SECTION 5
FISH COMMUNITY

Keeyask Hydropower Limited Partnership

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5.0 FISH COMMUNITY AND MOVEMENTS

5.1 INTRODUCTION

Fish play a key role in ecosystem function and are important to KCNs Members as a domestic and commercial resource. Under the *Constitution Act*, the KCNs have a treaty right to harvest fish for food. Fish and fish habitat are protected by the *Fisheries Act*. Construction and operation of the Keeyask Generating Station (GS) would result in large changes to fish habitat and ultimately the fish community. The environmental studies described in this section encompassed the entire fish community; however, for the purposes of the assessment, particular attention was focussed on species selected because of particular community, regulatory, or scientific concerns. The rationale for selection of VEC species is provided in Section 1. The species selected as VEC include lake sturgeon (sturgeon/namayo/*Acipenser fulvescens*), walleye (pickerel/okaow/*Sander vitreus*), lake whitefish (whitefish/atikameg/*Coregonus clupeaformis*), and northern pike (jackfish/unchwapayo/*Esox lucius*). The general characteristics of these species are presented in Appendix 5A, in brief:

- Given its special status to Members of the KCNs and regulators, lake sturgeon is discussed separately in Section 6.
- Walleye reside in semi-turbid lakes and rivers, where they are found near the bottom and in schools in the open-water. They spawn in the spring, typically in streams or shallow inshore areas over gravel, boulder, or rubble substrates. Although walleye are predominantly piscivorous, they will feed opportunistically on various insects and crayfish.
- Northern pike are typically associated with shallow, vegetated areas of lakes and slow meandering rivers and move into deeper water as they mature or to overwinter. They spawn in the spring in shallow water over heavily vegetated rivers, marshes, and bays of larger lakes. Northern pike are opportunistic feeders and will feed on whatever is readily accessible, including aquatic invertebrates, fish, ducklings, mice, and other small mammals.
- Lake whitefish is a schooling species that typically occurs in deep, cold-water lakes. They spawn during fall in shallow areas of lakes and rivers over boulders and gravel. Lake whitefish eggs incubate over winter, and hatch in the spring. Lake whitefish are typically bottom feeders that feed predominantly on benthic invertebrates.

A brief description of the information sources, methods, and study area for the fish community assessment are provided in Section 5.2. The fish community conditions for the study area are described in Section 5.3. The overall fish community and VEC fish species are described for each of the study reaches followed by a description of the movements for each VEC species in the entire study area. Project effects, including construction, operation, residual, and cumulative effects, and mitigation are described in Section 5.4 along with environmental monitoring and follow-up programs.

5.2 APPROACH AND METHODS

5.2.1 Overview to Approach

The environmental setting is described using several sources of information, including local knowledge, existing published information, and studies conducted specifically as part of the environmental impact assessment of the Project. Impacts of the Project on the fish community were assessed using current conditions in comparable reservoir environments and by modelling changes in aquatic habitat. The information sources and impact assessment approaches are discussed below.

An ecosystem-based approach was employed to assess the potential impacts of the Project on the fish community. Information presented incorporates findings from other aquatic components (*i.e.*, water quality, aquatic habitat, and lower trophic levels). This approach is consistent with the views held by the KCNs, and widely held ecological views, that all components of the aquatic environment are important to maintaining the whole, and that all fish species are interdependent and, therefore, of importance and value.

The approach taken for the fish community effects assessment was similar to the general approach taken for other aquatic environment components and was comprised of two major steps:

- A description of the existing aquatic habitat conditions to provide the basis for assessing the potential effects of the Project on these components; and
- An effects assessment in which the predicted post-Project environment was described and changes from existing environment quantified.

5.2.2 Study Area

The study area for fish community and movement investigations extends along the Nelson River from the Kelsey GS in the south downstream to Stephens Lake in the east (Map 1-2). The magnitude of physical change (*e.g.*, changes in water levels and flows) as a result of the Project differs substantially among areas (Project Description Supporting Volume [PD SV], Section 4.4) and, consequently, the study area was divided into three areas on the Nelson River as follows:

- Split Lake Area (Split Lake and adjoining waterbodies, including Assean Lake and Clark Lake) – this area is upstream of any suspected direct hydraulic influence of the Project (*i.e.*, outside the hydraulic zone of influence). However, the fish community may be affected if fish move from the directly affected downstream area (Keeyask Area) to the Split Lake Area;
- Keeyask Area (Nelson River and tributary streams extending from the outlet of Clark Lake to approximately 6 kilometres [km] downstream of Gull Rapids) – Project-related changes to the water regime and direct losses of habitat due to the presence of the GS (generating station) will occur within this reach (Physical Environment Supporting Volume [PE SV], Section 4.4). This area was subdivided at Gull Rapids, as the rapids form a boundary for the aquatic biota under existing

conditions and mark a boundary between the reservoir and downstream environment in the post-Project environment; and

- Stephens Lake Area (Stephens Lake and adjoining waterbodies) – this area is immediately downstream of the Keeyask Area and the Project will not affect the water regime. The fish community inhabiting this area uses habitat in the directly affected riverine section up to and including Gull Rapids. Stephens Lake, as the reservoir of the Kettle GS formed in the early 1970s, also provides a useful proxy to assist in predicting effects of the Project (Section 1).

The majority of fish community studies were conducted in the Keeyask area, as this area will be directly affected by the Project and quantitative estimates of pre- and post-Project fish use were required. Fish community studies were also conducted in the stream crossings along the proposed access roads.

5.2.3 Data and Information Sources

Section 1.5 summarizes the overall sources of information used for the Project, including technical studies, scientific publications and local knowledge. Specific sources of information used to characterize the environmental setting for the fish community are detailed below.

A number of fish community studies have been conducted previously in the study area. These studies have primarily focused on the impacts of generating stations, such as the Kettle GS, or on the effects of Churchill River Diversion (CRD)/Lake Winnipeg Regulation (LWR) and are largely limited to Split Lake and Stephens Lake. The province of Manitoba first surveyed the fish community of Split Lake in 1966 in order to set an annual commercial limit (Schlick 1968). Fish studies were conducted on Split and Stephens lakes in the 1970s as part of the Lake Winnipeg Churchill and Nelson River Study Board studies (Ayles *et al.* 1974) and in the 1980s as part of Manitoba's Ecological Monitoring Program (Patalas 1984; Kirton 1986; Hagenson 1987a, b, 1988, 1989, 1990; Derksen *et al.* 1988). During the 1990s, fish community investigations were conducted for Manitoba Hydro on Stephens Lake as part of the Lower Nelson River Forebay Monitoring Program (MacDonell and Horne 1994; Bretecher and Horne 1997; Bretecher and MacDonell 2000), and on Split Lake as part of Tataskweyak Environmental Monitoring Agency studies (Fazakas and Lawrence 1998; Fazakas 1999) and in the preparation of a long-term aquatic environmental monitoring plan for York Factory First Nation (YFFN; Mota and MacDonell 2000). The effects of previous hydroelectric development in northern Manitoba were assessed on the Split Lake Resource Management Area as part of the Split Lake Cree Post Project Environmental Review (PPER; Split Lake Cree - Manitoba Hydro Joint Study Group 1996a, b, c).

Fish community assessments were conducted as part of the Keeyask environmental studies over an 11-year period (1997–2008). The field program consisted of eight primary components (although activities among the components often overlapped), as follows:

- Habitat-based fish community assessment;
- Spring spawning habitat;
- Fall spawning habitat;
- Overwintering habitat;

- Tributary use;
- Drifting biomass;
- Stream crossings assessment; and
- Fish movements.

For each field component, a variety of gear types was used, including various sizes of gill nets, boat and backpack electrofishing, hoop nets, seine nets, drift traps, neuston tows, radio and acoustic telemetry, and Floy®-tags. A more detailed description of the approach and methods for these studies is presented in Appendix 5B.

5.2.4 Assessment Approach

Impacts of the Project on the fish community were assessed using two approaches:

- A comparison to current condition of fish species in Stephens Lake, which was used as a proxy for long-term effects, and in other comparable reservoirs (*e.g.*, the Limestone GS, Manitoba; La Grande Complex, Québec); and
- A model of short-term and long-term changes to aquatic habitat in the Keeyask area.

5.3 ENVIRONMENTAL SETTING

The environmental setting has been described based on available background data and the information collected in the course of the Keeyask environmental studies. The fish communities in the study area have been influenced by past hydroelectric development in northern Manitoba (*e.g.*, the Kelsey GS, CRD, LWR), resource harvesting activities, and the introduction of non-native fish species (*e.g.*, rainbow smelt, common carp).

5.3.1 Pre-1997 Conditions

Historical information on fish communities in the study area is largely limited to Split Lake and Stephens Lake, and these records are sporadic and difficult to compare to more recent data due to methodological differences. No pre-1997 information was located for the Nelson River between Clark and Stephens lakes, including Gull Lake, and only limited commercial fishing data were located for Assean Lake.

Split Lake has been commercially fished since 1954. Since this time, the fishery has been an entirely summer operation, with lake whitefish being the dominant species. The Split Lake walleye and northern pike fishery was closed in 1971 due to elevated mercury concentrations in the fish (Ayles *et al.* 1974). The average annual yield of the total commercial catch was 22,628 kg (**dressed weight**) between 1954 and 1996 (Manitoba Conservation *unpubl. data*). Split Lake also supported a domestic fishery with an estimated annual yield of 11,000 kg (Schlick 1968). TCN Members state that fishing on Split Lake has become increasingly difficult due to high water levels and debris that foul the nets (Split Lake Cree - Manitoba

Hydro Joint Study Group 1996c). The average annual yield of the commercial catch on Assean Lake between 1965 and 1996 was 8,660 kg (dressed weight; Manitoba Conservation *unpubl. data*).

The fish community in Split Lake was first described by Schlick (1968) in 1966. By this time, the lake had already been affected by the Kelsey GS, which was constructed between 1957 and 1961. The author documented 19 species in the lake, noting that white sucker dominated the experimental gillnet catch both in number and weight. Members of the Split Lake Cree indicated in the PPER that there had been an increase in lake whitefish parasites and defects in walleye and northern pike due to the Kelsey GS and a reduction of mooneye populations during the 1960s (Split Lake Cree - Manitoba Hydro Joint Study Group 1996c). A 1973 survey of the lake (Ayles *et al.* 1974) documented 11 species in Split Lake in addition to the 19 species previously reported by Schlick (1968). Ayles *et al.* (1974) noted an increase in lake whitefish and walleye production since the 1966 survey. The authors attributed the increase in walleye partially to the reduction in fishing pressure associated with the closure of the walleye and northern pike fishery in 1971, but had no explanation for the increase in lake whitefish. While common carp, an introduced species in Manitoba, was first reported in Split Lake in 1963, these fish were in poor condition. It has been postulated that hydroelectric development, in particular the Kettle GS in 1974, provided the necessary habitat requirements to allow the establishment of viable populations of carp populations in Split Lake (Badiou and Goldsborough 2006).

Studies conducted between 1983 and 1989 (Patalas 1984; Kirton 1986; Hagenson 1987a, b, 1988, 1989, 1990), after CRD/LWR was in operation, reported that the fish community of Split Lake, while showing considerable variation, was dominated by lake whitefish and white sucker. The lake also supported a relatively large number of mooneye when compared to the lakes of the Rat/Burntwood River (Derksen *et al.* 1988). Although comparisons of fish abundance data between these studies and the 1973 survey is difficult due to methodological differences, Ramsey and Patalas (1992, cited in Split Lake Cree - Manitoba Hydro Joint Study Group 1996c) concluded that walleye populations in Split Lake had decreased by 50% from 1973 to the 1980s, while sauger had increased during this period. The authors speculated that these changes could be related to the transport of sediments into the lake resulting from increased flows from the Burntwood River system under CRD.

Members of TCN and York Factory First Nation (YFFN) report that hydroelectric development, in general, has resulted in an overall decrease in fish populations in Split Lake and Clark Lake (with the exception of suckers) and the Burntwood and Aiken rivers (YFFN Evaluation Report [*Kipekiskwaywinan*]; Split Lake Cree - Manitoba Hydro Joint Study Group 1996c). Hydroelectric development has also been attributed by Members of Split Lake with a reduction of goldeye populations during the early 1980s (Split Lake Cree - Manitoba Hydro Joint Study Group 1996c). Consultants participating in the Split Lake PPER process noted that the fish community in Split Lake had likely changed as a result of hydroelectric development and that seasonal reversal of flows caused by CRD/LWR may have reduced the availability of rearing habitat, which would affect the growth of juvenile fish (Split Lake Cree - Manitoba Hydro Joint Study Group 1996c). Both the consultants and Split Lake Cree concluded that the effects in Clark Lake were similar to those observed in Split Lake (Split Lake Cree - Manitoba Hydro Joint Study Group 1996c).

Stephens Lake was formed by the construction and operation of the Kettle GS, which flooded the existing river and lakes to form one large lake. With the exception of a small sturgeon fishery, there was no commercial fishery on these waterbodies prior to construction of the Kettle GS (Split Lake Cree - Manitoba Hydro Joint Study Group 1996c). A commercial fishery operated intermittently on Stephens Lake between 1979 and 1994, producing an annual average yield of 1,339 kg (dressed weight; Manitoba Conservation *unpubl. data*). No information was located describing the fish community of the pre-Stephens Lake waterbodies. Some Members of the Split Lake Cree that participated in the PPER reported that Kettle-related flooding had disturbed fish habitat and migration patterns in Stephens Lake and that there were more suckers in Stephens Lake after the Kettle GS was constructed (Split Lake Cree - Manitoba Hydro Joint Study Group 1996c). In 1973, the Kettle Reservoir had among the poorest production of commercially important species of the Nelson River lakes, which was attributed to the recent development of the reservoir (Ayles *et al.* 1974). The dominant species at this time was lake whitefish, followed by walleye and cisco. In contrast, Moose Lake, a relatively isolated part of the Kettle complex, was found to have extremely abundant lake whitefish and cisco populations, which were thought to represent unexploited populations prior to flooding.

After CRD/LWR came into operation in 1976, studies conducted between 1983 and 1989 found that the Stephens Lake fish community, while showing considerable variation, was dominated by lake whitefish, mooneye, and longnose sucker (Patalas 1984; Kirton 1986; Hagenson 1987b, 1988, 1989, 1990). Although comparisons of fish abundance data between these studies and the 1973 survey were limited due to methodological differences, Ramsey and Patalas (1992, cited in Split Lake Cree - Manitoba Hydro Joint Study Group 1996c) reported that there had been a 50% reduction in lake whitefish and a 70% decline in longnose sucker in the lake since 1973, while mooneye and possibly sauger had increased. The authors attributed these changes to differences in sampling strategy, natural evolution of limnological conditions in the reservoir, or Kettle-related changes to the water regime, rather than to CRD/LWR. A survey of the Kettle reservoir area of Stephens Lake in mid-July 1993 found a community dominated by longnose sucker, followed by lake whitefish and cisco (MacDonell and Horne 1994), while a survey of the same area in mid-August of 1996 found the community dominated by sauger, walleye, and northern pike (Bretecher and Horne 1997).

The Split Lake Cree reported in the PPER that they felt that different currents and lake bottom debris from CRD had resulted in a disturbance to fish habitat and migration patterns in Stephens Lake (Split Lake Cree - Manitoba Hydro Joint Study Group 1996c). Consultants participating in the PPER process noted that hydroelectric development, in general, had changed the fish community structure in Stephens Lake and that the overall abundance of fish had likely increased (Split Lake Cree - Manitoba Hydro Joint Study Group 1996c).

Rainbow smelt were first reported in Split Lake and Stephens Lake in 1996 (Remnant *et al.* 1997). The colonization of waterbodies by rainbow smelt is generally considered to be an unfavourable occurrence. Rainbow smelt are an aggressive invading species that can alter the composition and abundance of native species, such as lake whitefish, cisco, and emerald shiner, residing in the waterbodies they invade. It is believed that rainbow smelt compete with these species for space and food and prey on their larvae (Franzin *et al.* 1994). Additionally, the consumption of rainbow smelt by predatory species such as walleye and northern pike may lead to an increase in mercury concentrations in these predators (Evans and

Loftus 1987). Consumption of rainbow smelt has also been linked to a condition called "belly burn" in commercial catches of walleye. Belly burn is generally thought to occur by the release of enzymes found in rainbow smelt that break down the flesh of walleye stomachs. This condition can negatively affect a commercial fishery by decreasing the amount of time to process fish and by depreciating the value of fish stock that has not been processed fast enough (Freshwater Fish Marketing Corporation [FFMC] 2003).

5.3.2 Current Conditions (Post-1996)

5.3.2.1 Overview and Regional Context

A total of 37 fish species are known to occur in the study area (Table 5-1). The principal large-bodied species include walleye, sauger, northern pike, yellow perch, burbot, lake whitefish, cisco, longnose sucker, white sucker, and lake sturgeon, while the most common small-bodied species include spottail shiner, emerald shiner, trout-perch, and the recently introduced rainbow smelt. The area is similar to the aquatic environment in much of the northern boreal forest of Manitoba, Ontario, and western Québec. From a biodiversity and conservation perspective, the aquatic environment of the study area is not unique despite its traditional and cultural values to the local Cree Nations. No species area listed on Schedule 1 of the *Species At Risk Act* (SARA), but lake sturgeon in the Nelson River have been assessed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and are currently being assessed for listing under SARA. Due to their cultural importance and designation as "endangered" by COSEWIC, lake sturgeon are discussed separately in Section 6. The Manitoba Conservation Data Centre does not list any S1 or S2 species for the area (Manitoba Conservation Data Centre 2012a; Manitoba Conservation Data Centre 2012b) but lists common carp and rainbow smelt as invasive species.

To put the study area into a regional context, the **catch-per-unit-effort** (CPUE) for the total catch and three VEC species were compared among six of the study area waterbodies, as well as selected Manitoba waterbodies and is presented in Table 5-2. Study area lakes generally have higher CPUEs than the reservoirs (Notigi Lake and Limestone reservoir), but lower than other Manitoba lakes (Wuskwatim, Leftrook, Cross, and several of the AEA offsetting lakes). The exception is Assean Lake, which has a CPUE comparable to that of the other Manitoba lakes. Likewise, CPUE in the Nelson River between Clark Lake and Gull Lake is lower than those observed in other riverine waterbodies in Manitoba (*i.e.*, Rat River, Burntwood River, and lower Nelson River), with the exception of the Churchill River. However, the CPUE for northern pike in this stretch of the Nelson River is among the highest observed for all riverine waterbodies examined.

Information on the general fish community of the study area, as well as information on the abundance and habitat use for the VEC species for each area, is presented in Sections 5.3.2.2 to 5.3.2.5. All biological information (size, health, condition, diet) is summarized and provided in Appendix 5C. Information on the movements of VEC species is presented separately in Section 5.3.2.6 for the study area as a whole because fish are capable of moving between the areas. The information presented in these sections was compiled from the data reports listed in Appendix 1B. Potential impacts of construction and operation of the Project on the fish community and potential mitigation options are discussed in Section 5.4.

5.3.2.2 Split Lake Area

The Split Lake Area (Map 5-1) was intensively sampled as part of Keeyask environmental studies with small mesh and standard gang index gill nets during the summer in 1997–1998 (standard gangs only) and 2001–2002, with additional focussed sampling in Clark Lake in 2004 (Map 5-2; Appendix 5B). An additional standard gang index gillnetting program was conducted in the York Landing arm of Split Lake during the fall of 1999. Sampling to address use of the area by spring and fall spawners was conducted between 2001 and 2004 in the riverine sections of this area, including the inflowing sections of the Burntwood and Nelson Rivers and the Assean and Aiken river systems, using a variety of equipment as described in Appendix 5B.

A total of 28 fish species was captured in Split Lake and adjacent waterbodies from 1997 to 2006 (Table 5-1). Lake sturgeon was among the species captured and is discussed separately in Section 6. During the summer, Split Lake was found to have a greater diversity of large- and small-bodied fish (total of 20 species) than either Clark Lake or Assean Lake (16 and 12 species, respectively) (Table 5-3 and Table 5-4).

In all three lakes, walleye, northern pike, and white sucker were the most abundant large-bodied species. Sauger were particularly abundant in Split Lake but were absent in Assean Lake. The coregonine populations in Assean Lake were greater than populations in Split and Clark lakes. In Split/Clark lakes, there was little difference observed among the use of habitat types for foraging while in Assean Lake, large-bodied fish showed a preference for habitat in the channel area of the lake compared to the east or west basins (Table 5-5). Some YFFN Members stated that fish have moved into deeper water in Split Lake during summer after water levels changed on the lake from CRD and LWR and were no longer abundant in the shallower water closer to the shore at York Landing (YFFN and Hilderman, Thomas, Frank, and Cram [HTFC] 2002). Evidence for the spawning of many large-bodied species was found throughout the Split Lake area, including the Aiken River and Assean River systems (white and longnose sucker, walleye, northern pike, lake whitefish, yellow perch), the Burntwood River below First Rapids (white and longnose sucker, yellow perch, freshwater drum, walleye, northern pike, lake whitefish), the Nelson River below the Kelsey GS (white sucker, walleye, northern pike), and Split and Clark lakes (cisco).

With respect to forage species, Assean Lake had the greatest abundance during the summer, but had the lowest species diversity (Table 5-4). In this lake, two species of shiner, emerald and spottail, accounted for more than 90% of the catch. The most prevalent forage species in Split and Clark lakes were spottail shiner, trout-perch, and rainbow smelt. Emerald shiner were also abundant in Split and Clark lakes, but were only common in surface-set nets (Table 5-6). Rainbow smelt were not captured in Assean Lake. There was little difference in the use of foraging habitat in nearshore and offshore areas of Split/Clark lakes by small-bodied fish (Table 5-5). Nearly twice as many small-bodied fish used foraging habitat in the west basin and channel areas of Assean Lake compared to the east basin. Several forage species, including cyprinids, cottids, rainbow smelt, and trout-perch, were observed to use the Burntwood River downstream of First Rapids and/or the Assean River for spawning.

A summer commercial fishery operated on Split Lake for 11 of 12 years between 1997 and 2008, during which time the total annual average yield when the lake was in production was 55,606 kg (round weight; FFMC *unpubl. data*). The main species harvested by the fishery were northern pike (33.7%), lake whitefish (22.1%), and walleye (22.1%). The southeast bay of Split Lake has been reported by some Members of YFFN as having been a good area for northern pike and lake whitefish fishing (YFFN and HTFC 2002). Since 1997, a commercial harvest has been reported for Assean Lake in only 2002–2004 and 2006–2008. The annual average yield for years in which Assean Lake was in production (five of the last 12 years) was 2,573 kg (round weight), of which northern pike was the dominant species harvested (FFMC *unpubl. data*).

Domestic harvest may also occur in the area, but the quantity and locations of such harvests are not available. Some YFFN Members have reported that the fish they catch are no longer as healthy and they are finding fish with tumours and growths on them (YFFN Evaluation Report [*Kipekiskwaywinan*]). Members have also commented on fish being different colours depending on water turbidity and that a lot of fish had scars from predatory fish.

A detailed analysis of VEC species is presented in the following sections.

5.3.2.2.1 Walleye

Distribution and Abundance

Walleye is a common species throughout the Split Lake Area. In Clark Lake, Split Lake, and Assean Lake, walleye accounted for approximately 20 to 50% of the index gillnet catch (Map 5-3). Although the relative contribution of walleye to the catch was relatively consistent among lakes, the overall CPUE in Assean Lake (26.9 fish/100 m/24 h) was higher than the CPUE in Split Lake (9.9 fish/100 m/24 h) and Clark Lake (6.2 fish/100 m/24 h) (Map 5-4). Although the proportion of walleye in the York Landing arm of Split Lake in 1999 (32.6% of the catch) was fairly consistent with the lake-wide sampling, the CPUE in this part of the lake was as much as twice the lake-wide averages observed in other years (19.9 walleye/100 m/24 h).

Walleye were captured in all of the tributaries of Split Lake and Clark Lake that were fished as part of the Keeyask environmental studies. Walleye made up about 11% of the spring catch in the Burntwood River, most of which were captured below First Rapids. Walleye were also observed at a site in the Odei River approximately 30 km upstream of its confluence with the Burntwood River. Walleye accounted for about 26% of the catch from the Nelson River during spring. During the spring, walleye were frequently captured at sites located at the confluence of the Grass and Nelson Rivers or immediately downstream of the Kelsey GS. In 2006, gill nets were set in this stretch of the Nelson River later in the season (late August to early September), during which time walleye were the most frequently captured species. At this time, most of the fish were captured at the confluence or at a site approximately 3 km upstream in the Grass River. The abundance of walleye in this reach of the Nelson River during the summer suggests that this area may support a resident population and is not just used in the spring for spawning.

During the spring, walleye had a higher relative abundance in the Assean River and Hunting River (17–25%) than in the Crying River (8%). Most of the walleye captured the Assean River were captured further upstream, in the vicinity of Assean Lake, rather than at the downstream reach near Clark Lake.

The abundance of walleye in the lower reach of the Assean River was similar in the spring (6% of the catch) and fall (5% of the catch). Walleye were captured at sites throughout the Aiken River during spring studies, making up about 40% of the combined catch. Walleye made up approximately 25% of the spring catch in the Mistuska River, with most of the catch from sites near the mouth of the river. In contrast, walleye were rare at the mouth of the Ripple River during spring (2% of the combined catch). During fall, walleye was the most frequently captured species in the York Landing arm of Split Lake and its tributaries (32% of the combined catch). At this time of year, walleye were most frequently captured at sites located at the mouths of the Aiken and Mistuska Rivers. Mark/recapture data indicates that the same population of walleye likely uses both the Aiken and Mistuska Rivers as a number of walleye tagged in one river have been recaptured in the other.

Habitat Use

Spawning Habitat

The Keeyask environmental studies provided evidence that walleye potentially spawn at several locations within the area (Appendix 5D).

Based on the capture of spawning walleye and larvae in the area, the Burntwood River in the vicinity of First Rapids is likely used for spawning. Spawning walleye were also captured at the confluence of the Grass River with the Nelson River, suggesting that this area may also provide spawning habitat for walleye.

Walleye likely spawn in the Assean River system as walleye eggs and larvae were captured in drift traps set in the river approximately 7 km upstream of Clark Lake and walleye in various stages of spawn were captured in the Hunting, Crying, and Assean rivers. The recapture of several walleye in Assean Lake and Split Lake two to three months after being tagged during the spring in the Assean River watershed suggests that some walleye enter the river system to spawn and then return to the lakes, possibly for summer feeding purposes.

YFFN Members identified walleye spawning areas between cabin sites on the Aiken River and on the upper reaches of the Mistuska River downstream of community cabins (YFFN and HTFC 2002). A large spawning run of walleye was observed in the Aiken River. The majority of spawning walleye were captured moving upstream, suggesting that walleye ascend the Aiken River from Split Lake to spawn. Many of the walleye that were in spawning condition at the time of their initial capture in 2002 were recaptured in the Aiken River in spawning condition again the following spring, indicating that some portion of the walleye population returns to the Aiken River to spawn in successive years. Based on the presence of spawning fish and mark/recapture data, a similar spawning run likely occurs in the Mistuska River. In contrast, none of the fish captured at the mouth of the Ripple River showed any signs of spawning in 2002 or 2003, suggesting that this river may not provide spawning habitat for the species. Furthermore, it is unlikely that this tributary is used for spawning as a large set of waterfalls at the mouth of this river impeded fish movement into the river.

Rearing Habitat

All but one of the seven young-of-the-year (YOY) walleye (less than 120 mm) captured in surface- and bottom-set small mesh gill nets set in Split/Clark lakes during the summer was captured in offshore habitat, which is characterized by deeper water and less macrophyte cover than nearshore habitat. In Assean Lake, all but one of the 24 YOY walleye was captured in the west basin or channel areas. They were captured in the west basin in sinking sets characterized by shallow water both with and without macrophyte cover, whereas in the channel they were captured in floating sets in deep water. Another two YOY walleye were captured in the Assean River approximately 7 km upstream of Clark Lake as part of the drift trap program conducted during 2002 and five YOY were captured in seine hauls performed in Clark Lake at the two sites closest to the mouth of the Assean River. These seven fish likely drifted down from spawning grounds in the Assean River after hatching.

Foraging Habitat

During the summer, adult/juvenile walleye (greater than 120 mm) were about twice as abundant in offshore habitat in Split/Clark lakes as nearshore habitat (Table 5-5). The offshore area of these lakes is generally characterized by deeper water with lower abundance of macrophytes compared to nearshore areas. In Assean Lake, walleye were captured more frequently utilizing foraging habitat in the channel area compared to either basin. Habitat characteristics were generally similar among the different areas of Assean Lake. The basins of Assean Lake consist primarily of a mixture of deep and shallow, low velocity water with soft silt and clay substrates, while the channel area is generally deeper and narrower than the basins with fewer macrophytes.

Overwintering Habitat

Surveys of walleye overwintering habitat in the Split Lake Area were not conducted as part of Keeyask environmental studies. Based on telemetry studies conducted during winter in the Nelson River between Clark Lake and Gull Rapids, walleye show a preference for low water velocity areas in off-current bays for overwintering (Section 5.3.2.3.1). Since this type of habitat is prevalent in Split, Clark, and Assean lakes, it is expected that these lakes provide ample overwintering habitat for walleye.

5.3.2.2.2 Northern Pike

Distribution and Abundance

Northern pike is a common species throughout the Split Lake area. In Clark Lake, northern pike accounted for approximately 30% of the index gillnet catch, while in Split Lake and Assean Lake, they accounted for less than 18% of the catch (Map 5-5). The CPUE for northern pike was generally similar among waterbodies, with the mean CPUE at each lake ranging from 6.0 at Split Lake to 9.6 at Clark Lake (Map 5-6). Although the relative abundance of northern pike in the catch from the York Landing arm of Split Lake in 1999 (10.7%) was generally lower than observed in the whole-lake sampling conducted in subsequent years, the average CPUE (6.0 northern pike/100 m/24 h) was consistent with the lake-wide sampling.

Northern pike were captured in all of the tributaries of Split Lake and Clark Lake that were fished as part of environmental studies. Northern pike made up about 19% of the catch in the Burntwood River during spring, with most of the fish captured in the reach immediately below First Rapids or further downstream near the mouths of smaller tributaries. Northern pike were the most frequently captured species in the Nelson River below the Kelsey GS during the spring, accounting for about 31% of the catch, but were relatively uncommon in this reach during late summer, accounting for only about 8% of the catch. In the Assean River, northern pike were the most frequently captured species during spring studies, accounting for 45% of the combined catch. However, the relative abundance of northern pike in the fall catch was much lower, with northern pike accounting for only 16% of the catch. The spring catches in the Crying and Hunting Rivers comprised 8 and 17% northern pike, respectively. Northern pike were not the dominant species in the Aiken River during the spring studies, making up only 14% of the combined catch. In contrast, northern pike made up 75% of the catch at the mouth of the Ripple River and 41% of the catch in the Mistuska River during this season. At all three of these rivers, northern pike made up about 30% of the catch during the fall, with most of the northern pike captured at sites located near the mouths of these rivers.

Habitat Use

Spawning Habitat

The Keeyask environmental studies provided evidence that northern pike potentially spawn at several locations within the area (Appendix 5D).

Based on the capture of spawning northern pike and larvae in the area, the Burntwood River in the vicinity of First Rapids is likely used for spawning. Spawning northern pike were also captured in the Nelson River above Split Lake during the spring of 2002, suggesting that this area may also provide suitable spawning habitat for the species.

Northern pike likely spawn in the Assean River system as northern pike larvae were captured in drift traps set in the river approximately 7 km upstream of Clark Lake and northern pike in various stages of spawn were captured in the Hunting, Crying, and Assean Rivers.

Large numbers of northern pike were observed in the Aiken River during spring 2002 and 2003, many of which were in spawning condition, which suggests that the Aiken River is also an important spawning area for the species. The majority of northern pike in spawning condition were captured moving upstream, suggesting that northern pike ascend the Aiken River from Split Lake to spawn. Based on the presence of northern pike in spawning condition, a similar spawning run likely occurs in the Mistuska River. The abundance of northern pike in post-spawning condition that were captured during the spring of 2002 and 2003 at the mouth of the Ripple River, combined with the lack of suitable habitat for spawning at this location, suggest that this area is used as a recovery/feeding area following spawning.

Rearing Habitat

Young-of-the-year northern pike (less than 150 mm) were captured in Split and Clark lakes in seine nets and small mesh index gill nets set in nearshore habitat, which is characterized by shallower water and a greater abundance of macrophyte cover than offshore areas. In Assean Lake, YOY northern pike were captured in small mesh index gill nets set in both the east and west basin, where they were considerably more abundant at sites characterized by aquatic vegetation. Several YOY northern pike were also captured in drift traps set in the Assean River approximately 7 km upstream of Clark Lake during 2002; these fish were likely drifting down to rearing habitat from spawning grounds.

Foraging Habitat

During the summer, adult/juvenile northern pike (greater than 150 mm) were captured in both nearshore and offshore areas of Split/Clark lakes (Table 5-5). They showed a slight preference for nearshore areas, which are characterized by shallower water and a greater abundance of macrophyte cover than offshore areas. Northern pike showed little preference among foraging habitat types in the different areas of Assean Lake; they were only marginally more abundant in the basins compared to the channel (Table 5-5). Habitat characteristics are generally similar among the different areas of Assean Lake, consisting primarily of a mixture of deep and shallow, low velocity water with soft silt and clay substrates, although the basins are generally shallower than the channel with more macrophytes.

Overwintering Habitat

Surveys of northern pike overwintering habitat were not conducted in the Split Lake Area as part of Keeyask environmental studies. Based on telemetry studies conducted during winter in the Nelson River between Clark Lake and Gull Rapids, northern pike show a preference for low water velocity areas in off-current bays for overwintering (Section 5.3.2.3.1). Since this type of habitat is prevalent in Split, Clark, and Assean lakes, it is expected that these lakes provide ample overwintering habitat for northern pike.

5.3.2.2.3 Lake Whitefish

Distribution and Abundance

Lake whitefish occur throughout the Split Lake area. However, they are not a major component of the fish community in Split or Clark lakes during summer, never accounting for more than 10% of the index gillnetting catch (Map 5-7). In contrast, lake whitefish composed about 20% of the index catch in Assean Lake in both 2001 and 2002. Likewise, the mean CPUE of lake whitefish in Assean Lake was more than five times higher than that observed in the other two lakes (Map 5-8). Both the proportion and CPUE of lake whitefish in the York Landing arm of Split Lake in 1999 (11.26% and 7.4 lake whitefish/100 m/24 h, respectively) was about twice as high as observed during the lake-wide sampling conducted in summer.

Lake whitefish were also captured in most of the major tributaries of Split and Clark lakes fished as part of the environmental studies. In the Assean River, lake whitefish were captured incidentally in hoop nets set during the spring (less than 1% of the catch); however, in the fall, they were the dominant species captured (65% of the catch). Lake whitefish were not captured in nets set at the mouths of either the Hunting or Crying Rivers. Similarly, lake whitefish were captured infrequently in the Aiken River and Ripple River during spring (less than 2% of the catch) and the relative abundance of the species increased at the mouths of these rivers during the fall to about 10%. In contrast, the relative abundance of lake whitefish remained fairly constant at the Mistuska River between seasons. Lake whitefish were captured in the Burntwood River during spring, where they made up approximately 4% of the catch. Most fish were captured at sites located at the confluence of the Odei and Burntwood Rivers, while a few more were captured downstream of First Rapids. During the same season, lake whitefish made up about 9% of the catch in the Nelson River downstream of the Kelsey GS; they were not captured in this stretch of the river in 2006 when gill nets were set later in the year (late August to early September). Most of the lake whitefish were captured at sites located at the confluence of the Grass and Nelson Rivers and in an off-current bay downstream of the spillway. Lake whitefish were also captured at sites upstream in the Grass River near tributary mouths.

Habitat Use

Spawning Habitat

The Keeyask environmental studies provided evidence that lake whitefish potentially spawn at several locations within the area (Appendix 5D).

Based on the capture of lake whitefish and coregonine larvae in the area during spring, the Burntwood River in the vicinity of First Rapids is likely used for spawning. Spawning adults have not been observed at this location as gill nets were not set in the river during the fall.

The Assean River may also provide lake whitefish spawning habitat. Several lake whitefish were captured at the mouth of the Assean River and in nearby Clark Lake in pre-spawn condition during fall; these fish were likely **staging** before ascending to spawning areas upstream in the Assean River. Large numbers of lake whitefish in spawning condition, many ripe and running, were captured in the Assean River approximately 200 metres (m) upstream of the bridge crossing at Provincial Road (PR) 280. The recapture of spawning lake whitefish during the fall of 2002 in approximately the same location in which they had been tagged the previous year, suggests that lake whitefish may return to the same location to spawn in successive years. A small number of whitefish larvae were captured in drift traps set approximately 7 km upstream of Clark Lake and at inshore locations in Clark Lake in neuston tows; it is likely that these larvae drifted down from upstream spawning locations in the Assean River.

It is possible that lake whitefish may also spawn in the tributaries of the York Landing arm of Split Lake. While few lake whitefish were captured directly in the Aiken and Mistuska Rivers during fall, several lake whitefish were captured in Split Lake at, or near, the mouths of these rivers, where they may stage prior to upstream spawning movements.

Rearing Habitat

Five YOY lake whitefish (less than 100 mm) were captured in seine hauls conducted in Clark Lake in nearshore habitat that had no macrophyte cover. In Assean Lake, the majority of YOY lake whitefish were captured in the west basin, where they were captured at shallow water sites both with and without macrophyte cover.

Foraging Habitat

During the summer, adult/juvenile lake whitefish (greater than 100 mm) were captured in both nearshore and offshore areas of Split/Clark lakes (Table 5-5). They showed a slight preference for offshore areas, which are characterized by deeper water and lower abundance of macrophyte cover compared to nearshore areas. In Assean Lake, lake whitefish were captured more frequently utilizing foraging habitat in the west and east basins compared to the channel area. The basins are generally characterized by a mixture of deep and shallow, low velocity water with soft silt and clay substrates, and macrophyte growth in shallow marshy bays.

Overwintering Habitat

Surveys of lake whitefish overwintering habitat were not conducted in the Split Lake Area as part of Keeyask environmental studies. Based on telemetry studies conducted during winter in the Nelson River between Clark Lake and Gull Rapids, lake whitefish show a preference for low water velocity areas in off-current bays for overwintering (Section 5.3.2.3.1). Since this type of habitat is prevalent in Split, Clark, and Assean lakes, it is expected that these lakes provide ample overwintering habitat for lake whitefish.

5.3.2.3 Keeyask Area

5.3.2.3.1 Nelson River between Clark Lake and Gull Rapids

During the summer, the Nelson River between Clark Lake and Gull Rapids (Map 5-9) was intensively sampled for large-bodied fish species with standard gang index gill nets from 2001 to 2002, and for small-bodied fish with small mesh index gill nets during 2001 and 2002 and seine nets from 2001 to 2003 (Map 5-10; Appendix 5B). An additional standard gang index gillnetting program was conducted during the fall in 1999. This stretch of the Nelson River, as well as several of its smaller tributaries, was sampled between 2001 and 2004 to address use of the area by spring and fall spawners using a variety of equipment as described in Appendix 5B. Backpack electrofishing was used during the spring and fall of 2002 and 2003 to assess the use of tributaries by forage species. The use of overwintering habitat in the Keeyask Area by the three VEC species was assessed using telemetry. The drifting fish community in the study area was quantified during the late summer and fall of 2003 and 2004.

A total of 35 fish species were captured in the Nelson River between Clark Lake and Gull Rapids, and adjacent waterbodies (Table 5-1). Lake sturgeon was among the species captured and is discussed separately in Section 6. During the summer, walleye, northern pike, and white sucker were the most abundant large-bodied species in both Gull Lake and the Nelson River (Table 5-7). However, several species, including lake whitefish, mooneye, sauger, and walleye were relatively more abundant in Gull Lake, whereas yellow perch, longnose sucker, and shorthead redhorse were more abundant upstream in the Nelson River. A similar species composition, in both Gull Lake and the upstream riverine section, was observed in fall 1999 (Table 5-7). There was little difference among the use of foraging habitat by large-bodied species among backbays and nearshore and offshore lacustrine areas; however, only about half as many fish were captured in riverine areas of the Nelson River (Table 5-8). Riverine habitats generally differed from other habitat types in being characterized as having faster water velocities. Several species of large-bodied fish were observed to spawn throughout the Nelson River between Clark Lake and Gull Rapids, including Gull Lake, wherever suitable habitat existed, including walleye, northern pike, and lake whitefish. A few species made use of the areas immediately upstream and downstream of Birthday Rapids (*e.g.*, white and longnose sucker, freshwater drum, walleye, and lake whitefish) and small tributaries (*e.g.*, yellow perch, northern pike).

With respect to forage species, the three most abundant species captured in gill nets set during the summer were spottail shiner, trout-perch, and rainbow smelt (Table 5-9). Emerald shiner were also abundant, but were only common in surface-set nets (Table 5-10). The two shiner species also dominated the seine catches, along with Johnny darter, longnose dace, and rainbow smelt (Table 5-11). Foraging small-bodied fish were particularly abundant in backbay areas and offshore lacustrine areas and, to a lesser extent, nearshore lacustrine areas (Table 5-8 and Table 5-12). They were infrequently captured foraging in riverine areas, which are generally characterized as having higher velocity waters. Many of the same forage species present in the mainstem were also captured in the tributaries during the spring and fall. Two Goose and Portage Creeks, along with Seebeesis Creek, generally supported a greater species diversity of forage species (six to twelve species) than the other creeks sampled (one to four species). Two Goose Creek yielded the most fish regardless of season, primarily due to an abundance of minnows and sculpins (Map 5-11). Mean CPUE values were also high in Trickle Creek in spring and Rabbit Creek in fall primarily due to large numbers of stickleback and darters, respectively. Several small-bodied fish, including cyprinids, cottids, darters, sticklebacks, logperch, and trout-perch, were observed to have spawned in the area downstream of Birthday Rapids and the area upstream of Gull Rapids. Spawning of cottids and cyprinids was also observed in several of the tributaries, including Portage, Two Goose, and/or Fork Creeks.

A commercial fishery on Gull Lake was reported in only 1998, at which time 206 kg (dressed weight) was harvested (FFMC, *unpubl. data*). The main species harvested in this year were lake whitefish and northern pike. Domestic harvest may also occur in the area, but the quantity and locations of such a fishery are not available. Many FLCN Members describe fish from the Nelson River as unpalatable or as unfit for human consumption due to a greater number of lesions and growths on the exterior of the fish indicating that they are diseased or contaminated (FLCN 2010 Draft).

A detailed analysis of VEC species is presented in the following sections.

Walleye

Distribution and Abundance

Walleye are an important component of the fish community of Gull Lake and upstream in the Nelson River, accounting for approximately 20% of the index gillnet catch (Map 5-3). During the summer, the mean CPUE of walleye in Gull Lake was about twice that observed upstream in the Nelson River (Table 5-7). Walleye were about equally abundant during the fall of 1999, during which time the species accounted for 14.7% of the catch (Table 5-7). Walleye were relatively uncommon in the small mesh index gillnet catch, accounting for 1.0% of the catch in bottom-set nets in the summer of 2001 and 2002. The capture rate in these nets was less than 1 fish/30 m/24 h in both years.

The proportion of walleye captured during the spring gillnetting programs (13.7%; 2001–2006) and fall (16.2%; 2001–2003) was similar to that observed during the standard gang index programs. Although walleye were generally common at the creek mouths, they were never caught upstream in any of the tributaries or their associated lakes (*i.e.*, Carscadden and Little Gull) surveyed, regardless of season or gear type.

Habitat Use

Spawning Habitat

Keeyask environmental studies provided evidence that walleye potentially spawn at several locations within the area (Map 5-12; detailed information is provided in Appendix 5D). The telemetry studies did not detect large congregations of walleye between Birthday and Gull rapids during spring that would have identified important spawning locations. The data suggests that walleye may spawn wherever suitable habitat is located within both the Nelson River and Gull Lake rather than congregating in one location. In particular, walleye may use Birthday Rapids for spawning as a few of the radio-tagged walleye were relocated in the vicinity of the rapids when water temperatures were within the species' preferred spawning range and several walleye were captured both above and below the rapids in spawning condition. However, the drift trap program provided little evidence to conclusively support that walleye spawn in the vicinity of Birthday Rapids as few walleye eggs or larvae were captured in the vicinity of the rapids.

Rearing Habitat

Young-of-the-year walleye (less than 120 mm) were captured in seine nets and small mesh index gill nets set in lacustrine, riverine, and backbay habitat throughout the Nelson River reach below Birthday Rapids (Map 5-12). Numerous YOY fish that could only be identified as belonging to the genus *Sander* were captured drifting out of Birthday Rapids, presumably to downstream rearing habitat.

Foraging Habitat

During the summer, adult/juvenile walleye (greater than 120 mm) were captured in all habitat types sampled in the Keeyask Area, although they were slightly more abundant in nearshore and offshore lacustrine habitat compared to backbay and riverine habitat (Map 5-12). Lacustrine habitats were generally characterized as having a mixture of deep and shallow areas with low to moderate water velocity, primarily gravel/cobble/boulder substrates, and sparse macrophyte cover.

Overwintering Habitat

All but one of the walleye in the Keeyask Area that had been implanted with radio-transmitters were relocated at least once during the tracking flights conducted during the winters of 2002 to 2004. These fish were relocated throughout Gull Lake, but were most frequently detected in Kahpowinic and Weejeeweeniya bays on the north side of Gull Lake, suggesting that these off-current areas may provide important overwintering habitat for the species (Map 5-12). One of the radio-tagged walleye appeared to have overwintered above Birthday Rapids during 2002–2003.

Northern Pike

Distribution and Abundance

Northern pike was the most frequently captured species during the standard gang index gillnetting program in both Gull Lake and the upstream reach of the Nelson River, accounting for more than 30% of the index gillnet catch (Map 5-3). During the summer, the mean CPUE of northern pike in Gull Lake was about the same as that observed upstream in the Nelson River (Table 5-7). The species was more abundant in the reach during the fall of 1999, during which time the species accounted for 60.4% of the standard gang index catch and had an average CPUE of 14.9 fish/100 m/24 h. Northern pike were relatively uncommon in the small mesh index gillnet catch, accounting for 1.2% of the catch in bottom-set nets in the summer of 2001 and 2002.

The proportion of northern pike captured during the tagging programs conducted in the reach during the spring (42.8%; 2001–2006) and fall (57.5%; 2001–2003) was similar to that observed during the summer index programs.

Northern pike were observed upstream in all of the tributaries assessed during the spring and fall except for Fork Creek. In both seasons, Portage Creek (1.0–1.5 fish/100 s) yielded the most northern pike during the 2003 backpack electrofishing survey of all of the tributaries fished (0–0.9 fish/100 s). Northern pike were also captured in Carscadden Lake during the summer standard gang index gillnetting survey in 2002, where they had a CPUE value of 18.8 fish/100 m/24 h. No northern pike were captured in Little Gull Lake.

Habitat Use

Spawning Habitat

Keeyask environmental studies provided evidence that northern pike potentially spawn at several locations within the area (Map 5-13; detailed information is provided in Appendix 5D). There is suitable spawning habitat for northern pike along the Nelson River mainstem between Birthday Rapids and Gull Rapids, notably at tributary mouths and in off-current bays. Telemetry studies located radio-tagged northern pike throughout this area when water temperatures were within the species' preferred spawning range, suggesting that the species spawns opportunistically wherever spawning habitat is available. The Nelson River may also provide spawning habitat for northern pike in the vicinity of Birthday Rapids and upstream of the rapids. A few spawning adults and northern pike larvae were captured below the rapids during spring and two of the radio-tagged northern pike were relocated near the rapids during the time water temperatures were within the preferred spawning range for the species (late-May to early-June) in 2002. Spawning northern pike and larvae were also captured upstream in several of the tributaries.

Rearing Habitat

Young-of-the-year northern pike (less than 150 mm) were observed upstream in several of the tributaries along the Nelson River mainstem (*e.g.*, Seebeesis, Effie, Nap, Portage, Rabbit, Trickle, and Two Goose) during backpack electrofishing surveys and also were captured in drift traps set in these tributaries indicating that these creeks provide important foraging habitat for immature northern pike (Map 5-13). Along the mainstem, northern pike YOY were primarily captured in backbay and nearshore lacustrine habitats, which are generally characterized by shallow, slower moving water with areas of macrophyte cover. Large numbers of YOY northern pike were captured in drift traps set immediately below Birthday Rapids, presumably drifting downstream to rearing habitat. In spring of 2004, a few YOY were also observed drifting downstream from spawning areas in the reach above Birthday Rapids.

Foraging Habitat

During the summer, adult/juvenile northern pike (greater than 150 mm) were about twice as abundant in backbay and nearshore lacustrine habitat types sampled in the Keeyask Area, compared to riverine and offshore lacustrine habitat (Map 5-13). Habitat preferred by northern pike for foraging are generally characterized as being shallow with standing to low water velocity, primarily soft silt/clay substrates, and, particularly in backbays, presence of macrophyte cover.

Overwintering Habitat

All of the northern pike that had been implanted with radio-transmitters were relocated at least once during the tracking flights conducted during the winters of 2002 to 2004. In all three years, small aggregations of these fish were frequently detected in Kahpowinic, Weejeeweeniya, and Effie bays on the north side of Gull Lake, suggesting that these off-current areas may provide important overwintering habitat for the species (Map 5-13).

Lake Whitefish

Distribution and Abundance

Environmental studies have shown that lake whitefish are not a major component of the fish community of the Nelson River between Clark Lake and Gull Rapids during summer, never accounting for more than 10% of the standard gang index gillnet catch (Map 5-7). The mean CPUE of lake whitefish in Gull Lake was about twice that observed upstream in the Nelson River (Table 5-7). Very few lake whitefish were captured in small mesh index gill nets set in the reach. Lake whitefish were no more abundant in the reach during the fall of 1999, during which time the species accounted for only 4.6% of the index catch and had an average CPUE of 1.1 lake whitefish/100 m/24 h.

The proportion of lake whitefish captured during the tagging programs conducted in the reach during the spring (3.4%; 2001–2006) and fall (7.4%; 2001–2003) was similar to that observed during the summer index program. Lake whitefish were never caught in any of the tributaries surveyed, regardless of season or gear type.

Habitat Use

Spawning Habitat

Keeyask environmental studies provided evidence that lake whitefish potentially spawn within the Keeyask Area (Map 5-14; detailed information is provided in Appendix 5D). The telemetry studies did not detect large aggregations of lake whitefish in the Nelson River mainstem during the fall, which would have identified important spawning locations. The presence of larvae in Gull Lake during the early spring indicates that some spawning occurs in this area. The capture of large numbers of larvae upstream and downstream of Birthday Rapids suggests that some spawning occurs in the vicinity of the rapids.

Rearing Habitat

Rearing habitat for lake whitefish occurs primarily in backbay and nearshore lacustrine habitat along the mainstem of the Nelson River downstream of Birthday Rapids, particularly those fed by small tributaries, as evidenced by the capture of YOY lake whitefish (less than 100 mm) during the small mesh index gillnetting and seining programs (Map 5-14). Large numbers of YOY lake whitefish and *Coregonus* spp. were captured in drift traps set immediately below Birthday Rapids during spring, presumably drifting downstream to rearing habitat. In spring of 2004, a few YOY were also observed drifting downstream from spawning areas in the reach above Birthday Rapids.

Foraging Habitat

During the summer, adult/juvenile lake whitefish (greater than 100 mm) were about twice as abundant in offshore lacustrine habitat sampled in the Keeyask Area compared to backbays and nearshore lacustrine habitats (Map 5-14). Lake whitefish were relatively uncommon in riverine habitat during this time. The preferred habitat of lake whitefish for foraging was generally characterized as being deep with low to moderate water velocity, primarily gravel/cobble/boulder substrates, and little to no macrophyte cover.

Overwintering Habitat

Four of the five lake whitefish implanted with radio transmitters were relocated at least once during radio tracking flights conducted during the winters of 2002 and 2003. The limited data suggest that this species overwinters in off-current areas Gull Lake, particularly in bays along the north shore (Map 5-14).

5.3.2.3.2 Gull Rapids

The Nelson River below Gull Rapids (Map 5-9) was sampled intensively with small mesh and standard gang index gill nets during the summer of 2002 and 2003 (Map 5-10; Appendix 5B). The use of Gull Rapids Creek and the Pond 13 system by forage species was assessed during fall of 2003 and spring of 2005 and 2006 using several techniques (Appendix 5B). Sampling to address use of the area by spring and fall spawners was also conducted in this area between 2001 and 2006 using a variety of equipment as described in Appendix 5B. The drifting fish community in the study area was quantified during the late summer and fall of 2003 and 2004.

A total of 32 fish species were captured in or immediately below Gull Rapids between 2001 and 2006 (Table 5-1). Lake sturgeon was among the species captured and is discussed separately in Section 6. During the summer, the most abundant large-bodied species below the rapids were walleye, sauger, and northern pike (Table 5-7). The use of riverine habitat below Gull Rapids for foraging by large-bodied fish was about twice the level in riverine habitat upstream of Gull Rapids and was more similar to levels in lacustrine habitats (Table 5-8). Evidence for the use of the Gull Rapids Area for spawning was observed for several large-bodied species including lake whitefish, white sucker, longnose sucker, yellow perch, freshwater drum, mooneye, northern pike, walleye, and sauger. Resource users and Elders from the KCNs have highlighted the importance of Gull Rapids as spawning habitat (FLCN 2010 Draft; CNP Keeyask Environmental Evaluation Report; FLCN Environment Evaluation Report [Draft]). There was little evidence for the use of Gull Rapids Creek for spawning of large-bodied species. Numerous YOY of at least one species of catostomid, longnose sucker, were captured in Gull Rapids Creek; these fish are likely part of a resident population that resides in its unnamed headwater lake.

The three most abundant forage species captured below the rapids in the summer were emerald shiner, trout-perch, and spottail shiner (Table 5-9). The use of riverine habitat below Gull Rapids for foraging by forage fish was about twice the level in riverine habitat upstream of Gull Rapids but was not as high as the level in lacustrine habitats (Table 5-8). The most abundant fish species in drift traps set below Gull Rapids during late summer and fall were rainbow smelt and emerald shiner. A greater species diversity was observed in traps set in August compared to those set later in the season. Likewise, the abundance of fish in the traps declined over time in both 2003 and 2004. The forage fish catch in Gull Rapids Creek during fall included at least seven species of forage fish but was dominated by longnose dace (greater than 80%). Three species of forage fish, brook stickleback, fathead minnow, and emerald shiner, were captured upstream in the headwater lake of this creek during summer. Analysis of results concluded that several small-bodied fish, including cyprinids, cottids, rainbow smelt, trout-perch, logperch, stickleback, and darters, spawned in Gull Rapids, but not in Gull Rapids Creek or the Pond 13 system.

There is no commercial fishery associated with the Gull Rapids Area specifically; however, since there is movement of fish between the Nelson River below Gull Rapids and Stephens Lake, they could be susceptible to commercial fisheries operating in Stephens Lake (described in Section 5.3.2.4). Gull Rapids is a valued domestic harvesting location to the Fox Lake Cree, particularly for walleye.

A detailed analysis of VEC species is presented in the following sections.

Walleye

Distribution and Abundance

The index gillnetting programs conducted in the reach below Gull Rapids indicated that walleye are an important component of the fish community, accounting for approximately 30% of the catch from 2002 to 2003 (Map 5-3). The CPUE for the species was relatively constant between years, ranging from 6.2 to 6.6 walleye/100 m/24 h (Map 5-4). Walleye were relatively uncommon in the small mesh index gill nets, accounting for about 2% of the bottom-set catch during the summer of 2002 and 2003.

The proportion of walleye captured during tagging programs conducted in and below Gull Rapids was about the same in the spring as during the fall, ranging from 22–25% of the catch. Several walleye were also captured in Pond 13 during the spring of 2005 and 2006. Walleye were not observed in Gull Rapids Creek.

Habitat Use

Spawning Habitat

Keeyask environmental studies provided evidence that Gull Rapids is an important spawning area for walleye inhabiting Stephens Lake (Map 5-12; detailed information is provided in Appendix 5D). Several larval walleye and *Sander* spp. were captured in drift traps set within and below Gull Rapids during the spring. Numerous spawning walleye were captured below the rapids during the spring, and a few of the walleye radio-tagged that were released into Stephens Lake were later relocated in this area when water temperatures were within the species' spawning range. There is little evidence from movement studies that walleye from Gull Lake move downstream into the rapids to spawn (as discussed in Section 5.3.2.6).

Rearing Habitat

The area immediately downstream of Gull Rapids likely does not provide important rearing habitat for walleye as evidenced by the capture of few YOY fish (less than 120 mm) in small mesh gill nets during summer. Rather, the capture of numerous YOY walleye in drift traps set below the rapids during spring suggests that immature walleye drift downstream to forage in rearing habitat in Stephens Lake during summer.

Foraging Habitat

The use of riverine habitat below Gull Rapids for foraging by adult/juvenile walleye (greater than 120 mm) was about twice the level in riverine habitat upstream of Gull Rapids and was more similar to the level in lacustrine habitats (Table 5-8).

Overwintering Habitat

There are limited data on the use of the Gull Rapids reach by overwintering walleye. None of the radio-tagged walleye were relocated within this reach during the winter. Due to the relatively high water velocities within and just downstream of Gull Rapids, most walleye likely overwinter further downstream in Stephens Lake. Four of the five fish implanted with transmitters that had been released below the rapids during the fall of 2001 were relocated in Stephens Lake over the following two winters (refer to Section 5.3.2.4).

Northern Pike

Distribution and Abundance

Index gillnetting studies indicated that northern pike are not a major component of the Gull Rapids Area fish community during the summer, accounting for only 12% of the catch from 2002 to 2003 (Map 5-5). The mean CPUE for the species ranged from 2.5 to 2.9 northern pike/100 m/24 h between sample years (Map 5-6). Northern pike were infrequently captured in small mesh index gill nets, accounting for less than 2% of the bottom-set gill net catch.

The tagging programs revealed that northern pike were not as prevalent in the Gull Rapids reach during the fall (2001–2003), when they composed an average of 16% of the catch, as they were during the spring (2001–2006), when they accounted for over 30% of the catch.

Northern pike were captured in both of the tributary waterbodies of Gull Rapids that were fished during the spring of 2005 and 2006. A few northern pike were captured in the hoop net set in Gull Rapids Creek and several more were captured in gill nets set in the Pond 13 system.

Habitat Use

Spawning Habitat

Keeyask environmental studies provided evidence that Gull Rapids is an important spawning area for northern pike inhabiting Stephens Lake (Map 5-13; detailed information provided in Appendix 5D). Several larval northern pike were captured in drift traps set within and below Gull Rapids during spring in 2001 and 2003 and numerous spawning northern pike were captured in and below the rapids during the spring. Although none of the radio-tagged northern pike were released in below Gull Rapids, the one radio-tagged northern pike that moved downstream into Stephens Lake was relocated at the base of the Gull Rapids on multiple occasions in 2003 when water temperatures were within the species' spawning range. There is little evidence from movement studies that northern pike from Gull Lake move downstream into the rapids to spawn (as discussed in Section 5.3.2.6).

Rearing Habitat

The area immediately downstream of Gull Rapids does not provide important rearing habitat for northern pike as evidenced by the absence of YOY fish (less than 150 mm) in small mesh gill nets set in the area during summer. Rather, the capture of large numbers of YOY northern pike in drift traps set below the rapids during spring, suggests that immature northern pike drift downstream to forage in rearing habitat in Stephens Lake during summer.

Foraging Habitat

The use of riverine habitat below Gull Rapids for foraging by adult/juvenile northern pike (greater than 150 mm) was considerably less than the level in riverine or lacustrine habitat upstream of Gull Rapids indicating that the Gull Rapids Area is not important as foraging habitat for the species (Table 5-8).

Overwintering Habitat

Limited information on the overwintering locations of northern pike is available for the Gull Rapids area. Due to the relatively high water velocities within and immediately below Gull Rapids, most northern pike likely overwinter further downstream in Stephens Lake. One of the northern pike implanted with a radio-transmitter was relocated in the winter at the base of Gull Rapids in 2003 after it had moved out of Gull Lake and through Gull Rapids.

Lake Whitefish

Distribution and Abundance

Data collected from the index gillnetting programs conducted below Gull Rapids from 2002 to 2003 indicated that lake whitefish are generally not a major component of the fish community during the summer, as no lake whitefish were captured in this reach during sampling (Map 5-7and Map 5-8). In contrast, lake whitefish accounted for almost half (46%) of the catch in gill nets set in and below the rapids during the fall.

Two lake whitefish were captured in gill nets set in the Pond 13 system during the spring of 2005 and 2006.

Habitat Use

Spawning Habitat

Keeyask environmental studies provided evidence that Gull Rapids is an important spawning area for lake whitefish inhabiting Stephens Lake (Map 5-14; detailed information is provided in Appendix 5D). The FLCN have also reported that lake whitefish spawn close to Gull Rapids (FLCN 2010 Draft). More than half of the lake whitefish captured as part of Keeyask environmental studies in the Gull Rapids Area during the fall of 2001–2003 were preparing or ready to spawn, most of which were captured at sites located at the base of the rapids. Likewise, several of the lake whitefish implanted with acoustic transmitters in Stephens Lake were frequently detected immediately below Gull Rapids from late September to early October 2002 and 2003. There is little evidence from movement studies that lake whitefish from Gull Lake move downstream into the rapids to spawn (as discussed in Section 5.3.2.6). The use of Gull Rapids as a spawning location is further supported by the capture of numerous lake whitefish or coregonine larvae in the drift traps set in and immediately downstream of Gull Rapids.

Rearing Habitat

The area immediately downstream of Gull Rapids does not provide important rearing habitat for lake whitefish as evidenced by the absence of YOY fish (less than 100 mm) in small mesh gill nets set in the area during summer. Rather, the capture of numerous YOY lake whitefish and fish that could only be identified as genus *Coregonus* in drift traps set below the rapids during spring, suggests that immature lake whitefish drift downstream to forage in rearing habitat in Stephens Lake during summer.

Foraging Habitat

No adult/juvenile lake whitefish (greater than 100 mm) were captured during the summer index gillnetting program, indicating that the Gull Rapids Area is not important as foraging habitat for the species.

Overwintering Habitat

Limited data exist for the overwintering use of the Gull Rapids reach by lake whitefish. Due to the relatively high water velocities in the Gull Rapids area, most lake whitefish likely overwinter in Stephens Lake. Only one of the radio-tagged lake whitefish that was released below Gull Rapids was relocated during winter tracking flights; it was observed in eastern Stephens Lake (described in Section 5.3.2.4).

5.3.2.4 Stephens Lake Area

Stephens Lake (excluding the riverine section below Gull Rapids; Map 5-15) was sampled intensively with small mesh and standard gang index gill nets during the summer from 2002 to 2003 (Map 5-16; Appendix 5B). Prior to Keeyask environmental studies, the Kettle reservoir was sampled with standard gang index gill nets during the summer in 1999. Sampling to address use of the area by spring and fall spawners was conducted between 2001 and 2006 in the riverine sections of this area, including the inflowing sections of the North and South Moswakot Rivers, using a variety of equipment as described in Appendix 5B. Fish use of main basin and bay habitat was assessed in the north arm of Stephens Lake during the summer of 2005 using small mesh gill nets and the two smallest panels from a standard gang index gill net. To assess fish drift out of Stephens Lake, the drifting fish community downstream of the Kettle GS was quantified during the open-water season of 2003 and 2004.

A total of 23 fish species were captured in the Stephens Lake Area from 1999 to 2006 (Table 5-1). Lake sturgeon was among the species captured during Keeyask environmental studies and is discussed separately in Section 6. During the summer, the most abundant large-bodied species in the lake were walleye, northern pike, and white sucker (Table 5-13). The CPUE for the total catch in Stephens Lake was considerably higher in the north arm compared to the old Nelson River channel, but there was little difference in the use of nearshore and offshore habitat for foraging in either area (Table 5-14). Several large-bodied species were found spawning in the Stephens Lake area: white sucker, walleye, northern pike, and lake whitefish in the South Moswakot River; yellow perch, walleye, northern pike, and lake whitefish in the North Moswakot River; and cisco and burbot in Stephens Lake. Likewise, Members of FLCN have reported that the North and South Moswakot Rivers and Looking Back Creek provide spawning habitat to walleye, northern pike, lake whitefish, sauger, and sucker (FLCN 2010 Draft).

With respect to forage species, spottail shiner, trout-perch, and rainbow smelt were the most abundant species in Stephens Lake during the summer (Table 5-15). Emerald shiner were also abundant in Stephens Lake, but were only common in surface-set nets (Table 5-16). Forage fish were most abundant in offshore habitat in the north arm of the lake and in nearshore habitat in the old Nelson River channel (Table 5-14). In comparison, they were relatively uncommon in offshore habitat in the old Nelson River channel, which was likely a reflection of these sites being the only ones fished in the lake that were characterized by moderate water velocity. Cyprinids were observed to have spawned in the North Moswakot River. A number of forage species, primarily emerald shiner and rainbow smelt, were captured in drift traps set in the Nelson River below the Kettle GS in 2003 and 2004. However, it is unclear whether these fish originated from this section of the river or drifted downstream out of Stephens Lake.

Habitat modelling studies conducted in the north arm of Stephens Lake during 2005 showed that the overall species diversity and abundance of fish in flooded main basin and bay areas were similar during the summer (Table 5-17). Mooneye, lake chub, and slimy sculpin, though captured relatively infrequently, were only captured at sites located in the main basin. Capture rates for trout-perch and both mature and immature walleye were higher in the main basin compared to the bays. In contrast, yellow perch were more frequently captured in flooded bays. Fish capture rates and diversity were relatively similar among the four habitat types sampled in flooded bays, but were higher in the main basin in shallow water habitat, regardless of macrophyte presence or absence, compared to deep, open water areas.

No commercial fishery was reported on Stephens Lake between 1997 and 2008 (FFMC *unpubl. data*). However, one Gillam resident holds an experimental license for Stephens Lake that authorizes harvesting for local sale. This fishery produces 100–300 pounds of fillets of walleye per day for 10 weeks. Northern pike are captured incidentally as part of this commercial harvest (FLCN 2010 Draft).

Domestic harvest also occurs in the area. The FLCN resource users harvests throughout Stephens Lake, notably the northern and western portions (FLCN 2010 Draft). However, many FLCN Members will not eat fish from Stephens Lake due to the poor quality of the fish fillets and fear that the meat is 'polluted' (FLCN 2010 Draft). Ferris Bay is a notable location for the FLCN to harvest lake whitefish, and to a lesser extent, walleye. Walleye are harvested by FLCN in large numbers at Looking Back Creek during the spring run immediately after the thaw. Recreational fishing occurs in locations that are easily accessible by boat or road (*e.g.*, on Stephens Lake by the Gillam marina, North and South Moswakot rivers by the highway).

A detailed analysis of VEC species is presented in the following sections.

5.3.2.4.1 Walleye

Distribution and Abundance

Walleye are found throughout the Stephens Lake area. The results of the index gillnetting programs indicated that this species is an important component of the fish community of Stephens Lake, accounting for approximately 36% of the index gillnet catches in 2002 and 2003 (Map 5-3). Although the proportion of walleye in the 2003 catch (28%) was lower than in 2002 (40%), the CPUE for the species was relatively constant between years, ranging from 7.1 to 8.6 walleye/100 m/24 h (Map 5-4). Walleye were relatively uncommon in the small mesh index gillnet catch, accounting for 2.3–4.1% of the catch in bottom-set nets in 2002 and 2003.

Walleye were captured in all of the tributaries of Stephens Lake that were fished as part of the environmental studies. During the spring, walleye accounted for a higher proportion of the combined catch in the North Moswakot River (17%) compared to the South Moswakot River (8%). At both rivers, walleye were more frequently captured in gill nets, which were set near Stephens Lake (22–47% of the catch), than in hoop nets, which were set in the upstream reaches (0.3–16%). Comparatively fewer walleye were captured in either river during the fall (less than 3% of the combined catch).

Habitat Use

Spawning Habitat

Keeyask environmental studies provided evidence that walleye potentially spawn at several locations within the Stephens Lake Area (Appendix 5D).

It is probable that walleye spawn in the North and South Moswakot Rivers as walleye in spawning condition were captured in both rivers during the spring of 2003. Data collected suggest that walleye spawn in the upper reaches of these tributaries, although it is not possible to identify an exact spawning location in either river as larval walleye were not captured in the drift nets set in the upstream reaches of these rivers. As discussed in Section 5.3.2.5.1, walleye were also observed spawning in Looking Back Creek during the spring stream crossing assessment.

