Keeyask Generation Project

Environmental Impact Statement

Supporting Volume

Aquatic Environment

KEEYASK

Hydropower Limited Partnership

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APPENDICES

APPENDIX 3A
AQUATIC HABITAT METHODS

3A.1 INTRODUCTION

This appendix describes field surveys conducted to acquire habitat data related to substrate type and macrophyte distribution required to:

i) Provide information on the existing environment in the Keeyask area; and

ii) Provide the field data necessary for the development of models to predict future conditions in the Keeyask reservoir based on conditions in Stephens Lake (described in Appendix 3B and Appendix 3C).

This appendix also describes field surveys and data analysis conducted to describe habitat of the tributary streams in the Keeyask area.

3A.2 KEEYASK AREA

3A.2.1 SUBSTRATE

The following data collection and mapping methods outline the approach taken to create the existing environment surface substrate map used to describe the bottom type habitat of the Keeyask area (Section 3.3.2.3, Map 3-14).

3A.2.1.1 Field Surveys

Data collection for substrate mapping consisted of both sonar and bottom-type validation surveys conducted during a number of field programs between 2001 and 2009.

The majority of the data collection was completed in August 2001. The 2001 boat-based survey used a Meridata MD100 digital depth sounder linked to a mapping grade GPS (Trimble ProXL). A river bottom profile generated in real-time on the unit's graphic display was used to interpret the bottom type, bottom compaction, and presence of aquatic vegetation. Bottom validation using a probe and Ponar dredge was conducted at irregular intervals along the survey transects. The survey covered the area from Clark Lake up to the safely navigable area above Gull Rapids and the base of Gull Rapids to 2.5 km downstream. The survey covered the north and south shorelines of the Nelson River, latitudinal transects spaced approximately 500 m apart were used to cover the river (Map 3A-1, Map 3A-2, Map 3A-3, and Map 3A-4).

In order to further validate the acoustic data collected in 2001, boat-based Ponar and rebar drag surveys were conducted in the area of Gull Lake and upstream of Gull Rapids in 2006. Boat-based Ponar and rebar drag surveys were conducted in 2007 downstream of Gull Rapids in order to determine the general areas of substrate changes along the transition boundary to Stephens Lake. An additional survey was conducted in 2008 in the downstream portion of Gull Lake in areas identified as important lake sturgeon habitat to collect substrate, depth and velocity information.

From 12–27 September 2008 a Price Type "AA" Current Meter (Model 1210) and a Ponar grab sampler were used in the vicinity of Caribou Island in Gull Lake in order to determine sturgeon habitat in the area. Discharges (outflow at Split Lake) at the time of sampling ranged from 4225–4845 m^3/s. The results of these velocity and bottom type samples were incorporated into the final substrate map.

In July 2009, an additional sonar survey was conducted approximately 2.5 km downstream of Gull Rapids in order to fill in data gaps not previously acquired. The survey was conducted with a Quester Tangent Corporation (QTC) Series V scientific grade echo sounder coupled to a Trimble Pro XRS sub-metre grade GPS. The transducer was positioned approximately 40 cm below the surface of the water adjacent to the hull of the boat. The echo sounder had a frequency of 50 kilohertz (kHz) and was set to collect at 5-second intervals. The survey consisted of six longitudinal transects filled in by multiple latitudinal tracks spaced approximately 250 m apart (Map 3A-3).

Additional validation data were compiled from a number of fish community and lower trophic level field programs conducted between 2001 and 2009 in which habitat data were recorded. These validation datasets consisted of GPS point observations describing surface and, in some cases, sub-surface substrate types.

3A.2.1.2 Mapping

The 2001 Meridata MD100 track data were classified according to substrate changes verified in the field and on the bottom profile read-out. Validation substrates were classified based on a simplified interpretation of the Wentworth particle size classification for granular materials (Table 3-2). A simple coding structure was used to create aggregate substrate classes where they occurred:

- Composition: 1 = Boulder Cobble; 2 = Gravel; 3 = Sand; 4 = Fines (25 original classes);
- Compaction: 1 = Hard; 2 = Moderate; 3 = Soft; and
- Vegetation Density: 1 = low; 2 = medium; 3 = high.

Data were post-processed in a Microsoft Excel worksheet, complete with ID, easting, northing, depth, compaction, composition, and vegetation density, for a total of 309,023 classified data points. Data were then imported into ArcGIS (ESRI 2009) geographic information systems (GIS) mapping software and plotted along with available base mapping.

