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Scientific Information in Support of Identifying Critical Habitat for SARA-listed White Sturgeon Populations in Canada: Nechako, Columbia, Kootenay and Upper Fraser (2009)

Information scientifique en appui à l'identification de l'habitat essentiel des populations d'esturgeons blancs inscrites à la liste de la LEP au Canada : Nechako, Columbia, Kootenay et haut Fraser (2009)

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

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ABSTRACT

This document reviews existing information relevant to the determination of critical habitat for white sturgeon in each of the four SARA-listed populations in Canada. The report introduces the concept of critical habitat (as distinguished from other habitats used by the species) and summarizes existing information about the location, extent, current status, and potential threats to freshwater habitat that is critical to survival or recovery of white sturgeon in Canada. The report documents sources of information, methods by which information was collected, reliability of the information, and provides a brief discussion of data gaps. Basic biological information on the primary life stages of white sturgeon is provided, including diets and habitat needs.

The legal definition of critical habitat is provided, along with the practical interpretation of this definition and the methods by which recommendations for critical habitat were determined for each population. In addition to recommendations for critical habitat, the recovery team has identified "important habitat," which is defined as habitat that is suspected to contain critical habitat, but for which existing knowledge is inadequate to meet the burden of proof, as set by the Recovery Team, to designate critical habitat. The purpose of identifying important habitat in addition to critical habitat is to recognize that full recovery for white sturgeon requires management of a larger set of geographic locations than can be identified at this time, and more specifically to recognize geographic locations that are likely to be identified as critical in the light of future information.

Critical and important habitats of each life stage are discussed and identified, where possible. Threats to these habitats, data gaps and data sources are also presented. Maps of critical habitat areas are provided for each watershed, with each map indicating boundaries of the critical habitat units.

Critical habitats defined in this document, when combined with functioning recruitment in each population, should provide the initial basis for population recovery. Although there remains some uncertainty regarding factors such as the precise timing and spatial location of some specific critical habitats proposed here, the greater uncertainty is the cause of persistent recruitment failure and identification of a feasible means of restoration. This is reflected in the knowledge gaps identified in the recovery strategy, which provides a guide to future studies with a strong focus on recruitment failure diagnosis and restoration. While some studies conducted on the species biology and movement may provide further information on definition of particular critical habitats, such studies should not supersede investigations of recruitment failure and its restoration because doing so may not be in the best interest of the species.

Disclaimer: The advice provided in this document followed DFO guidance available at the time of the review (2009).

RÉSUMÉ

Le présent document passe en revue l'information disponible pertinente à la détermination de l'habitat essentiel de l'esturgeon blanc pour chacune des quatre populations inscrites à la liste de la LEP au Canada. Le rapport introduit le concept d'habitat essentiel (en contraste avec les autres habitats de l'espèce) et résume l'information recueillie sur l'emplacement, l'étendue, l'état actuel, et les menaces potentielles à l'habitat d'eau douce qui est essentiel à la survie et le rétablissement de l'esturgeon blanc au Canada. Le rapport présente les sources des données, les méthodes de collecte et la fiabilité des données. Il fournit aussi une brève description des lacunes dans les données. Il fournit des données biologiques de base sur les principales étapes du cycle de vie de l'esturgeon blanc, y compris son régime alimentaire et ses besoins en matière d'habitat.

Le rapport fournit la définition juridique de l'habitat essentiel, ainsi que l'interprétation pratique de cette définition et les méthodes employées pour déterminer les recommandations en matière d'habitat essentiel pour chaque population. En plus des recommandations en matière d'habitat essentiel, l'équipe de rétablissement a identifié « l'habitat important », que l'on définit comme un habitat dont on soupçonne qu'il contient un habitat essentiel, mais pour lequel la connaissance existante ne permet pas de s'acquitter du fardeau de la preuve tel que requise par l'équipe de rétablissement pour le désigner comme un habitat essentiel. La désignation d'habitat important, en parallèle à celle d'habitat essentiel, vise à reconnaître que le rétablissement complet de l'esturgeon blanc nécessite la gestion d'un ensemble de lieux géographiques plus vaste que ceux que nous pouvons identifier en ce moment, et plus particulièrement, à indiquer les emplacements qui seront probablement identifiés comme essentiels à la lumière des données à venir.

Dans ce rapport on discute et identifie, si possible, les habitats essentiels et importants pour chaque stade biologique. Il présente également les menaces pesant sur ces habitats, les lacunes dans les données et les sources des données. Il comporte des cartes des aires d'habitat essentiel pour chaque bassin hydrographique. Chacune de ces cartes indique les limites des unités d'habitat essentiel.

Les habitats essentiels définis dans le présent document, lorsqu'ils sont combinés avec un recrutement fonctionnel pour chacune des populations, devraient assurer la première étape du rétablissement des populations. Bien que certaines incertitudes demeurent au sujet de facteurs comme le moment précis et localisation spatiale de certains habitats essentiels proposés dans ce rapport, le degré d'incertitude élevé concerne la cause de l'échec persistent du recrutement et l'identification d'une méthode faisable de rétablissement. Ceci se manifeste dans les lacunes dans les connaissances qui ont été identifiés dans la stratégie de rétablissement, qui servira de guide pour les prochaines études en mettant l'accent sur le diagnostic de l'échec du recrutement et le rétablissement. Même si certaines études menées sur les caractéristiques biologiques et les déplacements de l'espèce peuvent fournir davantage de renseignements sur la définition d'habitats essentiels particuliers, elles ne doivent pas se substituer à des études sur l'échec du recrutement et le rétablissement; une telle pratique ne serait peut-être pas dans le meilleur intérêt de l'espèce.

Avertissement : Les avis offerts dans le présent document sont conformes aux directives du MPO en vigueur au moment de l'examen (2009).

ACKNOWLEDGEMENTS

Much of the background material for this report has been taken from the Recovery Strategy for White Sturgeon, which was written by the White Sturgeon Recovery Team. The Recovery Team is made up of a number of regional technical and community working groups, and a National Technical Coordinating Committee:

- Bill Green (Canadian Columbia River Intertribal Fisheries Commission)
- Steve McAdam (Ministry of Environment, chair)
- Troy Nelson (Fraser River Sturgeon Conservation Society)
- Matt Neufeld (Ministry of Environment)
- Mike Ramsay (Ministry of Environment)
- Tola Coopper (Fisheries and Oceans Canada)
- Gary Birch (BC Hydro)
- Erin Stoddard (Ministry of Environment)
- Brian Toth (Lheidli T'enneh First Nation and the Carrier Sekani Tribal Council)
- Cory Williamson (Ministry of Environment)
- Chris Wood (Fisheries and Oceans Canada)

During development of the recovery strategy, members of the Technical Coordinating Committee were tasked with leading the regional groups through a process to collate and evaluate relevant existing information on critical habitat. Matt Neufeld (Ministry of Environment) led the process for the Kootenay River; Colin Spence (Ministry of Environment) and Gary Birch (BC Hydro) led the process for the Columbia River; and Cory Williamson (Ministry of Environment) led the process for the Nechako and Upper Fraser Rivers. They were supported in this role by other Committee members, in particular Steve McAdam (Ministry of Environment) and Tola Coopper (Fisheries and Oceans Canada), and reported results back to the Technical Coordinating Committee. This work provided the primary inputs for sections of this document pertaining to recommendations for white sturgeon critical habitats.

INTRODUCTION

1.1 PURPOSE OF DOCUMENT

The purpose of this document is to review existing information relevant to the determination of critical habitat for white sturgeon in each of the four SARA-listed populations. The report introduces the concept of critical habitat (as distinguished from other habitats used by the species) and summarizes existing information about the location, extent, current status, and potential threats to freshwater habitat that is critical to survival or recovery of white sturgeon in Canada. The report documents sources of information, methods by which information was collected, reliability of the information, and provides a brief discussion of data gaps. The report also includes maps to indicate the geographic location of critical habitat features. Much of the background information on white sturgeon that is included in this report comes directly from the White Sturgeon Recovery Strategy (National Recovery Team for White Sturgeon 2009).

It should be noted that this document was completed within the SARA-mandated timelines for completion of a Recovery Strategy. Due to these time constraints, some aspects of the strategy may not be as complete as the National Recovery Team, DFO or MOE would prefer. Ongoing attention to the subject area of critical habitat, the Recovery Strategy, and the development of Action Plans is expected to continue to improve the foundation for the identification of critical habitats.

1.2 THE SPECIES

White sturgeon, *Acipenser transmontanus*, (Figure 1) is the largest, longest-lived freshwater fish species in North America (Scott and Crossman 1973). Fish of over 6 m in length and over 100 years of age have been reported in the Fraser River (Scott and Crossman 1973). Growth rates and maturity vary significantly throughout the white sturgeon's range, but in general white sturgeon are slow-growing with a delayed onset of sexual maturity.

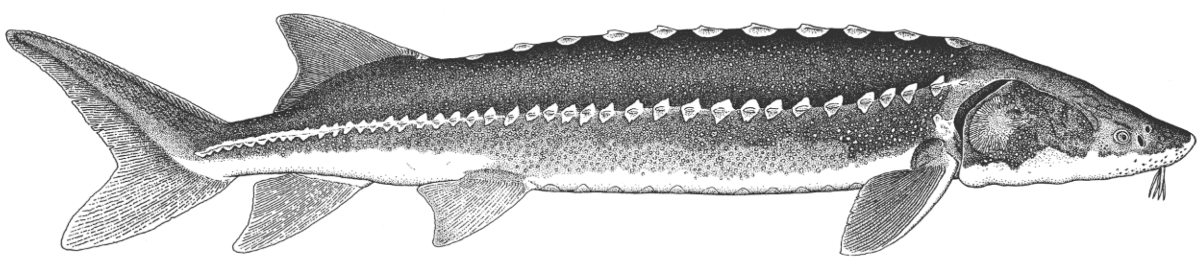

Figure 1. The white sturgeon, Acipenser transmontanus*. (Drawing by Paul Vecsei provided courtesy of Golder Associates Ltd.)*

Females and males may spawn for the first time as young as 26 and 11 years, respectively (Semakula and Larkin 1968), but often it is later. White sturgeon may spawn multiple times throughout their life, with intervals between spawning for females of 3 to 11 years (Semakula and Larkin 1968; Scott and Crossman 1973, Cory Williamson pers. comm.). Estimated survival is very low during the first year (0.000396 % [Gross et al. 2002]), and into the early juvenile period (Justice et al. (2009). Subsequently, survival rates are substantially higher (91% for ages $\geq$ 1 [Gross et al. 2002]; 92% [Walters et al. 2005]; more recent estimates [Irvine et al. 2007, Whitlock 2007] indicate survival rates of ~96% and this value is used in all calculations of mortality for this document).

White sturgeon are broadcast spawners, releasing large numbers of eggs and sperm into the water column of large river habitats. Egg deposition is believed to occur in proximity to the substrate in preferred habitat locations, rather than indiscriminately within the water column. Spawning occurs in the late spring and early summer, typically following the highest water levels of freshet, as water temperatures are rising, in fast water velocities, over coarse substrates (Parsley et al. 1993; Parsley and Kappenman 2000; Paragamian et al. 2002; Parsley et al. 2002; Perrin et al. 2003; RL&L 1994a; Liebe et al. 2004), though there are deviations from this general pattern.

Fecundity is directly proportional to female body size, ranging from about 0.7 million eggs in a medium-size female to 3 or 4 million in a large female (Scott and Crossman 1973). Eggs are fairly large (3.5 mm, Deng et al. 2002 cited in Coutant 2004), adhesive, and negatively buoyant.

After white sturgeon free embryos exhaust their yolk sac, they begin exogenous feeding. The highest daily mortality rate of young sturgeon occurs at the initiation of exogenous feeding (Gisbert and Williot 2002). First feeding varies from 8–16 days post-hatch, depending on water temperature (Doroshov et al. 1983; Buddington and Christofferson 1985; Gawlicka et al. 1995). Larval drift may occur post-hatch and during the initiation of first feeding (Kynard and Parker 2006).

Movement and migrations for later life stages of white sturgeon are linked to feeding, overwintering, and spawning activities. Different movement patterns appear primarily related to food type and availability, and differences in habitat availability and distribution. In general, most individuals seem to remain on summer feeding grounds and exhibit relatively localized movements (RL&L 2000a). They then migrate in fall or winter, followed by a period of relatively low activity during the winter, with the timing and length of inactivity variable among populations (RL&L 2000a; Nelson et al. 2004). Migrations to spawning areas occur in spring and sometimes in fall; spawning migrations are often more extensive than feeding and overwintering movements (RL&L 2000a). There is variation among populations in movement patterns, and movements in some populations may be strongly affected by dams. Additionally, there can be differences between inland and lower basin populations with respect to movements: extensive seasonal, food-related movement patterns observed in lower basin populations are not typical of many upper basin fish, which may reside in relatively small areas for months or years (R. Beamesderfer, pers. comm.).

