Kelsey Generating Station

Quantification of Fish Habitat for the Kelsey Re-Runnering Project, 2008

REPORT

A report prepared by North/South Consultants Inc. for Fisheries and Oceans Canada and Manitoba Hydro

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by

North/South Consultants Inc.
83 Scurfield Blvd.
Winnipeg, MB R3Y 1G4
Tel: (204) 284-3366   Fax: (204) 477-4173
Web: www.nscons.ca

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TECHNICAL SUMMARY

Re-runnering of the Kelsey Generating Station (GS) will increase the discharge capacity of the station so that under the same high inflow conditions, if there is an energy demand, more flow will be passed through the power house and less flow will be passed through the spillway. This increase in capacity will not, however, change the amount of inflow to Kelsey GS; therefore, absolute minimum and maximum water levels will remain the same. Increasing the capacity of the GS will also increase the opportunity for cycling of the plant, i.e., for a certain daily inflow, the amount of flow passing through the powerhouse will be maximized during on peak hours to meet the power demand and minimized during off peak hours to keep the total daily flow volume balanced.. Cycling in both the existing and re-runnered condition could occur as station operation shifts from 2 to 7 generating units (or less); therefore, the analysis focussed on the 2 to 7 unit range as a "worst case" scenario.

Determination of effects to aquatic habitat post re-runnering required the following:

1. Determination of existing environment (EE) and post-project (PP) water depths and elevation to differentiate areas that will undergo habitat modifications post project. For example, water elevations were required to determine how much area would be influenced by the Kelsey GS after re-runnering and to distinguish areas that would no longer be influenced by GS operation;
2. A description of the shorezone habitat to produce classifications of nearshore habitat types in order to quantify areas of habitat modification across the local landscape level; and,
3. An understanding of the composition of the nearshore area in each of the habitat types to describe potential effects to aquatic biota. Information on composition included substrate classification, presence of macrophytes and, in selected locations, benthic invertebrates.

Five zones defined by elevations wetted under different discharges were used to delineate habitat potentially affected by operational changes as a result of re-runnering. The first is from flows 428-628 m^3/s which represents an area within the EE 2-7 unit range that will no longer potentially be affected by cycling post project. The second and third zones are common to both EE and PP 2-7 unit ranges, and are 628-891 m^3/s and 891-1,700 m^3/s which are divided by the 5th percentile flow at 891 m^3/s. The fourth division represents the area that will potentially be affected by cycling post project (1,700-2,212 m^3/s), that is not affected by cycling in the existing environment. This area is currently subject to exposure due to natural variations in flow. The fifth division is at flows above 2,212 m^3/s, in which spilling occurs in both the EE and PP environments, and there are no effects of cycling.

The flow zone 1,700 – 2,212 m^3/s, which is potentially subject to cycling post-project and not subject to cycling in the existing environment , amounts to an area of 453,046 m^2 or 0.45 km^2. This area is located in the intermittently exposed zone and as an overall average within the zone is estimated to be wetted 55% of the time. Therefore, the productive area was adjusted to 55% of the total, which represents 249,175 m^2 or 0.25 km^2 of productive wetted habitat. Typical patterns of benthic invertebrate abundance indicate that production is lower in seasonally exposed areas; based on data from Wuskwatim Lake invertebrate density in the intermittently exposed zone is approximately 50% of that of nearby permanently wetted habitat. Assuming that this intermittently exposed habitat would only support 50% of the invertebrate density of permanently wetted areas during periods when it is wetted, then the affected habitat is equivalent to 0.12 km^2 of permanently wetted habitat. Given site-specific conditions, actual effects to invertebrate production within the intermittently exposed zone due to the addition of daily cycling may be negligible.

The flow zone between 628 and 1,700 m^3/s, common to both EE and PP 2-7 units, amounts to 2,051,377 m^2 or 2.05 km^2 in area. The most productive habitat in this flow range, habitat class A, accounts for 36% of this area or 749,640 m^2 or 0.75 km^2. Habitat classes B and C in this flow range are considered to be of lower value due to their general lack of macrophyte habitat and lower suitability for benthic invertebrates. This area is estimated to be subject to potential cycling 27% of the time in the existing environment and potential cycling 57% of the time in the post project period. Changes in cycling in this flow range could amount to a net increase in the frequency of cycling by 30%. Assuming a uniform distribution of cycling over time in the existing and post-project periods, this increase in the frequency of cycling would not be expected to have a detectable effect on productivity since the negative effects of cycling (e.g., dewatering of macrophyte habitat preventing plant growth) would already occur under the 27% cycling scenario. Therefore, a neutral effect to habitat productivity is assessed for this flow range.

The 428-628 m^3/s flow zone exclusive to the EE 2-7 will no longer be potentially subject to cycling post project. This area accounts for an area of 132, 293 m^2 or 0.13 km^2. This area is of nominal value to macrophytes but higher populations of benthic invertebrates were observed in this range than in any other elevation range, and therefore this area is considered a high value net productive habitat gain.

Given a potential decrease in the production within 0.12 km^2 of habitat (presented as equivalent to permanently wetted habitat) in the flow zone between 1,700 – 2,212 m^3/s, a neutral effect in the flow zone between 628 and 1,700 m^3/s and a potential gain in production within 0.13 km^2 in the 428-628 m^3/s flow zone, a net productive gain within 0.01 km^2 of habitat is estimated post project. It should be noted that the reduction in production in the 1,700 – 2,212 m^3/s zone may be negligible given the short term duration of dewatering, and site-specific characteristics of the substrate and benthic invertebrate community.

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NORTH/SOUTH CONSULTANTS INC. STUDY TEAM

Friederike Schneider-Vieira: project management and planning; report editing.

Paul Cooley: project planning, aerial habitat survey, habitat classification, and report preparation.

Gaylen Eaton: habitat analysis and report preparation.

Laurel Neufeld: benthic invertebrate data analysis and report preparation.

Ginger Gill: field data collection.

Lisa Capar: field data collection.

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1.0 INTRODUCTION

Re-runnering will increase the discharge capacity of the Kelsey Generating Station (GS) meaning for the same amount of high inflows, if there is a power demand, less flow would be spilled and more would be passed through the GS after the re-runnering. Increasing the capacity of the GS will increase the opportunity for cycling of the plant, i.e., for a certain daily inflow, the amount of flow passing through the power house will be maximized during on peak hours to meet the power demand and minimized during off peak hours to keep the total daily flow volume balanced. Cycling in both the existing and re-runnered condition could occur as changes from 2 to 7 generating units (or less); therefore, the analysis focussed on the 2 to 7 unit range as a “worst case” scenario..

Currently, the range of water levels (from minimum to maximum river flows) downstream of the station is just under 4 m. This range will remain the same post re-runnering. The range that is routinely dewatered, i.e., within the 5^{th} and 95^{th} percentile flows, is approximately 3 m. This zone is referred to as the “intermittently exposed zone” (IEZ). Increasing the capacity of the station will increase the potential frequency for water level changes within the day, from approximately 27% of the time to 57% of the time, as cycling will be able to occur at higher flows than is currently possible. In addition, the maximum elevation that can be affected by cycling will be increased. Therefore, habitat that is now intermittently exposed on a weekly or seasonal basis could be affected by water level changes within the day post-project. Increasing the capacity of individual turbines will also increase the minimum elevation that can potentially be affected by cycling, i.e., the entire elevation range that can be affected by cycling will be shifted upwards such that some habitat that is typically wetted will no longer be potentially dewatered by cycling. This upward shift of the lower elevation potentially affected by cycling was only observed in these most recent analyses and was not part of the earlier assessment reports.).

Fisheries and Oceans Canada (DFO) has requested an estimate of the amount and type of habitat affected by cycling, as well as the additional areas that will potentially be affected by cycling post-project. At a meeting on February 11, 2008, Manitoba Hydro presented an approach to DFO outlining how the required habitat quantification and description would be conducted. DFO requested that detailed information on the proposed field program be provided once planning had been completed. This information was provided at subsequent meetings and final proposed locations for bathymetric and habitat transects were jointly selected with DFO’s representative prior to the field surveys. This document provides the results of the habitat analysis and supporting work (e.g., benthic invertebrate sampling).

The work described in this document includes the following:

- Classification of the nearshore habitat and selection of transect locations;
- Collection of bathymetry at transects to permit calculation of water surface elevations at selected river flows through the use of a hydrological model;
- Description of nearshore habitat at each transect location;
- Sampling of benthic invertebrates at selected low gradient locations where an extensive area is potentially affected by periodic dewatering;
- Use of the hydraulic model to calculate areas potentially affected by cycling in the existing environment and post re-runnering; and
- Providing a description of habitats potentially affected by cycling in the context of the total habitat in the nearshore environment.

It should be noted that this analysis focuses on habitat that would be affected by *potential* cycling in the existing environment in comparison to habitat that would be affected by *potential* cycling post re-runnering over the full range that could be used for cycling (2 to 7 units). In practice, cycling occurs to meet on peak power requirement or when it is economical, and historically Kelsey has been operated in cycling mode for only a fraction of the potential time and almost never over the full range (2 to 7 units). Water level changes caused by cycling at the GS occur within the overall water level changes resulting from seasonal and interannual variation in discharge of the Nelson River. During periods of high or low flows outside the cycling range, the water levels downstream of the station are a function of discharge in the Nelson River, rather than cycling at the GS..

2.0 METHODS

Determination of aquatic habitat changes post re-runnering required three main areas of enquiry:

4. Existing environment (EE) and post-project (PP) water depths and elevation were required to differentiate areas that will undergo habitat modifications post project. For example, water elevations were required to determine how much area would be influenced by the Kelsey GS after re-runnering and to distinguish areas that would no longer be influenced by GS operation;
5. The shorezone habitat needed to be described to produce classifications of nearshore habitat types in order to quantify areas of habitat modification across the local landscape level; and,
6. An understanding of the composition of the nearshore area in each of the habitat types was required to describe potential effects to aquatic biota. Information on composition included substrate classification, presence of macrophytes and, in selected locations, benthic invertebrates.

Each are described in turn in sections 2.2, 2.3, and 2.4.

2.1 STUDY AREA

The study area encompasses the Nelson River and adjoining Grass River where water levels are potentially affected by cycling at the Kelsey GS. This area is divided into six river reaches, referred to as the Grass River (lower section only), Kelsey GS West, Kelsey GS East, Nelson River, Sakitowak West, and Anipitapiskow Rapids (Figure 1). Two additional reaches, Downstream Anipitapiskow and Sakitowak East are backwatered from Split Lake and do not fall within the hydraulic zone of influence of cycling at the Kelsey GS. Data was collected from these areas at the request of DFO. However, these areas were not included in the total habitat areas that would be affected by cycling at the GS.

2.2 COMPARISON OF EXISTING AND POST-PROJECT WATER ELEVATIONS

2.2.1 Water Level Variations and Zones

Based on the results of the HEC-RAS model developed by Manitoba Hydro, re-runnering of the GS will cause an upward shift in the zone of habitat potentially affected by daily water level changes caused by cycling. Cycling can occur when flows are within the range of 2 to 7 units. In the existing environment, this corresponds to 428 to 1700 m^3/s while post re-runnering this corresponds to 628 to 2212 m^3/s. This upward shift will mean that the habitat between the elevations wetted by flows 1700 m^3/s to 2212 m^3/s will potentially be affected by cycling while habitat wetted by flows of 428 to 628 m^3/s will no longer be subject to cycling. Given that the habitat within the upper flow range falls within the intermittently exposed zone (1700 m^3/s to 2212 m^3/s), it is wetted on average only 55% of the time, regardless of cycling.

Overall, in the existing environment, habitat wetted by flows of 428 to 1700 m^3/s is potentially subject to cycling 27% of the time while post re-runnering habitat wetted by flows of 628 to 2212 m^3/s will potentially be subject to cycling 57% of the time.

2.2.2 Water Depth and Elevation Field Survey

Water depth and elevation information needed to describe the habitat with respect to the existing and post-project water regimes was collected by Manitoba Hydro's Engineering Surveys and Services at 51 cross-sections, each representing two potential field transects on opposing sides of the river (Figure 2). Transects were selected by Manitoba Hydro, North/South Consultants Inc., and DFO based on various criteria, including supplementing the existing hydraulic model, sampling from a range of habitat types in the area, and including low slope areas with potential macrophyte growth. At each transect site, depth of water and water surface elevation was collected across the full river cross section. Elevation of the river bed at each cross section was calculated by subtracting water depth from the corresponding water surface elevation.

Using the HEC-RAS hydraulic model, Manitoba Hydro estimated the water surface elevation and location of the water/land interface(shoreline) for the following conditions: 5th percentile flow (891 m^3/s), 95th percentile flow (3701 m^3/s), existing environment 2 unit flow (428 m^3/s), existing environment 7 unit flow (1700 m^3/s), post project 2 unit flow (628 m^3/s) and post project 7 unit flow (2212 m^3/s). The area of interest to this report lies between the water levels of EE 2 unit flow and the water levels of EE 95th percentile flow, and is defined here as the Nearshore Area (NSA).

2.3 SHOREZONE RECONNAISSANCE AND CLASSIFICATION

Aerial surveys were undertaken on July 7, 2008 using a Bell Jet Ranger helicopter and a Nikon D200 digital camera with integrated Global Positioning System (GPS) data to capture geographic location, elevation, date, and time in each photograph. Each of the 534 high resolution digital images was taken about 75 – 100 m above the water surface from an oblique aspect towards the shoreline.

2.3.1 Shoretype Associations

Shoretype associations were developed using indicators such as geomorphology, soils, shoreline configuration, and how water movements structure the availability of materials to form habitat. Shoretype associations, unlike detailed maps of river bottom types that show specific material distributions (e.g. gravel, cobble, sand), are more general interpretations of habitat distributions at the local landscape level. Each shoretype was derived by review of the shorezone photography (section 2.3), digital ortho images to interpret terrestrial terrain (landcover), and the aquatic habitat transects (described in section 2.4 below).

The nearshore zone classification included consideration of the bank materials, the nearshore substratum, whether within a lotic or lentic area, and whether or not the habitat had potential for macrophyte growth.

For the purposes of describing functional habitat types, shoretype associations and near shore zone classifications were aggregated into three classifications, each with similar habitat characteristics are described below and mapped in Figures 3 and 4. The associations between the shoretype, the nearshore zone and habitat class are defined for the study area are described in Table 1.

Habitat Class A: The shorezone is characterized by lowland topography (low slopes), abundant shrub understory, with predominantly fine-grained substrates composed of silt and silt/clay, lentic water mass and good potential for the growth of macrophytes. Organic matter may be present. Shoretypes are embayment, stream mouth and lowland deposition (representative photos are shown in Figure 5).

Habitat Class B: The shorezone is characterized by low to moderate topography with isolated bedrock outcrops. Substrates are composed of clay – silt/clay mixed or alternating with sand to sand and gravel. Water mass is usually lentic with low to moderately low potential for macrophyte growth. Slopes are moderate. Shoretypes are upland and lowland fines (representative photos are shown in Figure 6).

Habitat Class C: The shorezone is composed of steep shield topography or coarse glaciofluvial deposits with predominantly bedrock/boulder/cobble/gravel substrates. Sand substrates may be present but are not common. Water mass is generally lotic and the potential for macrophytes is low. Shoretypes are shield, built-up (at Kelsey GS) and upland aggregate (representative photos are shown in Figure 7).

2.4 NEARSHORE HABITAT SURVEY

An aquatic habitat survey was conducted to describe the habitat within the zone of water level variation. Benthic invertebrate samples were collected at selected low gradient locations where an extensive area is potentially affected by periodic dewatering. Detailed methodology for this portion of the 2008 field program is provided below.

2.4.1 Physical Monitoring

Substrate typing and water depths (±0.1 m) were measured with a metered aluminum depth rod. A Garmin Etrex® (GPS) receiver was used to record all sampling location coordinates (Universal Transverse Mercator [UTM] NAD 83). A Trimble GPS Pathfinder® ProXRS, using real-time differential corrections, was used to mark the start point, substrate transition, vegetation presence, and end point coordinates along each transect. Access to all sampling locations was by motorized boat.

2.4.2 Sampling Period and Locations

2.4.2.1 Substrate Transects

Substrate transects were surveyed 10 – 15 September, 2008. The substrate types and vegetation (including attached algae) were described along 54 transects (Figure 8). Twelve transects were located west of the Kelsey GS, in the Grass River. Seven transects were located in the isolated bay east of the GS. Twenty-three transects were located in the Nelson River mainstem due north of the GS, reaching past Anipitapiskow Rapids; and12 were located in the eastward division of the Nelson River, just past Sakitowak Rapids.

2.4.2.2 Benthic Invertebrates

Sediment-dwelling macroinvertebrate populations tend to be more stable in the fall, permitting the population to be better represented by samples collected during this time period. Invertebrate sampling was conducted on 13 September, 2008 at two locations: one in a vegetated bay to the west (west arm) of the GS, and the other in a bay to the east (east arm) of the GS (Figure 9).

2.4.3 Sample Collection and Field Measurements

2.4.3.1 Substrate Transects

Transects were measured in a perpendicular direction/orientation from the shoreline using metered tape. Water depth was measured at 0.5 m intervals using a rod. At each 0.5 m interval, the presence of vegetation/algae and substratum material was also assessed. GPS coordinates were logged at each interval where a substrate type change and/or vegetation presence change occurred and at the beginning and end of each transect. Transects were terminated at 3.5 m water depth or at the point where the boat became entrained in fast current.

GPS coordinates of transect start points were matched to HEC-RAS model shoreline points for the Kelsey study area by Manitoba Hydro (K. Wong, pers. comm. June 4th, 2009).

2.4.3.2 Benthic Invertebrates

Benthic invertebrates were collected with a petite Ponar grab (0.023 m^2 opening). Invertebrate sampling was collected at various depth-sites at two transects located in the west and east arms. The transect locations were established at the shoreline in each arm and based on water depth/elevation. In the west arm, samples were collected at four depth-sites (approximately 0.5 m; 2 m; 4 m; and 6 m); in the east arm, at three depth-sites (approximately 2 m; 4 m; and 6 m). Five samples (replicates) were taken at each depth-site to determine within-site benthic invertebrate variability. To ensure that disturbance from the sampler would not affect the replicates, each one was taken from different points around the boat (i.e., bow, stern, port, and starboard). Each benthic grab was sieved through a 400 micron sieve bucket and the sample contents were rinsed into a labelled container. Samples were fixed in 10% formalin and shipped to the North/South Consultants laboratory (Winnipeg, MB) for identification of invertebrates.