A series of Thiessen polygon analyses were conducted in order to interpolate the discrete data point classifications to the areas of the river between the survey transects. A buffer was applied such that the classified polygons would extend outside of the shoreline area. A Thiessen polygon interpolation is an exact method of interpolation that assumes that the values of the unsampled locations are equal to the value of the nearest sampled point. The method is known as a local interpolator because the other data points in the dataset do not influence the interpolation process (Heywood *et al.* 1998). The Thiessen polygons were smoothed in order to remove relics of the interpolation process. Like classes of the original 25 were aggregated to reduce the number of substrate classes.

The QTC acoustic data collected in 2009 were analyzed separately from the 2001 Meridata MD100 acoustic bottom type data. The QTC echo sounder data were analyzed using QTC Impact (QTC 2009). An unsupervised classification approach was used to identify the acoustic classes identifying the boundary between soft (depositional) and hard bottom types. The Ponar and rebar drag validation sites collected during the survey and classified according to a simplified Wentworth particle size classification (Table 3-2), were used to label the unsupervised classification classes representing soft and hard substrates. The classification allowed for the identification of the boundary between lake sedimentation and clean riverine hard substrates.

3A.2.2 ROOTED MACROPHYTES

The following data collection, mapping, and analysis methods were used to quantify and describe rooted macrophyte occupancy within the Keeyask area (Section 3.3.2.3, Table 3-5, Map 3-16).

3A.2.2.1 Surveys – 2001, 2003, and 2006

Information on aquatic plant abundance, species composition, and distribution was recorded during the boat-based bathymetric and aquatic habitat mapping survey conducted from late July to late August 2001 from Clark Lake to downstream of Gull Rapids (Map 3A-2, Map 3A-3, and Map 3A-4). For detailed survey methods for abundance and composition refer to Appendix 4A. The location of areas supporting rooted plants visible from the surface was transcribed directly onto field maps. Plants were identified on-site and species composition and relative densities were recorded. GPS transect data collected during the survey were coded as having low, medium, or high plant density (Section 3A.2.1.2).

Fifteen aquatic macrophyte beds were identified and mapped at seventeen locations in the Nelson River between Birthday and Gull rapids (including Gull Lake) during late August 2003. The average depths of these macrophyte beds ranged from 0.26 to 1.36 m. Aquatic macrophyte beds were mapped based on the abundance of macrophytes within a bed; individual plants or small groupings of plants were not mapped. A Trimble ProXR with a TSC1 datalogger for sub-metre accuracy was used to record data. Because 2003 was a low water year, the perimeters of macrophyte beds were walked and depths were taken manually (with a metre stick) and recorded in metres. The data collected in the field were then downloaded into Pathfinder Office v2.90 (Trimble 2009). Trimble Pathfinder point files were exported as shapefiles (environmental systems research institute) and imported into ArcGIS 9.3 (ESRI 2009). Polygons were digitized and presented as maps displaying the location of the macrophyte beds.

An aerial survey was conducted between Birthday and Gull rapids in August 2006, and aquatic macrophyte bed locations were recorded on maps. Based on these observations, the edges of the plant beds were delineated and these polygons were digitized into the GIS.

3A.2.2.2 Macrophyte Occupancy

A GIS-based analysis was used to determine the area of macrophyte habitat occupied relative to the total potential habitat available and the use of water depths among years of study. A series of spatial queries were executed in order to identify areas of potential plant habitat based on substrate, water movement and depth criteria generally associated with macrophyte cover. The following criteria were identified:

- Keeyask area reaches 5–8;
- Substrate identified as being silt/clay;
- Water movement identified as being standing or low velocity; and
- Depth being shallow (less than 3 m) or backwater habitat.

The query result areas were summed to give a total habitat occupied at the 95th percentile water level. The same procedure was replicated for the 5th percentile water level shoreline and depth inputs. The total area of habitat occupied, and total percent of suitable and potential habitat occupied for all three survey years were then summarized (Table 3-5).

Twenty random sample points were created for each macrophyte stand for each of the three years macrophyte beds were observed in the field (2001, 2003 and 2006). Point generation was constrained by a rule specifying that each point was spaced a minimum of 5 m from another to ensure that a discrete depth value was extracted from a depth grid. Smaller macrophyte stands therefore had fewer than 20 random points. The 95th percentile depth grid was used to extract values for 2001 and 2006 and the 5th percentile depth grid was used for 2003 points.

