January 2018

SIKSIKA BOW RIVER HAZARD STUDY

Survey and Base Data Collection Report

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FINAL REPORT

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Alberta Environment and Parks

SG1 WATER CONSULTING

Golder Associates

Executive Summary

Alberta Environment and Parks (AEP) commissioned Golder Associates Ltd. (Golder), in collaboration with SG1 Water Consulting Ltd. (SG1), in August 2017 to conduct the Siksika Bow River Hazard Study. The primary purpose of the study is to assess and identify river and flood hazards along a 217 km reach of the Bow River extending downstream of the Highwood River confluence, including Siksika Nation, the Hamlet of Bow City, and land in five municipal districts and counties. 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. Project stakeholders include the provincial government, local authorities, and the public. Key municipal stakeholders are Municipal District of Foothills, Rocky View County, Vulcan County, Wheatland County, and County of Newell. The project includes working with Siksika Nation.

The Siksika Bow River Hazard Study is comprised of multiple components and deliverables. This report documents the methodology and results of the Survey and Base Data Collection component. Tasks associated with this study component include cross section surveys on the Bow River as well as hydraulic and flood control structure data collection along the study reach. Additional base data collected in support of the study includes administrative data, cadastral data, infrastructure data (bridges and roads), benchmark surveys, and other relevant information.

Topographic, control point, and shallow-water surveys were performed using Real-time Kinematic (RTK) GPS units. Bathymetric surveys were conducted on the Bow River using an Acoustic Doppler Profiler (ADP) in combination with a boat-mounted RTK unit where flow depths were too deep to wade. Bridge survey data were collected using both an RTK and total station.

For survey planning and execution, the study area was divided into three main reaches: (1) above Siksika Nation; (2) through Siksika Nation; and (3) below Bassano Dam. The total length of channel surveyed along the Bow River is approximately 217 km. The salient project features surveyed between September 12 and October 26, 2017 are listed in Table i. The cross section data collected in this study will be combined with those collected by Golder (2015a; 2015b) along portions of the study reach following the June 2013 flood. A grand total of approximately 475 cross sections will be used for hydraulic modelling in this study.

Table i: Surveyed Cross Sections, Hydraulic Structures, and Flood Control Structures in the Study Area

Feature	Number of Surveyed Cross Sections or Locations			
	Reach #1 (Above Siksika Nation)	Reach #2 (Through Siksika Nation)	Reach #3 (Below Bassano Dam)	Totals
Cross Sections	62	221	71	**354**
Bridges	None	3	1	**4**
Flood Control Structures	None	1	None	**1**

Water levels were measured at each cross section as part of the survey. However, AEP, Golder, and SG1 agreed that there was limited value in obtaining discharge data because of extremely low flow conditions on the Bow River reach over the survey period.

Acknowledgements

The technical lead for the survey and base data collection component of the Siksika Bow River Hazard Study was Darren Shepherd of SG1 Water Consulting Ltd. (SG1). Hua Zhang and Dejiang Long, both of Golder Associates Ltd. (Golder), provided overall direction and support for this study component.

The survey program was conducted by Carmen Orosz of Golder with field support by Barry Duck Chief and Eric Grinnell. Jonah Jerry served as the client liaison when survey data were being collected along the reach of the Bow River through Siksika Nation. Office-based support related to data processing and mapping was provided by Nancy Guo, Sean Kurash, and Michael De Coste, all of Golder.

The authors express their special thanks to Kurt Morrison, project manager for Alberta Environment and Parks (AEP), who provided overall study management, background data, and technical guidance throughout the field program. The authors also express their gratitude to Peter Onyshko of AEP for his additional support and for providing background information and survey-related data.

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1.0 INTRODUCTION

1.1 Study Background and Objectives

Alberta Environment and Parks (AEP) commissioned Golder Associates Ltd. (Golder), in collaboration with SG1 Water Consulting Ltd. (SG1), in August 2017 to conduct the Siksika Bow River Hazard Study. The primary purpose of the study is to assess and identify river and flood hazards along a 217 km long reach of the Bow River extending downstream of the Highwood River confluence, including Siksika Nation, the Hamlet of Bow City, and land in five municipal districts and counties. 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. Project stakeholders include the provincial government, local authorities, and the public. Key municipal stakeholders are Municipal District of Foothills, Rocky View County, Vulcan County, Wheatland County, and County of Newell. The project includes working with Siksika Nation.

The Siksika Bow River Hazard Study is comprised of multiple components and deliverables. This report documents the methodology and results of the Survey and Base Data Collection component. Other major study components documented in accompanying reports include: Hydraulic Model Creation and Calibration; Open Water Flood Inundation Map Production; Open Water Flood Hazard Identification; Governing Flood Hazard Map Production; Flood Risk Assessment and Inventory; and Channel Stability Investigation.

Tasks associated with this study component include cross section surveys and hydraulic and flood control structure data collection on the Bow River. Additional base data collected in support of the study includes cadastral data, infrastructure data (bridges and roads), benchmark surveys, and other relevant project information.

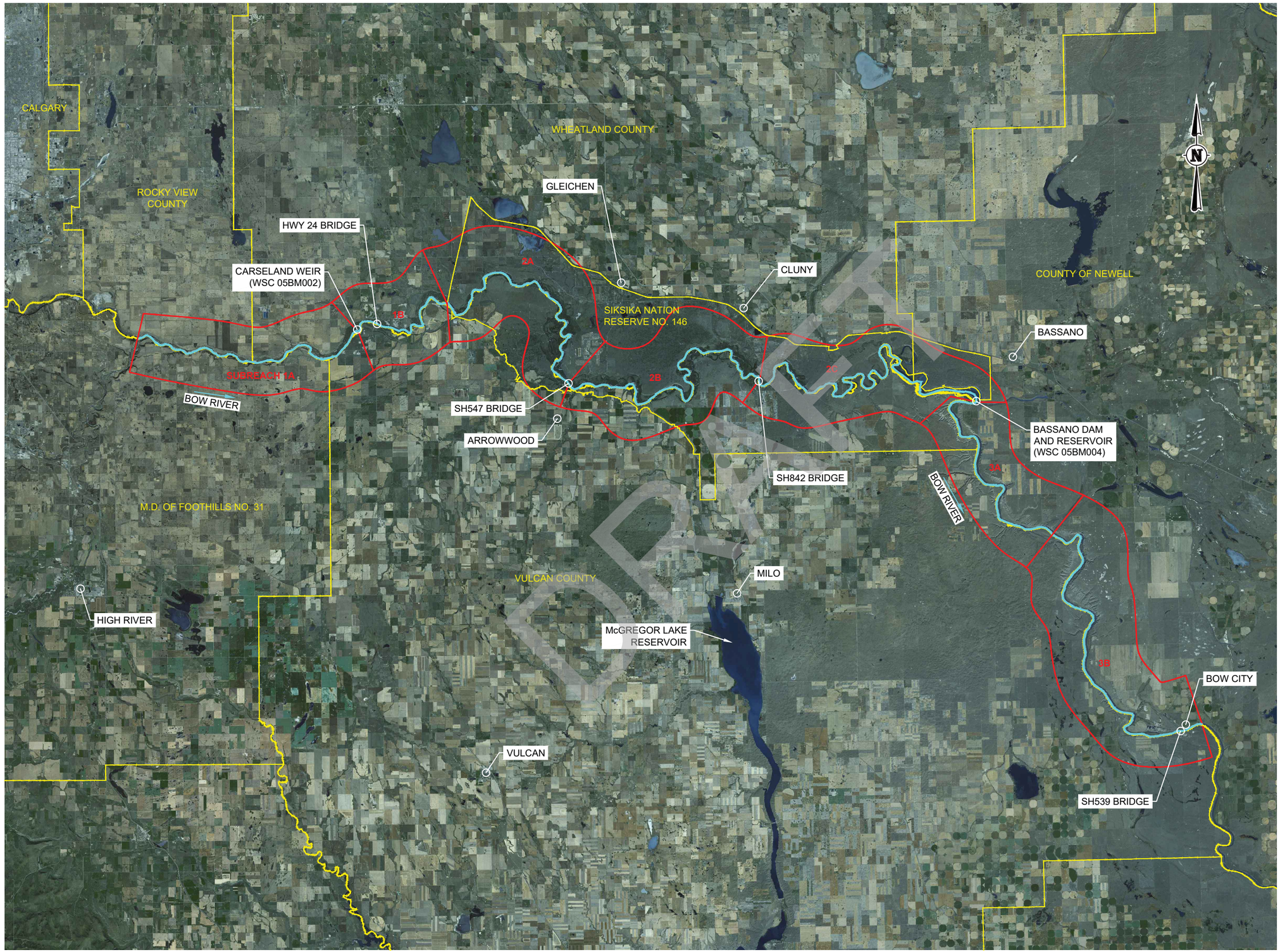
1.2 Study Area and Reaches

Figure 1 shows the study area and reach of the Bow River that was surveyed during the field program. Cross section surveys extended over a 217 km reach extending downstream of the Highwood River confluence. For survey planning and execution, the study area was divided into three main reaches: (1) above Siksika Nation; (2) through Siksika Nation; and (3) below Bassano Dam. These reaches were further subcategorized as outlined below (refer to Figure 1 and Table 1 for more detail).

- **Subreach 1A** – 28 km reach between the Highwood River confluence and the Carseland Weir
- **Subreach 1B** – 14 km reach from the Carseland Weir to the upstream boundary of Siksika Nation
- **Subreach 2A** – 30 km reach from the upstream boundary of Siksika Nation to SH547 (Arrowwood) bridge
- **Subreach 2B** – 35 km reach from SH547 bridge to SH842 bridge
- **Subreach 2C** – 46 km reach between SH842 (Cluny) bridge and Bassano Dam
- **Subreach 3A** – 25 km reach from Bassano Dam to Edge Flats
- **Subreach 3B** – 39 km reach from Edge Flats to the Hamlet of Bow City (near SH539 bridge)

1.3 Scope of Work

The survey and base data collection component of the Siksika Bow River Hazard Study was composed of a field program involving the survey of river cross sections, hydraulic structures, and a flood control structure. Base data collected for the study included infrastructure data (i.e., bridges, roads, and a flood control structure) and cadastral data. The field program was conducted in accordance with a Survey Plan that was prepared prior to commencing the field work (SG1, 2017).



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NOTES:

1. WORLD IMAGERY BY ESRI INC., DATED 17-JUL-2015.
2. THE STUDY AREA IS COMPRISED OF A 217 km LONG REACH OF THE BOW RIVER EXTENDING DOWNSTREAM OF THE HIGHWOOD RIVER CONFLUENCE TO THE HAMLET OF BOW CITY.
3. WATER SURVEY OF CANADA (WSC) HYDROMETRIC STATIONS ON THE BOW RIVER WITHIN THE STUDY AREA ARE LOCATED BELOW CARSELAND WEIR (WSC 05BM002) AND BELOW BASSANO DAM (WSC 05BM004).

LEGEND:

STUDY REACH

STUDY AREA / SUBREACHES

0 km 4 8 12 16

1 : 400

PREPARED FOR:

Alberta Environment and Parks

PROJECT:

SIKSIKA BOW RIVER HAZARD STUDY
SURVEY AND BASE DATA COLLECTION

TITLE:

Location Map of Study Area

DWN BY:	CHK'D BY:	REV NO:
RDJ	DMS	0
DWG NO: 10080-02-100		FIGURE NO: 1
DATE: 9-JAN-2018		

FILE LOC: H:\SG1\OwnCloud\Drafting\10080 Siksika Bow\Task 2\10080-02-100.dwg - 10080-02-100, PLOT DATE: 08-Jan-2018

2.0 SURVEY PROGRAM AND COLLECTED DATA

2.1 General

Surveying of the study area began on September 12, 2017. All field-related tasks were completed on October 26, 2017. The field program included surveying of cross sections, hydraulic structures, and a flood control structure along the study reach. In addition, selected Alberta Survey Control Monuments (ASCM) were surveyed upon the request of AEP in support of a Light Detection and Ranging (LiDAR) remote sensing verification survey, which was conducted by Airborne Imaging Inc. to ensure that the LiDAR-based DTM meets FHIP accuracy standards.

Water levels were measured at each cross section as part of the field program. River discharge measurements can be helpful in providing additional data in support of hydraulic model calibration. However, AEP, Golder, and SG1 agreed that there was limited value in obtaining discharge data because of extremely low flow conditions occurring on the Bow River along the study reach over the survey period.

2.2 Procedures and Methodology

The following survey equipment was used to collect the topographic, bathymetric, and structure data for this study:

- **Real-time Kinematic (RTK) GPS** – Trimble R10® RTK units were used to survey ground features and river bed levels in areas where hydraulic conditions allowed the surveyors to wade the channel or banks. The RTK units were also used to survey (i) the control points and benchmarks that were found or placed within the study area and (ii) the flood control structure and portions of the bridge structures.
- **Acoustic Doppler Profiler (ADP)** – A SonTek RiverSurveyor M9® was typically used in combination with a boat-mounted RTK unit to survey the river bed in areas where wading was not permissible.
- **Digital Echo Sounder (HyDrone-RCV®)** – A SonarMite Echo Sounder® and an RTK unit were mounted onto a HyDrone-RCV® hand-portable, remote-control catamaran boat to survey those areas of the channel where neither boating nor wading was possible.
- **Total Station** – A Nikon Nivo 5M® reflectorless total station was used to survey those areas of the bridge structures that were not collected using an RTK unit.

The field crew utilized the Can-Net Virtual Reference System (VRS) Network[1] to conduct the survey and base data collection for the study (Can-Net, 2016). This system utilizes network-corrected data calculated at multiple, fixed reference stations across Canada and broadcasts via a cellular network to define horizontal and vertical positions to within ±0.02 m. The VRS was utilized each day to establish a point for temporary (daily) base station set up, and then the RTK rover units were connected via radio link to the base station for surveying over the course of the day. At times when the HyDrone-RCV® was deployed, the RTK unit was set up to link directly to the VRS instead of connecting to a temporary base station.

All RTK data collected in this study were referenced to one of three Alberta Survey Control Markers (ASCM): ASCM 35501, ASCM 195099, and ASCM 897033. Quality assurance conducted by Golder during the field

[1] Can-Net operates two 24-hour base stations in close proximity to the study area, which were occasionally utilized during the field program in place of setting up temporary base stations along the study reach. These Can-Net stations are situated in the Town of Strathmore (STRA/202) and the City of Brooks (BROO/215).

program confirmed that these ASCMs compared well to one another, which is important for achieving survey precision. In addition to checking against one of these ASCMs at the start and end of each survey day, the field crew obtained a secondary check on data accuracy by having the static (temporary) RTK base station log data continuously over the course of the day.

All survey data were collected in the UTM coordinate system and subsequently projected into the 3TM 114° W coordinate system and referenced to NAD83 (CSRS) horizontal and CGVD28 vertical datums. The RTK data output provides an orthometric elevation with correct northing and easting coordinates. Ellipsoidal heights were transformed to CGVD28 orthometric heights using the HTv2.0 geoid model. Each RTK rover unit was pre-loaded with the geoid model files.

Each survey data point collected using either the RTK or total station was attributed a specific code. A schematic of survey point codes and corresponding descriptions is shown in Figure 2, which includes a complete list of survey codes for the RTK and total station.

All survey data were imported into a Geographic Information System (GIS) to allow for validation and further processing. In addition to the quality assurance and quality control (QA/QC) procedures for field data collection, the survey data were checked in Esri ArcGIS® for outliers and through visual inspection of triangulated irregular network (TIN) surfaces developed from the survey data. Similar procedures were applied to ensure concurrence among all datasets collected on different dates and using different types of survey equipment.

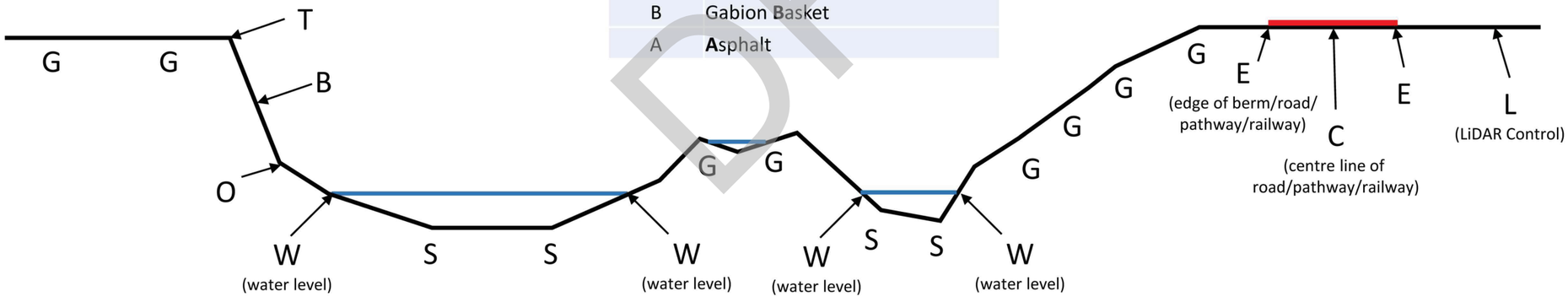
Survey Codes for River Surveys using RTK-GPS or Total Station (No Structures)

Purpose: - Create common definitions for survey points collected in the field for easier data processing in the office
- Reduce confusion or uncertainty for field staff regarding coding of points

Location Code	
G	**G**round
T	**T**op of Bank
B	**B**ank
O	T**o**e of Bank
W	**W**ater Level
S	**S**tream Bottom (under water)
E	**E**dge of Road/Berm/Pathway/Railway
C	**C**entre Line of Road/Berm/Pathway/Railway
L	**L**iDAR control point

Material Code	
1	Mud/Silt (<0.063 mm)
2	Sand (0.063 mm - 2 mm)
3	Gravel (2 mm - 6.4 cm)
4	Cobble (6.4 cm - 25 cm)
5	Boulder (> 25 cm)
6	Bedrock
C	**C**oncrete
G	**G**rass
R	**R**iprap
T	**T**rees (large, trunk > 10 cm)
W	**W**illows and Shrubs
B	Gabion Basket
A	**A**sphalt

Examples	
G2	Ground, Sand
G4	Ground, Cobble
W3	Water Level, Gravel
GG	Ground, Grass
GT	Ground, Trees
CA	Centre Line, Asphalt
BR	Bank, Riprap
LC	LiDAR control, Concrete



Version 0, August 25, 2017

Golder Associates Ltd.

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NOTES:
1. SURVEY CODE INFORMATION WAS PROVIDED BY GOLDER ASSOCIATES LTD.
2. REFER TO SECTION 2.2 OF THE REPORT FOR MORE INFORMATION.