Resource users from FLCN report that walleye likely spawn in Stephens Lake in the far corner of Ferris Bay and leave the area after spawning (FLCN 2010 Draft). Very few walleye in spawning condition were captured in Stephens Lake main during the spring tagging programs. A few pre-spawn and ripe fish were captured in 2003 and 2006 at sites located along the south shore of the lake approximately 5 km from Gull Rapids. While it is possible that walleye may spawn in this area, it is more likely that these fish were moving to Gull Rapids to spawn. As described in Section 5.3.2.3.2, Gull Rapids is believed to provide important spawning habitat to walleye populations in Stephens Lake.

Rearing Habitat

Twenty-one YOY walleye (less than 120 mm) were captured as part of the small mesh index gillnetting program in nearshore habitat in the north arm and the old Nelson River channel of Stephens Lake. The sites where YOY walleye were captured were characterized by shallow, low velocity water and soft substrates, with and without macrophyte cover.

An additional three YOY walleye were captured in drift traps set in the Nelson River downstream of the Kettle GS during late July 2004; however, it is unclear whether these fish originated in this stretch of the river or if they had drifted downstream from Stephens Lake.

Foraging Habitat

During the summer, adult/juvenile walleye (greater than 120 mm) were considerably more abundant in the north arm of Stephens Lake compared to the old Nelson River channel, but there was little difference in the use of nearshore and offshore habitat for foraging in either area (Table 5-14). In the north arm of Stephens Lake, adult/juvenile walleye were captured almost exclusively at sites located in flooded main basin during summer 2005 and were rarely captured at sites located in either Ross Wright or O'Neil bays (Table 5-17). In the main basin, they showed a preference for habitat characterized by macrophytes.

Overwintering Habitat

Telemetry studies conducted during the winter of 2002 and 2003 located two walleye in a bay on the south shore of Stephens Lake located approximately 5 km downstream of Gull Rapids, and three walleye in area south of an island cluster approximately 5 km from the Butnau River, suggesting that Stephens Lake provides suitable overwintering habitat for walleye (Map 5-17).

5.3.2.4.2 Northern Pike

Distribution and Abundance

Northern pike is a common species throughout the Stephens Lake area. Index gillnetting studies indicated that northern pike are an important component of the Stephens Lake fish community, accounting for up to 36% of the standard gang index gillnet catches in 2002 and 2003 (Map 5-5). The mean CPUE was consistent between years, ranging from 6.8 to 9.0 northern pike/100 m/24 h (Map 5-6). Northern pike were infrequently captured in small mesh index gill nets set in Stephens Lake in 2002 and 2003, with an average CPUE of 1.4 northern pike/30 m/24 h.

Northern pike were captured in all of the tributaries of Stephens Lake that were fished as part of Keeyask environmental studies. During the spring and fall, northern pike were commonly captured throughout both the North and South Moswakot Rivers, making up 33–72% of the combined catches at each river. During the spring of 2005, northern pike were also captured in Looking Back Creek and in the spring of 2006, one northern pike was captured in Blood Creek, a tributary of the South Moswakot River.

Habitat Use

Spawning Habitat

Keeyask environmental studies provided evidence that northern pike potentially spawn at several locations within the Stephens Lake Area (Appendix 5D).

Spawning habitat for northern pike likely exists in the North and South Moswakot Rivers as a few northern pike in spawning condition were captured in both rivers during the spring of 2003. However, it was not possible to identify an exact spawning location in either river as larval northern pike were not captured in the drift nets set in the upstream reaches of these rivers. As discussed in Section 5.3.2.5.1, northern pike in spawning condition were also observed in Looking Back Creek during the spring stream crossing assessment.

As described in Section 5.3.2.3.2, northern pike populations in Stephens Lake are also thought to use habitat in Gull Rapids for spawning.

Rearing Habitat

The capture of YOY northern pike (less than 150 mm) in small mesh gill nets in the old Nelson River channel of Stephens Lake was restricted to nearshore habitat, where they were primarily found at sites characterized by shallow, low velocity waters, soft substrates, and macrophyte cover. In the north arm of Stephens Lake, YOY northern pike were captured at sites located in both flooded main basin and flooded bays, where they were more frequently captured in habitat with structure (macrophytes/woody debris).

Foraging Habitat

During the summer, adult/juvenile northern pike (greater than 150 mm) were considerably more abundant in nearshore habitat in both the north arm of Stephens Lake and the old Nelson River channel (Table 5-14). However, they were relatively uncommon in offshore habitat in old channel. In the north arm of Stephens Lake, northern pike were captured at sites located in both flooded bays (Ross Wright and O'Neil) and main basin (Table 5-17). At both locations, they were most common in habitat with structure (macrophyte/woody debris) and were rarely captured in open, deep water habitat.

Overwintering Habitat

There are limited data on the use of Stephens Lake for overwintering by northern pike as none of the radio-tagged fish were released downstream of Gull Rapids. However, it is expected that Stephens Lake provides ample overwintering habitat for northern pike because it has numerous off-current bays with low water velocity, which is the preferred habitat of northern pike during winter based on telemetry studies conducted in the Nelson River between Clark Lake and Gull Rapids (Section 5.3.2.3.1).

5.3.2.4.3 Lake Whitefish

Distribution and Abundance

Although lake whitefish occur throughout the Stephens Lake area, data collected as part of the index gillnetting program in Stephens Lake in the summer of 2002 and 2003 indicated that lake whitefish are not a major component of the fish community, never accounting for more than 10% of the catch (Map 5-7). CPUE values were generally consistent among sampling years, ranging from 1.7 to 2.0 lake whitefish/100 m/24 h (Map 5-8). Very few lake whitefish were captured in small mesh index gill nets set in the lake.

Lake whitefish were only captured incidentally in hoop nets set during the fall in the upper reaches in the North Moswakot River (1% of the catch) and South Moswakot River (3%). They were more abundant in the gillnet catches in the lower reaches of both rivers (33% and 58%, respectively) at this time. During the spring, lake whitefish were more common in the lower reach of the South Moswakot River (19%) than in the North Moswakot River (9%).

Habitat Use

Spawning Habitat

Keeyask environmental studies provided evidence that lake whitefish potentially spawn within the Stephens Lake Area (Appendix 5D).

Lake whitefish may spawn in the North and South Moswakot Rivers as several lake whitefish in spawning condition were captured in both rivers during the fall of 2002 and 2003. However, it was not possible to identify an exact spawning location in either river as larval lake whitefish were not captured in the drift nets set in the upstream reaches of these rivers.

Several larval lake whitefish were captured in neuston tows throughout the south channel of Stephens Lake during spring in 2001 to 2004. This observation, combined with the absence of larvae in tows conducted in the northern portion of the lake near Looking Back Creek, suggests that these larvae may have drifted downstream into the lake from Gull Rapids. A few lake whitefish that were preparing to spawn were captured in Stephens Lake between the north basin and the main channel during the fall gillnetting program in 2002, but it is likely that these fish were moving to Gull Rapids to spawn. As described in Section 5.3.2.3.2, Gull Rapids is believed to provide important spawning habitat to lake whitefish populations in Stephens Lake. Resource users from FLCN have reported that lake whitefish spawn along reefs and islands throughout Stephens Lake, in Ferris Bay and lake whitefish at Looking Back Creek (FLCN 2010 Draft).

Several *Coregonus* spp. larvae that could not be identified to species were captured in drift traps set in the Nelson River below the Kettle GS on 30 June 2004. If these larvae were lake whitefish, it is possible that they were not spawned in this reach of the river, but rather drifted downstream from Stephens Lake.

Rearing Habitat

It is unclear where rearing habitat for lake whitefish occurs in Stephens Lake as only one YOY lake whitefish (less than 100 mm) was captured in the lake. This fish was located in offshore habitat approximately 2 km upstream of the Kettle GS.

Foraging Habitat

During the summer, adult/juvenile lake whitefish (greater than 100 mm) were considerably more abundant in the north arm of Stephens Lake compared to the old Nelson River channel in both nearshore and offshore habitat (Table 5-14). In the north arm, they were about two to ten times more abundant in deep open water habitat in flooded main basin areas than in any other habitat type sampled (Table 5-17).

Overwintering Habitat

Only one of the radio-tagged lake whitefish that was released below Gull Rapids was relocated during winter tracking flights. During the winter of 2002, this fish was located on multiple occasions in an area along the south shore of Stephens Lake approximately 5 km upstream of the Kettle GS, suggesting that Stephens Lake provides suitable overwintering habitat for lake whitefish.

5.3.2.5 Access Roads Stream Crossings

Five streams will be crossed by the north and south access roads. The construction of the north access road was assessed in the Keeyask Infrastructure Project Environmental Assessment Report (KIP EA). The current assessment considers the operation of the north access road stream crossings and the construction and operation of the south access road stream crossings. Fish use of the streams potentially crossed by the proposed Keeyask access roads (Map 5-18) was assessed during the fall of 2004 and again in the spring of 2005 using a variety of equipment as described in Appendix 5B. A description of fish use of the tributaries at the potential north and south access road crossing sites is provided for each tributary below.

5.3.2.5.1 North Access Road

Looking Back Creek

No fish were captured in Looking Back Creek during the fall 2004 electrofishing survey. A total of seven walleye and 54 northern pike were captured in a hoop net oriented to capture fish moving upstream at the crossing site during spring 2005. The majority of northern pike females were ready to spawn and none were in post-spawning condition. In contrast, both to ready-to-spawn and post-spawn males were captured. One northern pike egg was captured in a kick net sample at the crossing. All of the walleye males were ready to spawn, as was the one female for which maturity could be determined. The capture of northern pike and walleye in spawning condition suggests that these fish were moving to spawning habitat further upstream in Looking Back Creek, while the presence of some northern pike in post-spawn condition suggests that spawning may also take place further downstream.

The stream crossing location is in close proximity to Stephens Lake, with no barriers to fish passage downstream. At the time of the spring survey, the nearest upstream barrier to fish passage was a beaver dam located approximately 2 km upstream, from which point beaver dams were present into the headwaters of the creek. The diversity of habitat and size of the stream likely means that it provides spawning, foraging, and rearing habitat for a number of both small- and large-bodied spring and summer spawning species. However, this creek maintains little to no flow in the winter and therefore is not suitable for fall spawning species such as lake whitefish. It would appear that the crossing location may provide overwintering habitat for small- and large-bodied fish species in some years but not in others. It is expected that cyprinids and suckers may also use this site for feeding and rearing. This site is not expected to support spawning habitat for walleye or suckers, but northern pike may spawn along the margins of the channel. As described in the KIP EA, this stream will be crossed by a clear span bridge with no effect to fish use of the tributary.

Unnamed Tributary of South Moswakot River

No fish were captured in the tributary either during the fall 2004 or spring 2005 electrofishing surveys. The presence of numerous beaver dams along the Unnamed Tributary likely inhibits fish passage to the stream crossing location from the pond upstream of the crossing and from areas downstream. At the stream crossing location, the Unnamed Tributary may provide some habitat for small-bodied species such as brook stickleback and fathead minnow during the open-water season, although access to the site likely is difficult. The pond located approximately 1 km upstream of the stream crossing location was found to contain some water with little oxygen. The dissolved oxygen concentration of 1.7 milligrams per liter (mg/L) was well below Manitoba's Water Quality Standards, Objectives and Guidelines instantaneous minimum objective of 3 mg/L for the protection of mature life stages of cool-water aquatic life in winter (Williamson 2002). When the crossing was assessed in February 2009, the Unnamed Tributary was frozen to the bottom.

Large-bodied species such as northern pike are not expected to make use of the Unnamed Tributary at the stream crossing location due to numerous beaver dams impeding passage and the distance from potential overwintering sites. If small-bodied fish are present in the area (*e.g.*, brook stickleback and fathead minnow), it is likely that the habitat at the site could be used only for feeding and rearing, with deeper pools outside of the ROW being used as overwintering habitat. The Unnamed Tributary at the stream crossing location does not appear to support any potential spawning or overwintering habitat. As described in the KIP EA, this stream will be crossed by a culvert, with riprap to stabilize the banks on either side. The installation of this culvert is not expected to have altered fish use of this tributary.

5.3.2.5.2 South Access Road

Gull Rapids Creek

One adult white sucker was captured in Gull Rapids Creek during the fall 2004 electrofishing survey. Due to the presence of numerous beaver dams within the stream, it is likely that this fish was part of a population confined to the upper reaches of the creek. Although no small-bodied species were captured, species such as brook stickleback and fathead minnow are expected to occur in this creek as they have been recorded both upstream and downstream of the crossing site (described in Gull Rapids discussion in Section 5.3.2.3.2). Longnose sucker, fathead minnow, emerald shiner, and brook stickleback were captured during the summer sampling of the unnamed headwater lake of Gull Rapids Creek, which is located approximately 1 km upstream of the crossing site. Fish are believed to reside year-round in this lake and may move downstream to the crossing site if passage permits.

Following the spring freshet, flow is minimal. Stagnant conditions with ponded water occurred along the creek due to the presence of beaver dams and the low stream gradient and broad floodplain. When the crossing was assessed in March 2005, Gull Rapids Creek was frozen to the bottom.

Small-bodied species of fish, such as brook stickleback and fathead minnow, may use the creek in the crossing area for spawning and rearing, but move to deeper pools to overwinter. Fish passage from the Nelson River to the crossing site is unlikely due to the presence of beaver dams, as is passage further upstream to the headwater lake. However, if passage exists during spring, fish from the Nelson River may move upstream to forage and spawn, and fish such as brook stickleback and fathead minnow from the headwater lake may move downstream to use habitat at the crossing site during spring and summer.

Unnamed Tributary of Stephens Lake

No fish were captured during either fall 2004 or spring 2005 electrofishing surveys. This creek receives minimal flow following the spring freshet and would be expected to freeze to the bottom during winter. Fish access to a small lake upstream is affected by the presence of beaver dams; however, access to Stephens Lake, approximately 400 m downstream, is uninhibited. Large-bodied species such as northern pike are not expected to make use of this creek near the ROW due to the shallow water depth and small size of the creek. Small-bodied species, such as brook stickleback, may use the creek in the crossing area for spawning and rearing, but move to deeper pools to overwinter.

Gillrat Lake Creek

One juvenile northern pike was captured during the fall 2004 fall electrofishing survey. No fish were captured during the spring 2005 sampling period. This creek drains bogs and fens as well as Gillrat Lake. It maintains flow through the open-water season, but likely freezes to the bottom in winter. Numerous beaver dams restrict upstream fish passage to Gillrat Lake; downstream of the crossing location, the creek was not impacted by dams or other impasses. Thus, fish from Stephens Lake have access to the creek at the road. Habitat at the site is most suited to species such as longnose dace that prefer flowing water over coarser substrates. Species that prefer slower flowing waters with abundant instream vegetation, such as northern pike, may move through the ROW to area to access ponded water upstream of the crossing site for spawning, foraging, and rearing. Overwintering within the creek would be limited to deeper pool areas located upstream of the ROW and be limited to species tolerant of stagnant conditions and low dissolved oxygen levels.

5.3.2.6 Fish Movements

This study was conducted to determine to what extent large-bodied VEC species move within and among the different areas of the study area. Of particular interest were movements over Gull Rapids and Long Rapids. Information on the movement of walleye, northern pike, lake whitefish, and lake sturgeon was obtained from the recapture of large numbers of individually Floy®-tagged fish and through repeated tracking of a relatively small number of fish implanted with radio- or acoustic-transmitters (Appendix 5B). A detailed analysis of the movements of each VEC species is presented below, with the exception of lake sturgeon, which is presented separately in Section 6.

5.3.2.6.1 Walleye

A total of 5,472 walleye were Floy®-tagged within the study area between 1999 and 2005 (Table 5-18). Of these fish, 996 walleye were recaptured one or more times between 2001 and 2008 for a total of 1,036 recaptures. Thus, the recapture rate for individual walleye in the study area was 18.2%. Local resource harvesters accounted for the majority of these recaptures (811 walleye), for a total harvest rate of 14.8%.

Thirty walleye were implanted with radio transmitters during the spring and fall of 2001 and released in the Nelson River between Birthday Rapids and Gull Rapids, and in Stephens Lake downstream of Gull Rapids; 29 were relocated at least once between 2001 and 2004 (Table 5-19). An additional 56 walleye implanted with acoustic transmitters were released below the Kelsey GS following turbine passage studies and monitored in the reach between the GS and Split Lake over the open-water seasons of 2006 and/or 2008 (North/South Consultants Inc. [NSC] and Normandeau Associates Inc. 2007, 2009).

Use of the Study Area

Floy®-tagging studies showed that there was little movement of walleye between the Split Lake area, the reach of the Keeyask Area between Clark Lake and Gull Rapids, and Stephens Lake/Gull Rapids areas (Map 5-19). Although walleye generally remained in the same waterbody in which they were tagged, some were observed to move between waterbodies and pass through the generating stations (or spillways) along the lower Nelson River.

The majority of walleye Floy®-tagged in the Aiken River system were recaptured in the same waterbody in which they were tagged (Table 5-18). However, Floy®-tagged walleye were frequently recaptured in waterbodies of the Aiken River system other than the one in which they were originally tagged, suggesting that walleye move freely between the Aiken, Ripple, and Mistuska Rivers and the York Landing arm of Split Lake. Two walleye Floy®-tagged in the Aiken River system were found as far upstream as the Nelson River in vicinity of the Kelsey GS. None of the fish in the Aiken River system were recaptured downstream of Split Lake. All of the walleye recaptured in the Aiken River system during the spring spawning surveys (2002, 2003, and 2004) had been tagged in the system, indicating that walleye from the Keeyask Area do not migrate to the Aiken River to spawn (Table 5-20). Likewise, all of the walleye captured in the fall survey (2004) had been tagged in the Aiken River system. This result suggests that there is a resident population of walleye in the tributaries of the Aiken River system. The recapture of several walleye that had been Floy®-tagged in the Ripple, Aiken, and Mistuska Rivers by local harvesters in Split Lake throughout the open-water season suggests that many of the walleye that spawn in the Aiken River system return to Split Lake. The capture of one such walleye during winter indicates that some of these walleye may also overwinter in the Split Lake.

Floy®-tagging studies indicated that walleye move freely among the waterbodies of the Assean River system. In total, 13 of the walleye tagged in the Assean, Crying, or Hunting Rivers were recaptured in the same river in which they were tagged, and six of the walleye had moved among these rivers. Several of the walleye Floy®-tagged in these tributaries were recaptured in Assean Lake, Clark Lake, and Split Lake. Some walleye tagged within the Assean River system displayed larger movements. One fish that was tagged in the Assean River was recaptured at the confluence of the Nelson and Grass Rivers in the vicinity of the Kelsey GS. A single walleye tagged in the Assean River system was relocated downstream of Clark Lake. This fish was tagged in the Hunting River and was recaptured by a local resource user over 100 km downstream in the North Moswakot River. All of the walleye recaptured in the Assean River system during the spring spawning surveys (2001 and 2002) and fall surveys had been tagged in the system, indicating that walleye from the Keeyask Area do not make use of habitat in the Assean River system (Table 5-20).

Telemetry studies conducted below the Kelsey GS showed that the majority of walleye tracked during the open-water season tracked made extensive movements between the Grass River and the Nelson River between the GS and Split Lake (NSC and Normandeau Associates Inc. 2007, 2009). Immediately after release, several of the walleye appeared to have moved out of the area monitored and are thought to have moved further downstream into Split Lake. Some of the walleye appeared to show an affinity to the location or habitat in which they were initially captured prior to turbine passage. Few of the walleye Floy®-tagged in the vicinity of the Kelsey GS were recaptured. Of the fish that were recaptured, three were relocated close to their tagging location, and one was recaptured by local harvester in Split Lake (Table 5-18).

Only one Floy®-tagged walleye was recaptured during fish community studies in Split Lake (2001–2002, 2005–2006). This fish had been tagged in the Nelson River between Birthday Rapids and Gull Lake and represented 2.0% of the walleye that had been Floy®-tagged in the reach between Clark Lake and Gull Rapids at the time of its capture. Of Floy®-tagged walleye reported harvested from Split Lake by local resource users, the majority had been tagged in the Aiken River and Mistuska River and, to a lesser extent, from the Burntwood River, Assean River, Ripple River, Clark Lake, and Split Lake.

Few walleye that were Floy®-tagged within the Nelson River between Clark Lake and Gull Rapids were recaptured (Table 5-18) and none of the Floy®-tags reported harvested by local resources users were captured in this reach. Many of the Floy®-tagged fish that were recaptured were located within this reach, with fish showing movement between the Gull Lake and the Nelson River. Likewise, most of the radio-tagged walleye relocated above Gull Rapids remained in Gull Lake throughout the year. Several of these individuals did move out of the lake and moved toward Birthday Rapids in some years during spring, but only one fish was ever relocated above these rapids. Two radio-tagged walleye were detected on multiple occasions throughout the year in the Nelson River in the vicinity of Two Goose Creek. Some of the walleye Floy®-tagged within this reach showed larger movements. Five walleye were recaptured in the Split Lake area, two in the Burntwood River and three in Split Lake or Assean Lake. One Floy®-tagged walleye moved downstream out of Gull Lake and was recaptured in the Nelson River near Deer Island, a movement of approximately 175 km. This fish passed downstream through three generating stations (Kettle, Limestone, and Long Spruce). One of the radio-tagged walleye also moved downstream out of Gull Lake into Stephens Lake; this movement occurred during spring. All but one of the walleye recaptured in the Nelson River between Clark Lake and Gull Rapids during the spring spawning surveys (2001–2004, 2006, and 2008) had been tagged in the reach (Table 5-20). The recapture of a single walleye that had been tagged in Stephens Lake, representing 0.1% of the walleye Floy®-tagged below Gull Rapids, is suggestive that walleye do not typically move upstream through Gull Rapids to spawn in the Nelson River. All of the walleye recaptured during surveys conducted later in the open-water season (2001–2004, 2006–2008) had been tagged in the Nelson River.

The majority of walleye that had been Floy®-tagged the Gull Rapids and Stephens Lake areas were recaptured in the same waterbody in which they were tagged (Table 5-18). However, Floy®-tagging studies showed that walleye move between the North and South Moswakot Rivers and Stephens Lake. A single walleye that had been Floy®-tagged immediately downstream of Gull Rapids during spring, was recaptured two years later upstream of Gull Rapids in Gull Lake. All of the radio-tagged walleye released in Stephens Lake were relocated in subsequent years in the lake. One of these fish was detected as far north as the South Moswakot River, and a few individuals were relocated in an area of the lake near the Butnau dam. During the spring, many of the radio-tagged walleye were relocated at the base of the Gull Rapids, one fish in consecutive years, suggesting that this area is used for spawning. The recapture of several walleye that had been Floy®-tagged during the spring immediately below Gull Rapids later in the open-water season of subsequent years further downstream in Stephens Lake, indicates that walleye move downstream into Stephens after spawning in the rapids. The recapture of a walleye Floy®-tagged in Stephens Lake in the South Moswakot River during the spring spawning surveys (Table 5-20) suggests that a portion of the walleye in Stephens Lake use habitat in this tributary for spawning. None of the walleye that had been Floy®-tagged upstream of Gull Rapids were captured during any of the open-water surveys in the Stephens Lake or Gull Rapids areas (Table 5-20), suggesting that habitat in this reach is not typically used by walleye populations inhabiting the Nelson River above Gull Rapids.

Movements Over Large Rapids

Mark/recapture and telemetry studies have shown that walleye are capable of making both upstream and downstream movements through Long Rapids, Birthday Rapids, and Gull Rapids (Map 5-19; Table 5-19).

Gull Rapids

None of the walleye Floy®-tagged and recaptured during the spring and fall of 2001 and 2002 in Gull Lake (upstream to approximately 15 km of Gull Rapids) and Stephens Lake (downstream to approximately 10 km of Gull Rapids) were observed to have moved over Gull Rapids (Table 5-21). Limiting the mark-recapture studies to this period and geographical area ensures that sampling effort upstream and downstream of the rapids was approximately equal. In contrast, several walleye were recaptured during this time on the same side of Gull Rapids on which they were tagged.

When the dataset is expanded to include all fish Floy®-tagged in the study area, and all subsequent recaptures that occurred between 2001 and 2008, several of the Floy®-tagged walleye were observed to have moved downstream through Gull Rapids (Table 5-22). However, the number of walleye to cross Gull Rapids remains low compared to the number of walleye that were recaptured on the same side of the rapids. In total, four Floy®-tagged walleye were observed to have moved downstream over Gull Rapids. Three of these fish were recaptured by local harvesters in Stephens Lake or its tributaries and the other was recaptured by a local harvester 175 km downstream in the Nelson River near Deer Island. Only one Floy®-tagged walleye was observed to have passed upstream through Gull Rapids. This fish was recaptured in Gull Lake two years after it had been Floy®-tagged in Stephens Lake.

The movement of fish implanted with radio-transmitters during telemetry studies was similarly low (Table 5-19). Only a single radio-tagged walleye was observed to have moved downstream through Gull Rapids during the three years of monitoring. This fish passed downstream into Stephens Lake during the spring of 2002 where it was detected multiple times. None of the walleye released downstream of Gull Rapids was relocated upstream of the rapids.

Birthday Rapids and Long Rapids

Few of the Floy®-tagged or radio-tagged walleye were observed to have passed through either Birthday Rapids or Long Rapids. One Floy®-tagged walleye moved downstream through Birthday Rapids; it had been tagged in Clark Lake and was recaptured in the Nelson River below Birthday Rapids. An additional Floy®-tagged walleye that was recaptured by a local harvester in the North Moswakot River that had passed downstream through both Long and Birthday rapids, as well as Gull Rapids, from its tagging location in the Hunting River four years prior. One Floy®-tagged and one radio-tagged walleye moved upstream over Birthday Rapids. The radio-tagged fish crossed Birthday Rapids during spring and remained in the Nelson River upstream of the rapids where it was subsequently detected multiple times throughout the year. An additional five Floy®-tagged walleye moved upstream over both Birthday and Long rapids; two were recaptured in the Burntwood River and three in Split Lake or Assean Lake.

5.3.2.6.2 Northern Pike

A total of 7,995 Floy®-tags were applied to northern pike in the study area between 1999 and 2005 (Table 5-23). Of these fish, 408 fish were recaptured one or more times between 2001 and 2008 for a total of 420 recaptures. The recapture rate of individual northern pike in the study area was 5.1%. A large proportion of northern pike recaptures were by local resource users, for a total harvest rate of 2.3% for the species.

All of the 14 northern pike tagged with radio transmitters during the spring and fall of 2001 in the Nelson River between Birthday Rapids and Gull Rapids, including Gull Lake, were relocated at least once between 2001 and 2004 (Table 5-24). An additional 58 northern pike implanted with acoustic transmitters were released below the Kelsey GS following turbine passage studies and monitored in the reach between the GS and Split Lake over the open-water seasons of 2006 and/or 2008 (NSC and Normandeau Associates Inc. 2007, 2009).

Use of the Study Area

Floy®-tagging studies showed that there was little movement of northern pike between the Split Lake area, the reach of the Keeyask Area between Clark Lake and Gull Rapids, and Stephens Lake/Gull Rapids areas (Map 5-20). Although northern pike generally remained in the same waterbody in which they were tagged, some were observed to move between waterbodies and pass through the generating stations (or spillways) along the lower Nelson River.

The majority of northern pike Floy®-tagged in the Aiken River system were recaptured in the same waterbody in which they were tagged (Table 5-23). However, Floy®-tagged northern pike were frequently recaptured in waterbodies of the Aiken River system other than the one in which they were originally tagged, suggesting that northern pike move freely between the Aiken, Ripple, and Mistuska Rivers and the York Landing arm of Split Lake. Two northern pike Floy®-tagged in the Aiken River system were found as far upstream as the Nelson River in vicinity of the Kelsey GS. None of the fish in the Aiken River system were recaptured downstream of Split Lake. All of the northern pike recaptured in the Aiken River system during the spring spawning surveys (2002, 2003, and 2004) had been tagged in the system, indicating that northern pike from the Keeyask Area do not migrate to the Aiken River to spawn (Table 5-25). Likewise, all of the northern pike captured in the fall survey (2004) had been tagged in the Aiken River system. This result suggests that there is a resident population of northern pike in the tributaries of the Aiken River system. The recapture of several northern pike that had been Floy®-tagged in the Ripple, Aiken, and Mistuska Rivers by local harvesters in Split Lake throughout the open-water season suggests that many of the northern pike that spawn in the Aiken River system return to Split Lake.

Likewise, the Floy®-tag data indicated that northern pike move freely among the tributaries of the Assean River system and nearby lakes (Assean, Clark, and Split). Two northern pike tagged within the Assean River system displayed larger movements. Between spring of 2002 and 2003, one northern pike moved from the Hunting River to the Aiken River and the other moved from the Assean River downstream into the Nelson River below Birthday Rapids. All of the northern pike recaptured in the Assean River system during the spring spawning surveys (2001 and 2002) and fall surveys had been tagged in the system, indicating that northern pike from the Keeyask Area do not make use of habitat in the Assean River system (Table 5-25). The recapture of several northern pike that had been Floy®-tagged in the tributaries of the Assean River system during spring downstream in Split and Clark lakes during the summer and fall suggests that many of the northern pike that spawn in the Assean River system move downstream to these lakes after spawning. The capture of two such northern pike during winter indicates that some of these northern pike overwinter in the Split Lake. However, some proportion of northern pike that spawn in the Assean River move upstream into Assean Lake after spawning as evidenced by the recapture of several fish there later in the open-water season that had been tagged in the Assean River during spring.

Few of the northern pike Floy®-tagged in the Nelson River downstream of the Kelsey GS or in the Burntwood/Odei Rivers were recaptured (Table 5-23). Only one northern pike was recaptured during fish community studies in these rivers (2001–2002, 2005–2006, 2007) and it was located in proximity to its tagging location (Table 5-25). Local harvesters reported catching four of the northern pike tagged in the Burntwood or Nelson Rivers in Split Lake, suggesting that northern pike move between these tributaries and Split Lake. Likewise, telemetry studies conducted below the Kelsey GS showed that the majority of northern pike that were tracked made extensive movements during the open-water season between the Grass River and the Nelson River between the GS and Split Lake (NSC and Normandeau Associates Inc. 2007, 2009). Immediately after release, several of the northern pike appeared to have moved out of the area monitored and are thought to have moved further downstream into Split Lake. Some of the northern pike appeared to show an affinity to the location or habitat in which they were initially captured prior to turbine passage.

Only one Floy®-tagged northern pike was recaptured during fish community studies in Split Lake (2001–2002, 2005–2006); this fish had been tagged in the Aiken River (Table 5-25). Of Floy®-tagged walleye reported harvested from Split Lake by local resource users, the majority (greater than 75%) had been tagged in the Ripple River, Split Lake, and Aiken River and, to a lesser extent, from the Assean River (10%), Nelson River between Birthday Rapids and Gull Rapids (5%), Burntwood River (3%), Nelson River downstream of Kelsey GS (3%), and Nelson River between Gull Rapids and Stephens Lake (2%).

All of the northern pike recaptured in Clark Lake during the open-water surveys (2002, 2004–2006) had been tagged in either Clark Lake or the Assean River (Table 5-25). Although most of the northern pike that had been tagged in Clark Lake were recaptured in the lake, one northern pike was recaptured during the spring in the Assean River and another moved from Clark Lake approximately 140 km downstream into the Nelson River near Swift Creek between June of 2004 and August of 2005, and had passed through three generating stations (Kettle, Long Spruce, and Limestone) or their spillways.

Few northern pike that were Floy®-tagged within the Nelson River between Clark Lake and Gull Rapids were recaptured (Table 5-23) and only one of the Floy®-tags reported harvested by local resources users was captured in this reach. Many of the Floy®-tagged fish that were recaptured were relocated within this reach, with northern pike showing movement between the Gull Lake and the Nelson River. Likewise, all but one of the northern pike that had been radio-tagged and released within the Nelson River between Clark Lake and Gull Rapids were relocated within this reach. In every season, radio-tagged northern pike were often relocated at, or near the mouths, of smaller tributaries. Some of the marked northern pike within this reach showed larger movements. One of the radio-tagged northern pike and four Floy®-tagged northern pike moved from Gull Lake downstream past Gull Rapids. The radio-tagged northern pike moved downstream through Gull Rapids between 25 November 2002 and 3 April 2003, where it was detected multiple times in the area below the rapids throughout the following year. An additional two northern pike that had been tagged in Gull Lake were later relocated within Gull Rapids during spring of 2003 when water levels were low enough to set gill nets in the rapids. Local resource users reported harvesting nine Floy®-tagged northern pike that had moved upstream out of the Nelson River; four were recaptured in Split Lake or Assean Lake, one in the Nelson River in the vicinity of the Kelsey GS, two in the Aiken River system, one in the Burntwood River, and the other in the Assean River. Three of the radio-tagged northern pike were also observed to have moved into upstream lakes; two into Clark Lake and the other into Assean Lake. All but one of the northern pike recaptured in the Nelson River between Clark Lake and Gull Rapids during the spring spawning surveys (2001–2004, 2006, and 2008) had been tagged in the reach (Table 5-25). The recapture of a northern pike that had been tagged in Assean River, representing less than 0.1% of the northern pike Floy®-tagged above Long Rapids, is suggestive that northern pike do not typically move downstream through Long Rapids to spawn in the Nelson River. None of the northern pike captured during the spring surveys had been tagged below Gull Rapids, indicating that northern pike residing in Stephens Lake do not spawn in the reach above Gull Rapids. All of the northern pike recaptured during surveys conducted later in the open-water season (2001–2004, 2006–2008) had been tagged in the Nelson River.

The majority of northern pike that had been Floy®-tagged the Gull Rapids and Stephens Lake areas that were recaptured were relocated in the same waterbody in which they were tagged (Table 5-23). However, Floy®-tagging studies showed that northern pike move between the North and South Moswakot Rivers and Stephens Lake. One of the northern pike tagged in these waterbodies was reported harvested as far upstream as Split Lake. Another northern pike that had been tagged in Stephens Lake was recaptured approximately 150 km downstream in the Nelson River at the Lower Limestone Rapids. To reach the recapture location, this fish would have to have passed through the three generating stations or their spillways. All of the northern pike recaptured in the North and South Moswakot Rivers during the spring survey (2003) had been tagged in the waterbody in which they were recaptured and none of the northern pike captured in Stephens Lake during the spring surveys (2001–2006) had been tagged in any of the lake's tributaries (Table 5-25). The recapture of several northern pike that had been Floy®-tagged during spring in areas that are thought to be used for spawning (*e.g.*, upstream in the North Moswakot River, immediately below Gull Rapids) later in the open-water season in Stephens Lake suggests that northern pike may move downstream into Stephens Lake after spawning. Three northern pike that had been Floy®-tagged in the Nelson River upstream of Gull Rapids were recaptured during the spring surveys (2001–2006) in the Gull Rapids areas (Table 5-25). These fish represented a maximum of 0.1% of the northern pike that had been Floy®-tagged in the reach between Clark Lake and Gull Rapids at the time of capture, suggesting that habitat in this reach is not typically used by northern pike populations inhabiting the Nelson River above Gull Rapids for spawning.

Movements Over Large Rapids

Radio-telemetry and mark/recapture studies have shown that northern pike are capable of making both upstream and downstream movements through Long Rapids, Birthday Rapids, and Gull Rapids (Map 5-20; Table 5-24).

Gull Rapids

None of the northern pike Floy®-tagged and recaptured during the spring and fall of 2001 and 2002 in Gull Lake (upstream to approximately 15 km of Gull Rapids) and Stephens Lake (downstream to approximately 10 km of Gull Rapids) were observed to have moved over Gull Rapids (Table 5-26). Limiting the mark-recapture studies to this period and geographical area ensures that sampling effort upstream and downstream of the rapids was approximately equal. In contrast, several northern pike were recaptured during this time on the same side of Gull Rapids on which they were tagged.

When the dataset is expanded to include all northern pike Floy®-tagged in the study area, and all subsequent recaptures that occurred between 2001 and 2008, several of the Floy®-tagged northern pike were observed to have moved downstream through Gull Rapids (Table 5-27). However, the number of northern pike to cross Gull Rapids remains low compared to the number of northern pike that were recaptured on the same side of the rapids. In total, five Floy®-tagged northern pike were observed to have moved downstream through Gull Rapids. Four of these fish moved into the Nelson River below Gull Rapids or Stephens from Gull Lake and one northern pike that had been tagged in Clark Lake was recaptured in the Nelson River about 120 km downstream of the Kettle GS near Deer Island. An additional two northern pike that had been Floy®-tagged in Gull Lake were recaptured within the rapids. Only one Floy®-tagged northern pike was observed to have passed upstream through Gull Rapids. This fish was recaptured in Split Lake by a local harvester just over a year after it had been Floy®-tagged in the Nelson River below Gull Rapids.

The movement of northern pike implanted with radio-transmitters during telemetry studies was similarly low (Table 5-24). Only one radio-tagged northern pike was observed to have moved downstream through Gull Rapids during the three years of monitoring. This fish passed downstream into Stephens Lake between late November of 2002 and early April of 2003, and was detected multiple times in the reach below Gull Rapids over the course of the following year.

Birthday Rapids and Long Rapids

Few of the Floy®-tagged or radio-tagged northern pike were observed to have passed through either Birthday Rapids or Long Rapids. Two Floy®-tagged northern pike moved downstream through both Long Rapids and Birthday Rapids; one had been tagged in the Assean River and was recaptured about one year later in the Nelson River downstream of Birthday Rapids and the other had been tagged in Clark Lake and was recaptured approximately 140 km downstream in the Nelson River near Swift Creek. An additional northern pike moved downstream through only Birthday Rapids, it had been tagged in the Nelson River upstream of the rapids and was recaptured the following day in the river below the rapids, but this movement may have resulted from tagging stress. Local resource users reported harvesting 10 Floy®-tagged and one radio-tagged northern pike that had moved upstream over Birthday Rapids and Long Rapids and two more that moved upstream over only Long Rapids. Five of these northern pike were reported harvested from Split Lake, one from Assean Lake, one from the Nelson River in the vicinity of the Kelsey GS, one from the Mistuska River, and one from the Burntwood River. Two of the radio-tagged northern pike that were relocated had also moved upstream through Birthday Rapids and Long Rapids. One of the northern pike was relocated in Gull Lake during May and June of 2002, and, after moving upstream through the rapids, was relocated in Clark Lake on 6 July of that year. Another northern pike, which had last been detected in the Nelson River below Birthday Rapids during July and August of 2003, was recaptured at the outlet of Clark Lake during spring 2004.

5.3.2.6.3 Lake Whitefish

A total of 1,713 lake whitefish were tagged with Floy®-tags in the study area between 1999 and 2004 (Table 5-28). Of these fish, 123 fish were recaptured one or more times for a total of 143 recaptures. The recapture rate of individual lake whitefish in the study area was 7.2%. The harvest rate of Floy®-tagged lake whitefish in the study area was 1.3%.

Of the 30 lake whitefish tagged with either acoustic or radio transmitters during the fall of 2001, 24 were relocated at least once between 2001 and 2004 (Table 5-29).

Use of the Study Area

Floy®-tagging studies showed that there was little movement of lake whitefish between the Split Lake area, the reach of the Keeyask Area between Clark Lake and Gull Rapids, and Stephens Lake/Gull Rapids areas (Map 5-21). Although lake whitefish generally remained in the same waterbody in which they were tagged, some were observed to move between waterbodies and pass through the generating stations (or spillways) along the lower Nelson River.

None of the lake whitefish Floy®-tagged in the Aiken River system were recaptured outside of the system. However, Floy®-tagging studies showed that lake whitefish were able to move freely between the waterbodies within this system. The few lake whitefish recaptured in the Aiken River system during the fall spawning survey (2004) and spring surveys (2002–2004) had been tagged in the system, indicating that lake whitefish from the Keeyask Area do not migrate to the Aiken River to spawn or feed (Table 5-30). The recapture of several lake whitefish that had been Floy®-tagged in the Mistuska River by local harvesters in Split Lake throughout the open-water season suggests that many of the lake whitefish may return to Split Lake after spawning in the river. The capture of five such individuals during winter indicates that some of these lake whitefish may also overwinter in the Split Lake.

Although most of the recaptured lake whitefish that had been Floy®-tagged in the Assean River system were recaptured in the Assean River shortly after being tagged, two lake whitefish tagged in the river were later relocated in Assean Lake. Floy®-tag data also indicated that lake whitefish move between the Assean River and Clark Lake. The furthest downstream movement of a Floy®-tagged lake whitefish in the study area was 63 km, from the tagging location in Assean River into Stephens Lake, between October 2001 and October 2002. All of the lake whitefish recaptured in the Assean River system during the fall spawning surveys (2001 and 2002) had been tagged in the river or in Clark Lake, indicating that lake whitefish from the Keeyask Area do not make use of habitat in the Assean River system (Table 5-30).

Few lake whitefish were tagged elsewhere in Split Lake area. No lake whitefish were recaptured during spring and summer surveys in the Burntwood/Odei Rivers, the Nelson/Grass Rivers below the Kelsey GS, or in Split Lake (Table 5-30). Of Floy®-tagged lake whitefish reported harvested from Split Lake by local resource users, all had been tagged in the Mistuska River.

Only one of the fish tagged in the Nelson River above Gull Rapids was recaptured (Table 5-28); it was recaptured within 5 km of its tagging location in Gull Lake approximately one year after it had been tagged. None of the Floy®-tags reported harvested by local resources users were captured in this reach. Most of the radio-tagged lake whitefish relocated in the Nelson River above Gull Rapids remained in Gull Lake throughout the year. Only one of these fish moved out of the lake upstream into the Nelson River during fall of 2001 and 2002, only to be relocated in back in Gull Lake the following summers. The two lake whitefish tagged with transmitters that were released in the Nelson River upstream of Gull Lake moved into Gull Lake shortly after being released, where they were detected on multiple occasions. Two of the lake whitefish moved downstream out of Gull Lake into Stephens Lake; because these movements occurred shortly after being implanted with transmitters it is thought that these movements may have resulted from post-operative stress. One of these fish was later detected in this reach multiple times during the open-water season of 2002 and 2003, indicating that it had likely survived. The only lake whitefish recaptured in the Nelson River between Clark Lake and Gull Rapids during the fall spawning surveys (2001–2004, and 2007) had been tagged in the reach (Table 5-30), indicating that lake whitefish do not move upstream through Gull Rapids to spawn in the Nelson River.

The majority of lake whitefish Floy®-tagged in the Gull Rapids and Stephens Lake areas were recaptured in the waterbody in which they were tagged (Table 5-28). However, Floy®-tagging studies showed that lake whitefish move between the North and South Moswakot Rivers and Stephens Lake. One of the lake whitefish Floy®-tagged immediately below Gull Rapids moved 57 km downstream and was recaptured in the Long Spruce spillway. At some time between October of 2002 and October of 2003, this fish had gone downstream through both the Kettle and Long Spruce generating stations. Most of the lake whitefish implanted with transmitters and released in Stephens Lake were relocated in subsequent years in the lake. Immediately after being released at the base of Gull Rapids in fall 2001, many of the lake whitefish were relocated moving northward in Stephens Lake. Many of the lake whitefish with transmitters were relocated at the base of the Gull Rapids during fall, four in consecutive years (2002 and 2003), suggesting that this area is used for spawning. Except for one that was recaptured at the mouth of the North Moswakot River in fall 2005, none of these fish was detected in the study area at any other time of the year, suggesting that after spawning they moved out of the range of detection for the rest of the year. One of the radio-tagged lake whitefish was relocated in Stephens Lake near the Kettle GS multiple times between fall 2001 and spring 2002. Two of the lake whitefish with transmitters moved upstream to Gull Lake, one of which was later detected multiple times throughout the open-water season in the lake. Because of the length of time between detections (10 months to 2.5 years), the season in which these movements occurred could not be determined. The recapture of two lake whitefish that had been Floy®-tagged in the South Moswakot River in below Gull Rapids during the fall spawning surveys (2002 and 2003) (Table 5-30) suggests that a portion of the lake whitefish in the tributaries use habitat at Gull Rapids for spawning, at least in some years. Only one of the lake whitefish that had been Floy®-tagged upstream of Gull Rapids was captured during the fall surveys below Gull Rapids, suggesting that habitat in this reach is not typically used by lake whitefish populations in the Split Lake Area or in the Nelson River above Gull Rapids.

Movements Over Large Rapids

Telemetry and mark/recapture studies have shown that lake whitefish are capable of making both upstream and downstream movements through Birthday Rapids and Gull Rapids (Map 5-21; Table 5-29). Lake whitefish were only observed moving downstream through Long Rapids, although the species is likely capable of passing upstream through these rapids as well.

Gull Rapids

None of the lake whitefish Floy®-tagged and recaptured during the spring and fall of 2001 and 2002 in Gull Lake (upstream to approximately 15 km of Gull Rapids) and Stephens Lake (downstream to approximately 10 km of Gull Rapids) were observed to have moved over Gull Rapids (Table 5-31). Limiting the mark-recapture studies to this period and geographical area ensures that sampling effort upstream and downstream of the rapids was approximately equal. In contrast, numerous lake whitefish were recaptured during this time on the same side of Gull Rapids on which they were tagged.

When the dataset is expanded to include all fish Floy®-tagged in the study area, and all subsequent recaptures that occurred between 2001 and 2007, only one of the Floy®-tagged lake whitefish were observed to have moved downstream through Gull Rapids (Table 5-32). This fish moved from the Assean River, downstream through Gull Rapids, into Stephens Lake between October of 2001 and October of 2002.

Two of the lake whitefish implanted with transmitters in Gull Lake also passed downstream through Gull Rapids. Because these fish passed downstream into Stephens Lake shortly after being released, it is likely these movements resulted from post-operative stress. Two of the acoustic-tagged lake whitefish released in Stephens Lake were relocated in Gull Lake, indicating they had moved upstream through Gull Rapids. These fish represented just over 10% of the lake whitefish released below Gull Rapids.

Birthday Rapids and Long Rapids

Few lake whitefish were observed to have passed through either Birthday Rapids or Long Rapids. One Floy®-tagged lake whitefish that was recaptured immediately below Gull Rapids had passed downstream through both Long and Birthday rapids, as well as Gull Rapids, from its tagging location in the Assean River one year prior. One of the acoustic-tagged lake whitefish went upstream over Birthday Rapids during late September 2002 and moved back downstream though the rapids into Gull Lake prior to June of 2003. None of the lake whitefish marked during Keeyask environmental studies was observed to have passed upstream through Long Rapids.

5.3.2.7 Current Trends/Future Conditions

Comparable historic data were located for only Split Lake and Stephens Lake. These data were collected during the 1980s by Manitoba Fisheries Branch as part of the Ecological Monitoring Program (EMP). Fish were sampled under both the EMP and Keeyask studies during the summer using overnight sets (16–24 h) of standard gang experimental gill nets (as described in Appendix 5B). Although the fishing gear was comparable, comparisons between the data sets are difficult because there were differences in sampling strategy and timing. A specific objective of gillnetting surveys conducted as part of Keeyask environmental studies was to determine fish species composition and abundance in relation to different habitat types. Consequently, the same net set locations and dates were generally sampled in each year, whereas net set locations, dates, and number of sites surveyed by the province varied among years.

Comparison of historic and recent catch per unit effort (CUE; number of fish per set) values shows a decline in the total catch at both lakes (Figure 5-1). Whether this difference is due to variations in sampling methodologies or change in fish populations is unknown. There also appears to have been a shift in the fish community in both lakes since the 1980s. Although the CUE of several species have declined in both lakes (including cisco, lake whitefish, longnose sucker, and mooneye), the CUE of walleye and northern pike has increased substantially. The abundance of white sucker in Stephens Lake has remained relatively constant, with a slight increase in CUE in recent years, but has declined somewhat in Split Lake. In contrast to walleye populations, there has been little change observed in sauger abundance since the 1980s. In both lakes, the overall trend has been a shift in the fish community favouring those species that prefer lacustrine conditions (*e.g.*, walleye, northern pike) with a reduction in the abundance of those that are adapted to riverine conditions (*e.g.*, longnose sucker). Studies conducted as part of the Limestone GS Monitoring Program (Bretecher and MacDonell 2000; Johnson *et al.* 2004) have demonstrated that adaptation of fish populations to habitat changes can require decades.

In addition to habitat-related changed caused by hydroelectric development (*i.e.*, CRD/LWR, Kettle GS, Kelsey GS), fish populations in the study area have more recently been affected by the introduction of rainbow smelt. Rainbow smelt were first detected in Split and Stephens lakes in 1996 and currently account for up to 40% of the catch at Split Lake in small mesh gill nets and up to 12% of the catch in Stephens Lake. In addition to changing species composition, rainbow smelt are also affecting the diet of predatory species in these lakes. At present, rainbow smelt occur in up to 60% of the stomachs of predatory fish captured in standard gangs in Split Lake, and up to 30% of the piscivores captured in Stephens Lake.

Due to the amount of time that fish populations require to adapt to habitat changes, combined with the ongoing effects of rainbow smelt introduction, it is expected that the fish populations in the study area are still evolving.

5.4 PROJECT EFFECTS, MITIGATION AND MONITORING

5.4.1 Construction Period

The following section considers effects related to the construction of the GS, construction of the south access road, and operation of the construction camp and north and south access roads during the construction period. Construction of the north access road and clearing of the construction camp and work areas was addressed under the EIS for the Keeyask Infrastructure Project (Keeyask Hydropower Partnership Ltd. 2009).

The assessment is based on construction-related effects to water quality (Section 2.5.1), physical attributes of aquatic habitat (Section 3.4.1), and lower trophic levels (sections 4.2.4.1, 4.3.4.1, 4.4.4.1, and 4.5.4.1). Because the impacts to fish species in general, including VEC species, from most construction-related impacts are similar, no distinction is made among fish species (*i.e.*, walleye, northern pike, lake whitefish) in the discussion below unless there are species-specific effects. Effects that begin during construction but are a permanent feature of operation (*e.g.*, flooding of terrestrial area) are considered under the operation section (Section 5.4.2).

5.4.1.1 Upstream of the Outlet of Clark Lake

No construction-related impacts are expected upstream of the outlet of Clark Lake as fish communities and habitat in this reach will not be directly affected by construction of the Keeyask GS. Moreover, the construction-related disturbance to fish communities and habitat in the reach downstream of Clark Lake are not expected to result in an increase in upstream fish movements into Split and Clark lakes due to the presence of Long Rapids.

5.4.1.2 Downstream of the Outlet of Clark Lake

5.4.1.2.1 Disruption of Spawning Activity due to Disturbance by Construction Activity and Habitat Loss/Alteration

The construction of cofferdams will result in a sequential loss of aquatic habitat in Gull Rapids and relatively higher velocities in the south channel (Section 3.4.1.1). Habitat in Gull Rapids is currently used for spawning by numerous fish species, including all of the VEC species. In particular, Gull Rapids is thought to be the primary spawning location of lake whitefish in Stephens Lake. To protect spawning fish and developing larvae, the construction schedule (PD SV) has been modified, where practical, to avoid instream work during two periods: 15 May to 15 July for spring spawners and emergence of larvae; and 16 September to 30 April for fall spawners (rationale for these periods is provided in Appendix 1A). Instream construction activities that cannot be scheduled without incurring significant construction delays and costs to avoid the fall spawning period will occur in four years (2014, 2015, 2017, and 2019) or to avoid the spring spawning period will occur in one year (2018).

The north channel rock groin will be in place (mid-August 2014) when instream construction activities first overlap with the spawning period of lake whitefish (construction of the powerhouse stage I cofferdam in the fall 2014), and may reduce the number of staging lake whitefish in the area by altering attraction flows. Sensory disturbances from construction activities may also deter lake whitefish from seeking spawning habitat in the area. In subsequent years, much of the spawning habitat in Gull Rapids will have already been destroyed when construction activities overlap with the fall spawning period (2015 and 2017). However, any fall spawners that do return to the area will be susceptible to stranding (Section 5.4.1.2.3). While it is unlikely that any lake whitefish would be spawning in the vicinity of the powerhouse stage I cofferdam due to a lack of attraction flows, the removal of this cofferdam in fall 2019 could result in sedimentation of any lake whitefish eggs laid downstream of the cofferdam.

The construction of the south dam Stage II upstream and downstream cofferdams will coincide with the spring spawning period in 2018. At this time, the principle concern for the spring spawning species, in particular lake sturgeon (discussed in Section 6.4) and walleye, is that they move into Gull Rapids and get trapped (Section 5.4.1.2.3). It is expected that few fish will be attracted to the area as a result of sensory disturbances associated with construction activities and changes in attraction flow resulting from the flow passing through the spillway.

It is not known to what extent spawners will use habitat in south channel for spawning during Stage I construction, as the distribution of water velocity will have been altered by the diversion of the entire Nelson River flow through the south channel. Likewise, it not known whether habitat in the river channel downstream of the GS during Stage II construction will be used for spawning once flow is diverted through the newly constructed spillway, and later through the GS intake and tailrace.

The construction and removal of the cofferdams will reduce the amount of spawning habitat available to fish populations in Stephens Lake, particularly lake whitefish. While spawning will occur at other locations in the system during the construction period (*e.g.*, Ferris Bay, North and South Moswakot Rivers), the result will be a smaller than normal year class for species such as lake whitefish and, possibly, walleye that rely primarily on spawning habitat in Gull Rapids.

5.4.1.2.2 Alteration of Aquatic Habitat in Stephens Lake due to Sediment Deposition

Instream construction activities are expected to result in 0.1–0.6 cm layer of sediment to form on the bottom of Stephens Lake (Section 3.4.1.4). Most of the deposition is expected to occur near the entrance of Stephens Lake downstream of Gull Rapids. This amount of deposition is not anticipated to affect fish use of habitat in the lake.

5.4.1.2.3 Stranding of Fish when Cofferdams are Dewatered

The cofferdams will not affect fish populations in the Nelson River upstream of Gull Rapids or in Stephens Lake by acting as a barrier to upstream or downstream movements of fish through Gull Rapids because such movements are currently thought to be incidental. While the cofferdams are being constructed, there is the potential to trap fish in the area that is to be dewatered. The number of fish that would be susceptible to stranding will be minimized by avoiding instream work during the spring and fall spawning periods, where practical (see Section 5.4.1.2.1). In addition, a salvage fishery will be conducted within the cofferdams prior to dewatering to release fish that do become trapped. During Stage II construction, fish could also become trapped in pools that form in the south channel after a spill. When such an event occurs, a fish salvage operation will be conducted to catch and release any stranded fish back into the Nelson River.

The construction of temporary causeways to access the N-5 and G-3 borrow areas has the potential to trap fish. The southern causeway will be designed and constructed with culverts that will provide access for fish to move through the causeway. At the northern location, access between the causeway and Pond 13 will be provided to minimize the potential for fish stranding. Therefore, the effect of the causeways will be negligible to the fish community in Stephens Lake.

5.4.1.2.4 Entrainment of Fish in Intake Pipes for Water Used for Construction

During the construction of the Project, water will be required for several uses including potable water for the camp and work areas, and water for mixing concrete. Intake pipes will be screened according to current end-of-pipe fish screening guidelines (Fisheries and Oceans Canada; formerly known as the Department of Fisheries and Oceans [DFO] 1995) to minimize the **entrainment** and **impingement** of fish. Consequently, it is expected that water intakes will have no effect on fish.

5.4.1.2.5 Blasting Effects

Blasting will generally be conducted in accordance with DFO guidelines for the use of explosives in or near Canadian fisheries waters (Wright and Hopky 1998) to ensure compliance with various fish and fish habitat protection provisions of the *Fisheries Act* (including provisions to protect spawning beds during egg incubation). Fish habitat setback distances can be met for all fish species. Spawning habitat setback distances cannot be met for lake whitefish for two areas: the powerhouse tailrace channel and spillway discharge channel. To mitigate impacts to lake whitefish, the blasting in these areas will be conducted outside of the lake whitefish spawning period.

5.4.1.2.6 Water Quality Effects from Instream Activities, Malfunctions, or Accidental Spills

The following summarizes the potential impacts to fish resulting from changes in water quality due to Project construction. A detailed discussion of potential effects of Project construction on water quality is found in Section 2.5.1.

Generally, the construction and removal of cofferdams will generate less than 5 mg/L of total suspended solids (TSS) downstream of Gull Rapids (Section 2.5.1.1). Larger TSS increases are expected to be of small magnitude and of short duration. Peak levels are predicted to be up to 15 mg/L for one day or up to 7 mg/L for one month (Section 2.5.1.1). These concentrations are well below levels that been described as being "low risk" to fish and their habitat (25–100 mg/L; Government of Canada 1993), as supporting "good to moderate fisheries" (25–80 mg/L; European Inland Fisheries Advisory Commission [EIFAC] 1964), or as having little effect (20–40 mg/L; Hayes *et al.* 1992). Instream sedimentation monitoring will trigger immediate corrective actions if TSS criteria are exceeded (described in Sediment Management Plan). Drainage of surface runoff to the Nelson River will be controlled following a Drainage Management Plan (as described in the PD SV) to minimize the amount of sediment produced and the potential for sediment to enter watercourses. Water pumped out of cofferdam and excavation areas and concrete wash water will be pumped into a settling pond until it meets a TSS criterion of less than 25 mg/L before being pumped into the Nelson River. Therefore, construction-related increases in TSS are anticipated to have a negligible effect on the fish communities of the Nelson River and Stephens Lake.

Underwater EMPAs in the reservoir will be armoured and of limited elevation to prevent erosion by flowing water. In shallow areas of the reservoir, they will be placed in areas where they will not increase the depletion of DO. As a result, any changes to water quality caused by EMPAs will have a negligible effect to fish.

Before being discharged into the Nelson River, wastewater effluent from the water treatment plant will meet Manitoba Conservation's Tier 1 Water Quality Standards for Secondary Treatment Technologies Discharging into Receiving Waters (as discussed in Section 2.5.1) and TSS levels in clarified effluent from the wash water from concrete aggregate and batch plant will be below those in the river. Liquid discharges to the Nelson River will not have a significant effect on fish because regulatory standards will be met or exceeded prior to discharge into the Nelson River.

As discussed in Section 2.5.1, no significant impacts are expected as a result of accidental spills and releases of hydrocarbons and other hazardous materials due to safe handling and spill containment measures outlined in the Project Description (PD SV). Consequently, accidental hydrocarbon spills and releases are expected to have no effect on fish.

5.4.1.2.7 Potential Harvest by the Workforce

The potential for increased fishing activity due to the presence of construction workers and increased access during Project construction is discussed in detail in the Resource Use Supporting Volume. To reduce the effects of increased harvesting, the KCNs and Manitoba Hydro, in consultation with Manitoba Water Stewardship, will develop an Access Management Plan prior to construction. Fishing by the workforce will be restricted in all construction areas for safety reasons. It should be noted that Manitoba Conservation is responsible for the management of fisheries in the province, including avoidance of adverse effects related to over-harvesting.

5.4.1.3 Access Road Stream Crossings

The north access road is being constructed as part of the Keeyask Infrastructure Project. Construction-related impacts of stream crossings for this road have been discussed as part of the environmental assessment report for this project (Keeyask Hydropower Partnership Ltd. 2009). The following is a discussion of the construction-related impacts associated with the construction of the south access road.

Although measures will be taken to minimize the input of sediments (as discussed in Section 2.5.1), small, short-term increases in TSS are expected during and immediately after installation of culverts. Additionally, there is a small potential for accidental spills and releases of hydrocarbons at the stream crossings, but spill containment measures that will be described in the spill response plan will minimize the potential for impacts affecting more than the local area.

At each of the three stream crossings along the south access road, there will be a direct loss of aquatic habitat due to the footprint of the road and the culvert. None of the habitat to be affected is considered critical (*i.e.*, spawning or overwintering habitat). Changes to aquatic habitat at each road crossing may include the following:

- Some decrease in depth for the length of the culvert at some sites and an increase in depth immediately upstream and downstream of the culvert at most sites;
- Some increase in sedimentation downstream of the culvert at most sites;
- Loss of rooted submergent aquatic plants in the immediate footprint of the road and culvert at most sites; and

- Increase in average velocity for the length of the culvert and a short length immediately upstream and downstream of the site.

There is not expected to be a reduction in invertebrate (Section 4) or forage fish production at any of the crossings. Consequently, the stream crossings should not result in a substantial change to the amount of food available to the fish community at any of the tributaries.

Movement of all fish at the proposed crossing locations is currently limited because of an abundance of beaver dams and obstructions downstream of the crossings. One juvenile northern pike and one adult white sucker were each captured at only one of the crossing sites. It is thought that, at present, the movement of all fish within the tributaries, and between the tributaries and larger systems is limited by natural blockages within the tributaries. None of these existing obstructions are likely to be removed. Consequently, construction of the south access road is unlikely to affect the local abundance of northern pike and larger suckers, or fish movement in general.

Given the appropriate sizing and installation of culverts, and strict adherence to the Manitoba Stream Crossing Guidelines for the Protection of Fish and Fish Habitat (Fisheries and Oceans Canada and Manitoba Natural Resources 1996), habitat alterations associated with the construction of the south access road stream crossings are not expected to significantly affect the fish community.

5.4.1.4 Net Effects of Construction with Mitigation

As described above, the effects of construction to the fish community can largely be addressed through the application of guidelines for construction activities and measures to reduce effects from water quality, dewatering, and harvesting. The major construction effect will be a decrease in the year-class strength of fish species residing in Stephens Lake that rely primarily on spawning habitat in Gull Rapids (lake whitefish and, to a lesser extent, walleye) during the years that the cofferdams are in place.

5.4.2 Operation Period

The following assessment is based on information related to the Project and direct effects to the physical environment (PE SV and summarized in Section 1), as well as assessments of effects to water quality (Section 2.5.2), physical attributes of aquatic habitat (Section 3.4.2), and lower trophic levels (sections 4.2.4.2, 4.3.4.2, 4.4.4.2, and 4.5.4.2). Operational effects are described for the large-bodied and forage fish communities as a whole, and in terms of specific effects to each of the VEC fish species. In order to describe the use of habitat in the Keeyask Reservoir by VEC fish species over the long-term, habitat in the reach post-Project was classified into six general habitat types (Map 5-22; Appendix 5B).

A habitat-based model was used to estimate the abundance of fish and available foraging habitat in the post-Project environment at four time steps (Years 1, 5, 15, and 30) for peaking and base loaded operation modes. Briefly, the model produced an estimate of fish use of foraging habitat in the reach of the Nelson River between Clark Lake and the Keeyask GS for each VEC species and the total catch of large-bodied and forage species as an overall mean CPUE and as the proportional increase in useable foraging habitat available. A habitat-specific CPUE was calculated by averaging site-specific values from habitat-based index gillnetting conducted in the study area from 2001-2004. In the case where a habitat types was not sampled due to its absence/scarcity in the existing environment, or due to methodological constraints, then a CPUE value was estimated from surrogate values in similar habitat. The area of aquatic habitat types in the existing environment and post-Project Year 30 was estimated using GIS analysis methods. An intermittently exposed zone was calculated to account for differences in habitat areas due to the mode of operation (*i.e.*, peaking or based load). For the intermediate time steps (Years 1, 5, and 15), the post-Project habitat areas and fish use were modified to account for reservoir expansion, peatland disintegration, loss and subsequent reestablishment of macrophyte beds, and water quality conditions. Two metrics were calculated to evaluate the effects of reservoir creation: 1) a weighted mean was used to calculate an overall CPUE for the study area; and 2) habitat was ranked to estimate the amount of suitable habitat. The assumptions and calculations of the model are described in detail in Appendix 5B.

In addition to the modelling exercise, the effects of operation-related pathways were considered through the use of empirical information from Stephens Lake and other reservoirs in northern Manitoba, reservoirs in other north temperate areas, the scientific literature, and available local knowledge.

Mitigation and enhancement measures that would reduce potential negative effects and provide alternate aquatic habitat upstream of the GS structure are noted in the relevant effects sections and are described in detail in Appendix 1A.

Predicted impacts on the fish community (including VEC species) in the study area resulting from habitat alteration due to operation of the Project are summarized in Figure 5-2. This assessment describes the effects of the Project to all fish species in general. Specific effects to any of the VEC species are presented after the general discussion.

5.4.2.1 Upstream of the Keeyask Reservoir

Operation-related pathways that could affect the fish community in this area are limited to effects to fish movements. Presently, it is not believed that this upstream reach contains critical habitat for fish populations in the Nelson River below Birthday Rapids and that immigration of fish to the reach from downstream areas is minimal. Changes in aquatic habitat in the Keeyask reservoir could result in increased fish movements upstream into Split/Clark lakes. In particular, there could be a mass influx of fish to this reach in the first year of impoundment as fish move upstream away from disturbed habitat in the reservoir, as has been seen during impoundment of the Desaulniers River, Québec (Boucher 1982).

Over the long-term, decreases in water velocity at Birthday Rapids resulting from operation of the Project could facilitate the movement of some large-bodied species upstream over Birthday Rapids. However, the small number of fish that currently move between the Split and Keeyask areas is not expected to increase substantially as Long Rapids, which are located downstream of Clark Lake, will still have white water post-Project and would be expected to continue to function as an impediment to upstream movements (Section 3.4.2.2). Based on the limited swimming ability of many forage species, it is believed that movements upstream over Birthday and Long rapids would be minimal.

The effects of immigration of fish from the Keeyask reservoir are not expected to be detectable in this reach over the long-term. Habitat changes in the Keeyask reservoir are not expected to affect fish in Split/Clark lakes since they are not dependent on habitat in that reach.

5.4.2.2 Within the Keeyask Reservoir

5.4.2.2.1 Spawning Habitat

Presently, large-bodied species including walleye, northern pike, and lake whitefish, are believed to spawn at various locations within the reach. It is expected that habitat alterations (Section 3.4.2.2), including the inundation of Birthday Rapids, siltation in Gull Lake (conversion of rock/cobble/gravel/sand substrates to silt/clay), and flooding of tributaries and creek mouths will detrimentally affect some areas currently used for spawning by some species, but will also result in the creation of newly flooded areas that will be suitable spawning habitat for some species. The inundation of Birthday Rapids may improve the ability of some species to move upstream through these rapids to access alternative spawning habitat above Birthday Rapids, such as Long Rapids, which will still have white water after impoundment (Section 3.4.2.2). Specific effects to spawning habitat for the three VEC species include the following:

- Walleye have been documented to spawn at Birthday Rapids, opportunistically throughout Gull Lake where suitable habitat exists, and at creek mouths. Some areas currently used by walleye (*e.g.*, Birthday Rapids, inlet to Gull Lake) would still be suitable post-impoundment (Map 5-23) and additional reefs will be formed at flooded islands.
- Northern pike spawn throughout the reach in tributary mouths and off-current bays and, to some extent, at Birthday Rapids. The inundation of terrestrial vegetation near the mouths of several tributaries resulting from higher water levels could result in a short-term increase in spawning habitat. However, much of this vegetation will decompose as water levels stabilize and spawning habitat in the long-term would be largely restricted to flooded tributary mouths (Map 5-24). Strange *et al.* (1991) reported that spawning success of northern pike in Wupaw Bay of Southern Indian Lake was enhanced in only the first year after impoundment of the lake. Higher water levels in the Nelson River and the removal of debris accumulation at the mouths of streams (Appendix 1A) will allow northern pike better access to suitable spawning habitat that currently exists upstream in tributaries such as Portage Creek by eliminating some impassable barriers that currently exist.
- Lake whitefish are thought to spawn at Birthday Rapids. Despite changes in velocity and depth, conditions this area is expected to remain suitable for spawning by lake whitefish after impoundment (Map 5-25). Condition at the constriction immediately upstream of Caribou Island may also continue to be suitable as site-specific velocities should be sufficient to prevent siltation.

To increase the amount of spawning habitat for lake whitefish and walleye, some areas in the reservoir will be modified prior to impoundment by constructing shoals of suitable materials (*i.e.*, boulder/cobble/gravel substrates) in the vicinity of known spawning locations. Shoals will be constructed with a minimum surface area of 0.1 ha in areas that will be shallow (for walleye depths range from 0.3–0.8 m below the minimum reservoir level) or moderately deep (for lake whitefish water depths range from 2.0–2.5 m below the minimum reservoir level to avoid freezing during winter). The shoals will be exposed to sufficient water velocity or wave action to prevent the deposition of fine sediments. Up to eight potential locations have been identified. Design criteria are based on shoals that have been constructed in other areas (Appendix 1A).

Spawning habitat for forage fish is not believed to be limited for most species. Boucher (1982) reported that newly flooded terrestrial habitat in the Desaulniers reservoir, Québec, provided increased spawning habitat for forage fish such as stickleback.

It is not believed that fish in the Nelson River upstream of Gull Rapids use Gull Rapids for spawning, therefore it is not expected that the loss of Gull Rapids due to the Project would have an effect on fish populations in this reach.

Aquatic habitat modelling showed that weekly cycling during operation of the GS would result in approximately 1,200 to 1,800 ha (Year 1 and 30 time steps, respectively; Table 3D-1) of the newly flooded habitat to be exposed intermittently. This fluctuation could result in the exposure and subsequent mortality of some fish eggs or larvae for those species spawning in less than 1 m of water if a period of stable water levels is followed by cycling during a spawning period.

