# Peace River Project Water Use Plan

## Peace River Side Channel Monitoring

## Implementation Year 1

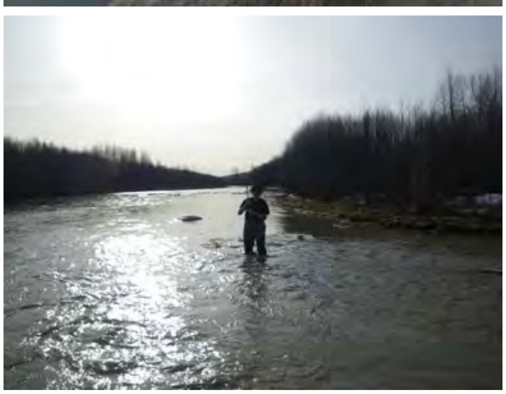
## Reference: GMSMON-7

**Main body of report. Appendices are listed separately.**

**Study Period: 2013**

**NHC and Mainstream Aquatics Ltd.**

**January 20, 2014**



# GMSMON-7 PEACE RIVER SIDE CHANNEL MONITORING 2013 STUDY

BC hydro

BC Hydro
6911 Southpoint Drive
Burnaby, BC

Final Report
2014 January 20

nhc
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AQUATICS LTD

# GMSMON-7
# PEACE RIVER SIDE CHANNEL MONITORING
# - 2013 STUDY -

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# EXECUTIVE SUMMARY

For over 40 years the W.A.C. Bennett Dam (along with GMS power station) and Peace Canyon Dam (PCN) have regulated downstream flow while generating power for British Columbia. Regulation of the Peace River has reduced the mean annual flood by approximately 70%, increased the winter flows, reduced daily variability, and increased diurnal variability. The reduction of the frequency and magnitude of large flood flows has resulted in a loss of side channel fish habit due to sedimentation of fines and vegetation encroachment. Two alternatives to increasing base flows were identified to potentially mitigate these effects; that is the use of spill events to potentially flush and restore side channel habitats and physical works to restore side channel habitats.

The Water Use Plan Consultative Committee (WUP CC) recognized the loss of side channel habitat and has set out a number of monitoring and works programs to address the loss. GMSMON-7 is one of the monitoring programs, tasked to address the following 3 questions:

1. What is the response of side channel water level to fluctuations in Peace River discharge?
2. What physical processes are occurring in the beds of side channels of the Peace River and is there a trend over time?
3. Which fish species and fish life stages are using the side channels of the Peace River and are changes occurring over time?

This report documents GMSMON-7 for 2013, the current and inaugural year. As the first year of the study, the goal is to collect baseline data and to provide recommendations for future monitoring.

Two test side channel sites 32L and 102.5R, selected for future improvement works, and two control side channels 40L and 112.5L were studied. Northwest Hydraulic Consultants Ltd. (NHC) and Mainstream Aquatics Ltd. began the study for BC Hydro July of 2013. However, NHC started instrumentation and data collection of physical data under a previous project in April of 2013.

Data collection during the first year of study included:

- Surveying the entrance of the side channels.
- Characterising the substrate.
- Installing pressure transducers to record water level within each of the side channels.
- Collecting flow measurements to develop stage-discharge rating curves for each side channel.
- Collecting water quality data at each side channel including temperature, pH, conductivity, dissolved oxygen, water clarity, and turbidity.

- Characterisation of side channel habitat with respect to Flat, Riffle, and Run habitat as well as depth, velocity, substrate class, substrate embeddedness, substrate compaction, and side channel cover.
- Collection of fish abundance with respect to species and life stage.

During the sampled period of first year of study, flow was not recorded in the test channels, but was recorded in the control channels. Water levels within the side channels mimicked the daily fluctuation of the mainstem; however, often with a reduced rate and magnitude. Side channels less connected with the mainstem - such as pool within the 32L test site - experienced the greatest dampening of water level variability. The lack of flow seen by the two test sites correlate with condition of their substrate; that is vegetated fine substrate (silt, clay, organics, and sand). The control sites were activated daily and although the banks were generally fine material, the bed was coarser ranging from gravel to cobble.

The purpose of the 2013 program was to collect information that described the fish habitat and fish community in each of the four side channels. To this end the 2013 fish and fish habitat component was successful. Fish habitats in all side channels were dominated by the Flat habitat type with small amounts of Riffle and/or Run habitat types, both in terms of number of units and surface area. Several of these habitats had the potential to dewater at minimum PCN Dam operational flows. All habitats were influenced by water level fluctuations/water flow, which resulted in frequent changes to water depth and velocity. Suspended sediments and sedimentation influenced water quality and substrate. Fines (clays, silts, and sands) were a dominant component of side channel substrate and rock substrates that were present were strongly influenced by sedimentation (i.e. high embeddedness and compaction).

Side channel fish communities recorded by the present study were consistent with findings by previous investigations. The 2013 results are sufficient to document future changes to fish species/life stage presence or absence, at least for the numerically abundant species.

The side channel fish community consisted of up to 16 species, with the numerically dominant species/life stage for all side channels, in each fish group as:

- Sportfish: young-of-the-year Mountain Whitefish
- Suckers: young-of-the-year unidentified sucker species
- Minnows: Redside Shiner (all life stages).

Sculpins were not numerous in any side channel. The juvenile life stage of all three sucker species (Longnose Sucker, Largescale Sucker, and White Sucker) were well represented in most side channels. In Side Channels 102.5R and 112L, Spottail Shiner, Longnose Dace, and Trout-perch also were present. Although documented by previous studies, the current study did not identify Kokanee or Bull Trout. Otherwise the findings for fish habitat and fish community were consistent with previous studies.

Fish species relative abundance was highly variable in 2013, caused by one or more factors that include clumped distribution of fish, variable sampling conditions, and insufficient sample sizes. The Peace River Fish Index Program (GMSMON-2) has addressed the issue of variable large fish catch rates with some success by standardizing fish collection methods, stratifying by habitat type, and maximizing sample sizes (see P&E 2002). The 2013 program adopted this strategy; however, the results highlighted two primary issues - variable sample conditions and limited sample sizes.

Although 2013 results are sufficient to document future changes to fish species/life stage presence or absence, at least for the numerically abundant species; low precision around catch rate estimates will hinder the ability to identify a change when one occurs, limiting the confidence in the programs ability to answer this key management question.

The following recommendations are proposed as part of the continued monitoring on physical characteristics of the Peace River side channels:

- Continue to work with other side channel monitoring programs to maximize data value and study efficiencies. This should include a workshop prior to the 2014 program that would be used to disseminate information, refine the goals of each program, and coordinate field activities.
- Continue monitoring stage (minimum of twice per year) and (discharge a minimum of five times per year) at all sites.
- Deploy Leveloggers, collect flow measurements, and collect geomorphic baseline data (survey and substrate) in test side channels following their construction.
- Insufficient flow measurements have been collected at control side channel 112.5L. Additional attempts should be made to collect flow measurements and develop a rating curve for higher water levels which will require additional site visits as high flows are targeted instead of the low flows required for Levelogger maintenance.
- The upstream Levelogger at 32L failed by 2013 August. Program budget and field crew should be prepared to accommodate potential failures of equipment.
- Suspended sediment and sedimentation appear to substantially influence the value and use of existing side channel fish habitats. Turbidity data loggers and expanded point measurements of water quality should be incorporated in the study to better capture these effects.
- The precision of catch rate estimates should be improved by increasing quantity of sampling (number of sample sites or repeated samples) or by:

    i) Ensuring sampling is done during similar season, condition, and operational flow in subsequent years.

ii) Stratifying sampling by habitat type.

iii) Focus fish collection on beach seine sampling.

iv) Focus sampling and analytical efforts on most numerous fish groups, such as: sportfish (young-of-the-year Mountain Whitefish), suckers (young-of-the-year sucker species), and minnows (Redside Shiner).

These recommendations are intended to fill data gaps of the current study, improve the precision of data, and maintain continuity with previous studies, thus improving the ability to address the key management questions.

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# CREDITS AND ACKNOWLEDGEMENTS

This report was co-authored by Mainstream Aquatics Ltd. and Northwest Hydraulic Consultants Ltd. The authors would like to thank Michael McArthur of BC Hydro for initiating the study and for providing valuable comments during the study. The authors would also like to thank personnel of Diversified Environmental Services and Ecoscape Environmental Consultants for assisting during the field program. Ecoscape Environmental Consultants provided water temperature data collected during their 2013 Peace River Side Channel Productivity Study (GMSMON-5).

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# CITATION

NHC and Mainstream Aquatics Ltd. 2014. GMSMON-7 Peace River Side Channel Response, 2013 Study. Prepared for BC Hydro. 2014 January 20.

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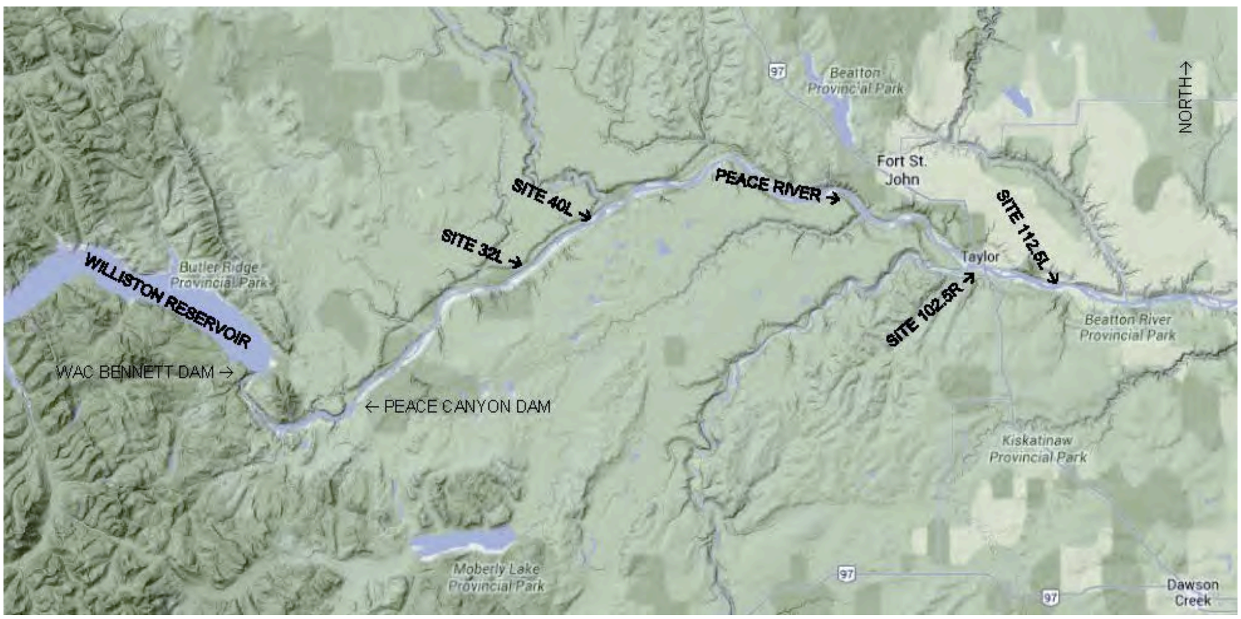
# 1 INTRODUCTION

## 1.1 Setting

The Peace River, with its headwaters in northeastern British Columbia (BC), cuts through the Rocky Mountains and crosses the BC-Alberta border where it combines with the Slave River and then with the Mackenzie River at Great Slave Lake before reaching the Beaufort Sea and Arctic Ocean. A series of dams and power stations were constructed and are operated by BC Hydro and Power Authority (BC Hydro) in northeastern BC. The W.A.C. Bennett Dam was constructed at the head of the Peace River Canyon in 1967. Flow from the upstream reservoir – Williston Reservoir – generates electricity at the underground power house of the Gordon M. Shrum power station (GMS). Peace Canyon Dam (PCN) - 14 km downstream of W.A.C. Bennett Dam - and the associated Dinosaur Reservoir provide no active storage, with water released from GMS also used for generation at PCN (**Figure 1**).

**Figure 1. Overview map of study reach**




*Base map from Google Maps ©2014*

## 1.2 Effects of Flow Regulation on Side Channels

Regulation of the Peace River (PCR) has resulted in changes to flow, specifically the timing and magnitude of annual (and larger) floods, and the transport of sediment (Church 2005). Changes include a reduction in the mean annual flood by approximately 70%, an increase in winter flows for power generation and ice control, reduced daily variability in seasonal flows (30-50%), and increased variability throughout each day. The current operational flow regime does not possess the stream power required to move the pre-existing bed sediments consisting of gravels and cobbles. Fine sediments and suspended loads are carried downstream of the Pine River by the current flow regime.

Long term storage provided by Williston Reservoir and regulation of the Peace River has impacted side channel habitat by reducing large flood flows that control vegetation establishment and transport fine sediments from the secondary channels along the mainstem (Church 1995, 2005). Similar impacts have been observed on the Nechako River above Fort Fraser (Rood and Neill 1987) where river regulation has reduced both the number and area of side or secondary channels. NHC *et al*. (2010) identifies a number of factors that lead to side channel morphological changes.

The regulated flow regime reduces natural water levels that would occur during the spring and summer, decreasing both the wetted area and side channel connectivity to the mainstem river, altering access to and value of fish habitat. These changes in concert with morphological and water quality changes have caused fish community changes in PCR above the Pine River.

## 1.3 Background

The Peace River Water Use Plan Consultative Committee (WUP CC) recognized that the changes in river morphology due to reduced peak flows were creating loss and continued degradation of fish habitat in side channels. Two alternatives to increasing base flows were identified to potentially mitigate these effects. That is,

1. The use of controlled and uncontrolled spill events to potentially restore side channel function and value (WUP's Flood Pulse Management Plan).
2. Restoration or further development of side channels to improve habitat under the present flow regime (WUP's Side Channel Management Plan).

The WUP set out a set of monitoring and work programs intended to address the loss of side channel habitat through these two strategies.

The Peace Spill Protocol (PSP) is an opportunistic group of studies initiated to quantify environmental effects of a spill; this includes geomorphic and substrate monitoring (GMSMON-8 PCR Side Channel Response) and side channel fisheries monitoring (GMSMON-7 PCR Side Channel Fisheries) as well as a range of other studies prior to, during, and following a spill (GMSMON-3 PCR Fish Stranding, GMSMON-4 W.A.C. Bennett Dam Entrainment Study, GMSMON-6 PCR Riparian Flooding, GMSMON-9 PCR Spill Hydrology, GMSMON-10 PCR Spill Photos, GMSMON-11 PCR Spill TGP/Temp, GMSMON-12 PCR Wildlife Survey, and GMSMON-13 Williston Fish Index).

The Peace River Side Channel Plan was initiated to improve fish habitat in selected side channels through physical works (GMSWORKS-3 PCR Trial Side Channels). In 2010, permanently open, ephemerally open, and closed ended side channels were classified along the Peace River between Hudson's Hope and Taylor (NHC *et al*. 2010). Potential physical works to improve access to and value of side channel habitat were identified, conceptualised, and prioritised. In 2013 two side channels projects, Site 32L and 102.5R were further developed with the production of plans and specifications in preparation for construction (NHC, 2013a and 2013b). Construction of 102.5R is expected to occur in 2014.

The Peace River Side Channel Fisheries Monitoring Program (GMSMON-7) was initiated in 2013. The program is guided by specific goals and builds upon the 2012 work (GMSMON-8) conducted by NHC and Mainstream (2013) for BC Hydro.

### 1.3.1 Management Questions

The WUP Consultative Committee proposed several key management questions to be answered with respect to each monitoring and works program. The questions to be addressed by the GMSMON-7 program are:

4. What is the response of side channel stage to fluctuations in discharge?

   *This question although partially answered through past numerical modelling of the Peace River (GMSWORKS-5), which allowed the simulation of steady flow and unsteady flow events, is to be further addressed through local site surveys, and on-going measurement of side channel stage and local flow in comparison to main channel flow.*

5. What physical processes are occurring in the beds of side channels of the Peace River and is there a trend over time?

   *From past assessment of side channel response along the Peace River conducted by NHC; there appears to have been deposition of silt lenses across many side channels. Although subsequent spill flows of substantial magnitude and duration (such as 2012 spill) is often adequate to remove such a silt lens, continued encroachment and maturation of vegetation across deposited silt reduced the effectiveness of such a spill remobilizing the sediment and side channels continue to narrow and or dry over time.*

   *The present GMSMON-7 work provides a record of the current state of the control and test side channels through both survey and substrate classification. Repetition of the study in future years will allow comparison of data and identification of any trends.*

6. Which fish species and fish life stages are using the side channels of the Peace River and are changes occurring over time?

   *Although past and on-going studies (i.e. GMSMON-5) are improving the knowledge of fish species and life stage in the river, GMSMON-7 is to further determine:*

   a. *The abundance and spatial distribution of fish within side channels with particular emphasis on small fish (defined as ≤ 200 mm length).*

   b. *The size structure, life stage composition, and health of species populations.*

### 1.3.2 Primary Hypotheses

The Fisheries Technical Committee developed detailed hypotheses regarding fisheries, ecological, geomorphic and wildlife impacts. This monitor specifically addresses fish, fish communities and side channel geomorphology, primarily through the following hypotheses:

- Hypotheses $H_1$: Morphology of side channels is:

  $H_{1a}$: changing over time;
  $H_{1b}$: changing more in trial sites[1] than control sites

- Hypotheses $H_2$: Bed material armouring in side channels is:

  $H_{1a}$: changing over time;
  $H_{1b}$: changing more in trial sites than control sites

- Hypotheses $H_3$: The relative abundance of fish species, age/size class structure, fish numbers, and species present in side channels is:

  $H_{3a}$: changing over time;
  $H_{3b}$: changing more in trial sites than control sites

## 1.4 Purpose and Objectives

The purpose of the Peace River Side Channel Fisheries Monitoring Program is two-fold. The first is to collect baseline data on flow, fish use, and substrate from selected side channels in order to document change caused by normal operational flows. The second is to assess response of selected side channels to improvement caused by physical works and to spill events.

The purpose of the 2013 Peace River Side Channel Fisheries Monitoring Program is limited to the collection of baseline data and, as the initial year of data collection, the study is also to provide recommendations for future monitoring. The study is based on the following objectives:

1. Establish bench mark controls and conduct cross-section surveys to characterize existing morphology and substrate texture of each side channel.
2. Install integrated stage and pressure data loggers to measure water level with the intent to develop a stage-discharge curve for each side channel.
3. Collect information that describes fish and fish habitat in each side channel.
4. Coordinate, and share collected data, with other active monitoring programs in order maximize efficiencies and data value.
5. Summarize the collected information and provide recommendations for future monitoring in a concise report.

[1] also referred to as test side channels

## 1.5 Study Area

The study area is the Peace River downstream from the Peace Canyon Dam (**Figure 1** and **Figure 15**). Four side channels were monitored. These include two targeted for future restoration under the Peace River Side Channel Plan:

- 32L located 9.5 km upstream of the Halfway River (**Figure 16**) ; and,
- 102.5R located immediately downstream of the Pine River confluence (**Figure 17**).

The two remaining two side channels will serve as controls for the side channels targeted for restoration. They are as follows:

- 40L located 2 km upstream of the Halfway River (**Figure 18**); control for 32L; and,
- 112L located 10 km downstream of the Pine River (**Figure 19**); control for 102.5R.

Side channels 40L and 112L were selected as controls based on biological, geomorphic, and flow similarities to the side channels targeted for restoration, as well as proximity to these side channels.

## 1.6 Study Period

The study period was dependent on measured parameters and the ability to initiate data collection activities. **Table 1** summarizes the timing and duration of major study components.

**Table 1 Study periods of major components.**

| Study Component/Parameter | Timing | | Duration (d) |
|---|---|---|---|
| | Start | End | |
| River stage | April 23-Aug 08 | - | ongoing |
| Bench mark controls | April 23 | April 27 | N/A |
| Channel cross-sections | April 23 | April 27 | N/A |
| Substrate texture | April 23 | August 10 | N/A |
| Water temperature[a] | July 04 | August 20 | 49 |
| Fish and fish habitat | July 30 | August 09 | 11 |

[a] Data collected by 2013 Peace River Productivity Program (GMSMON-5).

# 2 APPROACH AND METHODS

The study encompasses a range of data collection to support the monitoring objectives. NHC focused on collection and analyses of physical data pertaining to hydrology, hydraulics, substrate texture, and geomorphology. Mainstream Aquatics Ltd. focused on data collection pertaining to fish and fish habitat.

## 2.1 Quality Assurance

Quality assurance was an integral part of the work program. Steps were taken at each level of the office and field studies, data entry, data analyses, and reporting to minimize data bias and data error. Quality assurance procedures included:

1. Experienced personnel who were with familiar fish populations, and sample methods.
2. Use of standardized sampling protocols to reduce variability.
3. Use of standardized data entry forms to minimize transcription errors.
4. Use of field water quality meters calibrated at regular intervals.
5. Daily review of collected data to identify errors and inconsistencies.
6. Random checks of data during data entry.
7. Use of a standardized data storage and management system.
8. Summaries to identify outliers and atypical trends.
9. Review of materials by senior personnel.

Survey includes post processing and post correction of GPS base station data with stationary logging of 4 to 8 hours. Multiple benchmarks at each site are used to compare and verify with past and future surveys confirming repeatability and precision of equipment and methodology. NHC owns and maintains complete range of survey equipment to ensure equipment is properly maintained and configured prior to site deployment.

Substrate samples were done in consistent manner to previous substrate samples conducted under GMSMON-7 and GMSMON-8 (NHC and Mainstream Aquatics Ltd. 2013) to allow comparison of past and future substrate samples.

Water level sensors are tested at NHC's lab in static tanks prior to deployment to ensure correct operation prior to deployment. At hydrometric stations, water levels are surveyed when NHC is on site to identify any shifts or drifts in benchmarks or sensors. Discharge measurements are done in sets of two or more samples to ensure repeatability and identify any errors in equipment or implementation. NHC owns and maintains a complete range of flow measurement instrumentation, including ADCP, salt dilution, ADV, swoffer, Price meter, and pygmy meter. Application of the various measurement approaches are tested and validated against each other with duplicate field measurements throughout each field season to verify correct operation. ADV and swoffer instruments are calibrated and validated at NHC's lab and Price and pygmy metres are externally calibrated at the start of each field season or more frequently upon indication of drifting measurement.

## 2.2 Physical Data

### 2.2.1 Approach

The hypotheses to be tested suggest that the form and sediment characterization of the side channels have been changing with time. Although the test side channel improvement work may reverse some of the past undesirable changes - such as the infilling with silt - the potential reoccurrence and rate of change is to be monitored and compared with similar control channels.

### 2.2.2 Field Program

#### *2.2.2.1 Channel Morphology*

Cross sections were surveyed in each side channel to allow the monitoring of changes to channel geometry through erosion, scour, deposition, or migration of the channel. A combination of Nikon Total Station and Trimble RTK GPS survey equipment was used. Rebar markers were used to identify the ends of cross sections and each section was geo-referenced and photographed.

A minimum of two bench marks were installed near each hydrologic monitoring gauge site, with additional surveyed control points incorporated in gauge installation hardware. Benchmarks, installation hardware and logger elevations were surveyed relative to geodetic elevation.

#### *2.2.2.2 Substrate Texture*

Sediment samples were taken along surveyed cross sections in three of the four side channels. Sediment samples were not collected in Side Channel 102.5R; this test channel is densely vegetated without active substrate in its pre-excavated state[2]. Where taken samples were spread evenly along each cross section and when possible extended from active channel edge to active channel edge (the portion of the channel wetted at least every every two years) with the intent of targetting/capturing variation between the banks, bars, and channel bed. The number of sampling points was consistent for each cross-section within a side channel.

Photographs were taken for photo record and where possible to enable digital image processing determination of grain size distribution. The subject and scale of each photograph was selected with the following objectives:

1. Photographs taken perpendicular to the subject bed, bar, or bank
2. Capture examples of the largest stone size present

[2] Using the term *active* to classify channels that see flow typically at least once every 2 years (i.e. flow less than PCN spill flow (3,000 $m^3/s$)). *Active* substrate referring to substrate within an active channel and thus provided oportunity for fluvial mobilisation or deposition at flow equal or less than PCN spill flow.

3. Capture examples of the smallest grain size present and visible with the naked eye
4. Capture 100 grains
5. Have the photograph nearly if not completely filled with substrate stones
6. Photographs should be at consistent and known focal length and distant from subject and/or contain a measurable reference item

When the wetted portion of the channel along a cross section was too deep to wade safely, or too turbid for grain size to be determined, the portion of the channel not accessible was excluded and the sampling points were distributed evenly across the accessible portion of the channel. Sediment samples were collected 2013 August 8 and 9. During this time water levels were moderately low; preliminary discharge levels recorded at WSC gauge *07FA004 Peace River above Pine River* ranged from 700 to 1700 $m^3/s$ with higher flows occuring over night, so overall bed exposure of the side channels was good.

For each sediment sample location, the substrate type was noted and when possible a photograph of the substrate was taken. Vegetation frequently prevented photographing of the substrate, particularly in non-active channels such as 32L.

#### *2.2.2.3 Hydrometric Monitoring*

NHC installed and maintained eight hydrometric gauges along the four study side channels of the Peace River. Each of the hydrometric gauges used a submerged Solinst Levelogger pressure transducer ($\pm$ 0.05% accuracy)(3001 LT Levelogger Edge, M10/F30), paired with an above water Solinst Barologger pressure transducer ($\pm$ 0.05 kPa accuracy) (3001 LT Barologger Edge, M1.5/F5), to record continuous stream stage (water level) corrected for atmospheric pressure variability. When deployed under water, a Levelogger senses combined hydrostatic and atmospheric pressures. Local concurrent atmospheric pressure data, such as from a Barologger is used to correct for atmospheric pressure variability. Sampling frequency was set to record every 5 or 10 minutes to capture instantaneous peaks and to adequately capture hourly stage fluctuations.

**Table 2** lists the loggers deployed the schedule of deployment and download events that occurred in 2013. **Appendix I Site Layout and Surveys** provides plan view maps of logger location and **Appendix H Hydrometric Monitoring Site Installation and Description Sheets** provides further description of logger installations.

**Table 2 Levelogger and Barologger deployment and data download schedule, 2013.**

| Logger Name | Description | Event History |
|---|---|---|
| 32L Upstream | Peace main channel levelogger upstream of proposed channel excavation | Install: 2013 April 24<br>Download: 2013 June 10<br>Lowered: 2013 June 10<br>Malfunctioning: before 2013 Aug 08<br>Discontinued: 2013 Aug 08 |
| 32L Pool | Levelogger in pool immediately downstream of proposed channel excavation | Install: 2013 April 24<br>Download: 2013 June 10<br>Download: 2013 Aug 10 |
| 32L Downstream | Levelogger in intermittent side channel at downstream end of bar complex | Install: 2013 Aug 08 |
| 32L Barologger | Barologger, primarily for 32L and 40L | Install: 2013 April 24<br>Download: 2013 June 10<br>Download: 2013 Aug 10 |
| 40L Upstream | Levelogger at upstream end of monitoring side channel | Install: 2013 April 26<br>Download: 2013 Aug 10<br>Lowered: 2013 Aug 10 |
| 40L Downstream | Levelogger at downstream end of bar complex | Install: 2013 Aug 10 |
| 102.5R Channel | Levelogger on existing active side channel near entrance of proposed channel excavation | Install: 2013 June 11<br>Lowered: 2013 Aug 08<br>Download: 2013 Aug 10 |
| 102.5R Barologger | Barologger, primarily for 102.5R and 112.5L | Install: 2013 Jun 11<br>Download: 2013 Oct 02 |
| 112.5L Upstream | Levelogger on intermittent side channel at upstream end of bar complex | Install: 2013 June 11<br>Download: 2013 Aug 09<br>Lowered: 2013 Aug 09 |
| 112.5L Pool | Levelogger at downstream end of bar complex | Install: 2013 June 11<br>Download: 2013 Aug 09<br>Lowered + moved: 2013 Aug 09 |

Physical water level measurements were taken in reference to benchmarks during each site visit. The stage record for each gauge was examined, adjusted to geodetic elevation and compared to physical water level measurements. Drifts or shifts in the stage record were identified, and pro-rated offsets were applied to the stage record between physical water level measurements if changes in offsets were necessary. Discontinuities related to sensor download and maintenance were removed from the record. The entire stage record was then closely inspected and compared to air and water temperature records, as well as stage records from nearby sites, to ensure sensors were functioning properly and to identify any lower quality data or periods with water levels below sensor elevations. When possible, side channel water levels and discharge series were compared to main channel Peace River water levels.

Due to access restrictions caused by higher flows, many of the sensors were initially installed at elevations above the lowest expected water levels. When water levels dropped below sensor elevations, gaps occurred in the stage record. As of 2013 August 10 all sensors have been adjusted below the lowest expected water levels. While this prevents gaps in the stage record, it limits sensor access to periods of very low flows. Future logger downloads will need to be timed accordingly.

The sensors are comparatively inexpensive to purchase, however they are susceptible to damage during freezing. Installing the sensors relatively deep in the side channels reduced their likelihood of freezing. In addition, the sensors were encased in an environmental glycol solution to further reduce the chance of freezing at the sensor.

Discreet discharge measurements were calculated in three of the four side channels through either a spatially continuous measurement of sectional velocity, width, and depth using a boat mounted Teledyne RDI River Ray Acoustic Doppler Current Profiler (ADCP) or spatially segmented (typically 20 measurements) channel depth, width, and velocity measured with a handheld (i.e. wading) SonTek Flow Tracker Acoustic Doppler Velocimeter (ADV). Discharge measurements and rating curve development was limited at the sites by lack of flow, low channel gradient, and/or backwatering from the main channel. A sufficient number and range of flows were collected at two side channel locations to support the development of preliminary stage-discharge rating curves; lists of these measurements are provided in **Table 37** and **Table 39**.

### 2.2.3 Office Program

#### *2.2.3.1 Channel Morphology*

Plan and section drawings were developed using AutoCAD Civil3D to allow comparison with future surveys of the site.

#### *2.2.3.2 Substrate Texture*

As stated previously, sediment samples (photographs and/or field classification notes) were taken along the surveyed cross sections to allow repeatability of and comparison with future sample collection. For each sediment sample location, the substrate type was noted and when possible a photograph of the substrate was taken. These photographs were analyzed using digital image processing techniques to determine the grain size distribution. The analysis delineates each of the sediment grains and scales them based on a set scale bar included in each picture. Grain size distribution is a qualitative measure of surface sediment texture and its application is limited to gravel-sized sediments and greater (e.g., b-axis diameter > 2 mm). Silt and sand can frequently be identified in photographs, but the size of individual particles cannot be determined. Digital image processing is not appropriate for complicated substrates, such as materials partially wetted or covered by water, coarser material partially mantled by finer material, or material partial covered by vegetation or algae.

#### *2.2.3.3 Hydrometric Monitoring*

Aquatics Infomatics Inc. Aquarius software was used to organise, review, compare, and calculate errors for each discharge measurement and subsequently generate stage-discharge rating curves. Measurements with large error bounds or with uncertain measurement conditions were not used to develop rating curves. The preliminary rating curves were used to estimate discharge from the available stage record. It is difficult to time flow measurements with the highest and lowest flows, so rating curves were extrapolated beyond measured points. Uncertainty in the stage-discharge relation increases and is undefined beyond the measured data. Additional measurements over a broader range of flows are needed to confirm rating curve equations. Breaks in the rating curve may be present in the extrapolated portion of the curve. It is possible to estimate breakpoints between section and channel control in the field with a survey of the level, but it is preferable to establish these visually with a sufficient number of discharge measurements at high flows. Flood flow discharge measurements are not available and breakpoints between section and channel control could not be established within the gauged range of the rating curves.

## 2.3 Fish and Fish Habitat

### 2.3.1 Approach

The study component targeted small fish in side channels. Small fish (i.e. typically < 200 mm fork length) are defined as juveniles of large fish species (see Table 4 for size categories) and small fish species. Small fish were targeted because quantitative data that describes this component of the Peace River fish community are not robust and would complement the ongoing Peace River Fish Index Project (GMSMON-2), which focuses on large fish species residing in the mainstem Peace River. The sample methods used and information collected were intended to add to the existing fish database developed by the recently completed Site C baseline fish studies program and the 2012 Peace River Side Channel Response Study.

Habitat mapping completed by Mainstream *et al*. (2012) and Mainstream (2013a) established that, under typical day time operational flows, side channels selected for monitoring contained areas completely isolated from the main river that are not available to fish (i.e. isolated ponds), areas that are dewatered on a regular basis that are potentially accessible to fish, and areas that are permanently wetted and always available to fish.

The majority of fish collection sites were located in areas of each side channel that remained wetted at most Peace River flows (i.e. 350 $m^3$/s to 1500 $m^3$/s based on work by Mainstream *et al.* 2012). This strategy was used to maximize efficiencies and data value.The rationale for this strategy was as follows. Firstly, previous surveys by the recently completed Site C baseline fish studies established that areas completed isolated from the main river and that are frequently dewatered are not fish bearing or have severely limited fish communities (Mainstream 2010, 2011, 2013b). Secondly, if areas subjected to regular dewatering were wetted at the time of sampling the results would depend on the length of time available for fish dispersal into the newly wetted section, which would confound results interpretation. Thirdly, access to dewatered areas in some side channels during low flow was difficult and time consuming. Permanently wetted areas and areas subjected to dewatering were identified using habitat maps developed by the Peace River Hydraulic Habitat Study (Mainstream *et al.* 2012) or the Site C Peace River Habitat Assessment (Mainstream 2013a).

The authors acknowledge that the greatest change in fish community post enhancement will be in areas of each side channel that are, at present, frequently dewatered and that are largely non-fish bearing. These areas will become available to fish following enhancement. We assume based on existing evidence that under present conditions these areas are largely non fish-bearing, and therefore, do not warrant extensive sampling. However, to address the issue some sites were placed in areas subjected to dewatering if wetted at the time of sampling in order to establish fish presence/absence.

A range of fish collection methods were used to sample fish species and life stages expected to occur in shallow water side channel habitats. Fish collection methods, which had been field tested by previous studies (Mainstream 2010, 2011, 2013b) included small fish boat electrofisher, beach seine, and backpack electrofisher. It should be noted that these were not effective sampling methods for pelagic fish species such as Lake Whitefish and Kokanee that reside in deep water side channel habitats.

Site specific habitat characteristics were measured at fish collection sites. In addition, habitat characteristics were measured at transects that were uniformly distributed within each side channel. If the transect cross-section was wadeable at the time of sampling the full suite of habitat variables were measured (see Section 2.3.3). If not wadeable at the time of sampling, transects were traversed by boat, and only water depth and substrate characteristics were measured.