PREPARED FOR:
Alberta Environment and Parks

PROJECT:
SIKSIKA BOW RIVER HAZARD STUDY
SURVEY AND BASE DATA COLLECTION

TITLE:
Schematic of Survey Point Locations and Code Descriptions

DWN BY:	CHK'D BY:	REV NO:
RDJ	DMS	0
DWG NO: 10080-02-101		FIGURE NO: 2
DATE: 9-JAN-2018		

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River Cross Sections and Longitudinal Profiles

The channel data were collected by surveying cross sections perpendicular to the direction of river flow. A shapefile showing cross section locations was provided to the survey crew at the outset of the field work to provide guidance on where along the study reach to acquire data. The study reach extending above Bassano Dam was surveyed by boat in deeper sections of the channel and by wading the shallower areas. Extreme low-flow conditions on the Bow River over the survey period required the study reach below Bassano Dam to be surveyed by wading, with the exception of two deeper cross sections that required the bathymetric survey to be conducted using an echo sounder and RTK mounted onto a remotely-operated boat (HyDrone-RCV®).

The following procedures were adhered to when carrying out a bathymetric survey by wading:

- RTK rover units were used to collect cross-sectional information from a location approximately 2 to 5 m beyond water's edge on one side of the river channel to a location approximately 2 to 5 m beyond water's edge on the other side. A minimum of 20 points was established across the channel, and care was taken to reference points where the transverse bed slope changed significantly.
- Special attention was paid to surveying topographic slope breaks along the banks.
- Each of the surveyed data points was attributed with field codes that described substrate and vegetation types (refer to Figure 2).
- The water surface elevation was surveyed at all points along the cross section where the water made contact with the bank.

The adopted boat survey method used to define the bathymetry involved the following:

- The ADP was mounted onto a frame, which was fastened to the side of the river boat. Once the ADP was securely mounted on the boat, it was deployed in the water and the distance from the middle sensor to the water surface was measured using a standard tape measure.
- The RTK unit was attached to the top of the ADP mount at a measured offset from the water surface. This offset was measured and recorded on a daily basis.
- The ADP and RTK units were connected to a laptop data acquisition system that provided data storage and a real-time display of the position and data being collected. The system was checked to make sure that both units were communicating properly and data was being stored.
- A short calibration profile was run at the beginning of each day to verify that both the ADP offset and the level of the sounding head below the water surface remained consistent while the boat was in motion. Furthermore, the sounding depths were verified by direct measurements during the calibration process.
- The bathymetric data were collected by the ADP and RTK units at a frequency of one Hertz along the prescribed cross sections (i.e., a data point was collected every second). At a nominal boat speed of 0.75 m/s, this would correspond to a measured depth at intervals of about 0.75 m. In areas where water depth was less than approximately 0.5 m, survey points were collected by wading the channel, as described above.
- Bank topographic data were obtained using RTK rover units, as described above.

- The water surface elevation was surveyed at all points along the cross section where the water made contact with the bank.

Processing of the data collected using ADP and RTK included the following steps:

- Data were sorted using the UTM easting values and any points with UTM coordinates of zero were removed.
- Data were sorted by altitude, which corresponds to the elevation value supplied to the ADP from the RTK unit (instrument offsets were applied to the data during post-processing).
- Data were sorted by combined depth and those points with a zero depth or depths well outside of the possible range were discarded.
- Data were sorted by difference between the vertical beam (VB) depth and the averaged bottom track (BT) depth. The BT depth was used in cases where the VB depth returned an inaccurate value (i.e., shallow areas),
- Data were sorted by mean velocity. The ADP returns a value of zero when it cannot compute a flow velocity and vector. These values were removed, and the rest of the values within the data set were retained.

In total, less than five percent of the collected survey data points were removed during the above-mentioned process.

Hydraulic Structures

Hydraulic structures on the Bow River within the study area that could affect channel conveyance and water levels include traffic bridges, the Carseland Weir, and Bassano Dam. The features of each bridge that were surveyed included the following:

- Length of span (corner points, abutment-to-abutment)
- Width of bridge (corner points, outside-to-outside)
- Top of curb or solid guard rail elevations
- Low chord elevations
- Number and width of piers
- Location of piers and the distance of each pier relative to an abutment
- Type of piers (e.g., concrete, pile bent)
- Shape of pier (e.g., round nose, wedge-shaped, circular)
- Top of roadway (or path) profile

The hydraulic structures were surveyed using a total station, RTK, or a combination thereof. The total station was used in reflectorless mode to collect survey points on the underside of the main bridge structure. In reflectorless mode, the user aligns the unit crosshairs on the point that is to be surveyed and a laser beam is transmitted to the object and reflected from the structure without having to use a traditional total station prism or reflector target. The

RTK unit was used to collect structural data when there was a clear view of the sky (i.e., bridge deck, railings, etc.). Geo-located photos of each structure were taken during the survey.

Flood Control Structure

There is only one flood control structure along the Bow River and it was surveyed using an RTK to verify as-built elevations and to characterize its typical cross-sectional geometry. Survey data were collected along the crest of the flood control structure at regular intervals of 20 m or less. Geo-located photos of the flood control structure were taken by the surveyor.

2.3 Survey Standards and Accuracy

The accuracy of the points collected using the RTK system in conjunction with Can-Net's VRS network is considered to be within ±0.02 m in both horizontal and vertical directions. The spatial position and elevation of each RTK rover unit was calibrated daily to an Alberta Survey Control Marker (ASCM) benchmark. Furthermore, the daily survey protocol required that the field crews calibrate to, and then open and close at, an ASCM benchmark to maintain a ±0.02 m level of accuracy. The RTK data collectors were set to provide a warning when calculated maximum error exceeded 0.05 m for a manually-recorded point. When notified, the survey technician would either adjust their location or identify a better solution before surveying that point.

A portion of each bridge survey was conducted using a reflectorless total station that was set up over a temporary benchmark established using the RTK. The temporary benchmark setup and total station accuracy resulted in a combined total accuracy level of less than ±0.02 m. The exact accuracy for each point varied in proportion to the distance between the target and the survey instrument.

The bathymetric surveys conducted from the river boat using the RTK-ADP combination have a slightly reduced accuracy relative to the ground-based surveys, because the constant movement of the boat on the water surface creates pitch, roll, and yaw that influence the angle of the ADP beams. Depending on the water depth and the angle of deviation from vertical, the ±0.05 m accuracy from the RTK can be reduced by a few centimetres. Overall, the bathymetric surveys conducted using the RTK-ADP combination are considered to have an average accuracy of ±0.10 m in both the horizontal and vertical directions.

2.4 River Cross Sections and Longitudinal Profiles

The total length of the Bow River surveyed between the Highwood River confluence and the Hamlet of Bow City, combining all seven consecutive subreaches as shown in Figure 1, is approximately 217 km. A total of 354 cross sections were surveyed as part of the field program in September and October 2017. A summary of the surveyed river cross sections is provided in Table 1.

Table 1: Surveyed Cross Sections within the Study Area

Reach	Subreach ID	Subreach Description	Cross Section ID	Number of New Cross Sections (1)	Average Cross Section Spacing (2) (m)
Above Siksika Nation	1A	28 km reach between Highwood River confluence and Carseland Weir	XS-0 to XS-38	39	470
	1B	14 km reach from Carseland Weir to upstream boundary of Siksika Nation	XS-39 to XS-59	23	380
Through Siksika Nation	2A	30 km reach from upstream boundary of Siksika Nation to SH547 (Arrowwood) bridge	XS-60 to XS-128	71	360
	2B	35 km reach from SH547 (Arrowwood) bridge to SH842 (Cluny) bridge	XS-129 to XS-199	73	360
	2C	46 km reach between SH842 (Cluny) bridge and Bassano Dam	XS-200 to XS-275	77	430
Below Siksika Nation	3A	25 km reach from Bassano Dam to Edge Flats	XS-276 to XS-300	25	710
	3B	39 km reach from Edge Flats to the Hamlet of Bow City near SH539 bridge	XS-301 to XS-341	46	670

Notes:
1. The number of new cross sections includes those surveyed immediately upstream and downstream of each of the four bridges.
2. Average cross section spacing takes into account those cross sections surveyed in 2014/15 since they will be utilized in this study.

Appendix A contains plots of the surveyed main channel thalweg of each of the seven subreaches and water levels measured during the cross section survey. An overview of the surveyed cross section locations is provided in Appendix B.

The field data were supplemented by bathymetric data collected by Golder along portions of the study reach following the June 2013 flood on the Bow River (Golder, 2015a; Golder, 2015b). Data from these two survey programs that will be utilized in this study were collected for AEP in 2014 and 2015. It is anticipated that approximately 120 of these “post-2013 flood” cross sections will be used in the current study (refer to Appendix B for cross section locations). In total, on the order of 475 cross sections will be utilized in developing the hydraulic model.

Golder and SG1 conducted a comparative analysis of the cross section survey data collected in 2014/15 and in September/October 2017. The purpose of this analysis was to verify that the 2014/15 survey data can be utilized in the current study. Comparisons of cross-sectional geometry were made at eight (8) randomly-selected cross sections along the various subreaches as outlined in Table 2. Cross-sectional plots for each of these eight locations are provided in Figures 3 and 4.

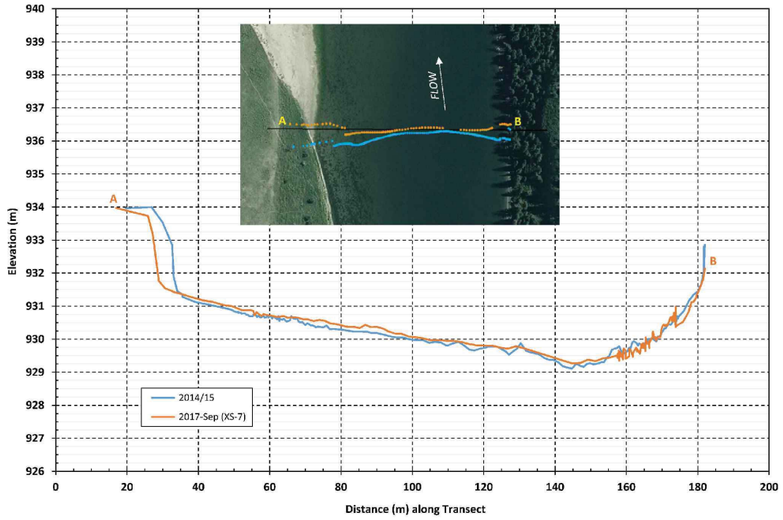
Table 2: Comparative Cross Section Locations within the Study Area

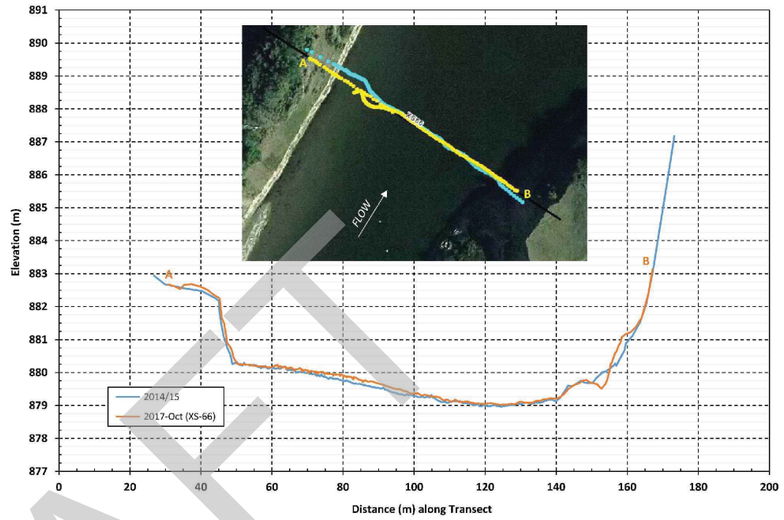
Reach	Subreach ID	Cross Section ID
Above Siksika Nation	1A	XS-7
	1B	XS-49
Through Siksika Nation	2A	XS-66
	2B	XS-195
	2C	XS-221.5
	2C	XS-228.5
	2C	XS-243.5
Below Siksika Nation	3B	XS-312.5

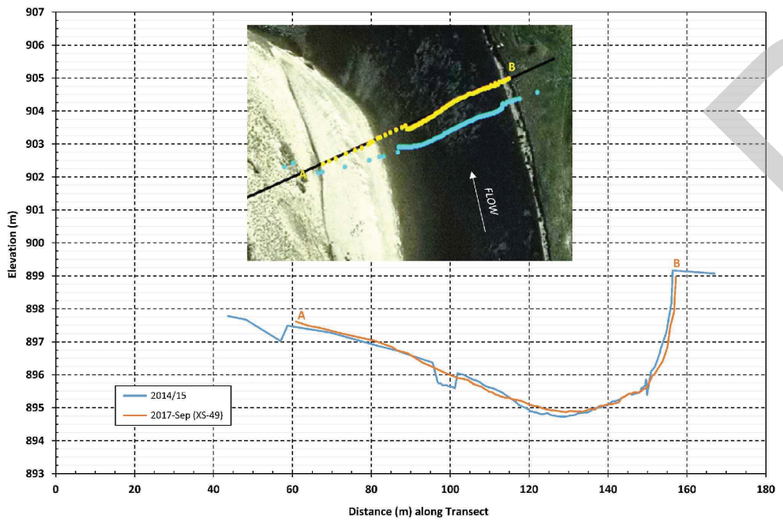
Notes:

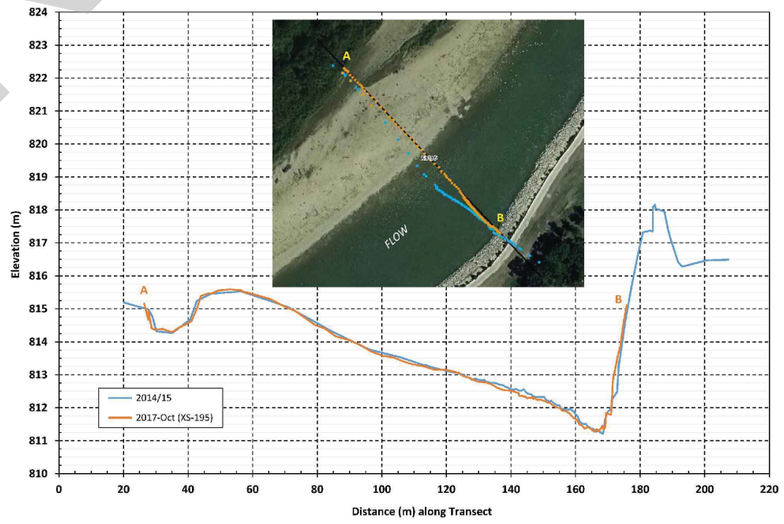
1. Four new cross sections added during the 2017 survey program were labelled as XS-221.5, XS-228.5, XS-243.5, and XS-312.5 in order to compare the surveyed cross sections between 2014/15 and 2017. In terms of cross section numbering, XS-221.5 for example is situated on the Bow River between XS-221 and XS-222.

As shown in the aerial imagery embedded within each of the cross-sectional plots of Figures 3 and 4, the field crew endeavoured to follow the 2014/15 cross section alignment when surveying the new cross section. In some cases, the new cross section ended up being slightly offset (upstream or downstream) from the previous one, which resulted in slight horizontal and/or vertical differences between the two surveys. Overall, the two data sets at each cross section match closely with one another, resulting in very similar flow areas at each particular location along the study reach. Golder and SG1 presented the results of the comparative analysis to AEP near the end of the field program. Upon review by AEP, it was collectively agreed that it would be acceptable for Golder to utilize the 2014/15 survey data as part of the Siksika Bow River Hazard Study.









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NOTES:

1. REFER TO SECTION 2.4 OF THE REPORT FOR MORE INFORMATION.
2. THE SURVEYED CROSS SECTIONS CORRESPOND TO THE FOLLOWING SUBREACHES:

CROSS SECTION ID	SUBREACH
XS-7	1A (ABOVE SIKSIKA NATION)
XS-49	1B (ABOVE SIKSIKA NATION)
XS-66	2A (THROUGH SIKSIKA NATION)
XS-195	2B (THROUGH SIKSIKA NATION)

PREPARED FOR:

Alberta Environment and Parks

PROJECT:

SIKSIKA BOW RIVER HAZARD STUDY
SURVEY AND BASE DATA COLLECTION

TITLE:

Comparative Plots of 2014/15 and 2017 Cross Sections: Subreaches 1A, 1B, 2A, and 2B

DWN BY:	CHK'D BY:	REV NO:
RDJ	DMS	0

DWG NO:	FIGURE NO:
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DATE: 9-JAN-2018

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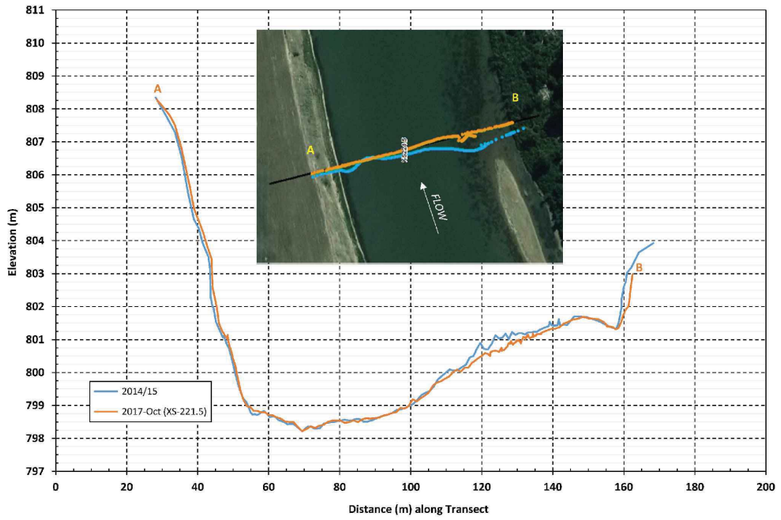