2.4.4 Laboratory and Data Analysis

2.4.4.1 Substrate Transects

In a GIS, transect lines were drawn from differentially corrected GPS start and end points for each transect. Each transect line was divided into 0.5 metre segments, referred to as transect segments, numbered in ascending order from shore. Each transect segment centroid was buffered 5 metres laterally (each side) to generate polygons for aerial calculations of habitat and to enable cartographic presentation of substrate material.

Not all transects surveyed reached as far offshore as the EE 2 unit boundary at the lowest extent of the Nearshore Zone. In such cases, the area of the transect between the limit of data and the position of the EE 2 unit flow was left as "unclassified" in the mapping. As a result, we refer to 'surveyed transect segments' as those with data, and 'total segment transects' which also include the unclassified segments.

2.4.4.2 Calculating Habitat Areas by Water Levels under Different Flows

An estimate of the total area for each shoretype class by water level was needed to form the basis for assessment. To do this, the proportion of each substrata in each transect was calculated. In the case where several transects represented the same shoretype, proportions were adjusted to reflect equal representation of each transect based on the frequency they occurred. Proportions were adjusted to each represent a 1 m unit of shoreline length. Proportions were then extrapolated to the all areas within the hydraulic zone of influence based on each shoretype's shoreline length.

It should be noted that only transects located within the hydraulic zone of influence were used in area calculations. Also, three transects were not included in the habitat area calculations due to absence of flow elevation points: DFO-P-5A, DFO-P-3B, and DFO-P-1A.

2.4.4.3 Benthic Invertebrates

In Winnipeg, invertebrate samples were rinsed with water using a 500 micron test sieve, transferred to 70% ethanol and sorted under a 3X desktop magnifier with lamp. Invertebrates were identified to major group (subclass, order, or family); Chironomidae were identified to subfamily. Samples were quantified by an invertebrate taxonomy technician. A Leica Mz12.5 microscope (maximum 100X magnification) and reference texts from Merritt and Cummins (1996), Peckarsky et al. (1990), and Clifford (1991) were used for identification. Scientific names used followed the Integrated Taxonomic Information System (ITIS) classification. Abundance of benthic invertebrates was calculated by dividing the total number of invertebrates per sample by the area of the sampler (0.023 m^2). Sample processing, taxonomy, and quality assurance were completed in accordance with North/South Consultants Inc. procedures (Appendix 1).

3.0 RESULTS

3.1 EXISTING ENVIRONMENT AND POST PROJECT AREAL COMPARISON

In the existing environment, 2.18 km^2 is estimated to be currently within the zone potentially affected by cycling at the Kelsey GS (2-7 unit range with existing turbines). Post-project this area is predicted to be 2.50 km^2 (2-7 unit range with re-runnered turbines) for a difference of 0.32 km^2. The value of this habitat is discussed in section 4.0. Cycling within this range can potentially occur 27% of the time with the existing turbines and 57% of the time in the re-runnered state.

3.2 SHOREZONE CLASSIFICATION

Approximately 74.2 km of shoreline was classified. Eight shoretypes were identified from the aerial photography with limited sub-variation in nearshore zones were evident in the transect data (see section 2.3.1).

The eight shoretypes were grouped into three habitat classes based on commonalities such as substrate materials, slope, water mass (lentic or lotic), macrophyte growth potential, topography, and depositional potential. The length and percentages of shoretypes in the hydraulic zone of influence, the downstream reaches (Sakitowak East and Anipitapikow Rapids) and the study area are shown in Table 2. Habitat class C (including shoretypes Precambrian shield, built-up and upland aggregate) was the most common representing 47% of the total study area. Habitat class B (shoretypes of lowland and upland fines) was least common (26% of the shoreline length) and Class A containing embayment, stream mouth and lowland depositional shorezones (which has the highest potential for the presence of aquatic macrophytes), existed in 27% of the study area. In the hydraulic zone of influence, habitat Class C was also the most common, comprising 45% of the total area, followed by Class A (30%) and Class B (25%).

Analysis of the shoretype data by substrata class and study reach (Table 3) shows patterns of habitat availability in the Study Area, as discussed below.

<u>Habitat Class A</u>

In the hydraulic zone of influence, habitat class A is most common in the Grass River and Kelsey GS West reaches representing 47.5% of the class. The remainder of habitat class A in the hydraulic zone of influence is located mainly in Kelsey GS East (14.2%), the Nelson River reach (6.4%) and it is the least common in the Anipitapikow Rapids area (3.5%).

By reach, about 90% of the Grass River reach is classified as Habitat Class A, followed by the Kelsey GS West reach which contains a 40% proportion of this class. The lowest proportions of Habitat Class A by reach are located in Anipitapiskow Rapids (2.7%), Sakitowak West (3.4%). Outside the hydraulic zone of influence, Sakitowak East was 62% habitat class A.

Lowland deposition shorezones are most common in the Grass River and the Kelsey GS West reaches, where this shoretype represents 85% and 31% of the shore length in each reach, respectively. These areas also had abundant rooted macrophyte distributions in the hydraulic zone of influence at 22.4% and 12.9% of total observations respectively. Stream mouth is widely distributed but most common in the Kelsey GS West with 33% of this type located here comprising 12.1% of all macrophyte observations. Sakitowak west had 28.9% of all plant observations concentrated in relatively small areas of lowland deposition (and also on upland fines where favourable microhabitats such as silt – silt/clay substrates and lentic water mass were present). Outside the hydraulic zone of influence, the majority of embayment shorezones are located in Downstream Anipitapiskow Rapids reach (63.6%) which makes up almost 37% of this area.

<u>Habitat Class B</u>

Habitat Class B is well distributed throughout the study area with over 30% of it located in Sakitowak West; it is least common in Grass River (2.3%) and Kelsey GS West (3%). More than half (53.9%) of the Upland Fine shoretype is found in the Sakitowak West reach due mainly to a well developed glacio-fluvial deposit found along the south shore. Lowland Fine shoretypes are most common downstream of Anipitapiskow Rapids (30% of this reach) followed by the Nelson River (22.6% of this reach).

<u>Habitat Class C</u>

Kelsey GS East contains the largest percentage of Habitat Class C (44.9%) with the remainder distributed approximately evenly in all reaches excepting Grass River. The Shield shoretype is widely available although almost 60% of this shoretype is found in the Kelsey GS East, Kelsey GS West and Nelson River reaches. Boulder/Cobble shorelines representative of the Upland Aggregate shoretype are not abundant in the study area but about one-third (31%) of that available is found downstream of Anipitapiskow Rapids. Almost 29% of the bedrock in the Study Area is found in Kelsey GS East. As expected, the Built-up shoretype is found only in the area near to Kelsey GS and accounts for 13.5% of the shore length in the Kelsey GS East reach.

3.3 NEARSHORE TRANSECTS

The boat-based surveys for aquatic habitat, aquatic plants and benthic invertebrates were done during a period of very high flows, permitting access to areas that are often not wetted. The preceding period was also generally characterized by flows well above median levels, which began in 2005 and continued through 2008 (Environment Canada, 2009), which would affect the distribution of plants and benthic invertebrates, as discussed below.

Fifty-four transects were surveyed in the nearshore zone of the Grass and Nelson rivers which resulted in 3,610 observations of nearshore zone habitat. A summary of substrate proportions by transect is located in Appendix 2, including percent occupancy of aquatic plants.

The nearshore area, which includes water levels for flows from 428 m^3/s to 3,701 m^3/s, within the hydraulic zone of influence is approximately 3.74 km^2 or 374 ha (Table 4). Data on bottom type was collected (i.e. at sites less than 3.5 m water depth or less than 100 m distance from shore) on 71.9% of the total transect distance, which is about 2.7 km^2 or 269 ha of the Nearshore Zone.

The offshore end of the nearshore transects where classification was difficult was most notable on the Built-up, Shield, and Upland Aggregate shoretypes that are relatively steep and water is flowing. In these shoretypes the nearshore estimates of the unclassified bottom type range from 46 – 69% of the nearshore. Fortunately, these swift lotic habitats tend to have fewer habitat transitions so the observations made in the shallows are expected to be similar at greater depth.

Depositional substrata dominate the stream mouth, lowland deposition and embayment, shoretypes where silt or silt/clay substrata account for 99%, 78% and 65% of the nearshore area by shoretype, respectively.

Lowland fine and Upland Fine nearshore area have a greater proportion of sand than the predominantly depositional shoretypes. In both shoretypes, sand and clay each occupies about equal proportions in the range of 28- 29%. Depositional areas in the Lowland Fine and Upland Fine NSA composed of clay would be considered a microhabitat in this Shoretype. The available data do not suggest that the deposition microhabitat is scattered heterogeneously within the NSA of this shoretype, but instead where deposition is found it is locally homogeneous. Therefore, the availability of clay depositional areas in the study area varies by shoretype but when present, the characteristics of all clay deposition areas are generally similar.

3.4 AQUATIC PLANTS

Over 95% of the aquatic plants were found on silt or silt/clay and less commonly on sand substrates. Aquatic plants were most plentiful (just under 50% of total observations) on the Grass River and in Kelsey GS West reaches, occupying up to 50% of each transect, particularly on the south shore. Aquatic plants also occupied two bay areas of the west shore of the Nelson River and the reach upstream of Sakitowak Rapids west in high but locally concentrated proportions (up to 80% of three transects; Figure 15). Plants in the Sakitowak Rapids West reach, accounted for over 28% of total observations.

Low or no presence of plants was noted on most mainstem Nelson River sites and in the east arm where substrates tended to be dominated by sand, gravel, boulder and bedrock materials (excepting bays where aquatic plants were observed in variable proportions which account for the remainder of the total observations; Figure 13). The percent occupancy by transect of aquatic plants is provided in Appendix 2.

Of all plants located on silt to silt/clay or sand substrates, almost 95% were located above the 5th percentile of flow. Submergent aquatic plants typically do not tolerate dewatering; however, the prolonged period of high flows has likely resulted in an upward shift in rooted macrophyte distribution in the shore zone. Just under 30% of observations of plants were located in areas wetted by flows greater than 2,212 m^3/s, at which spilling occurs in both EE and PP environments. These areas are note expected to be vegetated under more typical flow conditions. The flow range 1,700 – 2,212 m^3/s contained 23.5% of all observed macrophytes, and 42.6% were observed in the range between the 5th percentile and EE 7 unit or between 891 and 1,700 m^3/s flows (Figure 17). Figure 18 displays the distribution of occupation throughout the study area.

3.5 BENTHIC INVERTEBRATES

Five benthic grab replicates were collected at each of four sampling locations in the west arm and three sampling locations in the east arm of the Kelsey GS (Table 5, Figure 9 and Appendix 3). The distribution of benthic invertebrates was similar across the depth range, considering variation among replicates, with the exception of one sample in the west arm (#3). The exceptionally low abundance in this sample resulted in a lower overall invertebrate abundance within the west arm (Table 7). Mean total invertebrate abundance was 2,852 and 4,026 individuals/m^2 in the west and east arms, respectively (Table 6). Insecta, primarily Chironomidae and Ephemeroptera, was the most abundant invertebrate group in both the east and west arms, followed by Crustacea and Mollusca (tables 6 and 7).

With the exception of the one anomalous sample previously mentioned, total invertebrate abundance increased with increasing water depth and was greatest in the deepest samples in both the east and west arms (tables 6 and 7, Figure 20). Overall, insect abundance was similar at all depths in the east arm and was variable in the west arm. However, Chironimidae were most abundant in shallower samples and Trichoptera were most abundant in deep samples in both the east and west arms. Ephemeropteran abundance was greatest at mid and deep depths. Bivalvia, predominately Pisidiidae, and Crustacea were more abundant in deep samples while Annelida abundance was greatest in shallow samples in both the east and west arms (tables 6 and 7).

Elevation data were not available for the benthic invertebrate sampling sites, therefore, data were extrapolated from nearby habitat transects: Site DFO-P-4B for the west arm and Site DFO-P-2B for the east arm. Invertebrate samples collected at depths equal to or shallower than 2.1 m fell within the intermittently exposed zone (IEZ) and sites at 2.1 m of depth were within both the PP 2-7 and EE 2-7 unit zones in both the east and west arms (Figures 21 and 22). Invertebrate abundance within the IEZ may have been elevated in 2008 due to high water conditions prevailing since 2005. Samples collected at depths greater than 3.9 m were below the elevation range potentially affected by cycling in either the EE or PP . The highest invertebrate abundance in both the east and west arms occurred at the deepest sites, i.e., within the permanently wetted zone (below EE 2 unit flows) (Figures 21 and 22).

4.0 EFFECTS ASSESSMENT

4.1 VALUATION AND QUANTIFICATION OF HABITAT LOSS OR GAIN

The flow zone 1,700 – 2,212 m^3/s, which is potentially subject to cycling post-project and is not subject to cycling in the existing environment, amounts to an area of 453,046 m^2 or 0.45 km^2 (Table 8). This area is located in the intermittently exposed zone, and on average habitat in this area is estimated to be wetted 55% of the time. Therefore the productive aquatic habitat was adjusted to 0.55% of the total area, which represents 249,175 m^2 or 0.25 km^2. It should be noted that although 23.5% of the total macrophyte observations were located within this flow range, conditions of high flows over the past number of years would have increased macrophyte growth within this range. It is expected that macrophyte growth would substantially decrease with a return to more typical flow conditions, regardless of changes in cycling.

As discussed in section 3.5, it is expected that the higher benthic populations noted in relatively shallower ranges (within the IEZ) are the result of inundation over a number of years due to a prolonged period of high flows in the Nelson River (independent of the operations of the GS). Typically, in regulated reservoirs and below hydroelectric dams, fluctuating water levels result in lower invertebrate abundance in the intermittently exposed area with maximum abundance occurring below this exposure limit, within the permanently wetted the portion of the reservoir or watercourse (Armitage 1977; Fillion 1967; Fisher and Lavoy 1972; Janicki and Ross 1982). This pattern was observed in the nearshore of Wuskwatim Lake, MB, where benthic invertebrate abundance in the intermittently exposed zone was approximately 50% that of nearby permanently wetted habitats, when this habitat was re-wetted for a full growing season after having been dewatered the previous growing season (Manitoba Hydro and NCN 2003). Assuming, therefore, that habitat periodically exposed for longer periods (e.g., a growing season) would support only 50% of the production of permanently wetted habitat during periods when it is wetted, the productive capacity of the 249,175 m^2 or 0.25 km^2 of habitat would be equivalent to 124,587 m^2 or 0.12 km^2 of permanently wetted habitat

The effect of periodic exposure depends on the substrate quality as well as the frequency and duration of exposure. The re-runnering project would potentially increase the frequency of exposure within the day, but not affect exposure due to longer term changes in water levels (e.g., seasonal variations), which are controlled by outflow from Lake Winnipeg. Typically, Chironomidae and Oligochaeta are able tolerate the conditions of periodic exposure (dessication, freezing) in the upper littoral zone as well as be able to rapidly take advantage of newly wetted habitat, capable of colonizing bare substrates within a month (Fisher and Lavoy 1972; Scheifhacken et al. 2007). The quality of the intermittently exposed area is also influenced by the type of substrate affected by water level fluctuation; mineral-based substrate tends to freeze solid to some depth (hence, degraded quality for benthic invertebrates), whereas organic-based substrate freezes only at the surface, if at all, and also remains moist during intermittent exposure (hence, better quality for benthic invertebrates) (Koskenniemi 1994). In the Kelsey Study Area, Oligochaeta and Chironomidae, in particular, were proportionately more abundant in the intermittently exposed range (tables 6 and 7). Additionally, the qualitative substrate characterization at benthic invertebrate sampling locations indicates predominance of organic material within the intermittently exposed area of the west arm and across all sampling locations in the east arm (Table 5). Therefore, conditions in the IEZ would make the invertebrate community relatively more resistant to the effects of the daily water level changes that could occur more frequently post re-runnering.

To summarize, the nature of the effect post project in the zone between 1,700 to 2,212 m^3/s, which is where re-runnering would potentially cause an increase in cycling within the day, may negatively affect the equivalent of 0.12 km^2 of permanently wetted habitat; however, the actual effect may be negligible due to the duration of exposure and conditions within this zone.

The flow zone between 628 and 1,700 m^3/s, common to both EE and PP 2-7 units, amounts to 2,051,377 m^2 or 2.05 km^2 in area. The most productive habitat in this range, habitat class A, accounts for 36% of this area or 749,640 m^2 or 0.75 km^2. Habitat classes B and C in this flow range are considered to be of lower value due to their general lack of macrophyte habitat and lower suitability for benthic invertebrates. This area is estimated to be subject to *potential* cycling 27% of the time in the existing environment and *potential* cycling 57% of the time in the post project period. Changes in cycling in this flow range could amount to a net increase in the frequency of cycling by 30%. Assuming a uniform distribution of cycling over time in the existing and post-project periods, this increase in the frequency of cycling would not be expected to have a detectable effect on productivity since the negative effects of cycling (e.g., dewatering of macrophyte habitat preventing plant growth) would already occur under the 27% cycling scenario. Therefore, a neutral effect to habitat productivity is assessed for this flow range.

The 428-628 m^3/s flow zone exclusive to the EE 2-7 will no longer be potentially subject to cycling post project. This area accounts for an area of 132, 293 m^2 or 0.13 km^2. This area is of nominal value to macrophytes but higher populations of benthic invertebrates were observed in this range than in any other flow range and therefore this area is considered a high value net habitat gain.

Given a potential decrease in the production within 0.12 km^2 of habitat (presented as equivalent to permanently wetted habitat) in the flow zone between 1,700 – 2,212 m^3/s, a neutral effect in the flow zone between 628 and 1,700 m^3/s and a potential gain in production within 0.13 km^2 in the 428-628 m^3/s flow zone, a net productive gain within 0.01 km^2 of habitat is estimated post project. It should be noted that the reduction in production in the 1,700 – 2,212 m^3/s zone may be negligible given the short term duration of dewatering, and site-specific characteristics of the substrate and benthic invertebrate community.

5.0 REFERENCES

ARMITAGE, P. 1977. DEVELOPMENT OF THE MACRO-INVERTEBRATE FAUNA OF COW GREEN RESERVOIR (UPPER TEESDALE) IN THE FIRST FIVE YEARS OF ITS EXISTENCE. FRESHW. BIOL. 7: 441-454.CLIFFORD, H.F. 1991. Aquatic invertebrates of Alberta. The University of Alberta Press: Alberta. 538 pp.