Specific aspects of the fish and habitat component approach were as follows:

1. Use of standardized fish collection protocols that adhere to RIC/RISC standards (RIC 1997, RISC 2001) and standardized fish habitat collection protocols that adhere to FHAP standards (Slaney and Johnston 1996).
2. Fish collections were stratified by habitat type.
3. A single fish collection session was completed in mid-summer (late July and early August).
4. Collection sites were identical to those previously sampled by other surveys, whenever possible.
5. Habitat maps developed by the Peace River Hydraulic Habitat Study (Mainstream *et al.* 2012) or Site C Peace River Habitat Assessment (Mainstream 2013a) were used as a basis for delineation and characterization of fish habitats.

Fish and habitat data were recorded electronically onto standardized data forms (Microsoft Excel™) using a Trimble Recon® handheld computer. Field data were visually checked for completeness and backed up daily onto two independent storage devices.

### 2.3.2 Field Program

#### *2.3.2.1 Fish Collection*

The fish collection method used was dependent on the physical characteristics of the area to be sampled. Small fish boat electrofisher was used to sample channel margins and was effective for collection of all small fish species and juvenile life stages expected to occur in this side channel region. Beach seine was used to sample wadeable areas containing fine substrates and still or low velocity water. Backpack electrofisher was used to sample wadeable areas containing rock substrates and flowing water.

**Small Fish Boat Electrofisher**

The small fish boat electrofisher consisted of a double-bowed, inflatable drift boat equipped with a Smith-Root Type VI electrofisher system, two fixed boom anodes on the bow and a cathode wire array on the stern. Electrofisher settings were maintained at an amperage output of 4.0 to 6.0 A pulsed DC current and a frequency of 120 Hz. Voltage frequency was adjusted based on conductivity and sampling effectiveness. The sampling procedure involved an operator positioning the boat perpendicular to the channel margin while drifting downstream and outputting a continuous current of electricity. The boat electrofisher position was maintained in shallow water (i.e. < 0.50 m depth) along the channel margin in order to sample shallow water habitats frequented by small-sized fish. A single netter positioned at the bow of the boat captured the temporarily immobilized fish and placed them in a 30 L live well. The netter was equipped with a net having a mesh size of 0.5 cm. The netter was instructed not to bias their catch towards a particular species in order to provide a representative sample of the fish community. Sampled length of each site consisted of a single pass of approximately 500 m.

**Backpack Electrofisher**

A Smith-Root LR24 high output backpack electrofisher was used when conditions were suitable. Settings were maintained at an output of 250 – 300 VDC, 4.3 ms, and a frequency of 120 Hz. The backpack electrofisher operator waded upstream along the channel margin and sampled suspected fish holding areas. The netter, who was positioned in close proximity to the electrofisher operator, collected immobilized fish and placed them in a holding bucket. A single pass was used at each site. Sampled length was approximately 100 m.

**Beach Seine**

The beach seine was 4.5 m wide and 1.5 m high with a stretched mesh size of 5.0 mm (the depth of the capture bag was 1.4 m). A two-person crew sampled parallel to the channel margin for a predetermined distance (usually 25 m) before turning into shore. Depending on the habitat area available, one to three discrete, sequential (i.e. in same direction) hauls were conducted with the distance of each haul being at least 25 m, where possible. Captured fish were placed in a holding bucket for processing.

**Fish Processing**

All captured fish were held in a holding tank/bucket prior to processing. Data recorded for fish included species (Table 2) and fork length (to the nearest 1 mm). Total lengths were measured for sculpin species. When the catch at a site exceeded 20 individuals per species a subsample was measured. The first 20 individuals of each species were measured, while the remaining fish were identified and enumerated before release. Very small suckers (i.e. < 20 mm) that could not be identified to species were categorized as “unidentified young-of-the-year sucker spp.”.

#### *2.3.2.2 Fish Habitat*

**Fish Collection Sites**

Habitat types at each fish collection site were classified according to O'Neil and Hildebrand (1986), which conforms to classifications described in RISC (2001). The differences included the separation of grouped habitat complexes (i.e. Riffle-Pool) into Riffle or Pool and categorizing a Fast Glide as a Run and a Slow Glide as a Flat. Fish habitat assessment procedures followed those described in RISC (2001). At each backpack electrofisher and beach seine site, physical characteristics of a discrete habitat were measured along a transect perpendicular to the length of the sampled habitat. Note that habitat specific parameters (e.g., water depth, water velocity, and D90) were not recorded at small fish boat electrofisher sites due to variable conditions present within the sampled area.

**Table 3 Nomenclature and abbreviations used for fish species potentially recorded in monitored side channels.**

| Group | Common Name | Scientific Name | Species Label |
|---|---|---|---|
| Sportfish | Bull Trout | *Salvenlinus confluentus* | BT |
| | Goldeye | *Hiodon alosoides* | GE |
| | Kokanee | *Oncorhynchus nerka* | KO |
| | Lake Trout | *Salvelinus namaycush* | LT |
| | Mountain Whitefish | *Prosopium williamsoni* | MW |
| | Northern Pike | *Esox lucius* | NP |
| | Walleye | *Sander vitreus* | WP |
| | Yellow Perch | *Perca flavescens* | YP |
| Sucker | Sucker species | *Catostomus spp.* | SUCK |
| | Largescale Sucker | *Catostomus macrocheilus* | CSU |
| | Longnose Sucker | *Catostomus catostomus* | LSU |
| | White Sucker | *Catostomus commersoni* | WSU |
| Minnow/Trout-perch | Flathead Chub | *Platygobio gracilis* | FHC |
| | Lake Chub | *Couesius plumbeus* | LKC |
| | Longnose Dace | *Rhinichthys cataractae* | LNC |
| | Northern Pikeminnow | *Ptychocheilus oregonensis* | NSC |
| | Redside Shiner | *Richardsonius balteatus* | RSC |
| | Spottail Shiner | *Notropis hudsonius* | STC |
| | Trout-perch | *Percopsis omiscomaycus* | TP |
| Sculpin | Prickly Sculpin | *Cottus asper* | CAS |
| | Slimy Sculpin | *Cottus cognatus* | CCG |

Habitat parameters measured (definitions presented in **Appendix B**) at backpack electrofisher and beach seine sites were as follows:

- Date and time
- Geodetic location
- Water temperature (± 0.1°C)
- Water conductivity (± 2% full scale
- Instream habitat type
- Bank habitat type
- Substrate type (%)
- Available fish cover (%)

- Water clarity (cm)
- Water depth (cm) and velocity (m/s)
- D90 (cm)
- Substrate embeddedness (low, moderate, high)
- Substrate compaction (low, moderate, high)

Habitat parameters measured (definitions presented in **Appendix B**) at small fish boat electrofisher sites were as follows:

- Date and time
- Upstream and downstream geodetic location
- Dominant instream habitat type
- Dominant bank habitat type
- Dominant substrate type

Water depth and water velocity were measured at ¼, ½, and ¾ the sampled width using a Swoffer Model 2100 velocity meter and staff rod. Percent substrate composition was visually estimated using a classification system based on the Modified Wentworth Scale (Cummins 1962). D90 represented the average size of substrate particle that was in the 90$^{th}$ percentile and followed procedures outlined in MOE (1995). Embeddedness is the amount of fine particles (sand, silt, and clay) present within the substrate. Compaction evaluates the density or looseness of the substrate within the channel. Compaction and embeddedness were evaluated as low (1), moderate (2), or high (3). The percent cover was visually estimated for overhead cover, rock cover, large organic debris, submergent vegetation, emergent vegetation, and terrestrial vegetation. Finally, digital photographs were taken at each site.

**Habitat Transects**

In addition, transects set perpendicular to the channel and uniformly spaced at approximately 100 m intervals were used to measure habitat characteristics of the side channel. Habitat parameters (definitions presented in **Appendix B**) measured at each transect included:

- Date and time
- Start and end geodetic location
- Instream habitat type
- Wetted width (m)
- Channel width (m)
- Substrate type (%)
- Silt depth over rock substrate (cm)
- D90 (cm)
- Substrate embeddedness (low, moderate, high)
- Substrate compaction (low, moderate, high)
- Available fish cover (%)

When excessive water depth prevented wading, measured parameters were as follows:

- Date and time
- Geodetic location of each sample point
- Instream habitat type
- Wetted width (m)
- Channel width (m)
- Substrate class (rock or rines)

Digital photographs were taken at each transect.

#### *2.3.2.3 Water Quality*

**Point Measures**

Point measures of general water quality parameters were taken at each fish collection site. Most parameters were measured during each sample event. Exceptions were measurements of clarity and turbidity, which occurred once each sample day or at the beginning and end of each sample day. A Hanna HI98311 EC/TDS meter was used to measure pH (± 0.01), conductivity (± 2% full scale), and water temperature (± 0.1$^{o}$C). Surface water dissolved oxygen concentration (± 0.1 mg/L), dissolved oxygen percent saturation (%) were measured using an Oxyguard Handy Beta dissolved oxygen-temperature meter.

Water clarity (cm) was measured using a secchi plate mounted on a pole (plate was 2.5 cm wide x 21 cm long partitioned into three equal sections of black, white, and black). Surface water turbidity level (NTU) was measured using a Hach 2100P Turbidity Meter (Range 0 – 1000; ± 1% full scale). To account for within sample variation, an average turbidity was calculated by taking three measurements from each sample. If turbidity exceeded the meter range (i.e., 1000 NTU), the sample was diluted. Turbidity samples were collected in the field and then measured at the end of each day.

**Continuous Measures**

Water temperature data were collected by Ecoscape Environmental Consultants during the 2013 Peace River Side Channel Productivity Study (Schleppe *et al. 2013*). Water temperature (± 0.5$^{o}$C) was measured at half hour intervals using HOBO pendant temperature/light data logger mounted on artificial periphyton samplers. Nine data loggers were deployed in each side channel.

#### *2.3.2.4 Sample Effort*

Attempts were made to place a minimum of three fish collection sites in each major habitat type (i.e. Flat and Riffle) using one or more of the fish collection methods. Site selection was based on the following protocols. Sites that were previously sampled by other surveys were selected first. Sites were located in habitats that were wetted at the time of sampling. New sites were spatially located to provide a uniform distribution of effort within each side channel.

Daily flow conditions at the time of sampling prevented use of some fish collection methods and reduced the habitat available for sampling. Specifically small fish boat electrofisher could not be used in Side Channel 32 L due to low water levels and Riffle habitats were restricted in all side channels, which limited use of the backpack electrofisher technique. **Table 4** summarizes the type and number of sample sites in each side channel (Appendix A provides location data for each site).

**Table 4 Type and number of sampled sites in monitored side channels.**

| Side Channel | Method Type | | | | Habitat Transects |
|---|---|---|---|---|---|
| | Backpack Electrofisher | Beach Seine | Boat Electrofisher | Total | |
| 32L | 3 | 8 | 0 | 11 | 18 |
| 40L | 2 | 6 | 5 | 13 | 12 |
| 102.5R | 0 | 8 | 6 | 14 | 16 |
| 112L | 1 | 8 | 5 | 14 | 12 |
| **Total** | 6 | 30 | 16 | 52 | 58 |

### 2.3.3 Office Program

In the office, field data were compiled visually and compared to daily field forms for errors. The data was then subjected to several summary analyses including graphical examination to identify errors and outliers. The checked data were then imported into a single Microsoft Access™ file for data management and storage. Water temperature and light data were stored in Microsoft Excel™.

Data were analyzed using Microsoft® Excel and SPSS® software. Geodetic location information (UTM coordinates) were tabulated and plotted onto base maps using MapInfo Professional™. Base maps, which depicted Peace River water levels at PCN Dam operational flow of 283 $m^3$/s, were developed by the Peace River Hydraulic Habitat Study (Mainstream *et al.* 2012) or the Site C Peace River Habitat Assessment (Mainstream 2013a).

#### *2.3.3.1 Fish*

The analyses included summaries for each side channel for the following:

- Community structure
    - Species composition
    - Life stage presence/absence
- Median length and range
- Catch rate

Life stage was examined only for large fish species i.e. (sportfish, suckers, and Northern Pikeminnow). Life stage categories included young-of-the-year, juvenile, and adult. Life stage categories were assigned to each fish based on fork length at the time of capture using protocols and age-at-length data presented in Mainstream (2010, 2011, 2013b). **Table 5** summarizes the data used for life stage category designations.

**Table 5 Life stage category designations of large-fish species based on summer fork length (mm).**

| | | Young-of-the-Year | | | Juvenile | | | Adult | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Group | Common Name | n | Median | Range | n | Median | Range | n | Median | Range |
| Sportfish | Lake Trout | 1 | 49.0 | | | | | | | |
| | Mountain Whitefish | 152 | 53.0 | 32 - 74 | | | | 7 | 293.0 | 255 - 313 |
| | Northern Pike | | | | 11 | 167.0 | 123 - 269 | 5 | 542.0 | 231 - 687 |
| | Walleye | | | | | | | 3 | 397.0 | 327 - 423 |
| | Yellow Perch | 5 | 35.0 | 34 - 45 | | | | | | |
| Sucker | Largescale Sucker | 4 | 26.5 | 21 - 32 | 49 | 62.0 | 39 - 167 | 6 | 417.0 | 360 - 471 |
| | Longnose Sucker | 1 | 35.0 | | 35 | 52.0 | 39 - 70 | | | |
| | White Sucker | | | | 31 | 58.0 | 44 - 79 | 8 | 382.5 | 257 - 448 |
| | Sucker spp. | 317 | 21.0 | 11 - 35 | 1 | 46.0 | | | | |
| Minnow | Northern Pikeminnow | | | | 9 | 62.0 | 55 - 127 | | | |

Catch rate, which is used synonymously with catch-per-unit-effort (CPUE), was calculated for each side channel by dividing the number of fish captured by sampling effort. Catch rate was expressed as follows:

- Boat electrofisher - Number of fish/km
- Backpack electrofisher - Number of fish/100 m
- Beach seine - Number fish/100 m

### *2.3.3.2 Fish Habitat*

**Temperature and Water Quality**

Point measures of water quality parameters were presented as daily averages and range. Hourly temperature data collected in the field were transferred from the temperature data loggers into Microsoft Excel™ files. After the quality assurance assessment, summary information presented for each side channel included:

- Average daily temperature
- Minimum and maximum daily temperature
- Average daily temperature range

**Habitat Characteristics**

Summary analyses of fish collection site habitat data included the following:

- Substrate composition
- Physical cover
- D90
- Substrate compaction
- Substrate embeddedness

Habitats were delineated, mapped, and the surface area quantified using collected field data and habitat base maps generated by the Peace River Hydraulic Habitat Study (Mainstream *et al.* 2012) (Side Channel 32L, 40L, and 102.5R) or by the Site C Peace River Habitat Assessment (Mainstream 2013a) (Side Channel 112L). These documents provide a detailed description of methods used to generate the habitat base maps. The following steps were used by the current study to delineate, map, and quantify habitat surface area of each side channel.

1. Fish habitats were identified using information collected at fish sites and habitat transects (see Section 2.3.1) during the field program.
2. Fish habitat type units identified in the field were delineated and mapped on digital habitat base maps, which consisted of 1:5,000 scale ortho-rectified colour air photographs. The digital habitat maps illustrated the wetted surface area of fish habitats at PCN Dam discharge of 283 $m^3$/s. This flow was selected because it represents the amount of potential fish habitat available at the typical minimum operational discharge of the facility.
3. The wetted surface area of each habitat unit was quantified and the potential availability to fish was categorized. If the habitat unit was accessible to fish (i.e. connected to the Peace River via adjacent habitat units) it was categorized as accessible. If the habitat unit was separated from adjacent habitat units by dewatered sections, then it was categorized as not accessible.

All habitat mapping and quantifications were completed using MapInfo Professional™.

# 3 RESULTS

## 3.1 Side Channel 32L

Side Channel 32L is a 2.4 km long left bank side channel located approximately 10 km downstream of Farrell Creek. It is a test site scheduled for habitat establishment and/or restoration. The upstream end of the side channel has in-filled preventing flow from entering the channel when Peace Canyon Dam discharges are less than 1500 $m^3$/s. The channel is relatively dry with occasional isolated pools, potentially maintained through subsurface flow. Flow across the upper portion of Side Channel 32L is not expected prior to the proposed channel works. The lower third of the side channel experiences flow through the side channel at higher Peace River discharge and is backwatered during low Peace River discharge.

### 3.1.1 Physical Characteristics

#### *3.1.1.1 Channel Morphology*

Six cross sections were surveyed near the upstream end of Side Channel 32L, 2013 April 23 and 24. A Nikon total station was used to survey cross-sections as dense vegetation prevented Real Time Kinematic (RTK) logging of surveyed points and the development of break lines. A Trimble RTK GPS base station was used to track a stationary position each day to allow post processing of data and subsequent tie-in to geodetic datum. Five benchmarks were installed and surveyed at this time.

Three cross sections were surveyed 2013 August 8 near the downstream end of Side Channel 32L and four additional benchmarks were installed and surveyed. A lower vegetation density compared to the upstream portion of the channel allowed a Trimble RTK roving GPS to be used. Surveyed cross sections and benchmark locations are presented in the site layouts and surveys of **Appendix I**.

#### *3.1.1.2 Substrate Texture*

Five sample locations were selected along each of the nine cross-sections surveyed in Side Channel 32L. Dense vegetation frequently prevent photographing the substrate and none of the substrate photographs collected in Side Channel 32L were appropriate for digital image processing. Grain size distributions were not calculated due to the predominance of fine grained sediments and dense vegetation cover. Sites were predominantly silt-clay, with grain sizes less than 0.1 mm. Some areas contianed scattered small boulders, with limited sections of large cobbles and small boulders. In some areas larger grains (small boulders and large cobles) were buried in fine sediments (silt-clay) up to 20 cm thick. A summary of substrate types found in Side Channel 32L is given in **Table 32**.

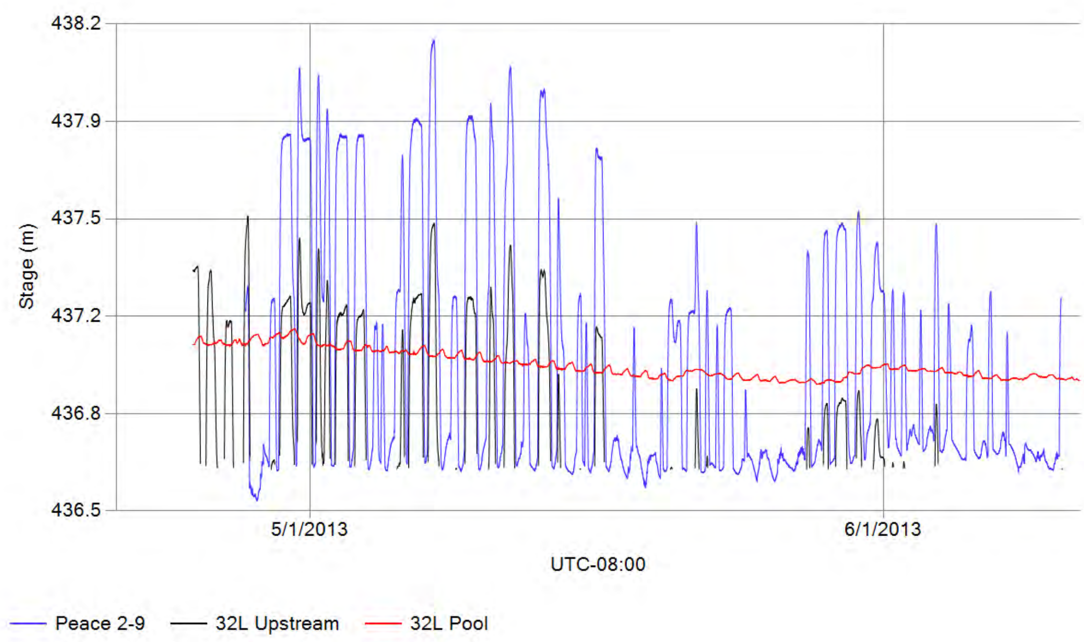
#### *3.1.1.3 Stage and Flow*

Three Leveloggers and a Barologger were installed in Side Channell 32 L. Leveloggers were installed near the upstream and downstream ends of the test channel, sites 32L Upstream and 32L Downstream respectively, with one additional Levelogger installed in a pool midway down the side channel, site 32L

Pool. A Barologger was installed adjacent to the 32L Pool Levelogger (**Appendix I**). Site 32L Upstream is within the Peace River. Stage fluctuations recorded at the Peace River gauge station site 2 (Peace 9), located approximately 1.75 km upstream on the main channel of the Peace River, are mirrored at site 32L Upstream (**Figure 2**). Site 32L Downstream is also expected to be connected directly to and under the influence of Peace River; data has yet to be downloaded from this site. Under normal flow conditions Site 32L Pool is not connected directly to the Peace River, but a similar stage fluctuation pattern suggests it is influenced by Peace River water levels likely through subsurface flow (**Figure 2**).

Lack of flow through Side Channel 32L prevents the development of a stage-discharge rating curve prior to the proposed channel works. Six cross sections surveyed along the upper portion of Side Channel 32L indicate a current bed elevation of approximately 437 m at the highest point (2013 April 24). Stage levels at sites 32L Upstream, 32L Pool and Peace 9 on the Peace River approximately 1.75 km upstream suggest Side Channel 32L should be deepened to at least 435.5 m at the upstream entrance to produce flow through the side channel during normal Peace River conditions to maintain flow for PCN discharges above 300 $m^3$/s. Current design has the test side channel excavated to 435.0 m where it meets the Peace River mainstem and slope at roughly 0.1% towards the downstream pool (near 32L Pool gauge).

**Figure 2 Stage record for sites 32L Upstream and 32L Pool compared to main channel stage recorded at Peace 9 approximately 1.75 km upstream**




### 32L Upstream Levelogger

The 32L Upstream Levelogger was installed 2013 April 24. The Levelogger was downloaded and re-deployed 2013 June 10. The Levelogger was found malfunctioning 2013 August 8 and data from June 10 onward were lost. Site 32L Upstream was abandoned and all equipment removed August 10. Stage data for site 32L Upstream exists from 2013 April 24 to June 10 (**Figure 20**). During this time water levels lower than 436.65 meters were below the sensor, resulting in missing data (**Table 33**). Flow through Side Channel 32L was not observed and not expected for Peace River flow less than 1,500 $m^3/s$ conditions (as reported by WSC 07EF001, Peace River at Hudson Hope). Due to lack of flow discharge measurements were not made at site 32L Upstream and a stage-discharge rating curve was not developed. Two benchmarks were installed at site 32L Upstream. A summary of the gauge installation is given in **Appendix H** and history of deployment provided in **Table 2**.

**32L Downstream Levelogger**

The 32L Downstream Levelogger was installed 2013 August 8. The logger has not yet been downloaded and no stage data are presented in this report. No flow through the site was observed. Some limited discharge measurements were made at site 32L Downstream, however flows were negative and/or near zero and a stage-discharge rating curve was not developed. Two benchmarks were installed at site 32L Downstream. A summary of the gauge installation is given in **Appendix H** and history of deployment provided in **Table 2**.

**32L Pool Levelogger**

The 32L Pool Levelogger was installed 2013 April 24. The Levelogger was downloaded and re-deployed 2013 June 10 and August 10. Stage data for site 32L Pool are continuous from April 24 to August 10 (**Figure 21**). Stage levels at site 32L Pool are not directly connected to main channel Peace River levels and flow through the pool was not observed. Site 32L Pool stage levels do however show similar patterns to stage levels at site 32L Upstream and stage levels in the main channel of the Peace River recorded at Peace 9 approximately 1.75 km upstream, suggesting some form of coupling possibly through subsurface flow (**Figure 2**).

The maximum and minimum daily stage for site 32L Pool are compared to the maximum and minimum daily stage for Peace 9 in **Figure 22**. Discharge measurements were not made at site 32L Pool and a stage-discharge rating curve was not developed. One benchmark was installed at site 32L Pool. A summary of the gauge installation is given in **Appendix H** and history of deployment provided in **Table 2**.

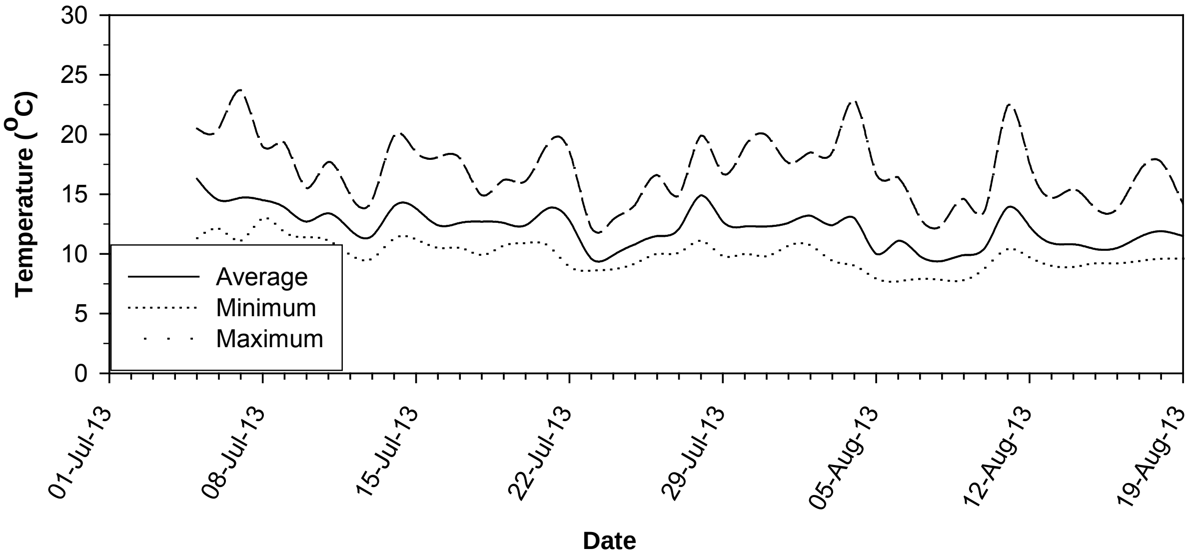
### 3.1.2 Fish Habitat

#### *3.1.2.1 Temperature and Water Quality*

**Water Temperature**

Water temperatures recorded between 2013 July 05 and August 19 ranged from 7.7°C to 23.7°C with an average of 12.2°C (**Figure 3** and **Appendix G, Table G1**). Average daily water temperatures were approximately 10°C at the beginning of the monitoring program. They increased through to the first week of August (13°C), and then gradually decreased until August 19 when the data loggers were removed. The daily range of water temperature averaged 7.1°C.

**Figure 3 Average daily water temperatures recorded in Side Channel 32L.**




### *3.1.2.2 Water Quality*

Water conductivity, pH, and dissolved oxygen measured at fish collection sites were variable (**Table 6** and **Appendix C, Table C1**). Conductivity values ranged from 180 to 416 µS/cm, pH values ranged from 6.83 to 8.65 pH units, and dissolved oxygen ranged from 6.9 to 9.6 ppm (65 to 102%). The variation likely reflected the relative importance of groundwater inputs versus inflow/outflow from the mainstem Peace River (see Section 3.1.1.3 for description of side channel flow). Water clarity was high (i.e. to the channel bed), which was consistent with measured water turbidity (2.4 to 2.7 NTU).

**Table 6 Summary of water quality parameters measured in Side Channel 32L.**

| Date | pH | | | Conductivity (µS/cm) | | | Dissolved Oxygen | | | | | Clarity (m) | | | Turbidity (NTU) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Concentration (ppm) | | Saturation (%) | | | | | | | | |
| | Mean | Range | *n* | Mean | Range | *n* | Mean | Range | Mean | Range | *n* | Mean | Range | *n* | Mean | Range | *n* |
| 13-Aug-3 | 7.14 | 6.83 - 7.42 | 8 | 388.1 | 351 - 416 | 8 | 7.9 | 6.9 - 9.6 | 79.9 | 65 - 102 | 8 | TCB[a] | TCB | 8 | 2.7 | | 1 |
| 13-Aug-4 | 7.93 | 7.37 - 8.65 | 3 | 263.7 | 180 - 416 | 3 | 8.6 | 7.7 - 9.4 | 93.0 | 86 - 100 | 2 | TCB | TCB | 3 | 2.4 | | 1 |
| Overall | 7.36 | 6.83 - 8.65 | 11 | 354.18 | 180 - 416 | 11 | 7.99 | 6.9 - 9.6 | 82.50 | 65 - 102 | 10 | TCB | TCB | 11 | 2.5 | 2.4 - 2.7 | 2 |

[a] To channel bed.

### *3.1.2.3 Habitat Characteristics*

At PCN Dam minimum operational discharge (283 $m^3$/s) Side Channel 32L contained an estimated 9,839 $m^2$ of potential fish habitat (**Table 7**, **Figure 23**). This included 5 Flat (**Photo 1**) habitat units (92% of available area) and 4 Riffle (**Photo 2**) habitat units (8% of available area). No Run habitats were recorded. In total, 25% of the potential fish habitat was not readily available to fish at minimum flow.

A summary of habitat characteristics measured at fish collection sites is presented in **Table 8**. Raw habitat data from fish collection sites and from habitat transects are presented in **Appendix D, Tables**

**D1** and **D2**, respectively. Habitat characteristics differed between habitat types. As expected, water depth was greater and water velocity lower in Flat habitat compared to Riffle habitat. Substrate composition at sites in Flat habitat was dominated by clay/silt/sand (40%) and cobble (51%), while cobble was the dominant substrate type in Riffle habitat (75%). Smaller (gravel/pebble) and larger (boulder/bedrock) rock substrates were scarce or absent in both habitat types. D90 values were similar (approximately 20 cm) and embeddedness and compaction values were high (i.e. rating > 2.5 out of 3.0) in both habitat types. There were limited amounts of instream cover at fish collection sites (< 11% surface area). Rock cover was present in both habitat types, while submergent vegetation and emergent vegetation provided instream cover only in the Flat habitat type.

**Table 7 Summary of habitat recorded in Side Channel 32L.**

| Habitat | Total | | | Amount Subject to Dewatering | | |
|---|---|---|---|---|---|---|
| | *n* | Surface Area ($m^2$) | Percent | *n* | Surface Area ($m^2$) | Percent |
| Flat | 5 | 9,086 | 92.4 | 1 | 2,358 | 26.0 |
| Riffle | 4 | 453 | 7.7 | 1 | 136 | 18.1 |
| Run | 0 | | | 0 | | |
| **Total** | **9** | **9,839** | **100.0** | **2** | **2,494** | **25.1** |

**Table 8 Habitat characteristics (mean ± standard error) measured at fish collection sites in Side Channel 32L.**

| Parameter[a] | Flat | Riffle |
|---|---|---|
| No. Sites | 9 | 2 |
| Average depth (m) | 0.33 ± 0.03 | 0.09 ± 0.02 |
| Average velocity (m) | 0.00 | 0.10 ± 0.04 |
| Substrate (%) | | |
| Organic matter | 0.0 | 0.0 |
| Clay/Silt/Sand | 40.0 ± 9.4 | 15.0 ± 5.0 |
| Gravel/Pebble | 5.0 ± 3.9 | 2.5 ± 2.5 |
| Cobble | 51.1 ± 8.3 | 75.0 ± 5.0 |
| Boulder | 3.9 ± 0.7 | 7.5 ± 2.5 |
| Bedrock | 0.0 | 0.0 |
| D90 (cm) | 19.4 ± 3.5 | 20.0 ± 1.3 |
| Embeddedness | 2.7 ± 0.2 | 3.0 ± 0.0 |
| Compaction | 3.0 ± 0.0 | 3.0 ± 0.0 |
| Cover (%) | | |
| Overhead | 0.2 ± 0.2 | 0.0 |
| Rock | 10.6 ± 3.9 | 7.5 ± 7.5 |
| Large woody debris | 0.0 | 0.0 |
| Submergent vegetation | 9.4 ± 6.6 | 0.0 |
| Emergent vegetation | 3.9 ± 2.2 | 0.0 |
| Terrestrial vegetation | 0.0 | 0.0 |

[a] See Section 2.3.3 for definitions.

**Photo 1 Example of Flat habitat in Side Channel 32L.**

**Photo 2 Example of Riffle habitat in Side Channel 32L.**

### 3.1.3 Fish Community

#### *3.1.3.1 Fish Species and Life Stage*

In total, 3,530 fish represented by 10 species were recorded in Side Channel 32L (**Table 9**). The species included one sportfish (Mountain Whitefish), three sucker (Longnose, Largescale, and White Suckers), four minnow (Lake Chub, Longnose Dace, Northern Pikeminnow, and Redside Shiner), and two sculpin (Prickly and Slimy Sculpins). The most numerically important fish were Redside Shiner (46.8%), unidentified young-of-the year suckers (35.8%), and Lake Chub (10.5%). All other fish species represented less than 3.0% of the sample.

**Table 9 Number of fish enumerated by species and capture method in Side Channel 32L.**

| Group | Species | Collection Methods[a] | | | | |
|---|---|---|---|---|---|---|
| | | BS | EF | SF | Total | % |
| Sportfish | Lake Trout | | | | 0 | 0.0 |
| | Mountain Whitefish | 85 | 1 | | 86 | 2.4 |
| | Northern Pike | | | | 0 | 0.0 |
| | Walleye | | | | 0 | 0.0 |
| | Yellow Perch | | | | 0 | 0.0 |
| Suckers | Largescale Sucker | 14 | 1 | | 15 | 0.4 |
| | Longnose Sucker | 23 | 1 | | 24 | 0.7 |
| | White Sucker | 1 | | | 1 | < 0.1 |
| | Sucker spp. | 1,237 | 28 | | 1,265 | 35.8 |
| Minnows[b] | Lake Chub | 356 | 14 | | 370 | 10.5 |
| | Longnose Dace | 2 | 37 | | 39 | 1.1 |
| | Northern Pikeminnow | 64 | | | 64 | 1.8 |
| | Redside Shiner | 1,623 | 29 | | 1,652 | 46.8 |
| | Spottail Shiner | | | | 0 | 0.0 |
| | Trout-perch | | | | 0 | 0.0 |
| Sculpins | Prickly Sculpin | 5 | 5 | | 10 | 0.3 |
| | Slimy Sculpin | 3 | 3 | | 6 | 0.2 |
| **Total** | | **3,411** | **119** | **-** | **3,530** | **100.0** |

[a] Methods: EF – backpack electrofisher; BS – beach seine; SF – small fish boat electrofisher.

[b] Includes true minnows (Family Cyprinidae) and Trout-perch (Family Percopsidae).