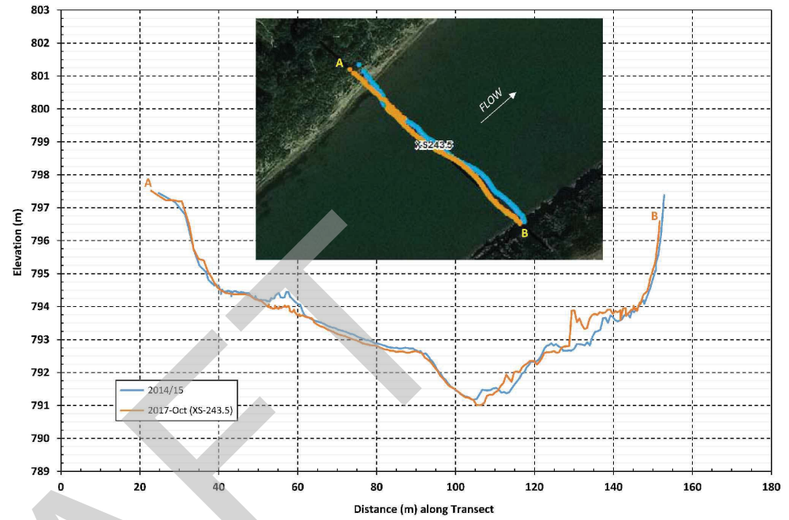

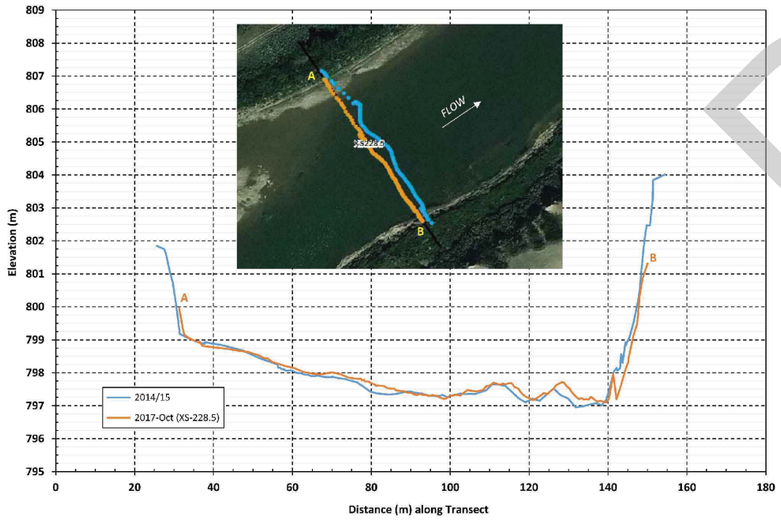

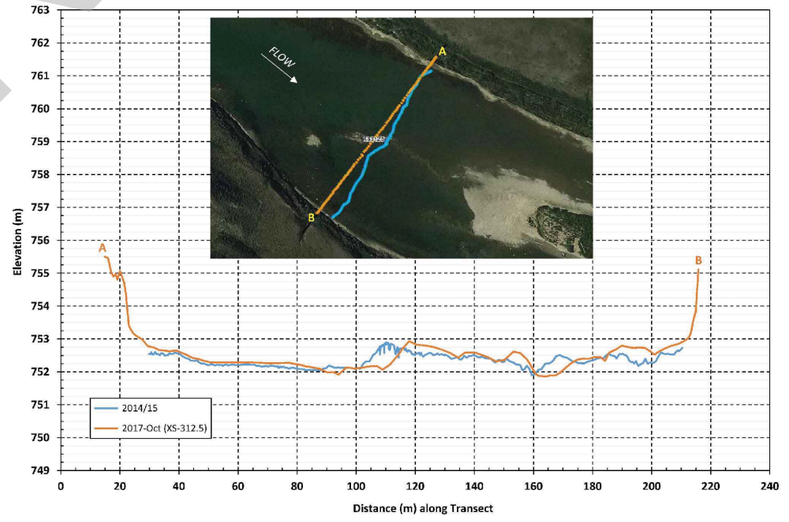

PREPARED BY:

SG1

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Golder Associates

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NOTES:

1. REFER TO SECTION 2.4 OF THE REPORT FOR MORE INFORMATION.
2. THE SURVEYED CROSS SECTIONS CORRESPOND TO THE FOLLOWING SUBREACHES:

CROSS SECTION ID	SUBREACH
XS-221.5	2C (THROUGH SIKSIKA NATION)
XS-228.5	2C (THROUGH SIKSIKA NATION)
XS-243.5	2C (THROUGH SIKSIKA NATION)
XS-312.5	3B (BELOW BASSANO DAM)

PREPARED FOR:

Alberta Environment and Parks

PROJECT:

SIKSIKA BOW RIVER HAZARD STUDY
SURVEY AND BASE DATA COLLECTION

TITLE:

Comparative Plots of 2014/15 and 2017 Cross Sections: Subreaches 2C and 3B

DWN BY:	CHK'D BY:	REV NO:
RDJ	DMS	0

DWG NO: 10080-02-108

DATE: 9-JAN-2018

FIGURE NO: 4

FILE LOC: H:\SG1\OwnCloud\Drafting\10080 Siksika Bow\Task 2\10080-02-108.dwg - 10080-02-108, PLOT DATE: 08-Jan-2018

2.5 Hydraulic Structures

The study area includes a total of four (4) traffic bridge crossings of the Bow River. A summary of the bridges within the study area is provided in Table 3.

Table 3: Hydraulic Structures within the Study Area

Bridge ID	Location	Bridge Type	No. of Spans	Corresponding Figure No.
HWY24	Near Carseland, AB	Traffic	5	B-3, C-1
SH547	Near Arrowwood, AB	Traffic	4	B-5, C-2
SH842	Near Cluny, AB	Traffic	5	B-6/B-7, C-3
SH539	Near Bow City, AB	Traffic	4	B-11, C-4

Bridge locations are shown in the map sheets provided in Figures B-3, B-5 to B-7, and B-11 of Appendix B. The bridge summary datasheets in Figures C-1 to C-4 of Appendix C include site photos, survey data point locations superimposed onto aerial imagery, and detailed information with regard to the bridge deck and piers.

Bridge data (i.e., detailed design and/or as-built survey drawings) were obtained from Alberta Transportation (AT) are not included in this report, but can be found in the digital study file.

The Carseland Weir, Johnson's Island Fuse Plug Dyke, and Bassano Dam are hydraulic structures situated along the study reach, but were not surveyed as part of the field program. The as-built survey data and construction drawings for these structures were obtained (in lieu of surveying them) for use in developing the hydraulic model and can be found in the digital study file.

2.6 Flood Control Structures

Only one flood control structure was identified on the Bow River within the study area. It is a berm comprised of interlocking concrete blocks, which is located along the right bank of the river adjacent to the Hidden Valley Resort & Golf Course, just upstream of the SH842 (Cluny) bridge. No berm structure is present over a 290 m long section along the top of bank between the upper and lower berms (refer to Figure D-1).

Details regarding the flood control structure at Hidden Valley Resort are provided in Table 4. The location of this flood control structure is shown in Figure B-6 of Appendix B. A summary datasheet for the flood control structure is provided in Figure D-1 of Appendix D.

Table 4: Flood Control Structure within the Study Area

Description	Subreach	Approximate Length (m)	Side of River (1)	Type	Corresponding Figure No.
Concrete block structure (berm) adjacent to Hidden Valley Resort	2A (through Siksika Nation)	1540 (upper berm) 500 (lower berm)	Right	Berm	B-6, D-1

Note: 1. Left or right refer to directions as seen by an observer looking downstream.

3.0 ADDITIONAL BASE DATA

Additional base data collected for this study included the following:

- Survey data and as-built drawings of traffic bridges located within the study area. These bridge datasets were provided by AT.
- As-built drawings and report for the Bassano Dam Project. These data were provided by the Eastern Irrigation District (EID).
- Provisional streamflow data from hydrometric gauging stations that are operated by Water Survey of Canada (WSC) and situated within the study area below the Carseland Weir (WSC 05BM002) and below Bassano Dam (WSC 05BM004).
- Available LiDAR data and imagery as provided by AEP and others (i.e., one-metre LiDAR DEM, AltaLIS LiDAR15, 2016 SPOT6 RGB 1.5 m orthoimagery, and other available orthoimagery taken during and following the June 2013 flood event).

4.0 CONCLUSIONS

Topographic, bathymetric, and supporting base data required to support other components of the Siksika Bow River Hazard Study were collected in accordance with AEP's requirements. The following conclusions are made:

- *River Cross Section Surveys* – Cross section survey data collected for this study in September and October 2017, combined with the other bathymetric data collected by Golder (2015a and 2015b) following the June 2013 flood, meet the current study requirements with regard to cross section spacing and alignment, extents of cross sections on the floodplains, labeling of survey points, and data accuracy.
- *Hydraulic and Flood Control Structure Surveys* – Hydraulic and flood control structure survey data collected in September and October 2017 meet the study requirements and include the necessary details for the hydraulic modelling to be performed in this study.

Report Signature Page

We trust that the information contained in this final version of the technical report is sufficient for your present needs. Please do not hesitate to contact Darren Shepherd (780.238.5868; Darren@SG1water.ca) or Hua Zhang (403.216.8962; Hua_Zhang@golder.com) if you have any questions or wish to discuss.

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SG1 Water Consulting Ltd.
President, Technical Lead

DS/HZ/DL/al

Reviewed by:

Original signed by:

Hua Zhang, Ph.D., P.Eng
Golder Associates Ltd.
Associate, Project Manager

Original signed by:

Dejiang Long, Ph.D., P.Eng.
Golder Associates Ltd.
Principal, Project Director

THIRD PARTY DISCLAIMER

This report has been prepared by SG1 Water Consulting Ltd. (SG1) and Golder Associates Ltd. (Golder) for the benefit of the client to whom it is addressed. The information and data contained herein represent SG1 and Golder's best professional judgment in light of the knowledge and information available to SG1 and Golder at the time of preparation. Except as required by law, this report and the information and data contained herein are to be treated as confidential and may be used and relied upon only by the client, its officers and employees. SG1 and Golder denies any liability whatsoever to other parties who may obtain access to this report for any injury, loss or damage suffered by such parties arising from their use of, or reliance upon, this report or any of its contents without the express written consent of Golder and the client.

REFERENCES

Can-Net, 2017. *VRS Explained*. Technical information on Can-Net's Virtual Reference Station (VRS) Network. http://www.can-net.ca/index.php?option=com_content&view=article&id=36&Itemid=230. Information accessed online on November 8, 2017.

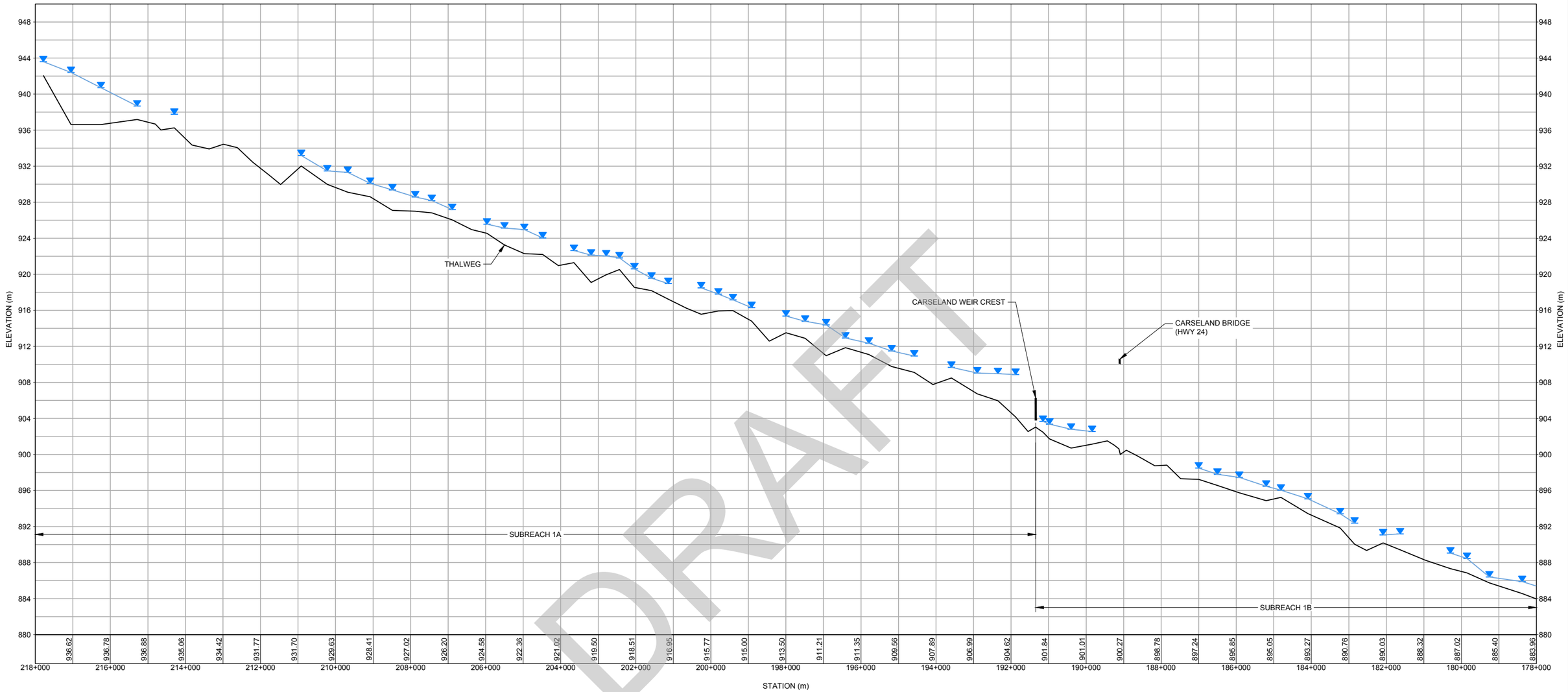
Golder Associates Ltd., 2015a. *Assessment of River Bathymetry Change After June 2013 Flood: Open-Water Survey for the Bow, Oldman, and South Saskatchewan Rivers.* Technical report prepared for Alberta Environment and Parks, September 2015, Report No. 1407947.

Golder Associates Ltd., 2015b. *Open-Water Survey for the Bow, Oldman, and South Saskatchewan Rivers: Phase II – Open-Water Surveys for Bow River Reaches: Bathymetry, Sediment and Vegetation.* Technical report prepared for Alberta Environment and Parks, November 2015, Report No. 1532441.

SG1 Water Consulting Ltd., 2017. *Siksika Bow River Hazard Study – Bow River from Highwood Confluence to Bow City: Survey Plan*. Letter report prepared for Alberta Environment and Parks, 18 September 2017. 44 pp.

APPENDIX A

Surveyed Thalweg and Water Surface Profiles



LEGEND

▼ WATER LEVELS MEASURED DURING CROSS SECTION SURVEY

NOTES

1. SURVEY DATA ALONG SUBREACHES 1A AND 1B WERE COLLECTED BY GOLDER IN 2017 ON SEPTEMBER 12, 14, 15, 16-18 AND OCTOBER 26.
2. GAPS IN THE WATER SURFACE PROFILE ARE REPRESENTATIVE OF SECTIONS ALONG THE STUDY REACH WHERE BATHYMETRIC DATA COLLECTED BY GOLDER IN 2015 FOR AEP ARE BEING USED TO SUPPLEMENT THE FIELD DATA.

0 2,500 5,000
METRES

HORIZONTAL SCALE 1:100,000
VERTICAL EXAGGERATION = 240X

CLIENT
ALBERTA ENVIRONMENT AND PARKS

PROJECT
SIKSIKA BOW RIVER HAZARD STUDY

TITLE
SURVEYED THALWEG AND WATER SURFACE PROFILE BOW RIVER ALONG SUBREACHES 1A AND 1B

CONSULTANT

Golder Associates | SG1 WATER CONSULTING

YYYY-MM-DD	2018-01-19
PREPARED	JDS
DESIGN	MD
REVIEW	DS
APPROVED	HZ

PROJECT No. 1783054 | Rev. 0 | FIGURE A-1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

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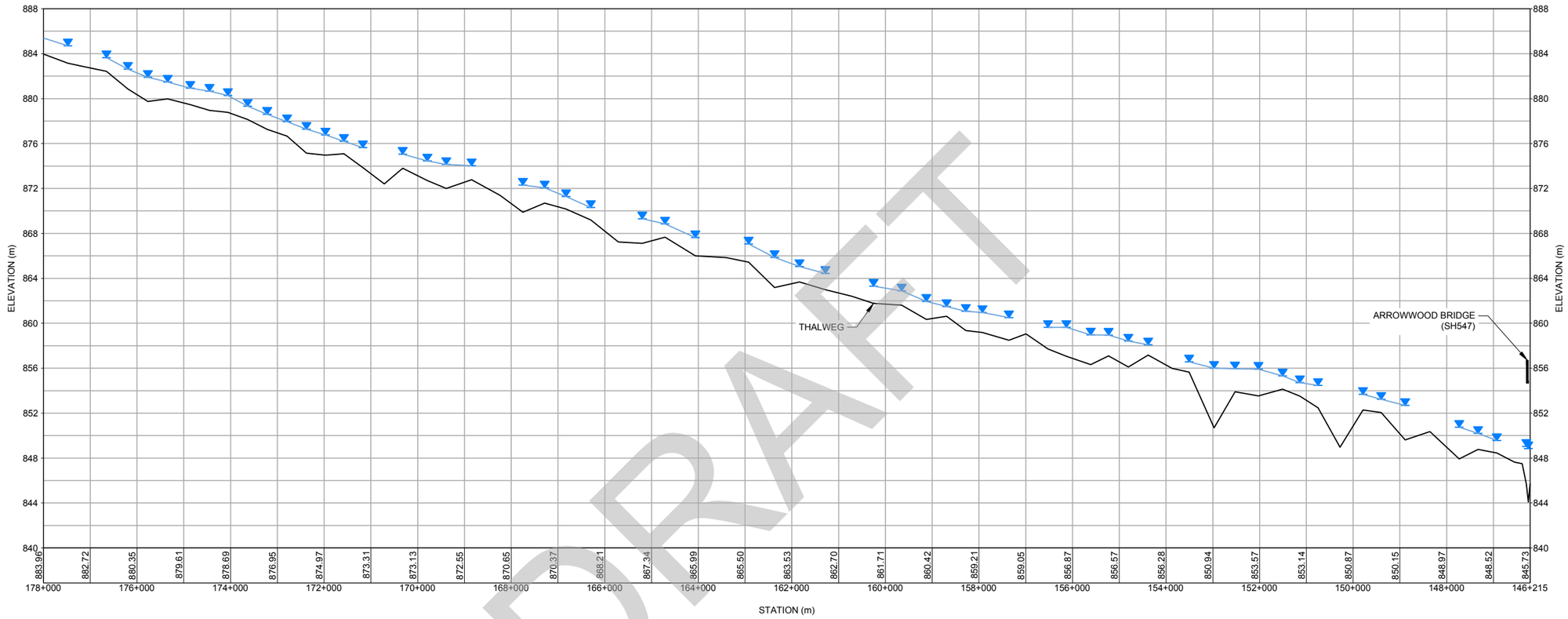

LEGEND

WATER LEVELS MEASURED DURING CROSS SECTION SURVEY

NOTES

1. SURVEY DATA ALONG SUBREACH 2A WERE COLLECTED BY GOLDER IN 2017 ON OCTOBER 4, 6, 8, 10-12 AND 24.
2. GAPS IN THE WATER SURFACE PROFILE ARE REPRESENTATIVE OF SECTIONS ALONG THE STUDY REACH WHERE BATHYMETRIC DATA COLLECTED BY GOLDER IN 2015 FOR AEP ARE BEING USED TO SUPPLEMENT THE FIELD DATA.