ENVIRONMENT CANADA, 2009. Water Survey of Canada, Archived Hydrometric Data. Available: http://www.wsc.ec.gc.ca/hydat/H2O/index_e.cfm?cname=WEBfrmDailyReport_e.cfm

FILLION, D. 1967. The abundance and distribution of benthic fauna of three mountain reservoirs on the Kananaskis River in Alberta. J. Appl. Ecol. 4: 1-11.INTEGRATED TAXONOMIC INFORMATION SYSTEM (ITIS). 2009. Available : www.itis.usda.gov.

FISHER, S.G. and LAVOY, A. 1972. Differences in littoral fauna due to fluctuating water levels below a hydroelectric dam. J. Fish. Res. Board Ca. 29: 1472-1476.

JANICKI, A.J. and R.N. ROSS. 1982. Benthic invertebrate communities in the fluctuating riverine habitat below Conowingo Dam. A report prepared for the Power Plant Siting Program of the Maryland Department of Natural Resources by the Martin Marietta Environmental Center. 36 pp.

KOSKENNIEMI, E. 1994. Colonization, succession and environmental conditions of the macrozoobenthos in a regulated, polyhumic reservoir, Western Finland. Int. Revue ges. Hydrobiol. 79: 521-555.

MANITOBA HYDRO and NISICHAWAYASHIK CREE NATION. 2003. Wuskwatim Generation Project environmental impact statement. Volume 5.

MERRITT, R.W. and K.W. CUMMINS. 1996. An introduction to the aquatic insects of North America. 3rd edition. Kendall/Hunt Publishing Co.: Iowa. 862 pp.

PECKARSKY, B.L., P. R. FRAISSINET, M.A. PENTON, and D.J. CONKLIN JR. 1990. Freshwater macroinvertebrates of northeastern North America. Cornell University Press: New York. 442 pp.

SCHEIFHACKE, N., C. FIEK, and K.-O. ROTHHAUPT. 2007. Complex spatial and temporal patterns of littoral benthic communities interacting with water level fluctuations and wind exposure in the littoral zone of a large lake. Fundamental and Applied Limnology. 169: 115-129.

<u>Personal Communications Cited</u>

Karen Wong. 2009. Manitoba Hydro, Winnipeg Manitoba.

TABLES AND FIGURES

Table 1. Shoretype association and nearshore zone habitats grouped into three habitat classes in the Nelson River down river of Kelsey Generating Station.

Shoretype Associations			
Shoretype Name	**Shoretype**	**Nearshore zone**	**Habitat Class**
Embayment	Localized lowland topography with abundant understory species, emergent plants may be found in shorezone	Predominantly fine grained - typically clay, organic matter may be present, low slope, overlying water mass is lentic, macrophytes may be present	**A**
Stream Mouth	Lowland topography with abundant shrub understory species, emergent plants in shorezone	Predominantly silt/clay based, low slope, organic matter or detritus may be present, overlying water mass is lentic, macrophytes may be present	**A**
Lowland Deposition	Lowland topography with abundant shrub understory species, emergent plants in shorezone	Nearshore zone predominantly silt/clay, low slope, overlying water mass is lentic, macrophytes may be present	**A**
Upland Fine	Moderate relief topography with deciduous and/or conifer overstory, overlying fine glaciolacustrine deposit	Bank is typically clay or silt/clay based, moderate slope, much of nearshore zone sandy with patches of gravel and deposition, overlying watermass is usually lentic, macrophytes may be present	**B**
Lowland Fine	Lowland topography with abundant shrub understory species, isolated bedrock outcrops and potential for emergent plants in shorezone	Nearshore zone sandy in shallow water, sand and gravel may be present or associated with infrequent bedrock outcrops, low to moderate slope, silt/clay bottom in patches or below sand, overlying water mass is lentic	**B**
Sheild	Shield topography with well drained soils, deciduous and/or conifer overstory, overlying bedrock parent material; shorezone predominantly bedrock	Predominantly bedrock, sand may be present and alternate with undulations in bedrock, moderate to high slope river bed, overlying water mass usually lotic or if lentic is proximate the lotic habitat	**C**
Built-Up	Built up topography with abundant bedrock and/or blast rock shorezone predominantly bedrock/blast rock	Predominantly bedrock/blast rock, overlying water mass is lotic	**C**
Upland Aggregate	Upland topography with well drained soils, deciduous and/or conifer overstory, overlying coarse glaciofluvial deposit	Predominantly boulder/cobble/gravel, infrequent bedrock outcrops, moderate slope, overlying watermass is usually lotic	**C**

Table 2. Length (m) and percent (%) of habitat classes by shoretype in the hydraulic zone of influence and study area where classified.

Habitat Class	Shoretype	Hydraulic Zone of Influence	% of Hydraulic Zone of Influence	Downstream reaches (Sakitowak East and downstream Anipitapiskow Rapids)	% of Downstream Reaches	Total Length (m) (Study Area)	% Study Area
CLASS A	Embayment	6,250	10	1,064	8	7,314	10
	Stream Mouth	3,979	6	60	0	4,039	5
	Lowland Deposition	8,282	13	589	5	8,871	12
	TOTAL	**18,511**	**30**	**1,713**	**13**	**20,224**	**27**
CLASS B	Lowland Fine	9,427	15	1,253	10	10,683	14
	Upland Fine	6,014	10	2,678	21	8,378	12
	TOTAL	**15,411**	**25**	**3,391**	**31**	**19,061**	**26**
CLASS C	Shield	20,729	34	4,992	39	30,399	35
	Built Up	1,692	3	0	0	1,692	2
	Upland Aggregate	5,116	8	2,081	16	12,234	10
	TOTAL	**27,537**	**45**	**7,073**	**56**	**44,325**	**47**
ALL		**61,490**	**100**	**12,717**	**100**	**74,206**	**100**

Table 3. Length of shoretype within the study area by: 1) kilometre (km) (top), 2) shoretype (%) (middle), and 3) shoretype by reach (%) (bottom).

Shoretype	Anipitapiskow Rapids	Down Stream Anipitapiskow Rapids	Grass River	Kelsey GS East	Kelsey GS West	Nelson River	Sakitowak East	Sakitowak West	Total
Embayment	-	4651.5	-	1288.2	309.8	-	1064.3	-	7313.8
Stream_Mouth	60.1	605.9	222.8	1337.3	676.2	808.4	-	328.5	4039.1
Lowland_Deposition	588.9	-	4149.3	-	3439.4	384.2	-	309.3	8871.1
Total Habitat Class A	**649.0**	**5,257.4**	**4,372.1**	**2,625.5**	**4,425.4**	**1,192.6**	**1,064.3**	**637.8**	**20,224.0**
Lowland_Fine	1253.1	3793.3	490.6	625.3	1460.9	1976.2	-	1081.0	10680.4
Upland_Fine	994.5	-	-	-	696.9	628.0	1683.2	4689.1	8691.7
Total Habitat Class B	**2,247.6**	**3,793.3**	**490.6**	**625.3**	**2,157.8**	**2,604.2**	**1,683.2**	**5,770.1**	**19,372.1**
Shield	2436.0	1277.6	-	7408.5	4182.0	3763.9	2556.0	4097.3	25721.4
Built_Up	-	-	-	1692.3	-	-	-	-	1692.3
Upland_Aggregate	350.7	2271.9	-	212.2	376.5	1168.4	1729.8	1086.8	7196.3
Total Habitat Class C	**2,786.7**	**3,549.5**	**0.0**	**9,313.0**	**4,558.5**	**4,932.3**	**4,285.8**	**5,184.1**	**34,610.0**
Total	**5,683.3**	**12,600.2**	**4,862.7**	**12,563.8**	**11,141.7**	**8,729.1**	**7,033.3**	**11,592.0**	**74,206.1**

Table 3. Continued.

Shoretype	Anipitapiskow Rapids	Down Stream Anipitapiskow Rapids	Grass River	Kelsey GS East	Kelsey GS West	Nelson River	Sakitowak East	Sakitowak West	Total
Embayment	-	63.6	-	17.6	4.2	-	14.6	-	100.0
Stream_Mouth	1.5	15.0	5.5	33.1	16.7	20.0	-	8.1	100.0
Lowland_Deposition	6.6	-	46.8	-	38.8	4.3	-	3.5	100.0
Average % Habitat Class A	**2.7**	**26.2**	**17.4**	**16.9**	**19.9**	**8.1**	**4.9**	**3.9**	**100.0**
Lowland_Fine	11.7	35.5	4.6	5.9	13.7	18.5	-	10.1	100.0
Upland_Fine	11.4	-	-	-	8.0	7.2	19.4	53.9	100.0
Average % Habitat Class B	**11.6**	**17.8**	**2.3**	**3.0**	**10.9**	**12.9**	**9.7**	**32.0**	**100.0**
Shield	9.5	5.0	-	28.8	16.3	14.6	9.9	15.9	100.0
Built_Up	-	-	-	100.0	-	-	-	-	100.0
Upland_Aggregate	4.9	31.6	-	2.9	5.2	16.2	24.0	15.1	100.0
Average % Habitat Class C	**4.8**	**12.2**	**0.0**	**43.9**	**7.2**	**10.3**	**11.3**	**10.3**	**100.0**

Table 3. Continued.

Shoretype	Anipitapiskow Rapids	Down Stream Anipitapiskow Rapids	Grass River	Kelsey GS East	Kelsey GS West	Nelson River	Sakitowak East	Sakitowak West
Embayment	-	36.9	-	10.3	2.8	0.0	15.1	0.0
Stream_Mouth	1.1	4.8	4.6	10.6	6.1	9.3	0.0	2.8
Lowland_Deposition	10.4	-	85.3	-	30.9	4.4	0.0	2.7
Total Habitat Class A	**11.4**	**41.7**	**89.9**	**20.9**	**39.8**	**13.7**	**15.1**	**5.5**
Lowland_Fine	22.0	30.1	10.1	5.0	13.1	22.6	0.0	9.3
Upland_Fine	17.5	0.0	0.0	0.0	6.3	7.2	23.9	40.5
Total Habitat Class B	**39.5**	**30.1**	**10.1**	**5.0**	**19.4**	**29.8**	**23.9**	**49.8**
Shield	42.9	10.1	0.0	59.0	37.5	43.1	36.3	35.3
Built_Up	0.0	0.0	0.0	13.5	0.0	0.0	0.0	0.0
Upland_Aggregate	6.2	18.0	0.0	1.7	3.4	13.4	24.6	9.4
Total Habitat Class C	**49.1**	**28.1**	**0**	**74.2**	**40.9**	**56.5**	**60.9**	**44.7**
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table 4. Estimated area (m^2) of the nearshore zone by substratum class and water level zone within the hydraulic zone of influence from the Kelsey GS. The nearshore area extends from EE 95 percentile to EE 2 unit steady state flow elevation.

Shoretype	Substratum	> 2,212 m^3/s (spilling EE and PP)	1,700-2,212 m^3/s (PP 2-7 Unit)	PP 2-7 and EE 2-7 Unit (>5th Percentile)	PP 2-7 and EE 2-7 Unit (<5th Percentile)	428-628 m^3/s (EE 2-7 Unit)	Total
Built Up	boulder	3386.6	2634.0	0.0	0.0	0.0	6020.6
	organic	376.3	0.0	0.0	0.0	0.0	376.3
	sand	3010.3	0.0	0.0	0.0	0.0	3010.3
	unclassified	0.0	1505.1	10535.9	3010.4	1505.1	16556.6
Built Up Total							**25,963.8**
Embayment	bedrock	0.0	0.0	21652.0	0.0	0.0	21652.0
	boulder	7160.1	7103.0	14207.1	0.0	0.0	28470.2
	clay	541309.7	0.0	64956.8	0.0	0.0	606266.5
	organic	21310.4	0.0	163379.1	0.0	0.0	184689.5
	sand	39695.1	0.0	43305.2	0.0	0.0	83000.3
	unclassified	0.0	0.0	3551.3	0.0	0.0	3551.3
Embayment Total							**927,629.8**
Lowland Deposition	bedrock	1741.2	1259.7	3347.0	0.0	0.0	6347.8
	boulder	1424.3	0.0	979.5	0.0	0.0	2403.8
	clay	40877.4	52056.8	127700.7	35471.2	7163.2	263269.3
	clay/cobble	133.2	0.0	0.0	0.0	0.0	133.2
	gravel	0.0	0.0	0.0	14690.7	2448.5	17139.2
	sand	315.0	0.0	1889.6	1049.3	0.0	3253.9
	unclassified	157.2	0.0	18940.9	14809.1	10159.4	44066.5
Lowland Deposition Total							**336,613.6**
Lowland Fine	bedrock	19472.2	15265.4	17910.8	668.2	0.0	53316.5
	boulder	1217.7	304.3	1217.1	0.0	0.0	2739.1
	clay	44888.0	30117.4	54510.3	5075.2	1903.3	136494.2
	clay/boulder	608.4	304.3	304.3	0.0	0.0	1217.0
	clay/cobble	0.0	304.3	0.0	0.0	0.0	304.3
	cobble	0.0	1825.6	608.4	0.0	0.0	2434.0
	sand	6849.5	19545.1	53783.7	58075.9	1388.0	139642.1
	sand/cobble	0.0	2672.5	0.0	722.1	0.0	3394.6
	unclassified	5396.8	10401.5	23860.9	47556.6	51729.8	138945.6
Lowland Fine Total							**478,487.4**
Shield	bedrock	90643.9	16688.8	26082.0	0.0	0.0	133414.8
	boulder	48073.2	11701.4	12898.1	3485.3	1027.7	77185.6
	clay	13293.3	16658.7	79424.8	0.0	954.0	110330.8
	cobble	1429.9	4414.6	3854.2	0.0	0.0	9698.7
	organic	912.9	0.0	0.0	0.0	0.0	912.9
	sand	39441.6	3798.7	52482.4	1027.6	0.0	96750.3
	unclassified	102412.4	86096.6	127356.1	45202.3	15983.7	377051.1
Shield Total							**805,344.1**

Table 4. Continued.

Shoretype	Substratum	> 2,212 m^3/s (spilling EE and PP)	1,700-2,212 m^3/s (PP 2-7 Unit)	PP 2-7 and EE 2-7 Unit (>5th Percentile)	PP 2-7 and EE 2-7 Unit (<5th Percentile)	428-628 m^3/s (EE 2-7 Unit)	Total
Stream Mouth	clay	0.0	50392.8	199553.5	20157.0	8063.0	278166.2
	unclassified	0.0	2016.0	0.0	0.0	0.0	2016.0
Stream Mouth Total							**280,182.3**
Upland Aggregate	bedrock	1550.7	5250.7	3500.1	0.0	0.0	10301.6
	boulder	1551.0	11254.3	6203.0	0.0	0.0	19008.3
	clay	25809.0	5249.4	0.0	0.0	0.0	31058.5
	sand	10855.3	45969.1	6801.3	0.0	0.0	63625.7
	unclassified	5250.6	0.0	145593.6	121977.8	11653.0	284474.9
Upland Aggregate Total							**408,469.0**
Upland Fine	bedrock	0.0	1899.6	9072.9	0.0	0.0	10972.5
	boulder	0.0	0.0	598.5	2394.1	0.0	2992.6
	clay	20794.5	23793.9	93912.1	3223.8	1934.2	143658.6
	cobble	0.0	0.0	1804.0	1804.1	0.0	3608.1
	sand	8997.4	22562.6	81965.2	17707.4	6158.2	137390.9
	sand/cobble	0.0	0.0	598.4	0.0	0.0	598.4
	unclassified	0.0	0.0	122593.5	52334.7	10222.3	185150.5
Upland Fine Total							**484,371.5**
Grand Total (m^2)		1,110,345.0	453,046.2	1,600,934.2	450,442.6	132,293.6	3,747,061.5
Grand Total (Ha)		111.0	45.3	160.1	45.0	13.2	374.7
Grand Total (%)		29.6	12.1	42.7	12.0	3.5	100

Table 5. Survey information for benthic invertebrate samples in the Kelsey GS study area, 2008.

Location	Sample	Replicate	Date	UTM (14U)		Substrate	Water Depth (m)
				Easting	Northing		
West Arm	1	1	13-Sep	651570	6213395	clay/organic	0.4
		2	13-Sep	651570	6213395	clay/organic	0.4
		3	13-Sep	651570	6213395	clay/organic	0.8
		4	13-Sep	651570	6213395	clay/organic	0.8
		5	13-Sep	651570	6213395	clay/organic	0.6
	2	1	13-Sep	651559	6213406	clay/mud/pebbles	1.9
		2	13-Sep	651559	6213406	clay/mud/pebbles	2.2
		3	13-Sep	651559	6213406	organic	2.0
		4	13-Sep	651559	6213406	organic	2.2
		5	13-Sep	651559	6213406	organic	2.0
	3	1	13-Sep	651547	6213461	clay balls	3.8
		2	13-Sep	651547	6213461	clay balls	3.9
		3	13-Sep	651547	6213461	clay balls	4.1
		4	13-Sep	651547	6213461	clay balls	4.0
		5	13-Sep	651547	6213461	clay balls	3.9
	4	1	13-Sep	651529	6213522	clay balls/shells	5.8
		2	13-Sep	651529	6213522	clay balls/shells	6.3
		3	13-Sep	651529	6213522	clay balls/shells	5.2
		4	13-Sep	651529	6213522	clay balls/shells	6.6
		5	13-Sep	651529	6213522	clay balls/shells	7.9
East Arm	1	1	13-Sep	656131	6213590	clay/organic	2.0
		2	13-Sep	656131	6213590	clay/organic	2.1
		3	13-Sep	656131	6213590	clay/organic	2.2
		4	13-Sep	656131	6213590	clay/organic	2.1
		5	13-Sep	656131	6213590	clay/organic	2.2
	2	1	13-Sep	655653	6213595	clay/detritus	4.5
		2	13-Sep	655653	6213595	clay/detritus	4.7
		3	13-Sep	655653	6213595	clay/detritus	4.4
		4	13-Sep	655653	6213595	clay/detritus	4.7
		5	13-Sep	655653	6213595	clay/detritus	4.5
	3	1	13-Sep	655654	6213606	clay/organic/wood/detritus	6.6
		2	13-Sep	655654	6213606	clay/organic/wood/detritus	6.4
		3	13-Sep	655654	6213606	clay/organic/wood/detritus	6.2
		4	13-Sep	655654	6213606	clay/organic/wood/detritus	6.8
		5	13-Sep	655654	6213606	clay/organic/wood/detritus	6.6
	4	1				bedrock - no sample	2.0
		2				bedrock - no sample	4.0
		3				bedrock - no sample	6.0

Table 6. Mean numbers of benthic invertebrates (individuals/m^2; ± standard error (SE)) collected at the west arm of the Kelsey GS, 2008.

