Lake St. Martin Emergency Outlet Channel
Assessment of Effects and Development of Offsetting

Physical Environment Supporting Volume (PESV)

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A report prepared for
Manitoba Infrastructure and Transportation
by
North/South Consultants Inc. and KGS Group

PREFACE

The following document was prepared to provide the information required under Schedule 1 of the *Applications for Authorization under Paragraph 35(2) (b) of the Fisheries Act Regulations.* As requested by Fisheries and Oceans Canada (DFO), key information from all relevant materials provided during the environmental review of the Lake St. Martin Emergency Relief Channel Project has been summarized in this document, following the subsections identified in Schedule 1 to the extent possible.

It should be noted that, because of the emergency requirement to complete this Project, it was exempted from a review under Canada's *Canadian Environmental Assessment Act (CEAA)* and *The Environment Act (Manitoba)*. In the absence of a formal screening, DFO issued *Fisheries Act* authorizations for the Project (Authorization # DA-11-1585-01; Authorization # DA-11-1585-A1; and Authorization # 14-HCAA-00582). The requirement for documentation and possible offsetting for any residual serious harm to fish that have arisen due to the Project was identified within the authorizations.

The following document is one of a series of reports listed below to address reporting requirements stipulated in the *Fisheries Act* authorizations. The report series is comprised of an assessment of Project-related effects determined from ongoing project monitoring, an offsetting plan in which the needs for offsetting measures are discussed, and a series of support volumes that summarize Project monitoring data collections and results by major ecosystem component (i.e., Physical Environment, Water Quality, Aquatic Habitat, and Fish). Reports and supporting volumes include the following:

- Assessment of Effects to Aquatic Habitat and Fish (AEHF)
- Offsetting Plan
- Physical Environment Supporting Volume (PESV; this volume)
- Water Quality Supporting Volume (WQSV)
- Aquatic Habitat Supporting Volume (AHSV)
- Fish Supporting Volume (FSV)

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4.0 PHYSICAL ENVIRONMENT

Sections within this supporting volume are numbered to match the corresponding section within the "Effects to Aquatic Habitat and Fish " document.

4.1 INTRODUCTION

4.1.1 Project Background

Widespread record flooding throughout southern Manitoba during 2011 led to water levels in Lake Manitoba and Lake St. Martin that were several feet higher than desirable, resulting in significant damage to hundreds of properties, restricted road access to several communities, and long-term evacuation of four First Nations communities in the vicinity of Lake St. Martin. As part of emergency relief measures, the Province of Manitoba, through Manitoba Infrastructure and Transportation (MIT), constructed the Lake St. Martin Emergency Outlet Channel System, which is comprised of two emergency channels (Figure .1-1).

The Reach 1 Emergency Outlet Channel (Reach 1) begins at the northeast shore of the north basin of Lake St. Martin and extends approximately 6 km to the bog area surrounding Big Buffalo Lake. Water from Reach 1 inundates the bog area and then follows the natural Buffalo Creek drainage until flowing into the lower Dauphin River and ultimately into Sturgeon Bay (Figure 4.1-1). Water began to flow through Reach 1 on 01 November 2011 and the channel was operated until 21 November 2012.

Computer models of potential water levels at the mouth of the Dauphin River indicated that there was a significant risk of major flooding of the Dauphin River communities in spring 2012. Consequently, a second channel (Reach 3 Emergency Channel; Reach 3) was constructed during winter 2011/2012. Reach 3 was designed to divert excess flow from Reach 1 and Buffalo Creek and away from the lower Dauphin River. Due to extremely mild winter conditions in 2011/2012, ice effects on both Reach 1 and the Dauphin River were much less severe than forecasted. Consequently, the proposed operation of Reach 3 was no longer required.

Heavy precipitation during winter 2013/2014 and spring 2014 again elevated water levels in Lake Manitoba and Lake St. Martin, prompting MIT to re-open Reach 1 at the beginning of July 2014. The channel was re-opened in two stages. The first occurred during in July 2014 when approximately 35 m of the berm closing Reach 1 was removed. The second stage occurred in November 2014, when an additional 10 m of the closure berm were removed to allow additional flow into the channel. Reach 1 currently remains in operation, and will remain so until at least 15 June 2015.

Collectively, construction and operation of Reach 1, as well as construction of Reach 3, are referred to hereafter as "the Project". Phases of the Project are defined as: Pre-Operation (up to 31 October 2011 and includes Historical and 2011 Flood periods), 2011/2012 Operation (01 November 2011 to 21 November 2012); 2011/2012 Closure (22 November 2012 to 04 July 2014); and 2014/2015 Operation (began 04 July 2014, and is ongoing).

Concurrent with construction of Reach 1 in summer 2011, MIT initiated studies and monitoring to help describe and assess environmental effects arising from the Project. These included studies to document changes to the physical environment (e.g., measurement of water flow through Reach 1 and the Dauphin River; sedimentation and erosion studies) and possible subsequent effects to the biological environment (e.g., possible change to fish community in Buffalo Creek). Environmental studies began in August 2011 and remain ongoing.

4.1.2 Study Area

The emphasis of aquatic monitoring is to determine what effects construction and operation of Reach 1 may have had on waterways downstream of the channel. These include the Buffalo Creek watershed (comprised of Big Buffalo Lake and the surrounding bog complex, and Buffalo Creek), the lower reach of the Dauphin River, and the southwest portion of Sturgeon Bay. However, these waterways are also affected by conditions occurring upstream of Reach 1 and, in some instances, fish move between areas upstream and downstream of Reach 1 (especially important is the movement of Lake Whitefish from Sturgeon Bay to spawning areas in Lake St. Martin). Consequently, some components of the aquatic monitoring program include waterways upstream of Reach 1.

Data analyses for the physical environment were divided spatially by Project area as follows:

- Lake St. Martin;
- Reach 1 and the Buffalo Creek watershed. For the purposes of sediment transport modeling, this area was sub-divided into three areas, including:
    - Reach 1;
    - The Bog Complex surrounding Big Buffalo Lake; and,
    - Buffalo Creek.
- The Dauphin River, which was subdivided into the upper Dauphin River (defined as the Dauphin River upstream of its confluence with Buffalo Creek) and the lower Dauphin River (defined as the Dauphin River downstream of Buffalo Creek to Sturgeon Bay; and,
- Sturgeon Bay.

4.1.3 Purpose of the Document

Hydrometric data, ice processes, water quality, vegetation cover, erosion, and sedimentation were characterized and compared between project phases to identify the potential impacts related to the construction and operation of Reach 1.

This volume is intended to compliment the “Lake St. Martin Emergency Outlet Channel - Assessment of Effects and Development of Offsetting: Assessment of Effects to Aquatic Habitat and Fish” document.

Figure 4.1-1. Location of the Reach 1 Emergency Outlet Channel, the Reach 3 Emergency Channel, and the Buffalo Creek watershed in relation to Lake St. Martin, the Dauphin River and Sturgeon Bay.

4.2 ASSESSMENT APPROACH

The characterization of the physical environment during each phase of the project is based on studies and monitoring programs initiated to document changes to the physical environment. A brief overview of the physical processes assessed within this volume is listed below. The details of each component, including a summary of the data collected, methods, analysis, and results are discussed individually for each reach of the system in Sections 4.3 to 4.6 of this report.

4.2.1 Data Sources

Hydrometric data, ice processes, water quality, vegetation cover, erosion, and sedimentation were characterized and compared between project phases to identify the potential impacts related to the construction and operation of Reach 1. A brief overview of these data sources is listed below.

Hydrometric Data – Water level data were collected during discrete periods on Reach 1, Big Buffalo Lake and Buffalo Creek starting in the fall of 2012 and continued through the 2014/2015 Operation. Periodic flow metering events were conducted on Reach 1 during the 2011/2012 and 2014/2015 Operation, and at a station in the lower reach of Buffalo Creek (BCTM) during the closure period. The hydrometric data were used to compute daily flows and was incorporated into the analyses and the numerical modeling.

Ice Processes – Ice reconnaissance surveys were also conducted along the Reach 1 System emphasizing on the upper Dauphin River. The purpose of the survey was to assess the ice conditions in the Dauphin River and to confirm the location and type of ice cover that caused restrictions in flows on the Dauphin River at the outlet of Lake St. Martin. Information on the ice conditions is necessary to determine winter discharges in the Dauphin River. Two surveys were conducted for this study; on December 20, 2012 and December 12, 2013. The surveys were conducted by helicopter and documented with photos while flying over the Reach 1 System.

TSS/Turbidity Data – Water samples were collected along the length of the Reach 1 System (includes Big Buffalo Lake, Buffalo Creek and the Lower Dauphin River), and regionally in water bodies and watercourses within the drainage basin from the beginning of Reach 1 construction, during the 2011/2012 Operation, and continued post closure through 2013 until freshet 2014 and again during the 2014/2015 Operation. Water samples were analyzed for general water quality parameters to determine potential impacts of the Project on the aquatic ecosystem. Turbidity and Total Suspended Solids (TSS) data were incorporated into the analyses and modeling of the physical environment.

Buffalo Creek Vegetation Cover Survey – A vegetation cover survey was conducted prior to the 2011/2012 Operation and in the summer of 2013 to assess the effects to the vegetation cover and riparian community as well as erosion along Buffalo Creek following operation of Reach 1. Results were compared between the pre- and post-operation surveys. A follow-up survey was conducted in June 2014 to estimate the vegetation cover regrowth along Buffalo Creek after a full growing season. Additionally, the 2014 survey examined areas of large woody debris and stands of potentially dead trees along Buffalo Creek to assist MIT in determining the extent of trees and woody debris that could fall into the stream and be washed downstream during potential future operation of Reach 1.

Buffalo Creek Cross Section Survey – Cross section surveys were conducted in 2011 and 2013 at 30 established transect locations along Buffalo Creek to compare pre- and post- operation conditions. These data were used to identify and measure areas of erosion and deposition along Buffalo Creek resulting from the 2011/2012 Operation. Results of the survey were also compared to the modeling results.

Dauphin River Bathymetric Survey – Bathymetric surveys of the Dauphin River were conducted prior to, during, and after the 2011/2012 Operation of Reach 1. Surveys aimed to assess impacts of the Project on the Dauphin River, in particular identifying potential areas of erosion and deposition and associated effects on fish habitat in the lower Dauphin River. Surveys emphasized the area extending from slightly upstream of the confluence with Buffalo Creek and downstream into Sturgeon Bay. Results of the survey were also compared to the modeling results.

Hydraulic and Sediment Transport Modeling – Numerical modeling was conducted to analyze flow patterns and trends in sediment transport, as well as to identify areas with a potential for sediment erosion and deposition along the Reach 1 System, including Reach 1, Buffalo Creek and Dauphin River, prior to, during and after the 2011/2012 Operation and during the 2014/2015 Operation of Reach 1. Three different models were used for the analysis, including a spreadsheet calculation model (“empirical” model) of the Reach 1 System, a 1-Dimensional (1D) HEC RAS Sediment Transport model of Buffalo Creek, and a 2-Dimensional (2D) hydraulic and sediment transport model of the Lower Dauphin River. Together, the models were used to identify areas of potential deposition and/or scour and estimate sediment load along the Reach 1 System to determine potential impacts as well as identify sediment transport trends.

Sedimentation Rate – Sediment traps were used to measure sedimentation rates in Sturgeon Bay throughout a variety of seasons during 2011/2012 Operation, 2011/2012 Closure, and 2014/2015 Operation.

4.2.2 Data Collection and Analysis

4.2.2.1 Hydrometric Data and Ice Processes

Hydrometric data were collected along the Reach 1 System to support the sediment transport models discussed in this report. Hydrometric data that were collected prior to November 2012 during operation of Reach 1 was obtained from the Analysis & Monitoring of Discharges & Ice Processes Report (KGS Group, 2014) of the Emergency Reduction of Lake Manitoba and Lake St. Martin Water Levels Project. This includes:

- Flow metering events on Reach 1 during operation;
- Water level measurements along the Reach 1 System during winter of 2011/2012; and,
- Ice reconnaissance survey of the Dauphin River during the winter of 2011/2012.

As part of the Project, a hydrometric monitoring program was conducted to obtain water level and discharge data along the Reach 1 System. This program included the following components:

- Installation of an array of pressure loggers in Reach 1, Buffalo Lake and Buffalo Creek to obtain a continuous recording of water levels and document changes in water level during the 2011/2012 Operation, 2011/2012 Closure and 2014/2015 Operation;
- Flow metering events on Reach 1 and Buffalo Creek to use in conjunction with the water level records to develop a flow record along the Reach 1 System during the 2011/2012 Operation, 2011/2012 Closure and 2014/2015 Operation; and,
- Ice reconnaissance survey of the Dauphin River in December 2012 and in December 2013.

A temporary hydrometric station on Buffalo Creek was set-up on May 14, 2013 at sample station BC-TM (Figure 4.2-1). The location of BC-TM was selected to be a sufficient distance upstream of the Dauphin River where the backwater effects were determined to be negligible. At the sample station, HOBO pressure loggers (Model U20-001-01, Onset Corporation) were installed to obtain a continuous recording of water levels at a 15 min interval. Data recorded by the water level loggers were then processed and adjusted with data from barometric loggers installed on the shore.

Flow meterings were conducted on Reach 1 between November 2011 and November 2014. Flows were recorded using a Teledyne RDI RiverRay – 600 kHZ Acoustic Doppler Current Profiler (ADCP). The ADCP was either connected to a boat or to the cableway system that was installed approximately 2 km downstream from the inlet of Reach 1. Flow readings at Reach 1 occurred on the following dates:

- November 18, 2011 following the opening of Reach 1 (2011/2012 Operation);
- March 21, April 17, and August 9, 2012 during operation of Reach 1 (2011/2012 Operation);
- November 15, 2012, immediately prior to closure Reach 1 (2011/2012 Operation);
- September 6, 2014 (2014/2015 Operation); and,
- November 18, 2014 (2014/2015 Operation).

The data listed above were supplemented with flow metering data conducted by MIT during the 2014/2015 Operation.

Flow metering was also carried out on Buffalo Creek at the BC-TM sample station using a Sontek Flow Tracker Acoustic Doppler Velocimeter (ADV) or the ADCP equipment on the following dates:

- May 14, 2013, during the spring freshet (2011/2012 Closure);
- August 14, 2013 (2011/2012 Closure);
- October 16, 2013 (2011/2012 Closure);
- May 15, 2014 (2011/2012 Closure); and,
- June 17, 2014, prior to the re-opening of Reach 1 (2011/2012 Closure).

Collection and processing of the flow metering data followed the widely accepted Water Survey of Canada (WSC) (Water Survey of Canada 1999; 2004) and United States Geological Survey (USGS; 2006; 2009) Guidelines for hydrometric surveys. On two occasions at the BC-TM station, the ADV was selected over the ADCP due to the shallower depth and lower flows that were present in the creek during the survey. In October 2013, a flow metering was also conducted using ADCP equipment to compare with the results of the ADV Flow Tracker.

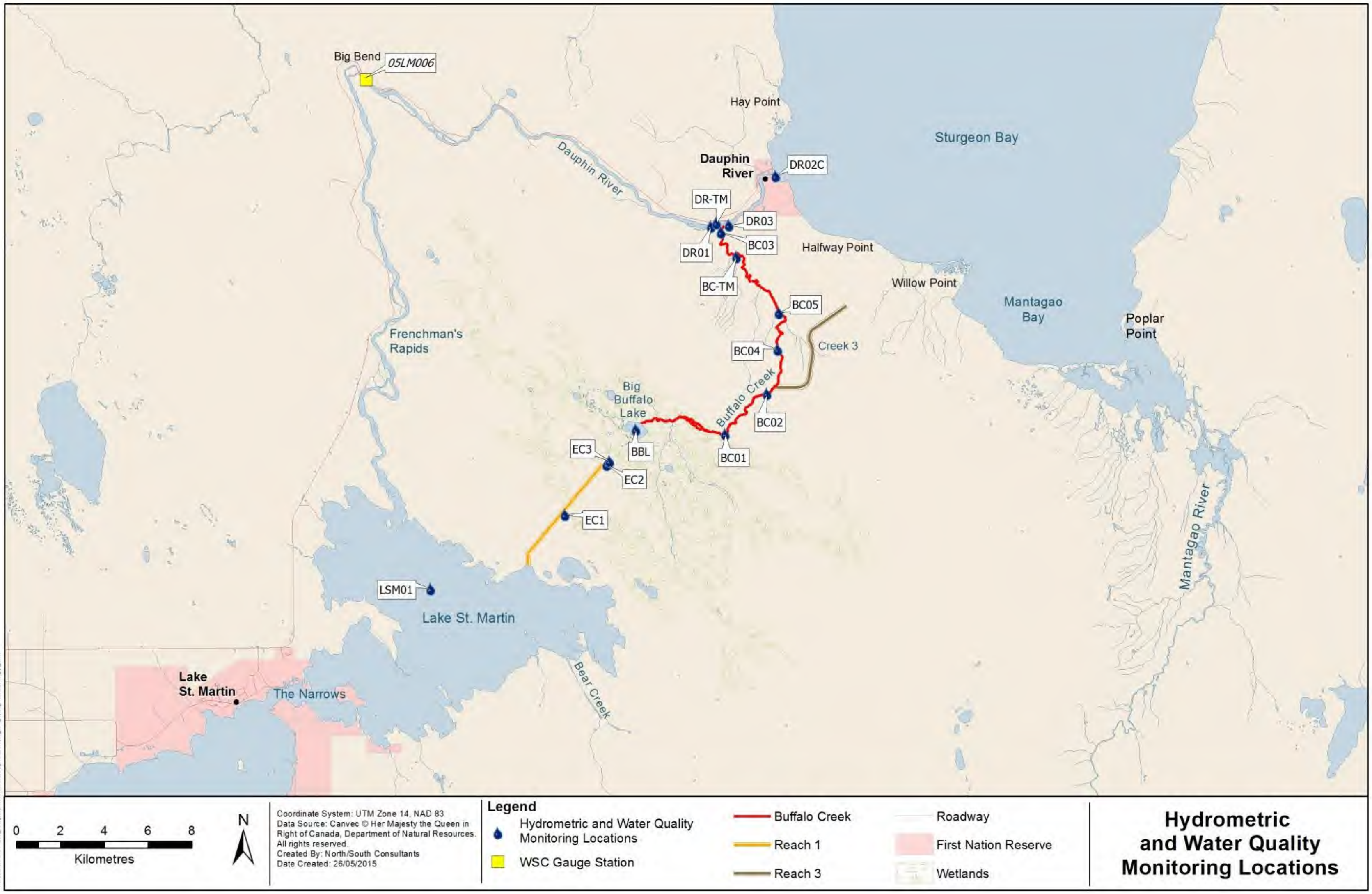

Figure 4.2-1. Hydrometric monitoring locations.

On Dauphin River, hydrometric daily flow records are available from WSC at the hydrometric station No. 05LM006 (Dauphin River near Dauphin River). A field program to collect hydrometric data on the Dauphin River was therefore not necessary for this study. The location of the WSC gauge on Dauphin River is shown on Figure 4.2-1.

4.2.2.2 TSS/Turbidity Data

Water quality monitoring of the Reach 1 System has been ongoing since early construction of Reach 1. Monitoring sites were established in Lake St. Martin, Reach 1, Big Buffalo Lake, Buffalo Creek and the Lower Dauphin River beginning upstream of the confluence with Buffalo Creek and the mouth of the river at Sturgeon Bay (Lake Winnipeg). Methods and data for water quality monitoring are provided in the Water Quality Supporting Volume. Analytical TSS data and *in situ* turbidity data collected as part of this monitoring were used to aide in determining the extent of suspended solids moving through the system and ultimately contributing to sediment inputs in the lower Dauphin River and downstream into Sturgeon Bay. In 2012, turbidity was added to the analytical data so that it could be correlated with *in situ* turbidity data measured in the field, and to potentially provide an alternate estimation of impacts from suspended solids.

The locations of the water quality monitoring sites are shown on Figure 4.2-1. Figure 4.2-1 has a greater number of monitoring sites than was presented in the Water Quality Supporting Volume. This is because additional sample stations were used, particularly along Buffalo Creek, which were not essential to describe changes in general water quality parameters (aside from TSS/turbidity) throughout the system.

Turbidity meters were installed within Buffalo Creek for a short period between October 26 and November 13, 2012 and within Buffalo Creek and the lower Dauphin River in 2013 and 2014 to collect long-term *in situ* data between the discrete water quality monitoring sampling events. Water quality data were also collected and analyzed at each turbidity meter location to verify the long-term *in situ* data and compare the turbidity readings to analytical data for TSS in support of the sediment transport analysis data. The 2013 Buffalo Creek Turbidity Meter (BC-TM) location was selected, as it was determined to be a sufficient distance upstream of the Dauphin River to avoid backwater effects during monitoring (monitoring station BC-TM in 2013 was approximately 700 m downstream of the 2012 location). The Dauphin River Turbidity Meter (DR-TM) location was selected upstream of the confluence with Buffalo Creek to provide background conditions. An initial visual survey of site conditions was completed to select suitable locations to install the turbidity meters including stable banks and channel bottoms as well as sufficient depth and flow.

Daily TSS records were computed for each phase of the project from the discrete TSS data and continuous data collected by the turbidity loggers, and converted to TSS with a relationship established between turbidity and TSS. To assess the potential relationships between turbidity and TSS, the long-term *in situ* turbidity data were imported into an excel spreadsheet for processing and data analysis. It was assumed that the laboratory analyzed turbidity would be more accurate than the turbidity meter data and, therefore, a relationship was developed to adjust the long-term *in situ* turbidity data. The adjustment factor was calculated using the average difference between the laboratory analyzed turbidity value and the measured value from the turbidity meter at the nearest time.

Separate correlations were developed between the TSS and turbidity data from each one of the turbidity loggers to compute continuous series of TSS data, based on the continuous records of turbidity. The continuous series of TSS were then used as input for the various sediment transport models described in Section 4.2.1.6.

4.2.2.3 Buffalo Creek Vegetation Cover Survey

Vegetation cover was examined along Buffalo Creek before and after the 2011/2012 Operation of Reach 1. Initially the vegetation survey was conducted to provide information that was incorporated into models to estimate flow and sediment along the creek once Reach 1 was opened in 2011. A survey was conducted in 2013 (post-operation) to estimate changes to riparian vegetation and erosion/deposition along the banks of the creek. A second post-operation/follow-up survey was conducted in 2014 primarily to document potential improvements after a full growing season. This was done to complement the data previously collected in 2013, which occurred in early July after a late spring (ice cover on the creek in May) following the closure of Reach 1 in November 2012. The 2014 survey also served as a pre-operation phase baseline for 2014/2015 Operation of Reach 1.

Thirty-one (31) vegetation survey transects were completed between stations 13+000 and 28+000 (see Figure 1 in Appendix 4.A). Transects were situated every 500 m along the length of the creek and spanned 100 m on each side of the creek. The following was recorded at each transect: transect orientation, start and end points, general description of cover types (e.g. bare, grass, shrub, trees), start and end distance of each cover type within the transect, and depth of soil organic layer. Methods and detailed results are discussed within Field Inspection Forms, and photographs are included that compare changes observed between surveys (Appendix 4.A). A brief description of change observed between the three surveys is provided below.

4.2.2.4 Buffalo Creek Cross Section Survey

A geodetic topographic survey of 30 cross-sections on Buffalo Creek was conducted prior to and after the 2011/2012 Operation of Reach 1. The 2013 survey was completed between July 3 and 7 and was conducted at the same location as the 30 cross sections that were initially surveyed in October 2011 prior to operation of Reach 1. The purpose of these surveys was to compare pre- and post-operating conditions in Buffalo Creek. Plans showing the location of the cross sections are provided on Figure 4.2-2. Comparisons of the 2013 cross sections (post 2011/2012 Operation) to the 2011 cross sections (Pre-2011/2012 Operation) are discussed in Section 4.4. GAIM imagery collected in 2011 and in 2013 was also used to support the cross section survey comparison. The comparison of the 2011 and 2013 GAIM imagery is also discussed in Section 4.4.

The thirty transects were surveyed at approximately 500 m intervals along Buffalo Creek. Each transect extended a minimum of 100 m from the centerline of the creek. The upstream limit (Sta. 13+000) had been previously established based on accessibility as this station is near the edge of the bog area surrounding Big Buffalo Lake. The downstream limit of the survey investigation (Sta. 27+500) is approximately 150 m upstream of the confluence with the Dauphin River.

Figure 4.2-2. Location of HEC-RAS model cross sections.

The survey information was completed in Universal Transverse Mercator (UTM) NAD83 CSRS and NAD 83 Zone 14 projection and using the CGVD28 Datum for the determination of all orthometric heights for elevation datum. The survey was captured using Global Positioning System (GPS) Real Time Kinematic (RTK) style surveying and a total station. Geodetic project control benchmarks were established using a GNSS L1/L2 GPS receiver to collect the static data and static occupations on control networks were performed by L1/L2 dual constellation (GPS and GLONASS) receivers using post-processing procedures and confirmed using data from the Canadian Active Control System (CACS) available online. The absolute accuracy of the control networks are +/- 2.0 cm (horizontal) and +/- 2.0 cm (vertical) and the relative precision of each section is 0.01 m.

At section 21+560 and section 24+203, field conditions were such that the surveyed cross sections in 2013 could not follow the exact alignment of the 2011 survey. At those locations, new survey pins were installed, and the section alignment was re-established.

It should be noted that during both the 2011 and 2013 surveys, a layer of peat was present at the bottom of Buffalo Creek at many locations on either side of the riparian channel. Normal changes in the peat between survey events can result in slight differences when comparing cross sections.

The results of the cross section comparison are discussed in Section 4.4.4.

4.2.2.5 Dauphin River Bathymetry Survey

To help determine the effects of the Project on fish habitat or on navigation in the lower Dauphin River bathymetric surveys were conducted from slightly upstream of the confluence with Buffalo Creek to downstream into Sturgeon Bay. Bathymetric surveys of the entire Dauphin River were conducted in July 2011 (pre-operation), as well as of the lower Dauphin River in June 2012 (during operation), June/July 2013 and June 2014 (post closure of 2011/2012 operation).

Bathymetric surveys were conducted using a sonar device mounted on the rear of a boat. A Lowrance HDS-8 chartplotter computer was used to power and log sonar data from a dual transducer configuration using a survey grade narrow cone multi-beam sonar and a high frequency side scanner. The sonar point locations were referenced by linking the sonar unit to a survey grade Topcon Global Positioning System (GPS) RTK receiver. All controls established were set by completing a static GPS network for the entire project area and were referenced to known GPS 3D monuments set along PTH 6 from Lundar to Fairford and along PR 513. Survey data were typically collected along each river bank, the river centerline, and a crisscross pattern along the length of the Dauphin River where site conditions allowed.

2011 Survey Program

The 2011 survey program was undertaken along the Dauphin River during high flows occurring in the summer of the 2011 flood (July 1-4, 2011), prior to the operation of the Lake St. Martin Emergency Outlet Channel (Reach 1). The water condition along the Dauphin River was at bank full, the water surface elevation of Lake St. Martin at the Dauphin River inlet was at El. 245.1 m (804.1 ft) and the water surface elevation of Lake Winnipeg at the mouth of Dauphin River was at El. 218.5 m (716.9 ft). The Dauphin River flow at the time of the survey was approximately 570 m^3/s (20,100 cfs).

The 2011 bathymetry was completed from the inlet of the Dauphin River at Lake St. Martin to the mouth of the river at Lake Winnipeg, adjacent to the Dauphin River First Nation community. All rapids and natural water drops were fully submerged at the time of the bathymetric survey and a continuous survey was able to be conducted along the complete reach length. Access along the banks of the river was limited during the survey. Most of the banks could not be captured as unknown flow conditions were occurring at the river's edge, as well as the presence of trees and submerged vegetation.

2012 Survey Program

The 2012 survey program was undertaken along the Dauphin River from upstream of Buffalo Creek at Station 46+200 to the mouth of the river at Lake Winnipeg and including Sturgeon Bay. The survey occurred on June 18-20, 2012 during operation of Reach 1. The Dauphin River flow downstream of Buffalo Creek at the time of the survey was approximately 330 m^3/s (11,700 cfs). The water surface elevation of Lake Winnipeg at the mouth of the Dauphin River at the time of the bathymetric survey was at El. 217.7 m (714.2 ft). The focus of the survey was to capture the river bottom to develop river bottom contours, profile and river cross-sections where possible.

2013 Survey Program

The 2013 survey program was undertaken along the Dauphin River from upstream of Buffalo Creek near Big Bend at Station 25+200 to the mouth of the river at Lake Winnipeg including Sturgeon Bay. The reach located upstream of the Buffalo Creek confluence was surveyed on June 5-7, while the reach downstream from the Buffalo Creek confluence to the Lake was surveyed on July 22-23. The purpose of this survey was to measure and record river bottom contours after the closure of Reach 1, which occurred in November of 2012. The water surface elevation of Lake Winnipeg at the mouth of the Dauphin River at the time of the bathymetric survey was at El. 217.9 m (714.9 ft). The Dauphin River flow downstream of Buffalo Creek at the time of the July 22-23 survey was approximately 300 m^3/s (10,700 cfs).

2014 Survey Program

The 2014 survey program was undertaken along the Dauphin River from upstream of Buffalo Creek at Station 46+200 to the mouth of the river at Lake Winnipeg and including Sturgeon Bay. The survey occurred on June 17-21, 2014 during operation of Reach 1. The Dauphin River flow at the time of the survey was approximately 330 m^3/s (11,700 cfs). The water surface elevation of Lake Winnipeg at the mouth of the Dauphin River at the time of the bathymetric survey was at El. 218.0 m (715.2 ft).

4.2.2.6 Hydraulic and Sediment Transport Modeling

Numerical hydraulic and sediment transport models were developed to assess the conditions prior to, during and post-operation of Reach 1 System, as well as to evaluate the potential effects of the operations (2011/2012 and 2014/2015) on the erosion and sediment deposition processes in the study area, including Reach 1, Buffalo Lake, Buffalo Creek, Dauphin River, and Lake Winnipeg. To complete this analysis, the following three models were developed:

- An **Empirical Model** was developed based on field measurements of TSS and turbidity and computed flows. The model included all reaches of the system.
- A one-dimensional (1D) **HEC-RAS Hydraulic and Sediment Transport Model** of Buffalo Creek was developed using surveyed cross sections of the creek. The results were compared to the empirical model results as well as the Buffalo Creek Vegetation and Cross Section surveys.
- A Two-Dimensional (2D) **Hydraulic and Sediment Transport Model of the Dauphin River**, using DHI's MIKE 21 Hydrodynamic Model (HD) and the Mike 21 Mud Transport Module (MTM), was developed to analyze flow patterns on the Dauphin River, and to identify areas of potential deposition and/or scour along the river downstream of Buffalo Creek and in Sturgeon Bay. The Dauphin River flow pattern and sediment transport analysis is documented in Section 4.5. The results of the 2D model were compared to the Dauphin River bathymetric surveys discussed in Section 4.5 as well as the results from the empirical and Buffalo Creek sediment transport models.

Empirical Model

To help quantify erosion through Reach 1, Buffalo Creek and the lower Dauphin River reaches of the Reach 1 System, an Empirical Model was developed as an Excel spreadsheet program. The model estimates cumulative volumes of suspended sediment being carried out of each reach (sediment inflow), and is indicative of the extent of erosion and sediment deposition of the smaller particles that occurred within each reach.

The empirical model combines measured TSS concentrations, computed average daily TSS concentrations from turbidity logger data, and estimated discharges to calculate a daily volume of suspended sediment at a given location. Sediment concentrations were based on actual TSS measurements taken at various locations in the Reach 1 System prior to, during and post 2011/2012 Operation and during 2014/2015 Operation, and computed average daily TSS using the turbidity data collected by the long-term *in situ* turbidity meters. Discharges along the system were estimated based on a combination of observations, measurements, flow records and computations.

The empirical model assumed an average soil density value of 1400 kg/m^3. The *in situ* or pre-excavation unit weight of the soil material within the channel is estimated to range between 2000 kg/m^3 and 2200 kg/m^3 based on observations and engineering judgment. The post-construction surface within the limits of the channel was disturbed from the excavation process, resulting in a loose and more exposed material that would be more vulnerable to riverine erosion than the *in situ* intact material. It is difficult to estimate a representative *in situ* density that would account for this disturbance; however, the unit weight that could be representative of this disturbed material is anticipated to be variable and in the range of 1100 to 1800 kg/m^3, based on previous experience and judgment. A sensitivity analysis was carried out to evaluate the potential impacts from this variability, and the selected value of 1400 kg/m^3 is believed to be conservative.

Two monitoring locations were selected for the analysis along each reach. One location was selected near or at the upstream end to capture "baseline" conditions prior to entering the reach. The second location was selected near the downstream end to capture "exit" conditions prior to exiting the reach. The net suspended sediment volume balance within a reach was assumed to be the difference in suspended sediment volume between exit conditions and baseline conditions. Figure 4.2-1 shows the location of these monitoring locations.

To estimate the actual effects of the operation of Reach 1, cumulative suspended volumes were also calculated using the daily flows computed for the Dauphin River and Buffalo Creek, if Reach 1 had not been operated. The flows in Dauphin River would have been greater than during the operation, therefore transporting a greater volume of suspended sediment originating from Lake St. Martin. The comparison of the cumulative volume with and without operation of Reach 1 is anticipated to provide the best estimate of the actual effects of the system at the exit of Buffalo Creek.

Reach 1

Baseline conditions in Reach 1 were based on TSS concentrations measured in Lake St. Martin (LSM1). During both operations of Reach 1 (2011/2012 and 2014/2015), it was assumed in the model that the TSS concentrations measured in the lake were representative of baseline conditions at the entrance of Reach 1. However, under normal conditions, the TSS concentrations measured in a standing body of water (i.e. Lake St. Martin) are generally lower than those in a moving body of water (i.e. Reach 1) and; therefore, this assumption was deemed conservative for this analysis.

Prior to January 17, 2012, TSS concentrations in Reach 1 were based on measurements taken at monitoring location EC1 that is situated near the midpoint between the Reach 1 inlet and Buffalo Lake bog. Data were not collected at the end of Reach 1 at monitoring location EC2 and EC3 until this date and, therefore, could not be used in the model. As a result, the net suspended sediment volume balance calculated in the model up to this point may not be completely indicative of what occurred throughout Reach 1 in 2011/2012. However, since Buffalo Creek is located downstream of Reach 1, any potential erosion or deposition occurring between monitoring location EC1 and EC2 would contribute to the baseline measurements on Buffalo Creek and is captured elsewhere in the model.

After January 17, 2012, exit conditions in Reach 1 were based on measurements taken at monitoring location EC2 that is situated at the end of Reach 1. Measured and estimated daily concentrations and the estimated balance of suspended sediment volumes after this date are therefore indicative of actual conditions in Reach 1.

Buffalo Creek

Prior to January 17, 2012, conditions near the upstream end of Buffalo Creek were based on measurements taken at monitoring location BC2, which is situated approximately 2 km downstream of the Buffalo Creek Inlet. Data were not continuously collected at monitoring location BC1 until this date and, therefore, could not be used to model conditions at the upstream end of Buffalo Creek. As a result, the net suspended sediment volume balance calculated in the model up to this point may not be completely indicative of what occurred throughout Buffalo Creek. However, observation made after January 17, 2012 showed that conditions at BC2 were similar to those at BC1. As such, it was likely that conditions observed at BC2 were representative of baseline conditions in Buffalo Creek.

After January 17, 2012, conditions at the upstream end of Buffalo Creek were based on measurements taken at monitoring location BC1. Measured and estimated daily concentrations and estimated daily volumes after this date are indicative of actual conditions in the entire creek.

Exit conditions in Buffalo Creek were based on measurements taken at monitoring location BC3 and BC-TM. BC3 is situated on Buffalo Creek immediately upstream of the confluence with the Dauphin River, while BC-TM is situated an additional 2 km upstream of BC3 (to avoid the backwater effects of the Dauphin River for hydrometric data collection). BC-TM was used, once the turbidity meter was installed on May 14, 2013, because it provides a daily average value of TSS (based on Turbidity) rather than discrete sampling events and is representative of the exit of Buffalo Creek.

Dauphin River

Baseline conditions in the Dauphin River during and post operation of Reach 1 were based on measurements taken at monitoring location DR1 and DR-TM. DR1 was situated in the nearest accessible open water location on the south shore of the Dauphin River, approximately 500 m upstream of the confluence of Buffalo Creek and the Dauphin River (Figure 4.2-1). DR-TM is located on the north shore of the Dauphin River, approximately 200 m upstream of the confluence of Buffalo Creek and the Dauphin River. DR-TM was used, once the turbidity meter was installed on May 14, 2013, because it provides a daily average value of TSS (based on Turbidity) rather than discrete sampling events and is representative of the baseline conditions on the Dauphin River.

Exit conditions in the Dauphin River were based on measurements taken at monitoring location DR2, which was situated on the Dauphin River downstream of the confluence of Buffalo Creek and the Dauphin River.

<u>HEC-RAS Sediment Transport Model of Buffalo Creek</u>

A HEC-RAS V.4.1.0 from the US Army Corps of Engineers backwater model was developed to simulate the hydraulic conditions on the reach of river between Big Buffalo Lake and Dauphin River. Hydraulic parameters resulting from the HEC-RAS model were used in a theoretical analysis of the potential for erosion and sediment deposition along Buffalo Creek. A numerical Sediment Transport model of Buffalo Creek was also developed using the sediment transport subroutine in the program HEC-RAS.

Model Description

The geometry of the HEC-RAS model utilized cross sections obtained from a combination of LiDAR and surveyed cross sections prior to the 2011/2012 Operation of the channel. The surveyed cross sections were located approximately 500 m apart, as shown on Figure 4.2-2. Additional cross sections were interpolated at approximately 75 m intervals to improve the numerical stability of the model. Additional cross sections were also added on the upstream end of the model to reach steady conditions outside of the study area.

A daily flow hydrograph of Buffalo Creek was used as upstream boundary condition for the HEC-RAS backwater model. A normal water depth of flow, based on a slope of 0.001, was applied as downstream boundary condition. A one day time-step was selected to optimize model stability and computational time.

Hydraulic Model Calibration

A Manning's 'n' value of 0.03 for the main channel and 0.08 for the overbank sections was selected based on knowledge of the channel characteristics and engineering judgment. Figure 4.2-3 shows the simulated water surface profile along with the 2014 surveyed water levels associated with a river flow of approximately 113 m³/s (4000 cfs). The comparison of the water surface profiles shows that there is good agreement between simulated and surveyed water levels, and that the selected channel roughness values are suitable for this application.

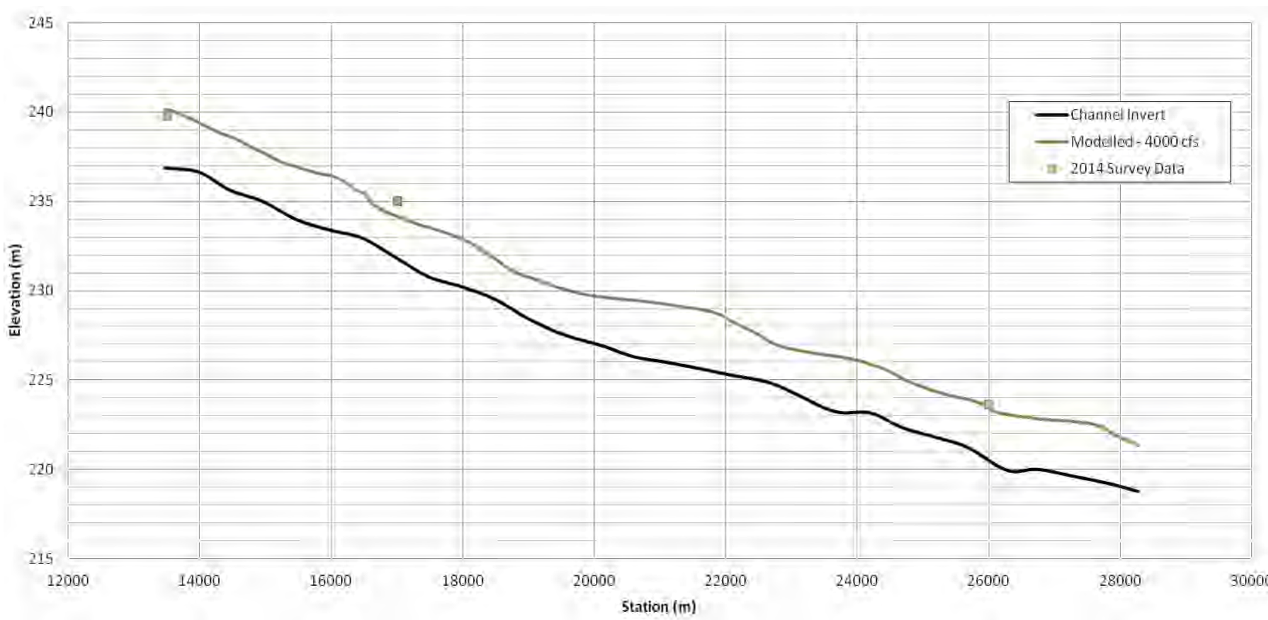

Figure 4.2-3. Simulated water surface profile for Buffalo Creek in 2014.

An analysis was completed to test the model's sensitivity to changes in channel roughness. The model was simulated for a range of channel and overbank roughness values smaller and greater than the selected values previously identified. The analysis indicated that although changes in channel roughness result in a notable change in water levels, resultant changes to velocities and shear stress were not sufficient to impact the results of the sediment transport analysis discussed in the subsequent sections of this report. Since the purpose of the model is to conduct a sediment transport analysis and define the potential for erosion in Buffalo Creek, and not on defining water levels, further refinements to the model calibration was not necessary.

Theoretical Analysis of erosion and sediment deposition processes

The initiation of particle movement occurs when the shear stress in the channel exceeds the critical shear stress of the particle in place. The U.S. Geological Survey (USGS) has published theoretical critical shear values for a range of sediment grain sizes (USGS, 2008). The values used for this analysis are shown in Table 4.2-1.

Table 4.2-1. Critical shear stress for erosion.

Class	Diameter (mm)	Minimum Critical Shear Stress for Erosion (N/m²)
Clay	0.002 - 0.005	-
Silt	0.005 - 0.075	0.03
Sand	0.075 - 4.75	0.11
Gravel	4.75 - 75	3.3
Cobble	75 - 250	64

Shear stress is a function of the river bed roughness, water depth and flow velocity. Therefore, potential for sediment erosion and deposition can also be determined by comparing flow velocities in the channel to critical velocities for erosion and deposition of particles, such as defined by Hjulstrom and provided on Figure 4.2-4. The Hjulstrom curve takes into account the cohesive properties of clay and silt particles, resulting in increasing critical erosion velocities with decreasing grain sizes for very small materials. However, as discussed previously, the clays and silts in Buffalo Creek are mostly non-cohesive in nature and will likely start eroding before sand and gravel particles. Therefore, Hjulstrom's critical erosion velocities for silts and clays were excluded from the analysis. Values from the Hjulstrom curve corresponding to the grain classes used for this analysis are shown in Table 4.2-2.

Minimum, median and maximum flows during the project phases were simulated with the HEC-RAS model with steady state conditions. Average shear stress and velocities obtain from the model results were compared to the critical values for deposition and erosion for each class of material. Results in the overbanks of the creek were analyzed separately from results in the main channel due to the wide range of expected values within a cross section. Results of the theoretical analysis of the potential for erosion and sediment deposition based on the Buffalo Creek HEC-RAS model are discussed in Section 4.4.

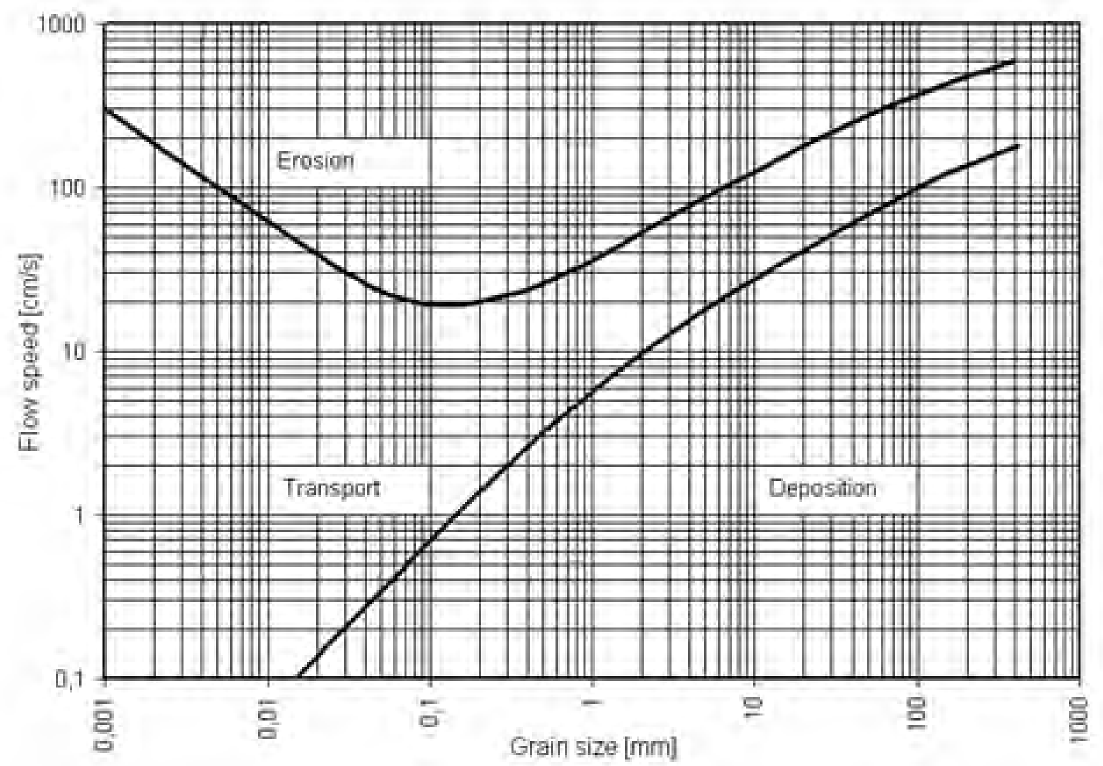

Figure 4.2-4. Hjulstrom curve.

Table 4.2-2. Critical velocity for deposition and erosion.

Class	Diameter (mm)	Maximum Critical Velocity for Deposition (m/s)	Minimum Critical Velocity for Erosion(m/s)
Clay	0.002 - 0.005	<0.001	-
Silt	0.005 - 0.075	0.005	-
Sand	0.075 - 4.75	0.18	0.2
Gravel	4.75 - 75	0.85	0.85
Cobble	75 - 250	1.5	3.2

2D Hydrodynamic Model

To study the changes to the physical environment and the possible subsequent effects to the biological environment in the Lower Dauphin River and Sturgeon Bay, a 2D hydrodynamic model was developed to numerically investigate the flow patterns in the Lower Dauphin River and identify areas with a potential for erosion and sediment deposition.

Model Description

The MIKE 21 software with Flexible Mesh (MIKE 21), developed by DHI Group in Denmark, is a two dimensional model simulating free surface flows. The model solves the depth-averaged 2D Navier-Stokes equations using a cell-centered finite volume solution technique to simulate flows in rivers, lakes, estuaries, bays, coastal areas, and overland flooding. MIKE 21 FM is a commercial software widely used in the industry in North America with many possible applications in river engineering.

The MIKE 21 model encompasses a reach of the Lower Dauphin River located between Station 47+800 (Upstream of Buffalo Creek) to Station 53+200 (in Sturgeon Bay) as shown in Figure 4.2-5. The digital elevation model (DEM) was built with data obtained from different sources. The bathymetry data in the Dauphin River and Lake Winnipeg were derived from the sonar survey data collected in 2011 and 2012. The topographic data outside of the river and the lake were obtained from the LiDAR data completed in June/July 2011. The integrated DEM for 2011 includes the river bathymetry data based on a sonar survey in 2011 and the LIDAR data completed in 2011. The DEM for 2012 was built based on the river bathymetry sonar survey in 2012 and the LIDAR data completed in 2011.

Figure 4.2-5. Extents of MIKE 21 model.

The computational mesh was diligently designed with a combination of quadrangular and triangular elements. The quadrangular mesh was only used in Buffalo Creek to adequately represent the narrow river channel, while the triangular mesh was applied to the rest of the study area. A refined mesh was used on Buffalo Creek, the Dauphin River and Sturgeon Bay. A coarser mesh was used in Lake Winnipeg away from shore.

Once the appropriate mesh sizing was established, the digital elevation data exported from the digital elevation model (DEM) were imported into the MIKE 21 model for mesh interpolation. Mesh interpolation is the process of draping the computational mesh onto the topographic and bathymetric data to assign the elevation data to the mesh. The mesh development incorporated the features captured in the DEM to facilitate the interpolation of the DEM to the mesh. The model geometry for the 2011 and 2012 MIKE 21 models were developed based on the DEM of the corresponding year. Figure 4.2-6 shows the mesh development and the location of model boundaries in the study area.

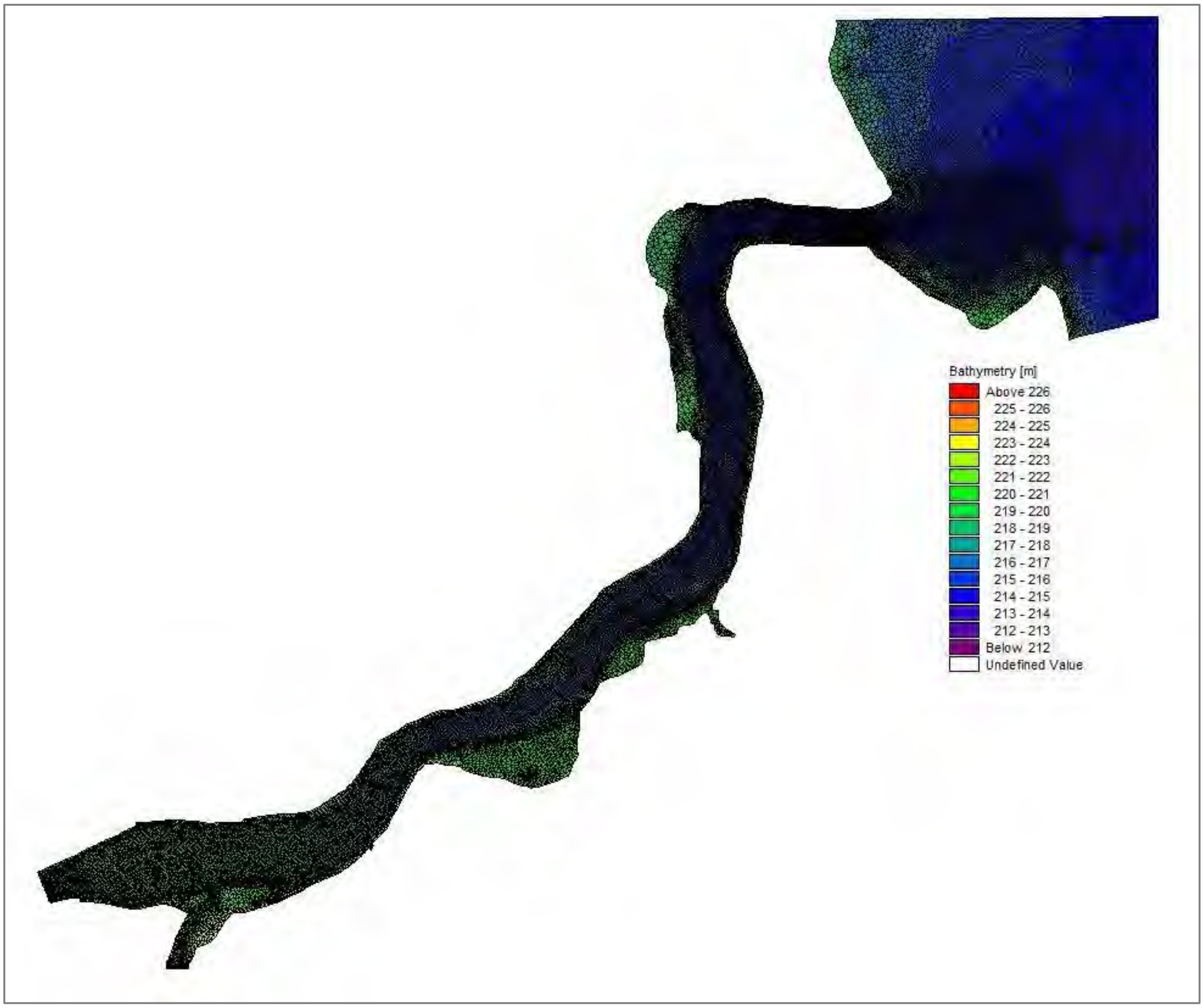

Figure 4.2-6. Computational mesh and boundary conditions of MIKE 21 model.

The upstream boundary conditions of the MIKE 21 model consisted of inflow hydrographs at the on Dauphin River and Buffalo Creek. A water level was applied at the downstream boundary of the model on Lake Winnipeg.

Model Calibration

The MIKE 21 model was calibrated to the hydraulic conditions observed during the summer of 2011 and 2012. The riverbed roughness coefficient (Manning's n) distribution in the model was adjusted in the study area to represent the July 2, 2011 and June 20, 2012 conditions, defined as follows:

July 2, 2011

- Dauphin River inflow of 568 m^3/s, as recorded at the WSC hydrometric Station 05LM006;
- Buffalo Creek inflow of 2 m^3/s, assumed in the absence of available data; and,
- Lake Winnipeg Water Level at El. 218.17 m (surveyed data).

June 20, 2012

- Dauphin River inflow of 215 m^3/s, as recorded at the WSC hydrometric Station 05LM006;
- Buffalo Creek inflow of 122 m^3/s, as computed with the routing model of Reach 1 System; and,
- Lake Winnipeg Water Level at El. 217.74 m (surveyed data).

Surveyed water levels on these dates were compared with the simulated water surface profiles from the MIKE 21 model with various roughness coefficients ranging from 0.016 to 0.020, as shown on Figures 4.2-7 and 4.2-8. The simulated water levels using a Manning's number of 0.018 were determined to give the best representation of the surveyed conditions in July 2011 and June 2012.

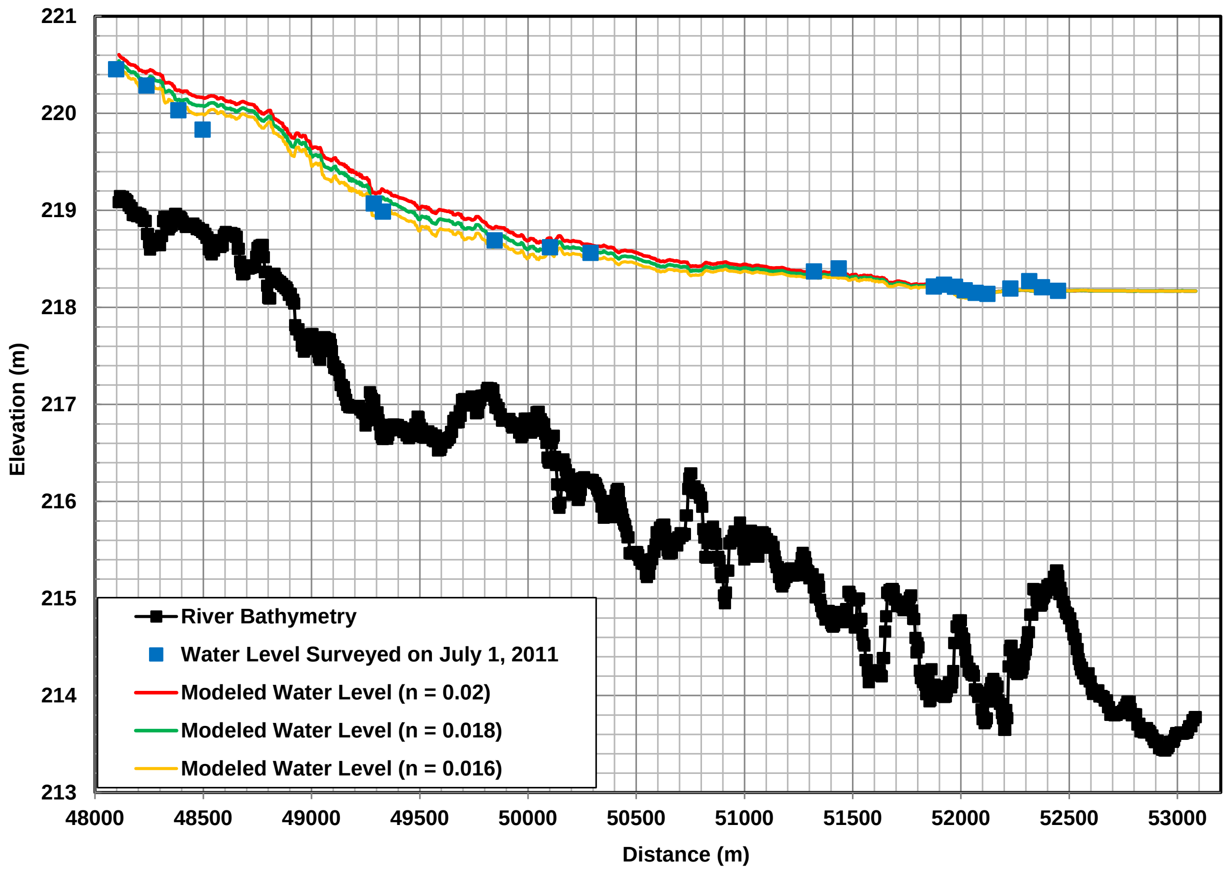

Figure 4.2-7. Computational mesh and boundary conditions of MIKE 21 model.

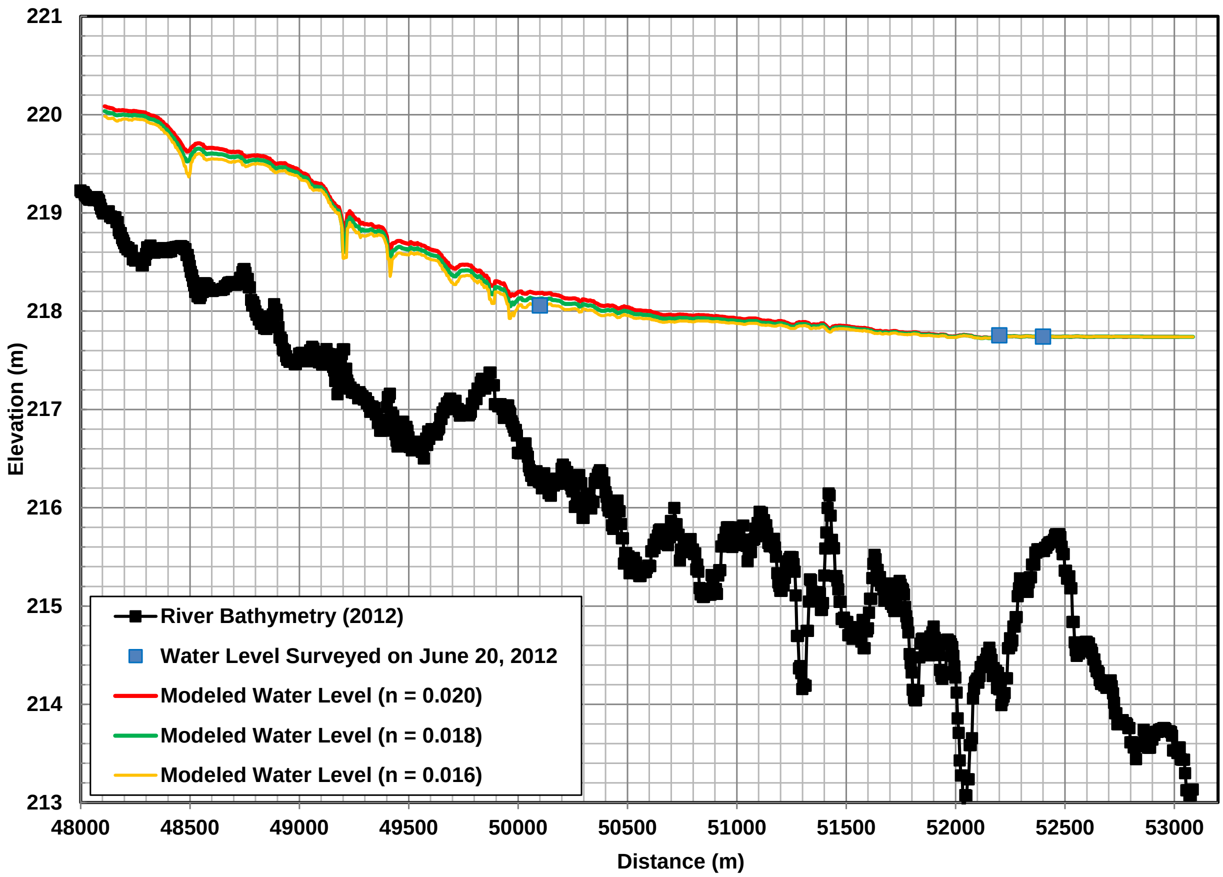

Figure 4.2-8. Computational mesh and boundary conditions of MIKE 21 model.

Ice covered conditions were also simulated with the MIKE 21 model. The calibration of the MIKE 21 model with presence of an ice cover was completed by adjusting the roughness coefficient of the ice-cover. The value of the ice-cover roughness coefficient can be defined as a variable dependant on its thickness.

The ice processes on the Dauphin River are fairly complex. The steep river slope existing on the Lower Dauphin River is prone to the formation of frazil ice pans which generally accumulate to form an ice dam. Upstream velocities are then reduced due to the backwater effect resulting from the presence of the ice dam, which helps the formation of a stable ice cover. When the ice dam reaches a certain height, the accumulated ice is pushed further downstream as a result of the difference in head across the ice dam, resulting in a decrease of the water level on its upstream side. In the middle of the winter, an ice cover is formed and the water levels in the river tend to stabilize.

Water levels were surveyed between November 20 and December 17, 2011 as well as January 6, 2012. The surveyed water levels reached a maximum on December 10, 2011 due to the accumulation of frazil ice, and then the river adjusted itself to relative stable water levels after December 15, 2011.

Calibration of the 2D model was done using a variable ice-cover roughness distribution computed from an independent 1D numerical ice model based on observed conditions as well as a uniform ice-cover with a constant thickness. The simulated water surface profiles obtained with both methods were compared with the water levels surveyed on December 7 and 16, 2011 with a Dauphin River flow of 446 m^3/s. A uniform ice cover of 0.65 m with a roughness of 0.038 was determined to achieve both numerical stability of the model and a good representation of the average ice conditions in winter on the Lower Dauphin River. A comparison of the simulated and surveyed water levels is shown in Figure 4.2-9.

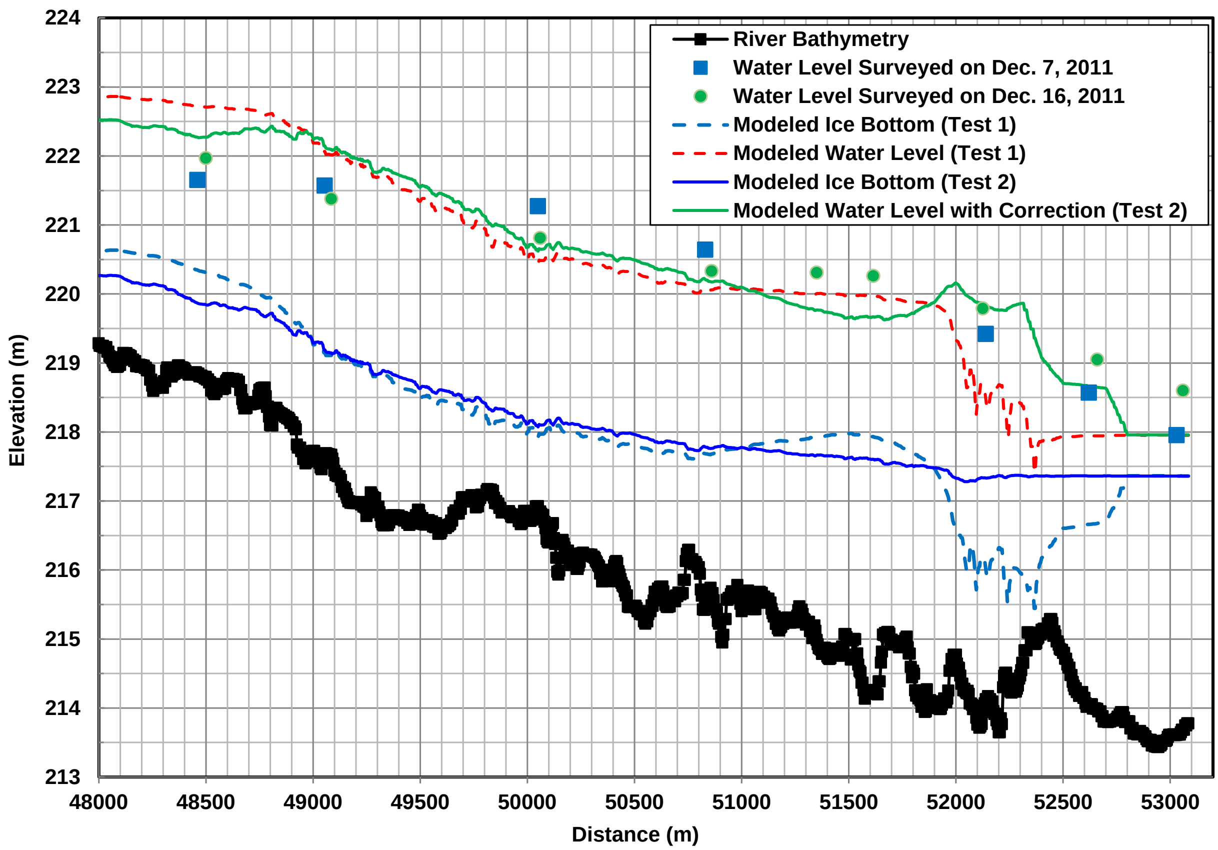

Figure 4.2-9. MIKE 21 model calibration for ice-covered conditions

Sediment Transport Analysis

A theoretical sediment transport analysis was carried out by comparison of the simulated velocities and critical velocities for erosion or sediment deposition for the different class of material present in the system.