Three large-fish species life stages were present in Side Channel 32L (**Table 10**). The young-of-the-year life stage was recorded for one species (Mountain Whitefish) and unidentified suckers. The juvenile life stage of four species was recorded – Largescale Sucker, Longnose Sucker, White Sucker, and Northern Pikeminnow. Although not specifically targeted by the program, the Longnose Sucker adult life stage also was present in the sample.

**Table 10 Large-fish species life stages recorded in Side Channel 32L (all methods and sampling events combined).**

| Group | Species | Life Stage | | |
|---|---|---|---|---|
| | | YOY | Juv | Adult |
| Sportfish | Lake Trout | | | |
| | Mountain Whitefish | X | | |
| | Northern Pike | | | |
| | Walleye | | | |
| | Yellow Perch | | | |
| Suckers | Largescale Sucker | | X | |
| | Longnose Sucker | | X | X |
| | White Sucker | | X | |
| | Sucker spp. | X | | |
| Minnows | Northern Pikeminnow | | X | |
| **Total Number** | | **2** | **4** | **1** |

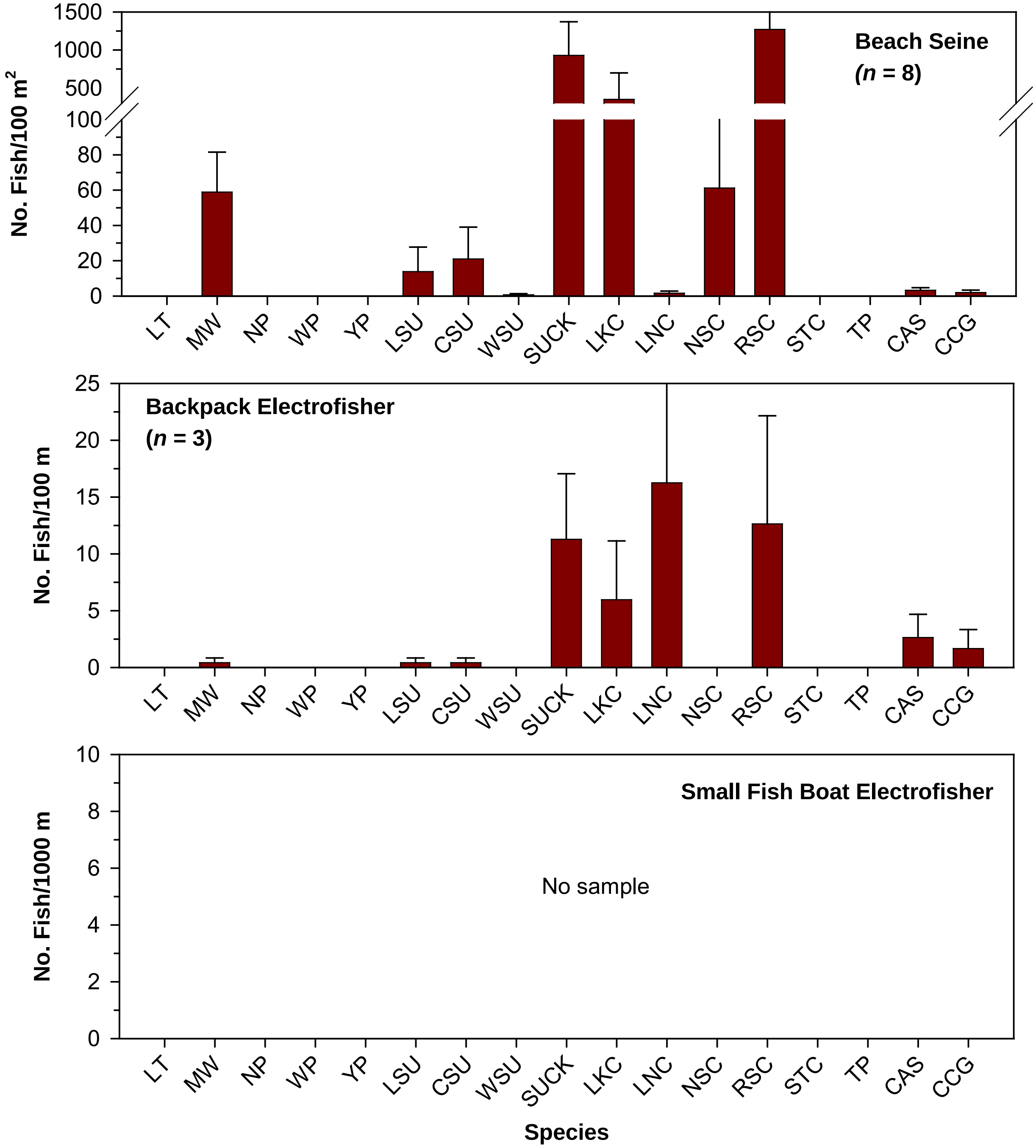
### *3.1.3.2 Catch Rate*

Catch rates were generated using the beach seine and backpack electrofisher samples; low water levels at the time of sampling precluded use of the small fish boat electrofisher. Beach seine and backpack electrofisher catch rates were variable as indicated by the large standard error around most of the estimates (**Figure 4**).

Redside Shiner (1,270 fish/100 $m^2$), unidentified young-of-the year sucker species (929 fish/100 $m^2$) and Lake Chub (352 fish/100 $m^2$) were the most abundant fish in the beach seine catch. Mountain Whitefish was the only sportfish encountered and the catch rate for this species was (59 fish/100 $m^2$). In the sculpin group, Prickly Sculpin and Slimy Sculpin were not abundant (< 4 fish/100 $m^2$).

Mean backpack electrofisher catch rates for all species were low (≤ 16 fish/100 m). Similar to the beach seine results, Redside Shiner and unidentified young-of-the-year suckers were among the more abundant species. The highest average catch, however, was recorded for Longnose Dace (16 fish/100 m). In the sculpin group, Prickly Sculpin and Slimy Sculpin were not abundant (< 3 fish/100 $m^2$).

**Figure 4 Average (± SE) catch rates of fish species/groups in Side Channel 32L.**




### *3.1.3.3 Biological Characteristics*

Median lengths of species/groups sampled in Side Channel 32L are summarized in **Table 11**. Raw biological data are present in **Appendix F**.

**Table 11 Fish species/groups fork length (mm) characteristics in Side Channel 32L.**

| Group | Common Name | Beach Seine/ Backpack Electrofisher | | | Small Fish Boat Electrofisher | | |
|---|---|---|---|---|---|---|---|
| | | *n* | Median | Range | *n* | Median | Range |
| Sportfish | Lake Trout | | | | | | |
| | Mountain Whitefish | 55 | 48.0 | 32 – 61 | | | |
| | Northern Pike | | | | | | |
| | Walleye | | | | | | |
| | Yellow Perch | | | | | | |
| Sucker | Largescale Sucker | 15 | 59.0 | 45 – 70 | | | |
| | Longnose Sucker | 10 | 71.0 | 62 - 82 | | | |
| | White Sucker | 1 | 62.0 | | | | |
| | Sucker species | 67 | 24.0 | 15 – 35 | | | |
| Minnow/ Trout-perch | Lake Chub | 31 | 45.0 | 32 – 57 | | | |
| | Longnose Dace | 23 | 45.0 | 33 – 59 | | | |
| | Northern Pikeminnow | 4 | 56.5 | 55 – 62 | | | |
| | Redside Shiner | 109 | 36.0 | 27 – 56 | | | |
| | Spottail Shiner | | | | | | |
| | Trout-perch | | | | | | |
| Sculpin | Prickly Sculpin | 10 | 54.5 | 42 – 85 | | | |
| | Slimy Sculpin | 6 | 55.5 | 43 – 76 | | | |
| | Sculpin species | | | | | | |

## 3.2 Side Channel 40L

Side Channel 40L is located approximately 2 km upstream of Halfway River, on the left side of the Peace River. It is a control site located near Side Channel 32L. The channel is substantially deeper and wider than Side Channel 32L and is regularly influenced by PCN Dam operational discharges. It is the only fish bearing side channel located upstream of the Halfway River in close proximity to Side Channel 32L (Mainstream 2010, 2011, 2013b).

### 3.2.1 Physical Characteristics

#### *3.2.1.1 Channel Morphology*

Five cross sections were surveyed 2013 April 26 near the upstream end of Side Channel 40L using Trimble RTK GPS. Two benchmarks were installed and surveyed at this time. Four additional benchmarks were installed and surveyed 2013 August 9. Surveyed cross sections and benchmark locations are presented in the site layouts and surveys of **Appendix I**.

#### *3.2.1.2 Substrate Texture*

Ten sample locations were selected along each of the five cross-sections surveyed in Side Channel 40L. Two of the sample locations provided substrate photographs appropriate for digital image processing. However, two locations does not constitute a sufficient sample size to accurately determine a grain size distribution for the channel. An additional twenty-three locations provided substrate photographs marginally appropriate for digital image processing. Grain size distribution values were calculated for all twenty five locations and are given in **Table 34** and are shown in **Figure 24**. Grain size distributions, however, should be considered estimates and only used in a qualitative capacity.

The top of the right bank of Side Channel 40L was mainly silt-clay. The channel was dominantly large and small cobbles with upstream sections containing small boulders and the presence of small and large gravel increasing furthur downstream. The top of the left bank contained small and large gravel along with small cobbles and some silt-clay. A summary of substrate types found in Side Channel 40L is given in **Table 35**.

#### *3.2.1.3 Stage and Flow*

Two Leveloggers were installed in Side Channel 40L: one near the upstream end, site 40L Upstream, and one near the downstream end, site 40L Downstream. The Barologger installed adjacent to site 32L Pool was used to compensate Side Channel 40L Levelogger data.

**40L Upstream Levelogger**

*Stage*

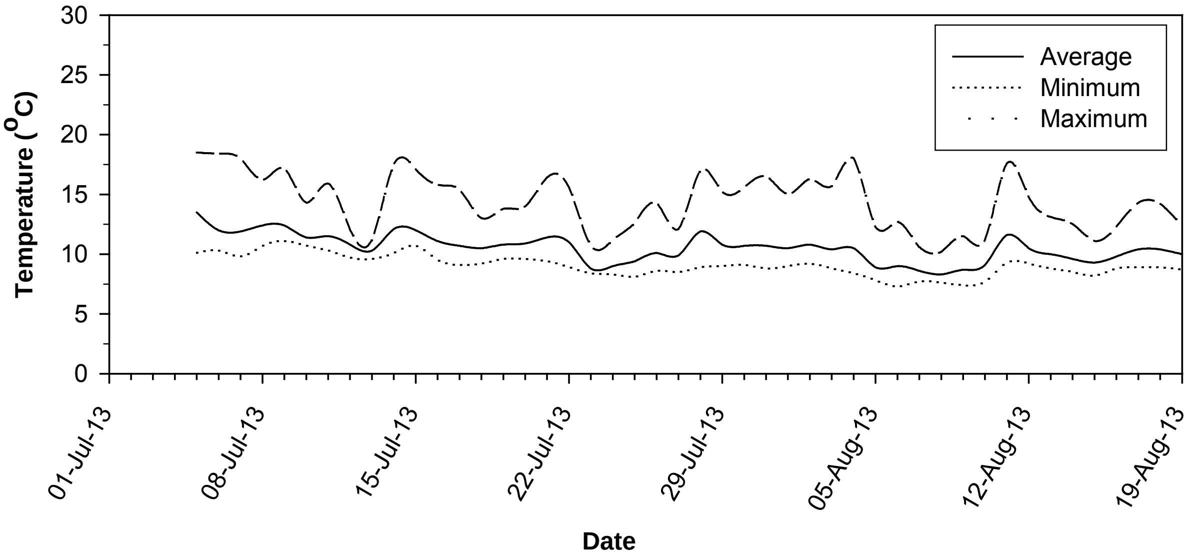
The 40L Upstream Levelogger was installed 2013 April 26. The Levelogger was downloaded and re-deployed 2013 June 10 and August 10. Stage data for site 40L Upstream exists from April 24 to June 10 (**Figure 25**). During this time water levels lower than 432.81 m were below the sensor, resulting in discontinuous data (**Table 36**). Three benchmarks were installed at site 40L Upstream. A summary of the gauge installation is given in **Appendix H** and history of deployment provided in **Table 2**.

*Discharge*

Discreet discharge measurements were made at site 40L Upstream 2013 April 24, June 10, and August 10. Thirteen different flow values were measured. Two flow values were measured during steady daily high flows, two during daily increasing flows, and the remaining nine during one daily increasing flow. Discharge measurements cover a range of flows from 2.2 $m^3/s$ at a stage of 433.044 m to 58.9 $m^3/s$ at a stage of 433.909. Discharge values calculated for stages outside of this range are extrapolated estimates; the current stage record ranges from 432.81 m to 434.401 m, with stage values lower than 432.81 below the sensor elevation resulting in missing data. The rating curve is shown in **Figure 26** and the residuals between the measured discharge and the discharge calculated from the rating curve are given in **Table 37**. The current rating curve shows very good fit (12.2% root mean square of errors). The preliminary stage-discharge relation for site 40L Upstream is as follows:

section, located closest to the 40L Upstream gauge, and called Cross Section 1 (**Appendix I**). To determine water depth at this cross section, the water surface elevation at the cross section was fist estimated from the 40L Upstream stage record by subtracting the difference in water surface elevation surveyed at the cross-section and recorded by the gauge 2013 April 26 at 12:20. While the slope in water surface between the gauge and the cross section will vary with flow levels, the change is expected to be small for normal flow conditions. Water surface elevation at the cross-section was then converted to depth at the deepest section, located midway on the left half of the channel based on surveyed bed elevations. The equation used for calculating water depth at Cross Section 1 is as follows:

**Figure 5 Average daily water temperatures recorded in Side Channel 40L.**




**General Water Quality**

Unlike Side Channel 32L, water conductivity, pH, and dissolved oxygen measured at fish collection sites in Side Channel 40L were generally constant (**Table 12** and **Appendix C, Table C1**). Conductivity values ranged from 163 to 226 µS/cm, pH values ranged from 7.50 to 8.02 pH units, and dissolved oxygen ranged from 8.2 to 10.2 ppm (91 to 105%). The absence of large variation likely reflected consistent influence by Peace River flow (see Section 3.2.1.3 for description of side channel flow). Water clarity at the time of sampling was high (1.3 to 1.8 m), which was consistent with measured water turbidity (3.7 to 5.4 NTU).

**Table 12 Summary of water quality parameters measured in Side Channel 40L.**

| Date | pH | | | Conductivity (µS/cm) | | | Dissolved Oxygen | | | | | Clarity (m) | | | Turbidity (NTU) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Concentration (ppm) | | Saturation (%) | | | | | | | | |
| | Mean | Range | *n* | Mean | Range | *n* | Mean | Range | Mean | Range | *n* | Mean | Range | *n* | Mean | Range | *n* |
| 13-Jul-30 | 7.50 | | 1 | 193.0 | | 1 | | | | | | 1.65 | | 1 | 3.7 | | 1 |
| 13-Jul-31 | 7.71 | 7.55 - 7.78 | 8 | 187.4 | 163 - 219 | 8 | 9.6 | 9.2 - 10.2 | 98.3 | 91 - 102 | 8 | 1.48 | 1.3 - 1.7 | 2 | 4.9 | 4.4 - 5.4 | 2 |
| 13-Aug-2 | 7.85 | 7.63 - 8.02 | 3 | 197.3 | 164 - 226 | 3 | 9.1 | | 99.7 | | 3 | 1.80 | | 1 | 4.0 | | 1 |
| Overall | 7.72 | 7.50 - 8.02 | 12 | 190.3 | 163 - 226 | 12 | 9.45 | 8.2 - 10.2 | 98.6 | 91 - 105 | 11 | 1.60 | 1.3 - 1.8 | 4 | 4.37 | 3.7 - 5.4 | 4 |

### 3.2.3 Habitat Characteristics

At PCN Dam minimum operational discharge (283 $m^3$/s) Side Channel 40L contained an estimated 125,725 $m^2$ of potential fish habitat (**Table 13**, **Figure 31**). Fish habitat was dominated by 6 Flat (**Photo 3**) habitat units (97% of available area), while 5 Riffle (**Photo 4**) habitat units represented a small percentage (3% of available area). No Run habitats were recorded. Unlike Side Channel 32L all potential fish habitat was available to fish at minimum flow.

A summary of habitat characteristics measured at fish collection sites is presented in **Table 14**. Raw habitat data from fish collection sites and from habitat transects are presented in **Appendix D, Tables D1** and **D2**, respectively. Habitat characteristics differed between habitat types. As expected, water depth was greater and water velocity lower in Flat habitat compared to Riffle habitat. Substrate composition at sites in Flat habitat was dominated by clay/silt/sand (93%) with much smaller amounts of cobble (6%) and boulder (1%). Cobble was the dominant substrate type in Riffle habitat (73%) with smaller percentages of gravel/pebble (15%) and boulder (13%) substrates. Average D90 values were 18 cm in Flat habitat and 22.5 cm in Riffle habitat. Embeddedness and compaction values were high in Flat habitat (a value of 3.0 out of 3.0); however, embeddedness was less in Riffle habitat (2.0 out of 3.0). There were limited amounts of instream cover at fish collection sites. Rock was the only instream cover type recorded in Riffle habitat. Flat habitat contained rock and emergent vegetation instream cover.

**Table 13 Summary of habitat recorded in Side Channel 40L.**

| Habitat | Total | | | Amount Subject to Dewatering | | |
|---|---|---|---|---|---|---|
| | *n* | Surface Area ($m^2$) | Percent | *n* | Surface Area ($m^2$) | Percent |
| Flat | 6 | 121,686 | 96.8 | 0 | | |
| Riffle | 5 | 4,039 | 3.2 | 0 | | |
| Run | 0 | | | 0 | | |
| **Total** | **11** | **125,725** | **100.0** | **0** | **0** | **0.0** |

**Table 14 Habitat characteristics (mean ± standard error) measured at fish collection sites in Side Channel 40L.**

| Parameter[a] | Flat | Riffle |
|---|---|---|
| No. Sites | 6 | 2 |
| Average depth (m) | 0.43 ± 0.05 | 0.27 ± 0.03 |
| Average velocity (m) | 0.00 | 0.58 ± 0.17 |
| Substrate (%) | | |
| Organic matter | 0.0 | 0.0 |
| Clay/Silt/Sand | 93.3 ± 2.1 | 0.0 |
| Gravel/Pebble | 0.0 | 15.0 ± 15.0 |
| Cobble | 5.8 ± 2.0 | 72.5 ± 12.5 |
| Boulder | 0.8 ± 0.8 | 12.5 ± 2.5 |
| Bedrock | 0.0 | 0.0 |
| D90 (cm) | 18.0 ± 3.0 | 22.5 ± 6.0 |
| Embeddedness | 3.0 ± 0.0 | 2.0 ± 0.0 |
| Compaction | 3.0 ± 0.0 | 3.0 ± 0.0 |
| Cover (%) | | |
| Overhead | 0.0 | 0.0 |
| Rock | 2.50 ± 1.1 | 20.0 ± 5.0 |
| Large woody debris | 0.0 | 0.0 |
| Submergent vegetation | 0.0 | 0.0 |
| Emergent vegetation | 1.7 ± 1.7 | 0.0 |
| Terrestrial vegetation | 10.0 ± 5.0 | 0.0 |

[a] See Section 2.3.3 for definitions.

**Photo 3 Example of Flat habitat in Side Channel 40L.**

**Photo 4 Example of Riffle habitat in Side Channel 40L.**

### 3.2.4 Fish Community

#### *3.2.4.1 Fish Species and Life Stage*

In total, 1,342 fish represented by 5 species were recorded in Side Channel 40L (**Table 15**). The species included two sportfish (Mountain Whitefish and Northern Pike), two minnow (Lake Chub and Redside Shiner), and one sculpin (Slimy Sculpin). The most numerically important fish were Mountain Whitefish (86.7%) and unidentified young-of-the-year suckers (11.1). All other fish species represented ≤ 1.0% of the sample.

**Table 15 Number of fish enumerated by species and capture method in Side Channel 40L.**

| Group | Species | Collection Methods[a] | | | | |
|---|---|---|---|---|---|---|
| | | BS | EF | SF | Total | % |
| Sportfish | Lake Trout | | | | **0** | **0.0** |
| | Mountain Whitefish | 798 | | 365 | **1,163** | **86.7** |
| | Northern Pike | 1 | | 5 | **6** | **0.4** |
| | Walleye | | | | **0** | **0.0** |
| | Yellow Perch | | | | **0** | **0.0** |
| Suckers | Largescale Sucker | | | | **0** | **0.0** |
| | Longnose Sucker | | | | **0** | **0.0** |
| | White Sucker | | | | **0** | **0.0** |
| | Sucker spp. | 144 | 5 | | **149** | **11.1** |
| Minnows[b] | Lake Chub | 1 | | | **1** | **0.1** |
| | Longnose Dace | | | | **0** | **0.0** |
| | Northern Pikeminnow | | | | **0** | **0.0** |
| | Redside Shiner | 5 | 2 | 6 | **13** | **1.0** |
| | Spottail Shiner | | | | **0** | **0.0** |
| | Trout-perch | | | | **0** | **0.0** |
| Sculpins | Prickly Sculpin | | | | **0** | **0.0** |
| | Slimy Sculpin | | 10 | | **10** | **0.7** |
| **Total** | | **949** | **17** | **376** | **1,342** | **100.0** |

[a] Methods: EF – backpack electrofisher; BS – beach seine; SF – small fish boat electrofisher.

[b] Includes true minnows (Family Cyprinidae) and Trout-perch (Family Percopsidae).

Three large-fish species life stages were present in Side Channel 40L (**Table 16**). The young-of-the-year life stage was recorded for one species (Mountain Whitefish) and unidentified suckers. The juvenile life stage of one species was recorded – Northern Pike. The Mountain Whitefish and Northern Pike adult life stage also was present.

**Table 16 Large-fish species life stages recorded in Side Channel 40L (all methods and sampling events combined).**

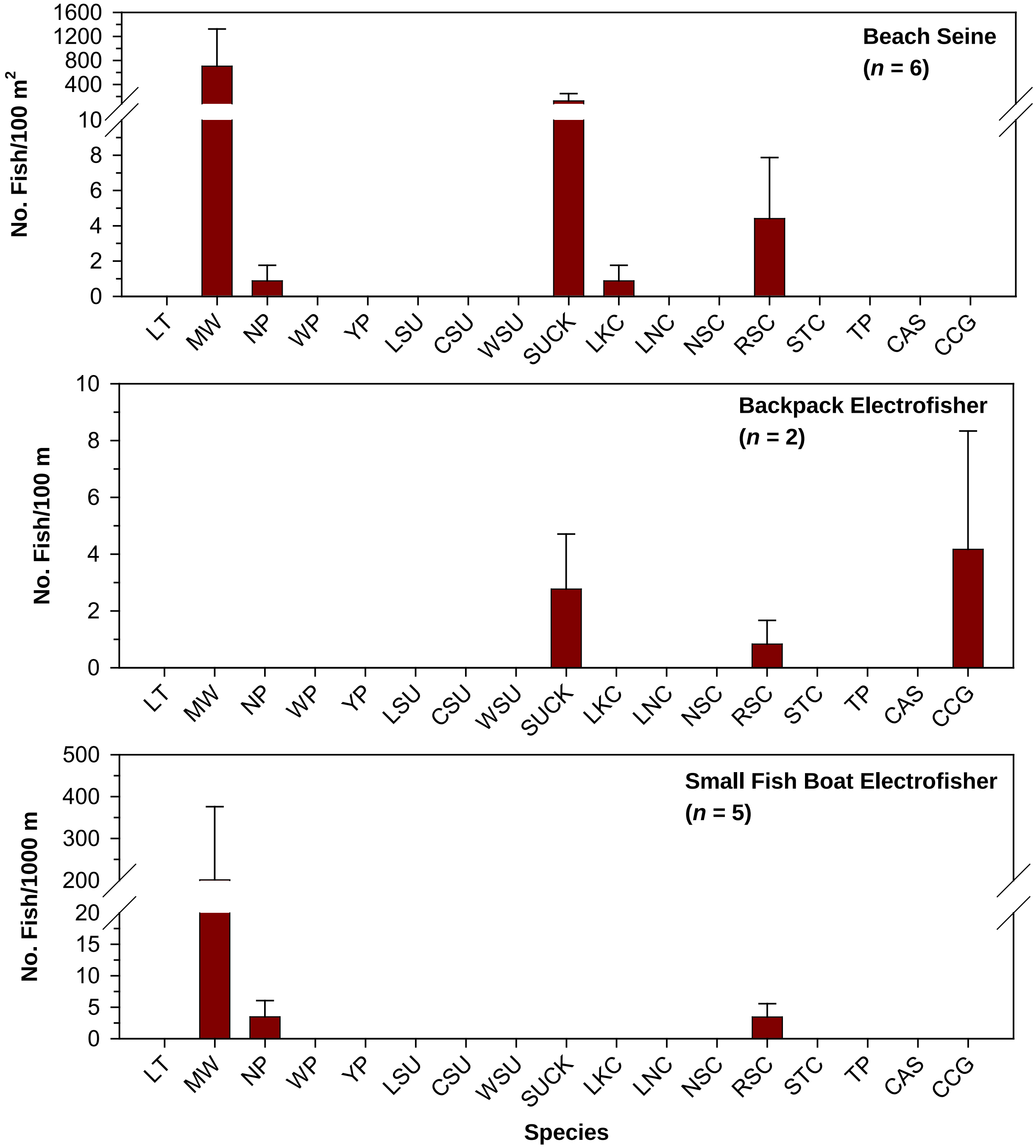
| Group | Species | Life Stage | | |
|---|---|---|---|---|
| | | YOY | Juv | Adult |
| Sportfish | Lake Trout | | | |
| | Mountain Whitefish | X | | X |
| | Northern Pike | | X | X |
| | Walleye | | | |
| | Yellow Perch | | | |
| Suckers | Largescale Sucker | | | |
| | Longnose Sucker | | | |
| | White Sucker | | | |
| | Sucker spp. | X | | |
| Minnows | Northern Pikeminnow | | | |
| **Total Number** | | **2** | **1** | **2** |

### *3.2.4.2 Catch Rate*

Catch rates were calculated using samples from all three sampling methods. Catch rates of both beach seine and backpack electrofisher were variable as indicated by the large standard error around most of the estimates (**Figure 6**).

Mountain Whitefish was the only abundant sportfish species (beach seine catch rate = 704 fish/100 $m^2$; small fish boat electrofisher catch rate = 201 fish per 1000 m). Unidentified young-of-the-year sucker species were also abundant but only in the beach seine catch (127 fish/100 $m^2$). Estimates of abundance were much lower for all other species - beach seine (< 5 fish/100 $m^2$), backpack electrofisher (< 5 fish/100 m), and small fish boat electrofisher (< 4 fish /1000 m).

**Figure 6 Average (± SE) catch rates of fish species/groups in Side Channel 40L.**




### *3.2.4.3 Biological Characteristics*

Median lengths of species/groups sampled in Side Channel 40L are summarized in **Table 17**. Raw biological data are present in **Appendix F**.

**Table 17 Fish species/groups fork length (mm) characteristics in Side Channel 40L.**

| Group | Common Name | Beach Seine/ Backpack Electrofisher | | | Small Fish Boat Electrofisher | | |
|---|---|---|---|---|---|---|---|
| | | *n* | Median | Range | *n* | Median | Range |
| Sportfish | Lake Trout | | | | | | |
| | Mountain Whitefish | 60 | 57.0 | 42 – 74 | 30 | 62.5 | 50 – 313 |
| | Northern Pike | 1 | 231.0 | | 2 | 474.0 | 261 – 687 |
| | Walleye | | | | | | |
| | Yellow Perch | | | | | | |
| Sucker | Largescale Sucker | | | | | | |
| | Longnose Sucker | | | | | | |
| | White Sucker | | | | | | |
| | Sucker species | 20 | 26.0 | 15 – 33 | | | |
| Minnow/ Trout-perch | Lake Chub | 1 | 47.0 | | | | |
| | Longnose Dace | | | | | | |
| | Northern Pikeminnow | | | | | | |
| | Redside Shiner | 7 | 46.0 | 37 – 50 | 6 | 47.5 | 43 – 77 |
| | Spottail Shiner | | | | | | |
| | Trout-perch | | | | | | |
| Sculpin | Prickly Sculpin | | | | | | |
| | Slimy Sculpin | 10 | 48.5 | 41 - 63 | | | |
| | Sculpin species | | | | | | |

## 3.3 Side Channel 102.5R

Side Channel 102.5R is a historic 500 m long channel that crosses an island located along the right bank of the Peace River 1 km upstream of the Taylor Bridge. It has been selected as a test site with the proposed work developing the channel to provide additional off-channel habitat and connectivity between an existing side channel and the main channel of Peace River. This site is located immediately downstream of the Pine River.

The Pine River is the most substantial tributary below the PCN with a watershed of 13, 665 km$^2$. The additional flow with an unregulated hydrograph and high sediment supply downstream of the Pine River reduces the downstream effects of regulation. Coarse sediment deposits at the confluence while fine sediments and suspended loads are generally carried downstream of the Pine River by the current flow regime. However there has been an increase in island area and narrowing of side channels through deposition and relatively rapid channel change at and near the confluence (NHC and Mainstream Aquatics Ltd. 2013). River conditions in general change downstream of the Pine River confluence, with increased turbidity, increased temperature, and a more natural hydrograph.

The change in conditions influenced downstream habitat supporting a unique fish assemblage; that is a community dominated by young-of-the-year and juveniles of sucker species, and supports Northern Pike, Yellow Perch, and Spottail Shiner. The latter two species although recorded by previous studies (Mainstream 2010, 2011, 2013b; NHC and Mainstream 2013b) were not encountered during 2013 study.

### 3.3.1 Physical Characteristics

#### *3.3.1.1 Channel Morphology*

Six cross sections were surveyed 2013 April 25 along Side Channel 102.5R using Trimble RTK GPS. Proximity to the District of Taylor, BC, allowed survey points to be collected using the Can-Net system; heavy vegetation and high alders limit the ability to use a total station for collecting survey data. Two benchmarks were installed and surveyed at this time. Two additional benchmarks were installed and surveyed 2013 June 11, with another two installed and surveyed on 2013 August 8 and 10. Surveyed cross sections and benchmark locations are presented in the site layouts and surveys of **Appendix I**.

#### *3.3.1.2 Substrate Texture*

The proposed excavation site crosses a well established island that is infrequently inundated by the Peace River. The ground is covered by dense grass, shrubs, alders, and cottonwood. Underlying materials appear to primarily be a mix of organics, silt, and sand. Due to the ground cover and lack of exposed coarse substrate no sediment sampling beyond broad catagorisation was completed along the 102.5R Test Side Channel.

The adjacent side channel is however regularly active with flow from open inlet to open outlet during moderate and higher Peace River discharge. The adjacent side channel has gravel and small cobble exposed at riffles upstream and downstream of the test site but any coarse material is buried under a layer of fine sand and silt for much of the channel.

#### *3.3.1.3 Stage and Flow*

A Levelogger was installed in the existing side channel, site 102.5R Channel, with a Barologger installed adjacent to it. The test channel portion of the 102.5R site will remain dry except under unusually large releases from Peace Canyon Dam until the proposed excavation is completed. Sites along this test channel - Side Channel 102.5R - are not yet monitored.

**102.5R Channel Levelogger**

*Stage*

Site 102.5R Channel - the channel south of the proposed test channel - is connected directly to and under the immediate influence of the Peace River. Preliminary stage fluctuations recorded at Water Survey of Canada (WSC) gauge *07FD002 Peace River near Taylor* , located approximately 0.9 km upstream on the main channel of Peace River, are mirrored at site 102.5R (**Figure 7**), however daily fluctuations on the main channel of Peace River show smaller variation than fluctuations at site 102.5R Channel.

The maximum and minimum daily stage for sites 102.5R Channel and WSC gauge *07FD002 Peace River near Taylor* are shown in **Figure 8**. Discharge records for WSC *gauge 07FD002 Peace River near Taylor* are not currently available for the period of record for 102.5R Channel discharge.