Location	West Arm									
Sample	1		2		3		4		Overall	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Number of replicates/sample	**5**		**5**		**5**		**5**		**20**	
Depth (m)	**0.6**	**0.1**	**2.1**	**0.1**	**3.9**	**0.1**	**6.4**	**0.5**		
Annelida										
Oligochaeta	739	406	122	42	0	0	9	9	217	234
Hirudinea	9	9	0	0	0	0	0	0	2	4
Total Annelida	**748**	**414**	**122**	**42**	**0**	**0**	**9**	**9**	**220**	**238**
Crustacea										
Amphipoda (unidentified)	0	0	0	0	0	0	0	0	0	0
Haustoriidae	0	0	0	0	235	79	922	263	289	214
Talitridae	157	126	0	0	0	0	0	0	39	66
Total Crustacea	**157**	**126**	**0**	**0**	**235**	**79**	**922**	**263**	**328**	**213**
Mollusca										
Bivalvia (unidentified)	0	0	9	9	0	0	0	0	2	4
Pisidiidae	0	0	26	17	9	9	209	102	61	62
Gastropoda (unidentified)	0	0	113	113	9	9	0	0	30	56
Hydrobiidae	104	17	243	83	35	16	26	17	102	57
Physidae	96	42	0	0	0	0	0	0	24	27
Planorbidae	43	27	17	17	0	0	0	0	15	17
Valvatidae	17	17	26	17	9	9	0	0	13	13
Total Mollusca	**261**	**64**	**435**	**119**	**61**	**22**	**235**	**102**	**248**	**99**
Platyhelminthes	0	0	0	0	0	0	0	0	0	0
Insecta										
Hemiptera										
Corixidae	17	11	0	0	9	9	17	11	11	9
Ephemeroptera										
Caenidae	35	25	61	61	0	0	0	0	24	32
Ephemeridae	26	17	104	11	304	53	2122	505	639	459
Trichoptera (unidentified)	0	0	9	9	26	26	0	0	9	14
Hydropsychidae	0	0	0	0	0	0	0	0	0	0
Leptoceridae	0	0	35	16	43	34	330	83	102	74
Molannidae	9	9	17	11	0	0	0	0	7	7
Phryganeidae	26	17	0	0	0	0	0	0	7	10
Polycentropodidae	0	0	0	0	0	0	0	0	0	0
Plecoptera (unidentified)	0	0	0	0	0	0	0	0	0	0
Diptera										
Ceratopogonidae	43	19	148	22	0	0	43	24	59	30

Table 6. Continued.

Location / Sample	West Arm 1 Mean	SE	2 Mean	SE	3 Mean	SE	4 Mean	SE	Overall Mean	SE
Chironomidae	9	9	0	0	0	0	0	0	2	4
Chironominae	1148	445	2122	434	157	22	304	81	933	461
Orthocladiinae	9	9	9	9	0	0	17	17	9	10
Tanypodinae	0	0	713	150	70	38	235	70	254	149
Empididae	9	9	0	0	0	0	0	0	2	4
Total Insecta	**1330**	**489**	**3217**	**592**	**609**	**69**	**3070**	**610**	**2057**	**683**
Total Invertebrates	**2496**	**1005**	**3774**	**619**	**904**	**91**	**4235**	**915**	**2852**	**907**

Table 7. Mean numbers of benthic invertebrates (individuals/m^2; ± standard error (SE)) collected at the east arm of the Kelsey GS, 2008.

Location / Sample	East Arm 1 Mean	SE	2 Mean	SE	3 Mean	SE	Overall Mean	SE
Number of replicates/sample	**5**		**5**		**5**		**15**	
Depth (m)	**2.1**	**0.0**	**4.6**	**0.1**	**6.5**	**0.1**		
Annelida								
Oligochaeta	148	35	0	0	17	17	55	37
Hirudinea	52	25	0	0	17	17	23	19
Total Annelida	**200**	**56**	**0**	**0**	**35**	**21**	**78**	**52**
Crustacea								
Amphipoda (unidentified)	0	0	17	17	43	24	20	18
Haustoriidae	9	9	226	83	1235	184	490	270
Talitridae	426	193	0	0	270	237	232	183
Total Crustacea	**435**	**188**	**243**	**89**	**1548**	**391**	**742**	**356**
Mollusca								
Bivalvia (unidentified)	0	0	0	0	0	0	0	0
Pisidiidae	9	9	765	180	887	357	554	279
Gastropoda (unidentified)	26	26	9	9	9	9	14	16
Hydrobiidae	0	0	104	70	17	17	41	44
Physidae	0	0	0	0	0	0	0	0
Planorbidae	0	0	0	0	0	0	0	0
Valvatidae	0	0	0	0	0	0	0	0
Total Mollusca	**35**	**25**	**878**	**239**	**913**	**367**	**609**	**301**

Table 7. Continued.

Location Sample	East Arm 1 Mean	 1 SE	 2 Mean	 2 SE	 3 Mean	 3 SE	Overall Mean	 SE
Platyhelminthes	0	0	0	0	26	26	9	15
Insecta								
Hemiptera								
Corixidae	0	0	0	0	0	0	0	0
Ephemeroptera								
Caenidae	26	17	0	0	0	0	9	11
Ephemeridae	226	37	1487	614	504	58	739	414
Trichoptera (unidentified)	0	0	9	9	9	9	6	7
Hydropsychidae	0	0	9	9	157	67	55	49
Leptoceridae	9	9	183	42	330	54	174	71
Molannidae	9	9	26	26	0	0	12	16
Phryganeidae	0	0	0	0	0	0	0	0
Polycentropodidae	0	0	113	53	835	260	316	222
Plecoptera (unidentified)	0	0	0	0	9	9	3	5
Diptera								
Ceratopogonidae	113	17	113	43	70	22	99	29
Chironomidae	0	0	0	0	0	0	0	0
Chironominae	1817	298	200	51	296	223	771	397
Orthocladiinae	9	9	70	35	61	33	46	29
Tanypodinae	426	95	217	36	435	178	359	119
Empididae	0	0	0	0	0	0	0	0
Total Insecta	**2635**	**395**	**2426**	**657**	**2704**	**718**	**2588**	**564**
Total Invertebrates	**3304**	**505**	**3548**	**941**	**5226**	**1480**	**4026**	**1053**

Table 8. Estimated area (m^2) of habitat classes by water level zone within the hydraulic zone of influence from the Kelsey GS.

Habitat		Water Level Zones					Totals	
Habitat Class	% Habitat Class Composition	> 2,212 m^3/s	PP 2-7 Unit (1,700 - 2,212 m^3/s)	PP 2-7 and EE 2-7 Unit (891 - 1,700 m^3/s)	PP 2-7 and EE 2-7 Unit (628-891 m^3/s)	EE 2-7 unit (428 - 628 m^3/s)	Totals (EE)	Totals (PP)
A	30	654,124	112,828	663,463	86,177	27,834	777,474	862,468
B	25	108,225	128,997	462,740	189,562	73,336	725,638	781,299
C	45	347,997	211,221	474,732	174,703	31,124	680,558	860,656
Totals	**100**	**1,110,345**	**453,046**	**1,600,934**	**450,443**	**132,293**	**2,183,671**	**2,504,423**

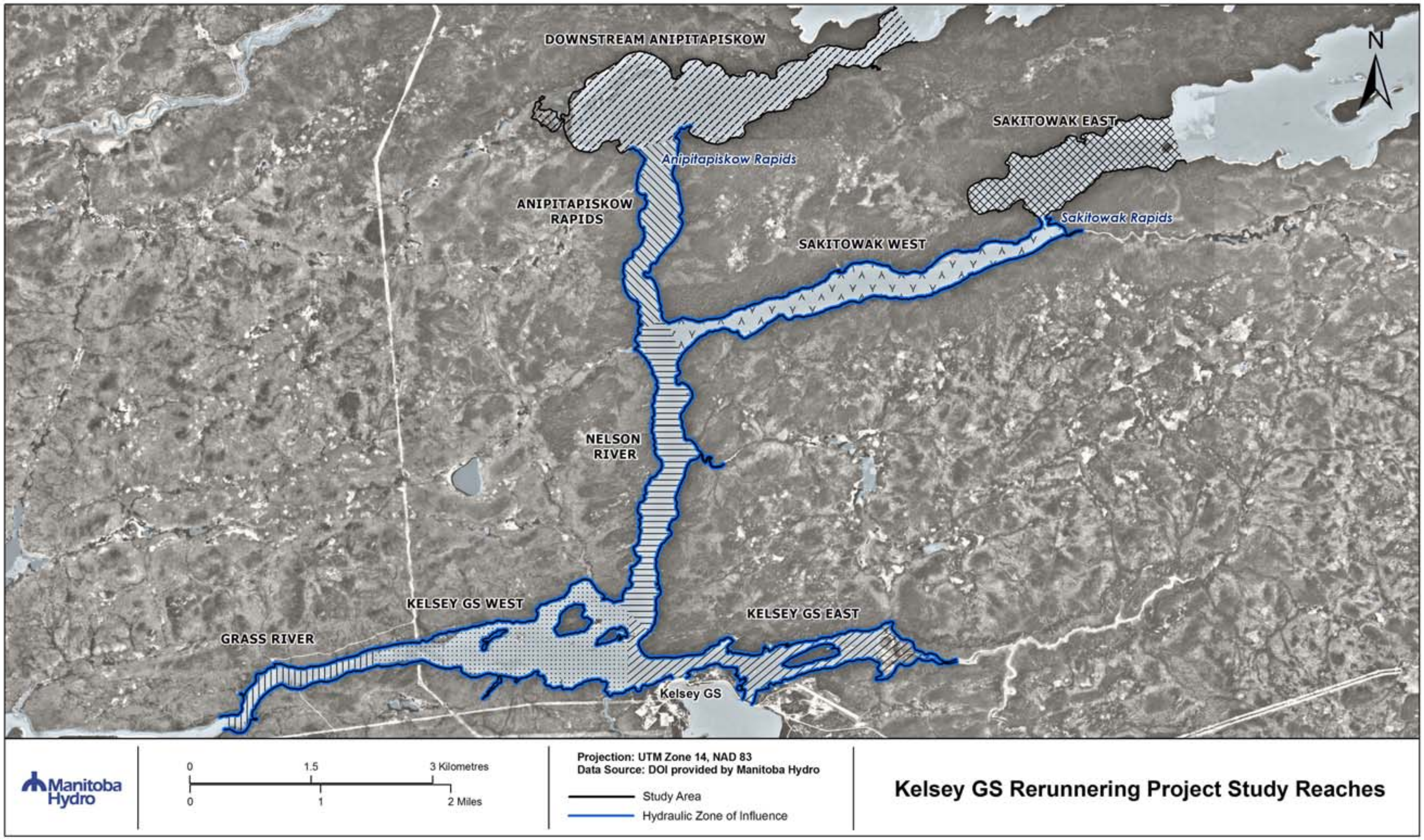

Figure 1. Study reaches and the hydraulic zone of influence used for the Kelsey GS Rerunnering Project, 2008.

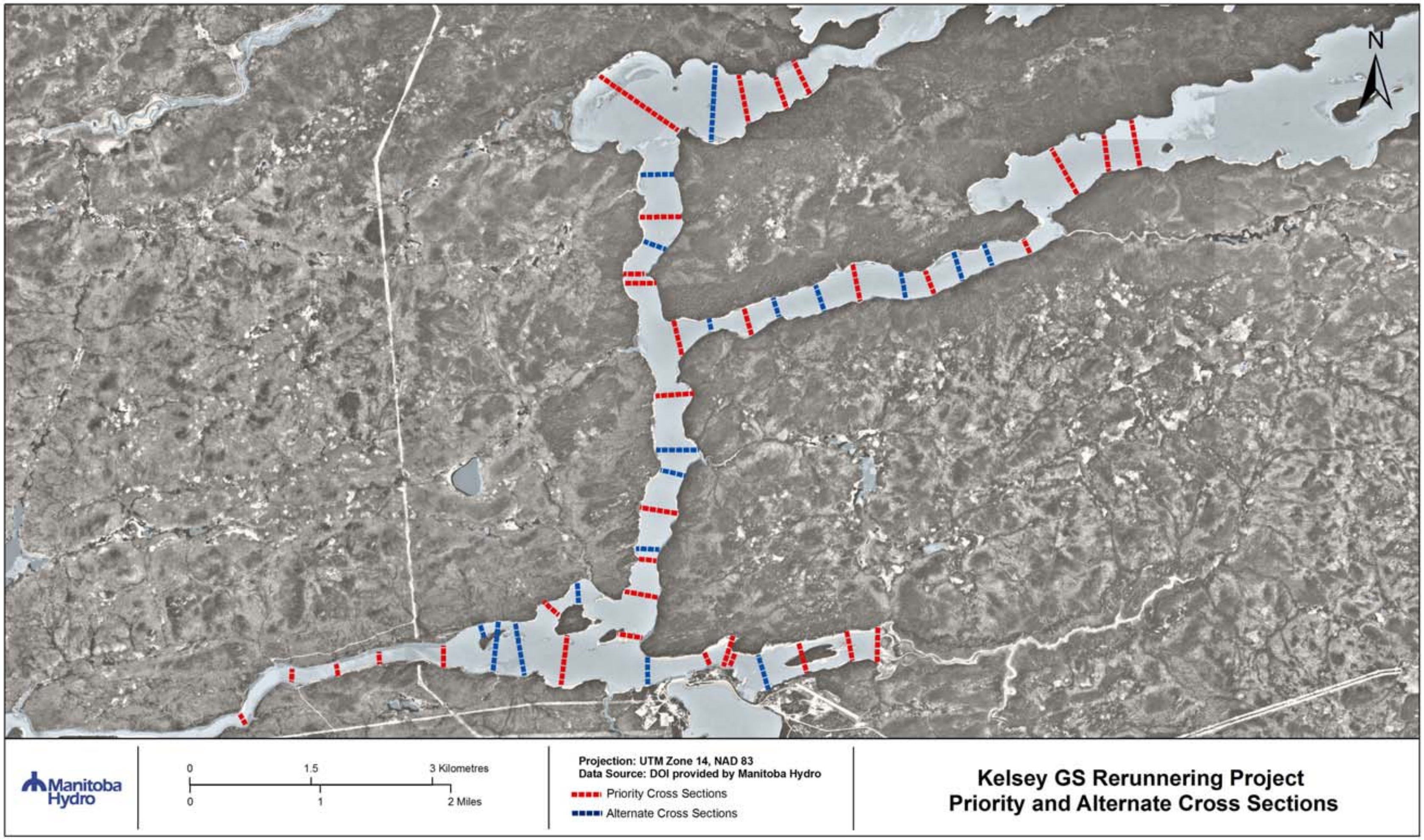

Figure 2. Fifty-one proposed priority and alternate cross section sites where water depth and elevation data was collected. Each cross-section represents two potential field transects on opposing sides of the river.

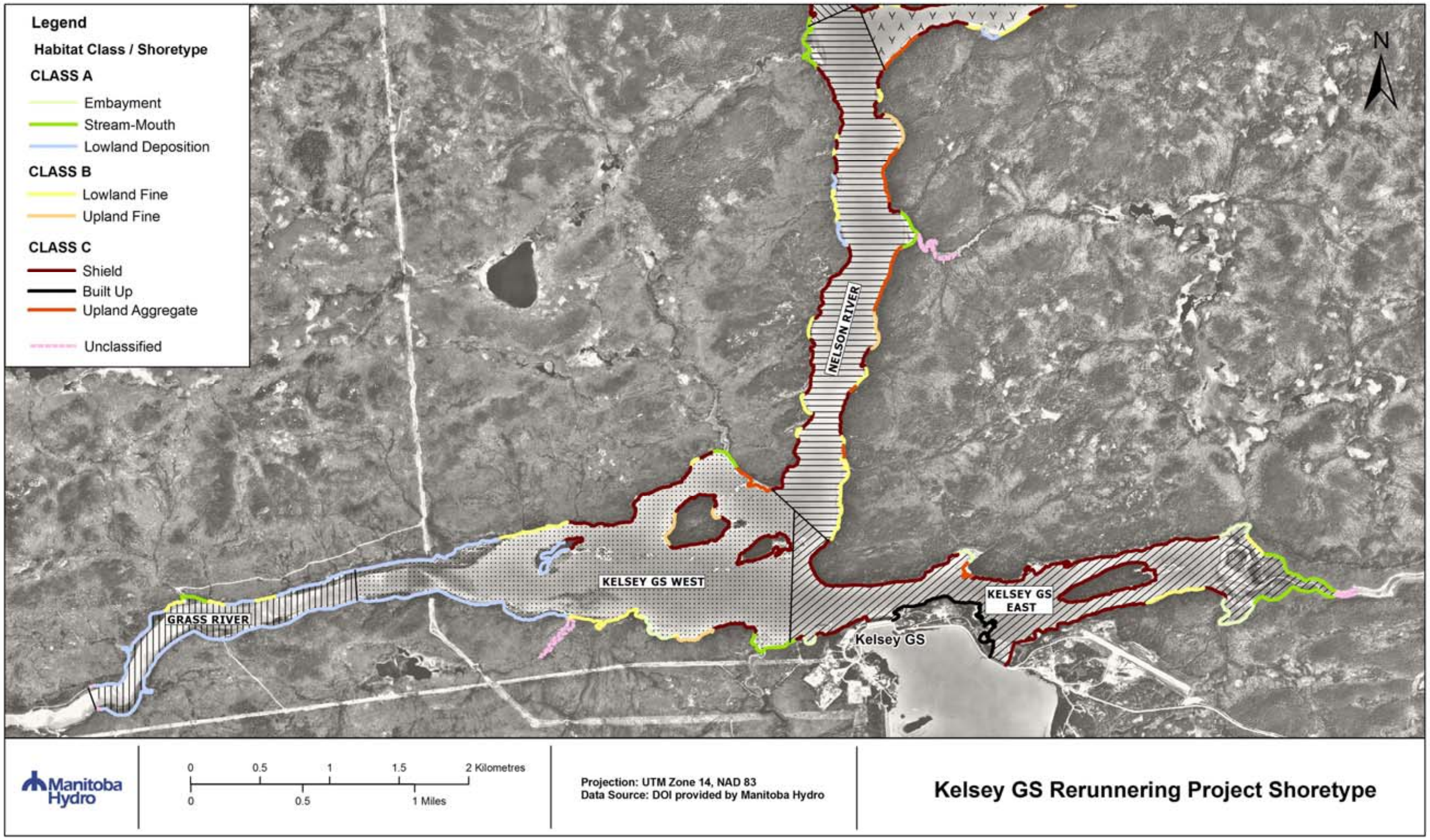

Figure 3. Habitat class and shoretype distribution for the study reaches including the Grass River, Kelsey GS West, Kelsey GS East, and the Nelson River reaches.