Preliminary substrate surveys conducted by North/South Consultants in 2011 and 2013 indicate that the riverbed material downstream of Station 50+500 was comprised of areas of gravel and sand (called sandy gravel hereafter). From Station 51+200 to Lake Winnipeg and into Sturgeon Bay, a high percentage of the substrate was gravel and sand. Upstream from Station 50+500 however, riverbed materials were comprised of more compact materials and contained cobble/gravel (called gravelly cobble hereafter), and boulder/cobble. After reviewing the background information (including the sample photos) and the USCS, the suggested gradation for “sandy gravel” is as follows:

- Gravel (64 – 2 mm): 45% - 60%
- Sand (2 – 0.063 mm): 30% - 25%
- Silt and Clay (less than 0.063 mm): 10% - 20%

The suggested gradation for “gravelly cobble” is as follows:

- Cobble (256 – 64 mm): 10% - 15%
- Gravel (64 – 2 mm): 40% - 50%
- Sand (2 – 0.063 mm): 15% - 20%
- Silt and Clay (less than 0.063 mm): 5% - 20%

Table 4.2-3 was developed based on the Hjulstrom curve (Figure 4.2-4) to assess the potential for erosion, transport or sediment deposition based on the critical velocity and grain size of the sediment.

Table 4.2-3. Critical velocity for deposition and erosion.

Class	Upper Limit of Grain Size (mm)	Maximum Critical Velocity for Deposition (m/s)	Minimum Critical Velocity for Erosion(m/s)
Silt/Clay	0.063	<0.005	0.2
Sand	2	0.1	0.5
Gravel	64	0.8	3.0
Cobble	256	1.5	5.1

The critical velocities were compared to the velocities simulated with the MIKE 21 model for flow a range of conditions representative of each project phase (5, 50 and 95 flow percentiles).

4.2.2.7 Sedimentation Rate

Sampling Periods

Sedimentation rates over eight different sampling periods (some of which overlapped) were measured in Sturgeon Bay, as follows:

- October 2011-August 2012 (open water to ice cover then back to open water);
- February-March 2012 (ice cover);
- March 2012-August 2012 (ice cover to open water);
- August-October 2012 (open water);

- October 2012-June 2013 (open water to ice cover then back to open water);
- January-April 2014 (ice cover);
- April-June 2014 (open water); and,
- June-October 2014 (open water).

The traps were set in transects that ran perpendicular to the southwest shore, beginning about 1.5 km from the shoreline and extending out as far as 10 km into the bay. Transects began in the vicinity of Hay Point and continued south to the mouth of Manatagao Bay.

Data Collection

Sediment traps consisted of three 0.5 m long plastic pipes with a 5.0 cm outer diameter (inner diameter of 4.68 cm), clamped together with cable ties. The bottom of each pipe was sealed. Foam was attached along the length of the trap to maintain the pipes upright in the water column. To anchor the trap, the bottom of the pipes was connected by a short rope to a cinder block. Effort was made to ensure that when the cinder block was lying flat, the length of rope attaching the block to the trap was such that bottom of the trap was suspended 30 cm above the lake bottom. Further buoyancy was provided by attaching a float to the top of the trap; this float also served to help in trap retrieval.

Configuration of the sediment trap assembly varied depending upon when the taps were to be emptied. Traps set in open water for subsequent retrieval during the same open water period were configured such that the float attached to the top of the trap was well below the water surface. A secondary anchor was attached to the trap anchor by a line at least 6 m long and a surface float was attached to the secondary anchor (see Figure 4.2-10). The trap was deployed by lowering the trap anchor and trap assembly (sediment trap and top float) to the bottom using the line connecting the secondary anchor to the trap anchor. The secondary anchor was then lower to the bottom using the surface float line. Effort was made to keep the line attaching the secondary and trap anchors taut so that the two anchors were as far apart as the line would allow. This was done to prevent the surface float line from tangling with the trap assembly during deployment.

Traps set in open water for deployment through the winter, or traps set through the ice for retrieval during open-water, were set similarly, except that a secondary anchor system was not used, there was no surface float, and the top float was at least 2 m below the water/ice surface. This was to prevent the trap from being moved around by ice during spring break up. Traps set and retrieved through the ice during winter were constructed in the same manner, except that a line attached to the top float was tied off to a pole on the surface of the ice.

At the time of deployment, the following information was recorded at each trap location:

- deployment date and time;
- location (UTM coordinates; recorded with a hand held GPS receiver);
- water depth (m); and,
- ice thickness (m; only for traps deployed in winter time).

Sediment traps were retrieved by one of three methods, as follows:

- Traps deployed in open water and retrieved during the same open water period were lifted to the water surface using the surface float;
- Traps deployed and retrieved during winter were lifted to the water surface using the attachment line connecting the trap to a pole frozen into the ice; and,
- Traps left in place during periods of ice cover (i.e., traps with a submerged top float) but retrieved in open water were first located with side scan sonar and then retrieved by divers.

During each method of retrieval, care was taken to avoid disturbing the sediments within the trap.

Upon retrieval, contents of the three plastic pipes comprising the trap were poured into a 4 L plastic container. The trap pipes were rinsed with water, which was also poured into the sample container. This process was repeated until the trap pipes were clean of sediment. Samples were labeled, the collection date and time were noted, and samples were kept refrigerated or frozen until delivery to the analytical laboratory. Samples were submitted to ALS Laboratories in Winnipeg, MB (a Canadian Association for Laboratory Accreditations, Inc. [CALA] accredited laboratory) for analysis of particle size, moisture content, dry weight, and organic content.

<u>Data Analysis</u>

Values that were less than the analytical detection limit (DL) were treated as equal to one half the DL for use in equations and calculation of means (e.g., < 1.0 g = 0.5 g). Dry weight and organic carbon content were used to calculate the inorganic dry weight for each sample using the following equation:

Inorganic Dry Weight (g) = Total Dry Weight (g) x (100 – Organic Carbon Content (%)/100)

For each trap, sedimentation rate was calculated using the following equation:

Sedimentation Rate (mg/cm^2/day) = Total Dry Weight (mg) / Area of Trap Opening (cm^2) / Length of Deployment (days)

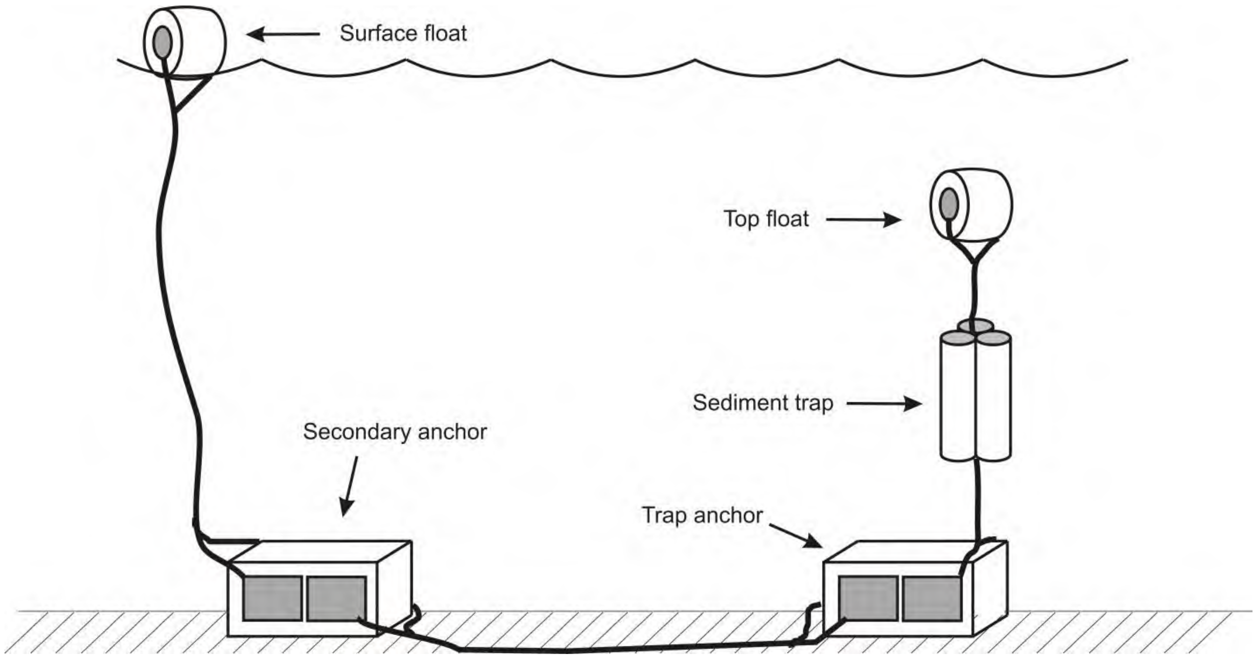

Figure 4.2-10. Sediment trap assembly.

4.3 LAKE ST. MARTIN MONITORING RESULTS

4.3.1 Lake St. Martin Water Levels

Historic water levels for the period of record from 1966 to 2010 on Lake St. Martin, that precede the 2011 flood conditions, are shown on Figure 4.3-1. The water levels are based on WSC data at gauge No. 05LM005 (Lake St. Martin near Hilbre). The 5th, 50th, and 95th percentile water levels of 242.7 m (796.4 ft), 243.3 m (798.4 ft), and 244.3 m (801.4 ft) respectively, for the period of 1966 to the fall of 2010, are shown on the graph. For comparison, the desirable range on Lake St. Martin is 242.9 m to 243.8 m (797 ft to 800 ft) and the flood stage was defined as 244.4 m (801.7 ft) in 2011.

As shown on Figure 4.3-1, the levels can vary by almost two meters within a given year. Inflows to Lake St. Martin are governed by the Fairford River Water Control Structure (FRWCS), which was first put into operation in 1961 and is located approximately 14km upstream of Lake St. Martin at the outlet of Lake Manitoba. Outflow from Lake St. Martin is naturally controlled by the Dauphin River. In the winter, ice conditions in the river restrict outflows on Lake St. Martin which generally causes an increase in water levels on the lake. For this reason, the FRWCS has historically been operated to limit inflows into Lake St. Martin during winter, and at the same time control water levels on the lake.

With the operation Reach 1, the FRWCS remained fully open during the winter of 2011/2012. Recorded water levels prior to, during, and following closure of Reach 1 are shown on Figure 4.3-2. The figure also illustrates the estimated water levels that would have occurred on Lake St. Martin without operation of Reach 1, assuming that the FRWCS would have remained fully opened throughout the period.

As shown on Figure 4.3-2, operation of Reach 1 was successful in lowering the water levels on Lake St. Martin by on average 0.6 m, and as much as 1m at the peak of the winter ice conditions during the winter of 2011/2012. With the Reach 1 in operation, water levels on the lake returned below the 95th percentile value as well as the flood stage value of 244.4m (801.7ft) about 6 months sooner than what is predicted to have occurred in the absence of Reach 1 operation.

4.3.2 Ice Processes

A solid ice cover typically forms on Lake St. Martin in the month of November and remains until the following spring break-up in April/May. Operation of Reach 1 does not change the ice processes in Lake St. Martin, with exception of at the inlet of Reach 1. During the 2011/2012 Operation, open water remained at the inlet of Reach 1 throughout the winter and extended approximately 400 m upstream of the inlet. Similar conditions were observed during the 2014/2015 Operation. During the 2011/2012 closure period, the inlet area remained ice covered, which is consistent with historic conditions at this location.

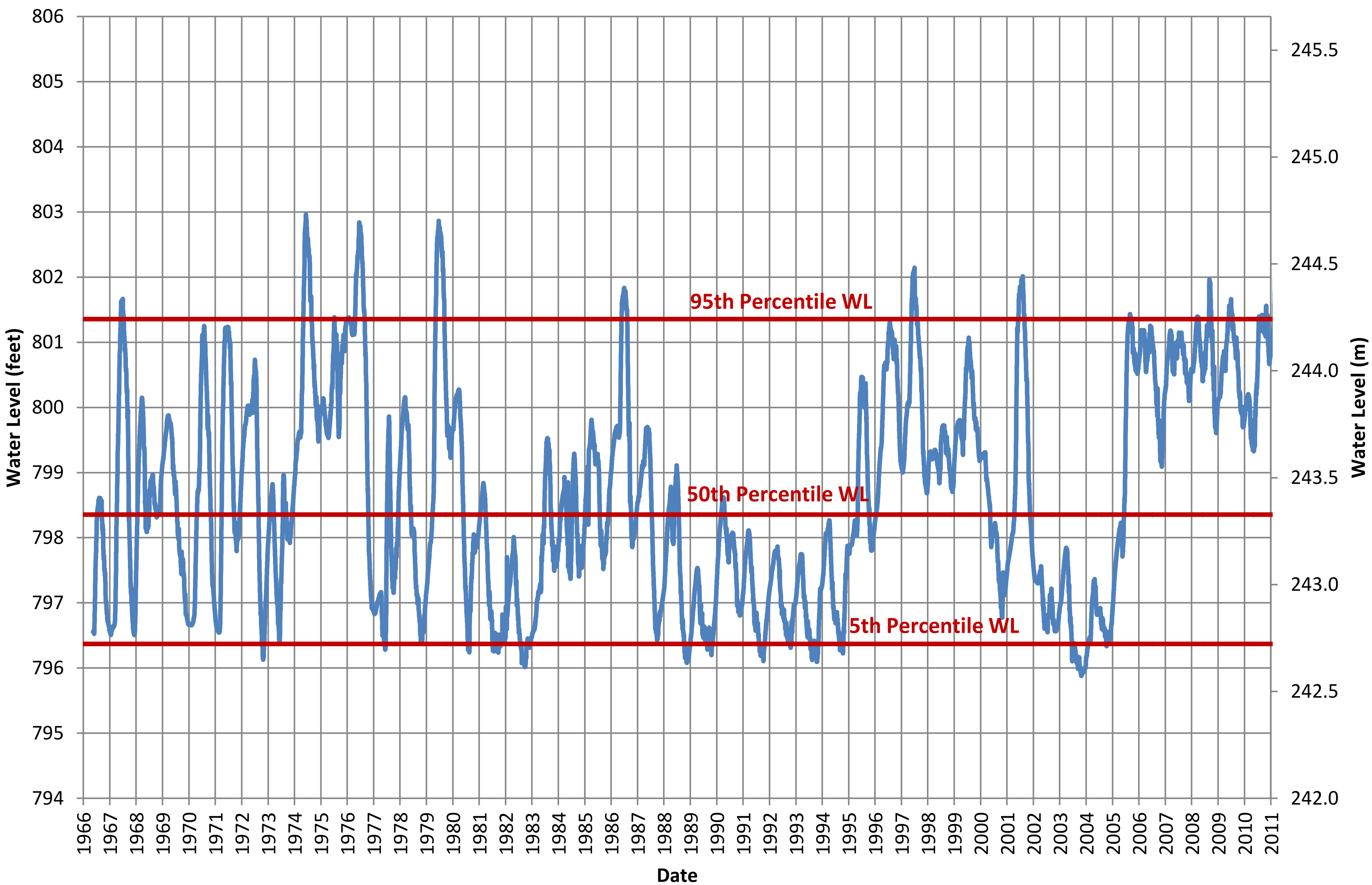

Figure 4.3-1. Historic Lake St. Martin Water Levels – 1966 to 2010.

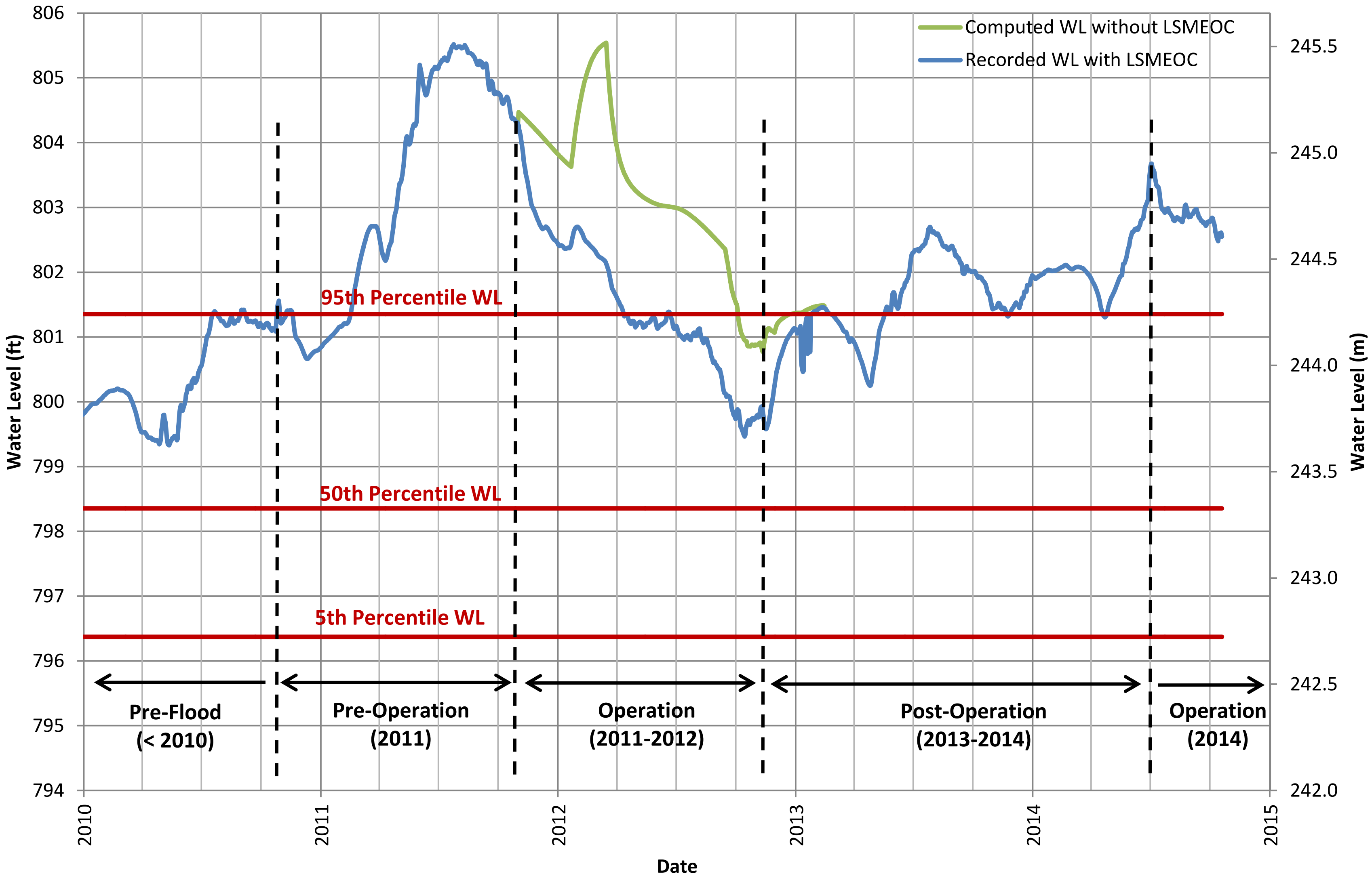

Figure 4.3-2. Lake St. Martin Water Levels with and without Reach 1.

4.4 REACH 1 AND BUFFALO CREEK WATERSHED MONITORING RESULTS

4.4.1 Flow

The water level records and hydrometric surveys carried out on Reach 1 and Buffalo Creek were compiled to compute hydrographs for the entire period of record. Rating curves were developed at each site from the surveyed water level and flow metering data, to convert the series of instantaneous water levels into a flow record. Figure 4.4-1 shows the computed flows at the EC1 monitoring station on Reach 1, along with the discharge measurements collected since 2011. The flows measured at Reach 1 during operation or at the BC-TM monitoring station on Buffalo Creek are considered representative of the entire Reach 1 and Buffalo Creek Watershed (Figure 4.4-2). The storage effect from Buffalo Lake and the local component of the inflow were not considered in this analysis, therefore, the computed flows for Buffalo Creek and Reach 1 are assumed to be identical.

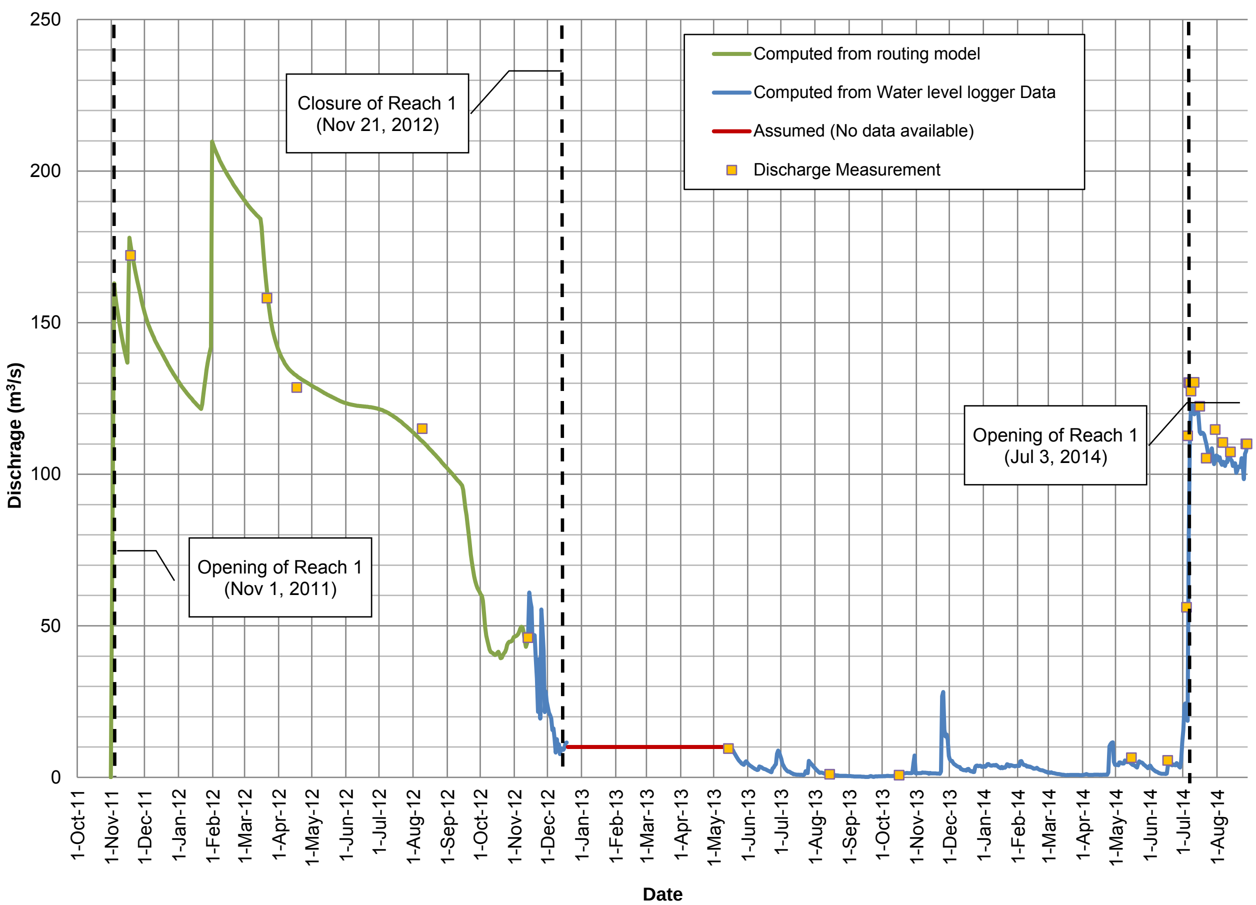

Figure 4.4-1. Buffalo Creek Discharge.

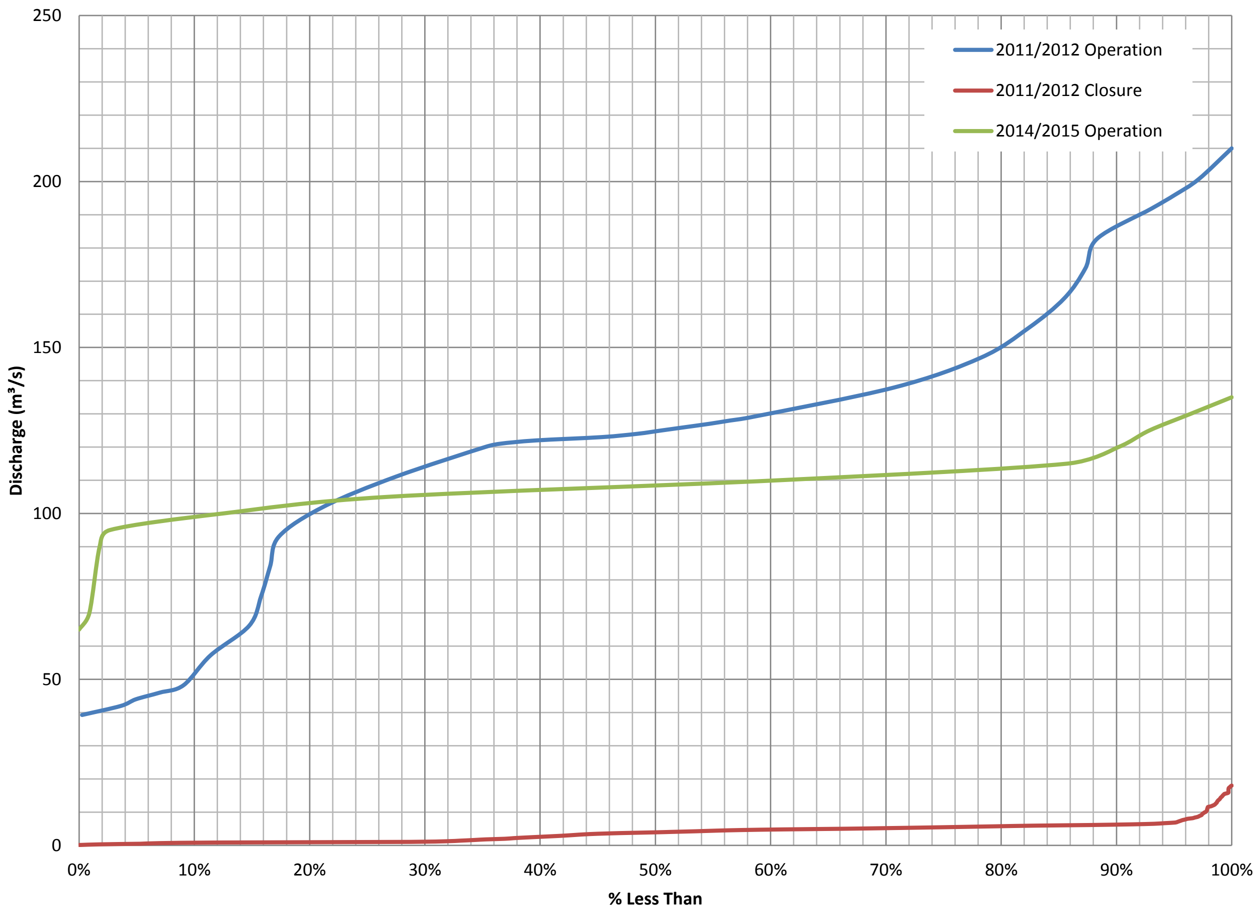

Figure 4.4-2. Duration curves of daily flows for the Reach 1 and Buffalo Creek watershed.

The standard 5, 50 and 95 percentiles flows utilized in the habitat assessment were derived from the duration curves of daily flows computed from the flow records at both sites. Table 4.4-1 summarizes these flow conditions for each project phase. It should be noted that the duration curve for the 2014/2015 operation period was computed based on a shorter time period since the channel was still in operation at the time of the analysis, and is based on the flows measured between July 3, 2014 to October 22, 2014.

Table 4.4-1. Modelled discharge (as 5th, 50th, and 95th percentiles) for Reach 1 and Buffalo Creek during each project phase.

Flow Percentile (%)	2011/2012 Operation (m^3/s)	2011/2012 Closure (m^3/s)	2014/2015 Operation (m^3/s)
5	44	0.5	97
50	125	3.9	109
95	196	6.9	128

4.4.2 TSS/Turbidity Data

Time series of TSS were computed for Reach 1 and Buffalo Creek from the turbidity records and the TSS data collected between 2011 and 2014. These computed concentrations used in conjunction with the computed flows for the corresponding period in the empirical model. Figures 4.4-3 and 4.4-4 show the times series of computed TSS on Reach 1 and Buffalo Creek, respectively.

During the 2011/2012 period, the TSS at the upstream end of Reach 1 (baseline in Lake St Martin) ranged from less than 5 mg/L up to almost 75 mg/L in September of 2012. During this period, the TSS at the exit of Reach 1 was always slightly greater than the baseline, except between March and May 2012, when it was almost double the baseline as it exceeded 25 mg/L. The maximum TSS concentration at the exit of Reach 1 was calculated at 95 mg/L. The difference that existed between the baseline and the exit of the channel suggested that sediment particles entered the system due to riverine erosion or due to sediment inflow from local run-off, and were transported in suspension to the outlet of Reach 1.

After closure of Reach 1 on November 21, 2012, the TSS at the exit of Reach 1 remained greater than the baseline until October 2013, possibly due to rainfall and erosion along the side slopes of the channel. In the absence of instantaneous data from turbidity loggers, the daily TSS concentration was interpolated between discrete TSS samples. While this method is adequate for a cumulative calculation of the total volume of suspended sediment, this may not have captured instantaneous peaks in TSS resulting from meteorological events.

A peak of TSS was observed following the opening of Reach 1 on July 3, 2014, where the TSS exceeded 175 mg/L. The increase in TSS was very brief and likely associated with the re-operation of Reach 1 and the flushing of smaller particles of sediment that would have settled in the standing water in Reach 1 during the closure period.

In Buffalo Creek, the TSS computed at the exit of the creek is always greater than the baseline, suggesting that erosion occurs in this reach. During the closure period in the summer of 2013, the TSS concentrations at the exit of the creek reached a maximum of 210 mg/L. These brief and local increases appear to be resulting from rainfall events and the run-off contribution from the local watershed. Additionally, erosion of the material displaced during the 2011/2012 Operation could have also contributed to the high TSS concentrations.

As for Reach 1, a peak of TSS was also observed following the initial operation on July 3, 2014, where the TSS exceeded 200 mg/L. The increase in TSS was very brief and likely associated with flushing of smaller sediment particles that would have settled in the standing water in Reach 1 during the closure period, and the loose till material along the side slopes of the channel that had eroded over time since closure of the 2011/2012 Operation.

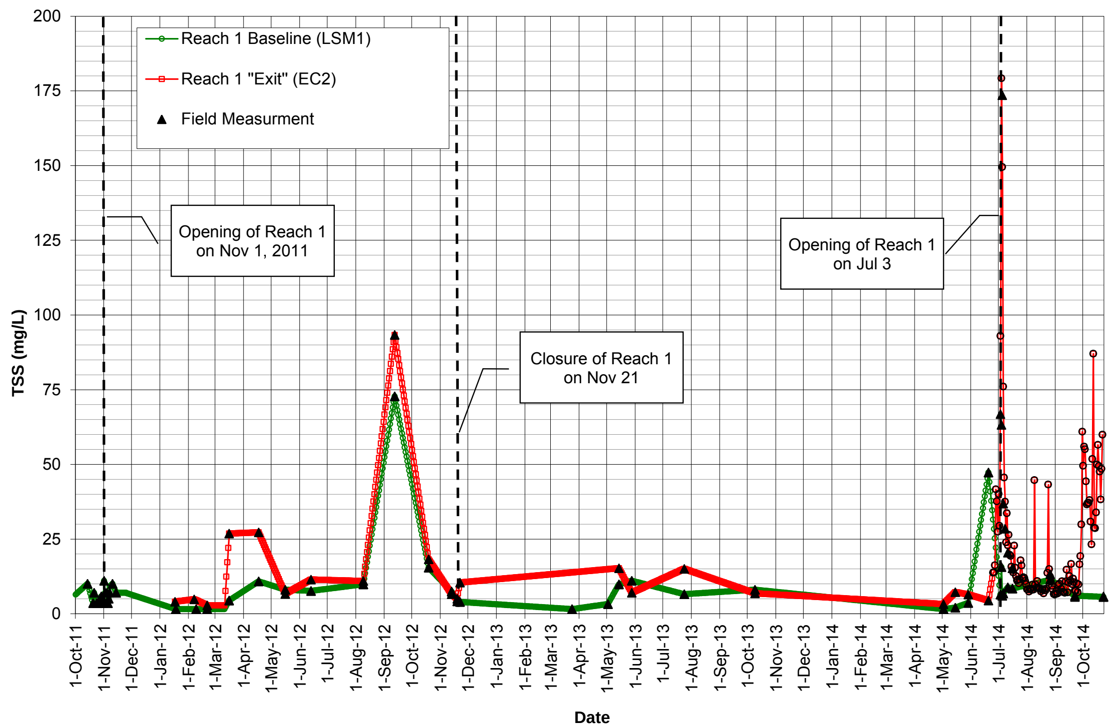

Figure 4.4-3. Times series of computed total suspended solids in Reach 1.

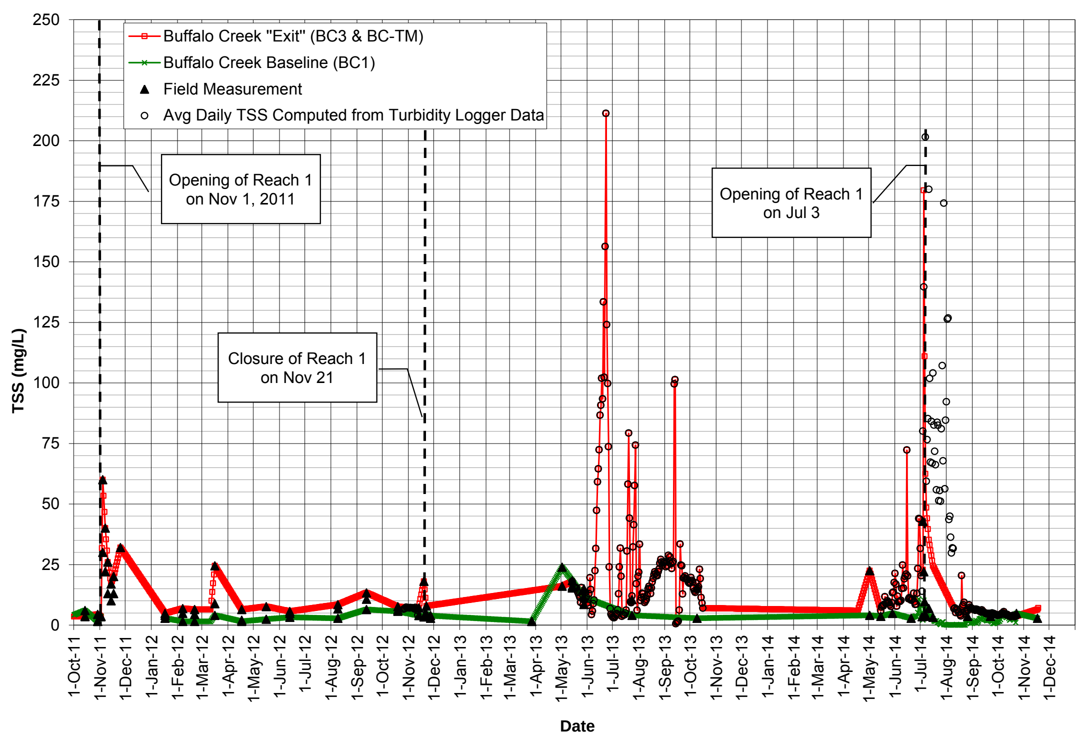

Figure 4.4-4. Times series of computed total suspended solids in Buffalo Creek.

4.4.3 Buffalo Creek Vegetation Cover Survey

In general, the 2011 survey showed full and dense vegetation coverage within the study area. Transects were composed of thick grasses adjacent to the creek which transitioned to dense shrubs followed by trees further from the creek. Few bare patches and no signs of erosion were noted. Numerous beaver dams were present along the length of the creek resulting in inundation of several transects. Following 2011-2012 Operation of Reach 1, the July 2013 survey showed extensive bare areas along the entire length of the creek. At the upstream reaches (stations13+000 to 19+500) most of the bare soil was organic in nature. Many shrubs were also dead. Larger trees were generally located further from the creek bank and appeared relatively healthy. The impact area from the high water levels appears to be narrowest between stations 13+500 and 16+000. Further downstream (stations 19+500 to 28+000), trees were often closer to the creek. High water reached deep into the trees resulting in large areas of dead mature trees. This is particularly evident when 2011 GAIM imagery is compared against 2013 GAIM imagery (see Figure 2 in Appendix 4.A). The vegetation impact zone represents areas where dead vegetation is present along the length of the creek. The understory beneath these trees was largely bare. Concentrations of debris (branches, trees) had accumulated at several locations (e.g. 19+500). Some trees near the creek had fallen over. Numerous areas of erosion and deposition were present, with much of the organic soil covered with variable depths of inorganic soils (silt, sand, gravel, cobble). Bank failures resulting in steep banks and slumping organic and inorganic soils, were also observed at several transects in 2013. There were no beaver dams along the creek in 2013. During the June 2014 survey, thick grass had begun to re-establish at the majority of bare areas. Few of the shrubs and trees that appeared dead in 2013 recovered. Conversely, large stands of trees that, in 2013, appeared were to have survived inundation, were visually dead or extremely stressed when observed during the follow-up survey in 2014; specifically along transects at stations 20+500 to 22+500. In 2014, areas with deposition of sand, gravel and cobble remained largely free of vegetation, while areas with deposited silt had much more vegetation. Beaver activity including several beaver dams were observed in 2014.

4.4.4 Cross Section Surveys

As indicated in Section 4.3.1.3, 30 cross sections were surveyed along Buffalo Creek in 2011 and 2013. The purpose of these surveys was to compare pre and post operating conditions in Buffalo Creek. Comparisons of the 2013 cross sections (post 2011/2012 Reach 1 Operation) to the 2011 cross sections (Pre 2011/2012 Reach 1 Operation) are provided in Appendix 4.B.

The results of the comparison show that erosion has occurred in Buffalo Creek almost along the entire reach. Typically, the erosion occurred within the main channel, generally making it 5 to 10 meters wider and 0.3m deeper on average. There were a few localized areas that showed deposition of material. These were generally located in the overbanks, immediately adjacent to the main channel, and field observations indicated that the material deposited usually consisted of gravels and cobbles.

Based on the 2011 and 2013 survey comparison, the total in-situ volume of material that was eroded from the channel was estimated to be approximately 86,500 m^3. This volume represents the amount of material displaced within the reach, between the outlet of Buffalo Lake and the confluence with Dauphin River. From the cross section comparison and vegetation survey, it is apparent that some of this material has deposited within the Buffalo Creek reach, and only a portion of this total volume is assumed to leave Buffalo Creek and enter the Dauphin River. This quantity is considered to be very approximate since interpolation is necessary between the cross sections which were approximately 500m apart, and it was assumed that each cross section is representative of conditions in the channel upstream and downstream. In reality, observations of conditions in the channel show that the magnitude of erosion changes more frequently than at the 500m intervals between sections. As such, the 86,500 m^3 should be used for comparison purposes only, and in conjunction with other results and modeling presented in this report.

4.4.5 Ice processes

In Buffalo Creek, the ice conditions prior to the 2011/2012 Operation of Reach 1 were not documented. However, based on the observations made during the 2011/2012 closure, it is anticipated that a solid ice cover would naturally form on the creek. Depending on the severity of the winter, some residual latent heat present in the water (mostly originating from the Buffalo Bog Lake) may not allow the formation of a complete and solid ice cover.

During the 2011/2012 Operation, the velocities in Reach 1 were on average 1.0 m/s. Some border ice was present, but no solid ice cover formed during the winter. Production of frazil ice was observed in the channel. The Buffalo Bog Lake was mostly covered, with some open water in the main flow paths. The flow velocities in Buffalo Creek were approaching 2.0 m/s for the 95^{th} percentile flow and were greater than 1.5 m/s on average. Some border ice was present but the creek was mostly open, with the exception of a small reach where an ice jam formed after large pieces of border ice were dislodged from the shore. Production of frazil ice was also observed in Buffalo Creek.

During the 2011/2012 closure, Reach 1 and the Buffalo Bog Lake were covered. Some open water areas remained in the bog, but to a lesser extent than during operation. Buffalo Creek was mostly ice covered.

Limited data are available for the 2014/2015 Operation period. The flows are similar in magnitude to the 2011/2012 Operation, suggesting that Reach 1 and Buffalo Creek would remain open. Some border ice was observed along Reach 1, with presence of frazil ice. An ice cover has also been observed at the Buffalo Creek outlet into Dauphin River, which is contrary to what occurred in 2011/2012.

4.4.6 Hydraulic and Sediment Transport Modeling

4.4.6.1 Empirical Model Results

To help quantify erosion through the Reach 1 System to the confluence between Buffalo Creek and Dauphin River, an Empirical Model was developed as an Excel spreadsheet program. The model estimates cumulative volumes of suspended sediment being carried out of each reach (sediment inflow), and is indicative of the extent of erosion and sediment deposition of the smaller particles that occurred within each reach.

Properties of the Buffalo Creek bed material defined in the model were based on substrate surveys conducted in September 2011 along the channel overbanks. The grain size distribution of the material that was used for the analysis is shown on Table 4.4-2. The class and diameter size of the material shown in the table were defined by the laboratory where the substrate material was tested, and were adopted for the Buffalo Creek analysis.

Table 4.4-2. Grain size distribution of Buffalo Creek substrate.

Class	Diameter (mm)	% Finer
Clay	0.002 - 0.005	49.1
Silt	0.005 - 0.075	69.9
Sand	0.075 - 4.75	93.3
Gravel	4.75 - 75	99.3
Cobble	75 - 250	100

The sediment load inflow referenced in Figure 4.4-4 was combined with a grain size distribution based on laboratory results of suspended solids from two water samples collected on January 17, 2012 on Buffalo Creek and on Dauphin River. The grain size distribution of the suspended solids is summarized in Table 4.4-3.

Table 4.4-3. Grain size distribution of suspended solids.

Class	Diameter (mm)	% Finer
Clay	0.002 - 0.005	16
Silt	0.005 - 0.075	93
Sand	0.075 - 4.75	100
Gravel	4.75 - 75	100
Cobble	75 - 250	100

2011/2012 Operation

Tables 4.4-4 to 4.4-7 present the suspended sediment volume balance computed with the empirical model for the 2011/2012 Operation for each one of the reaches between Lake St. Martin and the Exit of Buffalo Creek. The general trend is for sediment originating from Lake St. Martin and the sediment eroded along Reach 1 to deposit in Buffalo Lake Bog. Erosion and sediment transport resume along Buffalo Creek with higher velocities resulting from the operation of Reach 1. The total cumulative volume of suspended sediment released at the exit of Buffalo Creek is estimated at approximately 34,400 m^3. The total volume of sediment calculated at the inlet of Reach 1 is estimated at approximately 30,900 m^3, which constitutes a net balance of 3,500 m^3 at the outlet of Buffalo Creek.

As described in Section 4.5, the combined cumulative volume of suspended sediment downstream of the confluence with the Dauphin River during operation is estimated at 82,200 m³. Without operation of Reach 1, this volume is estimated at 73,300 m³ of suspended sediment, which represents an increase of 8,900 m³ that could be attributed to the operation of Reach 1.

Table 4.4-4. Suspended sediment volume balance in Reach 1 during the 2011/2012 Operation (Nov. 1, 2011 to Nov 21, 2012).

Description	Cumulative Sediment Volume (m³)
Baseline	30,900
Channel or “Exit”	58,000
Net Total	27,100

Table 4.4-5. Suspended sediment volume balance in the Buffalo Lake Bog during the 2011/2012 Operation (Nov. 1, 2011 to Nov 21, 2012).

Description	Cumulative Sediment Volume (m³)
Reach 1 Channel or “Exit”	58,000
Buffalo Creek baseline or near Entrance	17,000
Net Total	-41,100

Table 4.4-6. Suspended sediment volume balance in Buffalo Creek during the 2011/2012 Operation (Nov. 1, 2011 to Nov 21, 2012).

Description	Cumulative Sediment Volume (m³)
Baseline or near Entrance	17,000
Exit	34,400
Net Total	17,400

Table 4.4-7. Suspended sediment volume balance in the Reach 1 System from Entrance of Reach 1 to Exit of Buffalo Creek during the 2011/2012 Operation (Nov. 1, 2011 to Nov 21, 2012).

Description	Cumulative Sediment Volume (m³)
Reach 1 Baseline	30,900
Buffalo Creek Exit	34,400
Net Total	3,500

2011/2012 Closure

Following closure of Reach 1 in November 2012, the only sources of inflow to the system was local inflow to the Buffalo Creek watershed downstream of Reach 1 combined with the natural drainage of the Buffalo Lake. According to the empirical model results, sediment transport still occurred after closure of Reach 1 (Table 4.4-8). The additional suspended sediment eroded from the system could result from bank slumping and local erosion following recession of the flows and water levels in Buffalo Creek, combined with natural sediment transport processes occurring along Buffalo Creek and unrelated to the past operation of Reach 1. The total cumulative volume of suspended sediment released at the exit of Buffalo Creek is estimated at approximately 2,600 m³. The total volume of sediment calculated at the inlet of Reach 1 is estimated at approximately 1,100 m³, which constitutes a net balance of 1,500 m³.

As discussed in Section 4.5, the combined cumulative volume of suspended sediment downstream of the confluence with the Dauphin River during operation is estimated at 74,800 m³. Without operation of Reach 1, this volume is estimated at 72,600 m³ of suspended sediment, which represents an increase of 2,200 m³ that could be attributed to the operation.

The total combined volume of suspended sediment related to the operation of Reach 1 is then estimated at approximately 11,100 m³ (8,900 m³ during operation and 2,200 m³ after closure).

Table 4.4-8. Suspended sediment volume balance in Buffalo Creek during the 2011/2012 Closure (Nov. 21, 2012 to July 3, 2014).

Description	Cumulative Sediment Volume (m³)
Baseline	1,100
Channel or “Exit”	2,600
Net Total	1,500

2014/2015 Operation

Tables 4.4-9 to 4.4-12 present the suspended sediment volume balance computed with the empirical model for the 2014/2015 Operation for each one of the reaches between Lake St. Martin and the Exit of Buffalo Creek. The period of record is shorter than for the 2011/2012. Over this period, an overall lower volume of sediment transported was observed than during the 2011/2012 period. The general trend is similar to the 2012/2012 Operation. As demonstrated by the increase in volume of suspended sediment at the exit of Reach 1, the trend is for erosion to occur along Reach 1. According to the empirical model results and the change in TSS concentrations, a large portion of the suspended sediment settles and deposits in Buffalo Lake. As during the 2011/2012 Operation, erosion generally resumes along Buffalo Creek, which results in an increase in the volume of suspended sediment at the exit of Buffalo Creek. The effects of operation of Reach 1 on the volume of suspended sediment released from the system in Dauphin River are discussed in Section 4.5.

Table 4.4-9. Suspended sediment volume balance in Reach 1 during the 2014/2015 Operation (Jul. 3, 2014 to Oct. 22, 2014).

Description	Cumulative Sediment Volume (m³)
Baseline	6,200
Channel or “Exit”	17,200
Net Total	11,000

Table 4.4-10. Suspended sediment volume balance in the Buffalo Lake Bog during the 2014/2015 Operation (Jul. 3, 2014 to Oct. 22, 2014).

Description	Cumulative Sediment Volume (m³)
Reach 1 Channel or “Exit”	17,200
Buffalo Creek baseline or near Entrance	1,400
Net Total	-15,800

Table 4.4-11. Suspended sediment volume balance in Buffalo Creek during the 2014/2015 Operation (Jul. 3, 2014 to Oct. 22, 2014).

Description	Cumulative Sediment Volume (m³)
Baseline or near Entrance	1,400
Exit	10,600
Net Total	9,200

Table 4.4-12. Suspended sediment volume balance in Reach 1 System from Entrance of Reach 1 to Exit of Buffalo Creek during the 2014/2015 Operation (Jul. 3, 2014 to Oct. 22, 2014).

Description	Cumulative Sediment Volume (m³)
Reach 1 Baseline	6,200
Buffalo Creek Exit	10,600
Net Total	4,400

4.4.6.2 HEC-RAS model results

2011-2012 Operation

A steady state hydraulic model was simulated for the 5%, 50% and 95% flows of 44 m^3/s (1550 cfs), 125 m^3/s (4415 cfs) and 196 m^3/s (6920 cfs) for the 2011/2012 Operation, respectively, as previously discussed in Section 4.2.

The computed average shear stresses in the main channel and in the overbanks are shown in Figures 4.4-5 and 4.4-6 respectively, and are compared to the critical shear stress for erosion of the different grain classes. The computed average velocities in the main channel and in the overbanks are shown on Figures 4.4-7 and 4.4-8, and are compared to the minimum critical velocity for erosion of the different grain classes. Figures 4.4-9 and 4.4-10 show the resulting average velocities in the main channel and in the overbanks compared to the maximum critical velocity for deposition of the different grain classes.

As shown in Figures 4.4-5 to 4.4-8, the velocities and shear stresses that were present in the main channel and in the overbanks of Buffalo Creek during the 2011/2012 Operation of Reach 1, even for the minimum flow, were large enough to induce the movement of gravel size materials or smaller. In the main channel, the results also indicate that cobble size material could be subject to erosion in some areas. These results are consistent with cross section comparisons of pre and post operating conditions in Buffalo Creek, as discussed in Section 4.4.4. The cross section comparisons showed that erosion had occurred in Buffalo Creek, and that the erosion was concentrated in the main channel.

Once in movement, Figure 4.4-9 shows that for flows occurring during operation of Reach 1, there is a low potential for gravel size sediments or smaller to deposit in the main channel. When flows exceed median conditions, cobble size material also has a low potential for deposition. However, at the minimum flow, there are many locations where cobbles have a high potential for deposition.

In the overbanks, Figure 4.4-10 shows that gravel size sediment has a high potential for deposition during operation of Reach 1. The figure also shows that there are many areas where sand size sediment has the potential to deposit at the minimum flow.

These results on potential for deposition are also consistent with the pre and post cross section comparisons. As discussed in Section 4.4.4, the comparisons showed that deposition generally occurred in the overbanks, immediately adjacent to the main channel, and that the material deposited usually consisted of cobbles and gravels. The results are also consistent with the vegetation cover survey, discussed in Section 4.4.3, which showed that a layer of fine sediments could be found in the overbanks of the channel.

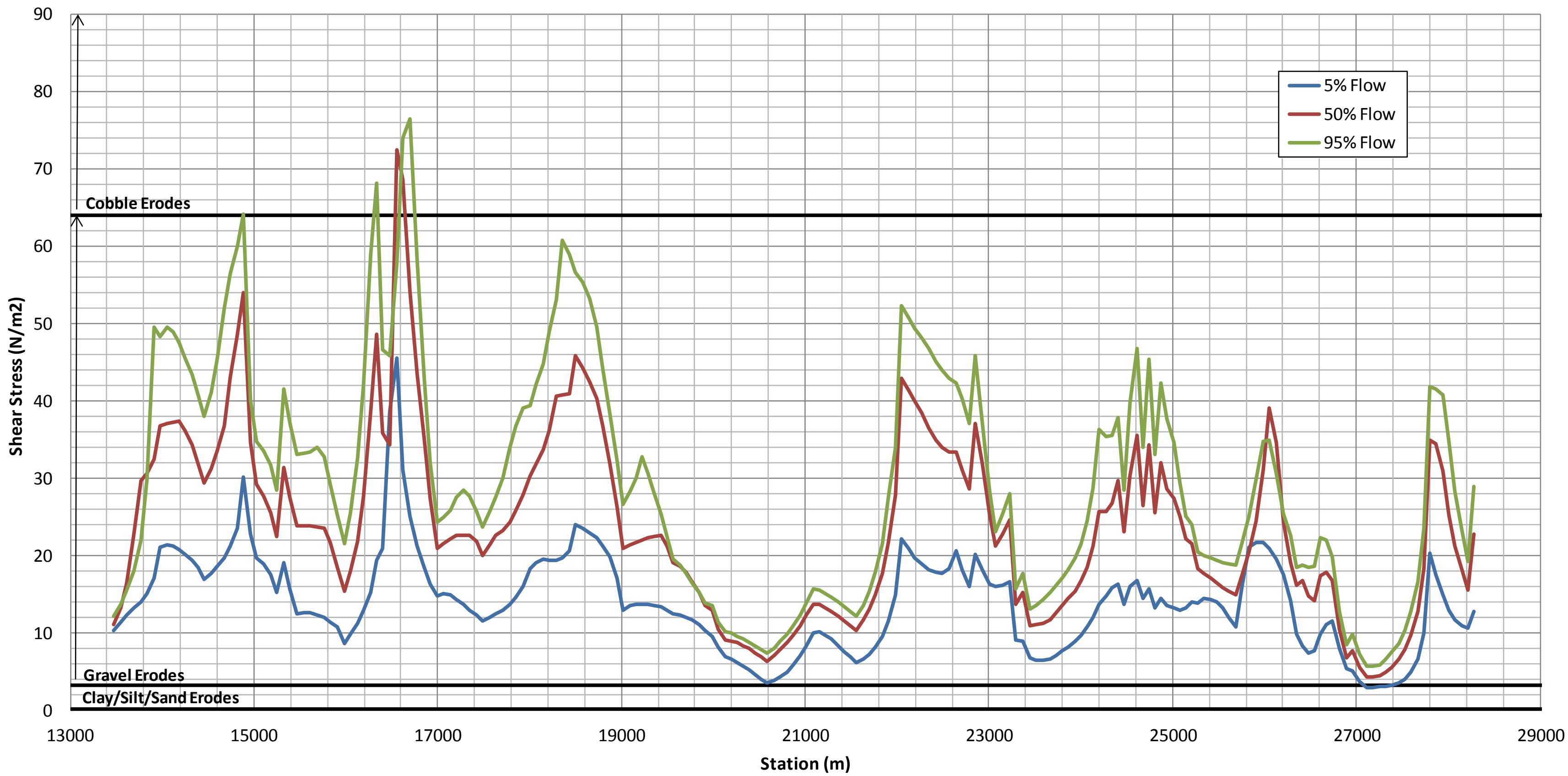

Figure 4.4-5. Comparison of computed Shear Stress profiles in the main channel with critical shear stresses for erosion.

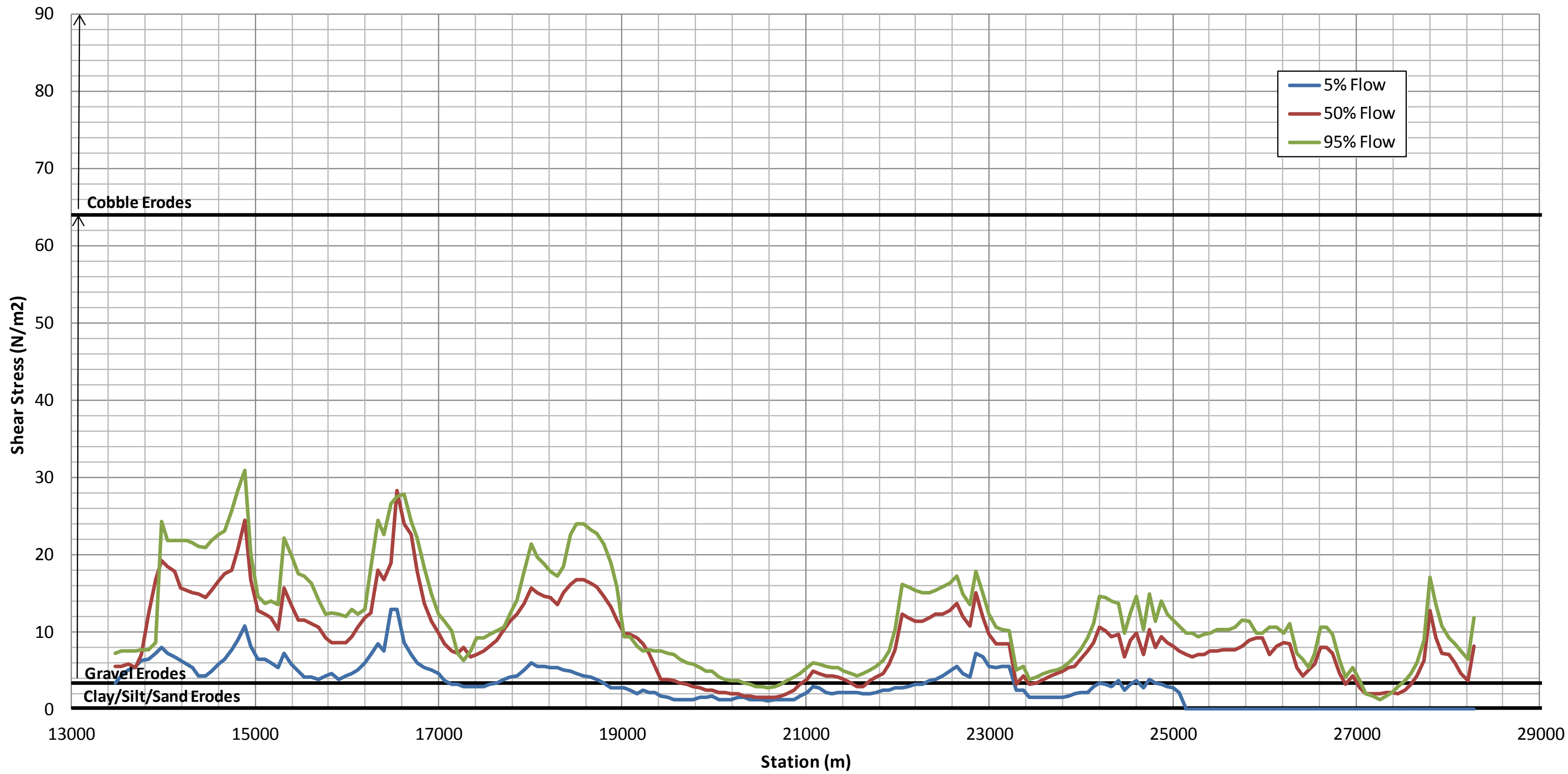

Figure 4.4-6. Comparison of computed Shear Stress profiles in the overbanks with critical shear stresses for erosion.

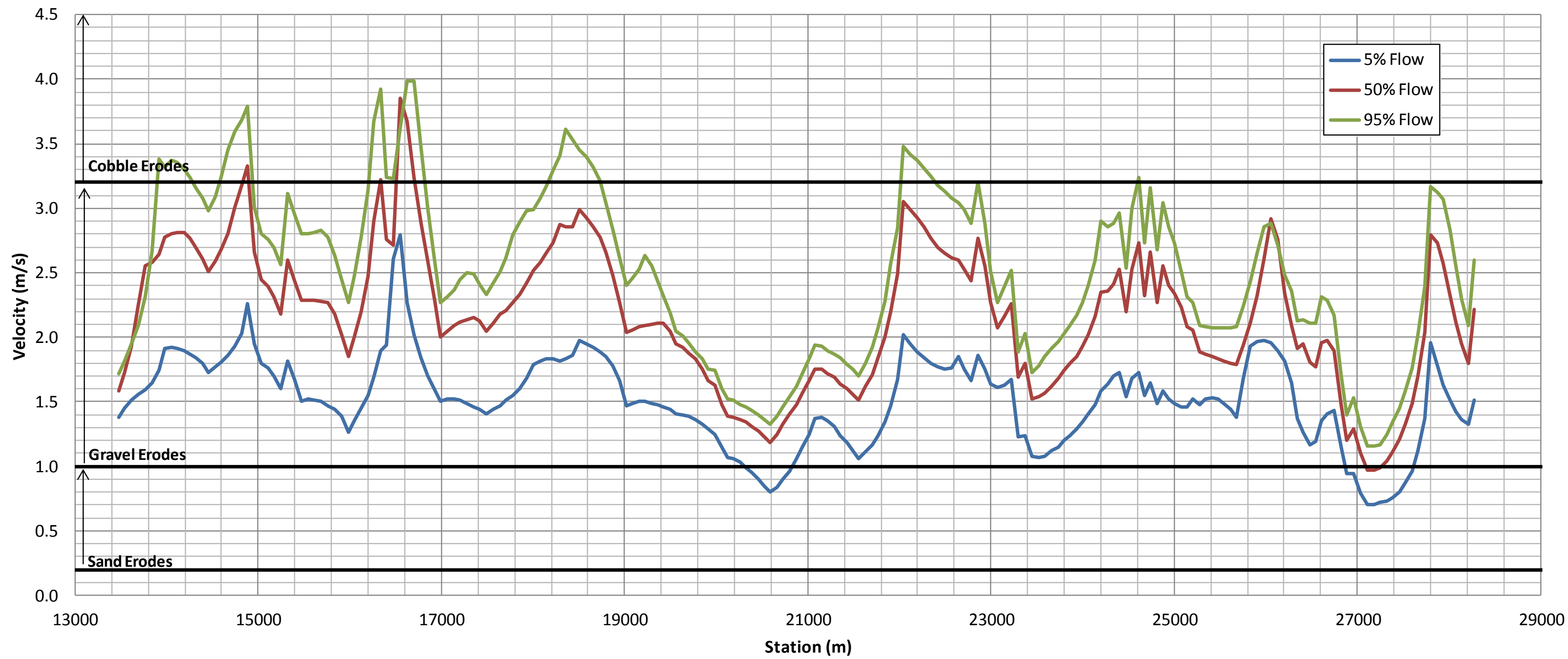

Figure 4.4-7. Comparison of computed velocity profiles in the main channel with minimum velocity for erosion.

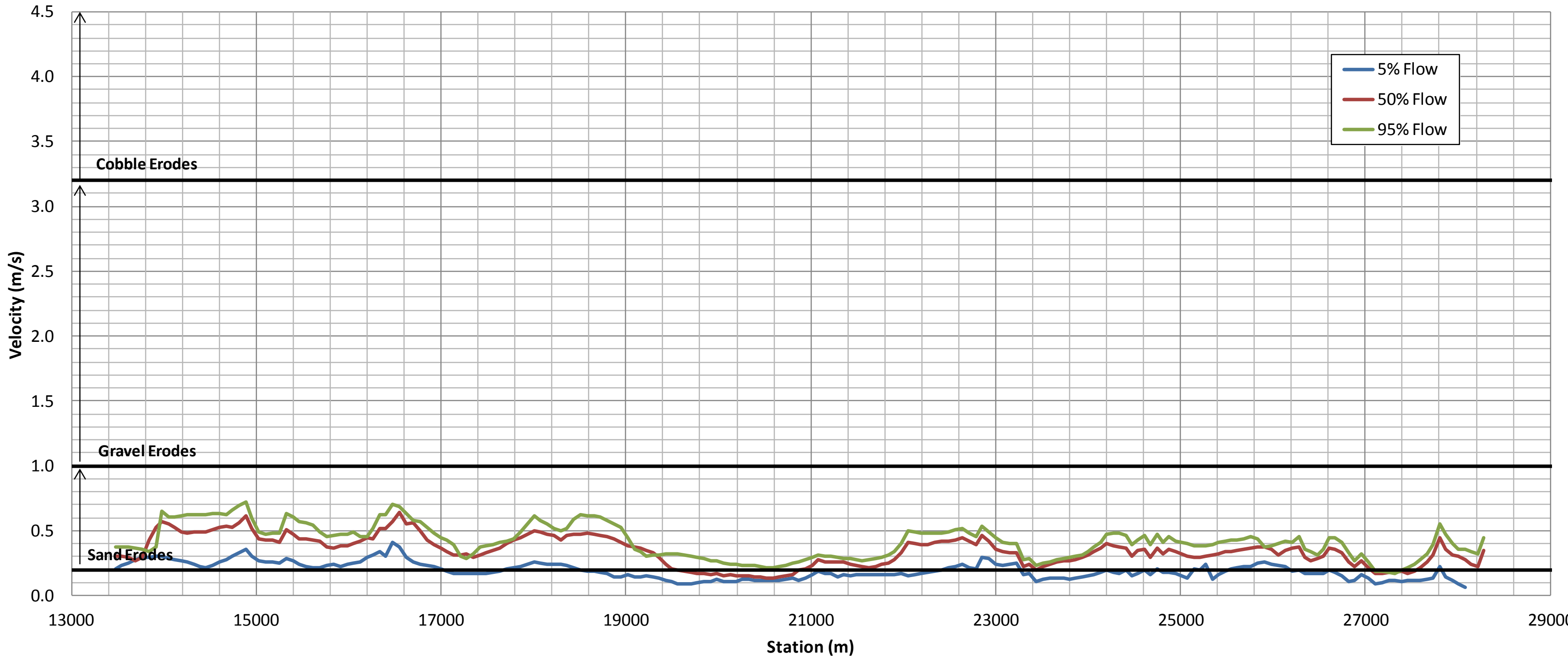

Figure 4.4-8. Comparison of computed velocity profiles in the overbanks with minimum velocity for erosion.

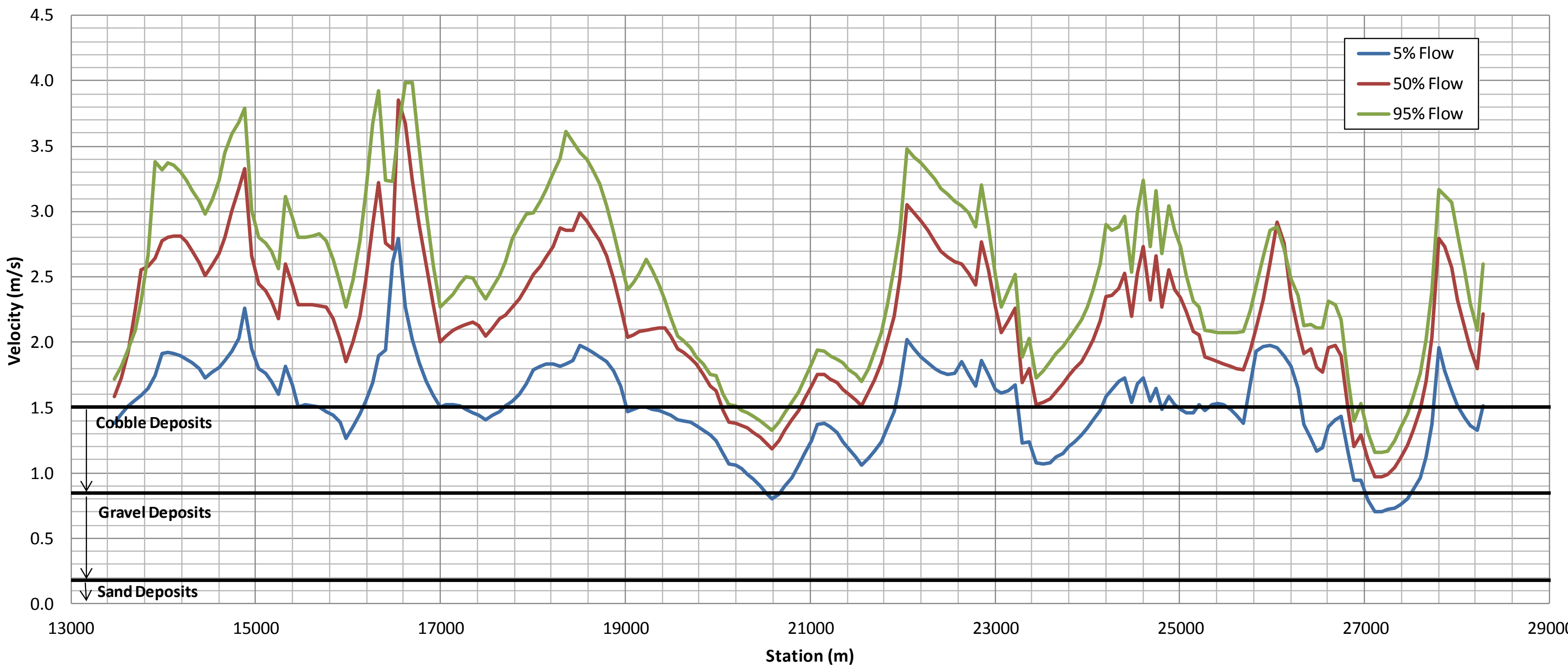

Figure 4.4-9. Comparison of computed velocity profiles in the main channel with maximum velocity for deposition.