**Figure 7 Stage record for site 102.5R Channel compared to preliminary stage from WSC site 07FD002 Peace River near Taylor. Site 102.5R Channel stage values below 402.81 m are below the sensor elevation prior to August 8, 2013, resulting in gaps in the stage record (Table 38).**

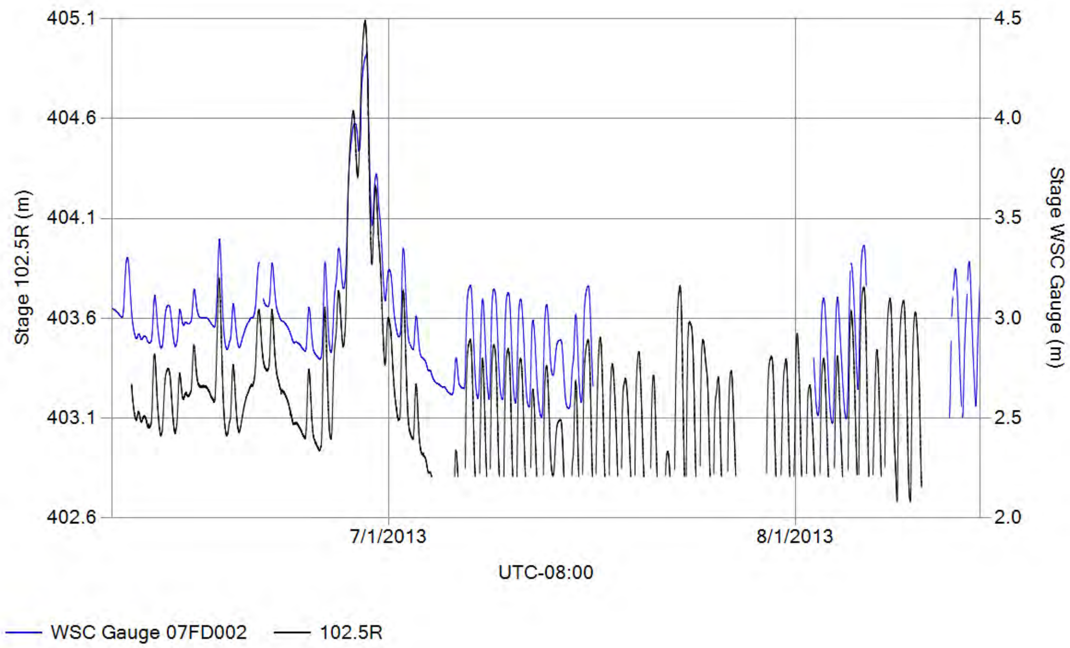
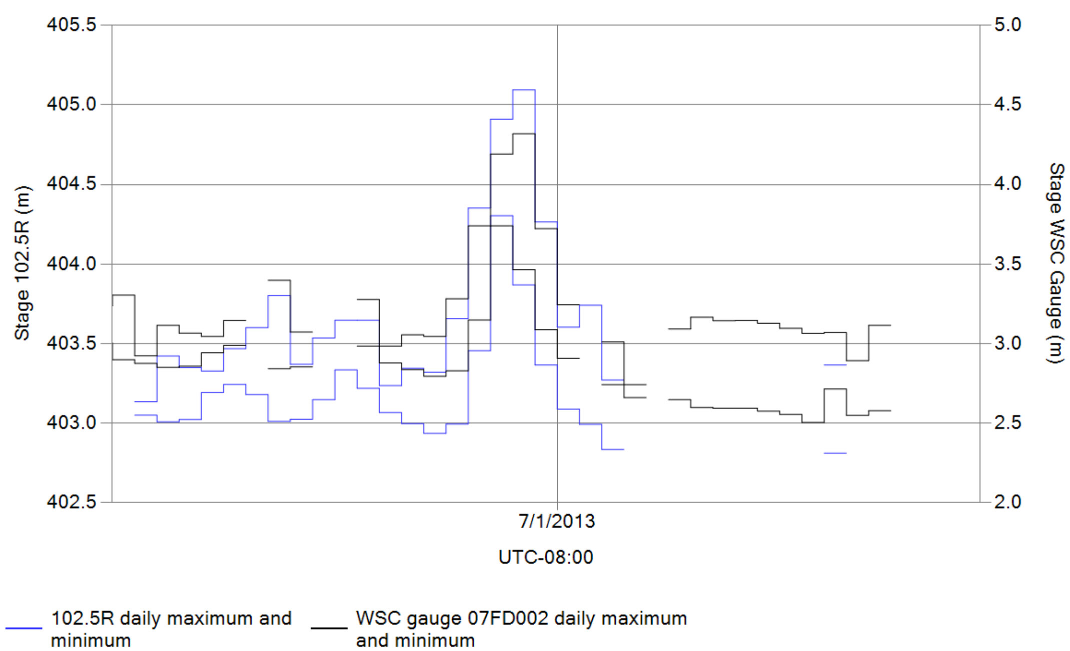



**Figure 8 Maximum and minimum daily stage for site 102.5R Channel compared to the preliminary maximum and minimum daily stage from WSC site 07FD002 Peace River near Taylor, located on the main channel of Peace River.**



The 102.5R Channel Levelogger was installed 2013 June 11. The Levelogger was moved to a lower elevation 2013 August 8 and downloaded and re-deployed on August 10. Stage data for site 102.5R Channel exist from 2013 June 11 to August 10 (**Figure 32**). Prior to 2013 August 8 water levels lower than 402.81 m were below the sensor, resulting in missing data (**Table 38**). Two benchmarks were installed at site 102.5R Channel. A summary of the gauge installation is given in **Appendix H** and history of deployment provided in **Table 2**.

*Test Channel Design*

The proposed excavation is to redevelop the 102.5R Test Side Channel with a minimum depth at its entrance of 401.8 m and slope 2 m up at 5H:1V to 10H:1V to the bottom of the banks. The proposed excavation should result in channel depth of 0.9 m to 2.2 m along the thalweg to a depth of 0 to 0.3 m at the banks at the entrance of the test side channel. The test side channel slopes to a thalweg elevation of 401.4 m resulting in depths increasing by roughly 0.4 m by its juncture with the Peace River mainstem. As designed the site is to be continuously wetted along the thalweg with a depth greater than 0.3 m for PCN discharge excess of 300 $m^3/s$ with water depth in the range of 0.3 to 1.5 m provided with PCN discharge between 300 and 2000 $m^3/s$..

*Discharge*

Discreet discharge measurements were made at site 102.5R Channel 2013 June 10 and August 8, with six different flow values measured. One flow value was measured during decreasing flows while the remaining five were measured during one daily increasing flow. Measurement of low flow discharge at this site is difficult to schedule as flow ceases at low Peace River levels. Discharge measurements cover a range of flows from 0.277 $m^3/s$ at a stage of 402.738 m to 9.90 $m^3/s$ at a stage of 403.256. Discharge values calculated for stages outside of this range are extrapolated estimates; the current stage record ranges from 402.603 m to 405.094 m, with stage values lower than 402.81 below the sensor elevation resulting in missing data prior to 2013 August 8. The rating curve is shown in **Figure 33** and the residuals between the measured discharge and the discharge calculated from the rating curve are given in **Table 39**. The current rating curve shows very good fit (15.8% root mean square of errors). The final stage-discharge relation for site 102.5R Channel is as follows:

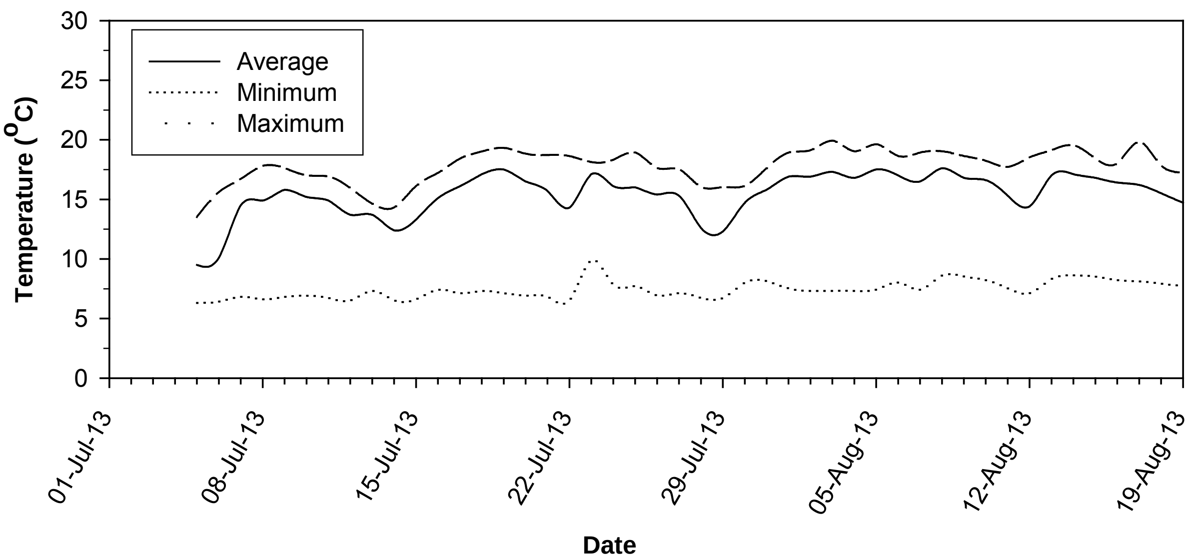
### 3.3.2 Fish Habitat

#### *3.3.2.1 Temperature and Water Quality*

**Water Temperature**

Water temperatures recorded between 2013 July 5 and August 19 ranged from 6.3°C to 19.9°C with an average of 15.4°C (**Figure 9** and **Appendix G, Table G1**). Average daily water temperatures were approximately 10.5°C at the beginning of the monitoring program (July 5) and then increased to approximately 15°C by 20 July. Average daily temperatures fluctuated around this value until August 19 when the data loggers were removed.

**Figure 9** **Average daily water temperatures recorded in Side Channel 102.5R.**




The daily range of water temperature averaged 10.4°C. The daily average and minimum water temperatures were lower, and the daily temperature range was larger than recorded at the other monitored side channels. Side Channel 102.5R is part of the Pine River confluence complex. As such, it is possible that this side channel is influenced by flow from the Pine River.

**General Water Quality**

Water conductivity, pH, and dissolved oxygen measured at fish collection sites in Side Channel 102.5R were generally constant (**Table 18** and **Appendix C, Table C1**). Conductivity values ranged from 280 to 339 µS/cm, pH values ranged from 7.55 to 8.16 pH units, and dissolved oxygen ranged from 6.4 to 7.9 ppm (68 to 86%). Dissolved oxygen concentrations were lower than expected, and may reflect inputs from the Pine River. Water clarity and turbidity at the time of sampling were variable and indicated high suspended sediment loads. Water clarity ranged between 0.01 m and 0.25 m, while turbidity ranged between 36 NTU and 3,056 NTU.

**Table 18 Summary of water quality parameters measured in Side Channel 102.5R.**

| Date | pH | | | Conductivity (µS/cm) | | | Dissolved Oxygen Concentration (ppm) | | Dissolved Oxygen Saturation (%) | | | Clarity (m) | | | Turbidity (NTU) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mean | Range | *n* | Mean | Range | *n* | Mean | Range | Mean | Range | *n* | Mean | Range | *n* | Mean | Range | *n* |
| 7-Aug-13 | 7.99 | 7.75 - 8.16 | 8 | 292.5 | 280 - 312 | 8 | 7.1 | 6.4 - 7.4 | 72.5 | 68 - 76 | 8 | 0.18 | 0.16 - 0.25 | 5 | 70.8 | 36 - 106 | 2 |
| 8-Aug-13 | 7.98 | 7.96 – 8.00 | 2 | 337.5 | 336 - 339 | 2 | 7.9 | | 86.0 | | 1 | 0.02 | 0.01 - 0.02 | 2 | 3,056 | | 1 |
| Overall | 7.99 | 7.75 - 8.16 | 10 | 301.5 | 280 - 339 | 10 | 7.2 | 6.4 - 7.9 | 74.0 | 68 - 86 | 9 | 0.14 | 0.01 - 0.25 | 7 | 1,065 | 36 - 3,056 | 3 |

The turbidity value recorded on August 8 (3,056 NTU) is considered high compared to turbidity values recorded on other sample days. The high value was caused by a combination of two factors. Firstly, a rain event occurred on the sample day of August 8, which resulted in sediment laidened surface runoff originating from sediment deposits along the side channel bank, to enter the side channel. Secondly, the Pine River, which provides source water to the side channel, contained turbid water at the time of sampling. It is not known whether the high turbidity value recorded in Side Channel 102.5R was anomalous. It should be noted that the weather and Pine River conditions observed on August 8 were not atypical for the study area.

### *3.3.2.2 Habitat Characteristics*

At PCN Dam minimum operational discharge (283 $m^3$/s) Side Channel 102.5R contained an estimated 24,917 $m^2$ of potential fish habitat (**Table 19**, **Figure 35**). Fish habitat was dominated by 3 Flat (**Photo 5**) habitat units (84% of available area). Other habitats included 2 Riffle (**Photo 6**) habitat units (12% of available area) and 1 Run (**Photo 7**) habitat unit (4% of available habitat). In total, 12% of the potential fish habitat was not readily available to fish at minimum flow.

A summary of habitat characteristics measured at fish collection sites is presented in **Table 20**. Raw habitat data from fish collection sites and from habitat transects are presented in **Appendix D, Tables D1** and **D2**, respectively. Habitat characteristics were measured only for Flat habitat because other habitats were not available at the time of sampling (i.e. dewatered or too deep to sample). Substrate composition at sites in Flat habitat was dominated by clay/silt/sand (55%) and cobble (41%). Average D90 was 12 cm. Embeddedness and compaction values were high (2.2 and 3.0 out of 3.0, respectively). There were limited amounts of instream cover at fish collection sites – rock (1.3% surface area) and submergent vegetation (14.4% surface area).

**Table 19 Summary of habitat recorded in Side Channel 102.5R.**

| Habitat | Total | | | Amount Subject to Dewatering | | |
|---|---|---|---|---|---|---|
| | *n* | Surface Area ($m^2$) | Percent | *n* | Surface Area ($m^2$) | Percent |
| Flat | 3 | 20,897 | 83.9 | 0 | | |
| Riffle | 2 | 2,922 | 11.7 | 1 | 1,759 | 60.2 |
| Run | 1 | 1,098 | 4.4 | 1 | 1,098 | 100.0 |
| **Total** | **6** | **24,917** | **100.0** | **2** | **2,857** | **11.5** |

**Table 20 Habitat characteristics (mean ± standard error) measured at fish collection sites in Side Channel 102.5R.**

| Parameter[a] | Flat | Riffle |
|---|---|---|
| No. Sites | 8 | 0 |
| Average depth (m) | 0.42 ± 0.04 | |
| Average velocity (m) | 0.01 ± 0.01 | |
| Substrate (%) | | |
| Organic matter | 0.0 | |
| Clay/Silt/Sand | 55.0 ± 16.1 | |
| Gravel/Pebble | 3.8 ± 3.8 | |
| Cobble | 41.3 ± 15.1 | |
| Boulder | 0.0 | |
| Bedrock | 0.0 | |
| D90 (cm) | 12.4 ± 0.2 | |
| Embeddedness | 2.2 ± 0.2 | |
| Compaction | 3.0 ± 0.0 | |
| Cover (%) | | |
| Overhead | 0.0 | |
| Rock | 1.3 ± 0.8 | |
| Large woody debris | 0.0 | |
| Submergent vegetation | 14.4 ± 9.7 | |
| Emergent vegetation | 0.0 | |
| Terrestrial vegetation | 0.0 | |

[a] See Section 2.3.3 for definitions.

**Photo 5 Example of Flat habitat in Side Channel 102.5R.**

**Photo 6 Example of Riffle habitat in Side Channel 102.5R.**

**Photo 7 Example of Run habitat in Side Channel 102.5R.**

### 3.3.3 Fish Community

#### *3.3.3.1 Fish Species and Life Stage*

In total, 958 fish represented by 10 species were recorded in Side Channel 102.5R (**Table 21**). The species included two sportfish (Mountain Whitefish and Northern Pike), three sucker (Longnose, Largescale, and White Suckers), four minnow (Longnose Dace, Redside Shiner, Spottail Shiner, and Trout-perch), and one sculpin (Slimy Sculpin). The most numerically important fish were unidentified young-of-the-year suckers (81.7%), followed by lower numbers of Longnose Dace (6.8%). All other fish species represented ≤ 3.0% of the sample.

Three large-fish species life stages were present in Side Channel 102.5R (**Table 22**). The young-of-the-year life stage was recorded for Mountain Whitefish, Longnose Sucker, and unidentified sucker species. The juvenile life stage of four species was recorded – Northern Pike, Largescale Sucker, Longnose Sucker, and White Sucker. The Longnose Sucker and White Sucker adult life stage also was present.

### Table 21 Number of fish enumerated by species and capture method in Side Channel 102.5R.

| Group | Species | Collection Methods[a] | | | | |
|---|---|---|---|---|---|---|
| | | BS | EF | SF | Total | % |
| Sportfish | Lake Trout | | | | **0** | **0.0** |
| | Mountain Whitefish | 1 | | | **1** | **0.1** |
| | Northern Pike | 5 | | 13 | **18** | **1.9** |
| | Walleye | | | | **0** | **0.0** |
| | Yellow Perch | | | | **0** | **0.0** |
| Suckers | Largescale Sucker | 10 | | | **10** | **1.0** |
| | Longnose Sucker | 9 | | 6 | **15** | **1.6** |
| | White Sucker | 6 | | 13 | **19** | **2.0** |
| | Sucker spp. | 782 | | 1 | **783** | **81.7** |
| Minnows[b] | Lake Chub | | | | **0** | **0.0** |
| | Longnose Dace | 64 | | 1 | **65** | **6.8** |
| | Northern Pikeminnow | | | | **0** | **0.0** |
| | Redside Shiner | 28 | | | **28** | **2.9** |
| | Spottail Shiner | 9 | | | **9** | **0.9** |
| | Trout-perch | 4 | | 5 | **9** | **0.9** |
| Sculpins | Prickly Sculpin | | | | **0** | **0.0** |
| | Slimy Sculpin | | | 1 | **1** | **0.1** |
| **Total** | | **918** | **-** | **40** | **958** | **100.0** |

[a] Methods: EF – backpack electrofisher; BS – beach seine; SF – small fish boat electrofisher.

[b] Includes true minnows (Family Cyprinidae) and Trout-perch (Family Percopsidae).

### Table 22 Large-fish species life stages recorded in Side Channel 102.5R (all methods and sampling events combined).

| Group | Species | Life Stage | | |
|---|---|---|---|---|
| | | YOY | Juv | Adult |
| Sportfish | Lake Trout | | | |
| | Mountain Whitefish | X | | |
| | Northern Pike | | X | |
| | Walleye | | | |
| | Yellow Perch | | | |
| Suckers | Largescale Sucker | | X | |
| | Longnose Sucker | X | X | X |
| | White Sucker | | X | X |
| | Sucker spp. | X | | |
| Minnows | Northern Pikeminnow | | | |
| **Total Number** | | **3** | **4** | **2** |

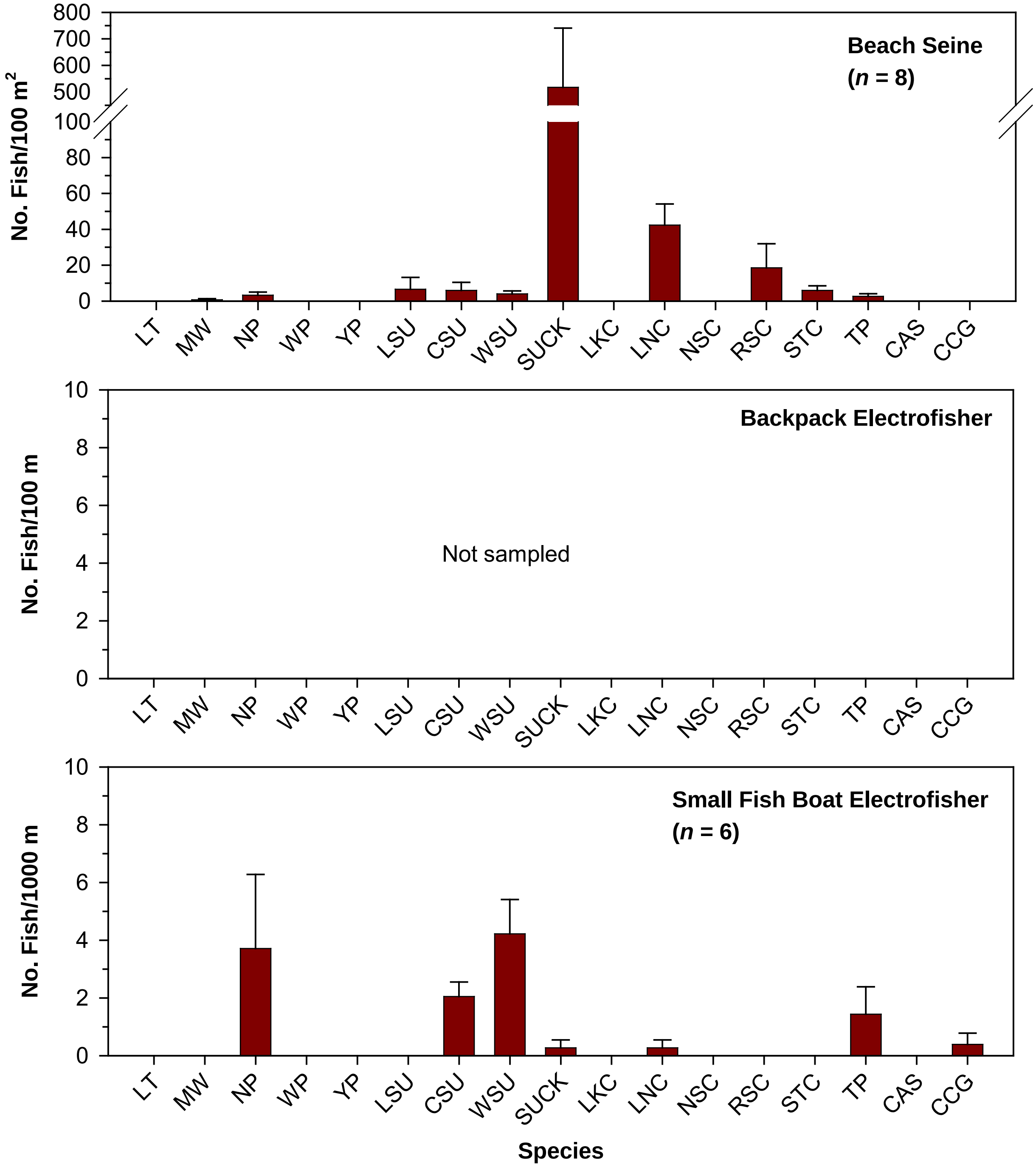
### *3.3.3.2 Catch Rate*

Catch rates were calculated using the beach seine and small fish boat electrofisher samples; high water turbidity at the time of sampling precluded use of backpack electrofisher. Catch rates of both beach seine and small fish boat electrofisher were variable as indicated by the large standard error around most of the estimates (**Figure 10**).

Beach seine catch rates for Mountain Whitefish and Northern Pike were low (0.7 fish/100 $m^2$ and 3.3 fish/100 $m^2$, respectively). Beach seine catch rates for all three sucker species also were low (< 7 fish/100 $m^2$). The most abundant fish in the beach seine catch were unidentified young-of-the-year suckers (517 fish/100 $m^2$), followed by Longnose Dace (42 fish/100 $m^2$), and Redside Shiner (19 fish/100 $m^2$).

Small fish boat electrofisher catch rates were low for all species (< 5 fish/1000 m). Northern Pike was the only sportfish species recorded using this method (3.7 fish/1000 m). White Sucker was the most abundant sucker species encountered (4.2 fish/1000 m), while Trout-perch was the most abundant minnow species (1.4 fish/1000 m).

**Figure 10 Average (± SE) catch rates of fish species/groups in Side Channel 102.5R.**




### *3.3.3.3 Biological Characteristics*

Median lengths of species/groups sampled in Side channel 102.5R are summarized in **Table 23**. Raw biological data are present in **Appendix F**.

**Table 23 Fish species/groups fork length (mm) characteristics in Side Channel 102.5R.**

| Group | Common Name | Beach Seine/ Backpack Electrofisher | | | Small Fish Boat Electrofisher | | |
|---|---|---|---|---|---|---|---|
| | | *n* | Median | Range | *n* | Median | Range |
| Sportfish | Lake Trout | | | | | | |
| | Mountain Whitefish | 1 | 43.0 | | | | |
| | Northern Pike | 5 | 159.0 | 135 – 167 | 3 | 268.0 | 181 – 269 |
| | Walleye | | | | | | |
| | Yellow Perch | | | | | | |
| Sucker | Largescale Sucker | 10 | 45.0 | 39 – 55 | | | |
| | Longnose Sucker | 9 | 48.0 | 21 – 82 | 6 | 386.5 | 167 – 450 |
| | White Sucker | 6 | 49.0 | 45 – 55 | 4 | 318.0 | 44 – 429 |
| | Sucker species | 126 | 21.0 | 11 – 28 | 1 | 17.0 | |
| Minnow/ Trout-perch | Lake Chub | | | | | | |
| | Longnose Dace | 58 | 21.0 | 12 – 54 | 1 | 37.0 | |
| | Northern Pikeminnow | | | | | | |
| | Redside Shiner | 28 | 42.0 | 32 – 47 | | | |
| | Spottail Shiner | 9 | 32.0 | 26 – 37 | | | |
| | Trout-perch | 4 | 35.0 | 22 – 49 | 5 | 55.0 | 48 – 65 |
| Sculpin | Prickly Sculpin | | | | | | |
| | Slimy Sculpin | | | | 1 | 55.0 | |
| | Sculpin species | 1 | 23.0 | | | | |

## 3.4 Side Channel 112.5L

Side Channel 112.5L is located along the left bank of Peace River 7.5 km downstream of the Taylor Bridge. It is a control site located near Side Channel 102.5R. The upper portion of Side Channel 112.5L is regularly inundated and dewatered, while the lower section is permanently wetted and open to Peace River flows.

### 3.4.1 Physical Characteristics

#### *3.4.1.1 Channel Morphology*

Two benchmarks were installed in Side Channel 112.5L on 2013 April 27, with two additional benchmarks installed and surveyed 2013 June 11 using Trimble RTK GPS. Three cross sections were surveyed on 2013 August 9. Surveyed cross sections and benchmark locations are presented in the site layouts and surveys of **Appendix I**.

#### *3.4.1.2 Substrate Texture*

Six sample locations were selected along each of the three cross-sections surveyed in Side Channel 112.5L. Three of the sample locations provided substrate photographs appropriate for digital image processing. Three locations does not provide an adequate sample size to accurately determine grain size distribution for the channel. An additional seven locations provided substrate photographs marginally appropriate for digital image processing. Grain size distribution values were calculated for all ten locations and are given in **Table 40** and shown in **Figure 36**. Grain size distributions, however, should be considered estimates and only used in a qualitative capacity.

Top of banks along Side Channel 112.5L was mainly silt-clay with small and large gravel and occasionally small to large cobbles. The channel was predominantly small and large gravel with frequent small and large cobbles. A summary of substrate types found in Side Channel 40L is given in **Table 41.**

#### *3.4.1.3 Stage and Flow*

Two Leveloggers were installed in Side Channel 112.5L, one near the upstream end, Site 123.5R Upstream, and one near the downstream end, site 112.5L Downstream. The Barologger installed adjacent to site 102.5R Channel was used to compensate Side Channel 112.5L Levelogger data.

**112.5L Upstream Levelogger**

The 112.5L Upstream Levelogger was installed 2013 June 11. The Levelogger was downloaded and re-deployed 2013 August 10. Stage data for site 112.5L Upstream are continuous from 2013 June 11 to August 10 (**Figure 37**). This site only experiences flow at higher Peace River water levels (i.e. 1200 to 1300 $m^3/s$ as reported by WSC *07FD002* Peace River Near Taylor). Due to this limitation discharge measurements were not able to be collected at site 112.5L Upstream and a stage-discharge rating curve was not developed. Two benchmarks were installed at site 112.5 Upstream. A summary of the gauge installation is given in **Appendix H** and history of deployment provided in **Table 2**.

Site 112.5L Upstream is regularly activated by main channel Peace River flows. Taking into account a 45 to 50 minute lag between flows at WSC gauge *07DF002 Peace River near Taylor* and flows at 112.5L Upstream, the upstream portion of Side Channel 112.5L is expected to activate for stages above 2.9 m (1220 $m^3/s$) at WSC gauge *07DF002 Peace River near Taylor* (**Figure 11**). Variations in daily low flow levels are small at site 112.5L Upstream compared to site 112.5L Pool and at WSC gauge *07DF002 Peace River near Taylor* during the period of record. The maximum and minimum daily stage for sites 112.5L Upstream, 112.5L Pool and WSC gauge *07FD002 Peace River near Taylor* are shown in **Figure 12**.

**112.5L Pool Levelogger**

The 112.5L Pool Levelogger was installed on 2013 June 11. On August 8 the Levelogger was found buried in silt and fine sand mud. The logger was retrieved and re-deployed at a new location across the channel. Water temperature records for 112.5L Pool were compared to nearby water and air temperature records and the stage record was closely examined and compared to nearby stage records to determine the approximate timing of burial. Stage data for site 112.5L Pool from 2013 July 26 to August 8, are likely influenced by burial and should be used with caution. Stage data for site 112.5L Pool from 2013 July 3 to July 26 may be influenced by burial.

**Figure 11 Stage record for sites 112.5L Upstream and 112.5L Pool compared to preliminary stage from Water Survey of Canada site 07FD002 Peace River near Taylor.**

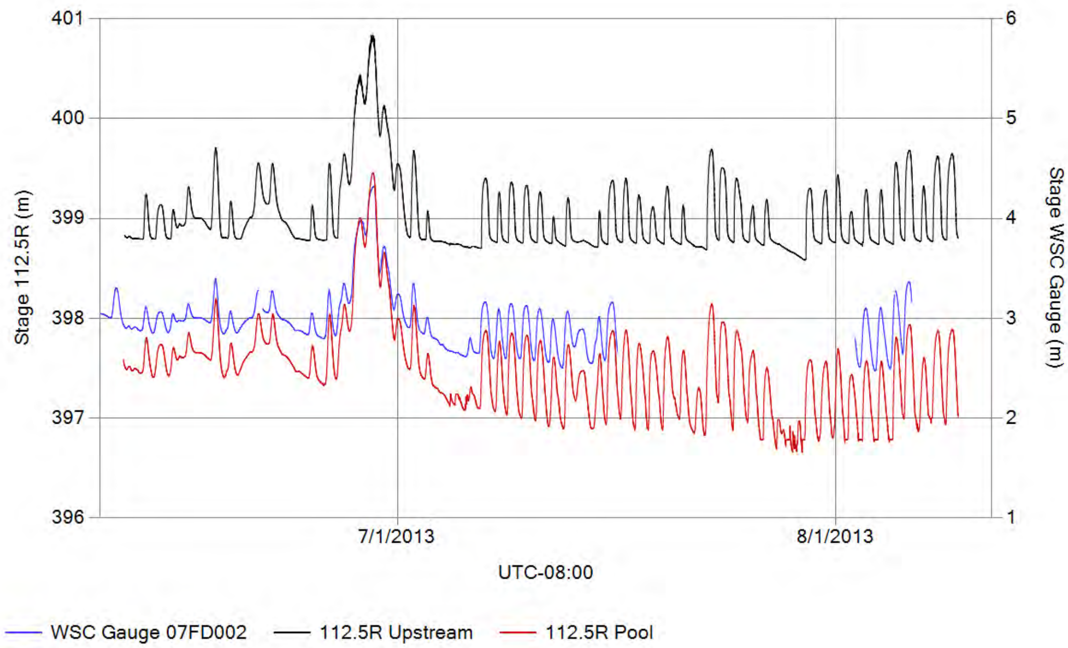
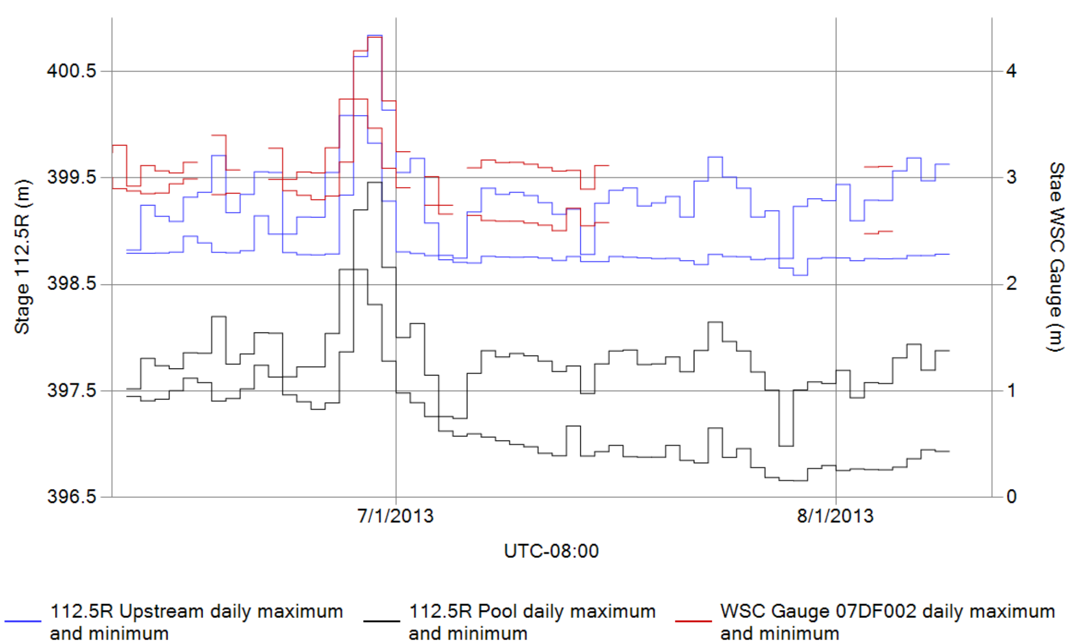



**Figure 12 Maximum and minimum daily stage for site 112.5L Upstream and 112.5L Pool compared to the preliminary maximum and minimum daily stage from WSC site 07FD002 Peace River near Taylor, located on the main channel of Peace River.**



Stage levels at site 112.5L Pool are directly related to main channel Peace River levels, however flow through Side Channel 112.5L is limited under normal flow conditions and the site frequently experiences backwater effects with outflow either ceasing or reversing. One discharge measurements was made at site 112.5L Pool 2013 June 11. This measurement showed minimal flow and confirmed backwatering effects as Peace River stage levels rose. Due to frequent backwatering rating curve development at this site is not expected to provide a viable method of monitoring flow. Direct measurement of flow or velocity (i.e. side mounted ADCP) may allow continuous measurement of flow at this location, but the cost and complexity is likely not warranted. Two benchmarks were installed at site 112.5L Pool. A summary of the gauge installation is given in **Appendix H** and history of deployment provided in **Table 2**.

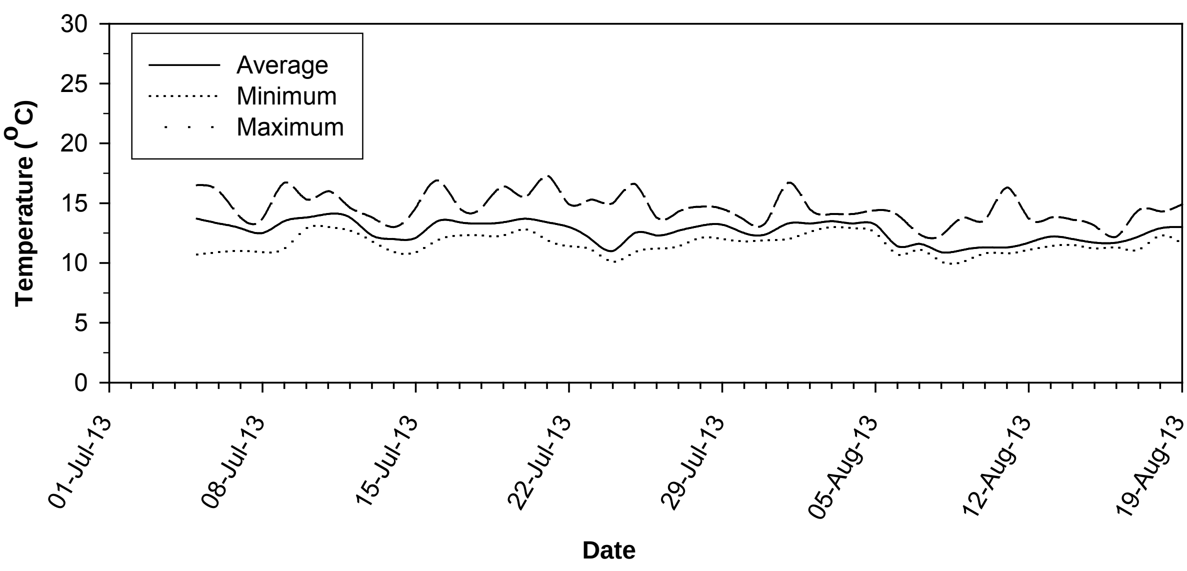
### 3.4.2 Fish Habitat

#### *3.4.2.1 Temperature and Water Quality*

**Water Temperature**

Water temperatures recorded between 2013 July 5 and August 19 ranged from 10.1°C to 17.3°C with an average of 12.6°C (**Figure 13** and **Appendix G, Table G1**). Average daily water temperatures were approximately 12°C during the entire period of monitoring. The daily range of water temperature averaged 3.0°C.