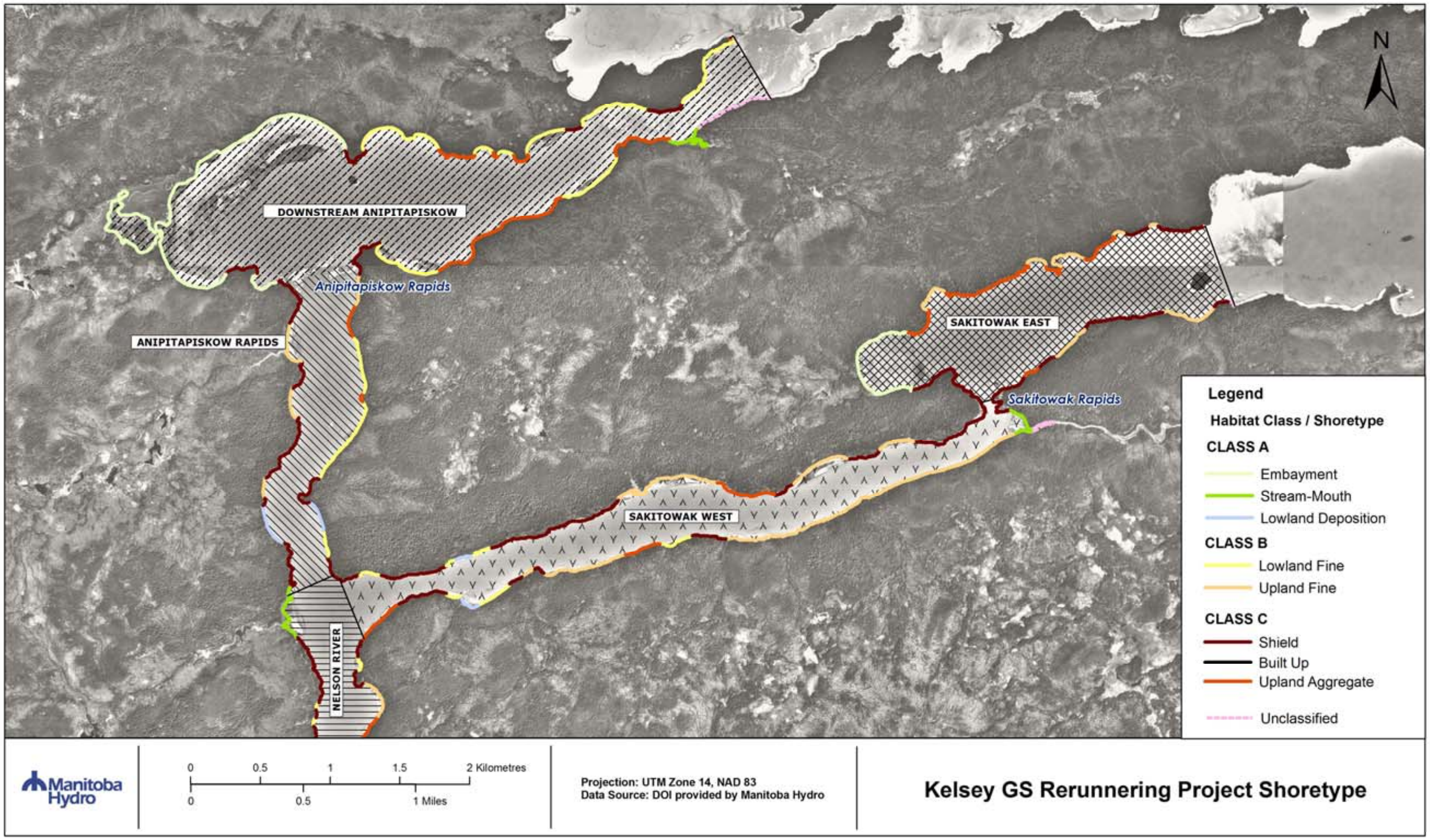

Figure 4. Habitat class and shoretype distribution for the Study Reaches including the Anipitapiskow Rapids, Downstream Anipitapiskow, Sakitowak West and Sakitowak East reaches.

Figure 5. Representative photos of habitat class A: representing embayment (1), stream mouth (2) and lowland deposition (3) shorezones. Note: macrophyte stands visible in photos.

Figure 6. Representative photos of habitat class B: upland fines (1) and lowland fines (2).

Figure 7. Representative photos of habitat class C: shield (1), built-up (2) and upland aggregate (3) shorezones. Note lotic water mass and steep(er) topography.

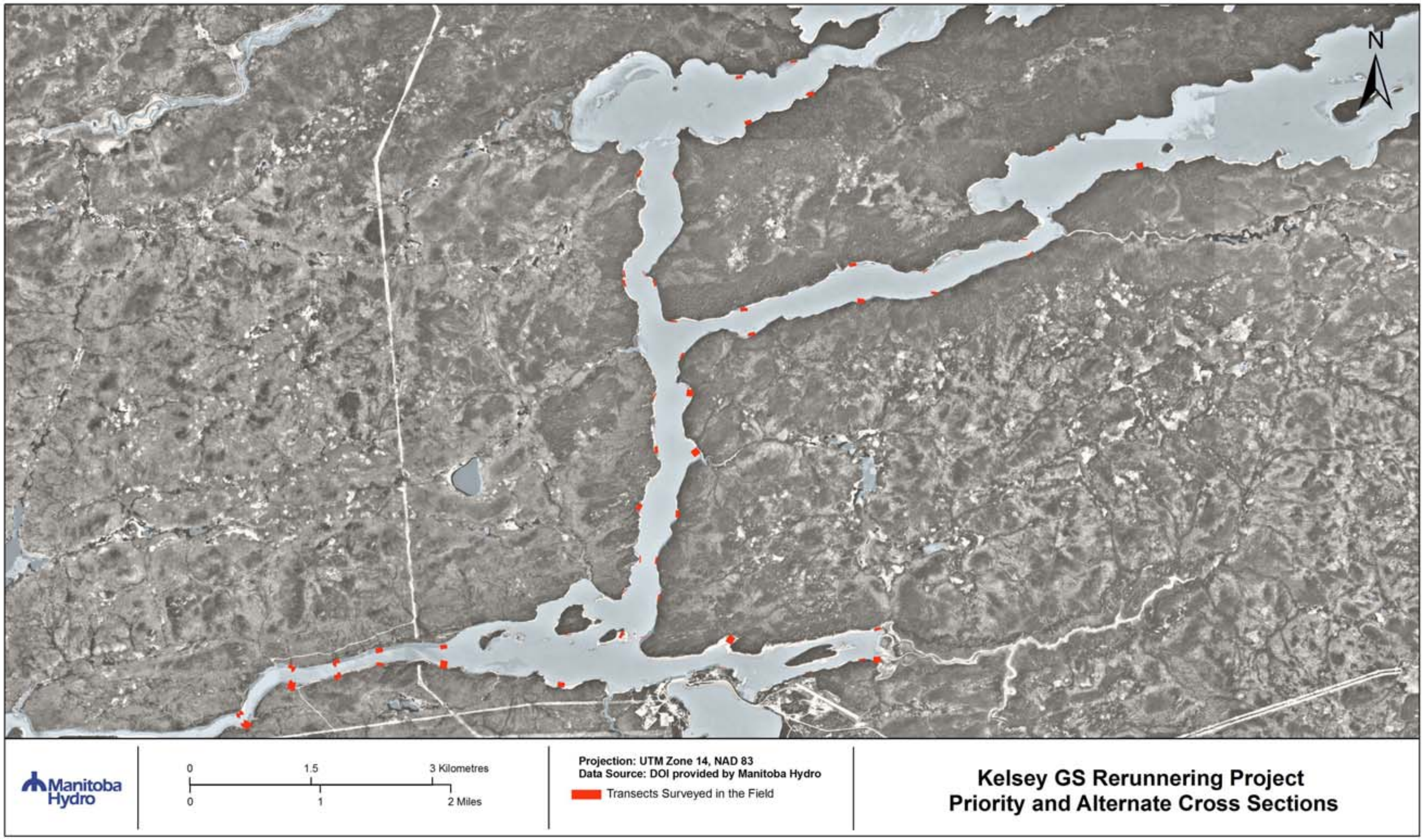

Figure 8. Surveyed transects (54).

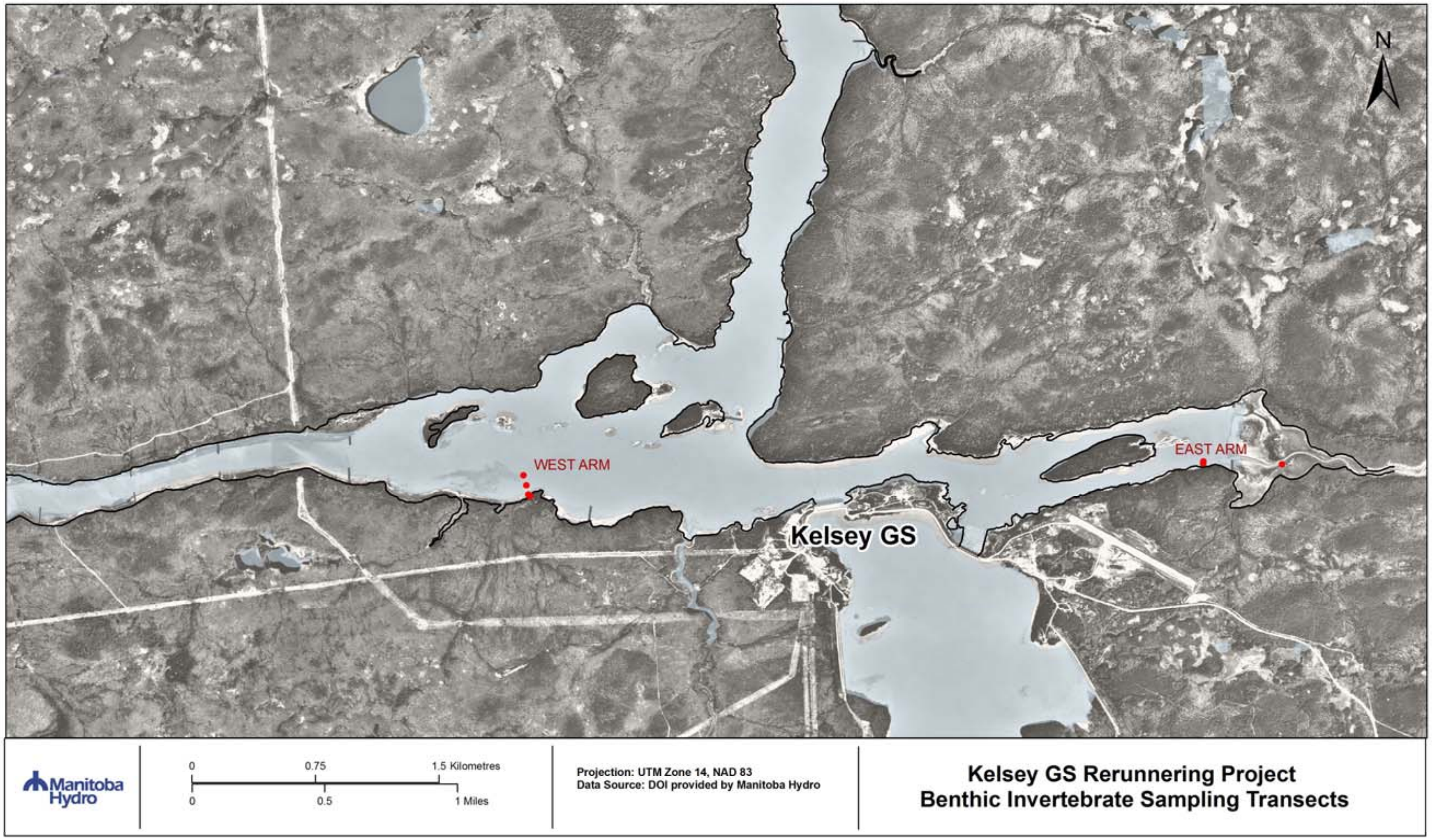

Figure 9. Benthic invertebrate sample locations

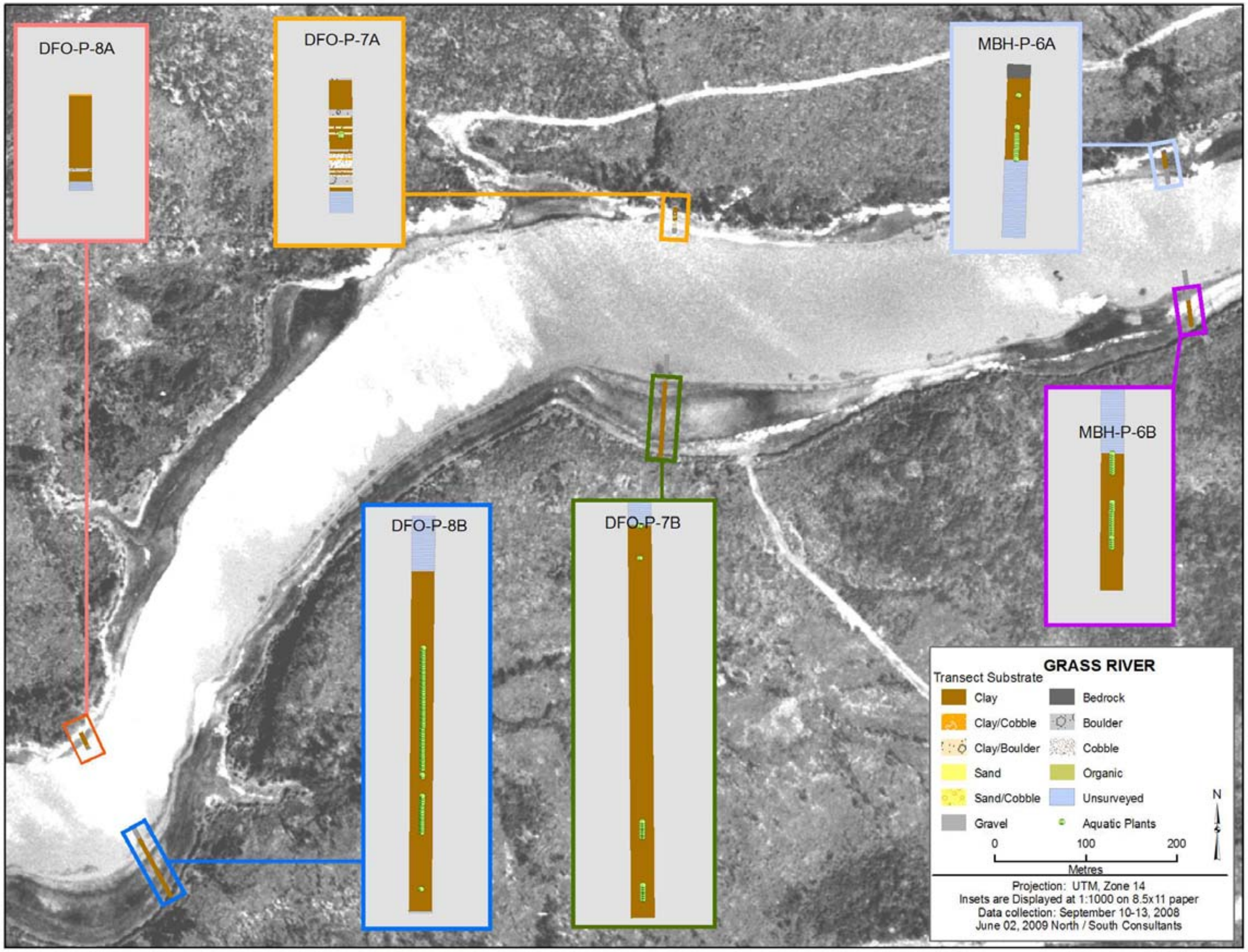

Figure 10. Substratum composition of transects in the Grass River section.

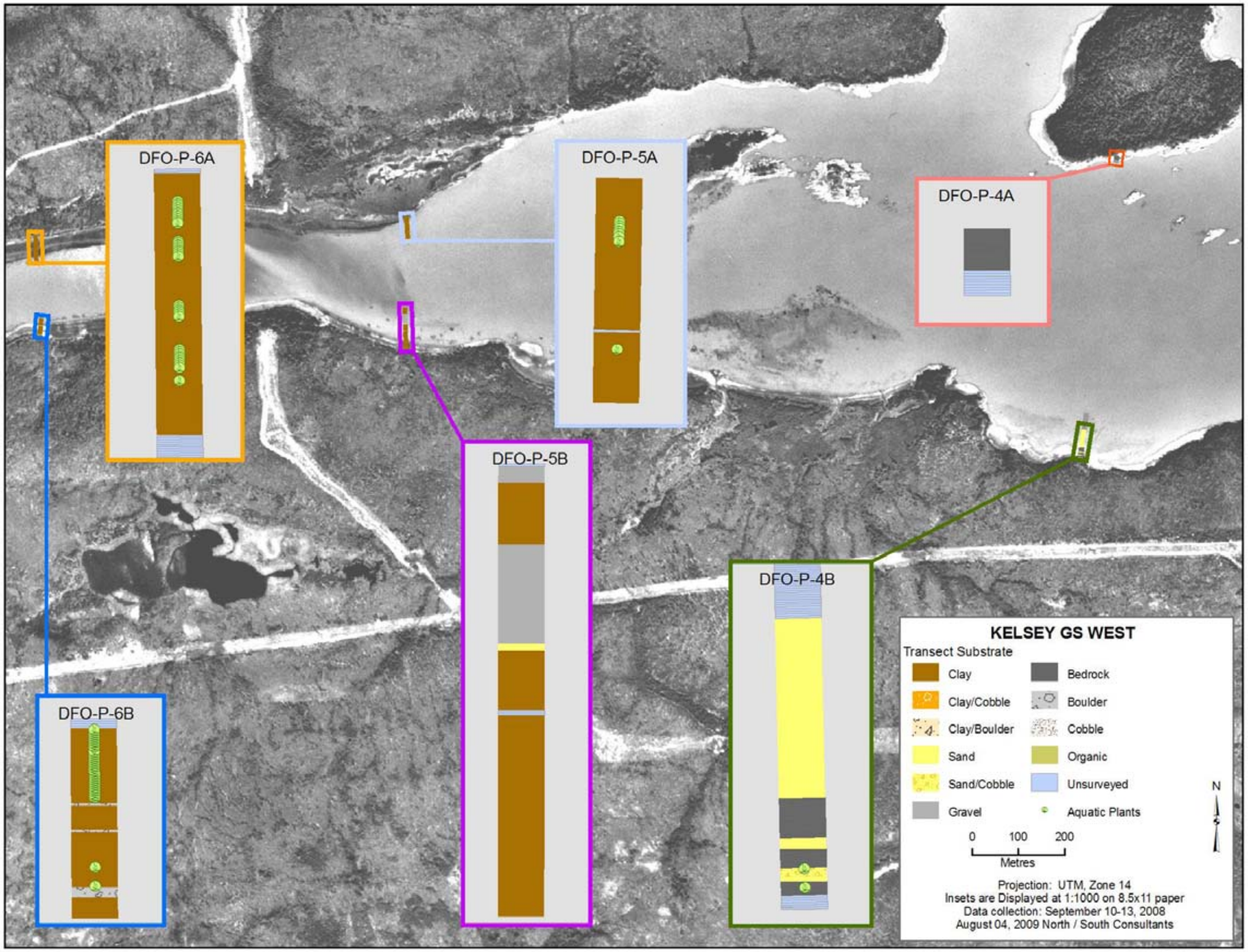

Figure 11. Substratum composition of transects in the Kelsey GS West section.