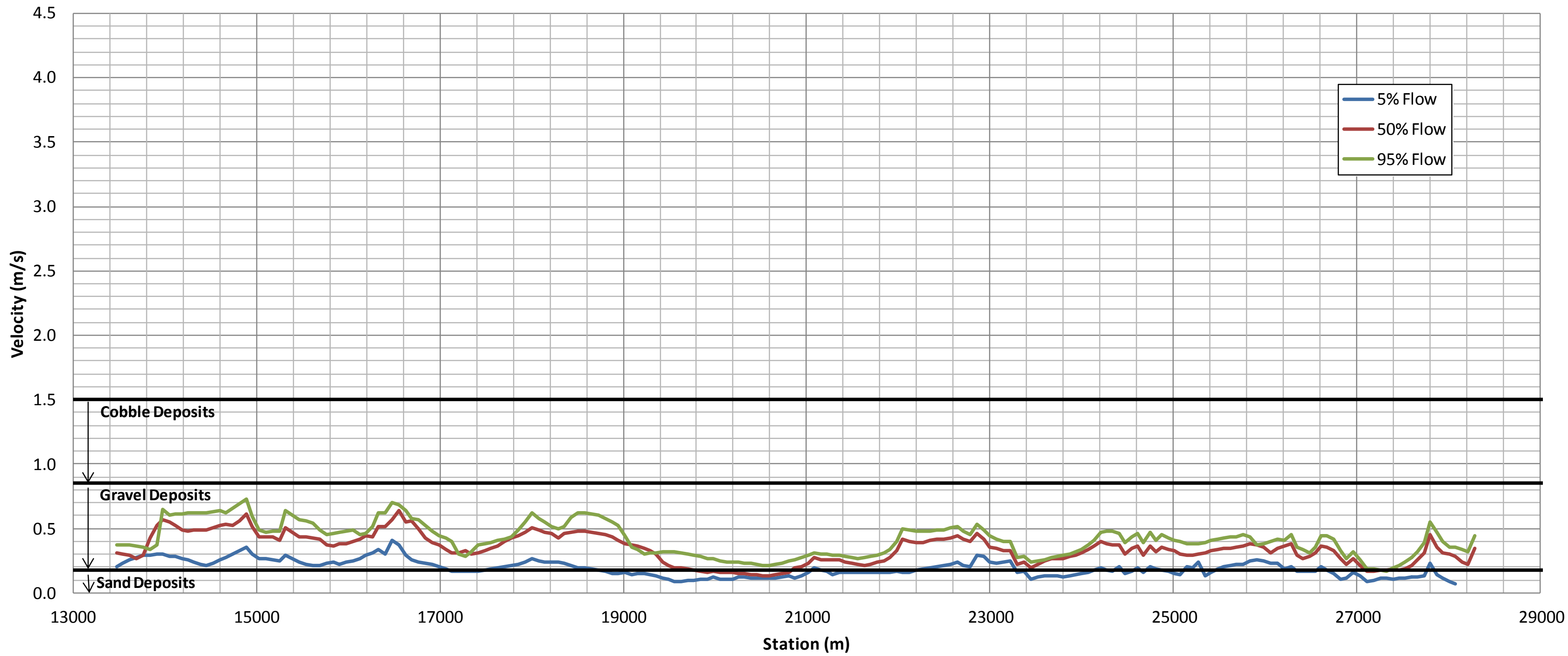

Figure 4.4-10. Comparison of computed velocity profiles in the overbanks with minimum velocity for deposition.

2011-2012 Closure

A steady state hydraulic model using the cross sections surveyed in 2013 was simulated for the 5%, 50% and 95% flows of 0.5 m^3/s (20 cfs), 3.9 m^3/s (140 cfs) and 6.9 m^3/s (245 cfs) for the 2011/2012 closure, respectively, as previously discussed in Section 4.2.

The computed average shear stresses in the main channel during the 2011/2012 closure are shown in Figure 4.4-11, and are compared to the critical shear stress for erosion of the different grain classes. The computed average velocities in the main channel are shown on Figure 4.4-12, and are compared to the minimum critical velocity for erosion of the different grain classes. Figures 4.4-13 show the resulting average velocities in the main channel compared to the maximum critical velocity for deposition of the different grain classes.

As shown on Figure 4.4-11 and 4.4-12, the computed average shear stresses and velocities in the Buffalo Creek channel are large enough to induce the movement of sands. Smaller gravel could also be mobilized and transported in some areas. Even for lower flows, gravels could be transported by bedload and erosion could occur in areas with higher flow velocities.

Once in movement, Figure 4.4-13 shows that there is a low potential for sands and smaller particles to deposit in the channel for median and high flows. At high flows, even gravels may not deposit in certain areas of the channel. However at low flows, the results of the analysis show that there are locations where the velocities are becoming small enough for potential deposition.

Contrary to the 2011-2012 Operation period, water levels in Buffalo Creek during the 2011-2012 closure period remained generally within the main channel and rarely exceeded the overbanks. On this basis, the potential for erosion and deposition was negligible for this period. In the rare locations where water levels exceeded the overbanks for brief periods of time, velocities would have remained low and there would have been a potential for deposition.

When compared to the 2011-2012 Operation period, the results of the 2011-2012 closure period indicate that the larger size materials such as gravels and cobbles had a greater potential for erosion in the main channel during the 2011-2012 Operation period. There was also a potential for erosion and deposition in the overbanks during the 2011-2012 Operation period. However since water levels generally did not exceed overbanks during the 2011-2012 Closure period, the potential for erosion and deposition was negligible in the overbanks during this period. The potential for deposition was greater during the 2011-2012 Closure period for smaller size material such as gravel and sands.

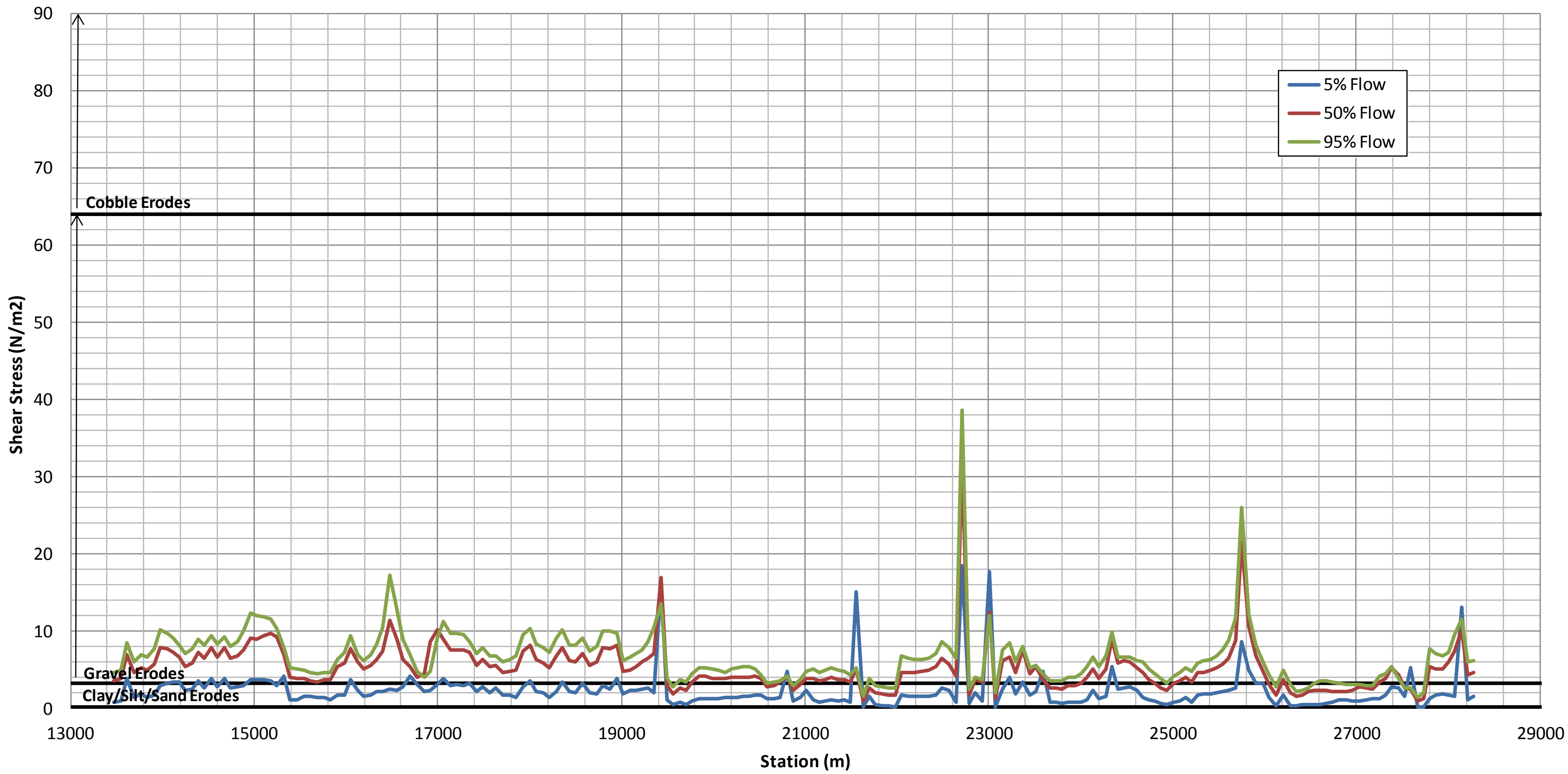

Figure 4.4-11. Comparison of computed Shear Stress profiles in the main channel with critical shear stresses for erosion.

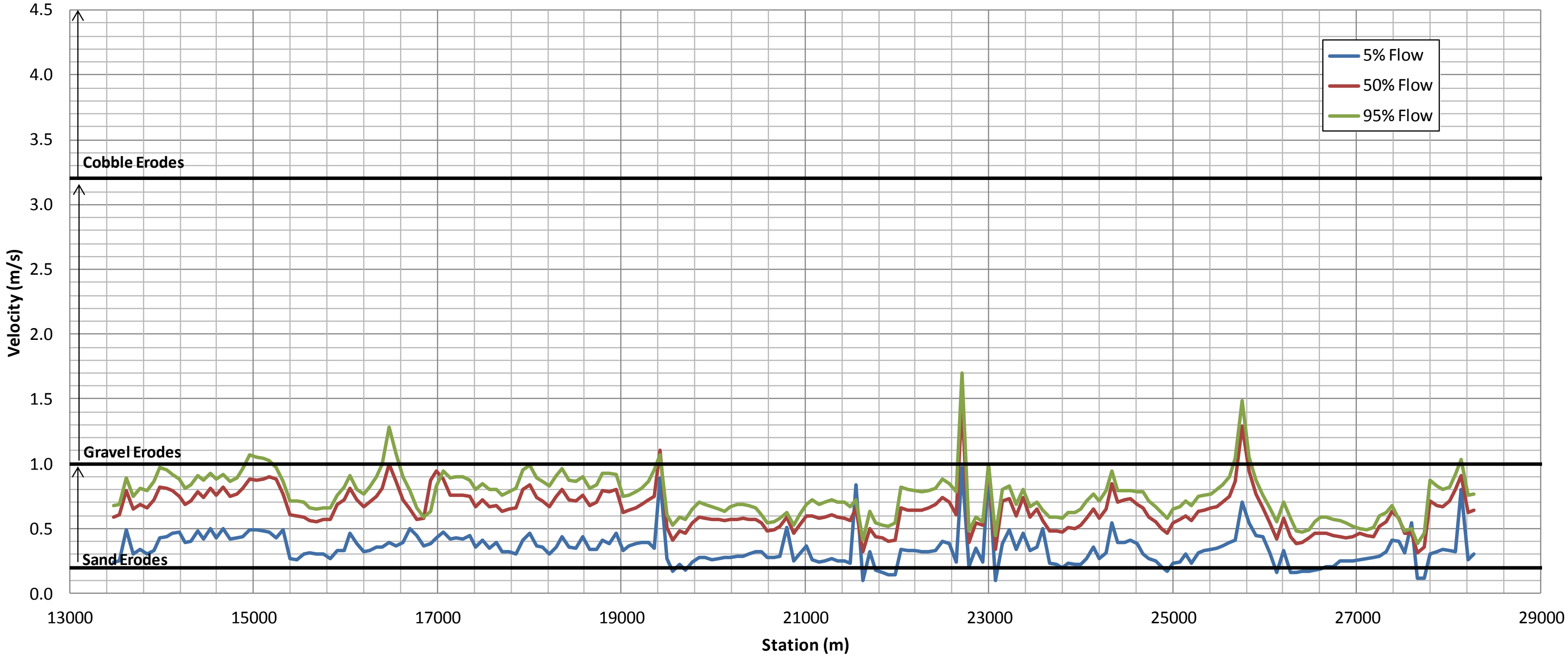

Figure 4.4-12. Comparison of computed velocity profiles in the main channel with minimum velocity for erosion.

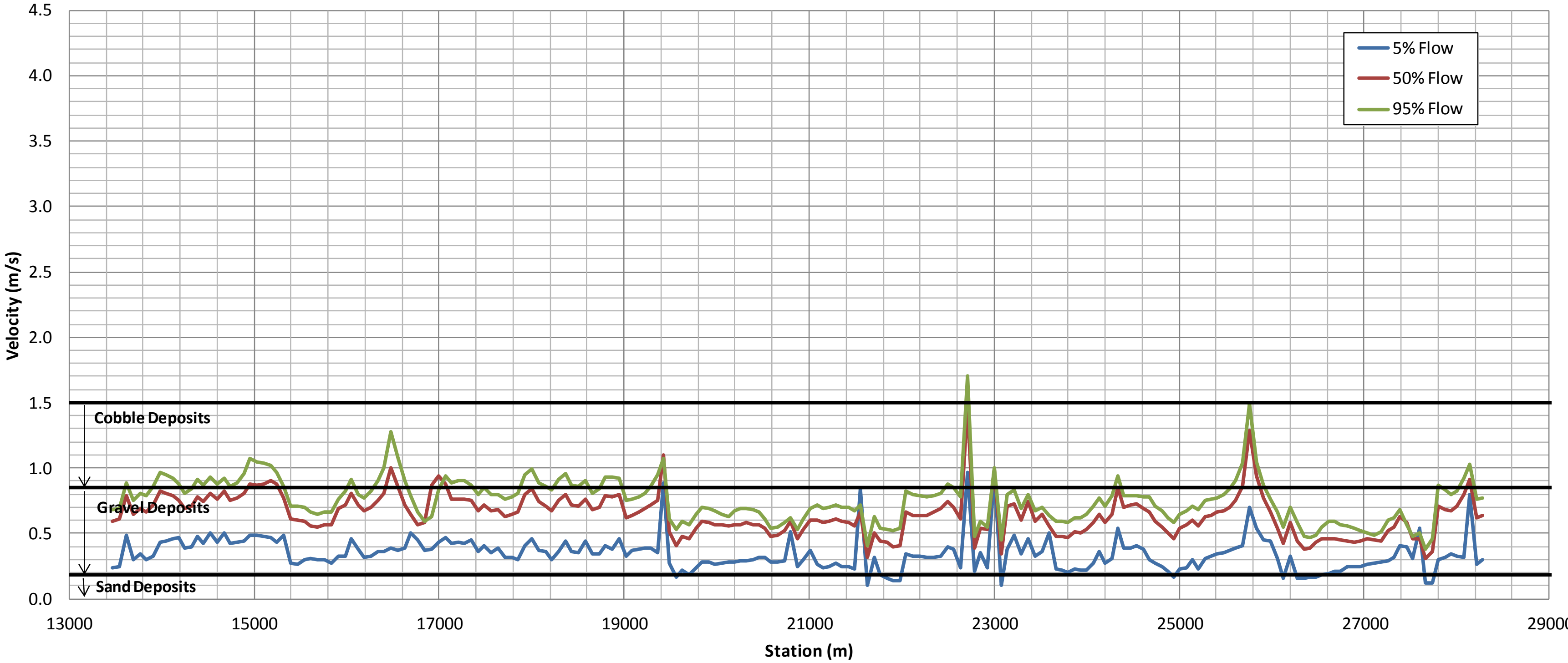

Figure 4.4-13. Comparison of computed velocity profiles in the main channel with maximum velocity for deposition.

2014-2015 Operation

A steady state hydraulic model using the cross sections surveyed in 2013 was simulated for the 5%, 50% and 95% flows of 97 m^3/s (3420 cfs), 109 m^3/s (3845 cfs) and 128 m^3/s (4534 cfs) for the 2011/2012 closure, respectively, as previously discussed in Section 4.2.

The computed average shear stresses in the main channel and in the overbanks are shown in Figures 4.4-14 and 4.4-15 respectively, and are compared to the critical shear stress for erosion of the different grain classes. The computed average velocities in the main channel and in the overbanks are shown on Figures 4.4-16 and 4.4-17, and are compared to the minimum critical velocity for erosion of the different grain classes. Figures 4.4-18 and 4.4-19 show the resulting average velocities in the main channel and in the overbanks compared to the maximum critical velocity for deposition of the different grain classes.

As shown in Figures 4.4-14 to 4.4-17, the range of computed velocities and shear stresses for the 2014/2015 closure is similar to the 2011/2012 Operation, despite the wider cross sections due to the past riverbank erosion that occurred during the 2011/2012 Operation. In the main channel, velocities and shear stresses are large enough to induce the movement of gravel size materials or smaller, and potential erosion of cobbles, locally.

Once in movement, Figure 4.4-18 shows that for flows occurring during the 2014/2014 Operation of Reach 1, there is a low potential for gravel size sediments or smaller to deposit in the main channel. When flows exceed median conditions, cobble size material also has a low potential for deposition.

In the overbanks, Figure 4.4-19 shows that gravel and sand size sediment has a potential for deposition during operation of Reach 1.

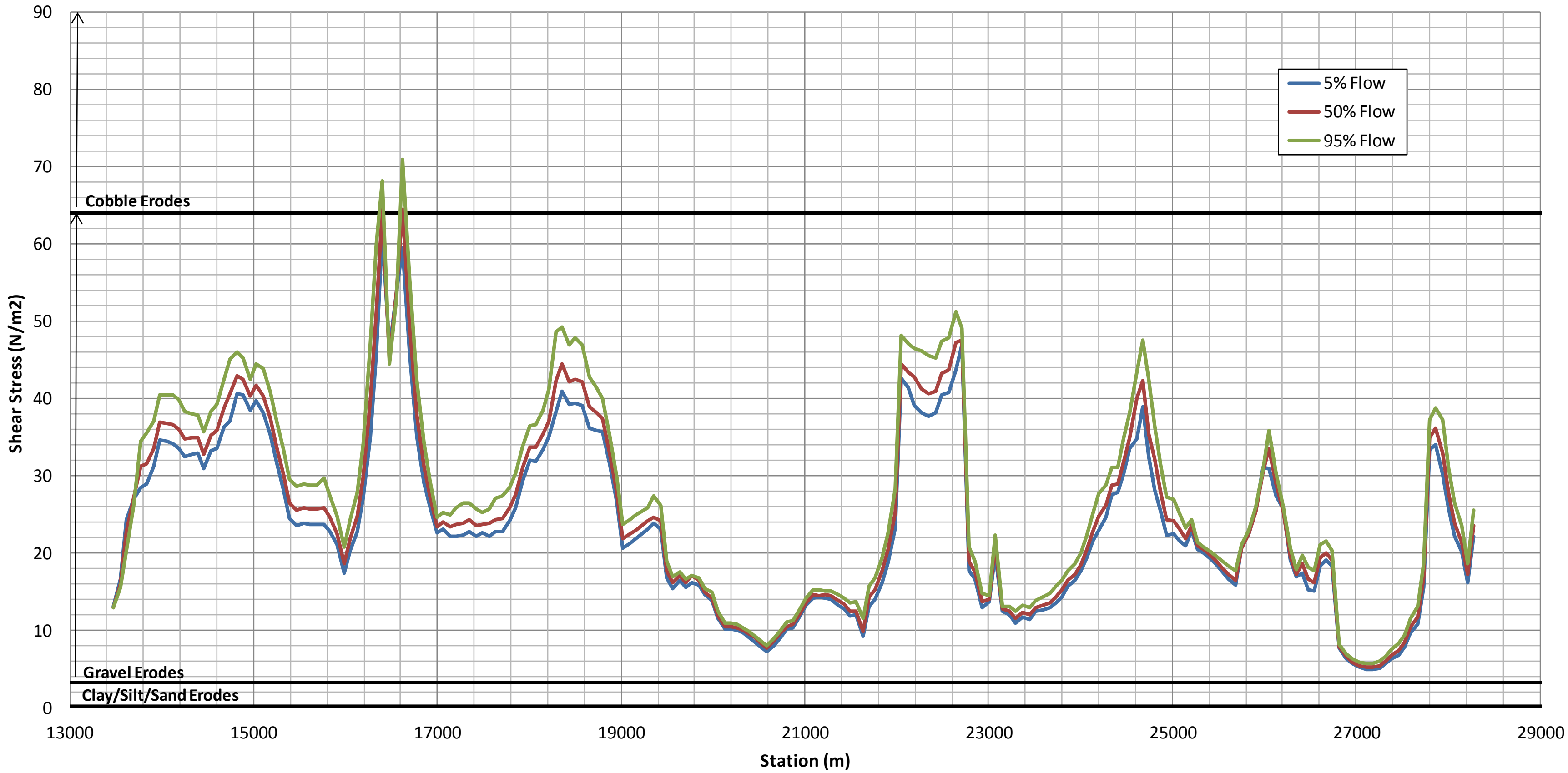

Figure 4.4-14. Comparison of computed Shear Stress profiles in the main channel with critical shear stresses for erosion.

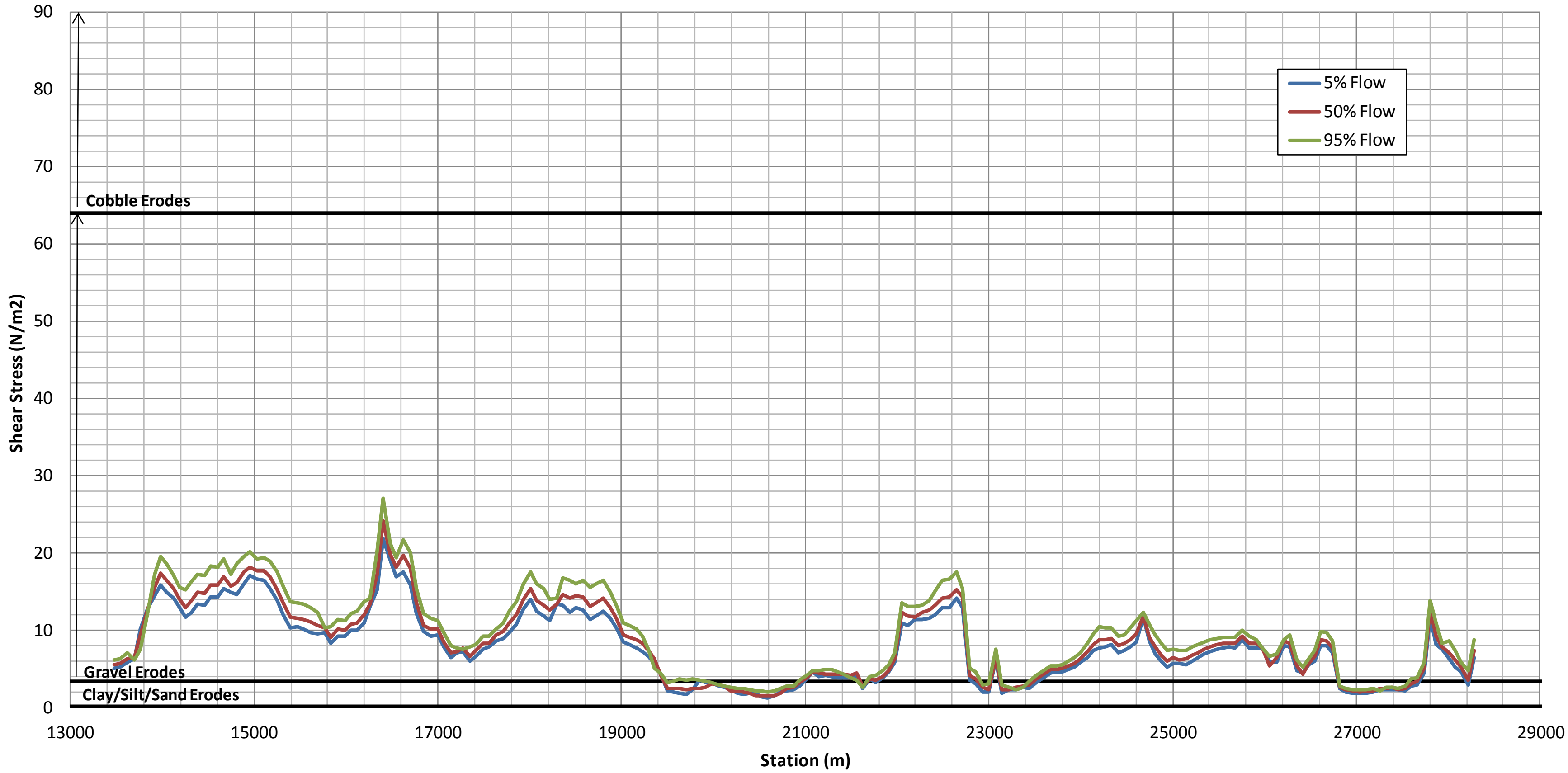

Figure 4.4-15. Comparison of computed Shear Stress profiles in the overbanks with critical shear stresses for erosion.

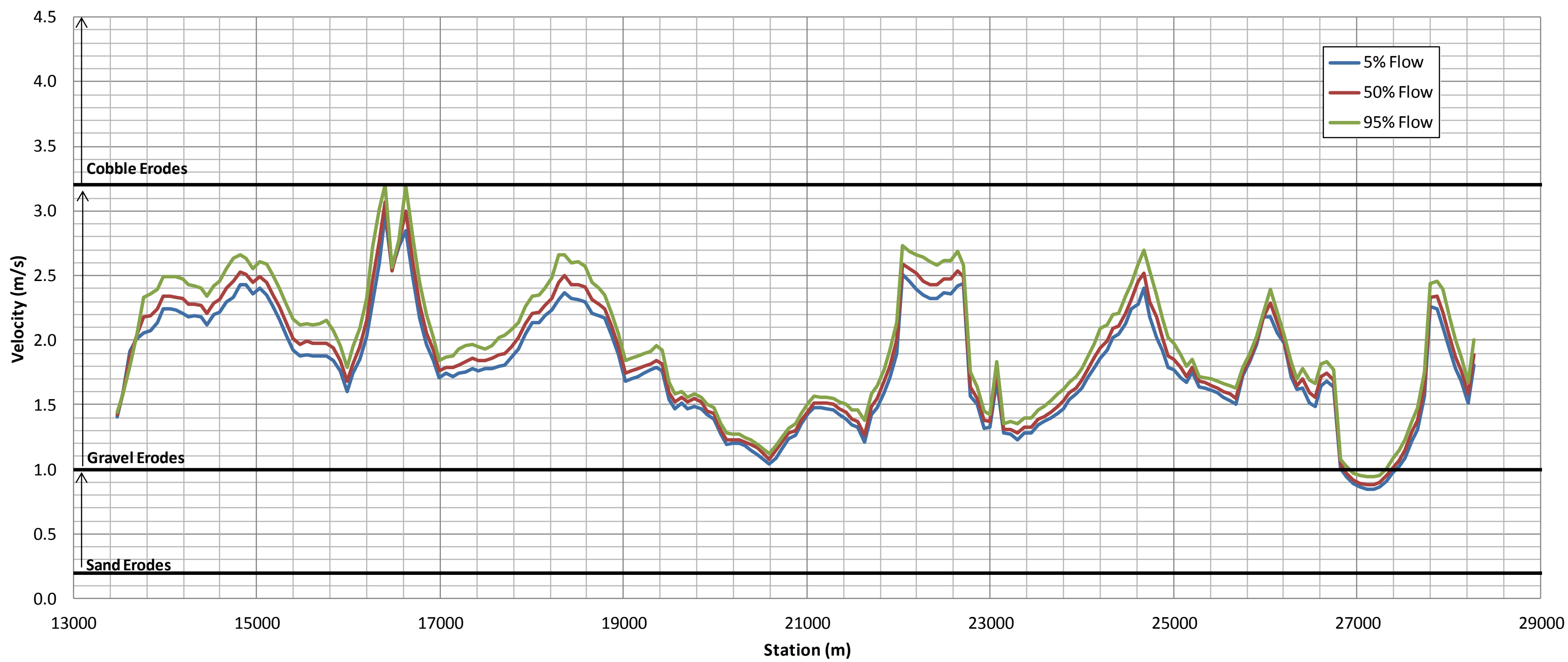

Figure 4.4-16. Comparison of computed velocity profiles in the main channel with minimum velocity for erosion.

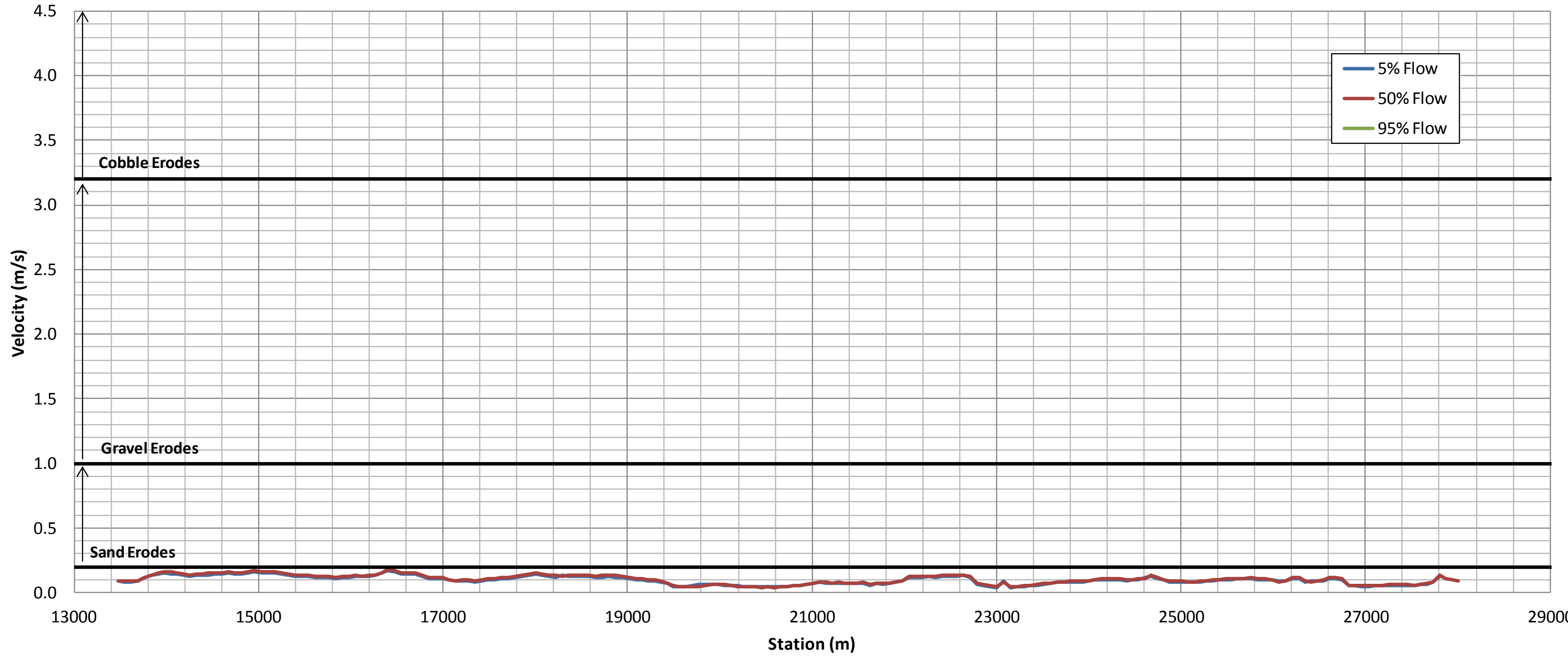

Figure 4.4-17. Comparison of computed velocity profiles in the overbanks with minimum velocity for erosion.

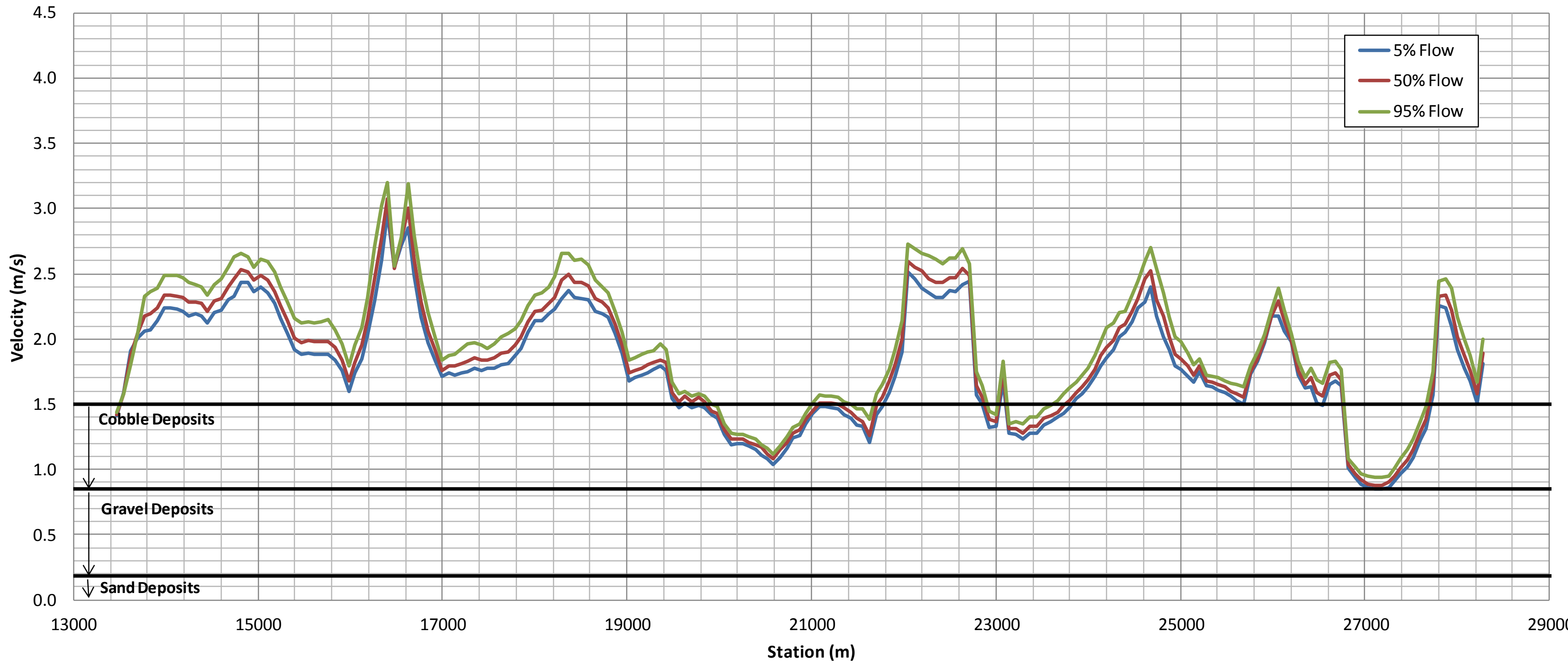

Figure 4.4-18. Comparison of computed velocity profiles in the main channel with maximum velocity for deposition.

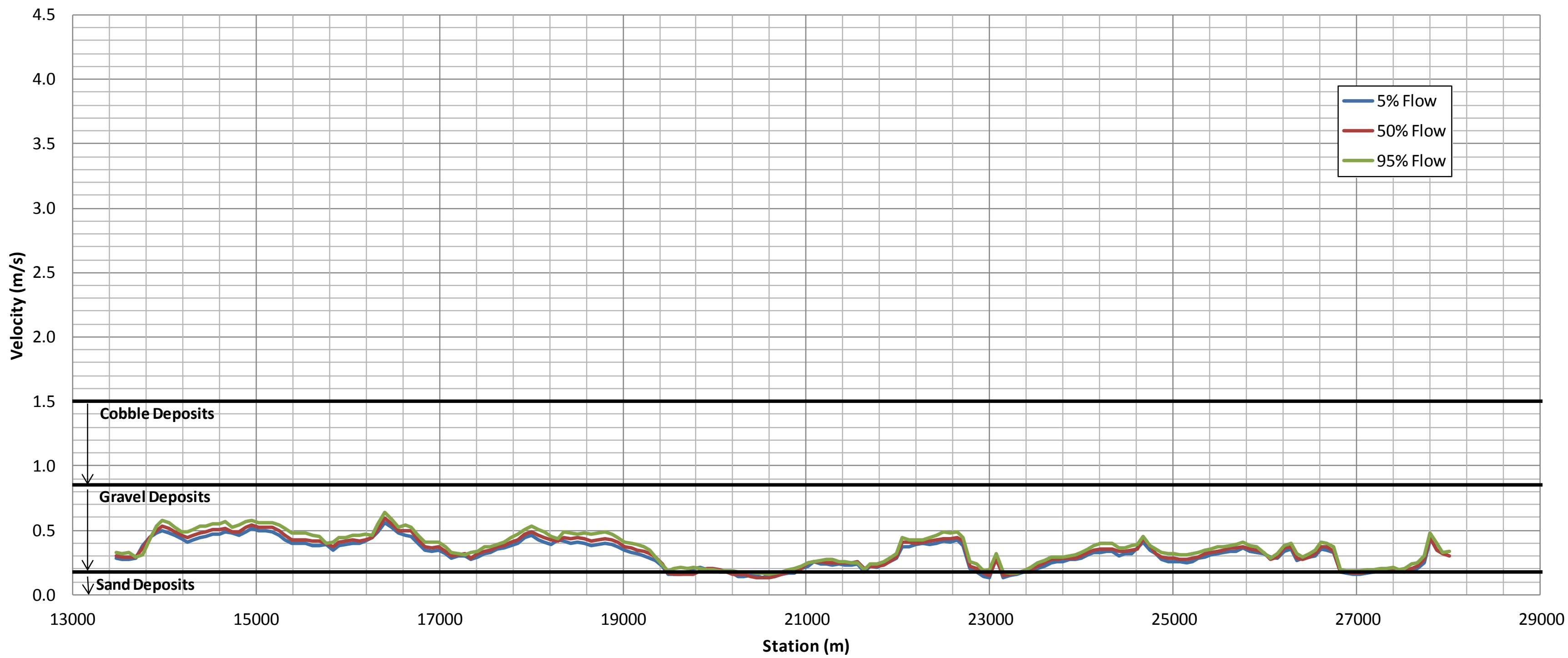

Figure 4.4-19. Comparison of computed velocity profiles in the overbanks with minimum velocity for deposition.

4.5 DAUPHIN RIVER MONITORING RESULTS

4.5.1 Flow

On Dauphin River, hydrometric data are available from the WSC hydrometric station No. 05LM006 (Dauphin River near Dauphin River). The flows recorded at the WSC station are shown on Figure 4.5-1. The Dauphin River flows were also computed without Reach 1 with a routing model of Lake St. Martin, to assess the effects of the operation of the emergency channel on the Upper and Lower Dauphin River flows, also shown on Figure 4.5-1.

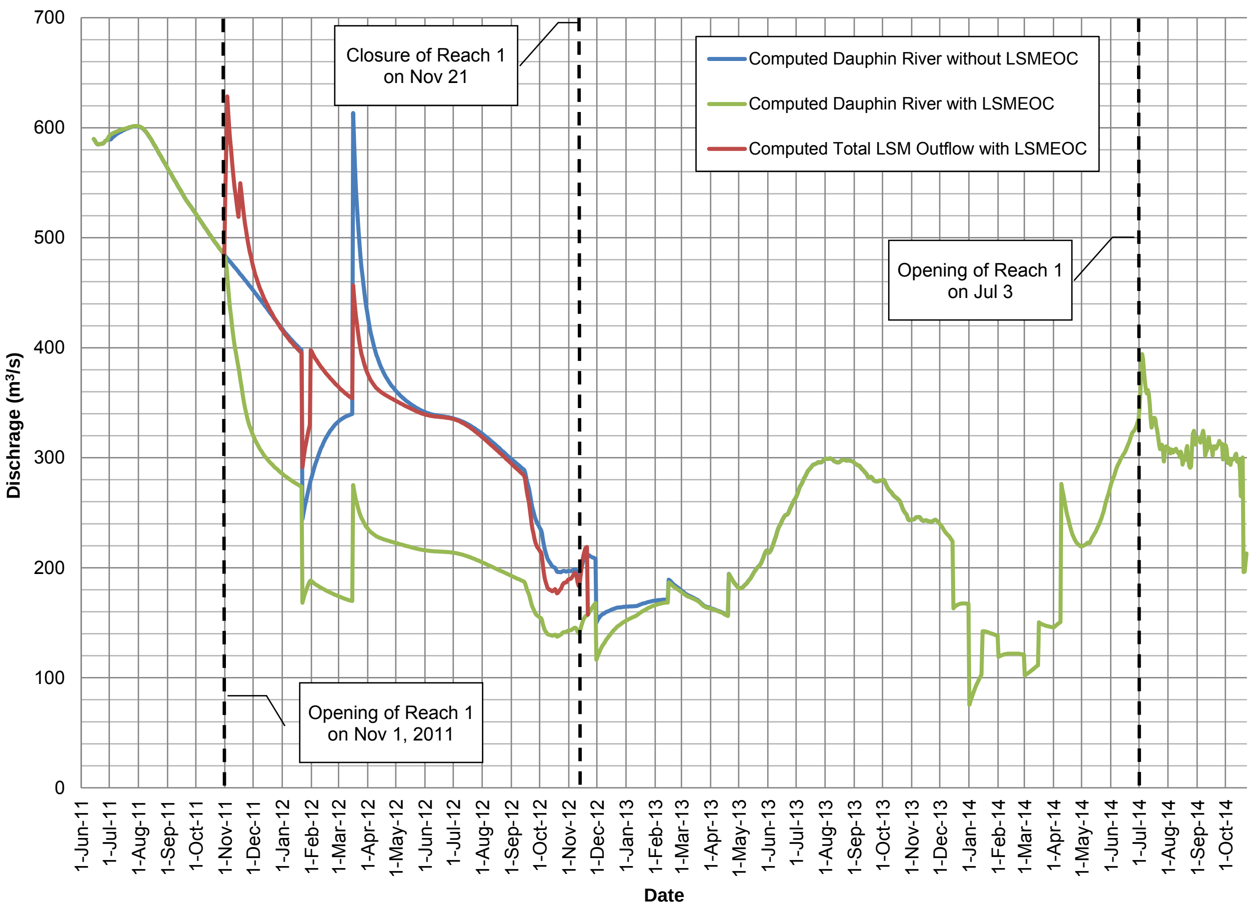

Figure 4.5-1. Computed Dauphin River flows with and without operation of Reach 1.

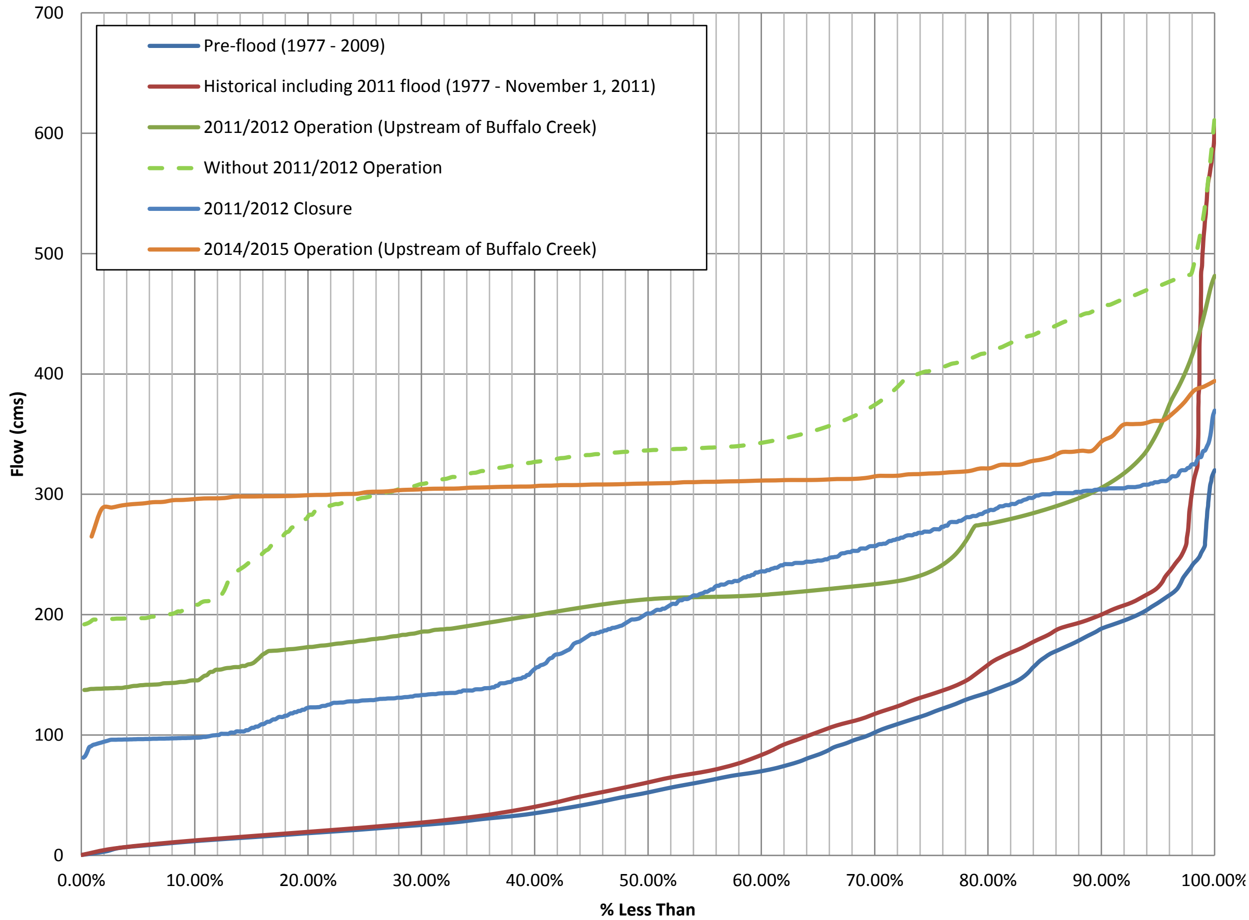

Figure 4.5-2. Duration Curves of Upper Dauphin River Flows.

The 5, 50 and 95 percentile flows utilized in the habitat assessment were derived from the duration curves of daily flows computed from the recorded or computed flows upstream of the confluence with Buffalo Creek, and presented in Figure 4.5-2. Table 4.5-1 summarizes these flow conditions for each project phase. It should be noted that the duration curve for the 2014/2015 Operation period was computed based on a shorter time period since the channel was still in operation at the time of the analysis, and is based on the flows measured between July 3, 2014 to October 22, 2014.

As indicated in Table 4.5-1, the Dauphin River flows upstream of Buffalo Creek were reduced by the 2011/2012 Operation of Reach 1. This reduction results from the additional outflow provided by Reach 1 during operation, which in turn also reduced the water levels on Lake St. Martin compared to the natural conditions without the operation of the emergency channel.

Table 4.5-1. Modeled discharge (as 5th, 50th, and 95th percentiles) for the Dauphin River (upstream of confluence with Buffalo Creek) during each project phase.

Flow Percentile (%)	Pre-flood (m^3/s)	2011 Flood (m^3/s)	2011/2012 Operation (m^3/s)	2011/2012 Without Operation (m^3/s)	2011/2012 Closure (m^3/s)	2014/2015 Operation (m^3/s)
5	8	-	141	197	97	292
50	58	368	213	337	201	309
95	212	603 (peak)	353	473	310	361

4.5.2 TSS/Turbidity Data

Time series of TSS were computed for Dauphin River from the turbidity records and the TSS data collected between 2011 and 2014. These computed concentrations were used in conjunction with the computed flows for the corresponding period in the empirical model.

As shown on Figure 4.5-3, During the 2011/2012 Operation, the TSS at the exit of Dauphin River exceeded the baseline (representative of the conditions existing upstream of the confluence with Buffalo Creek) following the initial operation of Reach 1. After March 2012, the difference in TSS concentration between the baseline and the exit of the Dauphin River appeared to be insignificant. The TSS concentration during the 2011/2012 Operation ranged from 0 to 30 mg/L.

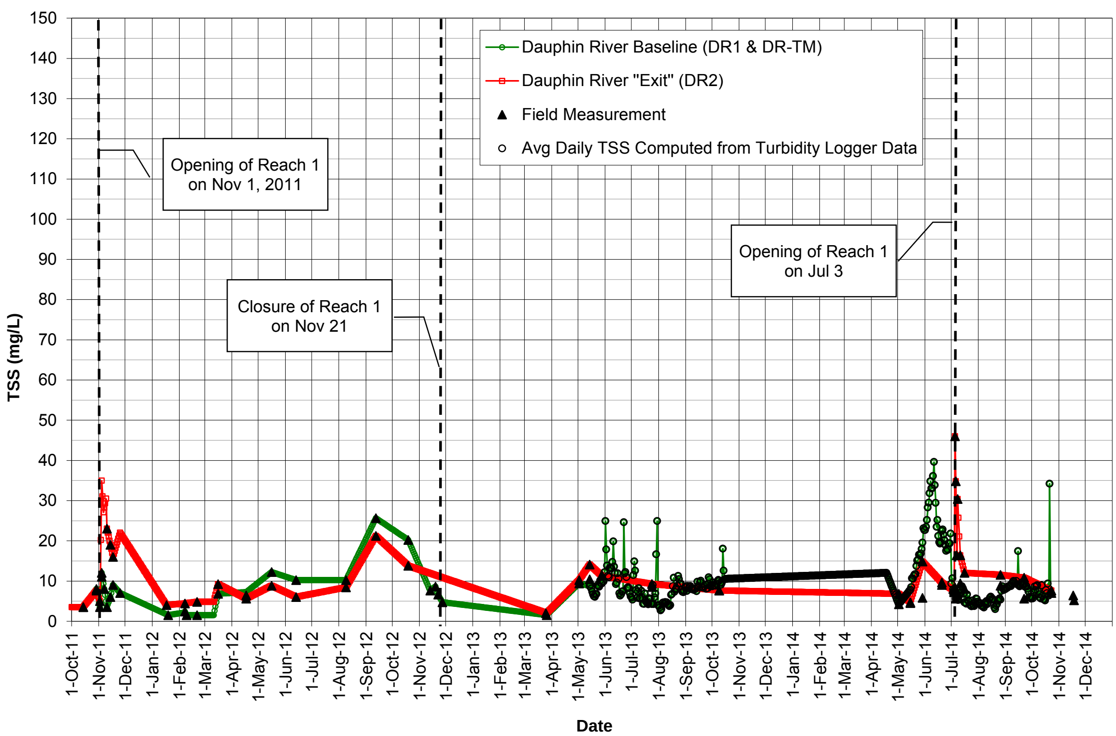

Figure 4.5-3. Times series of computed daily total suspended solids for the Dauphin River.

After closure of Reach 1 on November 21, 2012, the TSS concentrations were variable and never exceeded 40 mg/L at the exit of the Dauphin River. The differences in TSS between the baseline and Sturgeon Bay varied between 5 and 20 mg/L, but no significant difference could be noted.

A peak of TSS was also observed following the opening of Reach 1 on July 3, 2014, where the TSS reached a maximum of 50 mg/L. The increase in TSS was very brief and likely associated with the re-operation of the Reach 1 system and the flushing of smaller particles of sediment that would have settled in Reach 1 and Buffalo Creek.

4.5.3 Bathymetric Survey

The bathymetric surveys of the Lower Dauphin River carried out in June 2011, June 2013 and June 2014 were processed and compared to identify areas with notable changes in riverbed elevations (Appendix 4.C).

The comparison between the 2011 and 2013 surveys shows the potential changes in bathymetry that have occurred during the operation of Reach 1. The accuracy of the survey methods, considering the site conditions and the equipment used, was considered to be valid at a +/- 0.5 m. The initial purpose of the 2011 survey was to collect bathymetry data for the development of the hydraulic model. Therefore, the density of the SONAR data is coarser than what would typically be targeted for an analysis by comparison of riverbed elevations. The interpolation method between survey points required to develop a continuous surface could lead to local variations in elevation greater than -0.5 m / +0.5 m and may not necessarily be attributed to an actual change in bathymetry.

Between 2011 and 2013, the variations in bathymetry on the Dauphin River upstream of Buffalo Creek mainly ranged from - 0.5 m to + 0.5 m. Locally, some areas were lower in elevation in 2013 than in 2011 by 0.5 to 1.0m. Other areas, mostly located along the shoreline, were higher in elevation by 0.5 to 1.0m. These changes are considered representative of the natural conditions on the Dauphin River since they are also present upstream of the confluence with Buffalo Creek. As discussed in Section 4.5.1, the flow velocities at the centreline of this reach of the river have reached a magnitude greater than 1.5 m/s. Such velocity is capable of eroding gravel size material and of transporting cobbles up to 0.2 m in diameter. The natural conditions on the river, as observed upstream of the confluence with Buffalo Creek, appear to be variable, with local changes in elevation greater than -0.5 and +0.5 m.

Downstream of the confluence with Buffalo Creek, the differences in elevation are generally similar to those observed upstream of the confluence. Most of the variations in this reach are comprised between -0.5m and +0.5m. Locally, some areas exceed this range, however, no significant changes in bathymetry can be identified between the confluence and Station 51,500.

Downstream of Station 51,500, the variations are fairly similar to the rest of the reach, except in one area across the river showing a decrease in the riverbed elevation by 1.0 to 1.5m. This area appeared to be the location where some erosion occurred, and could be associated with the formation of the ice cover during the winter. The review of the ice processes identified this area as being prone to the formation of an ice dam, which would force more flow under the ice cover and generate higher velocities with a higher potential for erosion. This phenomenon has been known to naturally occur at this location prior to the operation of Reach 1. Finally, the variations in bathymetry in Sturgeon Bay are generally comprised between -0.5m and +0.5m. Some areas present a difference in elevation marginally greater than 0.5m.

The comparison between the 2013 and 2014 survey shows the potential changes in riverbed elevations that have occurred during the 2011/2012 Closure, and prior to the 2014/2015 Operation. Most of the changes observed in the Lower Dauphin River ranged between -0.5m and +0.5m. Some areas were actually lower in 2014 by up to 1.0m, and even 1.5m, locally. There are signs of sediment deposition as far downstream as Sturgeon Bay. Areas already identified as potentially subject to sediment deposition during the 2011/2012 Operation, shows that some erosion could have occurred during the 2011/2012 Closure.

In conclusion, the changes in riverbed elevations identified with the comparison of the 2011 and 2013 data, and again in 2013 and 2014, appear to be fairly uniform along the Lower Dauphin River. The variations in elevations generally range between -0.5 to 0.5m, with some areas showing signs of erosion principally along the centreline of the river and others some deposition, along the shoreline. One location at Station 52,050 presents signs of erosion that could have been attributed to the formation of an ice dam during the 2011/2012 winter. Changes of such magnitude are also present upstream of the confluence with Buffalo Creek, and appear to take part in the dynamic sediment transport processes that naturally occur in the Lower Dauphin River. On this basis, it cannot be confirmed if the changes in riverbed elevations observed on the Lower Dauphin River can directly be attributed to the operation of Reach 1. The sediment transport processes are further discussed in Section 4.5.5.

4.5.4 Ice processes

Natural Conditions

The Dauphin River is the only natural outlet from Lake St. Martin. It traverses over a distance of about 50 km from Lake St. Martin to its outlet into Lake Winnipeg and the water typically changes from approximately 242.9 to 243.8 m (797 to 800 ft) at Lake St. Martin to 216.7 to 217.9 m (711 to 715 ft) at Lake Winnipeg. Over the first 25 km, the river gradient is relatively flat and the flow has a low velocity. The discharge capacity at the outlet from Lake St. Martin is dominated by the frictional effects of the flow in the upper Dauphin River. Winter conditions can cause formation of an ice cover and significantly affect the discharge capacity. Typically, it has been observed that the greater is the outflow, the larger the potential reduction due to ice can be.

The lower 30 km of the river is steeply inclined, with a gradient of about 25 m over the relatively short length of the lower river. Velocities are relatively high. The formation of a smooth ice cover is rarely possible. In most years the ice cover forms as result of an accumulation of frazil ice pans formed in the fast flowing lower river. Rises in water level in the freeze-up period have, prior to 2011, been observed to be in the range of 1 to 2 m. The higher the flow, the higher the river water level must rise to create a stable ice cover. Conditions in the lower Dauphin River do not affect Lake St. Martin water levels or outflow.

In spring, the sudden increase in flow due to resumption of open water conditions at the outlet of Lake St. Martin could trigger ice jams in the lower river.

The Dauphin River slopes relatively gently over the first 40 km from its source at Lake St. Martin, with a gradient of about 0.3 m per 1000 m. This is comparable to many slowly moving streams in the flat topography of central Manitoba. However, it then steepens significantly over the next 10 km to a gradient that averages about 1 m per 1000 m of length, and in short portions of that reach, approaches 1 m per 700 m of length. Even in the last few kilometers where the river enters Lake Winnipeg the river slope remains steep. Flow velocities typically range between 0.5 to 1.5 m/s over the first 40 km and increase to approximately 2 m/s over the next 10 km.

This wide variation in slope of the river results in widely varying ice conditions. In the upper river, the sluggish flow can develop an ice cover due to border ice advancement, skim ice formation, and bridging of moving slush ice between border ice edges, even before the ice cover advances from downstream.

In the steep lower part of the river where the velocities are high, the river surface typically cools to freezing in early November. At that point, frazil ice begins to generate and coalesce into slush ice pans that travel down into Lake Winnipeg. The surface of Lake Winnipeg typically ices over in the area of the Dauphin River mouth by early November. At that point, the slush ice being delivered by the Dauphin River begins to amass at the river mouth and back up the water levels. This is the classic formation of a hanging ice dam, and would be expected to occur at this location when river flows are greater than about 70 m^3/s (2,470 cfs).

In the late fall of 2010, the river flow was in the order of 200 m^3/s (7,060 cfs). The ice cover advanced from Lake Winnipeg, being supplied continuously by a steady inflow of slush ice. Water levels were estimated to have risen over 2 m as the ice cover formed and stabilized. These photos showed recognizable landmarks such as roads, and the water levels that were occurring at that time could be estimated. It was reported that the road near Cranberry Creek was overtopped in 2010 by November 21, and provided more evidence of the rising stage of the river with the ice cover advancement.

In spite of the high flow in the Dauphin River, the water and ice levels did not exceed the bankfull stage in the Dauphin River communities and no serious damages occurred in 2010. Upstream, water did exceed bankfull stage and flooded part of PR 513 and an access road west of the Dauphin River community, but only at a few minor locations.

MIT reported that the river developed a full ice cover that extended from Lake Winnipeg to Lake St. Martin by mid-December in 2010. Short reaches of open water remained by that time.

This mode of ice formation and advancement, or variations of it, occurs every year, and affects the discharge capacity from Lake St. Martin. MWS has estimated that in previous years with normal river flow conditions, the stage-discharge relationship at the outlet of Lake St. Martin rises approximately 60 cm due to the formation of the ice cover.

Observations during the 2011/2012 Operation

The winter of 2011-2012 was exceptionally warm. The total degree days of freezing for the 2011-2012 winter were the lowest of the previous thirty years on record. The ice development during the winter was significantly affected by this, not only on the timing of occurrence of the ice cover, but also the maximum staging during the formation process.

In general, the mild temperature conditions allowed the ice cover to form and stabilize at lower water levels than predicted under normal conditions. Nevertheless, water level staging of 3 to 4 m was measured at some locations. Also since the frequency of the measurements were not continuous, it is possible that the peak water was not measured at other locations. The peak water level may have occurred either between two measurements or possibly later in the winter. The monitoring program ended on January 6, 2012. At that time the ice front was located just upstream of Buffalo Creek, therefore it was possible that additional staging still occurred.

4.5.5 Hydraulic and Sediment Transport Modeling

4.5.5.1 Empirical Model Results

2011/2012 Operation

Table 4.5-2 present the suspended sediment volume balance computed with the empirical model for the Dauphin River during the 2011/2012 Operation of Reach 1. The general trend is for sediment to leave the Upper Dauphin River into Sturgeon Bay. According to the empirical model results, the combined cumulative volume of suspended sediment at the confluence between Buffalo Creek and the Dauphin River is estimated at 82,200 m³. The Upper Dauphin River contributes to almost 60% of this volume, while the Reach 1 and the Buffalo Creek watershed is the source of the remaining 40%. The total volume of suspended sediment available for transport or deposition in the Lower Dauphin River should be analyzed in conjunction with the flow velocities occurring along this reach to identify the potential for transport or deposition. This analysis was carried out based on the MIKE-21 results and is discussed in Section 4.5.5.2.

Table 4.5-2. Suspended sediment volume balance for Reach 1 System from Exit of Buffalo Creek to Exit of Dauphin River (Nov. 1, 2011 to Nov 21, 2012).

Description	Cumulative Sediment Volume (m³)
Dauphin River Baseline	47,800
Buffalo Creek Exit	34,400
Combined Dauphin River Baseline & Buffalo Creek Exit	82,200

As indicated in Table 4.5-2, the combined volume of suspended sediment downstream of the confluence with Buffalo Creek during the 2011/2012 Operation is estimated at 82,200 m³. To assess the effects of the operation of Reach 1 on the volume of suspended sediment in the Dauphin River downstream of Buffalo Creek, the same volume was computed with the empirical model with Dauphin River flows obtained from the routing model if Reach 1 had not been operated. The total volume of suspended sediment at this location during the 2011/2012 Operation period, but if Reach 1 had not been operated, is estimated at 73,300 m³. Since the Upper Dauphin River flows would have been significantly greater without operation of the emergency channel, the cumulative volume of suspended sediment upstream of Buffalo Creek would also exceed the volumes actually observed at that location during operation. According to the empirical model results, the operation of Reach 1 contributed to an additional 8,900 m³ of suspended sediment in the Dauphin River downstream of the confluence with Buffalo Creek during operation. This amount represents approximately 12% of the total volume of sediment that would have naturally been transported in the Dauphin River without operation of Reach 1.

2011/2012 Closure

Table 4.5-3 presents the suspended sediment volume balance computed with the empirical model for the Dauphin River during the 2011/2012 Closure. The general trend is for sediment to leave the Upper Dauphin River, to a lesser degree than during the operation period. According to the empirical model results, the combined cumulative volume of suspended sediment at the confluence between Buffalo Creek and the Dauphin River is estimated at 74,800 m³. The Upper Dauphin River contributes to almost 97% of this volume, while Buffalo Creek is the source of the remaining 3%. The total volume of suspended sediment available for transport or deposition in the Lower Dauphin River should be analyzed in conjunction with the flow velocities occurring along this reach to identify the potential for transport or deposition. This analysis was carried out based on the MIKE-21 results and is discussed in Section 4.5.5.2.

Table 4.5-3. Suspended sediment volume balance for Reach 1 System from Exit of Buffalo Creek to Exit of Dauphin River (Nov. 21, 2012 to July 3, 2014).

Description	Cumulative Sediment Volume (m³)
Dauphin River Baseline	72,200
Buffalo Creek Exit	2,600
Combined Dauphin River Baseline & Buffalo Creek Exit	74,800

The total cumulative volume of suspended sediment in the Dauphin River downstream of the Buffalo Creek confluence during the 2011/2012 closure period was also estimated if Reach 1 had not been operated. Based on the empirical model results, this would amount to 72,600 m³. Conservatively assuming that without operation of Reach 1, flows in Buffalo Creek during the closure period would have been negligible, the residual effects of the operation of Reach 1 after closure of Reach 1 contributed to an additional 2,200 m³ of suspended sediment in the Dauphin River downstream of the confluence with Buffalo Creek. This amount represents only 3% of the total volume of sediment that would have naturally been transported in the Dauphin River without operation. The additional volume of suspended sediment can be explained by the combined effects of the drawdown on Buffalo Lake, riverbank instabilities following the recession of the water levels and the transport of finer sediment mobilized during the operation of the channel.

2014/2015 Operation

Table 4.5-4 presents the suspended sediment volume balance computed with the empirical model for the Dauphin River during the 2014/2015 Closure. Since these volumes were computed over a shorter period of time, the magnitude is smaller than that reported for the 2011/2012 period, however the same general trend can be observed. According to the empirical model results, the combined cumulative volume of suspended sediment at the confluence between Buffalo Creek and the Dauphin River during this shorter period is estimated at 25,400 m³. The Upper Dauphin River contributes to almost 58% of this volume, while Buffalo Creek is the source of the remaining 42%. Based on the shorter period of record, the contribution of each reach in suspended sediment appears to be similar in proportion as during the 2011/2012 Operation.

Table 4.5-4. Suspended sediment volume balance for Reach 1 System from Exit of Buffalo Creek to Exit of Dauphin River (Jul. 3, 2014 to Oct. 22, 2014).

Description	Cumulative Sediment Volume (m³)
Dauphin River Baseline	14,800
Buffalo Creek Exit	10,600
Combined Dauphin River Baseline & Buffalo Creek Exit	25,400

4.5.5.2 MIKE 21 Model Results

The 5, 50 and 95 percentile flows for the Dauphin River during the 2011/2012 Operation were simulated with the MIKE 21 model. The depth-averaged velocities and water depths were exported from the 2D model and used in this analysis. The simulated velocities for each flow conditions were compared with the theoretical critical velocities for deposition and erosion of each class of material, as defined by the Hjulstrom relationship presented in Figure 4.2-4.