**Figure 13 Average daily water temperatures recorded in Side Channel 112L.**




**General Water Quality**

Water conductivity and pH measured at fish collection sites were generally stable (**Table 24** and **Appendix C, Table C1**). Conductivity values ranged from 187 to 277 µS/cm and pH values ranged from 7.00 to 8.12 pH units. Dissolved oxygen ranged from 6.9 to 9.8 ppm (69 to 98%). Water clarity at the time of sampling was low (0.15 to 0.26 m), which was consistent with measured water turbidity (35 to 97 NTU).

**Table 24 Summary of water quality parameters measured in Side Channel 112L.**

| Date | pH | | | Conductivity (µS/cm) | | | Dissolved Oxygen | | | | | Clarity (m) | | | Turbidity (NTU) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Concentration (ppm) | | Saturation (%) | | | | | | | | |
| | Mean | Range | *n* | Mean | Range | *n* | Mean | Range | Mean | Range | *n* | Mean | Range | *n* | Mean | Range | *n* |
| 13-Aug-1 | 8.02 | 7.91 - 8.12 | 5 | 208.4 | 187 - 277 | 5 | 8.3 | | 88.6 | | 5 | | | | | | |
| 13-Aug-5 | 7.74 | 7.00 - 8.09 | 4 | 240.8 | 237 - 243 | 4 | 8.7 | 8.2 - 9.1 | 89.5 | 83 - 95 | 4 | 0.18 | 0.15 - 0.20 | 2 | 97.4 | | 1 |
| 13-Aug-6 | 7.82 | 7.71 - 8.02 | 6 | 210.7 | 208 - 212 | 6 | 9.5 | 9.3 - 9.8 | 89.8 | 89 - 90 | 6 | 0.24 | 0.23 - 0.26 | 6 | 34.5 | | 1 |
| Overall | 7.86 | 7.00 - 8.12 | 15 | 217.9 | 187 - 277 | 15 | 8.9 | 6.9 - 9.8 | 89.3 | 69 - 98 | 15 | 0.23 | 0.15 - 0.26 | 8 | 66.0 | 35 - 97 | 2 |

### *3.4.2.2 Habitat Characteristics*

At PCN Dam minimum operational discharge (283 $m^3/s$) Side Channel 112L contained an estimated 57,282 $m^2$ of potential fish habitat (**Table 25, Figure 39**). This included 2 Flat (**Photo 8**) habitat units (87% of available area) and 1 Run (**Photo 9**) habitat unit (13% of available area). No Riffle habitats were recorded. In total, 17% of the potential fish habitat was not readily available to fish at minimum flow.

A summary of habitat characteristics measured at fish collection sites is presented in **Table 26**. Raw habitat data from fish collection sites and from habitat transects are presented in **Appendix D, Tables D1** and **D2**, respectively. Habitat characteristics differed between habitat types. Substrate composition at sites in Flat habitat was dominated by clay/silt/sand (97%). Gravel/pebble was the dominant substrate type in Run habitat (85%) with a lesser amount of cobble (15%). D90 values were similar (approximately 10 cm), while embeddedness and compaction values were high (i.e. rating 3.0 out of 3.0) in both habitat types. There was no instream cover at fish collection sites in Flat habitat and a limited amount of rock cover was present in the Run habitat type.

**Table 25 Summary of habitat recorded in Side Channel 112L.**

| Habitat | Total | | | Amount Subject to Dewatering | | |
|---|---|---|---|---|---|---|
| | *n* | Surface Area ($m^2$) | Percent | *n* | Surface Area ($m^2$) | Percent |
| Flat | 2 | 49,777 | 86.9 | 1 | 2,344 | 4.7 |
| Riffle | 0 | | | 0 | | |
| Run | 1 | 7,505 | 13.1 | 1 | 7,505 | 100.0 |
| **Total** | **3** | **57,282** | **100.0** | **2** | **9,849** | **17.2** |

**Table 26 Habitat characteristics (mean ± standard error) measured at fish collection sites in Side Channel 112L.**

| Parameter[a] | Flat | Run |
|---|---|---|
| No. Sites | 8 | 1 |
| Average depth (m) | 0.35 ± 0.05 | 0.14 ± 0.02 |
| Average velocity (m) | 0.00 | |
| Substrate (%) | | |
| Organic matter | 0.0 | 0.0 |
| Clay/Silt/Sand | 96.9 ± 2.5 | 0.0 |
| Gravel/Pebble | 1.9 ± 1.9 | 85.0 |
| Cobble | 1.3 ± 0.8 | 15.0 |
| Boulder | 0.0 | 0.0 |
| Bedrock | 0.0 | 0.0 |
| D90 (cm) | 11.0 ± 1.9 | 8.0 |
| Embeddedness | 3.0 ± 0.0 | 3.0 |
| Compaction | 3.0 ± 0.0 | 3.0 |
| Cover (%) | | |
| Overhead | 0.0 | 0.0 |
| Rock | 0.0 | 5.0 |
| Large woody debris | 0.0 | 0.0 |
| Submergent vegetation | 0.0 | 0.0 |
| Emergent vegetation | 0.0 | 0.0 |
| Terrestrial vegetation | 0.0 | 0.0 |

[a] See Section 2.3.3 for definitions.

**Photo 8 Example of Flat habitat in Side Channel 112L.**

**Photo 9 Example of Run habitat in Side Channel 112L.**

### 3.4.3 Fish Community

#### *3.4.3.1 Fish Species and Life Stage*

In total, 3,145 fish represented by 14 species were recorded in Side Channel 112L (**Table 27**). The species included five sportfish, three sucker, and six minnows. No sculpin species were recorded. The most numerically important fish were Redside Shiner (72%), unidentified young-of-the-year suckers (18%), and Spottail Shiner (3%). All other fish species represented < 2.0% of the sample.

**Table 27 Number of fish enumerated by species and capture method in Side Channel 112L.**

| Group | Species | Collection Methods[a] | | | | |
|---|---|---|---|---|---|---|
| | | BS | EF | SF | Total | % |
| Sportfish | Lake Trout | 1 | | | **1** | **< 0.1** |
| | Mountain Whitefish | 10 | | 3 | **13** | **0.4** |
| | Northern Pike | 5 | | 7 | **12** | **0.4** |
| | Walleye | | | 4 | **4** | **0.1** |
| | Yellow Perch | 4 | | 1 | **5** | **0.2** |
| Suckers | Largescale Sucker | 7 | 1 | 3 | **11** | **0.3** |
| | Longnose Sucker | 28 | | 7 | **35** | **1.1** |
| | White Sucker | 49 | | 10 | **59** | **1.9** |
| | Sucker spp. | 531 | 31 | | **562** | **17.9** |
| Minnows[b] | Lake Chub | 6 | | 5 | **11** | **0.3** |
| | Longnose Dace | 9 | 1 | | **10** | **0.3** |
| | Northern Pikeminnow | 2 | | 3 | **5** | **0.2** |
| | Redside Shiner | 2,233 | | 38 | **2,271** | **72.2** |
| | Spottail Shiner | 82 | | 13 | **95** | **3.0** |
| | Trout-perch | 43 | | 8 | **51** | **1.6** |
| Sculpins | Prickly Sculpin | | | | **0** | **0.0** |
| | Slimy Sculpin | | | | **0** | **0.0** |
| **Total** | | **3,010** | **33** | **102** | **3,145** | **100.0** |

[a] Methods: EF – backpack electrofisher; BS – beach seine; SF – small fish boat electrofisher.

[b] Includes true minnows (Family Cyprinidae) and Trout-perch (Family Percopsidae).

Three large-fish species life stages were present in Side Channel 112L (**Table 28**). The young-of-the-year life stage was recorded for five species (Lake Trout, Mountain Whitefish, Yellow Perch, Largescale Sucker, and Longnose Sucker) and unidentified suckers. The juvenile life stage of five species was recorded – Northern Pike, Largescale Sucker, Longnose Sucker, White Sucker, and Northern Pikeminnow. The Northern Pike, Walleye, Longnose Sucker, and White Sucker adult life stage also was present in the sample.

**Table 28 Large-fish species life stages recorded in Side Channel 112L (all methods and sampling events combined).**

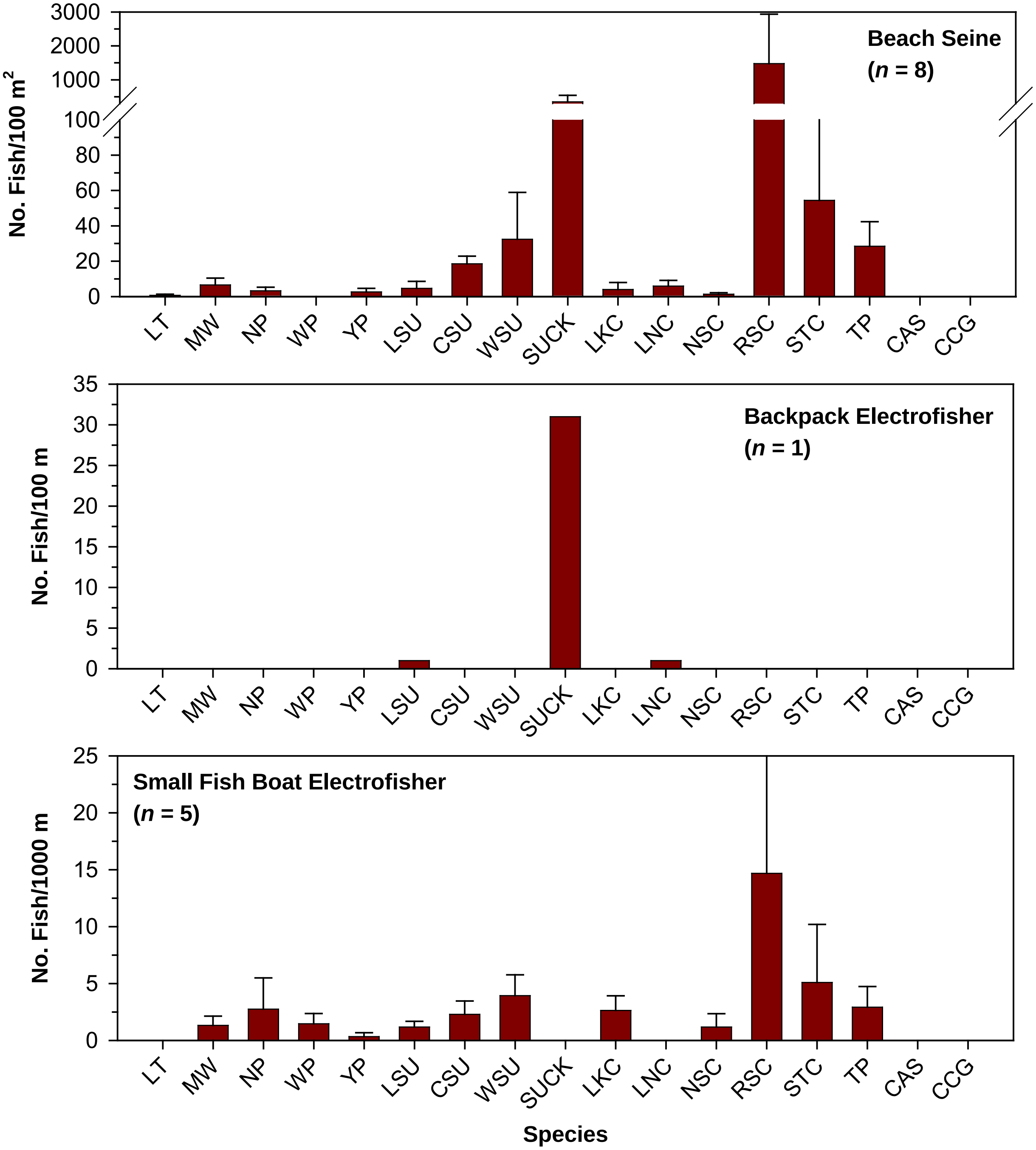
| Group | Species | Life Stage | | |
|---|---|---|---|---|
| | | YOY | Juv | Adult |
| Sportfish | Lake Trout | X | | |
| | Mountain Whitefish | X | | |
| | Northern Pike | | X | X |
| | Walleye | | | X |
| | Yellow Perch | X | | |
| Suckers | Largescale Sucker | X | X | |
| | Longnose Sucker | X | X | X |
| | White Sucker | | X | X |
| | Sucker spp. | X | X | |
| Minnows | Northern Pikeminnow | | X | |
| **Total Number** | | **6** | **6** | **4** |

### *3.4.3.2 Catch Rate*

Catch rates were generated using beach seine, backpack electrofisher, and small fish boat electrofisher samples (**Figure 14**). Redside Shiner (1,476 fish/100 $m^2$), unidentified young-of-the-year sucker species (351 fish/100 $m^2$), Spottail Shiner (54 fish/100 $m^2$), Trout-perch (28 fish/100 $m^2$) and White Sucker (32 fish/100 $m^2$) were the most abundant fish in the beach seine catch. Mountain Whitefish was the most numerous sportfish encountered (7 fish/100 $m^2$).

The highest backpack electrofisher catch rate was recorded for unidentified young-of-the-year suckers (31 fish/100 m). Small fish boat electrofisher catch rates were ≤ 5 fish/1000 m for most species. The only species considered abundant in the small fish boat electrofisher catch was Redside Shiner (15 fish/1000 m).

**Figure 14 Average (± SE) catch rates of fish species/groups in Side Channel 112L.**




### *3.4.3.3 Biological Characteristics*

Median lengths of species/groups sampled in Side channel 112L are summarized in **Table 29**. Raw biological data are present in **Appendix F**.

**Table 29 Fish species/groups fork length (mm) characteristics in Side Channel 112L.**

| Group | Common Name | Beach Seine/ Backpack Electrofisher | | | Small Fish Boat Electrofisher | | |
|---|---|---|---|---|---|---|---|
| | | *n* | Median | Range | *n* | Median | Range |
| Sportfish | Lake Trout | 1 | 49.0 | | | | |
| | Mountain Whitefish | 10 | 49.5 | 41 – 63 | 3 | 67.0 | 55 – 68 |
| | Northern Pike | 5 | 450.0 | 123 – 558 | | | |
| | Walleye | | | | 3 | 397.0 | 327 – 423 |
| | Yellow Perch | 4 | 35.0 | 34 – 45 | 1 | 40.0 | |
| Sucker | Largescale Sucker | 8 | 49.5 | 35 – 66 | 3 | 54.0 | 46 – 68 |
| | Longnose Sucker | 27 | 59.0 | 30 – 89 | 7 | 59.0 | 53 – 471 |
| | White Sucker | 22 | 58.0 | 50 – 79 | 6 | 382.5 | 64 – 448 |
| | Sucker species | 104 | 19.0 | 12 – 46 | | | |
| Minnow/ Trout-perch | Lake Chub | 6 | 63.5 | 55 – 68 | 4 | 60.5 | 47 – 67 |
| | Longnose Dace | 10 | 41.5 | 22 – 69 | | | |
| | Northern Pikeminnow | 2 | 93.5 | 79 –108 | 3 | 94.0 | 57 – 127 |
| | Redside Shiner | 38 | 42.0 | 35 – 64 | 21 | 44.0 | 36 – 74 |
| | Spottail Shiner | 20 | 67.0 | 43 – 79 | 13 | 62.0 | 51 – 79 |
| | Trout-perch | 42 | 51.0 | 16 – 71 | 8 | 55.0 | 49 – 71 |
| Sculpin | Prickly Sculpin | | | | | | |
| | Slimy Sculpin | | | | | | |
| | Sculpin species | | | | | | |

# 4 DISCUSSION

The purpose of the 2013 Peace River Side Channel Fisheries Monitoring Program is the collection of baseline data and to recommend study improvements for future monitoring.

## 4.1 Objective 1 - Collect Baseline Geomorphic Data

The collection of geomorphic data consisted of section surveys and substrate samples. A minimum of 5 sections were surveyed at each site and generally concentrated on the upstream portion of the side channel. The surveys were tied to geodetic datum as well as laid out with benchmarks to allow the same sections to be resurveyed in future years and channel elevation, width, and location compared.

Substrate was sampled at the sites, generally at the same location of the section surveys. Methodology followed that conducted for previous Peace River side channel studies (GMSMON-8, NHC & Mainstream, 2013). Measurements were repeated at 30% of the sites during subsequent trips to ensure methodology was repeatable and consistent.

Lack of active channel area and the presence of vegetation along certain cross sections limited the ability to take sediment samples and substrate photographs. The presence of complex substrates, including materials partially wetted or covered by water, coarser material partially mantled by finer material, and material partially covered by vegetation or algae prevented the determination of an accurate grain size distribution in each of the sampled Side Channels. Many sediment samples also contained clay-silt material, and grain size distributions are limited to gravel-sized sediments and greater (b-axis diameter > 2 mm). While grain size distributions were calculated for several sediment samples, these values should be considered estimates and only used in a qualitative capacity. Although grain size distributions were not always obtainable, classification of the substrate was still accomplished.

Both test sites infrequently experienced flow with fine substrate (silt, clay, organics, and sand) and extensive vegetation. The control sites were activated daily and although the banks were generally fine material, the bed was coarser ranging from gravel to cobble.

## 4.2 Objective 2 - Deploy Instrumentation and Collect Water Level and Flow data

Solonist Leveloggers were deployed to measure and record water level and temperature. The instruments were installed between 2013 April and August along with 2 Barologgers, one at 32L and one at 102.5R, to correct for atmospheric pressure. Three Leveloggers were installed at 32L; upstream within the Peace River mainstem, within the upper pool, and within the downstream portion of channel. The upstream logger failed and was abandoned by August. It reported water level similar to the mainstem gauge 1.75 km upstream (Peace 9) and has not been replaced. Two Leveloggers were installed at 40L; upstream and downstream ends of the side channel. Until the channel works are constructed only one Levelogger is to be installed at 102.5R; it is located in the adjacent side channel south of the site. Two Leveloggers have been installed at 112L; in a shallow source channel near the upstream end of the complex and within the outlet of the side channel.

Flow was not observed in the test channels, but was observed in the control channels. Water levels within the side channels mimicked the daily fluctuation of the mainstem however, often with a reduced rate and magnitude. Side channels less connected with the mainstem - such as the 32L pool - experienced the greatest dampening of water level variability.

### 4.2.1 Application of RISC Standards to Hydrometric Data and QA/QC Procedure

Each gauge uses a calibrated, recorder style sensor with a manufacturer stated accuracy of 0.05% full stage. Due to the potential fluctuations in flow and water level that can be experienced in the Peace River, 10 m full stage gauges have been used. This results in an accuracy of 5 mm which meets Resources Information Standards Committee (RISC) Grade B standard, but falls short of the RISC Grade A standard of 2 mm (Resources Information Standards Committee, 2009). The RISC standards present accuracy without consideration of water level range, preventing sites with substantial water level variation from meeting the standard.

Each site contains a minimum of three surveyed control points including benchmarks and gauge installation hardware, meeting RISC Grade A standard. Data calculation and assessment included data reviews for anomalies and comparison with other stations as per RISC Grade A standards. Rating curve accuracies of 12.2% and 15.8%, however, only meet RISC Grade B standards and discharge values calculated using the extrapolated portion of the rating curves (outside of the highest and lowest gauged flows) are RISC Grade E.

Stream channel conditions at each site appear stable and available discharge measurements are consistent with rating curves. Continued monitoring of channel stability along with a minimum of 5 discharge measurements per site per year (which improves rating curve accuracy to <7 %) are required to ensure Grade A RISC standards are met as side channel hydrometric monitoring continues. Once site stability is verified, fewer level and discharge measurements are required; minimum of 2 recommended but 1 is acceptable for Grade A standard.

### 4.2.2 Flow Measurement Challenges

The side channels are often dry, closed, or intermittently isolated from the main channel. This results in low flow, no flow, or reversing flow during a broad range of water levels, thus, impeding the collection of discharge measurements at many of the sites and hence the development of valid stage-discharge rating curves. A variety of techniques were deployed in an attempt to accommodate the daily range of flow; both handheld ADV and boat mounted ADCP. However, flow was only measurable during high water levels for many of the sites. In order to maintain costs field work targeted lower flows to allow for survey, substrate sampling, and Levelogger installation and maintenance. Without substantially increasing the field time the number of flow measurements and development of suitable rating curves will suffer.

## 4.3 Objective 3 - Collect Data to Characterise the Fish and Fish Habitat in Each Side Channel

The purpose of the fish and fish habitat component of the Peace River Side Channel Fisheries Monitoring Program is to collect baseline data on fish use from selected side channels. The information will be used to document change caused by normal operational flows and to assess response of fish communities to improvement caused by physical works and to spill events. The key management question of the fish and fish habitat component is “Which fish species and fish life stages are using side channels and are changes occurring over time?”

The 2013 program collected information that described the fish community and fish habitat in each of the four side channels. The program used proven fish collection and habitat measurement methods (i.e. used by previous investigations in the study area) to collect standardized data for several parameters. For each side channel, fish habitat was described in terms of water temperature, general water quality, and physical characteristics. For each side channel, the fish community was described in terms of species and life stage diversity, species relative abundance, and biological characteristics. These data in combination with information being collected by the physical characteristics component of the program and by other studies (i.e. Peace River Side Channel Productivity Study) are to be used as a basis to achieve the goal of the program. To this end the 2013 fish and fish habitat component was successful – the required data were collected.

Fish habitats in all side channels were dominated by the Flat habitat type with small amounts of Riffle and/or Run habitat types, both in terms of number of units and surface area. Several of these habitats had the potential to dewater at minimum PCN Dam operational flows. The collected data is of sufficient detail and quality to allow comparison to habitat units that result from post-restoration and spill events.

The characteristics of habitat at fish collection sites were consistent with data collected by the 2012 GMSMON-8 Peace River Side Channel Response Study (Side Channels 32L and 102.5R) (NHC and Mainstream 2013) and by the Site C Peace River Fish Inventory Studies (all side channels) (Mainstream 2010, 2011, 2013b). The following highlights important findings of this study. Firstly, all habitats were influenced by water level fluctuations/water flow, which resulted in frequent changes to water depth and velocity. Secondly, suspended sediments and sedimentation influenced water quality and substrate. Fines (clays, silts, and sands) were a dominant component of side channel substrate and rock substrates that were present were strongly influenced by sedimentation (i.e. high embeddedness and compaction). Although the 2013 results were consistent with findings by previous studies, future comparisons of site specific habitat conditions will be difficult unless Peace River discharge is the same because the water level at the time of sampling dictates the location of the sample site.

In 2013, the side channel fish community consisted of up to 16 species, which was generally consistent with the 18 species expected to occur in Peace River side channels (Mainstream 2010, 2011, 2013b). Differences between studies were as follows. The 2013 program recorded Lake Trout in Side Channel 112L, which is an atypical finding. The 2013 study did not document Kokanee (*Oncorhynchus nerka*) or Lake Whitefish (*Coregonus clupeaformis*). This was expected because the fish collection methods used were not effective for capture of these pelagic species. Finally, the 2013 program did not record Bull Trout (*Salvenlinus confluentus*). This species has been recorded during previous studies, but has never been a large numerical component of the side channel fish community.

In all side channels, the numerically dominant species/life stage in each fish group were:

- Sportfish: young-of-the-year Mountain Whitefish
- Suckers: young-of-the-year unidentified sucker species
- Minnows: Redside Shiner (all life stages).

Sculpins were not numerous in any side channel. The juvenile life stage of all three sucker species (Longnose Sucker, Largescale Sucker, and White Sucker) were well represented in most side channels. In Side Channels 102.5R and 112L, Spottail Shiner, Longnose Dace, and Trout-perch also were present.

The species/life stage composition of side channel fish communities recorded by the present study was consistent with findings by previous investigations (Mainstream 2010, 2011, 2013b; NHC and Mainstream 2013b). The 2013 results are sufficient to document future changes to fish species/life stage presence or absence, at least for the numerically abundant species.

Fish species relative abundance was highly variable in 2013 as evidenced by the large standard error around the catch rate estimate for most species in most side channels. This result is caused by one or more factors that can include clumped distribution of fish, variable sampling conditions, and insufficient sample sizes. The Peace River Fish Index Program has addressed the issue of variable large fish catch rates with some success by standardizing fish collection methods, stratifying by habitat type, and maximizing sample sizes (see P&E 2002). The 2013 program adopted this strategy; however, the results highlighted two primary issues - variable sample conditions and limited sample sizes.

Field conditions at the time of sampling varied in relation to water level and water clarity. For example water levels in Side Channel 32L were low at the time of sampling, which precluded use of the small fish boat electrofisher. In contrast, elevated water levels in Side Channel 40L at the time of sampling hindered use of the backpack electrofisher. Water clarity varied depending on sample date. In Side Channel 102.5R, water clarity was acceptable for fish collections on Day 1 of the field program (0.18 m), but a rain event on Day 2 caused water clarity to decline to near zero (0.02 m). The change in water clarity severely hampered fish capture effectiveness, causing a reduced catch rate. Variable sampling conditions would make it difficult to compare results between side channels and even between habitats within side channels.

The 2013 sample design stratified sampling by habitat type to account potential differences in fish community characteristics. Given the time constraints of the program, this approach limited the amount of sample effort that could be expended in each habitat with a particular fish collection method. As such, the maximum number of samples collected per side channel in 2013 were beach seine (8 sites), backpack electrofisher (3 sites), small fish boat electrofisher (6 sites).

Low precision around catch rate estimates will hinder the ability to identify a change when one occurs. Catch rate is arguably one of the primary metrics used to identify a change in a fish community. If the key management question of the fish and fish habitat component of the program (ie., "Which fish species and fish life stages are using side channels and are changes occurring over time?") is to be answered using catch rate metric, then adjustments are warranted to the approach used in 2013.

## 4.4 Objective 4 - Coordinate with Other Work Programs

Both NHC and Mainstream have been coordinating efforts internally, with BC Hydro, and with other consultants in attempt to maximise value to the program and BC Hydro. Specifically, work has been coordinated between this monitoring program and GMSWORKS-3, GMSMON-2, GMSMON-5, and GMSWORKS-6.

## 4.5 Objective 5 - Report

This document has been prepared to meet the fifth objective of reporting. The document has been formatted to provide a concise document that summarises the work completed, supported with appendices that further expand on the data collected. Recommendations for future monitoring are provided in the summary section of the report.

# 5 SUMMARY AND RECOMMENDATIONS

The Peace River downstream of the GMS and PCN experience a regulated flow regime with reduced peak flow levels and increased diurnal fluctuation of flow and water level. A consequence of the regulated flow regime is the infilling and encroachment of side channel habitat, leaving many of the side channels closed or intermittently isolated from the main channel and limiting the value of remaining habitat due to flow variability.

The altered flow regime and infilling of side channels is the impetus for this study, but also impedes the study. Many of the sites are often dry or have little flow preventing the measurement of flow and development of rating curves. The diurnal variable water level, flow, and turbidity conditions also impact the consistency and repeatability of fish sampling efforts. A variety of techniques have been deployed in attempt to accommodate the daily range of flow; that is both handheld ADV and boat mounted ADCP were used to collect flow measurements, and small fish boat electrofishing, beach seine netting, and backpack electrofishing fish collection methods were made available to accommodate the range of conditions.

The following two tables (**Table 30** and **Table 31**) re-states the WUP Consultative Committee management questions and Fisheries Technical Committee developed hypothesis in the context of the 2013 study.

### Table 30 2013 Study compared with GMSMON-7 management questions

| Questions and 2013 Study Findings | |
|---|---|
| Question 1: | What is the response of side channel stage to fluctuations in discharge? |
| Discussion 1: | Water level in side channels directly connected to the mainstem mimics that of the mainstem. Daily fluctuations for some gauges appear slightly greater than the mainstem (112.5L and 102.5R vs WSC 07DF002), but that may be an artefact of spatial distance between mainstem and side channel gauges.<br>Side channels not continuously directly connected to the mainstem, such as 32L Pool, have substantially less fluctuation in stage (i.e. 0.1 m vs 1.4 m daily fluctuation). |
| Question 2: | What physical processes are occurring in the beds of side channels of the Peace River and is there a trend over time? |
| Discussion 2: | This is the first year of study with only baseline data collected. Limited comparison of substrate with past studies (ie. GMSMON-8, NHC and Mainstream Aquatics Ltd. 2013) suggests no significant change in substrate distribution over the past year. |
| Question 3: | Which fish species and fish life stages are using the side channels of the Peace River and are changes occurring over time? |
| Discussion 3: | Upstream of the Pine River the fish community is dominated by young-of-the year Mountain Whitefish, young-of-the-year and juveniles ofsucker species, and minnows.<br>Downstream of the Pine River the fish community is dominated by young-of-the-year and juveniles of sucker species, and minnows. Northern Pike, Yellow Perch and Spottail Shiner were not encountered in Trila Side Channel 102.5L in 2013, but these species were recorded by previous studies,<br>An estimate of temporal change of side channel fish communities cannot be made with any certainty based on the existing data. |

**Table 31 2013 Study compared with GMSMON-7 hypothesis**

| Hypothesis | 2013 Study Finding |
|---|---|
| **Hypothesis 1** | Morphology of side channel is changing |
| A) With time? | Only baseline data collected, such a determination is not yet possible. |
| B) In trial sites more than control sites? | Base line data prior to trial site development, such a determination is not yet possible. |
| **Hypothesis 2** | Bed material armouring in side channel is changing |
| A) With time? | No indication of coarse substrate movement in the studied side channels since the last post spill assessment. Fine fluvial deposited sediment overlies much of the side channel substrate. |
| B) In trial sites more than control sites? | Base line data prior to trial site development, such a determination is not yet possible. Presently trial sites are primarily surfaced with fine sediment and vegetation experiencing only infrequent surface flow. |
| **Hypothesis 2** | Relative abundance of fish species, age/size class structure, fish numbers, and species present in side channels is changing |
| A) With time? | An estimate of temporal change of side channel fish communities cannot be made with any certainty based on the existing data. |
| B) In trial sites more than control sites? | Base line data prior to trial site development, such a determination is not yet possible. |

## 5.1 Physical Characteristics

The following recommendations are proposed as part of the continued monitoring on physical characteristics of the Peace River side channels:

- Continue monitoring stage at all currently operational sites. Maintain the installed Leveloggers by downloading and redeploying data a minimum of one to two times per year. The Leveloggers are susceptible to freezing. It is therefore recommended that they are inspected soon after breakup to limit any loss of data collection. Spare Leveloggers should be on hand during site inspections. Retrieval and redeployment of the loggers should be done during low water levels.
- A minimum of five flow measurements per year is recommended to maintain existing rating curves until it is shown that the rating curves are stable. This coincides with RISC Grade A standards (Resources Information Standards Committee, 2009). The minimum five flow measurements per year currently applies to side channels 40L and 102.5R to refine existing rating curves.
- Deploy Leveloggers and collect geomorphic baseline data (survey and substrate) in test side channels following their construction. Most immediately this pertains to the expected 2014 development of test side channel 102.5R, but may eventually also apply to test side channel 32L.

- Following deployment of new Leveloggers in constructed test side channels, flow measurements should be collected and rating curves developed; that is test channel 102.5R and potentially 32L.
- Additional attempts should be made to collect flow measurements and develop a rating curve for the gauges at control side channel 112.5L. The upstream gauged channel is only active during high Peace River levels. The downstream portion of the channel appears to generally experience slack, reversing, or zero flow conditions. Flow measurements for the upper side channel should target Peace River flows greater than 1200 $m^3/s$ (as measured near Taylor by WSC 07FD002). Measurable flow is not expected for the downstream gauge until Peace River flows exceed 2500 $m^3/s$ at Taylor. Access of the gauges for downloading data will need to be done during low flow..

It is expected that similar to the upstream Levelogger at 32L, instrumentation will experience damage or failure. Changes at the sites can be expected over time that will affect rating curve stability. The work program should be prepared with budget, time, and reserve equipment to accommodate equipment failures and between two and eight discharge measurements and subsequent processing per year. Flow requirements for discharge are generally in conflict with data download requirements and should be scheduled accordingly.

In addition to the data collected under this program, data collected through other programs such as GMSMON-8, GMSWORKS-6, and GMSWORKS-5 and air photographs regularly collected by BC Hydro (i.e. 2013 August 11) should be incorporated in assessing the geomorphic change of test and control side channels either following the development of the test channels or from spill flows.

## 5.2 Fish and Fish Habitat

The fish and fish habitat component of the 2013 program collected information that described the fish community and fish habitat in each of four side channels. The program used proven fish collection and habitat measurement methods to collect standardized data for several parameters. For each side channel, fish habitat was described in terms of water temperature, general water quality, and physical characteristics. For each side channel, the fish community was described in terms of species and life stage diversity, species relative abundance, and biological characteristics. To this end the 2013 fish and fish habitat component was successful – the required data were collected.

The following recommendations are made to adjust the fish and fish habitat component of the program to address three factors that can limit the success of the program:

1. Suspended sediment and sedimentation are criteria that can substantially influence the value and use of side channel fish habitats. The following recommendations are to improve the current monitoring program by better monitoring and accounting for these criteria.

    - Turbidity data loggers should be considered to allow continuous monitoring. Sites should be located in the mainstem and side channels to allow comparison of effect.

- Point measurements of water quality should be expanded from measurements at fish collection sites to measurements at fixed site locations.

2. Provided that field time and sampling effort are not increased, the precision of catch rate estimates can be improved by applying the following principals:

   - PCN Dam operational flows during sampling should be similar between years and ideally low flow.
   - Sampling should occur during the same season and under the same conditions (e.g., water temperature and water clarity).
   - Sampling should continue to be stratified by habitat type.
   - Limit fish collection methods to beach seine. Beach seine was found to be the most effective fish collection method in 2013 when compared to all other methods in terms of fish capture efficiency, number of species encountered and number of dominant habitat types sampled. As such, fish data collected using this method is the most sensitive to changes in side channel habitat condition. Limiting fish collection methods to beach seine will triple the available sample size (given no substantive change in budget), which will result in increased coverage of habitats within each side channel and improve the precision of beach seine catch rate estimates. This recommendation is intended to increase the value and reliability of the catch rate metric and all other fish-related metrics.