The number of random sample points generated for 2001 was 2,045 in 105 beds, 176 for 2003, and 1,592 for 2006 in 83 macrophyte beds; 2003 had fewer sample points because of a lower count of total beds (25). Descriptive statistics, including mean, minimum, maximum, and standard deviation, were generated from the depth points and are presented in Section 3.2.3.3. A box plot chart was generated to present a relative comparison of the depths and distribution of macrophyte stands over the three years.

3A.2.3 CREEK HABITAT

The following data collection and mapping methods were used to describe creek habitat and watershed area within the Keeyask area (Map 3-20).

3A.2.3.1 Aerial Survey of Tributaries

An aerial survey was conducted on 25 May 2005 along selected tributaries of the Nelson River between Birthday Gull rapids (Map 3A-5). Aerial video was captured along the tributaries using a GPS linked aerial video system (Red Hen Systems Inc., Fort Collins, Colorado) mounted on the nose of a Bell Jet Ranger helicopter. Aerial frame surveys were conducted at about 100 m above the tributaries.

3A.2.3.2 Creek Habitat Mapping

Where creek channels were well defined and visible, left and right banks were digitized from the 1999 and 2006 Manitoba Hydro digital orthographic photos. A scale of 1:5,000 was used to produce a vector representation of all perennial and a limited number of intermittent creeks in the Keeyask area. Digitizing was terminated at either upstream waterbodies (*i.e.*, Carscadden Lake) or where creek boundaries were no longer distinguishable on the photography. Where left and right creek banks were generally indistinguishable (*i.e.*, ill-defined channels due to the presence of peat), the centerline was digitized and buffered to a 3 m width to produce a more generalized representation of these creeks.

The Red Hen Systems geo-located aerial video was then used to locate and delineate habitat types, these included: riffle-run-pool sequences; glides; peatland pools; and peatland channels. Polygons were built to represent each habitat type cartographically and to determine the area of each habitat type.

3A.2.3.3 Creek Watershed Analysis

A spatial watershed database for selected tributaries in the study area was developed for the impact assessment. Existing federal hydrography and digital elevation datasets were identified for use in a GIS-based watershed mapping analysis.

The National Hydro Network (NHN 2009) was identified as the best available geographic information system (GIS) vector water features data set for the Keeyask area. An important feature of the dataset is the inclusion of a linear drainage network, in addition to the basic cartographic features. The network features are intended for water flow analysis, water and watershed management, environmental and hydrographical applications.

The Canadian Digital Elevation Data (CDED) (NHN 2009) digital elevation model was identified as the best available elevation data for the watershed analysis. The CDED consists of an ordered array of ground elevations at regularly spaced intervals. Elevation units are in metres above sea level relative to mean seal level. The appropriate CDED distribution tiles, managed by national topographic database 1:50,000 map sheet code, were downloaded for the study area. The tiles were then merged together prior to analysis.

Prior to beginning the watershed delineation analysis, a total of 188 study area tributary outlets were identified (Kelsey GS to Limestone GS). This was completed by spatially intersecting the 05UF000 NHN stream network with all major waterbodies in the study area. The NHN stream network, CDED digital elevation model, and tributary outlets were the three primary data inputs required for the analysis (Map 3A-6). The extension Arc Hydro (Maidment 2002) for ArcGIS ® was implemented for the drainage analysis. The three primary data inputs were used in the Arc Hydro model to delineate approximately 188 watersheds for the overall study area. The watersheds pertaining to the Keeyask area were selected out for further analysis and tabulation of areas.

3A.3 STEPHENS LAKE AREA

3A.3.1 SUBSTRATE

The following data collection and mapping methods were used to create substrate maps to describe the existing environment bottom type habitat of Stephens Lake (Section 3.3.2.4).

3A.3.1.1 Field Surveys

Substrate surveys were conducted in 2006 in selected study areas on Stephens Lake (Map 3A-7). The survey was conducted with a QTC Series V scientific grade echo sounder coupled to a Trimble Pro XRS sub-metre grade GPS. The transducer was positioned approximately 40 cm below the surface of the water adjacent to the hull of the boat. The echo sounder has a frequency of 50 kHz and was set to collect at 5-second intervals. Sonar data were processed using QTC Impact® acoustic waveform processing software. Data from 12–13 August, which included the four bays on the west side of Stephens Lake, were pooled together for multivariate analysis and classification. Acoustic data collected in the Kettle reservoir on 15 August was treated separately.