While the Project is predicted to have an effect on the composition of the fish community in this reach, it is not expected that this change will result in a detectable change in the level of predation on fish eggs.

5.4.2.2.2 Rearing Habitat

Flooding of existing littoral habitats and creation of new littoral habitats in unstable environments (*i.e.*, eroding shorelines, fluctuating water levels) could reduce the amount of rearing habitat available to many species of fish in this reach over the short-term. Initially, declines in water quality (Section 2.5.2.2) in off-current areas, particularly off-current bays, could result in short-term avoidance of these areas by YOY since many species of fish show a preference for shallow water habitat during this life stage. In contrast, the YOY of those species that show a preference for deep water habitats (*e.g.*, coregonines, burbot) would have an immediate increase of rearing habitat following impoundment that is not predicted to be affected by short-term declines in water quality. In the shallows, there would be a lack of aquatic plant cover available to YOY fish for the first 5–15 years after impoundment until aquatic plants beds re-develop in the reservoir (Section 3.4.2.2). However, flooded shrubs and other material remaining after reservoir clearing are expected to provide alternate cover. Flooding will result in several of the tributaries currently used by forage fish, northern pike, and white sucker for rearing, Seebeesis, Effie, and Rabbit creeks, being converted to nearshore lacustrine habitat that would be subject to low dissolved oxygen (DO) conditions in the short-term (Section 2.5.2.2).

An increase in the food base available to the YOY of many species, many of which are primarily planktivorous during their early life stages, is expected to occur during the first five to ten years after impoundment. Such a response is most likely to occur in off-current areas where there is expected to be an increase in the abundance of zooplankton in response to an increase of bacterial biomass resulting from the introduction of organic matter from decomposing terrestrial matter (Section 4.4.4.2).

Over the long-term, it is anticipated that the food base for the YOY of many species of fish could increase due to a small increase in the biomass of phytoplankton and zooplankton in the reservoir bays (Section 4.2.4.2 and Section 4.4.4.2). Much of the rearing habitat lost in littoral areas of the former Gull Lake immediately after flooding will reform over the long-term once aquatic plant beds re-establish and provide cover for YOY fish. Specific effects to rearing habitat of the three VEC species include the following:

- Suitable rearing habitat for walleye is expected to occur over mineral substrates in nearshore areas of the reservoir (Map 5-23);
- As aquatic macrophyte beds re-establish, they would provide cover for YOY northern pike in the shallows (Map 5-24); and
- The reservoir is expected to provide abundant rearing habitat for lake whitefish in nearshore areas without organic substrates (Map 5-25).

While the Project is predicted to have an effect on the composition of the fish community in this reach in the long-term, it is not expected that this change will result in a detectable change in the level of competition for rearing habitat among fish species. The abundance of walleye is predicted to gradually increase as a result of the Project, which has the potential to increase the level of predation on the YOY, particularly those species with which there is spatial overlap of preferred habitat. Since the abundance of forage species is predicted to increase moderately, it is thought that increased predation by piscivorous species (as a result of increased populations, described below) on YOYs on rearing grounds would be negligible.

5.4.2.2.3 Foraging Habitat

Initially, declines in water quality (Section 2.5.2.2) in off-current areas, particularly off-current bays, could result in short-term avoidance of these areas by the adults/juveniles of many species of fish. Moreover, seasonally low DO in these areas is expected to result in limited colonization of these areas by benthic invertebrates (Section 4.5.4.2) and forage fish for up to ten years after impoundment, which would further reduce the value of some of the existing and newly created aquatic habitat as foraging habitat for some species. In the shallows, there could be a lack of aquatic plant cover available to adult/juvenile northern pike and forage fish for the first 5–15 years after impoundment until aquatic plants beds re-develop in the reservoir (Section 3.4.2.2). However, flooded vegetation and other material are expected to provide alternate cover in the interim. The loss of aquatic macrophyte beds in the short-term should have a limited effect on foraging habitat for walleye and lake whitefish as the abundance of these species was highest during summer in habitat characterized by sparse macrophyte growth, suggesting that open-water is more suitable as foraging habitat.

The diversity of foraging habitat available to forage species in the reservoir would be reduced with the loss of run and riffle habitat in several tributaries of Gull Lake (*e.g.*, Effie, Sam Bay, Seebeesis, Rabbit creeks and the lower reaches of Hidden, Trickle, Portage, and Two Goose creeks) due to flooding (Section 3.4.2.2), particularly for species typically associated with current such as longnose dace, lake chub, Johnny darter, mottled sculpin, and slimy sculpin. Riffle habitat, in particular, is generally highly productive in terms of insect larvae (Section 4.5.4.2). It is expected that suitable habitat for these species would exist in the unflooded, upstream reaches of these tributaries.

After impoundment, there will be a moderate decrease in drifting invertebrates in the reservoir as a result of a decrease in water velocity (Section 4.5.4.2). The loss of drifting invertebrates will have a negligible effect on the VEC species since the diet of walleye and northern pike in Gull Lake consists primarily of fish, while that of lake whitefish consists primarily of benthic macroinvertebrates (Appendix 5C).

Over the long-term, the colonization of the newly flooded habitat will result in a large increase in macroinvertebrates (Section 4.5.4.2) and a moderate increase in forage fish, which could increase the forage base available for large-bodied species in the reach. Cover will be available in the shallows as aquatic plant beds re-establish (Section 3.4.2.2). Specific effects to foraging habitat of the three VEC species include the following:

- Walleye are expected to forage throughout the reach except in areas of high velocity or organic substrates (Map 5-23);
- Suitable foraging habitat for northern pike is expected to occur over mineral substrates in nearshore areas of the reservoir, in backbays along the upper reaches of the reservoir, and in the unflooded lower reaches of creeks such as Nap, Portage, Trickle, and Two Goose (Map 5-24); and
- The reservoir would continue to provide suitable foraging habitat for lake whitefish as did Gull Lake, particularly in offshore areas with flowing water (Map 5-25).

While the Project is predicted to have an effect on the composition of the fish community in this reach in the long-term, it is not expected that this change will result in a detectable change in the level of competition for foraging habitat among fish species. The abundance of walleye is predicted to gradually increase as a result of the Project, which has the potential to increase the level of predation on some species, particularly those species with which there is spatial overlap of preferred habitat (such as lake whitefish and white sucker). Since the abundance of forage species is predicted to increase moderately, it is thought that increased predation by walleye on foraging grounds would be negligible.

5.4.2.2.4 Overwintering Habitat

Reduction in water velocity and increase in depth (Section 3.4.2.2) could increase the amount of overwintering habitat available to the fish community. Localized reductions in oxygen concentration (DO) during winter, particularly during the first one to five years after impoundment (Section 2.5.2.2), may make some of the newly flooded areas unsuitable as overwintering habitat. However, it is expected that even in the initial years post-impoundment, there will be an abundance of overwintering habitat available to the fish community in this reach due to the creation of large areas of standing and low velocity deep water habitat within the reservoir (Map 5-23, Map 5-24 and Map 5-25).

There is the potential for fish to be stranded as ice forms over the bay of the reservoir created by the flooding of Little Gull Lake (*i.e.*, peat transport zone 9) when the channels leading into the bay freeze, isolating the bay from the rest of the reservoir (Section 2.5.2.2). Anoxic conditions could develop in this bay over the winter, resulting in fish mortality. Fish favouring shallow vegetated habitat, such as northern pike, would be most at risk. To allow fish to escape, two channels will be constructed to connect this area to the main reservoir (Appendix 1A). The dimensions of these channels were selected based on those of small tributaries where fish were known to move under ice; one channel will be approximately 400 m long and the other approximately 800 m long, and both will be 5 m wide at the base with a minimum water depth, under ice, of 1.0 m.

5.4.2.2.5 Movements

Based on the movements of VEC species inhabiting the Nelson River between Long and Gull rapids that have been studied (*i.e.*, walleye, lake whitefish, and northern pike), it is thought that there is minimal movement of fish upstream over Long or Birthday rapids and downstream over Gull Rapids. Furthermore, it does not appear that Split/Clark lakes or Stephens Lake provide critical habitat for large-bodied fish in the Keeyask Area.

Changes in aquatic habitat in the Keeyask reservoir could result in increased fish movements out of the reach. In particular, there could be a mass emigration of fish out of the reach in the first year of impoundment as fish move away from disturbed habitat. Emigration out of the Limestone reservoir, Manitoba (NSC 2012) and the Desaulniers River, Québec (Boucher 1982) during impoundment was linked with a sudden decrease in the abundance of fish. It is anticipated that some fish will move upstream away from disturbed areas in the Keeyask reservoir, but will quickly re-colonize the reservoir once water quality conditions stabilize. Those fish that do move downstream past the Keeyask GS would be lost to the reservoir as the barrier created by the GS will prevent them from returning upstream.

The number of fish moving out of the reservoir through the Keeyask GS over the long-term via the spillway (when it is in operation) and the turbines would be small based on telemetry studies conducted in the Limestone reservoir (Pisiak 2009). Less than 3% of the walleye (n = 34 fish) and approximately 14% of the northern pike (29) and lake whitefish (14) marked with acoustic transmitters and released into the reservoir potentially passed downstream through the GS or spillway during the open-water seasons of 2005–2007. During this time, the majority of the walleye, northern pike, and lake whitefish that remained in the reservoir showed a preference for the upper reach, which minimizes the potential of these species passing downstream through the Limestone GS. As discussed in Section 5.4.2.3.5, a trap and transport program to maintain upstream movement of fish from Stephens Lake to the reservoir will be implemented.

Decreases in water velocity at Birthday Rapids resulting from operation of the Project (Section 3.4.2.2) could facilitate the movement of some large-bodied species upstream over Birthday Rapids over the long-term. However, the small number of fish that currently move between the Split and Keeyask areas is not expected to increase substantially as Long Rapids downstream of Clark Lake would be present post-Project. Based on the limited swimming ability of many forage species, it is believed that movements upstream over Birthday and Long rapids would be minimal.

Overall, the effects of emigration of fish from the Keeyask reservoir are not expected to be detectable over the long-term.

5.4.2.2.6 Health

Growth and condition of many species could increase after impoundment in response to increased primary and secondary production (Section 4.2.4.2, Section 4.4.4.2 and Section 4.5.4.2). Increased growth could result in an increase in fecundity.

An increase in condition was observed in large-bodied species residing in the reservoirs of the La Grand Hydroelectric Complex, Robert Bourassa and Opinaca, in Québec (DesLandes *et al.* 1995; Hayeur 2001).

By the second or third year after impoundment, the **condition factors** of many of the dominant large-bodied species were 10–20% higher than those under natural conditions (Hayeur 2001). However, by the end of the series, 12–13 years after impoundment, growth and condition had declined, but were still higher or equal to levels observed before impoundment (DesLandes *et al.* 1995). Based on existing mean condition factors of VEC fish species in Stephens Lake, it is expected that condition over the long-term of walleye would be comparable to values currently observed in Gull Lake (Appendix 5C).

The incidence of deformities, erosion, lesions and tumours (**DELT**s) is not expected to increase in fish inhabiting this reach in response to the Project since hydroelectric development has not been documented to result in an increase in the rate of DELTs in other waterbodies in northern Manitoba (Table 5C-7).

5.4.2.2.7 Mortality/Injury

At present, this reach is subject to limited domestic and commercial fishing activity due to difficulty in access. The construction of the access road and reduction in velocity at Birthday Rapids could increase the potential for people to access this reach and could result in an increase in harvesting of species such as walleye, northern pike, and lake whitefish. Long-term increases in mercury levels in fish, particularly piscivorous species (*i.e.*, northern pike and walleye), would likely minimize harvesting activities in the initial years post-impoundment. It is expected that harvesting would remain within sustainable levels, given regulation of recreational fisheries, the absence of commercial fisheries, and the traditional sustainable approach employed by domestic harvesters. In addition, the KCNs have indicated that they prefer harvesting off-system areas due to concerns with fish quality, including mercury levels and palatability. It is also expected that the offsetting programs will redistribute existing domestic fishing pressure to a broader land base.

Downstream movement of fish through the generating station could result in mortality due to turbine strikes. However, this would affect the size of downstream populations and is discussed in the assessment of the downstream area (Section 5.4.2.3.7).

5.4.2.2.8 Habitat-based Modelling of Abundance

The habitat model is based on foraging habitat, which is likely the habitat that most influences the total amount of fish present in a system if other habitats (*e.g.*, spawning and overwintering) are sufficiently available. It should be noted that the model is based on fish production in habitat types and that actual fish numbers will require at least one generation to reflect productive capacity.

Based on habitat modelling, fish abundance is calculated to be 7% lower than in the existing environment for large-bodied species and 20% lower for forage species in the first year after impoundment in peaking mode of operation (the most expected and typical mode as described in the PE SV), but will gradually increase over time as aquatic habitat evolves (Table 5-33). However, within the first year of impoundment there would be an increase of 60-80% in the useable foraging area (Table 5-34). Specific effects to the three VEC species include the following:

- The abundance of walleye and lake whitefish could increase by 8% in the first year after impoundment and would remain higher than in the existing environment as the aquatic habitat evolves (Table 5-33). Within the first year of impoundment there would be an approximate doubling of the useable foraging area for these species (Table 5-34); and

- In contrast, the abundance of northern pike could be 36% lower in the first year after impoundment and would gradually increase over time as habitat evolves (Table 5-33). However, within the first year there could be as much as a 30% increase in useable foraging area for northern pike (Table 5-34).

At Year 30, an increase of about 3,400–5,200 ha (at 158 m above sea level [ASL] and 159 m ASL, respectively) in the area modelled of primarily deep, standing/low velocity habitat with soft silt/clay substrates (Table 3D-1) is expected to result in an increase in the overall mean CPUE for large-bodied and forage fish communities of 15% (Table 5-33) and just over a doubling of useable foraging habitat (Table 5-34). Specific effects to the VEC species include:

- There could be an increase in the overall mean CPUE of walleye by 25% and lake whitefish by 38% (Table 5-33). Moreover, impoundment would result in an almost doubling of the useable foraging habitat for walleye and more than a doubling of useable foraging habitat for lake whitefish (Table 5-34). Thus, both the density and quantity of these VEC species are expected to increase moderately in the long-term; and
- There would be a decrease in the overall mean CPUE for northern pike of 10% (Table 5-33). However, there would be a proportional increase in suitable foraging habitat for northern pike over the long-term of about 1.8 fold (Table 5-34). Thus, while the density of northern pike is expected to decrease moderately after impoundment, the number of northern pike should increase due to a moderate increase in the amount of useable foraging habitat available.

5.4.2.2.9 Abundance in Other Reservoirs

It is expected that the large-bodied fish community and VEC species in the Keeyask reservoir would respond to impoundment in a comparable manner to the main species in the reservoirs of the La Grande complex, Québec (Hayeur 2001; DesLandes *et al.* 1995). There was an immediate decrease in CPUE of most species (*e.g.*, walleye, northern pike, lake whitefish) in the first year after the impoundment of the Robert Bourassa and Opinaca reservoirs, which was attributed to a dilution of the fish population in response to flooding. Fish populations, particularly lake whitefish, cisco, and northern pike populations, generally increased over the following five years (Hayeur 2001). Specific effects to the three VEC species include the following:

- Walleye abundance remained low until **recruitment** improved in the eighth year after impoundment. The increase in recruitment in these reservoirs was attributed to increases in available spawning and rearing habitat in response to the rise in water levels;
- After the first year, northern pike abundance increased, partly in response to widespread increases in recruitment, and the species became the dominant predator within a few years of impoundment. Improved recruitment was attributed to increases in available spawning and rearing habitat due to the rise in water levels, increased zooplankton production, and increased cover from submerged trees. High recruitment levels were observed for about three years, after which they declined gradually; and

- Lake whitefish populations generally increased over several years (Hayeur 2001). DesLandes *et al.* (1995) reported that these short-term changes in lake whitefish CPUE in the La Grande Complex reservoirs appear to have resulted partially from redistribution of fish; lake whitefish were attracted to the highly productive bay areas with high rates of decomposition of terrestrial vegetation. Year-class strength increased during the year of impoundment, after which it gradually declined. This rapid, but short-term, increase in lake whitefish recruitment was likely due to the general increase in primary and secondary production after impoundment.

Most fish populations in the La Grande complex reservoirs returned to levels observed before impoundment after about 15 years (DesLandes *et al.* 1995; Hayeur 2001).

Currently, the production of the large-bodied fish community in Stephens Lake, as indicated by CPUE values, is about the same as in Gull Lake (Table 5-7 and Table 5-13), suggesting there may not be an increase in production in the Keeyask reservoir due to impoundment over the long-term.

- Walleye production is about 20% higher than in Gull Lake (Table 5-7 and Table 5-13), suggesting there could be an increase in walleye production in the Keeyask reservoir due to impoundment over the long-term.
- The production of northern pike is about 9% lower than in Gull Lake and lake whitefish about the same (Table 5-7 and Table 5-13), suggesting there would not be an increase in the production of these species in the Keeyask reservoir due to impoundment over the long-term.

In the Desaulniers reservoir, Québec, forage fish production increased immediately after impoundment due to a mass migration of small-bodied fish (stickleback, yellow perch, trout-perch, and sculpins) into the reservoir from the nearby Desaulniers Lake and River (Boucher 1982). The author attributed the migration to an increase in zooplankton in the reservoir. The CPUE of forage fish in Stephens Lake is currently about 50% lower than in Gull Lake (Table 5-9 and Table 5-15), suggesting that there would not be an increase in forage fish in the Keeyask reservoir due to impoundment over the long-term. However, forage fish production in Stephens Lake is not likely a good indicator of the long-term CPUE of forage fish in the Keeyask reservoir since lower production in the existing environment of Stephens Lake is primarily a result of a much lower abundance of rainbow smelt than currently found in Gull Lake. It is expected that even in the absence of the Project, rainbow smelt would continue to increase in Stephens Lake and would contribute to an increase in the overall forage fish production.

The conversion of the Keeyask reach to an area of deeper, slower moving water is expected to result in a shift in the species composition of the fish community. Over the long-term, the relative abundance of species typically associated with lacustrine conditions, such as walleye, white sucker, northern pike, burbot, emerald and spottail shiner, fathead minnow, pearl dace, sticklebacks, Iowa darter, and logperch, may increase. In contrast, species that prefer riverine conditions, such as longnose sucker, mooneye, goldeye, river and Johnny darter, sculpins, trout-perch, lake chub, and longnose dace, may become relatively less abundant. Such a shift has been observed for large-bodied species after impoundment at reservoirs further downstream on the Nelson River, including the Kettle reservoir (Bretecher and MacDonell 2000; Section 5.3.2.7), the Long Spruce reservoir (Johnson *et al.* 2004), and the Limestone reservoir (NSC 2012), as illustrated in Figure 5-3. The forage fish community has generally not been well studied in newly impounded reservoirs. After the impoundment of Southern Indian Lake, an increase in the depth and clarity of Wupaw Bay was attributed with an increase in the lake's suitability to pelagic forage fish, such as emerald shiner (Strange *et al.* 1991).

5.4.2.3 Downstream of the Keeyask Generating Station

Most of the changes to fish habitat downstream of the Keeyask GS from operation of the Project will occur within a 3 km reach between the powerhouse and Stephens Lake (Section 3.4.2.3). Effects of these changes to water levels, velocity, and sedimentation are discussed below. Given that the elevation of the tailrace of the GS is within the operating range of Stephens Lake, water levels in the river channel downstream of the GS are largely controlled by water levels on Stephens Lake and only a minimal amount of habitat is subject to dewatering due to cycling at the GS. As this habitat is already within the intermittently expose zone created by regulation of Stephens Lake, cycling from the GS is not expected to change its suitability as fish habitat. While a thin layer of sediment (0.1–0.6 cm) introduced during the construction phase is expected to persist on the bottom of Stephens Lake into the operation period, the amount of material is not expected to affect fish use of habitat within Stephens Lake (Section 5.4.1.2.2).

5.4.2.3.1 Spawning Habitat

Gull Rapids currently provides important spawning habitat for several species of fish inhabiting Stephens Lake. Construction of the GS would result in the loss of spawning habitat in Gull Rapids due to the footprint of the GS and dewatering (Section 3.4.2.3) for several species. Without mitigation, the loss of spawning habitat at Gull Rapids would likely result in a decrease in recruitment to the populations such as walleye and lake whitefish in Stephens Lake. While it is expected that walleye and lake whitefish would find alternative spawning habitat elsewhere in the reach, such as Looking Back Creek, North and South Moswakot Rivers, and Ferris Bay, the loss of spawning habitat will be partly mitigated by the construction of artificial spawning habitat in the tailrace of the GS. Information about the tailrace spawning structure is provided in lake sturgeon Section 6.4

Because Gull Rapids is one of the few locations known to be used for spawning by lake whitefish in Stephens Lake, a 0.1 ha spawning reef will also be constructed in the lake to provide additional spawning habitat post-Project (Appendix 1A). The reef was designed using criteria that have been successfully applied in other areas. It will consist of a mixture of boulders, cobbles, and gravels, placed to form a shoal 2.0–2.5 m below the minimum water elevation in Stephens Lake (to avoid freezing over winter), and exposure to sufficient water velocity or wave action to maintain the substrate free of fines.

Many species, including walleye and northern pike, may also spawn in areas along the north bank of the Nelson River just downstream of Gull Rapids (Appendix 5D). Habitat in this area is expected to be altered by post-Project sedimentation and changes in velocity distribution.

As there is an abundance of suitable spawning habitat available to northern pike elsewhere in Stephens Lake, the loss of spawning habitat at Gull Rapids is not expected to affect northern pike populations.

It is not expected that egg survival and hatchability would be affected by the Project as TSS and DO are not expected to change significantly in the Nelson River immediately below the GS or in Stephens Lake (Section 2.5.2.3) and would therefore not result in anoxia or siltation. It is not expected that the Project would result in a change in the level of predation on fish eggs since the fish community structure of Stephens Lake is not expected to change as a result of the Project.

5.4.2.3.2 Rearing Habitat

The effect of the Project on rearing habitat for the fish community and VEC fish species is expected to be minimal. Rearing habitat in the existing environment is located in the mainstem of Stephens Lake, where the Project is expected to have only a minimal effect on the quality or quantity of aquatic habitat (Section 3.4.2.3) and planktivorous prey (Section 4.2.4.2 and 4.4.4.2). This area would be accessible to fish hatched on constructed spawning habitat below the GS. While Gull Rapids Creek may presently provide important rearing habitat for sucker species, it is unlikely that the isolation of the creek from the main channel following the dewatering of the south channel of Gull Rapids (Section 3.4.2.3) will affect the populations that currently use habitat in this creek as these fish are thought to be resident populations from the unnamed headwater lake.

It is not expected that the Project would result in increased competition for available rearing habitat or increased predation of YOYs by larger fish since the community structure of Stephens Lake is not expected to change as a result of the Project.

5.4.2.3.3 Foraging Habitat

Impoundment and the loss of Gull Rapids will likely result in a moderate decrease in the amount of forage available to forage fish and the piscivorous species that feed on them, such as northern pike and walleye, in the river channel below the GS due to a decrease in drifting and benthic invertebrates (Section 4.5.4.2). However, this localized decrease should have a limited effect on the fish community in Stephens Lake as there is suitable foraging habitat available elsewhere in the lake, particularly in the north arm (Table 5-7 and Table 5-14). It is expected that there will be no effect to invertebrate production in Stephens Lake proper.

It is not expected that the Project would result in increased competition for available foraging habitat or increased predation by piscivores since the community structure of Stephens Lake is not expected to change as a result of the Project.

5.4.2.3.4 Overwintering Habitat

It is expected that Stephens Lake will continue to provide sufficient overwintering habitat for fish.

5.4.2.3.5 Movements

Forage fish are not thought to move upstream over Gull Rapids in the existing environment; therefore, the presence of the GS should not affect movement. The GS will block the movements of large-bodied fish upstream over Gull Rapids. However, this blockage would likely have a minimal effect to the fish community as fish in Stephens Lake are not presently believed to use habitat upstream of Gull Rapids.

The movement of fish inhabiting the Keeyask area downstream into Stephens Lake is also believed to be minimal. However, there could be a short-term increase in emigration of fish out of the reservoir while it is being impounded as was seen during the impoundment of the Limestone GS in 1989 (NSC 2012). As a result, there was a temporary increase in fish abundance below the Limestone GS as these fish were prevented from returning upstream by the presence of the GS. It is likely that there would be a similar short-term increase in fish abundance in Stephens Lake during the impoundment of the Keeyask reservoir.

Over the long-term, however, the number of large-bodied fish moving downstream through the Keeyask GS should be small based on telemetry studies conducted in the Limestone reservoir from 2005 to 2007 (Pisiak 2009; discussed in Section 5.4.2.2.5). It is not known what proportion of the forage fish community in Gull Lake currently moves downstream through Gull Lake into Stephens Lake. Once the turbines are in operation, those fish that do move downstream through the Keeyask GS will be susceptible to turbine mortality (discussed under heading Mortality/Injury below). During spillway operation, which would be in operation approximately 12% of the time on an annual basis based on historical records (though typically some years have frequent spills and other have none), relatively more fish may be entrained in the flow and move downstream than during normal GS operation due to high water velocities in the immediate reservoir upstream of the spillway.

While the amount of larval fish that currently drift from Gull Lake downstream over Gull Rapids to Stephens Lake is not known, given that Stephens Lake is much larger than Gull Lake and has abundant spawning habitat, the contribution from upstream is likely not required to maintain populations in Stephens Lake. It is expected the amount of drift, notably of walleye and lake whitefish, would be reduced post-impoundment. After the Project is built, downstream transport would be reduced due to lower velocities in the reservoir upstream of the GS compared to the existing environment. Spawning would generally occur in the upper portions of the reservoir and the large expanse of standing or low velocity water is expected to retain more larvae upstream of the GS than is currently the case.

Although creating a barrier to upstream fish movement is not expected to affect population size, DFO has identified the need to include upstream fish passage in the Project design to maintain existing connections among fish populations. This reflects a precautionary approach with respect to uncertainty regarding the importance of maintaining connections among populations. To address effects of the generating station on fish movements, three measures will be implemented. Upstream fish passage will be provided by a trap and transport program that will target key fish species (walleye, northern pike, lake whitefish, and lake sturgeon [discussed in Section 6]) during the initial period of operation. The results of the trap and transport program, fish movements, and fish populations will be monitored to assist in optimizing fish passage in the long-term. Turbines and spillways will be designed in a manner that will allow fish moving downstream to do so without significant mortality that would affect the fish populations (as described below under Mortality/Injury).

A specific trap and transport program is under development (see Appendix 1A) and will be implemented in close consultation with DFO and Manitoba Conservation and Water Stewardship. The conduct of the trap and transport program will be planned to avoid potential adverse effects, such as depletion of fish stocks in Stephens Lake and release of fish into unsuitable environments in the reservoir (*e.g.*, fish requiring fast-flowing water for spawning would not be transported to a deep section of the reservoir during the spawning season). Monitoring of the movements of fish that are transported in the program, as well as individuals that are immediately downstream of the station will be used to determine the success of the program. This would include both an assessment of the success in capturing fish for transport and determining whether transported fish are better able to fulfill their life history requirements than fish that remain below the generating stations. Results of monitoring would be used to refine the trap and transport program or provide the rationale for selection of a different method of fish passage.

5.4.2.3.6 Health

Growth and condition of the fish community in Stephens Lake is not expected to changes as the Project is expected to have a minimal effect to forage production (Section 5.4.2.3.3).

The incidence of DELTs is not expected to increase in fish inhabiting Stephens Lake in response to the Project since hydroelectric development has not been documented to result in an increase in the rate of DELTs in other waterbodies in northern Manitoba (Table 5C-7).

5.4.2.3.7 Mortality/Injury

Fish moving downstream from the Keeyask reservoir will be subject to potential injury or mortality due to passage through the turbines or down the spillway. Members of FLCN predict that the Keeyask Project will negatively affect fish populations by causing spillway and turbine mortality (FLCN 2008 Draft; FLCN 2009 Draft). Turbine passage can result in mortality of fish directly through a variety of mechanisms (*e.g.*, pressure changes, shear stress, turbulence, striking, grinding) or indirectly through increased susceptibility to disease and predation. Among other factors, the survival of fish entrained in turbines depends on the size, species, and health of the fish (Cada 2001). It is unclear from the literature whether fish size is positively related to turbine mortality or whether there are more complex interactions (reviewed in Jansen *et al.* 2004). Some studies have shown that fish shape, size, and behaviour interact to produce different types of injuries; larger fish may be more susceptible to blade strike whereas younger and small fish may be more susceptible to shear stress. While there are no stations that incorporate all of the features planned for Keeyask for the types of species present, estimated survival rates have been based on extrapolations from a similar station, the re-runnered Kelsey GS. Turbine passage studies conducted at the Kelsey G.S. found the following:

- The survival rate of walleye (mean length of 428 mm) experimentally introduced to a re-runnered turbine at the Kelsey GS was 88% and 75% for northern pike (greater than 450 mm) (NSC 2009); and
- About two thirds of the walleye passed through the turbines without injury (cuts/scrapes, scale loss, loss of equilibrium, mortality). The incidence of northern pike that passed through the turbines without injury decreased with northern pike length. The proportion of injury-free **sub-adult** northern pike (150–450 mm) was 72% compared to 38% for their adult con-specifics.

The injuries and mortalities observed at the Kelsey GS have been attributed to the turbines' high rotational speed and sharp leading edges. The turbine selection criteria for the Keeyask GS included several measures to reduce effects to fish; therefore, the rate of injury is expected to be somewhat lower than measured at the Kelsey GS. These features were selected based on experimental studies that have occurred at hydroelectric stations in Canada and the United States. Important features include methods to: reduce the probability of fish being struck while passing through the turbines (by eliminating overhang by structures such as wicket gates and reducing rotational speed); reduce the size of gaps where fish may become trapped; reduce the degree of injury (by providing blades with a thicker leading edge and reducing rotational speed); and incorporate measures to reduce turbulence. Based on the turbine specifications, the calculated survival rate for fish up to 500 mm long is greater than 90% (see Appendix 1A for details).

Forage and larval fish will also be susceptible to turbine mortality. While there are few studies of ichthyoplankton mortality through turbines, particularly specific to boreal fish species, mortality due to contact with blades, shear, and pressure was estimated to be less than 5% at low-head (less than 30 m), propeller-type facilities (Cada 1990).

Passage through the spillway is not expected to result in greater mortality or injury than currently occurs for fish moving downstream past Gull Rapids because the spillway channel will follow the old riverbed and not have any sudden drops, plunge pools, or barriers. Fish could become stranded in isolated pools that may form in portions of the south channel of Gull Rapids after the spillway ceases operation (Section 3.4.2.3). To mitigate this effect, channels will be excavated to connect the pools to Stephens Lake to prevent fish stranding when water is not passed through the spillway (Appendix 1A).

Fish may also move past the trash racks and turbines. As described in Appendix 1A, trash racks will be installed on the face of each intake to the powerhouse and be comprised of vertically oriented rectangular shaped steel bars with a clear bar spacing of 16.75 cm. As discussed in Appendix 1A, the largest individuals in the population (depending on species, greater than 1.4 m in fork length) will be physically excluded from passing downstream. Slightly smaller individuals would also not be expected to pass downstream as the opening would only be slightly larger than their body. Based on the estimated velocities at the intake (ranging from 1.0–1.2 metres/second) and fish swimming capabilities, few fish are expected to become permanently impinged on the trash rack. Smaller fish that are moving downstream would move past the trash racks to the turbines.

At present, this reach is subject to limited domestic and commercial fishing activity. The construction of the access road and boat launch will improve access this reach and therefore have the potential to increase the harvest of targeted large-bodied fish species (*e.g.*, walleye, northern pike, and lake whitefish), though concerns related to increased mercury levels in some species (*e.g.*, walleye and northern pike) may affect the interest in the fishery. It is expected that the current commercial harvest will cease operation (Socio-economic, Resource Use, and Heritage Resources Supporting Volume [SE SV], Resources Use Chapter); therefore, a negligible decrease in mortality due to harvest is expected.

5.4.2.4 Access Road Stream Crossings

Changes in the quantity and quality of aquatic habitat described under construction would continue under operation if the north and south access roads are to remain in place for the lifespan of the GS. However, given the small amount of habitat affected and the provision of fish passage where fish are present (*i.e.*, Looking Back Creek, Gull Rapids Creek, Gillrat Lake Creek), no effect to fish populations is expected due to operation of the north and south access roads.

5.4.2.5 Net Effects of Operation with Mitigation

Fish movement studies suggest that there is limited movement of large-bodied fish species among the three reaches in the study area. Therefore, it is expected that the Project will have a differing level of effect on the fish community and VEC fish species in the Keeyask reservoir (from the GS upstream to Clark Lake) than to fish communities located either upstream or downstream of the reservoir.

The most prominent effect to fish community in the Keeyask reservoir over the long-term is expected to be related to a decrease in habitat diversity in the reservoir. Project-related changes in the availability of habitat required by fish species to complete the various life history stages could result in a shift in the species composition. Habitat in the reservoir will be deeper and slower moving than that which occurs in the existing environment and could result in an increase in species associated with lacustrine conditions and a decrease in species that prefer riverine conditions. As well, there will be a loss of run and riffle habitat associated with the inundation of several tributaries. Specific effects to the three VEC species include:

- Walleye and lake whitefish populations in the Keeyask reservoir are expected to benefit from impoundment over the long-term. Both the habitat-based model and existing conditions in reservoirs used as proxies (*e.g.*, Stephens Lake, reservoirs in Québec) suggest that the abundance of these species in the Keeyask reservoir would be similar to or moderately higher than conditions that currently exist in Gull Lake. Over the long-term, there could be an increase of foraging habitat available to walleye and lake whitefish populations. However, the homogenization of habitat conditions in the reservoir could result in a decrease in spawning habitat for these species, which spawn over cobble/gravel substrates in faster flowing water. Creation of artificial spawning beds in the reservoir for walleye and lake whitefish will mitigate some of this loss. The inundation of Birthday Rapids could also result in a loss of spawning habitat for these species; however, it is expected that fish would find alternative suitable habitat within Birthday Rapids or would move further upstream to access habitat available at Long Rapids.
- The modelled density (*i.e.*, CPUE) of northern pike is expected to decrease over the long-term in the Keeyask reservoir following impoundment. However, it is expected that there will be an increase in the actual number of northern pike due to the increase in useable northern pike habitat resulting from the increase in the size of the reservoir. Existing conditions in reservoirs used as proxies also suggest that the abundance of northern pike in the Keeyask reservoir would be similar or slightly lower than currently found in Gull Lake. Once macrophyte beds re-establish in the reservoir, spawning habitat for northern pike would be available around flooded tributary mouths and in upstream unflooded reaches of creeks.

Below the Keeyask GS, it is anticipated that the major effect to the fish community and VEC species will be associated with the destruction of fish habitat in Gull Rapids. Without mitigation, the loss of spawning habitat at Gull Rapids would likely result in a significant decrease in recruitment to the populations of some large-bodied species (*e.g.*, lake whitefish, walleye) in Stephens Lake. It is expected that these species would find alternative spawning habitat elsewhere in the reach or would use artificial spawning habitat created below the GS as part of mitigation. Because Gull Rapids is one of the few locations known to be used by lake whitefish in Stephens Lake, artificial spawning reefs will also be constructed in the lake to ensure there is adequate spawning habitat available post-Project. Therefore, in the long-term, it is expected that there will be a small to moderate decrease in walleye and lake whitefish populations in Stephens Lake. In contrast, the loss of spawning habitat at Gull Rapids is not expected to result in a detectable decrease in recruitment to northern pike populations in Stephens Lake as sufficient alternative spawning habitat is available in Stephens Lake and tributaries. There will be sufficient habitat available in the Nelson River below the GS and in Stephens Lake for forage species such that the loss of habitat at Gull Rapids will be negligible in maintaining current population levels.

The fish community and VEC species upstream of Clark Lake are not expected to be impacted by the Project since Long Rapids will be unaffected by impoundment and should prevent detectable changes to the current level of migration into or out of this reach.

5.4.3 Residual Effects

Expected residual effects to the fish community and VEC fish species resulting from construction and operation of the Project are summarized in Table 5-35 and Table 5-36, respectively, and are described in brief below.

5.4.3.1 Construction Period

Once the appropriate mitigation measures (described in Appendix 1A) are applied to address construction effects to the fish populations:

- There will be no predicted effects for fish residing in the reach of the Nelson River between Clark Lake and Stephens Lake.
- There will be a decrease in the year-class strength of fish residing in Stephens Lake that rely primarily on spawning habitat in Gull Rapids for the years that the cofferdams are in place.

5.4.3.2 Operation Period

Residual effects to the fish community within and below the reservoir will primarily occur as a result of changes in the quality and quantity of aquatic habitat and changes in water quality and the availability of lower trophic levels as forage.

- For the first five to ten years after impoundment, fish habitat in the newly flooded areas of the reservoir will be of lower quality for fish due to low DO conditions, shoreline instability, and the absence of aquatic plants.
- For northern pike, the newly flooded terrestrial habitat will provide an increase in spawning habitat until this vegetation decomposes.
- Over the long-term, there will be an increase in fish abundance in the reservoir in response to an increase in aquatic habitat; however, there will be shift in the fish community towards species that prefer lacustrine (*e.g.*, walleye) rather than riverine conditions (*e.g.*, longnose sucker).

- Spawning habitat for species such as walleye and lake whitefish that is no longer available in the reservoir or at Gull Rapids will be partially mitigated by the creation of spawning habitat created at nearby locations.
- The number of fish entering Stephens Lake from upstream may be reduced compared to existing conditions due to the creation of the reservoir environment. A small proportion of the fish that do move downstream into Stephens Lake will be injured or killed by passage through the turbines or over the spillway.

5.4.3.3 Summary of Residual Effects

Walleye and lake whitefish in Stephens Lake are predicted to experience negative effects during construction, but effects will be neutral in the long-term. In the Keeyask reservoir, both species are expected to experience a small, positive (population increase) effect. No construction-related effects are predicted for northern pike, but this species will experience some short-term negative effects until appropriate habitat becomes established in the reservoir. Predicted effects are continuous (for the duration of the effect). Adverse effects during construction and the initial years of operation are reversible, as VECs are expected to recover over time. The ecological context is moderate, reflecting the importance of the top-level predators in the aquatic ecosystem (walleye and northern pike) and their sensitivity (lake whitefish).

The technical scale fish assessment is based on an analysis of existing habitats and their post-Project condition, observation of scale fish in a proxy reservoir (*i.e.*, Stephens Lake), and scientific literature that discusses their success in other reservoirs. These approaches provide moderate to high certainty regarding the prediction of adverse effects.

5.4.4 Environmental Monitoring and Follow-up

As described in Chapter 8 of the Keeyask Generation Project: Response to EIS Guidelines, Environmental Monitoring Plans are being developed as part of the Environmental Protection Program for the Project. The intent of the monitoring plans is to determine whether effects of the Project are as predicted and mitigation measures are functioning as intended. The monitoring plans will also provide for follow-up actions if effects are greater than predicted: the actions that would be taken depend on the nature and magnitude of the effect. The design of the monitoring plans will also consider uncertainties identified during the analysis and/or raised by the KCNs or during the regulatory review process. For example, the technical analysis predicts that effects to water quality will occur within the reservoir and downstream but that no effects will occur upstream in Split Lake; based on local knowledge, the KCNs have identified effects to Split Lake and therefore, Split Lake is being included in the monitoring program.

An outline of monitoring planned for the mercury in fish tissue component of the aquatic environment is provided below. A detailed monitoring plan will be provided in the Aquatic Effects Monitoring Plan (AEMP). This document will provide a detailed description of the rationale, schedule, sampling locations and sampling methods for the technical monitoring that is proposed for the Project. This plan will be implemented in consultation with regulators, in particular DFO and Manitoba Conservation and Water

Stewardship, and it is expected that it will change based on regulatory review and on-going review of monitoring results. This monitoring plan will be implemented during the construction phase of the Project and will continue into the operations phase. Reports detailing the outcomes of monitoring programs will be prepared and submitted to regulators, to meet conditions of the Environment Act licence and other authorizations for the Project.

Monitoring will be conducted during construction to provide information on fish responses (both behavioural and biological) to events such as blasting and sediment inputs. Information on the relative abundance and composition of the fish community within Split Lake, the reservoir and Stephens Lake, as well as indicators of fish health after full supply level (FSL) is reached, will be collected. To address concerns of the KCNs, the general health of all fish species in the reservoir will be monitored. Monitoring to determine the effectiveness of the mitigation and compensation measures will also be carried out. Monitoring of the fish community and mitigation/compensation measures will occur annually during the first three years after FLS is reached, and then every three to five years for the following 20–30 years, depending on results. For a more detailed description of monitoring planned for the fish community, please see the Aquatic Effects Monitoring Plan (AEMP).

Additional monitoring is planned specifically for the VEC species within the fish community (walleye, northern pike and lake whitefish). Monitoring for spawning activity and larval fish at locations where these would be expected to occur post-Project will confirm that these species have adequate spawning habitat in the reservoir and downstream of the GS, and that constructed habitat is functioning as intended. This monitoring will occur at a minimum of every two years during construction and annually during the first three years after FSL is reached and then at a minimum of every five years for the following 20–30 years, depending on results. In order to determine whether or not fish passage methods need to be modified, movements of fish upstream and downstream of the GS will be monitored, their behaviour in the immediate vicinity of the GS will be observed, and the frequency at which fish pass through the turbines or spillway will be measured and their survival rates calculated. Fish movement studies will occur for the first five years after FSL is reaches, and further monitoring will depend on results and subsequent development of fish passage. For a more detailed description of monitoring planned for walleye, northern pike and lake whitefish, please see the AEMP.

5.5 REFERENCES

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TABLES, FIGURES, AND MAPS

Table 5-1: Fish species captured in the Keeyask study area (as indicated by an X), 1997–2008

Cree Name	Common Name	Scientific Name	Abbreviation	Split Lake Area	Keeyask Area	Stephens Lake Area
	Blacknose shiner	*Notropis heterolepis*	BLSH		X	
	Brook stickleback	*Culaea inconstans*	BRST	X	X	
mineye	Burbot (maria)	*Lota lota*	BURB	X	X	X
	Common carp (carp)	*Cyprinus carpio*	CMCR	X	X	X
atoonapis	Cisco (tullibee)	*Coregonus artedi*	CISC	X	X	X
	Emerald shiner	*Notropis atherinoides*	EMSH	X	X	X
	Fathead minnow	*Pimephales promelas*	FTMN		X	
	Finescale dace	*Chrosomus neogaeus*	FNDC		X	
pesimo kinoosayo	Freshwater drum	*Aplodinotus grunniens*	FRDR	X	X	X
wepicheesis	Goldeye	*Hiodon alosoides*	GOLD	X	X	
	Iowa darter	*Etheostoma exile*	IWDR	X	X	
	Johnny darter	*Etheostoma nigrum*	JHDR	X	X	
	Lake chub	*Couesius plumbeus*	LKCH	X	X	X
namayo	Lake sturgeon (sturgeon)	*Acipenser fulvescens*	LKST	X	X	X
atikameg	Lake whitefish (whitefish)	*Coregonus clupeaformis*	LKWH	X	X	X
	Logperch	*Percina caprodes*	LGPR	X	X	
	Longnose dace	*Rhinichthys cataractae*	LNDC	X	X	X
mikwa namaypin	Longnose sucker (red sucker)	*Catostomus catostomus*	LNSC	X	X	X
wepicheesis	Mooneye	*Hiodon tergisus*	MOON	X	X	X
	Mottled sculpin	*Cottus bairdii*	MTSC		X	
	Ninespine stickleback	*Pungitius pungitius*	NNST	X	X	X
	Northern pearl dace	*Margariscus nachtriebi*	PRDC		X	
unchwapayo	Northern pike (jackfish)	*Esox lucius*	NRPK	X	X	X
	Northern redbelly dace	*Chrosomus eos*	NRDC		X	

Table 5-1: Fish species captured in the Keeyask study area (as indicated by an X), 1997–2008

Cree Name	Common Name	Scientific Name	Abbreviation	Split Lake Area	Keeyask Area	Stephens Lake Area
wekopaysakun kinoosayo	Rainbow smelt (smelt)	*Osmerus mordax*	RNSM	X	X	X
	River darter	*Percina shumardi*	RVDR		X	
sagiganayso	Sauger	*Sander canadensis*	SAUG	X	X	X
ooskanaso	Shorthead redhorse	*Moxostoma macrolepidotum*	SHRD	X	X	X
	Silver lamprey	*Ichthyomyzon unicuspis*	SLLM	X	X	X
	Slimy sculpin	*Cottus cognatus*	SLSC	X	X	X
	Spoonhead sculpin	*Cottus ricei*	SPSC		X	
	Spottail shiner	*Notropis hudsonius*	SPSH	X	X	X
	Trout-perch	*Percopsis omiscomaycus*	TRPR	X	X	X
okaow	Walleye (pickerel)	*Sander vitreus*	WALL	X	X	X
	Western blacknose dace	*Rhinichthys obtusus*	WBDC		X	
namaypin	White sucker (mullet)	*Catostomus commersonii*	WHSC	X	X	X
	Yellow perch (perch)	*Perca flavescens*	YLPR	X	X	X

Table 5-2: Comparison of mean catch-per-unit effort (CPUE; number of fish per 100 m of net per 24 hours) for large-bodied VEC species and total catch for selected northern Manitoba waterbodies

Waterbody	Study Year	Lake Whitefish	Northern Pike	Walleye	Total Catch
Study Area					
Split Lake	1997–2002	1.9	6.0	9.9	35.0
Clark Lake	1997–2004	1.4	9.6	6.2	31.8
Assean Lake	2001–2002	10.3	7.9	26.9	57.7
Nelson River	2001–2002	0.7	9.4	3.1	19.7
Gull Lake	2001–2002	1.8	8.7	6.3	24.8
Stephens Lake	2002–2003	1.8	7.9	7.9	23.5
Other					
Limestone Lake[1]	2004	21.1	9.4	0.0	81.2
Myre Lake[1]	2004	27.1	3.1	0.0	33.1
Pelletier Lake[1]	2004	22.4	8.5	57.7	107.6
Recluse Lake[1]	2004	15.3	6.3	20.3	47.9
Wasakaiowaka Lake[1]	2004	18.5	21.9	45.1	104.9
Maskwapin Lake[1]	2004	0.0	8.3	0.0	27.0
Caldwell Lake[1]	2005	23.5	12.0	12.7	62.3
Christie Lake[1]	2005	21.4	11.5	10.0	62.7
Thomas Lake[1]	2005	33.0	11.6	18.6	73.9
Kiask Lake[1]	2005	23.0	6.1	0.2	50.6
Atkinson Lake[1]	2004–2006	0.4	13.7	19.3	40.9
Cyril Lake[1]	2004–2006	14.1	9.8	0.7	31.4
War Lake[1]	2004–2006	2.6	8.9	5.4	21.2
Notigi Lake[2]	1999–2001	1.0	3.9	3.5	18.4
Leftrook Lake[3]	1999–2001	10.6	14.3	40.6	112.8
Wuskwatim Lake[4]	1998–2002	4.1	4.4	11.4	68.1
Cross Lake[5]: east basin	1992–2006	1.9	16.0	14.7	54.7
west basin	1992–2006	1.1	10.3	10.9	50.1
Limestone reservoir[6]	1992–2003	0.8	1.9	2.1	17.9
Churchill River[7]: pre-weir	1995–1996	1.8	4.0	0.0	9.3
post-weir	1999–2006	2.1	2.6	0.4	6.5
Rat River[8]	2004	0.9	4.9	19.4	43.2
Burntwood River[9]	2001–2002	2.1	4.8	12.1	34.3
Lower Nelson River[10]	2003	5.4	2.9	4.6	31.9

1. MacDonald (2007).
2. After Mota and Fazakas (2000) and Caskey and Mota (2003).
3. After Fazakas (2000) and MacDonald (2003).
4. After Manitoba Hydro and NCN (2003) and Kroeker and Mota (2003).
5. After Richardson and MacDonell (2007).
6. After Johnson et al. (2004).
7. After Pisiak and Bernhardt (2007).
8. Mota (2005).
9. Manitoba Hydro and NCN (2003).
10. After Johnson and MacDonell (2004).

Table 5-3: Number (n), relative abundance (RA; %), and catch-per-unit-effort (CPUE; number of fish/100 m of net/24 hours), by waterbody, of fish captured in standard gang index gill nets set in the Split Lake area during the summer 1997–2004

Species	Clark Lake																	
	1997 (n = 2)[1]			1998 (n = 2)			2001 (n = 2)			2002 (n = 2)			2004 (n = 2 [3])			Combined		
	n	RA	CPUE	n	RA	CPUE	n	RA	CPUE	n	RA	CPUE	n	RA	CPUE	n	RA	CPUE[4]
Burbot	1	0.2	na[2]	-	-	-	-	-	-	-	-	-	-	-	-	1	0.1	na
Cisco	18	4.0	2.4	3	1.3	0.3	-	-	-	-	-	-	2	2.2	0.4	23	2.0	0.6
Freshwater drum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Goldeye	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lake chub	1	0.2	na	-	-	-	-	-	-	-	-	-	-	-	-	1	0.1	na
Lake sturgeon	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lake whitefish	28	6.3	3.6	3	1.3	0.4	2	0.9	0.3	15	9.6	2.9	-	-	-	48	4.1	1.4
Longnose sucker	1	0.2	na	-	-	-	-	-	-	-	-	-	-	-	-	1	0.1	na
Mooneye	180	40.4	23.3	18	7.7	2.1	4	1.7	0.3	10	6.4	1.9	-	-	-	212	18.3	5.3
Northern pike	77	17.3	9.9	55	23.4	6.8	86	37.2	8.9	64	40.8	12.2	55	59.8	10.4	337	29.0	9.6
Rainbow smelt	-	-	-	2	0.9	na	1	0.4	0.1	2	1.3	0.4	1	1.1	0.2	6	0.5	na
Sauger	29	6.5	3.7	4	1.7	0.5	11	4.8	1.4	6	3.8	1.1	1	1.1	0.2	51	4.4	1.4
Shorthead redhorse	1	0.2	na	2	0.9	na	-	-	-	-	-	-	-	-	-	3	0.3	na
Trout-perch	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Walleye	45	10.1	5.7	60	25.5	7.5	75	32.5	9.0	20	12.7	3.8	25	27.2	4.8	225	19.4	6.2
White sucker	46	10.3	5.9	50	21.3	6.1	27	11.7	3.2	37	23.6	7.0	6	6.5	1.2	166	14.3	4.7
Yellow perch	19	4.3	na	38	16.2	na	25	10.8	2.8	3	1.9	0.6	2	2.2	0.4	87	7.5	na
Total	446	100	57.0	235	100	28.8	231	100	26.0	157	100	29.9	92	100	17.6	1161	100	31.8

Species	Split Lake															Assean Lake								
	1997 (n = 15)			1998 (n =14)			2001 (n =14)			2002 (n = 14)			Combined			2001 (n = 11)			2002 (n = 11)			Combined		
	n	RA	CPUE	n	RA	CPUE	n	RA	CPUE	n	RA	CPUE	n	RA	CPUE	n	RA	CPUE	n	RA	CPUE	n	RA	CPUE
Burbot	17	0.8	na	36	2.2	na	22	1.4	0.4	35	2.9	1.0	110	1.7	na	1	0.1	<0.1	3	0.2	0.1	4	0.1	0.1
Cisco	132	6.2	2.2	96	5.8	1.7	7	0.4	0.1	14	1.2	0.4	249	3.8	1.1	126	7.8	5.0	36	2.6	1.4	162	5.4	3.2
Freshwater drum	-	-	-	2	0.1	na	2	0.1	<0.1	1	0.1	<0.1	5	0.1	na	-	-	-	-	-	-	-	-	-
Goldeye	-	-	-	-	-	-	-	-	-	1	0.1	<0.1	1	0.0	<0.1	-	-	-	-	-	-	-	-	-
Lake chub	8	0.4	na	4	0.2	na	12	0.7	0.3	7	0.6	0.2	31	0.5	na	-	-	-	1	0.1	<0.1	1	0.0	<0.1
Lake sturgeon	2	0.1	na	-	-	-	-	-	-	2	0.2	0.1	4	0.1	na	-	-	-	-	-	-	-	-	-
Lake whitefish	130	6.1	2.4	77	4.6	1.5	63	3.9	1.5	70	5.8	2.1	340	5.1	1.9	308	19.0	11.8	239	17.0	8.7	547	18.1	10.3
Longnose sucker	24	1.1	na	28	1.7	na	3	0.2	0.1	24	2.0	0.7	79	1.2	na	-	-	-	-	-	-	-	-	-
Mooneye	254	11.9	5.5	164	9.9	2.9	27	1.7	0.6	55	4.6	1.6	500	7.5	2.7	-	-	-	-	-	-	-	-	-
Northern pike	333	15.6	6.3	275	16.6	4.9	252	15.5	5.4	275	22.9	7.5	1135	17.1	6.0	235	14.5	8.9	195	13.8	6.9	430	14.2	7.9
Rainbow smelt	5	0.2	na	16	1.0	na	26	1.6	0.7	11	0.9	0.3	58	0.9	na	-	-	-	-	-	-	-	-	-
Sauger	405	18.9	7.0	257	15.5	5.0	213	13.1	4.6	233	19.4	6.6	1108	16.7	5.8	-	-	-	-	-	-	-	-	-
Shorthead redhorse	5	0.2	na	4	0.2	na	5	0.3	0.1	4	0.3	0.1	18	0.3	na	-	-	-	-	-	-	-	-	-
Trout-perch	2	0.1	na	-	-	-	-	-	-	2	0.2	0.1	4	0.1	na	-	-	-	-	-	-	-	-	-
Walleye	505	23.6	9.1	470	28.3	8.4	693	42.6	16.0	227	18.9	6.2	1895	28.6	9.9	657	40.6	25.4	738	52.4	28.5	1395	46.1	26.9
White sucker	274	12.8	4.8	178	10.7	3.2	243	15.0	5.1	209	17.4	6.0	904	13.6	4.8	194	12.0	7.6	124	8.8	4.7	318	10.5	6.1
Yellow perch	43	2.0	na	54	3.3	na	57	3.5	1.3	32	2.7	0.8	186	2.8	na	99	6.1	3.8	72	5.1	2.6	171	5.6	3.2
Total	2139	100	39.7	1661	100	30.2	1625	100	36.1	1202	100	33.7	6627	100	35.0	1620	100	62.5	1408	100	52.9	3028	100	57.7

1. The number in parentheses represents the number of sites fished in a given year.
2. na = individual species values were not available; therefore a mean could not be calculated.
3. Includes sites that were fished in previous years.
4. The overall mean CPUE was calculated by averaging the mean value at each site across years.

Table 5-4: Number (n), relative abundance (RA; %), and catch-per-unit-effort (CPUE; number of fish/30 m of net/24 hours), by waterbody, of small-bodied fish captured in bottom-set small mesh index gill nets set in the Split Lake Area during the summer 2001–2004

Species	Clark Lake											
	2001 (n =2)[1]			2002 (n = 2)			2004 (n = 2 [2])			Combined		
	n	RA	CPUE	n	RA	CPUE	n	RA	CPUE	n	RA	CPUE[3]
Emerald shiner	-	-	-	2	1.2	0.5	6	6.4	1.6	8	2.8	0.7
Lake chub	1	4.8	0.3	-	-	-	3	3.2	0.8	4	1.4	0.4
Logperch	-	-	-	-	-	-	-	-	-	-	-	-
Rainbow smelt	4	19.0	1.1	6	3.5	1.6	29	14.9	8.0	39	13.6	3.6
Slimy sculpin	-	-	-	-	-	-	-	-	-	-	-	-
Spottail shiner	11	52.4	2.9	64	37.4	17.0	41	43.6	9.9	116	40.6	10.0
Trout-perch	5	23.8	1.3	99	57.9	26.2	15	16.0	4.1	119	41.6	10.5
Total	21	100.0	5.6	171	100.0	45.4	94	84.1	24.3	286	100.0	25.1

Species	Split Lake								
	2001 (n = 14)			2002 (n = 14)			Combined		
	n	RA	CPUE	n	RA	CPUE	n	RA	CPUE
Emerald shiner	16	2.8	0.6	90	6.0	3.5	106	5.2	2.0
Lake chub	8	1.4	0.3	31	2.1	1.2	39	1.9	0.7
Logperch	-	-	-	-	-	-	-	-	-
Rainbow smelt	223	39.4	8.3	205	13.8	7.8	428	20.8	8.0
Slimy sculpin	-	-	-	-	-	-	-	-	-
Spottail shiner	161	28.4	6.2	653	43.8	25.2	814	39.6	15.6
Trout-perch	158	27.9	6.2	511	34.3	19.5	669	32.5	12.6
Total	566	100.0	23.9	1490	100.0	57.2	2056	100.0	38.8

Species	Assean Lake								
	2001 (n = 7)			2002 (n = 7)			Combined		
	n	RA	CPUE	n	RA	CPUE	n	RA	CPUE
Emerald shiner	714	49.9	57.7	201	24.6	17.0	915	40.7	43.2
Lake chub	-	-	-	-	-	-	-	-	-
Logperch	-	-	-	-	-	-	-	-	-
Rainbow smelt	-	-	-	-	-	-	-	-	-
Slimy sculpin	2	0.1	0.6	-	-	-	2	0.1	0.3
Spottail shiner	627	43.8	60.5	551	67.4	43.1	1178	52.4	51.8
Trout-perch	88	6.1	7.2	66	8.1	4.8	154	6.8	6.0
Total	1431	100.0	117.4	818	100.0	74.8	2249	100.0	89.1

1. The number in parentheses represents the number of sites fished in a given year.
2. Includes sites that were fished in previous years.
3. The overall mean CPUE was calculated by averaging the mean value at each site across years.

Table 5-5: Mean catch-per-unit-effort (CPUE), by general habitat category, of the total catch and of VEC species in bottom-set index gill nets set in Split, Clark and Assean lakes during summer, 1997–2004

General Habitat Category[1]	Standard Gang Index Gill Nets[2]					Small Mesh Index Gill Nets[3]	
	Sets	Lake Whitefish	Northern Pike	Walleye	Total Catch	Sets	Forage Fish
Split/Clark lakes							
Nearshore lacustrine	28	1.9	8.4	6.5	33.0	12	27.6
Offshore lacustrine	56	3.0	5.2	12.9	39.8	26	37.5
Assean Lake							
East basin	6	8.6	7.7	17.0	46.3	2	55.3
West basin	12	13.1	8.4	17.8	49.4	10	99.8
Channel	4	4.4	6.8	69.2	99.6	2	83.7

1. General habitat categories are described in Table 5B-2.
2. CPUE = number of fish/100 m of net/24 hours.
3. CPUE = number of fish/30 m of net/24 hours.

Table 5-6: Comparison of the number (n), relative abundance (RA; %), and mean catch-per-unit-effort (CPUE; number of fish/30 m of net/24 hours) of forage fish captured in surface-set and bottom-set small mesh index gill nets set in the Split Lake area during summer, 2001–2004

Species	Clark Lake (n = 1)[1]						Split Lake (n = 7)					
	Surface-Set			Bottom-Set			Surface-Set			Bottom-Set		
	n	RA	CPUE	n	RA	CPUE	n	RA	CPUE	n	RA	CPUE
Emerald shiner	53	38.4	10.8	2	2.1	0.4	189	30.0	11.1	51	5.1	2.0
Lake chub	3	2.2	0.9	3	3.2	0.5	24	3.8	1.2	24	2.4	1.0
Logperch	-	-	-	-	-	-	-	-	-	-	-	-
Rainbow smelt	31	22.5	5.3	30	31.6	5.4	185	29.4	9.7	136	13.7	5.7
Slimy sculpin	-	-	-	-	-	-	-	-	-	-	-	-
Spottail shiner	51	37.0	9.3	15	15.8	2.6	183	29.0	10.3	492	49.4	20.5
Trout-perch	-	-	-	45	47.4	7.8	49	7.8	2.8	292	29.3	12.1
Total	138	100.0	32.7	95	100.0	27.3	630	100.0	34.6	995	100.0	44.1

Species	Assean Lake (n =2)					
	Surface-Set			Bottom-Set		
	n	RA	CPUE	n	RA	CPUE
Emerald shiner	660	89.1	91.9	65	12.7	9.1
Lake chub	-	-	-	-	-	-
Logperch	-	-	-	-	-	-
Rainbow smelt	-	-	-	-	-	-
Slimy sculpin	-	-	-	1	0.2	0.6
Spottail shiner	81	10.9	10.8	377	73.8	52.0
Trout-perch	-	-	-	68	13.3	9.2
Total	741	100.0	101.4	511	100.0	66.3

1. The number in parentheses represents the number of sites fished in a given year; only sites fished with both bottom- and surface-sets were included in the analysis.

Table 5-7: Number (n), relative abundance (RA; %), and catch-per-unit-effort (CPUE; number of fish/100 m of net/24 hours), by waterbody, of fish captured in standard gang index gill nets set in the Keeyask area during fall 1999 and summer 2001–2003

Species	Gull Lake											
	1999 (n = 12)[1]			2001 (n = 16)			2002 (n = 16)			Combined[2]		
	n	RA	CPUE	n	RA	CPUE	n	RA	CPUE	n	RA	CPUE[3]
Burbot	3	0.4	0.1	2	0.2	0.1	3	0.3	0.1	5	0.3	0.1
Cisco	4	0.5	0.1	3	0.3	0.1	3	0.3	0.1	6	0.3	0.1
Lake chub	-	-	-	2	0.2	0.1	1	0.1	<0.1	3	0.2	<0.1
Lake sturgeon	2	0.2	0.7	1	0.1	<0.1	1	0.1	<0.1	2	0.1	<0.1
Lake whitefish	40	4.8	1.4	90	8.9	2.4	46	5.2	1.2	136	7.2	1.8
Longnose sucker	-	-	-	4	0.4	0.1	6	0.7	0.2	10	0.5	0.1
Mooneye	2	0.2	0.1	53	5.2	1.5	52	5.9	1.3	105	5.5	1.4
Northern pike	503	61.0	17.1	308	30.5	8.1	368	41.5	9.4	676	35.7	8.7
Rainbow smelt	3	0.4	0.1	10	1.0	0.3	27	3.0	0.7	37	2.0	0.5
Sauger	2	0.2	0.1	29	2.9	0.8	18	2.0	0.5	47	2.5	0.6
Shorthead redhorse	1	0.1	<0.1	-	-	-	1	0.1	<0.1	1	0.1	<0.1
Walleye	115	13.9	3.8	284	28.1	7.5	193	21.8	5.0	477	25.2	6.3
White sucker	134	16.2	4.3	115	11.4	3.1	133	15.0	3.4	248	13.1	3.3
Yellow perch	16	1.9	0.5	109	10.8	2.9	34	3.8	0.9	143	7.5	1.9
Total	825	100.0	27.7	1010	100.0	26.9	886	100.0	22.7	1896	100.0	24.8

Table 5-7: Number (n), relative abundance (RA; %), and catch-per-unit-effort (CPUE; number of fish/100 m of net/24 hours), by waterbody, of fish captured in standard gang index gill nets set in the Keeyask area during fall 1999 and summer 2001–2003

Species	Nelson River between Clark Lake and Gull Lake											
	1999 (n = 4)			2001 (n = 8)			2002 (n = 8)			Combined[2]		
	n	RA	CPUE	n	RA	CPUE	n	RA	CPUE	n	RA	CPUE
Burbot	3	2.2	0.3	-	-	-	2	0.5	0.1	2	0.3	<0.1
Cisco	-	-	-	4	1.1	0.2	1	0.2	0.1	5	0.6	0.1
Lake chub	1	0.7	0.1	-	-	-	3	0.7	0.2	3	0.4	0.1
Lake sturgeon	-	-	-	-	-	-	-	-	-	-	-	-
Lake whitefish	4	2.9	0.4	13	3.6	0.7	15	3.6	0.8	28	3.6	0.7
Longnose sucker	3	2.2	0.3	4	1.1	0.2	6	1.4	0.3	10	1.3	0.2
Mooneye	1	0.7	0.1	10	2.8	0.5	3	0.7	0.1	13	1.7	0.3
Northern pike	78	56.9	8.2	138	38.5	6.7	237	56.2	12.1	375	48.1	9.4
Rainbow smelt	-	-	-	4	1.1	0.2	5	1.2	0.1	9	1.2	0.2
Sauger	2	1.5	0.2	1	0.3	0.1	2	0.5	0.1	3	0.4	0.1
Shorthead redhorse	-	-	-	5	1.4	0.2	3	0.7	0.2	8	1.0	0.2
Walleye	26	19.0	2.8	76	21.2	3.7	49	11.6	2.5	125	16.0	3.1
White sucker	16	11.7	1.7	36	10.1	1.7	43	10.2	2.2	79	10.1	2.0
Yellow perch	3	2.2	0.3	67	18.7	3.6	53	12.6	2.8	120	15.4	3.2
Total	137	100.0	14.5	358	100.0	17.9	422	100.0	21.5	780	100.0	19.7

Table 5-7: Number (n), relative abundance (RA; %), and catch-per-unit-effort (CPUE; number of fish/100 m of net/24 hours), by waterbody, of fish captured in standard gang index gill nets set in the Keeyask area during fall 1999 and summer 2001–2003

Species	Gull Rapids								
	2002 (n = 3)			2003 (n = 3)			Combined		
	n	RA	CPUE	n	RA	CPUE	n	RA	CPUE
Burbot	3	2.1	0.4	4	2.2	0.6	7	2.1	0.5
Cisco	-	-	-	1	0.5	0.1	1	0.3	0.1
Lake whitefish	-	-	-	-	-	-	-	-	-
Longnose sucker	2	1.4	0.2	11	6.0	1.6	13	4.0	0.9
Mooneye	2	1.4	0.3	23	12.6	3.2	25	7.6	1.7
Northern pike	18	12.4	2.5	21	11.5	2.9	39	11.9	2.7
Rainbow smelt	7	4.8	1.0	-	-	-	7	2.1	0.5
Sauger	49	33.8	6.8	58	31.9	8.3	107	32.7	7.5
Walleye	48	33.1	6.2	47	25.8	6.6	95	29.1	6.4
White sucker	16	11.0	2.2	17	9.3	2.4	33	10.1	2.3
Total	145	100.0	19.5	182	100.0	25.6	327	100.0	22.6

1. The number in parentheses represents the number of sites fished in a given year.
2. Does not include data from 1999 because it was conducted during the fall instead of summer.
3. The overall mean CPUE was calculated by averaging the mean value at each site across years .

Table 5-8: Mean catch-per-unit-effort (CPUE) of the total catch and of VEC species, by general habitat category, in index gill nets set in the Nelson River between Clark Lake and Gull Rapids and below Gull Rapids during the summer from 2001–2003

General Habitat Category[1]	Standard Gang Index Gill Nets[2]					Small Mesh Index Gill Nets[3]	
	Sets	Lake Whitefish	Northern Pike	Walleye	Total Catch	Sets	Forage Fish
Nelson River between Clark Lake and Gull Rapids							
Backbays	16	2.0	13.2	4.4	28.7	10	104.3
Nearshore lacustrine	8	1.0	11.4	7.0	25.8	6	37.1
Offshore lacustrine	12	1.9	4.7	6.7	22.9	10	72.8
Riverine	12	0.5	5.9	3.7	13.8	6	9.3
Below Gull Rapids							
Riverine	6	-	2.7	6.4	22.6	5	26.3

1. General habitat categories are described in Table 5B-2.
2. CPUE = number of fish/100 m of net/24 hours.
3. CPUE = number of fish/30 m of net/24 hours.