1.3 POPULATIONS AND STATUS

White sturgeon occur and are self-sustaining in three major drainages on the Pacific coast of North America: the Fraser, Columbia and Sacramento River systems. They are found in the mainstem of these rivers, as well as several larger tributaries. White sturgeon can exhibit facultative anadromy and have been observed in several coastal inlets and estuaries, typically near creek and river mouths. Some migration occurs via the ocean between the three major drainages and to other coastal watersheds, but the extent of exchange is small. Within Canada, white sturgeon occur only in British Columbia (Figure 2 and Figure 3). Based on geography and genetics they are divided into six populations: the lower, mid and upper Fraser River, Nechako River system, Columbia River, and Kootenay River. Smith et al. (2002) showed that the six populations are separated genetically. While there is genetic evidence of historic sub-structure within the Columbia population (Nelson and McAdam 2004), the extent of substructure within other populations has not been studied.

All six populations in British Columbia were listed as endangered by COSEWIC in November 2003. However, only four populations were legally listed under SARA (upper Fraser River, Nechako River, Columbia River and Kootenay River). Socioeconomic concerns were cited as the primary motivation for not listing the lower and mid-Fraser River populations. This document addresses critical habitat information for the four SARA-listed populations only.

1.3.1 Remnant Populations

The Recovery Team decided to focus recovery efforts on white sturgeon within the core of their range, and have therefore excluded four very small peripheral populations in the Columbia and Kootenay systems. No critical habitat is proposed in these areas, but the populations are briefly discussed for completeness.

Kinbasket Reservoir.— Anecdotal reports from local residents and traditional ecological knowledge have identified that white sturgeon were present in the extreme upper Columbia River prior to construction of Mica Dam and the formation of Kinbasket Reservoir (Prince 2001). There is anecdotal evidence that white sturgeon are still present in the Kinbasket Reservoir, although recent studies have failed to capture any (Prince 2009). At present, no critical habitat designations are recommended for this portion of the watershed.

Duncan Reservoir.— White sturgeon in Duncan Reservoir are considered remnants of the Kootenay Lake population (RL&L 1998c). The area upstream of Duncan Dam was clearly part of white sturgeon historic habitat, but it is not considered critical habitat. This habitat is considered to have played at most a minor role in limiting Kootenay white sturgeon.

Slocan Lake.— White sturgeon can be found in very small numbers in Slocan Lake (RL&L 1998b, 1998c). The Slocan River is a tributary of the Kootenay River and white sturgeon in the Slocan must have originated from Kootenay Lake since they were born after construction of Brilliant Dam (and therefore cannot have moved upstream from the Columbia River). Since the Slocan is downstream of Bonnington Falls any white sturgeon here would have been unable to return to the Kootenay. Slocan River and Slocan Lake were part of white sturgeon historic habitat, but they are not considered critical habitat. This habitat is considered to have played at most a minor role in limiting Kootenay white sturgeon.

Figure 2. Map of the Fraser River basin showing the approximate ranges for four of the white sturgeon populations in British Columbia. The species is principally found in the mainstem habitats of the Fraser and Nechako Rivers, although in some systems they make extensive use of tributaries and large lakes (such as in the Harrison or Stuart watersheds). Anecdotal records indicate sturgeon presence in several watersheds beyond the described boundaries.

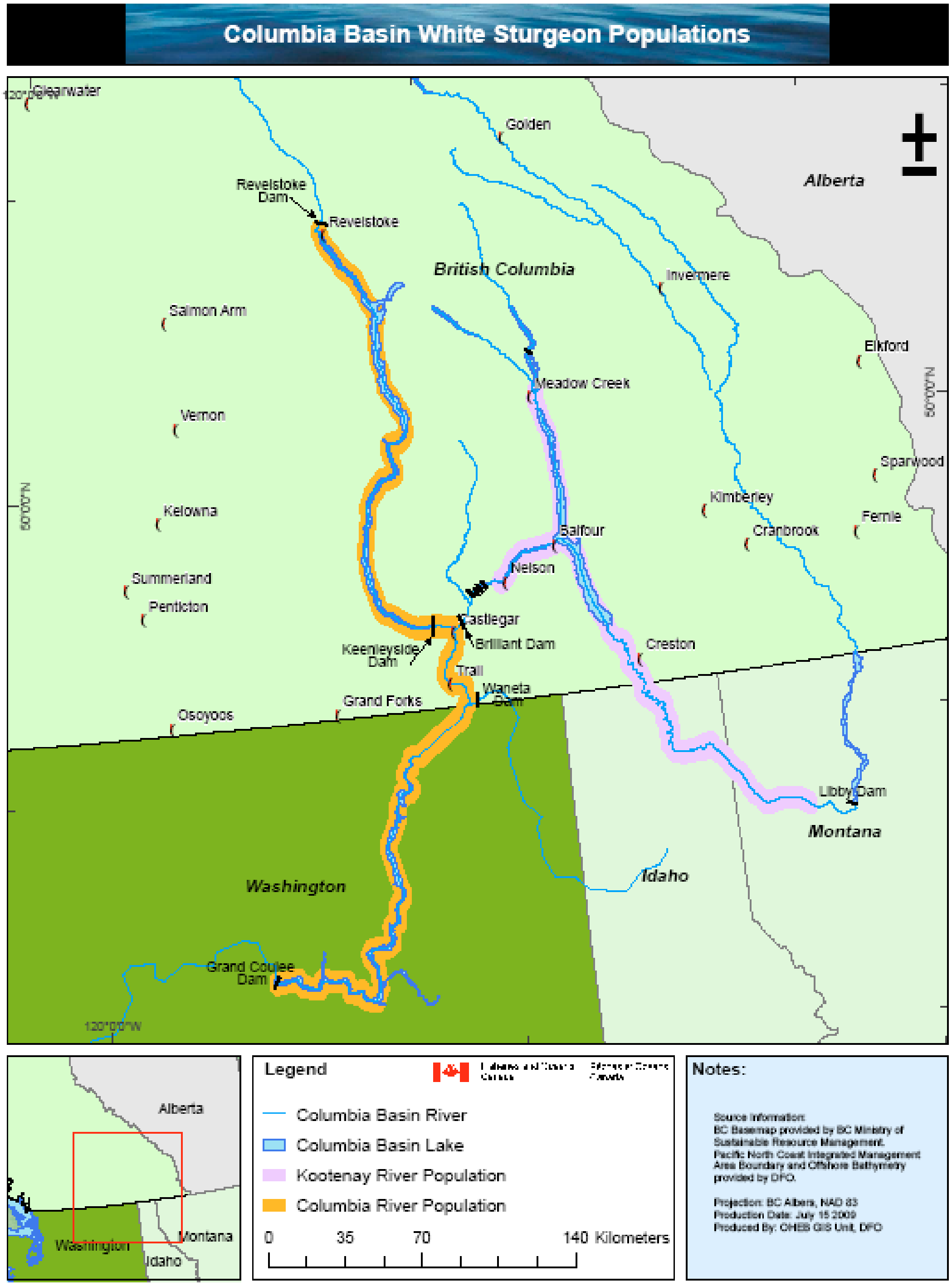

Figure 3. Map of the Columbia and Kootenay basins showing the approximate ranges for two of the white sturgeon populations in British Columbia. Records indicate sturgeon presence in several watersheds beyond the described boundaries (e.g., Duncan River and Slocan Lake), but in all cases abundance is very low (see text for details). White sturgeon are present in the Columbia to its confluence with the Pacific Ocean, but this document addresses only sturgeon upstream of Grand Coulee Dam.

Koocanusa.— Five adult sturgeon from the Kootenay population were transplanted into Koocanusa Reservoir, upstream of Kootenai Falls, by BC and Montana government staff in the mid-1970s. No critical habitat designation is required for the Koocanusa Reservoir, or areas in the Upper Kootenay River. There has been some discussion regarding use of the reservoir to provide habitat for a replicate population. If this plan proceeds, there may be a need to designate critical habitat within Canada at that time.

1.4 KEY LIFE STAGES AND HABITAT NEEDS

1.4.1 Life Stages

For consistency, we refer to the following major life stages throughout this document. This terminology has been reviewed by the Recovery Team, but it is acknowledged that a variety of other terms may be used in the literature. The divisions into the following life stages are useful for facilitating discussion of the life stage-specific biotic processes associated with habitats discussed in this document.

Spawning.— The spawning life stage refers to the primary period of active reproduction for mature individuals. Typically this is shortly after the peak of the spring freshet, but the actual timing varies considerably among locations. Where logical to do so, the spawning period may include staging near spawning areas immediately prior to spawning events.

Incubation.— The incubation life stage refers to the period from fertilization to hatch. Hatch occurs 5 to 10 days after fertilization depending on water temperature, with temperatures in excess of 20˚ C leading to abnormal development (Wang et al. 1985). Since incubation habitats are the same or contiguous with spawning habitats, the discussion of spawning and incubation is usually combined in this document.

Free embryo (0 – 12 days post-hatch).— During the free embryo period individuals tend to remain hidden (typically in interstitial spaces within river bed substrates) until the yolk sac is exhausted, but at the beginning of this period drift may occur until free embryos find appropriate hiding locations. The life stage ends at the onset of exogenous feeding. First feeding varies from 8–16 days post-hatch, depending on water temperature (Doroshov et al. 1983; Buddington and Christofferson 1985; Gawlicka et al. 1995). We use the period to 12 days post-hatch to capture the typical developmental range.

Larvae (12 – 40 days post-hatch).— During the larval period individuals emerge from hiding in interstitial spaces, show nocturnal drift, and initiate exogenous feeding. First feeding varies from 8–16 days post-hatch, depending on water temperature (Doroshov et al. 1983; Buddington and Christofferson 1985; Gawlicka et al. 1995). Nocturnal drift avoids predation but allows movement to lower velocity feeding habitats (e.g., side channels or floodplain). The highest daily mortality rate of young sturgeon occurs in the days of first and early feeding (Gisbert and Williot 2002). The division between this life stage and the next has been set somewhat arbitrarily at 40 days, although some researchers speak of a metamorphosis that occurs at this time.

Early Juvenile (40 days to 2 years).— Shortly after first feeding white sturgeon are morphologically very similar to later life stages. However, habitat use and diets may be substantially different than later life stages, primarily due to differences in body size. The 40 days to 2 years stage is one in which young fish become less susceptible to predation and by one year old fish are often observed holding in habitats that are similar to adult habitat types. The division between this life stage and the next has been set somewhat arbitrarily at two years of age. In general it is believed that once white sturgeon are one year old they tend to occupy habitat that is similar to that preferred by adults.

Late Juvenile and Adult (>2 years).— Individuals greater than two years old differ in size and sexual maturity, but habitat use is sufficiently similar that these fish can be addressed as one group during the rearing and overwintering phases. Food resources likely shift during this stage, with an increasing trend toward piscivory in older fish. This life stage may include fairly distinct activities such as staging, overwintering, migration and rearing.

1.4.2 Physical Habitat Needs

White sturgeon inhabit large rivers where they are associated with particular habitat features: slow, deep mainstem channels interspersed with a zone of swift and turbulent water, extensive floodplains with sloughs and side channels, and a snowmelt-driven hydrograph with prolonged spring floods (Coutant 2004). Most habitat use studies are recent and have come from regulated rivers, particularly the upper Columbia and Kootenay Rivers. The few studies completed on the Fraser River, which is the only unregulated system in the species' range, indicate that habitat use there may be quite different. Care must therefore be exercised when extrapolating observations and conclusions regarding sturgeon habitat and related behaviours from regulated systems. A considerable amount of work is still required to properly describe habitat requirements for white sturgeon.

Like many fish species, habitat use by white sturgeon varies with life stage and season. The following sections summarize what is currently known about habitat use by white sturgeon.

Spawning and Incubation Habitat.— White sturgeon naturally spawn during the spring freshet. There has been a considerable amount of work done to characterize white sturgeon spawning habitats, but much of the information has come from regulated rivers (e.g., Parsley and Beckman 1994; Parsley et al. 1993; Paragamian et al. 2001; Golder 2005). These studies indicate strict requirements for deep, swift water and coarse substrates. Parsley et al. (1993) characterized spawning habitat in the Columbia River below McNary Dam as having a 0.8 to 2.8 m sec^{-1} mean water column velocity, and boulder and bedrock substrates. Mean water column velocities typically range from 0.5 to 2.5 m sec^{-1} at most sites studied. Spawning habitat has recently been identified in the Columbia River just south of the US border at Northport, Washington, with conditions such as high turbulent flows, and coarse substrates (Howell and McLellan 2007a, b).