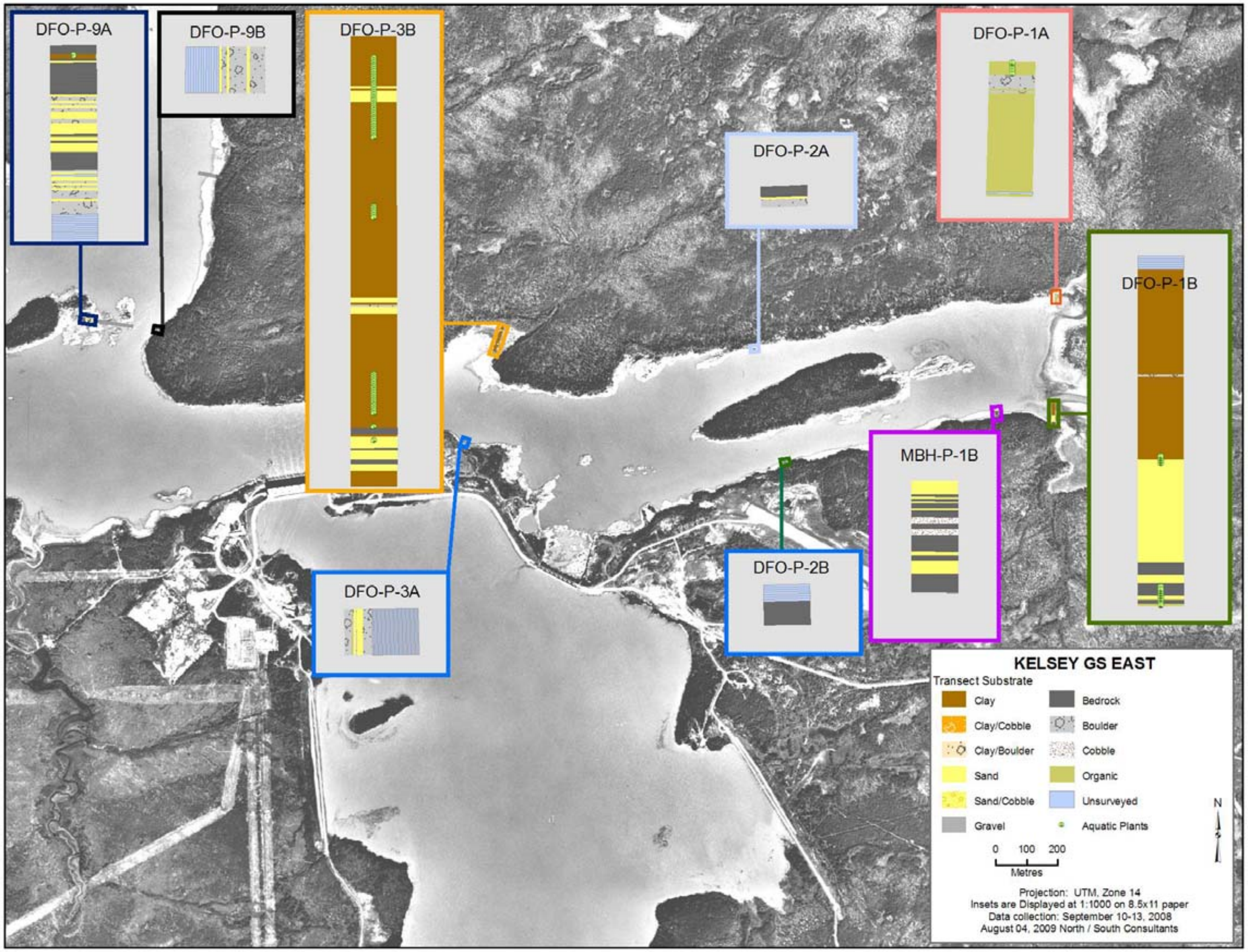

Figure 12. Substratum composition of transects in the Kelsey GS East section.

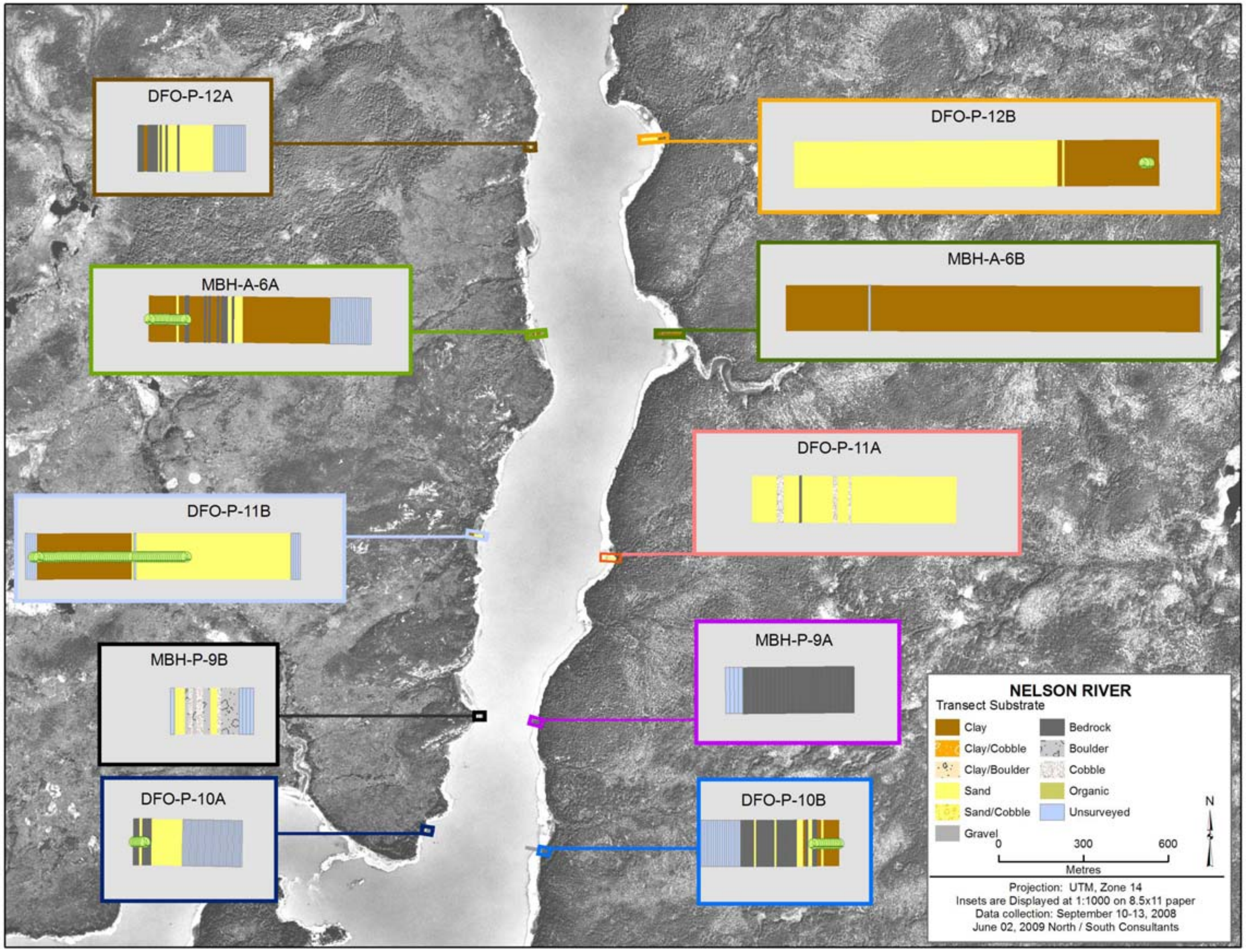

Figure 13. Substratum composition of transects in the Nelson River section.

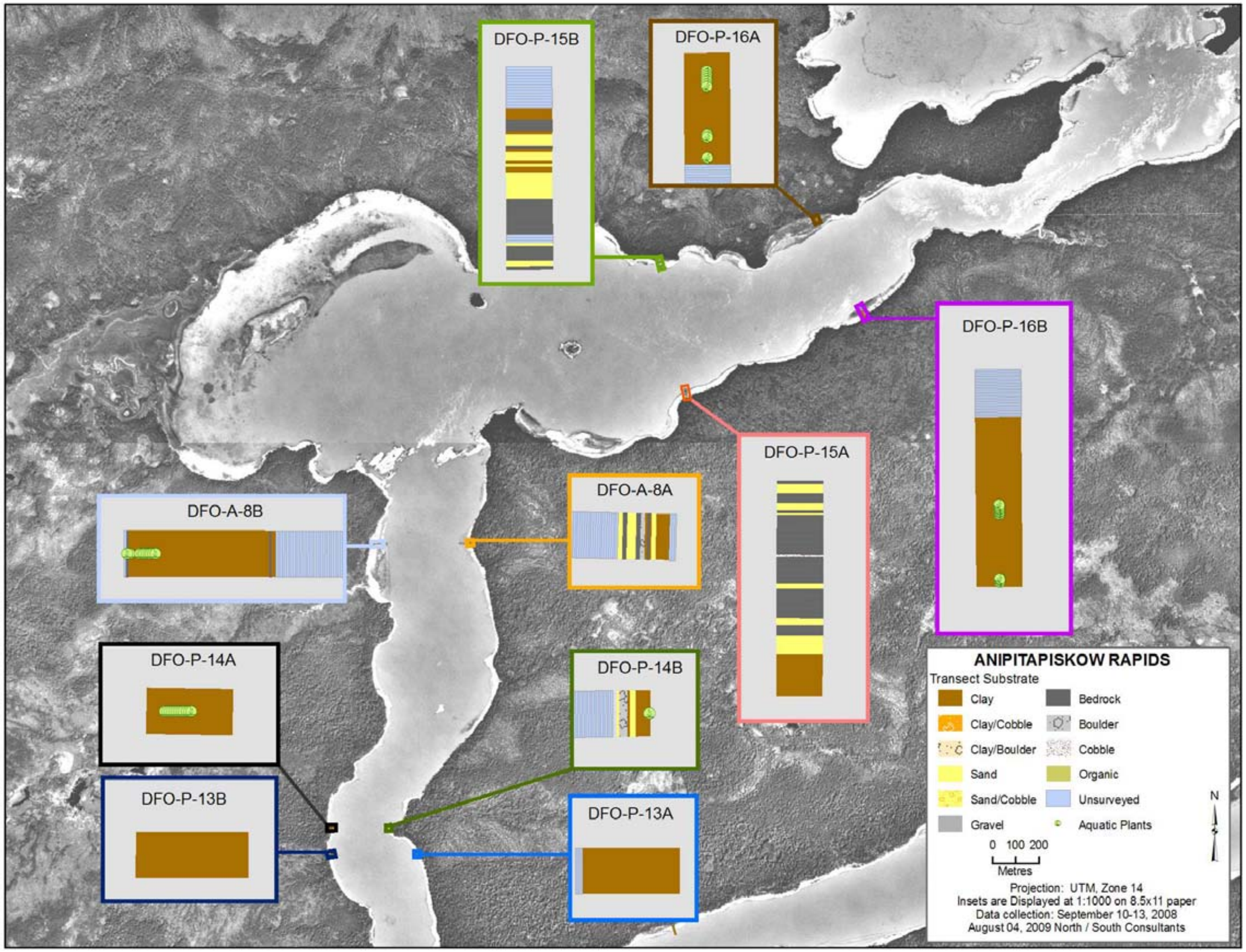

Figure 14. Substratum composition of transects in the Anipitapiskow Rapids section.

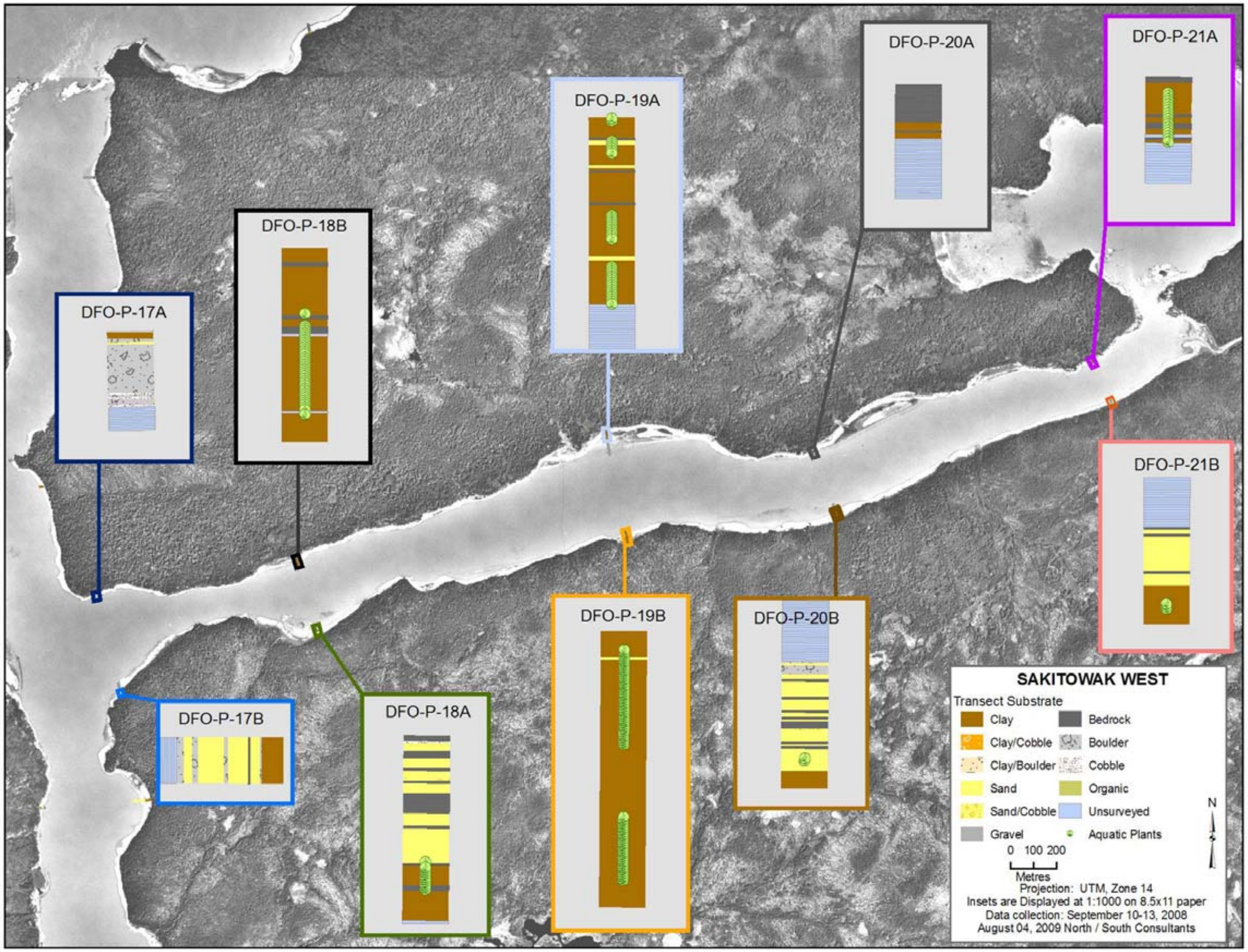

Figure 15. Substratum composition of transects in the Sakitowak Rapids West section.