Table 5-9: Number (n), relative abundance (RA; %), and catch-per-unit-effort (CPUE; number of fish/30 m of net/24 hours), by waterbody, of small-bodied fish captured in bottom-set small mesh index gill nets set in the Keeyask area during summer, 2001–2003

Species	Gull Lake								
	2001 (n = 12)[1]			2002 (n = 12)			Combined		
	n	RA	CPUE	n	RA	CPUE	n	RA	CPUE[2]
Emerald shiner	7	0.4	0.4	18	1.3	0.8	25	0.8	0.6
Lake chub	1	0.1	<0.1	1	0.1	<0.1	2	0.1	0.0
Rainbow smelt	451	28.4	20.8	371	26.6	17.0	822	27.5	19.3
Slimy sculpin	-	-	-	1	0.1	<0.1	-	-	-
Spottail shiner	850	53.6	40.9	443	31.7	20.3	1293	43.3	30.6
Trout-perch	278	17.5	13.5	563	40.3	26.4	841	28.2	20.0
Total	1587	100.0	75.6	1397	100.0	64.9	2984	100.0	70.4
Species	**Nelson River between Clark Lake and Gull Lake**								
	2001 (n = 4)			2002 (n = 4)			Combined		
	n	RA	CPUE	n	RA	CPUE	n	RA	CPUE
Emerald shiner	20	3.7	2.9	1	1.5	0.1	21	3.5	1.5
Lake chub	-	-	-	1	1.5	0.1	1	0.2	0.1
Rainbow smelt	241	44.5	36.7	24	35.8	3.4	265	43.6	20.0
Slimy sculpin	-	-	-	-	-	-	-	-	-
Spottail shiner	250	46.2	38.1	2	3.0	0.3	252	41.4	19.2
Trout-perch	30	5.5	4.3	39	58.2	5.6	69	11.3	5.0
Total	541	100.0	82.1	67	100.0	9.6	608	100.0	45.8
Species	**Gull Rapids**								
	2002 (n = 2)			2003 (n = 3)			Combined		
	n	RA	CPUE	n	RA	CPUE	n	RA	CPUE
Emerald shiner	66	53.2	19.6	18	18.8	3.9	84	38.2	10.2
Lake chub	-	-	-	-	-	-	-	-	-
Rainbow smelt	15	12.1	4.4	7	7.3	1.4	22	10.0	2.6
Slimy sculpin	2	1.6	0.3	-	-	-	2	0.9	0.1
Spottail shiner	23	18.5	6.8	21	21.9	4.5	44	20.0	5.4
Trout-perch	18	14.5	4.7	50	52.1	10.1	68	30.9	8.0
Total	124	100.0	35.9	96	100.0	19.9	220	100.0	26.3

1. The number in parentheses represents the number of sites fished in a given year.
2. The overall mean CPUE was calculated by averaging the mean value at each site across years.

Table 5-10: Comparison of the number (n), relative abundance (RA; %), and mean catch-per-unit-effort (CPUE; # fish/30 m of net/24 hours) of forage fish captured in surface-set and bottom-set small mesh index gill nets set in the Nelson River between Clark Lake and Gull Rapids during summer, 2001–2002

Species	Surface-Sets (n = 13)[1]			Bottom-Sets (n = 13)		
	n	RA	CPUE	n	RA	CPUE
Emerald shiner	1182	41.0	44.7	11	0.8	0.5
Lake chub	1	<0.1	<0.1	1	0.1	<0.1
Rainbow smelt	1437	49.8	54.2	322	23.8	13.6
Slimy sculpin	-	-	-	-	-	-
Spottail shiner	221	7.7	9.2	621	45.9	26.4
Trout-perch	45	1.6	1.9	397	29.4	16.9
Total	2886	100.0	110.0	1352	100.0	57.3

1. The number in parentheses represents the number of sites fished in a given year; only sites fished with both bottom- and surface-sets were included in the analysis.

Table 5-11: Number (n), relative abundance (RA; %), and catch-per-unit-effort (CPUE; number of fish/10 m haul), by waterbody, of small-bodied fish captured in seine hauls conducted in the Keeyask Area during summer, 2001–2003

Species	Gull Lake											
	2001 (n = 7)[1]			2002 (n = 11)			2003 (n = 19)			Combined		
	n	RA	CPUE	n	RA	CPUE	n	RA	CPUE	n	RA	CPUE[2]
Brook stickleback	2	0.1	<0.1	1	<0.1	<0.1	-	-	-	3	<0.1	<0.1
Emerald shiner	32	1.0	0.6	361	4.9	3.7	10465	64.1	56.1	10858	40.2	30.0
Fathead minnow	-	-	-	2	<0.1	<0.1	-	-	-	2	<0.1	<0.1
Finescale dace	-	-	-	-	-	-	-	-	-	-	-	-
Iowa darter	-	-	-	22	0.3	0.2	26	0.2	0.3	48	0.2	0.2
Johnny darter	60	1.8	1.0	660	9.0	6.8	746	4.6	6.2	1466	5.4	5.4
Lake chub	-	-	-	18	0.2	0.2	5	<0.1	<0.1	23	0.1	0.1
Logperch	-	-	-	3	<0.1	<0.1	4	<0.1	<0.1	7	<0.1	<0.1
Longnose dace	28	0.8	0.8	133	1.8	1.3	1757	10.8	11.5	1918	7.1	6.3
Mottled sculpin	-	-	-	3	<0.1	<0.1	12	0.1	0.1	15	0.1	<0.1
Ninespine stickleback	54	1.6	1.3	64	0.9	0.7	25	0.2	0.1	143	0.5	0.3
Pearl dace	-	-	-	7	0.1	<0.1	1	<0.1	<0.1	8	<0.1	<0.1
Rainbow smelt	2285	68.5	35.9	2617	35.5	23.3	265	1.6	2.4	5167	19.1	15.0
River darter	-	-	-	3	<0.1	<0.1	-	-	-	3	<0.1	<0.1
Slimy sculpin	4	0.1	0.1	81	1.1	0.9	10	0.1	0.1	95	0.4	0.3
Spottail shiner	551	16.5	10.2	2110	28.6	19.2	2229	13.7	24.1	4890	18.1	20.0
Trout-perch	321	9.6	5.0	1287	17.5	12.1	769	4.7	5.2	2377	8.8	7.2
Western blacknose dace	-	-	-	-	-	-	-	-	-	-	-	-
Total	3337	100.0	54.9	7372	100.0	68.1	16314	100.0	106.1	27023	100.0	105.1

Table 5-11: Number (n), relative abundance (RA; %), and catch-per-unit-effort (CPUE; number of fish/10 m haul), by waterbody, of small-bodied fish captured in seine hauls conducted in the Keeyask Area during summer, 2001–2003

Species	Nelson River between Clark Lake and Gull Lake											
	2001 (n = 3)[1]			2002 (n = 5)			2003 (n = 7)			Combined		
	n	RA	CPUE	n	RA	CPUE	n	RA	CPUE	n	RA	CPUE[2]
Brook stickleback	-	-	-	4	0.1	0.6	7	0.1	0.6	11	0.1	0.5
Emerald shiner	20	16.1	1.3	705	15.9	17.0	9201	75.9	252.6	9926	59.5	123.8
Fathead minnow	-	-	-	2	<0.1	<0.1	-	-	-	2	<0.1	<0.1
Finescale dace	-	-	-	-	-	-	1	<0.1	<0.1	1	<0.1	<0.1
Iowa darter	-	-	-	5	0.1	0.1	94	0.8	3.7	99	0.6	1.8
Johnny darter	5	4.0	0.4	852	19.2	44.3	756	6.2	38.5	1613	9.7	32.8
Lake chub	-	-	-	53	1.2	3.5	17	0.1	0.4	70	0.4	1.4
Logperch	-	-	-	26	0.6	3.8	10	0.1	0.2	36	0.2	1.4
Longnose dace	2	1.6	0.2	263	5.9	17.0	1487	12.3	97.3	1752	10.5	51.1
Mottled sculpin	-	-	-	13	0.3	0.4	7	0.1	0.2	20	0.1	1.4
Ninespine stickleback	29	23.4	2.0	16	0.4	0.9	10	0.1	0.4	55	0.3	0.9
Pearl dace	-	-	-	5	0.1	<0.1	5	<0.1	<0.1	10	0.1	<0.1
Rainbow smelt	40	32.3	2.9	812	18.3	22.1	21	0.2	0.5	873	5.2	8.2
River darter	-	-	-	5	0.1	<0.1	-	-	-	5	<0.1	<0.1
Slimy sculpin	-	-	-	80	1.8	3.1	31	0.3	0.7	111	0.7	1.3
Spottail shiner	15	12.1	1.1	1501	33.9	49.4	429	3.5	12.8	1945	11.7	22.7
Trout-perch	13	10.5	1.1	82	1.9	2.1	41	0.3	0.8	136	0.8	1.3
Western blacknose dace	-	-	-	4	0.1	-	-	-	-	4	<0.1	<0.1
Total	124	100.0	9.0	4428	100.0	166.3	12117	100.0	408.9	16669	100.0	307.8

1. The number in parentheses represents the number of sites fished in a given year.
2. The overall mean CPUE was calculated by averaging the mean value at each site across years.

Table 5-12: Mean catch-per-unit-effort (number of fish/10 m of shoreline) of the total forage fish catch, rainbow smelt, and young-of-the-year VEC species, by general habitat category, in seine hauls conducted in the Nelson River between Birthday Rapids and Gull Rapids during summer, 2001–2003

General Habitat Category[1]	Sets	Forage Fish	Young-of-the-Year		
			Walleye	Northern Pike	Lake Whitefish
Backbays	15	207.0	0.1	0.2	0.4
Nearshore lacustrine	26	81.9	0.3	0.4	0.4
Riverine	11	148.8	0.6	0.4	0.1

1. General habitat categories are described in Table 5B-2.

Table 5-13: Number (n), relative abundance (RA;%), and catch-per-unit-effort (CPUE; number of fish/100 m of net/24 hours) of fish captured in standard gang index gill nets set in the Stephens Lake area during summer, 2002–2003

Species	Stephens Lake								
	2002 (n = 32)[1]			2003 (n = 33)			Combined		
	n	RA	CPUE	n	RA	CPUE	n	RA	CPUE[2]
Burbot	1	0.1	<0.1	6	0.3	0.1	7	0.2	<0.1
Cisco	26	1.6	0.4	26	1.3	0.3	52	1.4	0.4
Lake chub	-	-	-	3	0.1	<0.1	3	0.1	<0.1
Lake sturgeon	-	-	-	1	<0.1	<0.1	1	<0.1	<0.1
Lake whitefish	147	8.9	2.0	142	6.9	1.7	289	7.8	1.8
Longnose sucker	-	-	-	19	0.9	0.2	19	0.5	0.1
Mooneye	27	1.6	0.4	155	7.5	1.9	182	4.9	1.2
Northern pike	511	31.1	6.8	733	35.7	9.0	1244	33.6	7.9
Rainbow smelt	36	2.2	0.4	18	0.9	0.2	54	1.5	0.3
Sauger	78	4.7	1.2	173	8.4	2.1	251	6.8	1.6
Trout-perch	-	-	-	1	<0.1	<0.1	1	<0.1	<0.1
Walleye	658	40.0	8.6	581	28.3	7.1	1239	33.5	7.9
White sucker	141	8.6	2.0	176	8.6	2.1	317	8.6	2.0
Yellow perch	19	1.2	0.2	20	1.0	0.2	39	1.1	0.2
Total	1644	100	22.0	2054	100	25.1	3698	100	23.5

1. The number in parentheses represents the number of sites fished in a given year.
2. The overall mean CPUE was calculated by averaging the mean value at each site across years.

Table 5-14: Mean catch-per-unit-effort (CPUE) of the total catch and of VEC species, by general habitat category, in index gill nets set in Stephens Lake during summer, 1999–2003

General Habitat Category[1]	Standard Gang Index Gill Nets[2]					Small Mesh Index Gill Nets[3]	
	Sets	Lake Whitefish	Northern Pike	Walleye	Total Catch	Sets	Forage Fish
Nearshore north arm	15	2.5	13.3	12.6	31.6	9	27.7
Offshore north arm	17	4.5	9.3	12.7	33.5	6	47.8
Nearshore old Nelson channel	17	0.1	7.1	4.0	16.3	14	43.3
Offshore old Nelson channel	26	0.3	1.7	2.0	12.1	2	14.1

1. General habitat categories are described in Table 5B-2.
2. CPUE = number of fish/100 m of net/24 hours.
3. CPUE = number of fish/30 m of net/24 hours.

Table 5-15: Number (n), relative abundance (RA; %), and catch-per-unit-effort (CPUE; number of fish/30 m of net/24 hours) of small-bodied fish captured in bottom-set small mesh index gill nets set in Stephens Lake during the summer 2002–2003

Species	Stephens Lake								
	2002 (n = 15)[1]			2003 (n = 16)			Combined		
	n	RA	CPUE	n	RA	CPUE	n	RA	CPUE[2]
Emerald shiner	47	4.9	2.9	74	7.6	2.5	121	6.2	2.7
Lake chub	-	-	-	1	0.1	<0.1	1	0.1	<0.1
Longnose dace	-	-	-	-	-	-	-	-	-
Rainbow smelt	115	12.0	4.6	67	6.8	2.3	182	9.4	3.4
Slimy sculpin	3	0.3	0.2	1	0.1	<0.1	4	0.2	0.1
Spottail shiner	563	58.7	24.0	676	69.1	22.8	1239	63.9	23.4
Trout-perch	231	24.1	11.0	160	16.3	5.5	391	20.2	8.2
Total	959	100.0	42.8	979	100.0	33.0	1938	100.0	37.7

1. The number in parentheses represents the number of sites fished in a given year.
2. The overall mean CPUE was calculated by averaging the mean value at each site across years.

Table 5-16: Comparison of the number (n), relative abundance (RA; %), and mean catch-per-unit-effort (CPUE; number of fish/30 m of net/24 hours) of forage fish captured in surface-set and bottom-set small mesh index gill nets set in Stephens Lake during summer 2003

Species	Surface-Sets (n = 3)[1]			Bottom-Sets (n =3)		
	n	RA	CPUE	n	RA	CPUE
Emerald shiner	223	44.7	41.4	2	1.5	0.4
Lake chub	-	-	-	-	-	-
Longnose dace	1	0.2	0.2	-	-	-
Rainbow smelt	20	4.0	3.7	20	14.6	3.6
Slimy sculpin	-	-	-	-	-	-
Spottail shiner	247	49.5	46.3	35	25.5	6.5
Trout-perch	8	1.6	1.5	80	58.4	14.6
Total	499	100.0	93.0	137	100.0	25.0

1. The number in parentheses represents the number of sites fished in a given year; only sites fished with both bottom- and surface-sets were included in the analysis.

Table 5-17: Catch-per-unit-effort (CPUE; number of fish/30 m of net/24 hours) of selected fish captured in gill nets set in flooded bay and main basin areas of Stephens Lake area during summer 2005 as part of habitat modelling studies

Species	Flooded Bay					Flooded Main Basin			
	Macrophyte	Open Deep	Open Shallow	Wood	Combined	Macrophyte	Open Deep	Open Shallow	Combined
	(n = 7)[3]	(n = 7)	(n = 6)	(n = 3)	(n = 23)	(n = 7)	(n = 1)	(n = 6)	(n = 14)
Small Mesh Index Gill Net									
Lake chub	-	-	-	-	-	0.5	-	0.2	0.3
Rainbow smelt	9.7	65.2	15.2	15.9	28.8	14.8	25.8	31.4	22.7
Shiner[1]	52.3	6.0	49.3	55.9	37.9	44.4	-	4.6	24.2
Slimy sculpin	-	-	-	-	-	-	-	0.2	0.1
Trout-perch	7.1	9.7	6.8	-	6.9	8.8	18.5	29.7	18.5
Yellow perch	5.4	-	6.5	4.4	3.9	0.5	-	-	0.2
Combination Gill Net[2]									
Burbot	-	0.1	-	-	<0.1	-	-	-	-
Cisco	0.1	0.5	0.4	-	0.3	0.4	-	0.2	0.3
Lake whitefish	0.2	0.4	0.1	0.3	0.2	0.1	1.1	0.2	0.2
Longnose sucker	-	0.1	-	-	<0.1	-	-	-	-
Mooneye	-	-	-	-	-	0.4	-	0.1	0.2
Northern pike <150 mm	0.4	-	0.1	0.4	0.2	0.5	-	-	0.3
≥150 mm	4.8	1.7	3.4	5.1	3.5	4.1	-	0.6	2.3
Sauger	0.1	-	-	-	<0.1	-	-	0.6	0.3
Walleye	0.3	-	-	0.2	0.1	4.5	0.6	0.5	2.5
White sucker	-	-	-	0.2	<0.1	0.2	-	0.6	0.3
Total catch	35.4	34.1	34.4	37.0	34.9	37.2	15.7	29.6	32.4

1. Predominantly spottail shiner and, to a lesser extent, emerald shiner.
2. Small mesh index gill net combined with 2 panels of standard gang gill net (1 and 2 " mesh).
3. n in parentheses represents the number of sites fished in each habitat type.

Table 5-18: Number of walleye marked with Floy®-tags and recaptured in Keeyask Study area waterbodies between 1999 and 2008

Tagging Waterbody	Location Code	Number Tagged	Number Recaptured[1]/Location																					Downstream of Study Area	Total Number Recaptured[3]	Individual Recapture Rate (%)
			Split Lake Area													Keeyask Area			Gull Rapids Area	Stephens Lake Area						
			1	2	3	4	5			8	9	10	11	?	Total[2]	12	13	Total[2]	14	15	16	17	Total[2]			
Split Lake Area																										
Split Lake	1	225	15	11	9	-	-	-	-	-	-	-	1	16	37	-	-	-	-	-	-	-	-	-	52	23.1
Aiken River	2	1752	137	299	71	12	-	-	-	-	-	-	1	59	564	-	-	-	-	-	-	-	-	-	564	32.2
Mistuska River	3	1020	59	8	69	-	-	-	-	-	-	-	-	67	199	-	-	-	-	-	-	-	-	-	199	19.5
Ripple River	4	18	4	-	-	-	-	-	-	-	-	-	-	-	0	-	-	-	-	-	-	-	-	-	4	22.2
Assean River	5	310	5	-	-	-	11	1	3	2	2	-	1	2	28	-	-	-	-	-	-	-	-	-	28	9.0
Crying River	6	53	-	-	-	-	-	1	-	4	-	-	-	-	5	-	-	-	-	-	-	-	-	-	5	9.4
Hunting River	7	107	-	-	-	-	1	-	-	1	-	-	-	-	2	-	-	-	-	-	1	-	1	-	3	2.8
Assean Lake	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Clark Lake (CL)	9	171	2	-	-	-	1	-	1	-	1	-	-	2	5	1	-	1	-	-	-	-	-	-	8	4.7
Burntwood/Odei River	10	58	8	-	-	-	-	-	-	-	-	1	-	1	2	-	-	-	-	-	-	-	-	-	10	17.2
Kelsey GS	11	124	-	-	-	-	-	-	-	-	-	-	3	1	4	-	-	-	-	-	-	-	-	-	4	3.2
Keeyask Area																										
Nelson River (CL-GL)	12	260	1	-	-	-	-	-	-	-	-	1	-	2	3	3	3	6	1	-	-	-	-	-	11	4.2
Gull Lake (GL)	13	236	-	-	-	-	-	-	-	-	-	1	-	-	1	-	8	8	1	-	-	-	-	1	11	4.7
Gull Rapids Area	14	848	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	66	15	-	1	16	-	82	9.7
Stephens Lake Area																										
Stephens Lake	15	161	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	1	-	-	1	-	6	3.7
North Moswakot River	16	74	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	4	-	6	-	6	8.1
South Moswakot River	17	39	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	2	-	-	2	-	3	7.7
Looking Back Creek	18	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total		5463	231	318	149	12	13	2	4	7	3	3	6	150	850	4	12	16	74	20	5	1	26	1	996	18.2

? Unknown whether Split Lake, Assean Lake, or Aiken, Ripple, Mistuska or Assean Rivers.

1. Does not include fish recaptured multiple times in a waterbody at any time.
2. Does not include fish recaptured multiple times within an area at any time.
3. Does not include fish recaptured multiple times anywhere in the study area at any time.

Table 5-19: Summary of movements of walleye radio-tagged in Gull and Stephens lakes between 2001 and 2004

Year	Number Tagged	Number Detected	Remained Within		Moved over GR		Moved over BR		Moved over LR	
			NR	STL	DS	US	DS	US	DS	US
2001/2002	30	28	23	5	-	-	-	-	-	-
2002/2003	-	29	23	4	1	-	-	1	-	-
2003/2004	-	24	19	5	-	-	-	-	-	-

NR = Nelson River between Clark Lake and Gull Rapids (including Gull Lake)
STL = Stephens Lake
DS = downstream
US = upstream
BR = Birthday Rapids
GR = Gull Rapids
LR = Long Rapids

Table 5-20: Number of walleye Floy®-tagged (n_T) and recaptured (n_R) and recapture rate (RR) of tagged fish during Keeyask Environmental Studies in study area waterbodies between 2001 and 2008

Location of Study	Period of Study	n_R	Tagging Location[1]	n_T	RR[2] (%)
Aiken River System (Aiken, Mistuska, Ripple Rivers, and York Landing arm of Split Lake)	31 May-11 Jun 2002	22	Aiken	1018	2.2
		0	Keeyask	197	0.0
	15 May-05 Jun 2003	86	Aiken	2264	3.8
		0	Keeyask	350	0.0
	04–19 Jun 2004	20	Aiken	2672	0.7
		0	Keeyask	456	0.0
	17 Sep-04 Oct 2004	13	Aiken	3005	0.4
		0	Keeyask	496	0.0
Assean River System (Assean, Hunting, and Crying Rivers, and Assean Lake)	10 May-24 Jun 2001	2	Assean	123	1.6
		0	Keeyask	50	0.0
	28 Aug-21 Oct 2001	0	Assean	127	0.0
		0	Keeyask	140	0.0
	19 May-06 Jul 2002	10	Assean	453	2.2
		0	Keeyask	197	0.0
	19 Aug-14 Oct 2002	2	Assean	470	0.4
		0	Keeyask	197	0.0
Burntwood River System (Burntwood and Odei rivers)	21 May-31 Jul 2001	0	Burntwood	3	0.0
		0	Keeyask	50	0.0
	05 Jun-18 Jul 2002	1	Burntwood	58	1.7
		0	Keeyask	130	0.0
	08 Jun-16 Jul 2005	0	Burntwood	58	0.0
		0	Keeyask	130	0.0
	21–26 Aug 2006	0	Burntwood	58	0.0
		0	Keeyask	130	0.0
	17 May-27 Jun 2007	0	Burntwood	58	0.0
		0	Keeyask	130	0.0
Kelsey Area (Nelson River between Split Lake and Kelsey GS, and Grass River)	21 May-31 Jul 2001	0	Kelsey	5	0.0
		0	Keeyask	50	0.0
	05 Jun-18 Jul 2002	0	Kelsey	130	0.0
		0	Keeyask	197	0.0
	15 Jun-16 Jul 2005	0	Kelsey	130	0.0
		0	Keeyask	456	0.0
	23 May-02 Jul 2006	3	Kelsey	130	2.3
		0	Keeyask	496	0.0
	17 May-27 Jun 2007	0	Kelsey	130	0.0
		0	Keeyask	496	0.0

Table 5-20: Number of walleye Floy®-tagged (n_T) and recaptured (n_R) and recapture rate (RR) of tagged fish during Keeyask Environmental Studies in study area waterbodies between 2001 and 2008

Location of Study	Period of Study	n_R	Tagging Location[1]	n_T	RR[2] (%)
Split Lake (excludes York Landing arm)	14–25 Aug 2001	0	Split L	0	-
		1	Keeyask	50	2.0
	12–25 Aug 2002	0	Split L	4	0.0
		0	Keeyask	130	0.0
	08 Jun-16 Jul 2005	0	Split L	4	0.0
		0	Keeyask	130	0.0
	15 Aug-10 Sep 2006	0	Split L	4	0.0
		0	Keeyask	130	0.0
Clark Lake	19–29 May 2002	0	Clark L	4	0.0
		0	Keeyask	197	0.0
	12–25 Aug 2002	0	Clark L	4	0.0
		0	Keeyask	197	0.0
	11 Sep-10 Oct 2002	0	Clark L	11	0.0
		0	Keeyask	197	0.0
	09 Jun-03 Jul 2004	0	Clark L	97	0.0
		1	Assean	470	0.2
		0	Keeyask	456	0.0
	16–22 Aug 2004	0	Clark L	97	0.0
		0	Keeyask	456	0.0
	18 Sep-10 Oct 2004	0	Clark L	171	0.0
		1	Assean	470	0.2
		0	Keeyask	496	0.0
	08 Jun-16 Jul 2005	0	Clark L	171	0.0
		0	Keeyask	496	0.0
	15 Aug-10 Sep 2006	1	Clark L	171	0.6
		0	Keeyask	496	0.0
Keeyask Area (Nelson River between Clark Lake and Gull Rapids)	21 May-31 Jul 2001	0	Keeyask	50	0.0
		0	Split L	131	0.0
		0	Stephens L	88	0.0
	14–26 Aug 2001	0	Keeyask	50	0.0
		0	Split L	131	0.0
		0	Stephens L	88	0.0
	22 Sep-08 Oct 2001	0	Keeyask	140	0.0
		0	Split L	135	0.0
		0	Stephens L	158	0.0
	09 Jun-15 Jul 2002	1	Keeyask	197	0.5
		0	Split L	1663	0.0
		0	Stephens L	209	0.0

Table 5-20: Number of walleye Floy®-tagged (n_T) and recaptured (n_R) and recapture rate (RR) of tagged fish during Keeyask Environmental Studies in study area waterbodies between 2001 and 2008

Location of Study	Period of Study	n_R	Tagging Location[1]	n_T	RR[2] (%)
Keeyask Area (Continued)	05–16 Aug 2002	0	Keeyask	197	0.0
		0	Split L	1663	0.0
		0	Stephens L	209	0.0
	10 Sep-13 Oct 2002	0	Keeyask	265	0.0
		0	Split L	1691	0.0
		0	Stephens L	268	0.0
	24 May-01 Jul 2003	4	Keeyask	350	1.1
		0	Split L	2937	0.0
		1	Stephens L	834	0.1
	03 Sep-11 Oct 2003	2	Keeyask	430	0.5
		0	Split L	2937	0.0
		0	Stephens L	1121	0.0
	09 Jun-21 Jul 2004	0	Keeyask	456	0.0
		0	Split L	3431	0.0
		0	Stephens L	1121	0.0
	22–25 Aug 2004	0	Keeyask	471	0.0
		0	Split L	3431	0.0
		0	Stephens L	1121	0.0
	14 Sep-09 Oct 2004	1	Keeyask	496	0.2
		0	Split L	1121	0.0
		0	Stephens L	3838	0.0
	23 May-02 Jul 2006	2	Keeyask	496	0.4
		0	Split L	3838	0.0
		0	Stephens L	1129	0.0
	15 Aug-10 Sep 2006	4	Keeyask	496	0.8
		0	Split L	3838	0.0
		0	Stephens L	1129	0.0
	28 Sep-03 Oct 2007	0	Keeyask	496	0.0
		0	Split L	3838	0.0
		0	Stephens L	1129	0.0
	04 Jun-04 Jul 2008	0	Keeyask	496	0.0
		0	Split L	3838	0.0
		0	Stephens L	1129	0.0
	12–27 Sep 2008	1	Keeyask	496	0.2
		0	Split L	3838	0.0
		0	Stephens L	1129	0.0

Table 5-20: Number of walleye Floy®-tagged (n_T) and recaptured (n_R) and recapture rate (RR) of tagged fish during Keeyask Environmental Studies in study area waterbodies between 2001 and 2008

Location of Study	Period of Study	n_R	Tagging Location[1]	n_T	RR[2] (%)
North Moswakot System	03 Sep-11 Oct 2002	1	N Moswakot	5	20.0
		0	Keeyask	197	0.0
	21 May-27 Jun 2003	2	N Moswakot	67	3.0
		0	Keeyask	350	0.0
	03 Sep-15 Oct 2003	0	N Moswakot	75	0.0
		0	Keeyask	430	0.0
South Moswakot System	04 Sep-13 Oct 2002	0	S Moswakot	5	0.0
		0	Keeyask	197	0.0
	21 May-27 Jun 2003	0	S Moswakot	37	0.0
		1	Stephens L	730	0.1
		0	Keeyask	350	0.0
	03 Sep-15 Oct 2003	0	S Moswakot	38	0.0
		0	Keeyask	430	0.0
Stephens Lake (includes Gull Rapids)	23 May-08 Jul 2001	2	Stephens L	88	2.3
		0	Keeyask	50	0.0
	28 Aug-05 Sep 2001	0	Stephens L	88	0.0
		0	Keeyask	50	0.0
	26 Sep-03 Oct 2001	0	Stephens L	158	0.0
		0	Keeyask	140	0.0
	12 Jun-15 Jul 2002	0	Stephens L	209	0.0
		0	Keeyask	197	0.0
	23 Jul-11 Aug 2002	2	Stephens L	209	1.0
		0	Keeyask	197	0.0
	26 Sep-14 Oct 2002	2	Stephens L	258	0.8
		0	Keeyask	197	0.0
	24 May-18 Jul 2003	11	Stephens L	730	1.5
		1	S Moswakot	37	2.7
		0	Keeyask	350	0.0
	22 Jul-09 Aug 2003	2	Stephens L	730	0.3
		1	S Moswakot	37	2.7
		2	N Moswakot	67	3.0
		0	Keeyask	350	0.0
	01 Sep-14 Oct 2003	7	Stephens L	1008	0.7
		1	S Moswakot	38	2.6
		0	Keeyask	430	0.0
	16 Jun-04 Jul 2004	0	Stephens L	1008	0.0
		0	Keeyask	456	0.0
	07 Jun-16 Jul 2005	0	Stephens L	1008	0.0
		0	Keeyask	496	0.0
	21 May-01 Jul 2006	1	Stephens L	1008	0.1
		0	Keeyask	496	0.0

Table 5-20: Number of walleye Floy®-tagged (n_T) and recaptured (n_R) and recapture rate (RR) of tagged fish during Keeyask Environmental Studies in study area waterbodies between 2001 and 2008

Location of Study	Period of Study	n_R	Tagging Location[1]	n_T	RR[2] (%)
Stephens Lake (Continued)	15 Aug-10 Sep 2006	0	Stephens L	1008	0.0
		0	Keeyask	496	0.0
	19–23 Sep 2007	0	Stephens L	1008	0.0
		0	Keeyask	496	0.0
	11–18 Sep 2008	0	Stephens L	1008	0.0
		0	Keeyask	496	0.0

1. Aiken = Aiken River System; Assean = Assean River System; Burntwood = Burntwood River system; Clark L = Clark Lake; Keeyask = Keeyask Area; Kelsey = Kelsey Area; N Moswakot = North Moswakot River System; S Moswakot = South Moswakot River System; Stephens L = Stephens Lake Area; Split L = Split Lake Area.
2. Calculated per tagging location for each period of study.

Table 5-21: Number of walleye Floy®-tagged and recaptured[1] above and below Gull Rapids during Keeyask Environmental Studies conducted in spring and fall of 2001 and 2002

Upstream of Gull Rapids[2]					Downstream of Gull Rapids[3]				
Period	**Caught**	**Tagged in GL**	**Recaps from GL**	**Recaps from STL**	**Period**	**Caught**	**Tagged in STL**	**Recaps from STL**	**Recaps from GL**
21 May-02 Jun 2001	41	16	-	-	23 May-12 Jul 2001	220	85	2	-
23 Sep-08 Oct 2001	106	81	-	-	26 Sep-03 Oct 2001	70	70	-	-
07 Jun-14 Jul 2002	15	7	1	-	12 Jun-15 Jul 2002	80	51	-	-
01-30 Oct 2002	60	56	-	-	26 Sep-14 Oct 2002	51	49	2	-
Total	222	160	1	0	Total	421	255	4	0

1. Includes fish that were recaptured multiple times (except for fish recaptured at the same site within 24 hours).
2. Includes Gull Lake (GL) to approximately 15 km upstream of Gull Rapids.
3. Includes Stephens Lake (STL) to approximately 10 km downstream of Gull Rapids.

Table 5-22: Number of walleye Floy®-tagged, by year and season, in the Split Lake and Keeyask areas and Stephens/Gull Rapids that were recaptured during Keeyask Environmental Studies[1] or by local harvesters, 1999–2008

Year	Season[5]	Tagged in Split Lake Area[2]					Tagged in Keeyask Area[3]					Tagged in Stephens Lake and Gull Rapids Areas[4]				
		Total # Tagged	Total # Recaptured[6]				Total # Tagged	Total # Recaptured				Total # Tagged	Total # Recaptured			
			Split	Keeyask	Stephens	D/S KGS[7]		Split	Keeyask	Stephens	D/S KGS		Split	Keeyask	Stephens	D/S KGS
1999	fall	-	-	-	-	-	7	-	-	-	-	-	-	-	-	-
	winter	-	-	-	-	-	7	-	-	-	-	-	-	-	-	-
2001	spring	131	4	-	-	-	49	-	-	-	-	88	-	-	2	-
	summer	134	-	-	-	-	50	1	-	-	-	88	-	-	-	-
	fall	135	-	-	-	-	140	-	-	-	-	158	-	-	-	-
	winter	135	-	-	-	-	140	-	-	-	-	158	-	-	-	-
2002	spring	1663	33	-	-	-	197	-	1	-	-	209	-	-	-	-
	summer	1676	19	-	-	-	223	-	-	-	-	215	-	-	4	-
	fall	1691	48	-	-	-	265	-	-	-	-	268	-	-	4	-
	winter	1691	18	-	-	-	265	-	-	-	-	268	-	-	-	-
2003	spring	2937	217	-	-	-	349	-	4	-	-	834	-	1	17	-
	summer	2937	20	-	-	-	389	-	-	-	-	913	-	-	9	-
	fall	2937	52	-	-	-	430	1	2	-	-	1121	-	-	7	-
	winter	2937	5	-	-	-	430	-	-	-	-	1121	-	-	-	-
2004	spring	3431	101	-	-	-	456	-	-	-	-	1121	-	-	1	-
	summer	3451	53	-	-	-	483	-	1	1	-	1121	-	-	35	-
	fall	3838	33	-	-	-	496	-	-	-	-	1121	-	-	-	-
	winter	3838	41	-	-	-	496					1121	-	-	-	-
2005	spring	3838	53	-	1	-	496	-	-	1	1	1129	-	-	20	-
	summer	3838	12	-	-	-	496	-	-	-	-	1129	-	-	-	-
	fall	3838	-	-	-	-	496	-	-	-	-	1129	-	-	-	-
	winter	3838	-	-	-	-	496	-	-	-	-	1129	-	-	-	-
2006	spring	3838	27	-	-	-	496	-	2	-	-	1129	-	-	2	-
	summer	3838	12	1	-	-	496	-	3	-	-	1129	-	-	-	-
	fall	3838	4	-	-	-	496	1	-	-	-	1129	-	-	-	-
	winter	3838	-	-	-	-	496	-	-	-	-	1129	-	-	-	-
2007	spring	3838	31	-	-	-	496	-	-	-	-	1129	-	-	-	-
	summer	3838	-	-	-	-	496	-	-	-	-	1129	-	-	-	-
	fall	3838	89	-	-	-	496	2	-	-	-	1129	-	-	-	-
	winter	3838	-	-	-	-	496	-	-	-	-	1129	-	-	-	-
2008	spring	3838	-	-	-	-	496	-	-	-	-	1129	-	-	-	-
	summer	3838	-	-	-	-	496	-	-	-	-	1129	-	-	-	-
	fall	3838	38	-	-	-	496	-	1	-	-	1129	-	-	-	-
	winter	3838	-	-	-	-	496	-	-	-	-	1129	-	-	-	-
Total			910	1	1	0		5	14	2	1		0	1	101	0

1. Areas shaded in gray represent times when Keeyask Environmental Studies were not conducted in the Keeyask Study Area
2. Includes Split and Clark lakes and their major tributaries systems (Burntwood, Nelson Aiken, Assean)
3. Includes the Nelson River between Clark Lake and Gull Rapids
4. Includes Gull Rapids, Stephens Lake, and its major tributaries (North and South Moswakot Rivers and Looking Back Creek)
5. Spring = 01 May-15 Jul; summer = 16 Jul-19 Sep; fall = 20 Sep-15 Nov; winter = 16 Nov-30 Apr
6. Includes fish that were recaptured multiple times (except fish recaptured at the same site within 24 hours)
7. Downstream of the Kettle Generating Station

Table 5-23: Number of northern pike marked with Floy®-tags and recaptured in Keeyask Study area waterbodies between 1999 and 2008

Tagging Waterbody	Location Code	Number Tagged	Number Recaptured[1]/Location – Split Lake Area											Keeyask Area			Gull Rapids Area	Stephens Lake Area				Downstream of Study Area	Total Number Recaptured[3]	Individual Recapture Rate (%)
			1	2	3	4	5	8	9	10	11	?	Total[2]	12	13	Total[2]	14	15	16	17	Total[2]			
Split Lake Area																								
Split Lake	1	290	11	5	4	1	-	-	-	-	1	1	23	-	-	-	-	-	-	-	-	-	23	7.9
Aiken River	2	533	11	24	7	4	-	-	-	-	-	4	50	-	-	-	-	-	-	-	-	-	50	9.4
Mistuska River	3	1217	21	2	75	2	-	-	-	-	1	8	107	-	-	-	-	-	-	-	-	-	107	8.8
Ripple River	4	342	11	5	11	6	-	-	-	-	-	4	37	-	-	-	-	-	-	-	-	-	37	10.8
Assean River	5	520	6	-	-	-	11	3	3	-	-	-	23	1	-	1	-	-	-	-	-	-	24	4.6
Crying River	6	71	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1	1.4
Hunting River	7	60	-	1	-	-	-	-	-	-	-	1	2	-	-	-	-	-	-	-	-	-	2	3.3
Assean Lake	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Clark Lake (CL)	9	490	-	-	-	-	1	-	7	-	-	-	8	-	-	-	-	-	-	-	-	1	9	1.8
Burntwood/Odei River	10	67	2	-	1	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	3	4.5
Kelsey GS	11	180	2	-	-	-	-	-	-	-	1	-	3	-	-	-	-	-	-	-	-	-	3	1.7
Keeyask Area																								
Nelson River (CL-GL)	12	1046	3	-	1	-	1	-	-	-	1	2	8	15	6	21	-	-	-	-	-	-	29	2.8
Gull Lake (GL)	13	1023	-	-	-	-	-	-	-	1	-	-	1	4	14	18	5	1	-	-	1	-	25	2.4
Gull Rapids Area	14	850	1	-	-	-	-	-	-	-	-	-	1	-	-	-	32	3	-	-	3	1	37	-
Stephens Lake Area																								
Stephens Lake	15	122	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	0.8
North Moswakot River	16	554	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	27	-	29	-	29	5.2
South Moswakot River	17	457	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	26	28	-	28	6.1
Looking Back Creek	18	54	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total		7876	68	37	99	13	14	3	10	1	4	20	267	20	20	40	38	6	29	26	61	2	408	5.2

? Unknown whether Split Lake, Assean Lake, or Assean, Aiken, Ripple, or Mistuska Rivers

1. Does not include fish recaptured multiple times in a waterbody at any time
2. Does not include fish recaptured multiple times within an area at any time
3. Does not include fish recaptured multiple times anywhere in the study area at any time

Table 5-24: Summary of movements of northern pike radio-tagged in Gull Lake and Stephens Lake between 2001 and 2004

Year	Number Tagged	Number Detected	Remained Within		Moved over GR		Moved over BR		Moved over LR	
			NR	STL	DS	US	DS	US	DS	US
2001/2002	14	14	14	-	-	-	-	-	-	-
2002/2003	-	12†	10	-	1	-	-	1	-	1
2003/2004	-	11*	9	1	-	-	-	2	-	2

* Includes one transmitter that was not detected, but was captured in Assean Lake by a local harvester

† Includes one fish that moved into Clark Lake

NR = Nelson River between Clark Lake and Gull Rapids (including Gull Lake)

STL = Stephens Lake

DS = downstream

US = upstream

BR = Birthday Rapids

GR = Gull Rapids

LR = Long Rapids

Table 5-25: Number of northern pike Floy®-tagged (n_T) and recaptured (n_R) and recapture rate (RR) of tagged fish during Keeyask Environmental Studies in study area waterbodies between 2001 and 2008

Location of Study	Period of Study	n_R	Tagging Location[1]	n_T	RR[2] (%)
Aiken River System (Aiken, Mistuska, Ripple Rivers, and York Landing arm of Split Lake)	31 May-11 Jun 2002	4	Aiken	469	0.9
		0	Keeyask	562	0.0
	15 May-05 Jun 2003	49	Aiken	1588	3.1
		0	Keeyask	1371	0.0
	04–19 Jun 2004	29	Aiken	2083	1.4
		0	Keeyask	1685	0.0
	17 Sep-04 Oct 2004	8	Aiken	2365	0.3
		0	Keeyask	2069	0.0
Assean River System (Assean, Hunting, and Crying Rivers, and Assean Lake)	10 May-24 Jun 2001	1	Assean	147	0.7
		0	Keeyask	200	0.0
	28 Aug-21 Oct 2001	0	Assean	186	0.0
		0	Keeyask	335	0.0
	19 May-06 Jul 2002	9	Assean	622	1.4
		0	Keeyask	562	0.0
	19 Aug-14 Oct 2002	1	Assean	651	0.2
		0	Keeyask	925	0.0
Burntwood River System (Burntwood and Odei rivers)	21 May-31 Jul 2001	0	Burntwood	4	0.0
		0	Keeyask	200	0.0
	05 Jun-18 Jul 2002	0	Burntwood	67	0.0
		0	Keeyask	562	0.0
	08 Jun-16 Jul 2005	0	Burntwood	67	0.0
		0	Keeyask	2069	0.0
	21-26 Aug 2006	0	Burntwood	67	0.0
		0	Keeyask	2069	0.0
	17 May-27 Jun 2007	0	Burntwood	67	0.0
		0	Keeyask	2069	0.0
Kelsey Area (Nelson River between Split Lake and Kelsey GS, and Grass River)	21 May-31 Jul 2001	0	Kelsey	7	0.0
		0	Keeyask	200	0.0
	05 Jun-18 Jul 2002	1	Kelsey	189	0.5
		0	Keeyask	562	0.0
	15 Jun-16 Jul 2005	0	Kelsey	189	0.0
		0	Keeyask	2069	0.0
	23 May-02 Jul 2006	0	Kelsey	189	0.0
		1	Aiken	2365	0.0
		0	Keeyask	2069	0.0
	17 May-27 Jun 2007	0	Kelsey	189	0.0
		0	Keeyask	2069	0.0

Table 5-25: Number of northern pike Floy®-tagged (n_T) and recaptured (n_R) and recapture rate (RR) of tagged fish during Keeyask Environmental Studies in study area waterbodies between 2001 and 2008

Location of Study	Period of Study	n_R	Tagging Location[1]	n_T	RR[2] (%)
Split Lake (excludes York Landing arm)	14–25 Aug 2001	0	Split L	0	-
		0	Keeyask	200	0.0
	12–25 Aug 2002	0	Split L	0	-
		0	Keeyask	562	0.0
	08 Jun-16 Jul 2005	0	Split L	0	-
		1	Aiken	2365	0.0
		0	Keeyask	2069	0.0
	15 Aug-10 Sep 2006	0	Split L	0	-
		0	Keeyask	2069	0.0
Clark Lake	19–29 May 2002	0	Clark L	6	0.0
		0	Keeyask	562	0.0
	12–25 Aug 2002	0	Clark L	6	0.0
		1	Assean	622	0.2
		0	Keeyask	562	0.0
	11 Sep-10 Oct 2002	1	Clark L	194	0.5
		2	Assean	651	0.3
		0	Keeyask	925	0.0
	09 Jun-03 Jul 2004	3	Clark L	387	0.8
		0	Keeyask	1685	0.0
	16–22 Aug 2004	1	Clark L	387	0.3
		0	Keeyask	1757	0.0
	18 Sep-10 Oct 2004	2	Clark L	490	0.4
		0	Keeyask	2069	0.0
	08 Jun-16 Jul 2005	0	Clark L	490	0.0
		0	Keeyask	2069	0.0
	15 Aug-10 Sep 2006	0	Clark L	490	0.0
		0	Keeyask	2069	0.0
Keeyask Area (Nelson River between Clark Lake and Gull Rapids)	21 May-31 Jul 2001	0	Keeyask	200	0.0
		0	Split L	158	0.0
		0	Stephens L	74	0.0
	14-26 Aug 2001	1	Keeyask	200	0.5
		0	Split L	158	0.0
		0	Stephens L	74	0.0
	22 Sep-08 Oct 2001	2	Keeyask	335	0.6
		0	Split L	197	0.0
		0	Stephens L	89	0.0
	09 Jun-15 Jul 2002	3	Keeyask	562	0.5
		0	Split L	1353	0.0
		0	Stephens L	163	0.0

Table 5-25: Number of northern pike Floy®-tagged (n_T) and recaptured (n_R) and recapture rate (RR) of tagged fish during Keeyask Environmental Studies in study area waterbodies between 2001 and 2008

Location of Study	Period of Study	n_R	Tagging Location[1]	n_T	RR[2] (%)
Keeyask Area (Continued)	05–16 Aug 2002	2	Keeyask	562	0.4
		0	Split L	1353	0.0
		0	Stephens L	163	0.0
	10 Sep-13 Oct 2002	1	Keeyask	925	0.1
		0	Split L	1578	0.0
		0	Stephens L	506	0.0
	24 May-01 Jul 2003	11	Keeyask	1371	0.8
		1	Split L	2697	0.0
		0	Stephens L	1349	0.0
	27 Aug-11 Oct 2003	9	Keeyask	1600	0.6
		0	Split L	2697	0.0
		0	Stephens L	1983	0.0
	09 Jun-21 Jul 2004	2	Keeyask	1685	0.1
		0	Split L	3385	0.0
		0	Stephens L	1983	0.0
	22–25 Aug 2004	0	Keeyask	1757	0.0
		0	Split L	3385	0.0
		0	Stephens L	1983	0.0
	14 Sep-09 Oct 2004	8	Keeyask	2069	0.4
		0	Split L	3770	0.0
		0	Stephens L	1983	0.0
	23 May-02 Jul 2006	0	Keeyask	2069	0.0
		0	Split L	3770	0.0
		0	Stephens L	2037	0.0
	15 Aug-10 Sep 2006	0	Keeyask	2069	0.0
		0	Split L	3770	0.0
		0	Stephens L	2037	0.0
	28 Sep-03 Oct 2007	0	Keeyask	2069	0.0
		0	Split L	3770	0.0
		0	Stephens L	2037	0.0
	04 Jun-04 Jul 2008	0	Keeyask	2069	0.0
		0	Split L	3770	0.0
		0	Stephens L	2037	0.0
	12–27 Sep 2008	1	Keeyask	2069	0.0
		0	Split L	3770	0.0
		0	Stephens L	2037	0.0

Table 5-25: Number of northern pike Floy®-tagged (n_T) and recaptured (n_R) and recapture rate (RR) of tagged fish during Keeyask Environmental Studies in study area waterbodies between 2001 and 2008

Location of Study	Period of Study	n_R	Tagging Location[1]	n_T	RR[2] (%)
North Moswakot System	03 Sep-11 Oct 2002	0	N Moswakot	127	0.0
		0	Keeyask	925	0.0
	21 May-27 Jun 2003	8	N Moswakot	364	2.2
		0	Keeyask	1371	0.0
	03 Sep-15 Oct 2003	23	N Moswakot	554	4.2
		0	Keeyask	1600	0.0
South Moswakot System	04 Sep-13 Oct 2002	0	S Moswakot	59	0.0
		0	Keeyask	925	0.0
	21 May-27 Jun 2003	5	S Moswakot	175	2.9
		0	Keeyask	1371	0.0
	03 Sep-15 Oct 2003	23	S Moswakot	457	5.0
		0	Keeyask	1600	0.0
Stephens Lake (includes Gull Rapids)	23 May-08 Jul 2001	6	Stephens L	74	8.1
		0	Keeyask	200	0.0
	28 Aug-05 Sep 2001	0	Stephens L	74	0.0
		0	Keeyask	200	0.0
	26 Sep-03 Oct 2001	0	Stephens L	89	0.0
		0	Keeyask	335	0.0
	12 Jun-15 Jul 2002	2	Stephens L	163	1.2
		0	Keeyask	562	0.0
	23 Jul-11 Aug 2002	1	Stephens L	163	0.6
		0	Keeyask	562	0.0
	26 Sep-14 Oct 2002	4	Stephens L	320	1.3
		0	Keeyask	925	0.0
	24 May-18 Jul 2003	6	Stephens L	810	0.7
		2	Keeyask	1371	0.1
	22 Jul-09 Aug 2003	1	Stephens L	810	0.1
		2	N Moswakot	364	0.5
		1	Keeyask	1371	0.1
	01 Sep-14 Oct 2003	3	Stephens L	972	0.3
		0	Keeyask	1600	0.0
	16 Jun-04 Jul 2004	0	Stephens L	972	0.0
		1	Keeyask	1685	0.1
	07 Jun-16 Jul 2005	0	Stephens L	972	0.0
		0	Keeyask	2069	0.0
	21 May-01 Jul 2006	1	Stephens L	972	0.1
		0	Keeyask	2069	0.0
	15 Aug-10 Sep 2006	1	Stephens L	972	0.1
		0	Keeyask	2069	0.0

Table 5-25: Number of northern pike Floy®-tagged (n_T) and recaptured (n_R) and recapture rate (RR) of tagged fish during Keeyask Environmental Studies in study area waterbodies between 2001 and 2008

Location of Study	Period of Study	n_R	Tagging Location[1]	n_T	RR[2] (%)
Stephens Lake (continued)	19–23 Sep 2007	0	Stephens L	972	0.0
		0	Keeyask	2069	0.0
	11–18 Sep 2008	0	Stephens L	972	0.0
		0	Keeyask	2069	0.0

1. Aiken = Aiken River System; Assean = Assean River System; Burntwood = Burntwood River system; Clark L = Clark Lake; Keeyask = Keeyask Area; Kelsey = Kelsey Area; N Moswakot = North Moswakot River System; S Moswakot = South Moswakot River System; Stephens L = Stephens Lake Area; Split L = Split Lake Area.
2. Calculated per tagging location for each period of study.

Table 5-26: Number of northern pike Floy®-tagged and recaptured[1] above and below Gull Rapids during Keeyask Environmental Studies conducted in spring and fall of 2001 and 2002

Upstream of Gull Rapids[2]					Downstream of Gull Rapids[3]				
Period	**Caught**	**Tagged in GL**	**Recaps from GL**	**Recaps from STL**	**Period**	**Caught**	**Tagged in STL**	**Recaps from STL**	**Recaps from GL**
21 May-02 Jun 2001	82	23	-	-	23 May-12 Jul 2001	230	74	6	-
23 Sep-08 Oct 2001	111	108	1	-	26 Sep-03 Oct 2001	16	15	-	-
07 Jun-14 Jul 2002	64	32	-	-	12 Jun-15 Jul 2002	122	74	2	-
01-30 Oct 2002	279	271	2	-	26 Sep-14 Oct 2002	165	157	5	-
Total	536	434	3	0	Total	533	320	13	0

1. Includes fish that were recaptured multiple times (except for fish recaptured at the same site within 24 hours)
2. Includes Gull Lake (GL) to approximately 15 km upstream of Gull Rapids
3. Includes Stephens Lake (STL) to approximately 10 km downstream of Gull Rapids

Table 5-27: Number of northern pike Floy®-tagged, by year and season, in the Split Lake and Keeyask areas and Stephens/Gull Rapids that were recaptured during Keeyask Environmental Studies[1] or by local harvesters, 1999–2008

Year	Season[5]	Tagged in Split Lake Area[2]					Tagged in Keeyask Area[3]					Tagged in Stephens Lake and Gull Rapids Areas[4]				
		Total # Tagged	Total # Recaptured[6]				Total # Tagged	Total # Recaptured				Total # Tagged	Total # Recaptured			
			Split	Keeyask	Stephens	D/S KGS[7]		Split	Keeyask	Stephens	D/S KGS		Split	Keeyask	Stephens	D/S KGS
1999	fall	-	-	-	-	-	16	-	-	-	-	-	-	-	-	-
	winter	-	-	-	-	-	16	-	-	-	-	-	-	-	-	-
2001	spring	158	1	-	-	-	200	-	-	-	-	74	-	-	6	-
	summer	186	-	-	-	-	200	-	1	-	-	74	-	-	-	-
	fall	197	-	-	-	-	335	-	2	-	-	89	-	-	-	-
	winter	197	-	-	-	-	335	-	-	-	-	89	-	-	-	-
2002	spring	1353	15	-	-	-	562	-	3	-	-	163	-	-	2	-
	summer	1401	2	-	-	-	661	-	2	-	-	243	-	-	2	-
	fall	1578	6	-	-	-	925	1	1	-	-	506	-	-	5	-
	winter	1578	5	-	-	-	925	1	-	-	-	506	-	-	-	-
2003	spring	2697	77	1	-	-	1371	2	12	2	-	1349	-	-	22	-
	summer	2697	9	-	-	-	1508	-	6	1	-	1466	1	-	17	-
	fall	2697	11	-	-	-	1600	-	3	-	-	1983	-	-	27	-
	winter	2697	1	-	-	-	1600	-	-	-	-	1983	-	-	-	-
2004	spring	3385	43	-	-	-	1685	1	2	1	-	1983	-	-	4	-
	summer	3427	16	-	-	-	1821	-	-	2	-	1983	-	-	6	-
	fall	3770	13	-	-	-	2069	-	8	-	-	1983	-	-	-	-
	winter	3770	13	-	-	-	2069	1	-	-	-	1983	-	-	-	-
2005	spring	3770	13	-	-	-	2069	-	-	-	-	2037	-	-	3	-
	summer	3770	3	-	-	1	2069	-	-	-	-	2037	-	-	-	-
	fall	3770	-	-	-	-	2069	-	-	-	-	2037	-	-	-	-
	winter	3770	-	-	-	-	2069	-	-	-	-	2037	-	-	-	-
2006	spring	3770	3	-	-	-	2069	1	-	-	-	2037	-	-	1	1
	summer	3770	6	-	-	-	2069	-	-	-	-	2037	-	-	1	-
	fall	3770	1	-	-	-	2069	-	-	-	-	2037	-	-	-	-
	winter	3770	-	-	-	-	2069	-	-	-	-	2037	-	-	-	-
2007	spring	3770	7	-	-	-	2069	1	-	-	-	2037	-	-	-	-
	summer	3770	-	-	-	-	2069	-	-	-	-	2037	-	-	-	-
	fall	3770	17	-	-	-	2069	1	-	-	-	2037	-	-	-	-
	winter	3770	-	-	-	-	2069	-	-	-	-	2037	-	-	-	-
2008	spring	3770	-	-	-	-	2069	-	-	-	-	2037	-	-	-	-
	summer	3770	-	-	-	-	2069	-	-	-	-	2037	-	-	-	-
	fall	3770	2	-	-	-	2069	-	1	-	-	2037	-	-	-	-
	winter	3770	-	-	-	-	2069	-	-	-	-	2037	-	-	-	-
Total			264	1	0	1		9	41	6	0		1	0	96	1

1. Areas shaded in gray represent times when Keeyask Environmental Studies were not conducted in the Keeyask study area
2. Includes Split and Clark lakes and their major tributaries systems (Burntwood, Nelson, Aiken, Assean)
3. Includes the Nelson River between Clark Lake and Gull Rapids
4. Includes Gull Rapids, Stephens Lake, and its major tributaries (North and South Moswakot Rivers and Looking Back Creek)
5. Spring = 01 May-15 Jul; summer = 16 Jul-19 Sep; fall = 20 Sep-15 Nov; winter = 16 Nov-30 Apr
6. Includes fish that were recaptured multiple times (except fish recaptured at the same site within 24 hours)

Table 5-28: Number of lake whitefish marked with Floy®-tags and recaptured in Keeyask study area waterbodies between 1999 and 2008

Tagging Waterbody	Location Code	Number Tagged	Number Recaptured[1]/Location																	Total Number Recaptured[3]	Individual Recapture Rate (%)
			Split Lake Area								Keeyask Area			Gull Rapids Area	Stephens Lake Area				Downstream of Study Area		
			1	2	3	5	8	9	?	Total[2]	12	13	Total[2]	14	15	16	17	Total[2]			
Split Lake Area																					
Split Lake	1	61	-	-	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1	1.6
Aiken River	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mistuska River	3	119	11	1	4	-	-	-	1	17	-	-	-	-	-	-	-	-	-	17	14.3
Ripple River	4	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Assean River	5	304	-	-	-	68	2	1	2	73	-	-	-	1	-	-	-	-	-	74	24.3
Assean Lake	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Clark Lake (CL)	9	33	-	-	-	1	-	-	-	1	-	-	-	-	-	-	-	-	-	1	3.0
Burntwood/Odei River	10	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Kelsey GS	11	25	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Keeyask Area																					
Nelson River (CL-GL)	12	66	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Gull Lake (GL)	13	101	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	1	1.0
Gull Rapids Area	14	739	-	-	-	-	-	-	-	-	-	-	-	15	2	2	1	5	1	21	2.8
Stephens Lake Area																					
Stephens Lake	15	47	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	1	-
North Moswakot River	16	93	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	1	1.1
South Moswakot River	17	117	-	-	-	-	-	-	-	-	-	-	-	2	-	1	3	4	-	6	5.1
Total		1713	11	1	5	69	2	1	3	92	-	1	1	18	3	4	4	11	1	123	7.2

? Unknown whether Split Lake, Assean Lake, or Assean River

1. Does not include fish recaptured multiple times in a waterbody at any time
2. Does not include fish recaptured multiple times within an area at any time
3. Does not include fish recaptured multiple times anywhere in the study area at any time

Table 5-29: Summary of movements of lake whitefish radio- and acoustic-tagged in Gull Lake and Stephens Lake between 2001 and 2004

Year	Number Tagged	Number Detected	Remained Within		Moved over GR		Moved over BR		Moved over LR	
			NR	STL	DS	US	DS	US	DS	US
2001/2002	30	21	13	6	**	-	-	-	-	-
2002/2003	-	16	8	8	-	-	-	1	-	-
2003/2004	-	11*	4	5	-	2	1	-	-	-

* Includes one transmitter that was not detected, but was relocated on shore

**Does not include two lake whitefish that moved downstream through Gull Rapids due to post-operative stress

NR = Nelson River between Clark Lake and Gull Rapids (including Gull Lake)

STL = Stephens Lake

DS = downstream

US = upstream

BR = Birthday Rapids

GR = Gull Rapids

LR = Long Rapids

Table 5-30: Number of lake whitefish Floy®-tagged (n_T) and recaptured (n_R) and recapture rate (RR) of tagged fish during Keeyask Environmental Studies in study area waterbodies between 2001 and 2008

Location of Study	Period of Study	n_R	Tagging Location[1]	n_T	RR[2] (%)
Aiken River System (Aiken, Mistuska, Ripple Rivers, and York Landing arm of Split Lake)	31 May-11 Jun 2002	0	Aiken	0	-
		0	Keeyask	49	0.0
	15 May-05 Jun 2003	0	Aiken	42	0.0
		0	Keeyask	128	0.0
	04–19 Jun 2004	2	Aiken	104	1.9
		0	Keeyask	159	0.0
	17 Sep-04 Oct 2004	1	Aiken	185	0.5
		0	Keeyask	167	0.0
Assean River System (Assean, Hunting, and Crying Rivers, and Assean Lake)	10 May-24 Jun 2001	0	Assean	7	0.0
		0	Keeyask	9	0.0
	28 Aug-21 Oct 2001	69	Assean	225	30.7
		0	Keeyask	34	0.0
	19 May-06 Jul 2002	0	Assean	225	0.0
		0	Keeyask	49	0.0
	19 Aug-14 Oct 2002	20	Assean	304	6.6
		0	Keeyask	104	0.0
Burntwood River System (Burntwood and Odei rivers)	21 May-31 Jul 2001	0	Burntwood	3	0.0
		0	Keeyask	9	0.0
	05 Jun-18 Jul 2002	0	Burntwood	3	0.0
		0	Keeyask	49	0.0
	08 Jun-16 Jul 2005	0	Burntwood	3	0.0
		0	Keeyask	167	0.0
	21–26 Aug 2006	0	Burntwood	3	0.0
		0	Keeyask	167	0.0
	17 May-27 Jun 2007	0	Burntwood	3	0.0
		0	Keeyask	167	0.0
Kelsey Area (Nelson River between Split Lake and Kelsey GS, and Grass River)	21 May-31 Jul 2001	0	Kelsey	0	-
		0	Keeyask	9	0.0
	05 Jun-18 Jul 2002	0	Kelsey	25	0.0
		0	Keeyask	49	0.0
	15 Jun-16 Jul 2005	0	Kelsey	25	0.0
		0	Keeyask	167	0.0
	23 May-02 Jul 2006	0	Kelsey	25	0.0
		0	Keeyask	167	0.0
	17 May-27 Jun 2007	0	Kelsey	25	0.0
		0	Keeyask	167	0.0

Table 5-30: Number of lake whitefish Floy®-tagged (n_T) and recaptured (n_R) and recapture rate (RR) of tagged fish during Keeyask Environmental Studies in study area waterbodies between 2001 and 2008

Location of Study	Period of Study	n_R	Tagging Location[1]	n_T	RR[2] (%)
Split Lake (excludes York Landing arm)	14–25 Aug 2001	0	Split L	0	-
		0	Keeyask	9	0.0
	12–25 Aug 2002	0	Split L	0	-
		0	Keeyask	49	0.0
	08 Jun-16 Jul 2005	0	Split L	0	-
		0	Keeyask	167	0.0
	15 Aug-10 Sep 2006	0	Split L	0	-
		0	Keeyask	167	0.0
Clark Lake	19–29 May 2002	0	Clark L	0	-
		0	Keeyask	49	0.0
	12–25 Aug 2002	0	Clark L	0	-
		0	Keeyask	49	0.0
	11 Sep-10 Oct 2002	0	Clark L	25	0.0
		1	Assean	304	0.3
		0	Keeyask	104	0.0
	09 Jun-03 Jul 2004	0	Clark L	31	0.0
		0	Keeyask	159	0.0
	16–22 Aug 2004	0	Clark L	31	0.0
		0	Keeyask	160	0.0
	18 Sep-10 Oct 2004	0	Clark L	33	0.0
		0	Keeyask	167	0.0
	08 Jun-16 Jul 2005	0	Clark L	33	0.0
		0	Keeyask	167	0.0
	15 Aug-10 Sep 2006	0	Clark L	33	0.0
		0	Keeyask	167	0.0
Keeyask Area (Nelson River between Clark Lake and Gull Rapids)	21 May-31 Jul 2001	0	Keeyask	9	0.0
		0	Split L	10	0.0
		0	Stephens L	4	0.0
	14–26 Aug 2001	0	Keeyask	9	0.0
		0	Split L	10	0.0
		0	Stephens L	4	0.0
	22 Sep-08 Oct 2001	0	Keeyask	34	0.0
		0	Split L	228	0.0
		0	Stephens L	61	0.0
	09 Jun-15 Jul 2002	0	Keeyask	49	0.0
		0	Split L	253	0.0
		0	Stephens L	63	0.0
	05-16 Aug 2002	0	Keeyask	49	0.0
		0	Split L	253	0.0
		0	Stephens L	63	0.0

Table 5-30: Number of lake whitefish Floy®-tagged (n_T) and recaptured (n_R) and recapture rate (RR) of tagged fish during Keeyask Environmental Studies in study area waterbodies between 2001 and 2008

Location of Study	Period of Study	n_R	Tagging Location[1]	n_T	RR[2] (%)
Keeyask Area (Continued)	10 Sep-13 Oct 2002	0	Keeyask	104	0.0
		0	Split L	357	0.0
		0	Stephens L	600	0.0
	24 May-01 Jul 2003	0	Keeyask	128	0.0
		0	Split L	399	0.0
		0	Stephens L	626	0.0
	27 Aug-11 Oct 2003	1	Keeyask	156	0.6
		0	Split L	399	0.0
		0	Stephens L	996	0.0
	09 Jun-21 Jul 2004	0	Keeyask	159	0.0
		0	Split L	467	0.0
		0	Stephens L	996	0.0
	22–25 Aug 2004	0	Keeyask	160	0.0
		0	Split L	467	0.0
		0	Stephens L	996	0.0
	14 Sep-09 Oct 2004	0	Keeyask	167	0.0
		0	Split L	550	0.0
		0	Stephens L	996	0.0
	23 May-02 Jul 2006	0	Keeyask	167	0.0
		0	Split L	550	0.0
		0	Stephens L	996	0.0
	15 Aug-10 Sep 2006	0	Keeyask	167	0.0
		0	Split L	550	0.0
		0	Stephens L	996	0.0
	28 Sep-03 Oct 2007	0	Keeyask	167	0.0
		0	Split L	550	0.0
		0	Stephens L	996	0.0
	04 Jun-04 Jul 2008	0	Keeyask	167	0.0
		0	Split L	550	0.0
		0	Stephens L	996	0.0
	12–27 Sep 2008	0	Keeyask	167	0.0
		0	Split L	550	0.0
		0	Stephens L	996	0.0
North Moswakot System	03 Sep-11 Oct 2002	0	N Moswakot	34	0.0
		0	Keeyask	104	0.0
	21 May-27 Jun 2003	0	N Moswakot	40	0.0
		0	Keeyask	128	0.0
	03 Sep-15 Oct 2003	0	N Moswakot	93	0.0
		0	Keeyask	156	0.0
South Moswakot System	04 Sep-13 Oct 2002	1	S Moswakot	52	1.9
		0	Keeyask	104	0.0

Table 5-30: Number of lake whitefish Floy®-tagged (n_T) and recaptured (n_R) and recapture rate (RR) of tagged fish during Keeyask Environmental Studies in study area waterbodies between 2001 and 2008

Location of Study	Period of Study	n_R	Tagging Location[1]	n_T	RR[2] (%)
South Moswakot System (Continued)	21 May-27 Jun 2003	0	S Moswakot	63	0.0
		1	Stephens L	523	0.2
		0	Keeyask	128	0.0
	03 Sep-15 Oct 2003	2	S Moswakot	117	1.7
		0	Keeyask	156	0.0
Stephens Lake (includes Gull Rapids)	23 May-08 Jul 2001	0	Stephens L	4	0.0
		0	Keeyask	9	0.0
	28 Aug-05 Sep 2001	0	Stephens L	4	0.0
		0	Keeyask	9	0.0
	26 Sep-03 Oct 2001	0	Stephens L	61	0.0
		0	Keeyask	34	0.0
	12 Jun-15 Jul 2002	0	Stephens L	63	0.0
		0	Keeyask	49	0.0
	23 Jul-11 Aug 2002	0	Stephens L	63	0.0
		0	Keeyask	49	0.0
	26 Sep-14 Oct 2002	12	Stephens L	514	2.3
		1	S Moswakot	52	1.9
		0	Keeyask	104	0.0
		1	Split L	399	0.3
	24 May-18 Jul 2003	0	Stephens L	523	0.0
		0	Keeyask	123	0.0
	22 Jul-09 Aug 2003	0	Stephens L	523	0.0
		0	Keeyask	128	0.0
	01 Sep-14 Oct 2003	4	Stephens L	786	0.5
		1	S Moswakot	117	0.9
		0	Keeyask	156	0.0
	16 Jun-04 Jul 2004	0	Stephens L	786	0.0
		0	Keeyask	159	0.0
	07 Jun-16 Jul 2005	0	Stephens L	786	0.0
		0	Keeyask	167	0.0
	21 May-01 Jul 2006	0	Stephens L	786	0.0
		0	Keeyask	167	0.0
	15 Aug-10 Sep 2006	0	Stephens L	786	0.0
		0	Keeyask	167	0.0
	19–23 Sep 2007	1	Stephens L	786	0.1
		0	Keeyask	167	0.0
	11–18 Sep 2008	0	Stephens L	786	0.0
		0	Keeyask	167	0.0

1. Aiken = Aiken River System; Assean = Assean River System; Burntwood = Burntwood River system; Clark L = Clark Lake; Keeyask = Keeyask Area; Kelsey = Kelsey Area; N Moswakot = North Moswakot River System; S Moswakot = South Moswakot River System; Stephens L = Stephens Lake Area; Split L = Split Lake Area.
2. Calculated per tagging location for each period of study.

Table 5-31: Movement of lake whitefish Floy®-tagged and recaptured[1] above and below Gull Rapids during Keeyask Environmental Studies conducted in spring and fall of 2001 and 2002

Upstream of Gull Rapids[2]					Downstream of Gull Rapids[3]				
Period	**Caught**	**Tagged in GL**	**Recaps from GL**	**Recaps from STL**	**Period**	**Caught**	**Tagged in STL**	**Recaps from STL**	**Recaps from GL**
21 May-02 Jun 2001	19	7	-	-	23 May-12 Jul 2001	17	4	-	-
23 Sep-08 Oct 2001	32	23	-	-	26 Sep-03 Oct 2001	63	57	-	-
07 Jun-14 Jul 2002	13	9	-	-	12 Jun-15 Jul 2002	3	2	-	-
01-30 Oct 2002	44	44	-	-	26 Sep-14 Oct 2002	468	451	11	-
Total	108	83	0	0		551	514	11	0

1. Includes fish that were recaptured multiple times (except for fish recaptured at the same site within 24 hours).
2. Includes Gull Lake (GL) to approximately 15 km upstream of Gull Rapids.
3. Includes Stephens Lake (STL) to approximately 10 km downstream of Gull Rapids.