Spawning has occurred in the Kootenai River[1] in an area characterized by large mobile sand deposits, but this area is believed to have extremely poor egg survival, since eggs collected from here have been coated in sand (Duke et al. 1999; Kock et al. 2006) and only one wild sturgeon larvae has ever been collected (hatched on a egg collection mat; Paragamian personal communication) despite significant collection effort. Spawning was observed in 2004 in the Nechako River over substrates dominated by gravel and fines, but these conditions appear to be one of the causes of ongoing recruitment failure (McAdam et al. 2005).

Evidence from the lower Fraser River indicates that white sturgeon use large side channels for spawning (Perrin et al. 2003) as well as more turbulent areas downstream of the Fraser canyon (RL&L 2000a). Physical characteristics of the side channels included gravel, cobble and sand substrates, and mostly laminar flows with near-bed velocities averaging 1.7 m s^{-1}. Boulder and cobble predominated in the mainstem study site. All sites were within a portion of the lower

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[1] Portions of the Kootenay River that occur within the US are referred to as the "Kootenai." We use the American spelling to refer to American portions of the river, and to the "Recovery Plan for the Kootenai River Population of the White Sturgeon (*Acipenser transmontanus*)." The plan was developed by the US Fish and Wildlife Service, with input from Canadian agencies, and refers to white sturgeon recovery in both Canadian and American portions of the river.

Fraser that is unconfined and largely unaffected by floodplain development. Coutant (2004) noted that successful spawning is most often associated with turbulent or turbid river sections areas upstream of floodplains.

Incubation success is thought to be greatest when discharges are high and steady (UCWSRI 2002). High velocities in egg deposition areas may exclude some predators and provide high turbidity, which may limit predator efficiency (Gadomski et al. 2005). Substrate condition may also influence larval survival (Gessner et al. 2005). Recent research has indicated a preference by 48 hour-old white sturgeon larvae for gravel sizes between 12 and 22 mm (Bennett et al. 2007).

Juvenile Habitat.— Juvenile (< 2 years) habitat for white sturgeon varies considerably with stage of development. In general, little is known about natural juvenile habitat use for white sturgeon populations in BC, with most information coming from laboratory studies or studies in other river systems. Parsley et al. (1993) defined physical habitat for juvenile white sturgeon in the lower Columbia River as 2 to 58 m depth, 0.1 to 1.2 m s^{-1} mean column velocity, and near-substrate velocity of 0.1 to 0.8 m s^{-1}. Note that the study was conducted downstream of McNary Dam, and the upper end of this depth range rarely exists in natural rivers. Nevertheless, their observations suggest that juvenile white sturgeon may be found at a range of depths, but that they prefer slow to moderate water velocities. Observations and traditional ecological knowledge in a number of locations within the Canadian range (e.g., Bennett et al. 2005; Failing and Gregory 2003), show that juveniles are often associated with the lower reaches or confluences of tributaries, large backwaters, side channels and sloughs. Sampling of side channel and slough habitat on the Kootenay has, however, shown little use of such habitats in comparison to the mainstem (Neufeld and Spence 2002). Extensive use of deep, low velocity mainstem habitats also occurs (RL&L 2000a; Golder 2003a; Neufeld and Spence 2004), especially as fish grow larger. Substrates at collection sites have varied from finer particles through to boulder and hard clay (Parsley et al. 1993; Young and Scarnecchia 2005). Feeding juveniles showed a slight preference for sand substrates, but occupied other substrates if food was present (Brannon et al. 1985). In the Kootenay system, and perhaps in other systems, there is use of lake habitat by juveniles.

Immature and Mature Adult Habitat.— Immature (over 2 years) and mature adult habitat use is variable, depending on time of year and life history-related activities, such as spawning, feeding, overwintering, and movements to and from these key habitats (RL&L 2000a; Neufeld 2005). In general, white sturgeon adults are found in deep areas, adjacent to heavy flows, defined by deposits of sand and fine gravels with backwater and eddy flow characteristics (RL&L 1994a, 2000a). Adults in the upper Fraser may be widely dispersed including use of tributaries, and may require long migrations to reach feeding and spawning habitats (Yarmish and Toth 2002). Most studies of adult habitat use have focussed on the physical features of spawning habitat. Considerably less attention has been given to other adult habitat requirements including overwintering, feeding, holding habitats, or migration habitats. Large lakes and rivers, where available, are extensively used at all times of the year (e.g. RL&L 1999a; Golder 2006a).

Summer residency. — During this period, which is typically July to September, the movements of white sturgeon in most populations tend to be more localized than in the spring to early summer or fall. In the Columbia (RL&L 1994a; Brannon and Setter 1992) and Kootenay Rivers (Apperson and Anders 1991), white sturgeon were reported to use shallower depths during the spring to summer period and exhibited frequent, short distance forays between shallow and deep-water areas to feed. Information on summer residency of Fraser white sturgeon is sparse, but movements appear to be localized (RL&L 1998a, 1999b) and associated with summer feeding activity. Sturgeon in the upper Columbia (i.e., above Hugh Keenleyside Dam [HLK]) may be an exception to the patterns described here, since their movements may be most affected due to a higher density of dams.

High-use areas in the upper Columbia River are generally depositional areas where food items settle out. These areas also support higher densities of other fish species that likely provide an additional food source (UCWSRI 2002). In Kootenay Lake, adults undertake an annual migration from the south end of the lake to the outlet of the Duncan River at the north end, where large numbers of spawning kokanee provide an excellent food source (RL&L 1999a). Summer residency in other populations is not as well understood, but is likely linked to food availability. In the upper Fraser, the pattern of habitat use in summer is linked to sturgeon spawning, but potentially also feeding on spawning cyprinids, and the end is clearly linked to the upstream migration of spawning salmon, especially sockeye.

Overwintering — Reduced activity is generally observed during winter months (e.g., RL&L 2000a; Nelson et al. 2004). Telemetry data for mature adults in the Fraser (RL&L 2000a) indicated that few individuals move more than 5 km during the winter. Individuals in all populations tend to utilize deeper, lower-velocity areas during this period. Large lakes and rivers are extensively used, where available (e.g. RL&L 1999a; Golder 2006a).

Migration Movements — Migration is defined in RL&L (2000a) as sustained, unidirectional movements, either upstream or downstream but not both, likely for feeding, spawning or overwintering. Migration patterns are being studied in many populations, but are not well understood for all BC populations. Migrations in the spring are associated with staging, spawning, and feeding activities associated with spring invertebrate hatches and spawning of other fish species. Fall movements are also associated with feeding opportunities (e.g., kokanee spawning near creek confluences). Mature white sturgeon do not usually reproduce annually, especially females, so movements of individuals may vary among years and by sex. The extent of movements is related to proximity between overwintering areas and spawning and feeding areas.

Connectivity among habitats is necessary, since fish must be able to move freely between feeding, holding and spawning areas to complete their life cycle. At present, connectivity is maintained throughout much of the species' range, but the variable is acknowledged as key for conservation planning of this species.

For the ALR component in the Columbia River, connectivity is required for the segment upstream from the Highway 1 Bridge to Big Eddy, and from Big Eddy to the spawning site at the golf course. Connectivity is identified specifically for those locations because flow releases from REV are a prerequisite for connectivity. The proposed minimum flow from REV may provide such connectivity; however, this must be evaluated once the flow is implemented. For the transboundary component in the Columbia River, connectivity is also an issue. Based on preliminary genetic data, it is believed that HLK currently divides a formerly contiguous population. The limited ability to alter present levels of connectivity at HLK is acknowledged, however, connectivity was likely critical prior to dam construction. At a minimum the present levels of connectivity within the transboundary reach should be maintained.

1.4.3 Water Quality

All aquatic organisms require water of sufficient quality to complete their life cycle. Aquatic species may be at risk when water quality degrades beyond specific thresholds for oxygen, temperature, pH, or pollutants. White sturgeon need cool, pollutant-free water. The current provincial water quality guidelines provide general direction for the protection of aquatic life (see http://www.env.gov.bc.ca/wat/wq/wq_guidelines.html#approved for details) and are likely sufficient for describing the general boundaries of required water quality for white sturgeon.

Additional research is needed to determine tolerance limits for other water quality factors affecting various white sturgeon life stages. Specific concerns include treated and untreated municipal and private sewage, and various other industrial and urban discharges, and non-point sources of pollution from agriculture, forestry, and urban areas.

Water Temperature.— One water quality variable for which we have a better understanding is the interaction between temperature and spawn timing. There appears to be a natural mechanism by which spawning is initiated when temperature exceeds a rough threshold. While other factors may have a secondary influence on spawn timing (e.g., flow and photoperiod – see Liebe et al. 2004) temperature appears to have a dominant effect. Threshold temperatures of 14 ºC and 13 ºC have been reported for the Columbia River at Waneta and the Nechako River respectively. Spawning in the Kootenai River occurs at a lower temperature (8.5-12 ºC; Paragamian et al. 2001) as does spawning at the Revelstoke site (10-11 ºC; Golder 2009). In these two latter cases it is challenging to identify such thresholds due to historic anthropogenic changes. For example, it is possible that the fish have a biological threshold that is not reached by the current thermal regime (e.g., Revelstoke spawning site) or are uniquely adapted to a cooler thermal regime (suggested for the Kootenai population). Maximum temperatures may also be a concern, particularly at the Waneta spawning site where spawning has occurred above the 20 ºC level where Wang et al. (1985) indicates that abnormal development may occur.

For all rivers where white sturgeon are undergoing recruitment failure it is important to note that thermal regime alterations are not considered to be the primary cause of recruitment failure, although they may have secondary effects (e.g., Revelstoke – Gregory and Long 2008). The Nechako River is perhaps the best example, since thermal regime would have been affected by flow regulation for 15 years prior to the initiation of recruitment failure (1967). Ongoing monitoring under the current thermal regime indicates that both past and existing thermal regimes were/are not a primary cause of recruitment failure.

The identification of temperature as a single habitat variable where we might be able to identify a preferred habitat attribute creates a challenging position. While it might be seen as desirable to manage temperatures to meet prescriptive temperature targets, it is deemed unlikely that this alone would lead to habitat improvements necessary to restore recruitment. The significant effort that might be expended to do so would also detract from the more important need to restore habitat conditions capable of supporting recruitment. Additionally, water temperature in large rivers is strongly correlated with flow, and any attempts to manage temperature through flow manipulations may have undesirable effects on more important habitat variables, possibly with a net negative impact. Due to the fact that temperature change is likely not the principle cause of recruitment failure, and that management for a single variable in a large river ecosystem will likely create unintended consequences, no specific temperature criteria are proposed at this time. Future consideration of temperature may be required, and if pursued would likely form part of a suite of habitat restoration measures necessary to restore recruitment.

New projects that might have an impact on the thermal regime of any of these rivers would be an exception to the statements above. If new projects are proposed that may affect the thermal regime of these rivers then temperature requirements for white sturgeon should be considered. However, it would be most effective to develop those as site-specific criteria given the potential differences among basins regarding their existing thermal regimes and the possibility of local adaptation.

1.4.4 Diets

Feeding behaviour of white sturgeon is specialized for dark, benthic habitats where prey are often located through direct contact, which is facilitated by highly sensitive taste receptors on barbels near the mouth (Brannon et al. 1985). Juvenile white sturgeon are primarily benthic feeders, feeding on a range of invertebrate and fish species. Diet varies throughout the year and with location depending on availability. Juveniles reportedly eat a variety of aquatic insects, isopods, mysids, clams, snails, small fishes, and fish eggs (Scott and Crossman 1973; McCabe et al. 1993). In the Upper Columbia River, *Mysis relicta*, a non-native pelagic crustacean, is the most common prey item of 1 – 2 year old juveniles (Golder 2006b). Adults feed predominantly on fish, particularly migratory salmonids where available, although crayfish and chironomids are also consumed (Scott and Crossman 1973; Partridge 1980).

CRITICAL HABITAT

Identification and protection of critical habitat are vital for management of species at risk, and are some of the most challenging aspects of species management. Despite their complexity, the core issue is the same for all species: to determine the role of habitat in population limitation, and to answer the question, "How much habitat, and of what type, is required to maintain viable populations of the species?"

