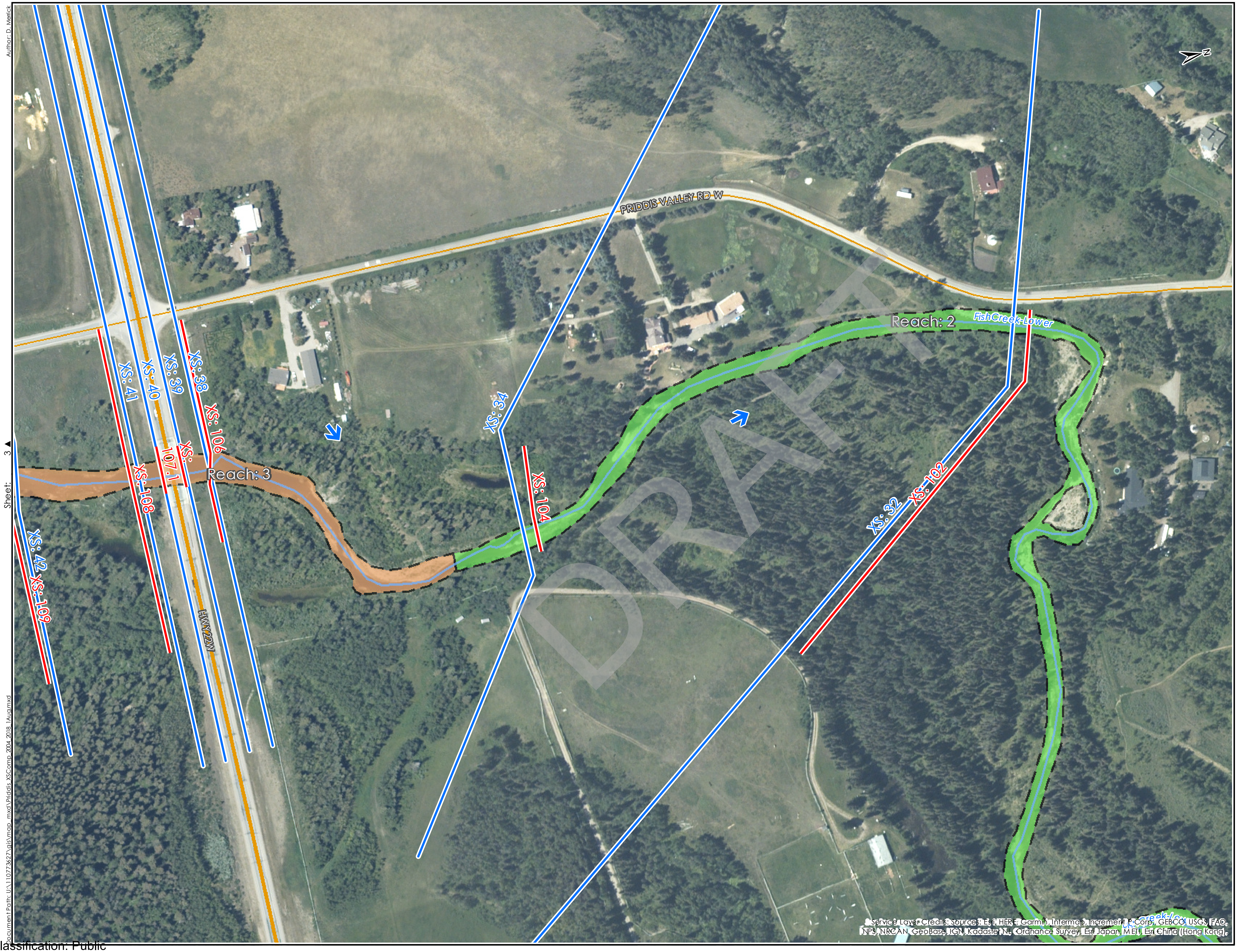


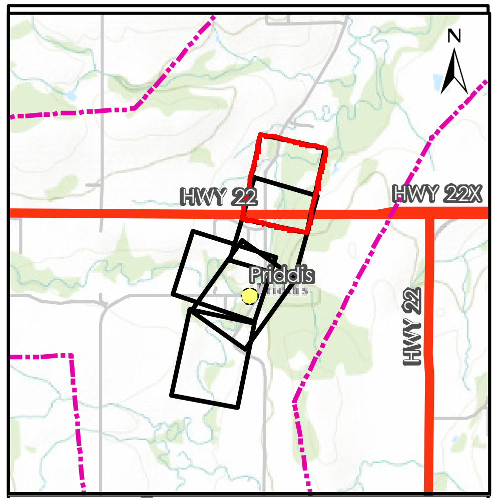


Alberta Government

Stantec

2018 Cross Sections
2004 Cross Sections

Banks - 2018

Reach 2
Reach 3
Major Road
Local Road
Creek
Flow Direction

50 25 0 50 Meters
Scale 1:2,500

Priddis River Hazard Study
Cross Section Locations: 2004 - 2018

| GIS: | QA/QC: | Approved: |
|---|---|---|
| DM | MA | MW |

| Spatial Ref: | Sheet: |
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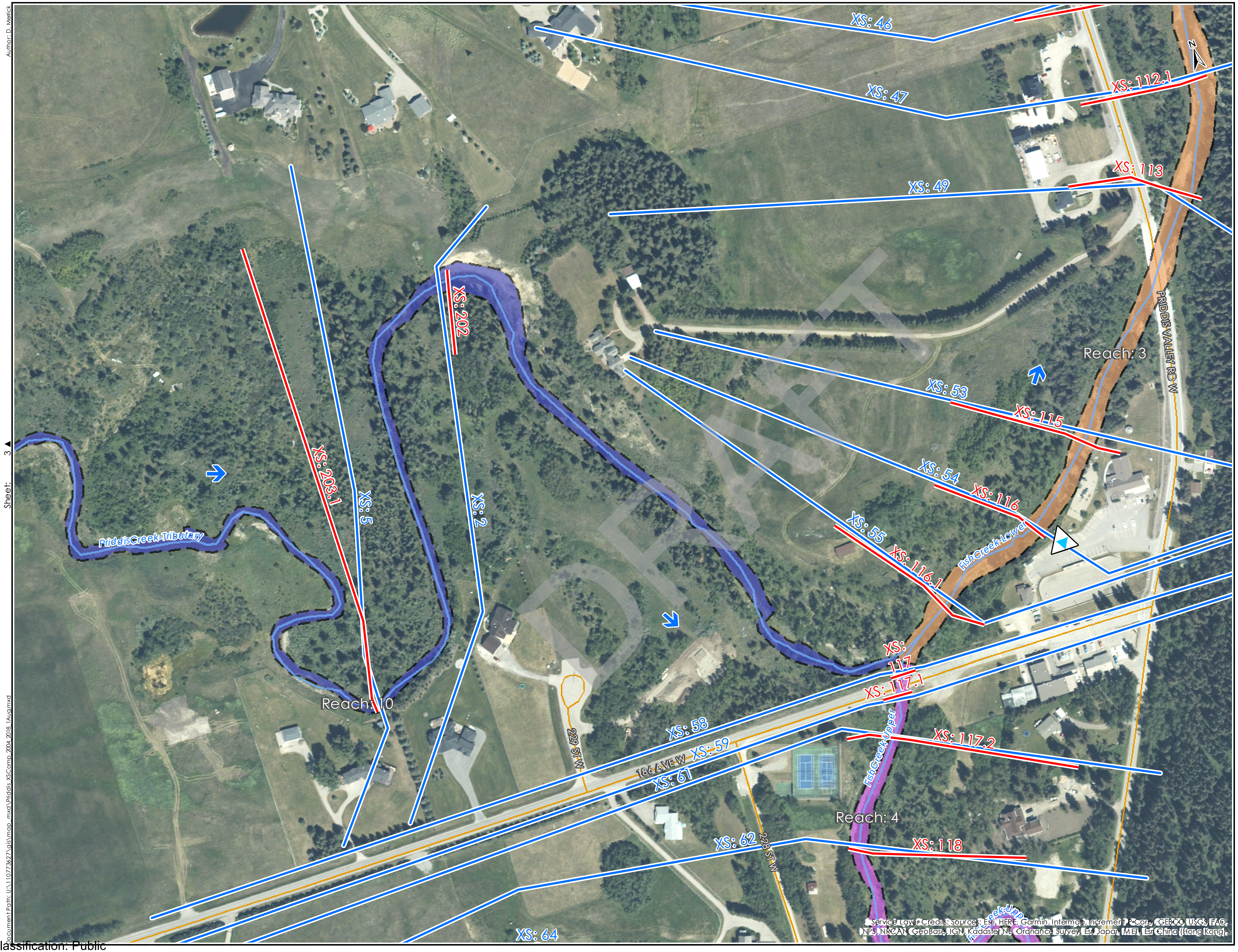


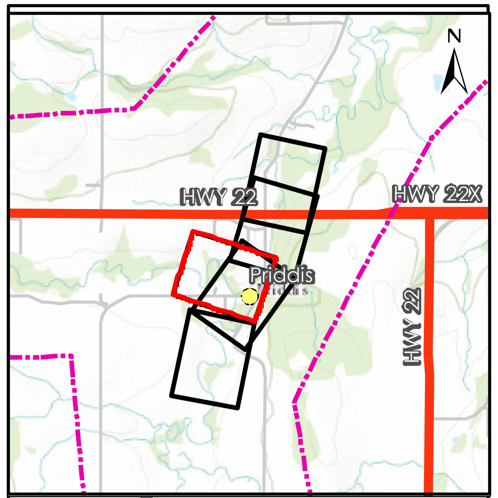


Alberta Government

Stantec

WSC Gauge Station

2018 Cross Sections

2004 Cross Sections

**Banks - 2018**

Reach 3

Reach 4

Reach 10

Local Road

Creek

Flow Direction

50 25 0 50 Meters

Scale 1:2,500

Priddis River Hazard Study
Cross Section Locations:
2004 - 2018

| GIS: | QA/QC: | Approved: |
|---|---|---|
| DM | MA | MW |

Spatial Ref: NAD 1983 CSRS 3TM 114

Sheet: 5 of 5

| Project No. | REV. | Date: |
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Sheet: 2 ►

Author: D. Merick

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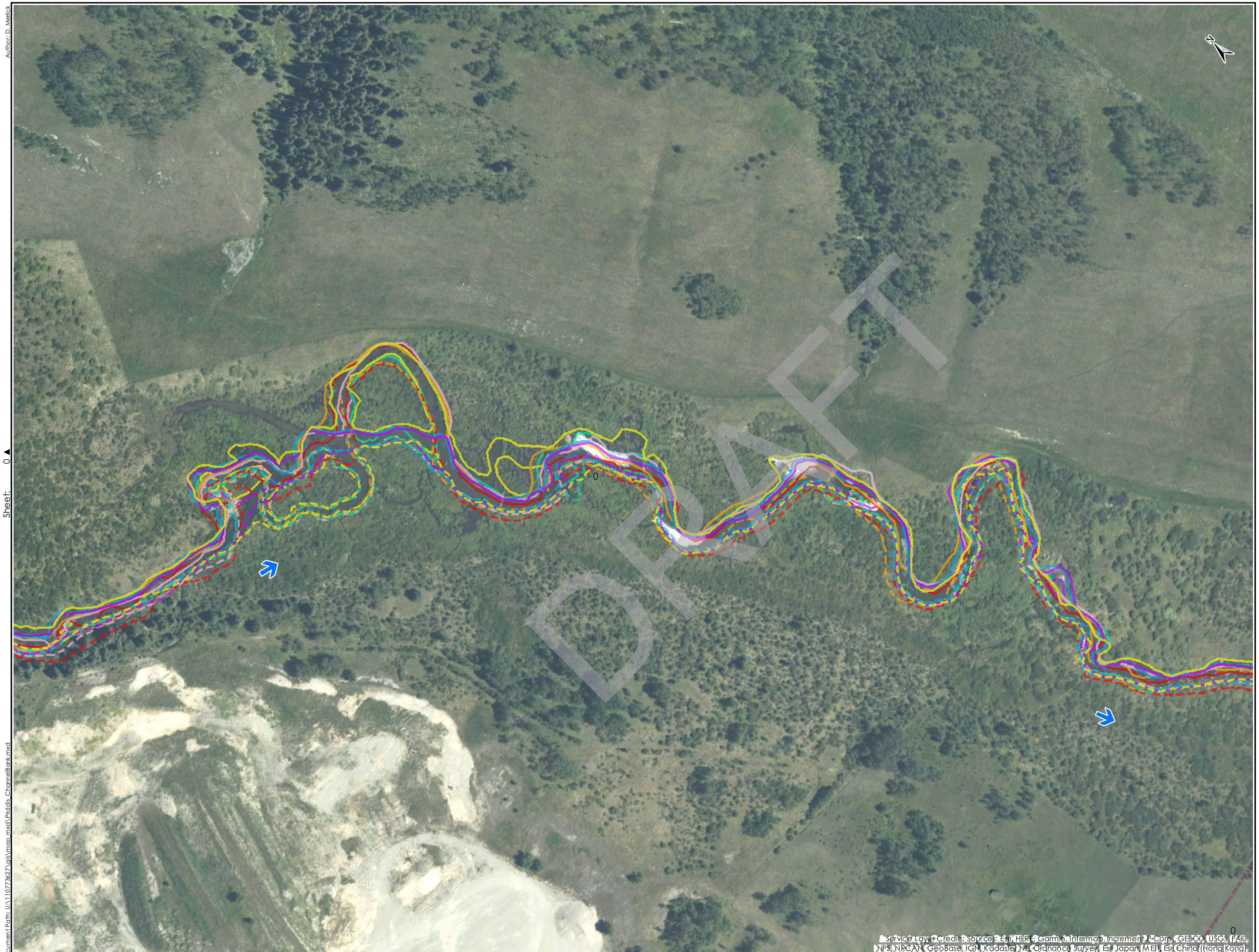
# APPENDIX B

## Channel Bank Delineations

Author: D. Merrick

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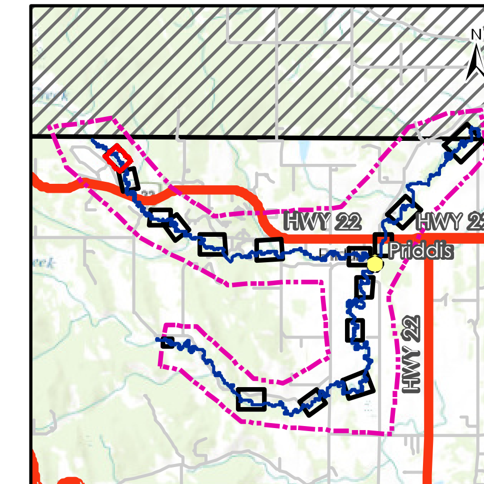


Alberta Government

Stantec

| Legend |
|---|
| Flow Direction |
| 1949 Left Bank |
| 1949 Right Bank |
| 1966 Left Bank |
| 1966 Right Bank |
| 1974 Left Bank |
| 1974 Right Bank |
| 1987 Left Bank |
| 1987 Right Bank |
| 1998 Left Bank |
| 1998 Right Bank |
| 2008 Left Bank |
| 2008 Right Bank |
| 2018 Left Bank |
| 2018 Right Bank |

10 5 0 10 20 30 40 50 Meters

Scale 1:2,000

**Priddis River Hazard Study**
**Channel Bank Comparison: 1949 - 2018**

| GIS: | QA/QC | APPROVED |
|---|---|---|
| DM | MA | MW |

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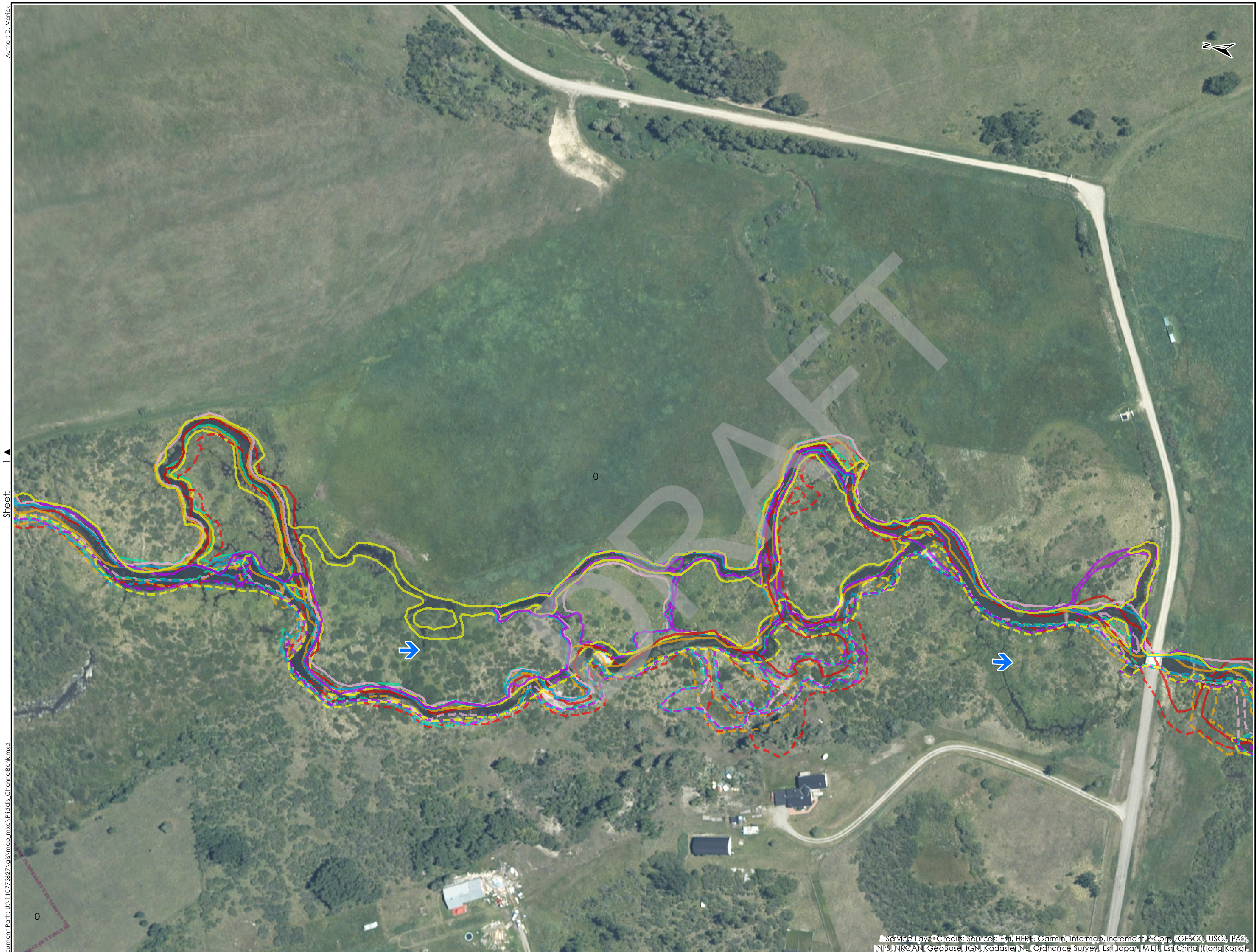


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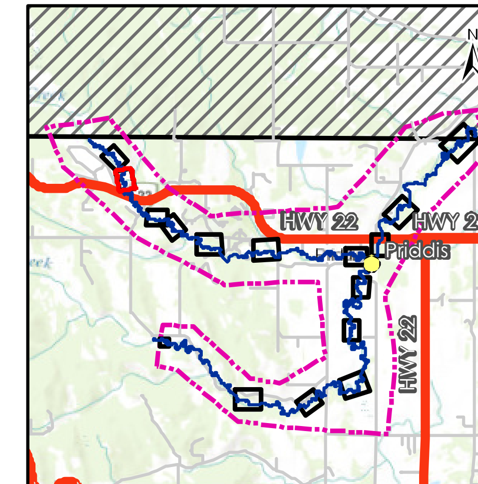


Alberta Government

Stantec

Flow Direction
1949 Left Bank
1949 Right Bank
1966 Left Bank
1966 Right Bank
1974 Left Bank
1974 Right Bank
1987 Left Bank
1987 Right Bank
1998 Left Bank
1998 Right Bank
2008 Left Bank
2008 Right Bank
2018 Left Bank
2018 Right Bank

10 5 0 10 20 30 40 50
Meters

Scale
1:2,000

Priddis River Hazard Study
Channel Bank Comparison:
1949 - 2018

| GIS: | QA/QC | APPROVED |
|---|---|---|
| DM | MA | MW |

Spatial Ref: NAD 1983 CSRS 3TM 114

Sheet: 2 of 16

| Project No. | REV. | Date: |
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Author: D. Merrick

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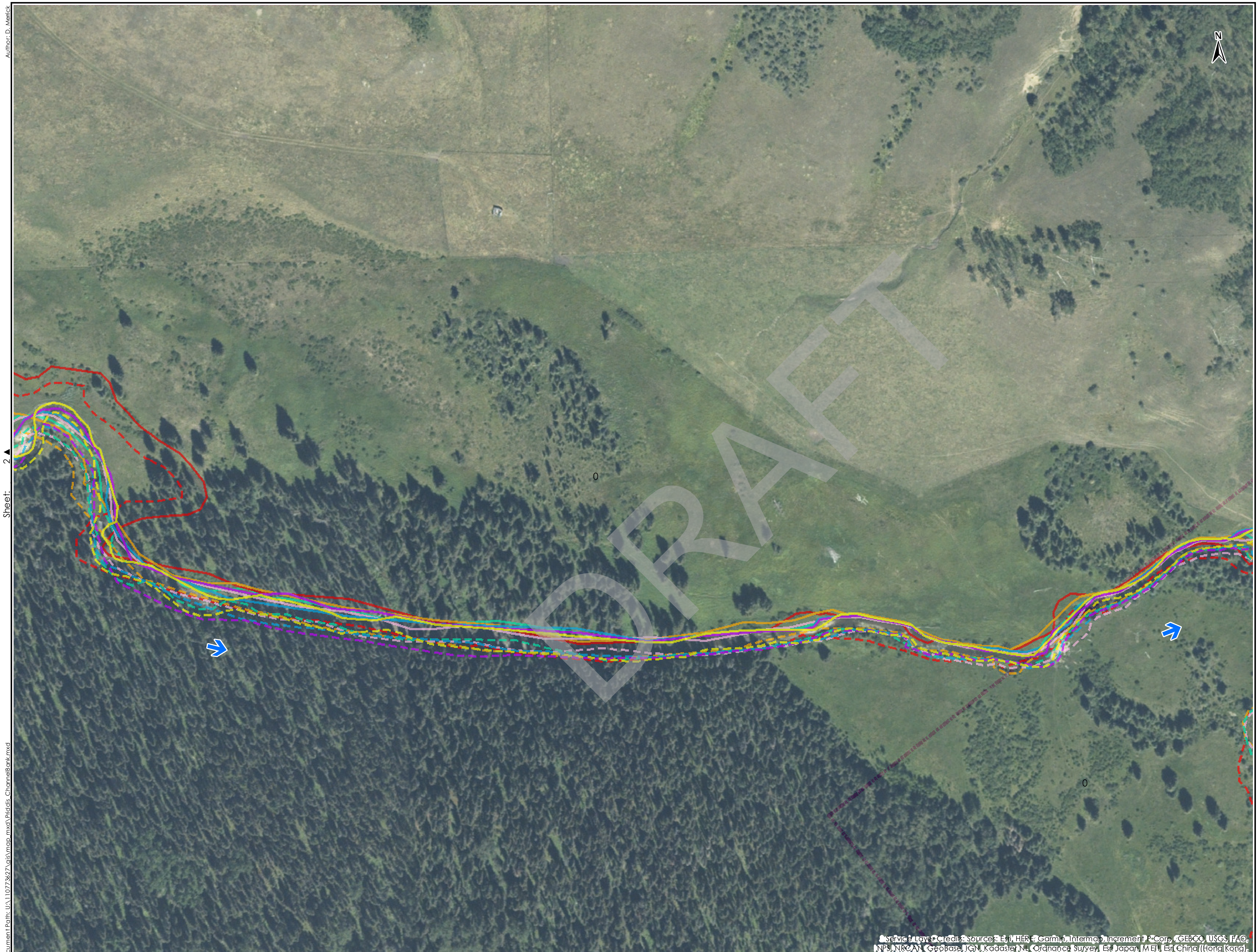