Table 5-32: Number of lake whitefish Floy®-tagged, by year and season, in the Split Lake and Keeyask areas and Stephens/Gull Rapids that were recaptured during Keeyask Environmental Studies[1] or by local harvesters, 1999–2008

Year	Season[5]	Tagged in Split Lake Area[2]					Tagged in Keeyask Area[3]					Tagged in Stephens Lake and Gull Rapids Areas[4]				
		Total # Tagged	Total # Recaptured[6]				Total # Tagged	Total # Recaptured				Total # Tagged	Total # Recaptured			
			Split	Keeyask	Stephens	D/S KGS[7]		Split	Keeyask	Stephens	D/S KGS		Split	Keeyask	Stephens	D/S KGS
1999	fall	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
	winter	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
2001	spring	10	-	-	-	-	9	-	-	-	-	4	-	-	-	-
	summer	10	-	-	-	-	9	-	-	-	-	4	-	-	-	-
	fall	228	69	-	-	-	34	-	-	-	-	61	-	-	-	-
	winter	228	-	-	-	-	34	-	-	-	-	61	-	-	-	-
2002	spring	253	-	-	-	-	49	-	-	-	-	63	-	-	-	-
	summer	253	2	-	-	-	49	-	-	-	-	63	-	-	-	-
	fall	357	19	-	1	-	104	-	-	-	-	600	-	-	14	-
	winter	357	-	-	-	-	104	-	-	-	-	600	-	-	-	-
2003	spring	399	1	-	-	-	128	-	-	-	-	626	-	-	2	-
	summer	399	1	-	-	-	128	-	-	-	-	626	-	-	-	-
	fall	399	-	-	-	-	156	-	1	-	-	996	-	-	8	1
	winter	399	-	-	-	-	156	-	-	-	-	996	-	-	-	-
2004	spring	467	3	-	-	-	159	-	-	-	-	996	-	-	-	-
	summer	472	5	-	-	-	160	-	-	-	-	996	-	-	-	-
	fall	550	1	-	-	-	167	-	-	-	-	996	-	-	-	-
	winter	550	5	-	-	-	167	-	-	-	-	996	-	-	-	-
2005	spring	550	-	-	-	-	167	-	-	-	-	996	-	-	-	-
	summer	550	-	-	-	-	167	-	-	-	-	996	-	-	2	-
	fall	550	-	-	-	-	167	-	-	-	-	996	-	-	1	-
	winter	550	-	-	-	-	167	-	-	-	-	996	-	-	-	-
2006	spring	550	-	-	-	-	167	-	-	-	-	996	-	-	-	-
	summer	550	-	-	-	-	167	-	-	-	-	996	-	-	1	-
	fall	550	-	-	-	-	167	-	-	-	-	996	-	-	-	-
	winter	550	-	-	-	-	167	-	-	-	-	996	-	-	-	-
2007	spring	550	-	-	-	-	167	-	-	-	-	996	-	-	-	-
	summer	550	-	-	-	-	167	-	-	-	-	996	-	-	-	-
	fall	550	5	-	-	-	167	-	-	-	-	996	-	-	1	-
	winter	550	-	-	-	-	167	-	-	-	-	996	-	-	-	-
2008	spring	550	-	-	-	-	167	-	-	-	-	996	-	-	-	-
	summer	550	-	-	-	-	167	-	-	-	-	996	-	-	-	-
	fall	550	-	-	-	-	167	-	-	-	-	996	-	-	-	-
	winter	550	-	-	-	-	167	-	-	-	-	996	-	-	-	-
Total			111	0	1	0		0	1	0	0		0	0	29	1

1. Areas shaded in gray represent times when Keeyask Environmental Studies were not conducted in the Keeyask study area.
2. Includes Split and Clark lakes and their major tributaries systems (Burntwood, Nelson Aiken, Assean) .
3. Includes the Nelson River between Clark Lake and Gull Rapids.
4. Includes Gull Rapids, Stephens Lake, and its major tributaries (North and South Moswakot Rivers and Looking Back Creek).
5. Spring = 01 May-15 Jul; summer = 16 Jul-19 Sep; fall = 20 Sep-15 Nov; winter = 16 Nov-30 Apr.
6. Includes fish that were recaptured multiple times (except fish recaptured at the same site within 24 hours).
7. Downstream of the Kettle Generating Station.

Table 5-33: Predicted weighted mean catch-per-unit-effort (CPUE) in the Keeyask area (outlet of Clark Lake to the Keeyask GS) using standard gang index gill nets (#fish/100 m/24 h) and small mesh index gill nets (#fish/30 m/24 h) during summer for the existing environment (EE) and four post-Project (PP) time steps at peaking operation (between 158 and 159 m above sea level)

Species	EE	Year 1	Year 5	Year 15	Year 30
Area (ha)	4979	9532	9717	9974	10156
Standard gangs					
Northern pike	6.1	3.9	4.5	5.2	5.5
Walleye	5.3	5.6	6.0	6.5	6.5
Lake whitefish	1.3	1.4	1.6	1.7	1.8
Total catch	19.2	17.9	19.7	21.5	22.0
Small mesh gangs					
Forage fish	53.2	42.3	50.1	58.3	61.0

Table 5-34: Predicted increase in post-impoundment weighted suitable habitat area (ha) of foraging habitat for fish in the Keeyask area (outlet of Clark Lake to the Keeyask GS) at four post-Project (PP) time steps at peaking operation (between 158 and 159 m above sea level) compared to the existing environment (EE)

Species	EE	Year 1	Year 5	Year 15	Year 30
Walleye	1.0	1.8	2.0	2.3	2.3
Northern pike	1.0	1.3	1.4	1.7	1.8
Lake whitefish	1.0	2.2	2.2	2.5	2.6
Large-bodied fish	1.0	1.8	1.9	2.1	2.2
Forage fish	1.0	1.6	1.8	2.2	2.3

Table 5-35: Residual effects on the fish community considering specifically walleye, northern pike, and lake whitefish: construction period

Environmental Effect	Mitigation/Enhancement	Residual Effect
Upstream of Construction Site		
None	None	No residual effects expected
Gull Rapids/Stephens Lake		
Construction activities and construction of cofferdams/GS structures will disturb spawning activity and result in a loss or alteration of spawning habitat to fish populations in Stephens Lake. The dewatering of areas inside of cofferdams has the potential to stand fish. Changes in water quality from a variety of construction activities has the potential to adversely affect fish health. Instream construction activities will alter aquatic habitat in Stephens Lake due to the deposition of 0.1-0.6 cm of sediment. Blasting activities have the potential to cause sensory disturbance, injury, and mortality to fish Fish can become impinged/entrained by water intake pipes. There is a potential for increased harvesting of fish by the construction workforce.	Avoidance of instream construction during sensitive spawning periods Fish salvage prior to dewatering Application of guidelines for end-of-pipe screening and blasting Measures to reduce effects to water quality (as described in Table 2-22) Harvest controls for construction workers as outlined in the Access Management Plan	Residual effects to the fish community will vary by VEC species: Walleye There will be an adverse, moderate effect to the abundance of walleye to a medium extent over the medium-term Northern pike No residual effects expected Lake whitefish There will be an adverse, moderate effect to the abundance of walleye to a medium extent over the medium-term

Table 5-35: Residual effects on the fish community considering specifically walleye, northern pike, and lake whitefish: construction period

Environmental Effect	Mitigation/Enhancement	Residual Effect
South Access Road Streams		
Potential effects include: changes in water quality due to construction activities; loss of habitat at crossing structure footprint; and loss of access to spawning and foraging habitat above stream crossings.	Installation of a clear-span bridge at Looking Back Creek and adherence to Manitoba Stream Crossing guidelines and other regulations for installation and maintenance of culvert at Unnamed Tributary and Gull Rapids Creek crossings	No residual effects expected

Table 5-36: Residual effects on the fish community considering specifically walleye, northern pike, and lake whitefish: operation period

Environmental Effect	Mitigation/Enhancement	Residual Effect
Split/Clark Lake		
Potential effects include: increased immigration of fish immediately post-impoundment and over the longer term due to reduced velocities at Birthday Rapids; and changes in habitat in the Keeyask reach affecting any fish moving from Split and Clark lakes to the Keeyask reach and back. The small number of fish that currently move between the Split and Keeyask areas is not expected to increase substantially as Long Rapids will be present post-Project. Fish in Split Lake are not dependent on habitat in the Keeyask reach, so no effect due to habitat alteration in the Keeyask reach is expected. The extent to which fish will emigrate upstream out of the Keeyask reach at impoundment is not known; however, effects to the overall Split/Clark population are not expected to be detectable.	None	No residual effects expected
Within the Reservoir		
Effects to the fish community will primarily occur due to changes in the quality and quantity of aquatic habitat, and changes in water quality and lower trophic levels. Immediately post-impoundment, there will be an apparent reduction in the number of fish due to the increase in the volume of the reservoir. For the first 5-10 years, suitability of newly flooded terrain will be less than in the long term due to periodic oxygen depletion, shoreline instability, and absence of aquatic plants. Initial predictions for long-term (>30 years) are as follows: water quality will be suitable in most sections of the reservoir;	Construction of winter escape channels at Little Gull Lake to avoid winterkill Spawning enhancements in reservoir Removal of debris accumulations at the mouths of streams to allow fish access to tributary habitat Provision of upstream fish passage by trap/catch and transport	Overall, there will be a positive, small effect to fish communities (*i.e.*, abundance) to a medium extent over the long-term. Residual effects will vary by VEC species: <u>Walleye</u> There will be a positive, small effect to the abundance of walleye to

Table 5-36: Residual effects on the fish community considering specifically walleye, northern pike, and lake whitefish: operation period

Environmental Effect	Mitigation/Enhancement	Residual Effect
some specific spawning sites in the existing environment will no longer be available post-impoundment (*e.g.*, inlet of Gull Lake, constriction in Gull Lake upstream of Caribou Island) but other areas are expected to provide suitable habitat; decreased water velocity and evolution of conditions in the flooded terrain will result in creation of suitable feeding habitat for many species, including northern pike, lake whitefish and walleye; suitable overwintering habitat (deep, low velocity) will be present; and loss of existing littoral habitats will be offset by development of new littoral habitats, though these will be of lower quality due to daily/weekly cycling within the reservoir. In the long-term, habitat modelling indicates there will a moderate increase in most large-bodied and forage fish, including walleye, northern pike, and lake whitefish. This observation is supported by the existence of a fish community in Stephens Lake with comparable density as Gull Lake. The composition of the fish community will shift towards species that prefer lacustrine rather than riverine conditions. The presence of the GS will be a barrier to fish movement from Stephens Lake to the reservoir. The construction of the access road and reduction of velocity at Birthday Rapids has the potential to increase access to the area, which could result in an increase in harvest. It is expected that harvesting will remain within sustainable levels given the regulation of recreational fisheries, the absence of commercial fisheries, and traditional sustainable approach of domestic fishers. The offsetting program is expected to redistribute existing domestic fishing pressure to a broader land base.		a medium extent over the long-term <u>Northern pike</u> There will be an adverse, small effect to the abundance of northern pike to a medium extent over the short-term <u>Lake whitefish</u> There will be a positive, small effect to the abundance of lake whitefish to a medium extent over the long-term

Table 5-36: Residual effects on the fish community considering specifically walleye, northern pike, and lake whitefish: operation period

Environmental Effect	Mitigation/Enhancement	Residual Effect
Downstream Generating Station/Stephens Lake		
Effects to the fish community will primarily be related to changes in habitat at Gull Rapids and immediately downstream, and changes in inputs from the reservoir upstream (water quality, drifting invertebrates, and fish). The loss of Gull Rapids may have a major effect on the fish community of Stephens Lake as it provides spawning habitat to many species; alternate areas are available for most species within Stephens Lake. Some species, such as lake whitefish, may experience a net loss in spawning habitat. The rapids also provide feeding habitat; however, numbers of many species are higher in other sections of Stephens Lake, indicating that alternate habitats are available and incoming drift is not a key food source. Changes in the downstream movement of larval, juvenile and adult fish due to the creation of the reservoir and presence of the GS structure (*e.g.*, dam, spillway, trash racks, and turbines). Potential for fish to become stranded after spillway operation. The construction of the access road and boat launch facilities have the potential to increase access to the area, which could result in an increase in harvest. However, it is expected that the current commercial harvest in Stephens Lake will cease.	Creation of spawning habitat below generating station and spawning reefs in Stephens Lake Measures to increase survival during downstream movement through turbines or over spillway	No residual effects expected

Table 5-36: Residual effects on the fish community considering specifically walleye, northern pike, and lake whitefish: operation period

Environmental Effect	Mitigation/Enhancement	Residual Effect
North and South Access Road Streams		
Potential effects include: loss of habitat at crossing structure footprint; and loss of access to spawning and foraging habitat above stream crossings.	Installation of a clear-span bridge at Looking Back Creek and adherence to Manitoba Stream Crossing guidelines and other regulations for installation and maintenance of culvert at Unnamed Tributary and Gull Rapids Creek crossings	No residual effects expected

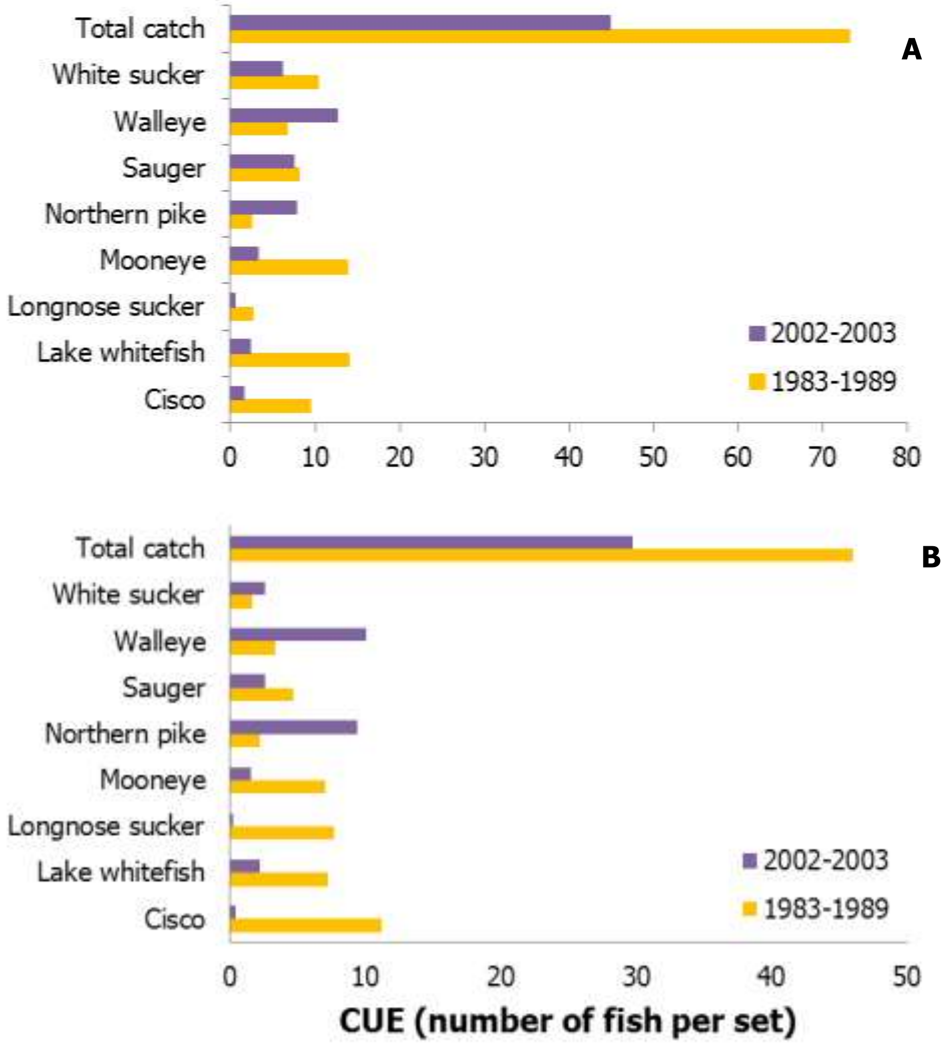


Figure 5-1: Comparison of historic (pre-1997; Ecological Monitoring Program) and recent (post-1997; Keeyask environmental studies) fish abundance in Split Lake (A) and Stephens Lake (B), as indicated by catch-per-unit-effort (CUE; number of fish/standard gang set)

A Within the Keeyask Reservoir

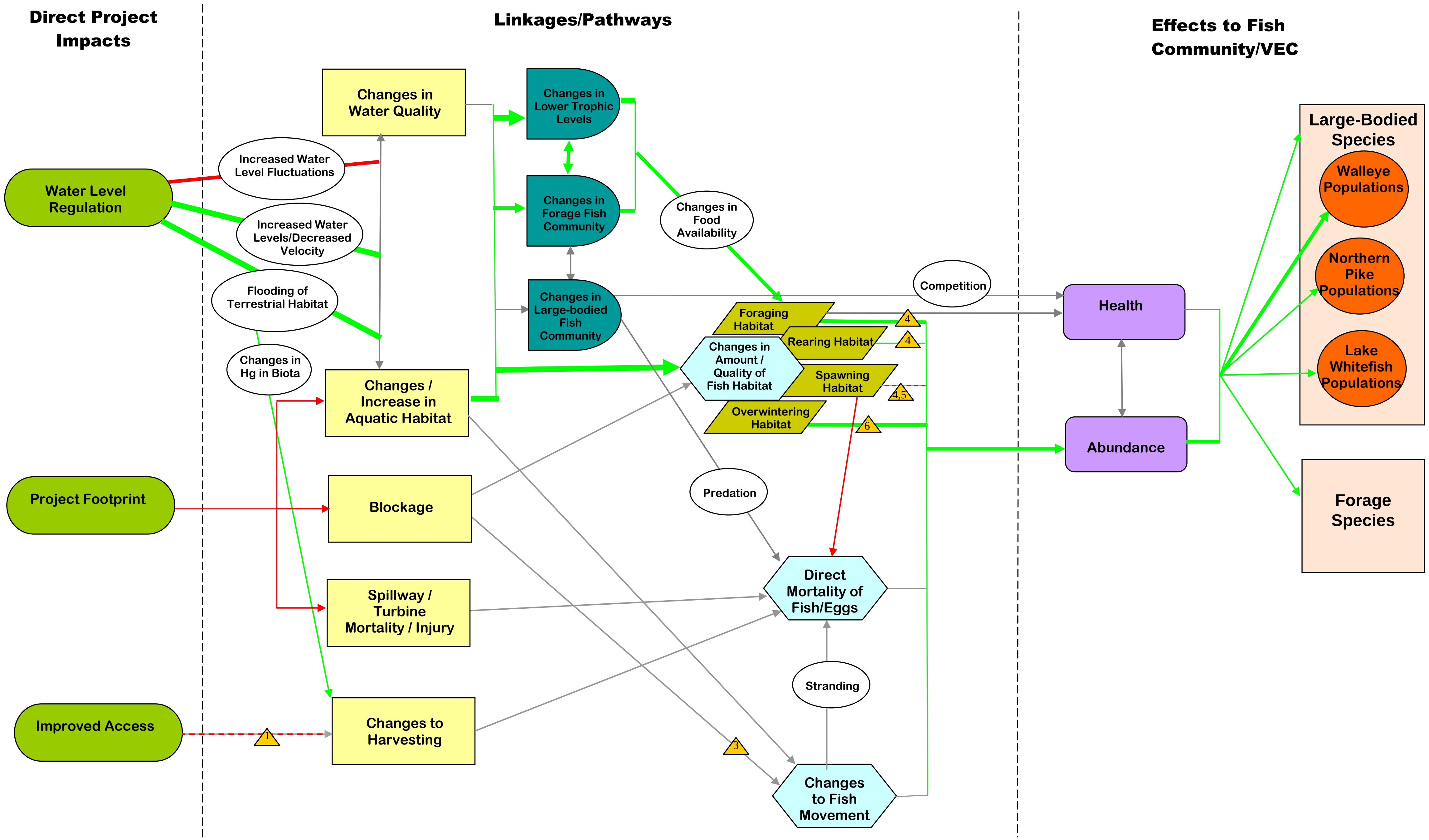


Figure 5-2: Summary of long-term effects to the fish community within (A) and downstream (B) of the Keeyask GS. Arrows indicate magnitude (thicker lines indicate greater magnitudes of effects) and type of effect (green = positive effect; red = negative effect; grey = no/minor effect; dashed = mitigated effect). Mitigation triangles: 1 = Access Management Plan; 2 = turbine/spillway design; 3 = trap and transport program; 4 = debris removal at stream mouths; 5 = spawning enhancements in reservoir; 6 = construction of escape channels at Little Gull Lake; 7 = creation of spawning habitat below GS; and 8 = construction of escape channels from spillway pools

B Downstream of the Keeyask GS

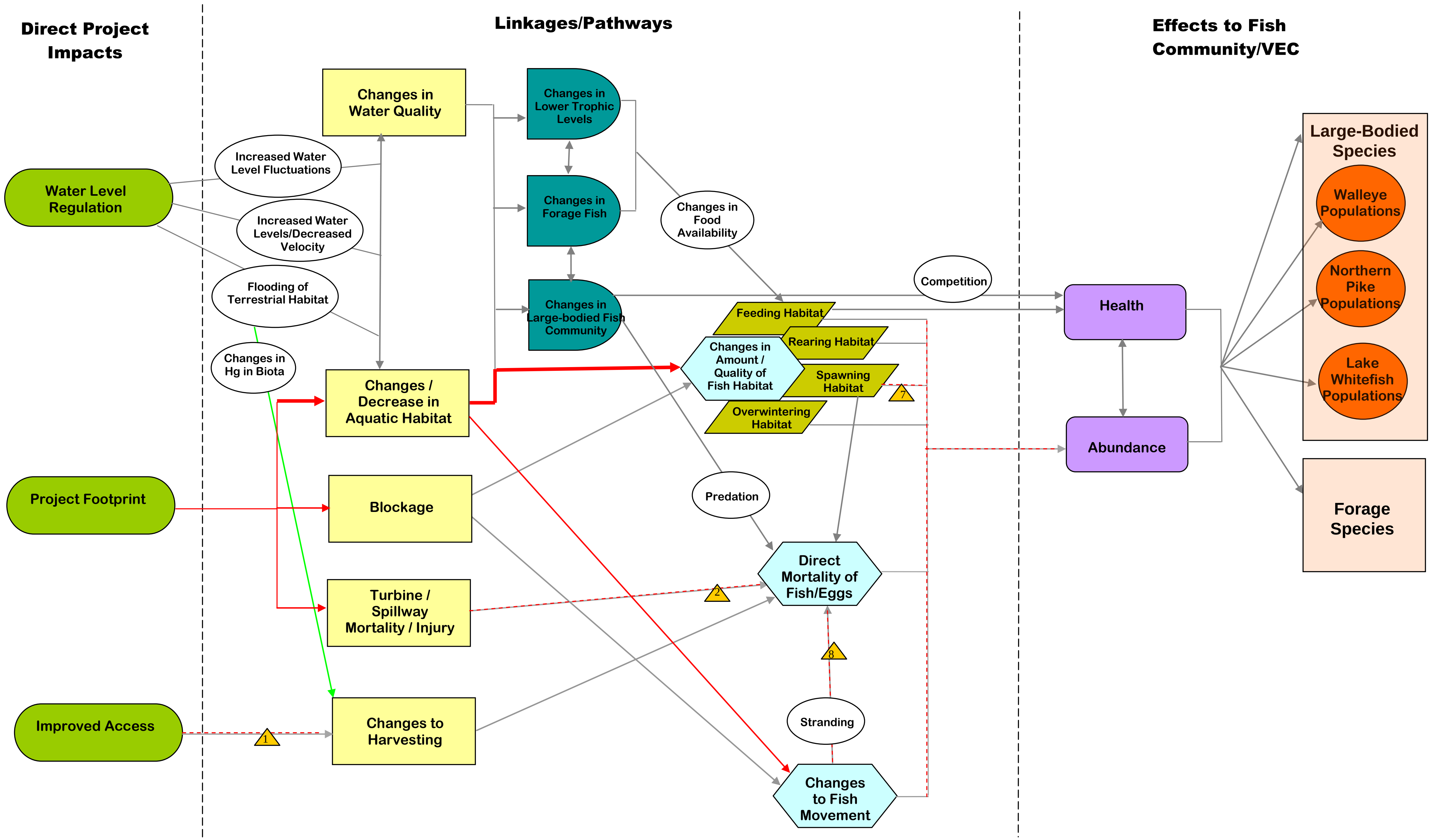


Figure 5-2: Summary of long-term effects to the fish community within (A) and downstream (B) of the Keeyask GS. Arrows indicate magnitude (thicker lines indicate greater magnitudes of effects) and type of effect (green = positive effect; red = negative effect; grey = no/minor effect; dashed = mitigated effect). Mitigation triangles: 1 = Access Management Plan; 2 = turbine/spillway design; 3 = trap and transport program; 4 = debris removal at stream mouths; 5 = spawning enhancements in reservoir; 6 = construction of escape channels at Little Gull Lake; 7 = creation of spawning habitat below GS; and 8 = construction of escape channels from spillway pools

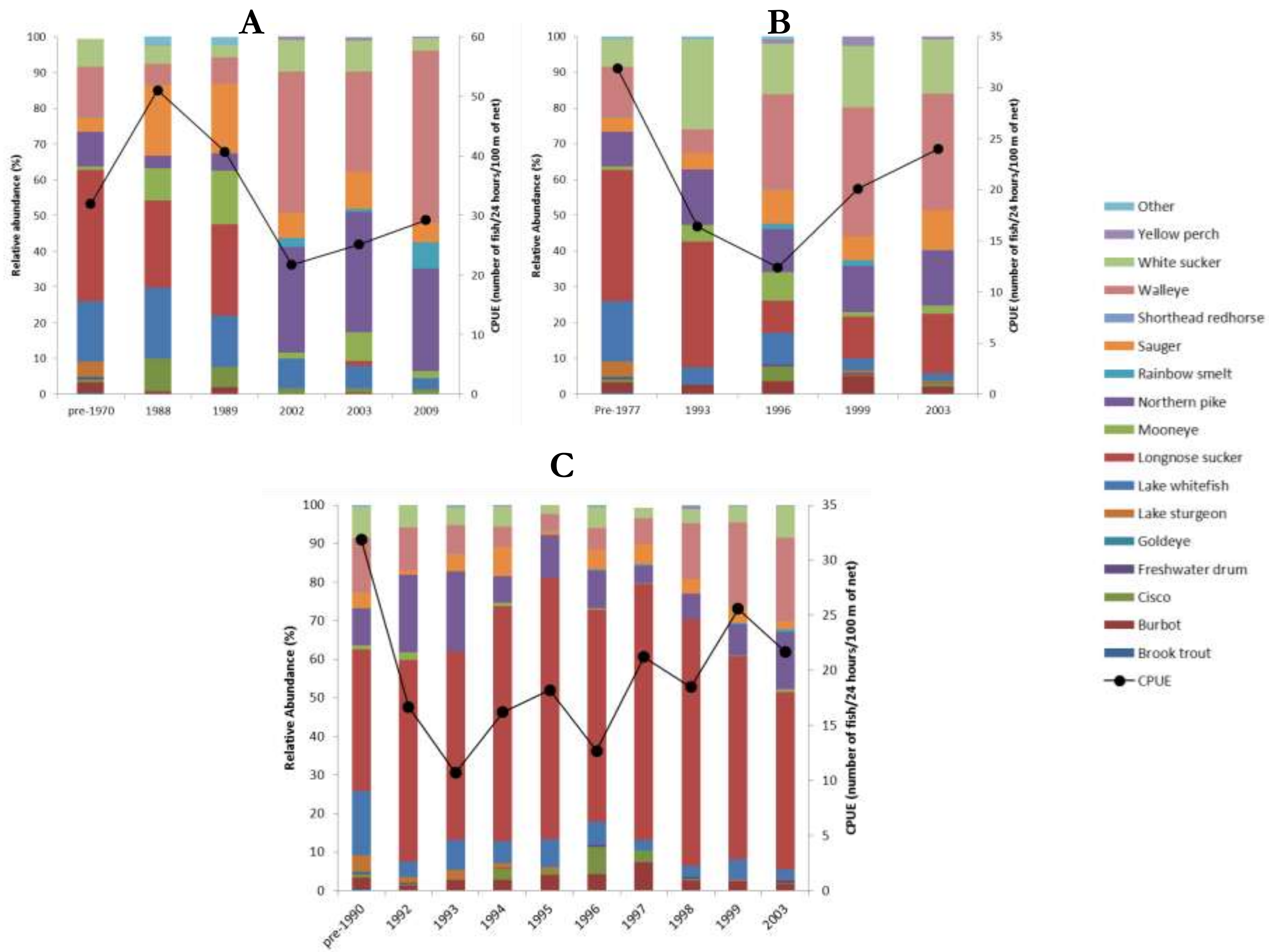
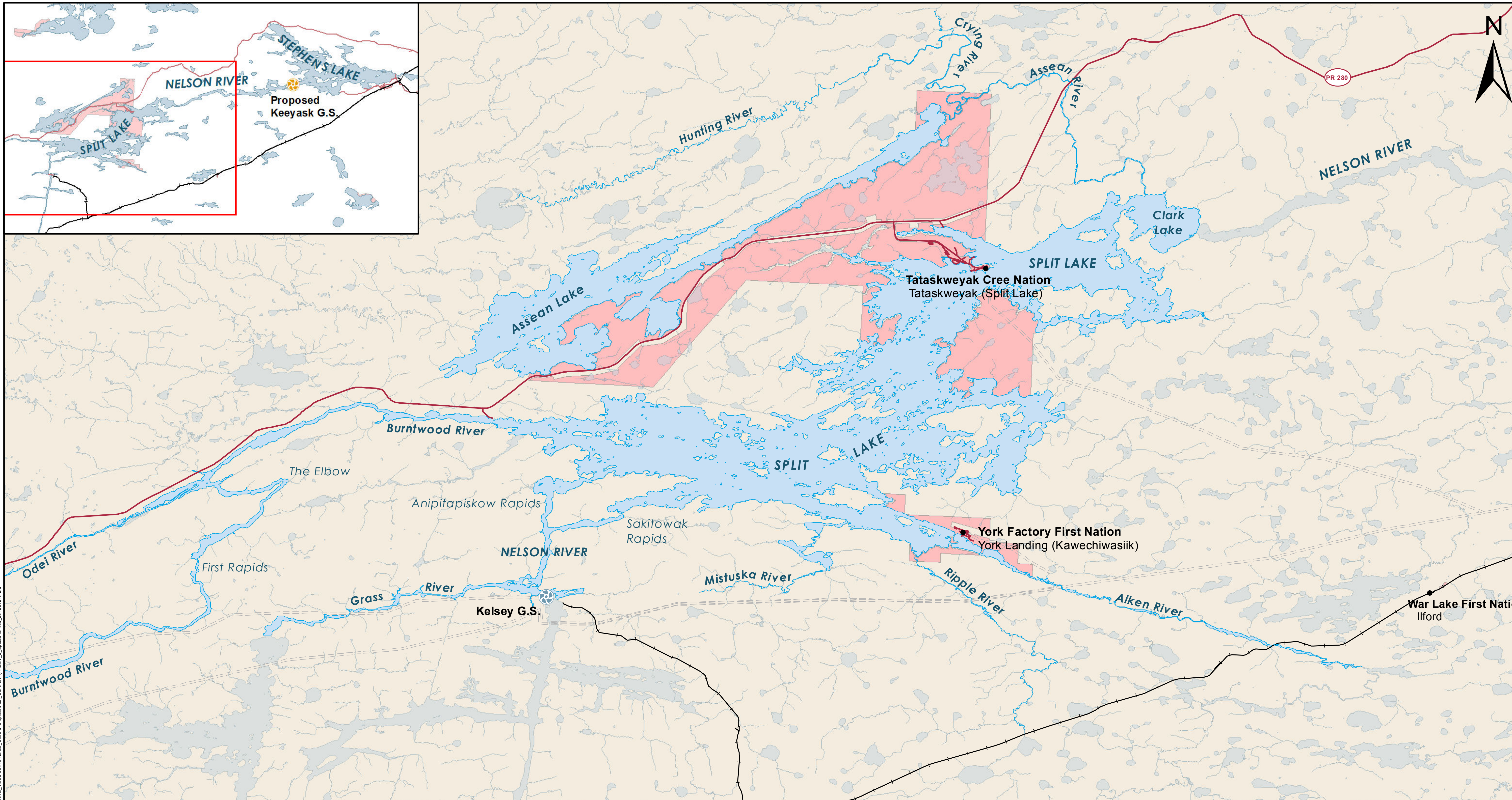


Figure 5-3: Relative abundance of fish species and catch-per-unit-effort (CPUE) of the total catch in standard gang index gill nets set during summer in the lower Nelson River reservoirs: Kettle reservoir (A); Long Spruce reservoir (B); and Limestone reservoir (C). The pre-impoundment fish community was estimated based on the fish community in the un-impounded reach of the Nelson River below the Limestone GS during summer 2003. The CPUE for the Kettle reservoir in 1988 and 1989 was calculated per overnight set rather than standardized to 24 hours.