Substrate validation data were acquired during the acoustic sonar surveys carried out on 12–15 August 2006. At pre-selected points along planned transects, detailed bottom information was collected using a Ponar bottom sampler and aluminum probe. A total of 310 substrate validation sample sites complete with GPS co-ordinates, substrate type and composition were documented in Ross Wright Bay (n=123), O'Neil Bay (n=131), the North Open Bay (n=11), and the South Open Bay (n=45). This is a subset of the 524 total validation samples collected in 2005 and 2006 in support of the macrophyte study on Stephens Lake. Validation substrates were classified based on a simplified interpretation of the Wentworth particle size classification for granular materials (Table 3-2).

3A.3.1.2 Mapping

QTC Impact® uses principal component analysis to reduce the 166 acoustic elements or variables recorded in the field to three principal component variables (Q1, Q2, Q3) that contain greater than 90% of the variability found within the dataset. QTC Impact uses an unsupervised cluster analysis to group like samples together to form clusters of samples with similar bottom type acoustic response. The unsupervised classification approach requires user-supplied labelling of classes using validation data collected in the field after clustering. The unsupervised classification of the merged Ross Wright Bay, O'Neil Bay, and North and South Open Bay dataset resulted in six optimal acoustic bottom type classes. The distributions of classified QTC tracks for each of Ross Wright Bay, O'Neil Bay, and North and South Open Bays were mapped for further interpretation purposes. The Kettle reservoir dataset was classified separately and resulted in four acoustic bottom type classes. Classified QTC tracks were exported from QTC Impact (QTC 2009) and imported into ArcGIS 9.3 (ESRI 2009) GIS software for mapping. Classified acoustic sonar tracks were labelled with acoustic bottom type classes, according to their coincidence with the accompanying classified bottom type validation sites. The two datasets were then used to generate surface substrate maps for each of the four study areas by digitizing polygon boundaries around interpreted changes in substrate type.

3A.3.2 ROOTED MACROPHYTES

The following data collection, mapping, and analysis methods were used to describe existing environment rooted macrophyte habitat within Stephens Lake (Section 3.3.2.4) and to develop a predictive macrophyte model for the future Keeyask GS reservoir (Appendix 3C).

3A.3.2.1 Surveys

Areas of Stephens Lake that were historically inundated by impoundment by the Kettle GS in 1971 were surveyed in 2005 and 2006 to describe the existing aquatic habitat in previously flooded areas and assist in the development of a predictive aquatic macrophyte model. Species composition, abundance and distribution of vascular macrophytes and the variables that influence habitat preference (*i.e.*, water depth, slope, and substrate) were documented to support model development.

An aerial survey was conducted in late July, 2005, along the western shoreline of Stephens Lake to determine macrophyte bed locations and to direct the subsequent boat-based sampling program. Aerial video was captured along 72 km of shoreline using a GPS linked system (Red Hen Systems Inc., Fort Collins, Colorado) mounted on a Bell Jet Ranger helicopter. Aerial frame surveys were conducted at about 100 m above the lake surface. The locations of the macrophyte beds were recorded on maps.

From late July to early August 2005, 524 sites were visited by boat in the vicinity of Ross Wright and O'Neil bays in Stephens Lake and presence/absence macrophyte data and aquatic habitat information were collected. Macrophyte species were identified and at each location, water depth, bottom slope, and substrate type were recorded. Water depth (± 5 cm) was measured at the center of each plant stand using an incremented 5 m aluminium probe. Slope of the substrate was determined using the change in depth over a known distance using the aluminium probe, or a scientific-grade vertical echosounder operating at 50 kHz (QTC), coupled with Trimble Pro XR differential (sub-meter) GPS. Substrate type at the location of the macrophyte bed was classified based on texture or compaction with the probe, and/or with a 'Petit' Ponar dredge (bottom dredge sampler).

In early August 2006, sampling was directed to areas where plants were recorded as absent in 2005. Information from the first field survey was used to locate areas where plants were absent and boat-based sampling was used to collect depth, slope, and substrate information. Effort was stratified within the preferred water depth range observed in 2005, as well as above and below this depth range.

3A.3.2.2 Mapping and Data Analysis

Data collected in Stephens Lake were used to develop a predictive macrophyte model. Model development is described in Appendix 3C.