0 2,500 5,000
METRES

HORIZONTAL SCALE 1:100,000
VERTICAL EXAGGERATION = 240X

CLIENT
ALBERTA ENVIRONMENT AND PARKS

PROJECT
SIKSIKA BOW RIVER HAZARD STUDY

TITLE
SURVEYED THALWEG AND WATER SURFACE PROFILE BOW RIVER ALONG SUBREACH 2A

CONSULTANT

YYYY-MM-DD	2018-01-09
PREPARED	JDS
DESIGN	MD
REVIEW	DS
APPROVED	HZ

PROJECT No. 1783054 | Rev. 0 | FIGURE A-2

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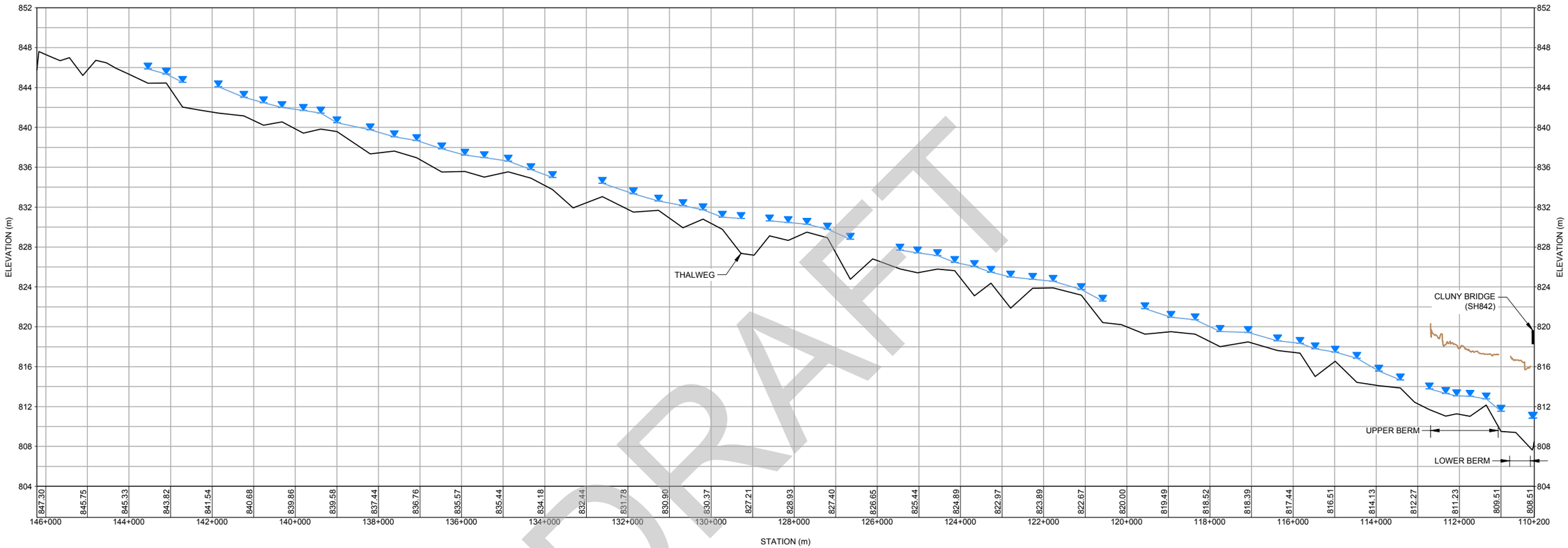

LEGEND

- WATER LEVELS MEASURED DURING CROSS SECTION SURVEY
- TOP OF BERM STRUCTURE

NOTES

1. SURVEY DATA ALONG SUBREACH 2B WERE COLLECTED BY GOLDER IN 2017 ON OCTOBER 4, 5, 7, 13-15 AND 25.
2. GAPS IN THE WATER SURFACE PROFILE ARE REPRESENTATIVE OF SECTIONS ALONG THE STUDY REACH WHERE BATHYMETRIC DATA COLLECTED BY GOLDER IN 2015 FOR AEP ARE BEING USED TO SUPPLEMENT THE FIELD DATA.

0 2,500 5,000 METRES

HORIZONTAL SCALE 1:100,000
VERTICAL EXAGGERATION = 240X

CLIENT
ALBERTA ENVIRONMENT AND PARKS

PROJECT
SIKSIKA BOW RIVER HAZARD STUDY

TITLE
SURVEYED THALWEG AND WATER SURFACE PROFILE BOW RIVER ALONG SUBREACH 2B

CONSULTANT

YYYY-MM-DD	2018-01-09
PREPARED	JDS
DESIGN	MD
REVIEW	DS
APPROVED	HZ

PROJECT No. 1783054 Rev. 0 FIGURE A-3

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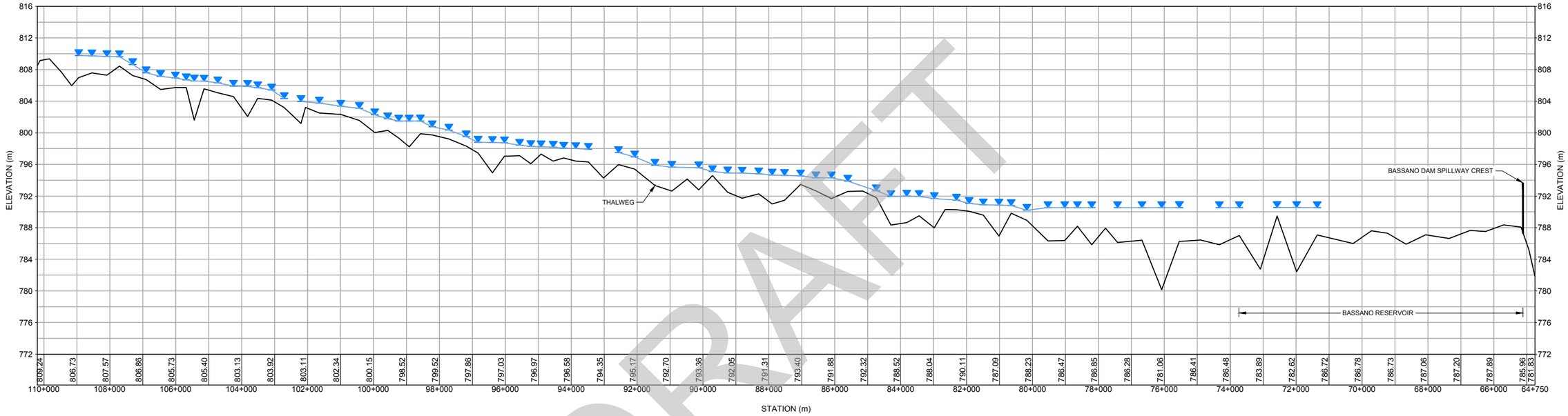

LEGEND

▼ WATER LEVELS MEASURED DURING CROSS SECTION SURVEY

NOTES

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2. GAPS IN THE WATER SURFACE PROFILE ARE REPRESENTATIVE OF SECTIONS ALONG THE STUDY REACH WHERE BATHYMETRIC DATA COLLECTED BY GOLDER IN 2014 AND 2015 FOR AEP ARE BEING USED TO SUPPLEMENT THE FIELD DATA.

0 2.5 5
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HORIZONTAL SCALE 1:125,000
VERTICAL EXAGGERATION = 240X

CLIENT
ALBERTA ENVIRONMENT AND PARKS

PROJECT
SIKSIKA BOW RIVER HAZARD STUDY

TITLE
SURVEYED THALWEG AND WATER SURFACE PROFILE BOW RIVER ALONG SUBREACH 2C

CONSULTANT
Golder Associates
SG1 WATER CONSULTING

YYYY-MM-DD	2018-01-09
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DESIGN	MD
REVIEW	DS
APPROVED	HZ

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Rev. 0
FIGURE A-4

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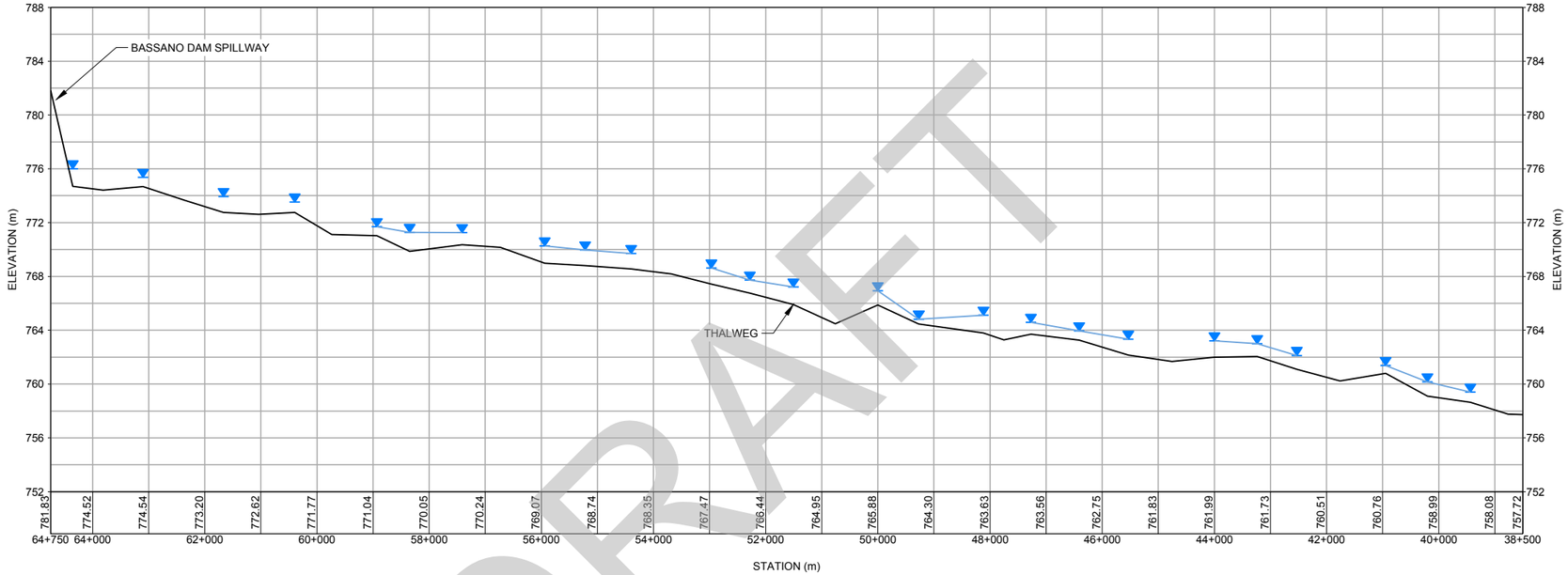

LEGEND

▼ WATER LEVELS MEASURED DURING CROSS SECTION SURVEY

NOTES

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2. GAPS IN THE WATER SURFACE PROFILE ARE REPRESENTATIVE OF SECTIONS ALONG THE STUDY REACH WHERE BATHYMETRIC DATA COLLECTED BY GOLDER IN 2014 AND 2015 FOR AEP ARE BEING USED TO SUPPLEMENT THE FIELD DATA.

0 2,500 5,000 METRES

HORIZONTAL SCALE 1:100,000
VERTICAL EXAGGERATION = 240X

CLIENT
ALBERTA ENVIRONMENT AND PARKS

PROJECT
SIKSIKA BOW RIVER HAZARD STUDY

TITLE
SURVEYED THALWEG AND WATER SURFACE PROFILE BOW RIVER ALONG SUBREACH 3A

CONSULTANT

Golder Associates | SG1 WATER CONSULTING

YYYY-MM-DD	2018-01-09
PREPARED	JDS
DESIGN	MD
REVIEW	DS
APPROVED	HZ

PROJECT No. 1783054 | Rev. 0 | FIGURE A-5

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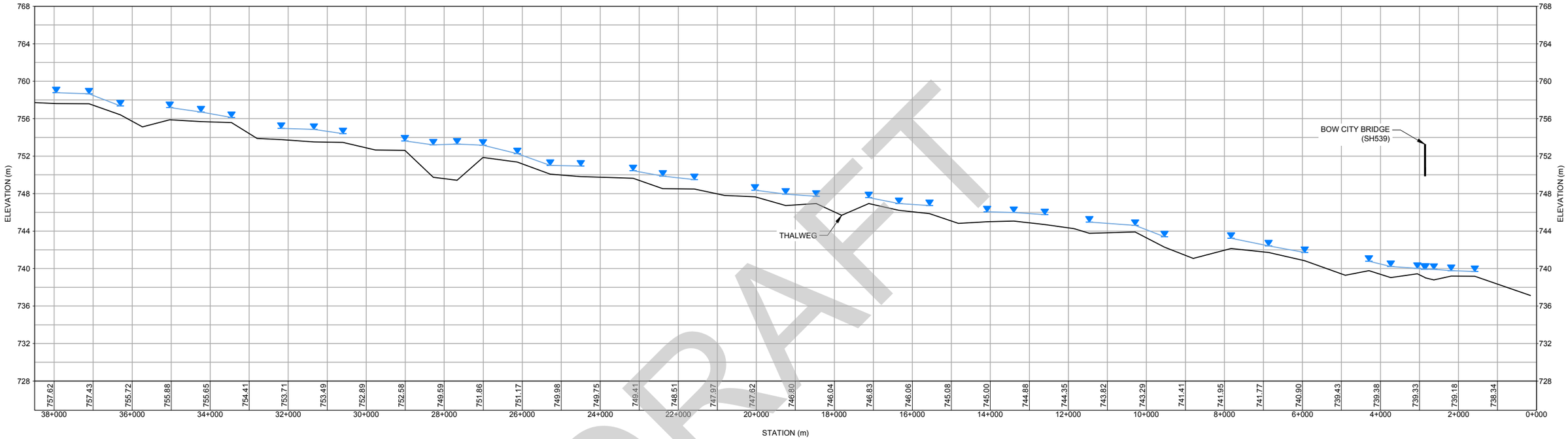

LEGEND

▼ WATER LEVELS MEASURED DURING CROSS SECTION SURVEY

NOTES

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2. GAPS IN THE WATER SURFACE PROFILE ARE REPRESENTATIVE OF SECTIONS ALONG THE STUDY REACH WHERE BATHYMETRIC DATA COLLECTED BY GOLDER IN 2014 AND 2015 FOR AEP ARE BEING USED TO SUPPLEMENT THE FIELD DATA.

0 2,500 5,000 METRES

HORIZONTAL SCALE 1:100,000
VERTICAL EXAGGERATION = 240X

CLIENT
ALBERTA ENVIRONMENT AND PARKS

PROJECT
SIKSIKA BOW RIVER HAZARD STUDY

TITLE
SURVEYED THALWEG AND WATER SURFACE PROFILE BOW RIVER ALONG SUBREACH 3B

CONSULTANT

Golder Associates | SG1 WATER CONSULTING

YYYY-MM-DD	2018-01-09
PREPARED	JDS
DESIGN	MD
REVIEW	DS
APPROVED	HZ

PROJECT No. 1783054 | Rev. 0 | FIGURE A-6

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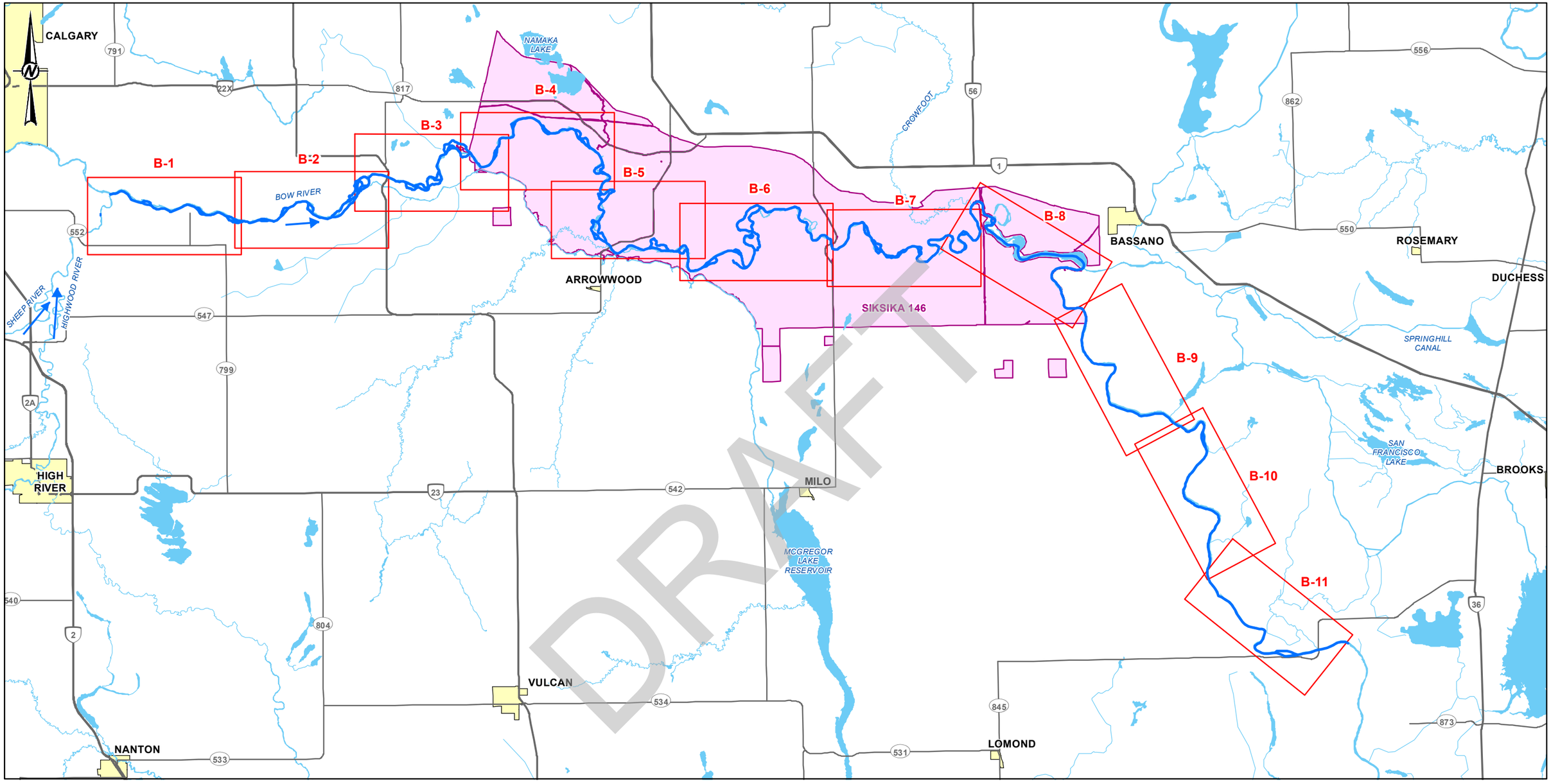
APPENDIX B

Cross Section, Hydraulic Structure, and Flood Control Structure Locations



LEGEND

- FLOW DIRECTION
- PRIMARY HIGHWAY
- SECONDARY HIGHWAY
- WATERCOURSE
- SURVEY REACH
- WATERBODY
- POPULATED PLACE
- FIRST NATION RESERVE
- MAP EXTENT

0 75 150

1:350,000 KILOMETRES

REFERENCE(S)

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DATUM: NAD 83 CSRS PROJECTION: 3TM 114