3. To maximize data quality while accounting for the low fish numbers of some species the monitoring program should focus sampling and analytical efforts on a select number of target species/fish groups (i.e. most numerous), while continuing to monitor species and life stage diversity. The species and life stages to target are:

   - Sportfish -- young-of-the-year Mountain Whitefish
   - Suckers -- young-of-the-year sucker species
   - Minnows -- Redside Shiner

4. The author's acknowledge that the greatest change in fish community post enhancement will be in areas of each side channel that are, at present, frequently dewatered and that are largely non-fish bearing. These areas will become available to fish following enhancement. We assume based on existing evidence that under present conditions these areas are largely non fish-bearing, and therefore, do not warrant extensive sampling. For future studies during the post-enhancement phase we recommend additional sampling in areas of each side channel that are to be enhanced, as well as in comparable areas of control side channels that will not be enhanced.

These recommendations are intended to fill data gaps for important factors that influence the fish community, to modify the design in order to increase the precision of data, or to focus the program to maximize the quality of the data. These adjustments will maintain continuity with previous studies and improve the component's ability to address the key management question: "Which fish species and fish life stages are using side channels and are changes occurring over time?"

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# TABLES NOT INCLUDED IN THE REPORT BODY

**Table 32 Summary of substrate types found in Side Channel 32L.**

| Location ID | Cross section | Sample number | Location | Substrate type* |
|---|---|---|---|---|
| 32L 1-1 | 1 | 1 | Top of right bank | CL |
| 32L 1-2 | 1 | 2 | In channel | CL |
| 32L 1-3 | 1 | 3 | In channel | CL |
| 32L 1-4 | 1 | 4 | In channel | CL |
| 32L 1-5 | 1 | 5 | Top of left bank | CL |
| 32L 2-1 | 2 | 1 | Top of right bank | CL |
| 32L 2-2 | 2 | 2 | In channel | CL |
| 32L 2-3 | 2 | 3 | In channel | CL |
| 32L 2-4 | 2 | 4 | In channel | CL |
| 32L 2-5 | 2 | 5 | Top of left bank | CL |
| 32L 3-1 | 3 | 1 | Top of right bank | CL |
| 32L 3-2 | 3 | 2 | In channel | CL |
| 32L 3-3 | 3 | 3 | In channel | CL |
| 32L 3-4 | 3 | 4 | In channel | CL, LC, SB |
| 32L 3-5 | 3 | 5 | Top of left bank | CL |
| 32L 4-1 | 4 | 1 | Top of right bank | CL, LC, SB |
| 32L 4-2 | 4 | 2 | In channel | CL |
| 32L 4-3 | 4 | 3 | In channel | CL |
| 32L 4-4 | 4 | 4 | In channel | CL, SB |
| 32L 4-5 | 4 | 5 | Top of left bank | CL, SB |
| 32L 5-1 | 5 | 1 | Top of right bank | CL |
| 32L 5-2 | 5 | 2 | In channel | CL |
| 32L 5-3 | 5 | 3 | In channel | CL |
| 32L 5-4 | 5 | 4 | In channel | CL |
| 32L 5-5 | 5 | 5 | Top of left bank | CL |
| 32L 6-1 | 6 | 1 | Top of right bank | CL |
| 32L 6-2 | 6 | 2 | In channel | LC, SB |
| 32L 6-3 | 6 | 3 | In channel | LC, SB |
| 32L 6-4 | 6 | 4 | In channel | LC, SB |
| 32L 6-5 | 6 | 5 | Top of left bank | CL |
| 32L 7-1 | 7 | 1 | Top of right bank | CL |
| 32L 7-2 | 7 | 2 | In channel | CL, LG, SC |
| 32L 7-3 | 7 | 3 | In channel | CL, LG, SC |
| 32L 7-4 | 7 | 4 | In channel | CL, LG, SC |

| Location ID | Cross section | Sample number | Location | Substrate type* |
|---|---|---|---|---|
| 32L 7-5 | 7 | 5 | Top of left bank | CL |
| 32L 8-1 | 8 | 1 | Top of right bank | CL |
| 32L 8-2 | 8 | 2 | In channel | CL |
| 32L 8-3 | 8 | 3 | In channel | CL |
| 32L 8-4 | 8 | 4 | In channel | CL |
| 32L 8-5 | 8 | 5 | Top of left bank | CL |
| 32L 9-1 | 9 | 1 | Top of right bank | CL |
| 32L 9-2 | 9 | 2 | In channel | CL |
| 32L 9-3 | 9 | 3 | In channel | CL |
| 32L 9-4 | 9 | 4 | In channel | CL, LG, SC |
| 32L 9-5 | 9 | 5 | Top of left bank | CL, LG, SC |

* CL: silt-clay (< 0.1 mm)
SD: sand (< 2 mm)
SG: small gravel (2-16 mm)
LG: large gravel (16-64 mm)
SC: small cobble (64-128 mm)
LC: large cobble (128-256 mm)
SB: small boulder (> 256 mm)

**Table 33 Summary of site 32L Upstream stage record data gaps. All gaps are caused by water levels dropping below the sensor elevation.**

| From time | To time | Hour affected | Days affected |
|---|---|---|---|
| 2013-04-25 02:10 | 2013-04-25 09:20 | 7.2 | 0.3 |
| 2013-04-26 00:10 | 2013-04-26 09:10 | 9.0 | 0.4 |
| 2013-04-26 21:00 | 2013-04-27 09:50 | 12.8 | 0.5 |
| 2013-04-27 18:20 | 2013-04-28 22:00 | 27.7 | 1.2 |
| 2013-04-29 02:30 | 2013-04-29 09:00 | 6.5 | 0.3 |
| 2013-04-30 04:00 | 2013-04-30 07:50 | 3.8 | 0.2 |
| 2013-05-01 03:00 | 2013-05-01 08:20 | 5.3 | 0.2 |
| 2013-05-02 02:20 | 2013-05-02 09:00 | 6.7 | 0.3 |
| 2013-05-03 02:00 | 2013-05-03 10:10 | 8.2 | 0.3 |
| 2013-05-04 01:00 | 2013-05-05 17:00 | 40.0 | 1.7 |
| 2013-05-06 02:50 | 2013-05-06 08:10 | 5.3 | 0.2 |
| 2013-05-07 03:10 | 2013-05-07 09:30 | 6.3 | 0.3 |
| 2013-05-07 23:30 | 2013-05-08 21:20 | 21.8 | 0.9 |
| 2013-05-08 22:10 | 2013-05-09 09:20 | 11.2 | 0.5 |
| 2013-05-10 00:50 | 2013-05-10 15:40 | 14.8 | 0.6 |
| 2013-05-11 01:00 | 2013-05-11 11:50 | 10.8 | 0.5 |
| 2013-05-12 01:40 | 2013-05-13 08:30 | 30.8 | 1.3 |
| 2013-05-14 00:20 | 2013-05-14 09:20 | 9.0 | 0.4 |
| 2013-05-14 13:20 | 2013-05-15 14:20 | 25.0 | 1.0 |
| 2013-05-15 15:10 | 2013-05-16 09:30 | 18.3 | 0.8 |
| 2013-05-16 22:00 | 2013-05-20 11:50 | 85.8 | 3.6 |
| 2013-05-20 13:50 | 2013-05-21 19:40 | 29.8 | 1.2 |
| 2013-05-22 00:50 | 2013-05-22 10:50 | 10.0 | 0.4 |
| 2013-05-22 12:10 | 2013-05-27 20:20 | 128.2 | 5.3 |
| 2013-05-28 00:20 | 2013-05-28 18:00 | 17.7 | 0.7 |
| 2013-05-29 00:30 | 2013-05-29 10:00 | 9.5 | 0.4 |
| 2013-05-30 00:40 | 2013-05-30 12:50 | 12.2 | 0.5 |
| 2013-05-30 19:50 | 2013-05-31 10:40 | 14.8 | 0.6 |
| 2013-06-01 01:40 | 2013-06-01 11:40 | 10.0 | 0.4 |
| 2013-06-01 12:50 | 2013-06-02 01:50 | 13.0 | 0.5 |
| 2013-06-02 03:20 | 2013-06-03 18:50 | 39.5 | 1.6 |

**Table 34 Summary of grain size distributions for sediment samples collected in Side Channel 40L. Grain size distributions should be considered estimates and only used in a qualitative capacity.**

| Location ID | Cross section | Sample number | Ideal for GSD analysis | $D_{10}$ (mm) | $D_{20}$ (mm) | $D_{30}$ (mm) | $D_{40}$ (mm) | $D_{50}$ (mm) | $D_{60}$ (mm) | $D_{70}$ (mm) |
|---|---|---|---|---|---|---|---|---|---|---|
| 40L 1-1 | 1 | 1 | Yes | 1.7 | 2.6 | 4.0 | 5.7 | 7.6 | 10.8 | 14.8 |
| 40L 1-3 | 1 | 3 | No | 20.4 | 28.2 | 40.0 | 44.1 | 47.5 | 51.3 | 56.2 |
| 40L 1-4 | 1 | 4 | No | 11.3 | 24.4 | 34.6 | 61.4 | 80.9 | 102.3 | 121.8 |
| 40L 1-5 | 1 | 5 | No | 2.5 | 5.8 | 11.1 | 20.1 | 34.5 | 51.6 | 65.3 |
| 40L 1-6 | 1 | 6 | No | 2.8 | 5.3 | 9.6 | 15.2 | 23.8 | 35.1 | 60.1 |
| 40L 2-4 | 2 | 4 | No | 3.1 | 8.0 | 14.9 | 20.0 | 25.6 | 31.4 | 42.8 |
| 40L 2-5 | 2 | 5 | No | 19.7 | 29.2 | 33.8 | 36.9 | 40.0 | 45.1 | 64.5 |
| 40L 2-6 | 2 | 6 | No | 2.1 | 7.2 | 16.4 | 23.1 | 29.7 | 39.3 | 50.9 |
| 40L 2-7 | 2 | 7 | No | 3.0 | 6.6 | 12.1 | 21.0 | 33.0 | 40.9 | 50.0 |
| 40L 2-8 | 2 | 8 | No | 2.6 | 4.8 | 8.6 | 15.2 | 23.7 | 40.5 | 46.9 |
| 40L 2-9 | 2 | 9 | No | 3.9 | 9.3 | 16.3 | 22.3 | 28.9 | 34.7 | 47.9 |
| 40L 2-10 | 2 | 10 | Yes | 1.4 | 2.2 | 3.5 | 4.8 | 6.9 | 10.7 | 15.4 |
| 40L 3-4 | 3 | 4 | No | 1.9 | 4.1 | 7.5 | 12.2 | 17.1 | 30.3 | 51.8 |
| 40L 3-6 | 3 | 6 | No | 1.8 | 2.8 | 3.6 | 5.3 | 7.2 | 9.7 | 15.1 |
| 40L 3-8 | 3 | 8 | No | 1.9 | 3.9 | 9.8 | 15.9 | 28.1 | 39.9 | 50.9 |
| 40L 4-6 | 4 | 6 | No | 5.7 | 33.8 | 65.3 | 82.4 | 97.5 | 118.8 | 144.2 |
| 40L 4-7 | 4 | 7 | No | 1.9 | 4.6 | 12.2 | 19.3 | 26.5 | 35.8 | 45.8 |
| 40L 4-8 | 4 | 8 | No | 3.2 | 6.7 | 13.9 | 31.3 | 38.2 | 42.7 | 48.5 |
| 40L 4-9 | 4 | 9 | No | 2.1 | 4.2 | 10.3 | 18.6 | 24.8 | 30.8 | 45.0 |
| 40L 4-10 | 4 | 10 | No | 7.3 | 12.2 | 16.1 | 22.0 | 27.5 | 33.5 | 50.0 |
| 40L 5-6 | 5 | 6 | No | 1.6 | 3.0 | 6.1 | 12.7 | 21.4 | 31.3 | 41.8 |
| 40L 5-7 | 5 | 7 | No | 1.8 | 3.5 | 6.9 | 10.9 | 15.3 | 22.0 | 28.6 |
| 40L 5-8 | 5 | 8 | No | 1.5 | 2.6 | 5.3 | 9.6 | 18.7 | 29.6 | 41.9 |
| 40L 5-9 | 5 | 9 | No | 2.4 | 5.3 | 8.2 | 11.0 | 13.4 | 16.6 | 20.5 |
| 40L 5-10 | 5 | 10 | No | 2.4 | 3.8 | 5.6 | 7.4 | 11.0 | 16.5 | 24.1 |

**Table 35 Summary of substrate types found in Side Channel 40L.**

| Location ID | Cross section | Sample number | Location | Substrate type* |
|---|---|---|---|---|
| 40L 1-1 | 1 | 1 | Top of left bank | CL, SG |
| 40L 1-2 | 1 | 2 | In channel | SC, LC |
| 40L 1-3 | 1 | 3 | In channel | LC, SC, SB |
| 40L 1-4 | 1 | 4 | In channel | LC, SC |
| 40L 1-5 | 1 | 5 | In channel | LC, SC |
| 40L 1-6 | 1 | 6 | In channel | LC, SC, SB |
| 40L 1-7 | 1 | 7 | In channel | CL, SC, LC |
| 40L 1-8 | 1 | 8 | In channel | SC, LC |
| 40L 1-9 | 1 | 9 | In channel | CL |
| 40L 1-10 | 1 | 10 | Top of right bank | CL |
| 40L 2-1 | 2 | 1 | Top of right bank | CL |
| 40L 2-2 | 2 | 2 | In channel | CL |
| 40L 2-3 | 2 | 3 | In channel | CL, SC, LC |
| 40L 2-4 | 2 | 4 | In channel | SC, LC |
| 40L 2-5 | 2 | 5 | In channel | CL, SC, LC, SB |
| 40L 2-6 | 2 | 6 | In channel | SC, LC |
| 40L 2-7 | 2 | 7 | In channel | SC, LC |
| 40L 2-8 | 2 | 8 | In channel | SC, LC, SB |
| 40L 2-9 | 2 | 9 | In channel | SC, LC |
| 40L 2-10 | 2 | 10 | Top of left bank | CL, SG, LG |
| 40L 3-1 | 3 | 1 | Top of right bank | CL |
| 40L 3-2 | 3 | 2 | In channel | CL |
| 40L 3-3 | 3 | 3 | In channel | CL, SC |
| 40L 3-4 | 3 | 4 | In channel | LG, SC, LC |
| 40L 3-5 | 3 | 5 | In channel | LG, SC, LC |
| 40L 3-6 | 3 | 6 | In channel | CL, LG, SC, LC |
| 40L 3-7 | 3 | 7 | In channel | CL, LG, SC, LC, SB |
| 40L 3-8 | 3 | 8 | In channel | CL, LG, SC, LC, SB |
| 40L 3-9 | 3 | 9 | In channel | SG, LG, LC |
| 40L 3-10 | 3 | 10 | Top of left bank | SG, LG, SC |
| 40L 4-1 | 4 | 1 | Top of right bank | CL |
| 40L 4-2 | 4 | 2 | In channel | CL |
| 40L 4-3 | 4 | 3 | In channel | CL |
| 40L 4-4 | 4 | 4 | In channel | CL, LG, SC, LC |

| Location ID | Cross section | Sample number | Location | Substrate type* |
|---|---|---|---|---|
| 40L 4-5 | 4 | 5 | In channel | CL, SC, LC |
| 40L 4-6 | 4 | 6 | In channel | CL, SC, LC |
| 40L 4-7 | 4 | 7 | In channel | LG, SC, LC |
| 40L 4-8 | 4 | 8 | In channel | LG, SC, LC |
| 40L 4-9 | 4 | 9 | In channel | SG, LG, SC, LC |
| 40L 4-10 | 4 | 10 | Top of left bank | CL, SG, LG, SC, LC |
| 40L 5-1 | 5 | 1 | Top of left bank | CL, LG, SC, LC |
| 40L 5-2 | 5 | 2 | In channel | CL |
| 40L 5-3 | 5 | 3 | In channel | CL |
| 40L 5-4 | 5 | 4 | In channel | CL |
| 40L 5-5 | 5 | 5 | In channel | CL, LC, SB |
| 40L 5-6 | 5 | 6 | In channel | LG, SC, LC |
| 40L 5-7 | 5 | 7 | In channel | SG, LG, SC, LC |
| 40L 5-8 | 5 | 8 | In channel | SG, LG, SC, LC |
| 40L 5-9 | 5 | 9 | In channel | SG, LG, SC, LC, SB |
| 40L 5-10 | 5 | 10 | Top of right bank | CL, SG, LG, SC, SB |

* CL: silt-clay (< 0.1 mm)
SD: sand (< 2 mm)
SG: small gravel (2-16 mm)
LG: large gravel (16-64 mm)
SC: small cobble (64-128 mm)
LC: large cobble (128-256 mm)
SB: small boulder (> 256 mm)

**Table 36 Summary of site 40L Upstream stage record data gaps. All gaps are caused by water levels dropping below the sensor elevation.**

| From time | To time | Hour affected | Days affected |
|---|---|---|---|
| 2013-04-27 02:00 | 2013-04-27 10:40 | 8.7 | 0.4 |
| 2013-04-27 22:20 | 2013-04-28 20:30 | 22.2 | 0.9 |
| 2013-04-29 06:50 | 2013-04-29 08:40 | 1.8 | 0.1 |
| 2013-05-01 06:20 | 2013-05-01 08:30 | 2.2 | 0.1 |
| 2013-05-02 05:40 | 2013-05-02 09:20 | 3.7 | 0.2 |
| 2013-05-03 05:20 | 2013-05-03 10:10 | 4.8 | 0.2 |
| 2013-05-04 04:50 | 2013-05-04 11:10 | 6.3 | 0.3 |
| 2013-05-04 18:40 | 2013-05-04 21:30 | 2.8 | 0.1 |
| 2013-05-05 02:50 | 2013-05-05 15:00 | 12.2 | 0.5 |
| 2013-05-07 06:50 | 2013-05-07 09:40 | 2.8 | 0.1 |
| 2013-05-08 03:50 | 2013-05-08 16:00 | 12.2 | 0.5 |
| 2013-05-09 02:30 | 2013-05-09 09:40 | 7.2 | 0.3 |
| 2013-05-10 04:20 | 2013-05-10 14:00 | 9.7 | 0.4 |
| 2013-05-11 04:50 | 2013-05-11 11:50 | 7.0 | 0.3 |
| 2013-05-12 05:00 | 2013-05-12 14:30 | 9.5 | 0.4 |
| 2013-05-12 22:40 | 2013-05-13 08:50 | 10.2 | 0.4 |
| 2013-05-14 03:40 | 2013-05-14 09:40 | 6.0 | 0.3 |
| 2013-05-14 20:30 | 2013-05-15 11:30 | 15.0 | 0.6 |
| 2013-05-15 19:30 | 2013-05-15 22:00 | 2.5 | 0.1 |
| 2013-05-16 02:40 | 2013-05-16 10:00 | 7.3 | 0.3 |
| 2013-05-17 01:50 | 2013-05-18 12:20 | 34.5 | 1.4 |
| 2013-05-18 16:30 | 2013-05-20 00:20 | 31.8 | 1.3 |
| 2013-05-20 03:30 | 2013-05-20 09:00 | 5.5 | 0.2 |
| 2013-05-21 04:20 | 2013-05-21 10:10 | 5.8 | 0.2 |
| 2013-05-22 04:40 | 2013-05-22 10:10 | 5.5 | 0.2 |
| 2013-05-22 16:00 | 2013-05-22 23:40 | 7.7 | 0.3 |
| 2013-05-23 04:20 | 2013-05-23 10:10 | 5.8 | 0.2 |
| 2013-05-23 22:30 | 2013-05-24 13:20 | 14.8 | 0.6 |
| 2013-05-24 16:30 | 2013-05-27 19:50 | 75.3 | 3.1 |
| 2013-05-28 04:10 | 2013-05-28 17:40 | 13.5 | 0.6 |
| 2013-05-29 04:10 | 2013-05-29 10:00 | 5.8 | 0.2 |
| 2013-05-30 05:50 | 2013-05-30 12:30 | 6.7 | 0.3 |
| 2013-06-02 11:00 | 2013-06-02 23:20 | 12.3 | 0.5 |

| From time | To time | Hour affected | Days affected |
|---|---|---|---|
| 2013-06-03 05:40 | 2013-06-03 18:30 | 12.8 | 0.5 |
| 2013-06-04 03:40 | 2013-06-04 11:50 | 8.2 | 0.3 |
| 2013-06-04 18:40 | 2013-06-05 12:50 | 18.2 | 0.8 |
| 2013-06-05 23:30 | 2013-06-06 17:00 | 17.5 | 0.7 |
| 2013-06-06 23:50 | 2013-06-07 16:20 | 16.5 | 0.7 |
| 2013-06-07 20:00 | 2013-06-10 13:20 | 65.3 | 2.7 |
| 2013-06-11 00:20 | 2013-06-12 17:20 | 41.0 | 1.7 |
| 2013-06-13 00:40 | 2013-06-13 13:50 | 13.2 | 0.5 |
| 2013-06-14 03:00 | 2013-06-14 16:30 | 13.5 | 0.6 |
| 2013-06-14 20:10 | 2013-06-15 18:10 | 22.0 | 0.9 |
| 2013-06-15 23:10 | 2013-06-17 13:10 | 38.0 | 1.6 |
| 2013-06-18 00:10 | 2013-06-18 17:30 | 17.3 | 0.7 |
| 2013-06-18 23:20 | 2013-06-20 15:00 | 39.7 | 1.7 |
| 2013-06-20 22:50 | 2013-06-21 16:20 | 17.5 | 0.7 |
| 2013-06-21 22:50 | 2013-06-24 11:10 | 60.3 | 2.5 |
| 2013-06-24 18:10 | 2013-06-25 15:10 | 21.0 | 0.9 |
| 2013-06-26 01:20 | 2013-06-26 10:00 | 8.7 | 0.4 |
| 2013-06-27 05:10 | 2013-06-27 12:20 | 7.2 | 0.3 |
| 2013-06-30 06:40 | 2013-06-30 12:50 | 6.2 | 0.3 |
| 2013-07-01 00:20 | 2013-07-01 16:00 | 15.7 | 0.7 |
| 2013-07-02 01:40 | 2013-07-02 16:10 | 14.5 | 0.6 |
| 2013-07-02 22:10 | 2013-07-05 17:20 | 67.2 | 2.8 |
| 2013-07-05 21:40 | 2013-07-06 12:50 | 15.2 | 0.6 |
| 2013-07-07 05:00 | 2013-07-07 14:10 | 9.2 | 0.4 |
| 2013-07-08 02:20 | 2013-07-08 10:10 | 7.8 | 0.3 |
| 2013-07-09 01:30 | 2013-07-09 11:00 | 9.5 | 0.4 |
| 2013-07-10 02:40 | 2013-07-10 10:40 | 8.0 | 0.3 |
| 2013-07-11 02:00 | 2013-07-11 11:30 | 9.5 | 0.4 |
| 2013-07-11 23:00 | 2013-07-12 10:30 | 11.5 | 0.5 |
| 2013-07-14 00:50 | 2013-07-14 13:30 | 12.7 | 0.5 |
| 2013-07-15 03:00 | 2013-07-15 10:30 | 7.5 | 0.3 |
| 2013-07-16 04:00 | 2013-07-16 10:30 | 6.5 | 0.3 |
| 2013-07-17 03:00 | 2013-07-17 10:40 | 7.7 | 0.3 |
| 2013-07-18 03:10 | 2013-07-18 09:20 | 6.2 | 0.3 |
| 2013-07-19 03:20 | 2013-07-19 09:30 | 6.2 | 0.3 |

| From time | To time | Hour affected | Days affected |
|---|---|---|---|
| 2013-07-20 03:00 | 2013-07-20 14:00 | 11.0 | 0.5 |
| 2013-07-21 03:00 | 2013-07-21 15:30 | 12.5 | 0.5 |
| 2013-07-22 03:10 | 2013-07-22 10:10 | 7.0 | 0.3 |
| 2013-07-23 04:30 | 2013-07-23 08:00 | 3.5 | 0.1 |
| 2013-07-24 01:30 | 2013-07-24 09:10 | 7.7 | 0.3 |
| 2013-07-25 03:40 | 2013-07-25 09:30 | 5.8 | 0.2 |
| 2013-07-26 00:40 | 2013-07-26 10:30 | 9.8 | 0.4 |
| 2013-07-27 03:00 | 2013-07-27 18:20 | 15.3 | 0.6 |
| 2013-07-27 23:00 | 2013-07-29 10:10 | 35.2 | 1.5 |
| 2013-07-30 03:50 | 2013-07-30 11:10 | 7.3 | 0.3 |
| 2013-07-31 05:10 | 2013-07-31 10:10 | 5.0 | 0.2 |
| 2013-08-01 03:00 | 2013-08-01 10:40 | 7.7 | 0.3 |
| 2013-08-02 03:10 | 2013-08-02 11:10 | 8.0 | 0.3 |
| 2013-08-03 04:00 | 2013-08-03 13:30 | 9.5 | 0.4 |
| 2013-08-04 05:50 | 2013-08-04 14:50 | 9.0 | 0.4 |
| 2013-08-05 07:50 | 2013-08-05 10:40 | 2.8 | 0.1 |
| 2013-08-06 05:20 | 2013-08-06 10:40 | 5.3 | 0.2 |
| 2013-08-07 04:00 | 2013-08-07 10:10 | 6.2 | 0.3 |
| 2013-08-08 05:30 | 2013-08-08 09:50 | 4.3 | 0.2 |
| 2013-08-09 05:50 | 2013-08-09 09:40 | 3.8 | 0.2 |

**Table 37 Summary of discharge measurements used to develop the 40L Upstream rating curve.**

| Date/Time yyyy-mm-dd hh:mm | Stage (m3/s) | Discharge (m3/s) | Made By | R Error (%) | R Error Value (m3/s) |
|---|---|---|---|---|---|
| 2013-08-10 10:27 | 433.044 | 2.22 | DDM/LJC | -13.5 | -0.35 |
| 2013-08-10 10:32 | 433.033 | 2.84 | DDM/LJC | 16.4 | 0.40 |
| 2013-08-10 10:36 | 433.065 | 2.86 | DDM/LJC | 1.7 | 0.05 |
| 2013-08-10 10:40 | 433.107 | 3.52 | DDM/LJC | 4.8 | 0.16 |
| 2013-08-10 10:49 | 433.194 | 4.38 | DDM/LJC | -8.8 | -0.42 |
| 2013-08-10 10:45 | 433.157 | 4.78 | DDM/LJC | 15.5 | 0.64 |
| 2013-08-10 10:54 | 433.234 | 5.77 | DDM/LJC | 3.0 | 0.17 |
| 2013-08-10 11:03 | 433.322 | 7.03 | DDM/LJC | -9.9 | -0.77 |
| 2013-08-10 11:13 | 433.404 | 9.13 | DDM/LJC | -12.6 | -1.31 |
| 2013-04-26 15:27 | 433.871 | 39.1 | DDM/LJC | -10.5 | -4.57 |
| 2013-08-08 13:39 | 433.909 | 58.9 | DDM/LJC | 21.6 | 10.50 |
| **Discharge measurements NOT used in developing the 40LUpstream rating curve** | | | | | |
| **Date/Time yyyy-mm-dd hh:mm** | **Stage (m3/s)** | **Discharge (m3/s)** | **Made By** | **Rejection notes** | |
| 2013-06-10 18:35 | 433.294 | 9.74 | DDM/LJC | Poor consistency in Q measurements between ADCP passes | |
| 2013-08-09 11:41 | 433.454 | 18.4 | DDM/LJC | Poor consistency in Q measurements between ADCP passes | |

**Table 38 Summary of site 102.5R stage record data gaps. All gaps are caused by water levels dropping below the sensor elevation.**

| From time | To time | Hour affected | Days affected |
|---|---|---|---|
| 2013-07-04 07:00 | 2013-07-06 01:00 | 42.0 | 1.8 |
| 2013-07-06 07:00 | 2013-07-06 20:15 | 13.3 | 0.6 |
| 2013-07-07 14:25 | 2013-07-07 22:35 | 8.2 | 0.3 |
| 2013-07-08 11:30 | 2013-07-08 18:00 | 6.5 | 0.3 |
| 2013-07-09 10:35 | 2013-07-09 18:50 | 8.3 | 0.3 |
| 2013-07-10 11:05 | 2013-07-10 18:45 | 7.7 | 0.3 |
| 2013-07-11 10:15 | 2013-07-11 19:55 | 9.7 | 0.4 |
| 2013-07-12 06:45 | 2013-07-12 19:00 | 12.3 | 0.5 |
| 2013-07-14 08:35 | 2013-07-14 23:05 | 14.5 | 0.6 |
| 2013-07-15 11:45 | 2013-07-15 18:35 | 6.8 | 0.3 |
| 2013-07-16 12:45 | 2013-07-16 19:00 | 6.3 | 0.3 |
| 2013-07-17 11:15 | 2013-07-17 19:20 | 8.1 | 0.3 |
| 2013-07-18 10:45 | 2013-07-18 17:50 | 7.1 | 0.3 |
| 2013-07-19 10:30 | 2013-07-19 18:05 | 7.6 | 0.3 |
| 2013-07-20 10:35 | 2013-07-20 23:05 | 12.5 | 0.5 |
| 2013-07-21 10:45 | 2013-07-22 02:05 | 15.3 | 0.6 |
| 2013-07-22 10:05 | 2013-07-22 18:45 | 8.7 | 0.4 |
| 2013-07-23 12:45 | 2013-07-23 15:55 | 3.2 | 0.1 |
| 2013-07-24 09:35 | 2013-07-24 17:15 | 7.7 | 0.3 |
| 2013-07-25 11:30 | 2013-07-25 18:10 | 6.7 | 0.3 |
| 2013-07-26 08:10 | 2013-07-26 19:35 | 11.4 | 0.5 |
| 2013-07-27 10:15 | 2013-07-29 18:25 | 56.2 | 2.3 |
| 2013-07-30 11:45 | 2013-07-30 21:00 | 9.3 | 0.4 |
| 2013-07-31 12:55 | 2013-07-31 20:30 | 7.6 | 0.3 |
| 2013-08-01 10:35 | 2013-08-01 19:30 | 8.9 | 0.4 |
| 2013-08-02 10:15 | 2013-08-02 20:05 | 9.8 | 0.4 |
| 2013-08-03 11:25 | 2013-08-03 22:30 | 11.1 | 0.5 |
| 2013-08-04 13:30 | 2013-08-04 23:30 | 10.0 | 0.4 |
| 2013-08-05 15:50 | 2013-08-05 18:45 | 2.9 | 0.1 |
| 2013-08-06 13:25 | 2013-08-06 20:50 | 7.4 | 0.3 |
| 2013-08-07 12:00 | 2013-08-07 18:25 | 6.4 | 0.3 |

**Table 39 Summary of discharge measurements used to develop the 102.5R rating curve.**

| Date/Time yyyy-mm-dd hh:mm | Stage (m3/s) | Discharge (m3/s) | Made By | R Error (%) | R Error Value (m3/s) |
|---|---|---|---|---|---|
| 2013-08-08 17:35 | 402.738 | 0.28 | DDM/LJC | 6.7 | 0.02 |
| 2013-08-08 17:38 | 402.758 | 0.31 | DDM/LJC | -25.6 | -0.11 |
| 2013-08-08 17:46 | 402.785 | 0.75 | DDM/LJC | 11.1 | 0.08 |
| 2013-08-08 17:53 | 402.837 | 1.23 | DDM/LJC | -4.7 | -0.06 |
| 2013-08-08 17:48 | 402.814 | 1.25 | DDM/LJC | 25.0 | 0.25 |
| 2013-06-11 11:25 | 403.256 | 9.90 | DDM/LJC | -4.8 | -0.50 |

**Table 40 Summary of grain size distributions for sediment samples collected in Side Channel 112.5R. Grain size distributions should be considered estimates and only used in a qualitative capacity.**

| Location ID | Cross section | Sample number | Ideal for GSD analysis | $D_{10}$ (mm) | $D_{20}$ (mm) | $D_{30}$ (mm) | $D_{40}$ (mm) | $D_{50}$ (mm) | $D_{60}$ (mm) | $D_{70}$ (mm) |
|---|---|---|---|---|---|---|---|---|---|---|
| 112.5R 1-2 | 1 | 2 | No | 0.4 | 0.6 | 0.9 | 1.6 | 2.6 | 5.7 | 11.3 |
| 112.5R 1-5 | 1 | 5 | No | 0.8 | 3.4 | 10.1 | 14.1 | 16.9 | 19.2 | 22.1 |
| 112.5R 2-1 | 2 | 1 | Yes | 2.2 | 6.5 | 10.8 | 16.1 | 23.5 | 27.1 | 33.6 |
| 112.5R 2-2 | 2 | 2 | No | 17.2 | 20.6 | 24.8 | 28.0 | 30.6 | 33.2 | 35.8 |
| 112.5R 2-3 | 2 | 3 | No | 24.5 | 28.5 | 32.2 | 39.2 | 49.5 | 55.3 | 60.7 |
| 112.5R 2-4 | 2 | 4 | Yes | 5.6 | 9.2 | 12.9 | 16.2 | 19.8 | 23.2 | 28.1 |
| 112.5R 2-5 | 2 | 5 | No | 3.7 | 6.8 | 10.2 | 12.6 | 15.8 | 19.0 | 22.6 |
| 112.5R 2-6 | 2 | 6 | No | 1.0 | 1.4 | 1.8 | 2.1 | 2.5 | 3.1 | 4.6 |
| 112.5R 3-1 | 3 | 1 | No | 3.1 | 5.3 | 7.0 | 9.8 | 13.1 | 16.4 | 21.3 |
| 112.5R 3-2 | 3 | 2 | Yes | 11.7 | 15.4 | 18.4 | 21.0 | 24.1 | 29.4 | 38.7 |

**Table 41 Summary of substrate types found in Side Channel 112.5R.**

| Location ID | Cross section | Sample number | Location | Substrate type* |
|---|---|---|---|---|
| 112.5R 1-1 | 1 | 1 | Top of right bank | CL |
| 112.5R 1-2 | 1 | 2 | In channel | CL, LG, SG, SC |
| 112.5R 1-3 | 1 | 3 | In channel | CL, LC, SB |
| 112.5R 1-4 | 1 | 4 | In channel | CL, LG, SC, LC |
| 112.5R 1-5 | 1 | 5 | In channel | SG, LG, SC, LC |
| 112.5R 1-6 | 1 | 6 | Top of left bank | CL |
| 112.5R 2-1 | 2 | 1 | Top of right bank | SG, LG, SC |
| 112.5R 2-2 | 2 | 2 | In channel | SG, LG, SC, LC |
| 112.5R 2-3 | 2 | 3 | In channel | SG, LG, SC, LC |
| 112.5R 2-4 | 2 | 4 | In channel | LG, SC, LC |
| 112.5R 2-5 | 2 | 5 | In channel | LG, SC, SG, LC |
| 112.5R 2-6 | 2 | 6 | Top of left bank | CL, SG, LG |
| 112.5R 3-1 | 3 | 1 | Top of right bank | SG, LG, CL, SC, LC |
| 112.5R 3-2 | 3 | 2 | In channel | Cl, LG, SC, LC |
| 112.5R 3-3 | 3 | 3 | In channel | SC, LG, LC |
| 112.5R 3-4 | 3 | 4 | In channel | LC, LC |
| 112.5R 3-5 | 3 | 5 | In channel | LG, SC, LC |
| 112.5R 3-6 | 3 | 6 | Top of left bank | CL |