3A.4 REFERENCES

3A.4.1 LITERATURE CITED

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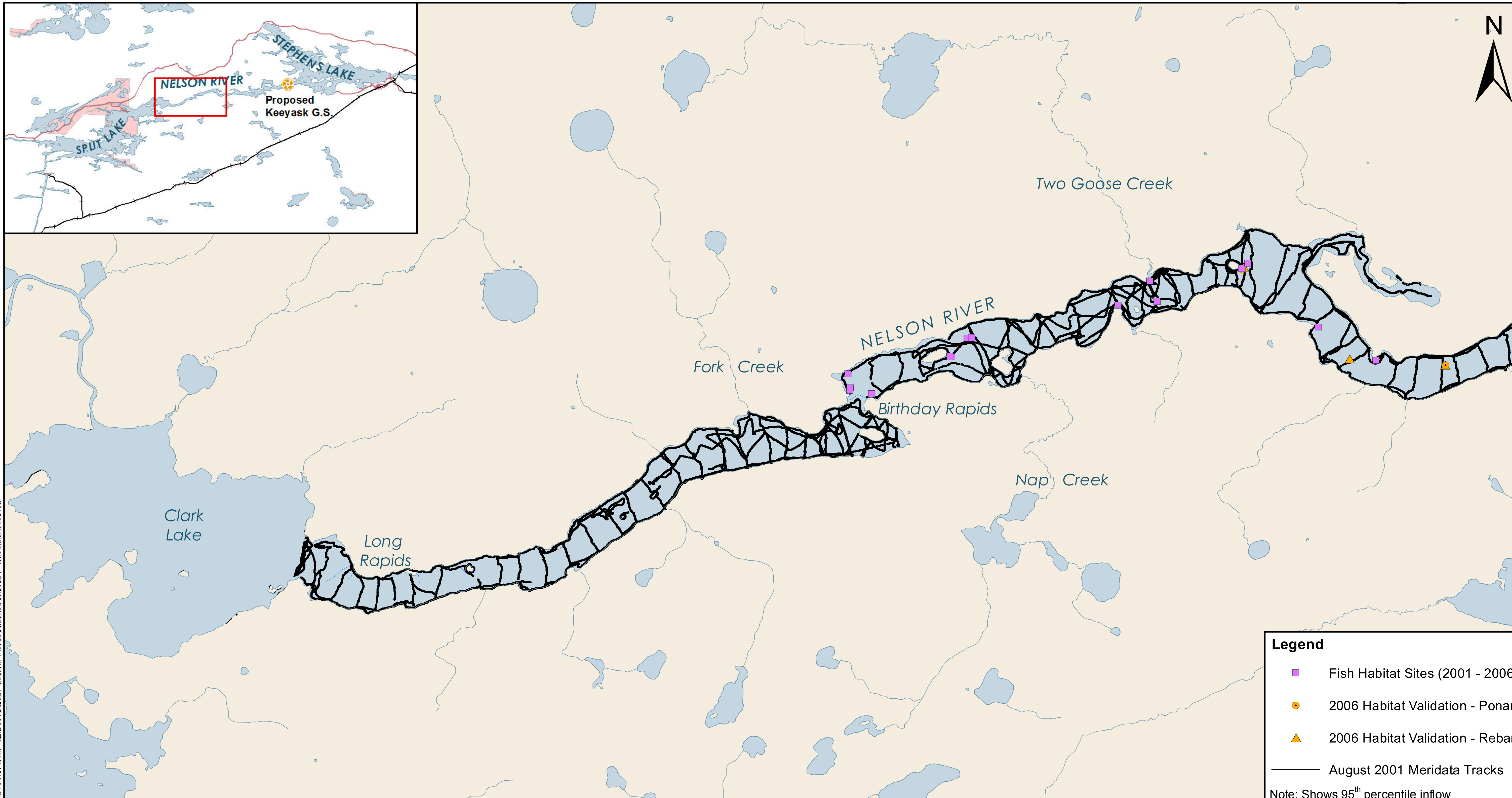