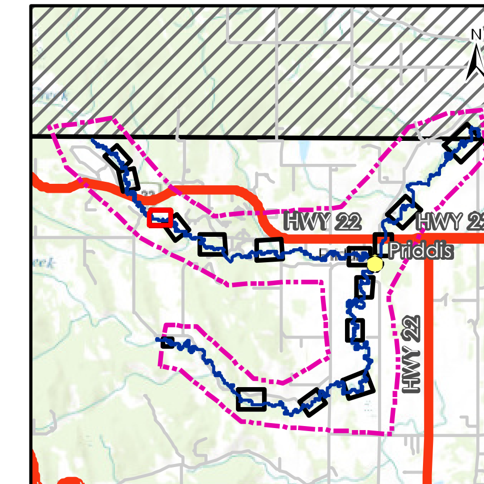


Alberta Government

Stantec

| | |
|---|---|
| Flow Direction | |
| 1949 Left Bank | 1949 Right Bank |
| 1966 Left Bank | 1966 Right Bank |
| 1974 Left Bank | 1974 Right Bank |
| 1987 Left Bank | 1987 Right Bank |
| 1998 Left Bank | 1998 Right Bank |
| 2008 Left Bank | 2008 Right Bank |
| 2018 Left Bank | 2018 Right Bank |

10 5 0 10 20 30 40 50
Meters

Scale 1:2,000

## Priddis River Hazard Study
## Channel Bank Comparison: 1949 - 2018

| GIS: | QA/QC | APPROVED |
|---|---|---|
| DM | MA | MW |

Spatial Ref: NAD 1983 CSRS 3TM 114

Sheet: 3 of 16

| Project No. | REV. | Date: |
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Author: D. Merrick

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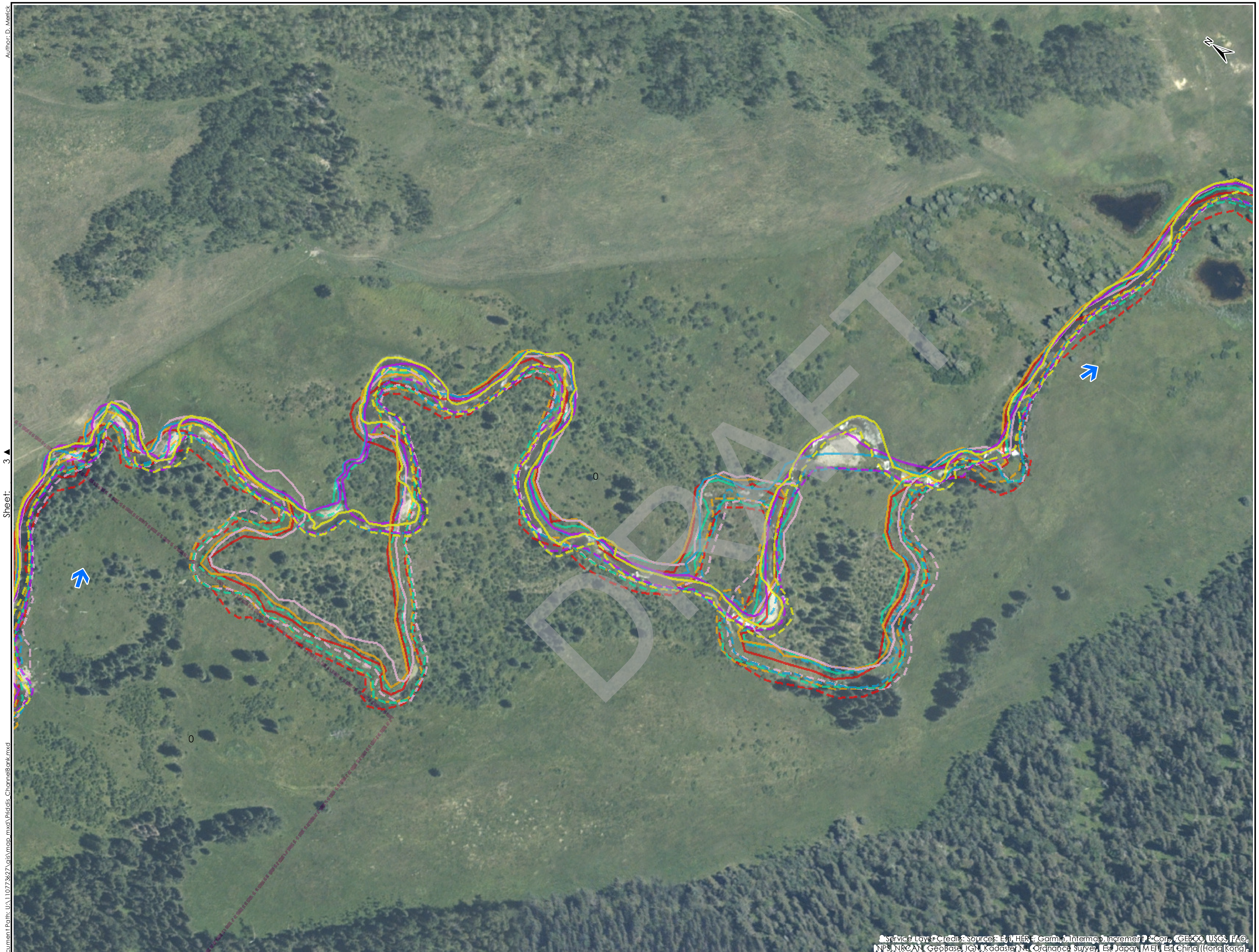


Author: D. Merrick

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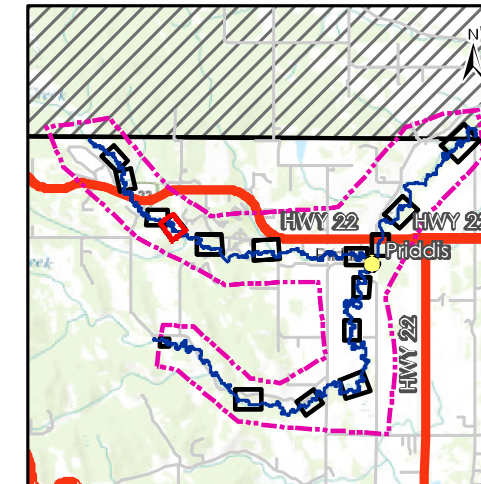


Alberta Government

Stantec

| Legend |
|---|
| Flow Direction |
| 1949 Left Bank |
| 1949 Right Bank |
| 1966 Left Bank |
| 1966 Right Bank |
| 1974 Left Bank |
| 1974 Right Bank |
| 1987 Left Bank |
| 1987 Right Bank |
| 1998 Left Bank |
| 1998 Right Bank |
| 2008 Left Bank |
| 2008 Right Bank |
| 2018 Left Bank |
| 2018 Right Bank |

10 5 0 10 20 30 40 50
Meters

Scale 1:2,000

**Priddis River Hazard Study**
**Channel Bank Comparison: 1949 - 2018**

| GIS: | QA/QC | APPROVED |
|---|---|---|
| DM | MA | MW |

| Spatial Ref: | Sheet: |
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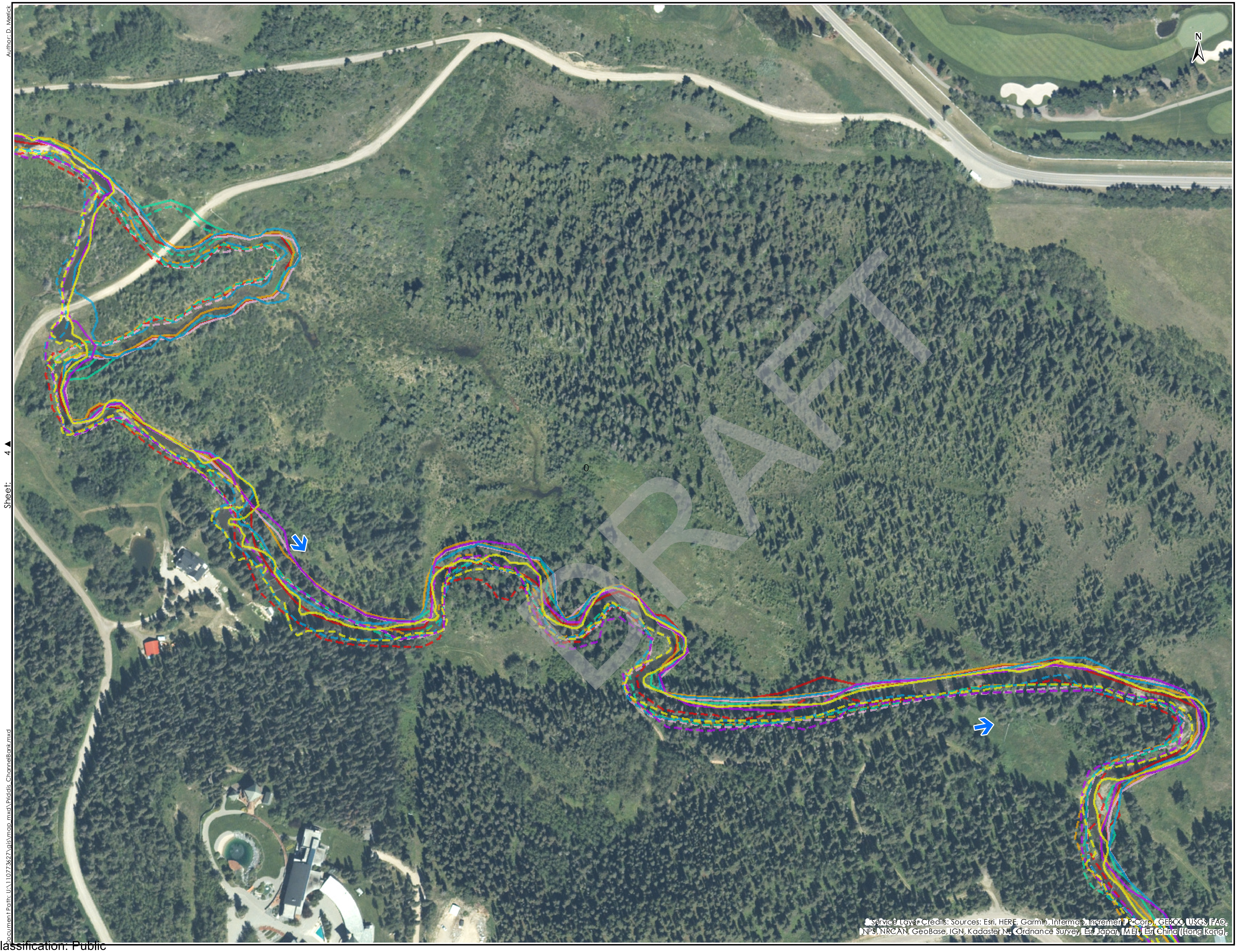


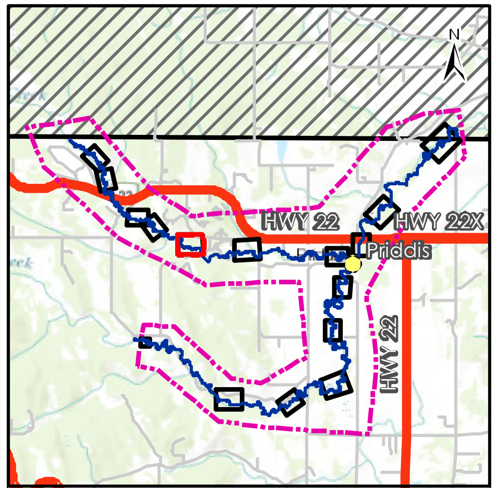


Alberta Government

Stantec

Flow Direction
1949 Left Bank
1949 Right Bank
1966 Left Bank
1966 Right Bank
1974 Left Bank
1974 Right Bank
1987 Left Bank
1987 Right Bank
1998 Left Bank
1998 Right Bank
2008 Left Bank
2008 Right Bank
2018 Left Bank
2018 Right Bank

10 5 0 10 20 30 40 50
Meters
Scale
1:2,500

Priddis River Hazard Study
Channel Bank Comparison:
1949 - 2018

| GIS: | QA/QC | APPROVED |
|---|---|---|
| DM | MA | MW |

| Spatial Ref: | Sheet: |
|---|---|
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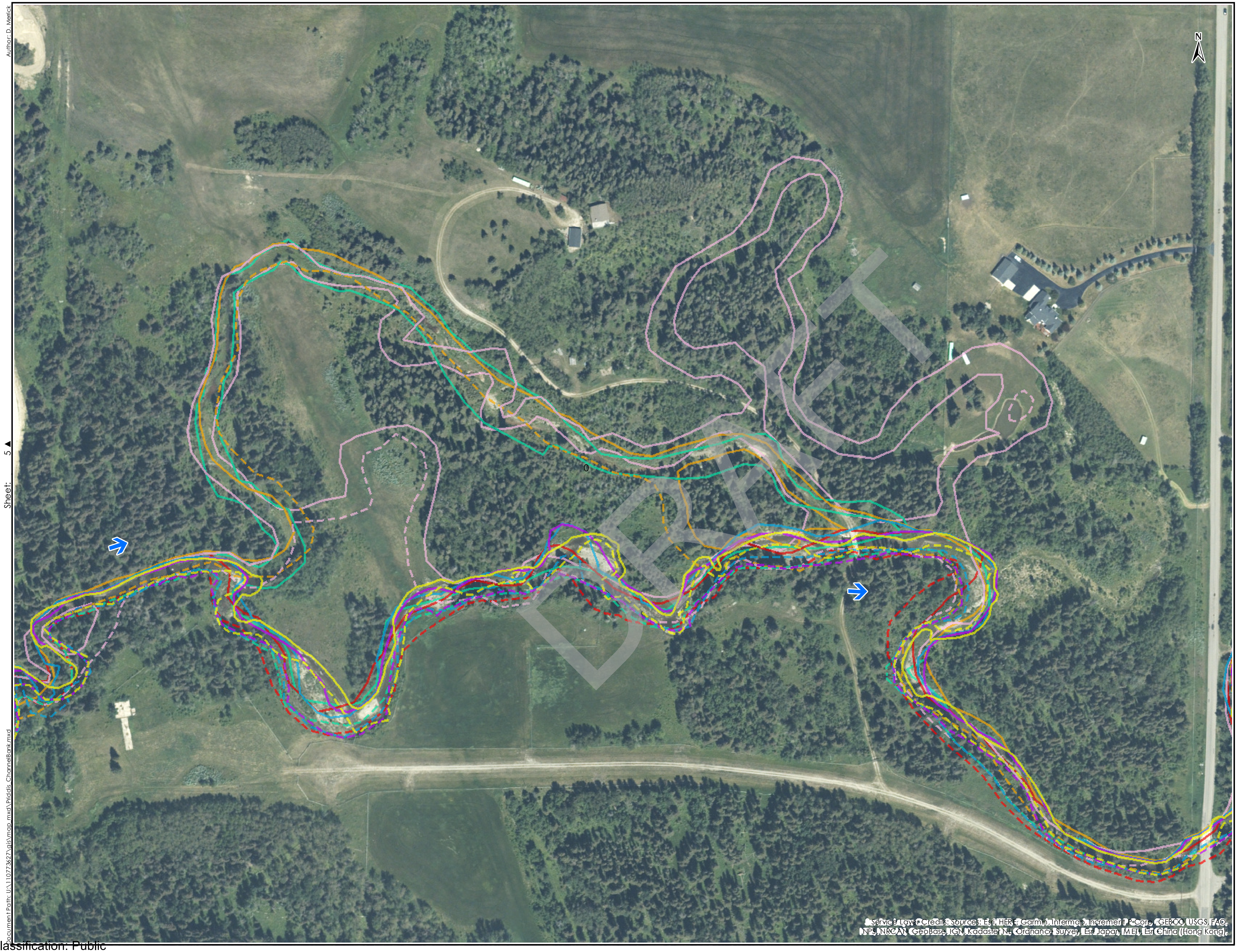
Author: D. Merrick

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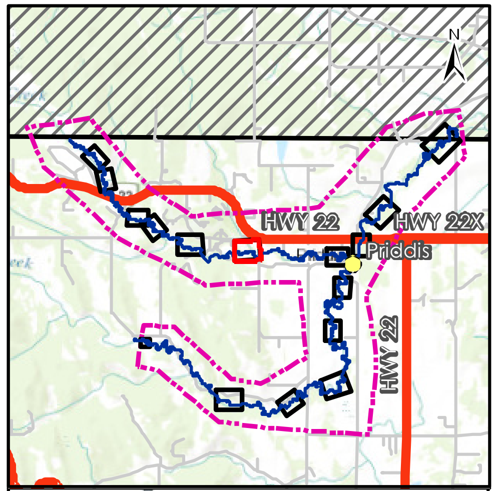


Alberta Government

Stantec

Flow Direction

1949 Left Bank

1949 Right Bank

1966 Left Bank

1966 Right Bank

1974 Left Bank

1974 Right Bank

1987 Left Bank

1987 Right Bank

1998 Left Bank

1998 Right Bank

2008 Left Bank

2008 Right Bank

2018 Left Bank

2018 Right Bank

10 5 0 10 20 30 40 50
Meters

Scale
1:2,500

Priddis River Hazard Study

Channel Bank Comparison:
1949 - 2018

| GIS: | QA/QC | APPROVED |
|---|---|---|
| DM | MA | MW |

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Classification: Public

Author: D. Merrick

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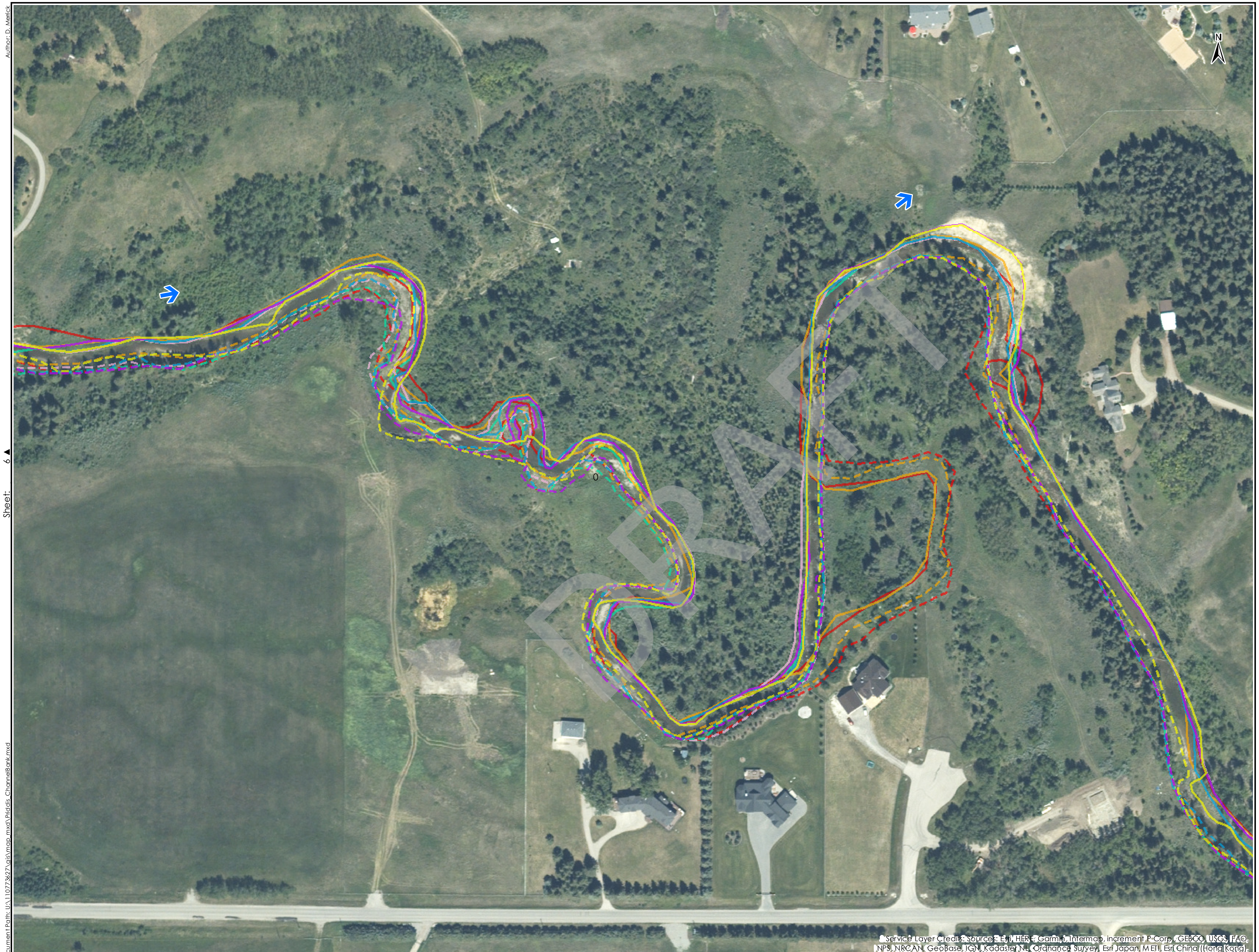


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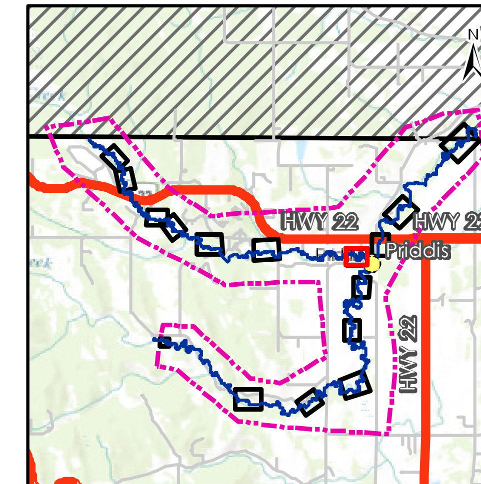


Alberta Government

Stantec

Flow Direction

1949 Left Bank

1949 Right Bank

1966 Left Bank

1966 Right Bank

1974 Left Bank

1974 Right Bank

1987 Left Bank

1987 Right Bank

1998 Left Bank

1998 Right Bank

2008 Left Bank

2008 Right Bank

2018 Left Bank

2018 Right Bank

10 5 0 10 20 30 40 50 Meters

Scale 1:2,000

**Priddis River Hazard Study**

**Channel Bank Comparison: 1949 - 2018**

| GIS: | QA/QC | APPROVED |
|---|---|---|
| DM | MA | MW |

| Spatial Ref: | Sheet: |
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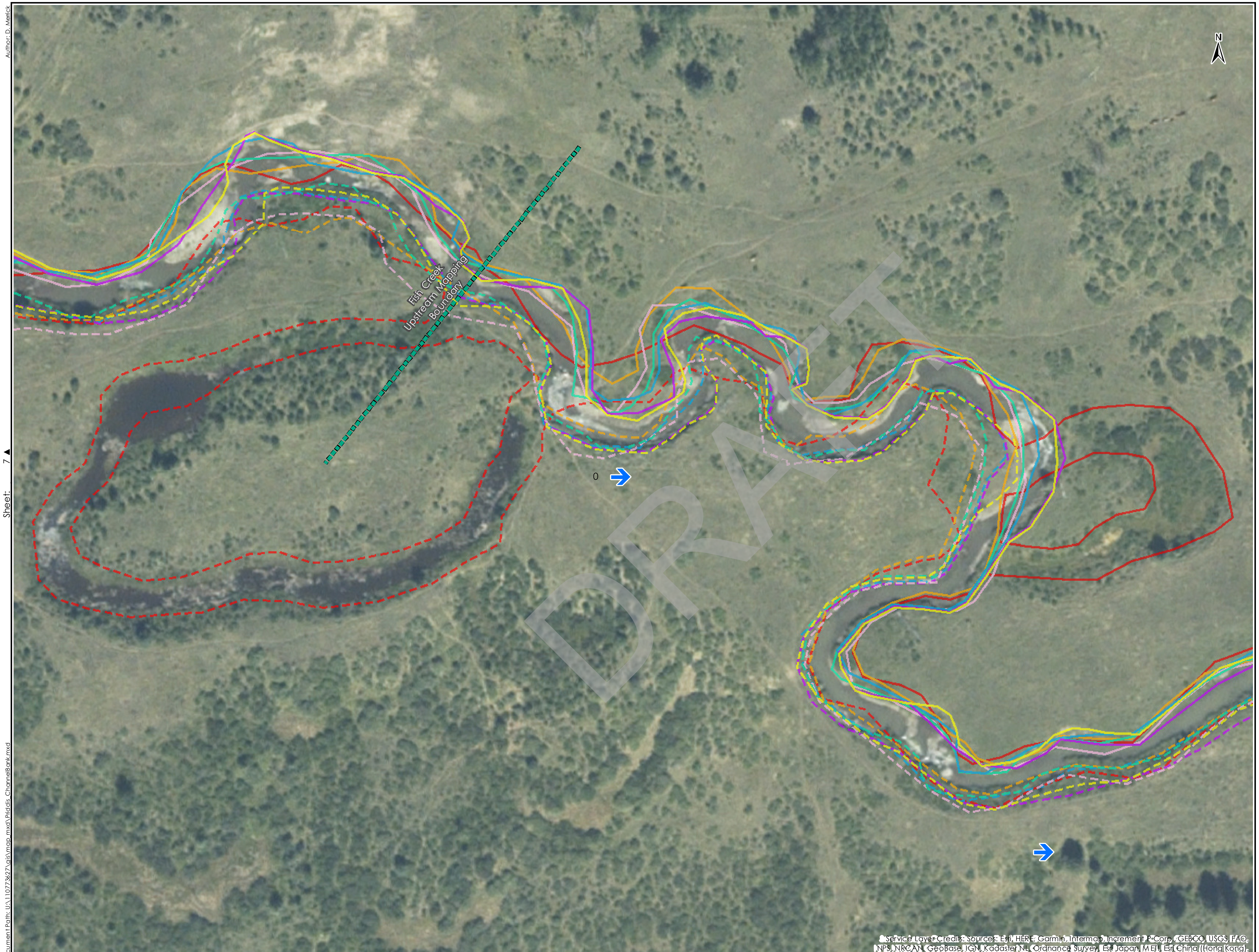