The term "critical habitat" has a specific and legal meaning for SARA-listed species. It is:

"…the habitat that is necessary for the survival or recovery of a listed wildlife species and that is identified as the species' critical habitat in a recovery strategy or in an action plan for the species." [s. 2(1)]

In the absence of formal SARA policy on critical habitat identification a series of tools were used to complement the legal definition and guide discussions:

- Rosenfeld and Hatfield (2006) suggest several practical working definitions that provide general guidance and screening criteria for evaluating candidate critical habitats.
    - **Habitat that is disproportionately important.** The litmus test is whether loss of a particular habitat unit will result in significant population level effects for a population at the abundance level of the recovery target. This emphasizes prioritization of habitat protection based on the population consequences of habitat loss or gain, with the understanding that if a particular habitat unit can be lost without population level effects, it is unlikely to be critical.
    - **The minimum subset of habitats required for a species or population to persist.** This emphasizes that the default objective may not be to protect the entire range of a species, and that for some species different configurations or subsets of habitat of varying quality may ensure species persistence.
    - **Habitats that are necessary to maintain ecosystem integrity and function.** This emphasizes that discrete habitat patches must function "properly," and processes that influence habitat quality must be maintained (e.g., river flooding, riparian buffer, etc.). This may result in expanding the suite of candidate critical habitats to include habitats that are essential for *maintaining* core critical habitat. For example, riparian areas affect instream habitat qualities (e.g., shading, erosion, LWD recruitment); even though fish do not directly inhabit these areas, portions or aspects of riparian area should be considered within the definition of critical habitat.
- Draft DFO Guidelines for the Identification of Critical Habitat for Aquatic Species outlines that critical habitat will be identified as a geospatial area denoting coordinates on a map and

characterized by its important biophysical features. The features of critical habitat are biological, physical and chemical in nature that are essential to the healthy functioning of the critical habitat. Identification of these features needs to take into account functionality of the critical habitat over various life stages and movements of the species.

The geospatial or biophysical features of critical habitat can include; riparian vegetation; areas not presently occupied, or degraded, but required for recovery; the availability of food supply, water depth or flow, physical structures or substrate (i.e., for cover, spawning, rearing and forage activities); etc.

- The DFO Science document, Documenting Habitat Use of Species at Risk and Quantifying Habitat Quality (DFO 2007), suggests a series of guiding principles to consider when trying to determine critical habitat for a species at risk.
    - Provide functional descriptions of the features or attributes that a species' aquatic habitat must have to allow successful completion of all life history stages.
    - Provide information on the spatial extent of the areas that are likely to have the necessary features or attributes.
    - Provide advice on how much habitat of various qualities / properties exists at present.
    - Provide advice on the degree to which supply of suitable habitat meets the demands of the species both at present, and when the species reaches biologically based recovery targets for abundance, range, and number of populations.
    - Provide advice on the extent to which various threats can alter the quality and/or quantity of habitat that is available.
    - Provide advice on feasibility of restoring habitat to higher values, if supply may not meet demand by the time recovery targets would be reached.

All of this advice was considered in order to identify, to the extent possible, based on the best available information, the habitat necessary for survival or recovery of white sturgeon, the features of that habitat, the life stages it supports and any threats to that habitat.

1.5 GENERAL APPROACH

A reasonable approach to determine critical habitat for a species at risk is to consider the amount and type of habitat required for the species to meet and maintain its recovery target, an approach supported by existing guidance including Rosenfeld and Hatfield (2006) and recent DFO guidance documents (DFO 2007, DFO 2007b). At present it is not possible to complete a quantitative relationship between habitat and population size primarily because white sturgeon in each of the SARA-listed stocks are at very low abundance.

Instead, we assumed that areas of present high use are de facto critical habitat at current population levels. As populations expand toward target recovery levels additional critical habitats will likely need to be added to the set of habitats identified here. To the extent feasible, critical habitat definitions were based on habitat associations developed from detailed empirical work. Where detailed studies were lacking or inconclusive we relied on expert opinion and application of a precautionary approach, as described in SARA and DFO guidance documents (e.g., DFO 2007, draft DFO policy). The precautionary approach recognizes that the absence of full scientific certainty shall not be used as a reason for postponing decisions where there is a risk of serious or irreversible harm. This approach allowed critical habitat definitions to be developed for less-well studied populations such as the Upper Fraser River and for early life stages in areas currently afflicted by recruitment failure.

We continue to believe that the priority for recovery efforts should be on resolving recruitment failure in each of the dam-affected populations. Identification of additional critical habitats is a task that will be addressed with future studies as recovery efforts proceed.

1.6 CRITICAL VS. IMPORTANT HABITAT

Identifying critical habitat requires a judgment to be made on the extent to which habitat contributes to a species' survival or recovery. In this document we also identify “important habitat,” which is suspected to contain critical habitat, but for which existing knowledge is inadequate to meet the burden of proof, as set by the Recovery Team, to designate critical habitat. The distinction between critical and important thus rests entirely on that burden of proof: both habitats are believed to be necessary to the survival or recovery of the species, but the degree of certainty is considerably lower for habitats that we define as important. The purpose of identifying important habitat in addition to critical habitat is twofold: to recognize that full recovery of white sturgeon requires management of a larger set of geographic locations than will be designated as critical habitat at this time, and more specifically, to highlight geographic locations that are likely to be identified, at least in part, as critical habitat in the light of future information. We believe that this information will be useful to habitat managers who must make decisions in the face of incomplete information.

1.7 PROCESS

Providing information on critical habitat was a separate and discrete task during development of the Recovery Strategy. The White Sturgeon Recovery Team is made up of a number of regional technical and community working groups, with representation on the National Technical Coordinating Committee. In 2007, members of the Committee were tasked with leading the regional groups through a process to collate and evaluate relevant existing information on critical habitat. Matt Neufeld (Ministry of Environment) led the process for the Kootenay River; Colin Spence (Ministry of Environment) led the process for the Columbia River; and Cory Williamson (Ministry of Environment) led the process for the Nechako and Upper Fraser Rivers. They were supported in this role by other Committee members. The basin-specific groups were tasked with determining candidate critical habitats and recommending critical habitats. They were asked to document sources of information, methods by which information was collected, reliability of the information, and descriptions of data gaps. In 2008, this process was repeated to capture new information and analyses. By this time, Gary Birch (BC Hydro) was the chair of the Columbia River group. The results of these basin-specific discussions are provided in the following sections. All background information in this document was assembled during development of a SARA-compliant Recovery Strategy for white sturgeon, or basin-specific recovery or conservation plans.

During their assessment of information related to habitat use, each team was asked to categorize the degree of habitat use (high, medium, low) and their overall level of certainty (confirmed use, suspected, unknown), based on abundance and frequency of use. The groups were not given definitions of these terms, but were able to categorize habitat use using the terms. In assessing habitat use the relative size of the population or group of fish using the area was considered. Since different expert groups have assessed habitat use for each population using their own understanding of these terms, caution is warranted when making comparisons among watersheds.

The process used to identify important habitat for white sturgeon was identical to that used to identify critical habitat, with the additional distinction that the basin teams were asked to assess the burden of proof and assign habitats to one of three categories: critical, important, and other.

Important habitats of each life stage are discussed and data gaps and data sources are presented.

In addition to deciding which habitats are critical and important the basin teams were required to provide help in defining the boundaries of these habitats. There is inevitably some subjectivity associated with this task, but it was based on consideration of the available scientific information. The elevational boundary of critical and important habitats was limited to the annual high water mark. All boundaries were demarcated on maps.

The recovery team sought consensus throughout the process of identifying important and critical habitats, and in almost all cases was able to reach consensus on recommendations. However, the recovery team was not able to reach consensus on three locations for the Columbia population, specifically the spawning site adjacent to the Revelstoke Golf Course, and two rearing, feeding areas in the lower Kootenay River downstream of Brilliant Dam, the Brilliant Tailrace and Bridge Hole. The available information on these sites is included in this document, but the views of what that information means differs. As the responsible agency DFO assessed the information and the views and made a precautionary determination designating these areas as critical habitat.

POPULATION TARGETS

In developing population recovery targets, the Recovery Strategy focuses on abundance and population growth rate. An interim abundance target of 1000 mature individuals is proposed for each of the four SARA-listed populations of white sturgeon, where mature is defined as 25 years of age and older. Based on the available scientific literature (reviewed in the Recovery Strategy) this target is believed sufficient to meet abundance criteria to offset threats from demographic, environmental and genetic stochasticity over the next 100 years provided abundance is rebuilding. The long term objective is to have all populations self-supporting, but conservation aquaculture is required in some instances as an interim measure. At present there is insufficient information to conduct a full-blown population viability analysis for any of the white sturgeon populations in Canada; these targets are therefore deemed interim over the next 10 years.

The targets are above current abundance and growth rates in the SARA-listed populations. As critical habitat must include habitat required for recovery this information was used to ensure designations were reasonable and conservative. Current population abundance is presented in Table 1 as context for the recovery targets; population trends are discussed in the Recovery Strategy and in Ptolemy and Vennesland (2003).

Table 1. Abundance estimates for mature (>160 cm) white sturgeon in British Columbia. Estimates for populations with recruitment failure (Nechako, Kootenay, and Columbia) have been updated to 2009 levels using assumed annual survival rates. Fraser River populations are assumed to be relatively stable, and therefore approximately accurate for 2009.

Population or Component	**Number of mature fish in 2009**	**Reference for uncorrected abundance estimate**
Lower Fraser	9316	Nelson et al. 2009
Mid Fraser	749	RL&L 2000a
Upper Fraser	185	Yarmish and Toth 2002
Nechako	360 [1]	RL&L 2000a
Columbia [2]:		
Columbia above HLK	44 [3]	Golder 2006a
Columbia between HLK and Canada-US border	814 [4]	Irvine et al. 2007
Columbia below border to Roosevelt Reservoir	1420 [5]	Howell and McLellan 2007a, b
Kootenay	526 [6]	Paragamian et al. 2005
total in Canada	11796 [7]	

[1] Assumes 95% of uncorrected estimate are mature, with 96 % annual survival to 2009. There are no adult survival estimates specific to the Nechako River population; this assumed survival value is taken from Whitlock (2007) and Irvine et al. (2007).

[2] These 3 groups of sturgeon are components of the same listed population but are currently studied separately and therefore abundances are presented here separately. Population substructuring within the Columbia River is currently being investigated.

[3] Population estimated at 52 in 2003 and is projected for 2008 based on a 96% survival rate per year.

[4] The uncorrected abundance estimate is for the year 2003 and combines separate estimates for two river sections from HLK to the US border. The 2009 estimate assumes 90% are mature, with a mean annual survival rate of 96%; this survival estimate is from Irvine et al. 2007 and Whitlock 2007. Abundance estimates are for wild (i.e., naturally produced) fish.

[5] Assumes 70% of the uncorrected abundance estimate from 2006 are mature, with 96% annual survival to 2008 (Howell and McLellan 2007a, b). The survival estimate is from Irvine et al. (2007) and Whitlock (2007).

[6] Assumes 95% of uncorrected estimate are mature, and a 96% annual survival to 2006.

[7] Total in Canada excludes Columbia below border to Roosevelt Reservoir since these fish reside predominantly in the US.

IMPORTANT AND CRITICAL HABITATS

In the following sections, critical and important habitats of each life stage are discussed and identified, where possible. Threats to these habitats, data gaps and data sources are also presented. Maps of critical habitat areas are provided for each watershed, with each map indicating boundaries of the critical habitat units.

1.8 UPPER FRASER

Knowledge of habitat use for the Upper Fraser white sturgeon population is more limited than for other populations. Although a variety of studies have been completed showing habitat associations based on capture rates, no telemetry work has been conducted, and no spawning sites have been confirmed at this time. High use habitats have been identified for juvenile rearing and feeding, adult holding and feeding, and adult overwintering life stages. This information is summarized in Table 2. As additional information is collected, it will become possible to identify other habitats and to make additional recommendation for designating critical habitat.

Two of the locations identified (Red Rock and Cottonwood Canyon) are downstream of the Nechako-Fraser confluence, and therefore in an area of overlap between the Upper Fraser population and the mid-Fraser population. These areas are identified as critical and important respectively, based solely on their influence on the Upper Fraser population.

Table 2. Summary of information base for white sturgeon habitats in the Upper Fraser River.

Area	Confirmed (√), Suspected (S), or Unknown (?) Use by Life Stage and Degree of Use (H=High, M=Moderate, L=Low)					
	Spawn	free embryo larvae & early juvenile	Juvenile (> 2yrs)	Adult	Winter	Overall Assessment
Penny	?	?	(√) H	(√) H	(√) H	Critical
Grand Canyon (Longworth)	(S)M	?	(√) H	(√) H	(√) H	Critical
Bowron River confluence	(S)H	?	(√) H	(√) H	(S)H	Critical
McGregor River to Limestone Creek	?	?	(√) H	(√) H	(√) H	Critical
Giscome/Tay Creek	?	?	(√) H	(√) H	(S)H	Critical
Willow River confluence	(S)M	?	(√) H	(√) H	(√) H	Critical
Salmon River confluence	?	?	(√) H	(√) H	(√) H	Critical
Nechako River confluence	(S)M	?	(√) H	(√) H	(S)H	Critical
Red Rock	(S)H	?	(√) H	(√) H	(S)H	Critical
Longworth – Crescent Spur	?	?	(√) M	(√) M	(S)M	Important
Sinclair Mills	?	?	(√) M	(√) M	(S)M	Important
Shelley	?	?	(√) M	(√) M	(S)M	Important
Torpy River confluence	?	?	(√) M	(√) M	(S)M	Important
Slim Creek confluence	?	?	?	(√) M	(S)M	Important
Blackwater River confluence	?	?	?	(√) M	(S)M	Important
Cottonwood Canyon	(S)M	?	?	(√) M	(√) M	Important

1.8.1 Spawning and Incubation Habitat

Spawning has not been observed in the Upper Fraser River, although spawning and subsequent recruitment clearly occurs because all evidence indicates the population is stable and self-sustaining. Based on habitat characteristics, life history timing and habitat use data several likely spawning sites have been identified. Following a precautionary approach these habitats have been recommended as critical. In all cases these habitats have also been recommended as critical for other life stages. Spawning and incubation critical habitats include:

- Bowron River confluence
- Red Rock
- Longworth Canyon
- Willow River confluence
- Nechako River confluence
- Cottonwood Canyon

The Bowron River confluence and Red Rock sites are both rated as high use habitats. All other locations are rated as moderate use.