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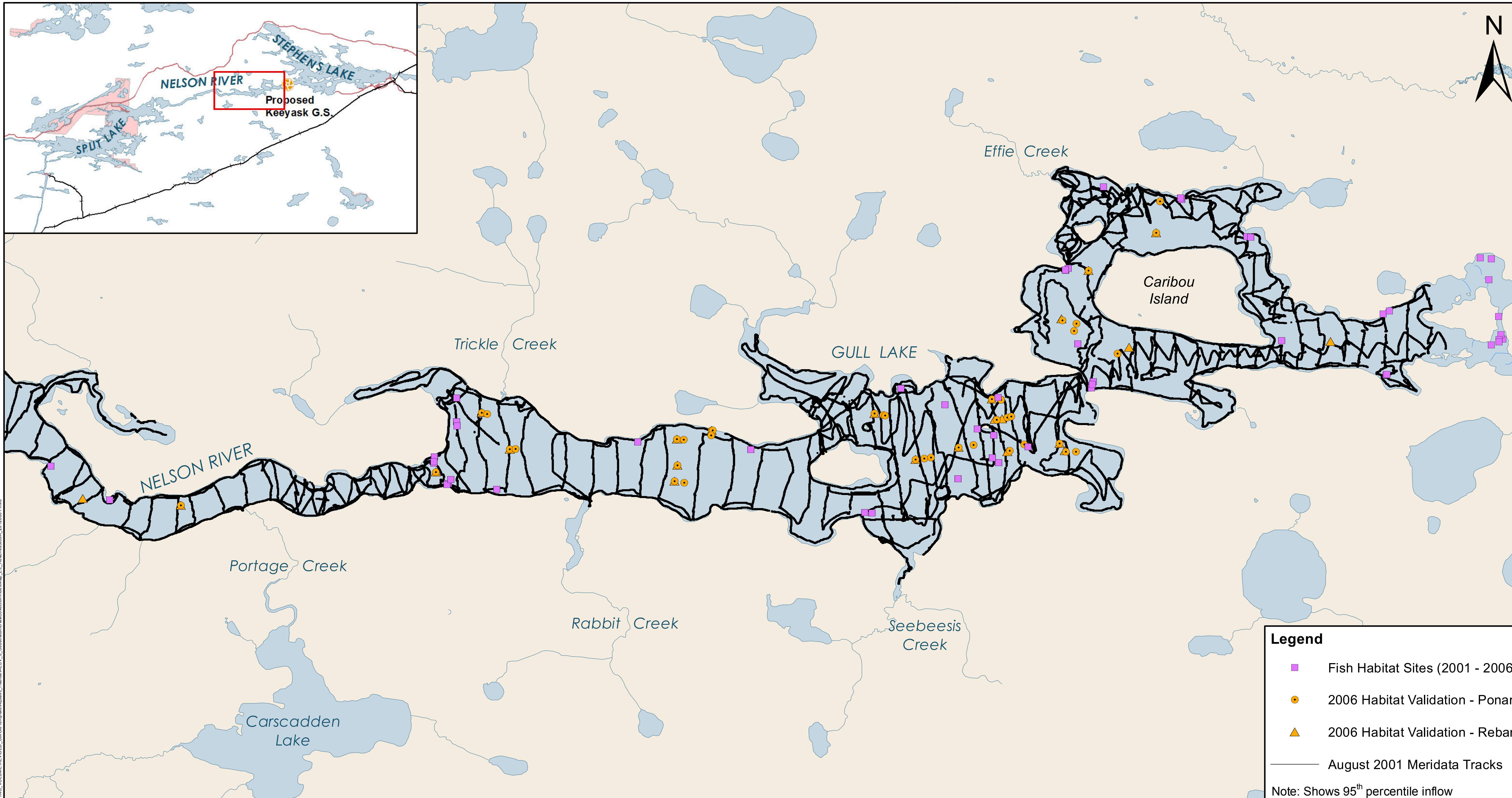
0 2.5 5 Kilometres
0 1 2 Miles

Projection: UTM Zone 15, NAD 83
Data Source: NTS base 1:50 000,
Stephens Lake Shoreline-Quickbird@Digitalglobe, 2006
Nelson River Shoreline modelled by Manitoba Hydro