As computed with the MIKE 21 model, velocities in the Lower Dauphin River downstream of the confluence with Buffalo Creek range from 0.5 to 1.5 m/s for the 5th percentile flow. Some areas exceed 1.5 m/s, locally. For the 95th percentile, the computed velocities are greater than 1.5 m/s between the confluence with Buffalo Creek and the exit of the Dauphin River in Sturgeon Bay. According to the Hjulstrom relationship, velocities of 0.5 m/s and greater can erode sand size particles, and are able to transport gravel size material. As flow velocities reach 1.5 m/s, bed material of a gravel size can be eroded, and cobbles with a diameter up to 0.20 m can now be transported by bed load. The range of velocity that existed in the Lower Dauphin River during operation indicates that the general trend is for river bed material to be eroded and transported further downstream until the velocities and shear stresses reach the critical value for deposition of the material.

During the 2011 flood, the flows observed on the Lower Dauphin River have exceeded the 95th percentile calculated for the 2011/2012 Operation period. The range of velocities and therefore the sediment transport processes previously described naturally occurred prior to the operation of Reach 1.

The empirical model computed the total volume of suspended sediment resulting from the operation of Reach 1 and released at the downstream end of Buffalo Creek at 8,900 m^3.The suspended sediment was essentially constituted of clay, silts and sands. Suspended sediment of such sizes will deposit when velocities are lower than 0.01 m/s. Since the minimum velocities during the 2011/2012 Operation generally exceeded 0.5 m/s, it appears that the suspended sediment released from the Reach 1 System would be transported through the Lower Dauphin River into Sturgeon Bay. Some local deposition may occur in back eddies or near the shoreline, however the volume of sediment that will deposit is anticipated to be marginal. The sediment transport processes within Sturgeon Bay are further discussed in Section 4.6.

During the 2011/2012 Closure, the simulated velocities at the median flow remained greater than 0.5 m/s on average. The remaining volume of suspended sediment released from the Reach 1 System at the exit of Buffalo Creek is anticipated to continue to be transported in suspension to Lake Winnipeg.

The velocities in the Lower Dauphin River are such that the smaller particles up to the sand size would be transported in suspension into Sturgeon Bay. Larger particles of the cobble size diameter, could be transported by bed load, and gravel could be eroded. As shown with the bathymetric survey and the simulated flow patterns and velocities, the sediment transport processes in the Lower Dauphin River appear to be highly dynamic and to naturally occur on the Lower Dauphin River. The additional suspended sediment released from Buffalo Creek as the result of the operation of Reach 1 will continue to be transported in suspension into Sturgeon Bay.

4.6 STURGEON BAY MONITORING RESULTS

4.6.1 Water Level

Historical daily water levels for the period of record from 1957 to 2014 on Lake Winnipeg are shown on Figure 4.6-1. The water levels are based on the WSC data at gauge No. 05SD002 (Lake Winnipeg at Matheson Island Landing), which is located approximately 80km South-East of Dauphin River. The 5th, 50th, and 95th percentile water levels of 217.0m (711.9 ft), 217.6m (713.9 ft), and 218.3m (716.14 ft) respectively, for the period of 1957 to the fall of 2014, are shown on the figure.

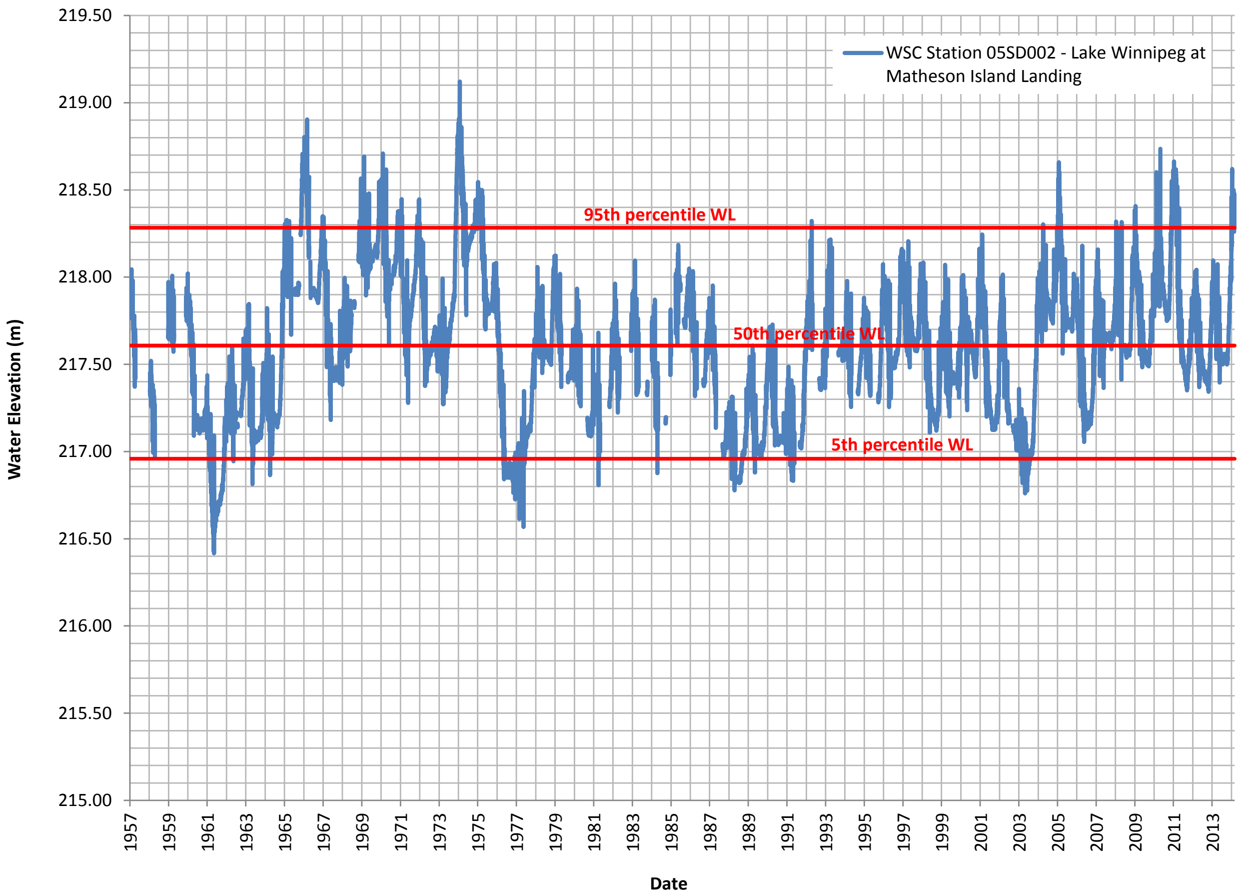

Figure 4.6-1. Recorded water level on Lake Winnipeg.

In 2011, Manitoba Hydro estimated that, at most, Reach 1 running at full capacity would contribute less than 2.5 cm (one inch) to the level of Lake Winnipeg (KGS and AECOM 2011). On this basis, and since the channel evaluated by Manitoba Hydro was larger than the one that was actually constructed, it has been determined that the impacts of the Reach 1 System on Lake Winnipeg water levels are negligible.

4.6.2 Sedimentation Rates

The modeled sediment input indicates that the majority of the suspended sediment entered Sturgeon Bay during the 2011/2012 Operation of Reach 1 during the first month of operation.

The results of sediment trap sampling are shown in Table 4.6-1. Sampling conducted under ice cover indicated that sediment deposition was uniform and occurred at low levels during the winter months, when external factors such as wind-driven current and waves are not a factor. During the open water season, sediment deposition was still uniform throughout the area sampled, but as a result of wind and current driven re-suspension of sediments, it was much higher, as shown on Figures 4.6-2 to 4.6-9. Results from the sediment traps agree with the seasonal variation presented in the State of the Lake Winnipeg (EC and MWS 2011), with sedimentation rates higher in the fall than spring and summer, as shown on Figures 4.6-5 and 4.6-9. It appears that no evident relationship can be established between sedimentation rate and trap distances from the mouth of the Dauphin River.

According to the 1999-2007 State of the Lake report for Lake Winnipeg, while inputs from rivers that discharge into the lake do affect sediment dynamics in the lake, it has been shown that “antecedent winds were the most significant contributor to suspended sediment dynamics” (EC and MWS 2011). While the north basin of Lake Winnipeg is deeper than the south (mean depth of 13.3m and 9m, respectively), the whole lake is quite shallow compared to other lakes than cover a similar amount of area, and it has been shown that “wind driven mixing can reach the bottom, even of the north basin, at least occasionally during most open water season”. The maximum water depths in Sturgeon Bay were measured at 12m, which is less than the average for the north basin. In addition, analyses of satellite imagery by McCullough et al. (2001) indicate that TSS are generally higher in Sturgeon Bay than the rest of the north basin of the Lake.

4.6.3 Hydraulic and Sediment Transport Modeling

The results of the empirical model and the MIKE 21 model showed that the suspended sediment inflow from Reach 1 would remain in suspension in the Lower Dauphin River and would enter Sturgeon Bay. For all flow conditions simulated with the MIKE 21 model during operation and closure, the main flow path is located in front of the exit of Buffalo Creek, at the south end of the model. This main flow path presents velocities exceeding 0.5 m/s further than 500m away from the exit of the river into the bay. Eventually, past this point, velocities become nil.

In theory, the velocities outside of the main flow path where the flows from the Dauphin River enter Sturgeon Bay are such that sediment particles of the sand size category and smaller could deposit. However, as demonstrated in the previous section, the processes affecting the suspension of sediment in Sturgeon Bay are mostly induced by wind effects. Depending on the wind conditions, material originating from Dauphin River could deposit in Sturgeon Bay, and be re-suspended under the effects of wind generated waves and currents.

Table 4.6-1. Summary of sedimentation rates during winter, summer and fall in Sturgeon Bay from October 2011 to October 2014.

Site ID	October 2011 to August 2012						
	Number of Days Deployed	Total Dry Weight (g)	Sedimentation Rate (mg/cm^2/day)	Sand (%)	Silt (%)	Clay (%)	Texture
ST-1	-	-	-	-	-	-	-
ST-2	-	-	-	-	-	-	-
ST-3	-	-	-	-	-	-	-
ST-4	-	-	-	-	-	-	-
ST-5	-	-	-	-	-	-	-
ST-6	-	-	-	-	-	-	-
ST-7	-	-	-	-	-	-	-
ST-8	-	-	-	-	-	-	-
ST-9	-	-	-	-	-	-	-
ST-10	-	-	-	-	-	-	-
ST-11	-	-	-	-	-	-	-
ST-12	-	-	-	-	-	-	-
ST-13	-	-	-	-	-	-	-
ST-14	-	-	-	-	-	-	-
ST-15	-	-	-	-	-	-	-
ST-16	-	-	-	-	-	-	-
ST-17	-	-	-	-	-	-	-
ST-18	-	-	-	-	-	-	-
ST-19	-	-	-	-	-	-	-
ST-20	-	-	-	-	-	-	-
ST-21	-	-	-	-	-	-	-
ST-22	-	-	-	-	-	-	-
ST-23	-	-	-	-	-	-	-
ST-24	-	-	-	-	-	-	-
ST-25	-	-	-	-	-	-	-
ST-26	-	-	-	-	-	-	-
ST-27	-	-	-	-	-	-	-
ST-28	-	-	-	-	-	-	-
ST-29	-	-	-	-	-	-	-
ST-30	-	-	-	-	-	-	-
ST-31	-	-	-	-	-	-	-
ST-32	-	-	-	-	-	-	-
ST-33	-	-	-	-	-	-	-
ST-34	-	-	-	-	-	-	-
ST-35	296	129.9	8.50	1.17	88.8	10	Silt
ST-36	296	79.2	5.19	0.32	90.8	8.89	Silt
ST-37	296	71.9	4.71	0.17	86.4	13.4	Silt loam
ST-38	296	69.8	4.57	0.35	88.1	11.5	Silt
ST-39	-	-	-	-	-	-	-
ST-40	296	354.0	23.18	67.2	26.7	6.14	Sandy loam
ST-41	297	146.6	9.57	3.46	87.9	8.6	Silt
ST-42	296	86.1	5.64	0.44	86.5	13.1	Silt loam
ST-43	297	67.0	4.37	3.33	83	13.7	Silt loam
ST-44	-	-	-	-	-	-	-
ST-45	-	-	-	-	-	-	-
ST-46	295	233.0	15.31	17	74.6	8.38	Silt loam
ST-47	297	144.6	9.44	1.22	87.2	11.6	Silt
ST-48	296	75.9	4.97	0.21	90.1	9.67	Silt

Table 4.6-1. Continued.

Site ID	October 2011 to August 2012						
	Number of Days Deployed	Total Dry Weight (g)	Sedimentation Rate ($mg/cm^2/day$)	Sand (%)	Silt (%)	Clay (%)	Texture
ST-49	295	178.1	11.70	12.9	75.3	11.8	Silt loam
ST-49B	-	-	-	-	-	-	-
ST-50	297	134.4	8.77	4.96	88.4	6.66	Silt
ST-51	295	108.1	7.10	1.51	88.2	10.3	Silt
ST-51B	-	-	-	-	-	-	-
ST-52	295	88.7	5.83	0.68	81.4	18	Silt loam
ST-53	295	158.1	10.39	11.1	80.9	7.99	Silt
ST-53B	-	-	-	-	-	-	-
ST-54	295	99.5	6.54	0.59	92.5	6.89	Silt
ST-55	-	-	-	-	-	-	-
ST-55B	-	-	-	-	-	-	-
ST-56	296	67.6	4.43	0.65	85.7	13.7	Silt loam
ST-56B	-	-	-	-	-	-	-
ST-57	297	73.4	4.79	6.49	82.5	11	Silt
ST-58	296	97.5	6.38	2.58	86.3	11.1	Silt
ST-58B	-	-	-	-	-	-	-
ST-59	296	94.8	6.21	1.41	89.6	8.94	Silt
ST-60	296	96.0	6.29	0.83	92.2	6.93	Silt
ST-61	297	88.2	5.76	0.7	80.8	18.5	Silt loam
ST-61B	-	-	-	-	-	-	-
ST-62	-	-	-	-	-	-	-
ST-63	-	-	-	-	-	-	-
Average	**-**	**119.2**	**7.8**	**6.1**	**83.2**	**10.7**	**-**
SD	**-**	**65.9**	**4.3**	**14.1**	**13.2**	**3.3**	**-**

Table 4.6-1. Continued.

Site ID	February to March 2012						
	Number of Days Deployed	Total Dry Weight (g)	Sedimentation Rate (mg/cm^2/day)	Sand (%)	Silt (%)	Clay (%)	Texture
ST-1	40	<1	-	-	-	-	-
ST-2	40	<1	-	-	-	-	-
ST-3	40	<1	-	-	-	-	-
ST-4	38	<1	-	-	-	-	-
ST-5	38	7.3	-	-	-	-	-
ST-6	40	<1	-	-	-	-	-
ST-7	40	<1	-	-	-	-	-
ST-8	40	<1	-	-	-	-	-
ST-9	40	<1	-	-	-	-	-
ST-10	38	<1	-	-	-	-	-
ST-11	39	<1	-	-	-	-	-
ST-12	39	<1	-	-	-	-	-
ST-13	38	<1	-	-	-	-	-
ST-14	38	<1	-	-	-	-	-
ST-15	38	<1	-	-	-	-	-
ST-16	36	<1	-	-	-	-	-
ST-17	36	<1	-	-	-	-	-
ST-18	36	<1	-	-	-	-	-
ST-19	36	<1	-	-	-	-	-
ST-20	38	<1	-	-	-	-	-
ST-21	-	-	-	-	-	-	-
ST-22	36	<1	-	-	-	-	-
ST-23	38	<1	-	-	-	-	-
ST-24	38	<1	-	-	-	-	-
ST-25	37	<1	-	-	-	-	-
ST-26	39	<1	-	-	-	-	-
ST-27	38	<1	-	-	-	-	-
ST-28	39	<1	-	-	-	-	-
ST-29	39	<1	-	-	-	-	-
ST-30	39	<1	-	-	-	-	-
ST-31	39	<1	-	-	-	-	-
ST-32	39	<1	-	-	-	-	-
ST-33	39	<1	-	-	-	-	-
ST-34	39	<1	-	-	-	-	-
ST-35	-	-	-	-	-	-	-
ST-36	-	-	-	-	-	-	-
ST-37	-	-	-	-	-	-	-
ST-38	-	-	-	-	-	-	-
ST-39	-	-	-	-	-	-	-
ST-40	-	-	-	-	-	-	-
ST-41	-	-	-	-	-	-	-
ST-42	-	-	-	-	-	-	-
ST-43	-	-	-	-	-	-	-
ST-44	-	-	-	-	-	-	-
ST-45	-	-	-	-	-	-	-
ST-46	-	-	-	-	-	-	-
ST-47	-	-	-	-	-	-	-
ST-48	-	-	-	-	-	-	-

Table 4.6-1. Continued.

Site ID	February to March 2012						
	Number of Days Deployed	Total Dry Weight (g)	Sedimentation Rate (mg/cm^2/day)	Sand (%)	Silt (%)	Clay (%)	Texture
ST-49	-	-	-	-	-	-	-
ST-49B	-	-	-	-	-	-	-
ST-50	-	-	-	-	-	-	-
ST-51	-	-	-	-	-	-	-
ST-51B	-	-	-	-	-	-	-
ST-52	-	-	-	-	-	-	-
ST-53	-	-	-	-	-	-	-
ST-53B	-	-	-	-	-	-	-
ST-54	-	-	-	-	-	-	-
ST-55	-	-	-	-	-	-	-
ST-55B	-	-	-	-	-	-	-
ST-56	-	-	-	-	-	-	-
ST-56B	-	-	-	-	-	-	-
ST-57	-	-	-	-	-	-	-
ST-58	-	-	-	-	-	-	-
ST-58B	-	-	-	-	-	-	-
ST-59	-	-	-	-	-	-	-
ST-60	-	-	-	-	-	-	-
ST-61	-	-	-	-	-	-	-
ST-61B	-	-	-	-	-	-	-
ST-62	-	-	-	-	-	-	-
ST-63	-	-	-	-	-	-	-
Average	**-**	**<1**	-	-	-	-	-
SD	**-**	**-**	-	-	-	-	-

Table 4.6-1. Continued.

Site ID	March to August 2012						
	Number of Days Deployed	Total Dry Weight (g)	Sedimentation Rate (mg/cm^2/day)	Sand (%)	Silt (%)	Clay (%)	Texture
ST-1	-	-	-	-	-	-	-
ST-2	-	-	-	-	-	-	-
ST-3	141	42.1	5.79	0.63	87.7	11.6	Silt
ST-4	-	-	-	-	-	-	-
ST-5	141	49.7	6.83	3.36	78.7	18	Silt loam
ST-6	-	-	-	-	-	-	-
ST-7	-	-	-	-	-	-	-
ST-8	140	52.0	7.20	0.62	90.8	8.54	Silt
ST-9	-	-	-	-	-	-	-
ST-10	-	-	-	-	-	-	-
ST-11	-	-	-	-	-	-	-
ST-12	141	71.4	9.81	0.7	82.8	16.5	Silt loam
ST-13	143	97.4	13.20	6.12	87.8	6.1	Silt
ST-14	119	13.0	2.12	0.63	83.1	16.3	Silt loam
ST-15	-	-	-	-	-	-	-
ST-16	-	-	-	-	-	-	-
ST-17	143	98.7	13.38	3.86	86	10.2	Silt
ST-18	141	81.4	11.19	0.36	92.3	7.33	Silt
ST-19	141	57.8	7.94	1.17	80.4	18.4	Silt loam
ST-20	139	59.5	8.30	0.69	85.7	13.7	Silt loam
ST-21	-	-	-	-	-	-	-
ST-22	141	103.8	14.27	3.45	90.2	6.36	Silt
ST-23	139	60.1	8.38	0.57	85.1	14.4	Silt loam
ST-24	-	-	-	-	-	-	-
ST-25	141	128.3	17.63	16.6	76	7.39	Silt loam
ST-26	139	131.4	18.32	14.7	79	6.3	Silt loam/silt
ST-27	141	60.5	8.32	0.47	72.7	26.9	Silt loam
ST-28	-	-	-	-	-	-	-
ST-29	-	-	-	-	-	-	-
ST-30	140	75.6	10.47	0.49	94.4	5.08	Silt
ST-31	141	66.9	9.20	0.62	68.5	30.9	Silty clay loam
ST-32	141	85.2	11.71	8.51	82.9	8.59	Silt
ST-33	140	112.3	15.55	7.92	82.7	9.4	Silt
ST-34	140	102.0	14.12	6.05	88.5	5.42	Silt
ST-35	-	-	-	-	-	-	-
ST-36	-	-	-	-	-	-	-
ST-37	-	-	-	-	-	-	-
ST-38	-	-	-	-	-	-	-
ST-39	-	-	-	-	-	-	-
ST-40	-	-	-	-	-	-	-
ST-41	-	-	-	-	-	-	-
ST-42	-	-	-	-	-	-	-
ST-43	-	-	-	-	-	-	-
ST-44	-	-	-	-	-	-	-
ST-45	-	-	-	-	-	-	-
ST-46	-	-	-	-	-	-	-
ST-47	-	-	-	-	-	-	-
ST-48	-	-	-	-	-	-	-

Table 4.6-1. Continued.

Site ID	March to August 2012						
	Number of Days Deployed	Total Dry Weight (g)	Sedimentation Rate (mg/cm^2/day)	Sand (%)	Silt (%)	Clay (%)	Texture
ST-49	-	-	-	-	-	-	-
ST-49B	-	-	-	-	-	-	-
ST-50	-	-	-	-	-	-	-
ST-51	-	-	-	-	-	-	-
ST-51B	-	-	-	-	-	-	-
ST-52	-	-	-	-	-	-	-
ST-53	-	-	-	-	-	-	-
ST-53B	-	-	-	-	-	-	-
ST-54	-	-	-	-	-	-	-
ST-55	-	-	-	-	-	-	-
ST-55B	-	-	-	-	-	-	-
ST-56	-	-	-	-	-	-	-
ST-56B	-	-	-	-	-	-	-
ST-57	-	-	-	-	-	-	-
ST-58	-	-	-	-	-	-	-
ST-58B	-	-	-	-	-	-	-
ST-59	-	-	-	-	-	-	-
ST-60	-	-	-	-	-	-	-
ST-61	-	-	-	-	-	-	-
ST-61B	-	-	-	-	-	-	-
ST-62	-	-	-	-	-	-	-
ST-63	-	-	-	-	-	-	-
Average	**-**	**77.5**	**10.7**	**3.9**	**83.8**	**12.4**	**-**
SD	**-**	**30.1**	**4.1**	**4.8**	**6.6**	**7.1**	**-**

Table 4.6-1. Continued.

Site ID	August to October 2012						
	Number of Days Deployed	Total Dry Weight (g)	Sedimentation Rate (mg/cm^2/day)	Sand (%)	Silt (%)	Clay (%)	Texture
ST-1	-	-	-	-	-	-	-
ST-2	-	-	-	-	-	-	-
ST-3	-	-	-	-	-	-	-
ST-4	-	-	-	-	-	-	-
ST-5	-	-	-	-	-	-	-
ST-6	-	-	-	-	-	-	-
ST-7	-	-	-	-	-	-	-
ST-8	-	-	-	-	-	-	-
ST-9	-	-	-	-	-	-	-
ST-10	-	-	-	-	-	-	-
ST-11	-	-	-	-	-	-	-
ST-12	-	-	-	-	-	-	-
ST-13	-	-	-	-	-	-	-
ST-14	-	-	-	-	-	-	-
ST-15	-	-	-	-	-	-	-
ST-16	-	-	-	-	-	-	-
ST-17	-	-	-	-	-	-	-
ST-18	-	-	-	-	-	-	-
ST-19	68	94.6	26.96	0	64.6	35.4	Silty clay loam
ST-20	68	88.2	25.14	0	74.2	25.8	Silt loam
ST-21	-	-	-	-	-	-	-
ST-22	68	127.4	36.31	1.02	71.6	27.4	Silt loam / Silty clay loam
ST-23	68	98.6	28.10	0.13	59.1	40.7	Silt Clay loam / Silty clay
ST-24	-	-	-	-	-	-	-
ST-25	68	116.9	33.32	39.3	35.8	24.9	Loam
ST-26	68	133.2	37.96	18	55	27	Silt loam
ST-27	-	-	-	-	-	-	-
ST-28	-	-	-	-	-	-	-
ST-29	-	-	-	-	-	-	-
ST-30	-	-	-	-	-	-	-
ST-31	-	-	-	-	-	-	-
ST-32	-	-	-	-	-	-	-
ST-33	67	167.0	48.30	8.35	70.1	21.6	Silt loam
ST-34	67	191.3	55.33	6.06	72.1	21.8	Silt loam
ST-35	-	-	-	-	-	-	-
ST-36	-	-	-	-	-	-	-
ST-37	-	-	-	-	-	-	-
ST-38	-	-	-	-	-	-	-
ST-39	-	-	-	-	-	-	-
ST-40	-	-	-	-	-	-	-
ST-41	-	-	-	-	-	-	-
ST-42	-	-	-	-	-	-	-
ST-43	-	-	-	-	-	-	-
ST-44	-	-	-	-	-	-	-
ST-45	-	-	-	-	-	-	-
ST-46	-	-	-	-	-	-	-
ST-47	-	-	-	-	-	-	-
ST-48	-	-	-	-	-	-	-

Table 4.6-1. Continued.

Site ID	August to October 2012						
	Number of Days Deployed	Total Dry Weight (g)	Sedimentation Rate (mg/cm^2/day)	Sand (%)	Silt (%)	Clay (%)	Texture
ST-49	-	-	-	-	-	-	-
ST-49B	-	-	-	-	-	-	-
ST-50	-	-	-	-	-	-	-
ST-51	-	-	-	-	-	-	-
ST-51B	-	-	-	-	-	-	-
ST-52	-	-	-	-	-	-	-
ST-53	-	-	-	-	-	-	-
ST-53B	-	-	-	-	-	-	-
ST-54	-	-	-	-	-	-	-
ST-55	-	-	-	-	-	-	-
ST-55B	-	-	-	-	-	-	-
ST-56	-	-	-	-	-	-	-
ST-56B	-	-	-	-	-	-	-
ST-57	-	-	-	-	-	-	-
ST-58	-	-	-	-	-	-	-
ST-58B	-	-	-	-	-	-	-
ST-59	-	-	-	-	-	-	-
ST-60	-	-	-	-	-	-	-
ST-61	-	-	-	-	-	-	-
ST-61B	-	-	-	-	-	-	-
ST-62	-	-	-	-	-	-	-
ST-63	-	-	-	-	-	-	-
Average	**-**	**127.2**	**36.4**	**9.1**	**62.8**	**28.1**	**-**
SD	**-**	**36.3**	**10.7**	**13.7**	**12.8**	**6.7**	**-**

Table 4.6-1. Continued.

Site ID	October 2012 to June 2013						
	Number of Days Deployed	Total Dry Weight (g)	Sedimentation Rate (mg/cm^2/day)	Sand (%)	Silt (%)	Clay (%)	Texture
ST-1	-	-	-	-	-	-	-
ST-2	-	-	-	-	-	-	-
ST-3	-	-	-	-	-	-	-
ST-4	-	-	-	-	-	-	-
ST-5	-	-	-	-	-	-	-
ST-6	-	-	-	-	-	-	-
ST-7	-	-	-	-	-	-	-
ST-8	-	-	-	-	-	-	-
ST-9	-	-	-	-	-	-	-
ST-10	-	-	-	-	-	-	-
ST-11	-	-	-	-	-	-	-
ST-12	-	-	-	-	-	-	-
ST-13	-	-	-	-	-	-	-
ST-14	-	-	-	-	-	-	-
ST-15	-	-	-	-	-	-	-
ST-16	-	-	-	-	-	-	-
ST-17	-	-	-	-	-	-	-
ST-18	-	-	-	-	-	-	-
ST-19	-	-	-	-	-	-	-
ST-20	-	-	-	-	-	-	-
ST-21	-	-	-	-	-	-	-
ST-22	-	-	-	-	-	-	-
ST-23	-	-	-	-	-	-	-
ST-24	-	-	-	-	-	-	-
ST-25	-	-	-	-	-	-	-
ST-26	-	-	-	-	-	-	-
ST-27	-	-	-	-	-	-	-
ST-28	-	-	-	-	-	-	-
ST-29	-	-	-	-	-	-	-
ST-30	-	-	-	-	-	-	-
ST-31	-	-	-	-	-	-	-
ST-32	-	-	-	-	-	-	-
ST-33	-	-	-	-	-	-	-
ST-34	-	-	-	-	-	-	-
ST-35	253	53.5	4.10	2.85	78.2	18.9	Silt loam
ST-36	253	33.5	2.57	0.51	73.4	26.1	Silt loam
ST-37	253	28.3	2.17	1.47	76	22.6	Silt loam
ST-38	253	20.6	1.58	1.44	75.1	23.5	Silt loam
ST-39	-	-	-	-	-	-	-
ST-40	253	48.8	3.74	28.4	59.8	11.8	Silt loam
ST-41	253	40.6	3.11	1.47	74.1	24.4	Silt loam
ST-42	253	22.7	1.74	0.14	77.1	22.8	Silt loam
ST-43	243	10.2	0.81	1.16	65.4	33.4	Silty clay loam
ST-44	-	-	-	-	-	-	-
ST-45	-	-	-	-	-	-	-
ST-46	253	47.8	3.66	12.7	69.3	18.1	Silt loam
ST-47	-	-	-	-	-	-	-
ST-48	253	30.4	2.33	2.6	69.3	28.1	Silty clay loam

Table 4.6-1. Continued.

Site ID	October 2012 to June 2013						
	Number of Days Deployed	Total Dry Weight (g)	Sedimentation Rate (mg/cm^2/day)	Sand (%)	Silt (%)	Clay (%)	Texture
ST-49	-	-	-	-	-	-	-
ST-49B	-	-	-	-	-	-	-
ST-50	-	-	-	-	-	-	-
ST-51	242	24.6	1.97	2.1	79.9	18	Silt loam
ST-51B							
ST-52	242	15.5	1.24	0.25	73.1	26.7	Silt loam
ST-53	-	-	-	-	-	-	-
ST-53B	-	-	-	-	-	-	-
ST-54	242	27	2.16	1.32	75.5	23.2	Silt loam
ST-55	242	22.7	1.82	0.2	78.2	21.6	Silt loam
ST-55B	-	-	-	-	-	-	-
ST-56	242	16.6	1.33	0.15	83	16.9	Silt loam
ST-56B	-	-	-	-	-	-	-
ST-57	243	11.2	0.89	1.12	71.4	27.5	Silt loam / Silty clay loam
ST-58	-	-	-	-	-	-	-
ST-58B	-	-	-	-	-	-	-
ST-59	242	27.9	2.23	2.06	73.1	24.8	Silt loam
ST-60	-	-	-	-	-	-	-
ST-61	-	-	-	-	-	-	-
ST-61B	-	-	-	-	-	-	-
ST-62	-	-	-	-	-	-	-
ST-63	-	-	-	-	-	-	-
Average	**-**	**28.3**	**2.2**	**3.5**	**73.6**	**22.8**	**-**
SD	**-**	**12.9**	**1.0**	**7.0**	**5.6**	**5.1**	**-**

Table 4.6-1. Continued.

Site ID	January to April 2014						
	Number of Days Deployed	Total Dry Weight (g)	Sedimentation Rate (mg/cm^2/day)	Sand (%)	Silt (%)	Clay (%)	Texture
ST-1	-	-	-	-	-	-	-
ST-2	75	< 1.0	-	-	-	-	-
ST-3	-	-	-	-	-	-	-
ST-4	-	-	-	-	-	-	-
ST-5	-	-	-	-	-	-	-
ST-6	75	< 1.0	-	-	-	-	-
ST-7			-	-	-	-	-
ST-8	74	< 1.0	-	-	-	-	-
ST-9	74	< 1.0	-	-	-	-	-
ST-10	71	< 1.0	-	-	-	-	-
ST-11	70	< 1.0	-	-	-	-	-
ST-12	70	< 1.0	-	-	-	-	-
ST-13	-	-	-	-	-	-	-
ST-14	-	-	-	-	-	-	-
ST-15	74	< 1.0	-	-	-	-	-
ST-16	-	-	-	-	-	-	-
ST-17	-	-	-	-	-	-	-
ST-18	-	-	-	-	-	-	-
ST-19	-	-	-	-	-	-	-
ST-20	-	-	-	-	-	-	-
ST-21	-	-	-	-	-	-	-
ST-22	-	-	-	-	-	-	-
ST-23	-	-	-	-	-	-	-
ST-24	-	-	-	-	-	-	-
ST-25	-	-	-	-	-	-	-
ST-26	-	-	-	-	-	-	-
ST-27	-	-	-	-	-	-	-
ST-28	-	-	-	-	-	-	-
ST-29	-	-	-	-	-	-	-
ST-30	-	-	-	-	-	-	-
ST-31	-	-	-	-	-	-	-
ST-32	70	< 1.0	-	-	-	-	-
ST-33	-	-	-	-	-	-	-
ST-34	-	-	-	-	-	-	-
ST-35	75	< 1.0	-	-	-	-	-
ST-36	-	-	-	-	-	-	-
ST-37	75	< 1.0	-	-	-	-	-
ST-38	75	< 1.0	-	-	-	-	-
ST-39	-	-	-	-	-	-	-
ST-40	-	-	-	-	-	-	-
ST-41	74	< 1.0	-	-	-	-	-
ST-42	74	< 1.0	-	-	-	-	-
ST-43	75	< 1.0	-	-	-	-	-
ST-44	-	-	-	-	-	-	-
ST-45	-	-	-	-	-	-	-
ST-46	-	-	-	-	-	-	-
ST-47	74	< 1.0	-	-	-	-	-
ST-48	74	< 1.0	-	-	-	-	-

Table 4.6-1. Continued.

Site ID	January to April 2014						
	Number of Days	Total Dry Weight (g)	Sedimentation Rate ($mg/cm^2/day$)	Sand (%)	Silt (%)	Clay (%)	Texture
ST-49	73	< 1.0	-	-	-	-	-
ST-49B	-	-	-	-	-	-	-
ST-50	-	-	-	-	-	-	-
ST-51	72	< 1.0	-	-	-	-	-
ST-51B			-	-	-	-	-
ST-52	73	< 1.0	-	-	-	-	-
ST-53	70	< 1.0	-	-	-	-	-
ST-53B	-	-	-	-	-	-	-
ST-54	-	-	-	-	-	-	-
ST-55	70	< 1.0	-	-	-	-	-
ST-55B	-	-	-	-	-	-	-
ST-56	70	< 1.0	-	-	-	-	-
ST-56B	-	-	-	-	-	-	-
ST-57	70	< 1.0	-	-	-	-	-
ST-58	70	< 1.0	-	-	-	-	-
ST-58B	-	-	-	-	-	-	-
ST-59	-	-	-	-	-	-	-
ST-60	70	< 1.0	-	-	-	-	-
ST-61	70	< 1.0	-	-	-	-	-
ST-61B	-	-	-	-	-	-	-
ST-62	70	< 1.0	-	-	-	-	-
ST-63	75	< 1.0	-	-	-	-	-
Average	**-**	**<1**	-	-	-	-	-
SD	**-**	**-**	-	-	-	-	-

Table 4.6-1. Continued.

Site ID	April to June 2014						
	Number of Days Deployed	Total Dry Weight (g)	Sedimentation Rate ($mg/cm^2/day$)	Sand (%)	Silt (%)	Clay (%)	Texture
ST-1	-	-	-	-	-	-	-
ST-2	75	14.1	3.64	0.49	68.7	30.8	Silty clay loam
ST-3	-	-	-	-	-	-	-
ST-4	-	-	-	-	-	-	-
ST-5	-	-	-	-	-	-	-
ST-6	75	7	1.81	1.34	59.4	39.2	Silty clay loam
ST-7	-	-	-	-	-	-	-
ST-8	77	216.3	54.44	0.25	48.3	51.5	Silty clay
ST-9	77	248.6	62.57	0.27	45	54.7	Silty clay
ST-10	77	3.6	0.91	0.71	58.1	41.2	Silty clay
ST-11	78	4.7	1.17	0.79	56.2	43	Silty clay
ST-12	77	5.8	1.46	0.52	58.7	40.8	Silt Clay loam / Silty clay
ST-13	-	-	-	-	-	-	-
ST-14	-	-	-	-	-	-	-
ST-15	77	4.7	1.18	3.94	55.2	40.8	Silt Clay loam / Silty clay
ST-16	-	-	-	-	-	-	-
ST-17	-	-	-	-	-	-	-
ST-18	-	-	-	-	-	-	-
ST-19	-	-	-	-	-	-	-
ST-20	-	-	-	-	-	-	-
ST-21	-	-	-	-	-	-	-
ST-22	-	-	-	-	-	-	-
ST-23	-	-	-	-	-	-	-
ST-24	-	-	-	-	-	-	-
ST-25	-	-	-	-	-	-	-
ST-26	-	-	-	-	-	-	-
ST-27	-	-	-	-	-	-	-
ST-28	-	-	-	-	-	-	-
ST-29	-	-	-	-	-	-	-
ST-30	-	-	-	-	-	-	-
ST-31	-	-	-	-	-	-	-
ST-32	77	8.8	2.21	4.66	58.2	37.1	Silty clay loam
ST-33	-	-	-	-	-	-	-
ST-34	-	-	-	-	-	-	-
ST-35	76	4	1.02	1.11	57.4	41.5	Silty clay
ST-36	-	-	-	-	-	-	-
ST-37	75	5.2	1.34	0.16	58.7	41.2	Silty clay
ST-38	75	3.8	0.98	1.22	58.4	40.4	Silt Clay loam / Silty clay
ST-39	-	-	-	-	-	-	-
ST-40	-	-	-	-	-	-	-
ST-41	77	9.5	2.39	0.82	67.1	32.1	Silty clay loam
ST-42	77	5.8	1.46	2.24	58.2	39.5	Silty clay loam
ST-43	75	3.4	0.88	0.91	51.4	47.6	Silty clay
ST-44	-	-	-	-	-	-	-
ST-45	-	-	-	-	-	-	-
ST-46	-	-	-	-	-	-	-
ST-47	77	10.5	2.64	0.59	71.6	27.8	Silt loam / Silty clay loam
ST-48	77	5.7	1.43	3.63	59.4	37	Silty clay loam

Table 4.6-1. Continued.

Site ID	April to June 2014						
	Number of Days Deployed	Total Dry Weight (g)	Sedimentation Rate (mg/cm^2/day)	Sand (%)	Silt (%)	Clay (%)	Texture
ST-49	77	115.6	29.09	17	64.5	18.5	Silt loam
ST-49B	-	-	-	-	-	-	-
ST-50	-	-	-	-	-	-	-
ST-51	78	77.5	19.26	0.61	69	30.4	Silty clay loam
ST-51B	-	-	-	-	-	-	-
ST-52	77	4.7	1.18	1.77	62.9	35.3	Silty clay loam
ST-53	77	14.5	3.65	4.4	59.3	36.3	Silty clay loam
ST-53B	-	-	-	-	-	-	-
ST-54	-	-	-	-	-	-	-
ST-55	78	5.3	1.32	0.82	59.7	39.5	Silty clay loam
ST-55B	-	-	-	-	-	-	-
ST-56	78	3.9	0.97	1.67	57.5	40.8	Silt Clay loam / Silty clay
ST-56B	-	-	-	-	-	-	-
ST-57	77	5.9	1.48	0.64	56.8	42.6	Silty clay
ST-58	77	7.8	1.96	0.78	62.5	36.7	Silty clay loam
ST-58B	-	-	-	-	-	-	-
ST-59	-	-	-	-	-	-	-
ST-60	77	6.7	1.69	0.85	65.6	33.6	Silty clay loam
ST-61	77	5.9	1.48	5.33	56.5	38.2	Silty clay loam
ST-61B	-	-	-	-	-	-	-
ST-62	77	9.6	2.42	9.04	63.7	27.3	Silt loam / Silty clay loam
ST-63	75	3.1	0.80	0.89	57.7	41.4	Silty clay
Average	**-**	**30.0**	**7.5**	**2.1**	**59.4**	**38.4**	**-**
SD	**-**	**63.5**	**16.0**	**3.3**	**6.0**	**7.1**	**-**

Table 4.6-1. Continued.

Site ID	June to October 2014						
	Number of Days Deployed	Total Dry Weight (g)	Sedimentation Rate ($mg/cm^2/day$)	Sand (%)	Silt (%)	Clay (%)	Texture
ST-1	-	-	-	-	-	-	-
ST-2	109	107.1	19.04	0.24	46.9	52.8	Silty clay
ST-3	-	-	-	-	-	-	-
ST-4	-	-	-	-	-	-	-
ST-5	-	-	-	-	-	-	-
ST-6	109	90.7	16.13	0.27	49.3	50.4	Silty clay
ST-7	-	-	-	-	-	-	-
ST-8	108	98.3	17.64	0.14	45.9	54	Silty clay
ST-9	109	66.1	11.75	<0.10	43.1	56.9	Silty clay
ST-10	109	68.9	12.25	<0.10	46	54	Silty clay
ST-11	109	84.7	15.06	<0.10	46.1	53.8	Silty clay
ST-12	110	107.8	18.99	0.68	49.5	49.8	Silty clay
ST-13	-	-	-	-	-	-	-
ST-14	-	-	-	-	-	-	-
ST-15	108	82	14.71	0.2	46.7	53.1	Silty clay
ST-16	-	-	-	-	-	-	-
ST-17	-	-	-	-	-	-	-
ST-18	-	-	-	-	-	-	-
ST-19	-	-	-	-	-	-	-
ST-20	-	-	-	-	-	-	-
ST-21	-	-	-	-	-	-	-
ST-22	-	-	-	-	-	-	-
ST-23	-	-	-	-	-	-	-
ST-24	-	-	-	-	-	-	-
ST-25	-	-	-	-	-	-	-
ST-26	-	-	-	-	-	-	-
ST-27	-	-	-	-	-	-	-
ST-28	-	-	-	-	-	-	-
ST-29	-	-	-	-	-	-	-
ST-30	-	-	-	-	-	-	-
ST-31	-	-	-	-	-	-	-
ST-32	110	129	22.73	2.66	57.2	40.1	Silt Clay loam / Silty clay
ST-33	-	-	-	-	-	-	-
ST-34	-	-	-	-	-	-	-
ST-35	108	118.1	21.19	0.99	64.1	34.9	Silty clay loam
ST-36	-	-	-	-	-	-	-
ST-37	109	91	16.18	<0.10	47.5	52.5	Silty clay
ST-38	109	92.3	16.41	<0.10	49.2	50.7	Silty clay
ST-39	-	-	-	-	-	-	-
ST-40	-	-	-	-	-	-	-
ST-41	108	78.9	14.16	0.38	61.7	37.9	Silty clay loam
ST-42	108	93.9	16.85	<0.10	48.8	51.2	Silty clay
ST-43	110	76.6	13.50	0.18	45.6	54.3	Silty clay
ST-44	-	-	-	-	-	-	-
ST-45	-	-	-	-	-	-	-
ST-46	-	-	-	-	-	-	-
ST-47	108	104.8	18.81	0.71	69.1	30.2	Silty clay loam
ST-48	108	85.7	15.38	<0.10	50.7	49.2	Silty clay

Table 4.6-1. Continued.

Site ID	June to October 2014						
	Number of Days Deployed	Total Dry Weight (g)	Sedimentation Rate (mg/cm^2/day)	Sand (%)	Silt (%)	Clay (%)	Texture
ST-49	108	115.3	20.69	23.8	57	19.3	Silt loam
ST-49B	115	122.8	20.69	28.7	52.9	18.4	Silt loam
ST-50	-	-	-	-	-	-	-
ST-51	108	112.1	20.12	<0.10	70.9	29.1	Silty clay loam
ST-51B	115	121.8	20.53	0.16	70.5	29.3	Silty clay loam
ST-52	108	92.4	16.58	<0.10	49.9	50	Silty clay
ST-53	-	-	-	-	-	-	-
ST-53B	116	122.8	20.52	19.4	52.3	28.3	Silty clay loam
ST-54	-	-	-	-	-	-	-
ST-55	109	44	7.82	0.2	57	42.8	Silty clay
ST-55B	116	148.7	24.84	0.12	63.2	36.7	Silty clay loam
ST-56	109	129.4	23.01	0.12	53.7	46.1	Silty clay
ST-56B	116	89.8	15.00	0.14	51.4	48.5	Silty clay
ST-57	110	112.1	19.75	0.37	55.7	43.9	Silty clay
ST-58	110	102	17.97	2.97	62.1	34.9	Silty clay loam
ST-58B	116	91.6	15.30	2.25	63	34.8	Silty clay loam
ST-59	-	-	-	-	-	-	-
ST-60	110	102.7	18.09	1.11	58.4	40.5	Silt Clay loam / Silty clay
ST-61	110	102.5	18.06	0.6	56	43.4	Silty clay
ST-61B	116	102.7	17.16	0.6	56.4	43	Silty clay
ST-62	110	161.8	28.51	2.45	70.9	26.6	Silt loam
ST-63	109	93.1	16.55	0.35	47.5	52.1	Silty clay
Average	**-**	**99.6**	**17.5**	**3.8**	**54.4**	**42.9**	**-**
SD	**-**	**21.3**	**3.6**	**8.2**	**7.8**	**10.7**	**-**

Figure 4.6-2. Sedimentation rates in Sturgeon Bay, October 2011 to August 2012.

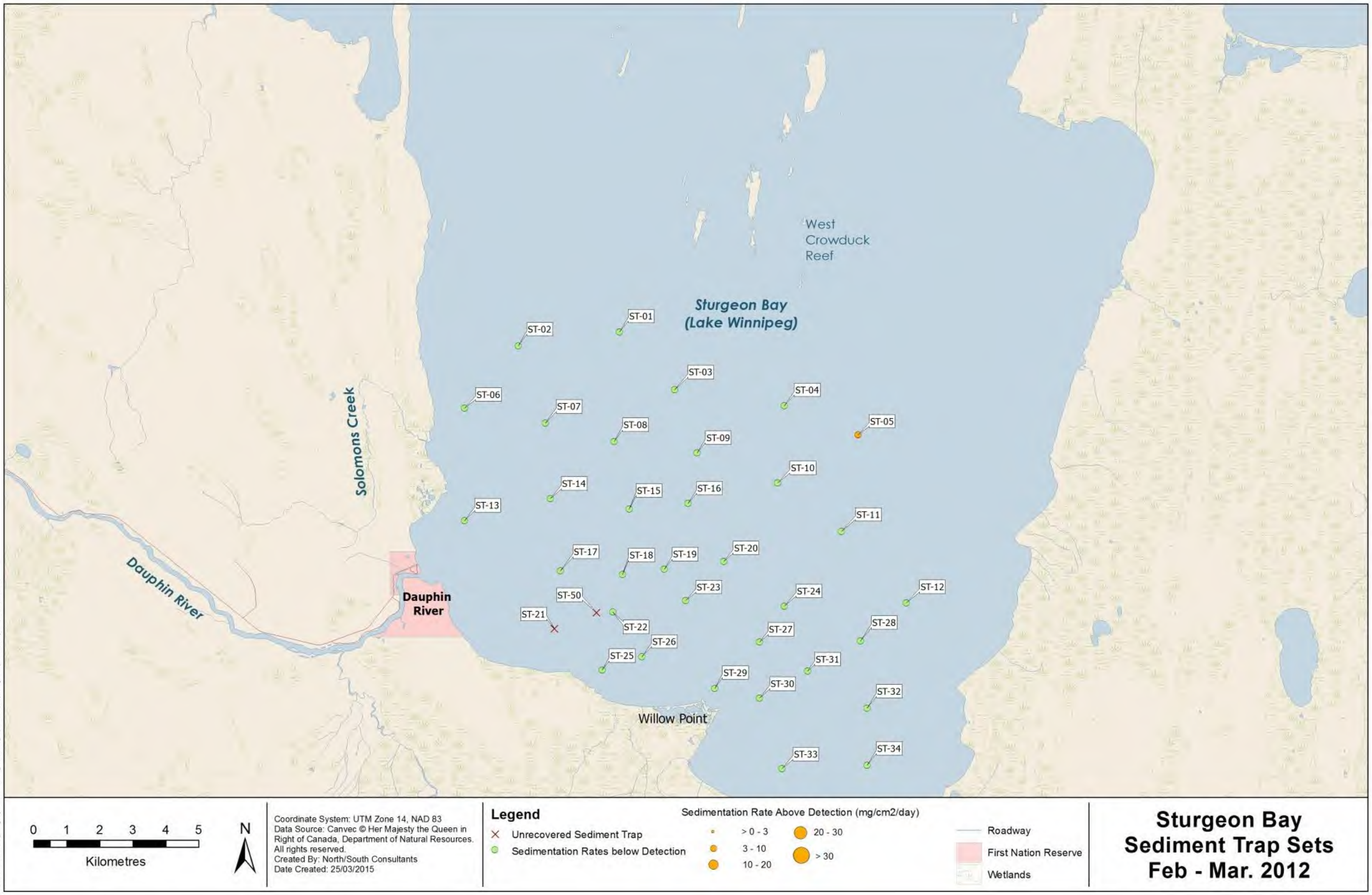

Figure 4.6-3. Sedimentation rates in Sturgeon Bay, February to March 2012.

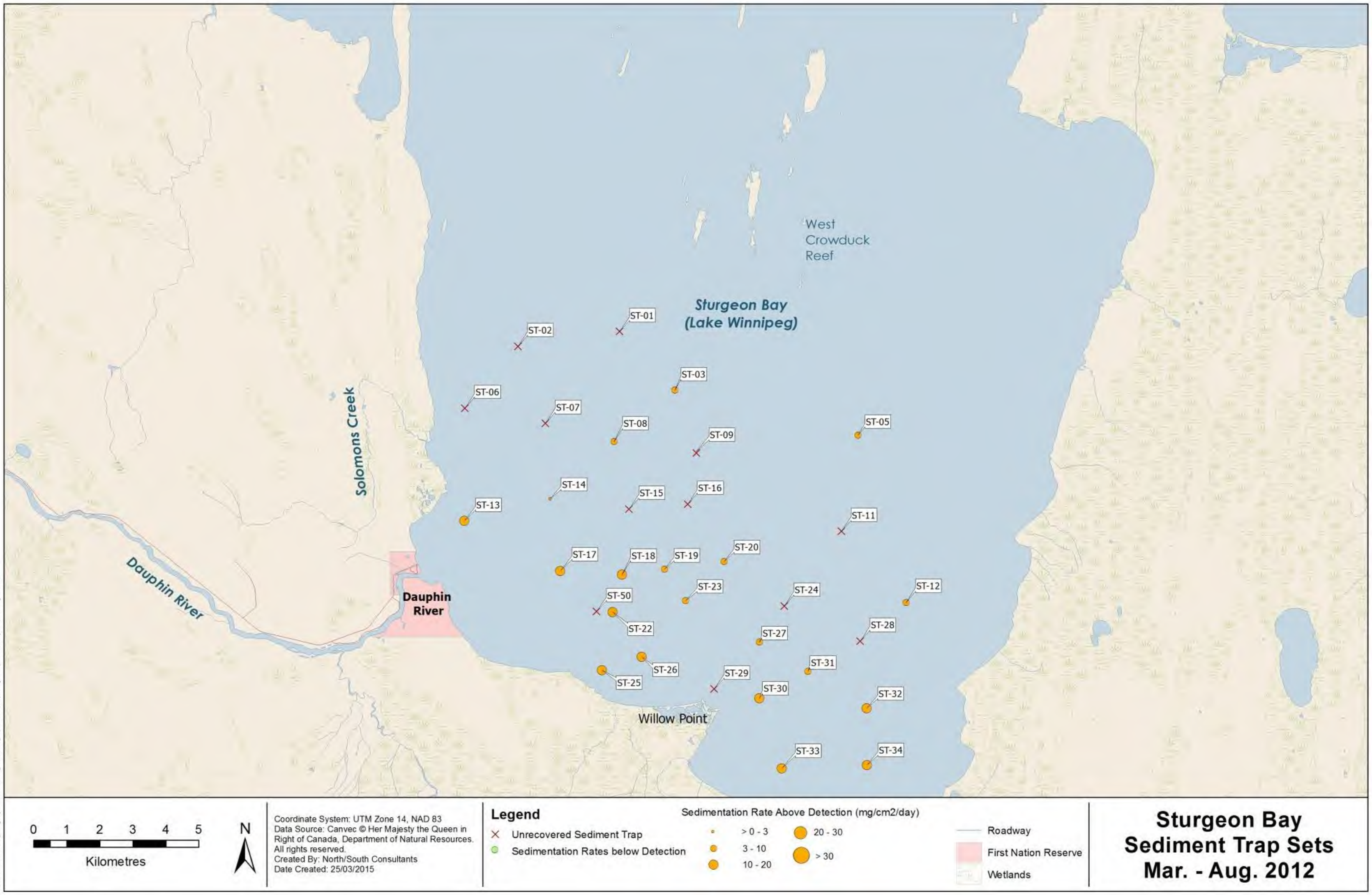

Figure 4.6-4. Sedimentation rates in Sturgeon Bay, March to August 2012.

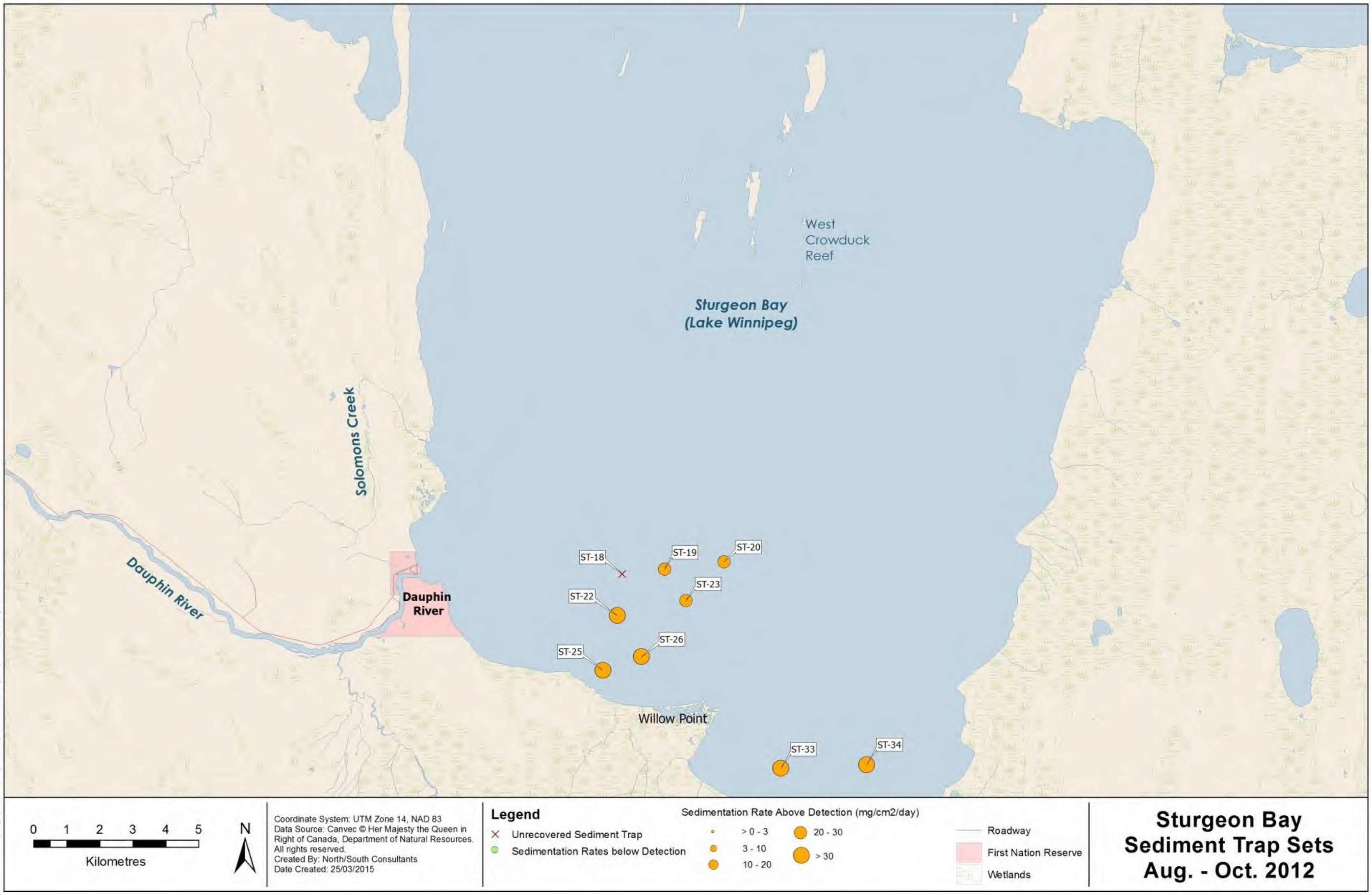

Figure 4.6-5. Sedimentation rates in Sturgeon Bay, August to October 2012.

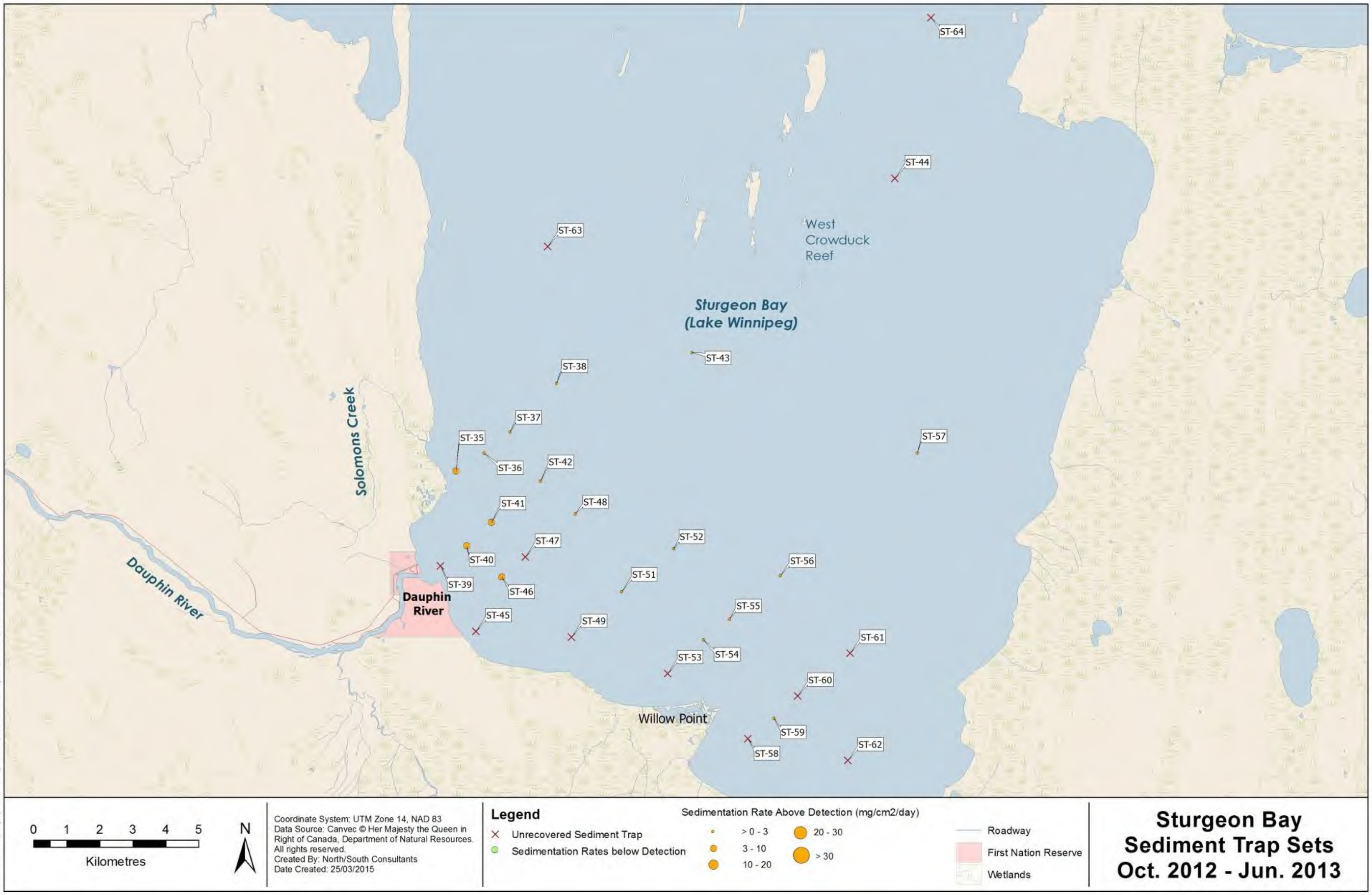

Figure 4.6-6. Sedimentation rates in Sturgeon Bay, October 2012 to June 2013.

Figure 4.6-7. Sedimentation rates in Sturgeon Bay, January to April 2014.

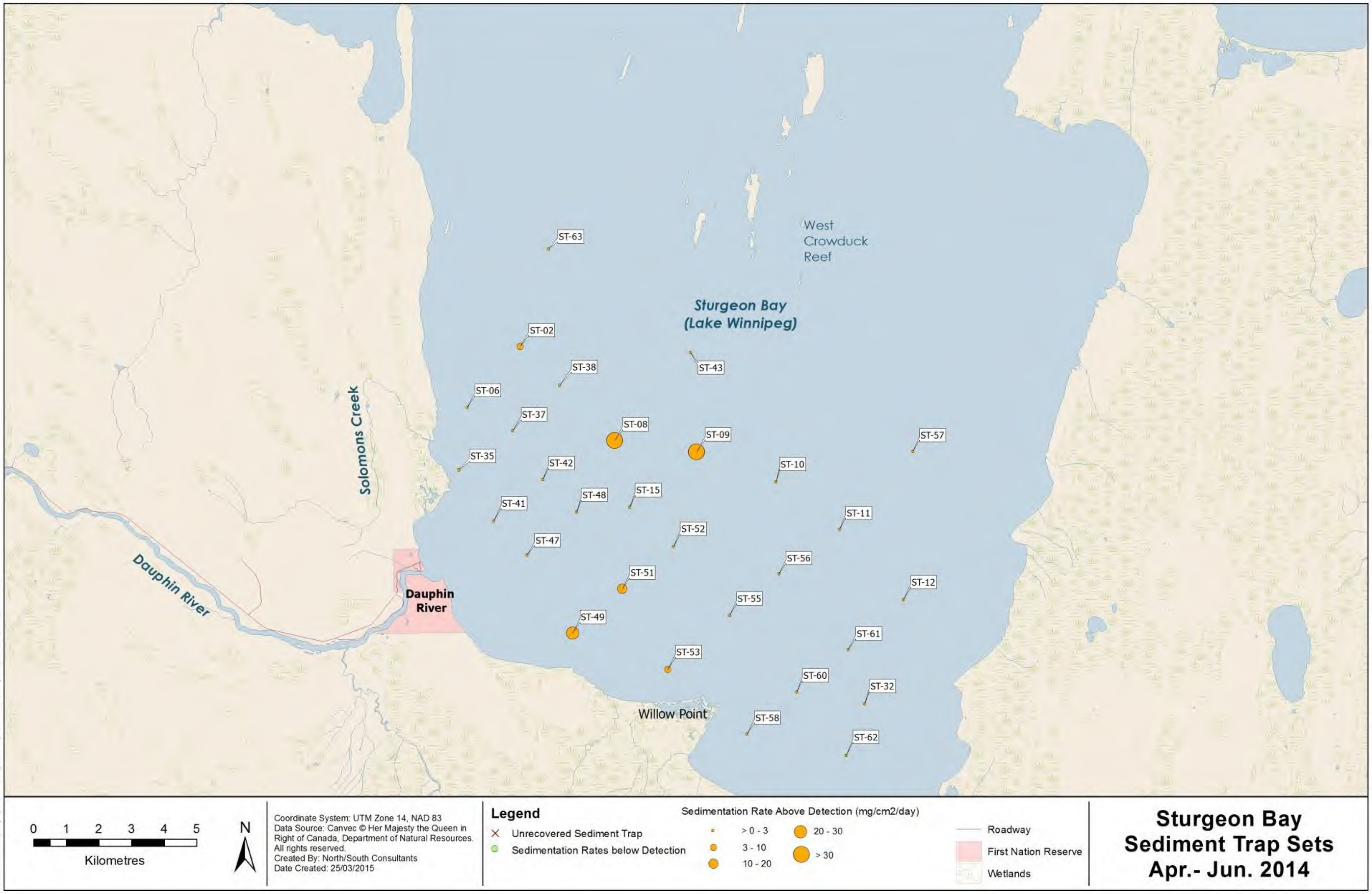

Figure 4.6-8. Sedimentation rates in Sturgeon Bay, January to April 2014.

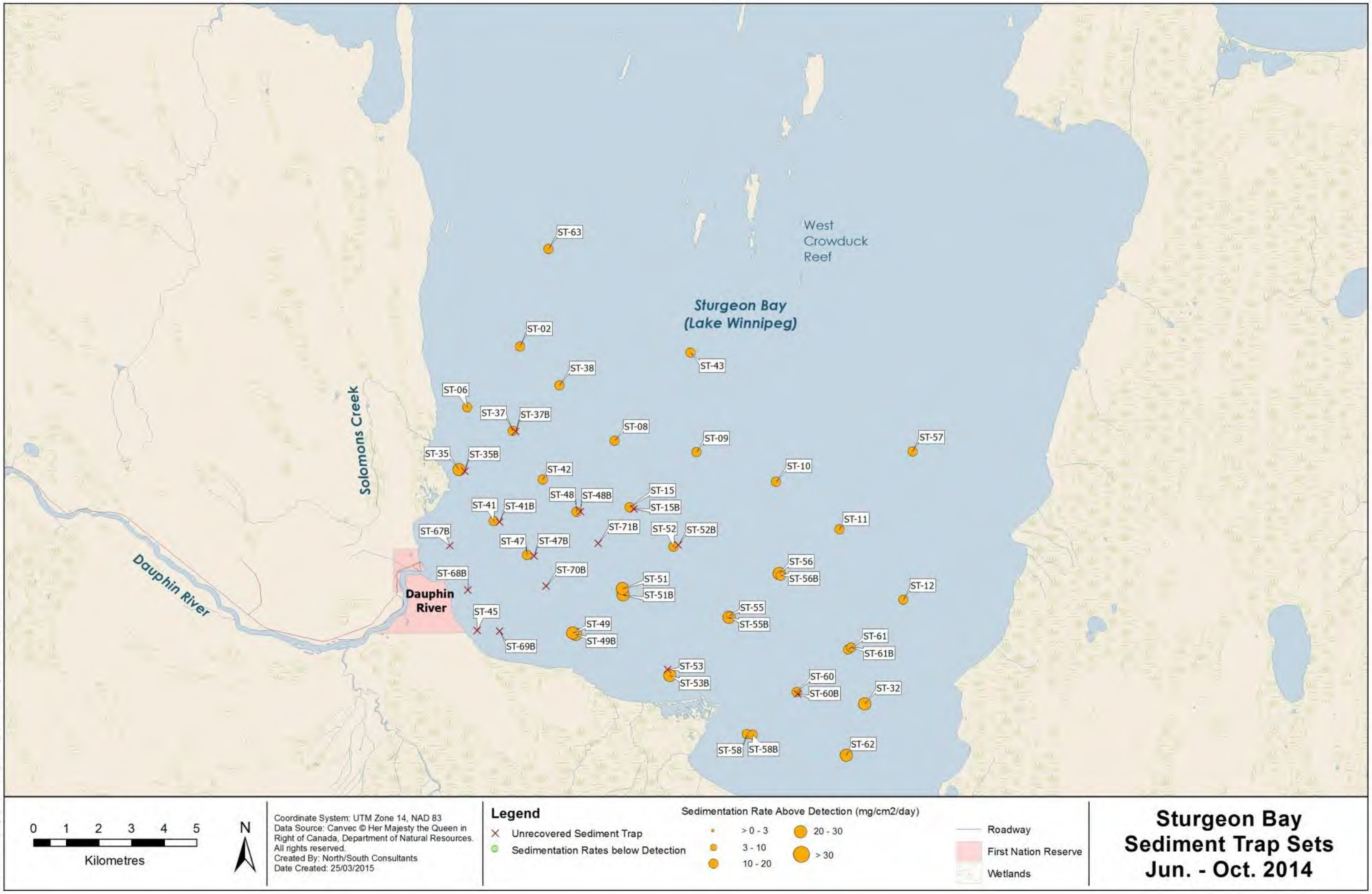

Figure 4.6-9. Sedimentation rates in Sturgeon Bay, June to October 2014.