* CL: silt-clay (< 0.1 mm)
SD: sand (< 2 mm)
SG: small gravel (2-16 mm)
LG: large gravel (16-64 mm)
SC: small cobble (64-128 mm)
LC: large cobble (128-256 mm)
SB: small boulder (> 256 mm)

# FIGURES NOT INCLUDED IN THE REPORT BODY

**Figure 15 Overall study area.**

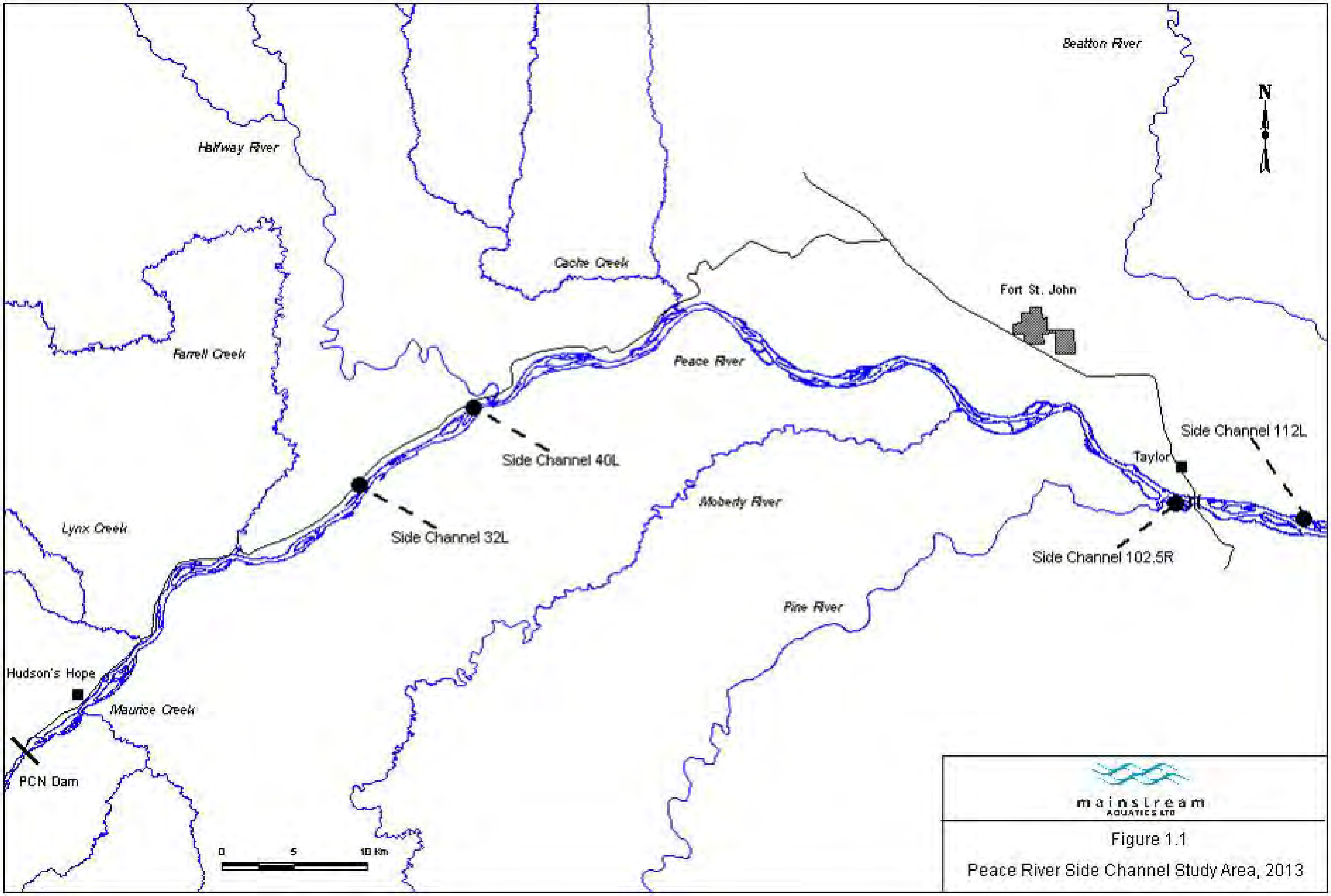

**Figure 16 Side Channel 32L study area.**

**Figure 17 Side Channel 102.5R study area.**

**Figure 18 Side Channel 40L study area.**

**Figure 19 Side Channel 112L study area.**

**Figure 20 Stage record for site 32L Upstream. Sampling interval is 10 minutes. Stage values below 436.65 m are below the sensor elevation resulting in gaps in the stage record (Table 33)**

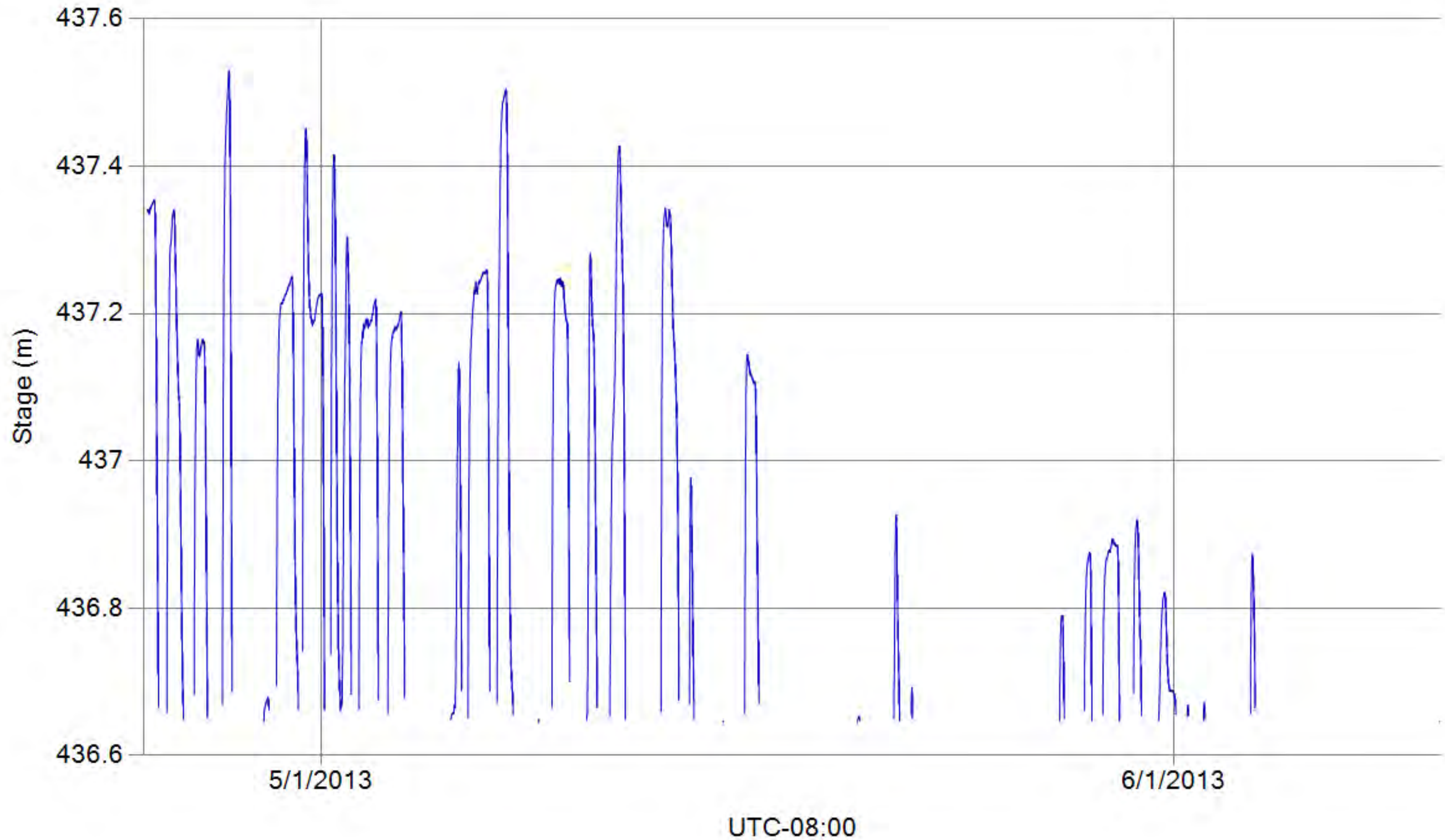

**Figure 21 Stage record for site 32L Pool. Sampling interval is 10 minutes.**

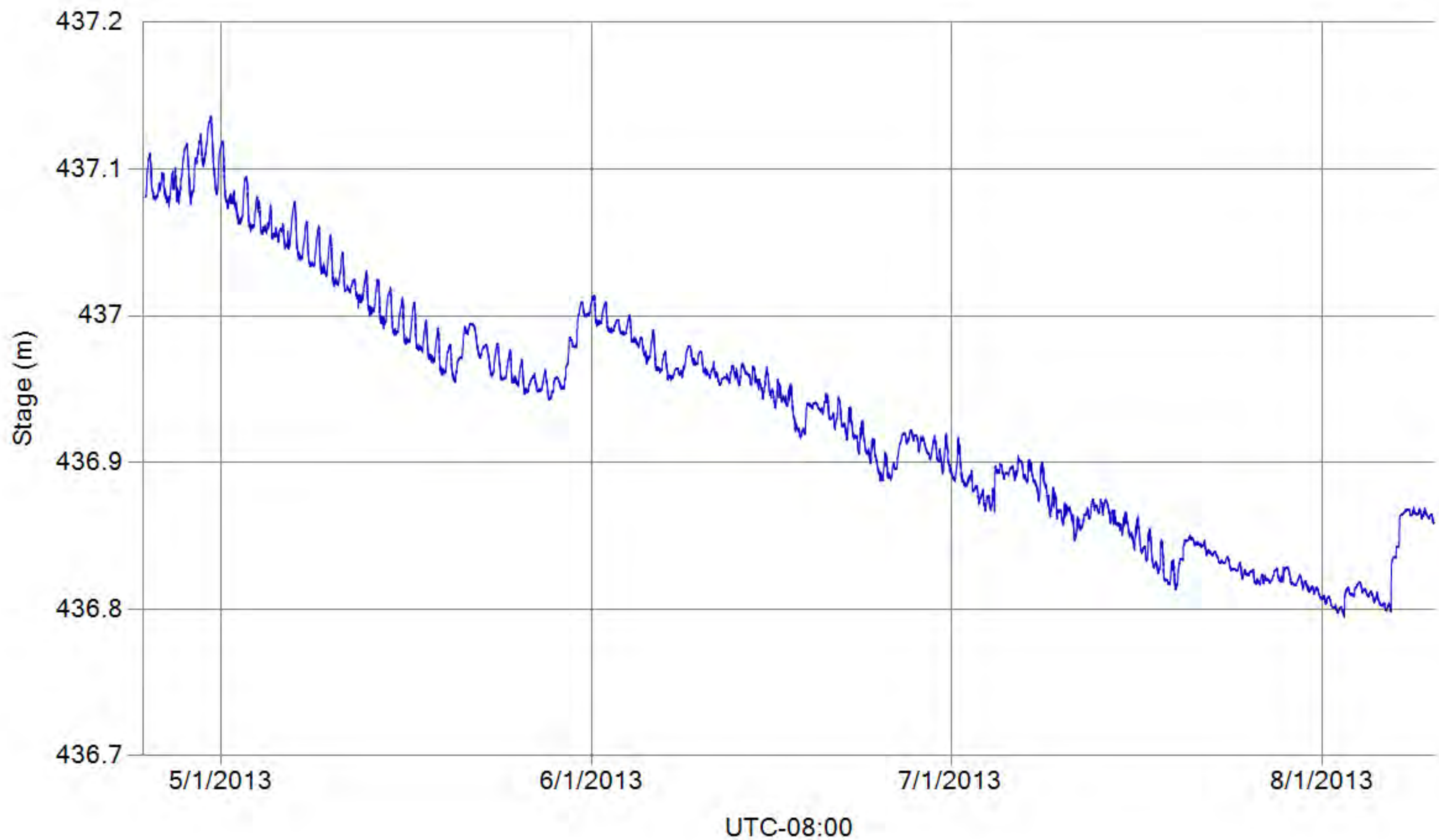

**Figure 22 Maximum and minimum daily stage for site 32L Pool compared to the maximum and minimum daily stage for Peace 9, located approximately 1.75 km upstream on the main channel of Peace River.**

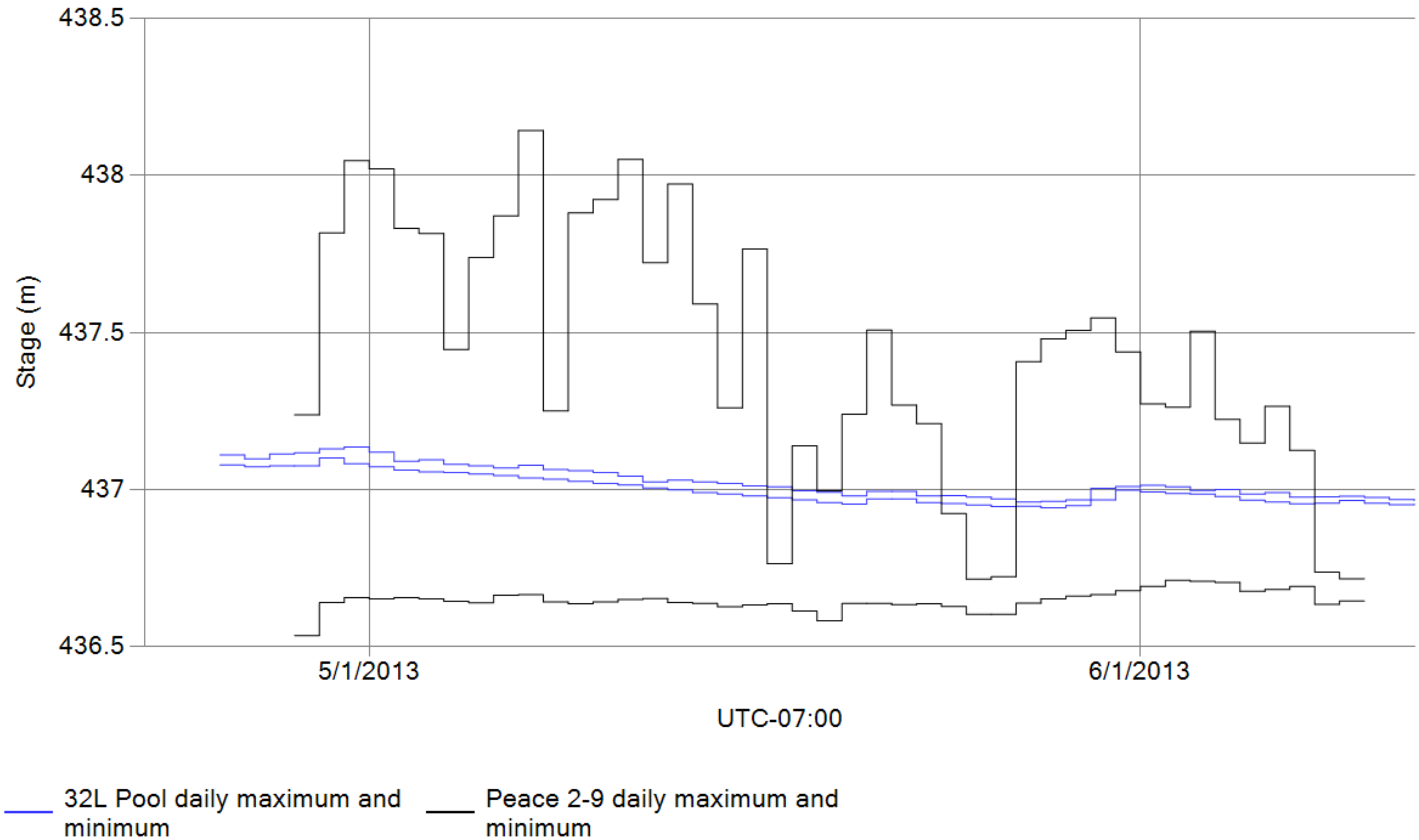

**Figure 23 Fish habitats identified in Side Channel 32L.**

**Figure 24** Grain size distributions for sediment samples collected in Side Channel 40L. Only samples 40L 1-1 and 40L 2-10 are ideal for determining grain size distributions. Grain size distributionss should be considered estimates and only used in a qualitative capacity.

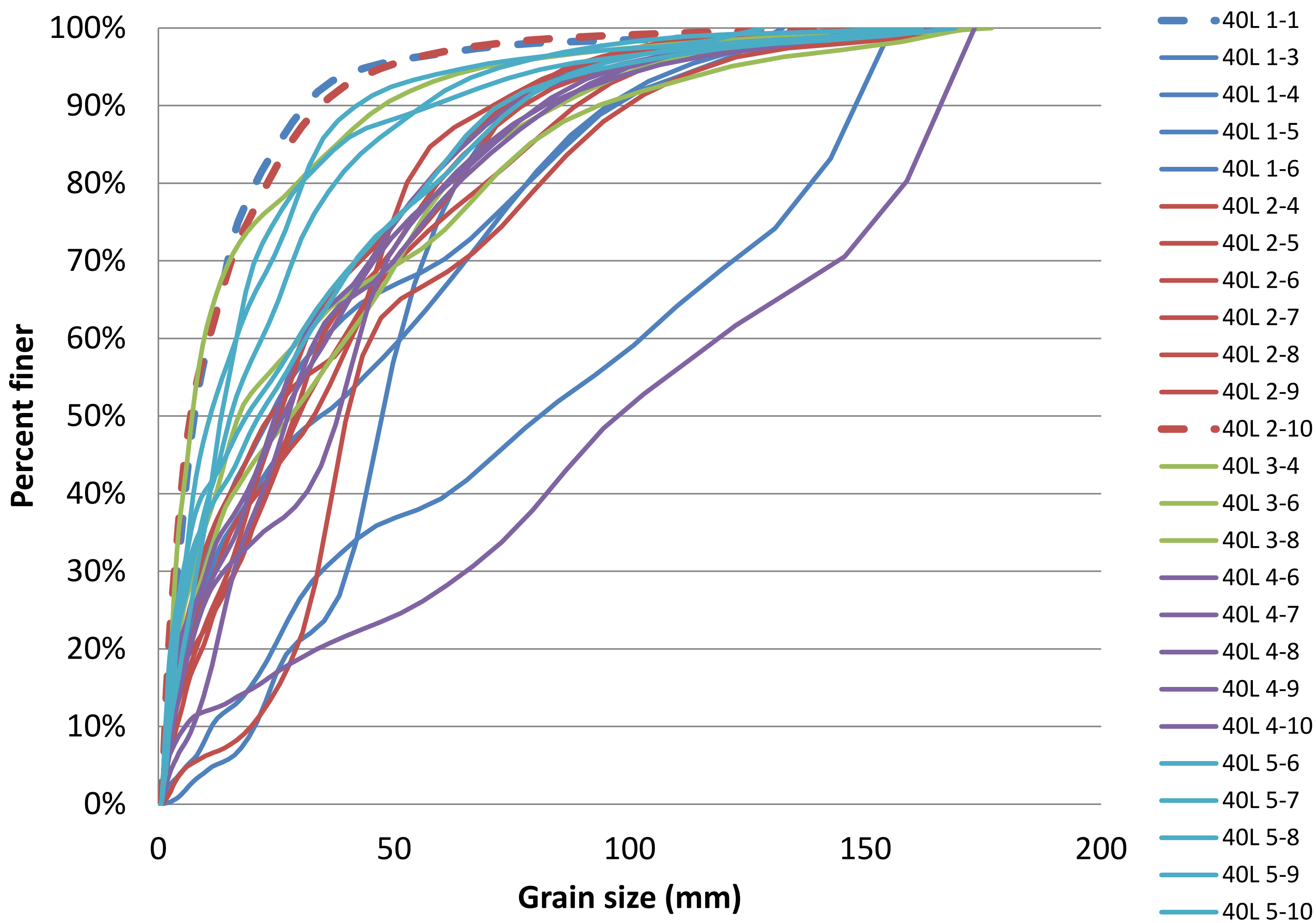

**Figure 25 Stage record for site 40L Upstream. Sampling interval is 10 minutes. Stage values below 432.81 m are below the sensor elevation resulting in gaps in the stage record (Table 36).**

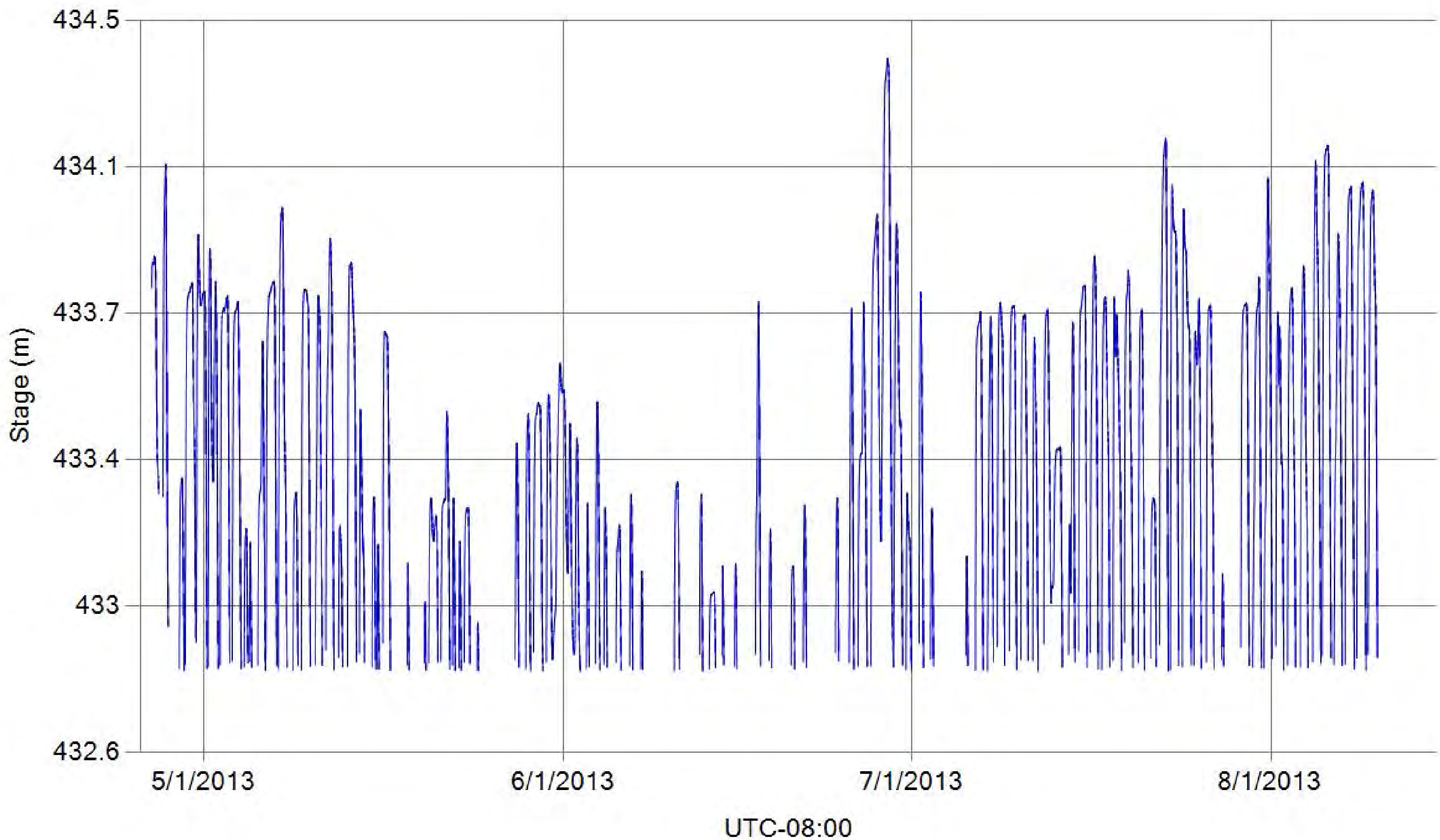

**Figure 26** **Rating curve for site 40L Upstream. Within the gauged range the current rating curve shows very good fit (12.2% root mean square of errors), meeting RISC grade B standards(Resources Information Standards Committee, 2009), represented by a green bar below the curve. Discharge values calculated using the extrapolated portion of the rating curve (outside the highest and lowest gauged flow) are RISC Grade E, represented by grey bars below the curve. Gauged stages range from 433.044 m to 433.909 m; the current stage record ranges from 432.81 m to 434.401 m, with stage values lower than 432.81 below the sensor elevation resulting in gaps in the data record (Table 36). Grey measurements points were not used in developing the rating curve (Table 37).**

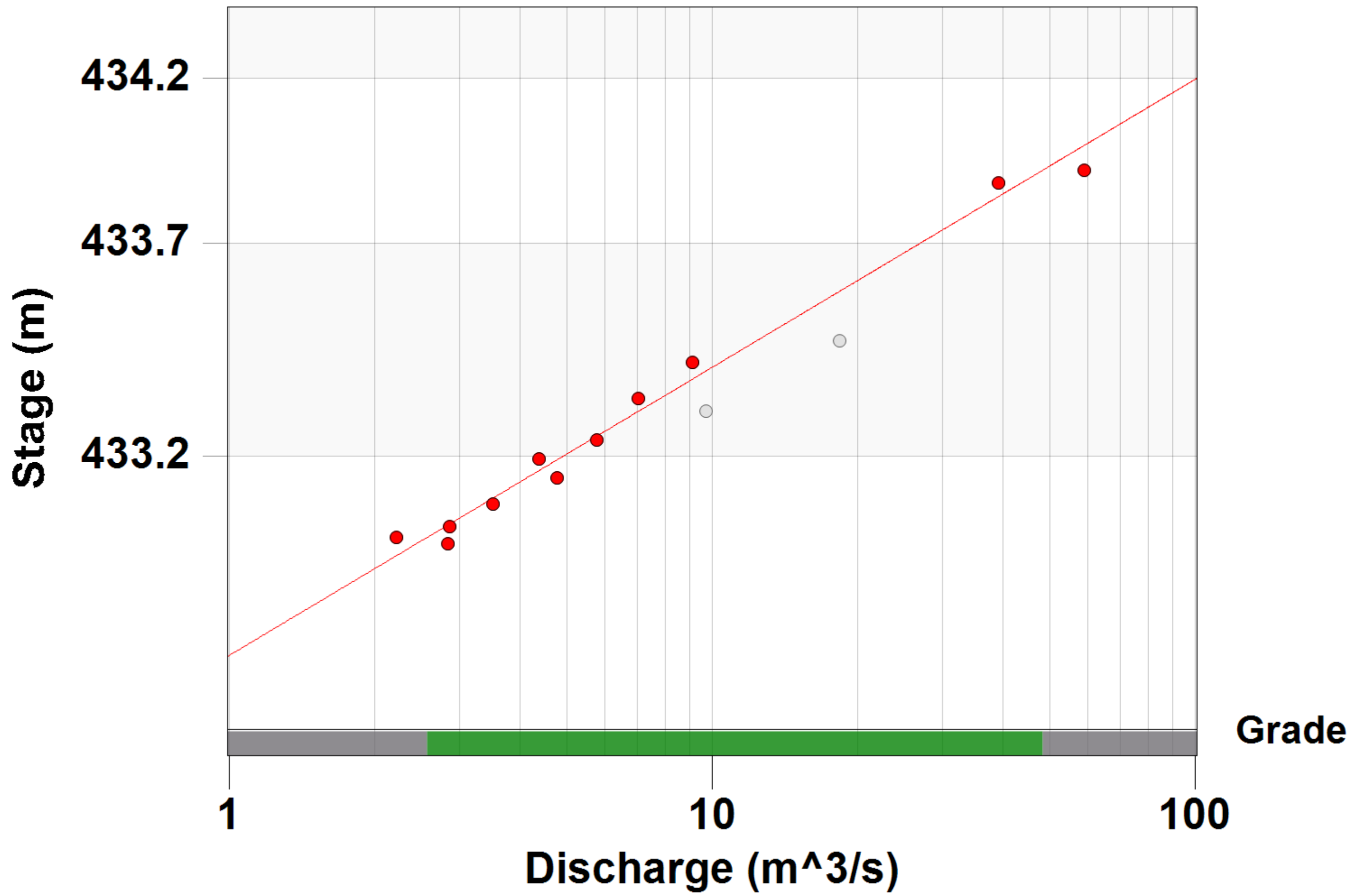

**Figure 27 Calculated discharge for site 40L Upstream. Sampling interval is 10 minutes. Discharge values below 0.83 $m^3/s$ are below the sensor elevation resulting in gaps in the discharge record (Table 36).**

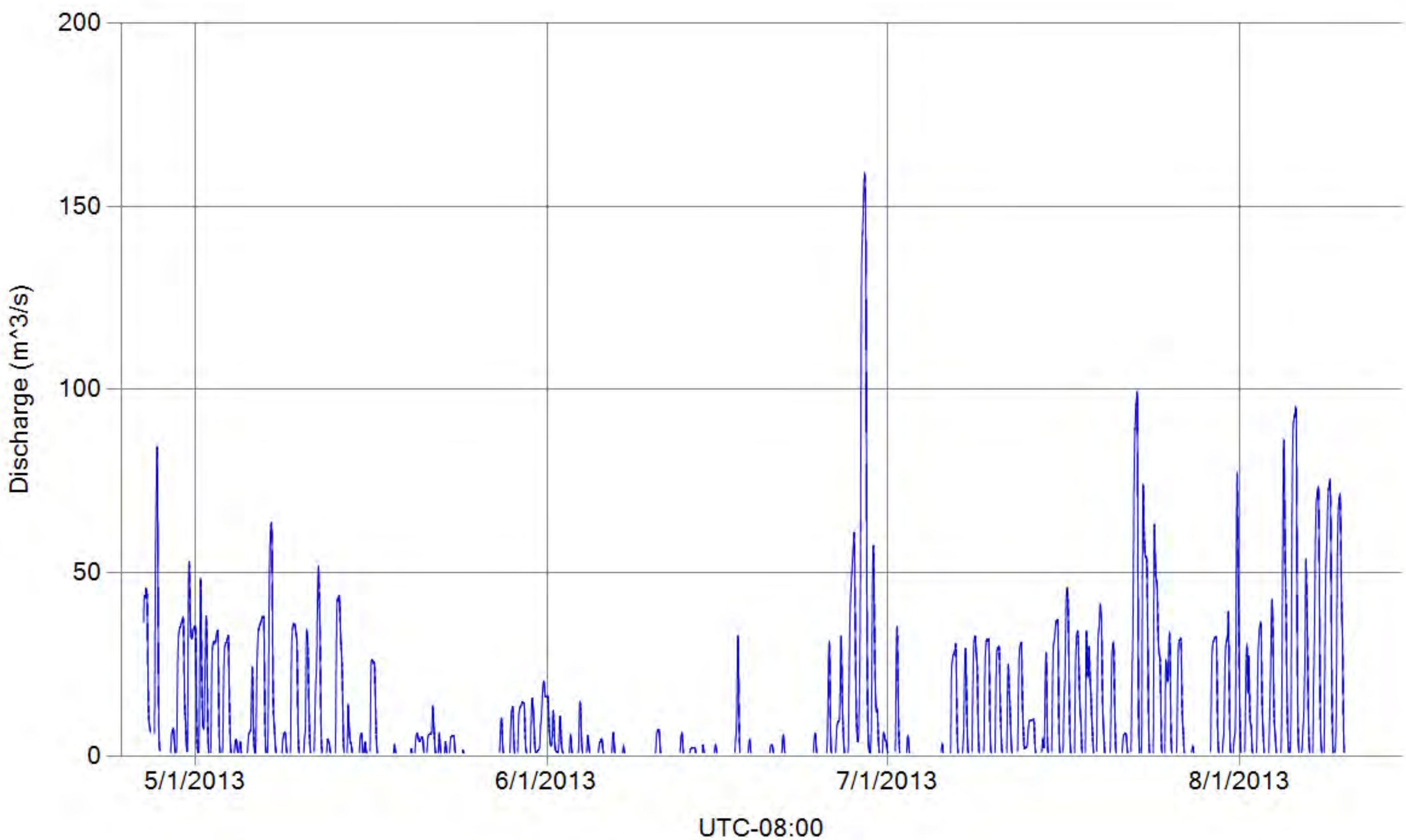

**Figure 28 Calculated depth for the deepest section of cross section 1, the cross section closest to site 40L Upstream. Depths below 0.23 m are below the sensor elevation resulting in gaps in the depth record (Table 36).**