Substratum Data Collection Index Map

Existing Environment - Reaches 2A - 5



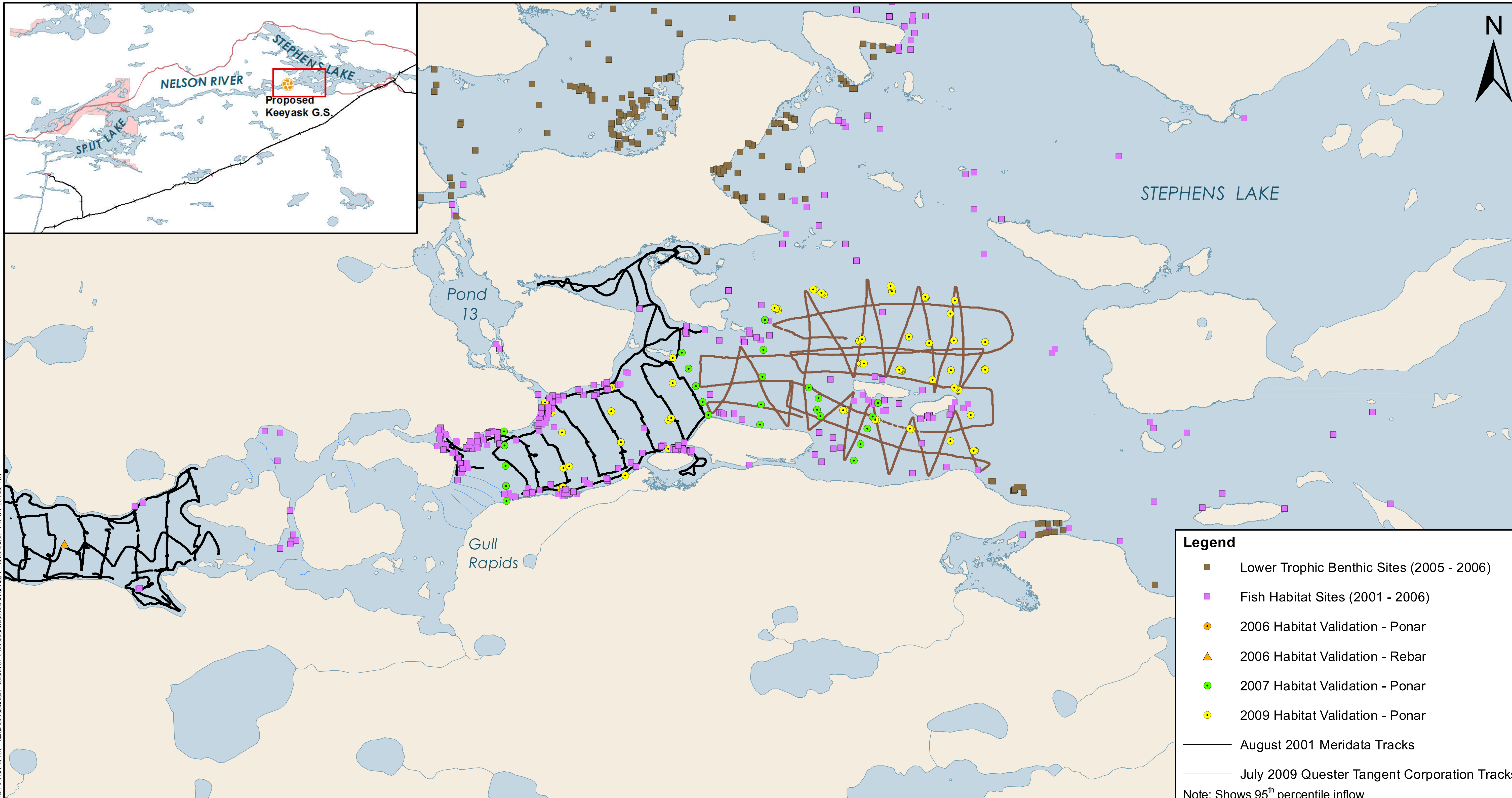
0 2.5 5 Kilometres

0 1 2 Miles

Projection: UTM Zone 15, NAD 83
Data Source: NTS base 1:50 000,
Stephens Lake Shoreline-Quickbird@Digitalglobe, 2006
Nelson River Shoreline modelled by Manitoba Hydro