CLIENT: Alberta Government

CONSULTANT: Golder Associates; SG1 WATER CONSULTING

YYYY-MM-DD	2018-01-23
DESIGNED	G. TANG
PREPARED	B. PENDERGAST
REVIEWED	D. SHEPHERD
APPROVED	H. ZHANG

PROJECT: SIKSIKA BOW RIVER HAZARD STUDY

TITLE: **LOCATION MAP**

PROJECT NO.	CONTROL	REV.	FIGURE
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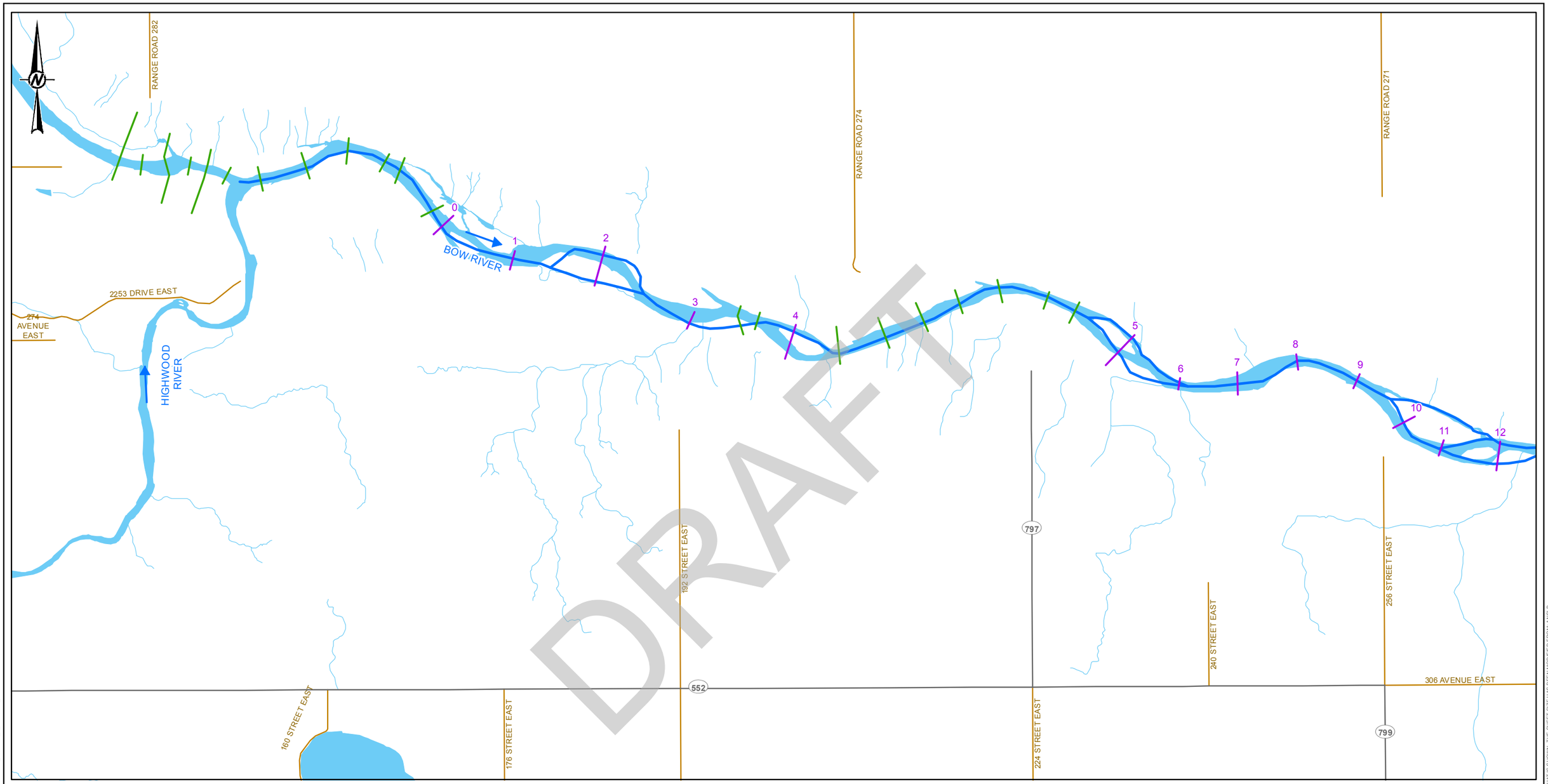


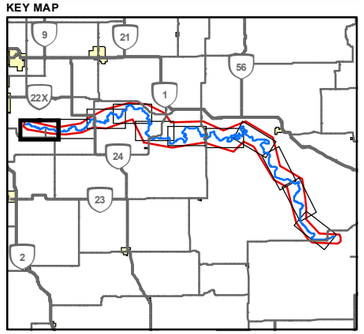
LEGEND

- SURVEY REACH
- FLOW DIRECTION
- WATERCOURSE
- WATERBODY
- POPULATED PLACE
- FIRST NATION RESERVE

CROSS SECTIONS

- SURVEYED CROSS SECTION (2017)
- SURVEYED CROSS SECTION (2015)

KEY MAP



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CLIENT

Alberta Government

CONSULTANT

Golder Associates

SG1 WATER CONSULTING

YYYY-MM-DD	2018-01-19
DESIGNED	G. TANG
PREPARED	B. PENDERGAST
REVIEWED	D. SHEPHERD
APPROVED	H. ZHANG

PROJECT

SIKSIKA BOW RIVER HAZARD STUDY

TITLE

CROSS SECTION LOCATIONS - BOW RIVER ALONG SUBREACH 1A

PROJECT NO.	CONTROL	REV.	FIGURE
1783054		0	B-1

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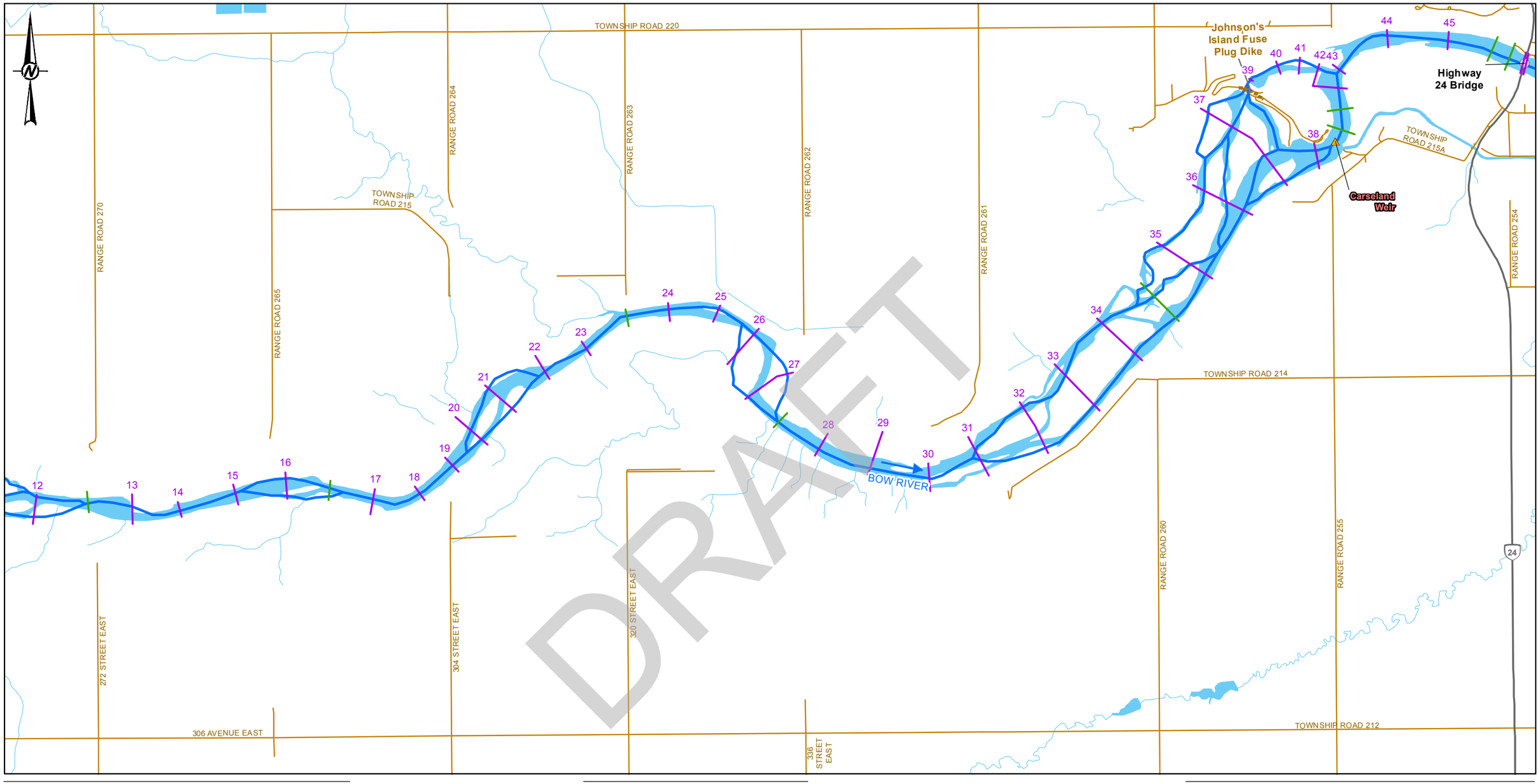


LEGEND

- SURVEY REACH
- FLOW DIRECTION
- WATERCOURSE
- WATERBODY
- POPULATED PLACE
- FIRST NATION RESERVE

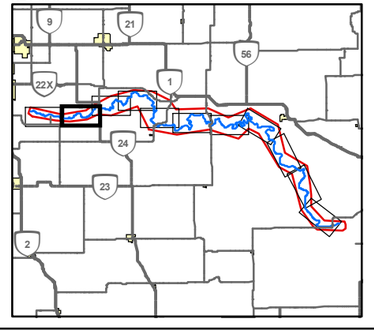
CROSS SECTIONS

- SURVEYED CROSS SECTION (2017)
- SURVEYED CROSS SECTION (2015)

HYDRAULIC STRUCTURES

- BRIDGE
- WEIR
- FUSE PLUG DIKE

KEY MAP



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1:35,000 KILOMETRES

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CLIENT

Alberta Government

CONSULTANT

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YYYY-MM-DD	2018-01-19
DESIGNED	G. TANG
PREPARED	B. PENDERGAST
REVIEWED	D. SHEPHERD
APPROVED	H. ZHANG

PROJECT

SIKSIKA BOW RIVER HAZARD STUDY

TITLE

CROSS SECTION AND HYDRAULIC STRUCTURE LOCATIONS - BOW RIVER ALONG SUBREACHES 1A AND 1B

PROJECT NO.	CONTROL	REV.	FIGURE
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TOWNSHIP ROAD 222
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817
24
BOW RIVER
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IRRIGATION CANAL
RANGE ROAD 245
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RANGE ROAD 254
RANGE ROAD 252A
RANGE ROAD 252
RANGE ROAD 263
RANGE ROAD 250
RANGE ROAD 244
SIKSIKA 146
Johnson's Island Fuse Plug Dike
Highway 24 Bridge
Carseland Weir
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LEGEND

- SURVEY REACH
- FLOW DIRECTION
- RAILROAD
- WATERCOURSE
- WATERBODY
- POPULATED PLACE
- FIRST NATION RESERVE

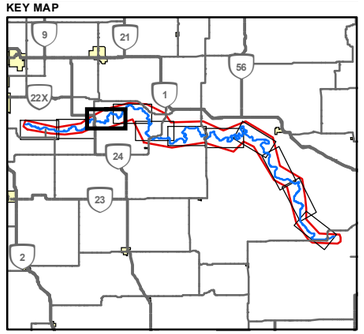
CROSS SECTIONS

- SURVEYED CROSS SECTION (2017)
- SURVEYED CROSS SECTION (2015)

HYDRAULIC STRUCTURES

- BRIDGE
- WEIR
- FUSE PLUG DIKE

KEY MAP



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CLIENT
Alberta Government

CONSULTANT
Golder Associates
SG1 WATER CONSULTING

YYYY-MM-DD	2018-01-19
DESIGNED	G. TANG
PREPARED	B. PENDERGAST
REVIEWED	D. SHEPHERD
APPROVED	H. ZHANG

PROJECT
SIKSIKA BOW RIVER HAZARD STUDY

TITLE
CROSS SECTION AND HYDRAULIC STRUCTURE LOCATIONS - BOW RIVER ALONG SUBREACHES 1B AND 2A

PROJECT NO.	CONTROL	REV.	FIGURE
1783054		0	B-3

PATH: I:\CLIENTS\AEP\1783054\Mapping\MXD\Hydrology\01_Survey & Base Data Collection\1783054_Appendix_B_Structures_Rev0.mxd PRINTED ON: 2018-01-19 AT: 11:26:04 AM

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

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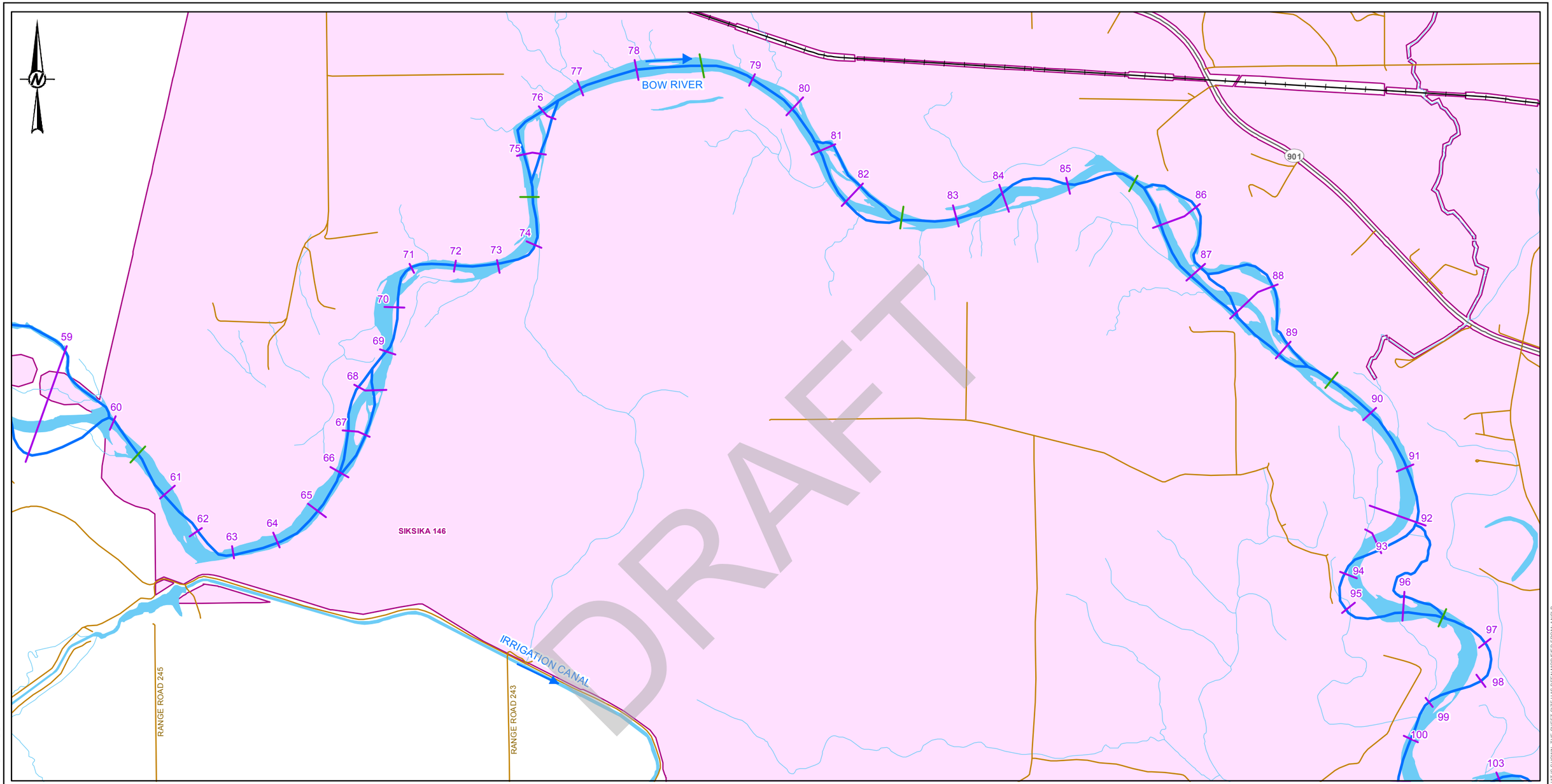


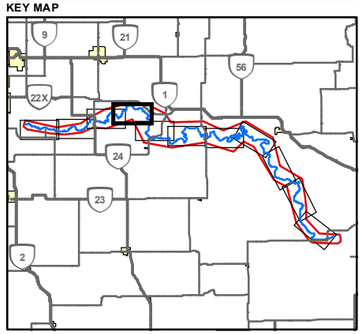
LEGEND

- SURVEY REACH
- FLOW DIRECTION
- RAILROAD
- WATERCOURSE
- WATERBODY
- POPULATED PLACE
- FIRST NATION RESERVE

CROSS SECTIONS

- SURVEYED CROSS SECTION (2017)
- SURVEYED CROSS SECTION (2015)

KEY MAP



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CLIENT: Alberta Government

CONSULTANT: Golder Associates; SG1 WATER CONSULTING

YYYY-MM-DD	2018-01-19
DESIGNED	G. TANG
PREPARED	B. PENDERGAST
REVIEWED	D. SHEPHERD
APPROVED	H. ZHANG

PROJECT: SIKSIKA BOW RIVER HAZARD STUDY

TITLE: **CROSS SECTION LOCATIONS - BOW RIVER ALONG SUBREACH 2A**

PROJECT NO.	CONTROL	REV.	FIGURE
1783054		0	B-4

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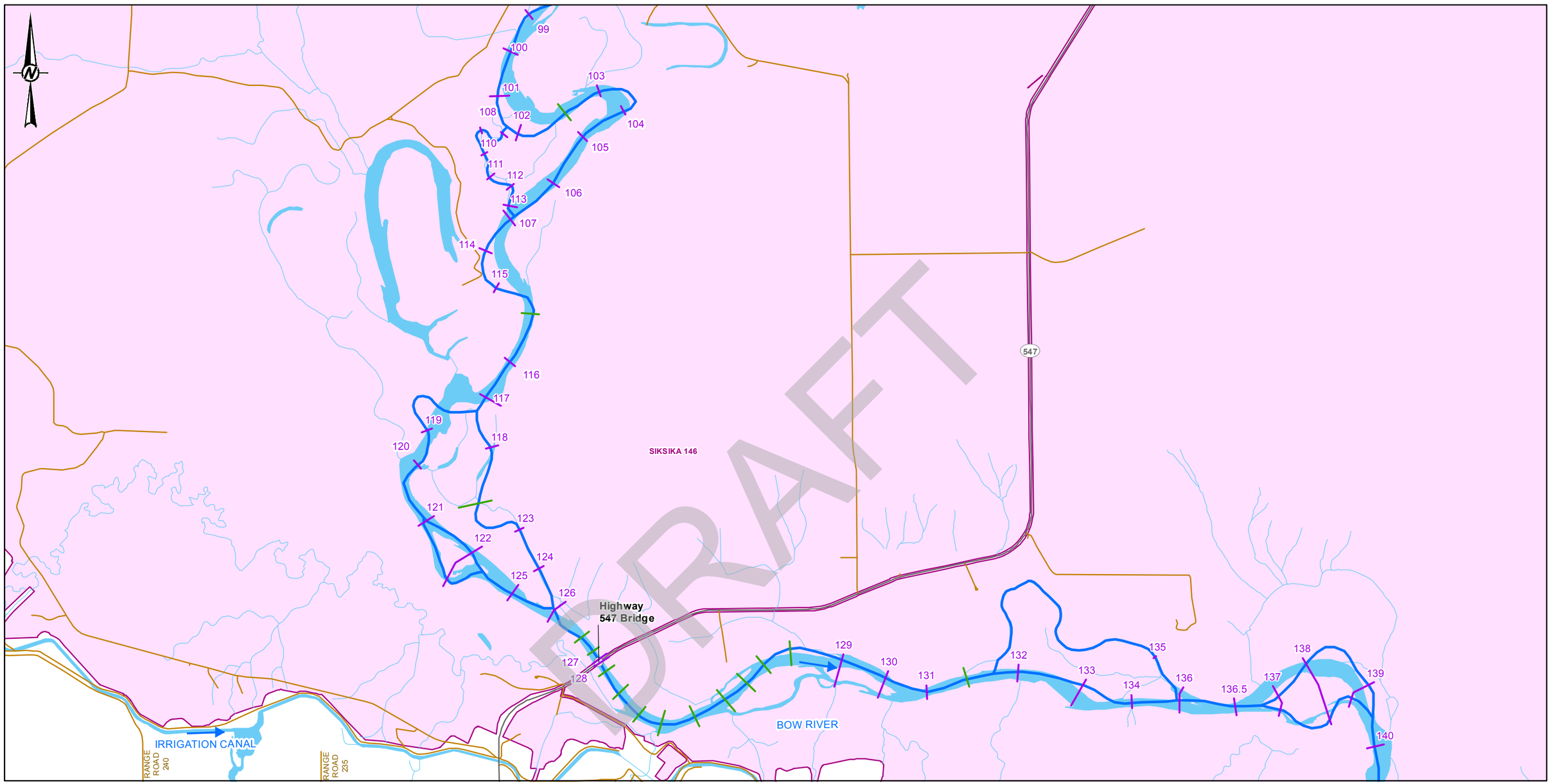