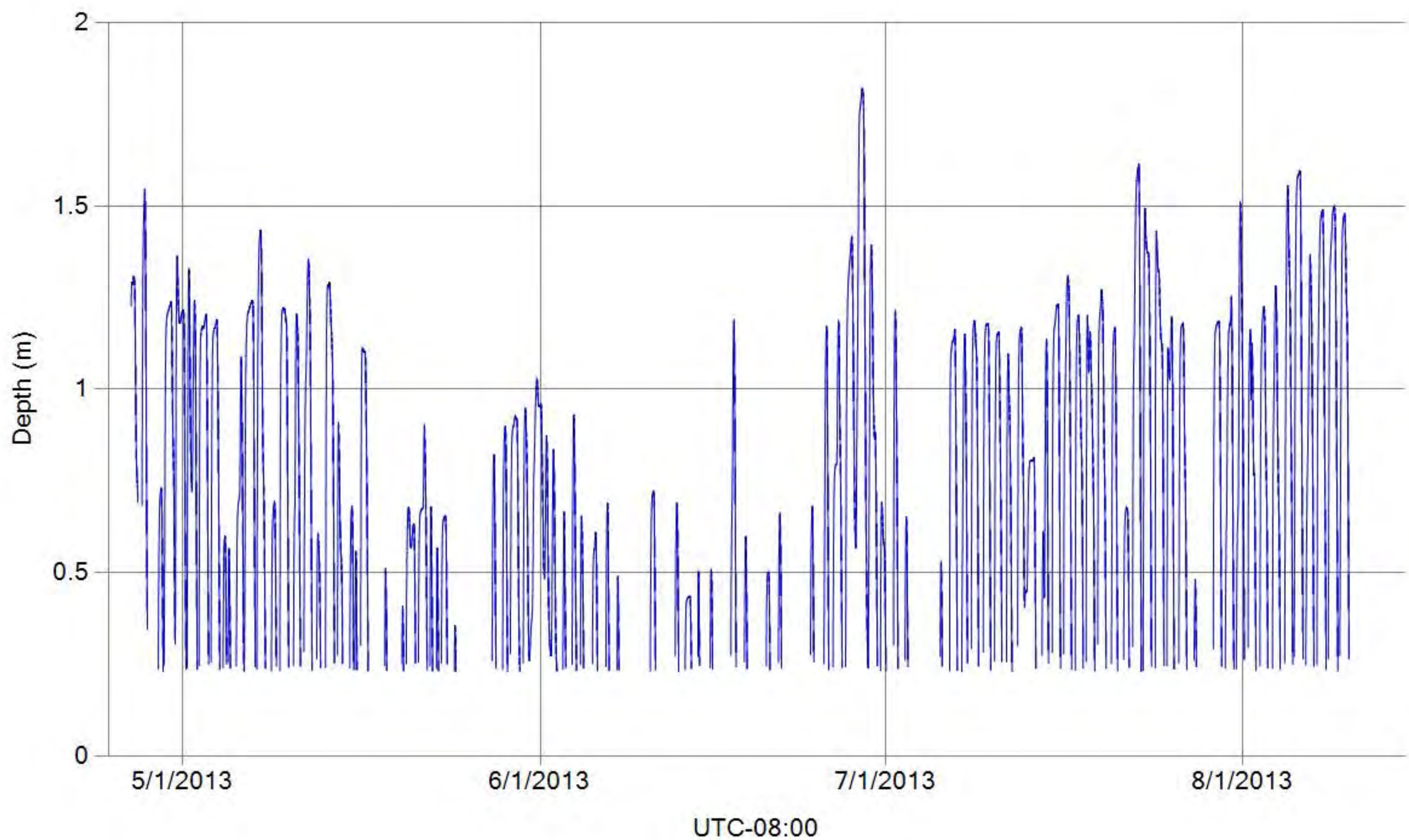

**Figure 29 Stage-wetted width rating curve for cross section 1, the cross section closest to site 40L Upstream. Rating points are based on elevations and widths surveyed along the cross section.**

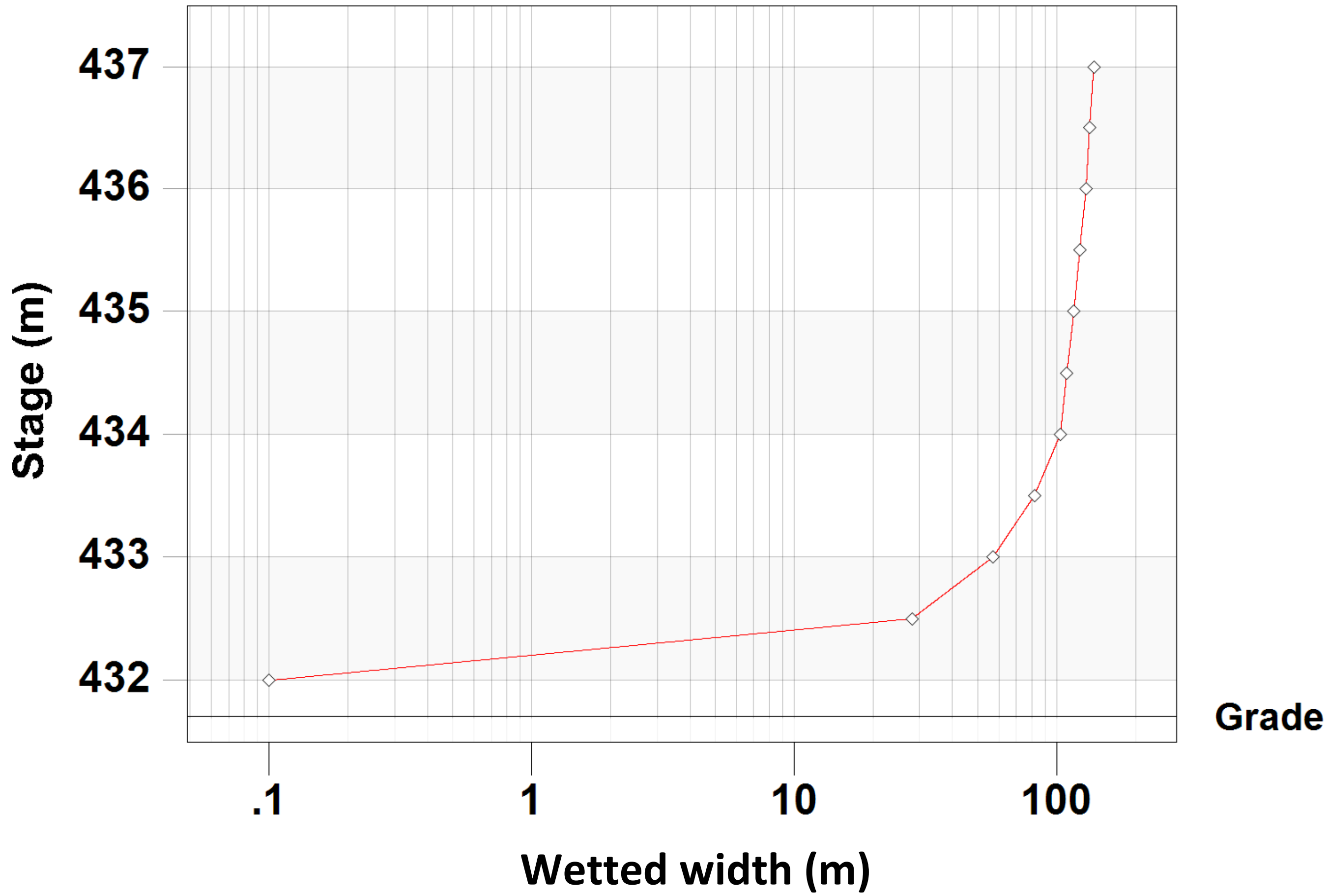

**Figure 30** **Calculated wetted width for cross section 1, the cross section closest to site 40L Upstream. Wetted widths smaller than 41.3 m represent stages below the sensor elevation resulting in gaps in the wetted width record (Table 36).**

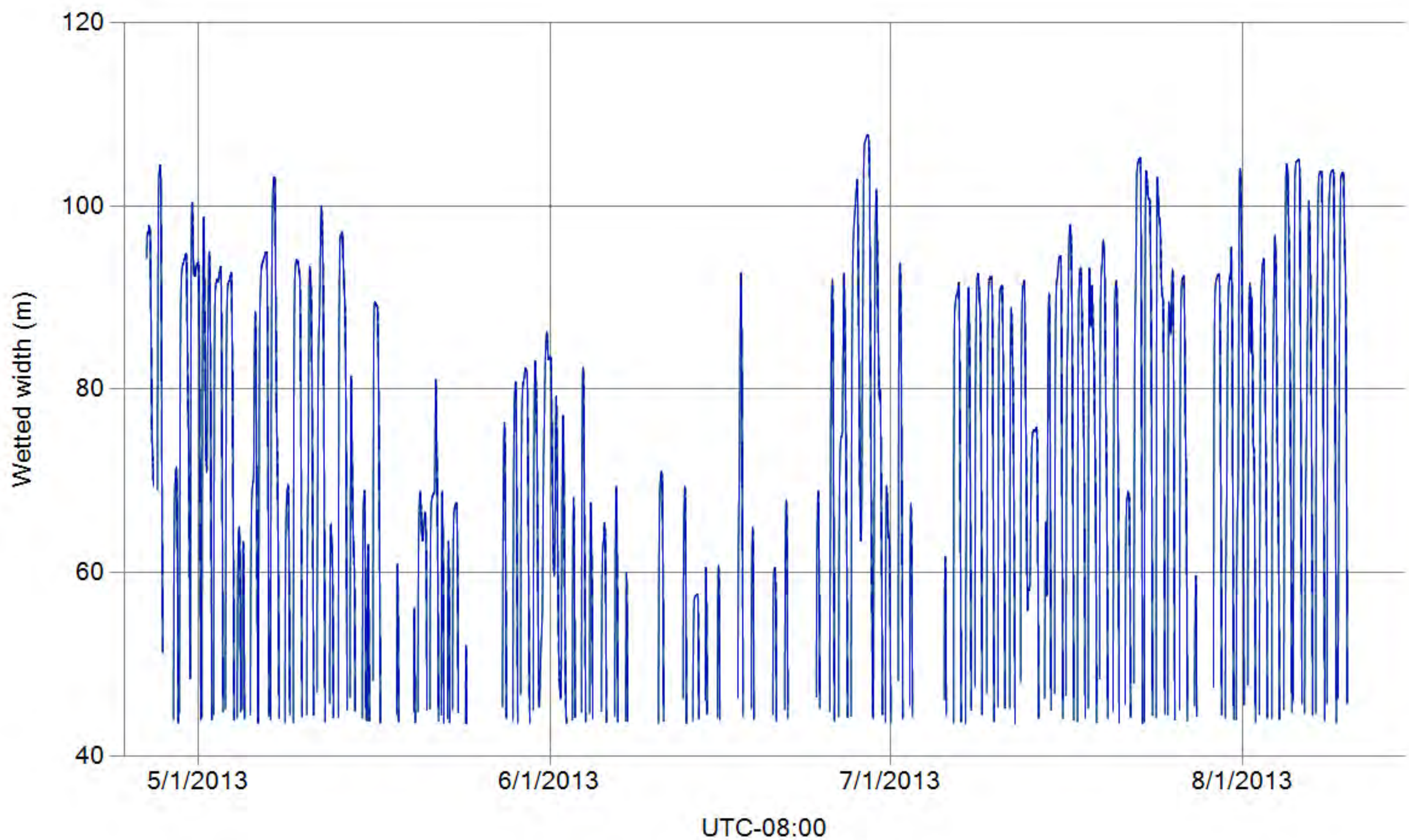

**Figure 31 Fish habitats identified in Side Channel 40L.**

**Figure 32 Stage record for site 102.5R Channel. The sampling interval is 5 minutes. Stage values below 402.81 m are below the sensor elevation prior to August 8, 2013, resulting in gaps in the stage record (Table 38).**

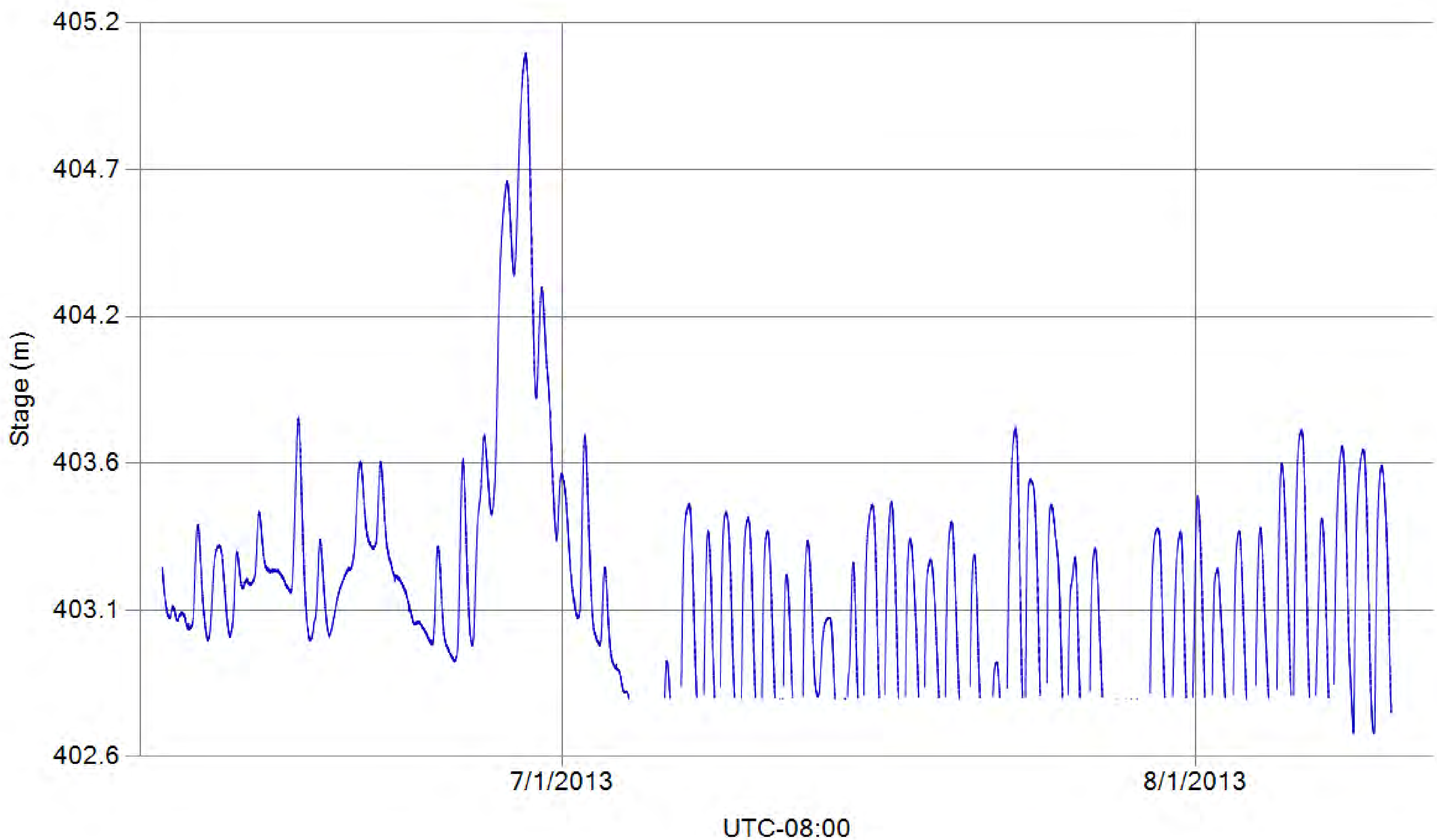

**Figure 33 Rating curve for site 102.5R Channel. Within the gauged range the current rating curve shows very good fit (15.8% root mean square of errors), meeting RISC grade B standards(Resources Information Standards Committee, 2009), represented by a green bar below the curve. Discharge values calculated using the extrapolated portion of the rating curve (outside the highest and lowest gauged flow) are RISC Grade E, represented by grey bars below the curve. Gauged stages range from 402.738 m to 403.256 m; the current stage record ranges from 402.603 m to 405.094 m, with stage values below 402.81 m below the sensor elevation prior to August 8, 2013, resulting in gaps in the data record (Table 38).**

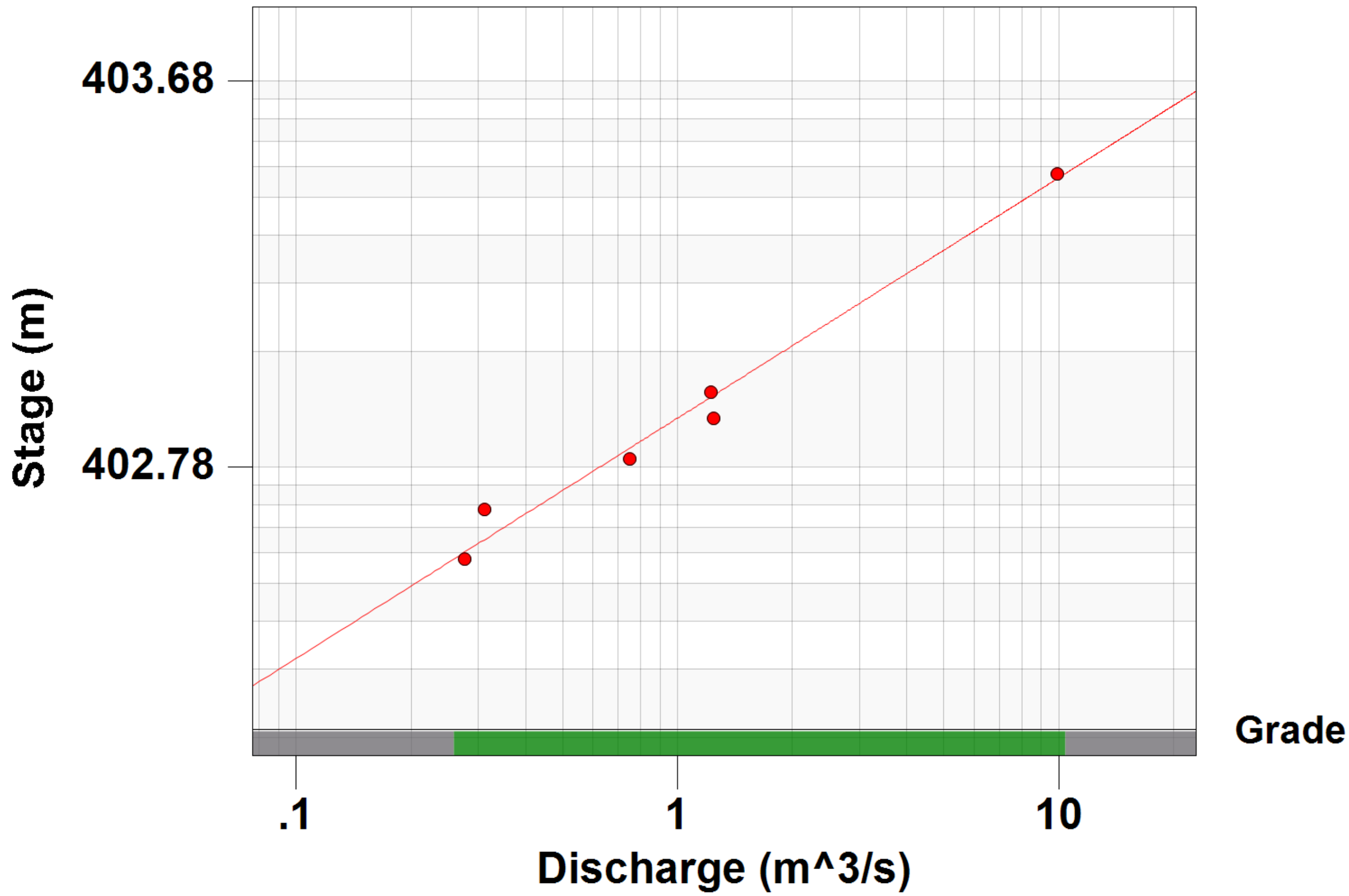

**Figure 34 Discharge record for site 102.5R Channel. The sampling interval is 5 minutes. Discharge values below 0.95 $m^3/s$ are below the sensor elevation prior to August 8, 2013, resulting in gaps in the stage record (Table 38).**

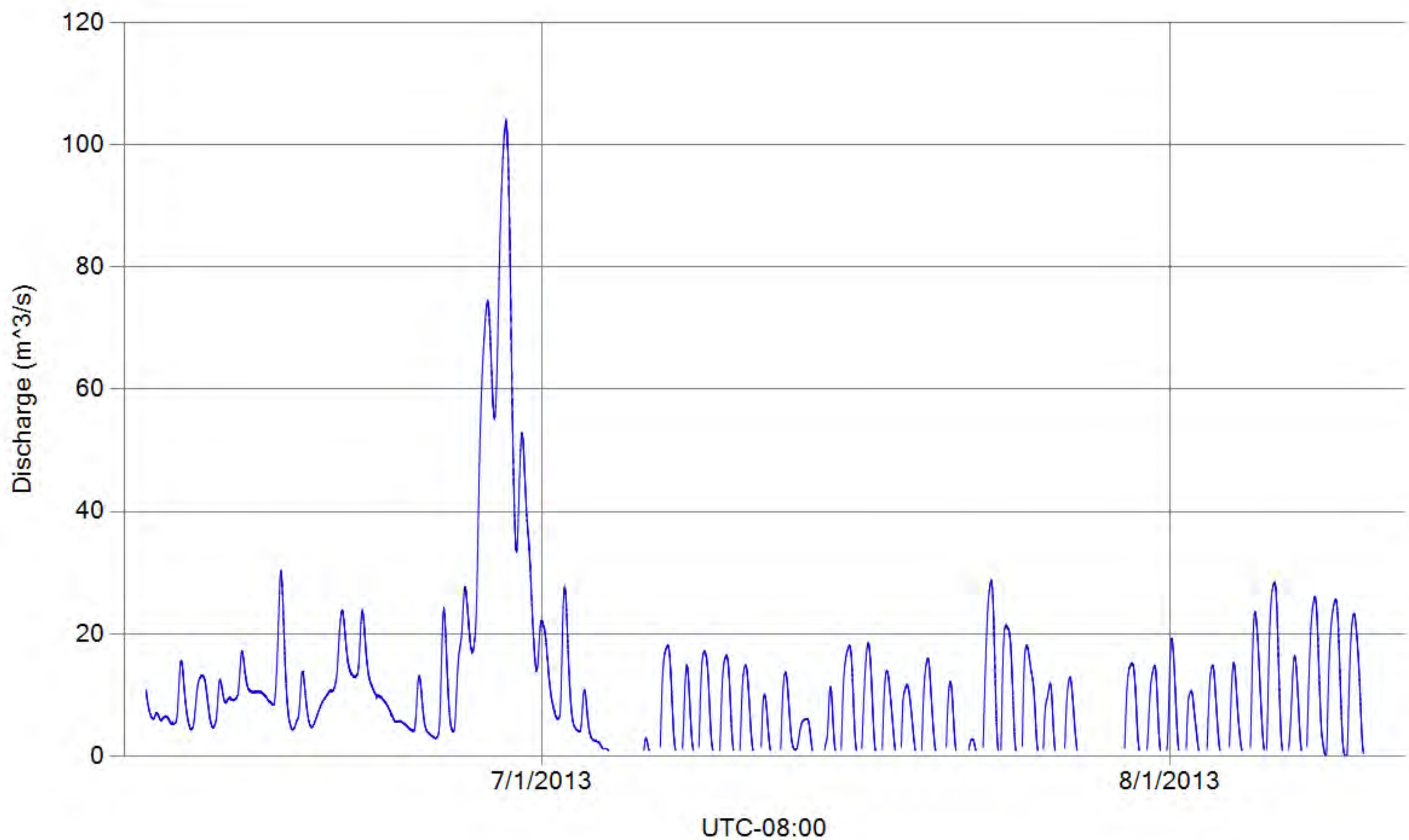

**Figure 35 Fish habitats identified in Side Channel 102.5R.**

**Figure 36 Grain size distributions for sediment samples collected in Side Channel 112.5R. Only samples 1125R 2-1, 1125R 2-4 and 1125R 3-3 are ideal for determining grain size distributions. Grain size distributionss should be considered estimates and only used in a qualitative capacity.**

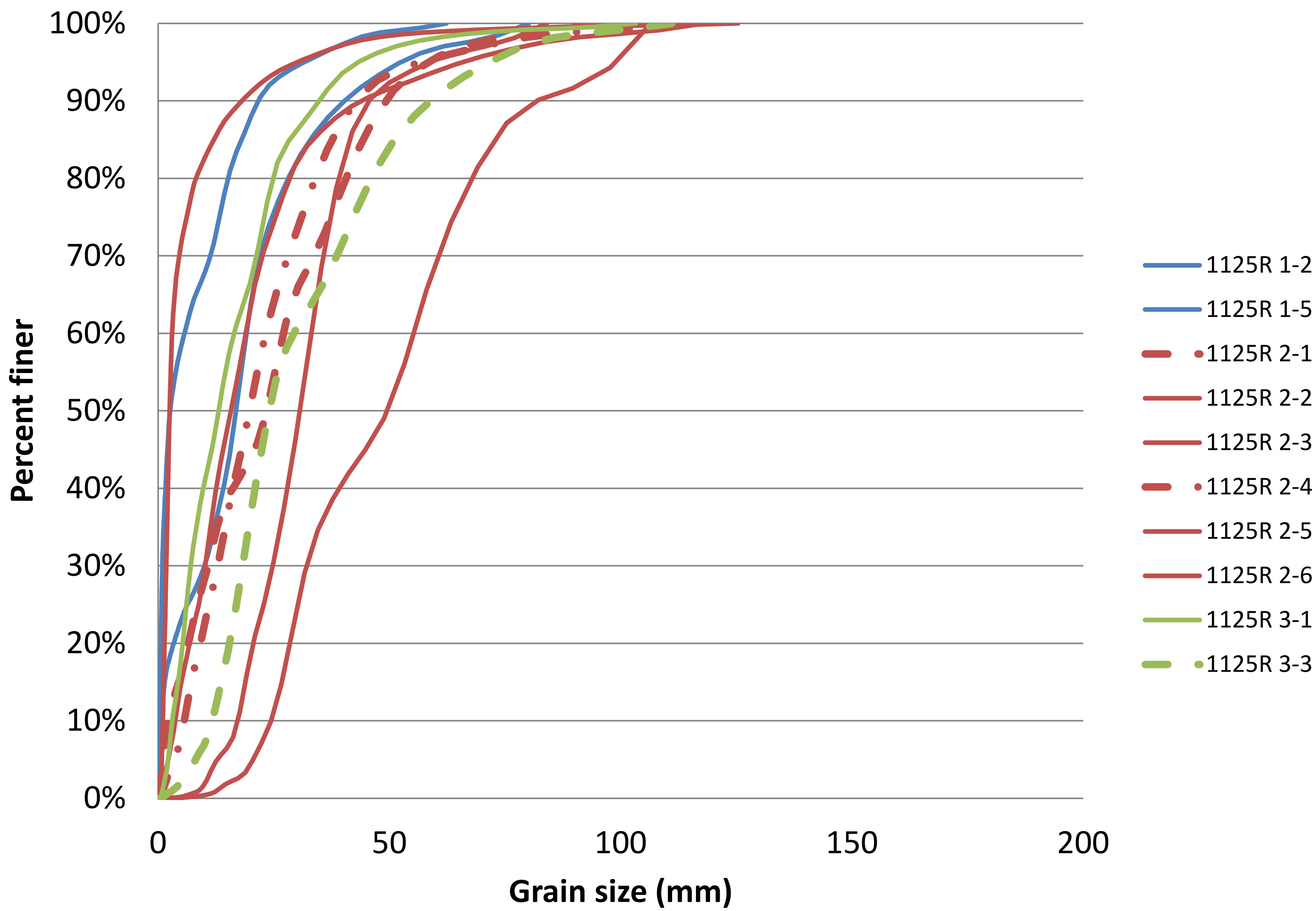

**Figure 37 Stage record for site 112.5R Upstream. Sampling interval is 5 minutes.**

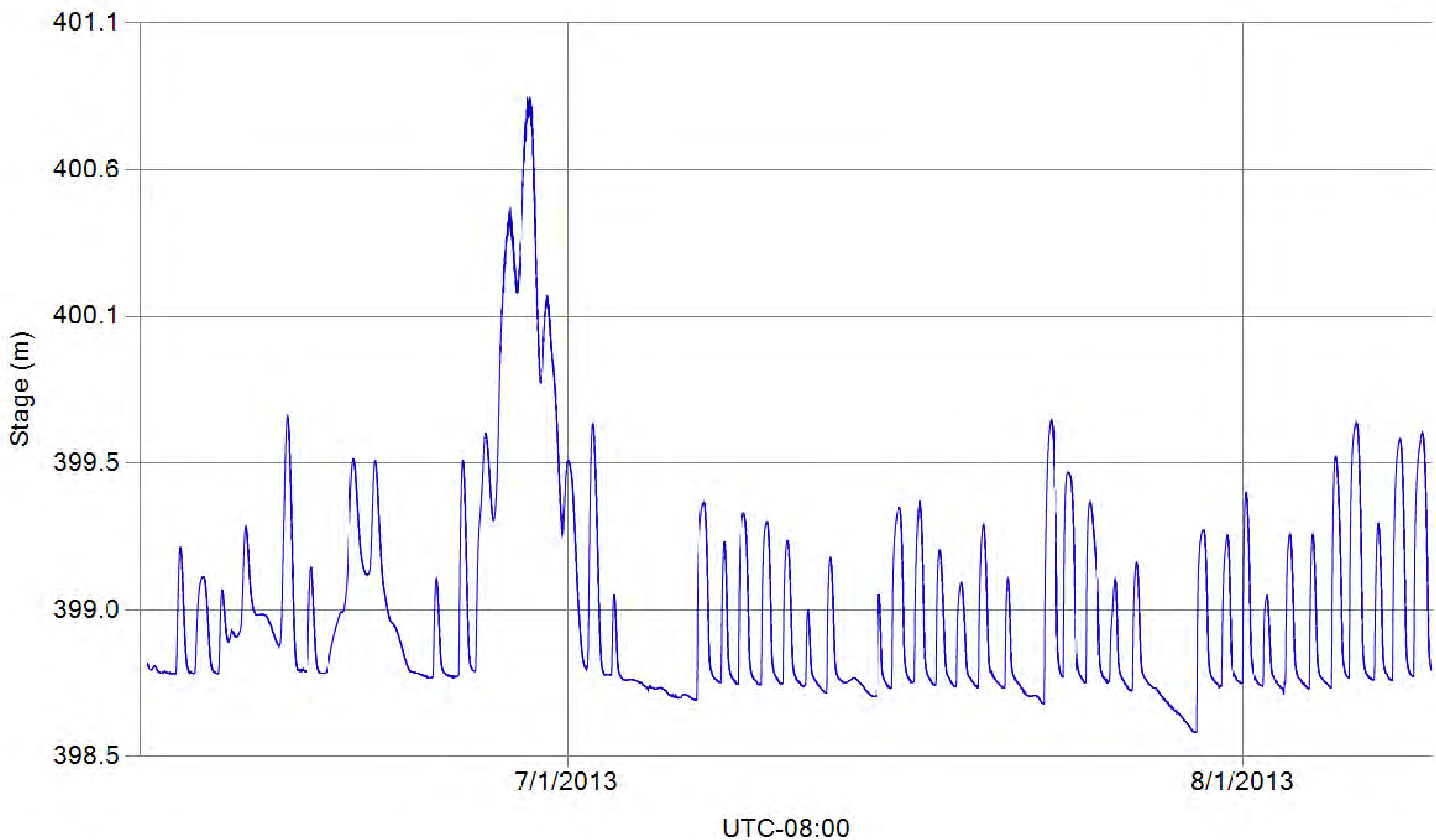

**Figure 38 Stage record for site 112.5R Pool. Sampling interval is 5 minutes. The logger was found buried in mud 2013 August 8. Estimated mud effected times are shown in red and black.**

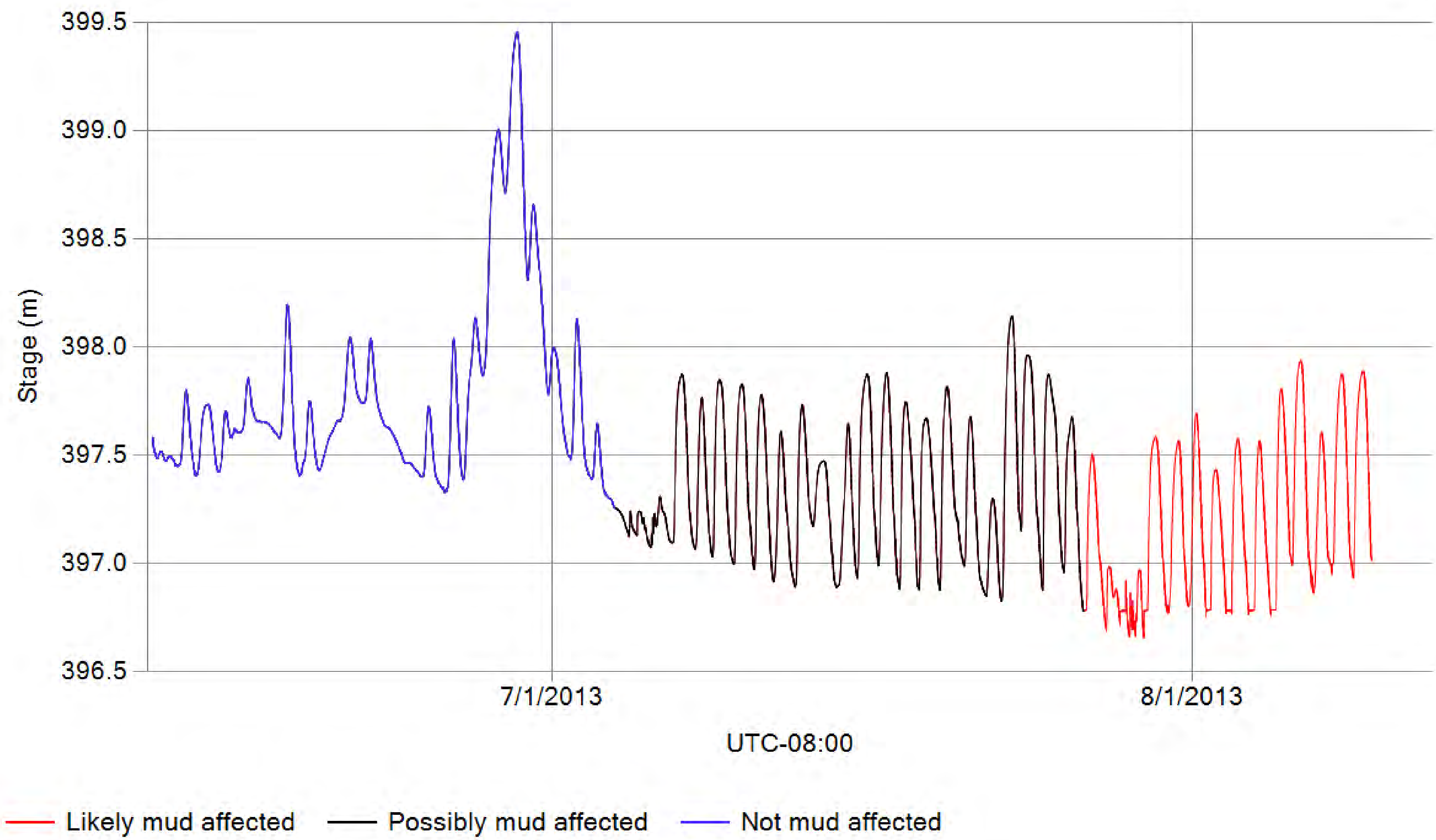

**Figure 39 Fish habitats identified in Side Channel 112L.**