Substratum Data Collection Index Map

Existing Environment - Reaches 5 - 9A



KEEYASK Hydropower Limited Partnership

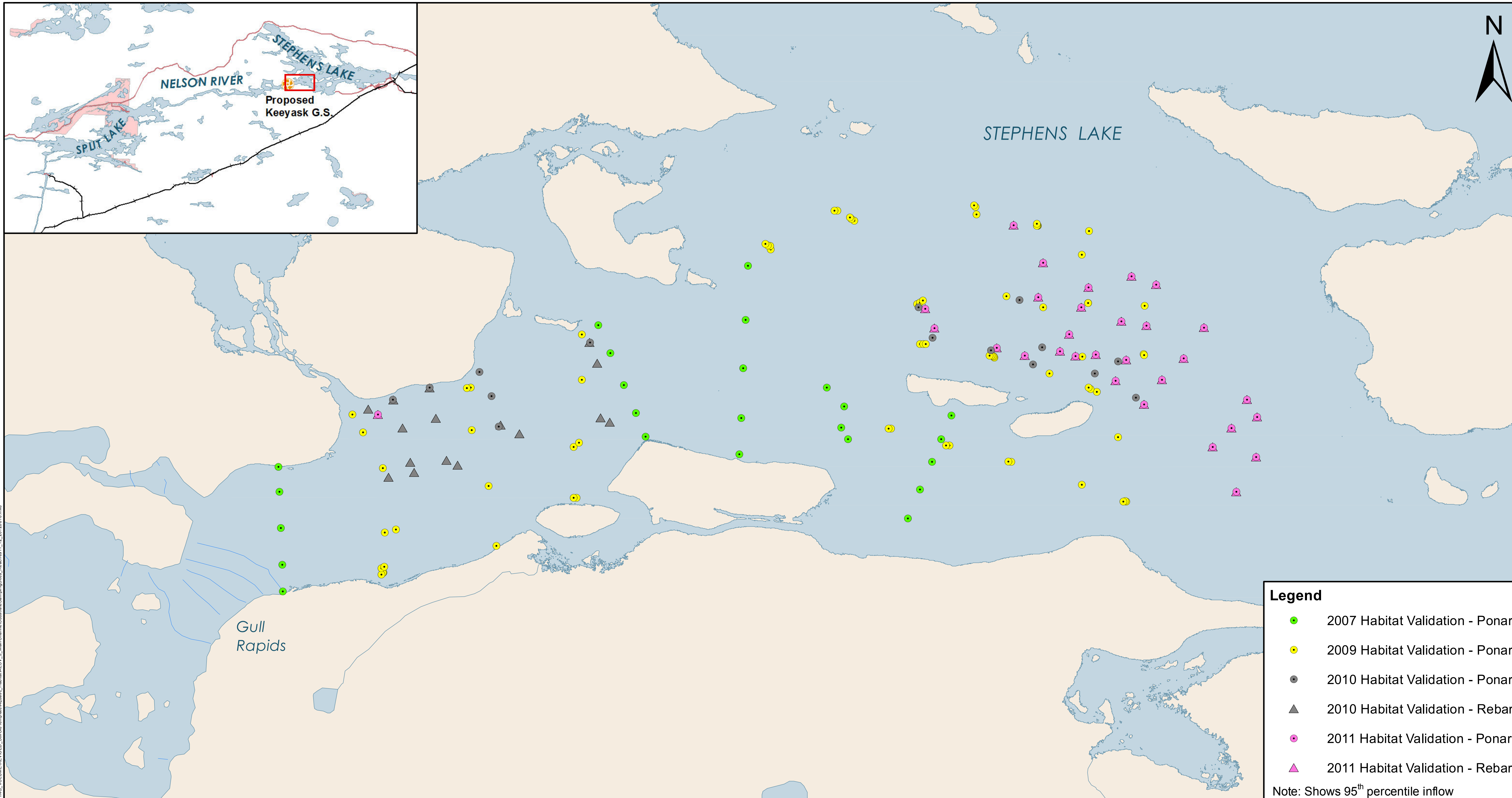
0 1 2 3 Kilometres

0 0.5 1 1.5 Miles

Projection: UTM Zone 15, NAD 83
Data Source: NTS base 1:50 000,
Stephens Lake Shoreline-Quickbird@Digitalglobe, 2006
Nelson River Shoreline modelled by Manitoba Hydro

Substratum Data Collection Index Map

Existing Environment - Reaches 9A, 9B, 11,12
and Stephens Lake



KEEYASK
Hydropower Limited Partnership

0 1 2 Kilometres
0 0.5 1 Miles

Projection: UTM Zone 15, NAD 83
Data Source: NTS base 1:50 000,
Stephens Lake Shoreline-Quickbird@Digitalglobe, 2006
Nelson River Shoreline modelled by Manitoba Hydro

Main Channel Substrate Sampling Sites

Existing Environment - Reaches 11 and 12