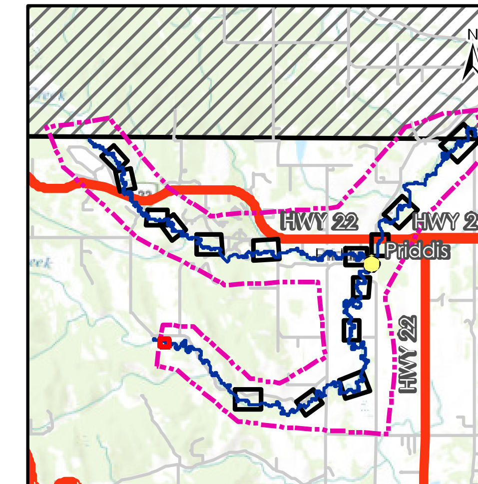


Alberta Government

Stantec

Flow Direction
1949 Left Bank
1949 Right Bank
1966 Left Bank
1966 Right Bank
1974 Left Bank
1974 Right Bank
1987 Left Bank
1987 Right Bank
1998 Left Bank
1998 Right Bank
2008 Left Bank
2008 Right Bank
2018 Left Bank
2018 Right Bank

6.5 3.25 0 6.5 13 19.5 26 32.5
Meters
Scale 1:1,000

## Priddis River Hazard Study
## Channel Bank Comparison: 1949 - 2018

| GIS: | QA/QC | APPROVED |
|---|---|---|
| DM | MA | MW |

Spatial Ref: NAD 1983 CSRS 3TM 114

Sheet: 8 of 16

| Project No. | REV. | Date: |
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| 110773627 | A | 31 Jul 2019 |

Author: D. Merrick

Sheet: 7

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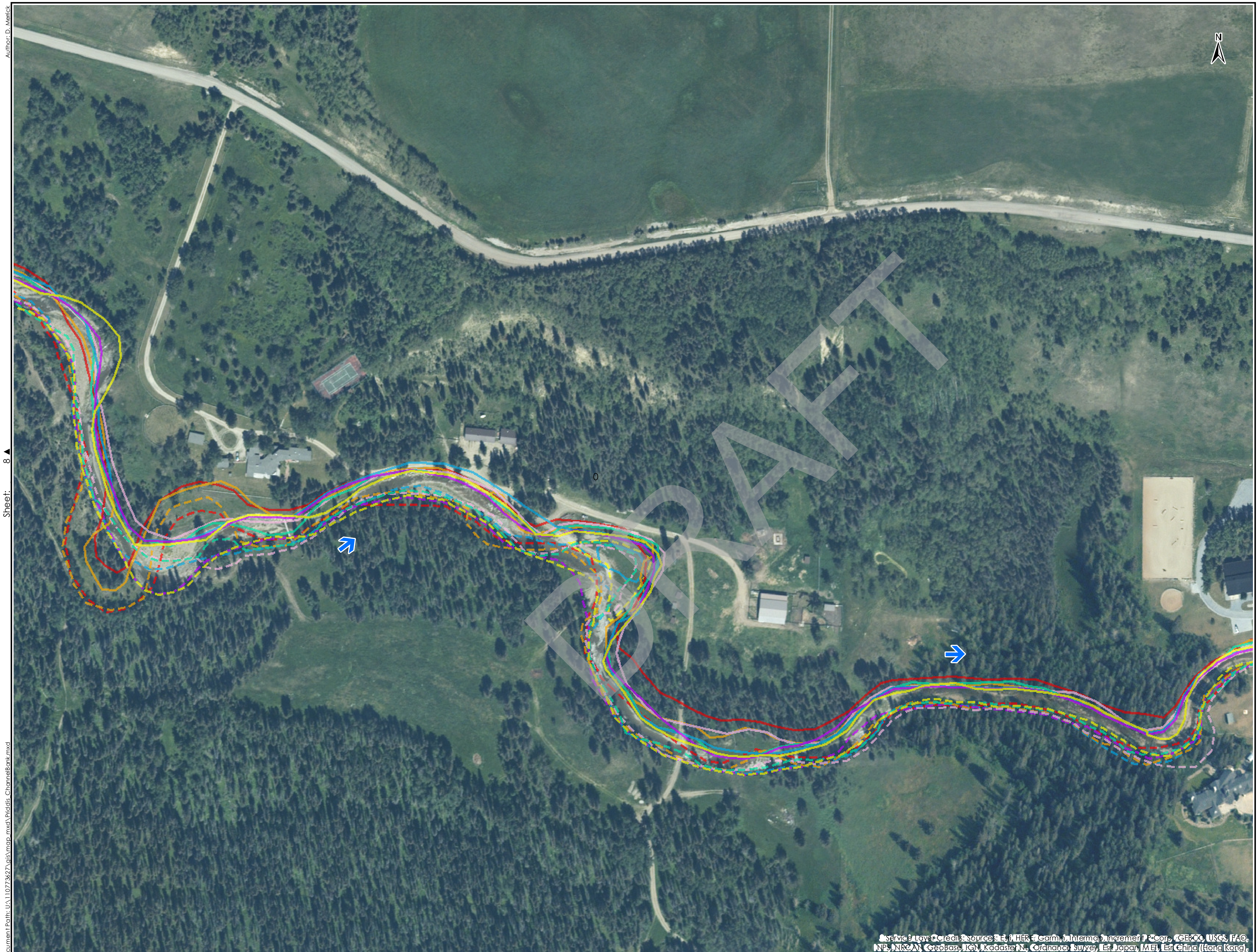


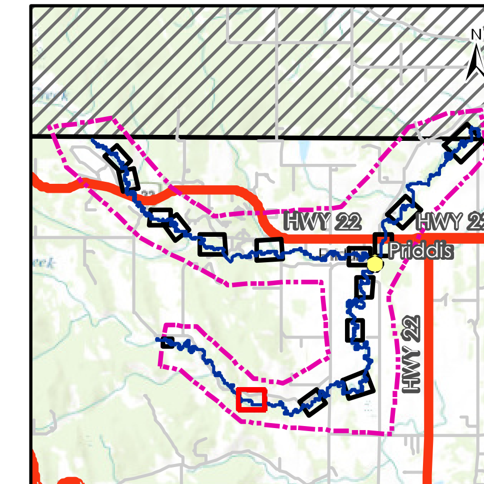


Alberta Government

Stantec

Flow Direction
1949 Left Bank
1949 Right Bank
1966 Left Bank
1966 Right Bank
1974 Left Bank
1974 Right Bank
1987 Left Bank
1987 Right Bank
1998 Left Bank
1998 Right Bank
2008 Left Bank
2008 Right Bank
2018 Left Bank
2018 Right Bank

10 5 0 10 20 30 40 50
Meters

Scale
1:2,500

Priddis River Hazard Study
Channel Bank Comparison:
1949 - 2018

| GIS: | QA/QC | APPROVED |
|---|---|---|
| DM | MA | MW |

Spatial Ref: NAD 1983 CSRS 3TM 114



| Project No. | REV. | Date: |
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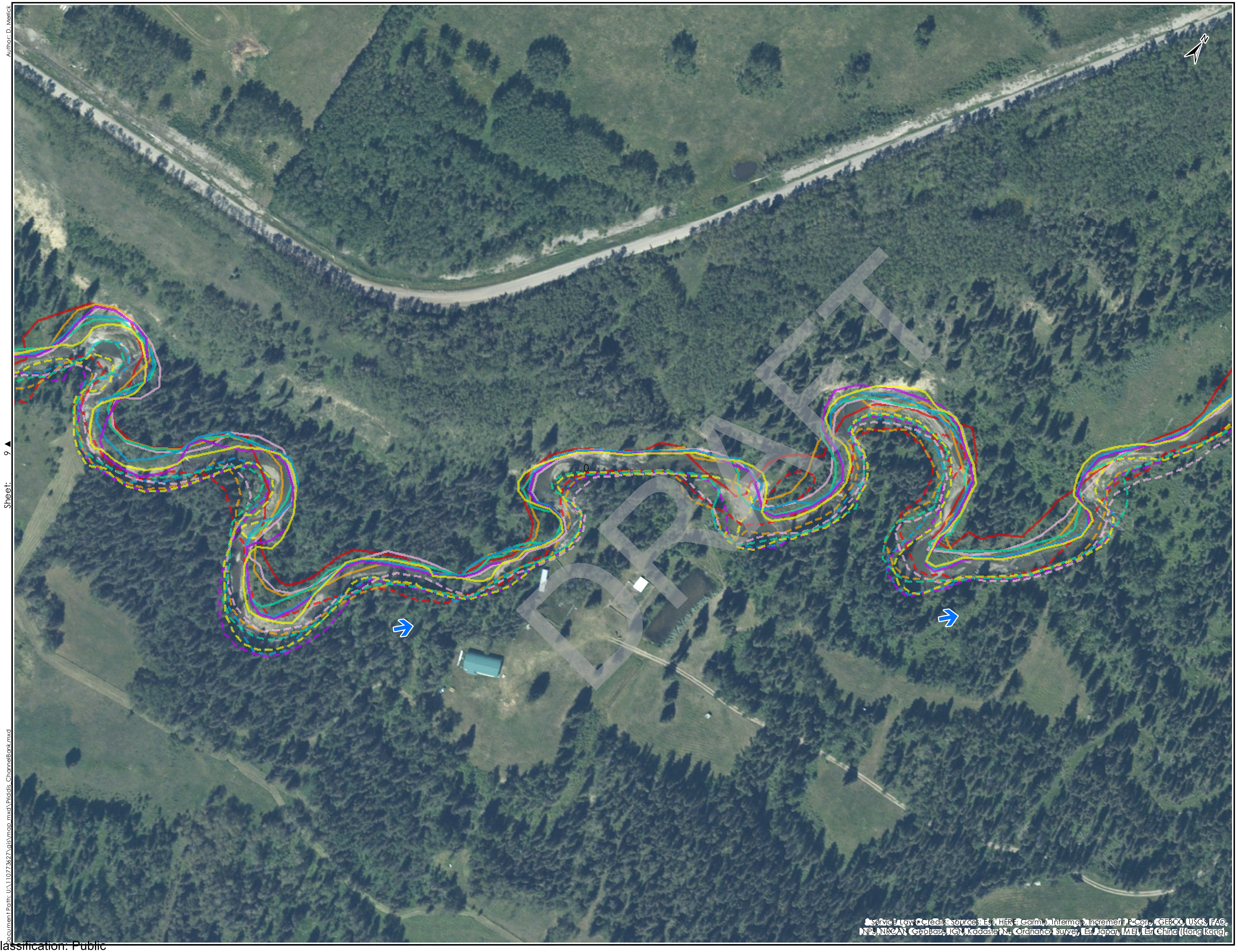


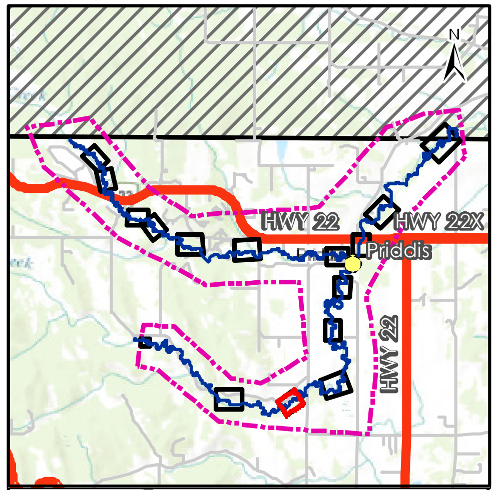


Alberta Government

Stantec

Flow Direction
1949 Left Bank
1949 Right Bank
1966 Left Bank
1966 Right Bank
1974 Left Bank
1974 Right Bank
1987 Left Bank
1987 Right Bank
1998 Left Bank
1998 Right Bank
2008 Left Bank
2008 Right Bank
2018 Left Bank
2018 Right Bank

10 5 0 10 20 30 40 50
Meters

Scale 1:2,000

Priddis River Hazard Study
Channel Bank Comparison:
1949 - 2018

| GIS: | QA/QC | APPROVED |
|---|---|---|
| DM | MA | MW |

Spatial Ref: NAD 1983 CSRS 3TM 114

Sheet: 10 of 16

Project No. 110773627 | REV. A | Date: 31 Jul 2019

Author: D. Merrick

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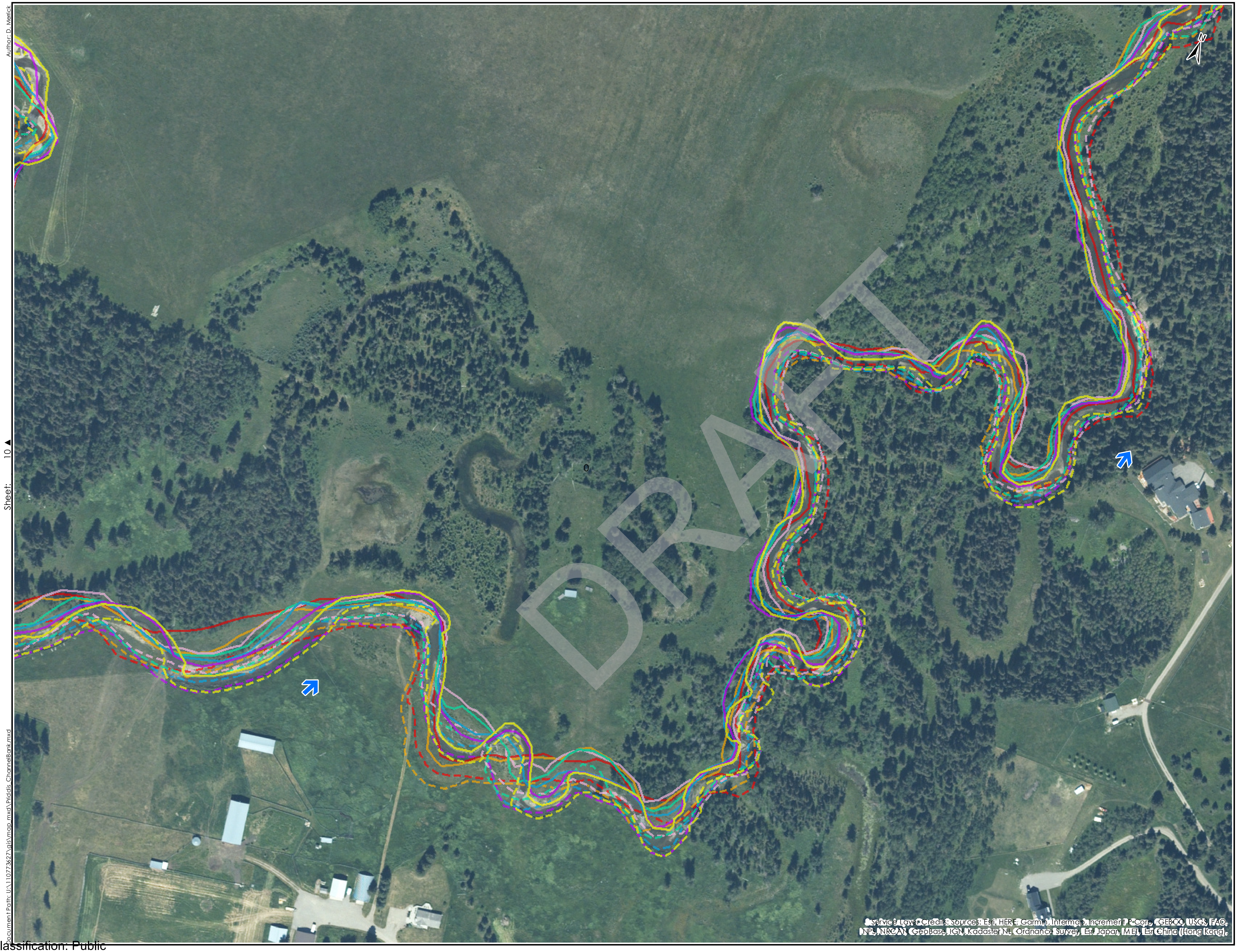
Classification: Public




Author: D. Merrick

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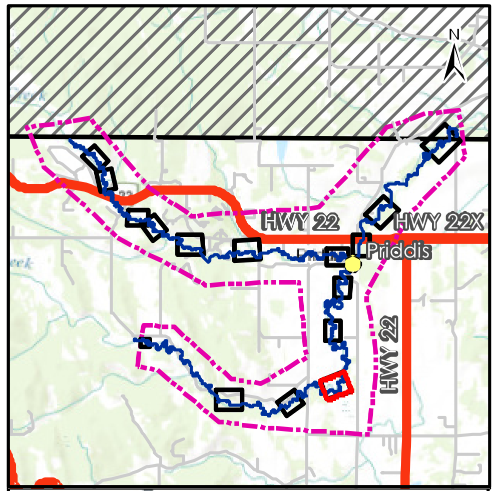



Alberta Government

Stantec

Flow Direction

1949 Left Bank

1949 Right Bank

1966 Left Bank

1966 Right Bank

1974 Left Bank

1974 Right Bank

1987 Left Bank

1987 Right Bank

1998 Left Bank

1998 Right Bank

2008 Left Bank

2008 Right Bank

2018 Left Bank

2018 Right Bank

10 5 0 10 20 30 40 50
Meters

Scale 1:2,500

Priddis River Hazard Study
Channel Bank Comparison:
1949 - 2018

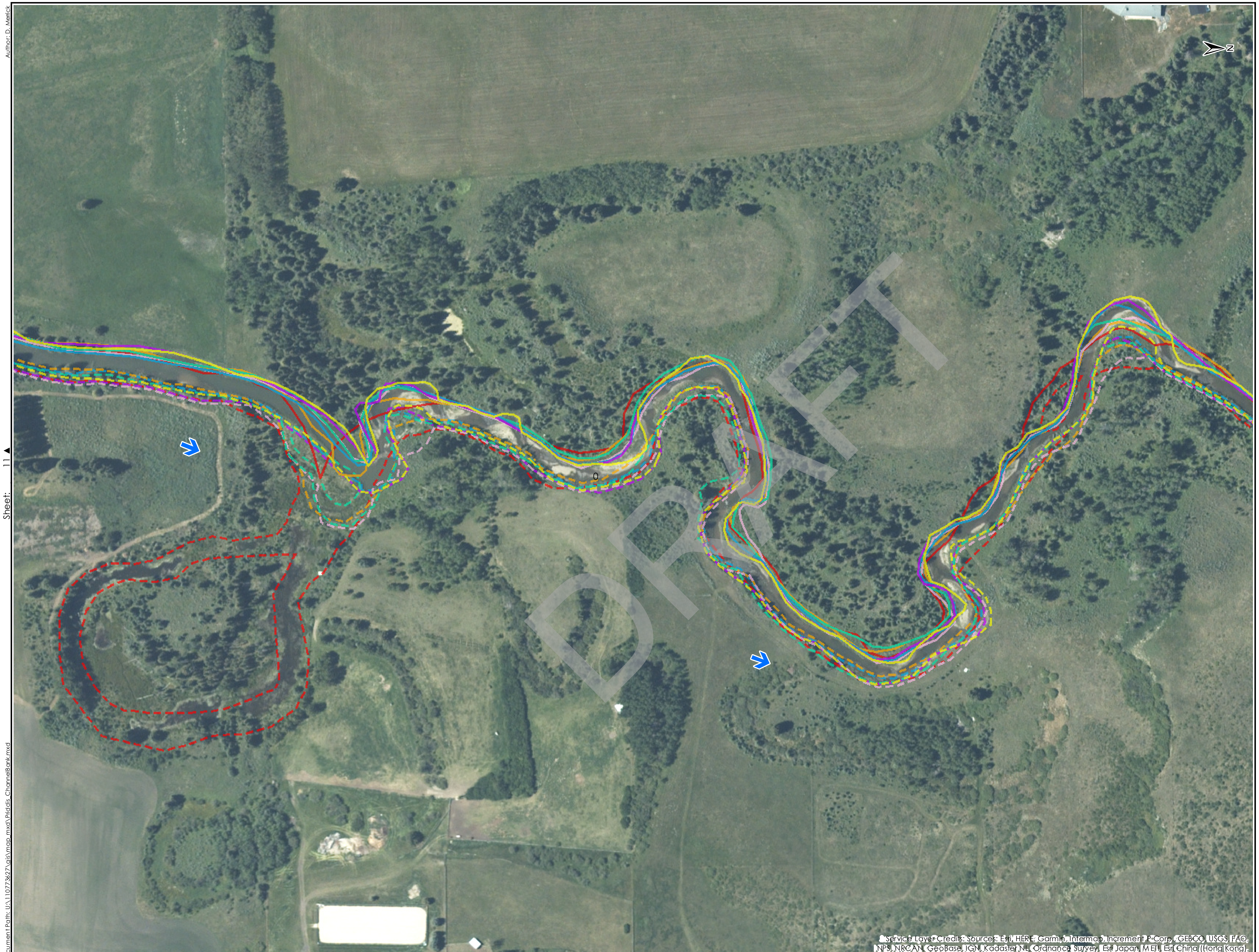
| GIS: | QA/QC | APPROVED |
|---|---|---|
| DM | MA | MW |

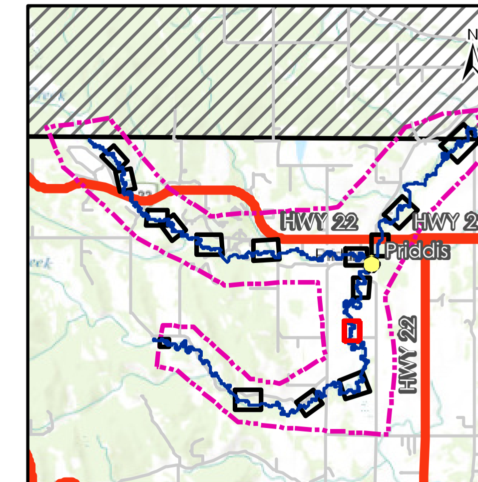
Spatial Ref: NAD 1983 CSRS 3TM 114

Sheet: 11 of 16

| Project No. | REV. | Date: |
|---|---|---|
| 110773627 | A | 31 Jul 2019 |

Classification: Public




Alberta Government

Stantec

Flow Direction
1949 Left Bank
1949 Right Bank
1966 Left Bank
1966 Right Bank
1974 Left Bank
1974 Right Bank
1987 Left Bank
1987 Right Bank
1998 Left Bank
1998 Right Bank
2008 Left Bank
2008 Right Bank
2018 Left Bank
2018 Right Bank