LEGEND

- SURVEY REACH
- FLOW DIRECTION
- WATERCOURSE
- WATERBODY
- POPULATED PLACE
- FIRST NATION RESERVE

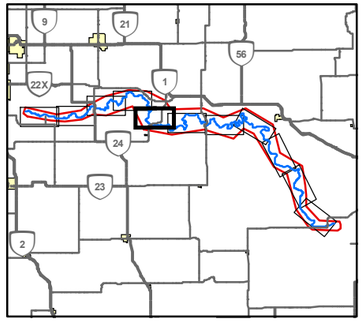
CROSS SECTIONS

- SURVEYED CROSS SECTION (2017)
- SURVEYED CROSS SECTION (2015)

HYDRAULIC STRUCTURES

- BRIDGE

KEY MAP



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CLIENT

Alberta Government

CONSULTANT

Golder Associates

SG1 WATER CONSULTING

YYYY-MM-DD	2018-01-19
DESIGNED	G. TANG
PREPARED	B. PENDERGAST
REVIEWED	D. SHEPHERD
APPROVED	H. ZHANG

PROJECT

SIKSIKA BOW RIVER HAZARD STUDY

TITLE

CROSS SECTION AND HYDRAULIC STRUCTURE LOCATIONS - BOW RIVER ALONG SUBREACHES 2A AND 2B

PROJECT NO.	CONTROL	REV.	FIGURE
1783054		0	B-5

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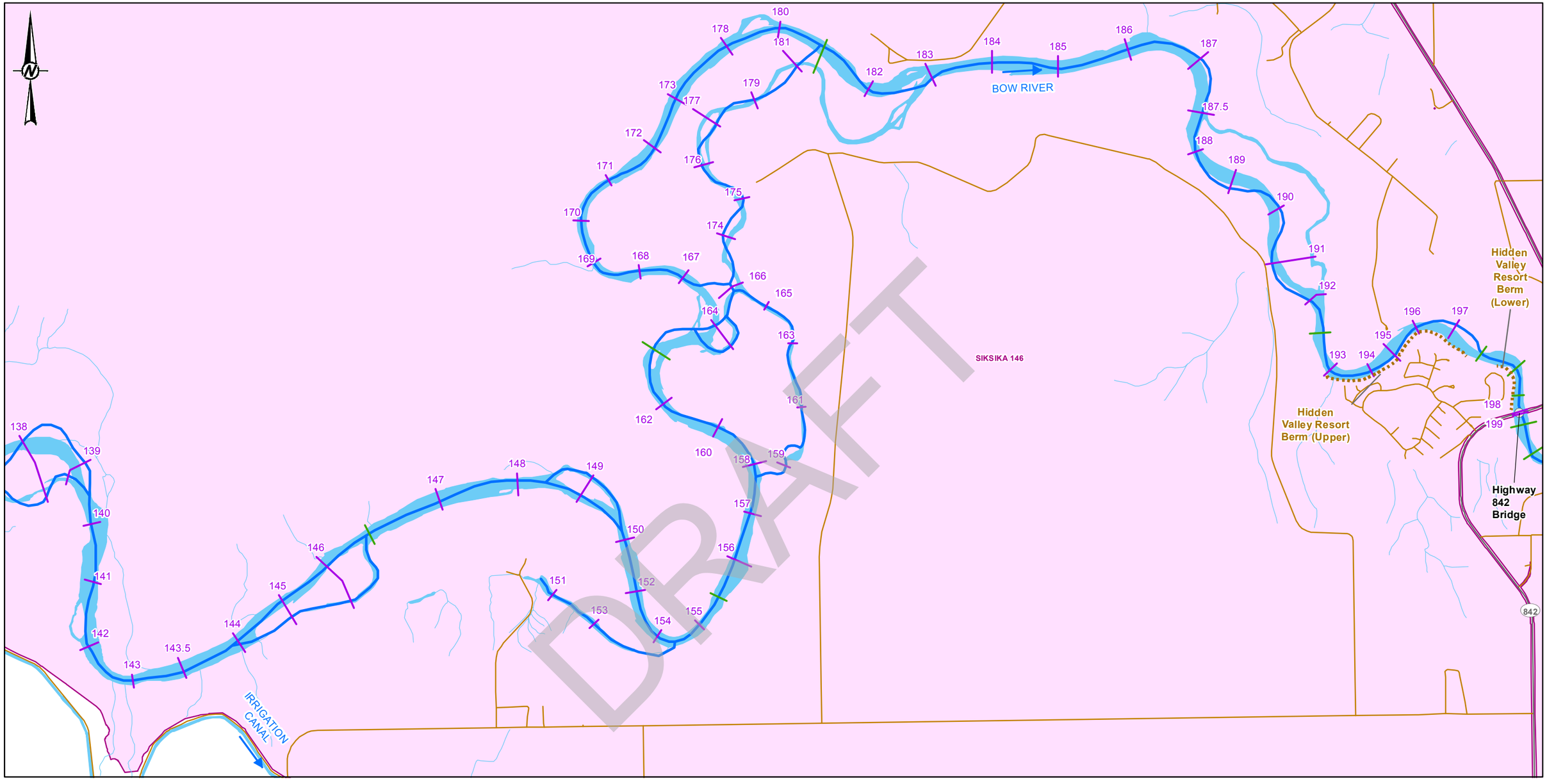


LEGEND

- SURVEY REACH
- FLOW DIRECTION
- WATERCOURSE
- WATERBODY
- POPULATED PLACE
- FIRST NATION RESERVE

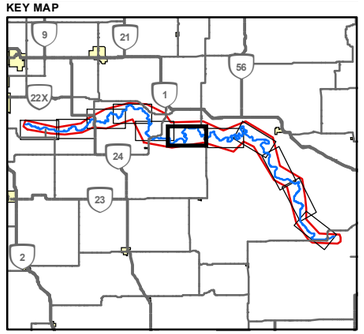
CROSS SECTIONS

- SURVEYED CROSS SECTION (2017)
- SURVEYED CROSS SECTION (2015)

HYDRAULIC STRUCTURES

- BRIDGE
- FLOOD CONTROL STRUCTURE

KEY MAP



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1:35,000 KILOMETRES

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YYYY-MM-DD	2018-01-19
DESIGNED	G. TANG
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REVIEWED	D. SHEPHERD
APPROVED	H. ZHANG

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PROJECT

SIKSIKA BOW RIVER HAZARD STUDY

TITLE

CROSS SECTION, HYDRAULIC STRUCTURE AND FLOOD CONTROL STRUCTURE LOCATIONS - BOW RIVER ALONG SUBREACHES 2B AND 2C

PROJECT NO.	CONTROL	REV.	FIGURE
1783054		0	B-6

PATH: I:\CLIENTS\AEP\1783054\Mapping\MXD\Hydrology\01_Survey & Base Data Collection\1783054_Appendix_B_Structures_Rev0.mxd PRINTED ON: 2018-01-19 AT: 11:26:17 AM

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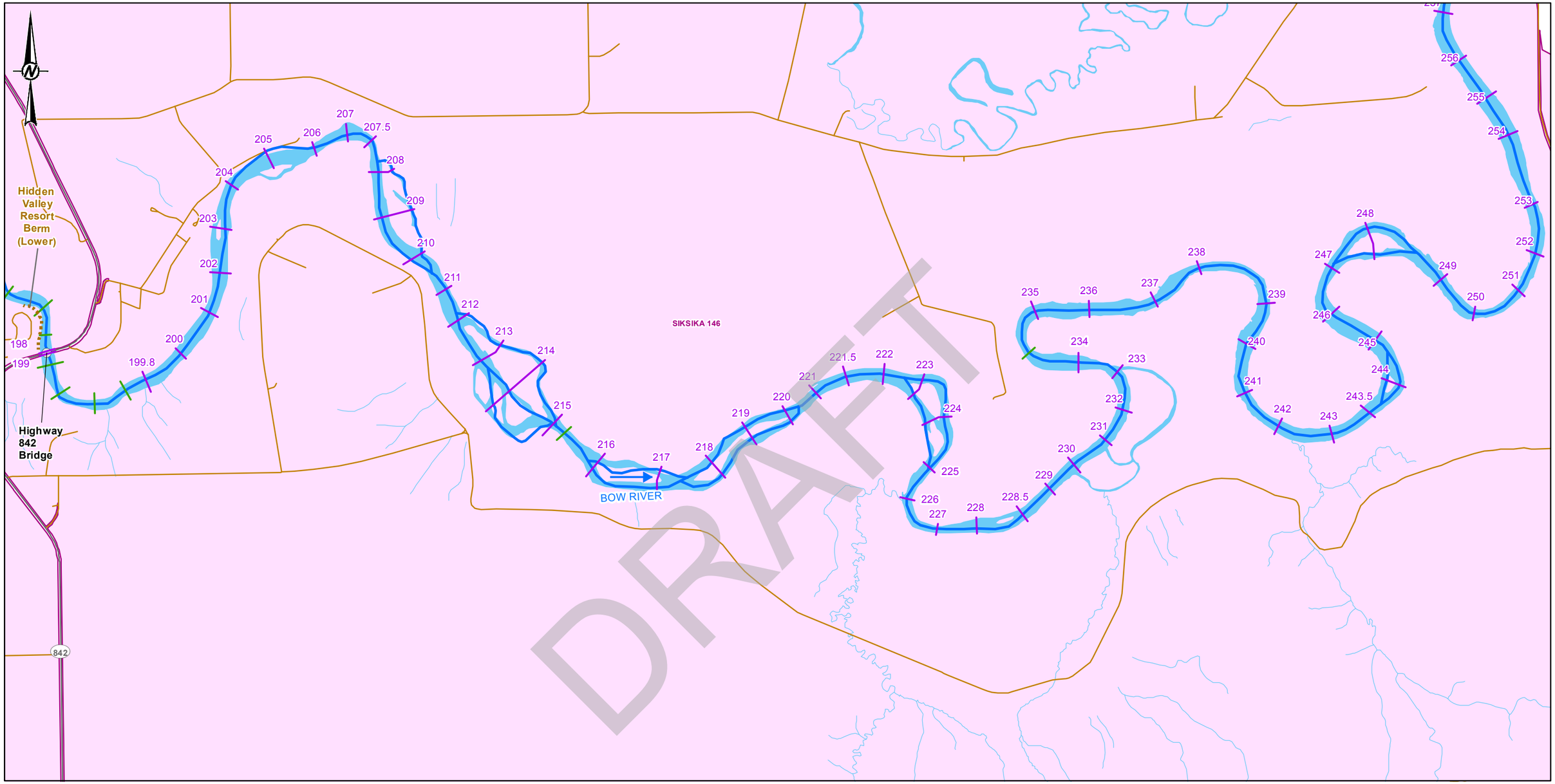


LEGEND

- SURVEY REACH
- FLOW DIRECTION
- WATERCOURSE
- WATERBODY
- POPULATED PLACE
- FIRST NATION RESERVE

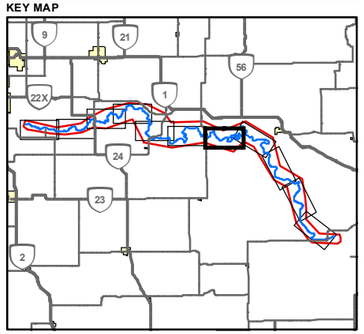
CROSS SECTIONS

- SURVEYED CROSS SECTION (2017)
- SURVEYED CROSS SECTION (2015)

HYDRAULIC STRUCTURES

- BRIDGE
- FLOOD CONTROL STRUCTURE

KEY MAP



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Golder Associates

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REVIEWED	D. SHEPHERD
APPROVED	H. ZHANG

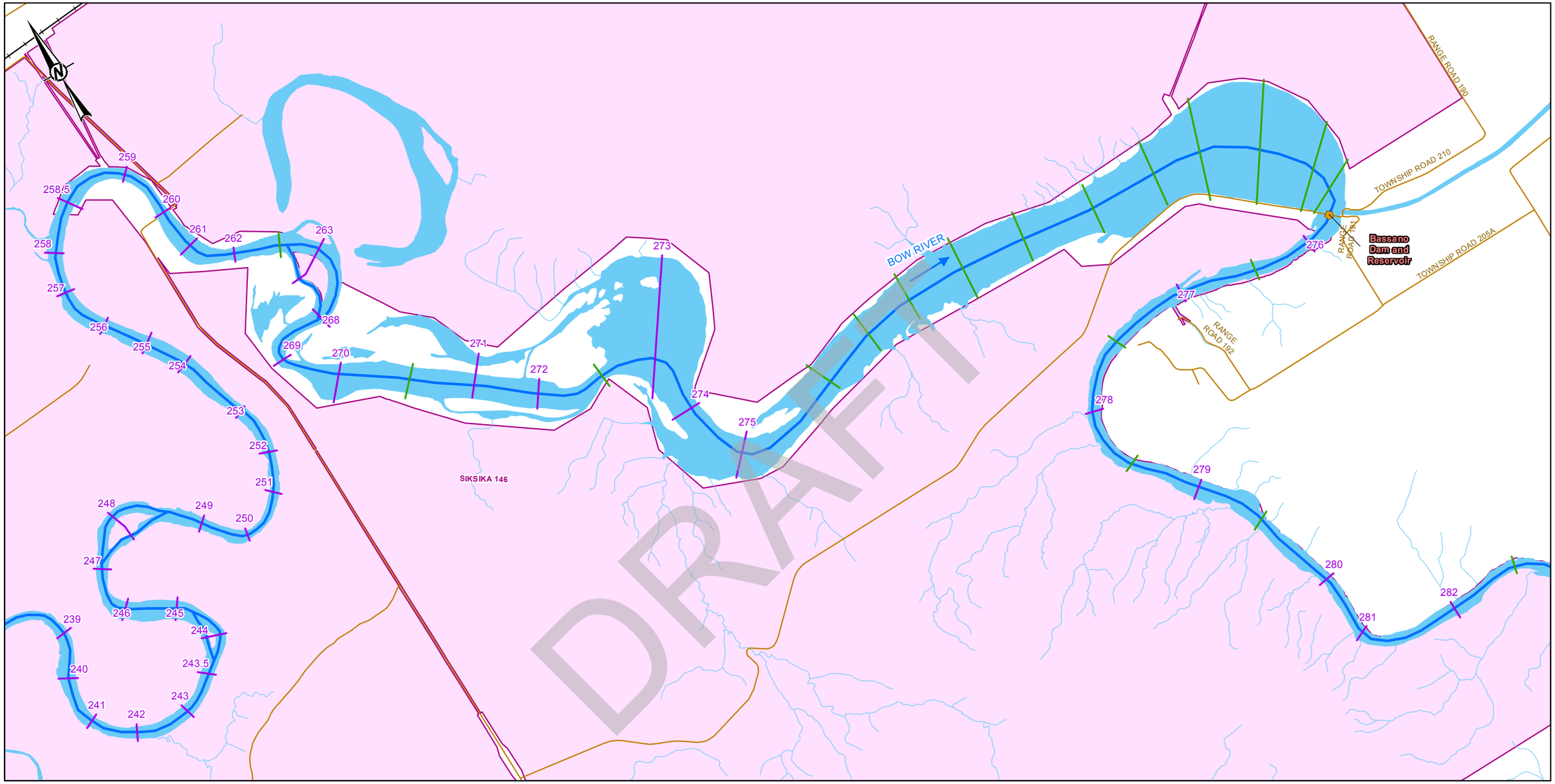
PROJECT

SIKSIKA BOW RIVER HAZARD STUDY

TITLE

CROSS SECTION, HYDRAULIC STRUCTURE AND FLOOD CONTROL STRUCTURE LOCATIONS - BOW RIVER ALONG SUBREACH 2C

PROJECT NO.	CONTROL	REV.	FIGURE
1783054		0	B-7



LEGEND

- SURVEY REACH
- FLOW DIRECTION
- RAILROAD
- WATERCOURSE
- WATERBODY
- POPULATED PLACE
- FIRST NATION RESERVE

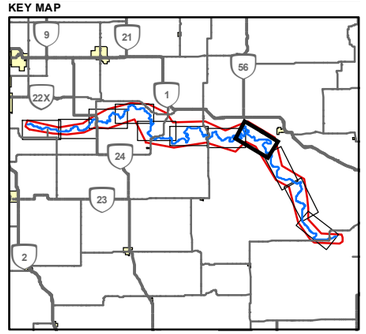
CROSS SECTIONS

- SURVEYED CROSS SECTION (2017)
- SURVEYED CROSS SECTION (2014/15)

HYDRAULIC STRUCTURES

- DAM

KEY MAP



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Golder Associates

SG1 WATER CONSULTING

YYYY-MM-DD	2018-01-19
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PREPARED	B. PENDERGAST
REVIEWED	D. SHEPHERD
APPROVED	H. ZHANG

PROJECT

SIKSIKA BOW RIVER HAZARD STUDY

TITLE

CROSS SECTION AND HYDRAULIC STRUCTURE LOCATIONS - BOW RIVER ALONG SUBREACHES 2C AND 3A

PROJECT NO.	CONTROL	REV.	FIGURE
1783054		0	B-8

PATH: I:\CLIENTS\AEP\1783054\Mapping\MXD\Hydrology\01_Survey & Base Data Collection\1783054_Appendix_B_Structures_Rev0.mxd PRINTED ON: 2018-01-19 AT: 11:26:28 AM