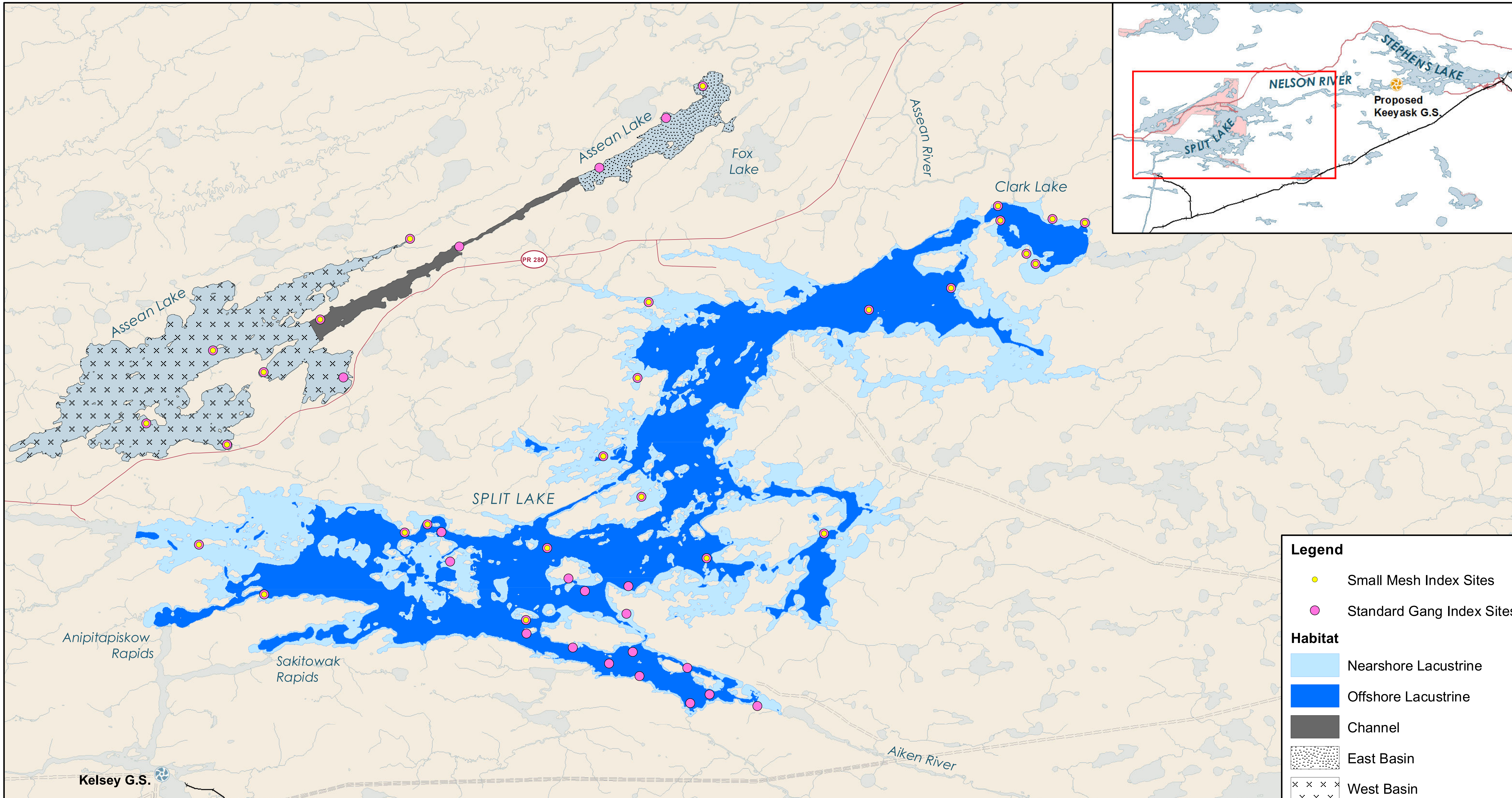
KEEYASK
Hydropower Limited Partnership

0 5 10 20 Kilometres
0 2.5 5 10 Miles

Projection: UTM Zone 15, NAD 83
Data Source: NTS base 1:50 000

Split Lake Area

Map 5-1



KEEYASK Hydropower Limited Partnership

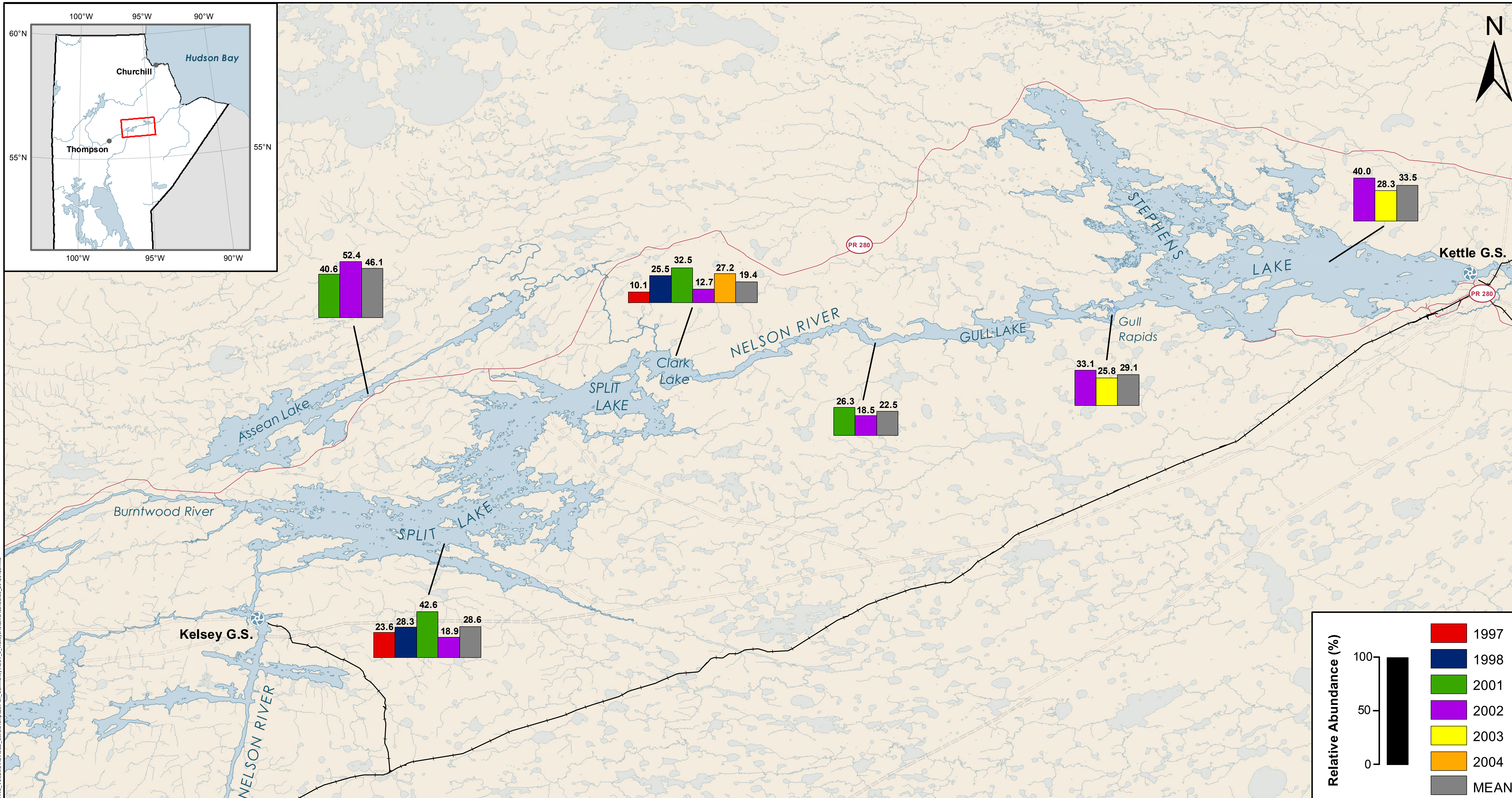
0 5 10 15 Kilometres
0 4 8 Miles

Projection: UTM Zone 15, NAD 83
Data Source: NTS base 1:50 000

Habitat-Based Index Gillnetting Sites 1999-2004

Split Lake Area

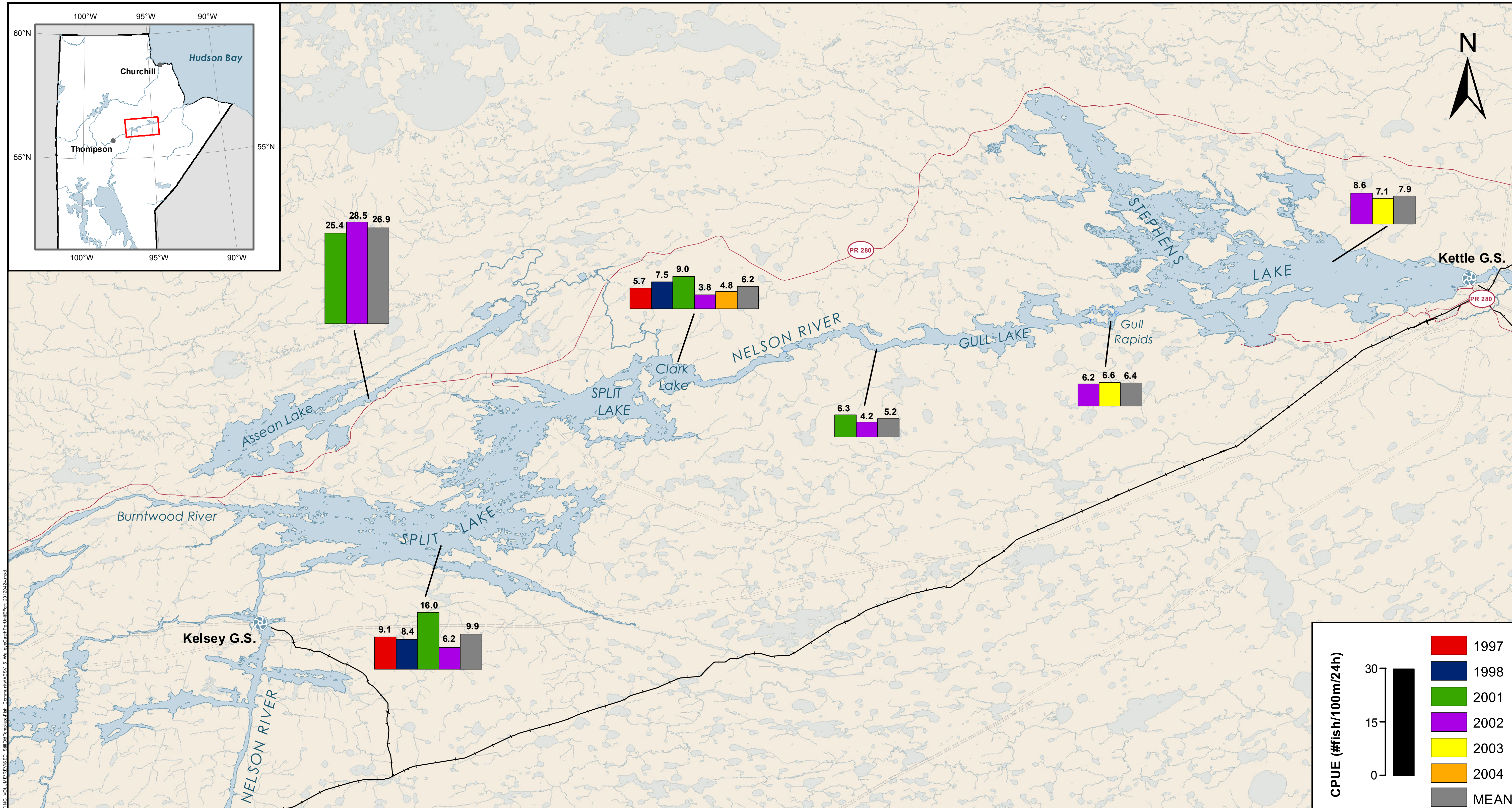
Map 5-2



KEEYASK Hydropower Limited Partnership

Projection: UTM Zone 15, NAD 83
Data Source: NTS base 1:50 000

Walleye Relative Abundance
Standard Gang Index Gill Nets



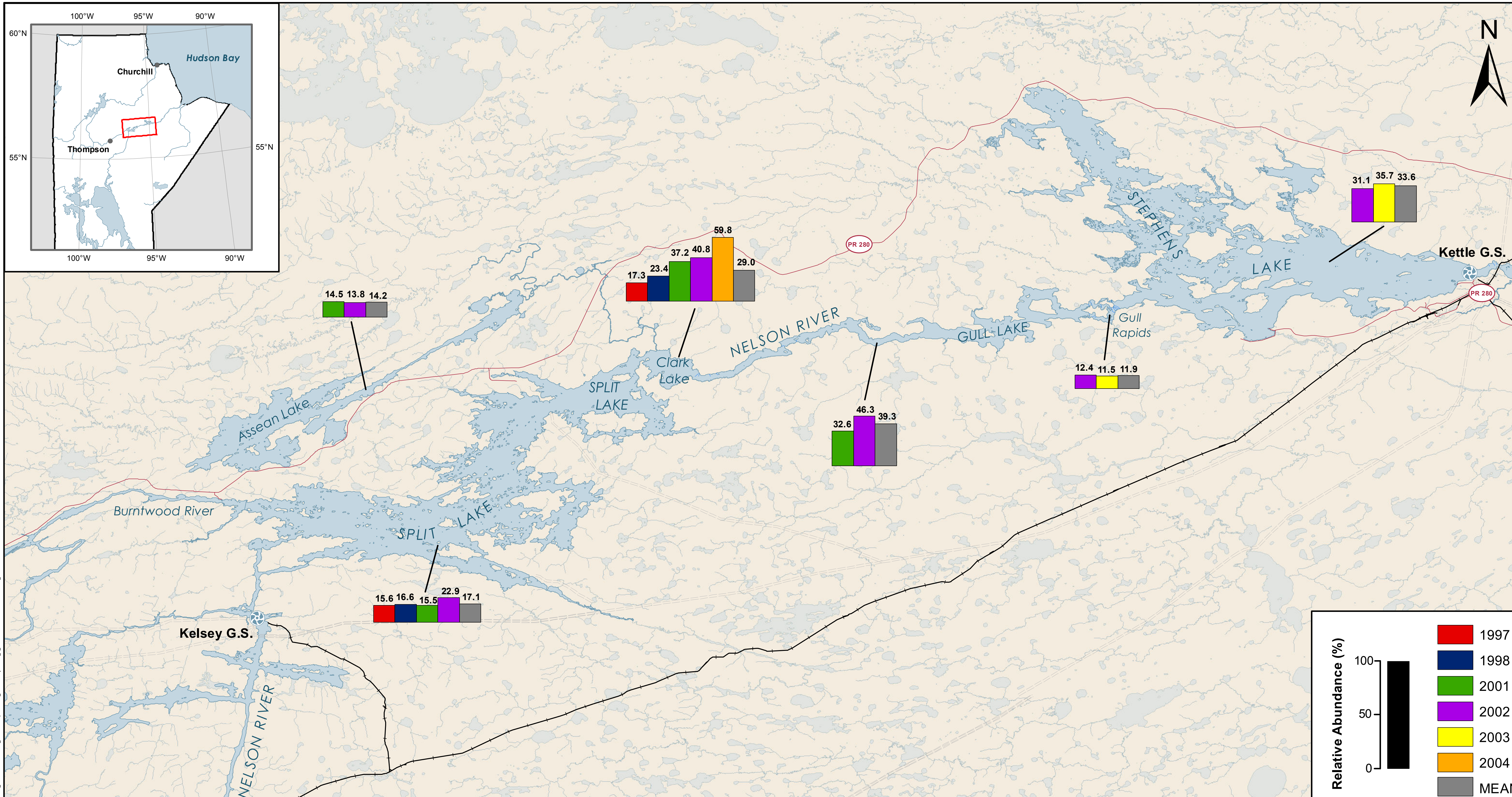
0 10 20 30 Kilometres
0 8 16 Miles

KEEYASK Hydropower Limited Partnership

Projection: UTM Zone 15, NAD 83
Data Source: NTS base 1:50 000

Walleye Catch-per-unit-effort

Standard Gang Index Gill Nets



KEEYASK Hydropower Limited Partnership

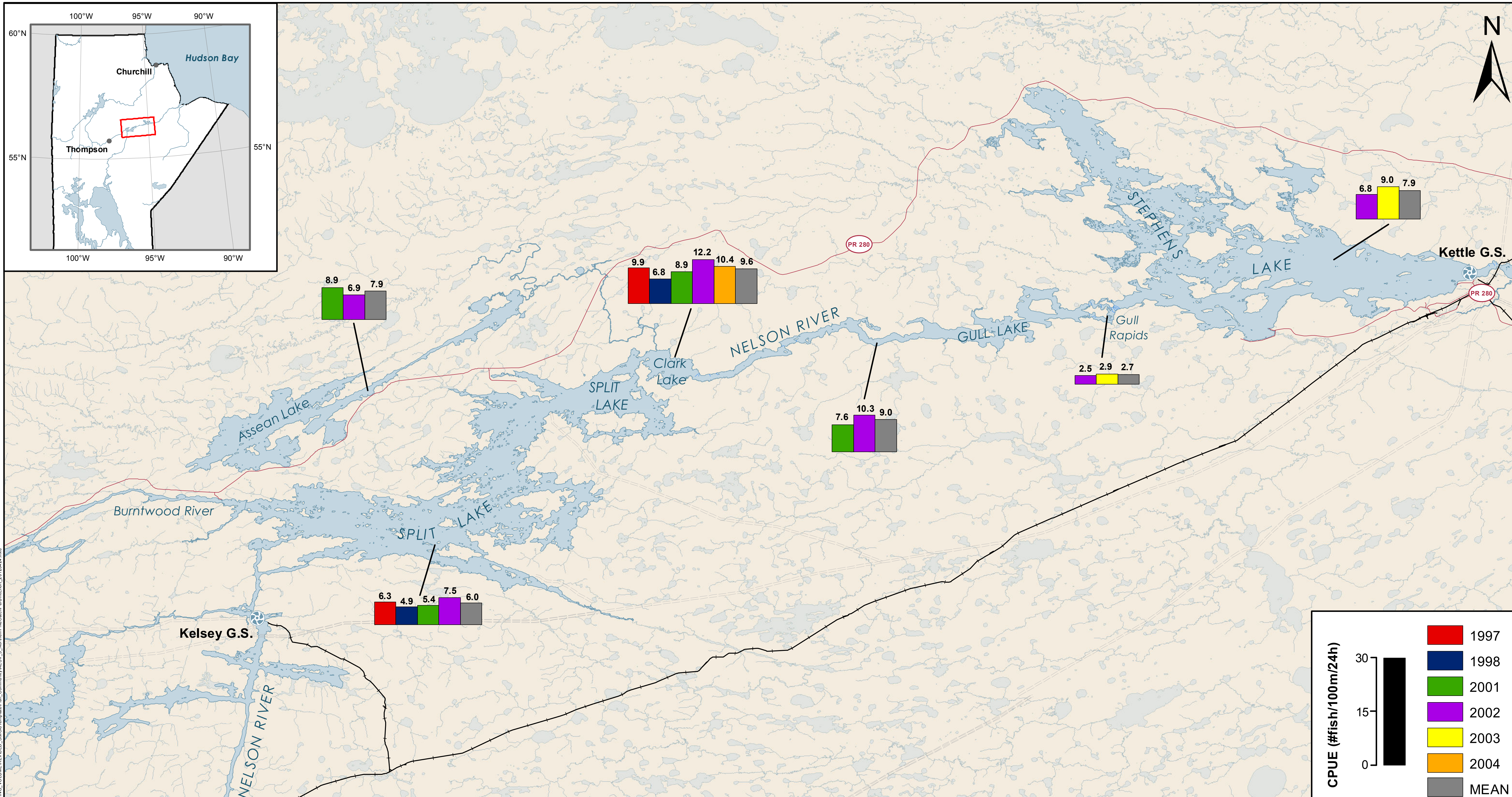
0 10 20 30 Kilometres
0 8 16 Miles

Projection: UTM Zone 15, NAD 83
Data Source: NTS base 1:50 000

Northern Pike Relative Abundance

Standard Gang Index Gill Nets

Map 5-5

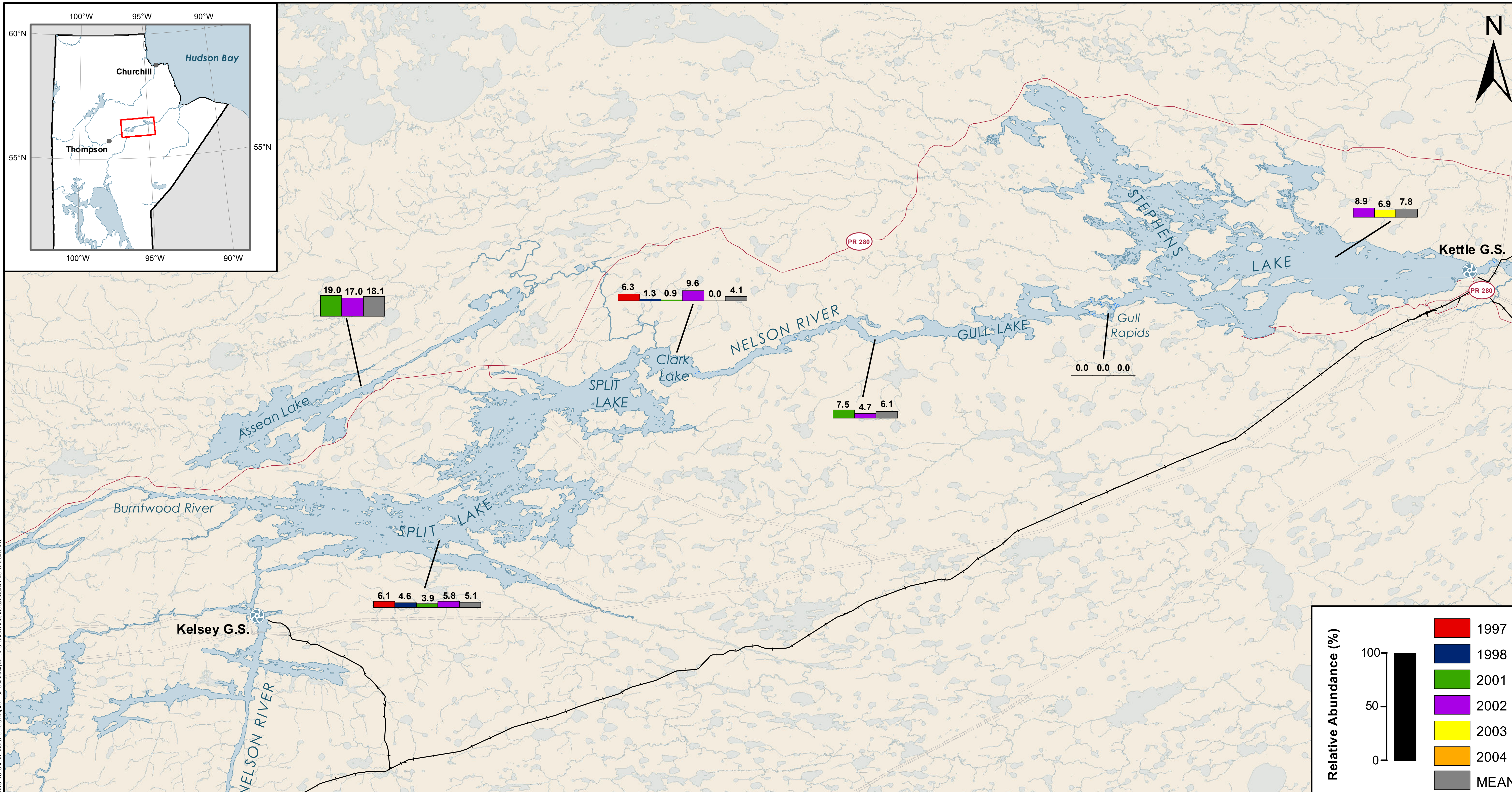


KEEYASK
Hydropower Limited Partnership

0 10 20 30 Kilometres
0 8 16 Miles

Projection: UTM Zone 15, NAD 83
Data Source: NTS base 1:50 000

Northern Pike Catch-per-unit-effort
Standard Gang Index Gill Nets

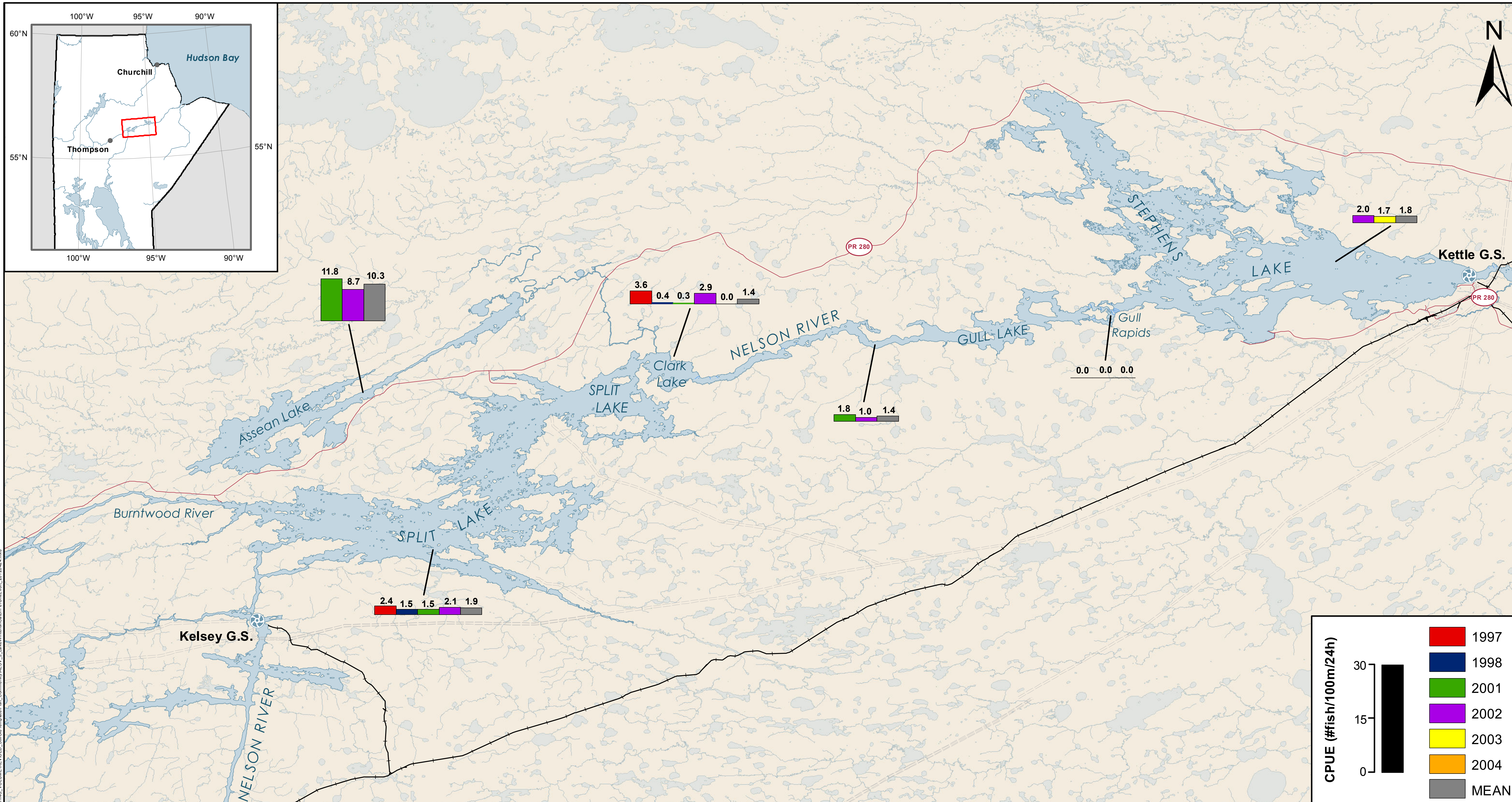


KEEYASK
Hydropower Limited Partnership

0 10 20 30 Kilometres
0 8 16 Miles

Projection: UTM Zone 15, NAD 83
Data Source: NTS base 1:50 000

Lake Whitefish Relative Abundance
Standard Gang Index Gill Nets



KEEYASK Hydropower Limited Partnership

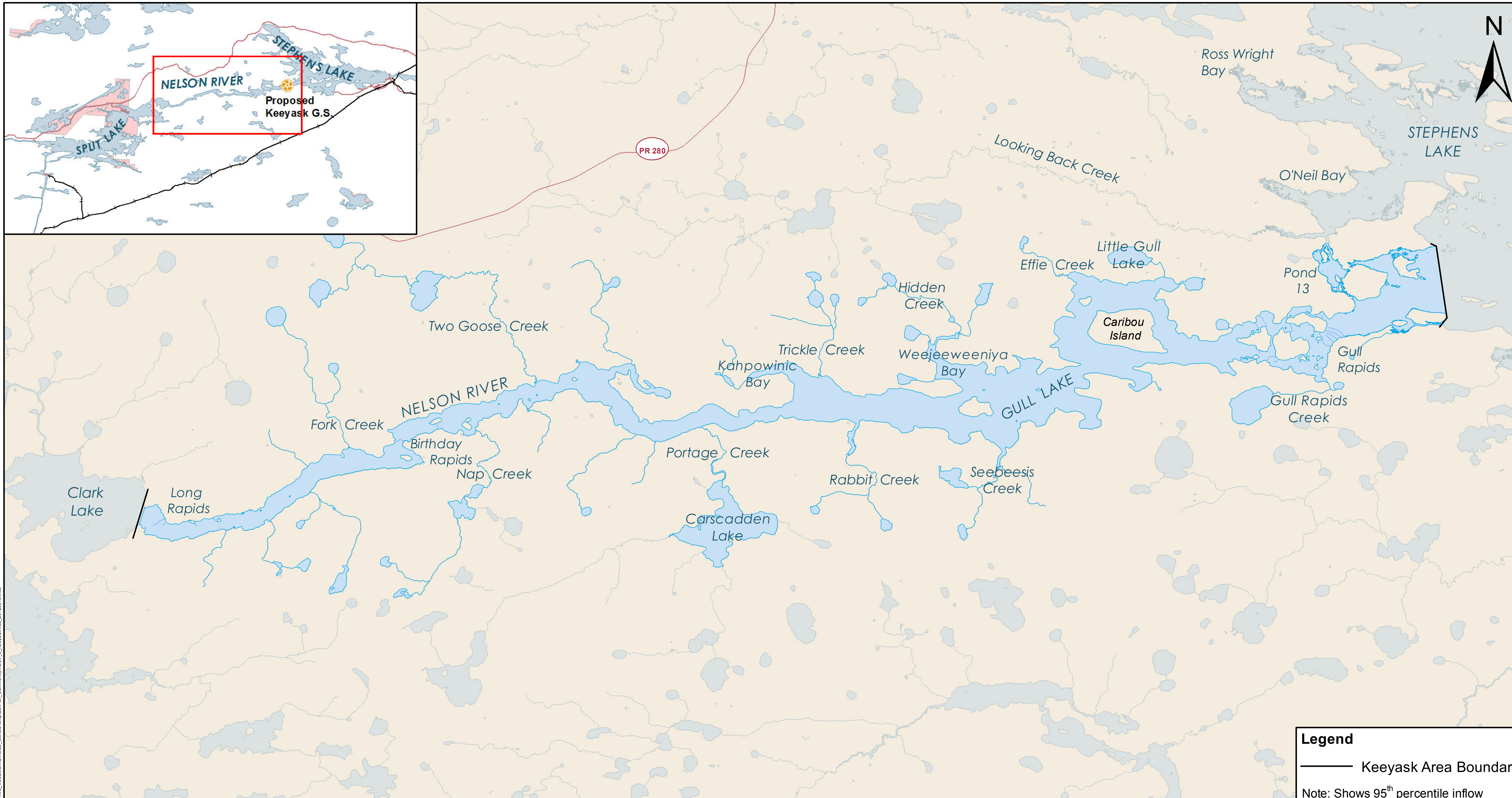
0 10 20 30 Kilometres

0 8 16 Miles

Projection: UTM Zone 15, NAD 83
Data Source: NTS base 1:50 000

Lake Whitefish Catch-per-unit-effort

Standard Gang Index Gill Nets



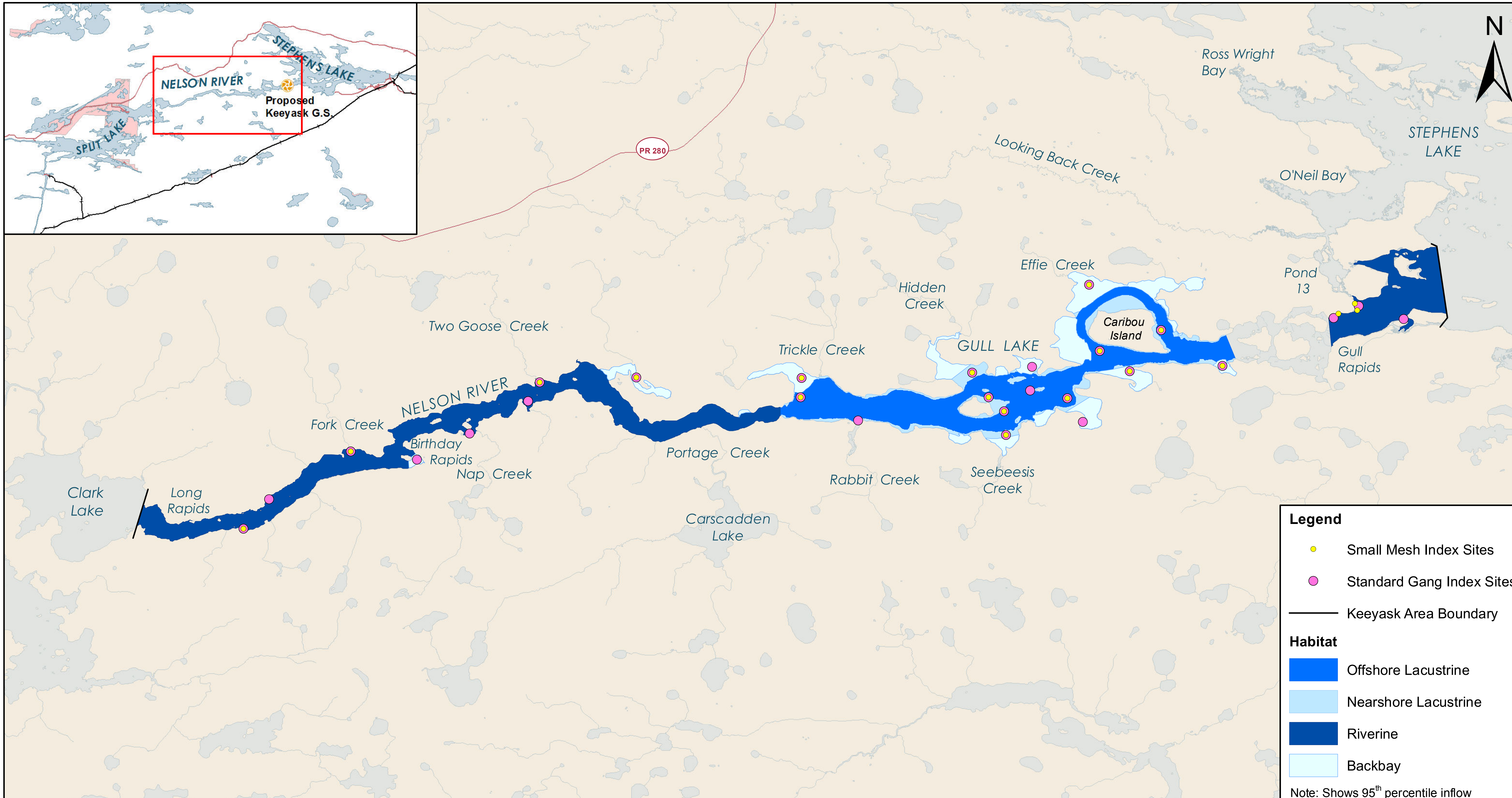
0 2.5 5 7.5 10 Kilometres

0 1.25 2.5 3.75 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

Keeyask Area
Existing Environment

Map 5-9



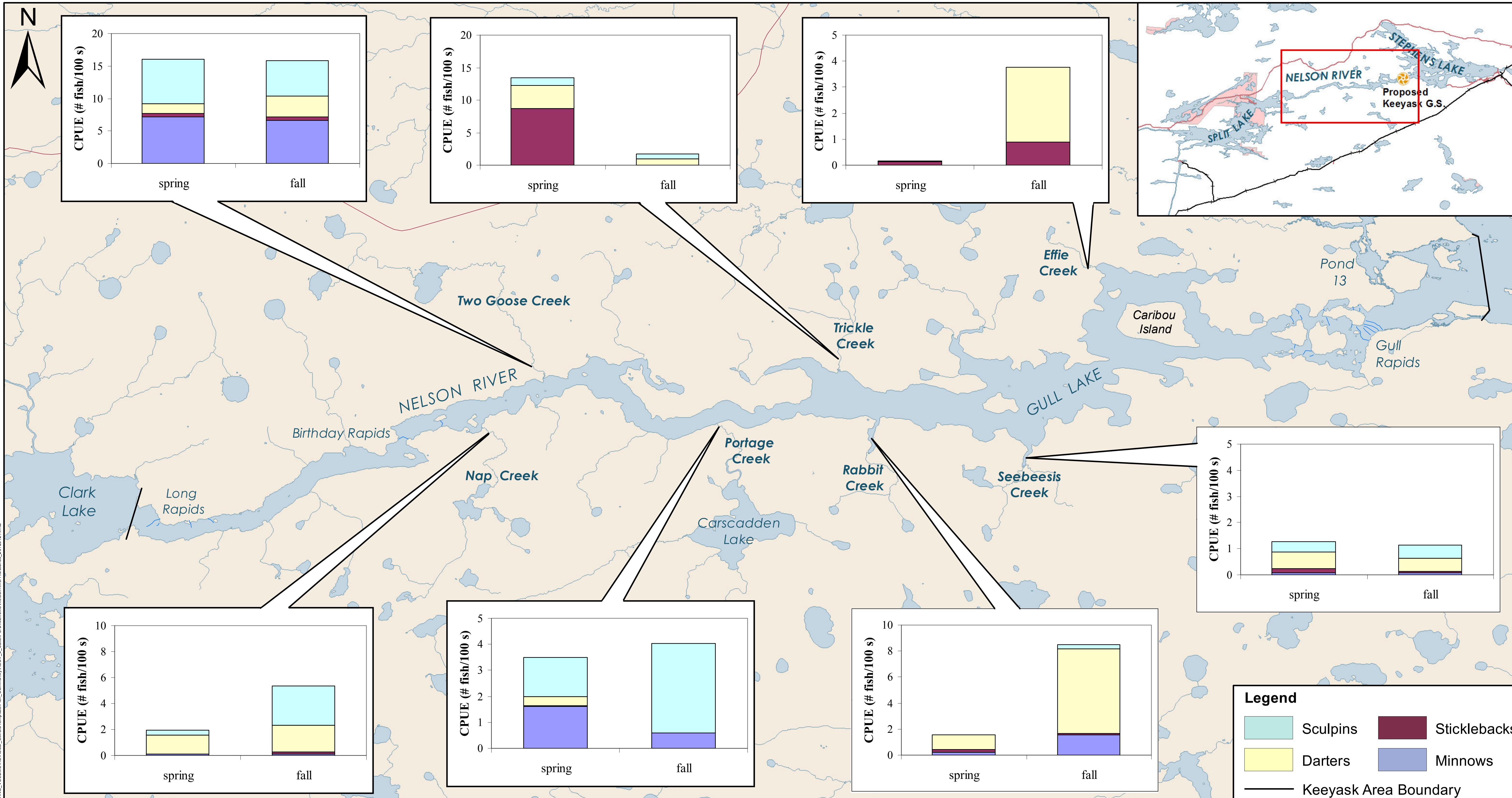
0 2.5 5 7.5 10 Kilometres

0 1.25 2.5 3.75 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

Habitat-Based Index Gillnetting Sites 1999-2003

Keeyask Area

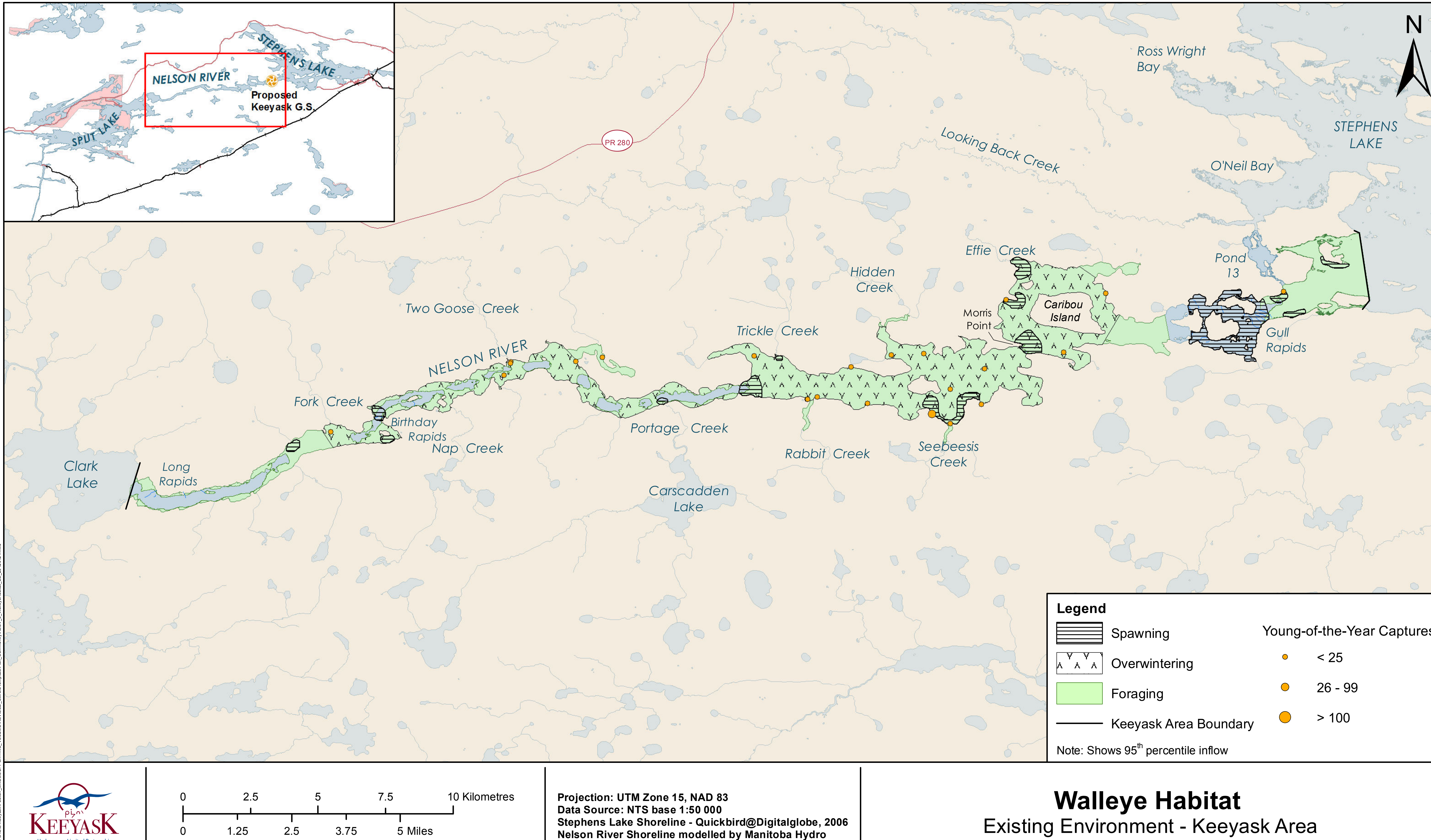


KEEYASK
Hydropower Limited Partnership

0 5 10 Kilometres
0 2.5 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

Catch-Per-Unit-Effort of Nelson River Tributaries
Keeyask Area



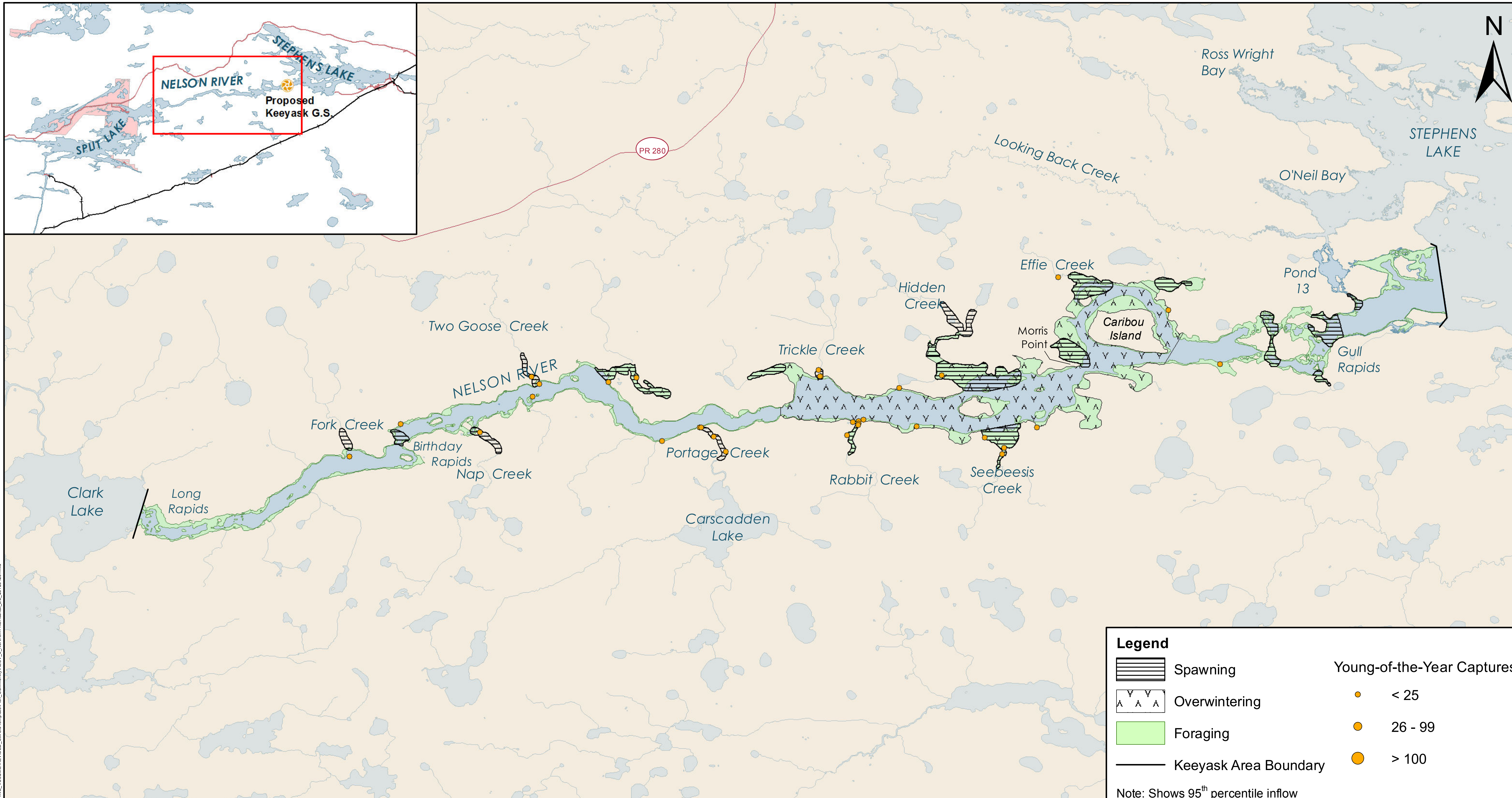
KEEYASK
Hydropower Limited Partnership

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

Walleye Habitat

Existing Environment - Keeyask Area

Map 5-12



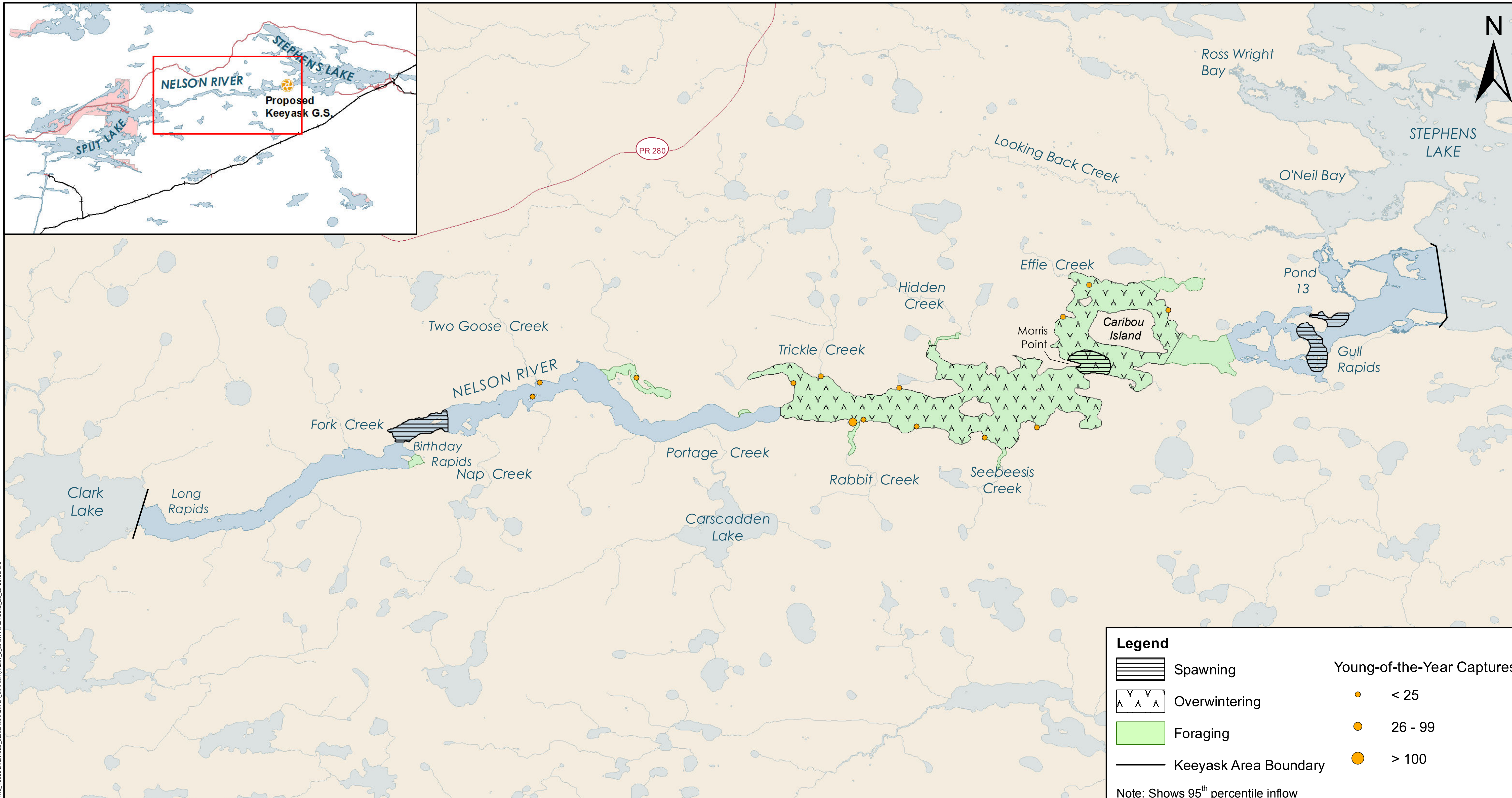
KEEYASK
Hydropower Limited Partnership

0 2.5 5 7.5 10 Kilometres
0 1.25 2.5 3.75 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

Northern Pike Habitat

Existing Environment - Keeyask Area



KEEYASK Hydropower Limited Partnership

0 2.5 5 7.5 10 Kilometres
0 1.25 2.5 3.75 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

Lake Whitefish Habitat

Existing Environment - Keeyask Area

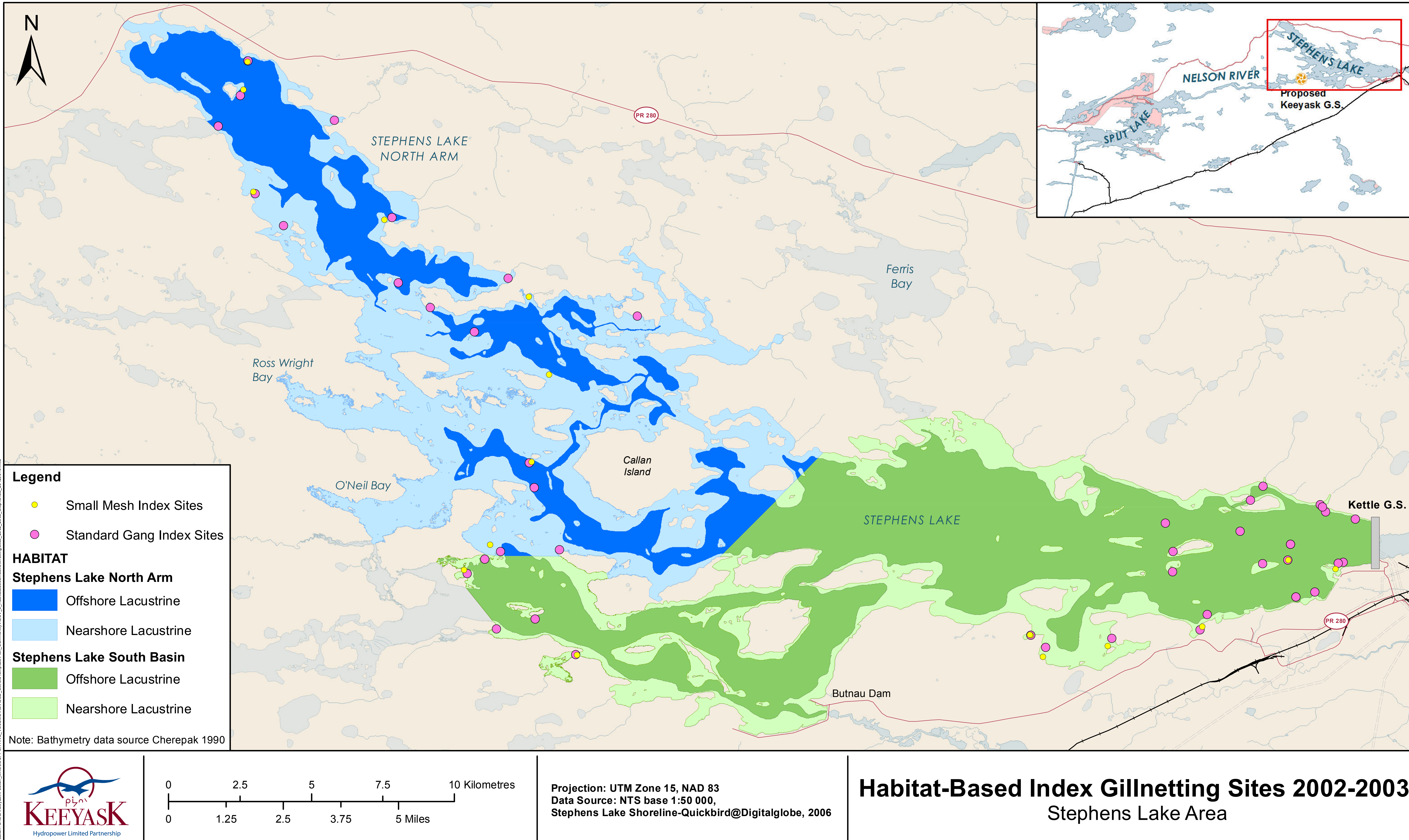
KEEYASK
Hydropower Limited Partnership

0 5 10 Kilometres
0 2 4 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

Stephens Lake Area

Map 5-15



KEEYASK Hydropower Limited Partnership

Projection: UTM Zone 15, NAD 83
Data Source: NTS base 1:50 000,
Stephens Lake Shoreline-Quickbird@Digitalglobe, 2006

Habitat-Based Index Gillnetting Sites 2002-2003

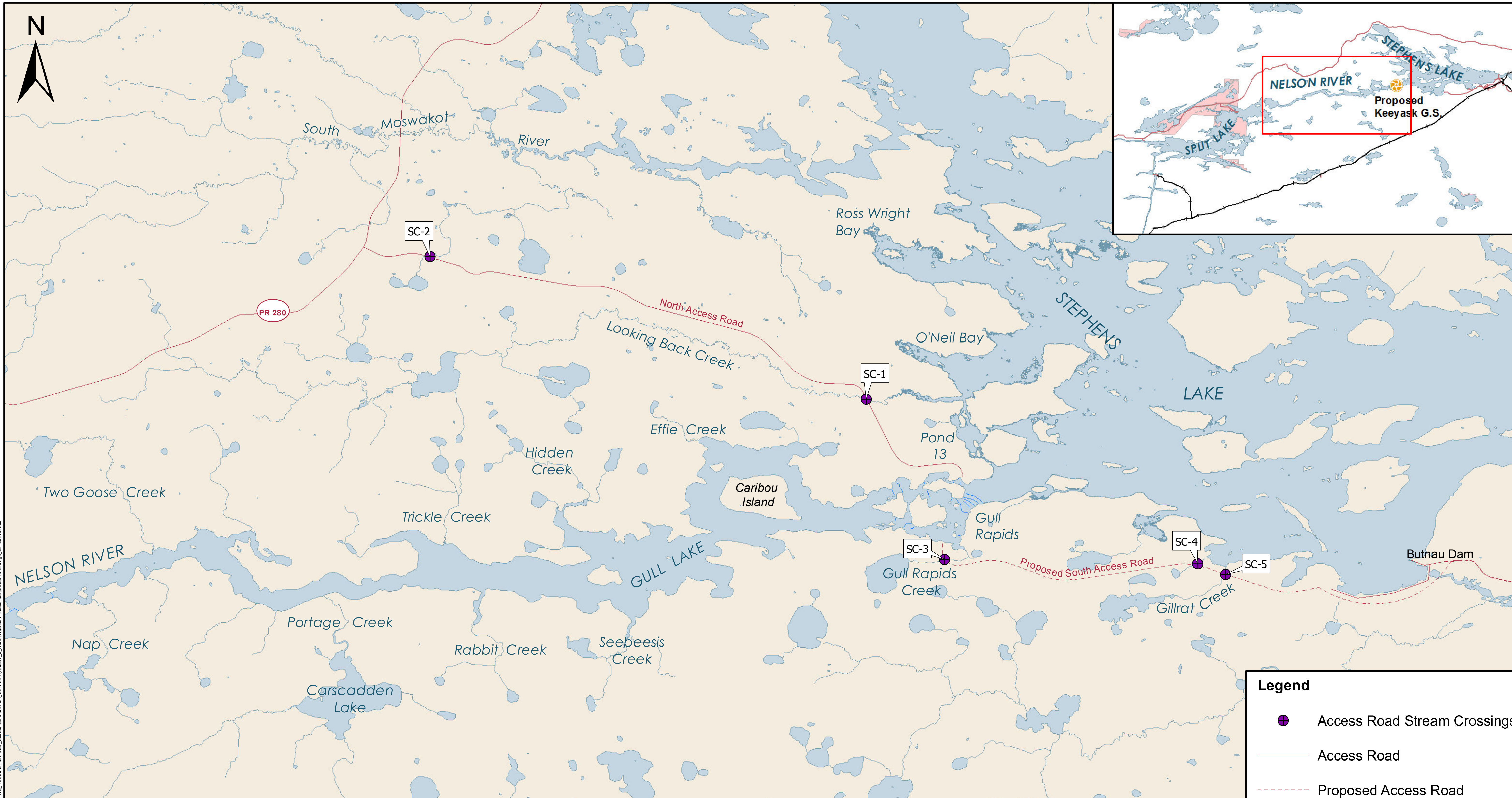
Stephens Lake Area

Projection: UTM Zone 15, NAD 83
Data Source: NTS base 1:50 000
Stephens Lake Shoreline-Quickbird @ Digitalglobe, 2006

KEEYASK Hydropower Limited Partnership

Walleye Radio Tracking - Overwintering

Stephens Lake Area

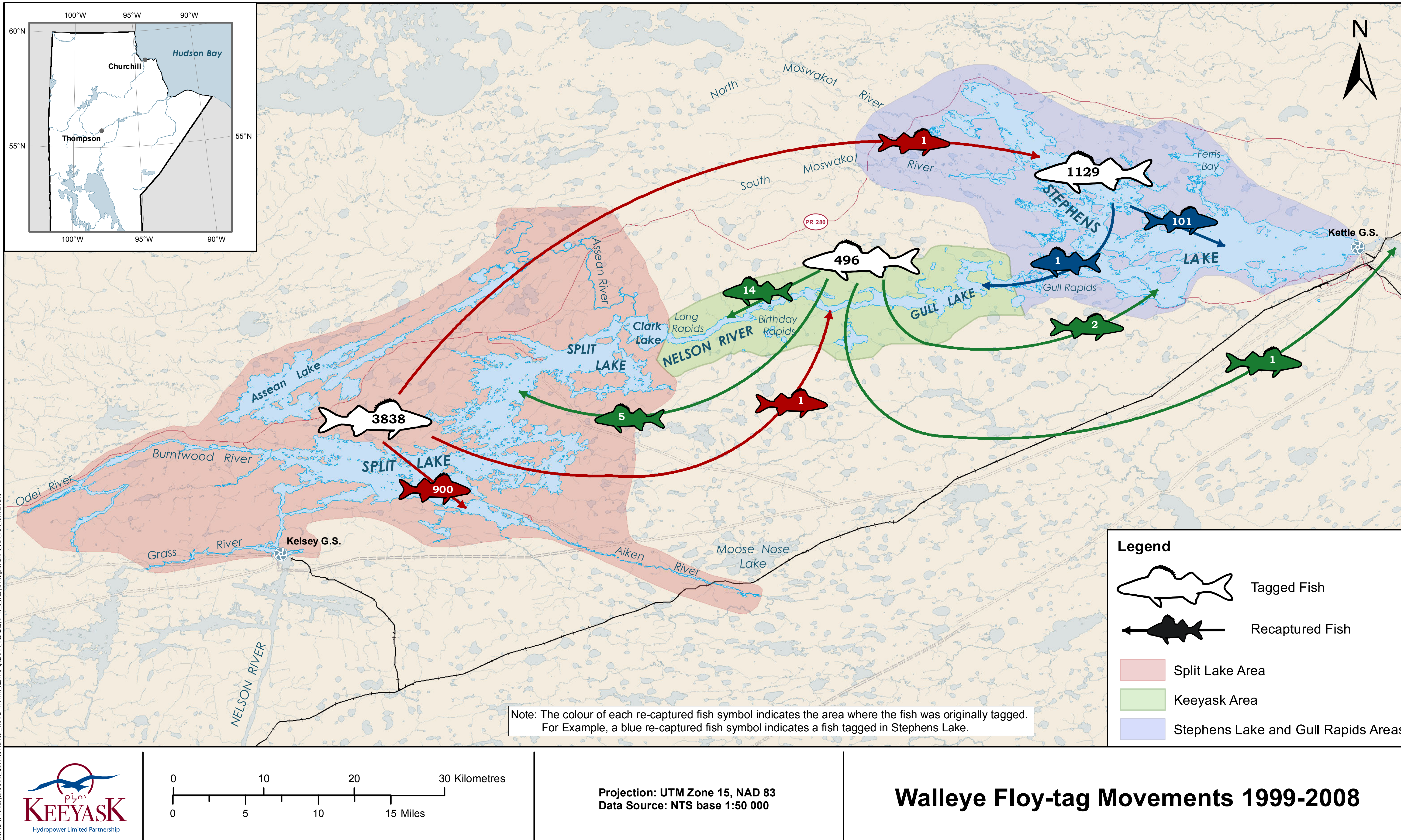


KEEYASK Hydropower Limited Partnership

0	2.5	5	7.5	10 Kilometres
0	1.25	2.5	3.75	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

North and South Access Road Stream Crossings

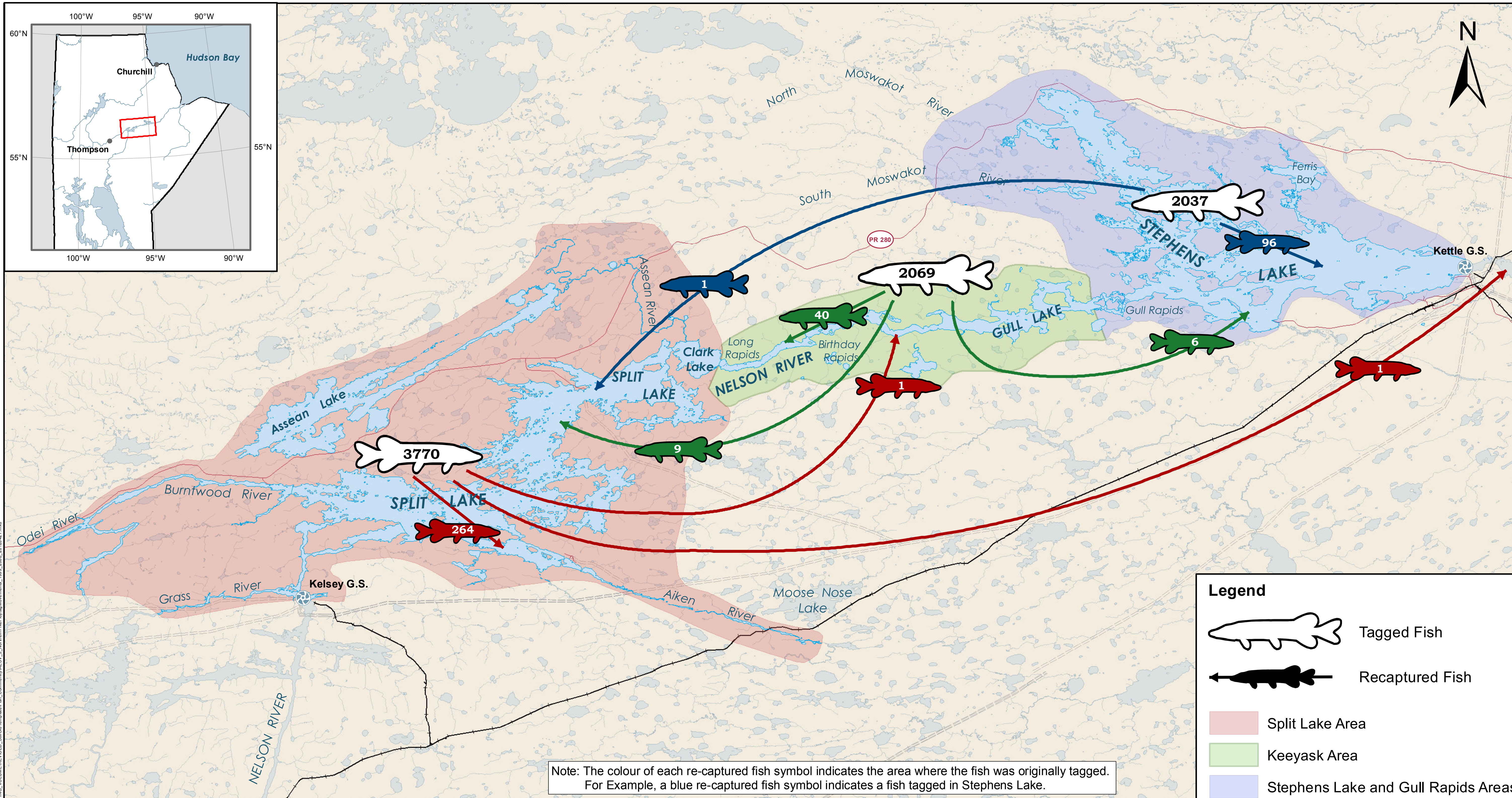


KEEYASK Hydropower Limited Partnership

Projection: UTM Zone 15, NAD 83
Data Source: NTS base 1:50 000

Walleye Floy-tag Movements 1999-2008

Map 5-19



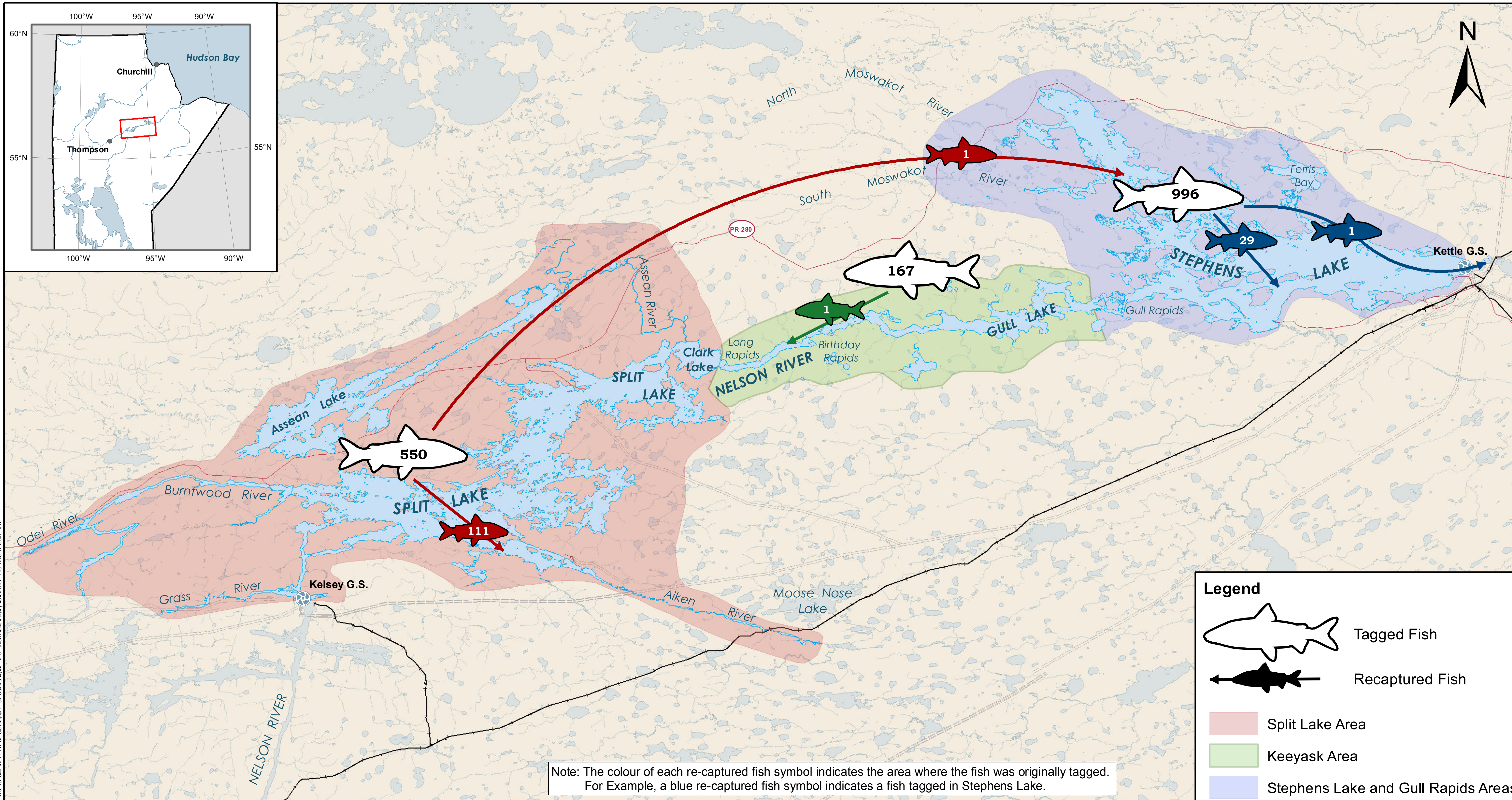
KEEYASK Hydropower Limited Partnership

0 10 20 30 Kilometres

0 5 10 15 Miles

Projection: UTM Zone 15, NAD 83
Data Source: NTS base 1:50 000

Northern Pike Floy-tag Movements 1999-2008

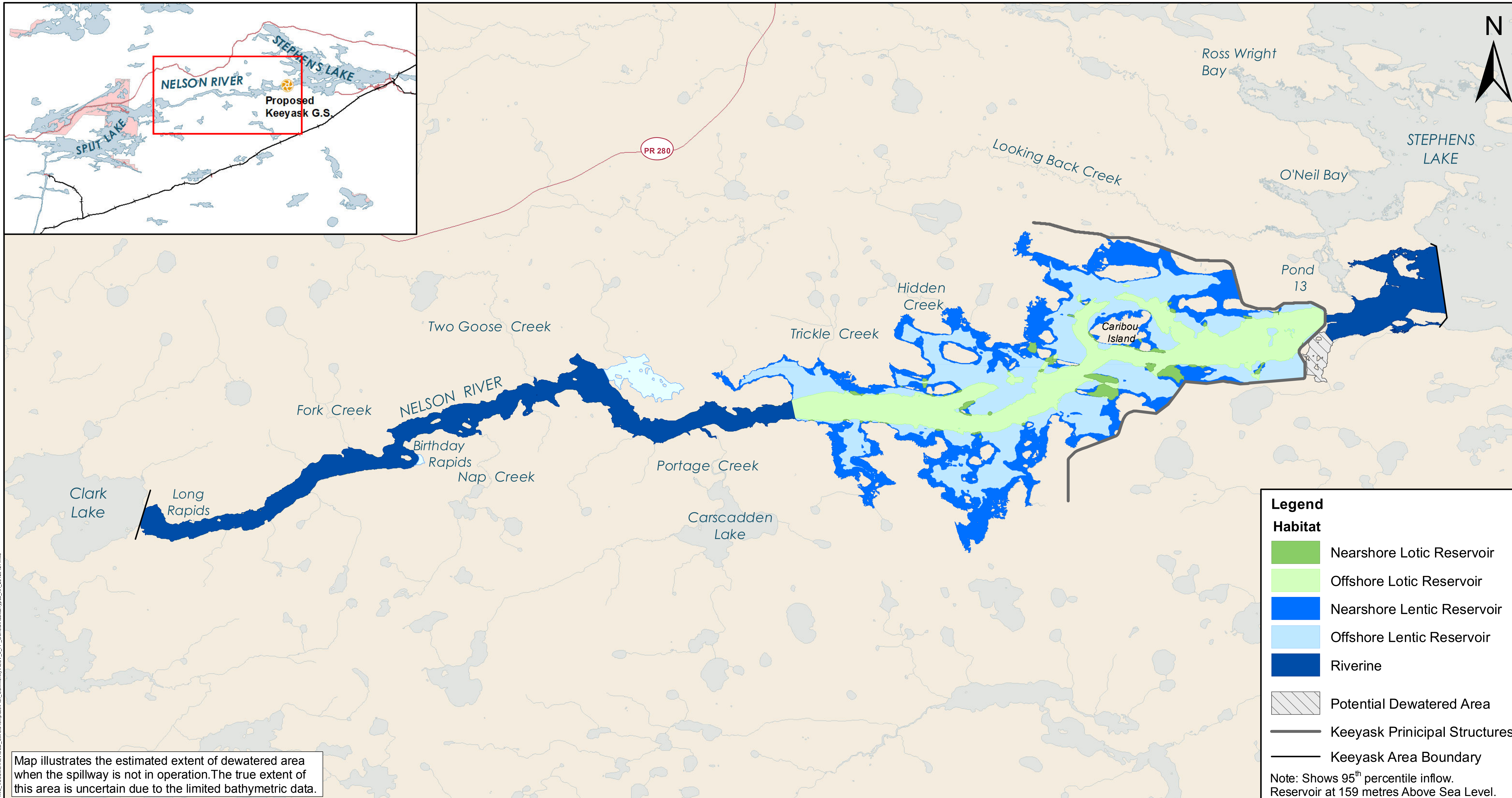


KEEYASK Hydropower Limited Partnership

0 10 20 30 Kilometres
0 5 10 15 Miles

Projection: UTM Zone 15, NAD 83
Data Source: NTS base 1:50 000

Lake Whitefish Floy-tag Movements 1999-2008

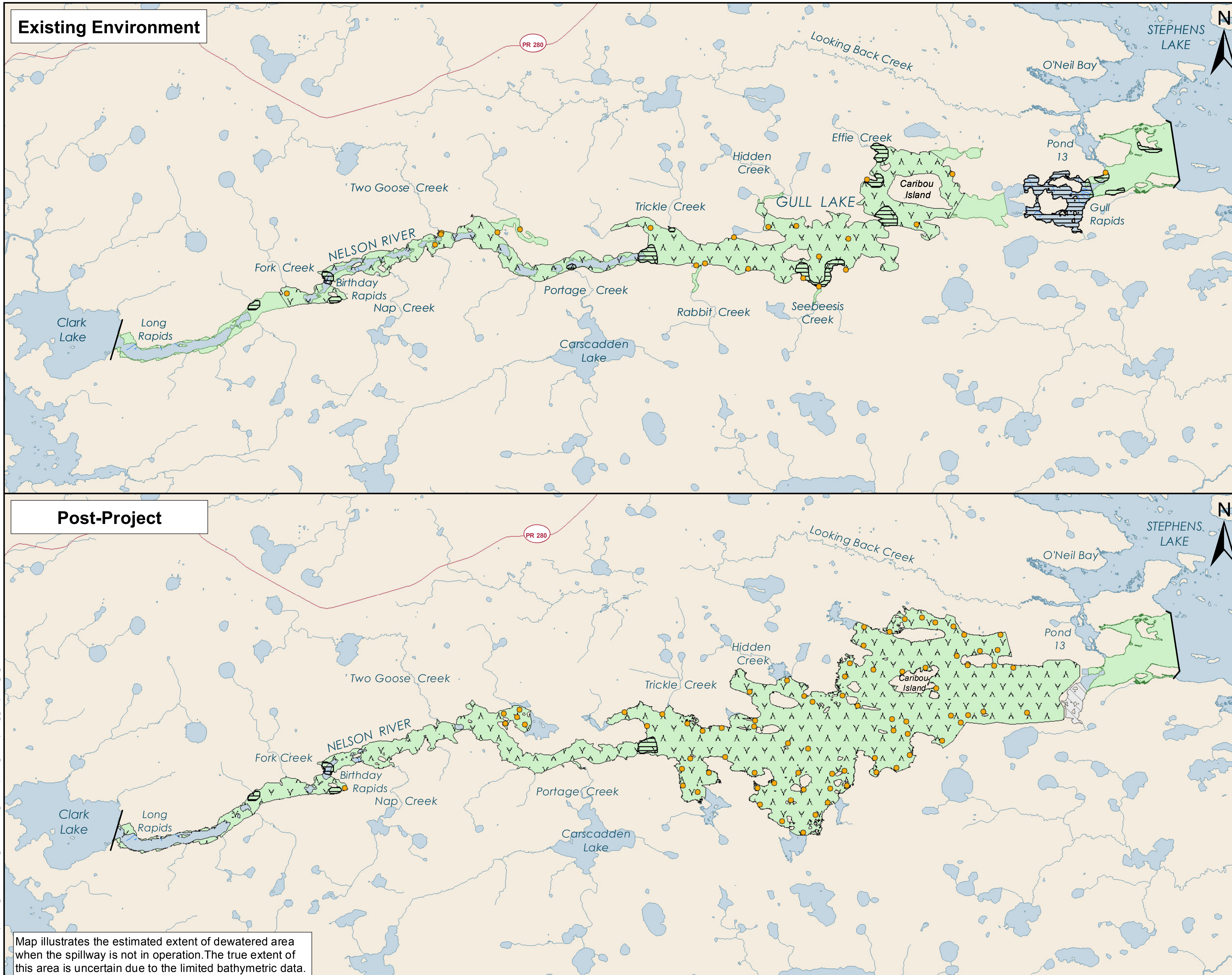


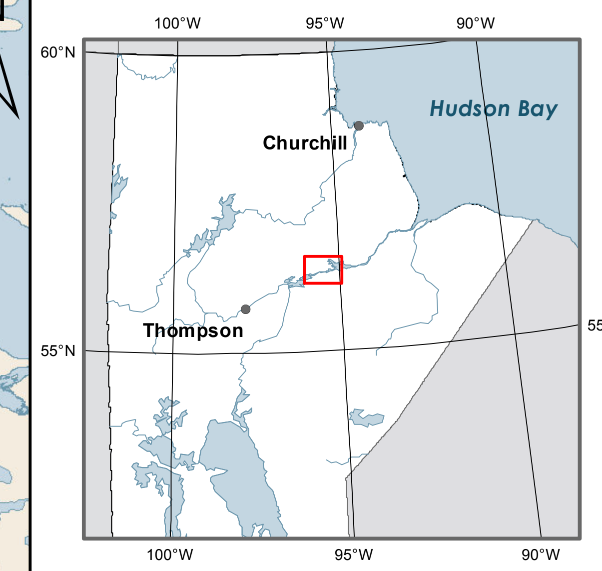
KEEYASK Hydropower Limited Partnership

0 2.5 5 7.5 10 Kilometres
0 1.25 2.5 3.75 5 Miles

Projection: UTM Zone 15, NAD 83
Data Source: NTS base 1:50 000
Stephens Lake Shoreline - Quickbird@Digitalglobe, 2006
Nelson River Shoreline (95th percentile inflow) modelled by Manitoba Hydro. Extents of dewatered area are estimated based on the existing environment 95th percentile inflow.

General Habitat Types
Post-Project - Keeyask Area





Legend

- Rearing
- Spawning
- Foraging
- Overwintering
- Potential Dewatered Area
- Keeyask Principal Structures
- Keeyask Area Boundary

Note: Existing Environment and Post-Project frames show 95th percentile inflow. Extents of dewatered area are estimated based on the existing environment 95th percentile flow. Mitigation measures are not shown

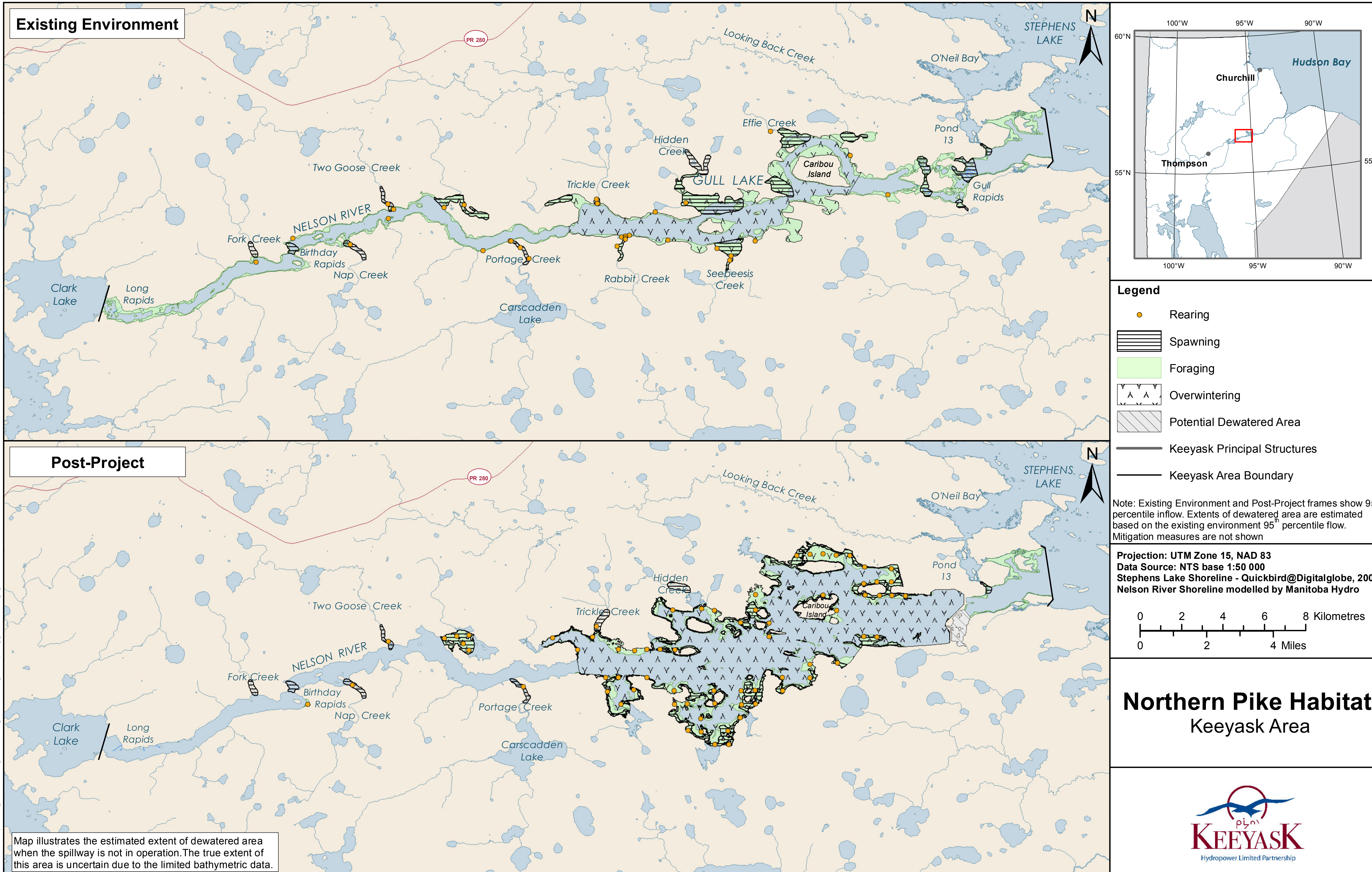
Projection: UTM Zone 15, NAD 83
Data Source: NTS base 1:50 000
Stephens Lake Shoreline - Quickbird@Digitalglobe, 2006
Nelson River Shoreline modelled by Manitoba Hydro

0 2 4 6 8 Kilometres
0 2 4 Miles

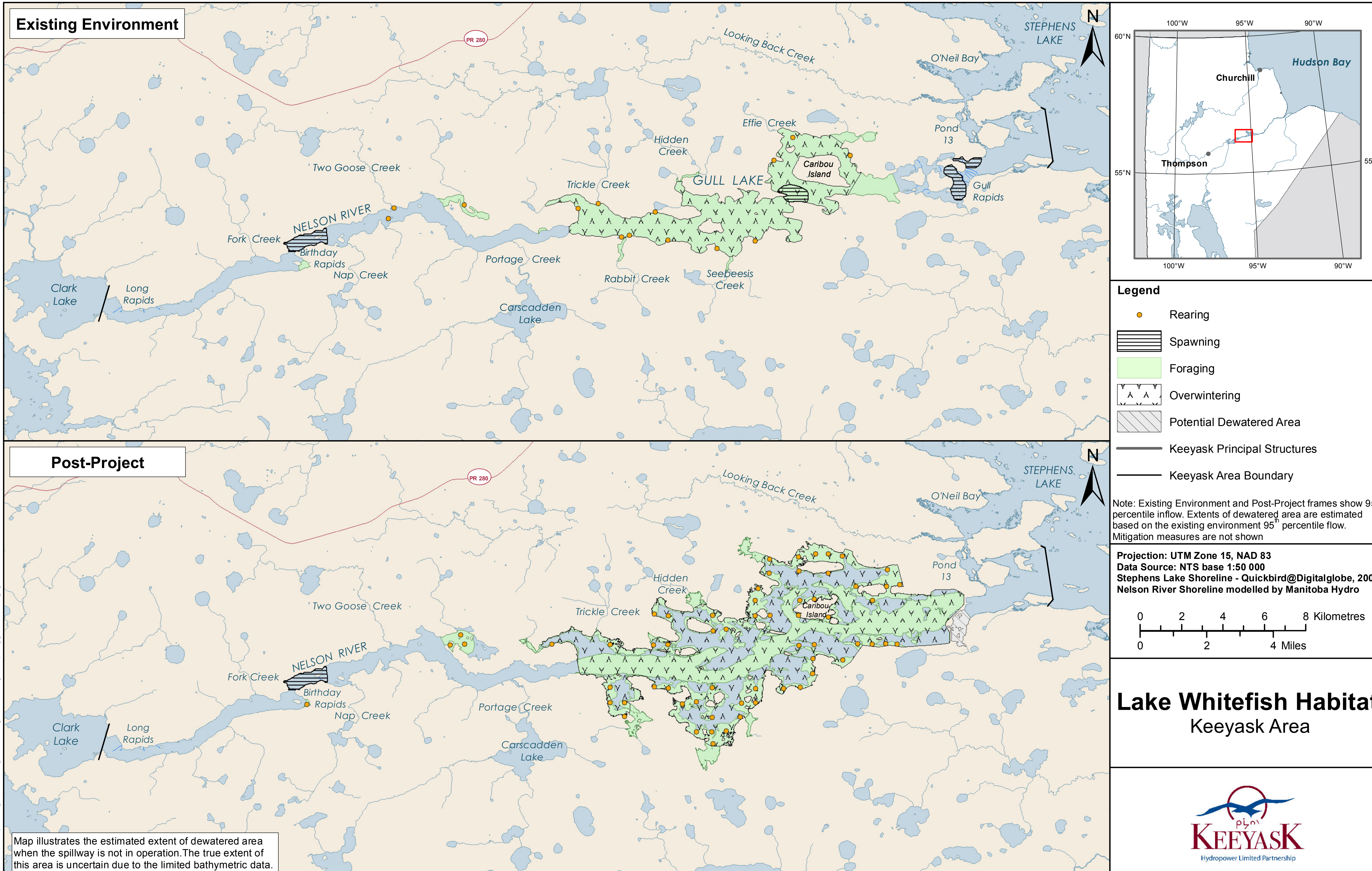
Walleye Habitat

Keeyask Area

KEEYASK
Hydropower Limited Partnership


Existing Environment
Post-Project
PR 280
Looking Back Creek
STEPHENS LAKE
O'Neil Bay
Effie Creek
Pond 13
Hidden Creek
Caribou Island
GULL LAKE
Gull Rapids
Trickle Creek
Two Goose Creek
NELSON RIVER
Fork Creek
Birthday Rapids
Nap Creek
Portage Creek
Rabbit Creek
Seebeesis Creek
Carscadden Lake
Clark Lake
Long Rapids
Hudson Bay
Churchill
Thompson
60°N
55°N
100°W
95°W
90°W
Legend
Rearing
Spawning
Foraging
Overwintering
Potential Dewatered Area
Keeyask Principal Structures
Keeyask Area Boundary
Note: Existing Environment and Post-Project frames show 95th percentile inflow. Extents of dewatered area are estimated based on the existing environment 95th percentile flow. Mitigation measures are not shown
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
0 2 4 6 8 Kilometres
0 2 4 Miles
Northern Pike Habitat
Keeyask Area
KEEYASK
Hydropower Limited Partnership
Map illustrates the estimated extent of dewatered area when the spillway is not in operation.The true extent of this area is uncertain due to the limited bathymetric data.

Map 5-24



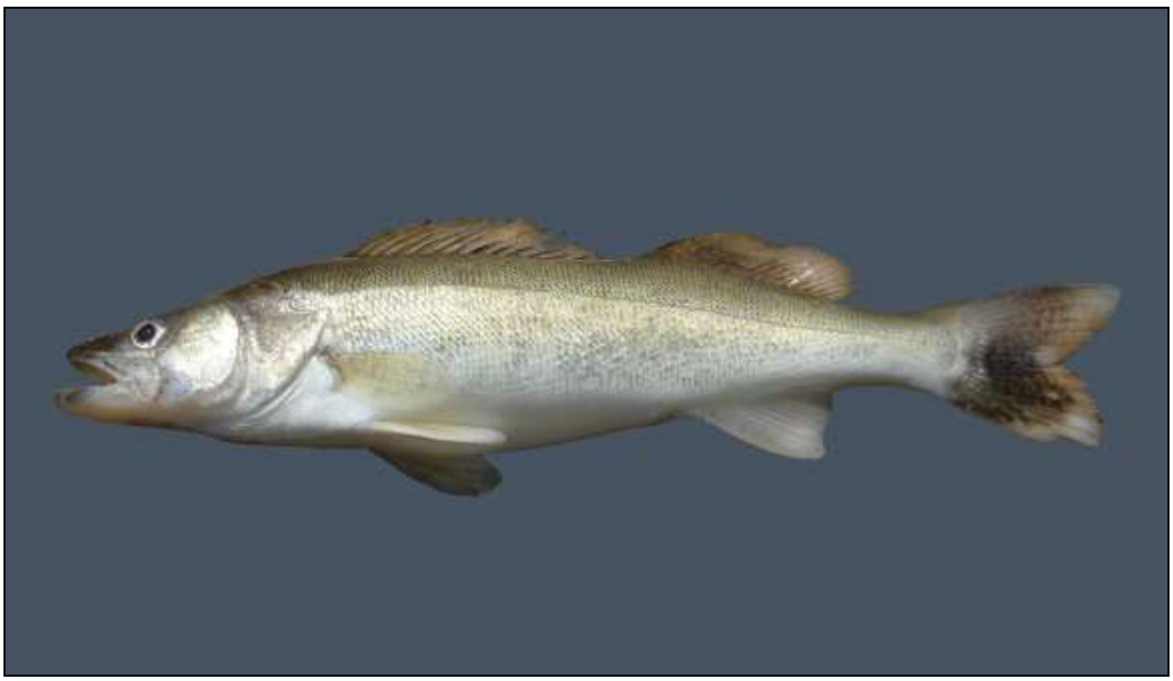
Existing Environment
Post-Project
PR 280
Looking Back Creek
STEPHENS LAKE
O'Neil Bay
Effie Creek
Pond 13
Hidden Creek
Caribou Island
GULL LAKE
Trickle Creek
Gull Rapids
Two Goose Creek
NELSON RIVER
Fork Creek
Birthday Rapids
Nap Creek
Portage Creek
Rabbit Creek
Seebeesis Creek
Clark Lake
Long Rapids
Carscadden Lake
N
100°W
95°W
90°W
60°N
55°N
Hudson Bay
Churchill
Thompson
Legend
Rearing
Spawning
Foraging
Overwintering
Potential Dewatered Area
Keeyask Principal Structures
Keeyask Area Boundary
Note: Existing Environment and Post-Project frames show 95th percentile inflow. Extents of dewatered area are estimated based on the existing environment 95th percentile flow. Mitigation measures are not shown
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
0 2 4 6 8 Kilometres
0 2 4 Miles
Map illustrates the estimated extent of dewatered area when the spillway is not in operation. The true extent of this area is uncertain due to the limited bathymetric data.
Lake Whitefish Habitat
Keeyask Area
KEEYASK
Hydropower Limited Partnership

APPENDICES

APPENDIX 5A
GENERAL ECOLOGY OF VEC FISH SPECIES

5A.1 WALLEYE

Walleye (Photo5A-1) spawn in the spring, generally close to ice break-up (water temperature 6 to 9°C), with lake populations spawning either in tributary streams or within the lake itself (Ford *et al*. 1995). Spawning typically occurs in streams or shallow inshore areas (water depth less than 2 metres [m]) over gravel, boulder, or rubble substrates where water flow is adequate for oxygenation and removal of waste products (*i.e.*, at the base of rapids, falls, or riffles in streams or wind-swept shorelines in lakes) (McPhail and Lindsey 1970; Scott and Crossman 1998). Less commonly, walleye have been observed spawning over organic substrate and dead vegetation in northern Manitoba (Manitoba Hydro and NCN 2003), and over dead vegetation in marshes in Wisconsin (Priegel 1970). Walleye may not spawn in some years when water temperature is not favourable (Scott and Crossman 1998). Male walleye generally become sexually mature at two to four years of age and at approximately 340 mm, and females at three to six years of age and at approximately 370 millimetres [mm] (Scott and Crossman 1998). Walleye may live to 20 years in northern waters (Scott and Crossman 1998).



Source: North/South Consultants Inc.

Photo 5A-1: Walleye / pickerel / okaow / *Sander vitreus*

It has been suggested that most female walleye release the majority of their eggs in just one night of spawning (Scott and Crossman 1998). The eggs are released, settling into gaps along the spawning substrate, and usually hatch within 12–18 days (Scott and Crossman 1998). Young walleye move into the upper levels of the open water approximately 10–15 days after hatching (Scott and Crossman 1998).

Walleye are tolerant of a wide range of environmental conditions, but generally prefer large, shallow, semi-turbid lakes. The species tends to prefer turbid slow moving water in lakes and rivers, often remaining near the bottom (Scott and Crossman 1998). They seek cover from sunlight under banks, sunken trees, rocky outcrops, weed beds, and by moving into deeper or more turbid waters during the day (Ryder 1977; Scott and Crossman 1998). As a result, walleye undergo diel changes in activity, moving into shallows at night to feed and retreating to cover during the day. During summer, walleye move into deeper water, possibly to avoid warming lake temperature, or in response to prey movements (Bodaly 1980; Ford *et al.* 1995; Scott and Crossman 1998). Summer movements generally do not exceed 8 km, but movements of 100 km or more have been observed (Magnin and Beaulieu 1968, cited in Scott and Crossman 1998). Young-of-the-year walleye exhibit strong schooling tendencies and may segregate themselves from juvenile and adult walleye by using different microhabitats to avoid cannibalism. Winter habitat preferences are similar to those in summer, with the exception of an avoidance of strong currents (Scott and Crossman 1998).

Walleye are opportunistic feeders. Young-of-the-year walleye feed predominantly on a variety of invertebrates and smaller fish species, including their conspecifics when other forage species are not readily available (Scott and Crossman 1998). As they mature, walleye become predominantly piscivorous, although they will still take advantage of various insect hatches and crayfish (Priegel 1963).

Walleye use sub-carangiform locomotion. A 200 mm long walleye switches from a sustained swimming speed (which can be maintained indefinitely) to a prolonged swimming speed (which can be maintained for a period of time up to 30 minutes) at a water velocity of approximately 0.5 metres per second [m/s] and moves from a prolonged swimming speed to a burst swimming speed (which can be maintained for a period of time up to 10 seconds) at a velocity of about 0.9 m/s (Katopodis 1993; Appendix 5E). A 500 mm long walleye makes the same changes at approximately 0.85 and 1.4 m/s. The pooled critical velocity (velocity at which fish moves from sustained to prolonged swimming) for 54 walleye of various sizes was found to be 0.56 m/s (Katopodis and Gervais 1991; Appendix 5E).

Walleye populations are vulnerable to overexploitation, as they are highly sought after in domestic, commercial, and recreational fisheries. Walleye are also sensitive to effects to spawning habitat, which is often limited to a few locations.

5A.2 NORTHERN PIKE

Northern pike (Photo 5A-2) begin to spawn shortly after ice break-up at water temperatures of 4 to 11°C. Spawning occurs during the day in shallow (less than 0.5 m deep) water over heavily vegetated floodplains of rivers, marshes, and bays of larger lakes (Diana *et al.* 1977; Casselman and Lewis 1996). In northern populations, the age of sexual maturity is reached at five years for males and six years for females, and at approximately 400 mm in length for both sexes (Scott and Crossman 1998).

Source: North/South Consultants Inc.

Photo 5A-2: Northern pike / jackfish / unchwapayo / *Esox lucius*

Northern pike eggs typically hatch within 12–14 days at typical spawning temperatures but can hatch in as little as 4–5 days at higher water temperatures (between 17.8 and 20°C) (Scott and Crossman 1998). Once hatched, young northern pike are inactive for 6–10 days and are often found attached during this period to vegetation by way of adhesive glands (Scott and Crossman 1998).

Northern pike inhabit vegetated areas of lakes and slow meandering rivers (McPhail and Lindsey 1970; Scott and Crossman 1998). Juvenile northern pike prefer habitats in quiet bays with adequate vegetation cover for both ambushing prey and seeking shelter from predators, such as larger northern pike (Chapman and Mackay 1990). Holland and Huston (1984) found that young northern pike were ten times more abundant in emergent vegetation and three times more abundant in submergent vegetation than in unvegetated areas. Adult northern pike prefer areas less than 5 m in depth for most of the year, moving into deeper water to overwinter (Diana *et al.* 1977; Inskip 1982; Scott and Crossman 1998). As an ambush predator, northern pike require cover (logs, weeds, stumps, boulders) to capture their prey (Inskip 1982), and are most commonly found in moderately vegetated areas along the interface between vegetation and open water (Inskip 1982; Randall *et al.* 1996; Casselman and Lewis 1996). Grimm (1989) suggested that waterbodies must contain more than 25% submerged macrophytes for a northern pike dominated fish community to exist.

Northern pike are opportunistic feeders and will feed on whatever is readily accessible, including aquatic invertebrates, fish, ducklings, mice, and other small mammals (Lawler 1965). After the yolk is absorbed, the diet of northern pike consists mainly of larger zooplankton and some immature aquatic insects (Scott and Crossman 1998). By the time YOY northern pike reach about 50 to 60 mm, fish comprise most of the diet, including their conspecifics (Scott and Crossman 1998; Hunt and Carbine 1951; Frost 1954).

Northern pike locomotion is generally considered somewhere between that of anguilliform and sub-carangiform swimming, and they display sustained and prolonged swimming speeds less than those of walleye (Katopodis and Gervais 1991). Critical velocity is 0.38 m/s for the species (Katopodis and Gervais 1991; Appendix 5E).

Given their preference for vegetated habitat, northern pike are particularly sensitive to any disturbance to aquatic macrophyte beds.

5A.3 LAKE WHITEFISH

Lake whitefish (Photo 5A-3) spawn during fall once water temperatures drop below 8°C (Scott and Crossman 1998). Spawning is known to occur in both lakes (Ford *et al*. 1995) and rivers (Scott and Crossman 1998). In lakes, lake whitefish generally spawn in water less than 5 m deep (Ford *et al*. 1995; Anras *et al*. 1999), with depths as shallow as 1.5 m having been documented (Weagle and Baxter 1974). In rivers, water depth for lake whitefish spawning may be as shallow as 1 m (Green and Derksen 1987). A wide variety of substrates are used for spawning, typically ranging from large boulders to gravel and sand (Lawrence and Davies 1978; Fudge and Bodaly 1984; Anras *et al*. 1999); the use of silt substrates with emergent vegetation has also been documented (Bryan and Kato 1975). Lake whitefish reach sexual maturity between ages six and seven, and at approximately 360 mm in length. Lake whitefish do not necessarily spawn every year (Scott and Crossman 1998).

Source: North/South Consultants Inc.

Photo 5A-3: Lake whitefish / whitefish / atikameg / *Coregonus clupeaformis*

Lake whitefish eggs incubate over winter, and hatch between March and May (Scott and Crossman 1998). After emerging from the substrate, larvae are planktonic for a period that may last several weeks. Initially located near spawning grounds, they soon become widely distributed by wind and currents. During their larval period, lake whitefish have little control over their direction of movement, although they are able to control their buoyancy, typically rising to the surface in the evening and descending again in the morning (Cucin and Faber 1985, cited in Richardson *et al.* 2001).

Post-larval juveniles remain in shallow water where they can use a variety of substrates, provided cover is available (Ford *et al.* 1995). Young-of-the-year lake whitefish generally move from shallow inshore water to deeper water by early summer (Scott and Crossman 1998). Adult lake whitefish typically occur in deep, cold-water lakes, where they are found at depths greater than 10 m over a wide variety of substrates. Lake whitefish are a demersal species, spending most of their time near bottom; however, they have been observed moving into shallow water habitats periodically, usually at night, to feed (Anras *et al.* 1999). Lake whitefish are a schooling species, with large schools often found in a very small area. While movements greater than 150 km have been observed, movements by the species are typically considerably shorter (Scott and Crossman 1998).

Lake whitefish are typically bottom feeders, but pelagic feeding and surface feeding have been observed (Scott and Crossman 1998). Benthic invertebrates are the preferred dietary item (primarily small clams and amphipods), but fish, zooplankton, and terrestrial invertebrates are also consumed. The diet of YOY lake whitefish consists mainly of zooplankton until they move to deeper water later in the open-water season, at which point they consume more benthic invertebrates and fish eggs (Scott and Crossman 1998; Becker 1983).

As a species that uses sub-carangiform locomotion, lake whitefish swimming speeds are very similar to those of walleye, with shifts from sustained to prolonged swimming and from prolonged to burst swimming at comparable velocities (described in Appendix 5E). Critical velocity for lake whitefish is 0.55 m/s (Katopodis and Gervais 1991; Appendix 5E).

Lake whitefish prefer cold water and, consequently, are sensitive to increases in water temperature at depth, as well as oxygen depletion. Spawning areas are particularly vulnerable, as eggs remain on the substrate for the entire winter where they are vulnerable to water level fluctuations (eggs may become exposed and frozen if water levels decline significantly between late fall and late winter), oxygen depletion, and sedimentation. Lake whitefish may also be affected by changes in the abundance of benthic invertebrates, which are their primary food source.