10 5 0 10 20 30 40 50
Meters
Scale 1:2,000

Priddis River Hazard Study
Channel Bank Comparison:
1949 - 2018

| GIS: | QA/QC | APPROVED |
|---|---|---|
| DM | MA | MW |

Spatial Ref: NAD 1983 CSRS 3TM 114

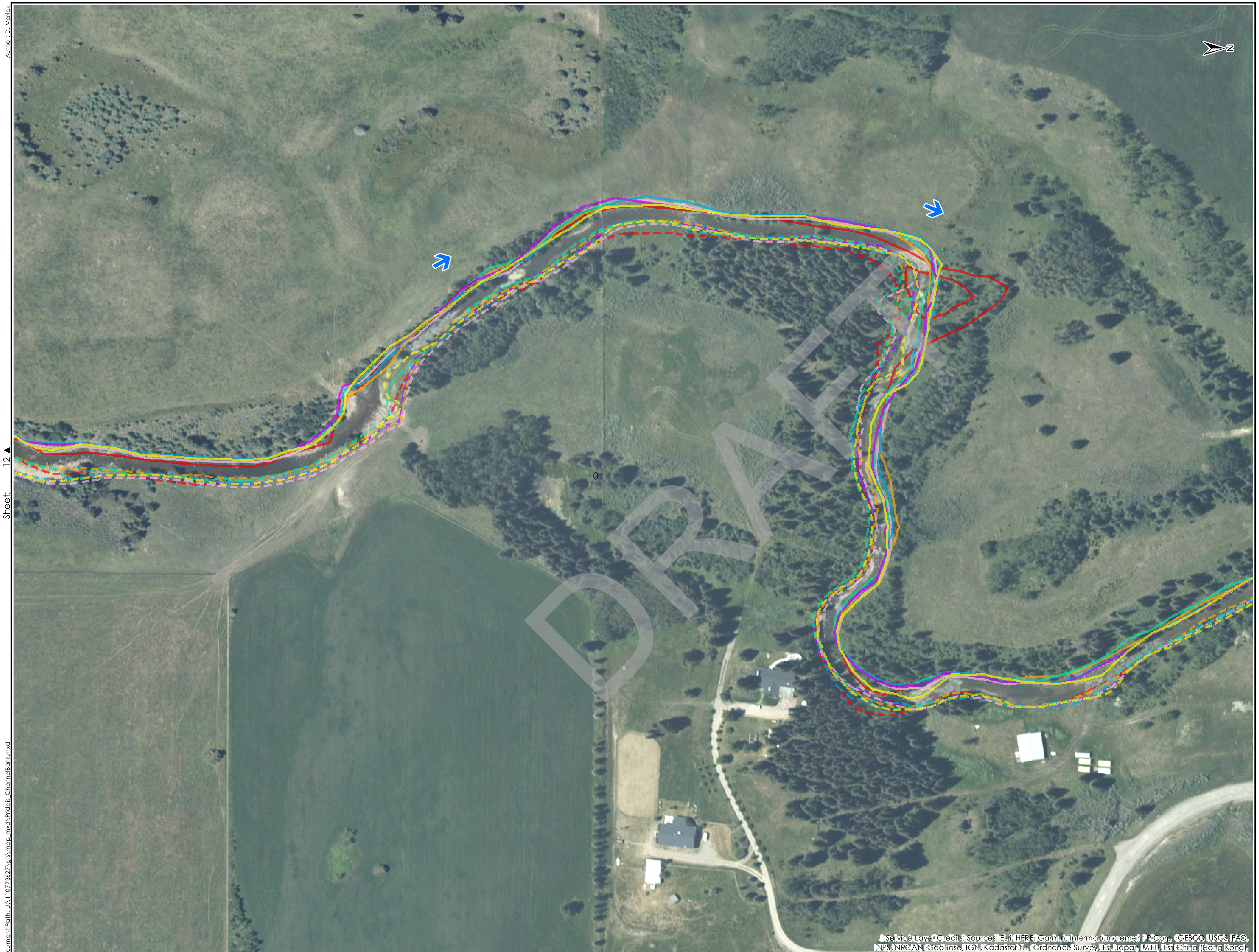
Sheet: 12 of 16

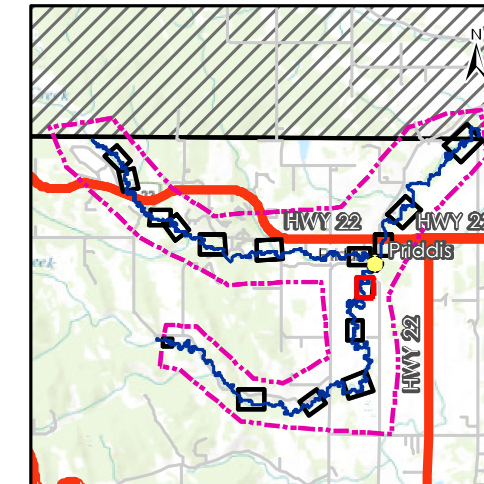
| Project No. | REV. | Date: |
|---|---|---|
| 110773627 | A | 31 Jul 2019 |

Author: D. Merrick

Document Path: U:\110773627\gis\map_mxd\Priddis_ChannelBank.mxd

Classification: Public




Alberta Government

Stantec

- Flow Direction
- 1949 Left Bank
- 1949 Right Bank
- 1966 Left Bank
- 1966 Right Bank
- 1974 Left Bank
- 1974 Right Bank
- 1987 Left Bank
- 1987 Right Bank
- 1998 Left Bank
- 1998 Right Bank
- 2008 Left Bank
- 2008 Right Bank
- 2018 Left Bank
- 2018 Right Bank

10 5 0 10 20 30 40 50 Meters

Scale 1:2,000

Priddis River Hazard Study
Channel Bank Comparison:
1949 - 2018

| GIS: | QA/QC | APPROVED |
|---|---|---|
| DM | MA | MW |

Spatial Ref: NAD 1983 CSRS 3TM 114

Sheet: 13 of 16

| Project No. | REV. | Date: |
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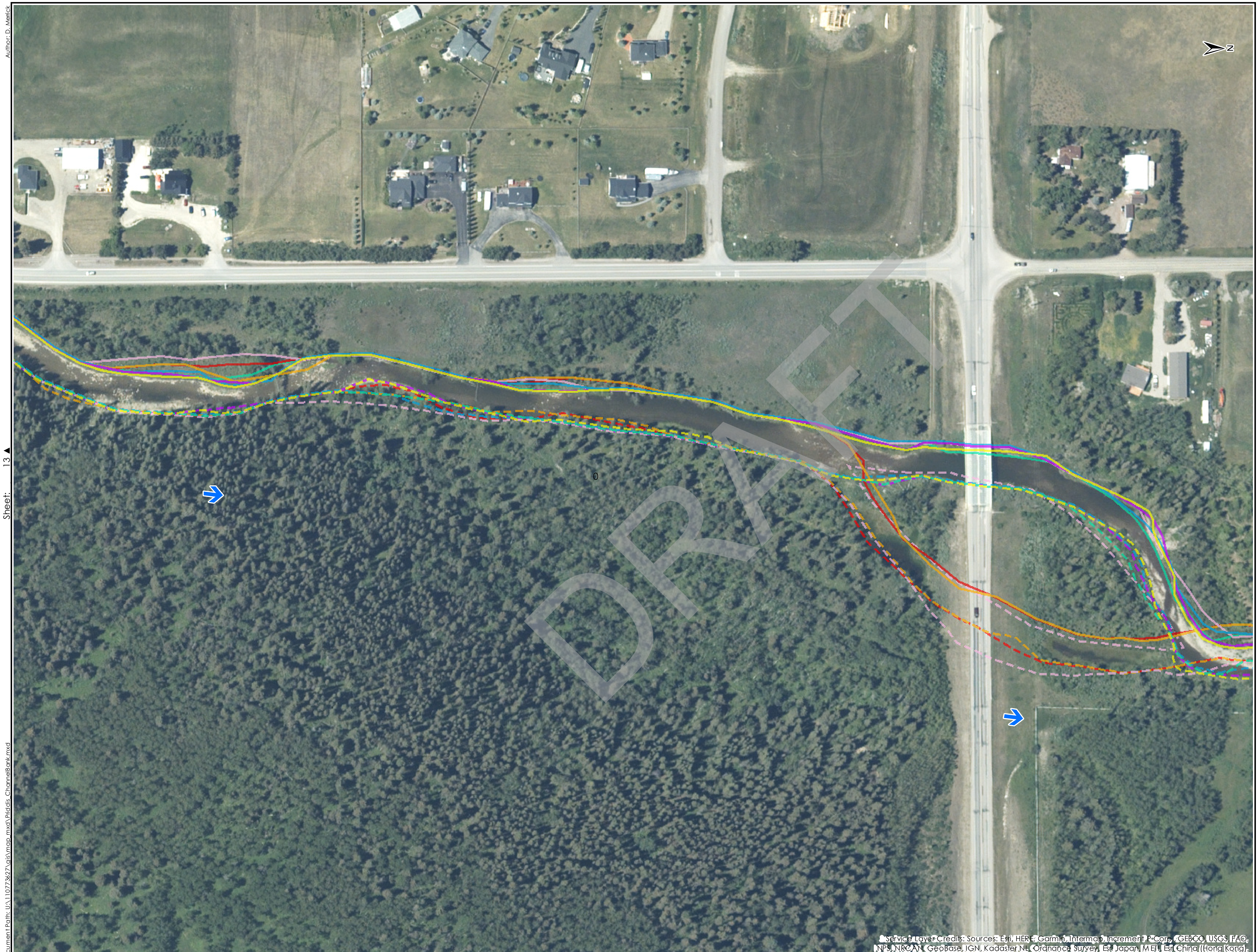


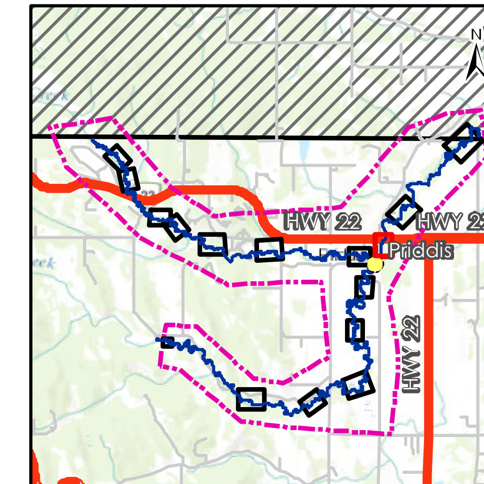


Alberta Government

Stantec

Flow Direction
1949 Left Bank
1949 Right Bank
1966 Left Bank
1966 Right Bank
1974 Left Bank
1974 Right Bank
1987 Left Bank
1987 Right Bank
1998 Left Bank
1998 Right Bank
2008 Left Bank
2008 Right Bank
2018 Left Bank
2018 Right Bank

10 5 0 10 20 30 40 50
Meters
Scale 1:2,000

Priddis River Hazard Study

Channel Bank Comparison: 1949 - 2018

| GIS: | QA/QC | APPROVED |
|---|---|---|
| DM | MA | MW |

Spatial Ref: NAD 1983 CSRS 3TM 114

Sheet: 14 of 16

| Project No. | REV. | Date: |
|---|---|---|
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Author: D. Merrick

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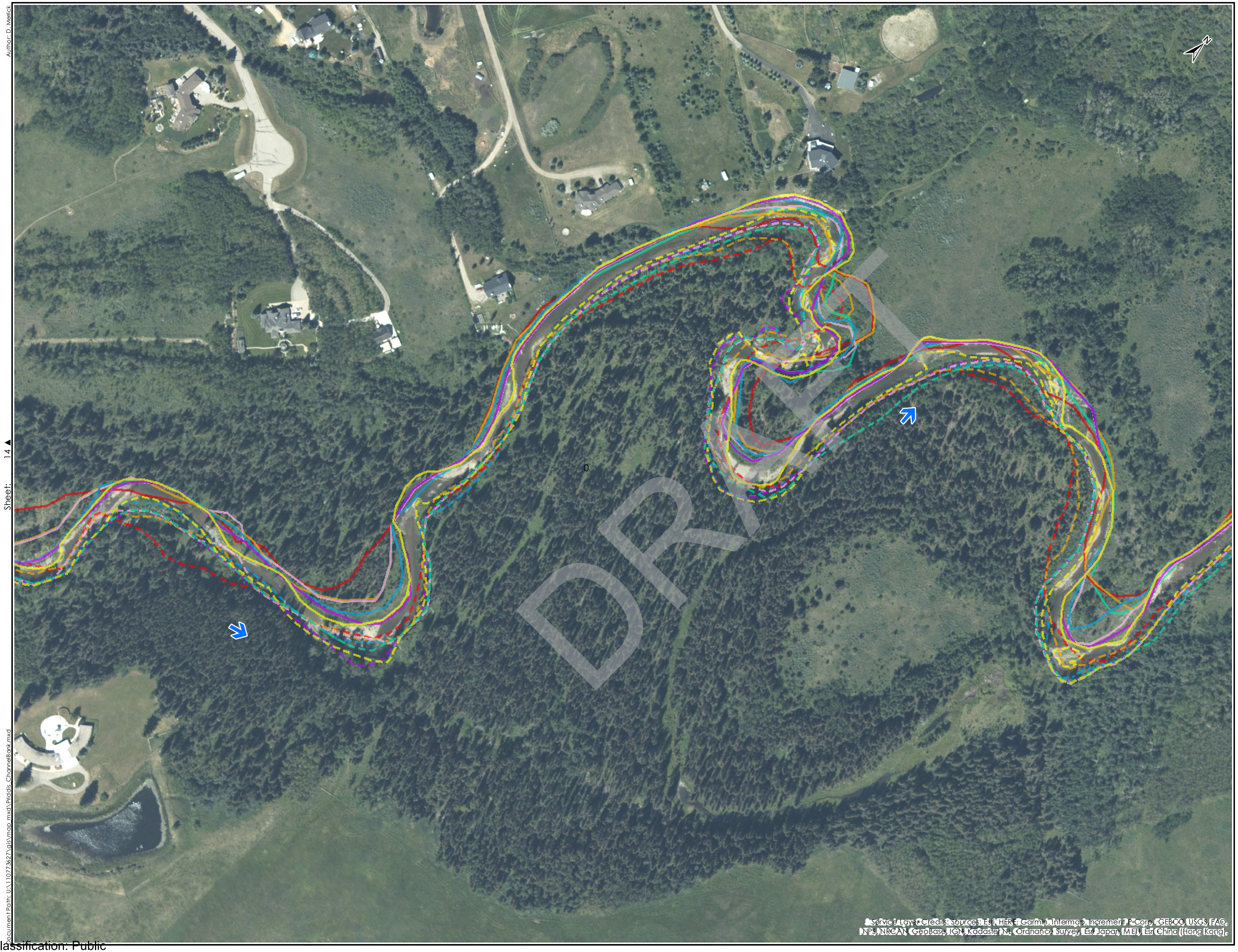
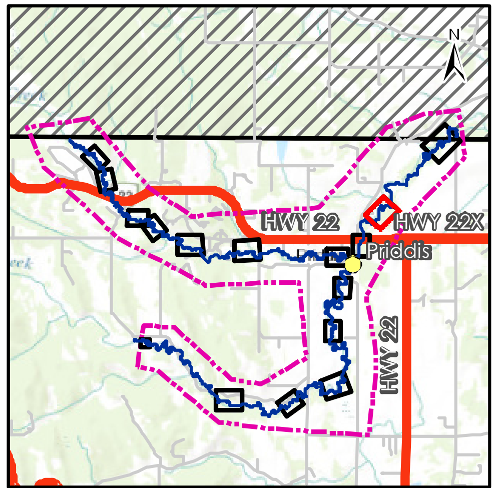
Classification: Public




Alberta Government

Stantec

Flow Direction
1949 Left Bank
1949 Right Bank
1966 Left Bank
1966 Right Bank
1974 Left Bank
1974 Right Bank
1987 Left Bank
1987 Right Bank
1998 Left Bank
1998 Right Bank
2008 Left Bank
2008 Right Bank
2018 Left Bank
2018 Right Bank

10 5 0 10 20 30 40 50
Meters

Scale 1:2,500

Priddis River Hazard Study
Channel Bank Comparison:
1949 - 2018

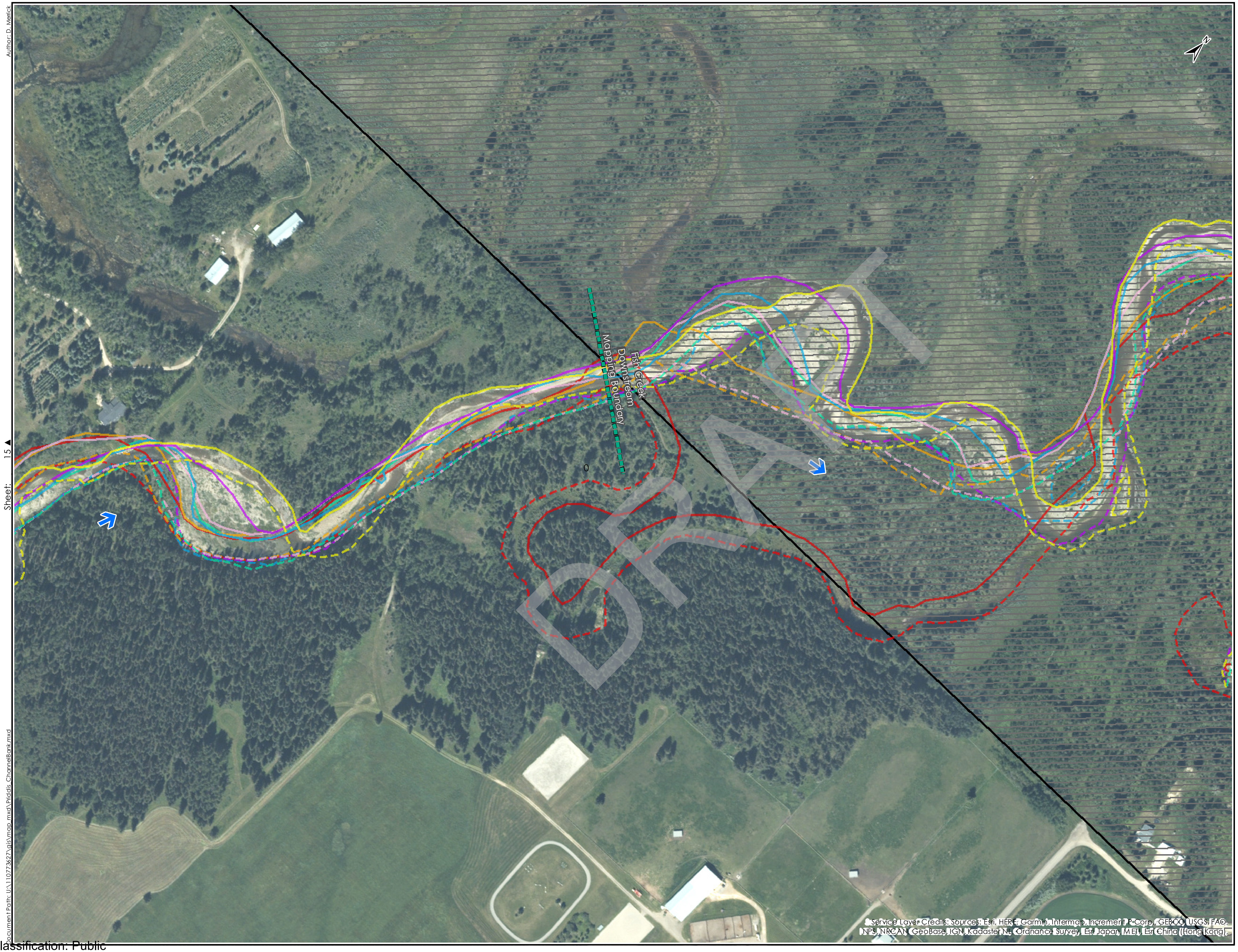
| GIS: | QA/QC | APPROVED |
|---|---|---|
| DM | MA | MW |

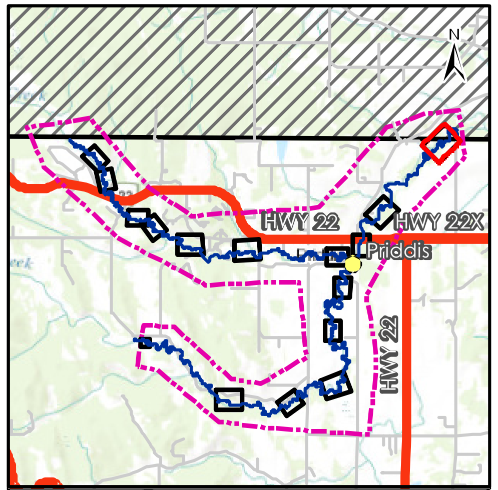
Spatial Ref: NAD 1983 CSRS 3TM 114

Sheet: 15 of 16

| Project No. | REV. | Date: |
|---|---|---|
| 110773627 | A | 31 Jul 2019 |

Classification: Public




Alberta Government

Stantec

Flow Direction
1949 Left Bank
1949 Right Bank
1966 Left Bank
1966 Right Bank
1974 Left Bank
1974 Right Bank
1987 Left Bank
1987 Right Bank
1998 Left Bank
1998 Right Bank
2008 Left Bank
2008 Right Bank
2018 Left Bank
2018 Right Bank
Tsuut'ina Nation

Meters 20 10 0 20 40 60 80 100
Scale 1:3,000

Priddis River Hazard Study
Channel Bank Comparison: 1949 - 2018

| GIS: | QA/QC | APPROVED |
|---|---|---|
| DM | MA | MW |

Spatial Ref: NAD 1983 CSRS 3TM 114
Sheet: 16 of 16

| Project No. | REV. | Date: |
|---|---|---|
| 110773627 | A | 31 Jul 2019 |

Author: D. Merlick
Document Path: U:\110773627\gis\map_mxd\Priddis_ChannelBank.mxd

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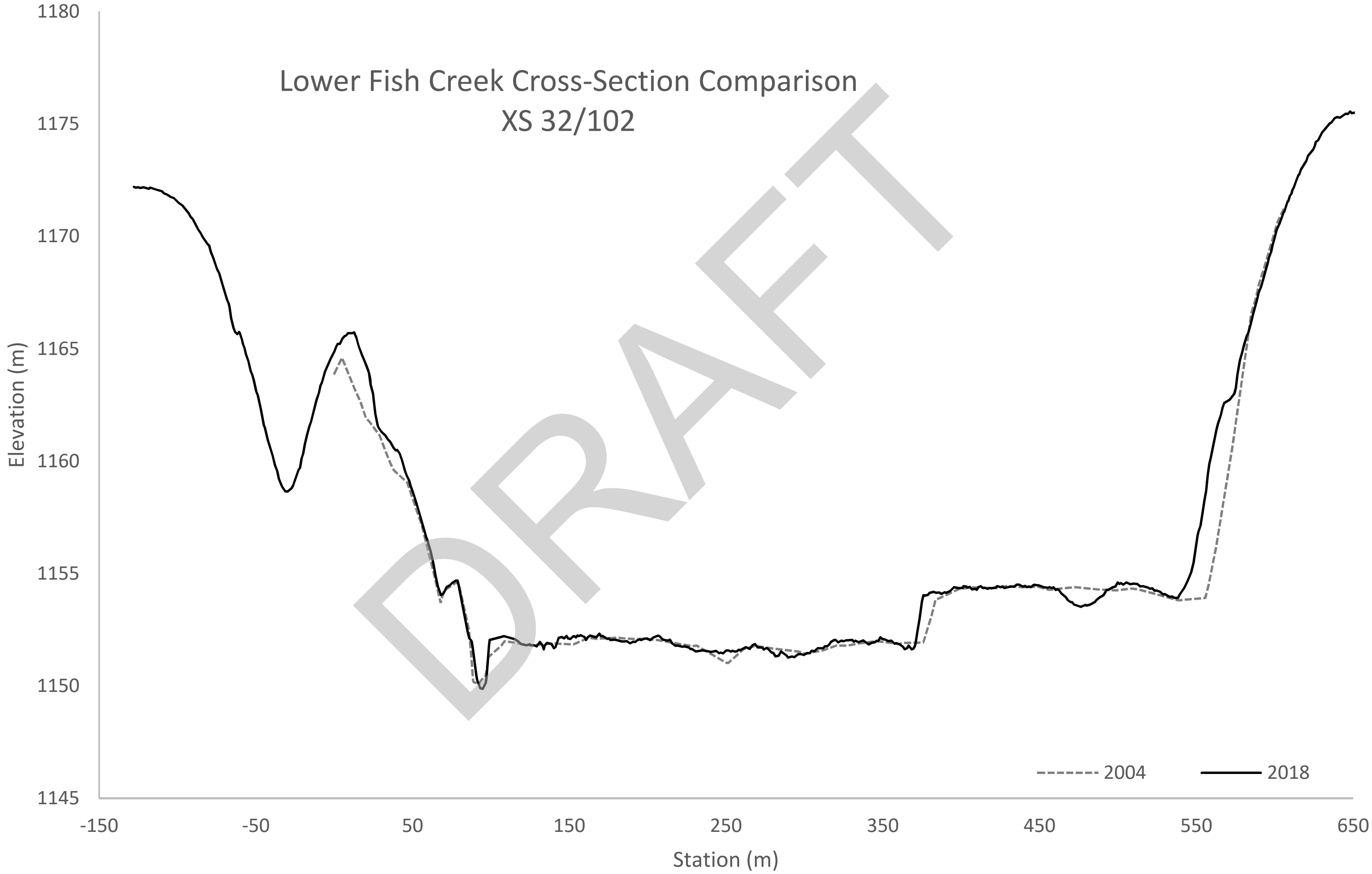
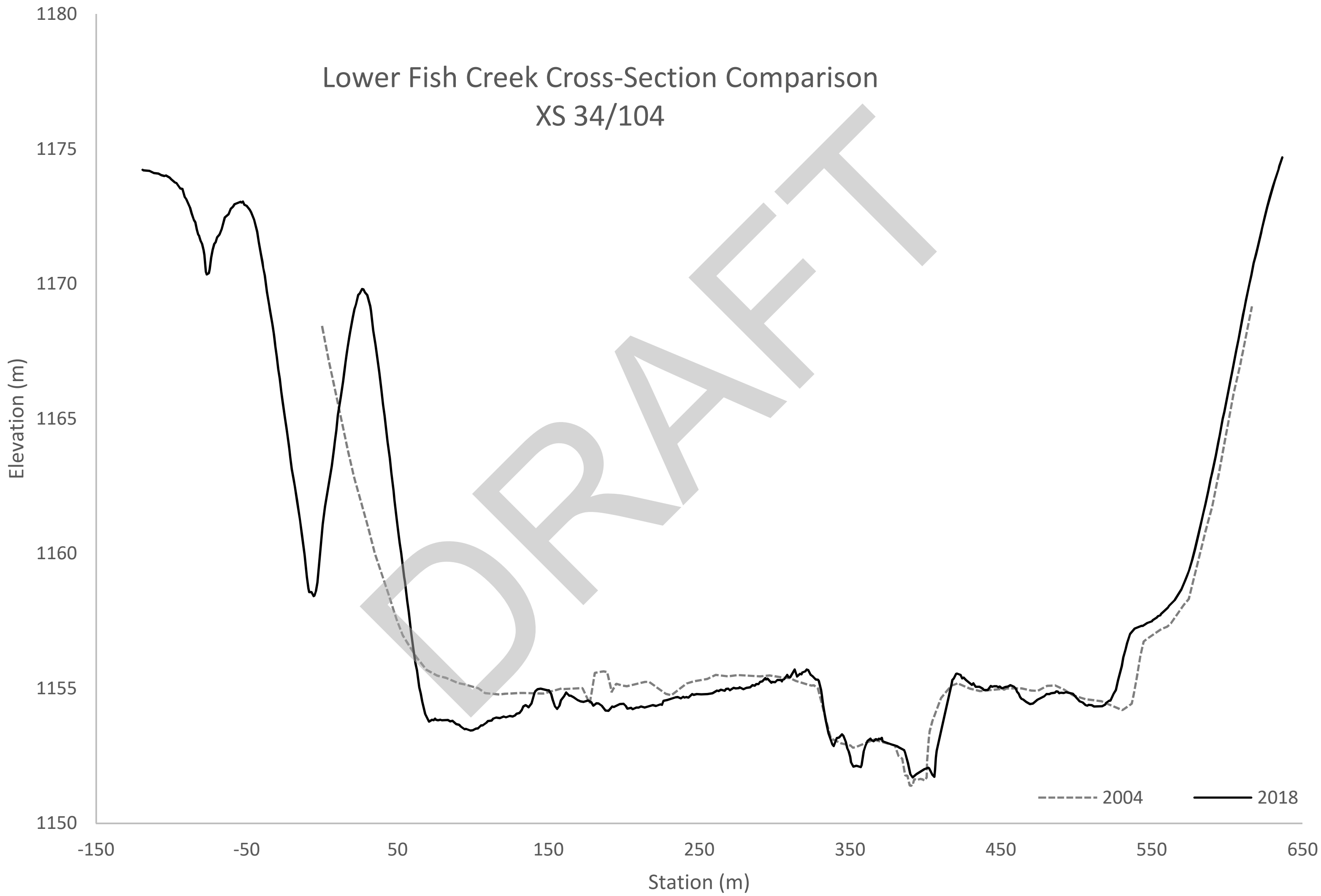
# APPENDIX C