1.8.2 Free Embryo, Larval and Early Juvenile Habitat

No data exist for free embryo, larval and early juvenile life stages in the Upper Fraser River. At this time uncertainty is too high to identify critical and important habitats for these life stages. However, habitats are likely in similar locations to spawning, which provides some assurance that appropriate habitats would be protected if spawning habitats are identified.

1.8.3 Late Juvenile and Adult Habitat

Considerably more information is available for late juveniles and adults than for any other life stage. A variety of high value habitats have been identified due to presence of adults and juveniles during multiple sampling periods and limiting habitat types such as deep pools and eddies. The following locations have been identified as critical habitats.

- Penny
- Grand Canyon (Longworth)
- Bowron River confluence
- McGregor River to Limestone Creek
- Giscome/Tay Creek
- Willow River confluence
- Salmon River confluence
- Nechako River confluence
- Red Rock

Additional locations have been identified as important habitats (Table 2).

1.8.4 Critical Habitat Attributes and Timing

This section provides a compilation of all geographic locations that are proposed as critical and important, and provides the attributes of these areas that make them critical to white sturgeon. Also provided is the time of year that different life stages use the habitat. The summary is provided in Table 3.

Table 3. Summary of attributes and timing for Upper Fraser white sturgeon critical habitats.

Location	Definition	Attributes & Rationale	Life Stages and Timing
Penny	Critical	This site is believed to provide good rearing and feeding opportunities for adults and juveniles, and good overwintering habitat.	• late juvenile (√), all year • adult (√), all year • winter (√), Oct - May • composite timing: all year
Grand Canyon (Longworth)	Critical	This site is believed to have high rearing potential. It provides essential rearing and feeding habitat, particularly for juveniles. Overwintering potential is also high due to deep pools, riffles and eddies that provide depositional areas for food. Capture records from October and telemetry records from November and May suggest overwintering. Spawning potential is thought to be moderate, although no spawning has been confirmed here.	• spawning (S), initiated mid-summer when daily mean temperature is 12 - 14º C • late juvenile (√), all year • adult (√), all year • winter (√), Oct - May • composite timing: all year
Bowron River confluence	Critical	Juveniles and adults have been caught here, and rearing potential is believed to be high. The site is thought to provide essential rearing and feeding habitat for both juvenile and adult fish. Overwintering potential is believed to be high due to presence of deep pools, riffles and eddies that provide overwintering habitat and depositional areas for food. Spawning potential is high due to many capture records from July which is the time when staging and spawning are likely to occur. Timing of the captures suggests site could be a staging area prior to spawning.	• spawning (S), initiated mid-summer when daily mean temperature is 12 - 14º C • late juvenile (√), all year • adult (√), all year • winter (√), Oct - May • composite timing: all year
McGregor River to Limestone Creek	Critical	Juveniles and adults have been caught at this site, including one Nechako fish. Rearing potential is high and the site likely provides good rearing and feeding habitat for juvenile and adult fish. Overwintering potential is high: fish were captured in mid-October when it is likely that they would have moved to overwintering locations. In addition, telemetry records show fish in the area in mid-November. Spawning potential is unknown.	• late juvenile (√), all year • adult (√), all year • winter (√), Oct - May • composite timing: all year
Giscome/Tay Creek	Critical	Only juveniles have been caught at this site. One fish that was not aged but assumed to be an adult based on size was also captured. Rearing potential is high. Primarily juveniles have been captured at this site, which suggests good rearing and feeding habitat specifically for that life stage. The habitat may not be as suitable for larger fish. Overwintering potential is high, but the site has not been sampled later than September 11. The consistent presence of juveniles in early fall suggests that this location provides overwintering habitat. The presence of tributaries and eddies suggests the site likely provides suitable food and habitat conditions. Spawning potential is unknown.	• late juvenile (√), all year • adult (√), all year • winter (S), Oct - May • composite timing: all year

Location	Definition	Attributes & Rationale	Life Stages and Timing
Willow River confluence	Critical	Juveniles and adults have been caught at this location. Rearing potential is high, and the site likely provides good rearing and feeding habitat for both juvenile and adult fish. Overwintering potential is high: fish have been captured in mid-October when it is likely that they would have moved to overwintering locations. Spawning potential is moderate. Two adult sized fish were captured on July 1, 2001, which is the approximate time that spawning occurs.	• spawning (S), mid-summer when daily mean temperature is 12 - 14º C • late juvenile (√), all year • adult (√), all year • winter (√), Oct - May • composite timing: all year
Salmon River confluence	Critical	There is high potential for the lower section of Salmon River to be utilized, and a number of fish were captured in the Fraser River near the confluence. Juveniles and adults have been caught here. Rearing potential is high, and the site likely provides good rearing and feeding habitat for both juvenile and adult fish. Overwintering potential is high: fish were captured in October when it is likely that they would have moved to overwintering locations. Spawning potential is unknown.	• late juvenile (√), all year • adult (√), all year • winter (√), Oct - May • composite timing: all year
Nechako River confluence	Critical	Juveniles and adults have been caught at this location. Rearing potential is high, and the site likely provides good rearing and feeding habitat for both juvenile and adult fish. Overwintering potential is high due to deep holes and eddies. Nechako River at the confluence is broad and shallow and unlikely to provide overwintering. Spawning potential is moderate. The Nechako stock likely spawns in the Nechako earlier in the summer (mid May – early June) due to warmer water temperatures in that system.	• spawning (S), mid-summer when daily mean temperature is 12 - 14º C • late juvenile (√), all year • adult (√), all year • winter (S), Oct - May • composite timing: all year
Red Rock	Critical	Juveniles and adults have been caught at this location. Rearing potential is high, as the site likely provides good rearing and feeding habitat for juvenile and adult fish. Overwintering potential is high due to deep holes and eddies. Spawning potential is high: telemetry records show potentially ripe female fish in the area during May and July, which is the period when fish could be staging and/or spawning.	• spawning (S), mid-summer when daily mean temperature is 12 - 14º C • late juvenile (√), all year • adult (√), all year • winter (S), Oct - May • composite timing: all year
Longworth – Crescent Spur	Important	This site is believed to have high rearing potential, due to presence of eddies and pools throughout. These features suggest the site likely provides good rearing and feeding opportunities for both adults and juveniles. Spawning potential is unknown, but there are some islands and side channels present, which are similar to confirmed spawning areas in the Nechako. Overwintering potential is high due to presence of large bends and steep banks, which suggest deep pools are present.	• late juvenile (√), all year • adult (√), all year • winter (S), Oct - May • composite timing: all year

Location	Definition	Attributes & Rationale	Life Stages and Timing
Sinclair Mills	Important	Juveniles and adults have been caught here, and rearing potential is thought to be high. The presence of juveniles suggests good rearing and feeding opportunities. Overwintering potential is also thought to be high, due to the presences of large bends and rock cliffs, which suggest deep pools are present. Spawning potential is unknown.	• late juvenile (√), all year • adult (√), all year • winter (S), Oct - May • composite timing: all year
Shelley	Important	Juveniles have been caught here, plus one adult. Rearing potential is high. The site likely provides good rearing and feeding habitat for juveniles but may be less suitable for large adult fish. Overwintering potential is high: the presence of steep cutbanks suggests deep holes and eddies likely provide suitable overwintering habitat. Spawning potential is unknown.	• late juvenile (√), all year • adult (√), all year • winter (S), Oct - May • composite timing: all year
Torpy River confluence	Important	Juvenile and adult rearing potential is high, and the site likely provides good rearing and feeding opportunities. Fish were captured at Torpy confluence or downstream suggesting it may be a source of food. Sampling records note an eddy in that location which may result in an accumulation of food in that area. Overwintering potential is high due to presence of an outside bend downstream of Torpy confluence, likely with sufficient depth. Presence of eddy would result in accumulation and deposition of food. Spawning potential is unknown.	• late juvenile (√), all year • adult (√), all year • winter (S), Oct - May • composite timing: all year
Slim Creek confluence	Important	This site has moderate rearing potential, with good rearing and feeding opportunities. Patricia Creek confluence may provide a source of food. Presence of fish in September but not August suggests usage may be limited or associated with availability of food. Overwintering potential is thought to be moderate, and the presence of adult fish in September suggests overwintering may occur at the site or in the vicinity. Spawning potential is unknown.	• adult (√), all year • winter (S), Oct - May • composite timing: all year
Blackwater River confluence	Important	Adults have been caught at this location. Rearing potential is moderate. The site likely provides good rearing and feeding habitat, however sampling has occurred in only one period. Overwintering potential is moderate due to eddies and potential for deep holes. Spawning potential is unknown: there is no telemetry or sampling data from period when spawning is assumed to occur.	• adult (√), all year • winter (S), Oct - May • composite timing: all year
Cottonwood Canyon	Important	Telemetry records show that this site is used by Nechako and upper/mid Fraser fish. Adults have been caught or observed at this location. Rearing potential is high. The site likely provides good rearing and feeding habitat for adult fish. Overwintering potential is high. Telemetry records from March and November and captures from April suggest the site does provide overwintering habitat. Spawning potential is moderate. Records include observations in July and August during the spawning period, and the August capture was assessed as a ripe female.	• spawning (S), mid-summer when daily mean temperature is 12 - 14º C • adult (√), all year • winter (√), Oct - May • composite timing: all year

1.8.5 <u>Activities Likely to Impact Critical Habitat</u>

Activities that could impact critical habitat include river regulation, instream activities such as gravel or sand dredging, linear developments, riparian, alterations or developments to instream or adjacent habitats, upstream land and water uses, and point and non-point source effluent discharges. These activities have been briefly reviewed and their threats prioritized by the basin-level recovery team (Table 4). Threats to white sturgeon and their habitats are discussed in more detail in Section 3 of the Recovery Strategy.

Table 4. Activities that may impact Upper Fraser white sturgeon critical habitat.

Impact Categories	Examples of Activities	Mechanism	Risk – Consequence (if it occurs)	Risk – Likelihood (that it will occur)	Uncertainty
Loss of habitat quantity and quality and fragmentation	▪ Instream works ▪ Land development ▪ Introduction of invasive species	▪ Physical removal of habitats ▪ Sedimentation ▪ Dewatering ▪ Render habitats unsuitable for use	Spawning and incubation – High Feeding - Moderate	Low – physical works in CH Moderate - sediment Low – altered flow	High uncertainty Impacts of invasive species not well understood
Altered hydrograph components	▪ Pine Beetle Deforestation	▪ Temperature change ▪ Productivity change ▪ Habitat availability & suitability	Spawning – High Feeding – Moderate Juveniles - High	Moderate	Very high uncertainty due to limited habitat information Impacts not fully understood
Pollution	▪ Non-point and point source discharges	▪ Deposition of substances ▪ Precludes use of habitat ▪ Damages food supply	High all life stages	Low	Low for ongoing discharges Spill event frequency and magnitude cannot be predicted
Alteration to food supply	▪ Fishing ▪ Invasive Species	▪ Lowering functionality of feeding areas impacting fitness of fish	Moderate	Low	High uncertainty on this threat; impacts to population.
Climate change	▪ n/a at local level	▪ Temperature change ▪ Productivity change ▪ Habitat availability & suitability ▪ Dewatering	Moderate to High	Moderate	Uncertainty very high Compounded by pine beetle deforestation

1.8.6 Data Gaps

There are substantial data gaps for this population. For example, no direct information exists on which habitats are used for spawning and incubation, and relatively little information exists on habitat use in general. Additional information is required to improve confidence in the determinations provided here, including the numbers of fish using these sites, the seasonality of habitat use, and the relative importance of other habitats. Although there are substantial data gaps in the life history and habitat use of white sturgeon in the Upper Fraser River, it is assumed that critical habitats for later life stages will provide the necessary functions for other life stages also.