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APPENDIX 5B
FISH COMMUNITY AND MOVEMENTS METHODS

5B.1 FIELD DATA COLLECTION AND ANALYSIS

A summary of fish community and movement studies conducted between 1997 and 2006 is presented in Table 5B-1. The field program was grouped into eight primary components (although activities among the components often overlapped), as follows:

- Habitat-based community assessment;
- Spring spawning habitat;
- Fall spawning habitat;
- Overwintering habitat;
- Tributary use;
- Drifting biomass;
- Stream crossing assessment; and
- Fish movements.

5B.1.1 HABITAT-BASED FISH COMMUNITY ASSESSMENT

This study was conducted to provide a replicable, habitat-based description of the fish community of study area waterbodies. Habitat types fished are described fully in Section 3.0. In summary, fish habitat was classified based on water depth, water velocity, substrate compaction, substrate composition, and presence of aquatic macrophytes (Section 3.0). These habitat classifications were further grouped into biologically meaningful habitat types in order to describe rearing and foraging habitat in the study area (Table 5B-2). These general habitat classifications were also applied in the post-Project to the Keeyask reservoir (Table 5B-3). The gear types used as part of the habitat-based assessment included standard gang index gill nets, boat electrofishing, small mesh index gill nets, and seine nets. In all waterbodies, sites were chosen to sample available habitat types, with emphasis on the most common habitat types. If a site spanned a composite of habitat types, the overall designation for that site was the dominate habitat type.

Standard gang index gill nets, which are the standard sampling gear used by Manitoba Fisheries Branch, were used to inventory lentic fish communities (Assean Lake, Split Lake, Clark Lake, portions of the Nelson River between Clark and Gull lakes, Gull Lake, and Stephens Lake). Index gill nets were set in each waterbody over two or three summers between 1999 and 2004 (Photo 5B-1). These results were combined with the results of similar studies conducted in Split and Clark lakes in 1997 and 1998 (Fazakas and Lawrence 1998; Fazakas 1999), the York Landing arm of Split Lake in 1999 (Mota and MacDonell 2000), and in Stephens Lake in 1999 (Bretecher and MacDonell 2000). Index gangs consisted of six panels (22.9 × 1.8 m) with stretched mesh sizes ranging from 1.5" (38 mm) to 5.0" (127 mm).

Source: North/South Consultants Inc.

Photo 5B-1: Aquatic environmental studies crew checking a standard gang index gill net in the study area

During late summer in 2003 and 2004, the fish community in the Keeyask area was also sampled with boat-based electrofishing, particularly in areas with medium to high velocities that could not be fished effectively using gill nets. These surveys were conducted using a Smith-Root (Type VIA) electrofishing system powered by a 5,000 W portable generator and mounted to a 5.5 m long aluminum boat with a 175 horsepower inboard Sport Jet-Drive motor. The electrofishing unit was run between 707–884 V, 3–6 A, 60 pulses per second, and a pulse width of 3–6 milliseconds. Because of gear-specific difference in the relative abundance of fish species sampled by electrofishing compared to gill nets, the habitat-specific electrofishing data has not been included in the discussion of fish use of habitat in the Keeyask area.

Small mesh index gill nets were used to sample the forage fish community (forage fish included all fish species that remain small-bodied in adult stage, such as rainbow smelt) of the same waterbodies surveyed with standard gangs (Photo 5B-2). These gill nets consisted of three panels (10.0 × 1.8 m) with stretched mesh sizes ranging from 16 to 25 mm.

Seine nets were also used to sample forage fish during the summer in Gull Lake, in the Nelson River below Birthday Rapids, and in Gull Rapids in 2002 and 2003, and in Clark Lake in 2004 (Photo 5B-3). Seine nets consisted of a 15 m long by 1.5 m deep panel of 4 mm mesh.

Source: North/South Consultants Inc.

Photo 5B-2: Forage fish caught in a small mesh index gill net in the study area

Source: North/South Consultants Inc.

Photo 5B-3: Pulling a seine net to sample the fish community in the littoral zone

In addition to providing an assessment of fish species composition, relative abundance (%), and CPUE data, information on fish size, condition, and sex and state of maturity were also obtained from fish captured (Photo 5B-4). Catch-per-unit-effort was expressed in different units for each gear type: for standard gangs, number of fish captured in a 100 m net set for 24 hours (h); for small mesh gangs, number of fish captured in 30 m net set for 24 h; and for seine nets, number of fish captured in a 10 m haul. Dietary and age data were obtained from VEC fish species captured as part of the index gillnetting programs. Fish captured in standard gang index gill nets were examined for DELTs. Fish captured were classified as YOY based on the following length limits: 120 mm for walleye; 150 mm for northern pike; and 100 mm for lake whitefish.

Source: North/South Consultants Inc.

Photo 5B-4: Aquatic environmental studies team members processing fish captured as part of fish community studies

A specific survey was conducted in Stephens Lake to provide information to develop models to infer fish species distribution in the proposed Keeyask reservoir. Fish were sampled in Stephens Lake using two types of gill nets (small mesh index gill nets, as described above, and nets consisting of two panels [22.9 × 1.8 m] of 38 and 51 mm mesh). Both types of gill nets were set at sites representing specific habitats in both the main basin of the lake and in Ross Wright and O'Neil bays in the summer of 2005. Size and diet information were recorded for large-bodied species.

5B.1.2 SPRING SPAWNING HABITAT

This study was conducted to provide information on spawning locations for walleye, northern pike, and white sucker. A variety of gear types were employed from mid-May to early July from 2001 to 2006 throughout the study area to capture adults of the target species, including short duration (2–4 h) sets of tagging gill nets (51–127 mm mesh), boat electrofishing (Smith-Root Type VIA electrofishing system and 5.5 m aluminum boat), angling (barbless hooks and heavy test line), snaring (common snare wire attached to long pole), hoop nets (1.2 m diameter opening and 25 mm mesh; Photo 5B-5), and dip nets (0.6 m opening with fine mesh net). Fish captured were assessed for sexual maturity to help assess the location of spawning habitat.

Source: North/South Consultants Inc.

Photo 5B-5: Hoop net set in the study area

Larval drift traps (Burton and Flannagan 1976) were also employed during this time period to identify potential spawning habitat in tributaries (Photo 5B-6; small trap [15 × 15 cm opening with 500 micrometre (µm) collecting net]; Assean River, North Moswakot River, South Moswakot River, Portage Creek, Nap Creek, Fork Creek, Two Goose Creek, Gull Rapids Creek, Pond 13) and the mainstem (large trap [43 × 85 cm opening with 950 µm collecting net]; below First Rapids, Birthday Rapids, and Gull Rapids, and in Gull Lake). Kick nets (0.5 m diameter D-ring frame and 500 µm collecting net) were used to sample fish eggs in Gull Rapids Creek and Pond 13 during May 2005 and 2006.

Potential spawning sites were also assessed through tracking of radio-tagged and acoustic-tagged fish as described in the Fish Movements section below.

Source: North/South Consultants Inc.

Photo 5B-6: Setting a drift trap to capture drifting larval fish and eggs

5B.1.3 FALL SPAWNING HABITAT

This study was conducted to provide information on spawning locations for lake whitefish. Adult lake whitefish were captured throughout the study area from late September to mid-October from 2001–2004 using short duration (2–4 h) sets of tagging gill nets (51–127 mm mesh) and hoop nets (as described above). Any lake whitefish captured were assessed for sexual maturity to help assess the location of spawning habitat.

At the onset of the open water season (usually mid-May to early June, 2001–2006), sampling was conducted to capture larval lake whitefish as they emerged from the substrate. A modified neuston sampler (Mason and Philips 1986; Mota *et al.* 2000; 45 × 45 cm opening with 500 μm collecting net) was used from 2001–2004 in lentic habitats (Clark Lake, Stephens Lake, Gull Lake; Photo 5B-7), while drift traps (as described for the spring spawning study) were used to sample lotic habitats.

Potential spawning habitats were also assessed through tracking of radio- and acoustic-tagged lake whitefish as described in the Fish Movements section below.

Source: North/South Consultants Inc.

Photo 5B-7: Performing a neuston tow to capture drifting larval fish

5B.1.4 OVERWINTERING HABITAT

This study was conducted to provide information on potential overwintering habitat in areas where it was felt that the Project could potentially adversely affect some characteristic of overwintering habitat (*e.g.*, water velocity, dissolved oxygen). Fish implanted with radio-tags were tracked periodically during the winter months from 2001 to 2004 to identify overwintering habitat for VEC species as described in the Fish Movements section below.

5B.1.5 TRIBUTARY USE

This study was conducted to assess fish use of several study area tributaries. The fish communities of these tributaries, including streams and rivers flowing into Split Lake (Aiken, Mistuska, Ripple Rivers), Clark Lake (Assean, Hunting, and Crying Rivers), Gull Lake and the upstream section of the Nelson River (Portage, Two Goose, Nap, Fork, Sam Bay, Gull Rapids, and Pond 13 Creeks), and Stephens Lake (North and South Moswakot Rivers), were sampled during spring and fall as part of the spawning studies using a variety of gear types (*e.g.*, hoop nets, gill nets, and drift traps). In addition to the data collected during these programs, additional surveys were conducted in the Keeyask area.

Backpack electrofishing was used to assess the fish community in eight of the tributary creeks (Nap, Two Goose, Portage, Trickle, Rabbit, Ox Bay, Effie, and Gull Rapids Creeks) of the Nelson River between Birthday Rapids and Stephens Lake due to their small size (Photo 5B-8). Fish species composition and abundance was assessed within 50 to 100 m sections of each stream during the spring and/or fall of 2002 and 2003 using a backpack electrofisher. Catch-per-unit-effort was expressed as the number of fish caught per 100 seconds of fishing effort.

Source: North/South Consultants Inc.

Photo 5B-8: Aquatic environmental studies team member conducting a backpack electrofishing survey in the study area

The fish communities of two small headwater lakes in the Keeyask area, Carscadden Lake and Little Gull Lake, were assessed during August 2002 using seine nets (as described earlier) and index gill nets (standard gangs and small mesh, as described earlier).

Comparisons of CPUE among tributaries and lakes could not be made because of the variety of gear types used and associated differences in CPUE calculations. Instead, comparisons were made using the relative abundance of fish species in the catches.

5B.1.6 DRIFTING BIOMASS

Drift traps were set during the open water season to describe, both spatially and temporally, the abundance and distribution of fish biomass drifting in the study area, and to provide the basis for assessing potential changes in production from specific areas (*i.e.*, Birthday Rapids, Gull Rapids) associated with the Project. Large drift traps (as described earlier) were set once overnight at sites located above and below Birthday Rapids, above and below Gull Rapids, and below the Kettle GS at monthly intervals over the open water season (June-October) in 2003 and 2004. Drifting fish biomass in 2003 was expressed quantitatively as drift density (number of fish/cubic metre).

5B.1.7 ACCESS ROADS STREAM CROSSINGS ASSESSMENT

This study was conducted to assess fish use of streams crossed by the North and South Access Roads. Data on fish species composition and abundance during the open-water season were obtained from 20 to 100 m long sections of five stream crossings in fall 2004 and/or spring 2005 and from Gull Rapids Creek Lake during July 2005. Due to the small size of the streams, it was not possible to assess fish populations in winter with gill nets. A variety of gear types were used to sample fish including: electrofisher (boat or backpack unit, as described earlier); gill nets (standard gang index gill nets, as described earlier, and one panel [22.9 × 1.8 m] of 38 or 95 mm mesh); seines (as described earlier); hoop nets (large net as described earlier and smaller, 0.6 m diameter opening and 25 mm mesh); and kick nets (as described earlier).

To provide information on the potential of these waterbodies to overwinter fish, the three crossings that were accessible in March 2005 and the two north access road crossings in February 2009 were sampled for flowing water. In March 2005, DO was measured at the unnamed tributary of the South Moswakot River approximately 1 km upstream of the crossing location at the outlet of a small headwater pond due to poor access at the crossing location.

5B.1.9 FISH MOVEMENTS

This study was conducted to: a) gain a general understanding of VEC species' movements within the study area; b) assess whether fish move upstream and/or downstream through Long Rapids, Birthday Rapids, and Gull Rapids; and c) document concentrated movements of fish that can be used to identify important habitat, such as spawning locations. Information on fish movements was obtained from recaptures of large numbers of Floy®-tagged fish and through repeated tracking of a relatively small number of radio-tagged and acoustic-tagged fish.

Fish were marked with individually numbered plastic Floy® FD-94 T-bar anchor tags throughout the study area between 1999 and 2005 (Photo 5B-9). These tags were applied between the basal pterygiophores of the dorsal fin using a Dennison Mark II tagging gun. A total of 15,180 fish were tagged, including 5,472 walleye, 7,995 northern pike, and 1,713 lake whitefish. The majority of individuals (8,158 fish) were tagged in Reach 1 (the Split Lake Reach). Fish selected to receive tags were captured using a variety of gear types (*e.g.*, gill nets, hoop nets, electrofishing, angling, snaring) at numerous locations throughout the study area. The recapture of marked fish was recorded during all North/South Consultants fisheries programs conducted in the study area, including those focused on lake sturgeon (as described in Section 6.0), as well as any recaptured further downstream (*e.g.*, Conawapa GS Environmental Studies Program, Lower Nelson River Aquatic Studies). The return of Floy®-tags (or tag numbers), and the associated catch information (*i.e.*, where and when fish were captured), from local fishers was promoted using posters offering rewards in Split Lake, Gillam, and Thompson.

Source: North/South Consultants Inc.

Photo 5B-9: A walleye marked with a Floy®-tag as part of fish movement studies

Thirty walleye, 14 northern pike, and 10 lake whitefish captured in Gull Lake (44 fish) or Stephens Lake (10 fish) were tagged with radio-transmitters (model MCFT-3A, Lotek Engineering Inc., Newmarket, Ontario) in the spring or fall of 2001 (Photo 5B-10). Radio-tagged fish were relocated from the air periodically between June 2001 to February 2004 using a helicopter equipped with a Lotek model SRX-400 receiver and a single 'yagi' antenna. An additional 20 lake whitefish were implanted in 2001 with acoustic-transmitters (model V16-4H-01-SHK1-R256, Vemco Ltd., Shad Bay, NS) in Gull Lake (10 fish) or Stephens Lake (10 fish; Photo 5B-11). These fish were tracked from June to October of 2001–2004 using 10 Vemco VR1 and VR2 submersible stationary receivers (positioned near the upstream and downstream sides of both Birthday Rapids and Gull Rapids) and by manual tracking by boat using a Vemco VR-60 ultrasonic receiver.

Source: North/South Consultants Inc.

Photo 5B-10: Aquatic environmental studies team member surgically inserting a radio tag into a walleye (note gill irrigation removed temporarily while photo was taken)

Source: North/South Consultants Inc.

Photo 5B-11: Aquatic environmental studies team member surgically inserting an acoustic tag into a lake whitefish

5B.2 IMPACT ASSESSMENT ANALYSIS

A habitat evaluation model was developed to estimate potential fish use of habitats at various time steps after impoundment for comparison with habitat use in the existing Upstream Keeyask Area. The before-and-after comparison was based on the change in area and proportion of aquatic habitat types and associated CPUE of each of the VEC species and VEC fish communities. The main steps in model development and application, in sequence, were:

1. Estimate fish use of different habitat types in the existing environment;
2. Calculate the area of each habitat type in the Upstream Keeyask Area existing environment (Appendix 3D);
3. Estimate area of the habitat types in Year 30 post-Project (Appendix 3D);
4. Modify the Year Thirty habitat areas for intermediate time steps (Years 1, 5, and 15) (Appendix 3D);
5. Estimate useable habitat areas in the Intermittently Exposed Zone (Appendix 3D);
6. Modify fish use metrics at the intermediate time steps; and

7. Model potential fish use of habitats and change habitat value and area in the Upstream Keeyask Area at each time step.

1. Estimate Fish Use of Different Habitat Types in the Existing Environment

Study area locations sampled with gill nets during summer 1997 and 1998 (Fazakas and Lawrence 1998; Fazakas 1999), 2001–2003, and 2004 (Clark Lake only) were classified according to water depth and velocity, substrate compaction and composition, and the presence or absence of rooted aquatic vegetation.

Based on the study area catch records, a habitat-specific CPUE was calculated for each VEC fish species as well as for the large-bodied and forage fish species assemblages by averaging the site-specific values of standard gang and small mesh index gill nets (Table 5B-4). Assean Lake catch data were not included in the calculation of habitat-specific CPUEs as this lake was found to have a substantially different fish community composition than other study area waterbodies.

Of the 21 habitat types present in the Upstream Keeyask Area existing environment or predicted to be present in the post-impoundment environment, nine had not been sampled during the study area sampling conducted between 1997 and 2004 due to their absence or scarcity in the study area waterbodies. In these cases, a CPUE value was estimated using surrogate values from similar habitat types that were sampled and professional judgment. For example, CPUE values for habitats with organic substrates, which were not sampled previously in the study area, were generated by discounting the corresponding soft mineral substrate habitat CPUE by 50% based on low CPUE values observed in water bodies characterized by an abundance of organic matter, such as Notigi Lake (Table 5-2).

No high velocity habitats (velocity more than 1.5 metres per second) were sampled in study area sampling between 1997 and 2004 owing to methodological challenges and safety concerns. Consequently, the CPUE values for the corresponding medium velocity habitat types were used as surrogates for the two high velocity habitats. However, the medium velocity CPUE values were discounted by 75% based on an assumption that fish use of high velocity habitats would be that much lower.

2. Calculate the Area of Each Habitat Type in the Existing Environment

The areas of habitat types present in the existing environment were calculated using geographic information system analysis and are shown in Appendix 3D.

3. Estimate Area of the Habitat Types in Year 30 post-Project

Estimates of specific habitat areas were based on a habitat model described in Section 3. Areas of each of the Year 30 post-Project habitat types are provided in Appendix 3D.

4. Modify the Year 30 Habitat Areas for Intermediate Time Steps (Years 1, 5, and 15)

Change to aquatic habitats in the existing environment and the evolution and expansion of habitats in the reservoir that are predicted to occur due to shoreline erosion, peat disintegration and sediment transport processes along with the loss and subsequent development over time of aquatic plant beds, were described for Year 1, 5, 15, and 30 time steps and tabulated (Appendix 3D). These area estimates were used to provide a comparison between habitat conditions in the existing Upstream Keeyask Area environment with habitat changes in the reservoir over time.

5. Estimate Useable Habitat Areas in the Intermittently Exposed Zone

Depending on the mode of operation, (peaking mode or base loaded), shallow water habitats at each Year 1, 5, 15, and 30 time step (Table 3D-1) may be more or less exposed to air on a frequent or infrequent basis. Intermittent exposure to air would have the effect of reducing the area of shore zone habitats that would be useable by fish and also would affect the biological productivity in those exposed areas. Estimates and assumptions regarding the effect of mode of operation on useable shallow water habitat areas are described in Appendix 3D.

6. Modify Fish Use Metrics at Intermediate Time Steps

It is anticipated that fish use of aquatic habitats in the downstream portion of the Keeyask reservoir (Reaches 5–9A in Map 3-26) would be affected by predicted changes in the dissolved oxygen (DO) and TSS concentrations in the early years post-impoundment. No similar effects are expected in the upstream reaches 2A-4 (Map 3-26). Analysis and discussion of DO and TSS predictions post-impoundment is presented in Water and Sediment Quality (Section 2).

Predicted changes to DO and TSS have potential negative consequences on fish use of habitats and habitat productivity. Consequently, modifications to the fish use metric (CPUE) to account for potential negative effects were undertaken. The CPUE modifications were confined to those portions of each habitat type that would be in the lower reaches (5–9A) of the reservoir.

Dissolved Oxygen

The DO regime was modelled as critical week bottom summer values in Year 1 and Year 5 (described in Section 2). Based on modelling results, some aquatic habitats, primarily those located in newly flooded terrestrial areas, would, under conditions specified in the model, be of reduced foraging value to fish because of near bottom hypoxic conditions created by the increased oxygen demand associated with disintegrating peat and organic substrates. Areas predicted to be more severely affected by reduced dissolved oxygen concentrations (bottom DO less than 2 mg/L) were associated with off-current habitats characterized by standing water with soft organic substrates. The total area of habitats with DO less than 2 mg/L was proportionally allocated to those habitat types. Areas predicted to be less severely affected by reduced dissolved oxygen concentrations (bottom DO greater than or equal to 2 mg/L but less than or equal to 6.5 mg/L) also included shallow water low velocity habitats as well as areas of deep, standing water habitat.

Habitat-specific fish use metrics (CPUE) used in Step 7 to follow, were modified to account for DO effects on fish behaviour (*i.e.*, avoidance of low DO areas), mortality (of eggs), and growth:

- Where DO was greater than or equal to 2 mg/L at the bottom, habitat was considered not useable by fish and the habitat-specific CPUE was set to zero for the DO affected portion of the habitat ;
- Where DO was greater than or equal to 2 mg/L but less than or equal to 6.5 mg/L at the bottom, habitat was considered less suitable and the habitat-specific CPUE was reduced by 50% for the DO stressed portion of the habitat; and

- Where DO was more than 6.5 mg/L at the bottom, it was assumed that there would be no DO related negative effects on fish use of habitats.

Total Suspended Solids

Total suspended solids are predicted to increase in the first year following impoundment of the Keeyask reservoir (Section 2). The majority of the increase in TSS is predicted to come from peat disintegration processes and thus result in a large organic component of the TSS. Depending on location, average increase in TSS is expected to range from:

- Less than 5 mg/L in mainstem lotic Zones 1, 2, and 3 (Map 2-22);
- 8–22 mg/L in lentic habitats found in Zones 4, 5, 10, 12, and 13;
- 40–86 mg/L in lentic habitats found in Zones 7, 8, 9, and 11.

Elevated organic TSS levels are predicted to persist for only a few hours at certain locations (*e.g.*, Zone 5) but would extend for days to weeks or months in other locations. TSS increases are also likely to exceed the predicted average increases on occasion because of re-suspension of bottom organic material and site-specific increase in shoreline erosion due to wind/wave events. On other occasions, TSS concentrations are likely to be below the predicted range of average concentrations. By the end of the first year after impoundment, TSS increase is expected to drop sharply as the source of particulates diminishes (Section 2).

Increases in TSS of the aforementioned magnitude and duration are expected to have a short-term effect on the fish community as follows:

- By preventing or reducing the successful development of eggs and larvae of certain fish species (*e.g.*, northern pike) that might spawn in shallow lentic environments;
- By altering fish use of habitats and their movements within the reservoir; and
- By reducing the availability and catchability of food.

EIFAC (1964) guidelines for the protection of inland fisheries suggest that waters with chronic TSS concentrations in the 25–80 parts per million (mg/L) range should support good to moderate fisheries with yields “somewhat diminished” relative to waters with less than 25 parts per million TSS.

DFO (in Government of Canada 1993) indicates that sediment increases resulting from placer mining operations in the 25–100 mg/L range would pose a “Low Risk” to fish and their habitat.

In New Zealand, Hayes *et al.* (1992) concluded that TSS concentrations in the range of 20–40 mg/L had little effect on the fish community of a shallow water lake when compared to a similar lake with TSS levels of 5 mg/L. Numerous indices (CPUE, condition, size) were higher in the turbid lake and also were higher in the turbid portions of the clear lake.

Considering the range of concentrations predicted to occur over an approximate one year period in the Keeyask reservoir, and the guidance provided by the EIFAC and DFO that relate to the risks to fish and fish habitat, it is suggested that TSS effects in the Upstream Keeyask Area could result in a 10%

reduction in fish habitat productivity that would persist for one year. It is suggested that this reduction be applied across all shallow, low velocity and standing water habitat types plus all deep, standing water habitat types in the lower reaches (5–9A) of the reservoir. The short-term (one year) reduction in habitat use/productivity related to increases in TSS concentration is in addition to the predicted decreases in habitat production/use by fish as a result of depressed DO that would accompany shoreline erosion and peat disintegration processes, including organic and mineral sedimentation, peat resurfacing and the formation of peat islands.

In summary, predicted increases in TSS in the first year of impoundment are expected to affect fish and fish use of habitats in the newly impounded reservoir. It was assumed that the forage value and fish use of all Year 1 Shallow-Standing water and Low Velocity habitats, plus all Deep-Standing water habitats would be reduced by 10% as a result of increased TSS levels.

The fish use metric (CPUE) of habitats used in Step 7 (to follow) was decreased by 10% at all Shallow-Standing water and Low velocity habitats, plus all Deep-Standing water habitats. TSS effects are not predicted beyond Year 1 (Section 2).

7. Model Change in Fish Use of Habitats and Habitat Value and Area in the Upstream Keeyask Area at Each Time Step

Two approaches, both based on an assumption that CPUE data reflect fish use of habitats in which they were caught, were used to evaluate the potential effects of reservoir creation and operation on the Upstream Keeyask Area fish community. The first approach predicts change to fish density (CPUE) associated with predicted habitat changes resulting from flooding and ongoing operation of the generating station. The second approach evaluates changes in area and suitability of habitats available to and used by VEC species. Both approaches use CPUE data described in Step 1.

Change in Fish Use of Habitats

Using CPUE data for each habitat type (Table 5B-4 from Step 1), a weighted mean CPUE ($CPUE_w$) was calculated for each VEC at each time step for each mode of operation (*i.e.*., 158 m above sea level [ASL] base loaded, 159 m ASL base loaded, and weekly cycling [peaking] between at 158 m and 159 m ASL).

$$CPUE_w = (\Sigma\ [Area_{hab} \times CPUE_{hab}]) \div (\Sigma\ Area_{hab})$$

where: $CPUE_w$ = weighted mean CPUE for Upstream Keeyask Area;

$Area_{hab}$ = useable area (ha) of each habitat type (as per Step 5); and

$CPUE_{hab}$ = mean CPUE for each habitat type (modified as required per Step 6).

The calculated $CPUE_w$ values for each Year 1, 5, 15, and 30 time steps are presented in Table 5B-5.

Change in Habitat Value and Area

A habitat ranking procedure, described in the following paragraphs, was used to predict potential changes in fish use of (value) and quantity of (area) fish habitat in the Upstream Keeyask Area as a result of creation and operation of the Project. The ranking of habitat value involved the calculation of a Relative Abundance Index (RAI) for each habitat type using fish CPUE data from habitat-based summer gillnetting at waterbodies in the study area. The validity of the model is based on an assumption that fish density associated with a habitat type would increase with increasing habitat suitability. CPUE data have been used elsewhere to model habitat suitability (Gallaway *et al.* 1999; Morris and Ball 2006) or to validate habitat evaluations that have employed Habitat Suitability Indices (HSI), assuming one should expect a close correspondence between CPUE data and HSI values (Brown *et al.* 2000).

The CPUE-based approach involved assigning each habitat type (T) in the pre- and post-Project environments (Section 3) an RAI_T value. Then, by multiplying the area of the habitat (H_T) by its RAI_T, a Weighted Suitable Habitat Area for each habitat type ($WSHA_T$) for each VEC.

For each VEC, the RAI_T was calculated by dividing the CPUE associated with a specific habitat type ($CPUE_T$) by the maximum habitat-specific CPUE ($CPUE_{MAX}$) observed in study area waterbodies for that VEC.

1. $RAI_T = CPUE_T/CPUE_{MAX}$

The ratio of $CPUE_T$ to $CPUE_{MAX}$ provides a value between 0 and 1 that was then used to calculate the Weighted Suitable Habitat Area ($WSHA_T$) of a habitat type (H_T) by multiplying its area by its RAI_T.

2. $WSHA_T = H_T \text{ (ha)} \times RAI_T$

The individual $WSHA_T$ of all habitat types in the existing Upstream Keeyask Area were then summed to provide a total WSHA value for each VEC.

3. Total existing environment WSHA = Σ all existing environment $WSHA_T$

The same procedure was followed for each habitat type predicted to be present in the Year 1, 5, 15, and 30 post-Project environments. The ratio of predicted (post-Project) WSHA to existing (pre-Project) WSHA was calculated for each VEC at each post-Project time step to estimate Project effects on the potential fish use of combined fish habitats in the Upstream Keeyask Area.

4. Post-Project WSHA/Existing WSHA = gain/loss in potential fish use of habitats (*i.e.*, productive capacity).

Results of the predicted changes in habitat value and area are presented in Table 5B-6.

Detailed Steps

Detailed steps that were taken to calculate a Weighted Suitable Habitat Area (WSHA) for each VEC (walleye, northern pike, lake whitefish, white sucker, rainbow smelt, large-bodied fish combined, and forage fish combined) follow.

Upstream Keeyask Area Existing Environment

1. Calculated the areas (ha) of each habitat type: H_1, H_2, H_3, ….. H_{20}) in the Upstream Keeyask Area existing environment (Appendix 3D).
2. Derived the CPUE statistic of the VEC for each habitat type in the pre-Project Upstream Keeyask Area (compiled from summer gillnetting data from study area waterbodies).
3. Calculated the VEC-specific Relative Abundance Index (RAI) of each of the habitat types in the existing environment. This involved:
    a. Using the CPUE for each habitat type, calculating a VEC-specific RAI for each habitat (H) by dividing the CPUE for a specific habitat type by the maximum CPUE observed or estimated in that habitat. Thus, $RAI_{H1} = CPUE_{H1}/CPUE_{MAX}$.
    b. Repeating this calculation for each habitat type to obtain RAI_{H1}, RAI_{H2}, RAI_{H3}, …. RAI_{H20}).
4. Calculated the VEC-specific Weighted Suitable Habitat Area (WSHA) for each habitat type by multiplying each habitat area (H) by its RAI value:

    $WSHA_1 = H_1 \text{ (ha)} \times RAI_{H1}$

    $WSHA_2 = H_2 \text{ (ha)} \times RAI_{H2}$

    ….

    ….

    $WSHA_{20} = H_{20} \text{ (ha)} \times RAI_{H20}$.
5. Calculated the VEC-specific Weighted Suitable Habitat Area in the Upstream Keeyask Area by summing habitat-specific WSHAs for all habitat types in the existing environment (*i.e.*, Total WSHA = $WSHA_1 + WSHA_2 + WSHA_3 + \ldots WSHA_{20}$.
6. Steps 1 through 5 were repeated for each VEC.

Upstream Keeyask Area Post-Project Environment

The same procedure was applied to each VEC species for each proposed operating scenario in the post-Project environment for each of the Year 1, 5, 15, and 30 time steps:

- Peaking between 158 and 159 m ASL;
- Base loaded at 158 m ASL; and
- Base loaded at 159 m ASL.

When calculating the RAI (Step 3 above) in the post-Project environment, the CPUE associated with certain habitats were modified prior to performing the calculation:

- To account for depressed DO conditions in Years 1 and 5, portions of certain habitats in the reservoir were assigned a CPUE of 0, were discounted 50%, or were not modified (described in Step 6 – Modification of Fish Use Metrics for Intermediate Time Steps).
- To account for elevated TSS condition in Year 1, the CPUE of certain habitats in the reservoir was reduced by 10% (described in Step 6 – Modification of Fish Use Metrics for Intermediate Time Steps).

The proportional change in the Weighted Suitable Habitat Area for each VEC species was determined by dividing the post-Project WSHA by the WSHA in the existing environment of the Upstream Keeyask Area.

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Table 5B-1: Summary of approach and methods used for fish community and movement studies in the Keeyask area, 1997–2008[1]

Study	Objective	Method	Equipment	Location[2]	Time of Sampling	Number of Sites[3]
Habitat-based fish community assessment	To provide replicable habitat-based description of the fish community of study area water bodies.	a) standard gang index gill nets	6 panels (22.9 × 1.8 m) of 38, 51, 76, 95, 108, and 127 mm stretched twisted nylon/monofilament mesh	SPL	Aug 1997-98, 2001-02, 2004	106
				NR	Oct 1999; Aug 2001-02	32
				GR	Aug 2002-03	9
				STL	Aug 1999, 2002-03	85
		b) small mesh index gill nets	3 panels (10 × 1.8 m) of 16, 20, and 25 mm stretched twisted nylon mesh	SPL	Aug 2001-02, 2004	52
				NR	Aug 2001-02	48
				GR	Aug 2002-03	8
				STL	Aug 2002-03	39
		c) boat electrofishing	5.5 m aluminum boat with inboard motor and Smith-Root Type VIA electrofishing system	NR	Aug-Sep 2003-04	93
		d) seine nets	1 panel (15 × 1.5 m) of 4 mm mesh	SPL	Aug 2004	7
				NR	Sep 2001; Aug 2002-03	52
				GR	Aug 2003	2
		e) aquatic habitat modelling	i) small mesh index gill nets as described above; and ii) 2 panels (22.9 × 1.8 m) of 38 and 51 mm stretched twisted nylon mesh	STL	Jul-Aug 2005	92
Spring spawning habitat	To identify habitat used for spawning by northern pike, walleye, and white sucker.	a) drift traps	i) 43 × 85 cm opening with 950 µm Nitex collecting net (large);or ii) 15 × 15 cm opening with 500 µm Nitex collecting net (small)	SPL	May-Jul 2001-02	i) 6 ii) 2
				NR	May-Jul 2001-04	i) 39 ii) 10
				GR	Jun-Jul 2001-04; May 2006	i) 3 ii) 4
				STL	May-Jun 2003	i) 0 ii) 7
		b) gill nets	i) 1-4 panels (22.9 × 1.8 m) of 51, 76, 95, 108, 127 and/or 140 mm stretched twisted nylon mesh; or ii) 1 panel (10 × 1.8 m) of 25 mm stretched twisted nylon mesh	SPL	May-Jun 2002-04	i) 101 ii) 0
				NR	May-Jun 2001-04	i) 118 ii) 0
				GR	May-Jul 2001-04; May 2005-06	i) 43 ii) 0
				STL	May-Jul 2001; Jun 2003-04	i) 33 ii) 2
		c) hoop nets	1.2 m diameter opening and 25 mm mesh	SPL	May-Jul 2001-04	12
				NR	May-Ju1 2001-02	4
				GR	May 2006	1
				STL	May-Jun 2003	4
		d) kick nets	0.5 m diameter D-ring frame and 500 µm Nitex collecting net	GR	May 2005-06	9
		e) dip nets	0.6 m opening and fine mesh net	STL	May 2006	6
		f) boat electrofishing	as described above	NR	May 2001; Jun 2002	29
		g) snaring	single loop of pliable brass wire attached to a long pole	SPL	Jun 2002; May 2003	5
		h) angling	barbless hook and heavy test line	SPL	May-Jun 2002-03	16
				NR	May-Jun 2001	6
				GR	Jun 2003	1
		i) radio telemetry	individually coded Lotek radio transmitters (model MCFT-3A) and helicopter tracking with SRX-400 receiver	NR, GR, STL	May-Jun 2002-03	44

Table 5B-1: Summary of approach and methods used for fish community and movement studies in the Keeyask area, 1997–2008[1]

Study	Objective	Method	Equipment	Location[2]	Time of Sampling	Number of Sites[3]
Fall spawning habitat	To identify habitat used for spawning by lake whitefish.	a) neuston sampler	45 × 45 cm opening with 500 µm Nitex collecting net	SPL	Jun 2004	6
				NR	May/Jun 2001-04	54
				STL	Jun 2001-04	62
		b) drift traps	i) 43 × 85 cm opening with 950 µm Nitex collecting net (large); or ii) 15 × 15 cm opening with 500 µm Nitex collecting net (small)	SPL	May-Jul 2001-02	i) 6 ii) 2
				NR	May-Jul 2001-04	i) 39 ii) 10
				GR	Jun-Jul 2001-04; May 2006	i) 33 ii) 4
				STL	May-Jun 2003	i) 0 ii) 7
		c) gill nets	2-4 (22.9 × 1.8 m) panels of 76, 95, 108, and/or 127 mm stretched twisted nylon mesh	SPL	Sep-Oct 2002, 2004	74
				NR	Sep-Oct 2001-04	258
				GR	Sep-Oct 2001-03	31
				STL	Sep-Oct 2002-03	129
		d) hoop nets	as described above	SPL	Sep-Oct 2001-02, 2004	7
				STL	Sep-Oct 2002-03	6
		e) radio telemetry	as described above	NR, GR, STL	Sep-Oct 2001-02	10
		f) acoustic telemetry	as described above	NR, GR, STL	Sep-Oct 2001-03	20
Overwintering habitat	To identify habitat used for overwintering by northern pike, walleye, and lake whitefish.	a) radio telemetry	as described above	NR, GR, STL	Jan-Mar 2002; Nov-Apr 2002-03	54
Tributary use	To assess the fish community of tributary water bodies (rivers, streams, lakes).	a) drift traps	15 × 15 cm opening with 500 µm Nitex collecting net (small)	SPL	May-Jun 2001-02	2
				NR	May-Jul 2001-03	10
				GR	May 2006	4
				STL	May-Jun 2003	7
		b) gill nets	1-4 panels (22.9 × 1.8 m) of 51, 76, 95, 108, and/or 127 mm stretched twisted nylon mesh	SPL	May, Sep-Oct 2002; May-Jun 2003; Jun, Sep-Oct 2004	66
				GR	Jun 2004; May 2005-06; Aug-Sep 2006	9
				STL	Sep-Oct 2002-03; May-Jun 2003; Jun 2004	116
		c) hoop nets	as described above	SPL	May-Jul 2001-04; Sep-Oct 2001-02, 2004	25
				NR	May-Ju1 2001-02	4
				GR	May 2006	1
				STL	Sep-Oct 2002-03; May-Jun 2003; Jun 2004	11
		d) backpack electrofisher	Smith Root backpack unit	NR	Jun-Jul 2002-03; Sep 2002-03	28
				GR	Sep 2003	3
		e) index gill nets (small mesh and standard gang)	as described above	NR	Aug 2002	2
		f) seine nets	as described above	NR	Aug 2002	2
Drifting biomass	To describe the abundance and distribution of drifting fish in specific areas during the open-water season.	a) drift traps	43 × 85 cm opening with 950 µm Nitex collecting net (large)	NR	Jul-Sep 2003, Jul-Sep 2004	6
				GR	Jun-Oct 2003, Jul-Oct 2004	4
				STL	Jul-Sep 2003, Jun-Sep 2004	2
Stream crossing assessment	To assess fish use of streams crossed by the Keeyask Access Road.	a) backpack/boat electrofisher	as described above	SC	Oct 2004; May 2005	8
		b) kick nets	as described above	SC	Oct 2004; May 2005	8
		c) hoop nets	i) as described above; or ii) 0.6 m diameter opening and 25 mm mesh	SC	May 2005	i) 1 ii) 2
		d) gill nets	1 panel (22.9 × 1.8 m) of 38 or 95 mm stretched twisted nylon mesh	SC	Oct 2004	1
		e) seine nets	as described above	SC	Jul 2005	1
		f) standard gang index gill net	as described above	SC	Jul 2005	1

Table 5B-1: Summary of approach and methods used for fish community and movement studies in the Keeyask area, 1997–2008[1]

Study	Objective	Method	Equipment	Location[2]	Time of Sampling	Number of Sites[3]
Fish movement	To assess general movement patterns of northern pike, walleye, and lake whitefish.	a) radio telemetry	as described above	NR, GR, STL	Jun 2001-Feb 2004	54
		b) acoustic telemetry	as described above	NR, GR, STL	Jun-Oct 2001-03	20
		c) mark and recapture	individually numbered Floy®-tag attached between fin membranes of dorsal fin	SPL	2001-04	8158
				NR	1999, 2001-04	2732
				GR	2001-05	2437
				STL	2001-05	1853

1. In addition to the programs described in this table, Floy®-tagged northern pike, walleye, and lake whitefish were captured incidentally in gill nets set to specifically target lake sturgeon from 2001–2008; the methods for these programs is described in Section 6.
2. SPL = Split Lake area; NR = Keeyask area: Nelson River between Clark Lake and Gull Rapids; GR = Keeyask area: Gull Rapids and downstream, riverine portion of Stephens Lake; STL = Stephens Lake area; SC = Keeyask access road stream crossings.
3. For radio/acoustic telemetry and mark/recapture methods, the number represents the number of fish marked rather than the number of sites sampled.

Table 5B-2: Description of general habitat types used to describe foraging and rearing habitat used by fish in the Keeyask area in the existing environment

Waterbody	General Habitat Type	Description[2]
Assean Lake	East basin	• Smaller basin (1,123 ha) with a mix of shallow and deep water with primarily low velocity, soft mineral-based substrates (fine silt, clay), and macrophyte beds abundant in shallow marshy bays and shore.
	West basin	• Larger basin (6,310 ha) with a mix of shallow and deep water with primarily low velocity, soft mineral-based substrates (fine silt, clay), and macrophyte beds abundant in shallow marshy bays.
	Channel	• Narrow channel with a mix of shallow and deep water with low velocity, soft mineral-based substrates, and a scarcity of macrophyte beds.
Split/Clark Lakes	Nearshore lacustrine	• Primarily shallow water with standing to low velocity, a combination of soft and hard mineral-based substrates (primarily fine silt, clay), and macrophyte beds abundant in some areas.
	Offshore lacustrine	• Primarily deep water with low velocity, a combination of soft and hard mineral-based substrates (primarily fine silt, clay), and a scarcity of macrophyte beds.
Nelson River[1]	Nearshore lacustrine	• Areas of Gull Lake with primarily shallow water with low velocity, a combination of soft (silt, clay) and hard (gravel, cobble, boulder) mineral-based substrates, and few macrophyte beds.
	Offshore lacustrine	• Areas of Gull Lake with primarily deep water with low velocity, hard (gravel, cobble, boulder) mineral-based substrates, and a scarcity of macrophyte beds.
	Riverine	• Areas of the Nelson River with a combination of shallow and deep water, primarily with low to medium[3] velocity, hard (cobble, boulder) mineral-based substrates, and a scarcity of macrophyte beds.
	Backbay	• Primarily shallow water with standing to low velocity, soft (silt, clay) mineral-based substrates, and abundant macrophyte beds.
Stephens Lake North	Nearshore lacustrine	• Areas of the north arm of the lake with primarily shallow water with low velocity, a combination of soft and hard mineral-based substrates, and macrophyte beds.
	Offshore lacustrine	• Areas of the north arm of the lake with primarily deep water with low velocity, a combination of soft and hard mineral-based substrates, and a scarcity of macrophyte beds.

Table 5B-2: Description of general habitat types used to describe foraging and rearing habitat used by fish in the Keeyask area in the existing environment

Waterbody	General Habitat Type	Description[2]
Stephens Lake South	Nearshore lacustrine	• Areas of the old Nelson River channel with primarily shallow water, with low to medium velocity, a combination of soft and hard mineral-based substrates, and macrophyte beds.
	Offshore lacustrine	• Areas of the old Nelson River channel with primarily deep water with low to medium velocity, a combination of soft and hard mineral-based substrates, and a scarcity of macrophyte beds.

1. Nelson River between Clark Lake and Gull Rapids, including Gull Lake.
2. Based on habitat classification system described in Section 3.0.
3. Areas with high water velocity (more than 1.5 m/s) were excluded as suitable foraging/rearing habitat because at water velocities more than 1.5 m/s fish of all lengths would employ burst swimming and endurance would be limited to 10 seconds or less.

Table 5B-3: Description of general habitat types used to describe foraging and rearing habitat used by fish in the Keeyask reservoir post-Project

Waterbody	General Habitat Type	Description[1]
Keeyask reservoir	Backbay reservoir	• Locations off of upper reservoir with shallow, standing water, a combination of soft (silt, clay) mineral-based substrates and organic deposition, and an abundance of macrophyte beds.
	Riverine reservoir	• Areas of the upper reservoir with a combination of shallow and deep water, primarily with low to medium[2] velocity, hard (cobble, boulder) mineral-based substrates, and a scarcity of macrophyte beds.
	Nearshore lentic reservoir	• Areas of the reservoir with shallow, standing water, a combination of soft (silt, clay) mineral-based substrates and organic deposition/peat, and an abundance of macrophyte beds.
	Offshore lentic reservoir	• Areas of the reservoir with deep, standing water, primarily soft (silt) mineral-based substrates, and a scarcity of macrophyte beds.
	Nearshore lotic reservoir	• Areas of the reservoir with shallow, low velocity water, soft (silt, clay) mineral-based substrates, and few macrophyte beds.
	Offshore lotic reservoir	• Areas of the reservoir with deep, low velocity water, a combination of soft (silt) and hard (cobble, boulder) mineral-based substrates, and a scarcity of macrophyte beds.

1. Based on habitat classification system described in Section 3.0.
2. Areas with high water velocity (more than 1.5 m/s) were excluded as suitable foraging/rearing habitat because at water velocities more than 1.5 m/s fish of all lengths would employ burst swimming and endurance would be limited to 10 seconds or less.

Table 5B-4: Mean habitat-specific catch-per-unit-effort (CPUE[1]) in the existing environment during summer

Habitat Classification					Habitat-Specific CPUE				
Depth	**Velocity**	**Compaction**	**Composition**	**Vegetation**	**NRPK[2]**	**WALL[2]**	**LKWH[2]**	**Tot-LB[2]**	**Tot-FF[3]**
deep	high	hard	mineral	no plants	0.7	1.7	0.0	4.2	4.6
deep	low	hard	mineral	no plants	6.1	4.2	1.4	21.5	65.0
deep	low	soft	mineral	no plants	3.0	12.8	4.7	34.2	41.7
deep	medium	hard	mineral	no plants	2.8	6.6	0.1	16.9	18.2
deep	medium	soft	mineral	no plants	2.3	5.0	0.0	12.8	16.0
deep	standing	hard	mineral	no plants	9.3	2.0	0.3	13.1	86.6
deep	standing	soft	mineral	no plants	4.6	6.0	0.9	20.7	55.5
deep	standing	soft	organic	no plants	2.3	3.0	0.5	10.4	27.8
shallow	high	hard	mineral	no plants	1.3	1.5	0.2	4.4	2.8
shallow	low	hard	mineral	no plants	12.4	7.1	0.9	26.4	30.3
shallow	low	soft	mineral	no plants	9.8	5.4	0.2	20.0	26.6
shallow	low	soft	mineral	plants	12.1	1.3	0.1	18.5	42.0
shallow	low	soft	organic	no plants	4.9	2.7	0.1	10.0	13.3
shallow	medium	hard	mineral	no plants	5.4	5.9	0.8	17.6	11.4
shallow	medium	soft	mineral	no plants	4.3	4.5	0.2	13.3	10.0
shallow	medium	soft	organic	no plants	2.1	2.2	0.1	6.7	5.0
shallow	standing	hard	mineral	no plants	15.7	11.5	13.7	43.3	168.3
shallow	standing	soft	mineral	no plants	12.4	8.7	3.2	32.8	147.8
shallow	standing	soft	mineral	plants	19.8	0.2	2.5	36.9	155.5
shallow	standing	soft	organic	no plants	6.2	4.3	1.6	16.4	73.9
shallow	standing	soft	organic	plants	9.9	0.1	1.2	18.5	77.7
				Mean	**7.0**	**4.6**	**1.6**	**19.0**	**51.4**

1. Red font indicates habitat types that were not sampled directly and where CPUE values were determined using surrogates or professional judgment.
2. Using standard gang index gill nets (NRPK = northern pike; WALL = walleye; LKWH = lake whitefish; Tot-LB = all large-bodied fish).
3. Using small mesh index gill nets (Tot-FF = all forage fish).

Table 5B-5: Weighted mean catch-per-unit-effort ($CPUE_w$) using standard gang index gill nets (#fish/100m/24h) and small mesh index gill nets (#fish/30m/24h) in the Upstream Keeyask Area during summer in the existing environment (EE) and four post-Project (PP) time steps for three operation modes (Base loaded at 158 and 159 m above sea level [ASL], and peaking between 158 and 159 m ASL)

Species	EE	Year 1 PP			Year 5 PP			Year 15 PP			Year 30 PP		
		Base Loaded		Peaking	Base Loaded		Peaking	Base Loaded		Peaking	Base Loaded		Peaking
		158	159		158	159		158	159		158	159	
Area (ha)	4979	8342	9532	9532	8342	9717	9717	8342	9974	9974	8342	10156	10156
Standard gangs													
Northern pike	6.1	3.8	4.1	3.9	4.7	5.0	4.5	5.3	6.0	5.2	5.6	6.4	5.5
Walleye	5.3	5.5	5.7	5.6	6.7	6.4	6.0	7.2	7.0	6.5	7.3	7.1	6.5
Lake whitefish	1.3	1.4	1.5	1.4	1.7	1.7	1.6	1.8	1.9	1.7	1.9	2.0	1.8
Total catch	19.2	17.7	18.5	17.9	21.5	20.9	19.7	23.3	23.5	21.5	23.9	24.3	22.0
Small mesh gangs													
Forage fish	53.2	41.9	44.8	42.3	52.4	55.2	50.1	59.5	66.9	58.3	61.8	71.2	61.0

Table 5B-6: Weighted suitable habitat area (WSHA; ha) in the Upstream Keeyask Area during summer in the existing environment (EE) and four post-Project (PP) time steps for three possible modes of operation (base loaded at 158 and 159 m above sea level [ASL], and peaking between 158 and 159 m ASL), and the ratio of predicted post-Project to existing WHSA (*i.e.*, PP/EE)

		WSHA											
		Year 1PP			Year 5PP			Year 15 PP			Year 30 PP		
Species	EE	Base Loaded		Peaking	Base Loaded		Peaking	Base Loaded		Peaking	Base Loaded		Peaking
		158	159		158	159		158	159		158	159	
Walleye	2247	3979	4264	4123	4358	4842	4602	4680	5484	5083	4750	5659	5206
Northern pike	1573	1870	2160	2016	1989	2439	2215	2249	3020	2635	2346	3308	2827
Lake whitefish	492	1019	1120	1070	1019	1178	1099	1108	1378	1243	1137	1458	1298
Large-bodied fish	2353	4133	4480	4309	4146	4684	4417	4500	5415	4959	4605	5714	5161
Forage fish	1593	2429	2802	2617	2596	3186	2892	2946	3963	3456	3063	4294	3680

		Proportional Increase in WSHA											
		Year 1 PP			Year 5 PP			Year 15PP			Year 30 PP		
Species	EE	Base Loaded		Peaking	Base Loaded		Peaking	Base Loaded		Peaking	Base Loaded		Peaking
		158	159		158	159		158	159		158	159	
Walleye	1.0	1.8	1.9	1.8	1.9	2.2	2.0	2.1	2.4	2.3	2.1	2.5	2.3
Northern pike	1.0	1.2	1.4	1.3	1.3	1.6	1.4	1.4	1.9	1.7	1.5	2.1	1.8
Lake whitefish	1.0	2.1	2.3	2.2	2.1	2.4	2.2	2.3	2.8	2.5	2.3	3.0	2.6
Large-bodied fish	1.0	1.8	1.9	1.8	1.8	2.0	1.9	1.9	2.3	2.1	2.0	2.4	2.2
Forage fish	1.0	1.5	1.8	1.6	1.6	2.0	1.8	1.8	2.5	2.2	1.9	2.7	2.3

APPENDIX 5C
BIOLOGICAL INFORMATION OF VEC FISH SPECIES CAPTURED DURING INDEX GILLNETTING PROGRAM IN THE STUDY AREA

5C.1 WALLEYE

5C.1.1 SPLIT LAKE AREA

Walleye captured with index gill nets set in Clark, Split, and Assean lakes ranged from 65 to 611 mm in length (Table 5C-1). Mean lengths were generally similar among the three waterbodies ranging from 345 mm at Split Lake to 364 mm at Clark Lake. Fish from all three lakes were generally in the same condition. The sub-sample of walleye aged from all three waterbodies ranged from 1–17 years.

Very few walleye captured in standard gang index gill nets set in either Split/Clark or Assean lakes between 2001 and 2004 had external DELTs (less than 0.5% of the catch; Table 5C-2). In Split/Clark lakes, three of the walleye captured exhibited fin deformities, while a single walleye captured in Assean Lake had a tumour.

The majority of walleye (more than 95%) captured in Clark, Split, and Assean lakes as part of the index gillnetting programs conducted between 2001 and 2004 whose stomachs contained food items had consumed fish. The most frequently consumed fish species by walleye in Clark and Split lakes was rainbow smelt, which occurred in 31 and 58% of stomachs that contained fish, respectively. As expected, given that rainbow smelt were not captured in gillnetting surveys of Assean Lake, none of the walleye captured in Assean Lake had consumed rainbow smelt. The most frequently consumed fish species in this lake was yellow perch, which occurred in 28% of stomachs that contained fish. Less than 5% of walleye had invertebrate remains in their stomach.

5C.1.2 KEEYASK AREA

5C.1.2.1 Nelson River between Clark Lake and Gull Rapids

Walleye captured with standard gang index gill nets in the Keeyask area ranged from 66 to 686 mm in length during the summer of 2001 and 2002 (Table 5C-1). Fish captured in the river upstream of Gull Lake were generally the same size and condition as fish captured in Gull Lake. The sub-sample of walleye aged ranged from 1–26 years.

None of the walleye captured in standard gang index gill nets in Gull Lake or the stretch of the Nelson River above Gull Lake in 2001 and 2002 displayed any external DELTs (Table 5C-3).

The majority of walleye (more than 95%) captured in the Keeyask area as part of the index gillnetting programs in 2001 and 2002 whose stomachs contained food items had consumed fish. During the fall of 1999, walleye had fed exclusively on fish. In both spring and fall, the most frequently consumed fish species was rainbow smelt, which occurred in 52% of stomachs that contained fish. About 5% of walleye had invertebrate remains in their stomach.

5C.1.2.2 Gull Rapids

Walleye captured with index gill nets set in the Nelson River below Gull Rapids in 2002–2003 ranged from 234 to 570 mm in length (Table 5C-1). The mean length and condition of fish captured in 2003 was greater than observed in 2002.

External DELTs were observed on a single walleye that was captured in standard gang index gill nets set in the Nelson River below Gull Rapids (Table 5C-3). This fish showed signs of fin erosion.

The majority of walleye (more than 90%) captured below Gull Rapids as part of the 2002–2003 index gillnetting programs whose stomachs contained food items had consumed fish. The most frequently consumed fish species was rainbow smelt, which occurred in 40% of stomachs that contained fish. Approximately 20% of walleye had invertebrate remains in their stomach.

5C.1.3 STEPHENS LAKE AREA

Walleye captured with index gill nets set in Stephens Lake (excluding the riverine portion immediately downstream of Gull Rapids) in 2002 and 2003 ranged from 108 to 633 mm in length (Table 5C-1). The mean length and condition factor of the catch was generally similar among years. The sub-sample of walleye aged ranged from 2– 22 years.

Several of the walleye captured in standard gang index gill nets set in Stephens Lake had external DELTs (about 1% of the catch; Table 5C-4). The most frequently observed DELT category was tumours, which was observed on six walleye. Four walleye had fin deformities and another two fish showed signs of fin erosion.

The majority of walleye (more than 90%) captured in Stephens Lake (excluding the reach immediately below Gull Rapids) as part of the 2002–2003 index gillnetting programs whose stomachs contained food items had consumed fish. The most frequently consumed fish species by walleye in Stephens Lake was rainbow smelt, which occurred in 30% of stomachs that contained fish. Approximately 30% of walleye had invertebrate remains in their stomach.

5C.2 NORTHERN PIKE

5C.2.1 SPLIT LAKE AREA

Northern pike captured in index gill nets set in Clark, Split, and Assean lakes ranged from 140 to 1,090 mm in length (Table 5C-5). The mean length of fish from Split Lake (470 mm) was smaller than in Clark Lake (518 mm) or Assean Lake (544 mm). The condition of northern pike was relatively constant among years and lakes, with annual average condition factors ranging from 0.69 to 0.79. The sub-sample of northern pike aged from all three waterbodies ranged from 1–15 years.

Only one of the northern pike captured in standard gang index gill nets set in Split/Clark Lake had an external DELT; a fin deformity. DELTs were not observed on any of the northern pike captured in Assean Lake (Table 5C-2).

Northern pike captured in index gill nets set in Clark, Split, and Assean lakes set during the summers of 2001 to 2004 fed primarily on fish, as is common for the species. The most frequently consumed fish species by northern pike in Clark and Split lakes was rainbow smelt, which occurred in 58 and 45% of stomachs that contained fish, respectively. As expected, given that rainbow smelt were not captured in gillnetting surveys of Assean Lake, none of the northern pike captured in Assean Lake had consumed rainbow smelt. The most frequently consumed fish species in this lake was yellow perch, which occurred in 21% of stomachs that contained fish. Northern pike captured in all three lakes frequently consumed crayfish; this prey item occurred in 16–51% of northern pike stomachs that contained food.

5C.2.2 KEEYASK AREA

5C.2.2.1 Nelson River between Clark Lake and Gull Rapids

Northern pike captured with standard gang index gill nets in the Gull Lake reach ranged from 171 to 1,017 mm in length (Table 5C-5). Fish captured in the river upstream of Gull Lake were generally the same size and condition as fish captured in Gull Lake. The sub-sample of northern pike aged ranged from 1–15 years.

Only one of the northern pike captured in standard gang index gill nets set in Gull Lake and the upstream reach of the Nelson River had a DELT (Table 5C-3). This fish had a tumour on its head.

The majority of northern pike (81%) captured as part of the index gillnetting program in Gull Lake and the stretch of the Nelson River upstream during the fall of 1999 and the summers of 2001 and 2002 whose stomachs contained food items had consumed fish. In both seasons, the most frequently consumed fish species was rainbow smelt, which occurred in 41% of stomachs that contained fish. During the summer, about 34% of the northern pike had invertebrate remains in their stomach. The most frequently consumed invertebrate group at this time was crayfish. In contrast to the mainstem, fewer of the northern pike captured in Carscadden Lake had fed on fish (67% of fish with stomach contents). The only species of prey fish that could be identified in these stomachs were yellow perch and a single burbot. Many northern pike in Carscadden Lake also consumed invertebrate prey (58%).

5C.2.2.2 Gull Rapids

Northern pike captured in index gill nets set immediately below Gull Rapids from 2002 to 2003 ranged from 236 to 687 mm in length (Table 5C-5). There was little difference in the size of fish between years (471–479 mm); however, the condition factor of northern pike captured in 2003 (0.89) was somewhat higher than that observed in 2002 (0.72).

None of the northern pike captured in standard gang index gill nets set in the Nelson River below Gull Rapids exhibited external DELTs (Table 5C-3).

Northern pike captured in index gill nets set immediately below Gull Rapids during summer from 2002 to 2003 fed primarily on fish. Approximately 67% of the northern pike captured whose stomachs contained food items had eaten fish. Northern pike had consumed at least three species of fish (white sucker, rainbow smelt, and sculpins), in addition to a number of unidentified fish remains. Northern pike frequently consumed crayfish; this prey item occurred in 44% of northern pike stomachs that contained food.

5C.2.3 STEPHENS LAKE AREA

Northern pike captured in index gill nets set in Stephens Lake in 2002 and 2003 ranged from 123 to 998 mm in length (Table 5C-5). The condition factor of northern pike was relatively constant between years, with an overall mean of 0.74. The sub-sample of northern pike aged ranged from 1–19 years.

Four northern pike captured in standard gang index gill nets set in Stephens Lake had external DELTs (less than 0.5% of the catch; Table 5C-4). These northern pike displayed deformities; two of the fin and two of the head.

Northern pike captured in index gill nets set in Stephens Lake from 2002–2003 fed primarily on fish. Approximately 55% of the northern pike captured whose stomachs contained food items had eaten fish, of which the most frequently consumed species was rainbow smelt (35% of stomachs that contained fish). Northern pike also frequently consumed crayfish (36% of stomachs that contained food).

5C.3 LAKE WHITEFISH

5C.3.1 SPLIT LAKE AREA

Lake whitefish captured with index gill nets set in Clark, Split, and Assean lakes ranged from 129 to 565 mm in length (Table 5C-6). The mean length of fish captured in Split Lake (372 mm) and Assean Lake (396 mm) were similar. Although the mean length of lake whitefish from Clark Lake (349 mm) was lower than in Split or Assean lakes, this result could be due to the small number of fish sampled from that lake. The mean condition of lake whitefish ranged from 1.44 at Clark Lake to 1.57 at Split Lake. The sub-sample of lake whitefish aged from all three waterbodies ranged from 1–24 years.

None of the lake whitefish captured in standard gang index gill nets set in either Split/Clark or Assean lakes displayed external DELTs (Table 5C-2).

Lake whitefish captured as part of the index gillnetting program in Clark, Split, and Assean lakes between 2001 and 2004 had fed almost exclusively on aquatic invertebrates. The most frequently consumed invertebrates included snails (Gastropoda), clams (Bivalvia), and clam shrimp (Laevicaudata/Spinicaudata/Cyclestherida). Two fish in Assean Lake and two fish in Split Lake had fish remains in their stomachs (yellow perch and emerald shiner).

5C.3.2 KEEYASK AREA

5C.3.2.1 Nelson River between Clark Lake and Gull Rapids

Lake whitefish captured during the summer of 2001 and 2002 with standard gang index gill nets in the Gull Lake reach ranged from 136 to 592 mm in length (Table 5C-6). Fish captured in the river above Gull Lake were about the same size and condition as fish captured in Gull Lake. The sub-sample of lake whitefish aged ranged from 1–25 years.

An external DELT (a deformed fin) was observed on one of the lake whitefish captured in standard gang index gill nets set in Gull Lake and upstream in the Nelson River (Table 5C-3).

Lake whitefish captured as part of the index gillnetting program in the Gull Lake reach during the fall of 1999 and the summers of 2001 and 2002 had fed almost exclusively on aquatic invertebrates. In both seasons, the most frequently consumed invertebrates included mayflies (Ephemeroptera), snails (Gastropoda), and clams (Bivalvia). Only 3% of the lake whitefish had fish remains in their stomachs.

5C.3.2.2 Gull Rapids

No lake whitefish were captured during the summer index gillnetting program from which biological data could be derived. As lake whitefish move to the base of Gull Rapids from Stephens Lake during fall, biological data for those fish (described in the Stephens Lake area) could be used to describe Gull Rapids lake whitefish.

5C.3.3 STEPHENS LAKE AREA

Lake whitefish captured with index gill nets set in Stephens Lake in 2002 and 2003 ranged from 124 to 569 mm in length (Table 5C-6). The mean condition factor of lake whitefish captured in both years was 1.77. The sub-sample of lake whitefish aged ranged from 1–25 years.

None of the lake whitefish captured in standard gang index gill nets set in Stephens Lake exhibited external DELTs (Table 5C-4).

Lake whitefish captured as part of the index gillnetting program in Stephens Lake (2002–2003) had fed almost exclusively on aquatic invertebrates. The most frequently consumed invertebrates were mayflies (Ephemeroptera), snails (Gastropoda), and clam shrimp (Laevicaudata/Spinicaudata/Cyclestherida). Only one lake whitefish had fish remains in its stomach. FLCN Members have similarly reported that lake whitefish in Stephens Lake feed on insects and small fish (FLCN 2010 Draft).

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Table 5C-1: Mean size, condition, and age, by waterbody and year, of walleye captured in standard gang index gill nets set in the study area during summer, 1997–2004

Waterbody	Year	Fork Length (mm)				Weight (g)				Condition Factor (K)				Age (y)			
		n[1]	Mean	Std[2]	Range	n	Mean	Std	Range	n	Mean	Std	Range	n	Mean	Std	Range
Split Lake	1997	505	318	95	65–600	503	477	396	25–3500	503	1.13	0.21	0.450–3.29	91	6.7	3.7	2–17
	1998	470	314	93	125–576	469	460	403	15–2650	469	1.11	0.17	0.48–1.78	147	6.5	3.3	2–15
	2001	693	372	60	170–596	684	718	376	50–2450	684	1.27	0.24	0.76–3.56	104	6.3	3.0	2–15
	2002	226	387	68	171–611	214	834	443	49–3000	214	1.30	0.21	0.93–3.37	109	6.3	3.2	1–14
	All Years	1894	345	86	65–611	1870	601	421	15–3500	1870	1.19	0.23	0.48–3.56	451	6.5	3.3	1–17
Clark Lake	1997	45	350	96	163–460	45	618	370	25–1150	45	1.16	0.14	0.51–1.50	8	8.6	4.2	2–16
	1998	60	338	97	147–548	60	566	457	25–1995	60	1.11	0.18	0.56–1.51	16	6.9	3.0	3–10
	2001	74	390	87	181–570	73	877	578	66–2400	73	1.25	0.14	0.98–1.53	18	8.1	4.3	2–14
	2002	20	388	93	152–554	20	844	477	35–2225	20	1.22	0.13	0.92–1.42	12	6.9	4.2	1–14
	2004*	25	355	134	162–555	23	770	751	32–2300	23	1.25	0.32	0.67–1.68	25	6.0	4.2	2–16
	All Years	224	364	100	147–570	221	726	536	25–2400	221	1.19	0.19	0.51–1.68	79	7.1	4.0	1–16
Assean Lake	2001	657	355	84	150–535	657	602	419	15–1900	657	1.12	0.14	0.24–1.71	122	6.8	4.1	2–16
	2002	738	349	79	135–560	734	564	382	24–1975	734	1.14	0.27	0.51–3.70	125	7.2	3.6	1–16
	All Years	1395	352	81	135–560	1391	582	400	15–1975	1391	1.13	0.22	0.24–3.70	247	7.0	3.9	1–16
Nelson River (including Gull Lake)	2001	359	407	101	156–587	359	1077	722	25–2800	358	1.30	0.20	0.53–2.74	128	6.8	4.4	2–18
	2002	242	446	101	66–686	242	1395	825	3–4750	242	1.33	0.16	0.88–1.72	134	8.5	5.2	1–26
	All Years	601	422	103	66–686	601	1205	780	3–4750	600	1.31	0.18	0.53–2.74	262	7.7	4.9	1–26
Gull Rapids	2002	48	408	57	315–554	47	972	465	375–2275	47	1.31	0.12	0.99–1.55	-	-	-	-
	2003	46	435	64	234–570	44	1407	530	275–2725	44	1.55	0.12	1.36–1.82	-	-	-	-
	All Years	94	421	61	234–570	91	1182	541	275–2725	91	1.43	0.17	0.99–1.82	-	-	-	-
Stephens Lake	2002	658	396	96	108–633	529	995	678	85–3050	529	1.24	0.13	0.69–1.90	120	9.8	4.9	2–20
	2003	581	438	86	147–621	571	1211	668	25–3700	571	1.28	0.17	0.69–1.80	128	10.1	4.8	2–22
	All Years	1239	416	94	108–633	1100	1107	681	25–3700	1100	1.26	0.15	0.69–1.90	248	10.0	4.9	2–22

1. Number of fish measured.
2. Standard deviation.
* Only sites that were fished in previous years were analyzed.

Table 5C-2: Frequency of occurrence (%) of deformities, erosion, lesions, and tumours (collectively referred to as DELTs) observed on VEC fish species captured in standard gang index gill nets set in the Split Lake area from 2001–2004

Species	DELT Category	Assean Lake			Split/Clark Lakes			
		2001	2002	Mean	2001	2002	2004	Mean
Lake whitefish	Deformity	0	0	0	0	0	0	0
	Erosion	0	0	0	0	0	0	0
	Lesion	0	0	0	0	0	0	0
	Tumour	0	0	0	0	0	0	0
		(308)	(239)	(547)	(65)	(85)	(2)	(152)
Northern pike	Deformity	0	0	0	0	0.3 (1*)	0	0.1 (1)
	Erosion	0	0	0	0	0	0	0
	Lesion	0	0	0	0	0	0	0
	Tumour	0	0	0	0	0	0	0
		(235)	(195)	(430)	(338)	(339)	(81)	(758)
Walleye	Deformity	0	0	0	0.4 (3)	0	0	0.3 (3)
	Erosion	0	0	0	0	0	0	0
	Lesion	0	0	0	0	0	0	0
	Tumour	0	0.1 (1)	0.1 (1)	0	0	0	0
		(657)	(738)	(1395)	(768)	(247)	(84)	(1099)

* The number in brackets represents the number of fish examined.

Table 5C-3: Frequency of occurrence (%) of deformities, erosion, lesions, and tumours (collectively referred to as DELTs) observed on VEC fish species captured in standard gang index gill nets set in the Keeyask area from 2001–2003

Species	DELT Category	Nelson River (including Gull Lake)			Reach below Gull Rapids		
		2001	2002	Mean	2002	2003	Mean
Lake whitefish	Deformity	0	1.6 (1*)	0.6 (1)	-	-	0
	Erosion	0	0	0	-	-	0
	Lesion	0	0	0	-	-	0
	Tumour	0	0	0	-	-	0
		(103)	(61)	(164)	(1)	(-)	(1)
Northern pike	Deformity	0	0	0	0	0	0
	Erosion	0	0	0	0	0	0
	Lesion	0	0	0	0	0	0
	Tumour	0	0.2 (1)	0.1 (1)	0	0	0
		(446)	(605)	(1051)	(18)	(21)	(39)
Walleye	Deformity	0	0	0	0	0	0
	Erosion	0	0	0	0	2.1 (1)	1.1 (1)
	Lesion	0	0	0	0	0	0
	Tumour	0	0	0	0	0	0
		(360)	(242)	(602)	(48)	(47)	(95)

* The number in brackets represents the number of fish examined.