## Cross-Section Comparisons

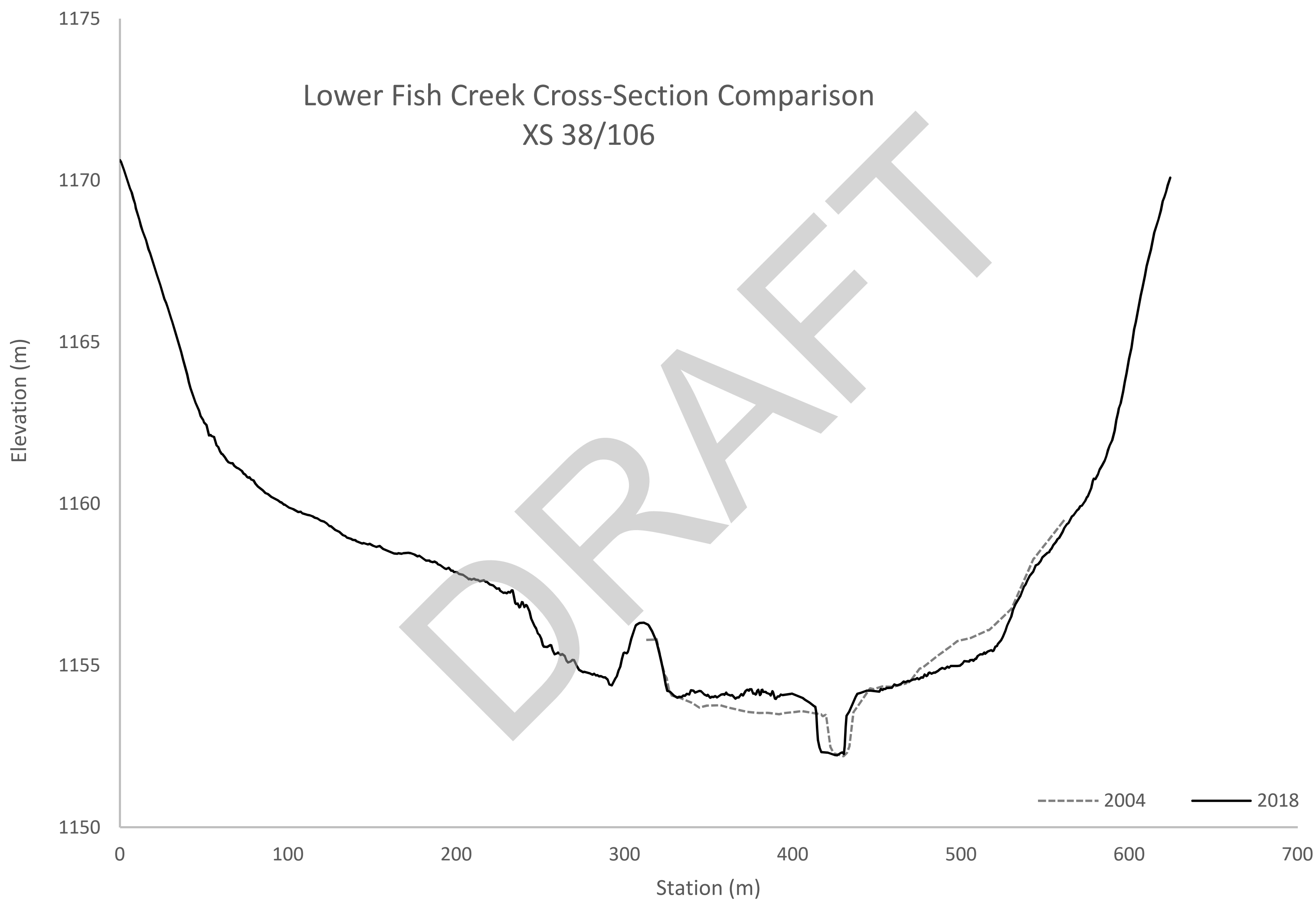
## APPENDIX C: CROSS SECTION COMPARISONS



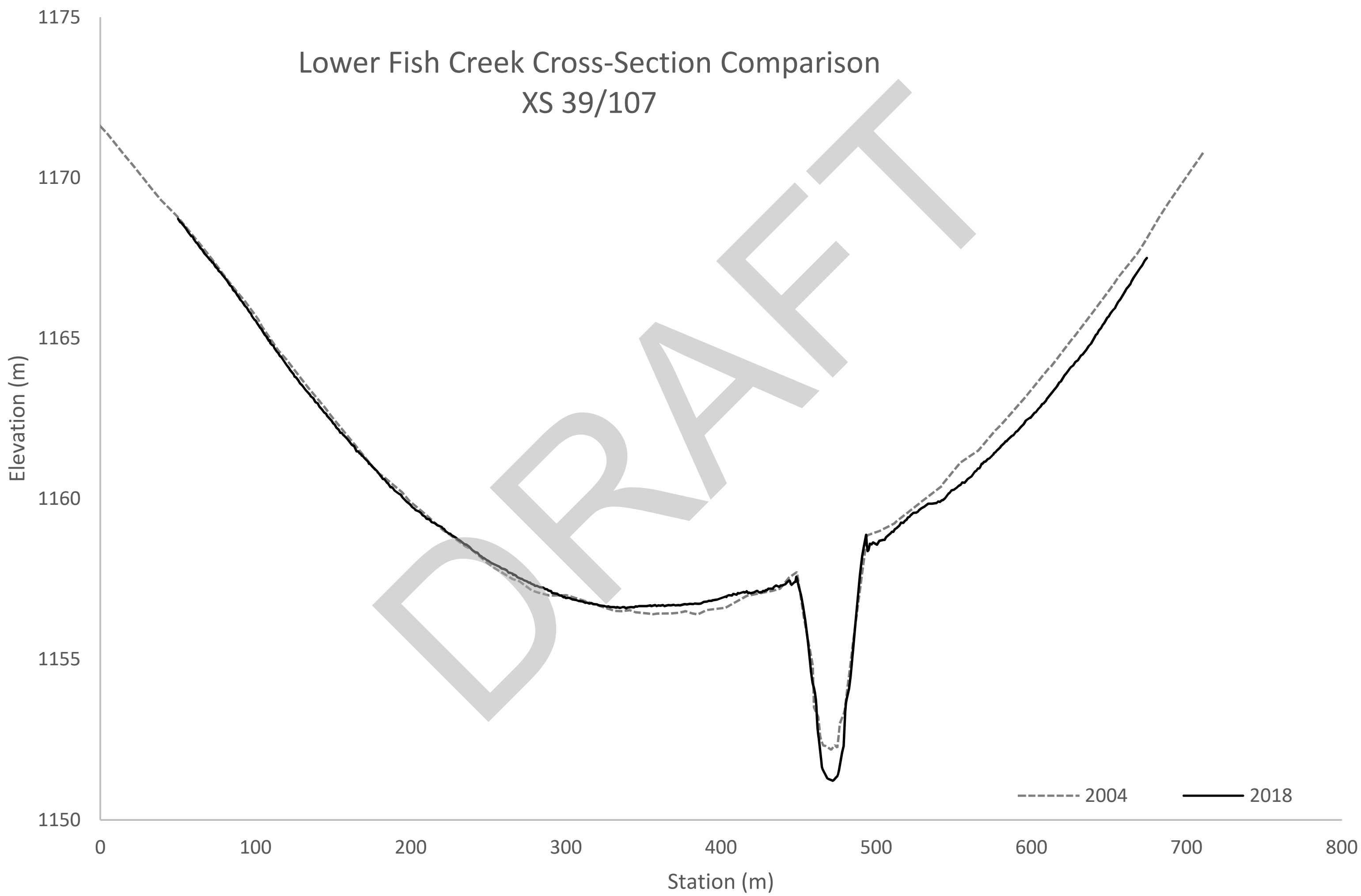
## APPENDIX C: CROSS SECTION COMPARISONS



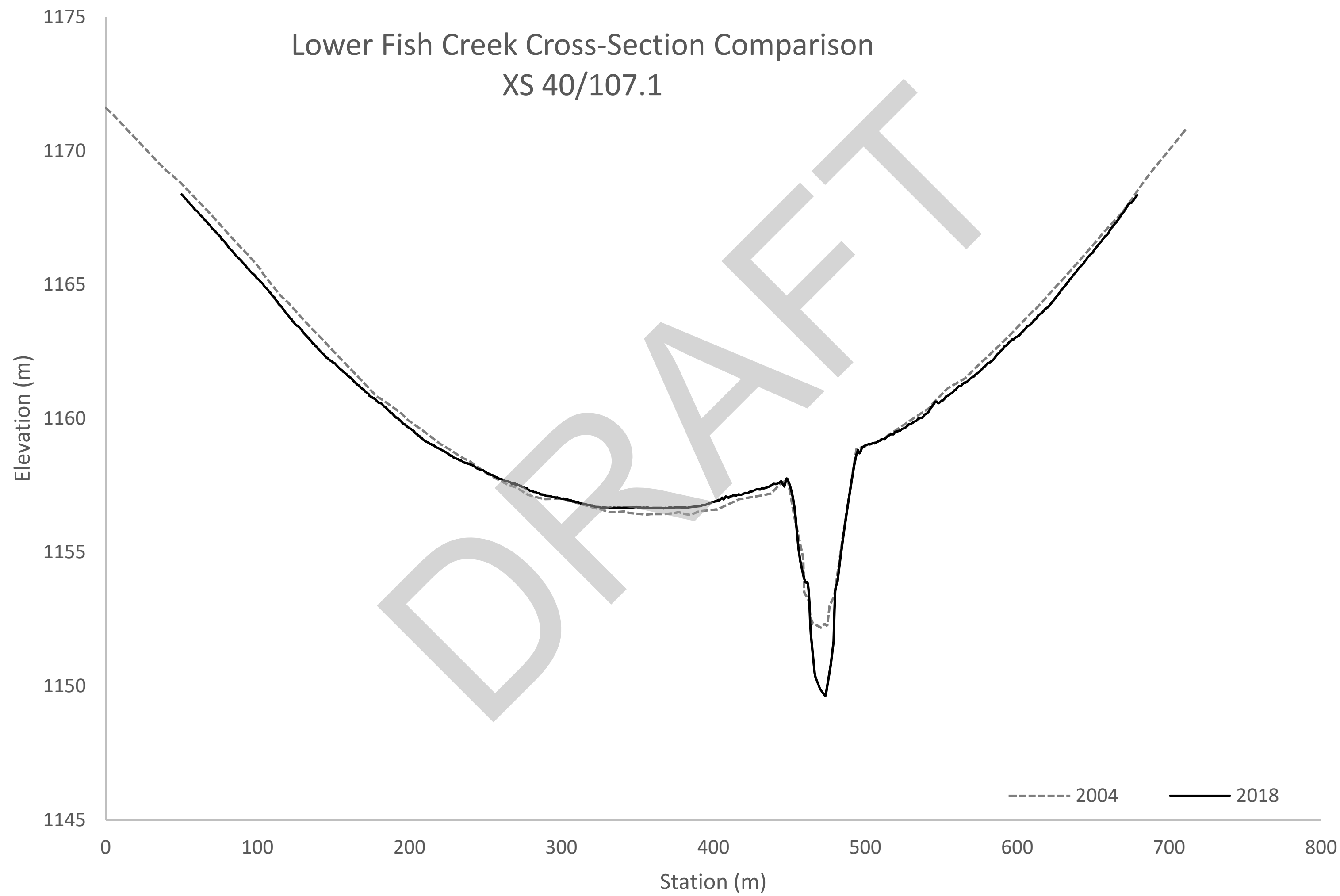
## APPENDIX C: CROSS SECTION COMPARISONS



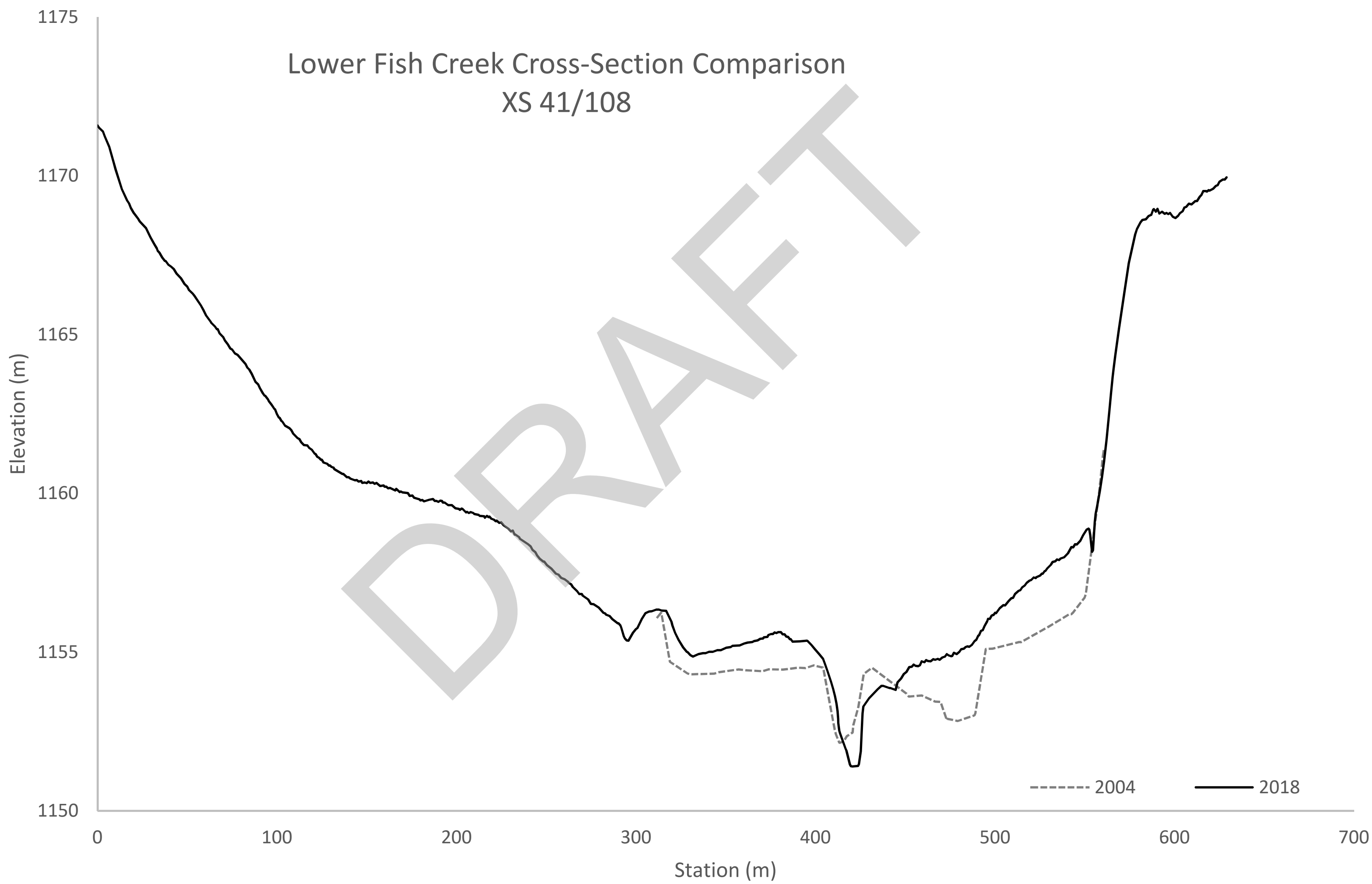
## APPENDIX C: CROSS SECTION COMPARISONS



**APPENDIX C: CROSS SECTION COMPARISONS**



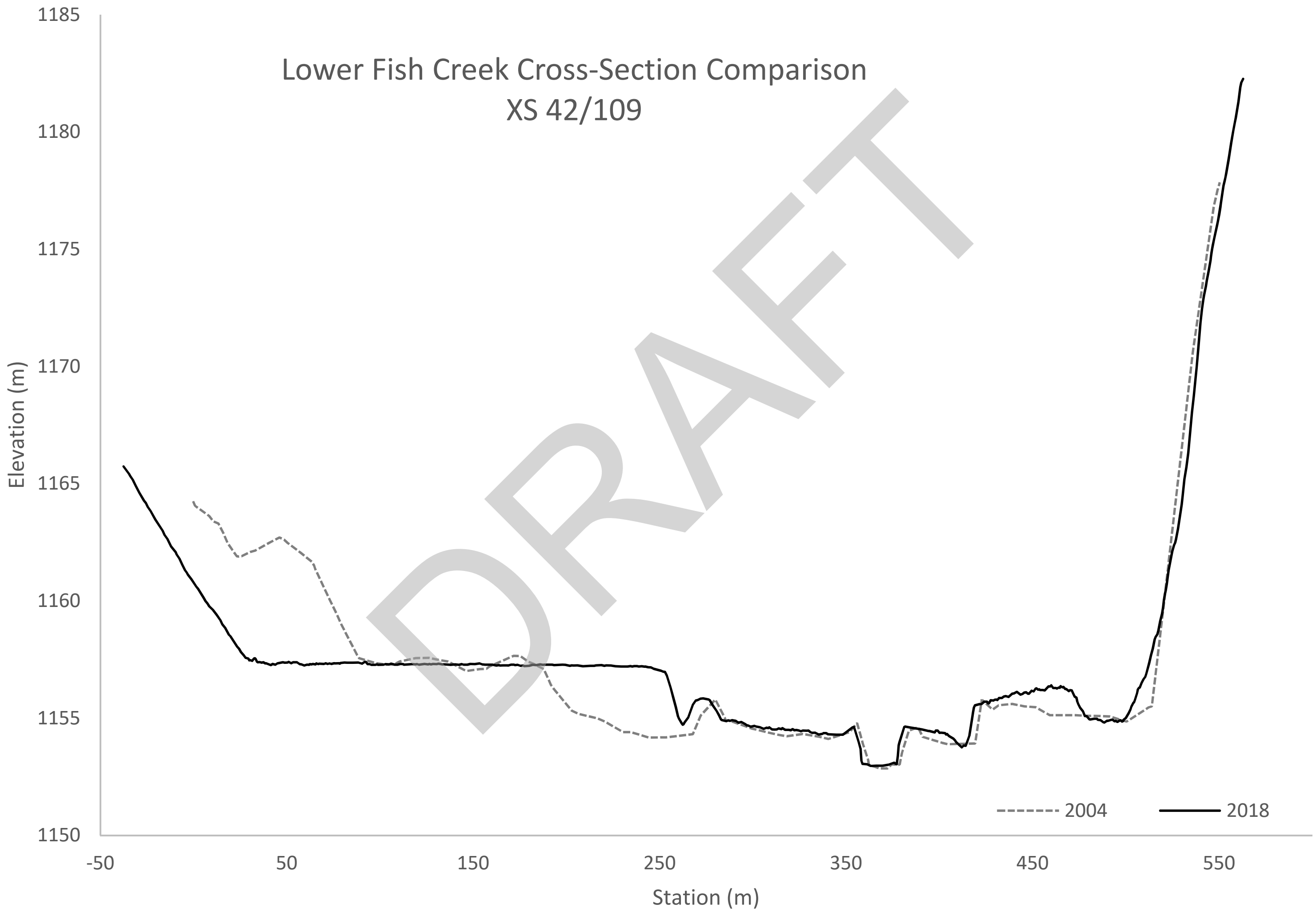
## APPENDIX C: CROSS SECTION COMPARISONS






Classification: Public

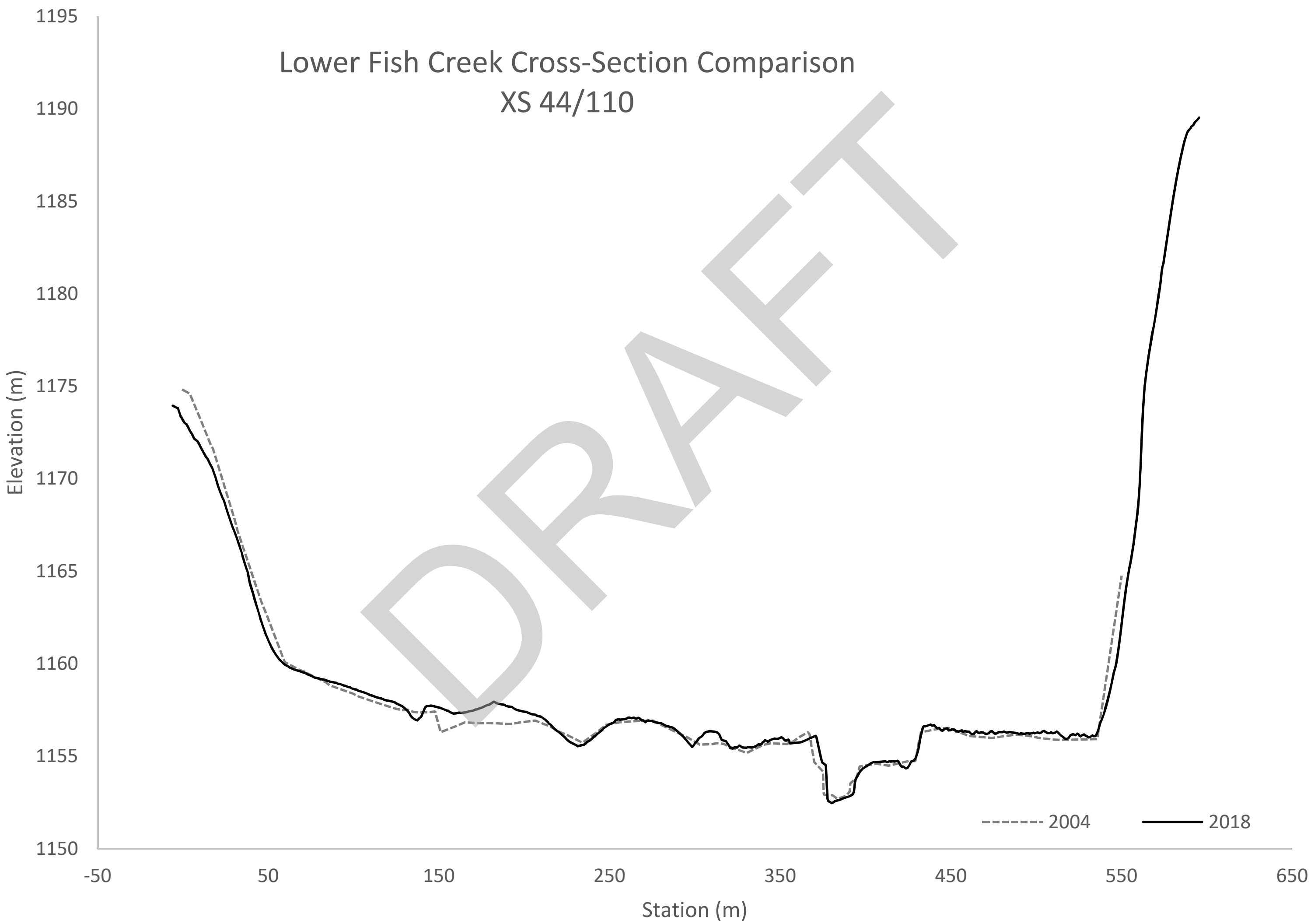
## APPENDIX C: CROSS SECTION COMPARISONS