1.8.7 Maps of Critical Habitat

Figure 4. Reference map for locations of Upper Fraser white sturgeon critical habitats.

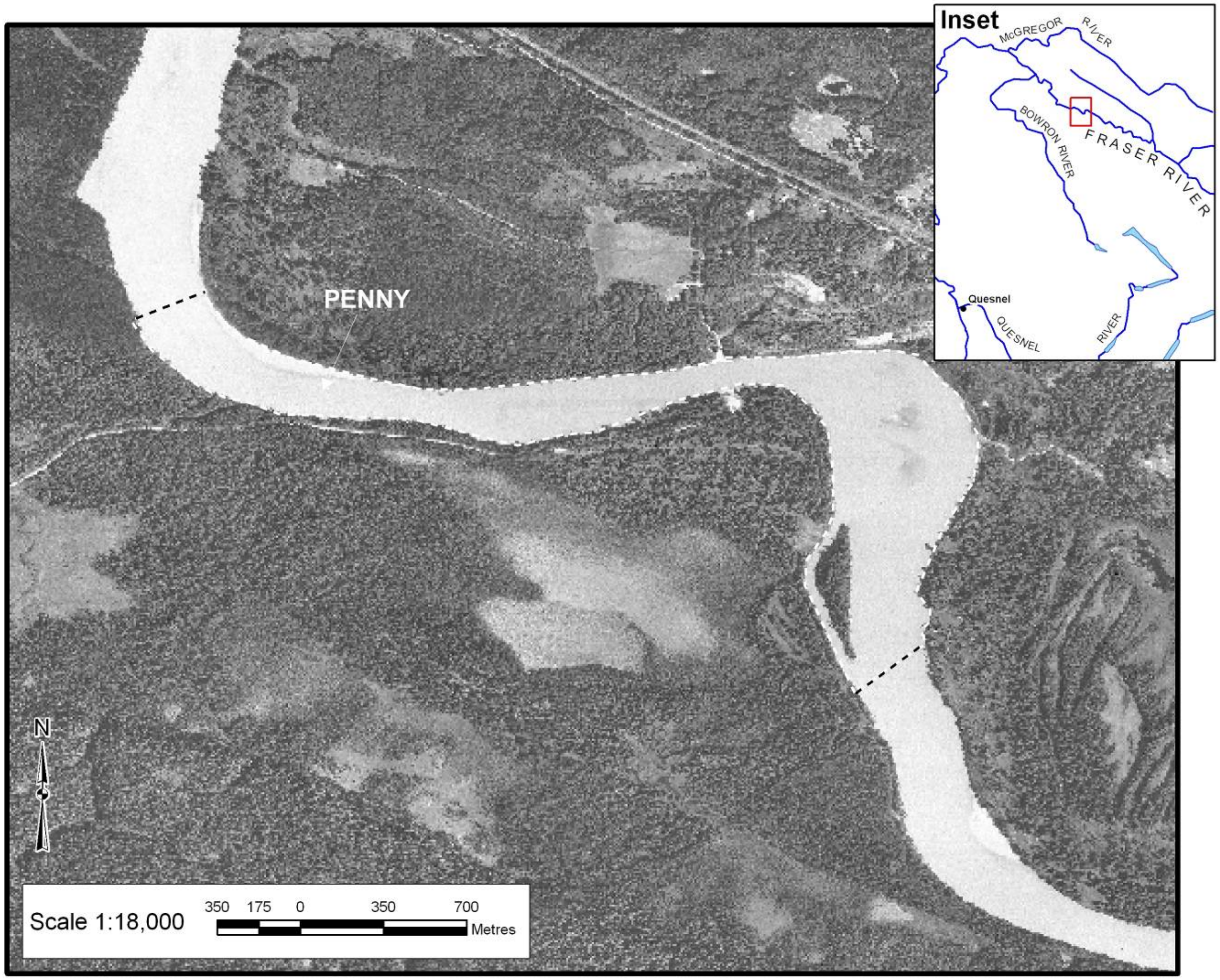

Figure 5. Map of critical habitat for Upper Fraser white sturgeon: Penny site.

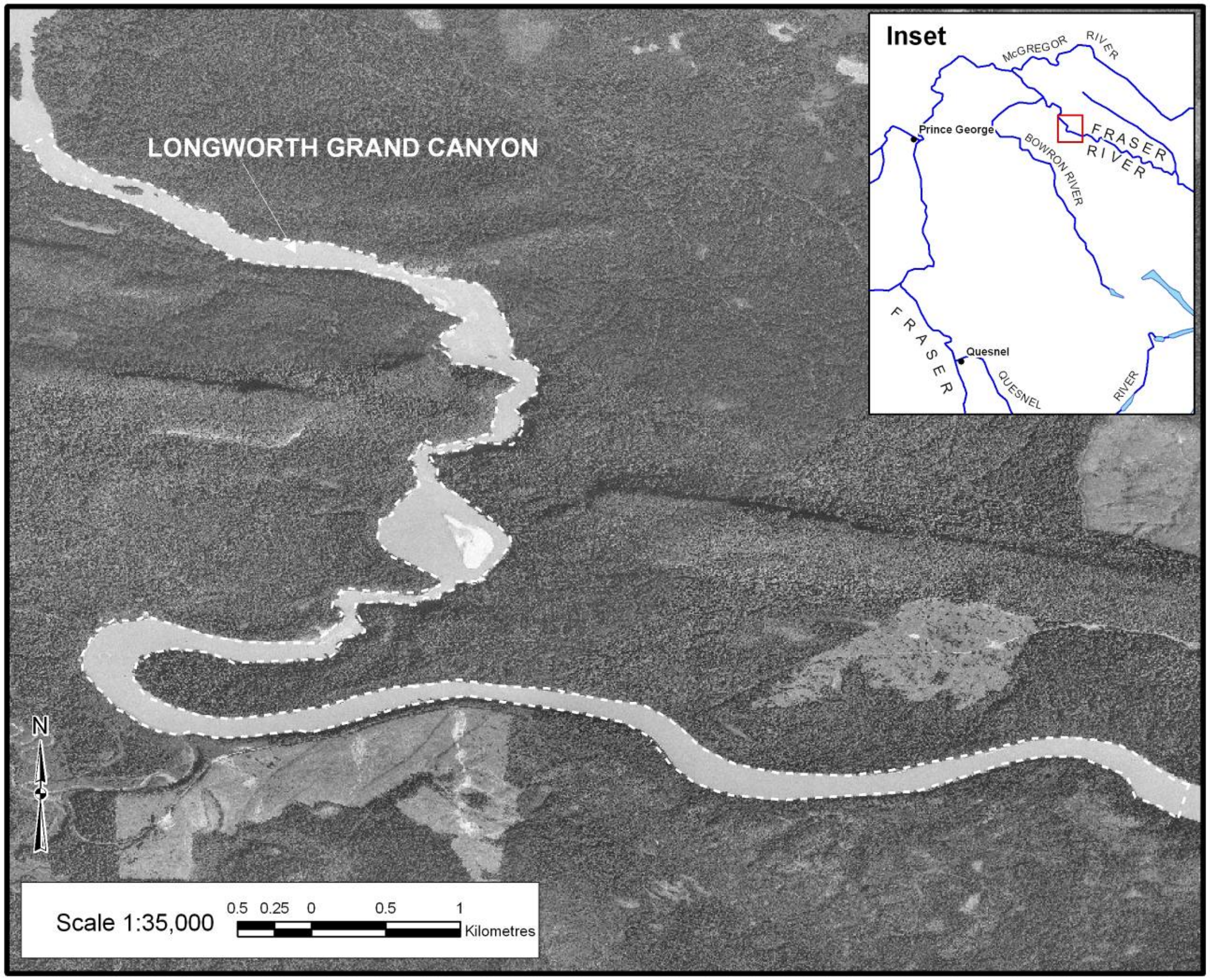

Figure 6. Map of critical habitat for Upper Fraser white sturgeon: Longworth Grand Canyon.

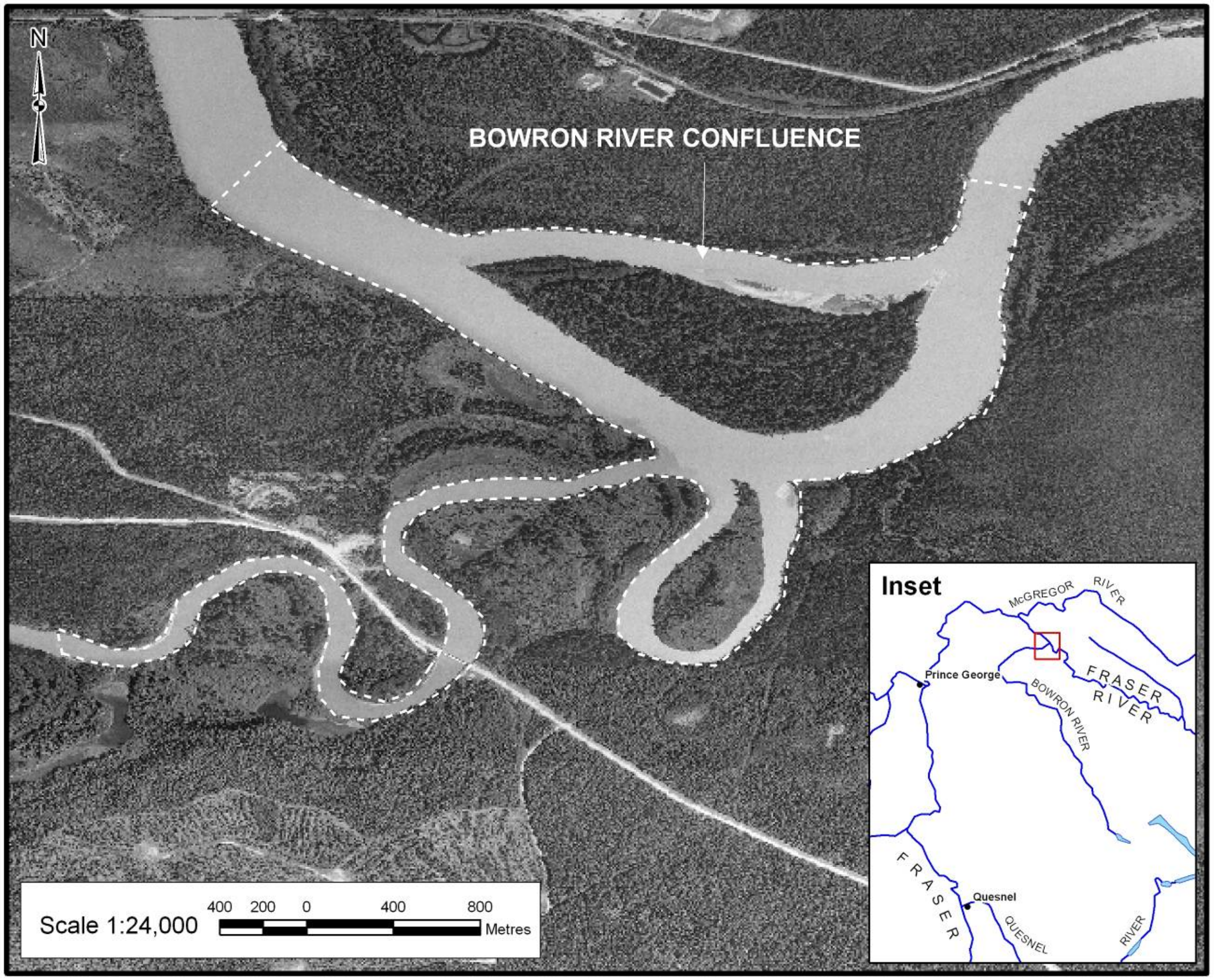

Figure 7. Map of critical habitat for Upper Fraser white sturgeon: Bowron River confluence with the Fraser River.