4.7 SUMMARY

Flows, water quality, erosion, sedimentation, vegetation cover, and ice processes were characterized and compared between project phases to identify the potential impacts related to the construction and operation of the Reach 1 System. Hydrometric data, total suspended solid concentrations, topographic and bathymetric surveys were used in conjunction with numerical hydraulic models to identify the potential effects of the operation of Reach 1 on the erosion and sediment deposition processes in the watershed.

The Reach 1 was successful in lowering the water levels on Lake St. Martin by on average 0.6m (2ft), and as much as 1m (3ft) at the peak of the winter ice conditions. With the operation of Reach 1, the median flows in Buffalo Creek during the operation were more than 30 times the median normal flow recorded during the 2011/2012 Closure.

The operation of Reach 1 had limited effects on the ice processes. Some open water was present in the area of the Reach 1 inlet, with formation of frazil ice in the channel itself. Buffalo Creek was fully open with presence of border ice during operation. Observations during the closure period showed that a solid ice cover would form on the creek under natural conditions. Despite the large area of open water on Buffalo Creek during operation, the production of frazil ice along this reach of river is reduced by the latent heat of the water originating from the Buffalo Lake.

The high flows in Buffalo Creek were accompanied with high velocities, which generated some erosion of the main channel and of the riverbanks, as demonstrated with a comparison of river cross sections prior to and after operation. The TSS measurements and the empirical model results indicated that some erosion also occurred in Reach 1 during its operation. As the flows from Reach 1 reached Buffalo Lake, the bulk of the suspended sediment deposited in the bog. The sediment that was then eroded in Buffalo Creek was transported in suspension into the lower Dauphin River.

The volume of suspended sediment released from Buffalo Creek as a result of the operation of Reach 1 was computed with the empirical model with and without operation of Reach 1. It was estimated that the operation resulted in an additional total volume of 8,900 m^3 of suspended sediment at the confluence between the lower Dauphin River and Buffalo Creek during operation and another 2,200 m^3 during the closure period. This amount represents approximately 12% of the total volume of sediment that would have naturally been transported in the Dauphin River without operation. Analyses of the grain size distribution of the suspended solids showed that the material was essentially constituted of clays and silts.

As simulated with the MIKE 21 model, the velocities in Dauphin River are such that the suspended material would be transported several hundred meters into Sturgeon Bay, with very limited local deposition occurring along the Dauphin River shoreline or in back eddies.

The cross section comparison in Buffalo Creek computed a total volume of displaced material of 85,000 m^3. This represents the total volume of material that was eroded and displaced within Buffalo Creek, and also includes some material that went in suspension. Simulated velocities and shear stresses showed that larger material could be transported by bed load. Some of this material may have left the system, however, a review of the simulated velocities and shear stresses showed that most of the coarser material has deposited in the overbank areas or in reaches with lower velocities, as also confirmed by direct observations.

According to the hydraulic modeling, the suspended sediment originating from the operation of Reach 1 and released at the exit of Buffalo Creek remains in suspension in the Dauphin River and eventually reaches Sturgeon Bay. Sediment traps installed in Sturgeon Bay demonstrated that no evident relationship can be established between sedimentation rate and trap distances from the mouth of the Dauphin River. This appears to be in agreement with the 1999-2007 State of the Lake report for Lake Winnipeg, while inputs from rivers that discharge into the lake do affect sediment dynamics in the lake, it has been shown that “antecedent winds were the most significant contributor to suspended sediment dynamics”.

4.8 REFERENCES

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Appendix 4A. Buffalo Creek Vegetation Cover Survey

Provided Within: Buffalo Creek vegetation cover survey results from 2013 and 2014.

Field Inspection Form

PROJECT: **Lake St. Martin Channel Monitoring - 2015**

CLIENT: **North/South Consultants Inc.**

CONTRACTOR:

FILE NO.: **13-0431-001 Task 16 (161 Additional Work)**

REPORT DATE: March 9, 2015

BY: Dan Leitch

POSITION TITLE: Environmental Scientist

Buffalo Creek Vegetation Cover Survey Results
June 17-19, 2014

1.0 Introduction

During a Steering committee meeting held on April 16, 2014, MIT expressed interest in conducting a follow-up vegetation cover survey along the banks of Buffalo Creek. This task was categorized as additional work under Task 16 (ESH-4) Buffalo Creek Watershed – Post-Project Evaluation. The intent of the 2014 survey was to discern the extent of natural regrowth of vegetation that had occurred after one full growing season following the 2011/2012 operation of the LSMEOC system. A survey had been conducted in July 2013; however, the LSMEOC System was closed in November 2012 during freeze-up and, with the late spring in 2014, ice was still melting off the lakes and creeks at the beginning of May. As such, during the 2013 survey, the water was still in the process of receding and there was not sufficient time for any natural regrowth of vegetation. Conversely, large stands of trees, that appeared to have survived inundation in 2011/2012, may have yet to show signs of distress. This led to additional concern of whether large woody debris that remains in Buffalo Creek could likely be washed into Sturgeon bay if the LSMEOC System was ever to be operated in the future. Prior to conducting the survey, figures produced for MIT using the 2011 and 2013 GAIM data to show the extent of trees that were likely killed and could likely fall into the creek potentially be washed downstream should the LSMEOC be operated again in the future.

In June 2015, it was determined that the LSMEOC would be operated again in late June/early July 2015. As such the proposed vegetation survey was pushed forward and was conducted between June 17 and June 19, 2014, in order to be complete prior to the 2014/2015 operation of the LSMEOC system. Using a helicopter for daily access/egress, and a canoe to navigate downstream, KGS Group completed vegetation surveys along 31 transects between Station 13+000 m and 28+000 m along Buffalo Creek.

The purpose of the vegetation survey along the Buffalo Creek was to assist in monitoring and assessing the impacts and recovery from operation of the emergency channel, specifically the changes to the riparian vegetation community and erosion along the river. The vegetation survey program involved walking perpendicular 100 m transects on both sides of the creek, and documenting the cover types along the transects. Vegetation cover types were used to estimate the amount of protection from erosion afforded to the soil via plant cover. Representative sample photos were taken. The soil composition was also recorded, particularly within the previously flooded area from past operation of the LSMEOC.

In addition to the vegetation cover survey, observations of areas with deadfall and larger amount of erosion were documented with photographs and waypoints. In the event of future operation, it is possible that deadfall near the creek could be carried away with higher water levels and moved downstream resulting in various issues including log jams and interference with fishing nets in the lower Dauphin River and Sturgeon Bay (Lake Winnipeg). Observations of areas of erosion will help identify when the erosion occurred (e.g. during 2011-2012 operation or during 2014-2015 operation).

2.0 Methodology

Sampling locations were set every 500 m along the length of the Buffalo Creek beginning at Station 13+000 m and continuing to just upstream of the confluence with the Dauphin River at Station 28+000 (Figure 1). The vegetation survey transects were run perpendicular to the creek when possible, starting from centreline and continuing for a distance of 100 m on each bank. Transect orientation was modified for those locations where the meander of the creek resulted in overlap of a transect from another location.

The bank on both sides of the creek was recorded to determine the centreline. Transect orientation (cardinal direction), start and end point, general description of cover types, start and end distance of each cover type within the transect, and soil composition and depth were also recorded. Cover types were placed in four broad categories:

- Bare: exposed mineral soil with no vegetation or soil organic layer;
- Grass: vegetation cover consists of grass, sedge, or rush families;
- Shrub: vegetation cover consists of woody species that do not form distinct trunks or canopies of leaves, especially those which do not normally exceed 10m in height; At times, a distinction was made between short herbaceous shrubs and taller woodier shrubs.
- Treed: vegetation cover consists of woody species which form distinct trunks and leaf canopies, and which normally can or do exceed 10m in height.

Photos 1 to 4 show the four representative cover types. A photo log was compiled with several photos taken along each transect. Some of these photos are provided in the results section below.

Photo 1. "Bare" substrate observed at 18+000.


Photo 2. “Grass” vegetation observed at 13+500.


Photo 3. “Shrub” vegetation observed at 26+000.


Photo 4. “Treed” vegetation observed at 25+000.

Composites or matrices of these four types were possible, and their corresponding ground cover was provided e.g. 50% area covered by grass 50% area covered by shrubs. Due to plant morphology and habit, total percentages greater than 100% were possible.

Soil composition including organic soil depths were measured from representative areas within each change in cover along a transect, where feasible (i.e. if substrate changes from grass to trees, a soil measurement was taken in each section). Soil was removed using a garden trowel and measured using a tape measure. When the organic soil depth was greater than could be measured within reason using the garden trowel, soil depth was recorded as 'greater than' the depth that was excavated (i.e. > x cm).

The survey was conducted over a 3 day period coinciding with other project activities (fisheries work, hydraulics work, brush cutters, and a GAIM flight). Personnel were: Day 1: Dan Leitch and Steve Offman; Day 2: Dan Leitch and John Burns; Day 3: Dan Leitch and Garrett Wellwood.

3.0 Results

The following subsections detail the results found for each transect, including orientation, description of terrain, cover types, and organic layer depths in soil. Unique features related to the investigation are also mentioned where appropriate. Where possible, observations were compared against conditions described during the 2013 and 2014 surveys. Due to the accuracy of the GPS and movement of creek banks due to varying water levels, detailed comparisons are not feasible. Photos contrasting several locations in 2013 and 2014 are included. Full records for each transect are found in Table 1 with the transect data broken into subsection A (left bank, when facing downstream) and subsection B (right bank, when facing downstream).

Soils along the length of Buffalo Creek were variable and showed signs of recent erosion along the riverbed. Soils further from the creek are outside of the flooded area and are generally dominated by sphagnum peat moss. Soil composition and depths are highly spatially variable so comparisons are difficult. At the upstream end of the creek (Stations 13+000 to 16+500), organic soils were predominant on the surface near the creek, with depths ranging from 1 to 20 cm. Beneath the organic soils was a mixture of inorganic soils including silt, clay, sand, gravel, and cobble. Beginning around Station 17+000, inorganic soils were more frequently seen above organic soils. These inorganic soils appeared to be recently deposited, and consisted predominantly of silt, but also sand, gravel, and cobble. At some locations, a thin layer of organic soil deposition was observed above the deposited inorganic soils, which was above the original organic soil. In 2013, many soils were also overlain with inorganic deposition, with observations of this beginning around 19+500 and continuing along much of the creek until Dauphin River. There was no note of inorganic soils observed in 2011.

Change at each transect from pre-operation (2011 survey) to post-operation (2013 survey) is described in the field inspection form for the 2013 survey (Appendix A). The focus of this field inspection form is primarily to document potential improvements after a full growing season following the 2011/2012 operation of the LSMEOC. The photos and descriptions provided herein are supplemented by imagery captured during GAIM flights that tended to correspond with the surveys, particularly in 2013 and 2014 (Appendix B). The 2013 survey was done in early July following a late spring, while the 2011 survey was conducted in late September. It is possible that some of the bare areas noted in 2013 were more related, in part, to the season. The 2014 survey was conducted in late June of 2014. While this is reasonably early in the growing season, it is one more year removed from operation of the LSMEOC and, therefore, vegetation had a full growing year since the previous survey. As noted earlier, due to the planned 2014/2015 operation of the LSMEOC, the survey had to be conducted earlier than initially planned. The survey in essence provided a baseline condition for the 2014/2015 operation of the LSMEOC.

An additional task included as part of the substrate cover survey of Buffalo Creek was the determination of the extent of potentially dead stands of trees and woody debris that could end up in the creek over time and/or if the LSMEOC channel was to be operated. Imagery captured during GAIM flights in 2011 and 2013 were used to create a figure highlighting the "Vegetation Impact Zone". Figure 2 (Sheets 1 to 8) shows areas adjacent to Buffalo Creek where vegetation died as a result of 2012-2013 operation of the LSMEOC. It shows narrower vegetation impact zones from 13+000 to 19+000, and generally broader impact zones from 19+000 downstream to the confluence with the Dauphin River.

In general, the large areas of dead trees observed in 2014 remained similar to what was observed in 2013. In some locations, dead trees have fallen over, possibly due to high wind events and the declining strength of the trunks and root structure. While many of the shrubs were still dead, regeneration from the roots had resulted in the resurgence of shrubs in numerous locations, particularly willows. The branches from the dead shrubs were still present above the surface, but are more frequently found along the ground with new green vegetation growing through and above it. In some cases (particularly between stations 20+500 and 22+500), trees that had appeared to be alive in 2013, appeared dead in 2014. Many areas were showing early successional stages of grass and herbaceous species during the 2013 survey. Many areas near the creek bank were relatively barren in 2013 however. Ground cover in 2014 near the creek bank was much thicker, taller and greener than what was observer in 2013.

Below is a brief description of each transect surveyed. For more detail, see Table 1.

3.1 13+000

This transect runs in a northeast-southwest orientation. This section is within the vast open bog area surrounding Buffalo Lake that was widely flooded during operation of the emergency channel. During the 2013 survey, both sides had dead shrubs and approximately 50% bare and 50% grass. A dense patch of dead willows was present near end of the right transect. In 2014, some bare areas were present in the first 2 m adjacent to the creek, but otherwise the grass was much thicker (90%-100% coverage) and taller. Also, some of the shrubs which appeared dead in 2013 had begun regrowth, particularly on the right transect. Most shrubs did not recover however. Organic soil depths were similar during both surveys and were fairly deep (>12 cm). There was no sign of deposition.

13+000 – Left. Transect from creek bank in 2013 (left) and 2014 (right)


13+000 – Left. Looking across creek from left bank in 2013 (left) and 2014 (right)


13+000-Right: Willows at end of right transect in 2013 (left) and 2014 (right).

3.2 13+500

This transect runs in a northwest-southeast orientation and is situated at a left turn in the creek and is comprised of grass, shrubs and bare ground cover. On the right, the transect ended in a marshy area with stagnant water with sedges and aquatic vegetation, while on the left, the transect ended in thick bush. In 2013, the majority of shrubs on the transect were dead and the ground cover was largely bare, but with a high percentage of young grass species emerging (especially on the left side). In 2014, with the exception of a small area (1 m) along the right creek bank, grass coverage was thick (100%) for the entire transect except for the flooded portion along the right transect where cattails (*typha spp.*) were observed. treed areas, which typically may not have thick groundcover had thick vegetative cover, possibly as a result of the lack of leaves on dead shrubs and trees, subsequently allowed sunlight to penetrate to the ground. In 2014, 100% grass coverage was observed in the open areas along the creek. None of the dead trees or shrubs appeared to have recovered. The flooded area on the right transect appeared to be larger and deeper in 2014 than in 2013, possibly as a result of recent beaver activity. Organic soils were present at the surface on both sides of the creek with depths of at least 2 cm. Beneath the organic soils, a mixture of till, silty clay and gravel were observed.


13+500-Right: Transect from creek in 2013 (left) and 2014 (right).


13+500-Left: Transect from creek in 2013 (left) and 2014 (right).

3.3 14+000

This transect runs in a northwest-southeast orientation. In 2013, greater than 50% of the area along the creek (up to the slope) was bare exposed soil, while the slopes were a mixture of grass, dead shrubs, and a dried up residue remnant from high water. In 2014, the same area along the creek was almost entirely grassed over with small bare areas (5%). None of the dead shrubs along the slope regenerated. High water from operation of the LSMEOC does not appear to have gone above the top of the slopes, and therefore the forested area in this section of the transect (on both sides) is similar between years. The left side transect runs into a flooded marsh area comprised of grasses, cattails and willows. This was observed in both 2013 and 2014. More and deeper open water was present in 2014, likely related to the obvious sign of beaver presence at that location. Similar to 2013, organic soil was present at the surface in 2014 (1-4 cm). Beneath the organic soil was a mixture of silty and sandy clays. An area with gravel deposition was noted approximately 100 m upstream from 14+000 and an area with erosion on left and deposition on right was noted 75 m downstream from 14+000 (photos below).

14+000-Right. Transect from creek in 2013 (left) and 2014 (right).

14+000-Left: Wet area above high water mark on left side in 2013 (left) and 2014 (right).

14+000: Looking downstream from left bank in 2013 (left) and 2014 (right).

14+000: Deposition on left side of creek 100 m upstream from 14+000 (2014).

14+000: Erosion on left side and deposition on right approximately 75 m downstream from 14+000 (2014).

3.4 14+500

This transect runs in a northwest-southeast orientation. In 2013, the area nearest the channel was largely bare on both sides of the creek with exposed soil on the left side and exposed cobble on the right. Young grass species were starting to emerge. In 2014, much of this area was covered with grass and other herbaceous plants, but much of the exposed cobble on the right transect was still bare. Further away from the creek, there is a relatively thin strip of dead shrubs on both banks as the slope increases slightly. This was present both years, but grass was growing in the understory and through the dead shrubs in 2014. Beyond the slope and outside of the flooded area, both sides transitioned from largely shrubs to largely trees. Organic soils near the creek ranged from 0 (cobble) to 15 cm. Cobble appeared to be depositional. Some of the cobble was also overlain with depositional organic soils. Beneath the organic soils was silty clay and sand. At a creek bend upstream from 14+500, obvious signs of erosion and deposition were noted (photos below).

14+500: Bare area on right side of creek in 2013 (left) and 2014 (right).

14+500: Right transect from creek bank in 2013 (left) and 2014 (right).

14+500: Left transect from creek bank in 2013 (left) and 2014 (right).

14+500: On right side of creek, looking downstream in 2013 (left) and 2014 (right).


14+500: On left side of creek, looking downstream in 2013 (left) and 2014 (right).

14+500: Erosion on right side approximately 175 m upstream from 14+500 (2014).


14+500: Erosion on left side (left) and deposition on right side (right) approximately 250 m upstream from 14+500 (2014).

3.5 15+000

This transect runs in a northwest-southeast orientation at a left turn in the creek. Extensive erosion on the right side and deposition on the left side have occurred at this location. Exposed silt on the right side appears to be as a result of erosion, while cobble on the left side appears to be depositional. In 2013, large bare areas of inorganic materials were observed adjacent to the channel. On the right side was a steep bank of exposed till which appeared to be actively eroding, as evidenced by the exposed tree roots and clumps of vegetation slumping down the slope. On the left side (inside bend) was a gently sloping expansive bare area of cobble deposition, and beyond that was a large area of dead shrubs with bare understory. In 2014, little appears to have changed. The right transect still had a steep unvegetated slope with exposed silt, while the left side of the creek still had large areas of exposed cobble. The area with dead shrubs further along the left transect had developed a thick layer of vegetation beneath it which has begun to grow through the dead shrubs. As the high water levels do not appear to have reached above the bank on the right, the vegetative composition appears to be the same between years. The slope on the left side is very gentle and the bank is much further away from the creek. Above the slope, the vegetative composition of short shrubs and young trees followed by larger trees remained the same. Organic soils were present further away from the creek up the slopes. Exposed cobble and silt covered the areas closer to the creek channel. Several areas of significant erosion and deposition were seen both upstream and downstream from transect 15+000 (photos below).


15+000: On right side of creek, looking downstream in 2013 (left) and 2014 (right).


15+000: On right side of creek, looking downstream in 2013 (left) and 2014 (right).

15+000: On left side of creek. Looking at transect from near creek bank in 2013 (left) and 2014 (right).

15+000: On left side of creek in 2013 (left) and 2014 (right).

15+000: On left side of creek above slope in 2013 (left) and 2014 (right).

15+000: Erosion approximately 150 m upstream from 15+000 (2014).


15+000: Erosion on right bank approximately 200 m downstream from 15+000 (2014).

15+000: Deposition on right bank approximately 300 m downstream from 15+000 (2014).

15+000: Erosion on left bank approximately 360 m downstream from 15+000 (2014).

3.6 15+500

The orientation of this transect followed a northwest-southeast direction. In 2013, bare areas (30-80%) with dead shrubs and young grass were found adjacent to the creek channel from the creek bank to the top of the slopes. In 2014, much of the bare areas were vegetated by grass and herbaceous species, but some bare areas remained, particularly on the left side slope. Several shrub species (willow, alder) were beginning to get established by 2014 on the top of the left slope however. Vegetation on the right side of the creek in 2014 was long and dense grass with a small amount of dead shrubs along the ground. Above the slopes on each side was outside of the impact zone from the elevated water levels and little change was observed. A mixture of jack pine, black spruce, aspen and willow were observed. Organic soils from 3 to 18 cm deep were observed at the surface in both 2013 and 2014 at most locations on both sides of the creek with clayey silt and silty clay beneath. The slope on the left side had negligible organics and was primarily clayey silt. There doesn’t appear to any significant erosion or deposition at this transect.

15+500: Looking downstream on left side of creek in 2013 (left) and 2014 (right).

15+500: Right transect from near creek bank in 2013 (left) and 2014 (right).

3.7 16+000

This transect is oriented in a northwest-southeast direction at a gentle right bend in the creek. In 2013, a relatively small bare eroded area (cobble, sand, silt) was noted on the left bank, while a larger bare area with deposition of sand, gravel and cobble was observed on the right side (inside bend). Both sides of the creek had dead shrubs with young grass species beginning to emerge in 2013. In 2014, the transect had largely been revegetated by grass and other herbaceous species although a thin strip of bare cobble, sand and silt remained along the creek bank on the left side while patches of deposited cobble, sand and silt were scattered for the first 20 m on the right side. Dead shrubs did not regenerate, but have largely fallen to the ground and are obscured by the thick layer of vegetation that has developed. Further from the channel, a dense mixture of shrubs and trees which was above the high water level was unchanged between years. Both ends of the transect ended in sphagnum bog. Where bare inorganic soils were not present, 4-5 cm of organic soils overlaid a clayey soil within the flooded portion of the transect. The ends of the transect were in sphagnum and therefor had a thick organic layer which was unchanged between years. An extended area of erosion was present on the left side approximately 50 m downstream from the transect (photos below).


16+000: Left bank, looking downstream in 2013 (left) and 2014 (right).


16+000: Right transect from creek bank in 2013 (left) and 2014 (right).


16+000: Deposition on left side (left) and erosion on right side (right) approximately 150 m upstream from 16+000.

16+000: Erosion on left side approximately 50 m downstream from 16+000 (2014).

3.8 16+500

This transect runs in a north-northwest to south-southwest orientation. Directly adjacent to the creek channel, a short eroded area exposing bare cobbles and gravel was observed on the right side beneath an area of bank failure. This was little changed between 2013 and 2014, although some vegetation was beginning to grow on the top of the bank failure and some emergent vegetation had begun to grow near the creek bank in 2014. Above the relatively steep bank and beyond the high water mark, shrubs transition to trees, then to a mixture of shrubs and trees in a sphagnum bog, which was unchanged between 2013 and 2014. A thin strip of dead shrubs was observed at the top of the right slope which does not appear to be regenerating. The slope on the left side was more gradual, and shows a large area of thick dead shrubs and trees that have been knocked over. In 2013, 30% of this area was bare, with extensive areas being covered with dead shrubs, deadfall and debris accumulation. Approximately 60% of the ground was covered with young grass growth. In 2014, none of dead shrubs or trees regenerated, but a thick layer of grass covered 100% of the area including beneath the dead shrubs and trees. Past the dead trees and debris and up a slight bank there is a well-defined end to the impacts of the high water (see photo below). Above the bank, shrubs transition to trees, then to a mixture of shrubs and trees in a sphagnum bog in both 2013 and 2014. Organic soils were observed on the surface at most locations, with depths up to 15 cm. Beneath the organic soils was a mixture of clayey silt and silty clay. With the exception of near the creek, no obvious signs of erosion or deposition were noted. Near the creek on the right side was an area showing both deposition and erosion. Deposited clayey silt with gravel and sand (5 cm) was above organic soil (10 cm), with much of the bank showing signs of erosion (see photo below). Beneath the organic soils was cobble. An area of erosion was observed approximately 175 m downstream from the transect (photo below).


16+500: On left side of creek, looking downstream in 2013 (left) and 2014 (right).


16+500: On left side of creek at end of dead vegetation zone, looking downstream in 2013 (left) and 2014 (right).


16+500: Looking downstream from right bank in 2013 (left) and from left bank 2014 (right).


16+500: Right bank looking upstream in 2013 (left) and from left bank 2014 (right).

16+500: Right bank: Deposition above eroding bank.

16+500: Erosion on right of creek 175 m downstream from transect (2014).

3.9 17+000

This transect runs in a northwest-southeast orientation and is situation immediately upstream of the beginning of Reach 3. In 2013, both sides of the creek showed a mix of bare cover, grass and dead shrubs extending 10 to 15 m from the creek banks. Bare areas were much reduced in 2014 compared to 2013 as most areas are now covered with a thick grass layer. Larger bare areas consisting of deposited cobbles and sand were still present on the right side of the creek. Dead shrubs observed in 2013 did not recover in 2014, but have become less obvious as they fall to the ground and the grass grows up and around it. Up the slope on the left side of the river is an area of herbaceous plants and very young poplar trees which transitions into a mixture of trees and shrubs comprised of poplar, willow and alder. This area is above the high water mark and did not change between years. A similar mixture of taller shrubs was observed on the right side of the river. The transect on the right side ended in wet peaty bush. Soils near the creek show signs of deposition of inorganic clayey silt, coarse sand, and gravel above the organic soils (1-5 cm). Above the creek banks, organic soils were observed at the surface at depths of 10 to >15 cm.

17+000: Right transect from near creek bank in 2013 (left) and 2014 (right).

17+000: Left side of creek looking downstream in 2013 (left) and 2014 (right).

17+000: Shrubs and young trees at clearing on top of left side bank in 2013 (left) and 2014 (right).

3.10 17+500

This transect runs west-northwest to east-southeast. In 2013, the area adjacent to the channel was largely bare ground with dead shrubs and grass. In 2014, much of this area has been vegetated by grass, but a large area of exposed deposited sand and gravel remained on the left side of the creek. Dead shrubs observed in 2013 did not recover, but are much less prominent in 2014 as many have fallen to the ground and grass grows above it. The right slope is slightly steeper and leads to small area of short shrubs and herbaceous vegetation and then on to taller shrubs with some young trees and a bog. High water does not appear to have breached the bank, and the vegetative community noted above the bank did not change between years. The left side had a gentler slope as this was the inside bend of river. Beyond the large area with dead shrubs and inorganic deposition, was an area with live shrubs where it appears high water levels did not reach. Inorganic soils overlay organic soils at most locations sampled along this transect. Soils on the left side were mainly sand near the creek and silt further away from the creek. On the right side was a mixture of silts and clays. Areas with sand were 3 to 15 cm deep, while silty soils ranged from 1 to 5 cm deep. Peat was observed at the end of the right transect


17+500: Right bank seen from creek bank in 2013 (left) and 2014 (right).


17+500: On left side of creek in 2013 (left) and 2014 (right).

17+500: Inorganic deposition on left side of creek, looking downstream (2014).

3.11 18+000

This transect runs in a northeast-southwest direction at a relatively strait section of the creek. A large bare area (20 m) of cobble and gravel was observed on the left side of the creek in 2013. In 2014, this area looked very similar as only a small area was revegetated. Beyond the bare exposed area on the left side in 2013 was a band of dead shrubs (17 m) which was also bare beneath. When visited in 2014, much of this area was now covered by grass, but up to 40% of some areas remained bare. The dead shrubs and trees did not recover. Beyond this, as the slope increased, an area of short shrubs (herbaceous and young poplar) transitioned to taller shrubs (alder) and then to trees. This area appears to be outside of the impacts of high water and was unchanged between years. On the right side of the river, the first 18 m were largely bare soil with grass and some dead shrubs in 2013. In 2014, this area was entirely covered by grass, but dead shrubs still protruded above. Up the slope and beyond the impact area of high water, shrubs transitioned to trees with a largely sphagnum understory which was unchanged between years. Depositional inorganic soils were noted at most sites along this transect, but particularly on the left side. On the left side, large areas of sand, gravel and cobble were observed closer to the creek, while further from creek, organic soils are overlain with 0.5 to 5 cm of silt. On the right side of the creek, a thin layer of organic soil overlaid silt which was above the organic soil.


18+000: Right transect seen from creek bank in 2013 (left) and 2014 (right).



18+000: Right side, looking downstream in 2013 (left) and 2014 (right).



18+000: Bare area on left transect in 2013 (left) and 2014 (right).



18+000: Left transect looking upstream in 2013 (left) and looking downstream in 2014 (right).


18+000: Silt overlaying organic soils on left side of creek (2014).

3.12 18+500

This transect runs in a northwest-southeast orientation. In 2013, bare areas with dead shrubs and grass were observed on both sides of the river, however most extensively on the right side. In 2014, the bare areas were much smaller (5%) as most of the area was covered with thick grass. The dead shrubs and trees did not recover, but new vegetation was beginning to grow beneath and through the dead shrubs and trees. Above the slope on the left side, and beyond the high water impact zone, the understory was largely sphagnum beneath shrubs with a small percentage of trees in both 2013 and 2014. On the right side, beyond the dead shrub area, vegetation transitioned to shrubs, then largely trees before ending in a grassy marsh area with standing water. This area was unchanged between 2013 and 2014. In 2013, inorganic soils were observed at the surface adjacent to the creek on the right side, while elsewhere 2-7 cm of organic soils were measured at the surface. On the right side in 2014, sand was noted near the creek, and deposited silt was noted throughout the area where dead shrubs and trees were seen. On the left side in 2014, a small amount of silt deposition was present above the organic soils. Peat was present at both ends of the transects in both 2013 and 2014. During the 2011 survey, this area was inundated by a beaver dam which flooded areas near the channel. No beaver dam was observed in 2013 in 2014 whoever a beaver lodge was present.

18+500: Right transect seen from creek bank in 2013 (left) and 2014 (right).

18+500: Right transect, looking downstream in 2013 (left) and 2014 (right).


18+500: Left transect seen from creek bank in 2013 (left) and 2014 (right).


18+500: Left transect, looking upstream in 2013 (left) and 2014 (right).


18+500: Erosion on left bank approximately 50 m upstream from transect.

18+500: Beaver lodge on right side of river, looking downstream (2014).

3.13 19+000

This transect runs in a northeast-southeast orientation. In 2013, the left side of the creek consisted of bare areas, dead shrubs, and early stage grass regrowth near the creek. In 2014, this area was almost entirely grassed over, with a small amount (5%) of bare areas remaining. Dead shrubs did not recover. The left transect transitions to live short shrubs followed by tall shrubs with a high percentage of grass before becoming largely treed. This remained consistent between 2013 and 2014. Standing water was present at the end of the transect. The right side had a similar, although slightly larger, area consisting of dead shrubs, bare areas, and early stage grass regrowth in 2013. In 2014 this areas was entirely grassed over, although a dead trees and debris (logs, etc.) still covered a large area approximately half way down the transect. Beyond the dead shrubs a small area of short shrubs followed by a tree/shrub mixture was observed both years. At the end of the transect, the understory became sphagnum-dominated. Exposed inorganic soils were noted in 2013 immediately adjacent to the creek on the left side, however elsewhere organic soils were noted on the surface. In 2014, depositional soils were observed on both sides of the creek. On the left side, a mix of deposited sand, gravel, cobble and silt were observed above the organic soil. On the right side of the creek, a thin layer of silt was present above the organic soils along much of the transect. Deposited organic soils were also observed above the silt along the right transect at one location. An area of bank erosion was noted approximately 100 m upstream from the transect (photo below).

19+000: Left transect seen from near creek bank in 2013 (left) and 2014 (right).

19+000: Right transect seen from near creek bank in 2013 (left) and 2014 (right).

19+000: Erosion on left side of creek approximately 100 m upstream (2014).

3.14 19+500

This transect followed an east-west alignment. In 2013, the left side was bare along the creek, followed by a large area of mature dead trees which were largely bare beneath (80%). High water marks were visible on many of the tree trunks. Lots of trees and debris were on the ground, as it appeared the trees at this location acted as a catch/dam/strainer for dead vegetation floating down the creek. In 2014, this section appeared similar but a lush layer of grass was present throughout the majority of the area. There was no bare area along the creek edge in 2014. Dead trees did not recover. At the end of the transect, live trees with a sphagnum understory were encountered both years. The terrain on the right side of the creek was much flatter. In 2013, bare areas were observed near the creek channel, with a combination of dead shrubs and trees for the entire transect distance. Aquatic emergent vegetation was found at several locations on this side. In 2014, the same area was largely grassed over, but did still have some bare exposed sand areas. The dead shrubs and trees did not recover. Depositional inorganic soils (1-5 cm) were observed on both sides of the creek in 2013. In 2014, thick layers of fine to medium sand were measured on the right side near the creek (10-15 cm) while further from the creek, thinner layers of silty sand (5 cm) were measured. On the left side in 2014, a mixture of deposited silty clay, silt and sandy silt was observed for the majority of the transect.


19+500: Right transect seen from near creek bank in 2013 (left) and 2014 (right).


19+500: Dead trees along right transect in 2013 (left) and 2014 (right).


19+500: Small channel on left transect in 2013 (left) and 2014 (right).


19+500: Dead trees along left transect in 2013 (left) and 2014 (right) (photos not from exactly same location).


19+500: High water mark on spruce trees on left transect in 2013.

3.15 20+000

This transect runs in a south-southwest to north-northeast direction and is just downstream from a sharp left turn in the creek. In 2013, the left side had a large bare area of cobble and gravel which extended for about half of the transect, followed by an area of dead shrub which was largely bare beneath. The entire area along the inside bend of the creek appears to have been inundated by high water, including the entire left transect. In 2014, most of the bare cobble areas were still exposed and all the dead shrubs remained dead. Grass was beginning to establish itself on the further half of the transect, however large bare areas remained near the creek in 2014. In 2013, the right side had a smaller bare area near the creek, followed by dead shrubs underlain by grass, then dead trees underlain by grass. In 2014, small bare areas remained near the creek, but grass had overtaken most of the transect including beneath the dead trees and shrubs. As the whole transect appears to have been inundated, deposited inorganic soils were observed on the surface throughout. In 2013, 1-5 cm of inorganics were measured above organic soils. In 2014, 3-13 cm of inorganics were measured above organic soils. On the left side in 2014, thick layers of sand, gravel and cobble were present near the creek, while mainly sand was present further along the transect. On the right side in 2014, silt overlaid organic soils for the length of the transect. An eroded bank was noted approximately 300 m upstream from the transect on the left side (outside bend of river).

* Due to camera malfunction in 2013, photos below are from 2011 and 2014 only.

20+000: Grass on right transect in 2011 (left) and 2014 (right). (Photos not from exact same location)

20+000: Looking downstream from right side of creek in 2011 (left) and 2014 (right). (Photos not from exact same location)

20+000: Trees along right transect seen in 2011 (left0 and 2014 (right). (Photos not from exact same location)

20+000: Bare area on left side of creek as seen from right bank (2014).

3.16 20+500

This transect was oriented in an east-west orientation at a strait stretch of creek shortly after a right turn. In 2013, both sides had bare areas with dead shrubs and a small proportion of grass. On the left side, live trees were encountered approximately half way along the transect. On the right side in 2013, the dead shrubs transitioned to a mixture of dead trees and dead shrubs. The entire right transect appears to have been inundated as all shrubs and trees were dead. In 2014, the entire left transect was covered in grass including beneath dead shrubs and trees. It appears as though live trees that were observed in 2013 died between 2013 and 2014 as no live trees were noted along the transect in 2014. The right side in 2014 was fully grassed over near the creek, but several bare patches were still present between 50 m and 100 m. In 2013, deposited inorganic soils were present above the organic soils throughout both sides of the transect in thicknesses varying from 1 cm to 13 cm. In 2014, similar depths of silt (<1 cm to >15 cm) were measured above organic soils on both sides of the creek.

* Due to camera malfunction in 2013, photos below are from 2011 and 2014 only.

20+500: Left transect from near creek bank in 20111 (left) and 2014 (right). (Photos not from exact same location)

20+500: Looking upstream from left bank in 2011 (left) and 2014 (right). (Photos not from exact same location)

20+500: Dead shrubs and grass along left transect (2014).


20+500: Dead trees and grass along left transect (2014).

3.17 21+000

This transect runs in an east-west direction at a gentle left turn in the creek. In 2013, the left side of the creek was comprised largely of dead shrubs, with bare areas near the creek channel and some dead trees near the end of the transect. In 2014, this area was covered by a thick layer of grass, while dead trees and shrubs did not recover. The high water mark can be seen on many of the mature dead spruce (see photo below). In 2013, the right side had a mixture of dead shrubs, grass, and bare patches for the first approximately 30 m. Beyond this was live shrubs and grass layer underlain by sphagnum which transitioned to trees approximately halfway along the transect at the end of a small clearing up the slope. In 2014, this transect had lots of grass near the creek, and then transitioned to an area of shrubs (1/2 dead) and then to an area of trees (1/2 dead). These trees appear to have died between 2013 and 2014 as these trees were live in 2013. In 2013, deposited inorganic soils above the organic soils were 6-13 cm thick on the left side and 4 cm thick on the right side near the creek. Peat was observed above the slope on the right side. In 2014, inorganic fine sand and silt was present along most of the transect including all of the left side and the first half of the right side. On the right side, organic soils (peat) was present starting at approximately 50 m. Thicknesses of inorganic soils above the organic soils in 2014 varied from 5 to 15 cm. An area of erosion and fallen trees was observed on left side of creek approximately 200 m upstream from the transect (photo below).

* Due to camera malfunction in 2013, photos below are from 2011 and 2014 only.

21+000: Right side of creek looking downstream in 2011 (left) and 2014 (right).

21+000: Right transect from near creek bank in 2011 (left) and 2014 (right). (Photos not from exact same location)

21+000: High water mark seen on dead spruce on left side of creek in 2014.

21+000: Erosion and fallen trees on left side of creek approximately 200 m upstream from transect 21+000 (2014).

3.18 21+500

This transect runs in a southwest-northeast orientation at a strait stretch of the creek. In 2013, the left side of the creek was dominated by dead shrubs for the first 32 m, followed by dead trees up to 57 m, followed by live spruce trees. The understory was bare for the first half of the left transect in 2013. In 2014, the area near the creek was a mixture of grass and shrubs (2/3 live), and then transitioned to an area of dead trees with a thick herbaceous groundcover. Trees were dead all the way to the end of the transect. These trees appear to have died between 2013 and 2014. The right side of the creek in 2013 had dead shrubs until 25 m, followed by live spruce trees which developed a sphagnum understory beyond 36 m. In 2014, dead shrubs were again seen for the first 23 m, although there was also a thick layer of grass growing beneath it. Beyond the dead shrubs, dead mature spruce trees were observed for the duration of the transect. These trees appear to have died between 2013 and 2014. In 2013, organic soil depths varied from 3 to >17 cm, with much of the area overlain by inorganic soils of 3 to 7 cm. In 2014, >13 cm of silt was observed in the area with dead shrubs on the left side, while on the right side, >15 cm of fine sand was observed. Within the mature trees, 3-8 cm of deposited silt was observed above organic soils in 2014.

* Due to camera malfunction in 2013, photos below are from 2011 and 2014 only.

21+500: Left side of creek looking upstream in 2011 (left) and 2014 (right).

21+500: Right side of creek in 2014 looking upstream (left) and downstream (right).

21+500: Right side of creek as seen from left side in 2014. Note high water mark on trees.

21+500: Dead spruce trees showing high water mark and a herbaceous understory on left transect in

2014.

3.19 22+000

This transect runs in a southwest-northeast direction at a relatively treed stretch of the creek. In 2013, the first approximately 13-18 m on both sides of the creek were dominated by dead shrubs, but also had bare areas and grass. Beyond the dead shrubs were live mature trees on the left and a mixture of dead and live mature trees on the right. Both sides end in a forested area with sphagnum understory. In 2014, dead shrubs were still present along the creek, but were less visible as many had fallen to the ground and thick layer of grass now existed. Within the trees, the first 26-43 m were dead, followed by live trees transitioning into bog. High water marks were visible on the mature spruce well away from the creek. A small proportion of shrubs were also present on the left side. In 2013, inorganic soils overlaid organic soils along most of the transect with the exception of the sphagnum areas near the end on each side. Depths ranged from >13 cm near the creek to 5-6 cm in the trees. In 2014, 3-5 cm of silt overlaid most of the transect with a thick layer of sand (>13 cm) also found on the left side near the creek (beneath silt). Peat was again observed at the surface at the end of the transects. An area of erosion and fallen trees on the right bank approximately 230 m downstream from the transect.

* Due to camera malfunction in 2013, photos below are from 2011 and 2014 only.

22+000: Mature spruce trees and herbaceous understory in 2011 (left) and 2014 (right). Note high water mark in 2014. (Photos not from exact same location)


22+000: Right side of creek, looking downstream in 2014.


22+000: Dead trees on right side of creek, as seen from creek bank in 2014.


22+000: Erosion and fallen trees on the right bank approximately 230 m downstream from 22+000 (2014).

3.20 22+500

This transect runs in an east-west direction at a left bend in the creek just downstream from a small rapid. The creek is particularly wide at the transect location. In 2013, the left side had a large bare area of gravel and sand adjacent to the creek. Beyond this, dead trees with a mainly bare understory were observed until near the end of the transect. The last 27 m of the transect had live trees and a few shrubs. In 2014, the same bare area was observed along the creek, although this time it had a small (5%) amount of grass. Beyond the bare area, dead trees were observed until the end of the transect. The trees at the end of the transect that were alive in 2013 appear to have died by 2014. The understory of this area was almost entirely grass. Large piles of debris (trees, sticks, etc.) were captured by trees on the left transect during high water (see photo below). The right side in 2013 had an area of dead trees with bare understory immediately adjacent to the creek for about 20 m, followed by live mature trees for the remainder of the transect. In 2014, a similar extent of dead trees was observed, although this time there was a 50% understory of herbaceous plants. The remainder of the transect was comprised of live trees. Organic soils in 2013 were beneath a 5-9 cm layer of inorganic soil deposition, with the exception of near the ends of transects. In 2014, 3-13 cm of silt was on the surface at most locations.

* Due to camera malfunction in 2013, photos below are from 2011 and 2014 only.

22+500: Mature spruce trees and herbaceous understory in 2011 (left) and 2014 (right). Note high water mark in 2014. (Photos not from exact same location)

22+500: Bare area on left side, looking downstream in 2014.


22+500: Dead trees, accumulated debris and grass on left transect in 2014.


22+500: Debris on rock in creek, as seen from left bank in 2014 (flow going left).


22+500: Dead trees and grass on right side, as seen from near creek bank in 2014.

3.21 23+000

This transect runs in a southwest-northeast direction. In 2013, dead shrubs were observed on both sides of the creek, with dead trees also present beyond the dead shrubs on the right side. The dead zones were approximately 30 m on both sides and were largely underlain by deposited bare exposed soils. Beyond the dead zone, live trees covered approximately half of the transect on each side. In 2014, the areas closest to the creek on each side were covered with thick grass. Dead shrubs were still present amongst the grass. Beyond the dead shrubs, dead trees were observed. An area of trees on the left side that was alive in 2013 was dead in 2014. Live trees were still present at the end of the transect on both sides. In 2013, organic soils were beneath 5-9 cm of inorganic deposition at test holes near the creek, while peat was observed on the surface further along the transect on each side of the creek. In 2014, 3-5 cm of silt was measured above organic soils near the creek, while peat was again observed near the end of the transect on each side.

* Due to camera malfunction in 2013, photos below are from 2011 and 2014 only.

23+000: Mature spruce trees and herbaceous understory in 2011 (left) and 2014 (right). Note high water mark in 2014. (Photos not from exact same location)

23+000: Grass and dead trees, looking downstream from right bank in 2014.

23+000: Dead trees and grass on left transect as seen from near creek bank in 2014.

23+000: Silt deposition above organic soil on the left side of the creek in 2014.

3.22 23+500

This transect runs in a north-south orientation near a sharp left bend in the river. During emergency channel operation, it appears water immersed the inside bend of the river including the entire left transect. In 2013, all vegetation on the left side of the river was dead. Dead shrubs were present from the creek bank to 50 m, while dead trees were present from 50 m to 100 m. The understory was bare for the entire left side transect. On the right side in 2013, dead trees were observed adjacent to the creek bank for the first 21 m. The understory was bare close to the creek, while a herbaceous understory was present starting at 9 m for the remainder of the transect. The remainder of the right side transect consisted of live trees with a sphagnum understory. In 2014, all the shrubs and trees on the left transect were still dead. Thick grass was present close to the creek around the dead shrubs, while a herbaceous layer was present beneath the dead trees. On the right side in 2014, grass cover was present near the creek along with a small proportion of new young shrubs. The extent of dead trees was similar as was observed in 2013, and live mature trees were again present for the majority of the transect. In 2013, 6 to >20 cm of inorganic soil was measured above organic soils, with the thickest layer of deposition being along the left transect. Only a narrow area of deposition was noted on the left side with organic soils at the surface for the majority of the transect. In 2014, 3 to >10 cm of silt was measured above organic soils near the creek, but silt was again observed along the full length of the left transect. An area of erosion and fallen trees on the left side of the creek and deposition on the right side of the creek was observed approximately 175 m upstream from the transect.

* Due to camera malfunctions in 2011 and 2013, photos below are from 2014 only.


23+500: Looking downstream from left bank (2014).


23+500: Grass and dead trees on left transect, as seen from shore (2014).


23+500: Dead trees on left transect, with herbaceous ground layer and accumulated debris on upstream side of trees. Note high water mark on tree trunks (2014).

23+500: Bog at end of right transect. Typical of what was seen at the end of many transects (2014).


23+500: Erosion and fallen trees on left (left) and deposition on right (right) approximately 175 m upstream from transect (2014).

3.23 24+000

This transect runs in an east-west orientation immediately upstream from a sharp S-turn in the creek. In 2013, the left bank was a steep eroded bank. At the top of the bank was a mixture of deciduous shrubs and trees for the duration of the transect. At 61 m, where the transect approached the river bank further down stream, the trees and shrubs were dead. On the right side of the river in 2013, the slope was much gentler, and the ground were largely wet and muddy. The creek appears to have flooded the full length of the right transect. Dead trees and shrubs dominated the first 68 m of the transect. The understory of that section was largely bare, but with increasing concentrations of grass as the transect progressed away from the creek. Live trees were present from 68 m to the end of the transect. In 2014, the steeply eroded bank on the left side appeared unchanged. A similar composition of shrubs and trees was recorded for the remainder of the transect although the bare areas noted in 2013 near the end of the transect were now covered with a herbaceous layer of vegetation. In 2014, the right transect was mainly grassed over. Some areas had stagnant water and emergent aquatic plants were growing (*typha* spp.) Trees remained dead, although it appears that some of the shrubs further from the creek had recovered. In 2013, deposited inorganic sediments varied from 8 to 13 cm above the organic soils along the right transect and near the creek along the left transect. Organic soils were on the surface at the majority of the left transect. In 2014, a similar pattern was observed with relatively small amounts of deposited silt near the creek on the left side and a thicker layer of silt on the right transect. Many areas were too wet to assess soil content.

High water levels forged new creek channels immediately downstream from the transect, essentially short-cutting the previous meandering route. While water continues to pass though the previous channel, it appears the majority of water now goes through the new channels, particularly during low water conditions.


24+000: Looking across creek at left transect from right bank in 2013 (left) and 2014 (right).


24+000: Dead trees on right transect in 2013 (left) and 2014 (right) (photos not from exactly the same location).

24+000: Looking upstream from left bank in 2013 (left) and 2014 (right).

24+000: Looking downstream from left bank in 2013 (left) and 2014 (right). Original channel is to the right, while new channel is on left (2014 photo).

24+000: Erosion immediately downstream from transect where near channels were created (2104)

3.24 24+500

This transect is oriented in an east-west direction downstream from the S-turn in the creek where new channels were created during high water. In 2013, the left side of the river was composed of dense dead shrubs with a bare understory until 34 m where a layer of live shrubs began. Beyond this, the vegetation became largely treed with a sphagnum understory. Effects from high water appear to end approximately 20 m from the creek bank. On the right side, bare areas with dead shrubs and trees span the entire transect in 2013. This side of the creek is lower and was clearly immersed by high water for its entire length. In 2014, the left side was unchanged other than the 90% grass cover near the creek where it was previously bare. The right side in 2014 showed a similar pattern. Dead shrubs and trees did not recover, but the understory was largely covered by grass near the creek and more herbaceous species within the dead trees further away from the creek. Soils in 2013 showed thick layers of inorganic deposition near the creek. 14-15 cm deep inorganics were measured above organics on the left side while >19 cm of inorganics were measure on the left side near the creek. Thinner inorganic layers were noted further from the creek on both sides. In 2014, 5 cm of silt was measured near the creek on both sides, while >15 cm of silt was present further along the right transect. Peat was observed at the end of the left transect which was unchanged between 2013 and 2014. An area of erosion and deadfall was observed approximately 190 m downstream from the transect (see photos below).


24+500: Left bank, looking downstream in 2013 (left) and 2014 (right).


24+500: Right transect seen from near creek bank in 2013 (left) and 2014 (right).


24+500: Along right transect, looking downstream in 2013 (left) and 2014 (right).


24+500: Erosion and deadfall on left (left) and right (right) of creek approximately 190 m downstream from transect.

3.25 25+000

This transect is oriented in a northwest-southeast direction. In 2013, the left side of the creek had a steep bank which appears to have slumped (see photo below). At the top of the slope were shrubs which were followed by deciduous trees and then coniferous trees. The right side in 2013 was less steep and had dead shrubs and a bare understory until 36 m. Much of the area consisted of exposed cobbles, gravel and sand. Beyond this was a mixture of live trees and shrubs. In 2014, the slumped bank was still present and had minimally more vegetation on it. Above the slope, a similar composition of shrubs and trees was observed. The right side in 2014 still had a bare cobble area adjacent to the creek although patches of grass had grown in a few locations. Beyond the cobble, thick grass was growing within the dead shrubs until near the end of the transect where the transect leaves the dead zone and live trees and shrubs are encountered. A fair bit of debris (logs, branches) was deposited within the dead shrub area. In 2013, 1 to 4 cm of inorganic soil overlaid organic soils near the creek, except for the large areas of coble which were deeper. Organic soils were present on the surface further from the creek on both sides. In 2014, the bank slump on the left side was identified as being mainly silt. Above the bank, trace silt was present above organic soils. On the right side in 2014, 10 cm of silty organic soil was observed above silt within the grassy area with dead shrubs. Peat was present at the end of the right transect. An area with cobble and gravel deposition was observed approximately 200 m upstream from the transect at a sharp bend in the creek (photo below).

25+000: Bank slump on left side of creek, looking upstream in 2013 (left) and 2014 (right).


25+000: Cobble area on right side of creek in 2013 (left) and 2014 (right) (photos not from exact same location).


25+000: Dead trees along right transect in 2013 (left) and 2014 (right) (photos not from exact same location).

25+000: Areas with cobble and gravel deposition approximately 200 m upstream from transect (2014).

3.26 25+500

This transect was oriented in an east-west direction at a left turn in the creek. In 2013, the left side of the creek had a very gentle slope and consisted of dead shrubs and a largely bare understory for the entire left-side transect. The entire left transect had clearly been inundated during high water. The right side of the creek has a steeper bank. In 2013, it had a thin layer of dead shrubs with a bare understory, followed by a progression of live shrubs followed by trees with a sphagnum understory starting at 54 m. In 2014, the left side had been completed vegetated over with mainly grass, but also herbaceous species further from the creek. None of the dead shrubs recovered. On the right side in 2014, the thin strip with dead shrubs now had a thick layer of vegetation growing beneath it. Above the bank, a similar composition of shrubs, and trees was observed. Soils in 2013 had 1 to 4 cm of inorganics above organic soils near the creek and along the left transect. In 2014, 5 to 8 cm of silt was observed at the surface on the left side. At one location, beneath the silt was 3 cm of organic soil followed by further silt. On the right bank, 10 cm of organic soil was measured above a layer of silt. An area of erosion was observed at an outside bend in the creek approximately 175 m upstream from the transect (photo below).



25+500: Right side of creek, looking downstream in 2013 (left) and 2014 (right).


25+500: Left transect in 2013 (left) and 2014 (right).


25+500: Left transect in 2013 (left) and 2014 (right).

25+500: Area of erosion on left side of creek approximately 175 m upstream from transect (2014).

3.27 26+000

This transect runs in a east-northeast to west-southwest direction at an S-turn in the river. The left transect approximately paralleled the river and had very little topography. In 2013, the ground cover was entirely comprised of dead shrubs and bare understory, with a small percentage of grass. The right side of the creek in 2013 had a similar area of dead shrub and bare understory adjacent to the creek until the transect went up the slope and a dense shrub coverage was encountered seemingly above the high water mark. Due to the winding nature of the creek at this point, this transect approaches the creek again near its end. In this area, dead shrubs and trees and a bare understory were again encountered. In 2014, there was a 3 m area adjacent to the creek on the left side which was still bare, but otherwise the remainder of the left transect was 100% covered by grass, None of the dead shrubs recovered. On the right side in 2014, areas near the creek both at the beginning and end of the transect (which were previously bare) were largely covered by grass. In 2013, a thin inorganic soil layer was observed above organic soils on the left side. On the right side, 4-13 cm of inorganic soils were present above the organic soils. In 2014, the small bare area adjacent to the creek was composed of 5 cm of silt above gravel. On the right bank in 2014 a silty organic soil was noted. An area of erosion on the left bank approximately 250 m upstream from transect was observed (photo below).


26+000: Right transect in 2013 (left) and 2014 (right).

26+000: Left transect in 2013 (left) and 2014 (right).

26+000: Bare area adjacent to creek on left side, looking upstream.

26+000: Area of erosion on left bank approximately 250 m upstream from transect.

3.28 26+500

This transect runs in a south-southeast to north-northwest direction and is situated between two bends in the creek. In 2013, the left side, which is fairly low and flat, was comprised entirely of dead shrubs and trees with a small amount of grass, but the understory was largely bare. The right side was also largely bare adjacent to the creek, but with a slightly higher coverage of grass. Dead shrubs were found until 59 m where the transect entered 100% live trees. In 2014, none of the dead shrubs or trees recovered. The first half of the left transect was fully grassed over while a more herbaceous layer was present further along the transect closer to the dead trees. The right side in 2014 was fully grass-covered near the creek with a more herbaceous groundcover seen within the dead shrubs. Some accumulated debris (branches) was also noted on the right side. Soils in 2013 had 2-5 cm of inorganic deposition above organic soils near the creek, and throughout the left transect. Organic soils were observed on the surface on the right side after the first 20 m. In 2014, 15 cm of sandy silt was measured above organic soils near the creek on the left side, while organic soil was noted on the right side of the creek. An area of erosion was noted on the on right side approximately 175 m downstream from transect (photo below).


26+500: Right transect from shore in 2013 (left) and 2014 (right).


26+500: Within dead shrubs on right transect in 2013 (left) and 2014 (right).

26+500: Accumulated debris on right transect (2014).


26+500: Left transect in 2013 (left) and 2014 (right).


26+500: Trees near end of left transect in 2013 (left) and 2014 (right).

26+500: Erosion on right side of creek approximately 175 m downstream from transect (2014).

3.29 27+000

This transect runs in an east-west direction at a left turn in the creek. The inside bend (left side) is low in elevation, while a distinct bank was present on the right side at approximately 20 m from the creek bank. In 2013, the left side of the river was composed of mainly dead shrubs with a smaller portion of grass and a largely bare understory. At 77 m the transect entered live mature trees. On the right side in 2013, a similar composition of dead shrubs, grass and bare understory was encountered adjacent to the creek. At 42 m (base of slope), the transect transitioned to shrubs and at 58 m, there was a mixture of shrubs and trees. In 2014, the lower lying areas which were largely bare were now covered with a thick layer of grass. Dead shrubs did not recover. Organic soils near the creek in 2013 were overlain with 2-3 cm of inorganic deposition at the low areas near the creek, while organic soils were observed on the surface up the bank on the right side. In 2014, 1 cm of silt was measured above >13 cm of fine gravel near the creek on the left side, while 1 cm of silt was measured above organic soils on the right side (near the creek). Erosion was noted at locations 100 m to 200 m downstream from the transect along the outside bend of the creek (photos below).

27+000: Right transect in 2013 (left) and 2014 (right).

27+000: Left transect in 2013 (left) and 2014 (right).

27+000: Near end of left transect in 2013 (left) and 2014 (right).



27+000: Eroded right bank approximately 100 m downstream (left) and 200 m downstream (right) from transect (2014 photos).

3.30 27+500

This transect runs in an east-west direction just downstream from a sharp right-hand bend in the creek. The inside bend of the river (right side) was lower in elevation, while there was a distinct bank on the left side near the creek. In 2013, the left side of the river had an area of dead shrubs with some grass but was largely bare until the slope increased at 34 m. Above the slope was a mixture of thick shrubs and trees until 59 m where 100% trees were encountered along with a sphagnum understory. The right side in 2013 had a larger flat area which was largely bare (cobble, sand) until 25 m. Beyond this, an area of dead shrubs with grass and bare understory transitions to an area of largely trees at 51 m, and then back to shrubs at 92 m. In 2014, the left side was covered with a thick layer of grass up to the slope. Dead shrubs did not recover. Up the slope appears to be outside of the high water impact zone and therefore appears that little changed between 2013 and 2014. On the right side in 2014, the cobble/sand area was largely still bare for about 6 m from the creek. Beyond that, grass covered the ground and grew through the dead shrubs. A similar composition of live shrubs and trees was observed beyond 50 m along the right transect. In 2013, a thin layer (1 cm) of inorganic soil was present above organic soil on the left side of the creek, while a thicker layer (3-5 cm) was present on the right side aside from the cobble area which was much thicker. In 2014, 6 cm of silt was measured above organic soil on the left side, while >15 cm of sand and gravel was measured near the creek on the right side and sandy silt was identified further from the creek.

27+500: Left transect in 2013 (left) and 2014 (right).

27+500: Left transect, looking downstream in 2013 (left) and 2014 (right).

27+500: Right transect in 2013 (left) and 2014 (right) (photo not from exactly same location).

3.31 28+000

This transect runs in an east-southeast to north-northwest direction at a right-hand bend in the creek. The right side is a large open area with low elevation, while the left side is sloped near the creek bank. On the left side in 2013, a small bare/grass patch adjacent to the creek transitioned to shrubs and then to trees. On the right side of the creek, a large (60 m) bare area with some grass leads to a band of shrubs, followed by trees up a gentle slope. In 2014 on the left side, aside from some erosion immediately at the water's edge, the ground was covered with thick grass up the slope. Shrubs and trees above the slope were beyond the impacted area and are therefore not changed. The right side in 2014 had a 4 m area adjacent to the creek which was still mostly bare, but the remainder of the open area was covered with grass. A similar composition of shrubs and trees was noted beyond the open area. Soils in 2013 were organic at the surface on the left, and a mixture of gravel, sand and silt on the right side. In 2014, 1 cm of silt was observed above organic soil on the left, while gravel, sand and silt were again noted on the right side of the creek.



28+000: Right transect from near creek bank in 2013 (left) and 2014 (right).



28+000: Looking downstream from left bank in 2013 (left) and 2014 (right) (photos not from exact same location).

28+000: Erosion on left bank, looking downstream (2014).

28+000: Erosion on left bank, looking upstream (2014).