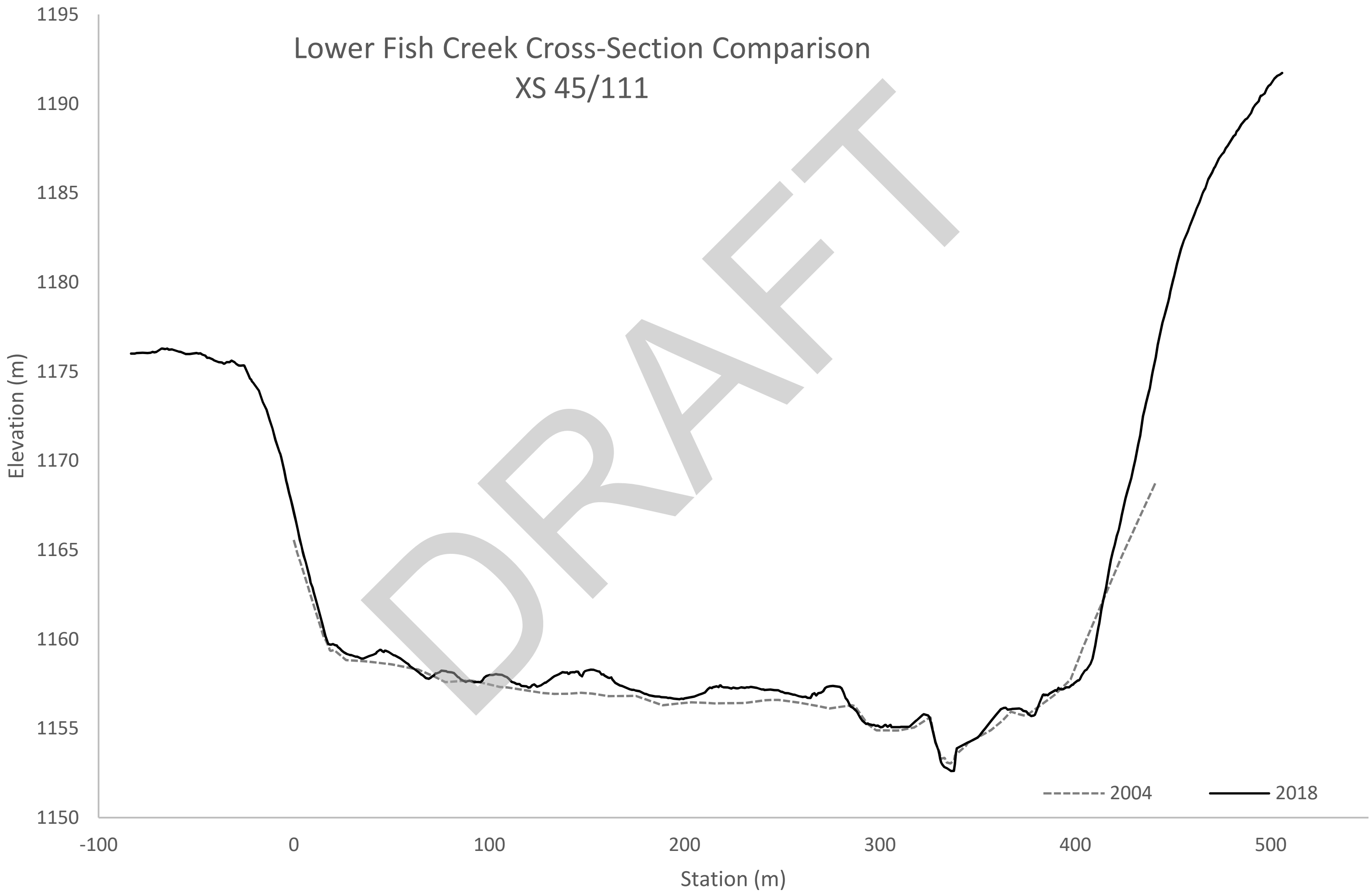



Classification: Public

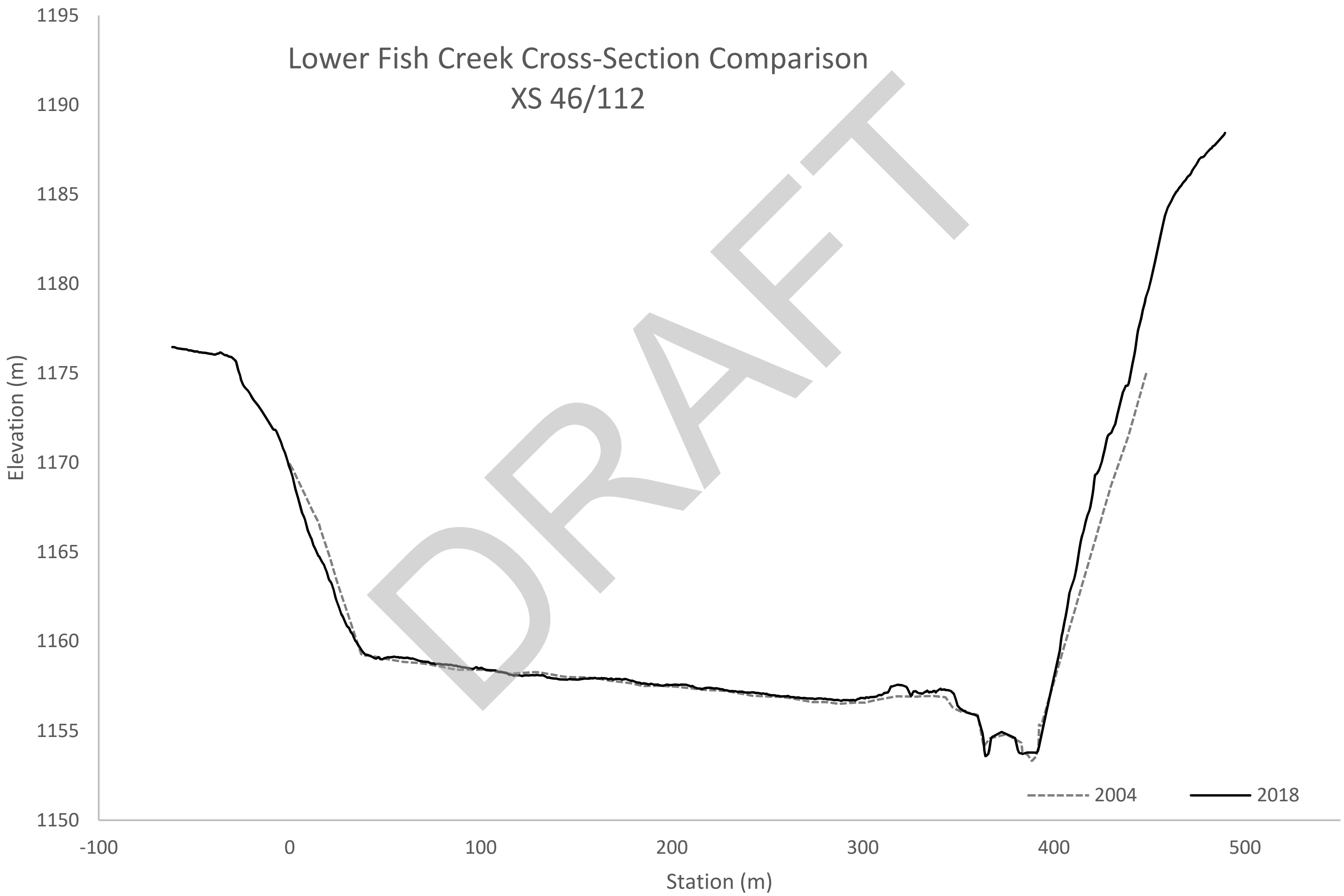
## APPENDIX C: CROSS SECTION COMPARISONS



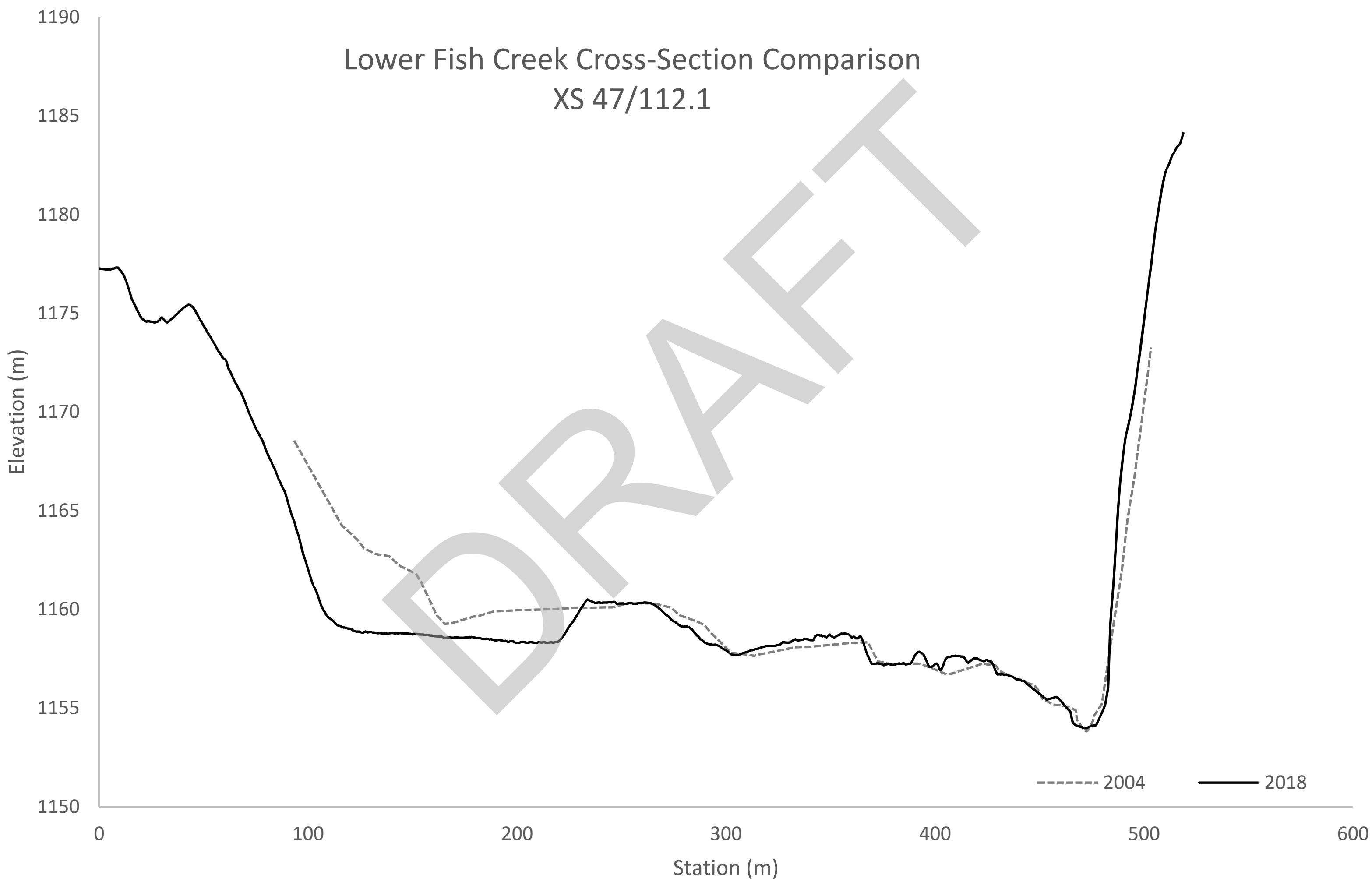
## APPENDIX C: CROSS SECTION COMPARISONS

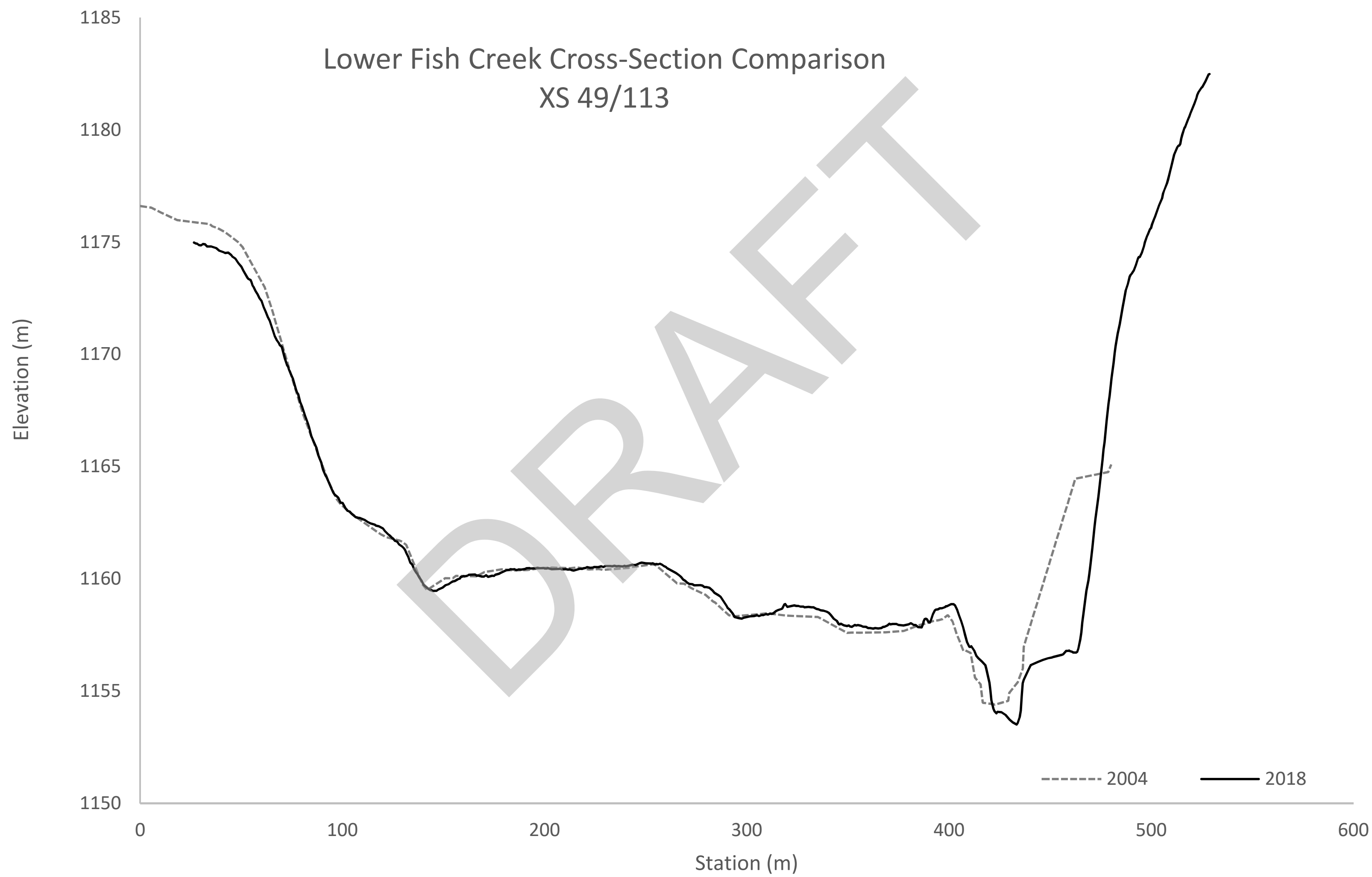


## APPENDIX C: CROSS SECTION COMPARISONS



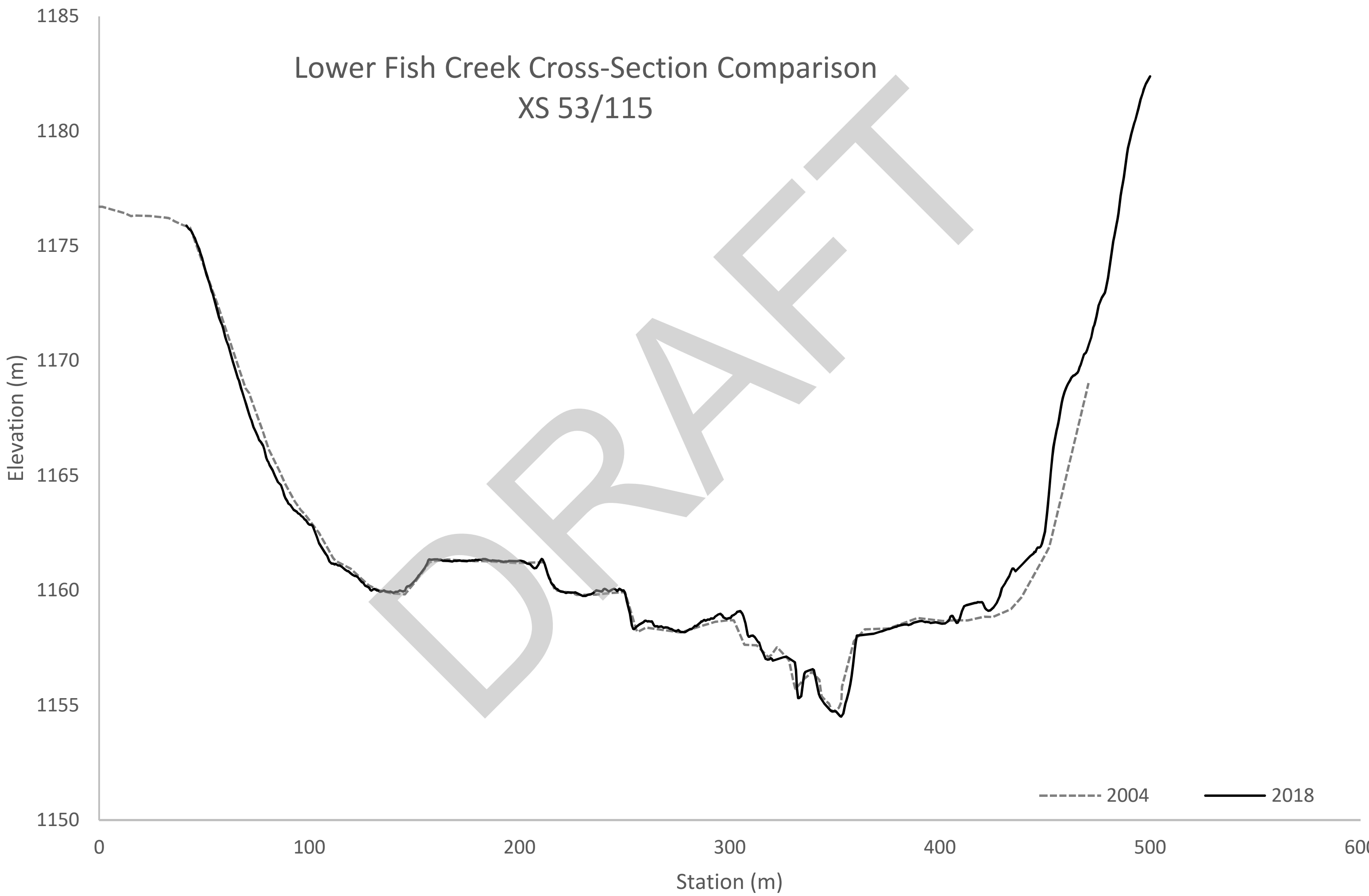
## APPENDIX C: CROSS SECTION COMPARISONS

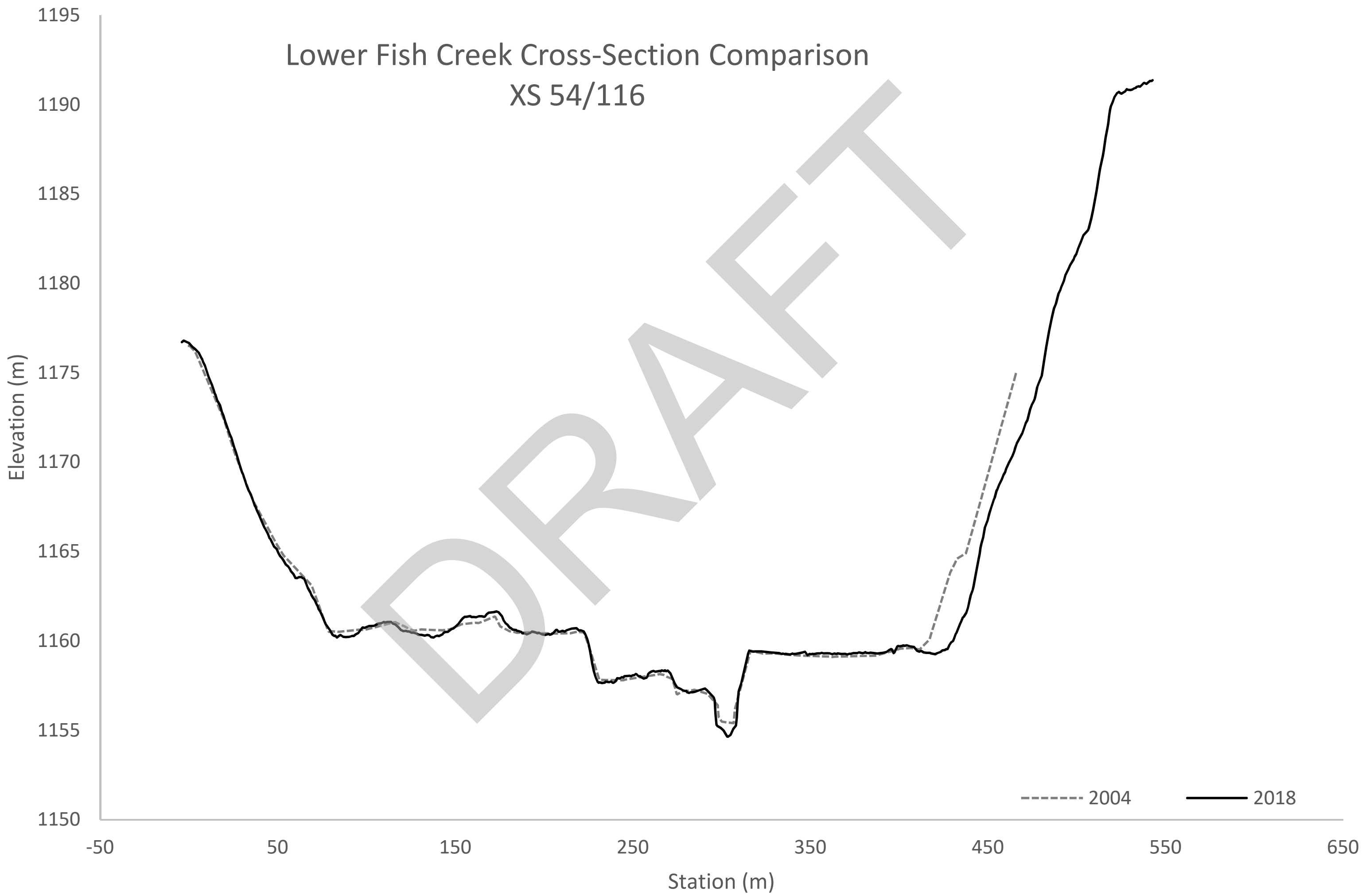




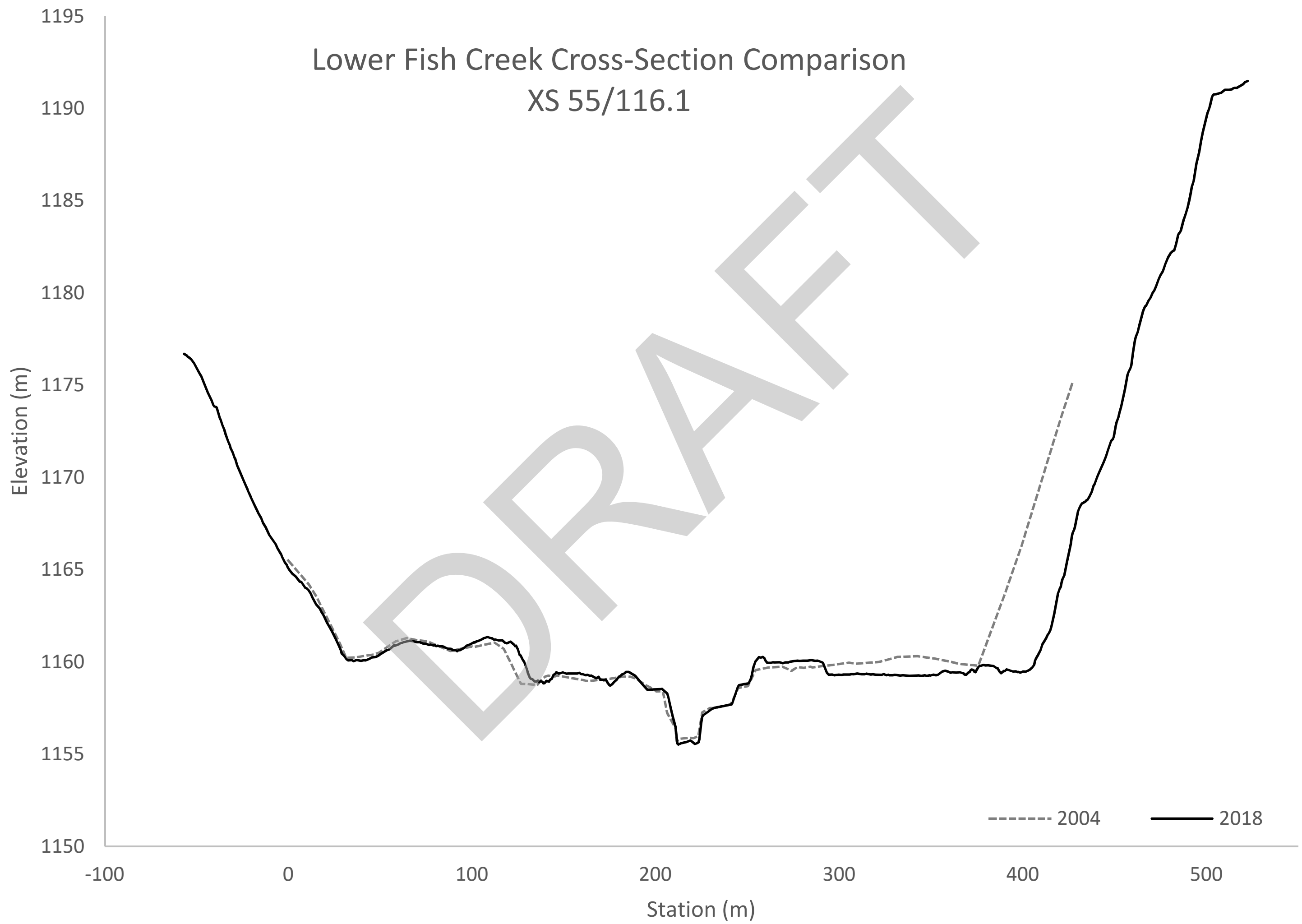
Lower Fish Creek Cross-Section Comparison
XS 49/113
DRAFT
Elevation (m)
1185
1180
1175
1170
1165
1160
1155
1150
0
100
200
300
400
500
600
Station (m)
2004
2018