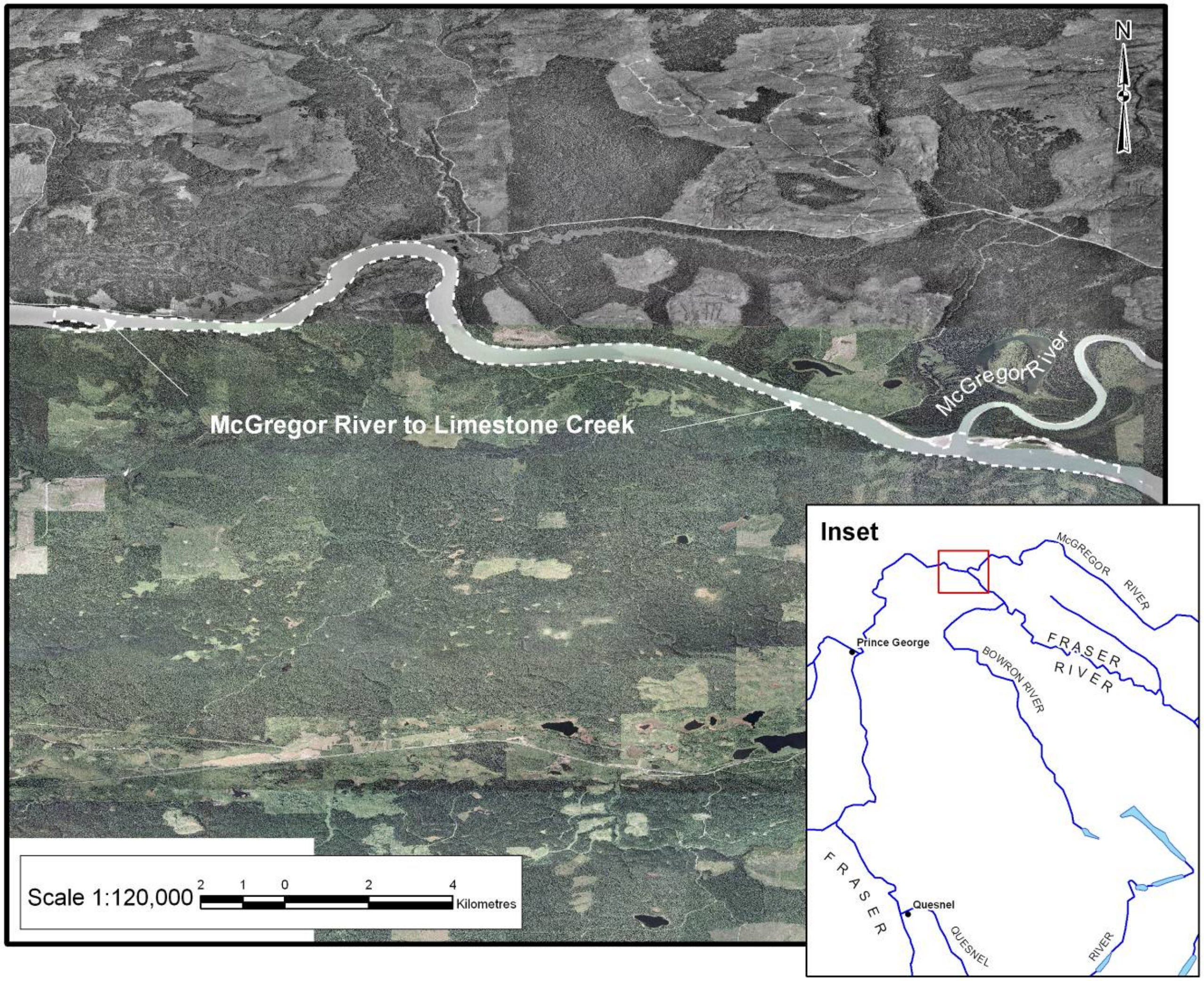

Figure 8. Map of critical habitat for Upper Fraser white sturgeon: McGregor River confluence with the Fraser River to Limestone Creek confluence.

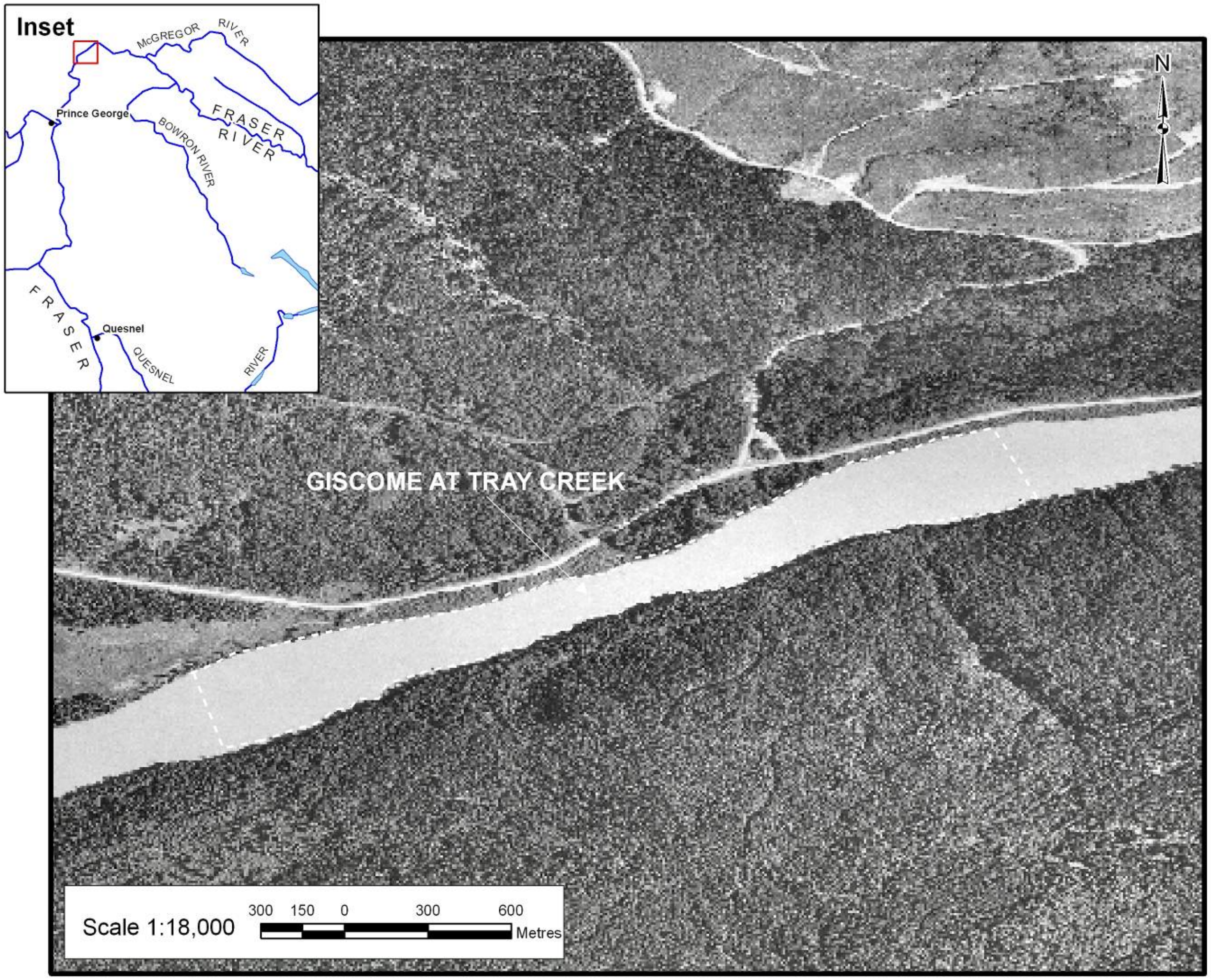

Figure 9. Map of critical habitat for Upper Fraser white sturgeon: Giscome at Tay Creek.

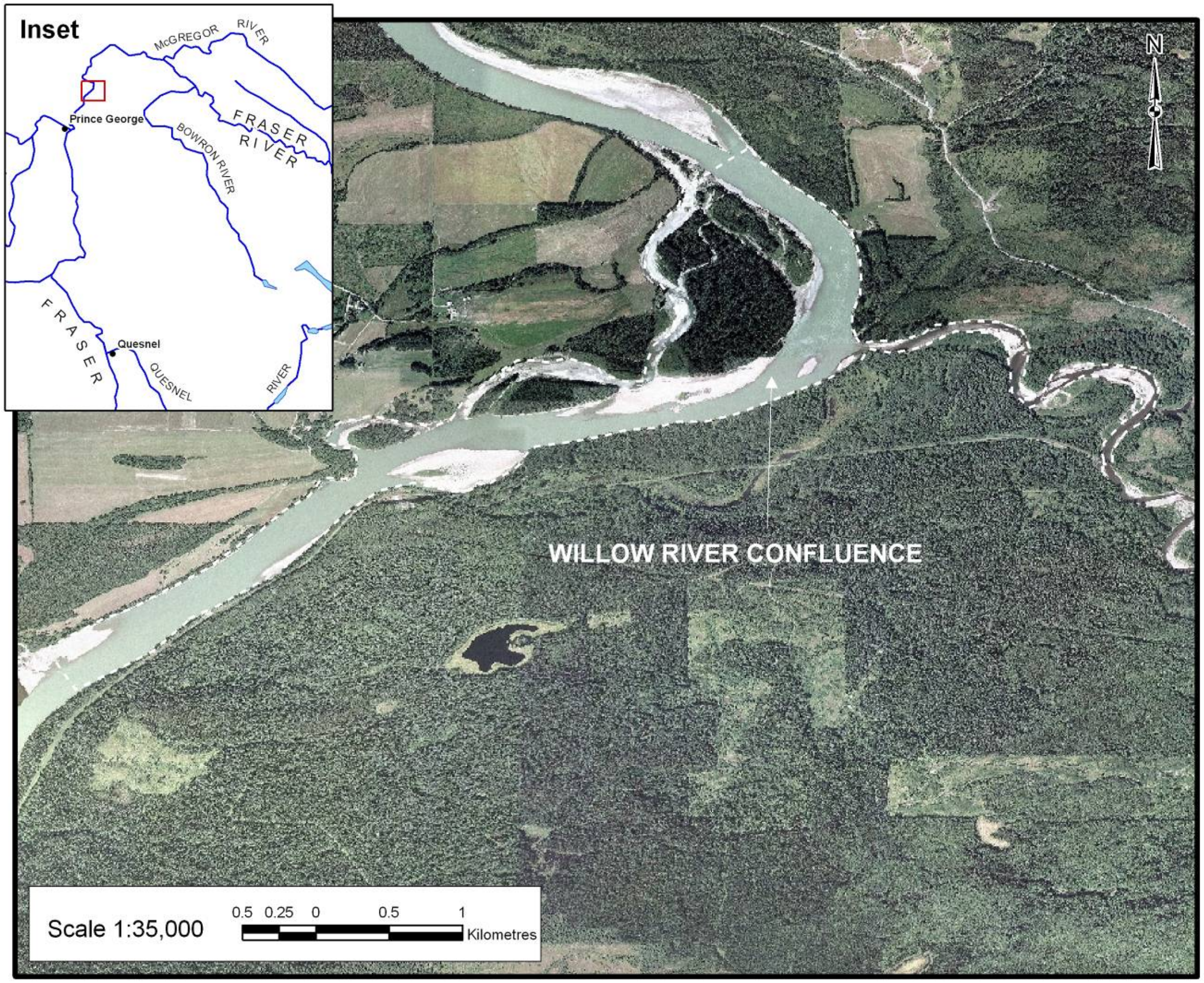

Figure 10. Map of critical habitat for Upper Fraser white sturgeon: Willow River confluence with the Fraser River.

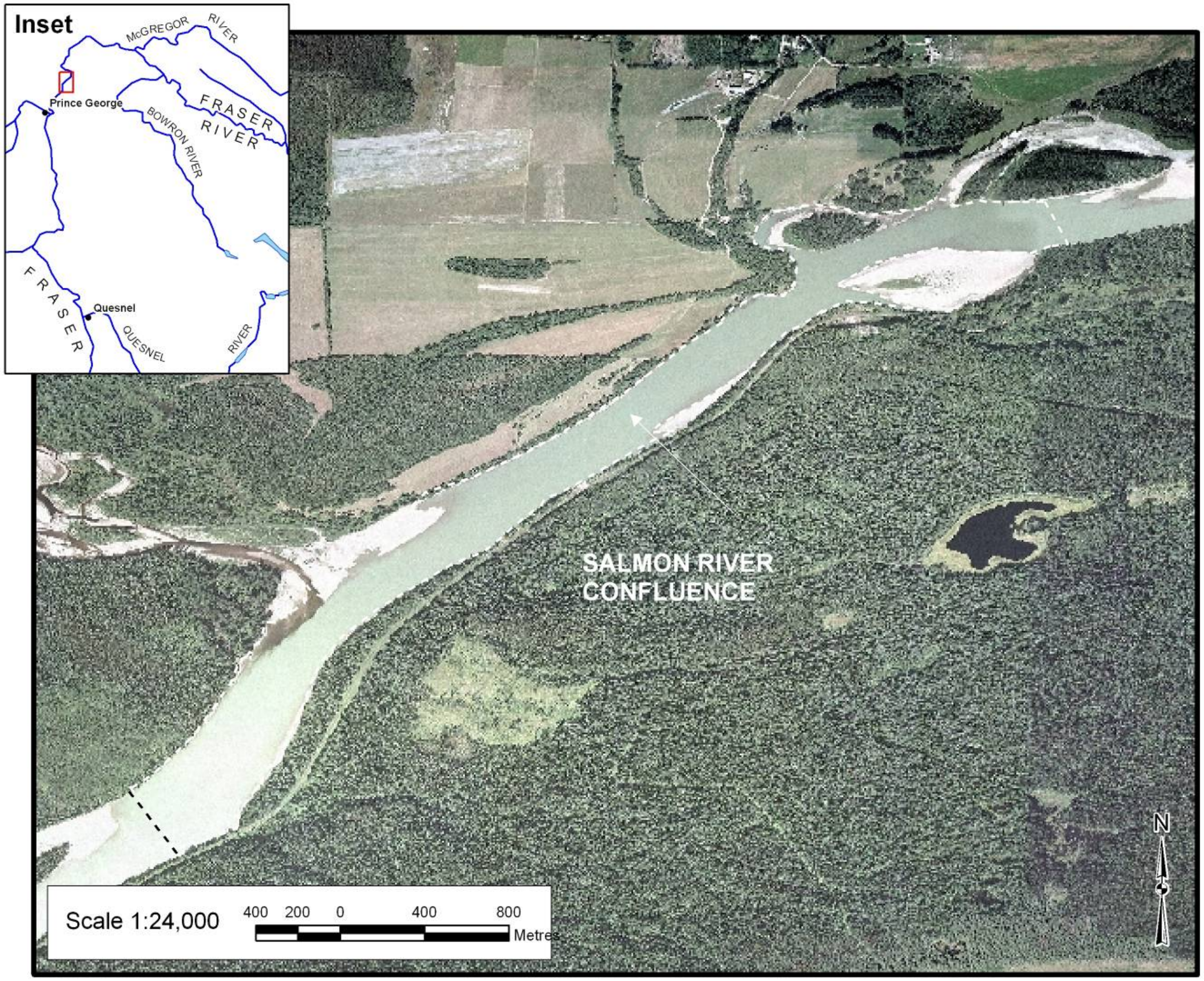

Figure 11. Map of critical habitat for Upper Fraser white sturgeon: Salmon River confluence with the Fraser River.