TABLE

TABLE 1
RESULTS OF VEGETATION COVER SURVEY

Station	Sub-Section	Bank *1	Transect Orientation	Cover Type	Start (m)	End (m)	Organic Layer (cm)
13+000	A	Left	Northeast	River	0	16	-
				Grass 90%; Bare 10%; Shrub (dead) 5%	16	60	>12
				Grass 100%; Shrub (dead) 15%	60	100	>12
	B	Right	Southwest	River	0	16	-
				Grass 50%; Bare 50%	16	18	20
				Grass 100%; Shrub (dead) 5%	18	58	>12
				Grass 50%; Shrub (regrowth) 50%	58	78	-
				Shrubs (mainly dead) 90%; Grass 75%	78	87	>12
				Grass 100%; Shrub (dead, standing) 75%	87	100	-
13+500	A	Left	Northwest	River	0	20	-
				Grass 100%; Shrub (dead) 10%	20	39	20 (above till)
				Grass 100%; Shrub (dead) 50%	39	44	>20
				Grass 100%; Shrub (tall, 90% dead) 75%	44	58	>20
				Grass 100%; Shrub (tall, 50% dead) 50%; Trees (dead) 25%	58	84	-
				Grass 100%; Shrub (tall) 90%	84	100	2 (above silty clay)
	B	Right	Southeast	River	0	20	-
				Grass 50%; Bare 50%	20	21	4 (above clay with gravel)
				Grass 100%; Shrub (dead) 5%;	21	34	-
				Grass 100%; Shrub (dead) 25%; Tree (dead) 10%	34	49	-
				Grass 100%; Shrub (dead) 20%; Tree (dead) 5% (marshy)	49	92	-
				Grass (typha) 40%; Shrub (dead) 40% (deeper water)	92	100	-
14+000	A	Left	Northwest	River	0	13	-
				Grass 100%	13	23	1 (above fine silty clay)
				Grass 90%; Shrubs (mostly dead) 60%	23	27	-
				Grass 100%; Shrubs 40%; Trees (dead) 5%	27	37	1 (above clay with silt and fine sand)

				Grass (typha) 100%; Shrubs 70% (wet)	37	52	-
				Grass 50%; Open Water 50%; Shrubs 20%	52	82	-
				Shrubs 80% (wet)	82	100	-
	B	Right	Southeast	River	0	13	
				Grass 95%; Bare 5%; Shrubs (dead) 5%	13	20	3 (above sandy clay)
				Grass 95%; Bare 5%; Shrubs (dead) 25%	20	28	-
				Shrubs (short) 100%	28	33	4 (above clay with rocks)
				Trees 50%; Shrubs 50%	33	46	-
				Shrubs (short) 100%; Trees 80%	46	78	-
				Trees 80%; Shrubs (short) 75%	78	100	-
14+500	A	Left	Northwest	River	0	8	-
				Grass 95%; Bare 5%	8	15	15 (above fine silty clay)
				Grass 75%; Bare 25%; Shrubs (dead) 25%	15	17	5 (above clay)
				Shrubs (short) 100%; Trees 40%	17	30	-
				Trees 75%, Shrubs 25%	30	50	<1 (above silty clay with sand)
				Trees 100%; Shrubs (short) 100%	50	100	-
	B	Right	Southeast	River	0	8	-
				Grass 60%; Bare 40%	8	18	mix of cobble and 3 cm org soil (above sand)
				Grass 90%; Shrubs (dead) 50%	18	20	-
				Shrubs 95%; Trees 5%	20	28	-
				Shrubs (tall) 50%; Trees 5% (100% herbaceous understory)	28	46	8
				Trees 100% (100% herbaceous understory)	46	69	-
				Trees 70%; Shrubs 30% (100% herbaceous understory)	69	100	-
15+000	A	Left	Northwest	River	0	10	-
				Bare 100%	10	24	0
				Grass 100%; Shrubs (dead) 60%; Trees (dead) 5%	24	44	-
				Shrubs 100%	44	65	9 (above clayey silt)
				Trees 100%; Shrubs 25% (100% herbaceous understory)	65	100	-
	B	Right	Southeast	River	0	10	-
				Bare 100%	10	12	0

				Trees 50%; Shrubs 50% (75% short shrub understory, 25% deadfall)	12	18	-
				Shrubs (tall) 75%; Trees 25% (100% herbaceous understory)	18	41	-
				Trees 25%; Shrubs 25% (100% herbaceous understory with sphagnum)	41	100	-
15+500	A	Left	Northwest	River	0	7	-
				Grass 95%; Shrubs (dead) 25%; Bare 5%	7	17	8 (above clayey soil)
				Shrubs 75%; Bare 25%	17	21	exposed clayey silt with negligible organics
				Trees (jack pine) 100% (75% short shrub understory)	21	55	-
				Shrubs (tall) 75%; Trees 25% (100% short shrub understory)	55	100	-
	B	Right	Southeast	River	0	7	-
				Grass 100%; Shrubs (dead) 20%	7	24	18 (above clayey silt)
				Shrubs 50%; Trees (dead) 40% (80% short shrub understory)	24	26	3 (above silty clay)
				Trees 80%; Shrubs 20% (understory 100% short shrubs)	26	40	-
				Shrubs (tall) 90%; Trees (spruce) 10% (short shrub and sphagnum understory)	40	100	-
16+000	A	Left	Northwest	River	0	9	-
				Bare (inorganics) 100%	9	10	0
				Grass 100%; Shrubs (dead) 15%	10	26	4 (above clay with rocks)
				Trees 95% (jack pine); Shrubs 5% (100% short shrub understory)	26	44	-
				Shrubs (tall) 100% (100% short shrub understory)	44	81	-
				Trees 100% (mainly jack pine) (100% short shrub understory)	81	100	-
	B	Right	Southeast	River	0	9	-
				Grass 75%; Shrubs (dead) 40%; Bare 25%	9	29	0
				Shrubs 80%; Trees 10%	29	49	5 (above clay)
				Shrubs (tall) 95%; Trees 5% (100% short shrub understory)	49	100	-
16+500	A	Left	North-Northwest	River	0	10	-
				Grass 100%; Shrubs (dead) 75%	10	28	15 (above clayey silt)

				Grass 100%; Shrubs and trees (dead) 90%	28	80	2 (above silty clay)
				Shrubs (short) 100%	80	84	-
				Trees (jack pine) 60%; Shrubs (40%) (100% short shrub understory)	84	100	-
	B	Right	South-Southeast	River	0	10	-
				Bare (cobble) 100%	10	12	0
				Shrubs (dead) 100%; Grass 90%; Bare 10%	12	17	5 cm of clayey silt with gravel and sand above 10 cm of organic soil, then cobble
				Shrubs (short) 100%	17	19	-
				Shrubs (tall) 100% (10% short shrub understory)	19	45	-
				Trees 75%; Shrubs 20% (100% short shrub understory)	45	100	-
17+000	A	Left	Northwest	River	0	15	-
				Grass 100%; Shrubs (dead) 10%	15	21	3 (above sandy silt)
				Grass 50%; Shrubs (dead) 50%; Bare 25%	21	25	clay with silt soil
				Shrubs (short) 100%	25	44	-
				Shrubs (tall) 80%; Trees 20% (100% short shrub understory)	44	100	-
	B	Right	Southeast	River	0	15	-
				Grass 50%; Bare (cobble with sand) 50%; Shrubs (dead) 40%	15	29	trace org., 1 cm silt, then coarse sand and gravel
				Grass 100%; Shrubs (dead) 80%	29	39	5 silt with fine sand, then 15 organic, then cobble
				Shrub (tall) 95%; Trees 5% (100% herbaceous understory)	39	66	10 above silty clay
				Shrub (tall) 65%; Trees 35%	66	83	>15 (wet at 13)
				Trees 50%; Shrubs 50%	83	100	organic peat, wet at 3 cm
17+500	A	Left	West-Northwest	River	0	12	-
				Grass 90%; Bare 10%; Shrub (dead) 20%	12	19	3 cm coarse sand, then >13 cm org. peat
				Grass 60%; Bare 40%; Shrubs (dead) 20%	19	21	15 cm sand and gravel, then org. peat
				Bare 75%; Shrubs (dead) 40%; Grass 10%	21	34	15 cm sand and gravel, then org. peat

				Grass 100%; Shrubs (dead) 40%; Deadfall logs 10%	34	74	3 cm deposited silt, then 20 cm organics, then silt
				Trees 60%; (100% herbaceous understory)	74	100	1 cm silt, then 5 cm org. peat, then cobble and coarse sand
	B	Right	East-Southeast	River	0	12	-
				Grass 100%; Shrubs (dead) 25%	12	15	15 (peat), then clayey silt
				Bare 60%; Shrubs (dead) 40%, Grass 25%	15	19	5 cm silt, then 8 cm org. peat, then clayey silt
				Shrubs (short) 100%	19	20	1 cm silt, then 5 cm organics, then 9 cm clayey silt, then silty clay
				Shrubs 85%; Trees 15%	20	60	15 cm peat, then silty fine sand
				Trees 40%; Shrubs 40% (sphagnum understory)	60	100	-
18+000	A	Left	Northeast	River	0	9	-
				Bare (cobble) 95%; Shrubs (dead) 10%; Grass 5%	9	25	sand, gravel, cobble with areas showing trace organic deposition
				Grass 95%; Shrubs (dead) 20%; Bare 5%	25	37	3 cm peat, then silt
				Shrubs (dead) 60%; Bare 40%; Grass 25%	37	43	5 cm silt, then 8 cm org. peat, then clayey silt
				Shrubs 100% (100% herbaceous understory)	43	49	0.5 cm silt above 6 cm of peat, then clayey silt
				Shrubs (tall) 95%	49	74	trace silt above 5 cm of peat, then silt with trace clay
				Trees 95%; Shrubs (tall) 5%	74	100	15 cm organic soil above then silt with trace sand
	B	Right	Southwest	River	0	9	-
				Grass 100%; Shrubs (dead) 50%	9	19	0.5 cm peat, then 4 cm silt, then peat
				Shrubs 100%	19	27	13 cm peat above silt with fine sand
				Shrubs (tall) 80%; Trees 20%	27	41	>18 cm peat
				Trees 50%; Shrubs 40%	41	97	
				Trees 90%; Shrubs 10%	97	100	peat
18+500	A	Left	Northwest	River	0	11	-

				Grass 95%; Shrubs (dead) 25%; Bare 5%	11	18	1 cm silt deposition, then 13 cm peat, then clayey silt
				Shrubs 90%; Trees 10%	18	36	6 cm organic soil above silt with trace clay
				Shrubs (tall) 100%	36	100	18 cm peat
	B	Right	Southeast	River	0	11	-
				Grass 95%; Shrubs (dead) 40%; Bare 5%	11	70	13 cm sand, then peat (near creek); 8 cm silt, then peat approx. 30 m from creek
				Shrubs (dead) 90% (75% herbaceous understory)	70	75	1 cm silt, then >20 cm org. peat
				Shrubs 80%; Trees 20% (grassy understory)	75	89	3 cm peat above silt with trace clay and sand
				Grass 100%; Shrubs 75% (wet)	89	100	peat
19+000	A	Left	Southwest	River	0	6	-
				Grass 95%; Shrubs (dead) 25%; Bare 5%	6	23	3 cm of sand with trace gravel and cobble above org. peat
				Grass 100%; Shrubs (dead) 40%	23	37	-
				Grass 75%; Shrubs 25%	37	42	10 cm silt at surface, then 13 cm organics, then stones
				Shrubs (tall) 90%; Trees 10%	42	100	-
	B	Right	Northeast	River	0	6	-
				Grass 100%; Shrubs (dead) 40%	6	26	1 cm organics, then 2 cm silt, then peat
				Grass 100%; Shrubs (dead, standing) 40%; deadfall	26	58	1 cm silt above >15 cm peat
				Shrubs (short) 60%; Grass 40%; deadfall	58	63	-
				Trees 75%; Shrubs 25% (100% herbaceous understory)	63	87	-
				Shrubs 80%; Trees 20%	87	100	-
19+500	A	Left	East	River	0	10	-
				Grass 100%; Shrubs (dead) 5%	10	19	organic silty clay
				Grass 90%; Trees (dead) 80%; Shrubs (short) 10%	19	91	5 cm silt, 5 cm sandy silt, then peat
				Shrubs 85%; Trees 15% (sphagnum understory)	91	100	-
	B	Right	West	River	0	10	-

				Grass 95%; Shrubs (dead) 10%; Bare (sand) 5%	10	34	15 cm fine-medium sand above roots near creek, then 10 cm sand above organics further from creek
				Grass 90%; Trees (dead) 80%	34	100	5 cm silty sand, 3 cm of peat, then fine sand
20+000	A	Left	South-Southwest	River	0	10	-
				Bare 100%; Shrubs (dead) 5%	10	39	sand, gravel, cobble
				Grass 90%; Shrubs (dead) 25%; Bare 10%	39	100	13 cm of sand above organics
	B	Right	North-Northeast	River	0	10	-
				Grass 95%; Shrubs (dead) 20%; Bare 5%	10	28	3 cm silt with organics, 5 cm silt, then organics
				Grass 100%; Shrubs (tall, dead) 95%; Trees (dead) 5%	28	100	8 cm silt, then organics
20+500	A	Left	West	River	0	6	-
				Grass 100%; Shrubs (dead) 20%	6	29	fine layer of silt above organic soil
				Grass 100%; Shrubs (dead) 100%	29	42	>15 cm silt
				Grass 100%; Trees (dead) 100%	42	100	8 cm silt above peat
	B	Right	East	River	0	6	-
				Grass 100%; Shrubs (dead) 5%	6	25	5 cm silt above peat
				Grass 100%; Shrubs (dead) 40%	25	47	13 cm silt above peat
				Grass 90%; Shrubs (dead) 90%; Bare 10%	47	100	6 cm silt above peat
21+000	A	Left	West	River	0	11	-
				Grass 100%; Shrubs (dead) 20%	11	43	5 cm fine sand above organic soil
				Grass 100%; Trees (dead) 45%; Shrubs 45%	43	100	15 cm of silt above peat
	B	Right	East	River	0	11	-
				Grass 100%; Shrubs (dead) 20%	11	25	8 cm silt above peat
				Shrubs (1/2 dead) 100%	25	53	8 cm silt above peat
				Trees (1/2 dead) 100%	53	100	peat
21+500	A	Left	Southwest	River	0	11	-
				Grass 50%; Shrubs (1/3 dead) 70%	11	26	>13 cm silt
				Trees (dead) 75% (100% herbaceous understory)	26	100	3 cm silt above peat

	B	Right	Northeast	River	0	11	-
				Grass 100%; Shrubs (dead) 75%	11	23	>15 cm fine sand
				Trees (dead) 100%; Grass 50% (herbaceous understory)	23	100	8 cm silt above organic soil
22+000	A	Left	Southwest	River	0	10	-
				Grass 100%; Shrubs (dead) 40%	10	26	3 cm silt above >13 cm sand
				Trees (dead) 100%; Shrubs (1/2 dead) 20%	26	69	5 cm silt above peat
				Trees 100%; Shrubs 10% (sphagnum understory)	69	100	peat
	B	Right	Northeast	River	0	10	-
				Grass 100%; Shrubs (dead) 10%	10	22	5 cm silt above peat
				Grass 100%; Trees (dead) 80%	22	48	5 cm silt above peat
				Trees 100% (100% herbaceous understory)	48	100	peat with trace silt
22+500	A	Left	West	River	0	22	-
				Bare 95%; Grass 5%	22	35	3 cm silt above sand/gravel
				Grass 95%; Trees (dead) 75%; Bare 5%	35	100	13 cm silt above peat
	B	Right	East	River	0	22	-
				Grass 100%; Shrubs (dead) 40%	22	29	3 cm silt above peat
				Trees (dead) 100%; Grass 50% (herbaceous understory)	29	42	-
				Trees 100%; Shrubs 40% (herbaceous and sphagnum understory)	42	100	-
23+000	A	Left	Southwest	River	0	20	-
				Grass 100%; Shrubs (dead) 50%	20	25	3 cm silt above organic soil
				Trees (dead) 75%; Shrubs (dead) 25% (100% herbaceous understory)	25	50	3 cm silt above organic soil
				Trees (dead) 90% (75% herbaceous understory)	50	78	peat
				Trees 100% (75% herbaceous understory)	78	100	peat
	B	Right	Northeast	River	0	20	-
				Grass 100%; Shrubs (dead) 50%	20	31	5 cm silt above organic soil
				Trees (dead) 75% (100% herbaceous understory)	31	45	-
				Trees 100%; Shrubs 25% (100% herbaceous understory)	45	100	peat
23+500	A	Left	South	River	0	6	-
				Grass 95%; Shrubs (dead) 40%	6	46	>10 cm silt

				Trees (dead) 100% (90% herbaceous understory)	46	100	3 cm of silt above organic soil
	B	Right	North	River	0	6	-
				Grass 90%; Shrubs (dead) 25%; Bare 10%; Shrubs 5%	6	16	13 cm organic soil above silt
				Trees 75%; Shrubs 10% (75% herbaceous understory)	16	20	-
				Trees 100% (sphagnum understory)	20	39	peat
				Trees 90%; Shrubs 40% (sphagnum understory)	39	100	peat
24+000	A	Left	West	River	0	12	
				Bare 100%	12	13	silt with gravel
				Shrubs 90%; Trees 10%	13	29	0.5 cm silt over organic soil
				Shrubs (tall) 50%; Trees 30% (100% herbaceous understory)	29	58	-
				Trees 80%; Shrubs 15% (100% herbaceous understory)	58	100	-
	B	Right	East	River	0	12	-
				Grass 100%; Shrubs (dead) 75%; Trees (dead) 10%	12	50	10 cm of silt above organic soils
				Grass 100%; Trees (dead) 90%; Shrubs 25% (wet ground)	50	66	-
				Trees 100%; Grass 50%; Shrubs 50%	66	100	-
24+500	A	Left	West	River	0	15	-
				Grass 90%; Shrubs (dead; on ground) 75%	15	23	5 cm silt above organic soil
				Grass 90%; Shrubs (dead; standing) 75%	23	33	5 cm silt above organic soil
				Shrubs 100% (100% herbaceous understory)	33	41	-
				Trees 100% (100% herbaceous understory)	41	60	-
				Shrubs (tall) 95%; Trees 5% (sphagnum understory)	60	100	peat
	B	Right	East	River	0	15	-
				Grass 75%; Shrubs (dead) 25%; Trees (dead) 5% (25% herbaceous understory)	15	28	5 cm silt above organic soil
				Shrubs (dead) 100%; Grass 50% (50% herbaceous understory)	28	64	>15 cm silt with organics
				Trees (dead) 100%; Grass 50% (50% herbaceous understory)	64	100	
25+000	A	Left	Northwest	River	0	11	-
				Bare 95% (5% herbaceous shrubs)	11	13	silt

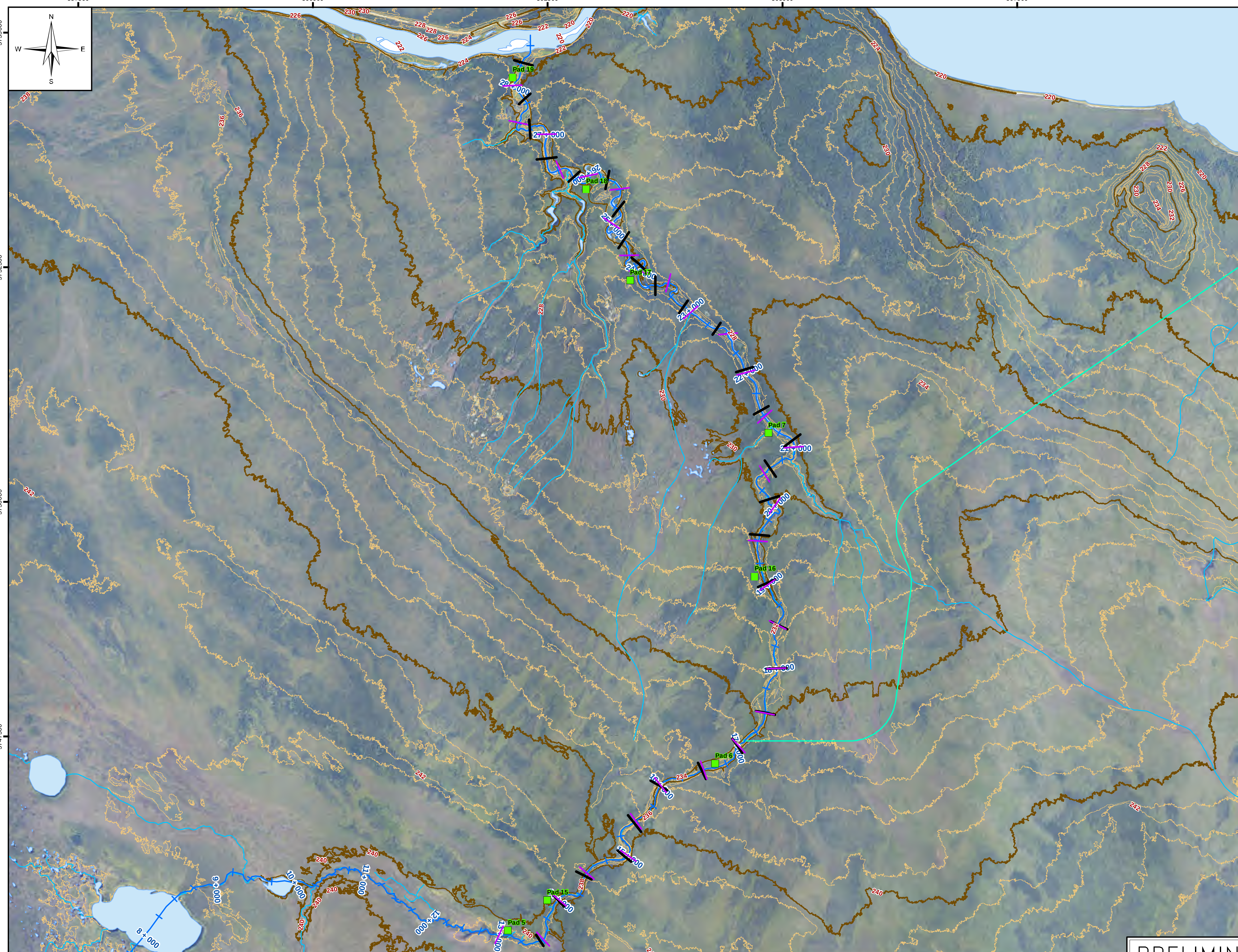
				Shrubs 25% (75% herbaceous shrubs)	13	17	-
				Shrubs 75%; Trees 10% (100% herbaceous understory)	17	26	trace silt above organic soil
				Trees (dead) 50%; Shrubs (tall) 50% (100% herbaceous understory)	26	44	-
				Trees 95%; Shrubs 5% (sphagnum understory)	44	58	peat
				Trees 100%; Shrubs 25% (sphagnum understory)	58	100	peat
	B	Right	Southeast	River	0	11	-
				Bare 100%	11	20	cobble
				Grass 100%; Shrubs (dead) 20%	20	38	10 cm silty organic soil above silt
				Grass 100%; Shrubs (dead) 20%	38	83	10 cm silty organic soil above silt
				Trees 50%; Shrubs 50% (sphagnum understory)	83	100	peat
25+500	A	Left	West	River	0	10	-
				Grass 100%; Shrubs (dead) 30%	10	37	5 cm silt above organic soil
				Shrubs (dead) 90%; Grass 50% (50% herbaceous understory)	37	100	8 cm silt, then 3 cm organic soil, then silt
	B	Right	East	River	0	10	-
				Shrubs (dead) 50%; Grass 50% (50% herbaceous understory)	10	18	10 cm organic soil above silt
				Shrubs 100% (100% herbaceous understory)	18	36	-
				Trees 50%; Shrubs 50%	36	53	-
				Shrubs (tall) 90%; Trees 10% (sphagnum understory)	53	100	-
26+000	A	Left	East-Northeast	River	0	7	-
				Bare 100%	7	10	5 cm silt above gravel
				Grass 100%; Shrubs (dead) 20%	10	75	-
				Grass 100%; Shrubs (dead) 65%	75	100	-
	B	Right	West-Southwest	River	0	7	-
				Grass 70%; Shrubs (dead) 50% (20% herbaceous understory)	7	19	silty organic soil
				Shrubs 95%; Trees 5%	19	62	-
				Shrubs (dead) 80%; Grass 80% (20% herbaceous understory)	62	100	-
26+500	A	Left	South-	River	0	8	-

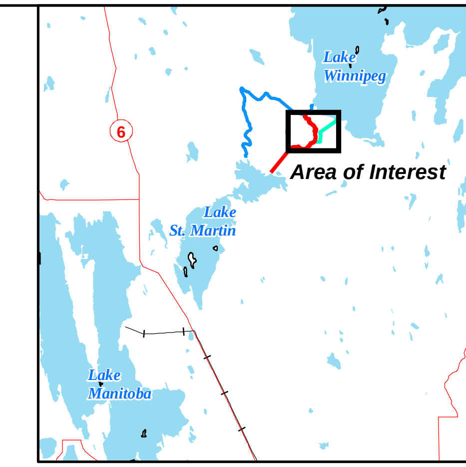
			Southeast	Grass 100%; Shrubs (dead) 20%	8	51	15 cm sandy silt above organic soil
				Shrubs (dead) 50% (100% herbaceous understory)	51	75	-
				Trees (dead) 70% (100% herbaceous understory)	75	100	-
	B	Right	North-Northwest	River	0	8	-
				Grass 100%; Shrubs (dead) 20%	8	34	organic soil
				Shrubs (dead) 100%; Grass 50% (50% herbaceous understory)	34	50	peat
				Shrubs (tall) 100% (100% herbaceous understory)	50	79	-
				Trees 80%; Shrubs (tall) 20% (herbaceous understory)	79	100	-
27+000	A	Left	West	River	0	12	-
				Grass 95%; Shrubs (dead) 30%; Bare 5%	12	27	1 cm silt above >13 cm fine gravel
				Grass 95%; Trees (dead) 75%	27	73	-
				Trees (dead) 100% (75% herbaceous understory)	73	84	-
				Trees 95%; Shrubs (tall) 5% (100% herbaceous understory)	84	100	-
	B	Right	East	River	0	12	-
				Grass 100%; Shrubs (dead) 40%	12	37	1 cm silt above organic soil
				Shrubs 100% (100% herbaceous understory)	37	50	-
				Trees 50%; Shrubs (tall) 50% (100% herbaceous understory)	50	75	-
				Trees 50%; Shrubs (tall) 50% (sphagnum understory)	75	100	-
27+500	A	Left	West	River	0	13	
				Grass 100%; Trees (dead) 5%	13	26	6 cm silt above organic soil
				Shrubs 80%; Trees 20% (herbaceous understory)	26	61	> 13 cm organic soil
				Trees 80%; Shrubs 20%	61	100	very wet
	B	Right	East	River	0	13	-
				Bare 95%; Grass 5%	13	19	>15 cm sand and gravel
				Grass 100%; Shrubs (dead) 5%	19	46	sandy silt
				Shrubs 70%; Trees 30%	46	100	-
28+000	A	Left	East-	River	0	10	-

			Southeast	Grass 100%	10	14	1 cm silt above organic soil
				Shrubs 100%	14	34	-
				Trees 50%; Shrubs 50%	34	65	-
				Trees 100% (sphagnum understory)	65	100	peat
	B	Right	West-Northwest	River	0	10	-
				Bare 75%; Grass 25%	10	14	stones, gravel and silt
				Grass 95%; Bare 5%	14	62	-
				Trees 100%; Shrubs 100%	62	100	-

*[1] Note: Bank left or bank right is based on facing downstream.

FIGURES





LEGEND:

- Constructed Helicopter Landing Pad
- Vegetation Survey Transect
- Cross Section
- Buffalo Creek Centreline
- Reach 3
- 5m Index Contour
- 1m Contour
- Water Feature
- Water Feature
- Island

DRAFT

0 500 1,000 1,500 2,000
Metres

SCALE: 1:40,000 METRIC 11"x17"

All units are metric and in metres unless otherwise specified.
Transverse Mercator Projection, NAD 1983, Zone 14
Elevations are in metres above sea level (MSL)

NO.	YY/MM/DD	DESCRIPTION	BY
A	14/10/17	ISSUED WITH FIELD INSPECTION FORM	STO

REVISIONS / ISSUE

Manitoba Infrastructure and Transportation

LSM EMERGENCY RELIEF CHANNEL MONITORING & DEVELOPMENT OF HABITAT COMPENSATION

LOCATIONS OF BUFFALO CREEK CROSS SECTIONS AND VEGETATION COVER TRANSECTS

PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION

OCTOBER 2014 | FIGURE 01 | REV. A

FileName: P:\Projects\2013\13-0431-001\Dwg\GIS\MXDs\RevA\Field_Inspection_Form\13-0431-001-Fig01_RevA.mxd
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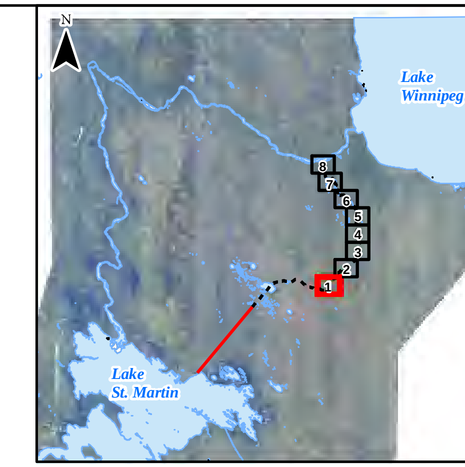

LEGEND:

- Buffalo Creek Centreline
- Dead Tree Limits
- Extent of Trees

NOTES:

1. Georeferenced Aerial Imaging and Mapping (GAIM) flown by TAIGA Air Services Ltd on July 7th, 2013.
2. Background Satellite Image provided by Atlis Geomatics, July 2011
3. Original ground surface based on LiDAR provided by Atlis Geomatics (June/July 2011)
4. All units are metric and in metres unless otherwise specified
   Transverse Mercator Projection, NAD 1983, Zone 14
   Elevations are in metres above sea level (MSL)

DRAFT

50 0 50 100 150 200

Metres

SCALE: 1:5,000 METRIC 11"x17"

NO.	YY/MM/DD	DESCRIPTION	BY
A	14/06/12	ISSUED WITH FIELD INSPECTION FORM	STO

REVISIONS / ISSUE

LSM EMERGENCY RELIEF CHANNEL MONITORING & DEVELOPMENT OF HABITAT COMPENSATION

VEGETATION IMAPACT ZONES

PRELIMINARY

NOT TO BE USED FOR CONSTRUCTION

JUNE 2014 | FIGURE02.01 | REV. A

FileName: P:\Projects\2013\13-0431-001\Dwg\GIS\MXDs\RevA\Field_Inspection_Form\13-0431-001-Fig02_RevA.mxd

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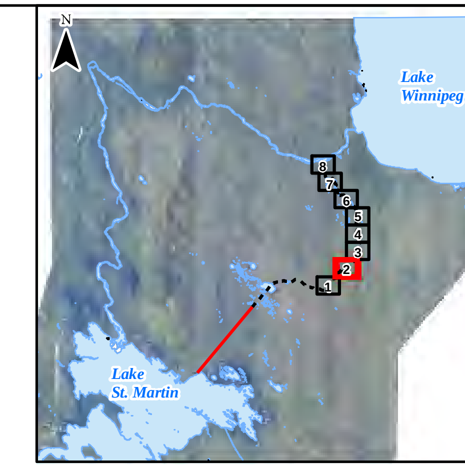

LEGEND:

- Buffalo Creek Centreline
- Dead Tree Limits
- Extent of Trees

NOTES:

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   Transverse Mercator Projection, NAD 1983, Zone 14
   Elevations are in metres above sea level (MSL)

DRAFT

50 0 50 100 150 200

Metres

SCALE: 1:5,000 METRIC 11"x17"

NO.	YY/MM/DD	DESCRIPTION	BY
A	14/06/12	ISSUED WITH FIELD INSPECTION FORM	STO

REVISIONS / ISSUE

Manitoba Infrastructure and Transportation

LSM EMERGENCY RELIEF CHANNEL MONITORING & DEVELOPMENT OF HABITAT COMPENSATION

VEGETATION IMAPACT ZONES

PRELIMINARY

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JUNE 2014 | FIGURE02.02 | REV: A

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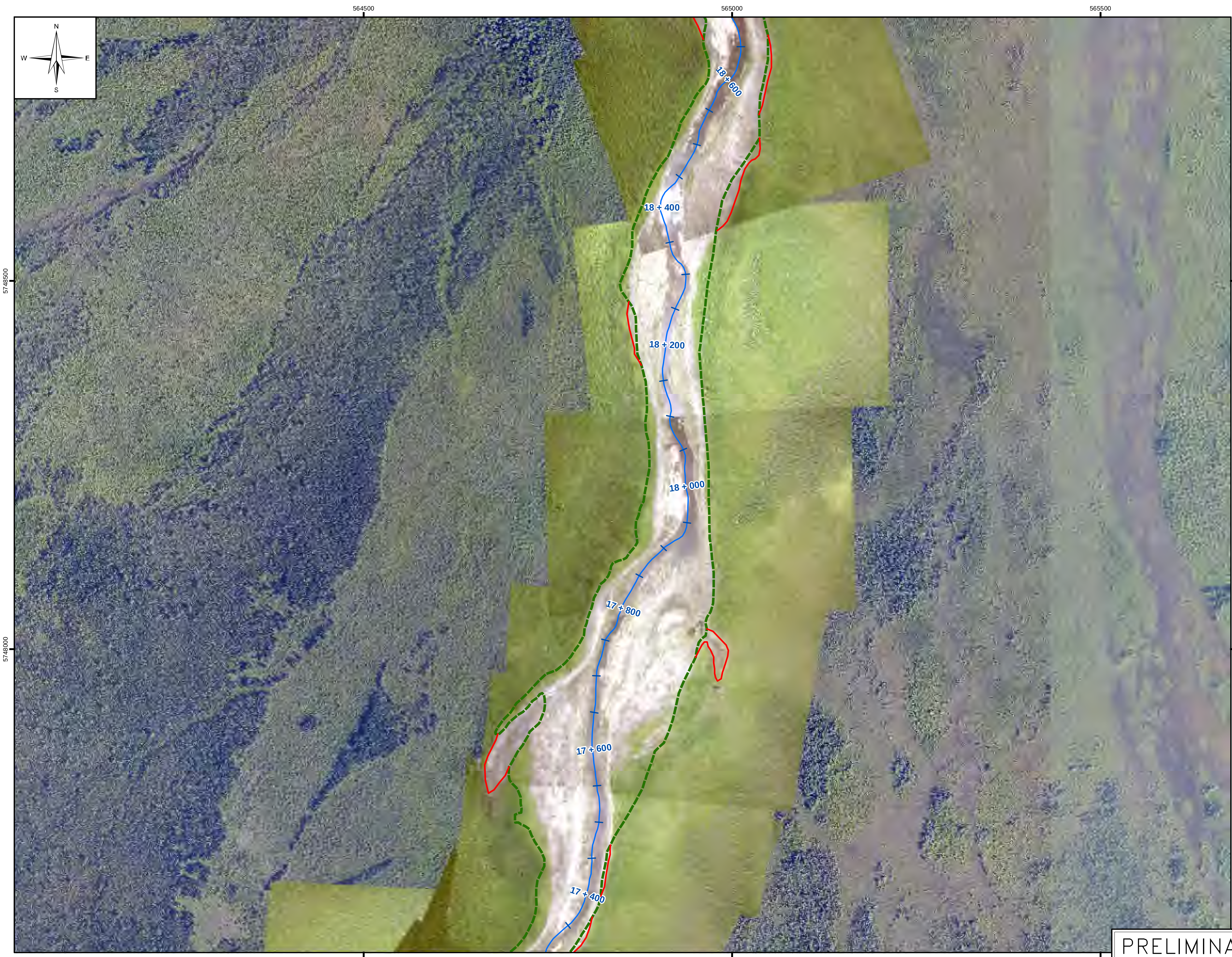

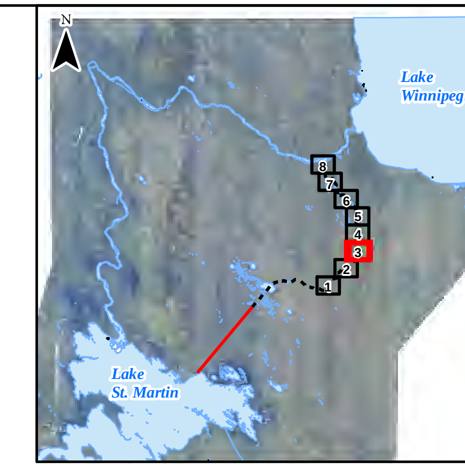

LEGEND:

- Buffalo Creek Centreline
- Dead Tree Limits
- Extent of Trees

NOTES:

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2. Background Satellite Image provided by Atlis Geomatics, July 2011
3. Original ground surface based on LiDAR provided by Atlis Geomatics (June/July 2011)
4. All units are metric and in metres unless otherwise specified
   Transverse Mercator Projection, NAD 1983, Zone 14
   Elevations are in metres above sea level (MSL)

DRAFT

50 0 50 100 150 200
Metres

SCALE: 1:5,000 METRIC 11"x17"

NO.	YY/MM/DD	DESCRIPTION	BY
A	14/06/12	ISSUED WITH FIELD INSPECTION FORM	STO

REVISIONS / ISSUE

LSM EMERGENCY RELIEF CHANNEL MONITORING & DEVELOPMENT OF HABITAT COMPENSATION

VEGETATION IMAPACT ZONES

PRELIMINARY
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JUNE 2014 | FIGURE02.03 | REV: A

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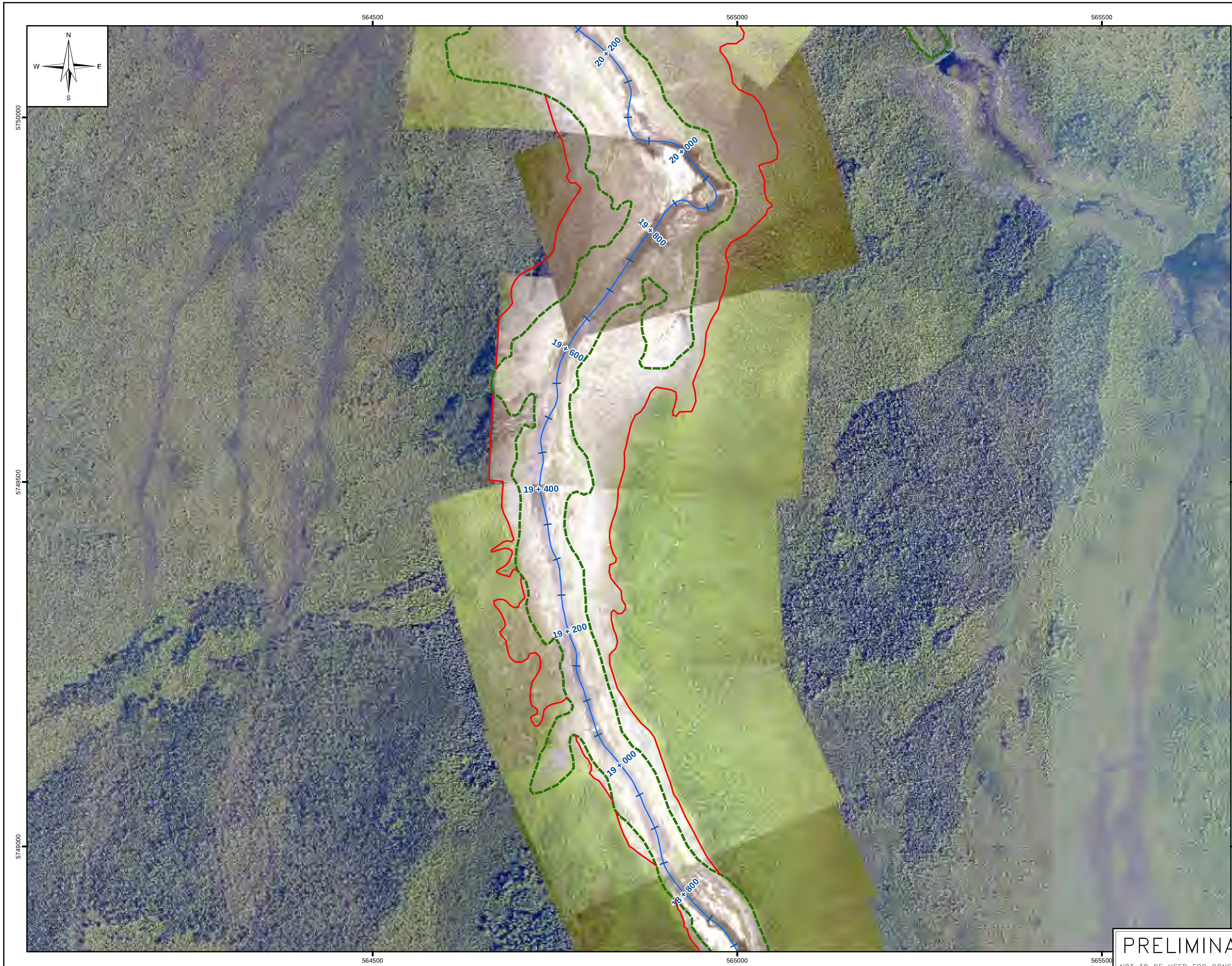

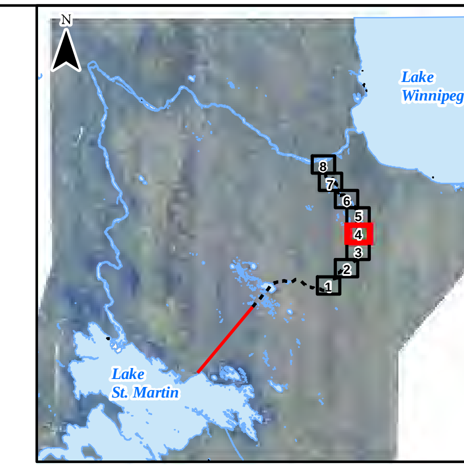

LEGEND:

- Buffalo Creek Centreline
- Dead Tree Limits
- Extent of Trees

NOTES:

1. Georeferenced Aerial Imaging and Mapping (GAIM) flown by TAIGA Air Services Ltd on July 7th, 2013.
2. Background Satellite Image provided by Atlis Geomatics, July 2011
3. Original ground surface based on LiDAR provided by Atlis Geomatics (June/July 2011)
4. All units are metric and in metres unless otherwise specified
   Transverse Mercator Projection, NAD 1983, Zone 14
   Elevations are in metres above sea level (MSL)

DRAFT

50 0 50 100 150 200
Metres

SCALE: 1:5,000 METRIC 11"x17"

NO.	YY/MM/DD	DESCRIPTION	BY
A	14/06/12	ISSUED WITH FIELD INSPECTION FORM	STO

REVISIONS / ISSUE

LSM EMERGENCY RELIEF CHANNEL MONITORING & DEVELOPMENT OF HABITAT COMPENSATION

VEGETATION IMAPACT ZONES

JUNE 2014 | FIGURE02.04 | REV: A

PRELIMINARY
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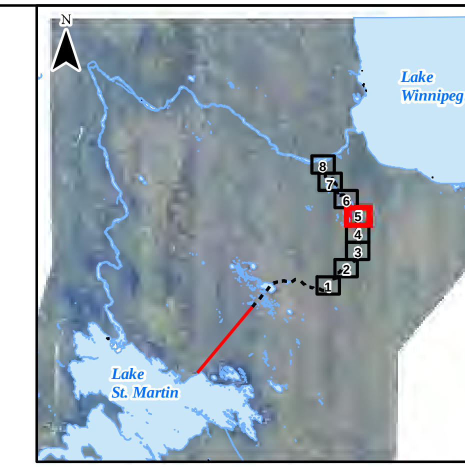


LEGEND:

- Buffalo Creek Centreline
- Dead Tree Limits
- Extent of Trees

NOTES:

1. Georeferenced Aerial Imaging and Mapping (GAIM) flown by TAIGA Air Services Ltd on July 7th, 2013.
2. Background Satellite Image provided by Atlis Geomatics, July 2011
3. Original ground surface based on LiDAR provided by Atlis Geomatics (June/July 2011)
4. All units are metric and in metres unless otherwise specified
   Transverse Mercator Projection, NAD 1983, Zone 14
   Elevations are in metres above sea level (MSL)

DRAFT

50 0 50 100 150 200
Metres

SCALE: 1:5,000 METRIC 11"x17"

NO.	YY/MM/DD	DESCRIPTION	BY
A	14/06/12	ISSUED WITH FIELD INSPECTION FORM	STO

REVISIONS / ISSUE

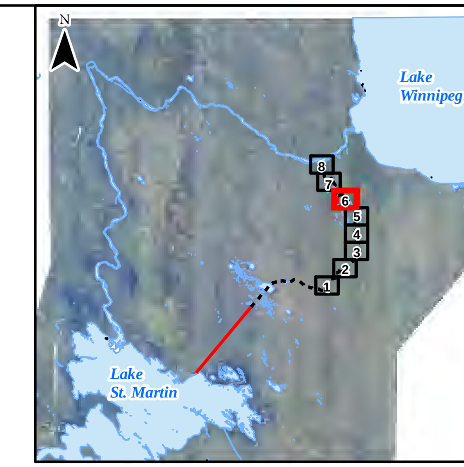
LSM EMERGENCY RELIEF CHANNEL MONITORING & DEVELOPMENT OF HABITAT COMPENSATION

VEGETATION IMAPACT ZONES

PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION

JUNE 2014 | FIGURE02.05 | REV: A

FileName: P:\Projects\2013\13-0431-001\Dwg\GIS\MXDs\RevA\Field_Inspection_Form\13-0431-001-Fig02_RevA.mxd
11"x17" PLOT SCALE 1:1



LEGEND:

- Buffalo Creek Centreline
- Dead Tree Limits
- Extent of Trees

NOTES:

1. Georeferenced Aerial Imaging and Mapping (GAIM) flown by TAIGA Air Services Ltd on July 7th, 2013.
2. Background Satellite Image provided by Atlis Geomatics, July 2011
3. Original ground surface based on LiDAR provided by Atlis Geomatics (June/July 2011)
4. All units are metric and in metres unless otherwise specified
   Transverse Mercator Projection, NAD 1983, Zone 14
   Elevations are in metres above sea level (MSL)

DRAFT

50 0 50 100 150 200
Metres

SCALE: 1:5,000 METRIC 11"x17"

NO.	YY/MM/DD	DESCRIPTION	BY
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LSM EMERGENCY RELIEF CHANNEL MONITORING & DEVELOPMENT OF HABITAT COMPENSATION

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JUNE 2014 | FIGURE02.06 | REV: A

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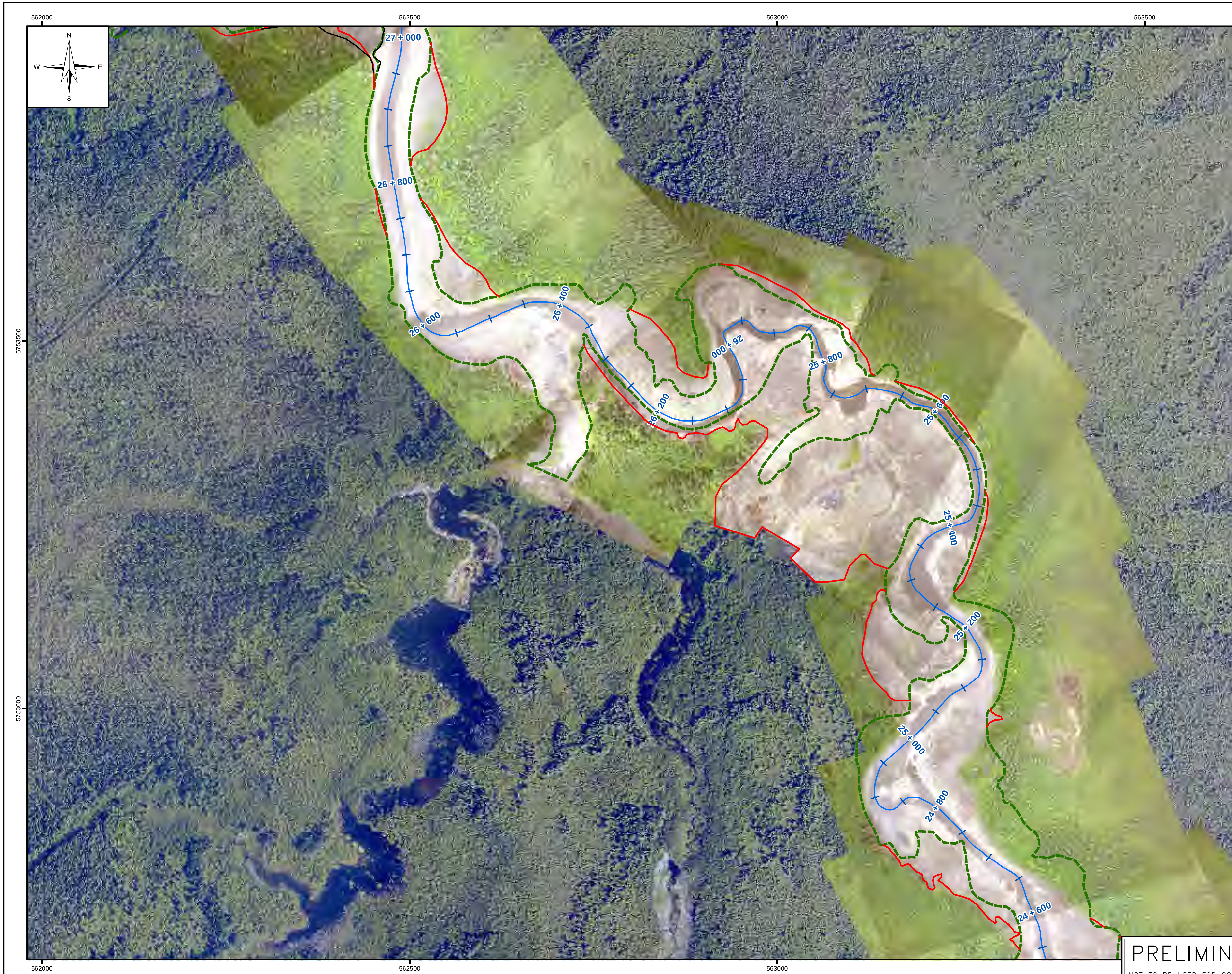

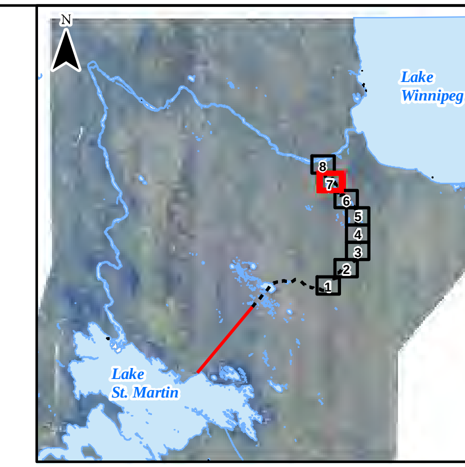

LEGEND:

- Buffalo Creek Centreline
- Dead Tree Limits
- Extent of Trees

NOTES:

1. Georeferenced Aerial Imaging and Mapping (GAIM) flown by TAIGA Air Services Ltd on July 7th, 2013.
2. Background Satellite Image provided by Atlis Geomatics, July 2011
3. Original ground surface based on LiDAR provided by Atlis Geomatics (June/July 2011)
4. All units are metric and in metres unless otherwise specified
   Transverse Mercator Projection, NAD 1983, Zone 14
   Elevations are in metres above sea level (MSL)

DRAFT

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Metres

SCALE: 1:5,000 METRIC 11"x17"

NO.	YY/MM/DD	DESCRIPTION	BY
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VEGETATION IMAPACT ZONES

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JUNE 2014

FIGURE02.07

REV: A

FileName: P:\Projects\2013\13-0431-001\Dwg\GIS\MXDs\RevA\Field_Inspection_Form\13-0431-001-Fig02_RevA.mxd
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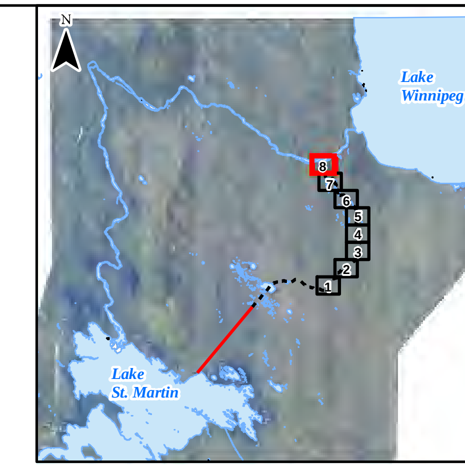
FileName: P:\Projects\2013\13-0431-001\Dwg\GIS\MXDs\RevA\Field_Inspection_Form\13-0431-001-Fig02_RevA.mxd
11"x17" PLOT SCALE 1:1



LEGEND:

- Buffalo Creek Centreline
- Dead Tree Limits
- Extent of Trees

NOTES:

1. Georeferenced Aerial Imaging and Mapping (GAIM) flown by TAIGA Air Services Ltd on July 7th, 2013.
2. Background Satellite Image provided by Atlis Geomatics, July 2011
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Transverse Mercator Projection, NAD 1983, Zone 14
Elevations are in metres above sea level (MSL)

DRAFT

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Metres

SCALE: 1:5,000 METRIC 11"x17"

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LSM EMERGENCY RELIEF CHANNEL MONITORING & DEVELOPMENT OF HABITAT COMPENSATION

VEGETATION IMAPACT ZONES

PRELIMINARY
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JUNE 2014 | FIGURE02.08 | REV: A

APPENDICES

Field Inspection Form

PROJECT: **Lake St. Martin Channel Monitoring - 2015**

CLIENT: **North/South Consultants Inc.**

CONTRACTOR:

FILE NO.: **13-0431-001 Task 16**

REPORT DATE: September 3, 2013

BY: Dan Leitch

POSITION TITLE: Environmental Scientist

Buffalo Creek Vegetation Cover Survey Results
July 3-5, 2013

1.0 Introduction

As part of the Buffalo Creek Watershed – Post-Project Evaluation (Task ESH-4) for the Lake St. Martin Emergency Relief Channel – Monitoring and Development of Habitat Compensation project, KGS Group completed 31 vegetation survey transects along Buffalo Creek between station 13+000 m and 28+000 m. Field work was completed between July 3, 2013 and July 5, 2013 with helicopter support for daily access. A canoe was used to navigate down the river between transects.

The purpose of the vegetation survey along the Buffalo Creek was to assist in monitoring and assessing the impacts of the emergency channel operation and changes to the riparian vegetation community as well as erosion along the river. The vegetation survey program involved walking perpendicular 100 m transects on both sides of the creek, and documenting the cover types along this transect. Vegetation cover types were used to estimate the amount of protection from erosion afforded to the soil via plant cover. Representative sample photos were taken. The soil organic layer depth was also measured to compare against pre-project observations as an indication of the quantity of organic fines that may have moved downstream.

In addition to the vegetation cover survey program, a detailed cross section survey program was completed concurrently by the GIS team. The results of the detailed cross section survey will be presented separately.

2.0 Methodology

Sampling locations were set every 500 m along the length of the Buffalo Creek beginning at Station 13+000 m and continuing to just upstream of the confluence with the Dauphin River at Station 28+000 (Figure 1). The vegetation survey transects were run perpendicular to creek when possible, starting from centreline of the stream and continuing for a distance of 100 m on each side of the creek. Transect orientation was modified for those locations where the meander of the creek resulted in overlap of a transect from another location.

The river bank on both sides of the creek was recorded to determine the centreline. Transect orientation (cardinal direction), start and end point, general description of cover types, start and end distance of each cover type within the transect, and depth of soil organic layer were also recorded. Cover types were placed in four broad categories:

- Bare: exposed mineral soil with no vegetation or soil organic layer;
- Grass: vegetation cover consists of Grass, sedge, or rush families;
- Shrub : vegetation cover consists of woody species which do not form distinct trunks or canopies of leaves, especially those which do not normally exceed 10m in height; At times, a distinction was made between short herbaceous shrubs and taller woodier shrubs.
- Treed: vegetation cover consists of woody species which form distinct trunks and leaf canopies, and which normally can or do exceed 10m in height.

Photos 1 to 4 show the four representative cover types. A photo log was compiled with several photos taken along most transects. Photos are stored on the project drive for possible future comparison or verification.

Composites or matrices of these four types were possible, and their corresponding ground cover was provided e.g. 50% area covered by Grass 50% area covered by Shrubs. Due to plant morphology and habit, total percentages greater than 100% were possible.

Organic soil depths were measured from a representative area within each cover change along a transect (i.e. if substrate changes from grass to trees, a soil measurement was taken in each section). Soil was removed using a garden trowel and measured using a tape measure. When the organic soil depth was greater than could be measured within reason using the garden trowel, soil depth was recorded as greater than the depth that was excavated (i.e. > x cm)

3.0 Results

The following subsections detail the results found for each transect, including orientation, description of terrain, cover types, and organic layer depths in soil. Unique features related to the investigation are also mentioned where appropriate. Where possible, observations were compared against conditions described during the 2011 survey. Due to the accuracy of the GPS, movement of creek banks due to varying water levels, and possible use of different starting points for the transects, detailed comparisons are not feasible. A detailed GIS survey was also conducted along the Buffalo Creek in order to quantify many of these differences. Photos contrasting several locations in 2011 and 2013 are included. Full records for each transect are found in Table 1 with the transect data broken into subsection A (left bank, when facing downstream) and subsection B (right bank, when facing downstream).

The organic soils in several areas, particularly at and beyond 19+500 appeared to be overlain with varying amounts of inorganic soils. When present, the inorganic soil depth was also measured. There was no note of inorganic soils observed in 2011.

General observations include large extents of dead shrubs and trees and bare areas where no vegetation is currently established along the creek. Many areas have recently begun to be colonized by young grass and shrub species. A comparison between the two surveys must consider the different time of year in which the surveys were conducted. The 2013 survey was done in early July following a late spring, while the 2011 survey was conducted in late September. It is possible that much of the bare areas noted in 2013 would be covered with grass and shrubs by late fall of 2013. It was also noted that water levels were lower in 2013 than in 2011. This may affect vegetation composition, transect centerlines and soil sampling. An abundance of beaver dams was also observed in 2011 creating large inundated areas at some of the transects. No beaver dams were observed in 2013.

The following sections provide a brief description of each of the transects surveyed. For more detail, see Table 1.

3.1 13+000

This transect runs in a northeast-southwest orientation. This section is within the vast open bog area surrounding Buffalo Lake. Both sides of the creek show grass and bare areas with some dead shrubs (willows) further away from the creek. The shrubs on the left side where at the beginning of the forest, while the shrubs on the right side were a small slightly elevated 'island' of shrubs which was otherwise surrounded by grass and bare areas. Organic soil depths along this transect varied from 13 to >16 cm. In 2011, this transect had much more water with large areas thick grass (sedges and rushes) being inundated with water. A small component (20%) of shrubs was also noted. No soil samples were taken in 2011 due to the high water levels. Photo 5 contrasts the transect as seen in 2011 and 2013.

3.2 13+500

This transect runs in a northwest-southeast orientation and is comprised of grass, shrubs and bare ground cover. To the southeast, the transect ends in a marshy area with stagnant water with sedges and aquatic vegetation. The vast majority of shrubs on the transect were dead and the ground cover was largely bare, but with a high percentage of young grass species emerging (especially on the northeast side). The organic layer of soil varied between 2 cm and 9 cm. When this transect was surveyed in 2011, the grasses were tall and thick and the wetland described above was drained. The wetland showed bare areas and many dead shrubs, while the shrubs on the northwest side were alive.

3.3 14+000

This transect runs in a northwest-southeast orientation. The ground surface nearest the creek is comprised of bare areas, young grass and dead shrubs. The side slopes are gentle leading to a mixture of trees and shrubs. The left side transect runs into a flooded marsh area comprised of grasses, cattails and willows at approximately 40 m. The right side transect had a slightly steeper bank and led to drier ground where a mixture of trees and shrubs predominated. Organic soil layers ranged from 2 to 5 cm. The 2011 survey made no note of a wetland along this transect, while the area nearest the channel consisted of thick grass and shrub layers at that time.

3.4 14+500

This transect runs in a northwest-southeast orientation. The area nearest the channel was largely bare with exposed soil and cobbles. Young grass species were starting to emerge. Further away from the creek, there is a relatively thin strip of dead shrubs on both banks as the slope increases slightly. Beyond this, both sides transitioned from largely shrubs to largely trees. The organic layer of soils ranged from <1 to 5 cm. The 2011 survey described very similar vegetation composition, but with grass near the channel, and no mention of any dead vegetation (Photo 6 compares 2011 and 2013 photos). The 2011 survey also observed deeper organic soils (14-15 cm) in the grassy creek bed area.

3.5 15+000

This transect runs in a northwest-southeast orientation. Bare areas of cobble and gravel were observed adjacent to the channel. Exposed roots along the steep slope on the right side suggest recent erosion activity (Photo 7). Above the slope, trees transition to shrubs as the transect enters a sphagnum bog at 52 m. The slope on the left side of the river is much more gradual (inside bend of river) and is bare (cobble, gravel) with dead shrubs for the first 42 m before it transitions to shrubs and then to trees. The organic layer of soils ranged from 0 (adjacent to creek channel) to 9 cm (in sphagnum bog). The 2011 description of this transect described grass and shrubs adjacent to the channel, no bare areas, and slightly higher measurements of organic soil in that area (2-4 cm).

3.6 15+500

The orientation of this transect followed a northwest-southeast direction. Bare areas with dead shrub and young grass were found adjacent to the creek channel. On the right side, shrubs transitioned to trees for approximately 23 m, and then back to shrubs. On the left side, the transect was dominated by trees once up from the river bank. The trees shifted from pine to aspen at 59 m. The organic layer of soil varied between <1 and 6 cm. The 2011 survey noted no bare areas, but a steady transition from grass to shrubs to trees. The soils found near the channel in 2011 were measured at 20 cm on both sides of the creek.

3.7 16+000

This transect is oriented in a northwest-southeast direction. A bare area (cobble, sand) was noted on both banks along with dead shrubs and young grass species. Further from the channel, a dense mixture of shrubs and trees was present. The transect on both sides of the river entered a sphagnum bog. The organic layer of soil varied from <1 cm near the channel to >10 cm in the sphagnum areas. Observations from 2011 noted some bare areas on the left side of the creek, but largely thick grass adjacent to the channel and a mixture of shrubs and trees further from the water. Organic soil depths in 2011 were measured between 0 and 6 cm.

3.8 16+500

This transect runs in a north-northwest to south-southwest orientation. Directly adjacent to the creek channel, a short area of bare cobbles and gravel was observed beneath an eroded bank. The slope on the left side was more gradual, and shows a large area of thick dead shrubs and trees that have been knocked over. Beneath the trees the substrate was largely bare. Once past the dead trees at 81 m, a line of grass and shrubs transitions to predominantly trees. The bank was slightly steeper on the right side and the extent of dead trees was much less. Above the bank, shrubs transition to trees, then to a mixture of shrubs and trees in a sphagnum bog. The depth of organic soil varied from 0 along the creek's edge to >10 in the sphagnum. The 2011 description of the transect noted the entire transect to be comprised of shrubs, and also observed the muskeg along the transect on the right side of the creek.

3.9 17+000

This transect runs in a northwest-southeast orientation. Both sides of the creek show a mix of bare cover, grass and dead shrubs extending 20 to 35 m from the creek centerline. Up the slope on the left side of the river is an area of herbaceous plants and very young poplar trees which transitions into a mixture of trees and shrubs comprised of poplar, willow and alder. A similar mixture of taller shrubs was observed on the right side of the river. The depth of organic soil varied from 0 along the creek's edge to 7 cm in the shrub area. Observations made in 2011 noted a mixture of grass and shrubs along the transect line, but made no mention of bare areas or dead vegetation. Photo 8 compares 2011 and 2013 photos.

3.10 17+500

This transect runs west-northwest to east-southeast. Adjacent to the channel is a mixture of largely bare ground with dead shrubs and grass. The right slope is slightly steeper and leads to small area of short shrubs and herbaceous vegetation and then on to taller shrubs with some young trees and a bog starting at 62 m. The left side had a gentler slope (inside bend of river), a larger area of bare cover and dead vegetation ending up in shrubs at 77 m. The organic layer of soil varied between 1 cm near the river to >10 cm in the bog. 2011 observations mainly grass and shrubs near the river leading into primarily shrubs with some trees. The muskeg area was also observed in 2011. Soil organic layers observed in 2011 were thicker near the channel (5-15 cm) than observed in 2013, while depths further from the creek were similar.

3.11 18+000

This transect runs in a northeast-southwest direction. A large bare area (20 m) of cobble and gravel was observed on the left side of the creek which had a band of dead shrubs beyond it (17 m) which was also bare beneath. Beyond this, as the slope increased, an area of short shrubs (herbaceous and young poplar) transitioned to taller shrubs (alder) and then to trees. On the right side of the river the first 18 m were largely bare soil with grass and some dead shrubs. Up the slope, shrubs transitioned to trees with a largely sphagnum understory. The depth of organic soil varied from 0 cm (cobble, gravel) to >10 cm (sphagnum). Observations made in 2011 noted high concentrations of grass adjacent to the creek as well as deep layers of organic soil (>25 cm) in the same area. Photo 9 compares 2011 and 2013 photos.

3.12 18+500

This transect runs in a northwest-southeast orientation. Bare areas with dead shrubs and grass were observed on both sides of the river, however more extensively on the right side. At 35 m on the left side the understory was largely sphagnum beneath shrubs with a small percentage of trees. On the right side, beyond the dead shrub area, vegetation transitioned to shrubs, then largely trees before ending in a grassy marsh area with standing water. The organic soil depths varied from 0 to 8 cm along this transect. During the 2011 survey, this area was inundated by a beaver dam which flooded areas near the channel. No beaver dam was observed in 2013. The 2011 survey recorded almost exclusively shrubs along this transect with grass on the right side of the river.

3.13 19+000

This transect runs in a northeast-southeast orientation. Both sides of the channel had large areas of bare soil, dead shrubs and young grass for the first 37-57 m. The left side transitions to short shrubs followed by tall shrubs with a high percentage of grass before becoming largely trees. Standing water was present at the end of the transect. The right side has a small area of short shrubs before entering a tree/shrub mixture. At 94 m, the understory became sphagnum-dominated. The organic soil depths varied from 0 to >12 cm. In 2011, the first 12-20 m on either side of the channel was inundated as a result of a beaver dam downstream. Similar compositions of grass/shrubs/trees were noted, as was the sphagnum terrain at the end of the transect on the left side. Organic soil depths measured in 2011 were slightly deeper, particularly close the creek channel. Photo 10 contrasts a shrub area in 2011 with a dead shrub area seen in 2013 at the same transect (we cannot confirm if the photos are from exactly the same locations, but they were both taken at 19+000).

3.14 19+500

This transect followed an east-west alignment. The left side was bare along the creek, followed by a large area of mature dead trees which were largely bare beneath. Many trees were on the ground, as it appeared the mature trees acted as a catch/dam/strainer for dead vegetation moving down the creek from upstream (see Photo 11). Live trees were encountered at 96 m of the left transect. The terrain on the right side of the creek was much flatter. Bare areas were observed near the creek channel, with a combination of dead shrubs and trees for the entire transect distance. Aquatic emergent vegetation was found at several locations on this side. Organic soil depths varied from 0 to 7 cm with several locations being overlain by 1 to 5 cm of inorganic soils (see Photo 12). In 2011, the right side was inundated by beaver activity with a combination of grass and shrub transitioning to largely trees at 21 m, while the left side showed a grass and bare area along the creek, then trees at 21 m which transitioned to shrubs at 91 m. Organic soil depths in 2011 were similar in range (1-12 cm) as those observed in 2013 with >30 cm measured deep along the left transect. No sample was taken from the same area in 2013. There was no mention of inorganic soils overtop of organic soils in 2011.

3.15 20+000

This transect runs in a south-southwest to north-northeast direction. The left side had a large bare area of cobble and gravel which extended to 41 m, followed by an area of dead shrub which was largely bare beneath. The right side had a smaller bare area, followed by dead shrubs underlain by grass, then dead trees underlain by grass. At 73 m the understory became sphagnum. Organic soil depths varied from 0 (near the creek) to >10 (sphagnum). Much of the organic soils on the transect were overlain by inorganic soils between 1 and 5 cm deep. In 2011, the left side was inundated due to beaver activity. The vegetation observed was a mix of grass and shrubs with no mention of any bare of treed areas. Organic soils varied from 4 to >30 cm. The cobble area observed in 2013 was inundated in 2011.

3.16 20+500

This transect was oriented in an east-west orientation. Both sides had bare areas with dead shrubs. On the left side, live trees were encountered at 54 m. On the right side the dead shrubs transitioned to a mixture of dead trees and shrubs. Soils on the entire transect were overlain by inorganic soils of 1 to 13 cm depth. Organic soils beneath varied from >3 to >5 cm. Due to the depth of inorganic soils, the depth of organic soils could only be measured as greater than a certain measurement, therefore, the precise organic soil depth is not known at many locations (deepest measurement to bottom of organic layer was 10 cm). The 2011 survey noted the same transition of grass to shrubs to trees, but with no mention of dead vegetation or bare areas. Organic soils depths in 2011 were between 5 to >30 cm with no mention of inorganic soils on top.

3.17 21+000

This transect runs in an east-west direction. The left side of the creek was comprised largely of dead shrubs, with bare areas near the creek channel and some dead trees near the end of the transect. The right side had dead shrubs and grass until 19 m, followed by a shrub layer underlain by sphagnum which transitioned to trees at 59 m. Organic soils depths varied from 0 to >10 cm, with some sites containing 4 to 13 cm of inorganic soils. 2011 observations showed high concentrations of grass near the creek channel followed by shrubs on both sides, which transitioned to trees on the right side. Organic soil depths varied from 5 to >30 cm, with no mention of inorganic soils.

3.18 21+500

This transect runs in a southwest-northeast orientation. The left side of the creek was dominated by dead shrubs for the first 32 m, followed by dead trees up to 57 m, followed by live trees. The right side of the creek had dead shrubs, followed by live trees at 25 m which developed a sphagnum understory beyond 36 m. Organic soil depths varied from 3 to >17 cm, with much of the area overlain by inorganic soils of 3 to 7 cm. 2011 observations noted predominantly shrubs and grass along the creek channel with trees beyond that. The first 10 m on the left side was flooded due to beaver activity. Soil depths measured varied from 6 to >30, with most measurements showing farily thick layers of organic soils.

3.19 22+000

This transect runs in a southwest-northeast direction. The first approximately 40 m on both sides of the creek were dominated by dead shrubs, but also had bare areas and grass. Away from the creek, the further half on both sides were dominated by trees with a sphagnum understory beyond approximately 45 m on both sides. Organic soils varied from 0 to >21 cm, much of which was overlain by inorganic soils. In 2011, the transect was described as being dominated by trees and showed organic soil depths from 8 to >30 cm.

3.20 22+500

This transect runs in an east-west direction. The creek is particularly wide in this reach (44 m across). The left side had a large bare area, followed by dead trees at 39 m and then live trees at 73 m. The right side had an area of dead trees immediately adjacent to the creek which ran until 43 m where the trees were alive. Soil depths varied from 0 to >21 cm, with some areas have deposits of inorganic soil above the organic soil. In 2011, a similar tree-dominated transect was observed, but with all trees being alive. Soil depths noted in 2011 varied from 6 to >30 cm.

3.21 23+000

This transect runs in a southwest-northeast direction. Dead shrubs ringed the creek channel on both sides which transitioned to trees at 49 and 33 m on the right and left sides of the creek respectively. On the right side, the trees were dead for the first 15 m, with live trees starting at 48 m. On the left side, trees were alive from 49 m to the end of the transect. Organic soils were 0 to >14 cm in depth, with 5-9 cm of inorganic soils on top of much of the organic soils. 2011 observations showed a similar progression of shrubs to trees with organic soils of 3 to >30 cm.

3.22 23+500

This transect runs in a north-south orientation. All vegetation on the left side of the river was dead with shrubs from the creek bank to 50 m and trees from 50 m to 100 m. On the right side, dead trees were adjacent to the creek bank for the first 21 m, part of which was underlain by herbaceous shrubs. The remainder of the right side transect consisted of live trees with a sphagnum understory. Organic soil depths varied from 0 to >20 cm, some of which was under up to 10 cm of inorganic soil. 2011 observations showed a high concentration of shrubs on the left side of the river as well as grass (where dead shrubs and bare ground was found in 2013). The remainder of the transect was noted be treed. Organic soil depths varied from 6 to >30 cm.