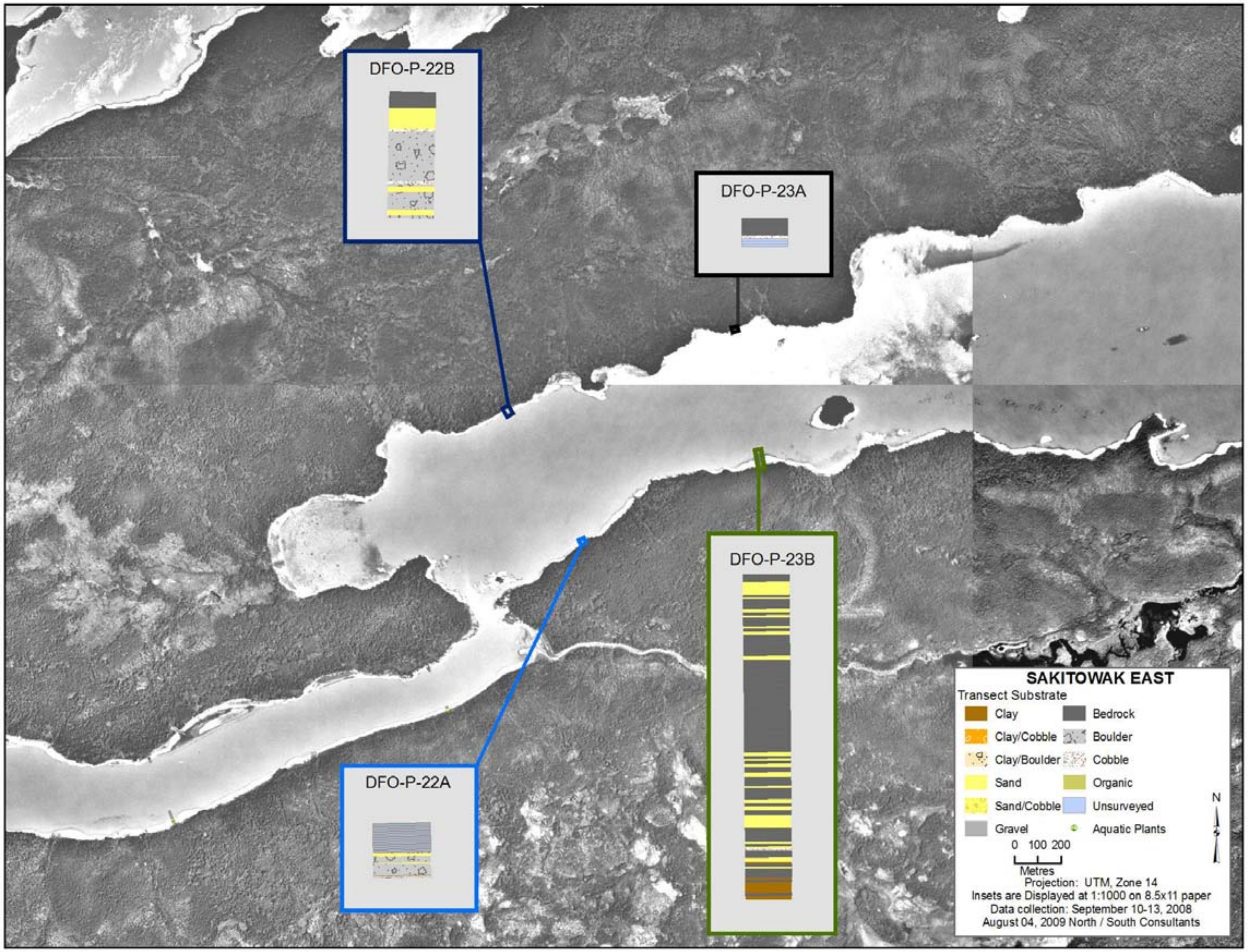

Figure 16. Substratum composition of transects in the Sakitowak Rapids East section.

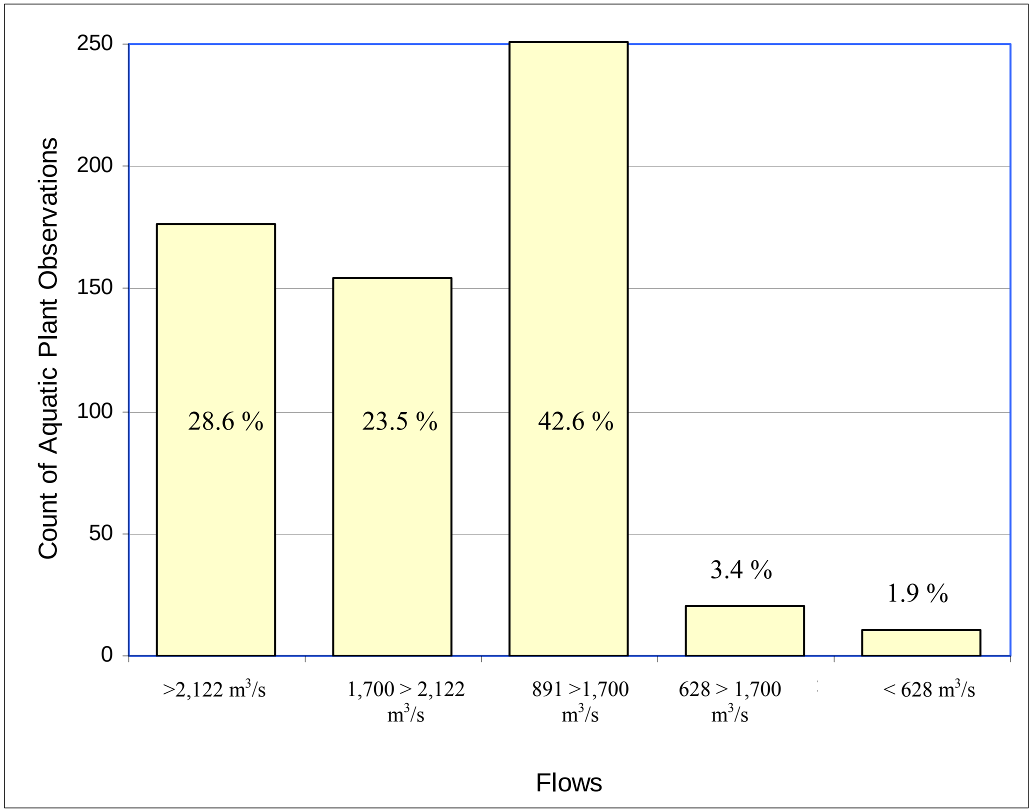

Figure 17. Frequency of aquatic plant observations on silt, silt/clay or sand substrates with respect to EE/PP water zone levels.

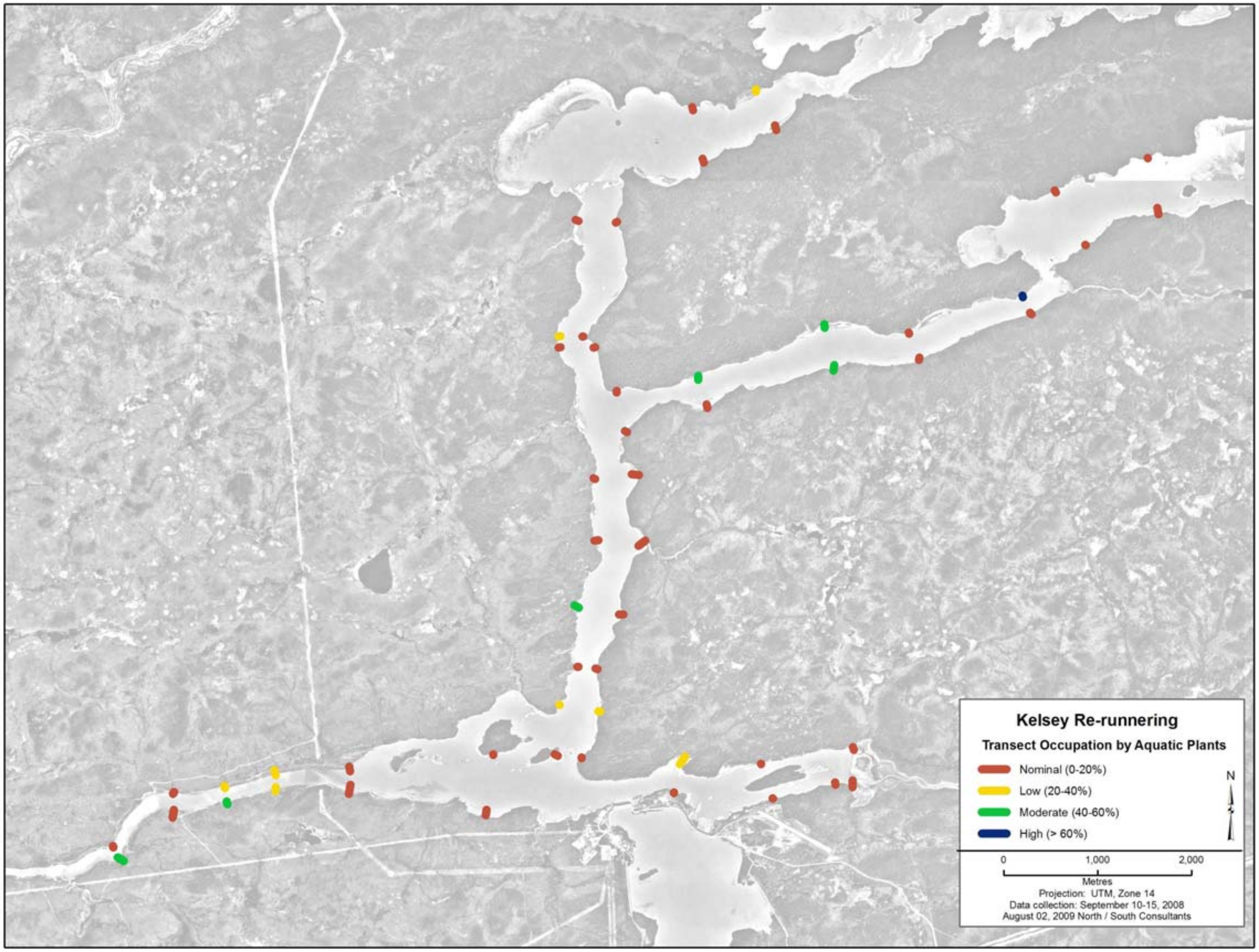

Figure 18. Percent occupation of aquatic plants in transects in the Kelsey GS study area.

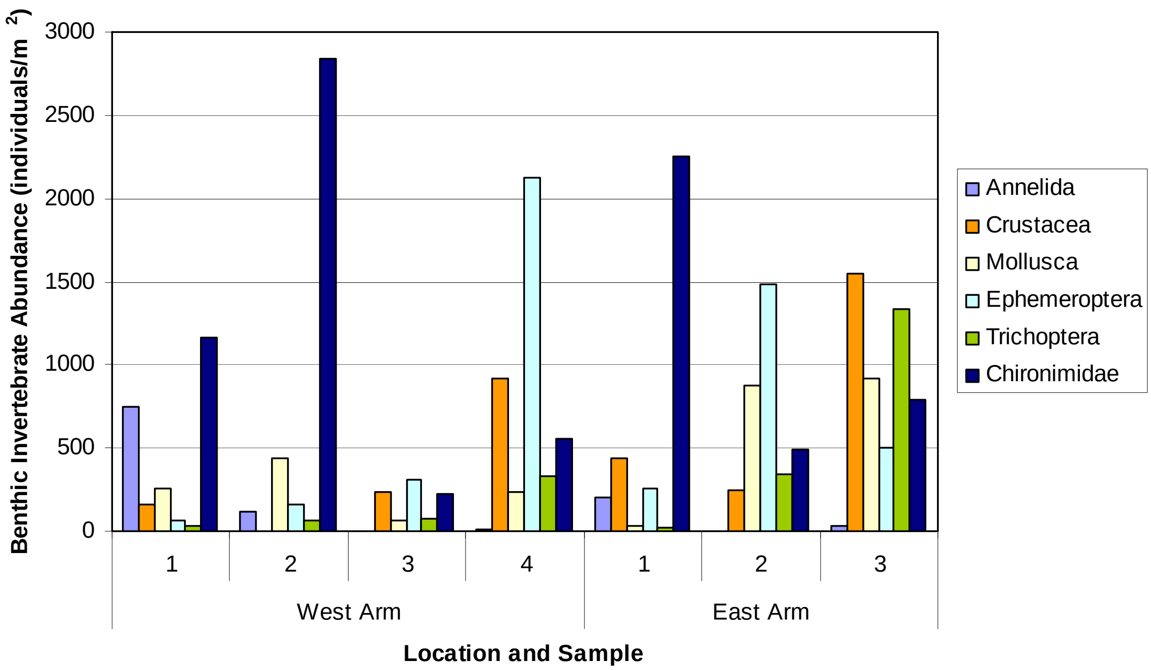

Figure 19. Mean number of benthic invertebrates (individuals/m^2) in transects in the west and east arms of the Kelsey GS study area.

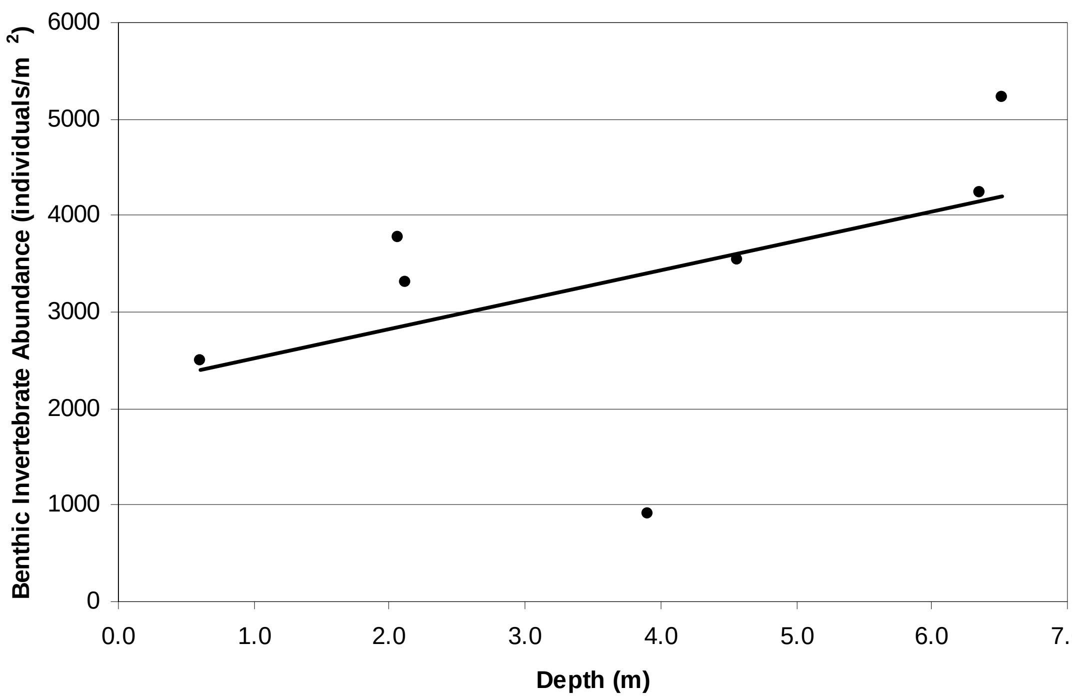

Figure 20. Abundance of benthic invertebrates sampled at various water depths in the west and east arms of the Kelsey GS study area.

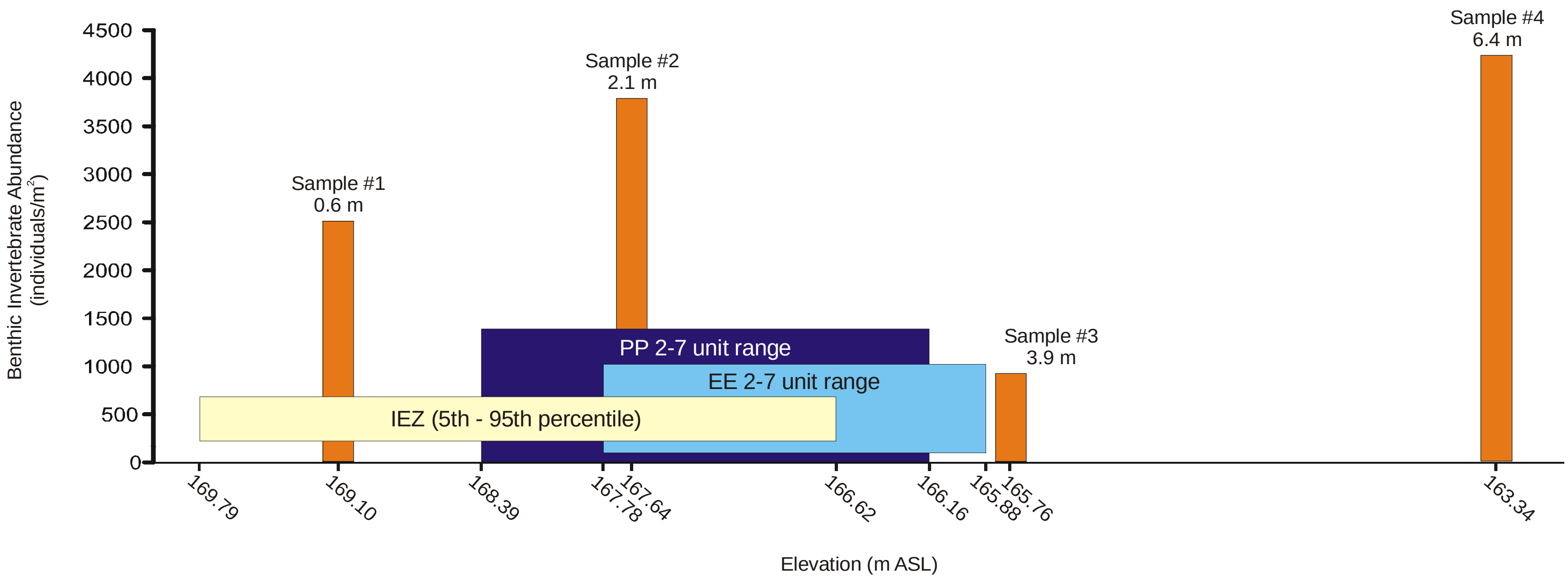

Figure 21. Abundance of benthic invertebrates and elevation at four sampling locations in the west arm of the Kelsey GS study area.

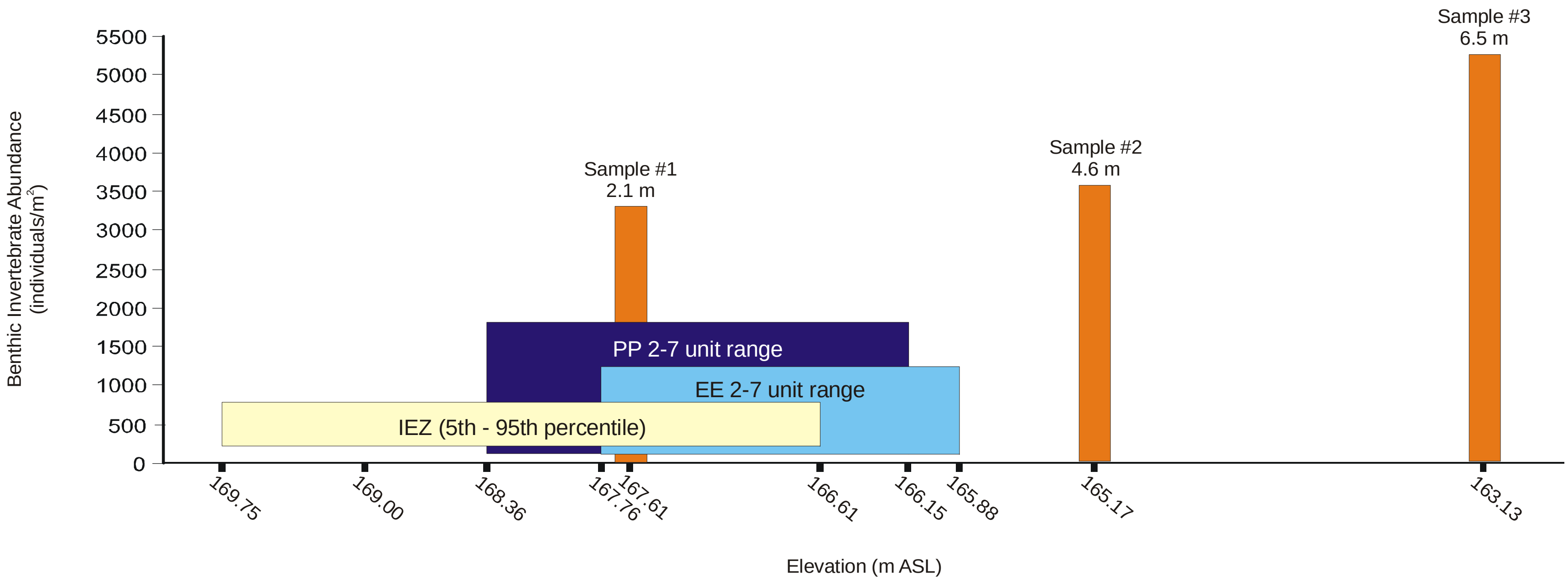

Figure 22. Abundance of benthic invertebrates and elevation at three sampling locations in the east arm of the Kelsey GS study area.