## APPENDIX C: CROSS SECTION COMPARISONS

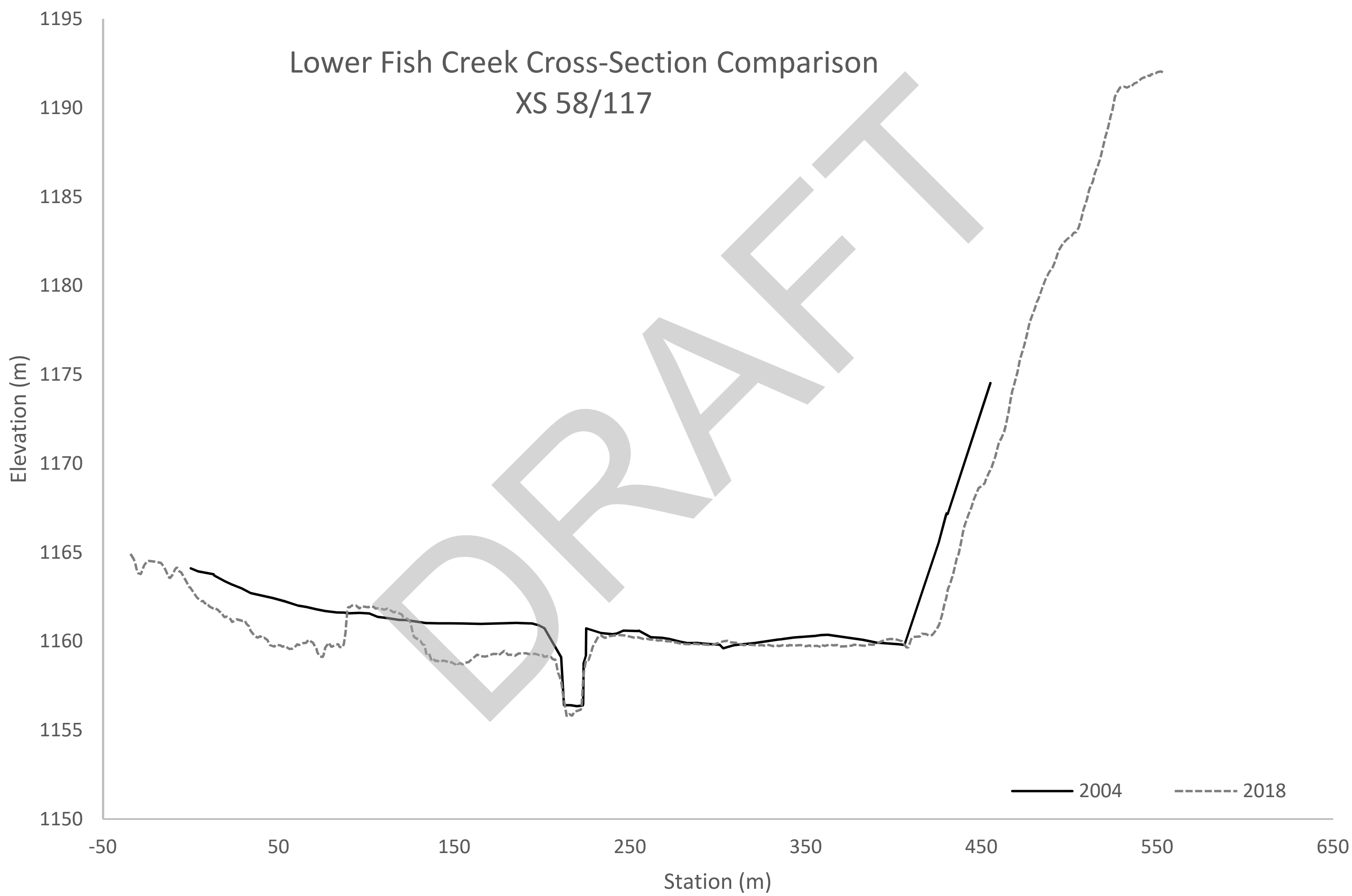



Lower Fish Creek Cross-Section Comparison
XS 54/116
DRAFT
Elevation (m)
Station (m)
1195
1190
1185
1180
1175
1170
1165
1160
1155
1150
-50
50
150
250
350
450
550
650
2004
2018

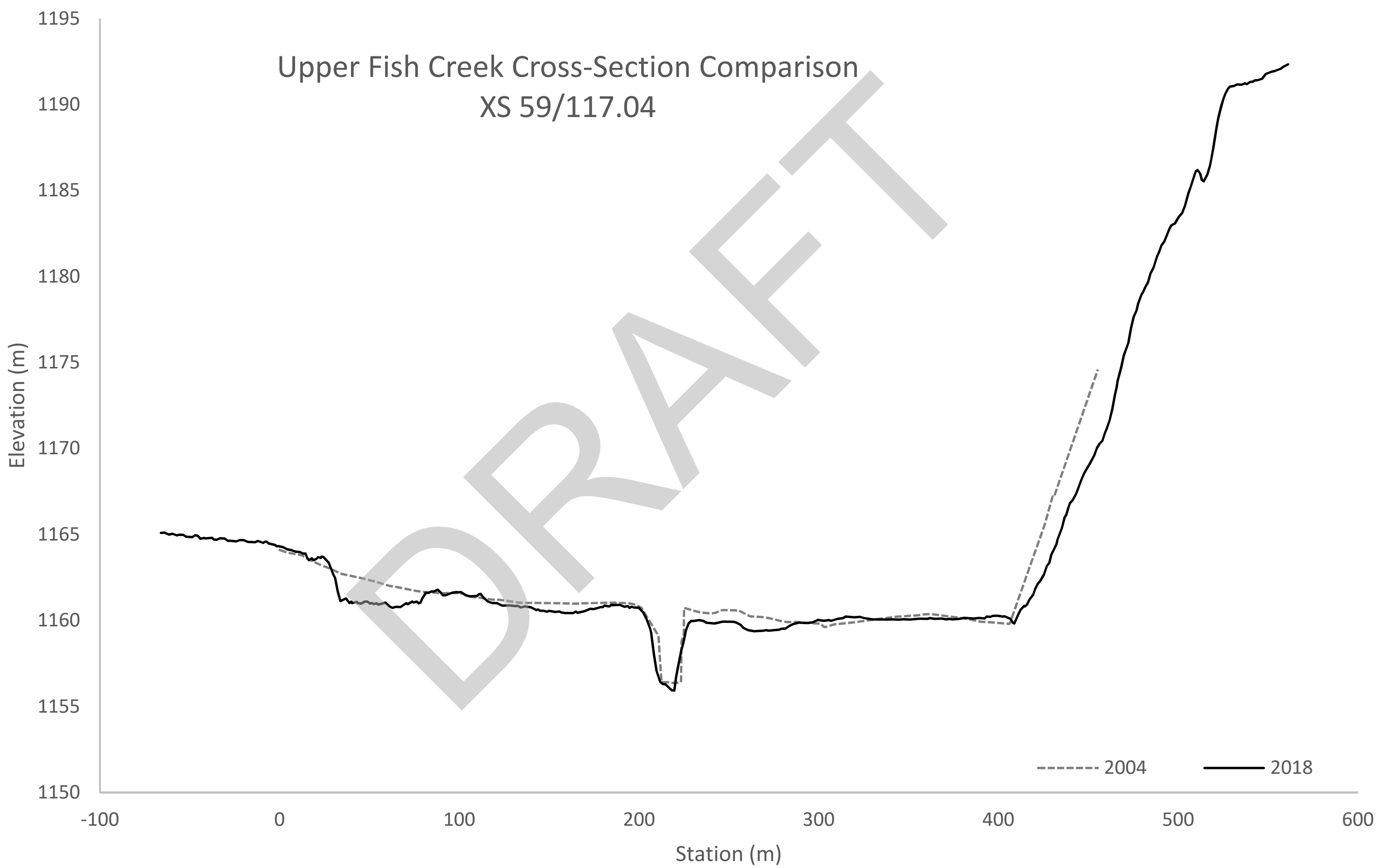
**APPENDIX C: CROSS SECTION COMPARISONS**



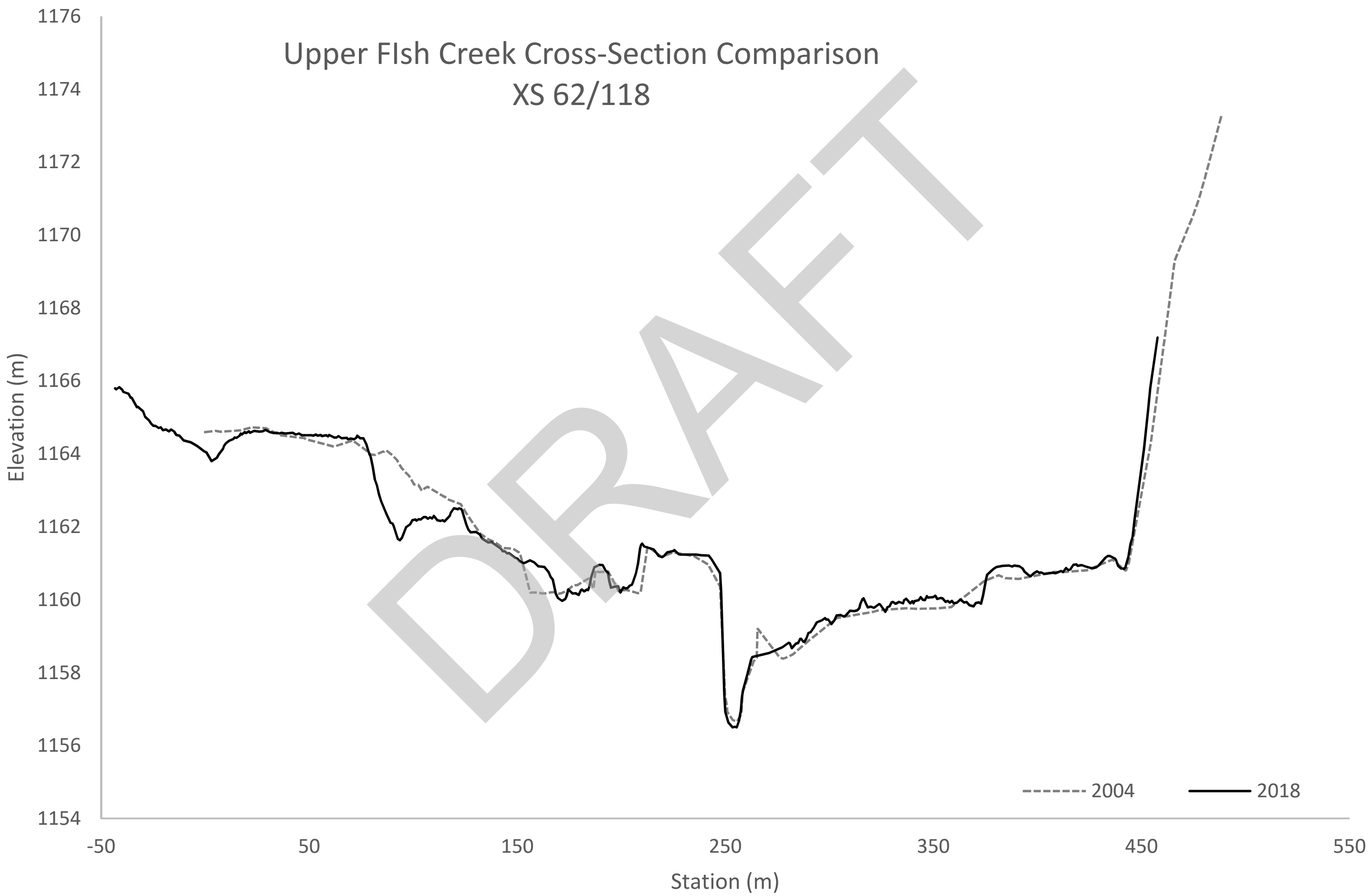
## APPENDIX C: CROSS SECTION COMPARISONS



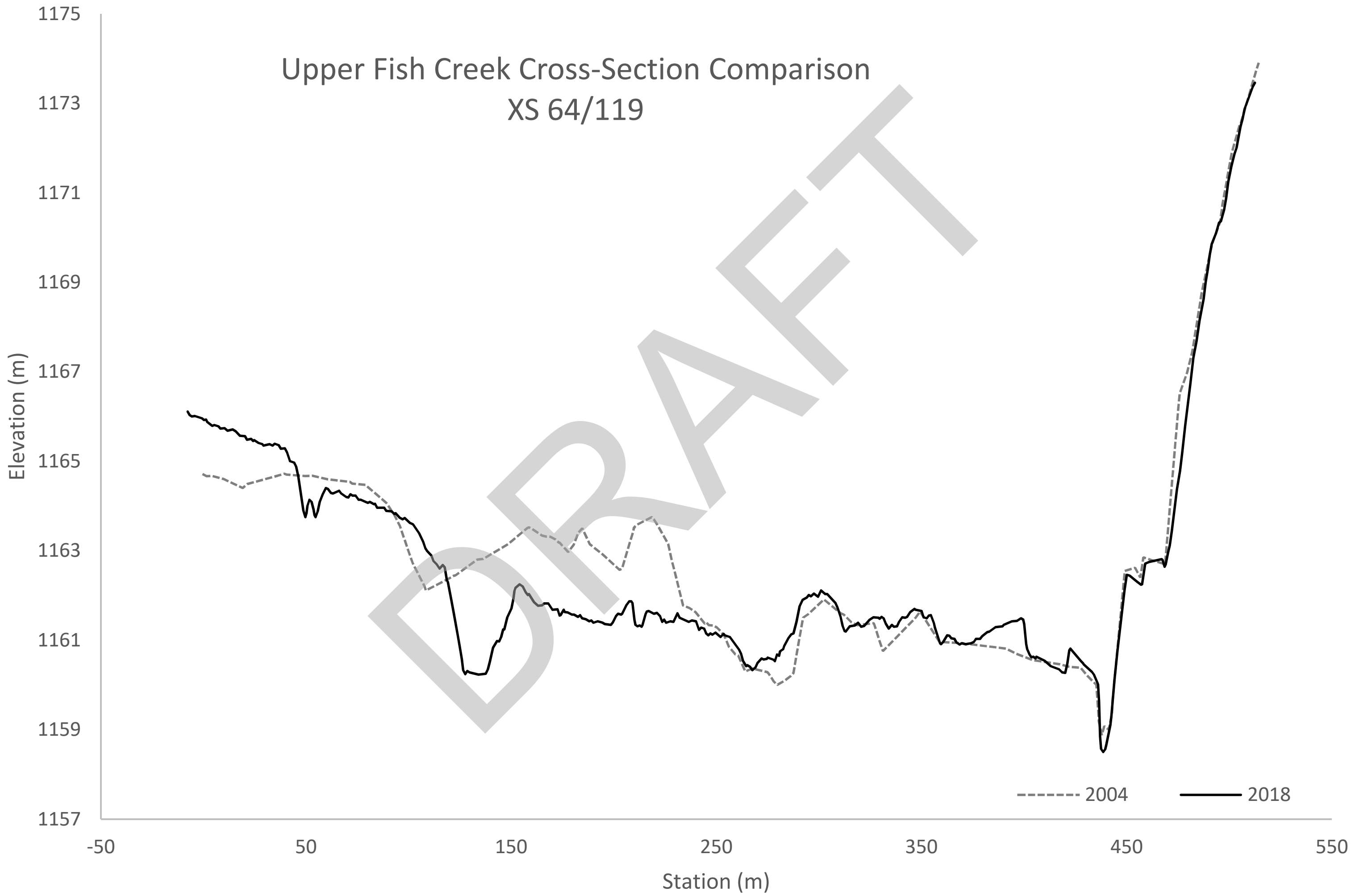
## APPENDIX C: CROSS SECTION COMPARISONS



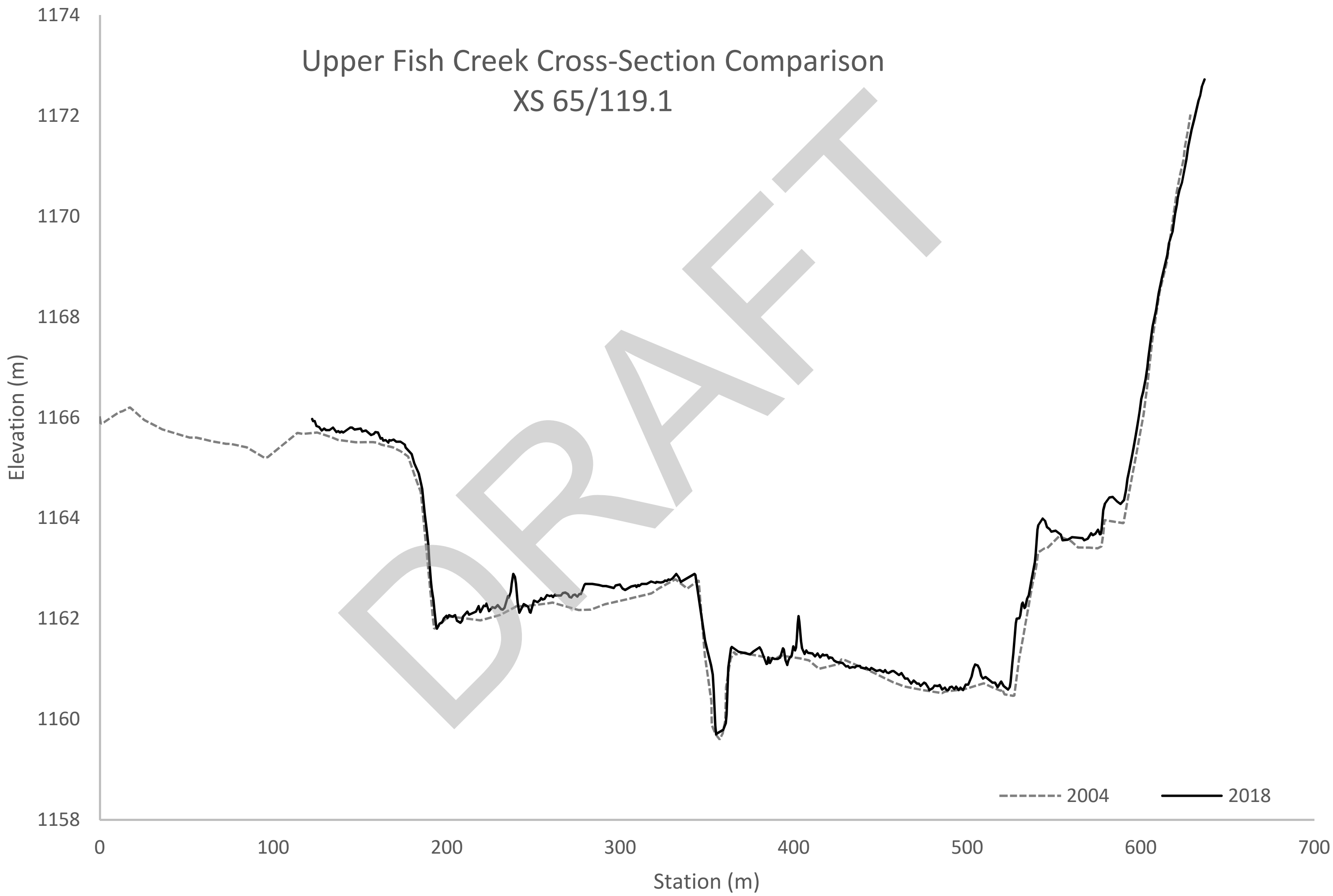
**APPENDIX C: CROSS SECTION COMPARISONS**



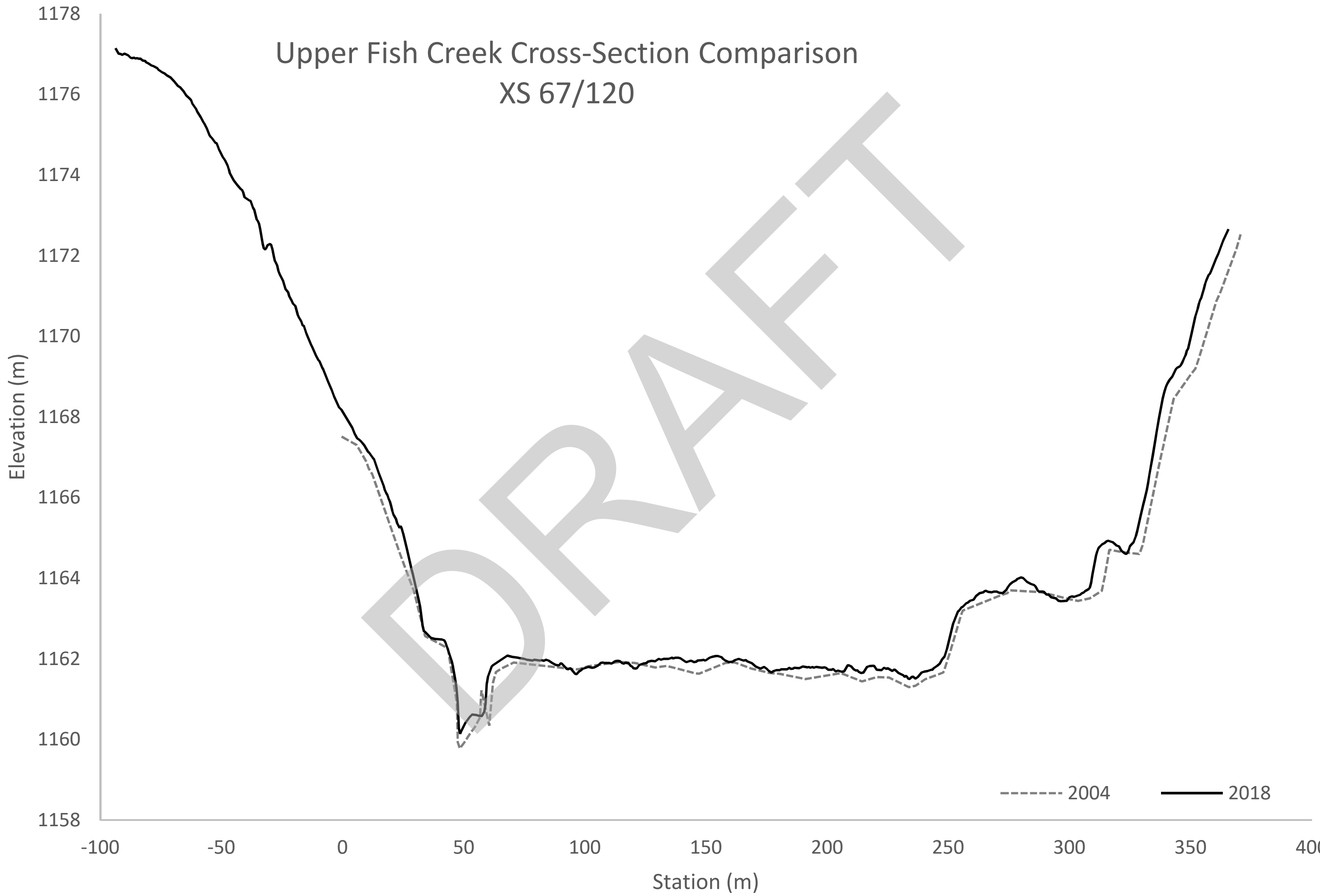
## APPENDIX C: CROSS SECTION COMPARISONS