3.23 24+000

This transect runs in an east-west orientation. The left bank was steep and showed signs of erosion. At the top of the bank was a mixture of deciduous shrubs and trees for the duration of the transect. At 61 m, where the transect approached the river bank further down stream, the trees and shrubs were dead. On the right side of the river, the slope was much gentler, and the sediments were largely wet and muddy. Dead trees and shrubs dominated the first 68 m of the transect. The understory of that section was largely bare, but with increasing concentrations of grass as the transect progressed away from the river. Live trees began at 68 m. Due to the amount of inorganic sediment overlying the organic sediments in most locations, we were not able to get to the bottom of the organic layer. Inorganic sediments varied from 8 to 13 cm. In 2011 the transect was dominated by shrubs and trees, with a grass component on the right side of the river. Organic soil depths measured in 2011 varied from 8 to >30 cm.

3.24 24+500

This transect is oriented in an east-west direction. The left side of the river is composed of dense dead shrubs with a bare understory until 34 m where a layer of live shrubs begins. Beyond this, the vegetation becomes largely treed with a sphagnum understory. On the right side, bare areas with dead shrubs and trees span the entire transect. The bottom of the organic soils was not reached using our sampling methodology as they were beneath sizable amounts of inorganic soils (2-15 cm). 2011 observations noted similar compositions of shrubs and trees and organic soil depths of 9 to >30 cm.

3.25 25+000

This transect is oriented in a northwest-southeast direction. The left side of the creek had a steeper bank and the presence of slump suggested recent erosion (see Photo 13). At the top of the slope were shrubs which were followed by deciduous trees and then coniferous trees. The right side was less steep and had dead shrubs and a bare understory until 36 m. Much of the area consisted of cobbles, gravel and sand. Beyond this was a mixture of live trees and shrubs. The organic soil depths varied from 0 (cobble, gravel, sand) to >13 cm with some areas having 1-4 cm of inorganic soils on top. In 2011, a similar shrub and tree mixture was described. Organic soils depths were between 7 and >30 cm. There was no mention of bare ground or dead vegetation during the 2011 survey.

3.26 25+500

This transect was oriented in an east-west direction. The left side of the creek had a very gentle slope and consisted of dead shrubs and a largely bare understory for the entire left-side transect. The right side of the creek had a thin layer of dead shrubs, followed by a progression of live shrubs to live trees with a sphagnum understory starting at 54 m. Organic soil depths varied from 7 to >13 cm. In 2011, organic soil depth measurements were lower (3-8 cm) with the exception of near the end of the transects were depths were >30 m. In 2011, extensive grass and shrub concentrations align with what was observed to be dead shrub and bare understory in 2013.

3.27 26+000

This transect runs in a east-northeast to west-southwest direction. The left transect approximately paralleled the river and there was very little topography. The cover was entirely comprised of dead shrubs and bare understory, with a small percentage of grass. The transect on the right side of the river had a similar area of dead shrub and bare understory adjacent to the river until the transect went up the slope and a dense shrub coverage was encountered. Due to the winding nature of the creek at this point, this transect approaches the creek near its end. In this area, dead shrubs and trees and a bare understory were encountered. Organic soils were 2 to >9 cm in depth. All sites had some inorganic soils above the organic soils, which was deeper on the lower left side. In 2011, it was noted that the level terrain in the area appeared to be a flood plain for the creek. Similar grass/shrub compositions were observed with organic soils of 4 to 17 cm in depth.

3.28 26+500

This transect runs in a south-southeast to north-northwest direction. The left side was fairly low and flat and was comprised entirely of dead shrubs and trees with a small amount of grass, but largely with a bare understory. The right side was also largely bare adjacent to the river, but with a higher coverage of grass. Dead shrubs were found until 59 m where the transect entered 100% trees. Organic soils were 3 to >10 cm in depth, with most areas buried beneath 2-5 cm of inorganic soil. Similar shrub/grass and tree compositions were observed in 2011, but without the bare areas or dead vegetation. Organic soil depths were measured from 2 to 20 cm in 2011.

3.29 27+000

This transect runs in an east-west direction. The left side of the river was composed of mainly dead shrubs with a smaller portion of grass and a largely bare understory. At 77 m the transect entered live trees. On the right side, a similar composition of dead shrubs, grass and bare understory was encountered. At 42 m, the transect transitioned to shrubs and at 58 m, there was a mixture of shrubs and trees. The organic soil depths varied from 1 to >11 cm, with 2-3 cm of inorganic soil overlaying several of the soil sample locations. The 2011 survey recorded similar compositions of shrubs and trees, but with grass where the 2013 survey noted bare ground. Organic soil depths of 5 to >30 cm were observed in 2011.

3.30 27+500

This transect runs in an east-west direction. The left side of the river had an area of dead shrubs with some grass but largely bare until the slope increased at 34 m. Beyond this is a mixture of thick shrubs and trees until 59 m where 100% trees were encountered along with a sphagnum understory. The right side had a larger flat area which was largely bare (cobble, sand) until 25 m. Beyond this, an area of dead shrubs with grass and bare understory transitions to largely trees at 51 m, and then back to shrubs at 92 m. Organic soils depths varied from 0 to >8 cm, with 1-5 cm of inorganic soils overlaying organic soils. In 2011, similar compositions were observed, but with high concentrations of grass adjacent to the creek. Organic soils measured in 2011 were between 5 and 25 cm.

3.31 28+000

This transect runs in an east-southeast to north-northwest direction. There is a fairly steep rise in topography on the left side of the creek where a small bare/grass patch transitions to shrubs and then to trees. On the right side of the creek, a large flat and largely bare area leads to a band of shrubs, followed by trees. Organic soils varied from 0 to >16 cm. In 2011 the vegetation description was similar to what was observed in 2013, with the exception of a large grassy area noted where it was observed to be largely bare in 2013 (on the right side). Organic soils in 2011 varied from 6 to 23 cm deep.

TABLE 1 – RESULTS OF VEGETATION COVER SURVEY

Station	Sub-Section	Bank *1	Transect Orientation	Cover Type	Start (m)	End (m)	Organic Layer (cm)
13+000	A	Left	Northeast	River	0	6	-
				Bare 50%; Grass 50%	6	47	16
				Shrub (dead) 80%; Grass 50%	47	100	16
	B	Right	Southwest	River	0	6	-
				Bare 50%; Grass 50%; Shrub (dead) 40%	6	65	14
				Grass 90%; Shrub 10%	65	82	>16
				Shrub (dead) 90%; Grass 10%	82	100	13
13+500	A	Left	Northwest	River	0	7	-
				Grass 90%; Bare 10%	7	13	4
				Grass 70%; Shrub 30%	13	27	5
				Shrub 100%	27	59	4
				Grass 100%	59	66	5
				Shrub 80%; Grass 20%	66	100	2
	B	Right	Southeast	River	0	7	-
				Bare 70%; Grass 30%	7	18	9
				Bare 40%; Grass 40%; Shrub 20%	18	22	5
				Grass 80% (~½ flooded≈marsh); Treed 20%	22	48	6
				Grass 70% (~¾ flooded≈marsh); Shrub 20%	48	100	5
14+000	A	Left	Northwest	River	0	13	-
				Bare 90%; Grass 10%	13	18	4
				Shrub 60%; Grass 40%	18	22	2
				Grass 80% (~¼ flooded≈marsh); Shrub 20%	22	41	4 (wet)
				Trees 50%; Grass (marsh) 50%	41	48	3 (wet)
				Grass 80%; Shrub 20% (all marsh)	48	68	not sampled - too much water
				Shrub 90%; Grass 10% (all marsh)	68	100	not sampled - too much water
	B	Right	Southeast	River	0	13	-
				Bare 80%; Grass 20%	13	24	2
				Grass 90%; Shrub 10%	24	31	2
				Trees 40%; Shrub 40%; Grass 20%	31	41	5
				Trees 100%	41	97	4
				Shrub 80%; Trees 20%	97	100	3

TABLE 1 – RESULTS OF VEGETATION COVER SURVEY

Station	Sub-Section	Bank *1	Transect Orientation	Cover Type	Start (m)	End (m)	Organic Layer (cm)
14+500	A	Left	Northwest	River	0	9	-
				Bare 70%; Grass 30%	9	16	3
				Bare 60%; Shrub (dead) 40% (bare understory)	16	17	4
				Shrub 50%; Grass 40%; Tree 10%	17	30	2
				Tree 80%; Shrub 20%	30	100	4
	B	Right	Southeast	River	0	9	-
				Bare 100%	9	19	4
				Shrub (dead) 80%; Bare 20%	19	25	<1
				Shrub 80%; Grass 20%	25	34	5
				Trees 80%; Shrub 20%	44	100	5
15+000	A	Left	Northwest	River	0	7	-
				Bare (cobble, gravel) 100%	7	23	0
				Shrub (dead) 100% (bare understory)	23	42	4
				Shrub 100%	42	59	4
				Tree 80%; Shrub 20%	59	100	7
	B	Right	Southeast	River	0	7	-
				Bare 100%	7	9	0
				Trees 100%	9	37	5
				Trees 50%; Shrub 50%	37	52	8
				Shrub 60%; Trees 40% (sphagnum understory)	52	100	9 (sphagnum)
15+500	A	Left	Northwest	River	0	5	-
				Bare 80%; Grass 20%	5	10	<1
				Shrub (dead) 70%; Bare 30% (bare understory)	10	14	3
				Bare 60%; Shrub 40%	14	16	<1
				Trees 100% (transitions from pine to aspen at 59 m)	16	100	4
	B	Right	Southeast	River	0	5	-
				Shrub (dead) 50%; Bare 40%; Grass 30%	5	22	5
				Shrub 100%	22	25	5
				Trees 100%	25	48	3
				Shrub 100%	48	100	6

TABLE 1 – RESULTS OF VEGETATION COVER SURVEY

Station	Sub-Section	Bank *1	Transect Orientation	Cover Type	Start (m)	End (m)	Organic Layer (cm)
16+000	A	Left	Northwest	River	0	9	-
				Bare (cobbles) 100%	9	10	<1
				Grass 80%; Bare 10%; Shrub (dead) 10%	10	19	7
				Shrub 100%	19	23	3
				Trees 100%	23	37	7
				Shrub 100%	37	55	7
				Shrub 70% (sphagnum understory)	55	86	>10 (sphagnum)
				Trees 100%	86	100	7
	B	Right	Southeast	River	0	9	-
				Bare 50%; Shrub (dead) 40%; Grass 10% (bare understory)	9	37	<1
				Shrub 100%	37	82	9
				Trees 80% (100% sphagnum bog)	82	100	>10 (sphagnum)
16+500	A	Left	North-Northwest	River	0	9	-
				Bare 100%	9	11	0
				Grass 60%; Shrub (dead) 30%; Bare 30%	11	31	6
				Trees (dead) 100% (bare understory)	31	81	1
				Shrub 50%; Grass 50%	81	90	5
				Trees 80%; Shrub 20%	90	100	4
	B	Right	South-Southeast	River	0	9	-
				Bare 100%	9	12	0
				Shrub (dead) 100% (bare understory)	12	15	8
				Shrub 100%	15	19	8
				Trees 100%	19	33	6
				Shrub 80%; Trees 20%	33	47	8
				Trees 50% (100% sphagnum bog)	47	100	>10
17+000	A	Left	Northwest	River	0	13	-
				Grass 50%; Bare 50%	13	22	1
				Shrub (herbaceous and young trees) 100%	22	39	4
				Shrub (tall) 90%; Trees 10%	39	100	7
	B	Right	Southeast	River	0	13	-

TABLE 1 – RESULTS OF VEGETATION COVER SURVEY

Station	Sub-Section	Bank *1	Transect Orientation	Cover Type	Start (m)	End (m)	Organic Layer (cm)
				Bare 90%; Shrub (dead) 10%	13	24	0
				Shrub (dead) 90%; Bare 10%	24	35	3
				Shrub 100%	35	100	5
17+500	A	Left	West-Northwest	River	0	9	-
				Tree/Shrub (dead) 80%; Grass 10% (bare understory)	9	77	1
				Shrub 100%	77	100	5
	B	Right	East-Southeast	River	0	9	-
				Bare 90%; Grass 10%	9	19	1
				Shrub (herbaceous, short) 100%	19	22	4
				Shrub (tall) 100%	22	62	8
				Shrub (short, young trees) 100% (sphagnum understory)	62	100	>10
18+000	A	Left	Northeast	River	0	7	-
				Bare 100%	7	27	0
				Shrub (dead) 60%; Grass 10%; Bare 30%	27	44	3
				Shrub (short) 100%	44	47	3
				Shrub (tall) 100%	47	68	5
				Trees 100%	68	100	7
	B	Right	Southwest	River	0	7	-
				Bare 50%; Grass 50%; Shrub (dead) 10%	7	25	4
				Shrub (short) 100%	25	28	7
				Shrub (tall) 90%; Trees 10% (sphagnum understory)	28	93	5
				Trees 100% (sphagnum understory)	93	100	>10
18+500	A	Left	Northwest	River	0	13	-
				Bare 70%; Shrub (dead) 40%; Grass 30%	13	24	5
				Shrub (short) 80%; Grass 20%	24	25	5
				Shrub (½ short, ½ tall) 90%; Grass 10%	25	35	7
				Shrub 70%; Trees 30% (sphagnum understory)	35	95	8
				Shrub 80% (100% sphagnum understory)	95	100	
	B	Right	Southeast	River	0	13	-
				Bare 100%	13	15	0
				Grass 50%; Shrub (dead) 50%; Bare 10%	15	74	2

TABLE 1 – RESULTS OF VEGETATION COVER SURVEY

Station	Sub-Section	Bank *1	Transect Orientation	Cover Type	Start (m)	End (m)	Organic Layer (cm)
				Shrub 100%	74	75	5
				Trees 70% Shrub 30%	75	89	7
				Grass (marsh) 100%	89	100	not sampled - too much water
19+000	A	Left	Southwest	River	0	6	-
				Bare 100%	6	8	0
				Shrub (dead) 70%; Bare 40%; Grass 40%	8	37	10
				Shrub (short) 70%; Grass 30%	37	47	11
				Shrub (short) 70%; Trees 50%	47	60	-
				Grass 100%; Shrub (tall) 70%	60	70	>12
				Trees 70%; Shrub (tall) 20%; Grass 10%	70	100	not sampled - too much water
	B	Right	Northeast	River	0	6	-
				Shrub (dead) 70%; Grass 50%; Bare 10%	6	57	2
				Shrub (short) 60%; Grass 40%	57	65	8
				Trees 60%; Shrub (tall) 40%	65	84	7
				Shrub (tall) 100%	84	94	7
				Shrub (tall) 100% (sphagnum understory)	94	100	>10 (sphagnum)
19+500	A	Left	East	River	0	11	-
				Bare 80%; Grass 20%	11	16	7 (under 3 cm inorg.)
				Trees (dead) 90%; Grass 10% (bare understory)	16	96	3 (under 1 cm inorg.)
				Trees 100%	96	100	-
	B	Right	West	River	0	11	-
				Bare 100%	11	13	0
				Shrub (dead) 40%; Bare 40%; Grass 20%	13	31	6
				Trees (dead) 100%; Grass 40%; Bare 10%	31	100	>5 (under 5 cm inorg.)
20+000	A	Left	South-Southwest	River	0	8	-
				Bare (cobble, gravel) 100%	8	41	0
				Shrub (dead) 70%; Bare 20%; Grass 10% (bare understory)	41	100	8 (under 1 cm inorg.)
	B	Right	North-Northeast	River	0	8	-
				Bare 100%	8	11	0
				Grass 70%; Shrub (dead) 50%; Bare 30%	11	32	9 (under 3 cm inorg.)

TABLE 1 – RESULTS OF VEGETATION COVER SURVEY

Station	Sub-Section	Bank *1	Transect Orientation	Cover Type	Start (m)	End (m)	Organic Layer (cm)
				Trees (dead) 100%; Grass 50%	32	73	>5 (under 5 cm inorg.)
				Trees (dead) 100% (sphagnum understory)	73	100	>10
20+500	A	Left	West	River	0	7	-
				Shrub (dead) 40%; Bare 30%; Grass 30%	7	35	10 (under 2 cm inorg.)
				Shrub (dead) 100%; Grass 70%	35	54	>5 (under 13 cm inorg.)
				Trees 100%	54	100	>3 (under 8 cm inorg.)
	B	Right	East	River	0	7	-
				Bare 80%; Shrubs (dead) 10%; Grass 10%	7	24	>5 (under 5 cm inorg.)
				Shrub (dead) 90%; Bare 10%	24	62	6 (under 1 cm inorg.)
				Tree (dead) 50%; Shrub (dead) 50%	62	100	>4 (under 6 cm inorg.)
21+000	A	Left	West	River	0	11	-
				Bare 100%	11	16	0
				Shrub (dead) 70%; Bare 30%; Grass 10% (bare understory)	16	77	4 (under 6 cm inorg.)
				Shrub (dead) 70%; Tree (dead) 30%; Grass 10% (bare understory)	77	100	>2 (under 13 cm inorg.)
	B	Right	East	River	0	11	-
				Grass 70%; Shrub (dead) 60%; Bare 30%	11	31	>6 (under 4 cm inorg.)
				Shrub 70%; Grass 30% (sphagnum understory)	31	59	>10
				Trees 100% (sphagnum understory)	59	100	>10
21+500	A	Left	Southwest	River	0	11	-
				Shrub (dead) 70%; Shrub 30% (bare understory)	11	19	3 (under 3 cm inorg.)
				Shrub (dead) 100% (bare understory)	19	32	>4 (under 3 cm inorg.)
				Trees (dead) 100% (bare understory)	32	57	7
				Trees 100%	57	100	>17
	B	Right	Northeast	River	0	11	-
				Shrub (dead) 70%; Bare 30%; Grass 10%	11	25	>3 (under 7 cm inorg.)
				Trees 100%	25	36	>3 (under 7 cm inorg.)
				Trees 100% (sphagnum understory)	36	100	>10

TABLE 1 – RESULTS OF VEGETATION COVER SURVEY

Station	Sub-Section	Bank *1	Transect Orientation	Cover Type	Start (m)	End (m)	Organic Layer (cm)
22+000	A	Left	Southwest	River	0	9	-
				Shrub (dead) 60%; Bare 40% (bare understory)	9	13	0 (I>13)
				Shrub (dead) 100% (bare understory)	13	27	>5 (under 5 cm inorg.)
				Trees 100%	27	45	>5 (under 6 cm inorg.)
				Trees 100% (sphagnum understory)	45	100	>21 cm
	B	Right	Northeast	River	0	9	-
				Shrub (dead) 70%; Grass 50%	9	21	>1 (under 11 cm of inorg.)
				Trees (dead) 100% (bare understory)	21	42	13 (under 7 cm of inorg.)
				Trees 80%; Shrub 20% (sphagnum understory)	42	100	>10
22+500	A	Left	West	River	0	22	-
				Bare 100%	22	39	0
				Trees (dead) 100% (bare understory)	39	66	0
				Trees (dead) 90%; Grass 10% (bare understory)	66	73	>6 (under 9 cm inorg.)
				Trees 100%	73	98	-
				Trees 90%; Shrubs 20%	98	100	>12
	B	Right	East	River	0	22	-
				Trees (dead) 100% (bare understory)	22	43	>5 (under 5 cm inorg.)
				Trees 100%; Grass 30%	43	100	>21
23+000	A	Left	Southwest	River	0	19	-
				Shrub (dead) 100% (bare understory)	19	49	6 (under 5 cm inorg.)
				Trees 100%	49	74	>4 (under 9 cm inorg.)
				Trees 100%; Grass 30%	74	100	>23
	B	Right	Northeast	River	0	19	-
				Shrub (dead) 50%; Bare 40%; Grass 10%	19	33	0 (I>16)
				Trees (dead) 100%	33	48	>4 (under 8 cm inorg.)
				Trees 100%; Grass 30%	48	100	>14
23+500	A	Left	South	River	0	5	-
				Shrub (dead) 80%; Bare 20% (bare understory)	5	50	>4 (under 10 cm inorg.)
				Trees (dead) 100% (bare understory)	50	100	0 (I>20)
	B	Right	North	River	0	5	-
				Trees (dead) 100% (bare understory)	5	9	>4 (under 6 cm inorg.)

TABLE 1 – RESULTS OF VEGETATION COVER SURVEY

Station	Sub-Section	Bank *1	Transect Orientation	Cover Type	Start (m)	End (m)	Organic Layer (cm)
				Trees (dead) 100% (herbacious understory)	9	21	10
				Trees 100% (sphagnum understory)	21	100	>20
24+000	A	Left	West	River	0	11	-
				Shrub 100%	11	20	>4 (under 8 cm inorg.)
				Trees 100%; Shrubs (short) 50%	20	61	>13
				Trees (dead) 50%; Shrub (dead) 50% (bare understory)	61	100	>15
	B	Right	East	River	0	11	-
				Trees (dead) 80%; Shrub (dead) 20% (bare understory)	11	42	0 (I>13)
				Trees (dead) 80%; Shrub (dead) 20%; Grass 50%	42	68	>6 (under 12 cm inorg.)
				Trees 100%	68	100	>1 (under 13 cm inorg.)
24+500	A	Left	West	River	0	13	-
				Shrub (dead) 90%; Grass 10% (bare understory)	13	21	>1 (under 14 cm inorg.)
				Shrub (dead) 80%; Trees (dead) 20% (bare understory)	21	34	>1 (under 15 cm inorg.)
				Shrub 100%	34	43	>8 (under 2 cm inorg.)
				Trees 100% (sphagnum understory)	43	62	>15
				Trees 50%; Shrubs 50% (sphagnum understory)	62	100	>15
	B	Right	East	River	0	13	-
				Trees (dead) 40%; Shrub (dead) 40%; Bare 20% (bare understory)	13	28	0 (I>19)
				Shrub (dead) 100%; Grass 50%	28	64	>3 (under 6 cm inorg.)
				Trees (dead) 60%; Shrub (dead) 40% (bare understory)	64	100	>6 (under 6 cm inorg.)
25+000	A	Left	Northwest	River	0	12	-
				Shrubs 100%	12	27	7 (under 4 cm inorg.)
				Trees (deciduous) 100%; Shrubs 80%	27	53	9
				Trees (coniferous) 100%; Shrubs 80%	53	100	>10
	B	Right	Southeast	River	0	12	-
				Shrubs (dead) 60%; Bare 40% (bare understory)	12	35	0
				Shrubs (dead) 100% (bare understory)	35	36	10 (under 3 cm inorg.)
				Trees 100%	36	86	>13 (under 1 cm inorg.)
				Trees 50%; Shrubs 50%	86	100	-

TABLE 1 – RESULTS OF VEGETATION COVER SURVEY

Station	Sub-Section	Bank *1	Transect Orientation	Cover Type	Start (m)	End (m)	Organic Layer (cm)
25+500	A	Left	West	River	0	11	-
				Shrub (dead) 100%; Grass 10% (bare understory)	11	91	7 (under 4 cm inorg.)
				Shrub (dead) 90%; Tree (dead) 10% (bare understory)	91	100	-
	B	Right	East	River	0	11	-
				Shrub (dead) 100% (bare understory)	11	15	9 (under 1 cm inorg.)
				Shrub (short) 100%	15	18	>6
				Shrub (tall) 100%	18	54	>10
				Shrub 80%; Trees 20% (sphagnum understory)	54	85	>13
				Trees 100%	85	100	>13
26+000	A	Left	East-Northeast	River	0	8	-
				Shrub (dead) 60%; Grass 20% (bare understory)	8	77	2 (under 1 cm inorg.)
				Shrub (dead) 100% (bare understory)	77	100	-
	B	Right	West-Southwest	River	0	8	-
				Shrub (dead) 50%; Bare 50% (bare understory)	8	25	>9 (under 5 cm inorg.)
				Shrub 100%	25	66	>6 (under 13 cm inorg.)
				Shrub (dead) 80%; Trees (dead) 20% (bare understory)	66	100	>6 (under 4 cm inorg.)
26+500	A	Left	South-Southeast	River	0	9	-
				Shrub (dead) 70%; Grass 10% (bare understory)	9	80	7 (under 2 cm inorg.)
				Shrub (dead) 60%; Trees (dead) 40% (bare understory)	80	100	>8 (under 5 cm inorg.)
	B	Right	North-Northwest	River	0	9	-
				Bare 60%; Grass 40%; Shrub (dead) 30%	9	32	6 (under 3 cm inorg.)
				Shrub (dead) 100%; Grass 20% (bare understory)	32	59	3
				Trees 100%; Shrub (short) 100%	59	100	>10
27+000	A	Left	West	River	0	13	-
				Shrub (dead) 80%; Grass 40% (bare understory)	13	77	1 (under 2 cm inorg.)
				Trees 100%	77	100	>11
	B	Right	East	River	0	13	-
				Shrub (dead) 70%; Grass 20% (bare understory)	13	42	5 (under 3 cm inorg.)
				Shrub 90%; Grass 10%	42	58	>11
				Trees 60%; Shrub (tall) 40%	58	100	-

TABLE 1 – RESULTS OF VEGETATION COVER SURVEY

Station	Sub-Section	Bank *1	Transect Orientation	Cover Type	Start (m)	End (m)	Organic Layer (cm)
27+500	A	Left	West	River	0	7	-
				Shrub (dead) 60%; Grass 10% (bare understory)	7	34	5 (under 1 cm inorg.)
				Trees 50%; Shrubs 50%	34	59	4 (under 1 cm inorg.)
				Trees 100%; Shrubs 80% (sphagnum understory)	59	100	-
	B	Right	East	River	0	7	-
				Bare 90%; Grass 10%	7	25	0
				Shrubs (dead) 60%; Grass 50% (bare understory)	25	51	>8 (under 5 cm inorg.)
				Trees 80% Shrubs 30%	51	92	>7 (under 3 cm inorg.)
				Shrubs 100%	92	100	-
28+000	A	Left	East-Southeast	River	0	5	-
				Grass 50%; Bare 50%	5	10	11
				Shrubs 100%	10	23	6
				Trees 50%; Shrubs 50%	23	45	>8
				Trees 100%	45	100	>16
	B	Right	West-Northwest	River	0	5	-
				Bare 70%; Grass 30%	5	45	0
				Grass 50%; Bare 50%	45	68	12 (under 1 cm inorg.)
				Shrub 90%; Trees 10%	68	75	>10
				Trees 80%; Shrub 40%	75	100	>10

*1 Note: Bank left or bank right is based on facing downstream.

Photo 1. “Bare” substrate observed at 18+000.

Photo 2. “Grass” vegetation observed at 13+500.

Photo 3. “Shrub” vegetation observed at 26+000.

Photo 4. “Treed” vegetation observed at 25+000.

Photo 5. Buffalo Creek at transect 13+000 (left photo: 2011; right photo: 2013)

Photo 6. Looking downstream from 14+500 (left photo: 2011; right photo: 2013)

Photo 7. Steep bank along Buffalo Creek at 15+000.

Photo 8. Looking downstream from 17+000 (left photo: 2011; right photo: 2013)

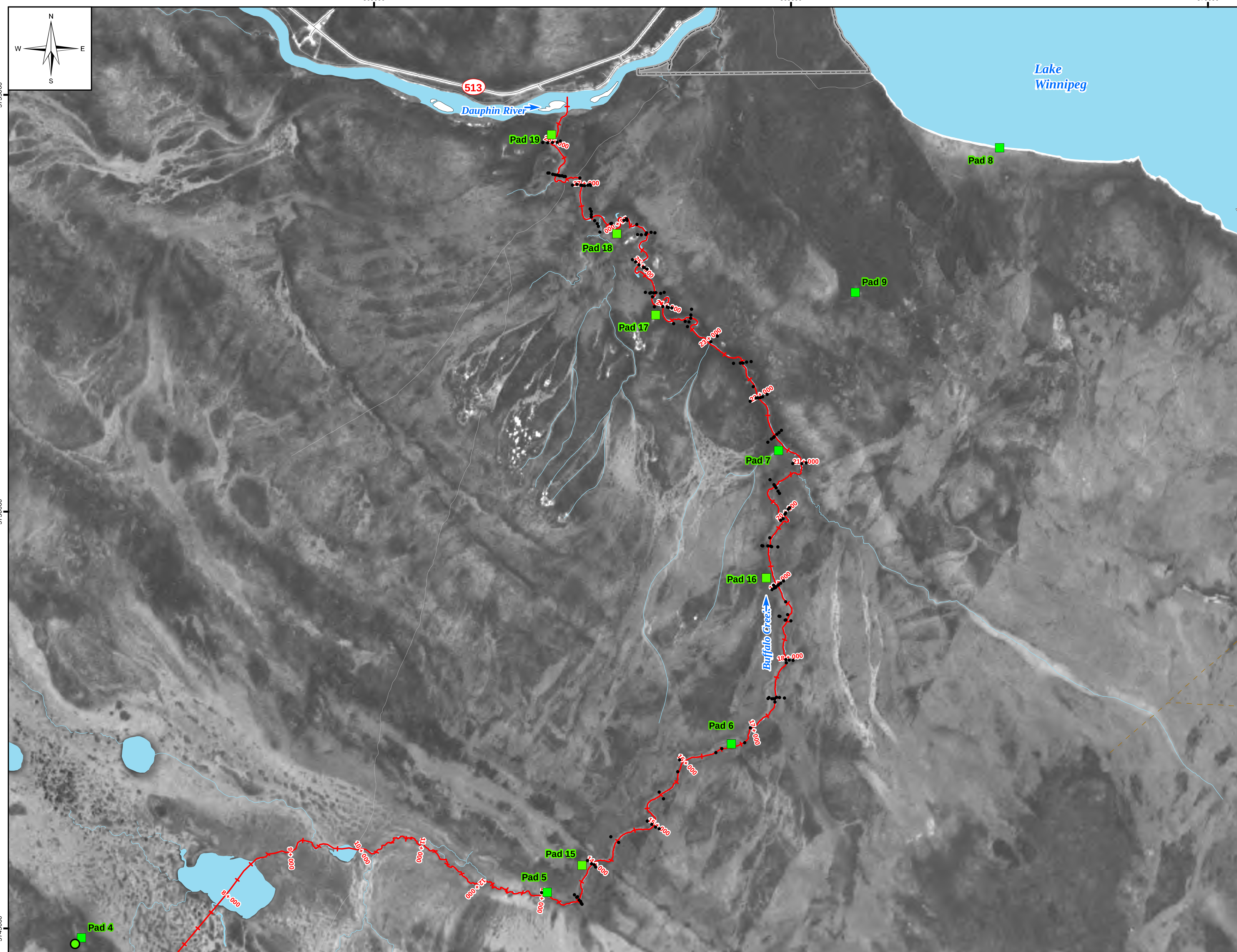
Photo 9. Looking downstream from 18+000 (left photo: 2011; right photo: 2013)

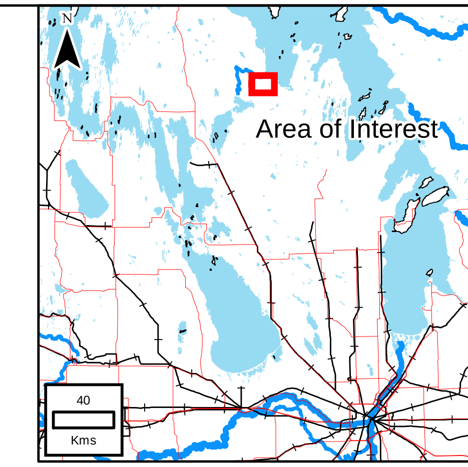
Photo 10. Shrub area adjacent to creek channel at 19+000 (left: 2011; right: 2013)

Photo 11. Left side of river at 19+500 showing large amount of dead trees.

Photo 12. Soil sampling hole at 19+500 showing organic soils (black) overlain by inorganic soils (grey).

Photo 13. Slump on left side of creek at 25+000 (looking upstream).





LEGEND:

- Vegetation Survey Transect Location
- Helicopter Landing Pad
- Lake St. Martin Channel Option L
- Road Paved 2 or more lanes
- Paved Street or Road
- Gravel Road
- Unclassified Road
- Accessway or Backlane
- Trail
- Railway
- Ditch
- River/Stream, Indefinite
- River/Stream
- Dugout; Pond;
- Lake
- Aboriginal Lands

DRAFT

0.5 0 0.5 1 1.5

Kilometres

SCALE: 1:45,000 METRIC 11"x17"

All units are metric and in metres unless otherwise specified.
Transverse Mercator Projection, NAD 1983, Zone 14
Elevations are in metres above sea level (MSL)

NO.	YY/MM/DD	DESCRIPTION	BY
0	13/08/30	ISSUED WITH DRAFT REPORT	STO

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LAKE ST. MARTIN EMERGENCY RELIEF CHANNEL

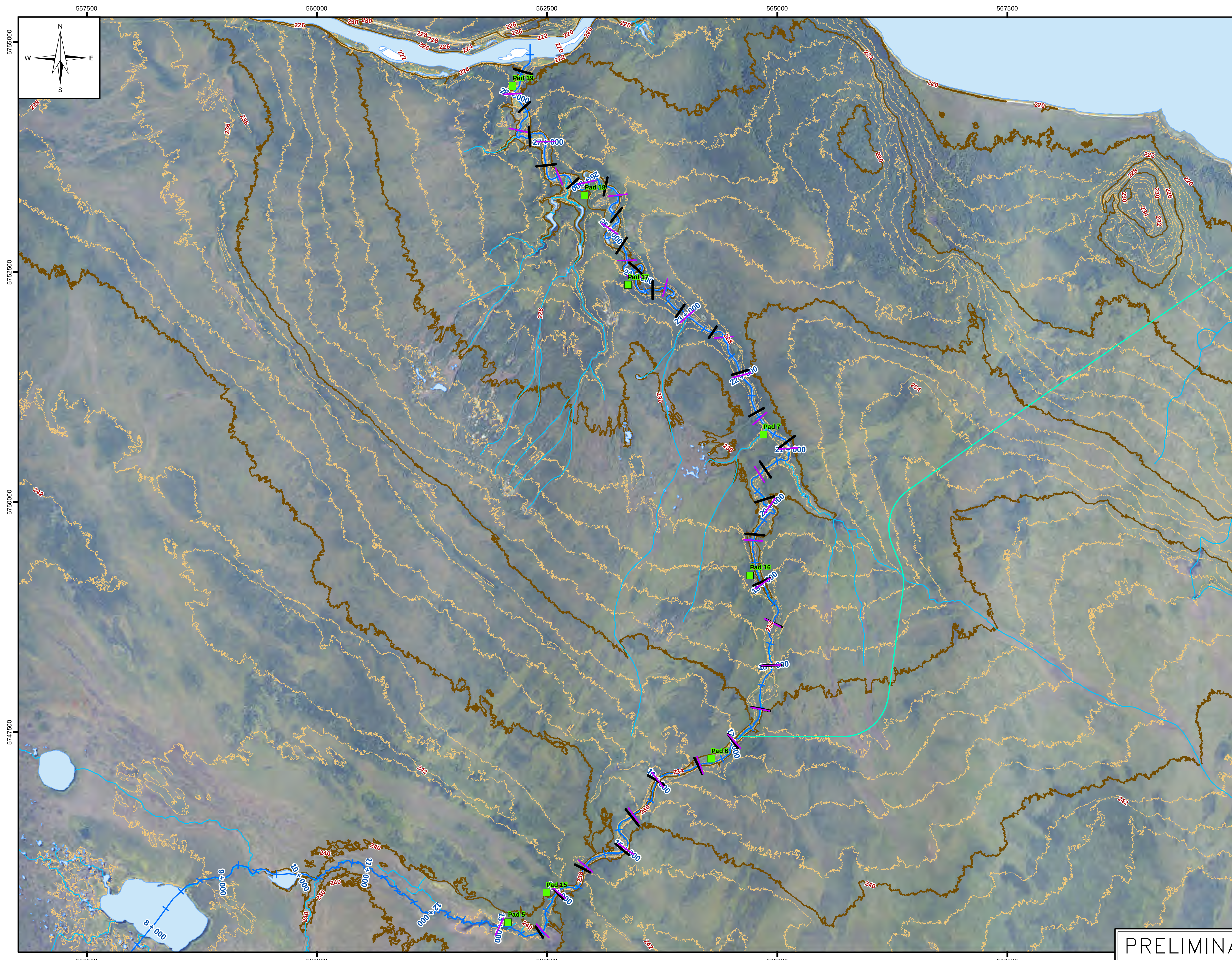
TRANSECT LOCATIONS OF VEGETATION COVER SURVEY

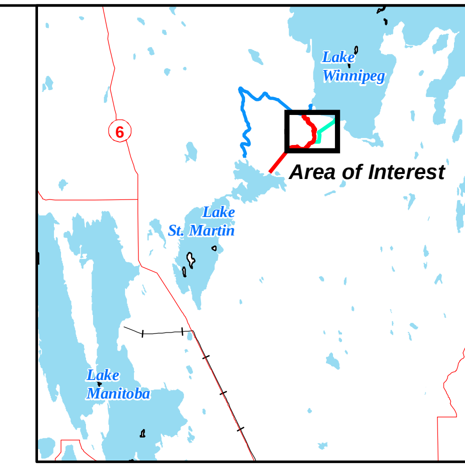
AUGUST 2013 | FIGURE 01 | REV: 0

FileName: P:\Projects\2013\13-0431-001\Dwg\GIS\MXDs\Rev0\DraftReport_20130830\13-0431-001_F02_Rev0.mxd
11"x17" PLOT SCALE 1:1

Appendix 4B. Buffalo Creek Vegetation Surveyed Cross Sections

Provided Within: Graphs showing cross sections surveyed in Buffalo Creek.





LEGEND:

- Constructed Helicopter Landing Pad
- Vegetation Survey Transect
- Cross Section
- Buffalo Creek Centreline
- Reach 3
- 5m Index Contour
- 1m Contour
- Water Feature
- Water Feature
- Island

DRAFT

0 500 1,000 1,500 2,000

Metres

SCALE: 1:40,000 METRIC 11"x17"

All units are metric and in metres unless otherwise specified.
Transverse Mercator Projection, NAD 1983, Zone 14
Elevations are in metres above sea level (MSL)

NO.	YY/MM/DD	DESCRIPTION	BY
A	14/10/17	ISSUED WITH FIELD INSPECTION FORM	STO

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Manitoba

LSM EMERGENCY RELIEF CHANNEL MONITORING & DEVELOPMENT OF HABITAT COMPENSATION

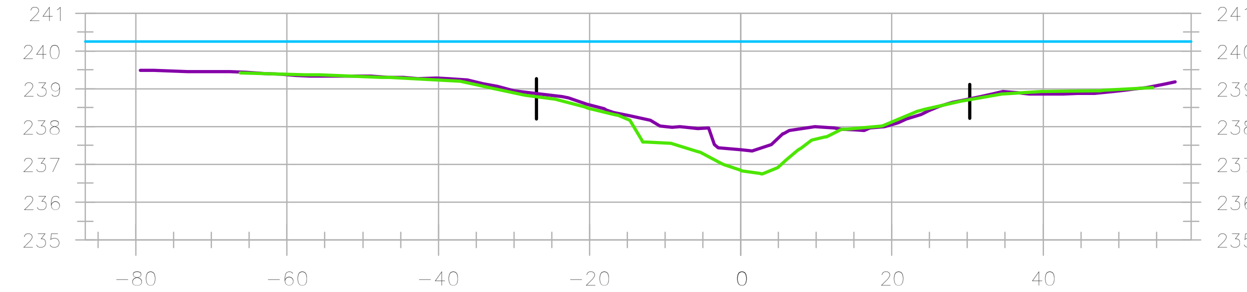
LOCATIONS OF BUFFALO CREEK CROSS SECTIONS AND VEGETATION COVER TRANSECTS

OCTOBER 2014 | FIGURE 01 | REV. A

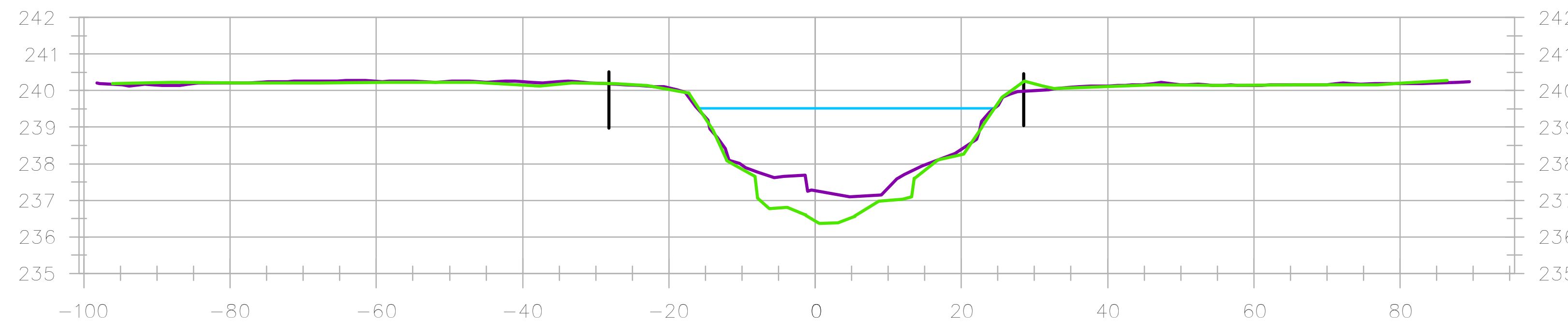
PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION

FileName: P:\Projects\2013\13-0431-001\Dwg\GIS\MXDs\RevA\Field_Inspection_Form\13-0431-001-Fig01_RevA.mxd
11"x17" PLOT SCALE 1:1

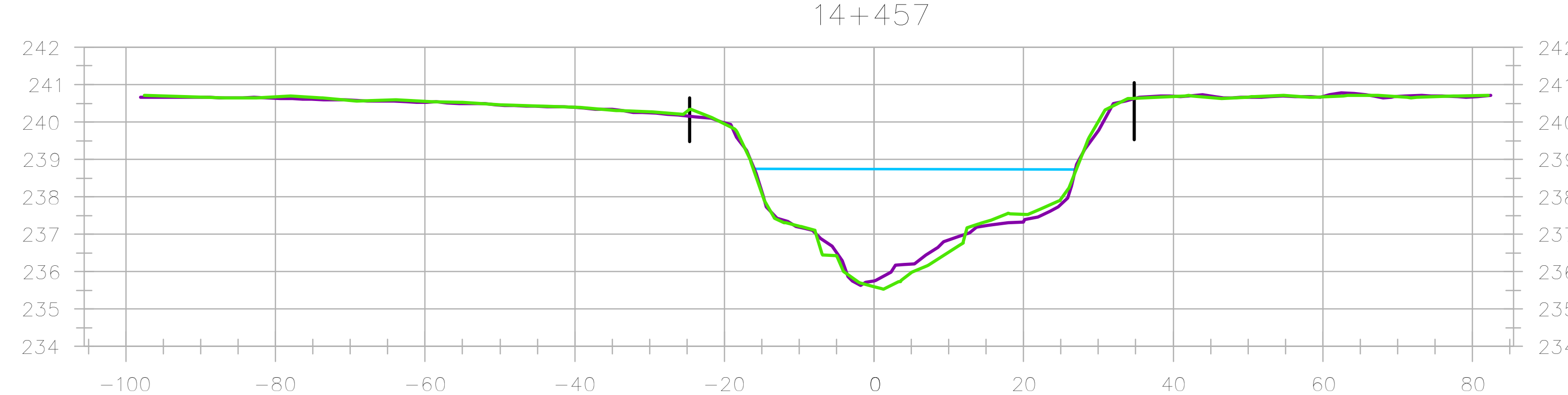
13+474



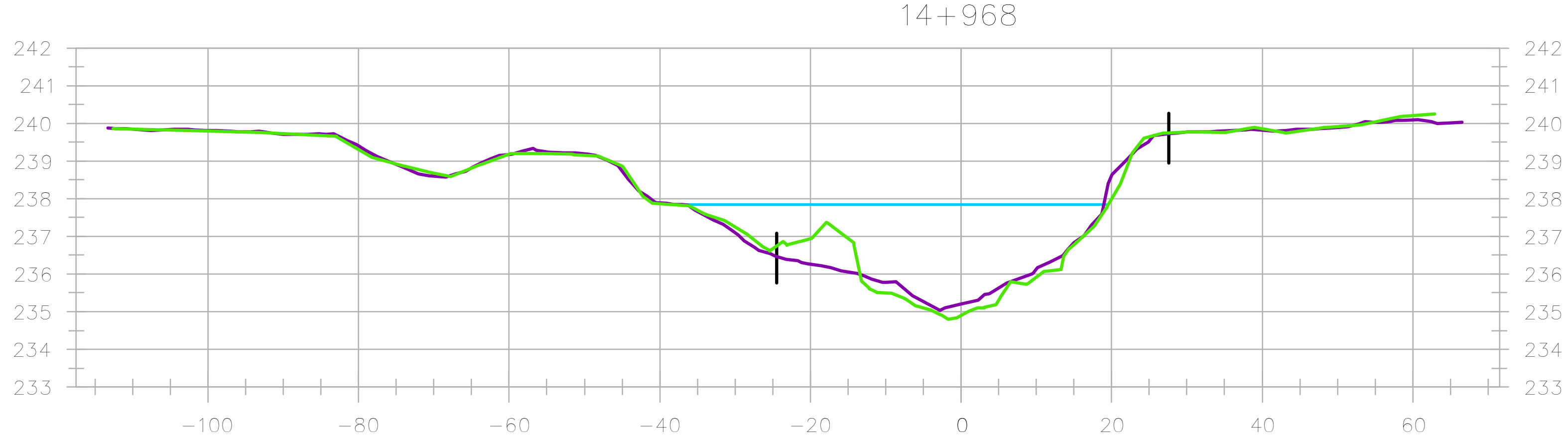
13+984



14+457



14+968



LEGEND:

- 2011 Survey
- 2013 Survey
- Average Water Level during operation of LSMEOC (computed)
- Rebar

GENERAL NOTES:
1. See Drawings 7 or 8 for Cross Section locations.
2. Sections are orientated looking downstream.
3. Normal changes in the peat between 2011 and 2013 can result in slight differences when comparing cross sections.

CROSS SECTION NOTES:
4. Section alignment was re-established during the 2013 survey.
5. Data was not collected during the 2011 Survey.

DRAFT

2 0 2 4 6 8
Metres

VERTICAL SCALE: 1:200 (5x Vertical Exaggeration)

10 0 10 20 30 40
Metres

HORIZONTAL SCALE: 1:1,000 (5x Vertical Exaggeration)

NO.	YY/MM/DD	DESCRIPTION	BY
B	15/01/08	ISSUED WITH DRAFT REPORT	PAL
A	14/10/17	ISSUED WITH PRELIMINARY DRAFT REPORT	PAL

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Manitoba INFRASTRUCTURE AND TRANSPORTATION

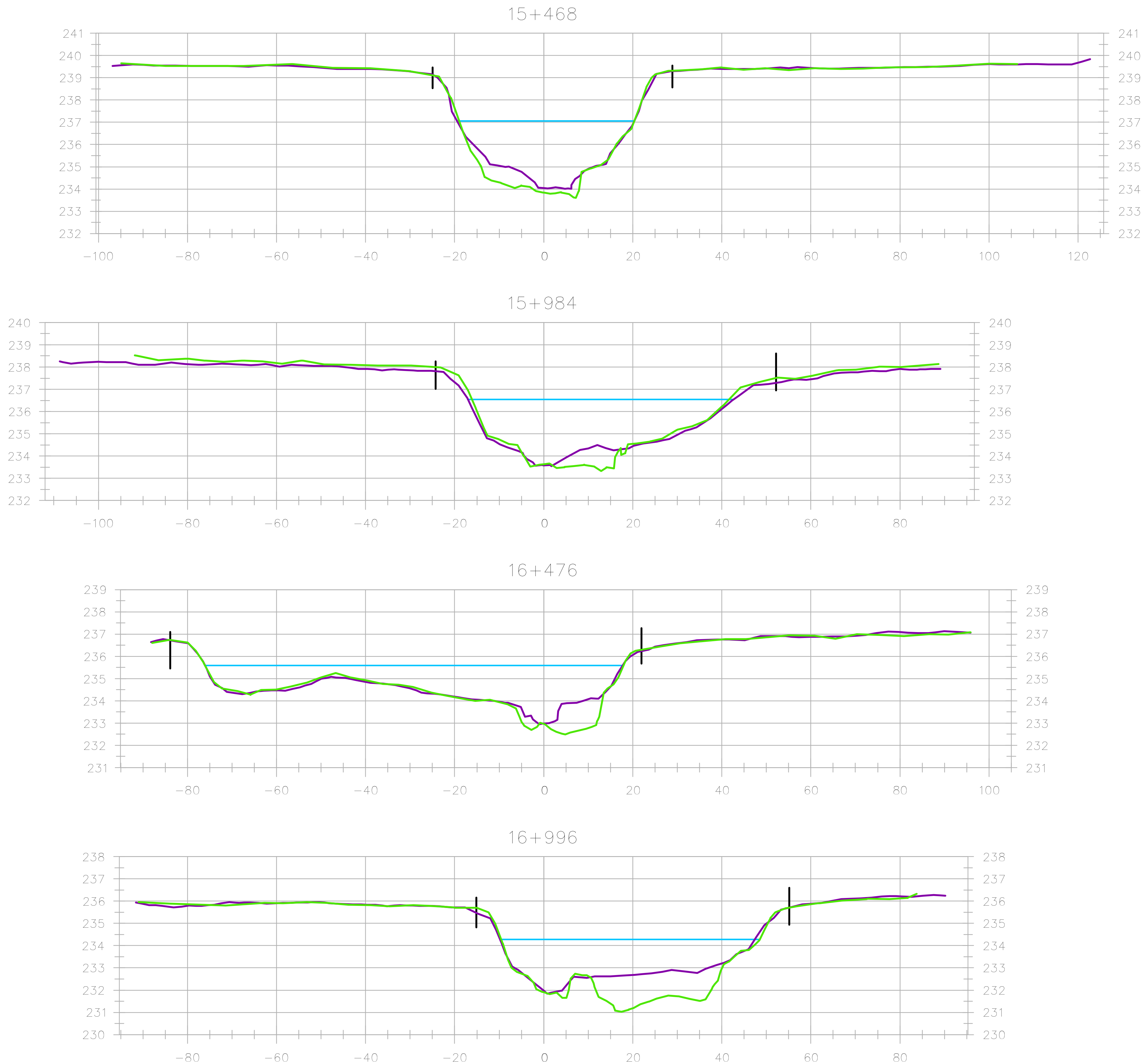
LSM EMERGENCY RELIEF CHANNEL MONITORING & DEVELOPMENT OF HABITAT COMPENSATION

BUFFALO CREEK CROSS SECTIONS

PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION

JANUARY 2015 | DRAWING 09.01 | REV. B

FileName: P:\Projects\2013\13-0431-001\Dwg\GIS\MXDs\RevB\Physical_Process_Report\13-0431-001-Fig09_RevB.mxd
11"x17" PLOT SCALE 1:1



LEGEND:

- 2011 Survey
- 2013 Survey
- Average Water Level during operation of LSMEOC (computed)
- Rebar

GENERAL NOTES:
1. See Drawings 7 or 8 for Cross Section locations.
2. Sections are orientated looking downstream.
3. Normal changes in the peat between 2011 and 2013 can result in slight differences when comparing cross sections.

CROSS SECTION NOTES:
4. Section alignment was re-established during the 2013 survey.
5. Data was not collected during the 2011 Survey.

DRAFT

2 0 2 4 6 8
Metres
VERTICAL SCALE: 1:200 (5x Vertical Exaggeration)

10 0 10 20 30 40
Metres
HORIZONTAL SCALE: 1:1,000 (5x Vertical Exaggeration)

NO.	YY/MM/DD	DESCRIPTION	BY
B	15/01/08	ISSUED WITH DRAFT REPORT	PAL
A	14/10/17	ISSUED WITH PRELIMINARY DRAFT REPORT	PAL

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Manitoba INFRASTRUCTURE AND TRANSPORTATION

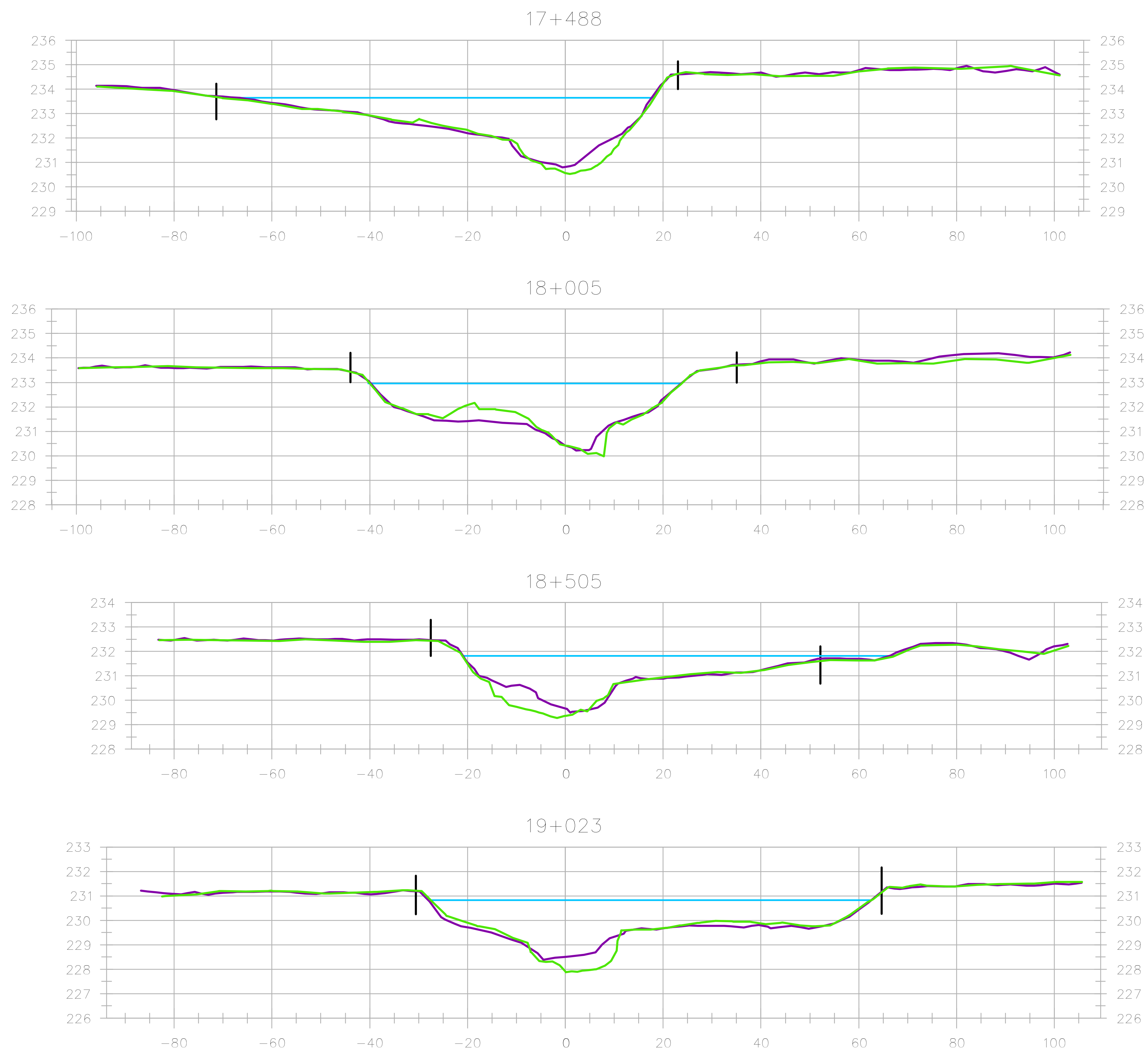
LSM EMERGENCY RELIEF CHANNEL MONITORING & DEVELOPMENT OF HABITAT COMPENSATION

BUFFALO CREEK CROSS SECTIONS

PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION

JANUARY 2015 | DRAWING 09.02 | REV: B

FileName: P:\Projects\2013\13-0431-001\Dwg\GIS\MXDs\RevB\Physical_Process_Report\13-0431-001-Fig09_RevB.mxd
11"x17" PLOT SCALE 1:1



LEGEND:

- 2011 Survey
- 2013 Survey
- Average Water Level during operation of LSMEOC (computed)
- Rebar

GENERAL NOTES:
1. See Drawings 7 or 8 for Cross Section locations.
2. Sections are orientated looking downstream.
3. Normal changes in the peat between 2011 and 2013 can result in slight differences when comparing cross sections.

CROSS SECTION NOTES:

4. Section alignment was re-established during the 2013 survey.
5. Data was not collected during the 2011 Survey.

DRAFT

2 0 2 4 6 8
Metres

VERTICAL SCALE: 1:200 (5x Vertical Exaggeration)

10 0 10 20 30 40
Metres

HORIZONTAL SCALE: 1:1,000 (5x Vertical Exaggeration)

NO.	YY/MM/DD	DESCRIPTION	BY
B	15/01/08	ISSUED WITH DRAFT REPORT	PAL
A	14/10/17	ISSUED WITH PRELIMINARY DRAFT REPORT	PAL

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Manitoba INFRASTRUCTURE AND TRANSPORTATION

LSM EMERGENCY RELIEF CHANNEL MONITORING & DEVELOPMENT OF HABITAT COMPENSATION

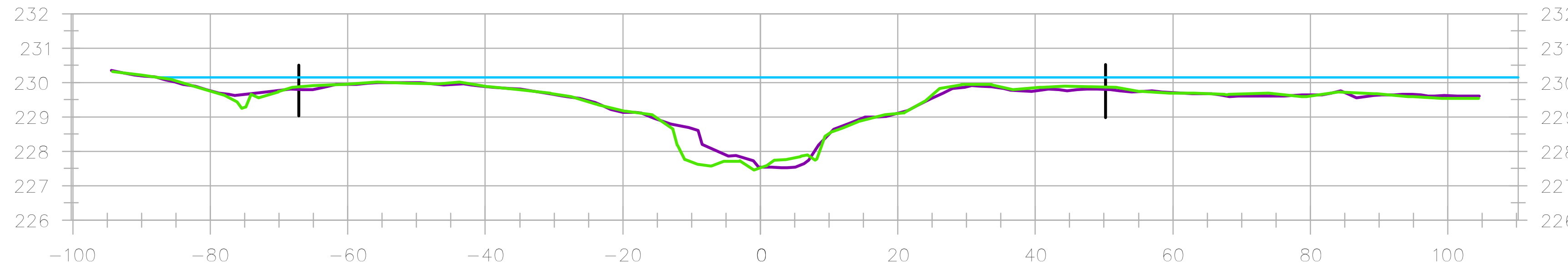
BUFFALO CREEK CROSS SECTIONS

PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION

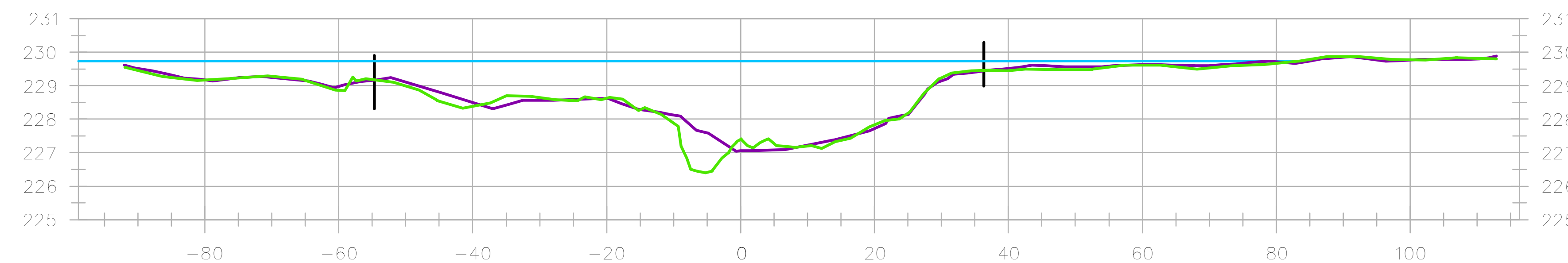
JANUARY 2015 | DRAWING 09.03 | REV. B

FileName: P:\Projects\2013\13-0431-001\Dwg\GIS\MXDs\RevB\Physical_Process_Report\13-0431-001-Fig09_RevB.mxd
11"x17" PLOT SCALE 1:1

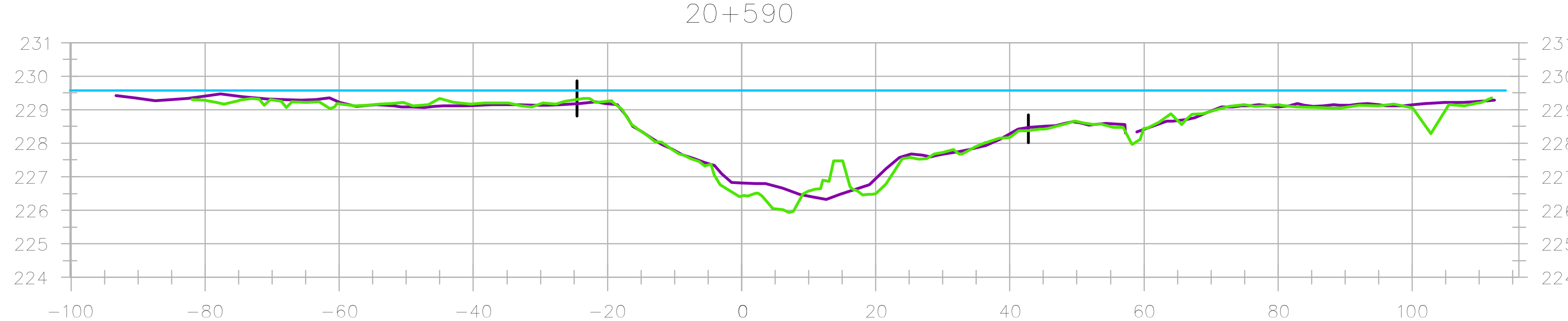
19+562



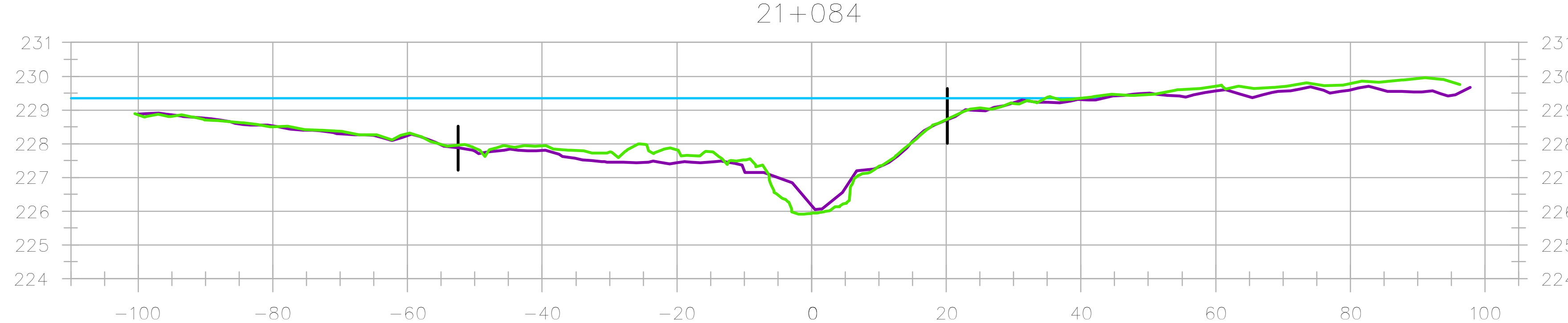
20+127



20+590



21+084



LEGEND:

- 2011 Survey
- 2013 Survey
- Average Water Level during operation of LSMEOC (computed)
- Rebar

GENERAL NOTES:

1. See Drawings 7 or 8 for Cross Section locations.
2. Sections are orientated looking downstream.
3. Normal changes in the peat between 2011 and 2013 can result in slight differences when comparing cross sections.

CROSS SECTION NOTES:

4. Section alignment was re-established during the 2013 survey.
5. Data was not collected during the 2011 Survey.

DRAFT

2 0 2 4 6 8
Metres

VERTICAL SCALE: 1:200 (5x Vertical Exaggeration)

10 0 10 20 30 40
Metres

HORIZONTAL SCALE: 1:1,000 (5x Vertical Exaggeration)

NO.	YY/MM/DD	DESCRIPTION	BY
B	15/01/08	ISSUED WITH DRAFT REPORT	PAL
A	14/10/17	ISSUED WITH PRELIMINARY DRAFT REPORT	PAL

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Manitoba INFRASTRUCTURE AND TRANSPORTATION

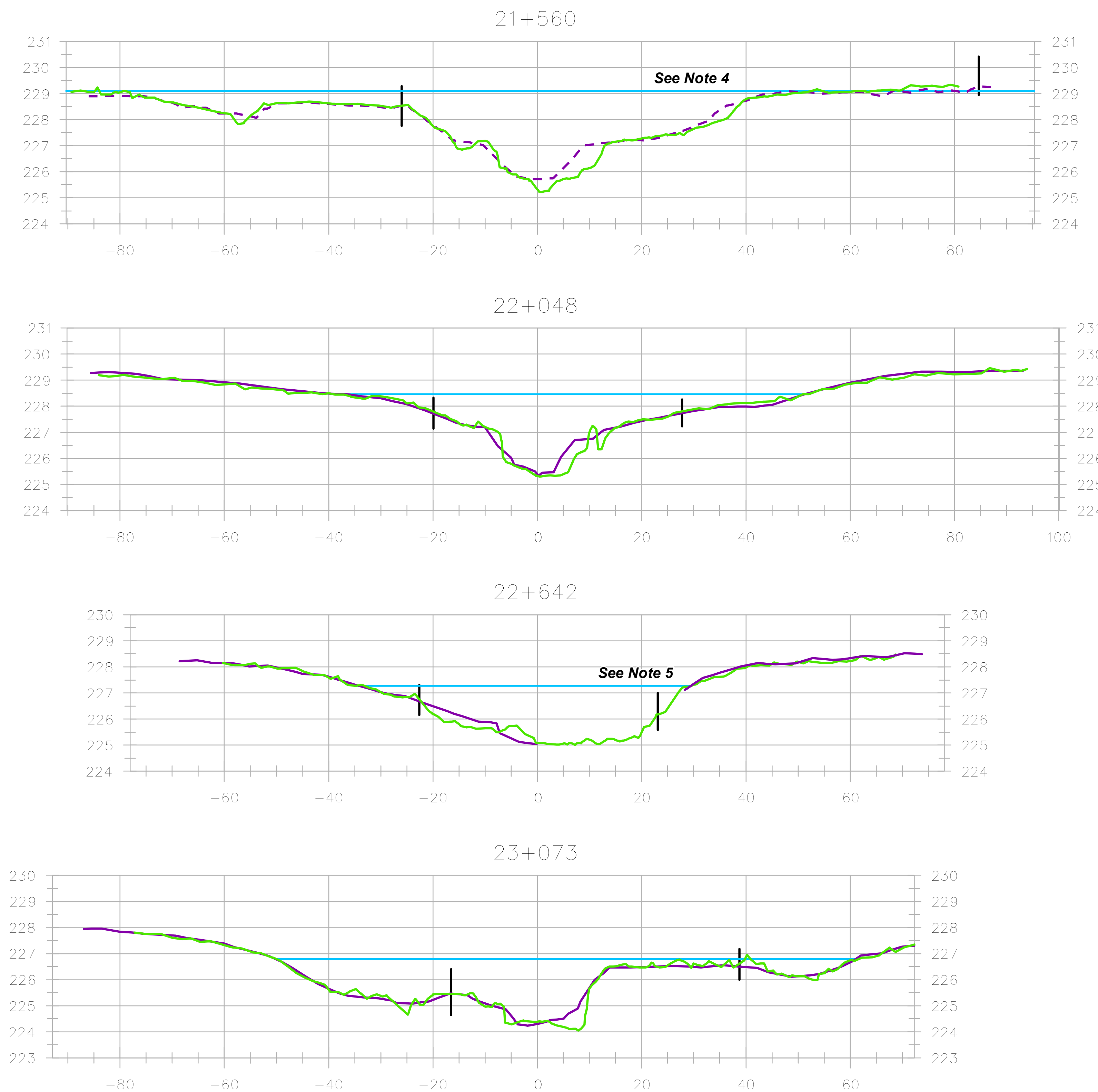
LSM EMERGENCY RELIEF CHANNEL MONITORING & DEVELOPMENT OF HABITAT COMPENSATION

BUFFALO CREEK CROSS SECTIONS

PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION

JANUARY 2015 | DRAWING 09.04 | REV. B

FileName: P:\Projects\2013\13-0431-001\Dwg\GIS\MXDs\RevB\Physical_Process_Report\13-0431-001-Fig09_RevB.mxd
11"x17" PLOT SCALE 1:1



LEGEND:

- 2011 Survey
- 2013 Survey
- Average Water Level during operation of LSMEOC (computed)
- Rebar

GENERAL NOTES:
1. See Drawings 7 or 8 for Cross Section locations.
2. Sections are orientated looking downstream.
3. Normal changes in the peat between 2011 and 2013 can result in slight differences when comparing cross sections.