APPENDIX 1.
NORTH/SOUTH CONSULTANTS INC. SAMPLE PROCESSING AND QUALITY ASSURANCE/QUALITY CONTROL (QA/QC) PROCEDURES

Sample Preparation and Sorting

1. The smallest sieve in the series should be the same size as the net mesh dimensions of the sampler used in the field; **smallest sieve size is 500 µm** as **drift traps and Ponar grab** samplers were used in the field;
2. Using a **500 µm sieve**, clean the preserved sample thoroughly with water to remove preservative. Discard all large sticks, leaves, and other debris as they are washed, mark relative amounts of each on your bench sheet. Forcefully wash any large debris (with attached invertebrates) with water and into the **500 µm sieve**;
3. Examine the **entire** sample in a tray. Sorting is to be conducted using a 10X stereomicroscope or 3X magnifying lamp;
4. To be counted, a specimen must have enough intact body parts to permit its identification to the targeted level, and it must have a head (this prevents a body and detached head from being counted as two animals);
5. Larval exuviae (e.g., chironomids), and empty shells (e.g., gastropods and bivalves) and cases (e.g., trichopterans) are not counted.
6. Sorted samples are checked by a second laboratory technician using a 10X stereomicroscope or 3X magnifying lamp;
7. Any additional invertebrates collected during the checking process are combined with the original sample, but counted separately;
8. Sorting efficiency must be ≥ 95%; anything less and the sample must be re-sorted **(See ATTACHMENT 1 – North/South Consultants Inc. QA/QC Procedures)**;
9. Invertebrate samples are transferred to 70% ethanol prior to transfer to the taxonomist for identification.

Taxonomic Identification

- Identifications will be done by an in-house taxonomic specialist;
- The target overall accuracy level for in-house invertebrate identifications and enumerations is 90% **(See ATTACHMENT 1 – North/South Consultants Inc. QA/QC Procedures).**

ATTACHMENT 1

Sample Processing

Sorting aquatic samples involves removing aquatic macro-invertebrates and plant material from the organic and inorganic material within each sample.

Sorting Samples

- All sorting is conducted with a 3x desktop magnifier or stereomicroscope;
- All sorted samples are checked by a 2nd laboratory technician;
- Any additional invertebrates/plant materials collected during the QA/QC process are combined with the original sample, but counted separately;
- Sorting efficiency must be ≥ 95% or the sample must be re-sorted.

Verification of Taxonomic Identification

North/South Consultants Inc. taxonomists communicate with external taxonomic specialists to ensure accuracy and consistency.

Sample Identifications

- Samples are identified to the appropriate taxonomic level by an in-house taxonomist. Ten percent of the in-house identifications are randomly selected and sent to an external taxonomy specialist for QA/QC. The accuracy of the sample subset is assessed for identification and enumeration; all unknown invertebrates/plants are sent to an external specialist;
- Incorrect identifications and/or enumeration discrepancies are noted on the laboratory datasheet;
- The target overall accuracy level for in-house invertebrate/plant identifications and enumeration is 90%. Corrected identifications and enumeration values received from the external taxonomist are corrected and used in place of in-house data discrepancies; all samples that fall outside the target accuracy level will be re-identified and/or re-enumerated.

Data Processing

Data from field books and laboratory bench sheets are entered into an MS Excel® data template. Data templates specify the Project Name, Study Area, Site Location/Description, GPS coordinates (Global Positioning System), Site Label, Sampling Date, Time of Day, Gear Type, Sieve Mesh Size in Field/Laboratory, Presence or Absence of Vegetation/Algae, Water Temperature, Water Depth, Substrate Type, Number of Splits, Taxonomic List, Life Stage, and Enumeration List. A 2nd and 3rd technician verifies all entered data and formulae to original field book and laboratory bench sheets. A final verification is conducted by the report author.

APPENDIX 2.
TRANSECT SUBSTRATE COMPOSITION

Table A2.1. Summary of substrate composition of field surveyed transect segments

Transect	Substrate Composition (%)							Surveyed Transect Segment Count	Total Transect Segment Count	Percent of Surveyed Segments with Aquatic Plants
	Sand	Clay	Bedrock	Gravel	Cobble	Organic	Boulder			
DFO-A-8A	34.8	34.8	21.7	0.0	0.0	0.0	8.7	23	118	0.0
DFO-A-8B	0.0	97.1	2.9	0.0	0.0	0.0	0.0	70	141	14.3
DFO-P-10A	69.7	0.0	30.3	0.0	0.0	0.0	0.0	33	73	24.2
DFO-P-10B	18.2	22.7	59.1	0.0	0.0	0.0	0.0	44	160	27.3
DFO-P-11A	92.3	0.0	1.1	0.0	6.6	0.0	0.0	91	91	0.0
DFO-P-11B	56.7	34.2	0.0	0.0	0.0	0.0	0.0	120	126	55.0
DFO-P-12A	65.8	5.3	28.9	0.0	0.0	0.0	0.0	38	54	0.0
DFO-P-12B	72.8	27.2	0.0	0.0	0.0	0.0	0.0	158	158	1.9
DFO-P-13A	0.0	100.0	0.0	0.0	0.0	0.0	0.0	55	59	0.0
DFO-P-13B	0.0	100.0	0.0	0.0	0.0	0.0	0.0	47	47	0.0
DFO-P-14A	0.0	100.0	0.0	0.0	0.0	0.0	0.0	36	36	33.3
DFO-P-14B	22.2	44.4	0.0	0.0	0.0	0.0	22.2	18	54	5.6
DFO-P-15A	23.9	19.3	55.7	0.0	1.1	0.0	0.0	88	88	0.0
DFO-P-15B	38.5	17.3	44.2	0.0	0.0	0.0	0.0	52	69	0.0
DFO-P-16A	0.0	100.0	0.0	0.0	0.0	0.0	0.0	44	101	22.7
DFO-P-16B	0.0	100.0	0.0	0.0	0.0	0.0	0.0	113	145	8.8
DFO-P-17A	2.6	7.7	0.0	0.0	7.7	0.0	82.1	39	51	0.0
DFO-P-17B	59.3	20.4	1.9	0.0	0.0	0.0	18.5	54	137	0.0
DFO-P-18A	45.9	27.0	25.7	0.0	1.4	0.0	0.0	74	75	16.2
DFO-P-18B	0.0	91.1	8.9	0.0	0.0	0.0	0.0	79	81	48.1
DFO-P-19A	6.2	90.1	3.7	0.0	0.0	0.0	0.0	81	227	44.4
DFO-P-19B	0.8	99.2	0.0	0.0	0.0	0.0	0.0	126	126	58.7
DFO-P-1A	0.0	0.0	0.0	0.0	0.0	88.1	11.9	59	60	10.2
DFO-P-1B	34.7	55.8	8.2	0.0	0.0	0.7	0.7	147	153	8.8
DFO-P-20A	0.0	25.9	74.1	0.0	0.0	0.0	0.0	27	57	0.0
DFO-P-20B	61.4	14.0	15.8	0.0	0.0	0.0	8.8	57	132	3.5
DFO-P-21A	0.0	72.7	27.3	0.0	0.0	0.0	0.0	22	37	81.8
DFO-P-21B	52.5	40.0	7.5	0.0	0.0	0.0	0.0	40	60	7.5

Table A2.1. Continued.

Transect	Substrate Composition (%) Sand	Clay	Bedrock	Gravel	Cobble	Organic	Boulder	Surveyed Transect Segment Count	Total Transect Segment Count	Percent of Surveyed Segments with Aquatic Plants
DFO-P-22A	14.7	2.9	0.0	0.0	2.9	0.0	79.4	34	73	0.0
DFO-P-22B	25.0	0.0	12.5	0.0	4.2	0.0	58.3	48	48	0.0
DFO-P-23A	0.0	0.0	87.5	0.0	12.5	0.0	0.0	8	11	0.0
DFO-P-23B	26.2	6.2	66.9	0.0	0.7	0.0	0.0	145	145	0.0
DFO-P-2A	12.5	0.0	50.0	0.0	0.0	0.0	37.5	8	8	0.0
DFO-P-2B	0.0	0.0	100.0	0.0	0.0	0.0	0.0	10	17	0.0
DFO-P-3A	29.6	0.0	0.0	0.0	0.0	3.7	66.7	27	72	0.0
DFO-P-3B	11.6	84.8	3.0	0.0	0.0	0.0	0.5	198	198	31.3
DFO-P-4A	0.0	0.0	100.0	0.0	0.0	0.0	0.0	15	24	0.0
DFO-P-4B	74.2	0.0	25.8	0.0	0.0	0.0	0.0	120	198	2.5
DFO-P-5A	0.0	100.0	0.0	0.0	0.0	0.0	0.0	85	86	10.6
DFO-P-5B	1.6	72.3	0.0	26.1	0.0	0.0	0.0	188	191	0.0
DFO-P-6A	0.0	100.0	0.0	0.0	0.0	0.0	0.0	118	138	29.7
DFO-P-6B	0.0	92.4	0.0	0.0	0.0	0.0	7.6	79	83	38.0
DFO-P-7A	0.0	68.5	0.0	0.0	14.8	0.0	16.7	54	64	3.7
DFO-P-7B	0.0	100.0	0.0	0.0	0.0	0.0	0.0	179	241	9.5
DFO-P-8A	0.0	95.8	0.0	0.0	0.0	0.0	4.2	48	53	0.0
DFO-P-8B	0.0	100.0	0.0	0.0	0.0	0.0	0.0	162	189	48.8
DFO-P-9A	32.4	2.7	39.2	0.0	0.0	0.0	25.7	74	343	1.4
DFO-P-9B	16.7	0.0	0.0	0.0	0.0	0.0	83.3	18	31	0.0
MBH-A-6A	8.2	81.2	10.6	0.0	0.0	0.0	0.0	85	104	21.2
MBH-A-6B	0.0	100.0	0.0	0.0	0.0	0.0	0.0	180	182	0.0
MBH-P-1B	34.7	0.0	53.1	0.0	12.2	0.0	0.0	49	49	0.0
MBH-P-6A	0.0	85.4	14.6	0.0	0.0	0.0	0.0	48	87	31.3
MBH-P-6B	0.0	100.0	0.0	0.0	0.0	0.0	0.0	59	125	49.2
MBH-P-9A	0.0	0.0	100.0	0.0	0.0	0.0	0.0	26	30	0.0
MBH-P-9B	27.8	0.0	0.0	0.0	22.2	0.0	50.0	18	23	0.0
TOTALS								**3,918**	**5,529**	

APPENDIX 3.
RAW NUMBERS OF BENTHIC INVERTEBRATES COLLECTED IN THE KELSEY GS STUDY AREA

Table A3.1. Raw numbers of benthic invertebrates collected in Ponar grab samples in the west arm of the Kelsey GS study area, 2008.

Location	West Arm																			
Sample	1					2					3					4				
Replicate	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Depth (m)	**0.4**	**0.4**	**0.8**	**0.8**	**0.6**	**1.9**	**2.2**	**2**	**2.2**	**2**	**3.8**	**3.9**	**4.1**	**4**	**3.9**	**5.8**	**6.3**	**5.2**	**6.6**	**7.9**
Annelida																				
Oligochaeta	53	12	14	0	6	4	1	6	1	2	0	0	0	0	0	0	0	1	0	0
Hirudinea	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Annelida	**54**	**12**	**14**	**0**	**6**	**4**	**1**	**6**	**1**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**
Crustacea																				
Amphipoda (unidentified)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Haustoriidae	0	0	0	0	0	0	0	0	0	0	11	5	0	7	4	27	2	20	39	18
Talitridae	15	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Crustacea	**15**	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**11**	**5**	**0**	**7**	**4**	**27**	**2**	**20**	**39**	**18**
Mollusca																				
Bivalvia (unidentified)	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Pisidiidae	0	0	0	0	0	1	2	0	0	0	0	1	0	0	0	10	0	11	2	1
Gastropoda (unidentified)	0	0	0	0	0	0	0	13	0	0	1	0	0	0	0	0	0	0	0	0
Hydrobiidae	3	3	1	2	3	5	2	4	4	13	0	1	0	1	2	1	0	0	0	2
Physidae	4	1	1	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Planorbidae	2	3	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
Valvatidae	0	0	0	2	0	2	1	0	0	0	0	0	0	0	1	0	0	0	0	0
Total Mollusca	**9**	**7**	**2**	**9**	**3**	**8**	**5**	**17**	**4**	**16**	**1**	**2**	**0**	**1**	**3**	**11**	**0**	**11**	**2**	**3**
Platyhelminthes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Insecta																				
Hemiptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Corixidae	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0
Ephemeroptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Caenidae	3	1	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0
Ephemeridae	0	0	1	0	2	3	2	3	2	2	7	3	9	6	10	53	15	58	84	34
Trichoptera (unidentified)	0	0	0	0	0	0	1	0	0	0	0	0	3	0	0	0	0	0	0	0
Hydropsychidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Leptoceridae	0	0	0	0	0	1	0	2	0	1	4	0	0	0	1	15	7	6	4	6
Molannidae	0	0	1	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Phryganeidae	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Polycentropodidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plecoptera (unidentified)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Diptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ceratopogonidae	1	0	2	0	2	5	2	3	4	3	0	0	0	0	0	1	0	3	0	1
Chironomidae	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chironominae	60	23	8	4	37	33	26	42	63	80	2	4	4	5	3	11	3	5	12	4
Orthocladiinae	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	2	0	0	0	0
Tanypodinae	0	0	0	0	0	13	12	8	23	26	1	1	1	5	0	8	0	4	6	9
Empididae	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Insecta	**68**	**25**	**13**	**5**	**42**	**56**	**43**	**58**	**101**	**112**	**14**	**8**	**17**	**16**	**15**	**90**	**26**	**77**	**106**	**54**
Total Invertebrates	**146**	**47**	**29**	**14**	**51**	**68**	**49**	**81**	**106**	**130**	**26**	**15**	**17**	**24**	**22**	**128**	**28**	**109**	**147**	**75**

Table A3.2. Raw numbers of benthic invertebrates collected in Ponar grab samples in the east arm of the Kelsey GS study area, 2008.

Location	**East Arm**														
Sample	**1**					**2**					**3**				
Replicate	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Depth (m)	**2**	**2.1**	**2.2**	**2.1**	**2.2**	**4.5**	**4.7**	**4.4**	**4.7**	**4.5**	**6.6**	**6.4**	**6.2**	**6.8**	**6.6**
Annelida															
Oligochaeta	3	6	3	1	4	0	0	0	0	0	0	0	0	0	2
Hirudinea	0	2	1	0	3	0	0	0	0	0	0	0	0	2	0
Total Annelida	**3**	**8**	**4**	**1**	**7**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**2**
Crustacea															
Amphipoda (unidentified)	0	0	0	0	0	0	0	0	0	2	1	0	1	0	3
Haustoriidae	0	0	1	0	0	1	1	11	6	7	22	33	23	43	21
Talitridae	5	24	0	4	16	0	0	0	0	0	1	0	1	28	1
Total Crustacea	**5**	**24**	**1**	**4**	**16**	**1**	**1**	**11**	**6**	**9**	**24**	**33**	**25**	**71**	**25**
Mollusca															
Bivalvia (unidentified)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pisidiidae	1	0	0	0	0	12	5	29	21	21	7	10	24	51	10
Gastropoda (unidentified)	0	0	0	3	0	0	0	0	0	1	0	0	0	1	0
Hydrobiidae	0	0	0	0	0	0	0	8	4	0	0	0	2	0	0
Physidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Planorbidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Valvatidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Mollusca	**1**	**0**	**0**	**3**	**0**	**12**	**5**	**37**	**25**	**22**	**7**	**10**	**26**	**52**	**10**
Platyhelminthes	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
Insecta															
Hemiptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Corixidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ephemeroptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Caenidae	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0
Ephemeridae	3	6	4	8	5	15	10	73	64	9	7	13	11	15	12
Trichoptera (unidentified)	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0
Hydropsychidae	0	0	0	0	0	0	0	1	0	0	1	1	2	9	5
Leptoceridae	0	0	0	1	0	2	3	7	6	3	10	9	7	3	9
Molannidae	1	0	0	0	0	0	0	0	0	3	0	0	0	0	0
Phryganeidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Polycentropodidae	0	0	0	0	0	3	0	2	1	7	20	5	16	41	14
Plecoptera (unidentified)	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Diptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ceratopogonidae	4	2	3	2	2	1	1	5	5	1	0	1	2	3	2
Chironomidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chironominae	30	54	24	60	41	1	6	8	4	4	1	0	1	27	5
Orthocladiinae	0	0	1	0	0	3	4	1	0	0	2	0		4	1
Tanypodinae	9	12	6	17	5	5	7	5	2	6	2	5	12	25	6
Empididae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Insecta	**47**	**74**	**40**	**89**	**53**	**31**	**31**	**102**	**82**	**33**	**43**	**36**	**51**	**127**	**54**
Total Invertebrates	**56**	**106**	**45**	**97**	**76**	**44**	**37**	**150**	**113**	**64**	**74**	**79**	**102**	**255**	**91**