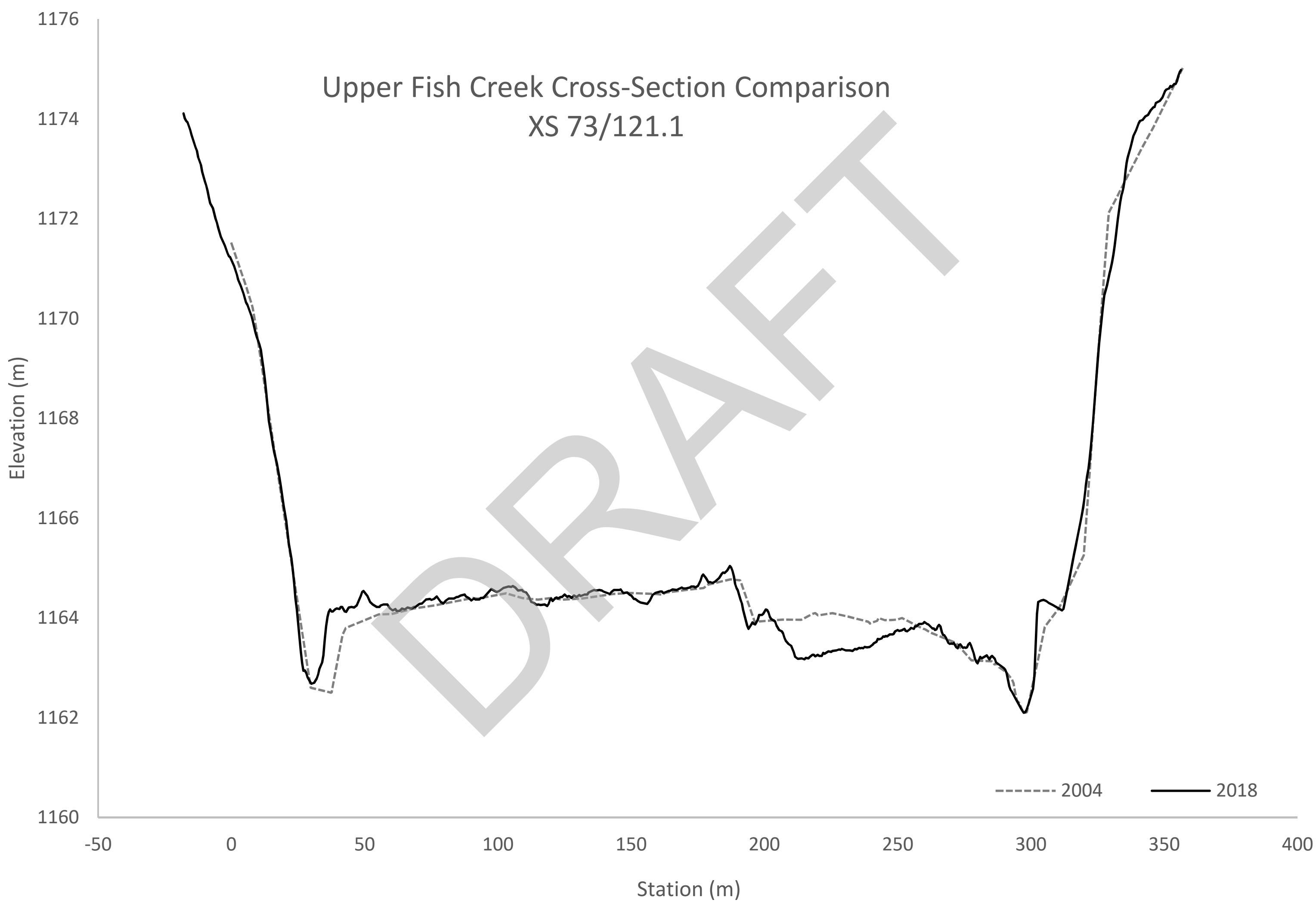
# APPENDIX C: CROSS SECTION COMPARISONS



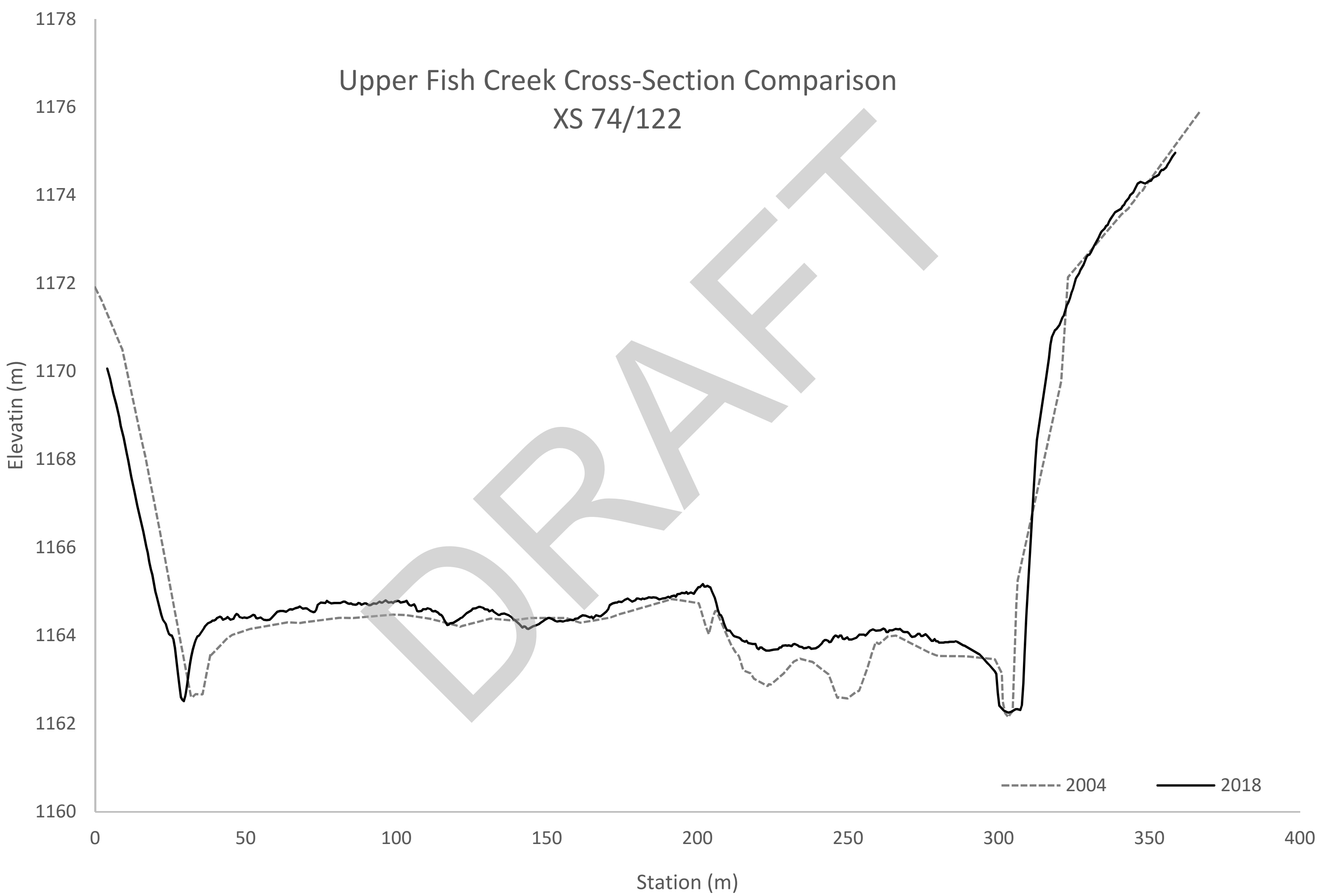
## APPENDIX C: CROSS SECTION COMPARISONS

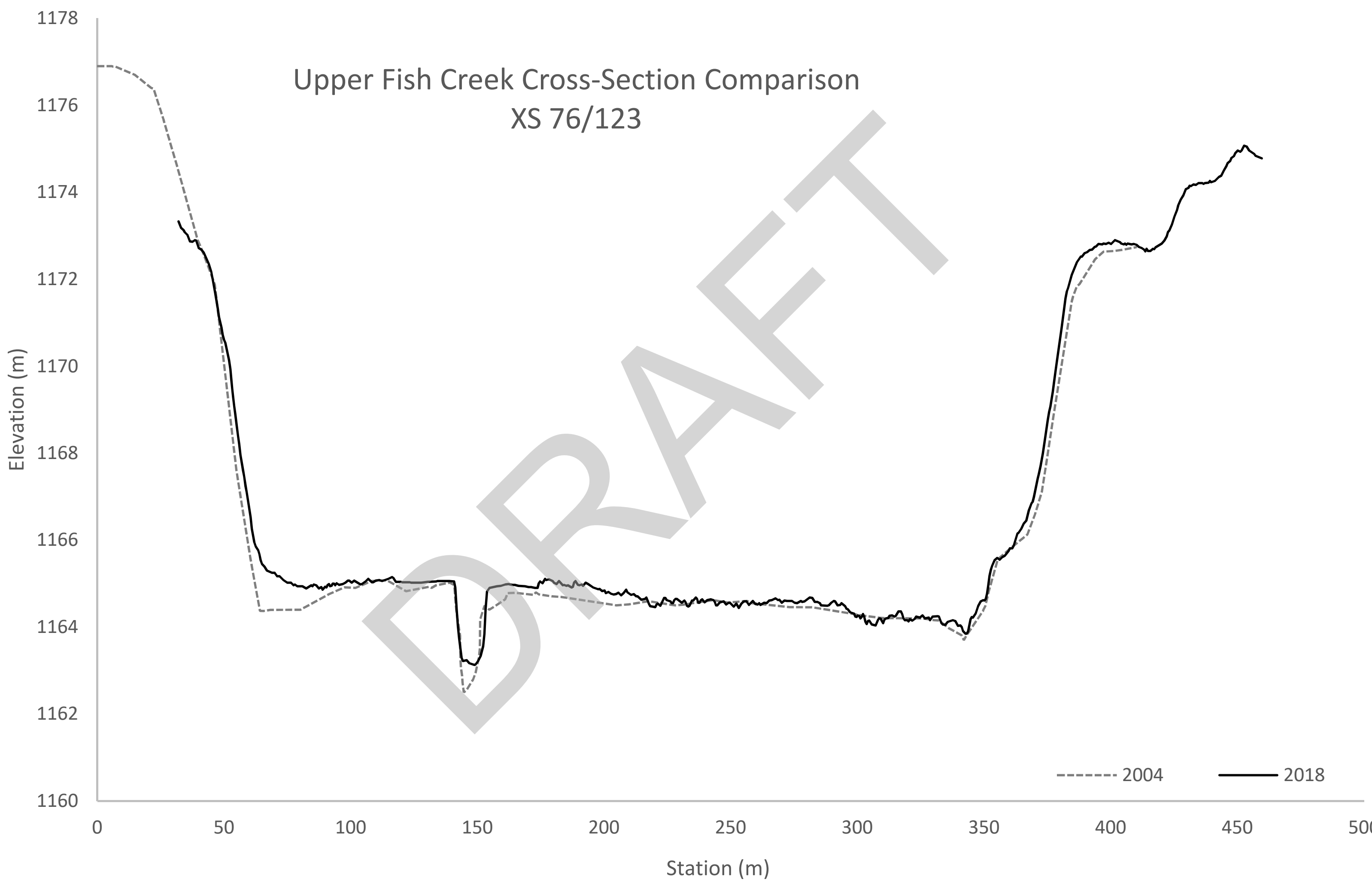


## APPENDIX C: CROSS SECTION COMPARISONS

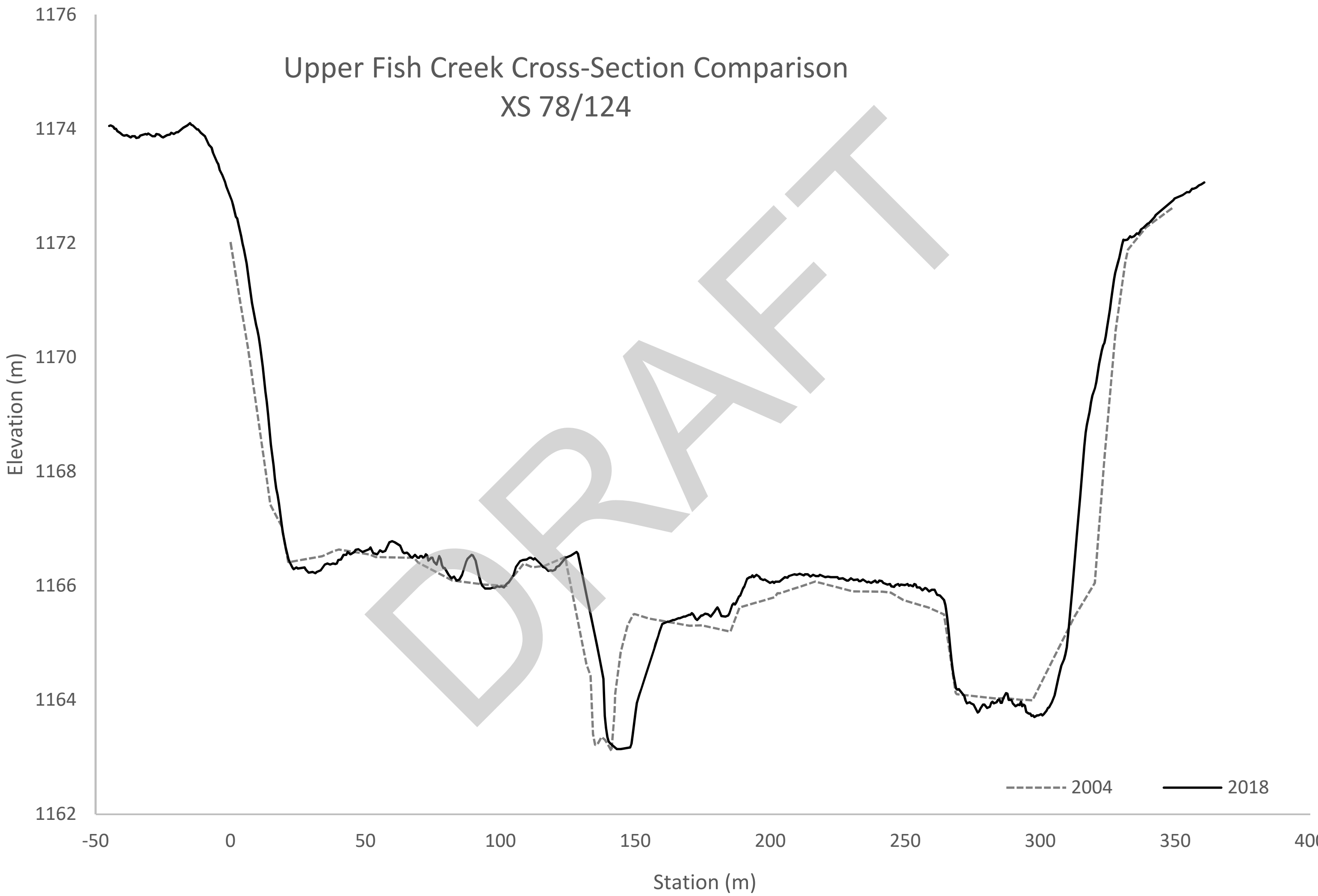


## APPENDIX C: CROSS SECTION COMPARISONS

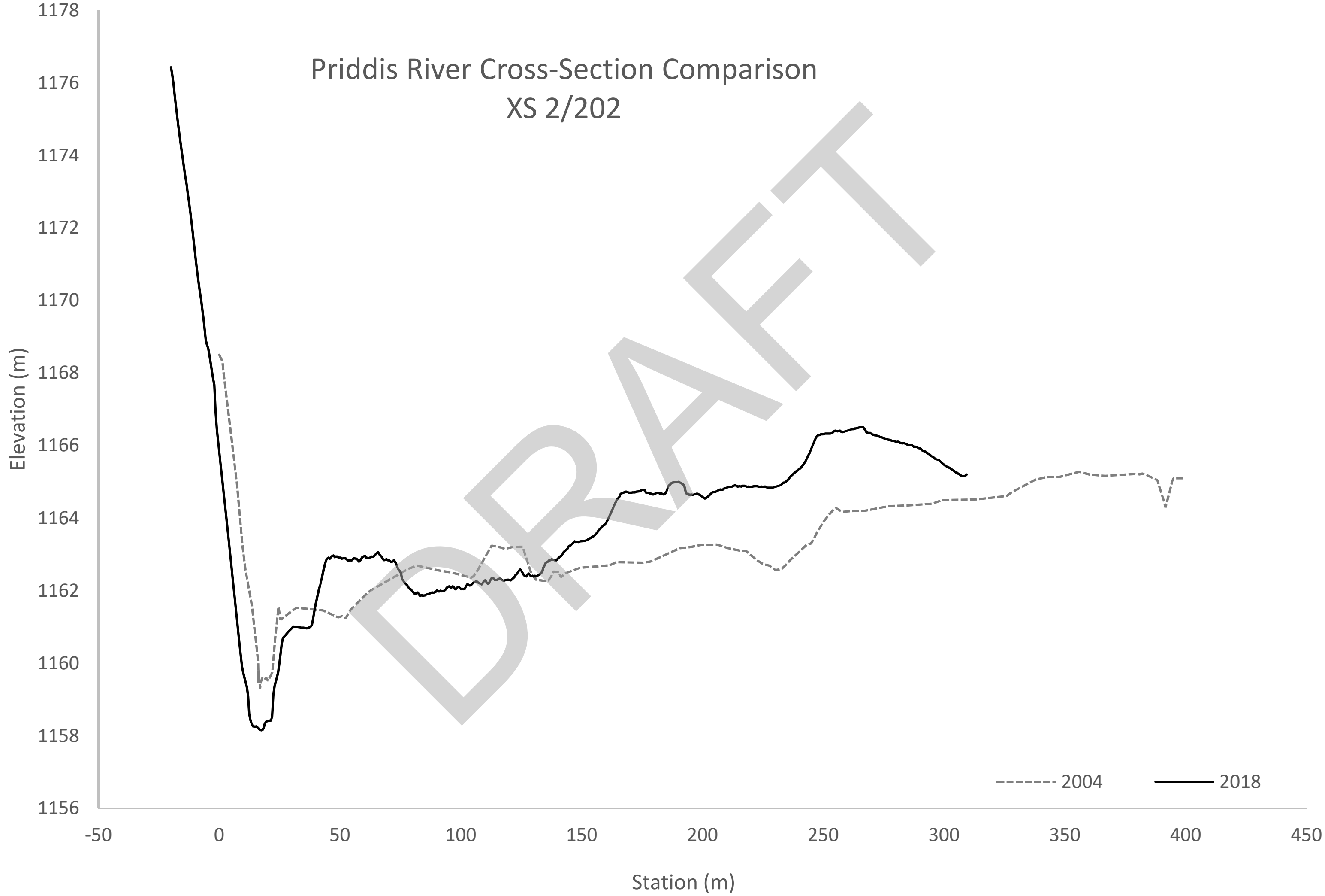



Upper Fish Creek Cross-Section Comparison
XS 76/123
Elevation (m)
1178
1176
1174
1172
1170
1168
1166
1164
1162
1160
0
50
100
150
200
250
300
350
400
450
500
Station (m)
2004
2018
DRAFT

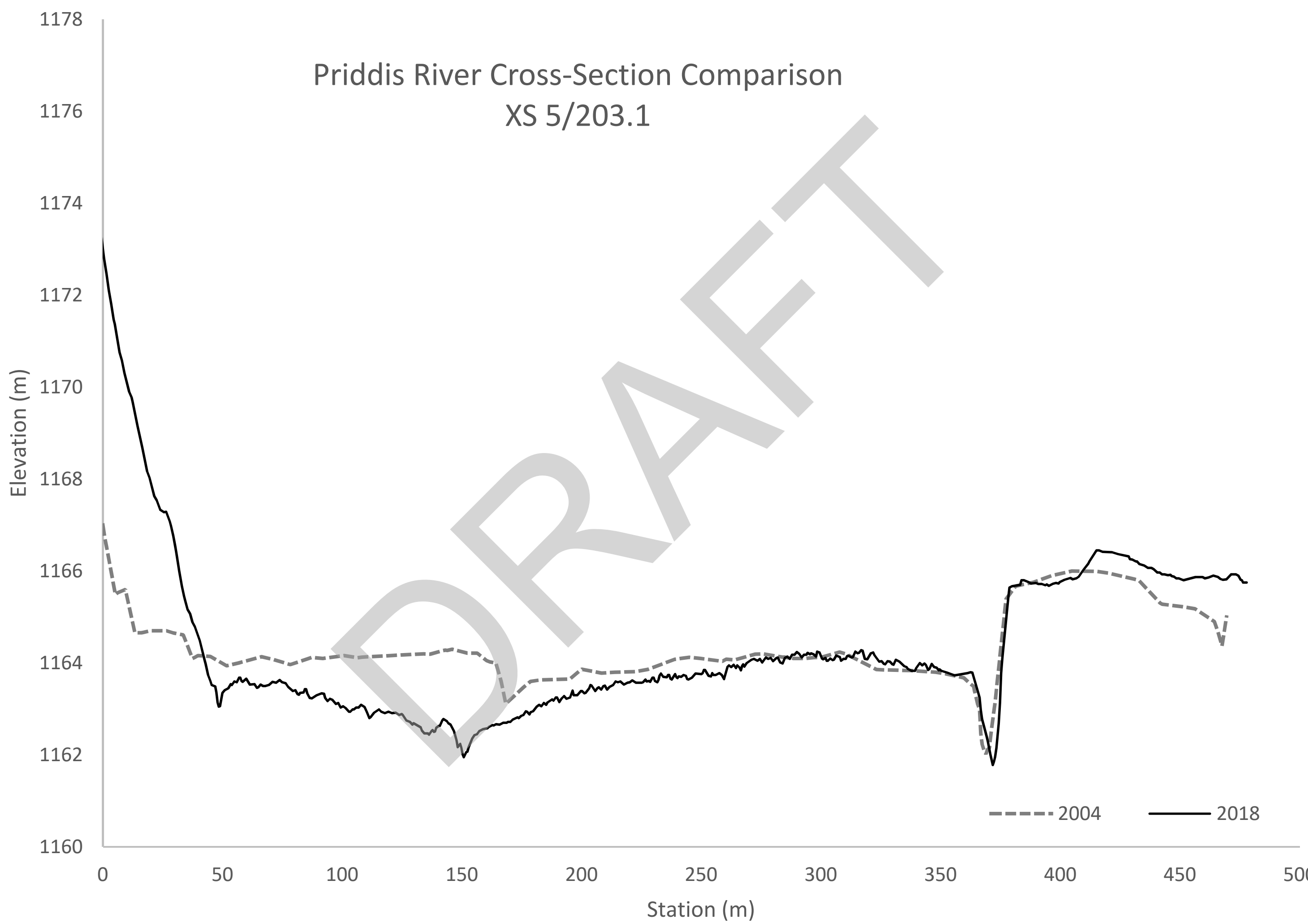
## APPENDIX C: CROSS SECTION COMPARISONS



## APPENDIX C: CROSS SECTION COMPARISONS



## APPENDIX C: CROSS SECTION COMPARISONS






Classification: Public