Table 5C-4: Frequency (%) of deformities, erosion, lesions, and tumours (collectively referred to as DELTs) observed on VEC fish species captured in standard gang index gill nets set in the Stephens Lake area from 2001–2003

Species	DELT Category	Stephens Lake		
		2002	2003	Mean
Lake whitefish	Deformity	0	0	0
	Erosion	0	0	0
	Lesion	0	0	0
	Tumour	0	0	0
		(147)	(142)	(289)
Northern pike	Deformity	0	0.5 (4)	0.3 (4)
	Erosion	0	0	0
	Lesion	0	0	0
	Tumour	0	0	0
		(511)	(733)	(1244)
		(36)	(18)	(54)
Walleye	Deformity	0	0.7 (4)	0.3 (4)
	Erosion	0	0.3 (2)	0.2 (2)
	Lesion	0	0	0
	Tumour	0.2 (1)	0.9 (5)	0.5 (6)
		(658)	(581)	(1239)

* The number in brackets represents the number of fish examined.

Table 5C-5: Mean size, condition, and age, by waterbody and year, of northern pike captured in standard gang index gill nets set in the study area during summer, 1997–2004

Waterbody	Year	Fork Length (mm)				Weight (g)				Condition Factor (K)				Age (years)			
		n[1]	Mean	Std[2]	Range	n	Mean	Std	Range	n	Mean	Std	Range	n	Mean	Std	Range
Split Lake	1997	333	468	137	163–890	333	890	767	50–6600	333	0.69	0.12	0.31–2.19	81	4.3	1.9	1–12
	1998	275	469	137	200–852	275	916	761	50–5225	275	0.71	0.10	0.42–1.44	81	4.5	1.5	2–10
	2001	252	468	129	225–1015	251	951	836	85–8700	251	0.77	0.13	0.36–1.55	98	4.6	1.9	2–15
	2002	274	474	135	190–992	263	949	864	61–7400	263	0.73	0.17	0.23–2.75	101	5.0	2.6	1–12
	All Years	1134	470	135	163–1015	1122	924	804	50–8700	1122	0.72	0.14	0.23–2.75	361	4.6	2.0	1–15
Clark Lake	1997	77	496	157	200–890	77	1165	1063	25–6350	77	0.70	0.11	0.31–1.24	21	4.6	1.9	2–8
	1998	55	466	144	220–753	55	909	730	95–2950	55	0.71	0.08	0.57–0.92	17	4.4	1.9	2–8
	2001	86	493	133	140–758	86	1090	760	85–3300	86	0.79	0.34	0.45–3.61	27	4.5	2.2	1–9
	2002	64	542	136	232–881	64	1370	1020	173–6050	64	0.75	0.28	0.49–2.81	16	6.6	4.2	2–15
	2004*	55	614	129	215–925	22	1798	1005	500–4600	22	0.76	0.07	0.67–0.99	55	6.4	2.1	1–12
	All Years	337	518	148	140–925	304	1187	937	25–6350	304	0.74	0.23	0.31–3.61	136	5.5	2.6	1–15
Assean Lake	2001	234	546	155	231–1090	234	1414	1329	74–9400	234	0.69	0.11	0.23–1.70	128	5.6	2.5	2–14
	2002	194	543	167	220–1013	194	1465	1439	100–8050	194	0.70	0.09	0.40–1.09	119	6.3	3.2	1–13
	All Years	428	544	160	220–1090	428	1437	1379	74–9400	428	0.70	0.10	0.23–1.70	247	6.0	2.9	1–14
Nelson River (including Gull Lake)	2001	445	490	168	171–985	443	1245	1226	50–8250	443	0.79	0.20	0.26–2.82	125	5.6	2.8	2–13
	2002	646	539	152	218–1017	645	1494	1316	75–10050	645	0.77	0.11	0.21–1.92	171	6.6	3.5	1–15
	All Years	1091	519	160	171–1017	1088	1393	1285	50–10050	1088	0.78	0.15	0.21–2.82	296	6.1	3.3	1–15
Gull Rapids	2002	18	471	81	298–586	18	822	384	200–1500	18	0.72	0.05	0.59–0.79	3	2.7	0.6	2–3
	2003	21	479	92	236–687	21	1107	649	56–3150	21	0.89	0.14	0.43–1.09	-	-	-	-
	All Years	39	475	86	236–687	39	976	555	56–3150	39	0.81	0.13	0.43–1.09	-	-	-	-
Stephens Lake	2002	510	521	142	123–998	446	1238	1093	45–7875	446	0.72	0.07	0.50–1.11	123	6.7	4.0	1–15
	2003	731	507	132	179–971	727	1219	1030	14–7300	726	0.76	0.14	0.16–1.33	127	7.3	4.7	1–19
	All Years	1241	512	136	123–998	1173	1226	1054	14–7875	1172	0.74	0.12	0.16–1.33	250	7.0	4.4	1–19

1. Number of fish measured.
2. Standard deviation.
* Only sites that were fished in previous years were analyzed.

Table 5C-6: Mean size, condition, and age, by waterbody and year, of lake whitefish captured in standard gang index gill nets set in the study area during summer, 1997–2004

Waterbody	Year	Fork Length (mm)				Weight (g)				Condition Factor (K)				Age (years)			
		n[1]	Mean	Std[2]	Range	n	Mean	Std	Range	n	Mean	Std	Range	n	Mean	Std	Range
Split Lake	1997	130	362	70	209–534	129	822	524	100–2600	129	1.50	0.18	1.07–2.01	38	7.5	3.7	3–19
	1998	77	363	78	150–506	77	849	474	50–2040	77	1.55	0.16	1.02–1.97	28	6.8	2.5	4–13
	2001	63	366	109	139–551	62	995	655	32–2300	62	1.58	0.28	1.03–2.56	61	7.1	4.4	2–22
	2002	70	407	81	181–565	70	1309	654	65–3325	70	1.70	0.22	1.10–2.34	69	8.0	3.3	3–20
	All Years	340	372	84	139–565	338	961	596	32–3325	338	1.57	0.22	1.02–2.56	196	7.5	3.7	2–22
Clark Lake	1997	27	390	109	132–540	27	1099	785	25–2525	27	1.46	0.18	1.09–1.77	15	9.9	6.8	2–24
	1998	3	344	67	278–411	3	667	404	300–1100	3	1.48	0.09	1.40–1.58	3	5.3	1.2	4–6
	2001	2	275	193	138–411	2	720	962	39–1400	2	1.75	0.38	1.48–2.02	2	3.5	2.1	2–5
	2002	15	288	142	141–530	15	635	765	33–2200	15	1.37	0.24	1.08–1.87	15	5.7	6.2	1–23
	2004*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	All Years	47	349	128	132–540	47	907	778	25–2525	47	1.44	0.21	1.08–2.02	35	7.4	6.4	1–24
Assean Lake	2001	308	390	77	132–531	308	1061	495	25–2450	308	1.57	0.20	0.79–2.10	133	5.3	2.9	2–16
	2002	239	403	65	129–542	236	1047	383	27–2175	236	1.51	0.27	1.10–3.85	119	7.3	3.2	1–20
	All Years	547	396	72	159–542	544	1055	449	25–2450	544	1.54	0.24	0.79–3.85	252	6.3	3.2	1–20
Nelson River (including Gull Lake)	2001	103	436	90	201–585	103	1653	886	125–4150	103	1.72	0.24	1.05–2.54	100	8.3	4.5	2–21
	2002	61	394	148	136–592	61	1592	1268	42–5525	61	1.76	0.49	0.95–4.47	57	9.3	7.2	1–25
	All Years	164	420	116	136–592	164	1630	1041	42–5525	164	1.74	0.35	0.954.47	157	8.6	5.6	1–25
Gull Rapids	2002	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2003	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	All Years	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stephens Lake	2002	144	449	86	137–568	108	1682	732	32–3300	107	1.69	0.19	1.07–2.04	86	9.6	4.8	2–25
	2003	142	420	116	124–569	136	1809	1030	22–4400	136	1.84	0.35	0.93–2.54	121	10.2	5.8	1–25
	All Years	286	435	102	124–569	244	1753	911	22–4400	243	1.77	0.30	0.93–2.54	207	9.9	5.4	1–25

1. Number of fish measured.
2. Standard deviation.
* Only sites that were fished in previous years were analyzed.

Table 5C-7: Comparison of the frequency of occurrence (%*) of deformities, erosions, lesions, and tumours (DELTs) on large-bodied VEC species captured in selected northern Manitoba waterbodies

Waterbody	Study Year	Lake Whitefish	Northern Pike	Walleye
Study Area				
Split Lake	2001–2002	0.0 (0)	0.2 (1)	0.2 (1)
Clark Lake	2001–2004	0.0 (0)	0.0 (0)	1.7 (2)
Assean Lake	2001–2002	0.0 (0)	0.0 (0)	0.1 (1)
Nelson River	2001–2002	0.0 (0)	0.0 (0)	0.0 (0)
Gull Lake	2001–2002	0.8 (1)	0.2 (1)	0.0 (0)
Stephens Lake	2002–2003	0.0 (0)	0.3 (4)	1.0 (13)
Other				
Notigi Lake[1]	2001	0.0 (0)	0.8 (1)	0.0 (0)
Leftrook Lake[2]	2001	2.0 (3)	0.0 (0)	0.0 (0)
Wuskwatim Lake[3]	2000–2002	1.4 (4)	0.4 (1)	0.3 (2)
Rat River[4]	2004	0.0 (0)	0.0 (0)	0.5 (2)
Burntwood River[5]	2001–2002	0.0 (0)	0.0 (0)	0.4 (1)
Lower Nelson River[6]	2003	1.0 (1)	0.0 (0)	3.5 (3)

* The number of fish displaying DELT is shown in parentheses.

1. After Caskey and Mota (2003).
2. After MacDonald (2003).
3. After Mota and Jansen (2003) and Kroeker and Mota (2003).
4. Mota (2005).
5. Manitoba Hydro and NCN (2003).
6. After Johnson and MacDonell (2004).

APPENDIX 5D
VEC FISH SPECIES SPAWNING HABITAT IN THE STUDY AREA

5D.1 WALLEYE

5D.1.1 SPLIT LAKE AREA

Potential walleye spawning areas in the Split Lake area are illustrated in Map 5D-1.

1. Moderate numbers of larval walleye were captured in the spring in drift traps set immediately downstream of First Rapids in both 2001 and 2002. Moderate numbers of walleye in spawning condition, including two ripe females, were captured in the Burntwood River in 2002 between 07 and 14 June, when water temperatures were between 5 and 12°C. All of these fish were captured at sites immediately below the rapids, so it is likely that spawning occurred nearby.
2. A small number of walleye were captured in this area in spawning condition during the spring of 2002. Three fish that were preparing to spawn were captured on 16 June and a ripe male and five spent males were captured nine days later; water temperature during this period ranged from 14–17°C. This area likely provides some suitable habitat for spawning.
3. Large numbers of walleye eggs and/or larvae were captured in drift traps set in this area during the spring of 2001 and 2002. Moderate numbers of walleye were also captured in ripe or near-ripe condition at the hoopnet site immediately upstream of the drift trap location. Most of these fish were moving in the upstream direction at the time of capture. The only fish identified as spent was moving downstream.
4. Large numbers of walleye that were in ripe or near-ripe condition were captured in hoop nets set in this area during the spring of 2001 and 2002. About equal numbers of these fish were captured moving towards Assean Lake as away from the lake.
5. Moderate numbers of walleye that were in ripe or near-ripe condition were captured in hoop nets set this area during the spring of 2001 and 2002. Most of these fish were moving in the upstream direction at the time of capture.
6. A small number of walleye that were in ripe or near-ripe condition were captured in hoop nets set this area during the spring of 2001 and 2002. Most of these fish were moving in the upstream direction at the time of capture.
7. Moderate numbers of walleye in ripe and running condition were captured in this area. Many of the walleye captured in this stretch had already spawned. This area likely provides some suitable habitat for spawning. YFFN Members have identified spawning areas on the upper reaches downstream of the community cabins (Hilderman, Thomas, Frank and Cram 2002).
8. Same as # 7 above.
9. The area likely provides some suitable habitat for spawning. Moderate numbers of ripe and running walleye were captured in this area. A greater proportion of the catch was in spawning condition compared to downstream areas. One walleye that was originally captured in ripe

condition in this area was later recaptured in spent condition at a site further downstream, suggesting that fish return downstream after spawning in the upper reaches of the river.

10. Large numbers of walleye, many of which were in spawning or spent condition, were captured in this area during the spring of 2003 and 2004. Most of the fish that were ripe or near-ripe were moving upstream at the time of capture, suggesting that fish likely move into the Aiken River from Split Lake to spawn. The upstream run occurred earlier in 2003 (15 to 20 May) than in 2002 (21 May to 09 June), likely due to increased water temperatures in the former year. The recapture of four walleye in spent condition a few days after initially being captured in pre-spawn condition at the upstream sites, which are located near the rail crossing, suggests that walleye likely spawn near these sites. As well, several of the walleye that had initially been captured at these upstream sites in spawning condition, were later recaptured in spent condition at sites further downstream in the river. Many of the walleye captured in spawning condition at the time of their initial capture in 2002 were recaptured in the Aiken River in spawning condition again the following spring, indicating that some portion of the walleye population returns to the Aiken River to spawn in successive years. YFFN Members have identified spawning areas between cabin sites (Hilderman, Thomas, Frank and Cram 2002).

5D.1.2 KEEYASK AREA

Potential walleye spawning areas in the Keeyask area are illustrated in Map 5D-2.

1. Radio-tagged walleye were frequently detected in this area during late-May and early June in every year that tracking occurred. A few walleye have been captured in this area in near-spawn condition.
2. A few of the radio-tagged walleye were detected below Birthday Rapids during the spring when water temperatures were within the species' spawning range in 2002 and 2003. Moderate numbers of ripe and pre-spawning walleye have been captured in this area during the spring. Only a few larval walleye were captured in drift traps set in this area during the spring of 2001; water temperatures at this time were between 15 and 16°C. However, large numbers of larvae that could only be identified as percid and *Sander* sp. were captured in subsequent years. Water temperatures were a few degrees higher at the start of drift sampling in these years (more than 15°C).
3. Two walleye in spawning condition were captured in this area during the spring of 2004 and this habitat likely provides suitable spawning habitat.
4. One ripe walleye was captured in this area during the spring of 2004 and this area likely provides suitable spawning habitat. A few larval fish that could only be identified as belonging to the family Percidae were captured downstream of this area during spring of 2003 and 2004.
5. This area provides some suitable habitat for spawning and a few ripe and running walleye have been captured in this area during the spring.
6. Same as # 5 above. As well, several spent individuals have been captured here.

7. This area provides some suitable habitat for spawning and a few pre-spawn and spent walleye have been captured in this area during the spring.

8. Same as # 7 above.

9. Same as # 7 above.

10. Spent walleye have been captured in this area during the spring.

11. A few larval fish that could only be identified to family Percidae were captured in this area during spring of 2002. A few ripe or near-ripe fish were also captured in this area during the spring. This area provides some suitable habitat for spawning.

12. Larval walleye were captured in this area during spring 2001–2003. Larval walleye were also captured downstream of this area in 2003, but these fish likely drifted downstream from Gull Rapids. Although larval walleye were not identified in the 2004 drift trap catch, a number of larvae that could only be identified as percids were observed, some of which were likely walleye. Walleye larvae were observed in drift traps when the water temperature in the Nelson River ranged between 15 and 21°C. Large numbers of ripe and near-ripe walleye were also captured in this area during the spring. Spawning fish were generally captured when the water temperature ranged from 7 to 17°C. Although relocation data for fish below Gull Rapids is limited, three of the radio-tagged walleye were detected in this area during the time water temperatures were in the appropriate range for walleye spawning in the years that telemetry was collected (2002 and 2003). Post-spawn walleye have also been captured along this stretch. The KCNs have indicated that Gull Rapids provides spawning habitat (FLCN 2010 Draft; CNP Keeyask Environmental Evaluation Report; FLCN Environment Evaluation Report [Draft]).

13. Large numbers of ripe and near-ripe walleye were captured in this area during the spring. Spent walleye were also captured in this stretch.

14. Same as # 13 above. Also, one of the radio-tagged walleye was detected in this area during the time water temperatures were in the appropriate range for walleye spawning in 2002.

15. A few near-ripe and ripe walleye were captured in this area. Spent walleye were also captured in this stretch.

5D.1.3 STEPHENS LAKE AREA

Potential walleye spawning areas in the Stephens Lake area are illustrated in Map 5D-3.

1. This area provides some suitable habitat for spawning and moderate numbers of ripe and running walleye were captured in the area from 22–28 May 2003, when water temperatures in the river ranged from 10–15°C. However, larvae were not captured in drift traps set in the area. FLCN Members have reported that walleye spawn in the North Moswakot River (FLCN 2010 Draft).

2. This area provides some suitable habitat for spawning and moderate numbers of ripe and running walleye were captured in the area from 23–29 May 2003, when water temperatures

ranged from 14 to 16°C. However, larvae were not captured in drift traps set in the area. FLCN Members have reported that walleye spawn in the South Moswakot River (FLCN 2010 Draft).

3. This area provides some suitable habitat for spawning and a few ripe and running walleye were captured in the area during the spring of 2005. Walleye eggs were not observed. FLCN Members have reported that walleye spawn in Looking Back Creek (FLCN 2010 Draft).

4. FLCN Members report that walleye spawning in the far corner of Ferris Bay (FLCN 2010 Draft).

5D.2 NORTHERN PIKE

5D.2.1 SPLIT LAKE AREA

Potential northern pike spawning areas in the Split Lake area are illustrated in Map 5D-4.

1. A few larval northern pike were captured in drift traps set below the rapids during the spring of 2001. A moderate number of ripe or near-ripe northern pike were captured in this area during the spring of 2002 when water temperatures ranged from 7–13°C.

2. A small number of ripe or near-ripe northern pike were captured in this area during the spring of 2002.

3. Same as # 2 above.

4. A moderate number of ripe or near-ripe northern pike were captured in this area during the spring of 2002 when water temperatures were between 11–12°C.

5. A small number of near-ripe northern pike were captured in this area during the spring of 2004.

6. A small number of ripe or near-ripe northern pike were captured in this area during the spring of 2004.

7. Same as # 6 above.

8. Same as # 6 above.

9. Large numbers of near-ripe northern pike and a few ripe northern pike were captured in this area during the spring of 2002. Most of these fish were moving upstream. A small number of northern pike larvae were captured in drift traps set downstream of the hoop nets in 2001 and 2002. Spent northern pike were also observed in this stretch; these fish were moving downstream.

10. Large numbers of near-ripe northern pike and a few ripe northern pike were captured in this area during the spring of 2001 and 2002. Post-spawn northern pike were also observed in this stretch.

11. A few near-ripe northern pike were captured in this area during the spring of 2001 and 2002. Spent northern pike were also captured in this stretch.

12. Same as # 11 above.

13. Moderate numbers of spent northern pike were captured in this area during spring in 2003.

14. Large numbers of northern pike that were in ripe condition were captured in this area during the spring of 2003 and 2004. Large numbers of spent northern pike were also captured here. In 2003, spawning was likely mostly completed by the time sampling commenced since water temperatures were consistently above 10°C and more northern pike were in spent rather than pre-spawn condition. In contrast, large numbers of ripe or near-ripe fish were captured from 05–09 June 2004, when water temperatures ranged from 5–13°C.

15. Large numbers of northern pike were observed in this area during the spring of 2002 and 2003, many of which were in spawning condition. Movement data from the hoop nets suggest that northern pike move to upstream locations in the river to spawn and return downstream to Split Lake post-spawn.

5D.2.2 KEEYASK AREA

Potential northern pike spawning areas in the Keeyask area are illustrated in Map 5D-5.

1. Radio-tagged northern pike were frequently detected in this area when water temperatures were within the species' preferred spawning range in both 2002 and 2003. A few ripe and near-ripe northern pike have also been captured here in the spring.

2. This area provides suitable spawning habitat for northern pike and a few ripe and near-ripe fish have been captured here in the spring.

3. Same as # 2 above.

4. Same as # 1 above.

5. A few sexually mature northern pike that were preparing to spawn were captured in this area. Around the same time, one of the radio-tagged northern pike was detected in this area in both 2002 and 2003.

6. A moderate number of ripe and near-ripe northern pike have been captured in this area during the spring.

7. Same as # 2 above.

8. Same as # 2 above.

9. Same as # 2 above.

10. Same as # 2 above. As well, moderate numbers of larval northern pike were captured in drift traps set upstream in the creek in 2001 and 2003.

11. Same as # 2 above.

12. Same as # 2 above. However, only a single larval northern pike was ever captured in the creek.

13. Same as # 2 above. As well, moderate numbers of larval northern pike were captured in drift traps set upstream in the creek in 2001 and 2002.

14. Sexually mature northern pike have been captured in this area in ripe or near spawn condition every spring that sampling has been conducted (2001–2004). At around the same time of year, a few of the radio-tagged northern pike were frequently detected in this area during the spring in both 2002 and 2003. A few larval northern pike have been captured in drift traps set below the rapids during the spring of 2001. Larvae were virtually absent from traps set in subsequent years, but the water temperature at the start of these programs exceeded the temperature at which northern pike larvae were captured in 2001 (14–16°C).

15. This area provides suitable spawning habitat for northern pike. However, no larvae were captured in this creek in 2003.

16. In all years that maturity was assessed as part of gillnetting studies (2001–2004), northern pike that were ripe or near-ripe northern pike were captured in this area. Spawning fish were generally captured when water temperatures in the lake ranged from 8–16°C. Around the same time of year (late-May to early June), one of the radio-tagged northern pike was detected in this area multiple times. A few larval northern pike were captured in drift traps set in 2001 and 2003. Larvae were generally observed in the catch when water temperatures ranged between 14 and 18°C. Drift traps set in 2002 were likely set too late in the season to capture larval northern pike as the water temperature had already reached 17°C by the first day of sampling. The KCNs have indicated that Gull Rapids provides spawning habitat (FLCN 2010 Draft; CNP Keeyask Environmental Evaluation Report; FLCN Environment Evaluation Report [Draft]).

17. A few ripe and near-ripe northern pike and a few larval northern pike were captured in this area during the spring of 2003. The KCNs have indicated that Gull Rapids provides spawning habitat (FLCN 2010 Draft; CNP Keeyask Environmental Evaluation Report; FLCN Environment Evaluation Report [Draft]).

18. This area provides suitable spawning habitat for northern pike, although the tributaries may not be accessible in all years. Several ripe and near-ripe northern pike were captured in the bay in 2004 but only one ripe female was captured in the tributary as part of sampling conducted in 2005 and 2006.

19. Same as # 18 above. Spent northern pike were captured in Pond 13 during the spring of 2006; however, larvae were not captured here.

5D.2.3 STEPHENS LAKE AREA

Potential northern pike spawning areas in the Stephens Lake area are illustrated in Map 5D-6.

1. A few ripe and running northern pike were captured in this area during the spring of 2003; however, larvae were not captured. FLCN Members have reported that northern pike spawn in the Moswakot rivers (FLCN 2010 Draft).

2. A few ripe and running northern pike were captured in this area during the spring of 2003.

3. Same as # 1 above.

4. Same as # 2 above.

5. A few ripe and near-ripe northern pike were captured in the area during the spring of 2005; however, northern pike eggs were not observed. Spent northern pike were also observed in this stretch. FLCN Members have reported that northern pike spawn in Looking Back Creek (FLCN 2010 Draft).

5D.3 LAKE WHITEFISH

5D.3.1 SPLIT LAKE AREA

Potential lake whitefish spawning areas in the Split Lake area are illustrated in Map 5D-7.

1. A few larval lake whitefish and unidentified coregonines were captured in drift traps set during the spring of 2001 and 2002. Spawning adults have not been observed at this location as sampling has not been conducted in this area during the fall.

2. Large numbers of ripe or near-ripe lake whitefish were captured in this area during the fall of 2001 and 2002. Many of these fish were recaptured in spawning condition on multiple occasions over the sampling period. Several of these fish were subsequently recaptured in post-spawn condition. Therefore, it is likely that the lake whitefish holding at this location had spawned nearby. The recapture of several spawning lake whitefish during the fall of 2002 in approximately the same location in which they had been tagged the previous year suggests that lake whitefish may return to the same location to spawn in successive years.

3. A number of sexually mature lake whitefish were captured at the mouth of the Aiken River during the fall of 2004; however, only one fish was in spawning condition at the time of capture. The absence of lake whitefish in the river itself suggests that lake whitefish may stage at the mouth prior to upstream spawning movement. The lack of ripe or ripening fish suggests that spawning had not yet occurred in this area by the end of the sampling program and that spawning movements may have occurred only after ice formation.

5D.3.2 KEEYASK AREA

Potential lake whitefish spawning areas in the Keeyask area are illustrated in Map 5D-8.

1. Several larval lake whitefish and unidentified coregonines were captured in drift traps set in this area during the spring of 2001, 2003, and 2004. However, few spawning adults have been captured in this area during the fall. Ripe fish were only observed in 2003, during which time water temperatures ranged from 4–7°C. In 2002, one of the acoustic-tagged lake whitefish was relocated in this area during late September.

2. A few of the radio-tagged and/or acoustic-tagged lake whitefish were relocated in this area when water temperatures were within the species preferred spawning range in 2001 and 2002. Also, a

few larval lake whitefish were captured in neuston tows conducted in this area in spring 2003 and 2004.

3. Large numbers of ripe or near-ripe lake whitefish were captured in this area during fall of 2001–2003. Many of the pre-spawn fish were recaptured on multiple occasions below the rapids, several of which were later recaptured in ripe condition. A few larval *Coregonus* were also captured in this stretch during spring 2003, suggesting that lake whitefish had spawned in the area the previous fall.

4. Coregonine larvae were captured in this area during spring 2003, suggesting that lake whitefish had spawned in the area the previous fall. The KCNs have indicated that Gull Rapids provides spawning habitat (FLCN 2010 Draft; CNP Keeyask Environmental Evaluation Report; FLCN Environment Evaluation Report [Draft]).

5D.3.3 STEPHENS LAKE AREA

Potential lake whitefish spawning areas in the Stephens Lake area are illustrated in Map 5D-9.

1. A few ripe and near-ripe lake whitefish were captured in this area during the fall of 2002 and 2003. However, no larvae were captured in this stretch during the spring of 2003. FLCN Members have reported that lake whitefish spawn in the Moswakot rivers (FLCN 2010 Draft).
2. Same as # 1 above.
3. FLCN have reported that lake whitefish spawn in Looking Back Creek (FLCN 2010 Draft).
4. FLCN have reported that lake whitefish spawn in Ferris Bay (FLCN 2010 Draft).

5D.4 REFERENCES

5D4.1 LITERATURE CITED

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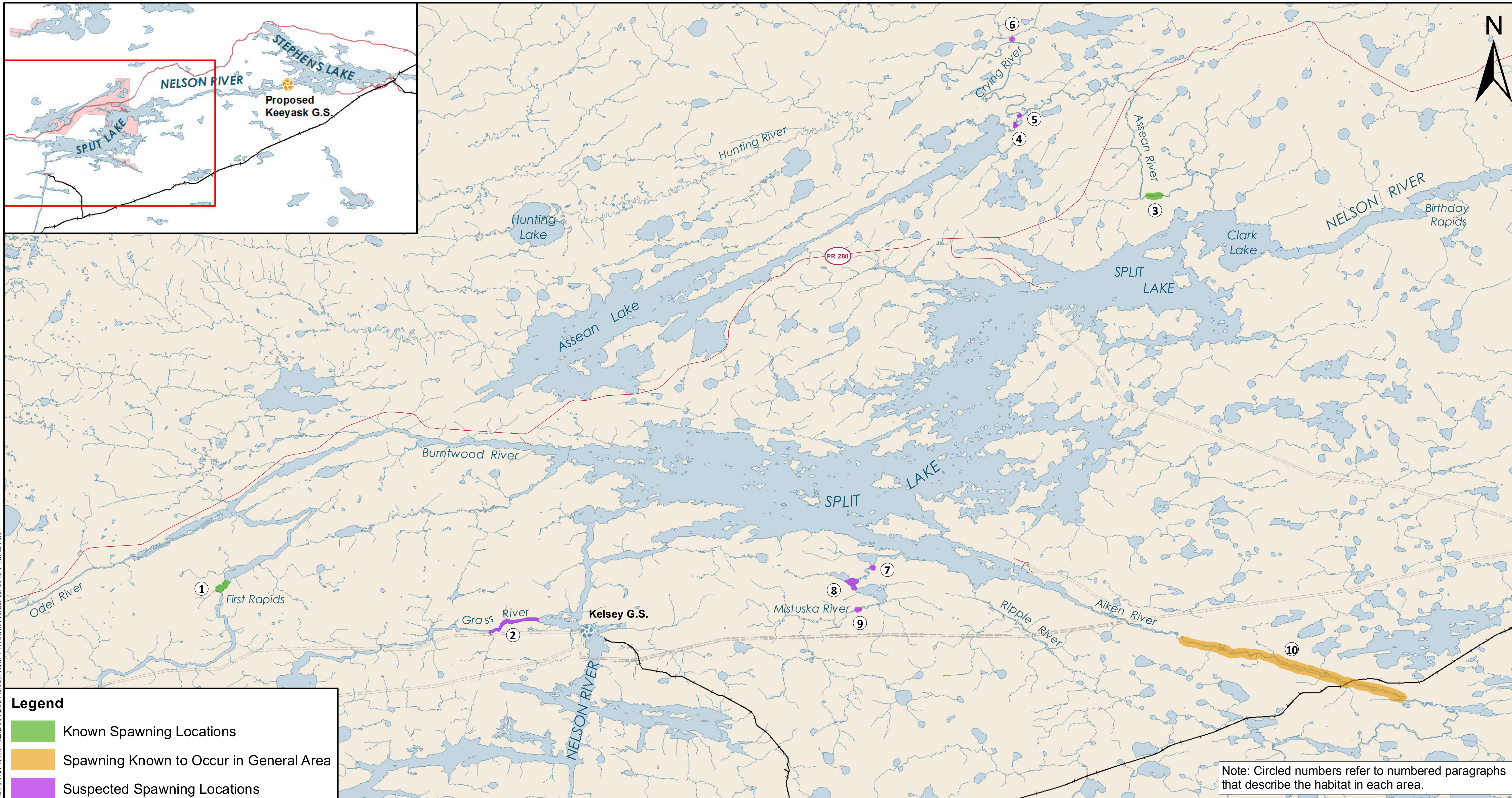


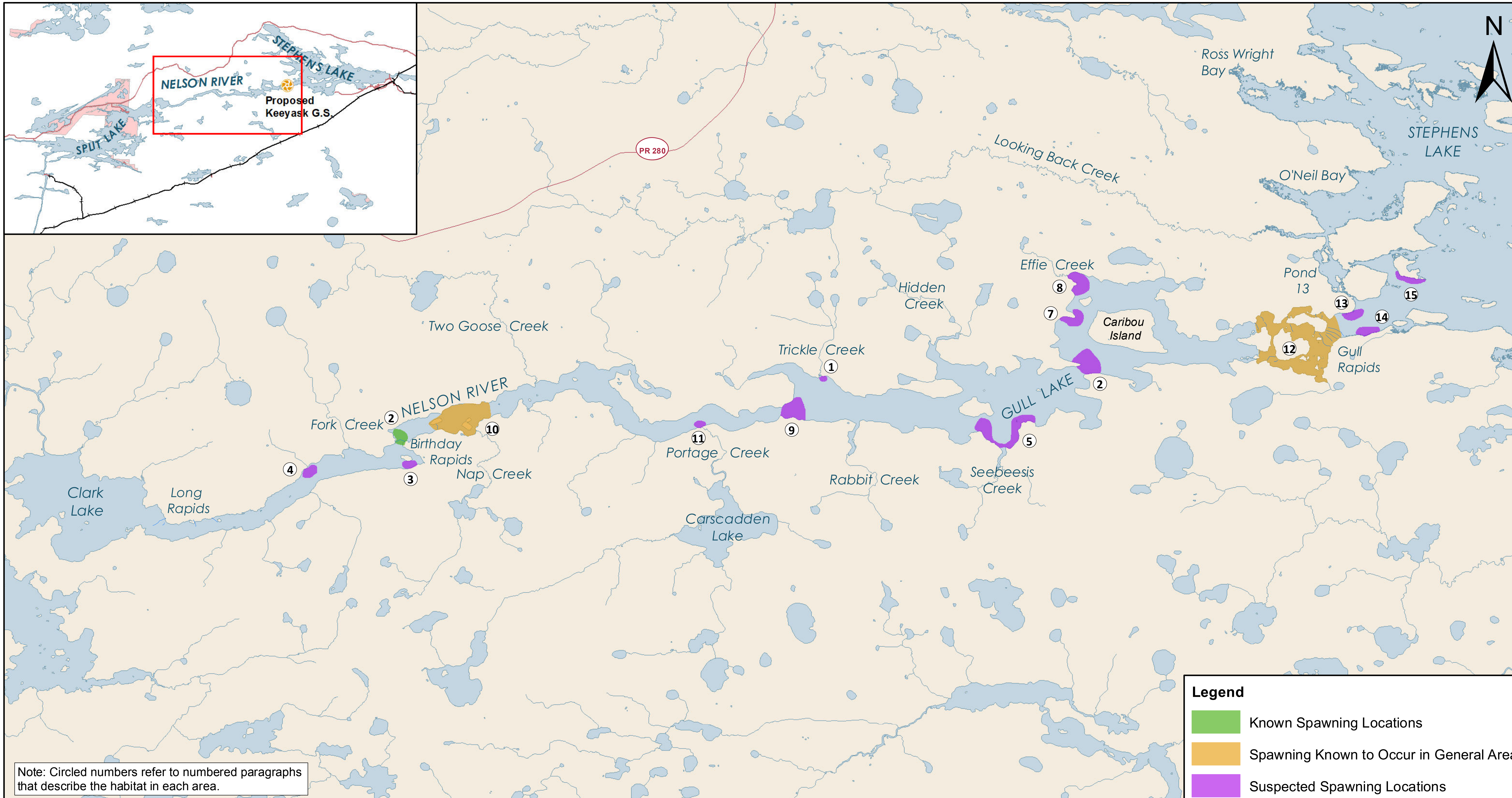
KEEYASK
Hydropower Limited Partnership

0 5 10 15 20 Kilometres
0 2.5 5 7.5 10 Miles

Projection: UTM Zone 15, NAD 83
Data Source: NTS base 1:50 000

Potential Walleye Spawning Areas

Selected Tributaries in the Split Lake Area



KEEYASK
Hydropower Limited Partnership

0 2.5 5 7.5 10 Kilometres
0 1.25 2.5 3.75 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

Potential Walleye Spawning Areas
Keeyask Area

KEEYASK Hydropower Limited Partnership

0 5 10 Kilometres

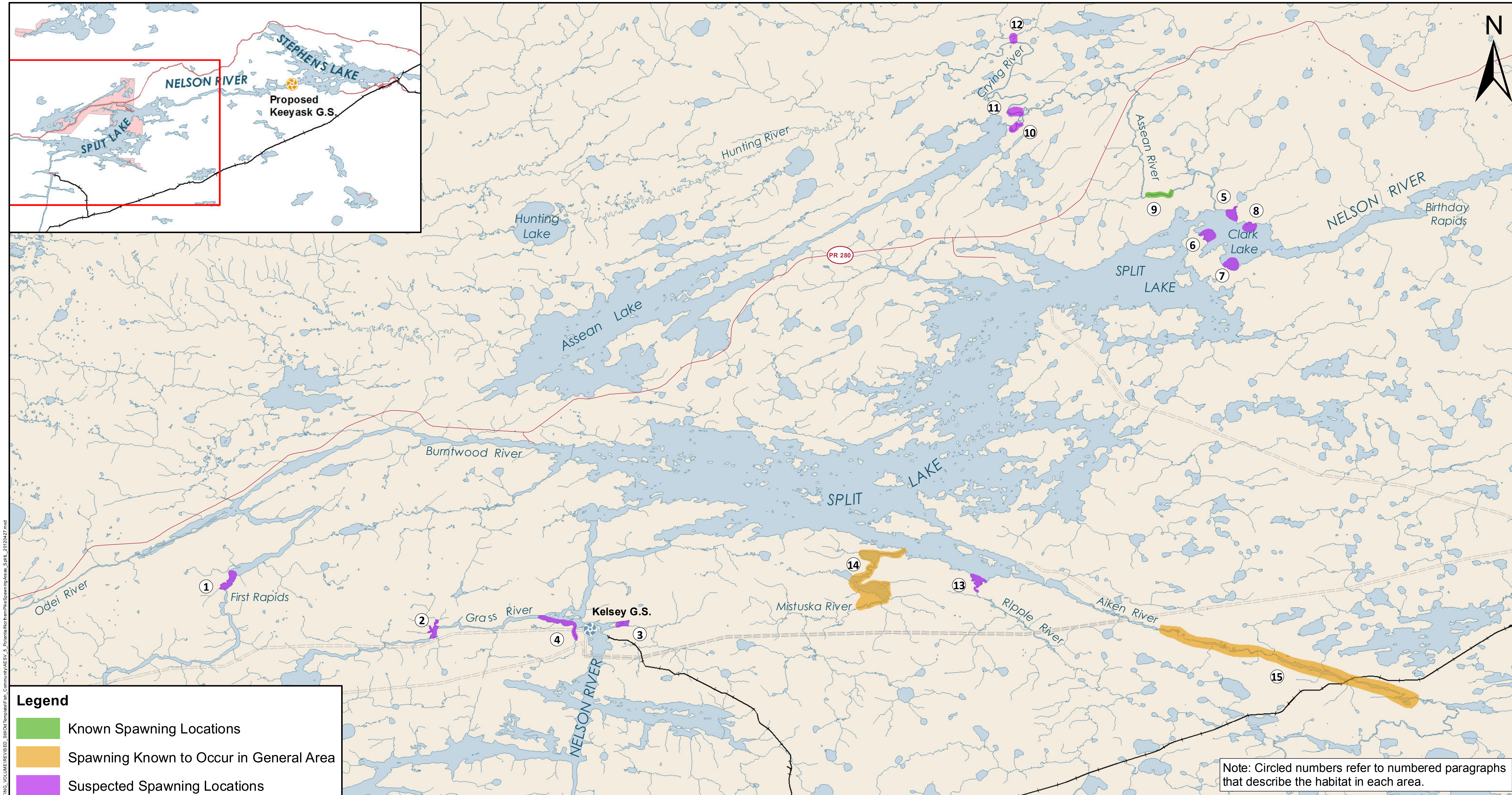
0 2.5 5 Miles

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

Potential Walleye Spawning Areas

Selected Tributaries in the Stephens Lake Area

Map 5D-3

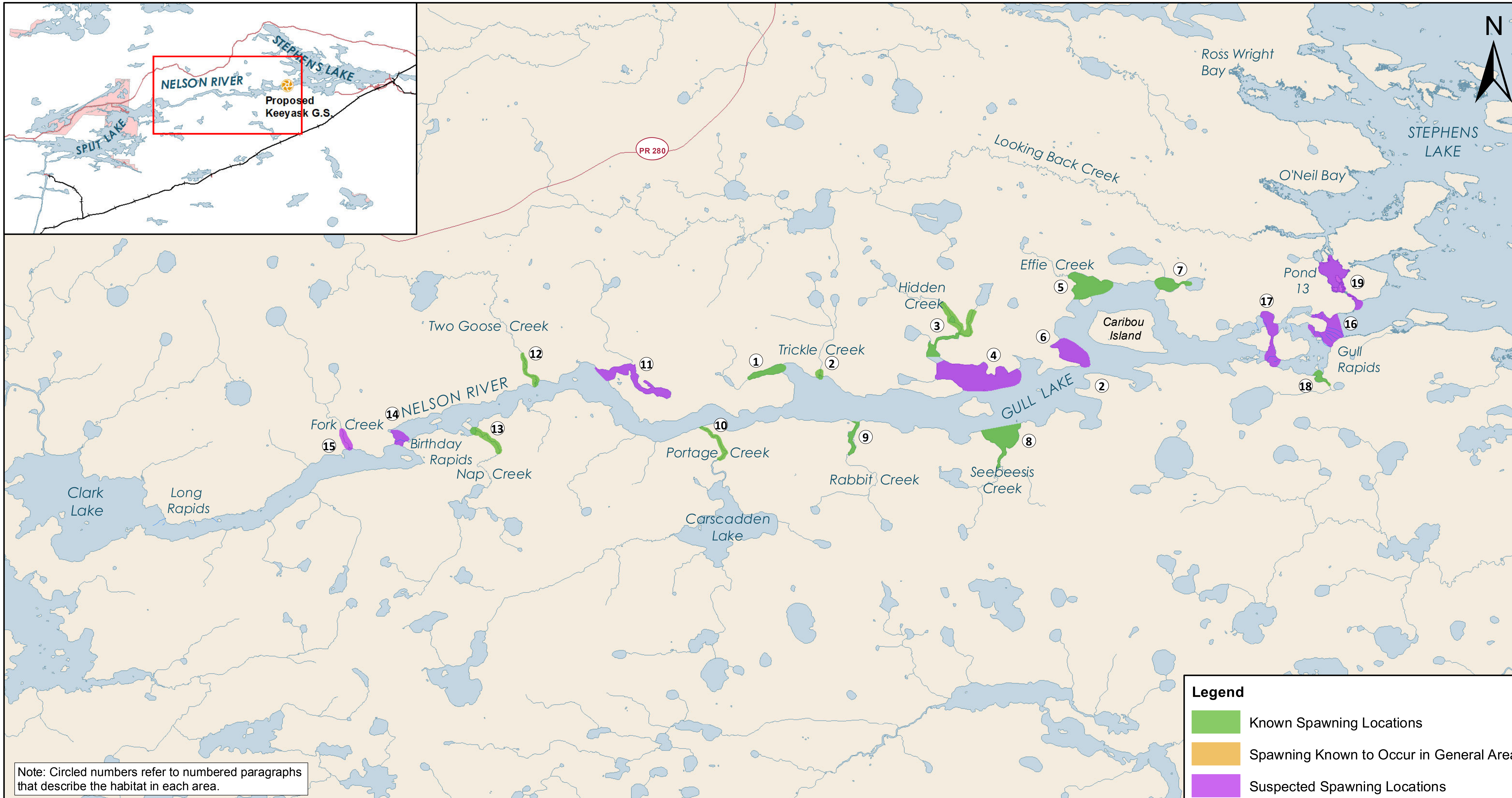


0 5 10 15 20 Kilometres
0 2.5 5 7.5 10 Miles

Projection: UTM Zone 15, NAD 83
Data Source: NTS base 1:50 000

Potential Northern Pike Spawning Areas

Selected Tributaries in the Split Lake Area

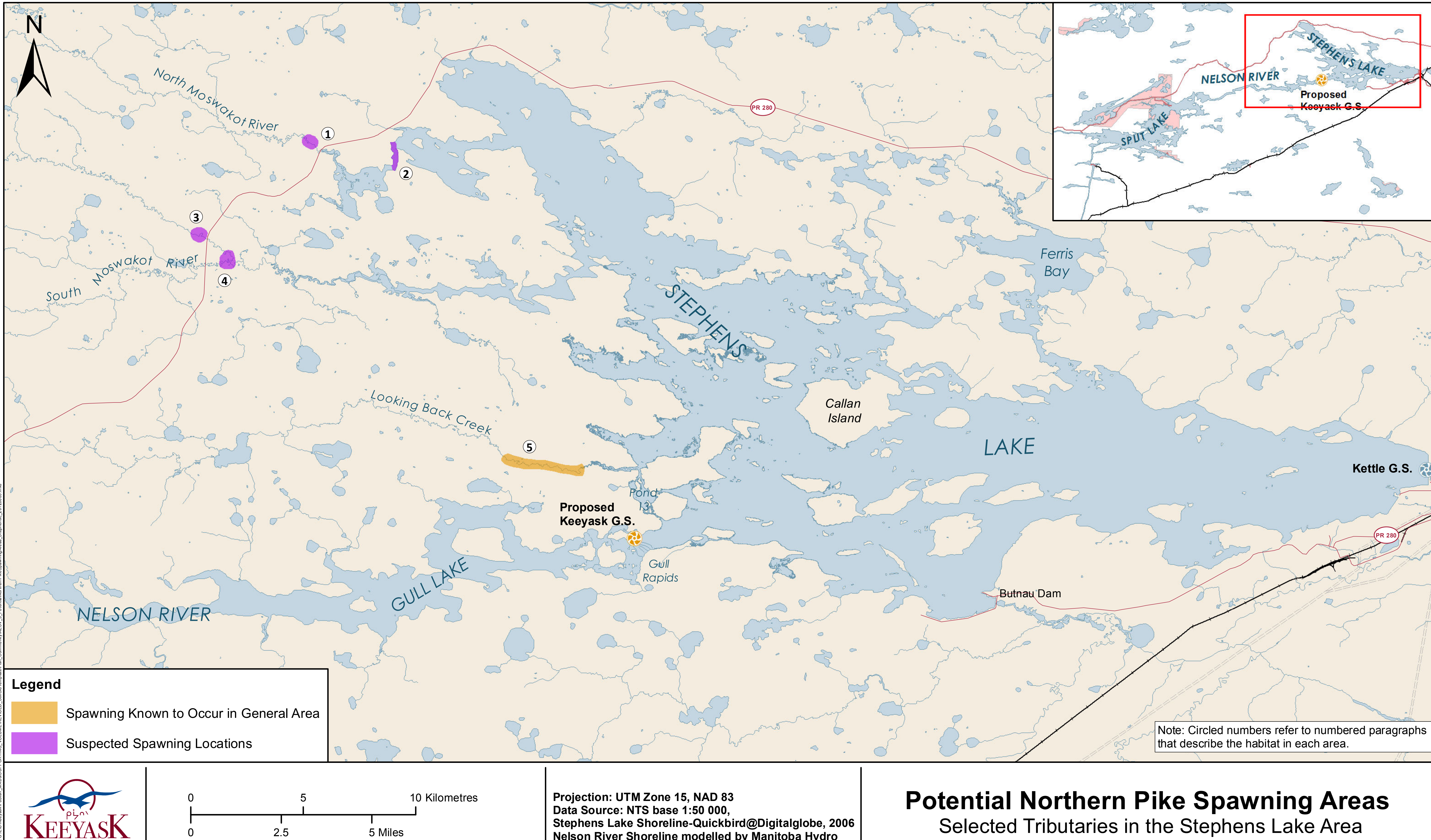


0 2.5 5 7.5 10 Kilometres
0 1.25 2.5 3.75 5 Miles

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

Potential Northern Pike Spawning Areas

Keeyask Area

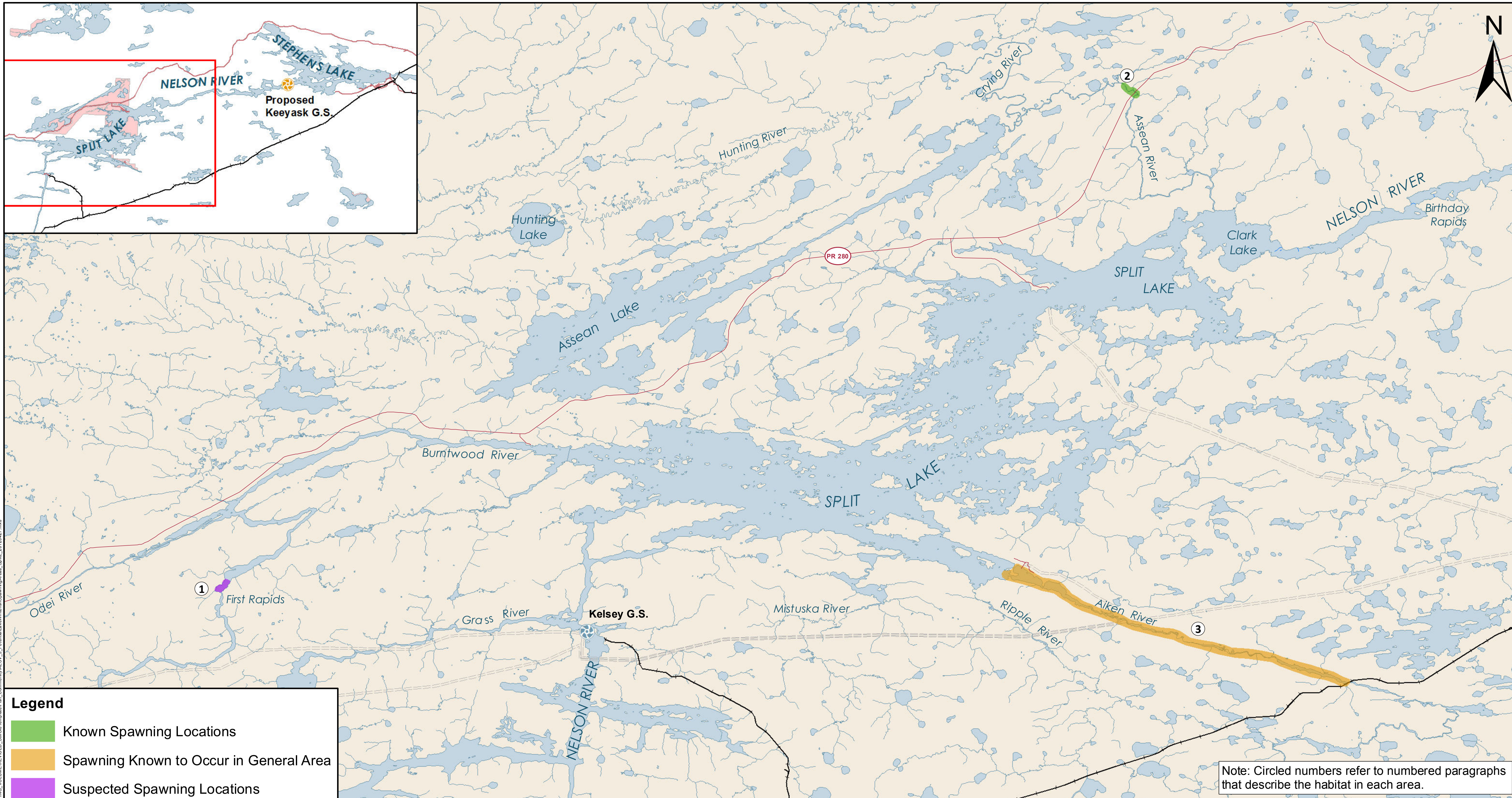


Projection: UTM Zone 15, NAD 83
Data Source: NTS base 1:50 000,
Stephens Lake Shoreline-Quickbird@Digitalglobe, 2006
Nelson River Shoreline modelled by Manitoba Hydro

KEEYASK Hydropower Limited Partnership

Potential Northern Pike Spawning Areas
Selected Tributaries in the Stephens Lake Area

Map 5D-6



0 5 10 15 20 Kilometres

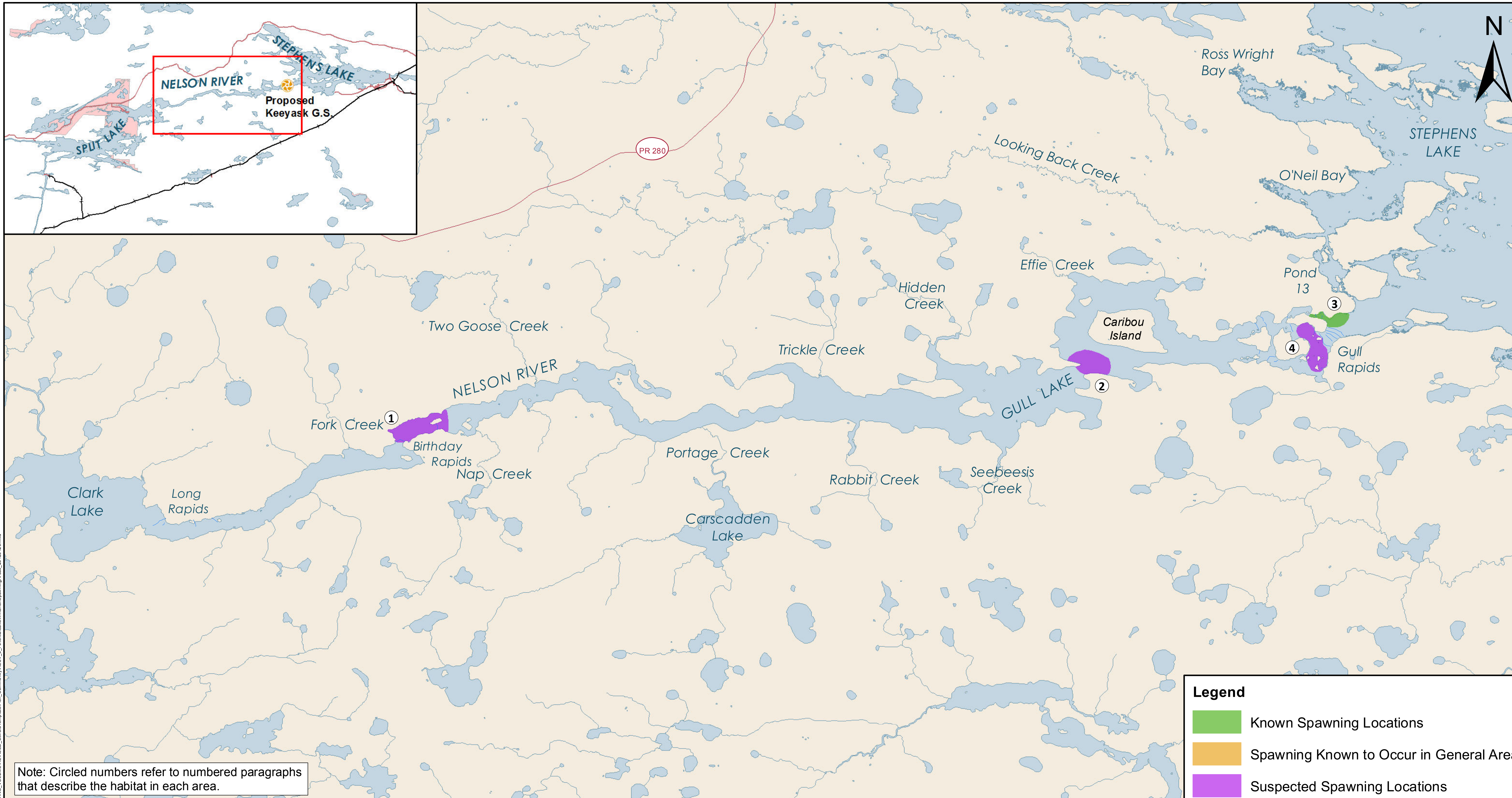
0 2.5 5 7.5 10 Miles

Projection: UTM Zone 15, NAD 83
Data Source: NTS base 1:50 000

Potential Lake Whitefish Spawning Areas

Selected Tributaries in the Split Lake Area

Map 5D-7

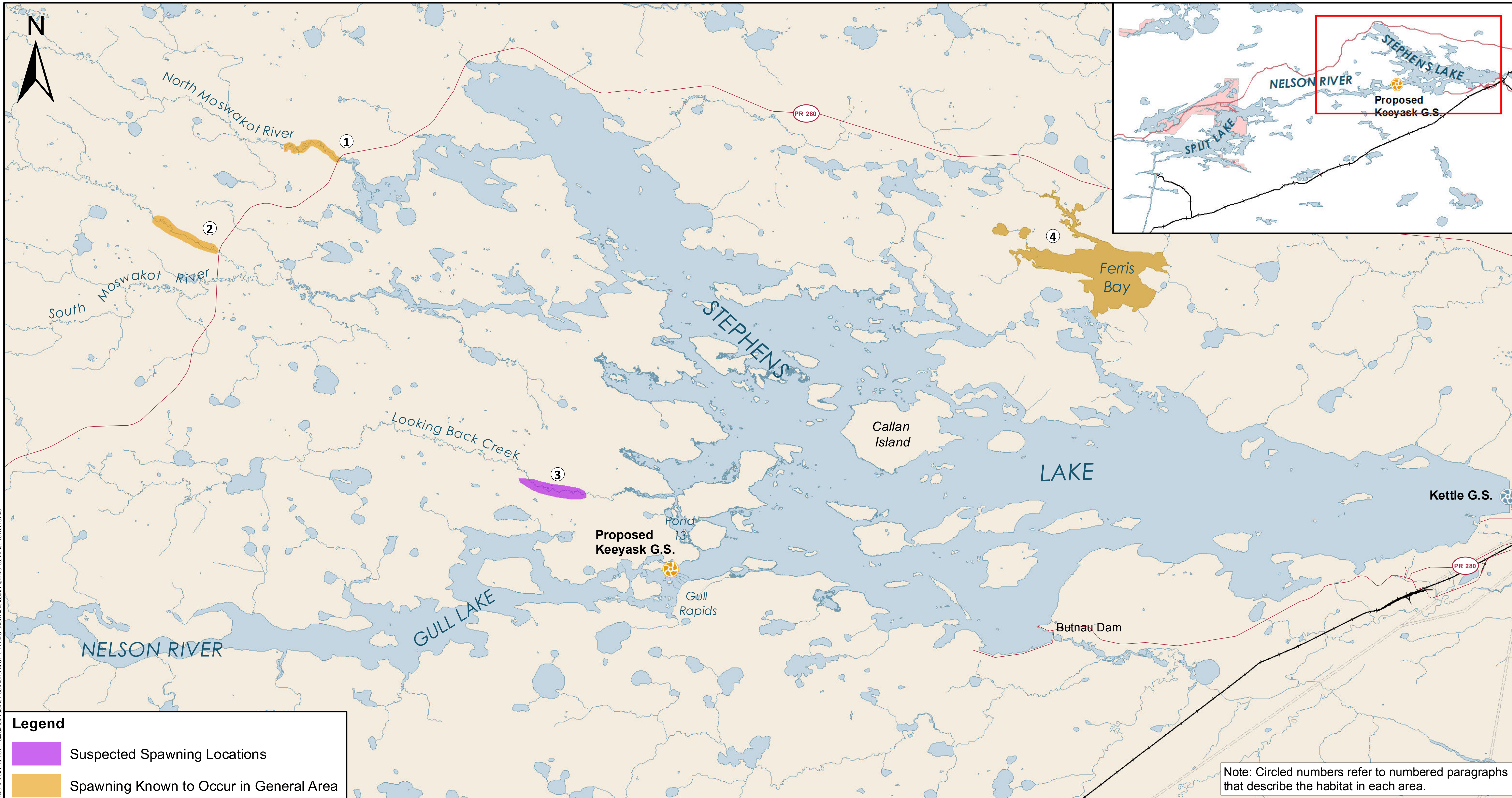


KEEYASK Hydropower Limited Partnership

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

Potential Lake Whitefish Spawning Areas

Keeyask Area



KEEYASK Hydropower Limited Partnership

0 5 10 Kilometres
0 2.5 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

Potential Lake Whitefish Spawning Areas

Selected Tributaries in the Stephens Lake Area

Map 5D-9

APPENDIX 5E
FISH SWIMMING PERFORMANCE

5E.1 INTRODUCTION

Fish swimming performance is generally described using three basic modes: sustained; prolonged; and burst. Sustained swimming is used to achieve relatively slow speeds for long time periods and is generated by aerobic metabolism (Beamish 1978). Burst swimming produces fairly high speeds for short time periods and is fuelled by energy from anaerobic processes (Beamish 1978). Prolonged swimming uses both aerobic and anaerobic energy sources to produce speeds intermediate between sustained and burst (Peake *et al.* 2000). Critical swimming velocity ($Ucrit_x$) has been defined as the maximum velocity a fish can swim against for time x (in minutes). $Ucrit_{60}$ is defined as the highest swimming speed that a fish can maintain indefinitely, or its maximum sustained speed (Beamish 1978).

Critical swimming velocity has been used to infer the ability of fish to swim against velocity in sustained, prolonged or burst modes of swimming. The ability of a fish to maintain position or traverse areas of a river is dependent on several physical and biological factors, including water velocity, mode of swimming (*e.g.*, subcarangiform versus anguilliform), water temperature, and fish length (Katopodis 1993). Studies on Ucrit by Katopodis (1993) demonstrate that for temperate fishes Ucrit can vary among fish species (Table 5E-1).

Classification of the swimming modes of fish is based on the nature of body movements. Fishes found in the study area represent approximate anguilliform and subcarangiform swimming modes (Lindsey 1978). Anguilliform swimming represents undulatory locomotion where the whole length of the body flexes into lateral waves. In comparison, other fishes, like the subcarangiform, are stronger swimmers as they swim by moving mostly the caudal fin and the posterior half of the body.

5E.2 SUBCARANGIFORM

Most average Ucrit values for subcarangiform fish species in the DFO database (all length classes pooled) with satisfactory sample sizes are similar, and have Ucrit values of about 0.55 m/s. Burst, prolonged, and sustained swimming speeds for fish using subcarangiform swimming mode are presented in Figure 5E-1.

5E.3 ANGUILLIFORM

In laboratory conditions, the anguilliform swimmers listed in Table 5E-1 demonstrate a lower aerobic metabolic scope when compared to subcarangiform fishes, and thus are expected to tire more readily. While listed as an anguilliform swimmer by DFO, northern pike are not particularly representative of the undulatory anguilliform swimming mode like that exhibited by eels (Webb 1998). Due to their ambush method of predation, northern pike tend to either move little or, as shown in Figure 5E-2 below, swim slowly or rapidly. Critical swimming velocity for anguilliform fish is lower than that of subcarangiform fish (Table 5E-1). Burst/prolonged and sustained swimming speeds for fish using anguilliform swimming mode are presented in Figure 5E-2.

5E.4 CLASSIFICATION OF WATER VELOCITY

Based on the material presented in Table 5E-1, Figure 5E-1 and Figure 5E-2, water velocity was classified into the following three groupings:

Low (0–0.5 m/s)

Sub-carangiform – all fish greater than 200 mm in length can use sustained swimming. Sub-carangiform fish 200 and 500 mm in length would shift from sustained to prolonged swimming at water velocities of 0.5 and 0.8 m/s, respectively.

Anguilliform – 200 and 500 mm long northern pike will shift from sustained to prolonged/burst swimming at water velocities of 0.1 and 0.2 m/s, respectively.

Medium (0.5–1.5 m/s)

Sub-carangiform – 200 and 500 mm long sub-carangiform fish will shift from prolonged to burst speed at velocities of 0.9 and 1.5 m/s, respectively.

Anguilliform – as water velocities increase from 0.5 to 1.5 m/s, northern pike would shift to more use of burst swimming as opposed to prolonged swimming, and the distance they could swim would decrease.

High (more than 1.5 m/s)

Sub-carangiform – at water velocities greater than 1.5 m/s, sub-carangiform fish of all lengths would employ burst swimming. Endurance would be limited to 10 seconds or less and 200 and 500 mm long fish would be restricted to distances of approximately 0.7 and 4.0 m/s.

Anguilliform – at water velocities greater than 1.5 m/s, northern pike of all lengths would employ burst swimming. As with sub-carangiform fish, endurance would be limited to 10 seconds or less and 200 and 500 mm long fish would be restricted to distances of approximately 0.7 and 4.0 m/s.

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Table 5E-1: Mean Ucrit values for select species found in the study area

		Ucrit (m/s)			
Common Name[1]	**Scientific Name**	**Mean**	**Standard Deviation**	**Range**	**n[2]**
Lake whitefish	*Coregonus clupeaformis*	0.545	0.173	0.151-0.905	166
Longnose sucker	*Catostomus catostomus*	0.568	0.212	0.150-1.081	150
Walleye	*Sander vitreus*	0.559	0.214	0.138-0.912	54
White sucker	*Catostomus commersonii*	0.553	0.126	0.326-0.800	20
Yellow perch	*Perca flavescens*	0.434	0.055	0.3130.537	115
Burbot*	*Lota lota*	0.396	0.081	0.201-0.525	52
Northern pike*	*Esox lucius*	0.382	0.150	0.105-0.773	187

Source: Table A11-1 Manitoba Hydro and NCN (2003)
1. Anguilliform; all others subcarangiform.
2. Number of fish measured.

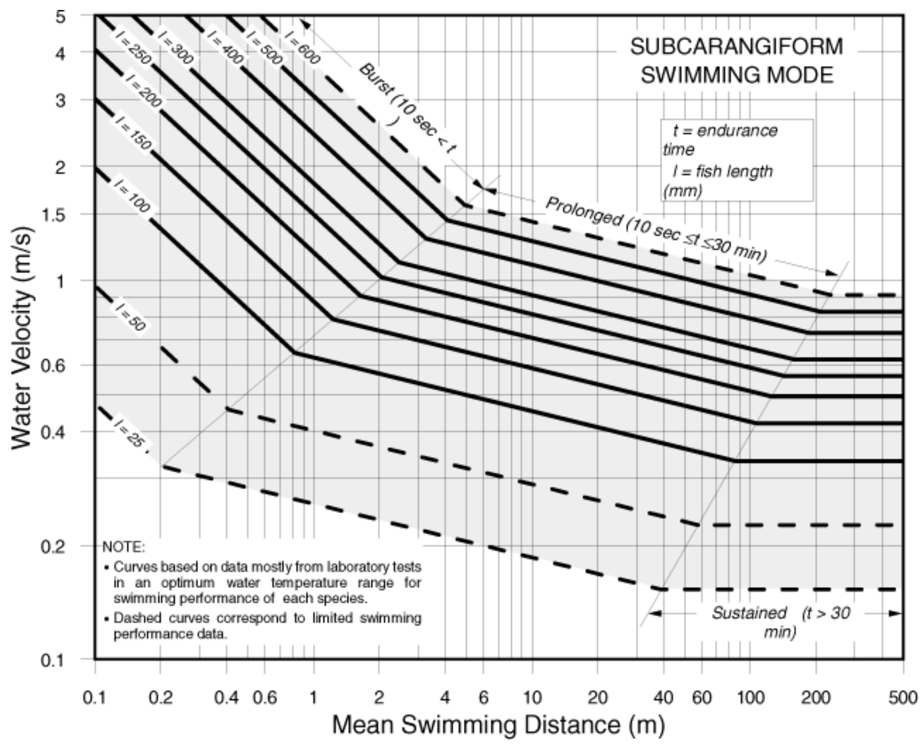

Figure 5E-1: Sustained, prolonged, and burst swimming for fish utilizing sub-carangiform locomotion (after Katopodis 1993)

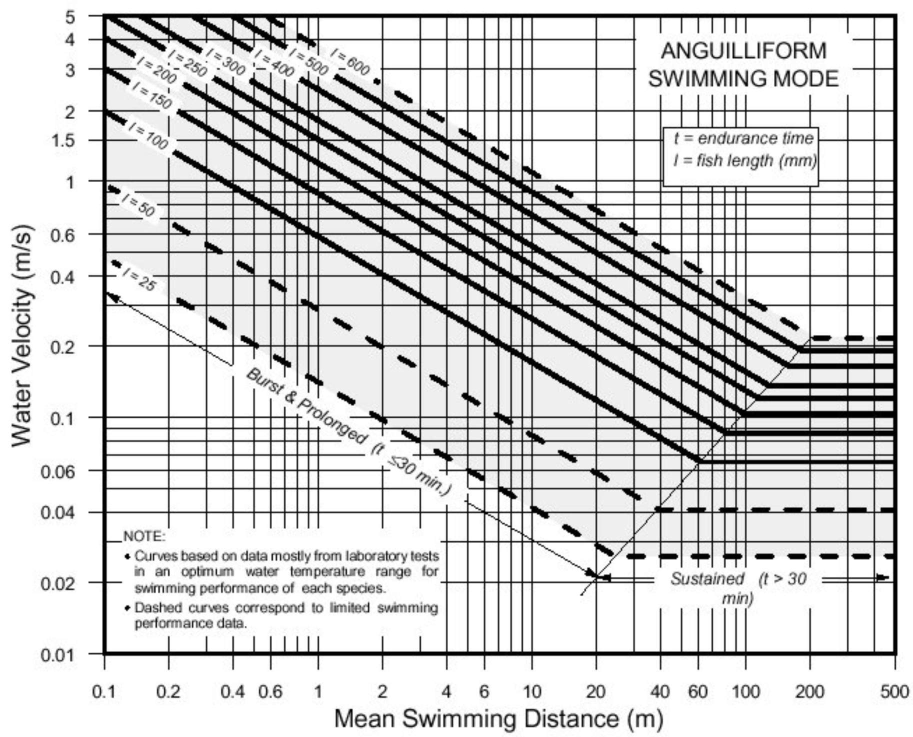

Figure 5E-2: Anguilliform swimming mode water velocities equating to sustained, prolonged, and burst swimming (after Katopodis 1993)