CROSS SECTION NOTES:
4. Section alignment was re-established during the 2013 survey.
5. Data was not collected during the 2011 Survey.

DRAFT

2 0 2 4 6 8
Metres
VERTICAL SCALE: 1:200 (5x Vertical Exaggeration)

10 0 10 20 30 40
Metres
HORIZONTAL SCALE: 1:1,000 (5x Vertical Exaggeration)

NO.	YY/MM/DD	DESCRIPTION	BY
B	15/01/08	ISSUED WITH DRAFT REPORT	PAL
A	14/10/17	ISSUED WITH PRELIMINARY DRAFT REPORT	PAL

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LSM EMERGENCY RELIEF CHANNEL MONITORING & DEVELOPMENT OF HABITAT COMPENSATION

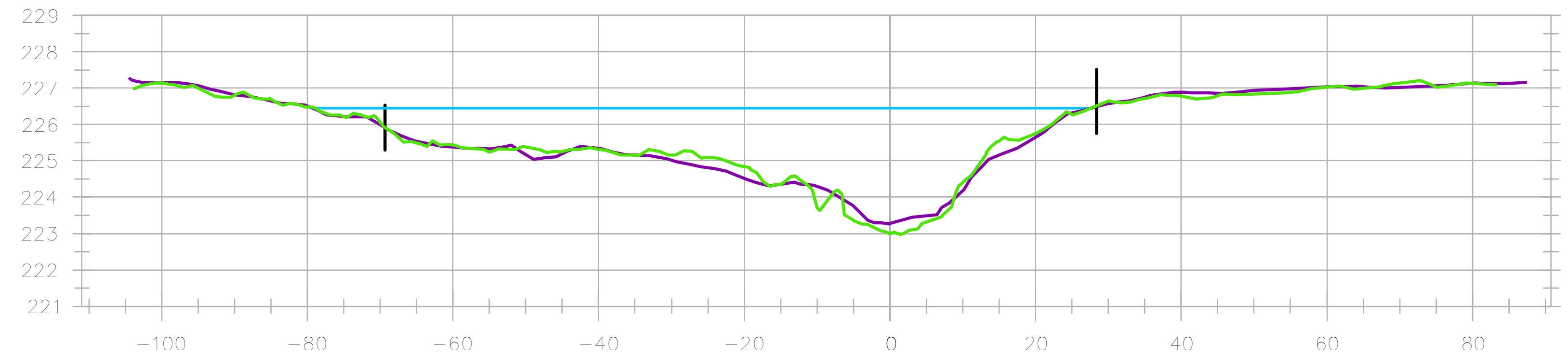
BUFFALO CREEK CROSS SECTIONS

PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION

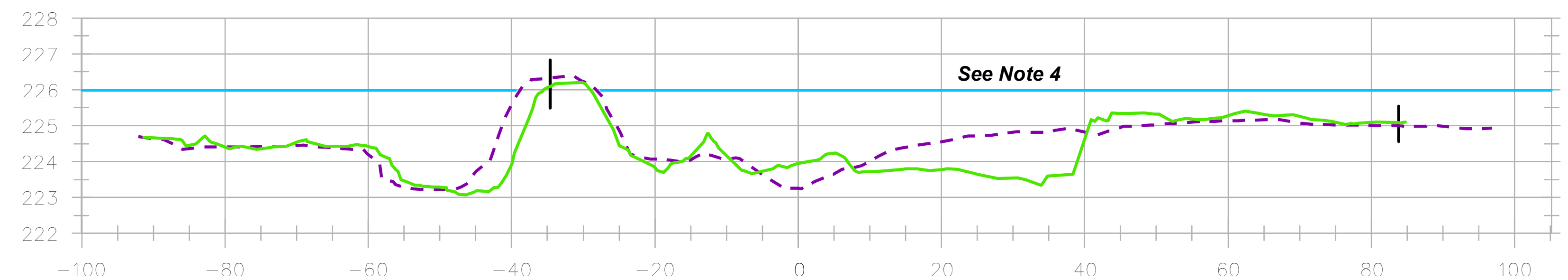
JANUARY 2015 | DRAWING 09.05 | REV. B

FileName: P:\Projects\2013\13-0431-001\Dwg\GIS\MXDs\RevB\Physical_Process_Report\13-0431-001-Fig09_RevB.mxd
11"x17" PLOT SCALE 1:1

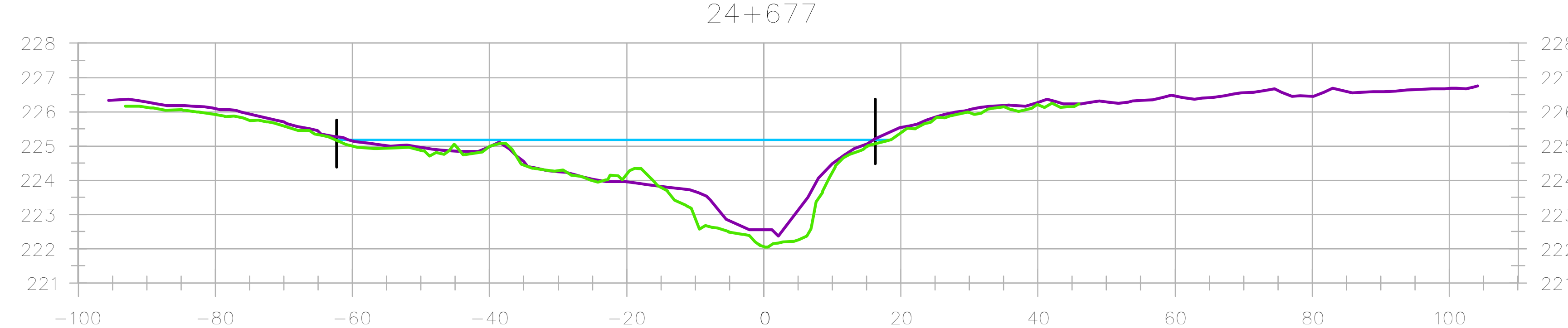
23+666



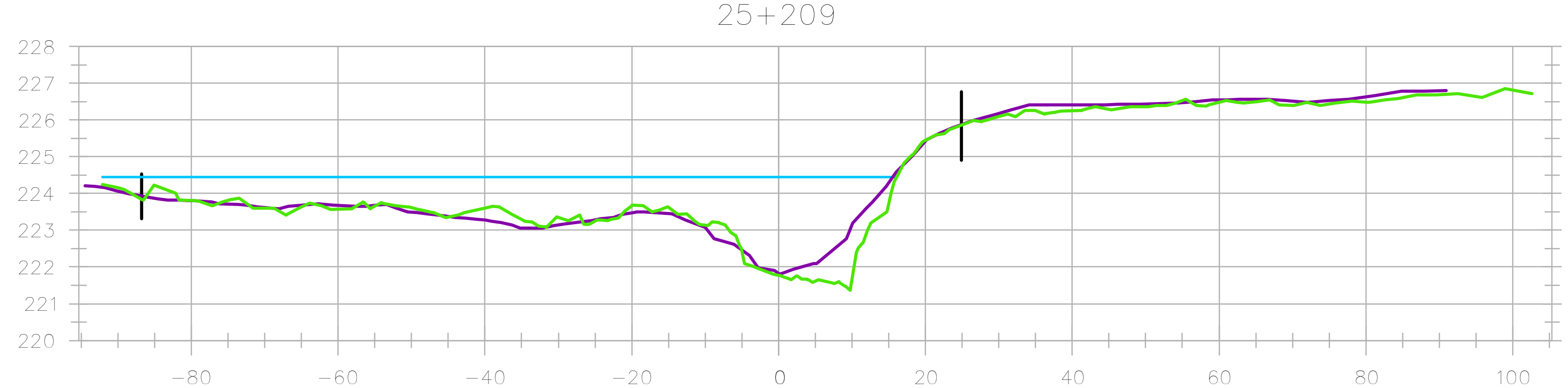
24+203



24+677



25+209



LEGEND:

- 2011 Survey
- 2013 Survey
- Average Water Level during operation of LSMEOC (computed)
- Rebar

GENERAL NOTES:

1. See Drawings 7 or 8 for Cross Section locations.
2. Sections are orientated looking downstream.
3. Normal changes in the peat between 2011 and 2013 can result in slight differences when comparing cross sections.

CROSS SECTION NOTES:

4. Section alignment was re-established during the 2013 survey.
5. Data was not collected during the 2011 Survey.

DRAFT

2 0 2 4 6 8
Metres

VERTICAL SCALE: 1:200 (5x Vertical Exaggeration)

10 0 10 20 30 40
Metres

HORIZONTAL SCALE: 1:1,000 (5x Vertical Exaggeration)

NO.	YY/MM/DD	DESCRIPTION	BY
B	15/01/08	ISSUED WITH DRAFT REPORT	PAL
A	14/10/17	ISSUED WITH PRELIMINARY DRAFT REPORT	PAL

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Manitoba INFRASTRUCTURE AND TRANSPORTATION

LSM EMERGENCY RELIEF CHANNEL MONITORING & DEVELOPMENT OF HABITAT COMPENSATION

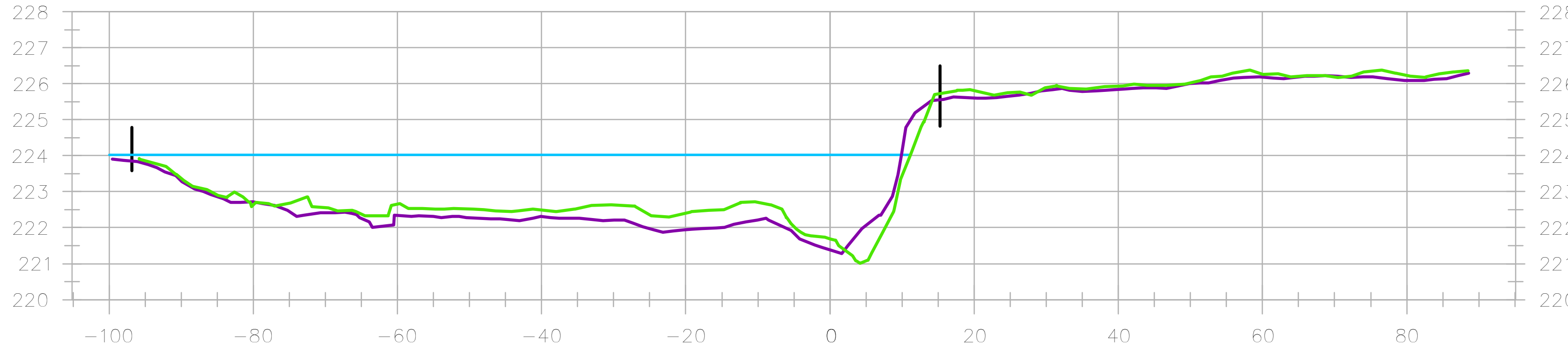
BUFFALO CREEK CROSS SECTIONS

PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION

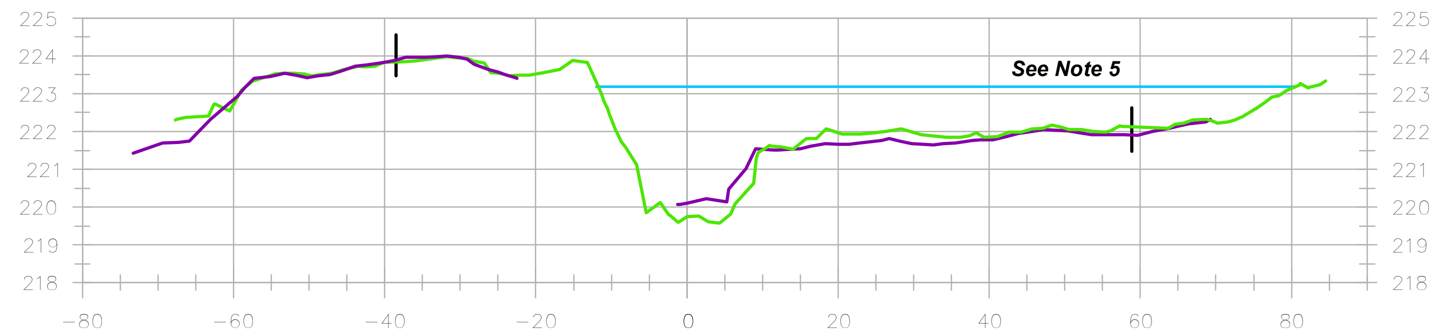
JANUARY 2015 | DRAWING 09.06 | REV: B

FileName: P:\Projects\2013\13-0431-001\Dwg\GIS\MXDs\RevB\Physical_Process_Report\13-0431-001-Fig09_RevB.mxd
11"x17" PLOT SCALE 1:1

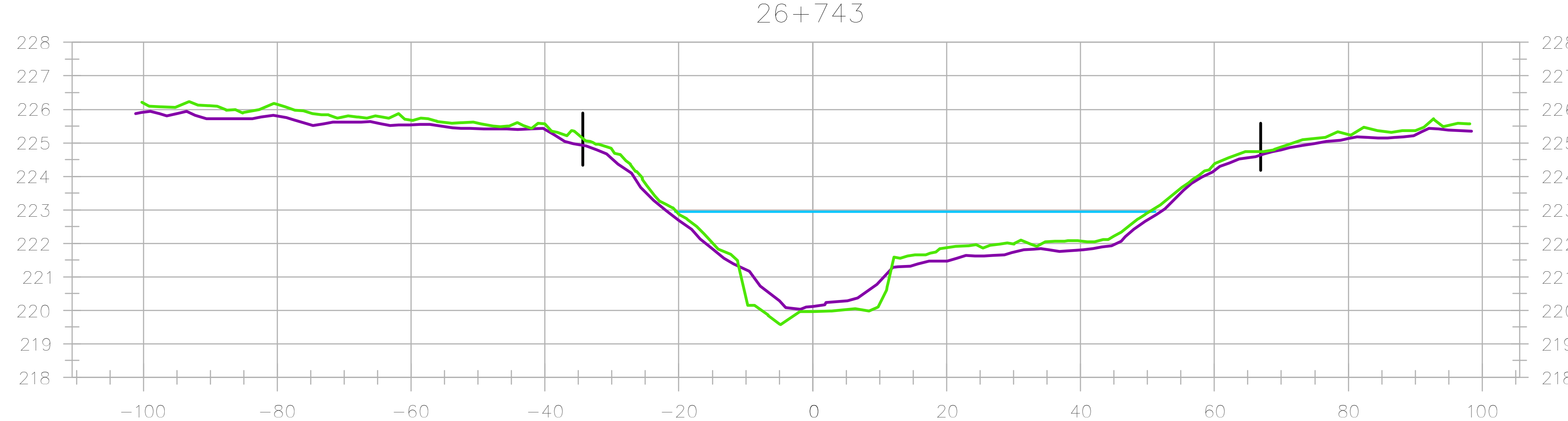
25+683



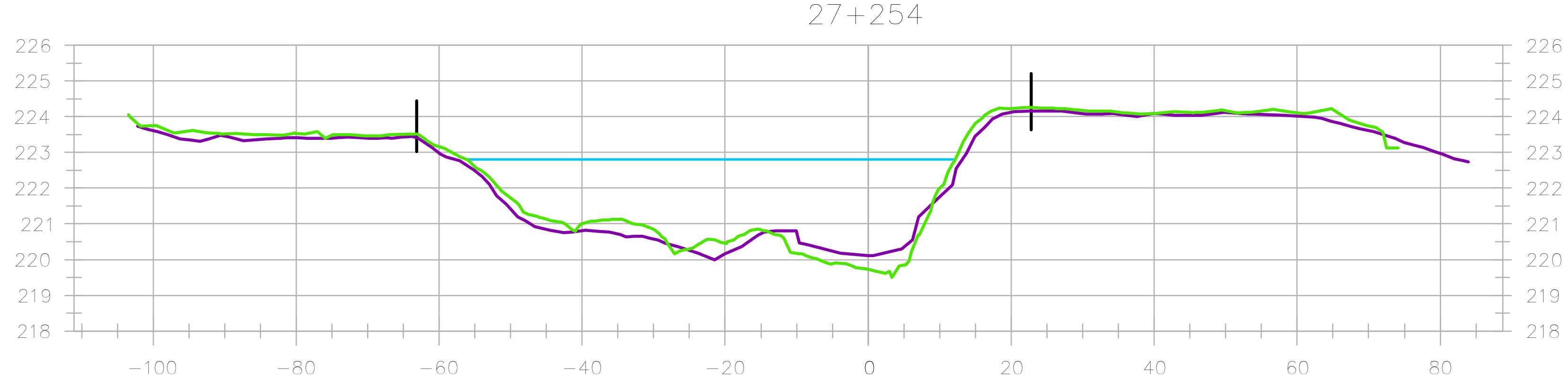
26+281



26+743



27+254



LEGEND:

- 2011 Survey
- 2013 Survey
- Average Water Level during operation of LSMEOC (computed)
- Rebar

GENERAL NOTES:
1. See Drawings 7 or 8 for Cross Section locations.
2. Sections are orientated looking downstream.
3. Normal changes in the peat between 2011 and 2013 can result in slight differences when comparing cross sections.

CROSS SECTION NOTES:
4. Section alignment was re-established during the 2013 survey.
5. Data was not collected during the 2011 Survey.

DRAFT

2 0 2 4 6 8
Metres
VERTICAL SCALE: 1:200 (5x Vertical Exaggeration)

10 0 10 20 30 40
Metres
HORIZONTAL SCALE: 1:1,000 (5x Vertical Exaggeration)

NO.	YY/MM/DD	DESCRIPTION	BY
B	15/01/08	ISSUED WITH DRAFT REPORT	PAL
A	14/10/17	ISSUED WITH PRELIMINARY DRAFT REPORT	PAL

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Manitoba INFRASTRUCTURE AND TRANSPORTATION

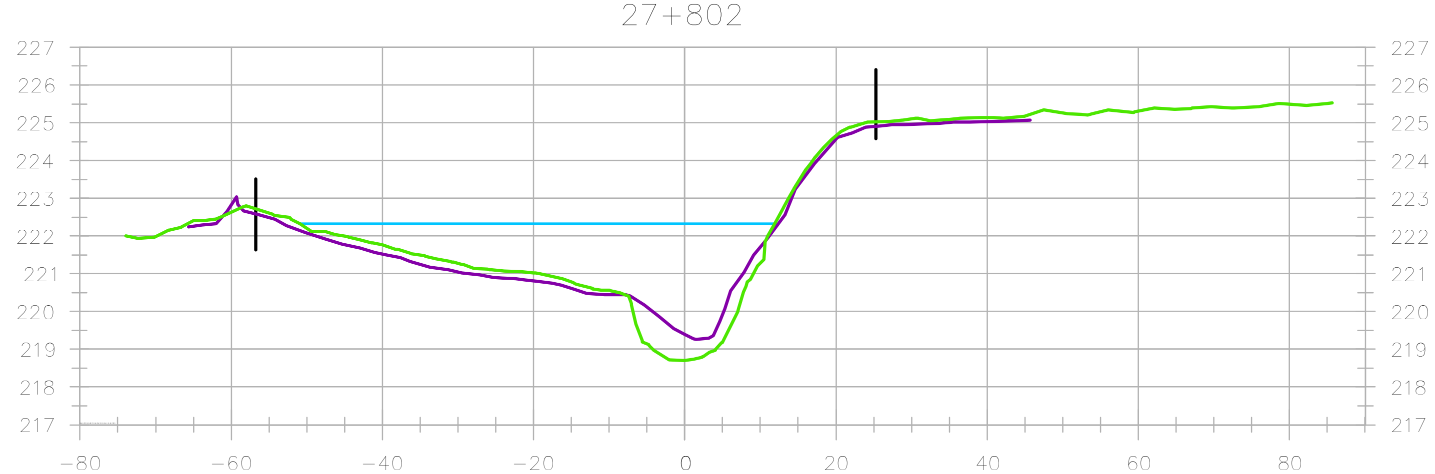
LSM EMERGENCY RELIEF CHANNEL MONITORING & DEVELOPMENT OF HABITAT COMPENSATION

BUFFALO CREEK CROSS SECTIONS

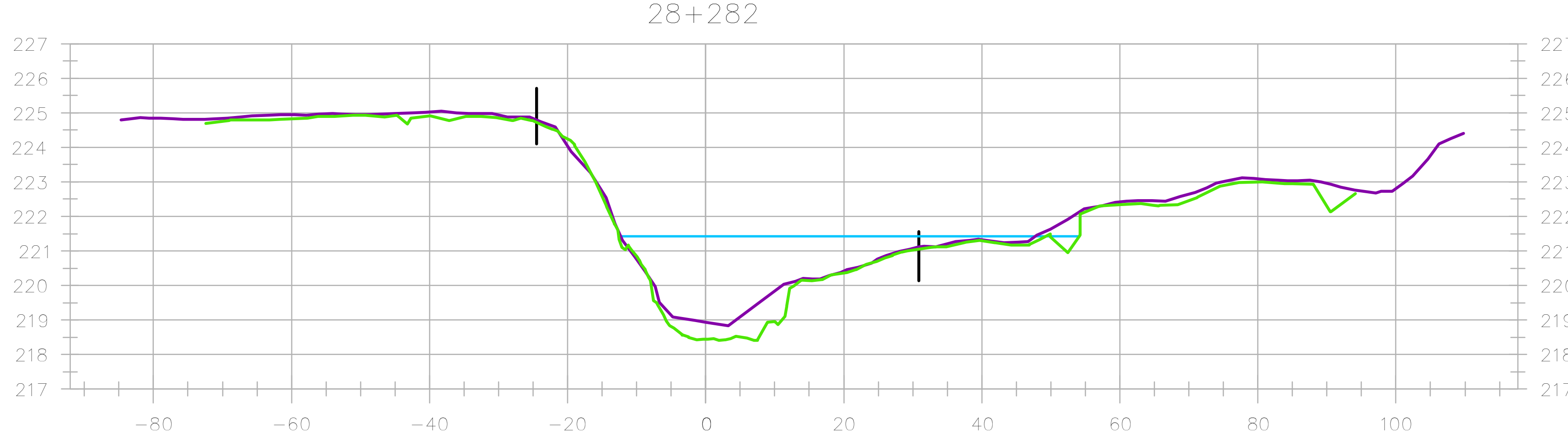
PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION

JANUARY 2015 | DRAWING 09.07 | REV. B

27+802



28+282



LEGEND:

- 2011 Survey
- 2013 Survey
- Average Water Level during operation of LSMEOC (computed)
- Rebar

GENERAL NOTES:

1. See Drawings 7 or 8 for Cross Section locations.
2. Sections are orientated looking downstream.
3. Normal changes in the peat between 2011 and 2013 can result in slight differences when comparing cross sections.

CROSS SECTION NOTES:

4. Section alignment was re-established during the 2013 survey.
5. Data was not collected during the 2011 Survey.

DRAFT

2 0 2 4 6 8

Metres

VERTICAL SCALE: 1:200 (5x Vertical Exaggeration)

10 0 10 20 30 40

Metres

HORIZONTAL SCALE: 1:1,000 (5x Vertical Exaggeration)

NO.	YY/MM/DD	DESCRIPTION	BY
B	15/01/08	ISSUED WITH DRAFT REPORT	PAL
A	14/10/17	ISSUED WITH PRELIMINARY DRAFT REPORT	PAL

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Manitoba INFRASTRUCTURE AND TRANSPORTATION

LSM EMERGENCY RELIEF CHANNEL MONITORING & DEVELOPMENT OF HABITAT COMPENSATION

BUFFALO CREEK CROSS SECTIONS

PRELIMINARY

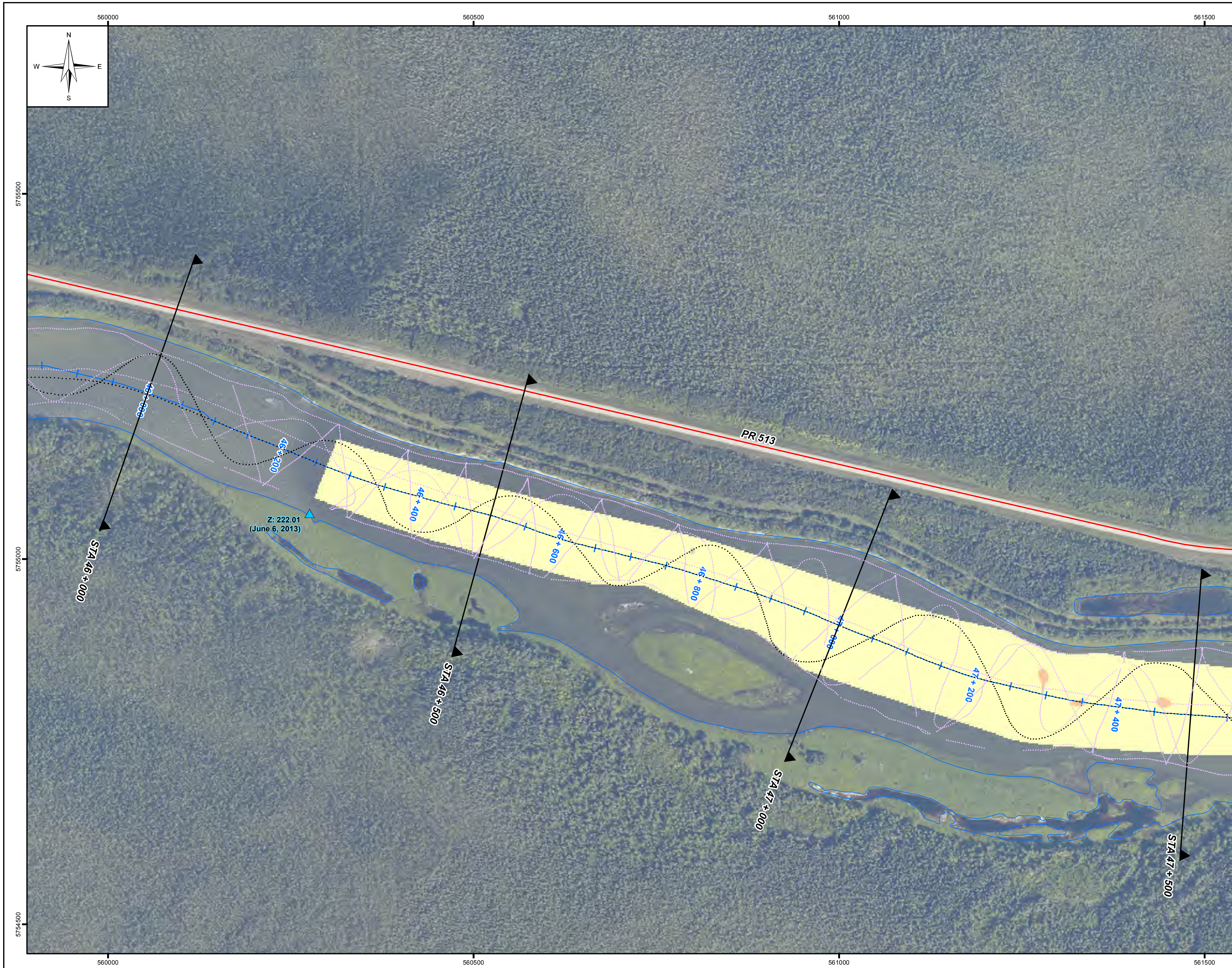
NOT TO BE USED FOR CONSTRUCTION

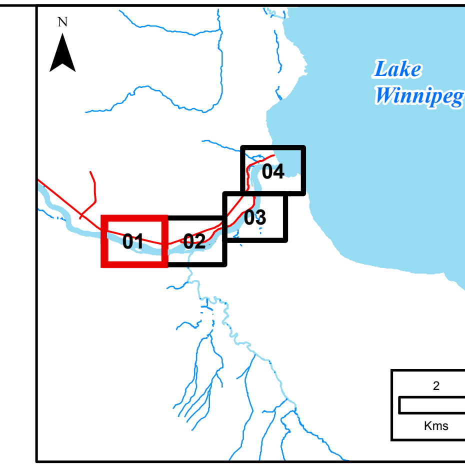
JANUARY 2015 | DRAWING 09.08 | REV: B

FileName: P:\Projects\2013\13-0431-001\Dwg\GIS\MXDs\RevB\Physical_Process_Report\13-0431-001-Fig09_RevB.mxd
11"x17" PLOT SCALE 1:1

Appendix 4C. Dauphin River Bathymetric Survey Comparisons

Provided Within: Maps showing bathymetric survey comparisons for the lower Dauphin River





LEGEND:

- 2013 Sonar Point
- 2011 Sonar Point
- Water Level (June 5–7th, July 22–23, 2012)
- Survey Control 2011 (See Note 3 Below)
- X–Section
- Dauphin River Centreline

TRANSPORTATION

- Gravel Road
- Trail
- Edge of Water (LiDAR)

From 2011 to 2013

Elevation Variation (m)

- < −2
- −2.0 – −1.5
- −1.5 – −1.0
- −1.0 – −0.5
- −0.5 – 0.5
- 0.5 – 1.0
- 1.0 – 1.5
- 1.5 – 2.0
- > 2.0

* SEE NOTE 1 FOR EXPLANATION

NOTES:

1. Negative elevation values indicates erosion and positive indicates deposition.
2. 2011 Sonar completed by KGS Group on June 29 – July 2, 2011.
   2013 Sonar completed by KGS Group on June 5–7, and July 22–23, 2013.
3. 2013 Control is outside map extents. Please see Figure 10.01–10.03 for 2013 Control.
4. Satelite image provided by Atlis Geomatics, July 2011
5. Original ground surface based on LiDAR provided by Atlis Geomatics (June/July 2011)
6. All units are metric and in metres unless otherwise specified
   Transverse Mercator Projection, NAD 1983, Zone 14
   Elevations are in metres above sea level (MSL)

DRAFT

50 0 50 100 150 200

Metres

SCALE: 1:5,000 METRIC 11"x17"

NO.	YY/MM/DD	DESCRIPTION	BY
B	15/01/08	ISSUED WITH DRAFT REPORT	PAL
A	14/10/17	ISSUED WITH PRELIMINARY DRAFT REPORT	PAL

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Manitoba INFRASTRUCTURE AND TRANSPORTATION

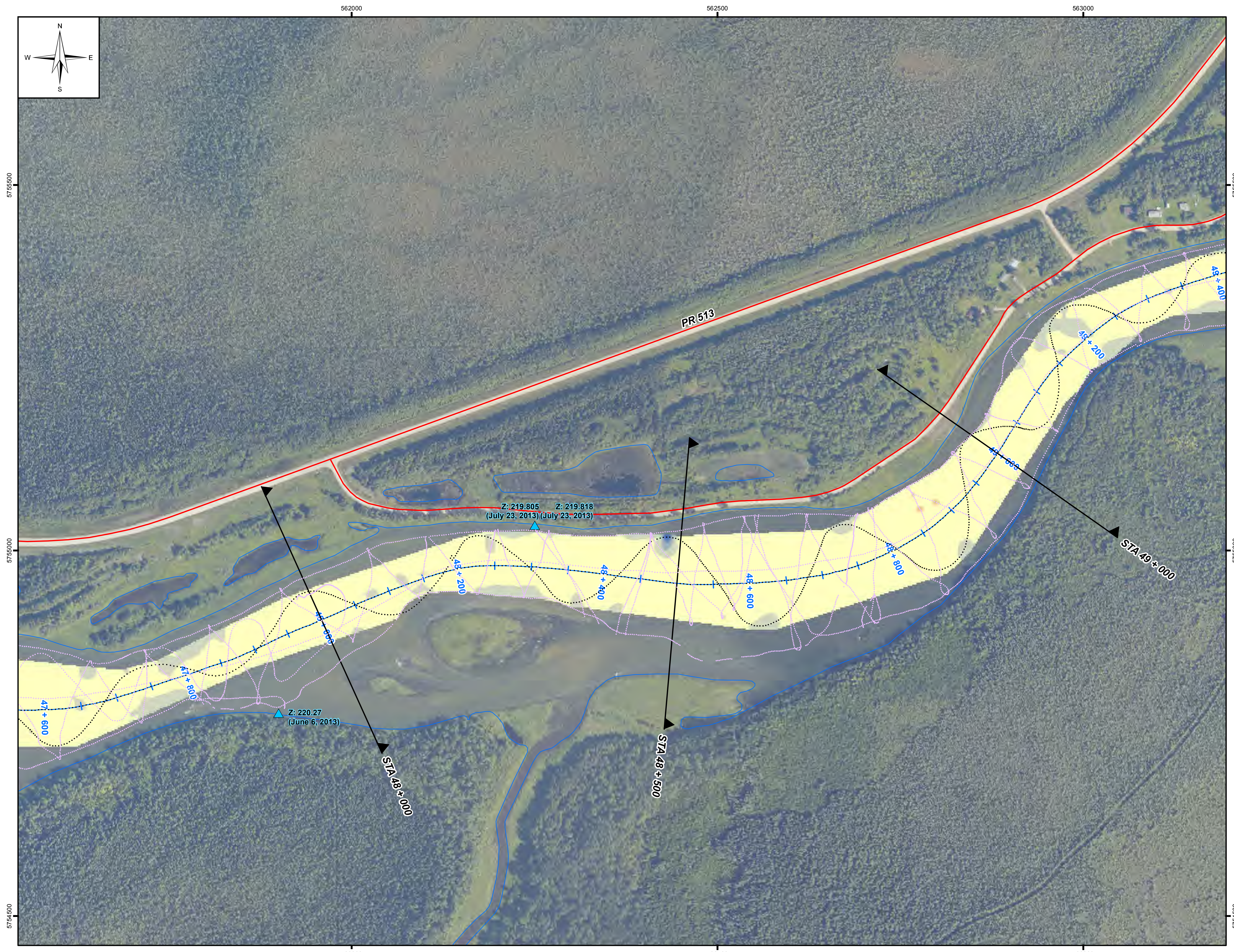
LSM EMERGENCY RELIEF CHANNEL MONITORING & DEVELOPMENT OF HABITAT COMPENSATION

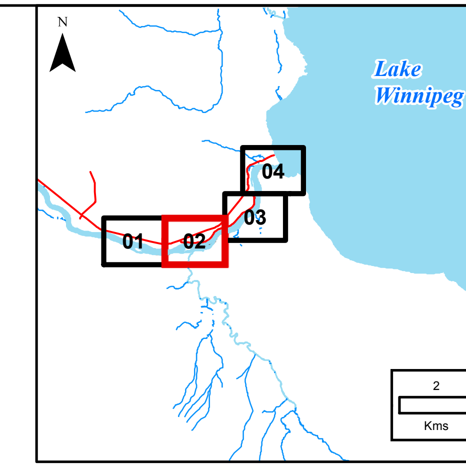
LOWER DAUPHIN RIVER BATHYMETRY DIFFERENCES OF 2011 TO 2013

JANUARY 2015 | DRAWING 15.01 | REV: B

FileName: P:\Projects\2013\13-0431-001\Dwg\GIS\MXDs\RevB\Physical_Process_Report_2014\13-0431-001_Fig15_RevB.mxd

11"x17" PLOT SCALE 1:1





LEGEND:

2013 Sonar Point
2011 Sonar Point
Water Level (June 5–7th, July 22–23, 2012)
Survey Control 2011 (See Note 3 Below)
X–Section
Dauphin River Centreline

TRANSPORTATION

Gravel Road
Trail
Edge of Water (LiDAR)

From 2011 to 2013

Elevation Variation (m)

- < −2
- −2.0 – −1.5
- −1.5 – −1.0
- −1.0 – −0.5
- −0.5 – 0.5
- 0.5 – 1.0
- 1.0 – 1.5
- 1.5 – 2.0
- > 2.0

* SEE NOTE 1 FOR EXPLANATION

NOTES:

1. Negative elevation values indicates erosion and positive indicates deposition.
2. 2011 Sonar completed by KGS Group on June 29 – July 2, 2011.
   2013 Sonar completed by KGS Group on June 5–7, and July 22–23, 2013.
3. 2013 Control is outside map extents. Please see Figure 10.01–10.03 for 2013 Control.
4. Satelite image provided by Atlis Geomatics, July 2011
5. Original ground surface based on LiDAR provided by Atlis Geomatics (June/July 2011)
6. All units are metric and in metres unless otherwise specified
   Transverse Mercator Projection, NAD 1983, Zone 14
   Elevations are in metres above sea level (MSL)

DRAFT

50 0 50 100 150 200

Metres

SCALE: 1:5,000 METRIC 11"x17"

NO.	YY/MM/DD	DESCRIPTION	BY
B	15/01/08	ISSUED WITH DRAFT REPORT	PAL
A	14/10/17	ISSUED WITH PRELIMINARY DRAFT REPORT	PAL

REVISIONS / ISSUE

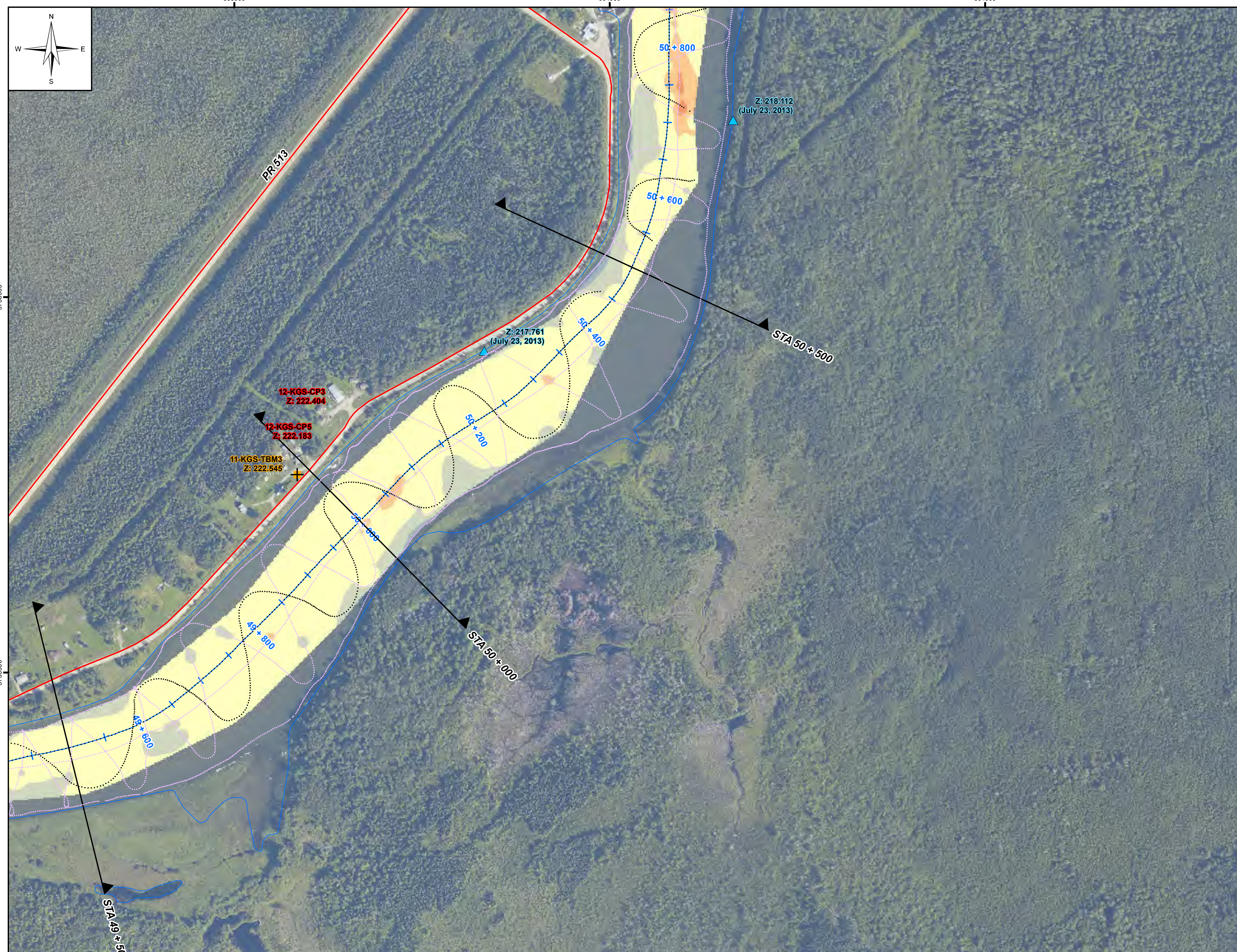
Manitoba INFRASTRUCTURE AND TRANSPORTATION

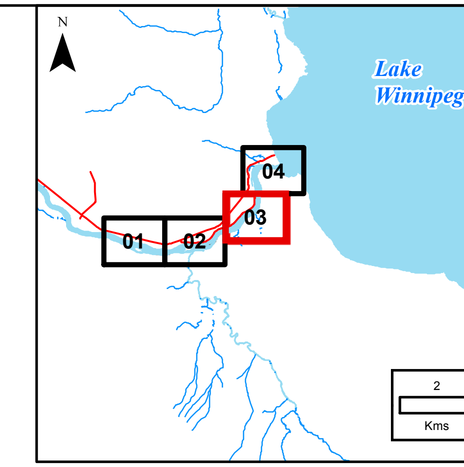
LSM EMERGENCY RELIEF CHANNEL MONITORING & DEVELOPMENT OF HABITAT COMPENSATION

LOWER DAUPHIN RIVER BATHYMETRY DIFFERENCES OF 2011 TO 2013

JANUARY 2015 | DRAWING 15.02 | REV: B

FileName: P:\Projects\2013\13-0431-001\Dwg\GIS\MXDs\RevB\Physical_Process_Report_2014\13-0431-001_Fig15_RevB.mxd
11"x17" PLOT SCALE 1:1





LEGEND:

- 2013 Sonar Point
- 2011 Sonar Point
- Water Level (June 5–7th, July 22–23, 2012)
- Survey Control 2011 (See Note 3 Below)
- X–Section
- Dauphin River Centreline

TRANSPORTATION

- Gravel Road
- Trail
- Edge of Water (LiDAR)

From 2011 to 2013
Elevation Variation (m)

- < −2
- −2.0 – −1.5
- −1.5 – −1.0
- −1.0 – −0.5
- −0.5 – 0.5
- 0.5 – 1.0
- 1.0 – 1.5
- 1.5 – 2.0
- > 2.0

* SEE NOTE 1 FOR EXPLANATION

NOTES:

1. Negative elevation values indicates erosion and positive indicates deposition.
2. 2011 Sonar completed by KGS Group on June 29 – July 2, 2011.
   2013 Sonar completed by KGS Group on June 5–7, and July 22–23, 2013.
3. 2013 Control is outside map extents. Please see Figure 10.01–10.03 for 2013 Control.
4. Satellite image provided by Atlis Geomatics, July 2011
5. Original ground surface based on LiDAR provided by Atlis Geomatics (June/July 2011)
6. All units are metric and in metres unless otherwise specified
   Transverse Mercator Projection, NAD 1983, Zone 14
   Elevations are in metres above sea level (MSL)

DRAFT

50 0 50 100 150 200
Metres

SCALE: 1:5,000 METRIC 11"x17"

NO.	YY/MM/DD	DESCRIPTION	BY
B	15/01/08	ISSUED WITH DRAFT REPORT	PAL
A	14/10/17	ISSUED WITH PRELIMINARY DRAFT REPORT	PAL

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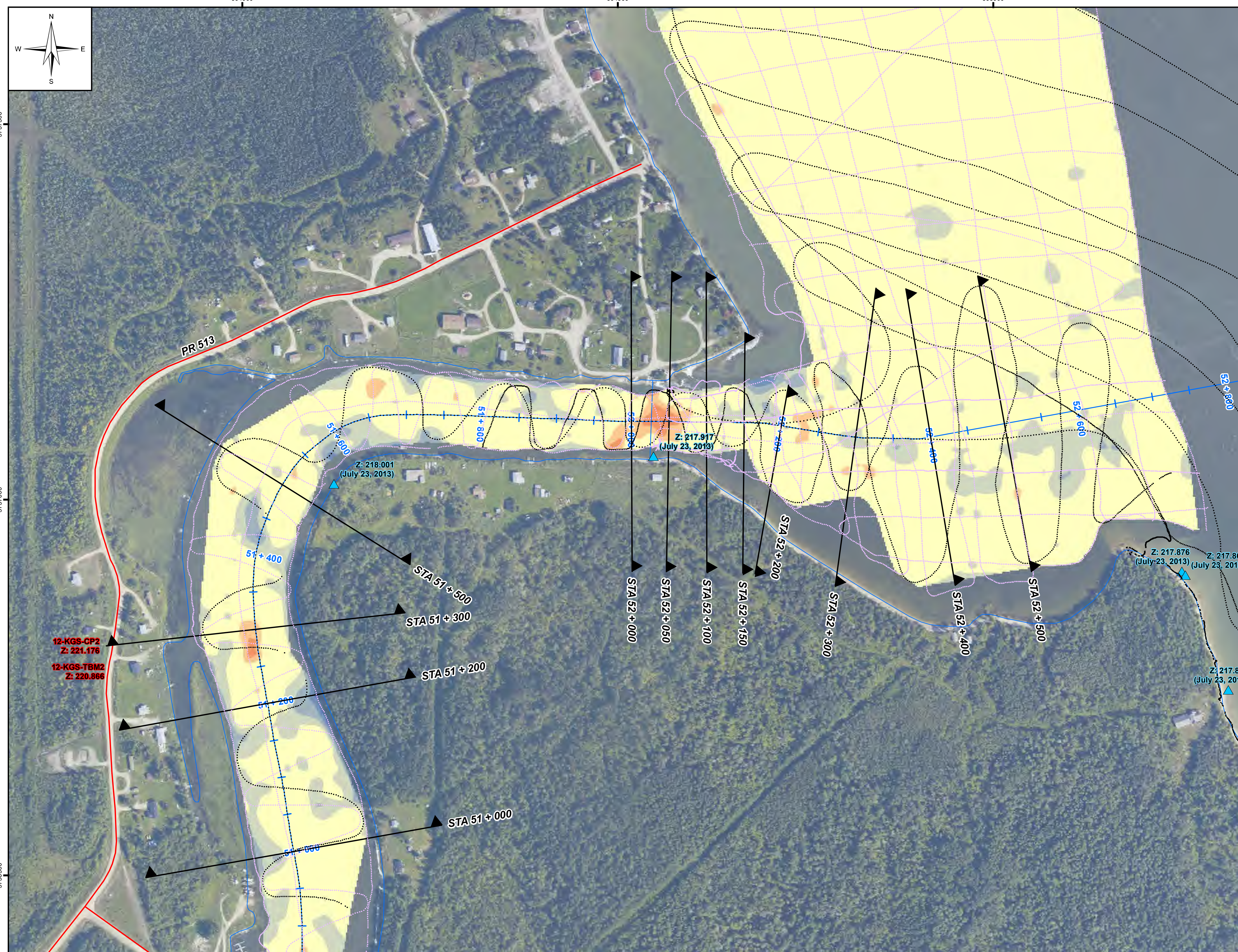
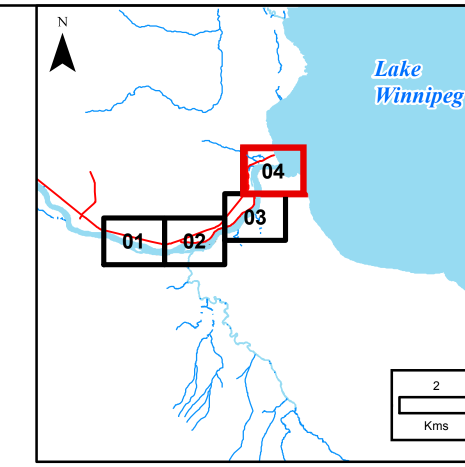
LSM EMERGENCY RELIEF CHANNEL MONITORING & DEVELOPMENT OF HABITAT COMPENSATION

LOWER DAUPHIN RIVER BATHYMETRY DIFFERENCES OF 2011 TO 2013

JANUARY 2015 | DRAWING 15.03 | REV: B

FileName: P:\Projects\2013\13-0431-001\Dwg\GIS\MXDs\RevB\Physical_Process_Report_2014\13-0431-001_Fig15_RevB.mxd
11"x17" PLOT SCALE 1:1





LEGEND:

- 2013 Sonar Point
- 2011 Sonar Point
- Water Level (June 5–7th, July 22–23, 2012)
- Survey Control 2011 (See Note 3 Below)
- X–Section
- Dauphin River Centreline

TRANSPORTATION

- Gravel Road
- Trail
- Edge of Water (LiDAR)

From 2011 to 2013

Elevation Variation (m)

- < −2
- −2.0 – −1.5
- −1.5 – −1.0
- −1.0 – −0.5
- −0.5 – 0.5
- 0.5 – 1.0
- 1.0 – 1.5
- 1.5 – 2.0
- > 2.0

* SEE NOTE 1 FOR EXPLANATION

NOTES:

1. Negative elevation values indicates erosion and positive indicates deposition.
2. 2011 Sonar completed by KGS Group on June 29 – July 2, 2011.
   2013 Sonar completed by KGS Group on June 5–7, and July 22–23, 2013.
3. 2013 Control is outside map extents. Please see Figure 10.01–10.03 for 2013 Control.
4. Satelite image provided by Atlis Geomatics, July 2011
5. Original ground surface based on LiDAR provided by Atlis Geomatics (June/July 2011)
6. All units are metric and in metres unless otherwise specified
   Transverse Mercator Projection, NAD 1983, Zone 14
   Elevations are in metres above sea level (MSL)

DRAFT

50 0 50 100 150 200

Metres

SCALE: 1:5,000 METRIC 11"x17"

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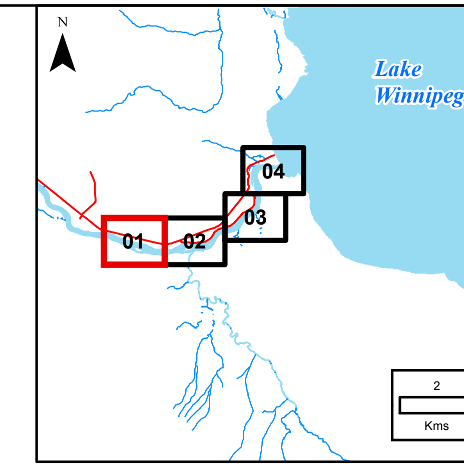
LOWER DAUPHIN RIVER BATHYMETRY DIFFERENCES OF 2011 TO 2013

JANUARY 2015 DRAWING 15.04 REV: B

FileName: P:\Projects\2013\13-0431-001\Dwg\GIS\MXDs\RevB\Physical_Process_Report_2014\13-0431-001_Fig15_RevB.mxd
11"x17" PLOT SCALE 1:1



LEGEND:

- 2014 Sonar Point
- 2013 Sonar Point
- Water Level (June 17–21, 2014)
- X–Section
- Dauphin River Centreline

TRANSPORTATION

- Gravel Road
- Trail
- Edge of Water (LiDAR)

From 2013 to 2014

Elevation Variation (m)

- < −2
- −2.0 – −1.5
- −1.5 – −1
- −1.0 – −0.5
- −0.5 – 0.5
- 0.5 – 1.0
- 1.0 – 1.5
- 1.5 – 2.0
- > 2.0

* SEE NOTE 1 FOR EXPLANATION

NOTES:

1. Negative elevation values indicates erosion and positive indicates deposition.
2. 2013 Sonar completed by KGS Group on June 5–7th, and July 22–23, 2013. 2014 Sonar completed by KGS Group on June 17–21, 2014.
3. 2013 & 2014 are outside map extents. Please see Figure 10.01–10.03 for control.
4. Satellite image provided by Atlis Geomatics, July 2011
5. Original ground surface based on LiDAR provided by Atlis Geomatics (June/July 2011)
6. All units are metric and in metres unless otherwise specified
   Transverse Mercator Projection, NAD 1983, Zone 14
   Elevations are in metres above sea level (MSL)

DRAFT

50 0 50 100 150 200

Metres

SCALE: 1:5,000 METRIC 11"x17"

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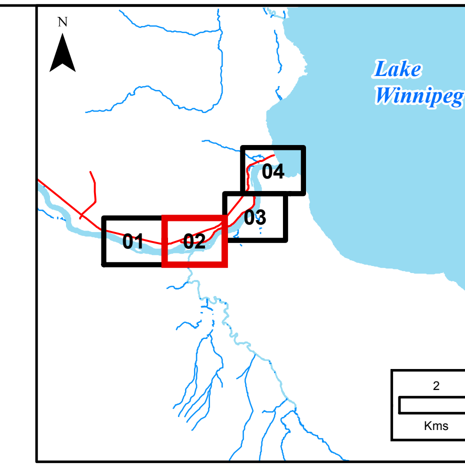
LOWER DAUPHIN RIVER BATHYMETRY DIFFERENCES OF 2013 TO 2014

JANUARY 2015 | DRAWING 16.01 | REV. B

FileName: P:\Projects\2013\13-0431-001\Dwg\GIS\MXDs\RevB\Physical_Process_Report_2014\13-0431-001_Fig16_RevB.mxd

11"x17" PLOT SCALE 1:1



LEGEND:

· 2014 Sonar Point	From 2013 to 2014 Elevation Variation (m)	
· 2013 Sonar Point		
Water Level (June 17–21, 2014)		< −2
X–Section		−2.0 − −1.5
Dauphin River Centreline		−1.5 − −1
TRANSPORTATION		−1.0 − −0.5
Gravel Road		−0.5 − 0.5
Trail		0.5 − 1.0
Edge of Water (LiDAR)		1.0 − 1.5
		1.5 − 2.0
		> 2.0

* SEE NOTE 1 FOR EXPLANATION

NOTES:

1. Negative elevation values indicates erosion and positive indicates deposition.
2. 2013 Sonar completed by KGS Group on June 5–7th, and July 22–23, 2013. 2014 Sonar completed by KGS Group on June 17–21, 2014.
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   Transverse Mercator Projection, NAD 1983, Zone 14
   Elevations are in metres above sea level (MSL)

DRAFT

50 0 50 100 150 200

Metres

SCALE: 1:5,000 METRIC 11"x17"

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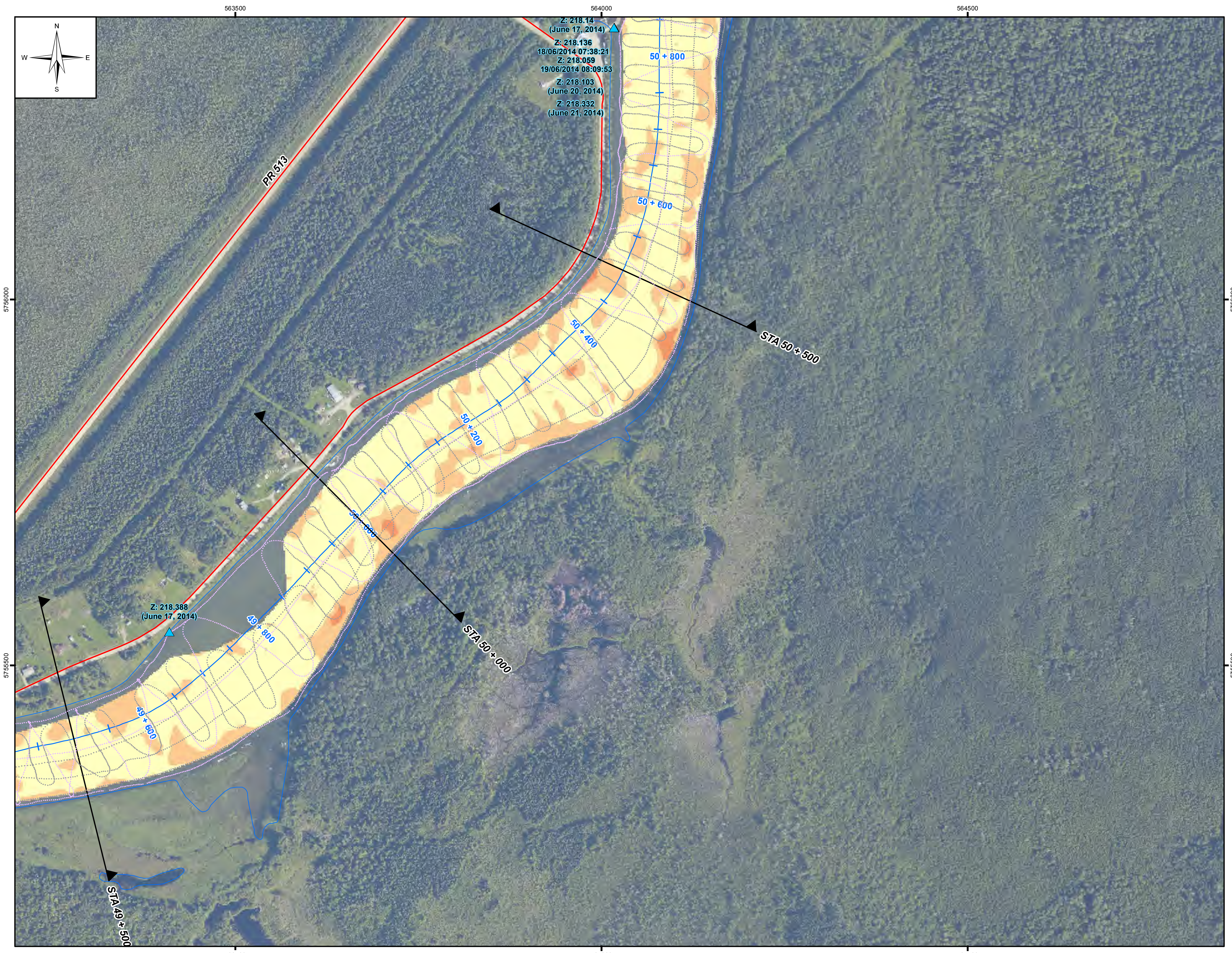
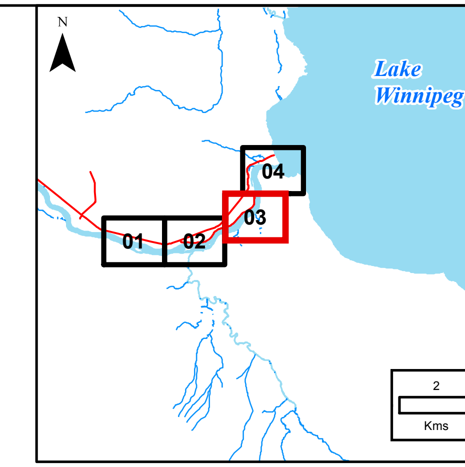
LSM EMERGENCY RELIEF CHANNEL MONITORING & DEVELOPMENT OF HABITAT COMPENSATION

LOWER DAUPHIN RIVER BATHYMETRY DIFFERENCES OF 2013 TO 2014

JANUARY 2015 | DRAWING 16.02 | REV: B





LEGEND:

- 2014 Sonar Point
- 2013 Sonar Point
- Water Level (June 17–21, 2014)
- X–Section
- Dauphin River Centreline

TRANSPORTATION

- Gravel Road
- Trail
- Edge of Water (LiDAR)

From 2013 to 2014

Elevation Variation (m)

- < −2
- −2.0 − −1.5
- −1.5 − −1
- −1.0 − −0.5
- −0.5 − 0.5
- 0.5 − 1.0
- 1.0 − 1.5
- 1.5 − 2.0
- > 2.0

* SEE NOTE 1 FOR EXPLANATION

NOTES:

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DRAFT

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Metres

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LSM EMERGENCY RELIEF CHANNEL MONITORING & DEVELOPMENT OF HABITAT COMPENSATION

LOWER DAUPHIN RIVER BATHYMETRY DIFFERENCES OF 2013 TO 2014

JANUARY 2015 | DRAWING 16.03 | REV. B

FileName: P:\Projects\2013\13-0431-001\Dwg\GIS\MXDs\RevB\Physical_Process_Report_2014\13-0431-001_Fig16_RevB.mxd
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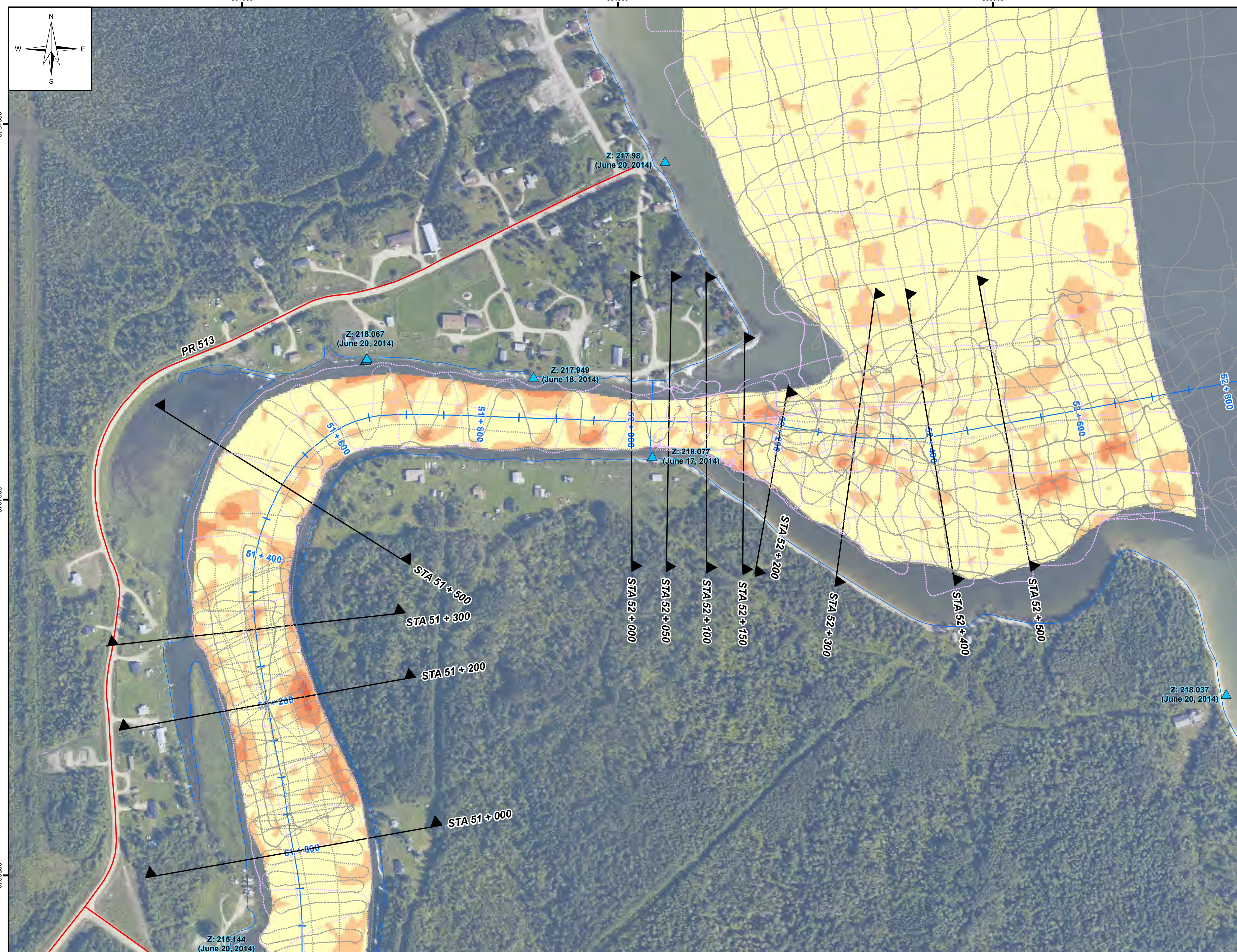

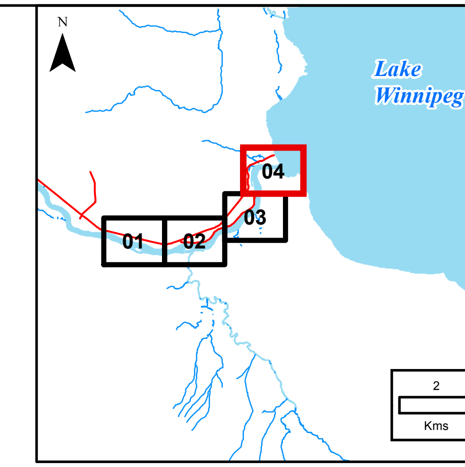

LEGEND:

- 2014 Sonar Point
- 2013 Sonar Point
- Water Level (June 17–21, 2014)
- X–Section
- Dauphin River Centreline

TRANSPORTATION

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From 2013 to 2014

Elevation Variation (m)

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LOWER DAUPHIN RIVER BATHYMETRY DIFFERENCES OF 2013 TO 2014

JANUARY 2015 | DRAWING 16.04 | REV. B

FileName: P:\Projects\2013\13-0431-001\Dwg\GIS\MXDs\RevB\Physical_Process_Report_2014\13-0431-001_Fig16_RevB.mxd
11"x17" PLOT SCALE 1:1