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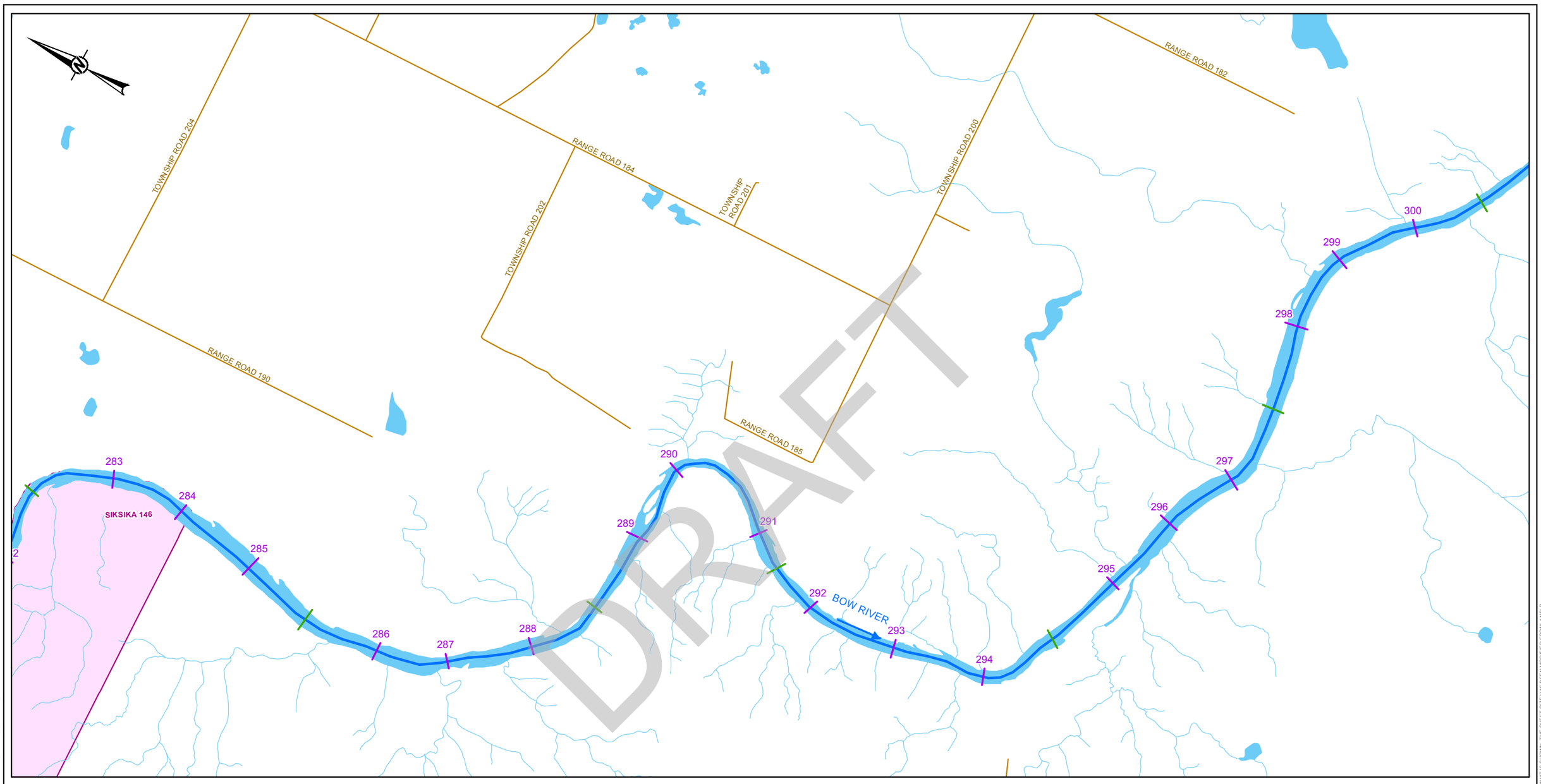


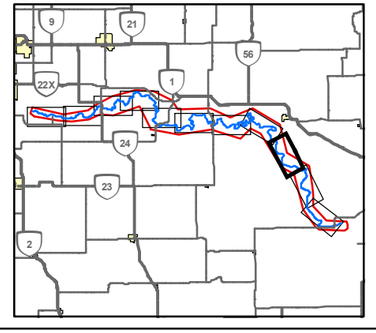
LEGEND

- SURVEY REACH
- FLOW DIRECTION
- WATERCOURSE
- WATERBODY
- POPULATED PLACE
- FIRST NATION RESERVE

CROSS SECTIONS

- SURVEYED CROSS SECTION (2017)
- SURVEYED CROSS SECTION (2014/15)

KEY MAP



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CLIENT

Alberta Government

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YYYY-MM-DD	2018-01-19
DESIGNED	G. TANG
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PROJECT

SIKSIKA BOW RIVER HAZARD STUDY

TITLE

CROSS SECTION LOCATIONS - BOW RIVER ALONG SUBREACH 3A

PROJECT NO.	CONTROL	REV.	FIGURE
1783054		0	B-9

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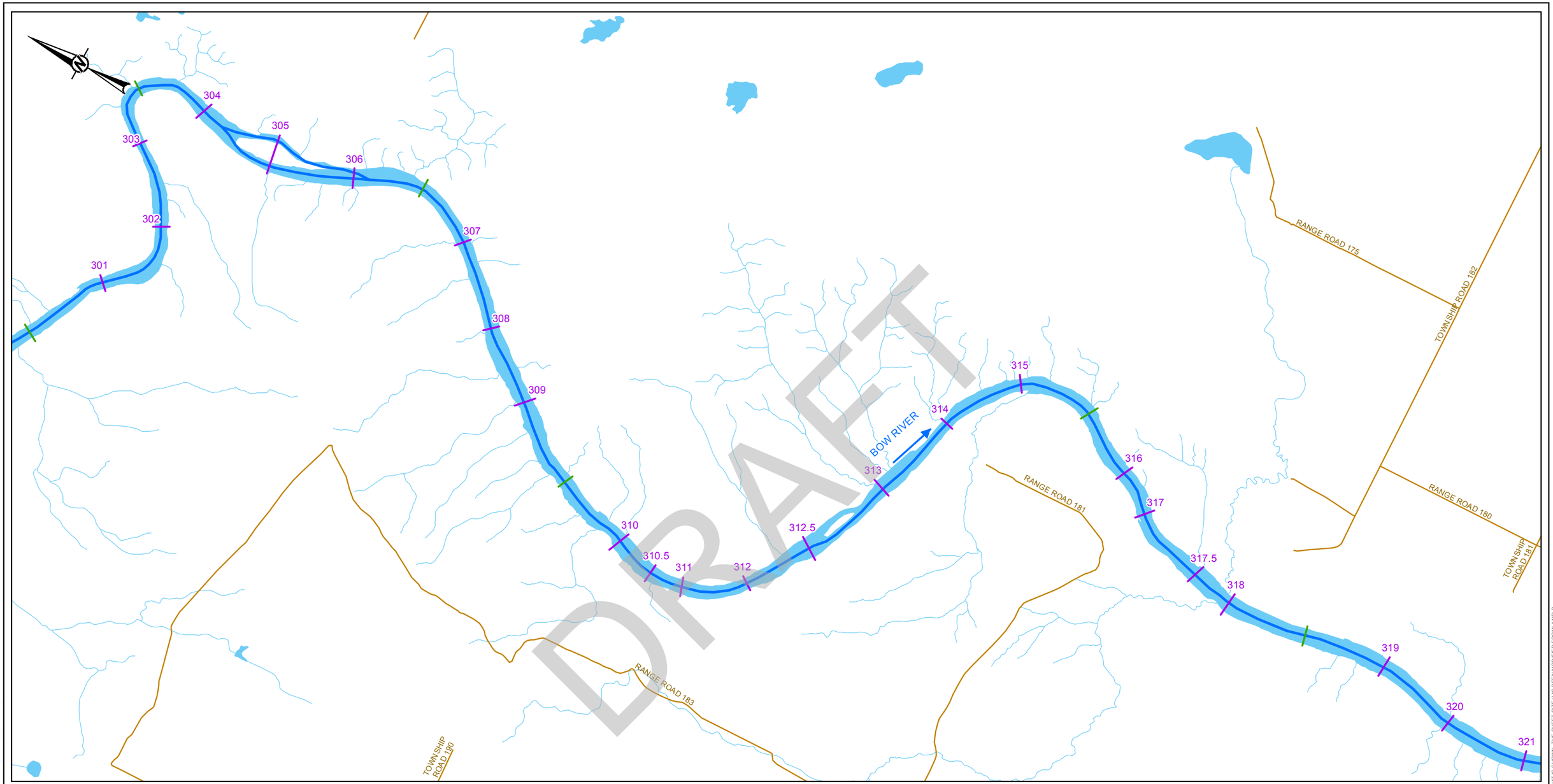


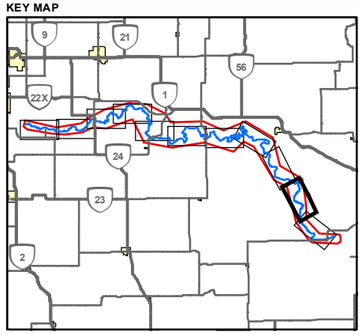
LEGEND

- SURVEY REACH
- FLOW DIRECTION
- WATERCOURSE
- WATERBODY
- POPULATED PLACE
- FIRST NATION RESERVE

CROSS SECTIONS

- SURVEYED CROSS SECTION (2017)
- SURVEYED CROSS SECTION (2014/15)

KEY MAP



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CLIENT: Alberta Government

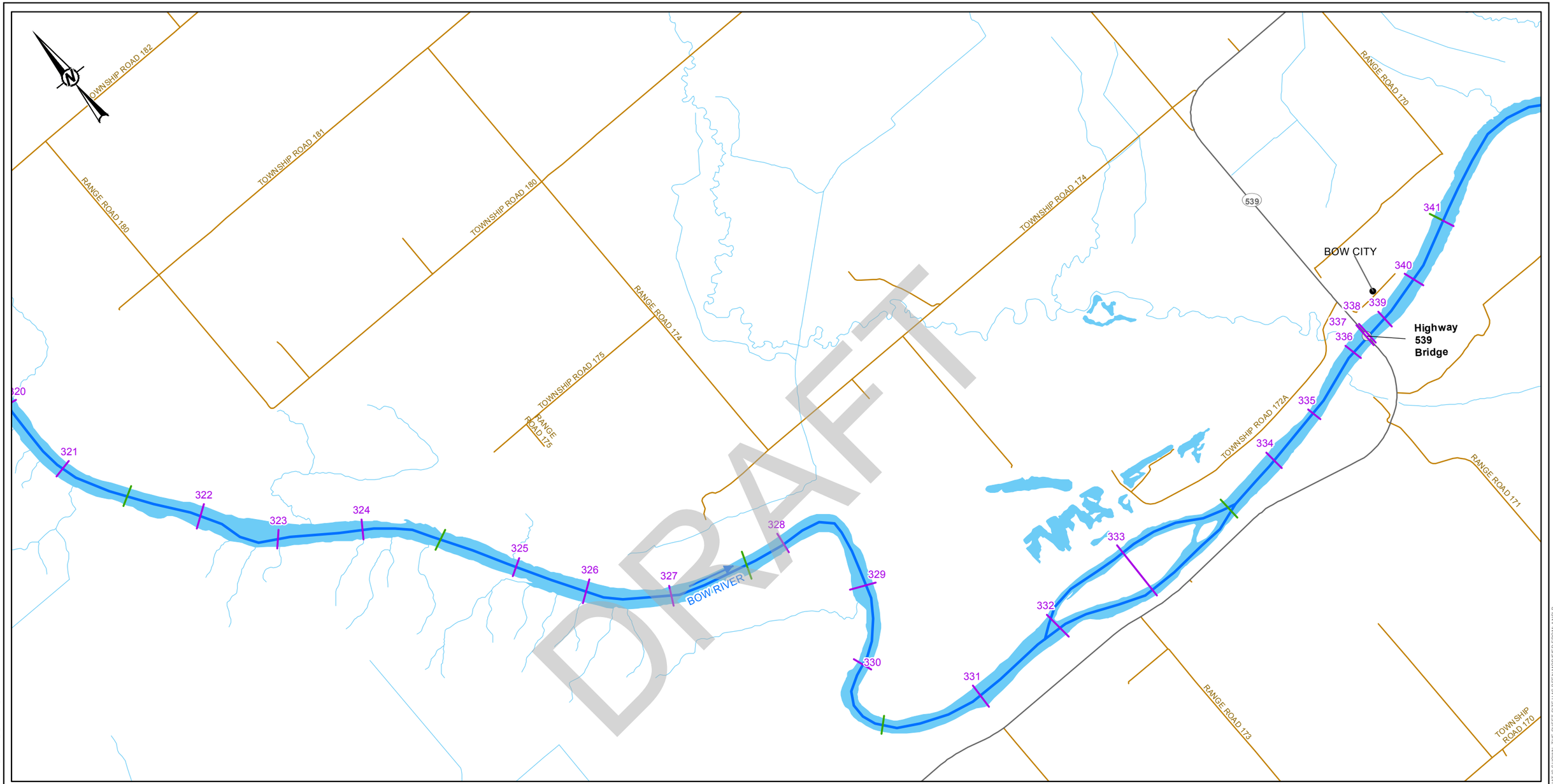
CONSULTANT: Golder Associates; SG1 WATER CONSULTING

YYYY-MM-DD	2018-01-19
DESIGNED	G. TANG
PREPARED	B. PENDERGAST
REVIEWED	D. SHEPHERD
APPROVED	H. ZHANG

PROJECT: SIKSIKA BOW RIVER HAZARD STUDY

TITLE: **CROSS SECTION LOCATIONS - BOW RIVER ALONG SUBREACH 3B**

PROJECT NO.	CONTROL	REV.	FIGURE
1783054		0	B-10



LEGEND

- SURVEY REACH
- FLOW DIRECTION
- WATERCOURSE
- WATERBODY
- POPULATED PLACE
- FIRST NATION RESERVE

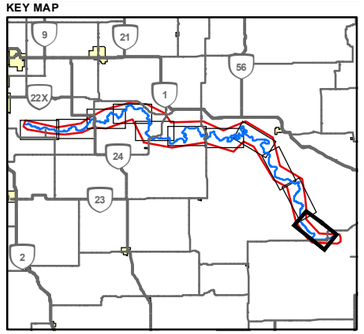
CROSS SECTIONS

- SURVEYED CROSS SECTION (2017)
- SURVEYED CROSS SECTION (2014/15)

HYDRAULIC STRUCTURES

- BRIDGE

KEY MAP



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CLIENT: Alberta Government

CONSULTANT: Golder Associates; SG1 WATER CONSULTING

YYYY-MM-DD	2018-01-19
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PREPARED	B. PENDERGAST
REVIEWED	D. SHEPHERD
APPROVED	H. ZHANG

PROJECT: SIKSIKA BOW RIVER HAZARD STUDY

TITLE: **CROSS SECTION AND HYDRAULIC STRUCTURE LOCATIONS - BOW RIVER ALONG SUBREACH 3B**

PROJECT NO.	CONTROL	REV.	FIGURE
1783054		0	B-11

PATH: I:\CLIENTS\AEP\1783054\Mapping\MXD\Hydrology\01_Survey & Base Data Collection\1783054_Appendix_B_Structures_Rev0.mxd PRINTED ON: 2018-01-19 AT: 11:26:42 AM

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25mm 0

APPENDIX C

Hydraulic Structure Datasheets

IMAGE REF: 10080-SV1.085.JPG

1. View looking downstream from left bank.

IMAGE REF: 20171026_104938.JPG

2. View looking across the river from right bank.

WATERBODY	DESCRIPTION	NAME / IDENTIFIER	BRIDGE FILE NUMBER	RECORD HOLDER	USAGE	TOTAL LENGTH OF SPAN (m)	DECK WIDTH (m)	AVERAGE TOP-OF-CURB OR SOLID GUARD RAIL ELEVATION (m)	AVERAGE LOW CHORD ELEVATION (m)	NUMBER OF PIERS	PIER DETAILS			
											#	CENTRE STATION (m)	WIDTH (m)	TYPE	SHAPE
BOW RIVER	HIGHWAY 24 NEAR CARSELAND, AB	CARSELAND BRIDGE	7870	ALBERTA TRANSPORTATION	TRAFFIC	190.50	9.75	910.57	910.32	4	1	38.10	1.75	CONCRETE	TRIANGULAR NOSE AND TAIL (VERTICAL)
											2	76.20	1.75	CONCRETE	TRIANGULAR NOSE AND TAIL (VERTICAL)
											3	114.30	1.75	CONCRETE	TRIANGULAR NOSE AND TAIL (VERTICAL)
											4	152.40	1.75	CONCRETE	TRIANGULAR NOSE AND TAIL (VERTICAL)

PREPARED BY:

SG1
SG1 Water Consulting Ltd.
7303 118A St NW, Edmonton, AB, Canada T6G 1V3
Tel: 780.238.5868 | SG1water.ca

IN COLLABORATION WITH:

Golder Associates
Suite 102 - 2535 3 Avenue SW
Calgary, AB, Canada T2A 7W5
Tel: 403.299.5600 | www.golder.com

NOTES:

1. WORLD IMAGERY BY ESRI INC., DATED 17-JUL-2015. THE BRIDGE SURVEY WAS CONDUCTED BY GOLDER ON 26-OCT-2017.
2. DETAILS OF BRIDGE SURVEY WILL BE USED FOR HYDRAULIC MODELLING. PIER CENTRE STATIONS, AS SHOWN IN TABLE BELOW, ARE WITH RESPECT TO VALUES USED IN HYDRAULIC MODEL.
3. COORDINATE SYSTEM IS 3TM MERIDIAN 114° W REFERENCED TO VERTICAL AND HORIZONTAL DATUMS OF CGVD28 AND NAD83 (CSRS), RESPECTIVELY.
4. REFER TO REPORT SECTION 2.5 AND HYDRAULIC MODEL FOR MORE INFORMATION.
5. LEFT OR RIGHT REFER TO DIRECTIONS AS SEEN BY AN OBSERVER LOOKING DOWNSTREAM.

LEGEND:

SURVEY DATA POINT

0 m 20 40 60 80
1 : 2000

PREPARED FOR:

Alberta Environment and Parks

PROJECT:

SIKSIKA BOW RIVER HAZARD STUDY
SURVEY AND BASE DATA COLLECTION

TITLE:

Hydraulic Structure Datasheet
Traffic Bridge - Bow River
Highway 24 Bridge near Carseland, AB

DWN BY:	CHK'D BY:	REV NO:
RDJ	DMS	0

DWG NO: 10080-02-102

DATE: 9-JAN-2018

FIGURE NO: C-1

FILE LOC: H:\SG1\OwnCloud\Drafting\10080 Siksika Bow\Task 2\10080-02-102.dwg - 10080-02-102, PLOT DATE: 08-Jan-2018

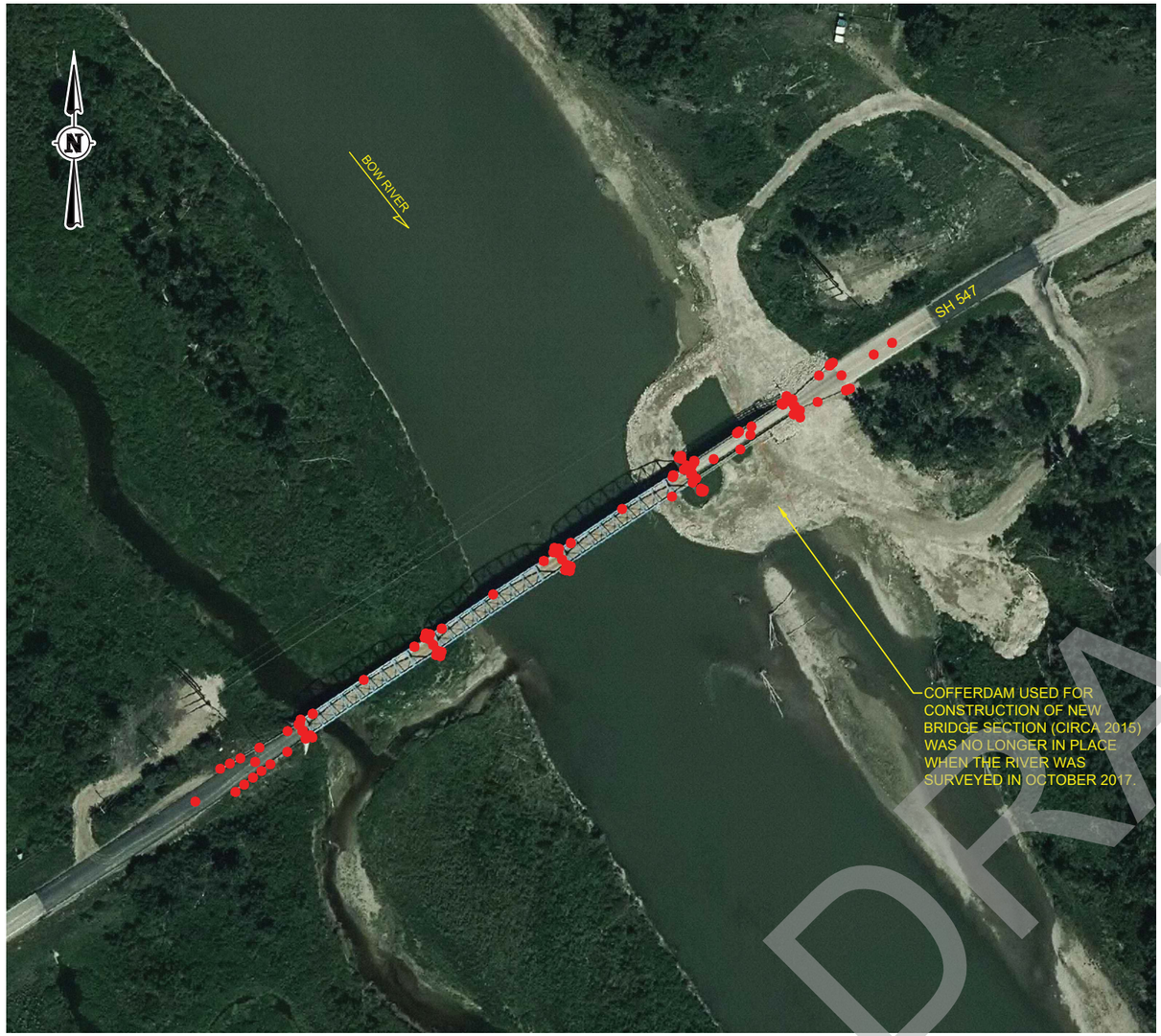

IMAGE REF: 20171024_123103.JPG

1. View looking downstream from left bank. Note that the construction cofferdam, as shown in the aerial image to the left, had been removed prior to river surveying.

IMAGE REF: 10080-SV1.064.JPG

2. View looking across the river from right bank at the bridge abutment.

WATERBODY	DESCRIPTION	NAME / IDENTIFIER	BRIDGE FILE NUMBER	RECORD HOLDER	USAGE	TOTAL LENGTH OF SPAN (m)	DECK WIDTH (m)	AVERAGE TOP-OF-CURB OR SOLID GUARD RAIL ELEVATION (m)	AVERAGE LOW CHORD ELEVATION (m)	NUMBER OF PIERS	PIER DETAILS				
											#	CENTRE STATION (m)	WIDTH (m)	TYPE	SHAPE
BOW RIVER	HIGHWAY 547 NEAR ARROWWOOD, AB	ARROWWOOD BRIDGE	1293	ALBERTA TRANSPORTATION	TRAFFIC	204.17	4.20 (NEW, LEFT) 5.94 (OLD, RIGHT)	856.70	854.66	3	1	42.53	1.22	CONCRETE	CIRCULAR (TWO COLUMNS)
											2	96.28	2.40	CONCRETE	TRIANGULAR NOSE (SLOPED) AND TAIL (VERTICAL)
											3	150.43	2.40	CONCRETE	TRIANGULAR NOSE (SLOPED) AND TAIL (VERTICAL)

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Tel: 403.299.5600 | www.golder.com

NOTES:

1. WORLD IMAGERY BY ESRI INC., DATED 17-JUL-2015. THE BRIDGE SURVEY WAS CONDUCTED BY GOLDER ON 24-OCT-2017.
2. DETAILS OF BRIDGE SURVEY WILL BE USED FOR HYDRAULIC MODELLING. PIER CENTRE STATIONS, AS SHOWN IN TABLE BELOW, ARE WITH RESPECT TO VALUES USED IN HYDRAULIC MODEL.
3. COORDINATE SYSTEM IS 3TM MERIDIAN 114° W REFERENCED TO VERTICAL AND HORIZONTAL DATUMS OF CGVD28 AND NAD83 (CSRS), RESPECTIVELY.
4. REFER TO REPORT SECTION 2.5 AND HYDRAULIC MODEL FOR MORE INFORMATION.
5. LEFT OR RIGHT REFER TO DIRECTIONS AS SEEN BY AN OBSERVER LOOKING DOWNSTREAM.

LEGEND:

SURVEY DATA POINT

0 m 20 40 60 80

1 : 2000

PREPARED FOR:

Alberta Environment and Parks

PROJECT:

SIKSIKA BOW RIVER HAZARD STUDY
SURVEY AND BASE DATA COLLECTION

TITLE:

Hydraulic Structure Datasheet
Traffic Bridge - Bow River
SH547 Bridge near Arrowwood, AB

DWN BY:	CHK'D BY:	REV NO:
RDJ	DMS	0

DWG NO: 10080-02-103

DATE: 9-JAN-2018

FIGURE NO: C-2

FILE LOC: H:\SG1\OwnCloud\Drafting\10080 Siksika Bow\Task 2\10080-02-103.dwg - 10080-02-103, PLOT DATE: 08-Jan-2018

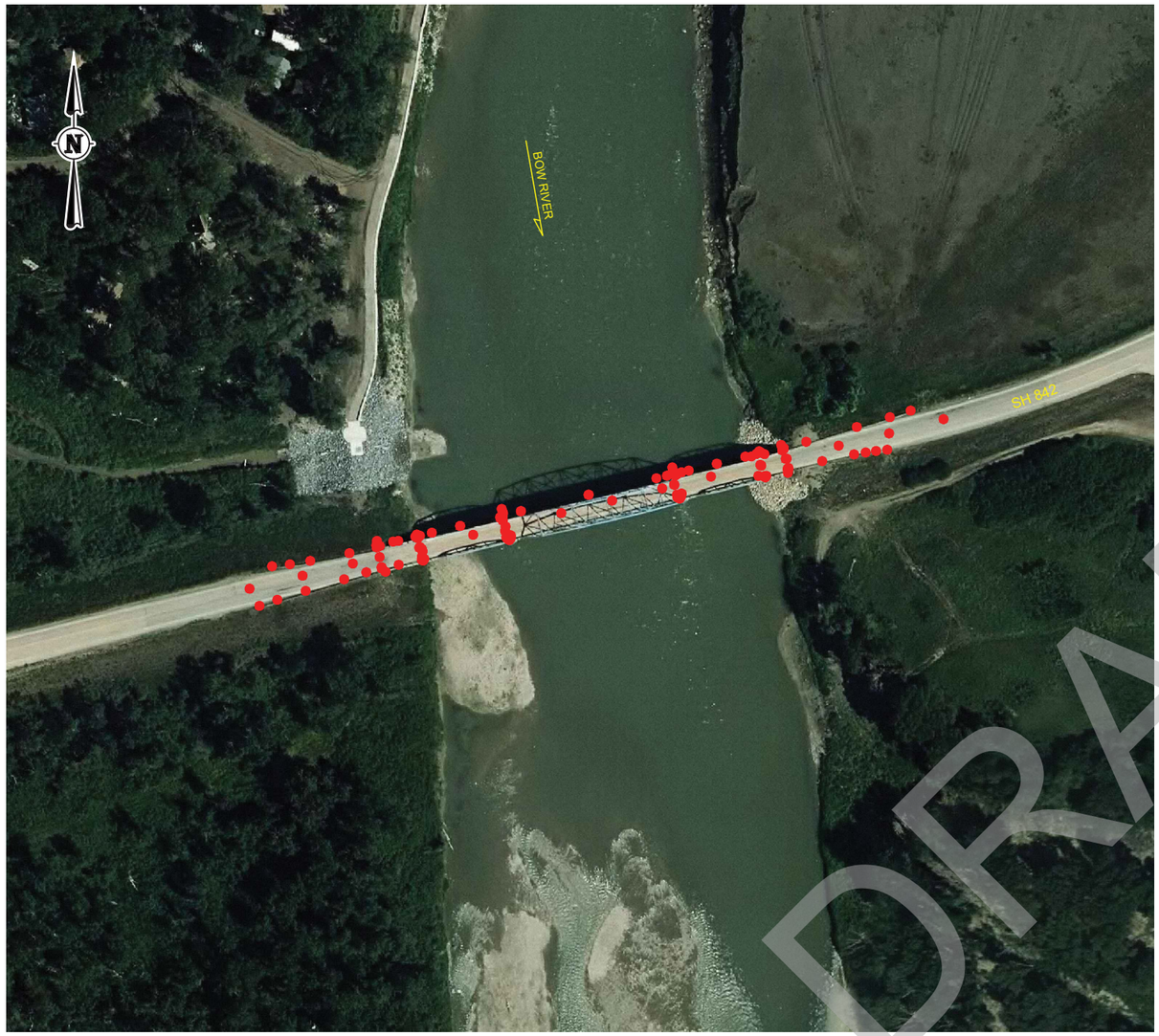

IMAGE REF: 10080-SV1.047.JPG

1. View looking across channel from right bank.

IMAGE REF: 10080-SV2.007.JPG

2. View looking upstream from left bank.

WATERBODY	DESCRIPTION	NAME / IDENTIFIER	BRIDGE FILE NUMBER	RECORD HOLDER	USAGE	TOTAL LENGTH OF SPAN (m)	DECK WIDTH (m)	AVERAGE TOP-OF-CURB OR SOLID GUARD RAIL ELEVATION (m)	AVERAGE LOW CHORD ELEVATION (m)	NUMBER OF PIERS	PIER DETAILS				
											#	CENTRE STATION (m)	WIDTH (m)	TYPE	SHAPE
BOW RIVER	HIGHWAY 842 NEAR CLUNY, AB	CLUNY BRIDGE	6754	ALBERTA TRANSPORTATION	TRAFFIC	146.25	6.71	819.63	818.28	4	1	14.48	1.07	CONCRETE	TRIANGULAR NOSE AND TAIL (SLOPED)
											2	45.44	1.22	CONCRETE	TRIANGULAR NOSE AND TAIL (SLOPED)
											3	106.91	1.22	CONCRETE	TRIANGULAR NOSE AND TAIL (SLOPED)
											4	137.87	1.07	CONCRETE	TRIANGULAR NOSE AND TAIL (SLOPED)

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NOTES:

1. WORLD IMAGERY BY ESRI INC., DATED 17-JUL-2015. THE BRIDGE SURVEY WAS CONDUCTED BY GOLDER ON 25-OCT-2017.
2. DETAILS OF BRIDGE SURVEY WILL BE USED FOR HYDRAULIC MODELLING. PIER CENTRE STATIONS, AS SHOWN IN TABLE BELOW, ARE WITH RESPECT TO VALUES USED IN HYDRAULIC MODEL.
3. COORDINATE SYSTEM IS 3TM MERIDIAN 114° W REFERENCED TO VERTICAL AND HORIZONTAL DATUMS OF CGVD28 AND NAD83 (CSRS), RESPECTIVELY.
4. REFER TO REPORT SECTION 2.5 AND HYDRAULIC MODEL FOR MORE INFORMATION.
5. LEFT OR RIGHT REFER TO DIRECTIONS AS SEEN BY AN OBSERVER LOOKING DOWNSTREAM.

LEGEND:

● SURVEY DATA POINT

0 m 20 40 60 80

1 : 2000

PREPARED FOR:

Alberta Environment and Parks

PROJECT:

SIKSIKA BOW RIVER HAZARD STUDY
SURVEY AND BASE DATA COLLECTION

TITLE:

Hydraulic Structure Datasheet
Traffic Bridge - Bow River
SH842 Bridge near Cluny, AB

DWN BY:	CHK'D BY:	REV NO:
RDJ	DMS	0

DWG NO: 10080-02-104

DATE: 9-JAN-2018

FIGURE NO: C-3

FILE LOC: H:\SG1\OwnCloud\Drafting\10080 Siksika Bow\Task 2\10080-02-104.dwg - 10080-02-104, PLOT DATE: 08-Jan-2018

IMAGE REF: 10080-SV1.014.JPG

1. View looking downstream from left bank.

IMAGE REF: 10080-SV1.010.JPG

2. View looking upstream from right bank.

WATERBODY	DESCRIPTION	NAME / IDENTIFIER	BRIDGE FILE NUMBER	RECORD HOLDER	USAGE	TOTAL LENGTH OF SPAN (m)	DECK WIDTH (m)	AVERAGE TOP-OF-CURB OR SOLID GUARD RAIL ELEVATION (m)	AVERAGE LOW CHORD ELEVATION (m)	NUMBER OF PIERS	PIER DETAILS				
											#	CENTRE STATION (m)	WIDTH (m)	TYPE	SHAPE
BOW RIVER	HIGHWAY 539 NEAR BOW CITY, AB	BOW CITY BRIDGE	7447	ALBERTA TRANSPORTATION	TRAFFIC	225.93	9.00	753.26	749.88	3	1	49.98	1.50	CONCRETE	CIRCULAR (ARRAY OF THREE COLUMNS)
											2	112.97	1.50	CONCRETE	CIRCULAR (ARRAY OF THREE COLUMNS)
											3	175.95	1.50	CONCRETE	CIRCULAR (ARRAY OF THREE COLUMNS)

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NOTES:

1. WORLD IMAGERY BY ESRI INC., DATED 17-JUL-2015. THE BRIDGE SURVEY WAS CONDUCTED BY GOLDER ON 26-SEP-2017.
2. DETAILS OF BRIDGE SURVEY WILL BE USED FOR HYDRAULIC MODELLING. PIER CENTRE STATIONS, AS SHOWN IN TABLE BELOW, ARE WITH RESPECT TO VALUES USED IN HYDRAULIC MODEL.
3. COORDINATE SYSTEM IS 3TM MERIDIAN 114° W REFERENCED TO VERTICAL AND HORIZONTAL DATUMS OF CGVD28 AND NAD83 (CSRS), RESPECTIVELY.
4. REFER TO REPORT SECTION 2.5 AND HYDRAULIC MODEL FOR MORE INFORMATION.
5. LEFT OR RIGHT REFER TO DIRECTIONS AS SEEN BY AN OBSERVER LOOKING DOWNSTREAM.

LEGEND:

● SURVEY DATA POINT

0 m 20 40 60 80 100

1 : 2500

PREPARED FOR:

Alberta Environment and Parks

PROJECT:

SIKSIKA BOW RIVER HAZARD STUDY
SURVEY AND BASE DATA COLLECTION

TITLE:

Hydraulic Structure Datasheet
Traffic Bridge - Bow River
SH539 Bridge near Bow City, AB

DWN BY:	CHK'D BY:	REV NO:
RDJ	DMS	0

DWG NO: 10080-02-105

DATE: 9-JAN-2018

FIGURE NO: C-4

FILE LOC: H:\SG1\OwnCloud\Drafting\10080 Siksika Bow\Task 21\10080-02-105.dwg - 10080-02-105, PLOT DATE: 08-Jan-2018

APPENDIX D

Flood Control Structure Datasheet

ADJACENT WATERBODY	DESCRIPTION	APPROXIMATE LENGTH (m)	SIDE OF RIVER	TYPE
BOW RIVER	INTERLOCKING CONCRETE BLOCK STRUCTURE SITUATED ADJACENT TO HIDDEN VALLEY RESORT NEAR ARROWWOOD, AB	1540 (UPPER) 500 (LOWER)	RIGHT	BERM

IMAGE REF: 20171025_113824.JPG

1. View looking downstream at the lower berm near its downstream end. Note SH 842 (Arrowwood) Bridge in the background.

IMAGE REF: 20171025_131401.JPG

2. View looking downstream at the upper berm midway along its length.

IMAGE REF: 20171025_133100.JPG

3. View looking downstream from the upstream end of the upper berm.

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NOTES:

1. WORLD IMAGERY BY ESRI INC., DATED 17-JUL-2015. THE BERM SURVEY WAS CONDUCTED BY GOLDER ON 25-OCT-2017.
2. DETAILS OF FLOOD CONTROL STRUCTURE SURVEY WILL BE USED FOR HYDRAULIC MODELLING.
3. COORDINATE SYSTEM IS 3TM MERIDIAN 114° W REFERENCED TO VERTICAL AND HORIZONTAL DATUMS OF CGVD28 AND NAD83 (CSRS), RESPECTIVELY.
4. REFER TO REPORT SECTION 2.6 AND HYDRAULIC MODEL FOR MORE INFORMATION.
5. LEFT OR RIGHT REFER TO DIRECTIONS AS SEEN BY AN OBSERVER LOOKING DOWNSTREAM.

LEGEND:

- SURVEY DATA POINT

0 m 100 200 300 400
1 : 10,000

PREPARED FOR:

Alberta Environment and Parks

PROJECT:

SIKSIKA BOW RIVER HAZARD STUDY
SURVEY AND BASE DATA COLLECTION

TITLE:

Flood Control Structure Datasheet
Berm Adjacent to Hidden Valley Resort near Cluny, AB

DWN BY:	CHK'D BY:	REV NO:
RDJ	DMS	0
DWG NO: 10080-02-106		FIGURE NO: D-1
DATE: 9-JAN-2018		

FILE LOC: H:\SG1\OwnCloud\Drafting\10080 Siksika Bow\Task 2\10080-02-106.dwg - 10080-02-106, PLOT DATE: 08-Jan-2018

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