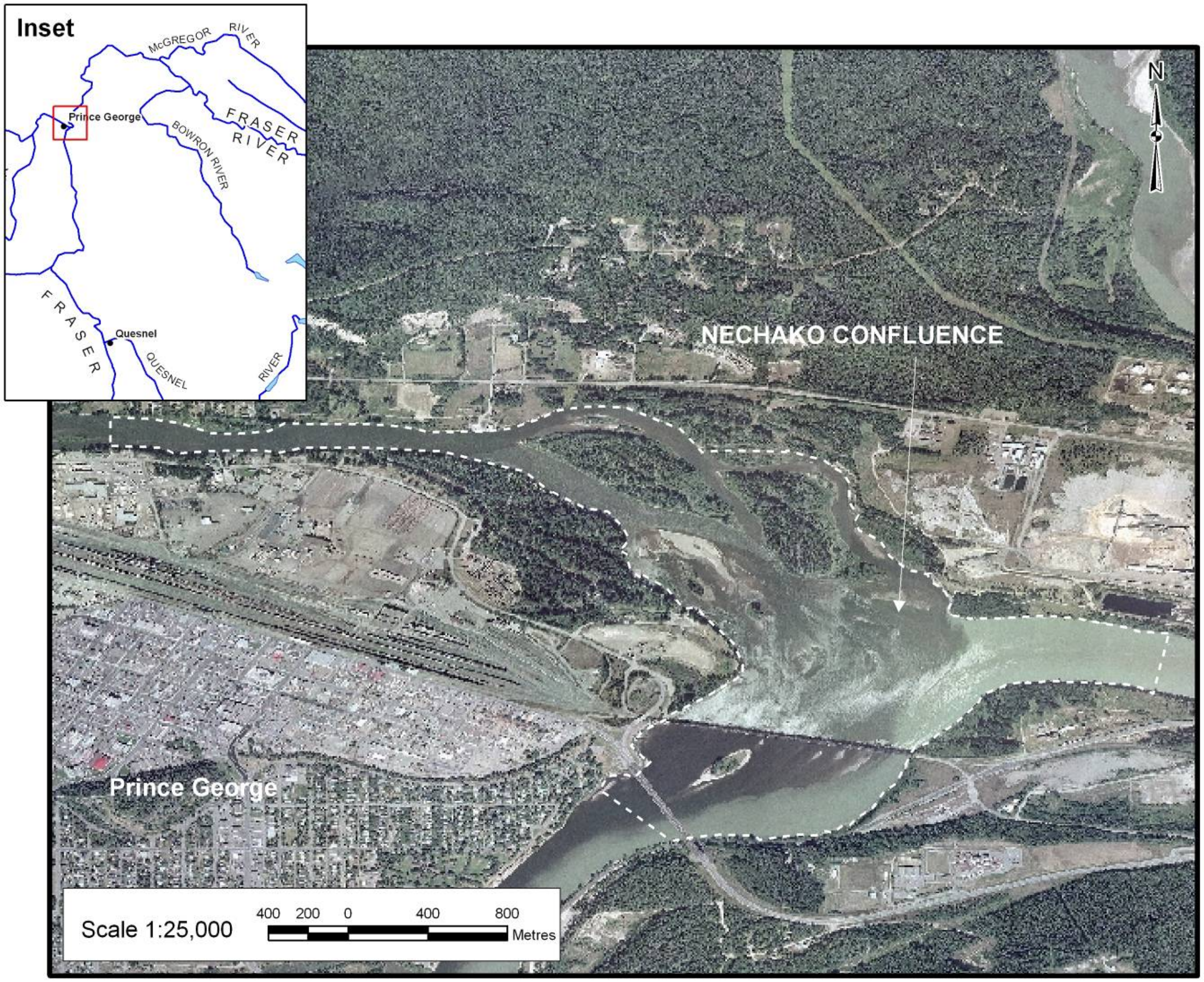

Figure 12. Map of critical habitat for Upper Fraser white sturgeon: Nechako River confluence with the Fraser River.

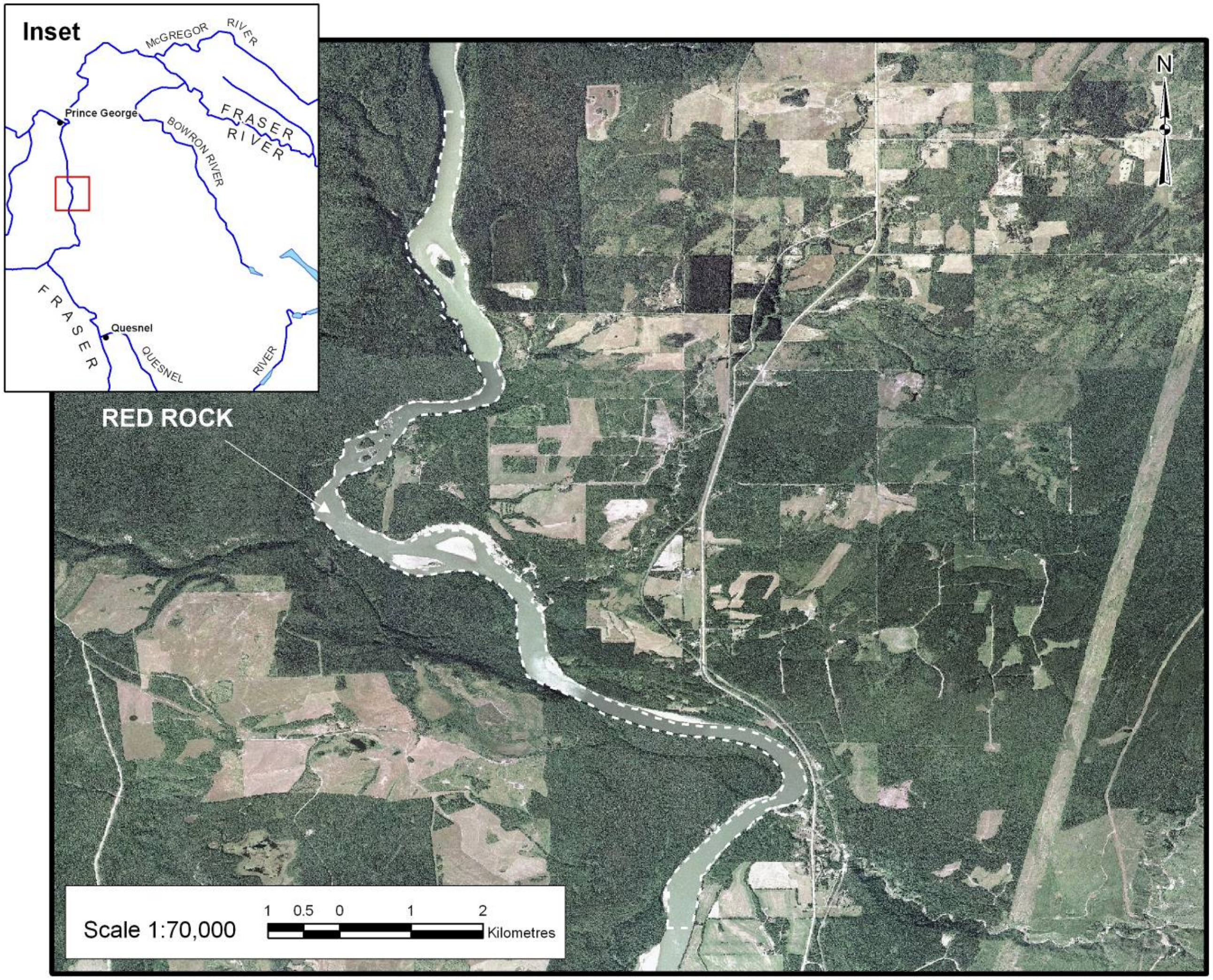

Figure 13. Map of critical habitat for Upper Fraser white sturgeon: Red Rock site.

1.9 NECHAKO

In the Nechako system, white sturgeon occur from the confluence with the Fraser River, upstream to Cheslatta Falls, and through much of the Stuart River watershed, a major tributary. We refer to this population as Nechako white sturgeon. Data indicate limited movement of Nechako white sturgeon into the Fraser, however, feeding at the Fraser River confluence has been observed. Current distribution in the Nechako may be limited by population declines and the alteration of flows (and related effects) below Kenney Dam (NWSRI 2004).

The information base for the Nechako white sturgeon population is substantial, based on many years of intensive study. High use habitats have been identified for all life stages, and this information is summarized in Table 5. As additional information is collected, it will become possible to refine recommendation for designating critical habitat.

Table 5. Summary of information base for white sturgeon habitats in the Nechako system. A blank cell means that the life stage does not consistently use the habitat.

Area	Confirmed (√), Suspected (S), or Possible (?) Use by Life Stage and Degree of Use (H=High, M=Moderate, L=Low)						
	Spawn	**Free embryo & larvae (0 – 40 days)**	**Early juvenile (40 days – 2 yrs)**	**Late Juvenile and Adult**	**Winter**	**Staging**	**Overall Assessment**
Vanderhoof braided section (km 135.3-142)	(√) H	(√) H				(√) H	Critical
Sinkut R–116 Hole (km 115.3-117.8)			(√) H	(√) H	(√) H	(√) H	Critical
Leduc Ck confluence 125- Hole (km 124.4-126)			(√) H	(√) H	(√) H	(√) H	Critical
Nechako- Finmoore (km 91.1-98.6)			(√) H	(√) H			Critical
Keilor's Point (km 109.9-110.9)			(√) H	(√) H	(√) M	(√) M	Critical
Culvert Hole (km 132.2-132.8)			(?) H		(√) M		Critical
Powerline Crossing- 129 Hole (km 129.4-130.1)			(?) H		(√) M		Critical
Sturgeon Point (Stuart River, km 47.6-51.6)				(√) M	(S) M		Critical

Area	Confirmed (√), Suspected (S), or Possible (?) Use by Life Stage and Degree of Use (H=High, M=Moderate, L=Low)						
	Spawn	Free embryo & larvae (0 – 40 days)	Early juvenile (40 days – 2 yrs)	Late Juvenile and Adult	Winter	Staging	Overall Assessment
Stuart Lake (Pinchi Bay)				(√) H	(√) M		Critical
Stuart Lake (Tachie River Confluence)				(√) H	(√) M		Critical
Lower Half of Stuart Lake				(√) M	(S) M		Critical
Middle River Confluence with Trembleur Lake				(√) M	(S) M		Critical
Fraser Lake				(√) M	(S) M		Critical
Nechako (km 129.4-135.3)						(√) H	Important
Upstream of Nautley (km 192.6-213)	(?) L	(?) L					Important
Isle Pierre- Nechako (km 67.2-81.5)				(√) M	(S) M		Important
Upper Half of Stuart Lake				(?)H	(S) M		Important
Braeside (km 163.5-165.4)	(S) H	(S) H				(√) M	Important
Francois, Takla, Trembleur and Tezzeron Lakes				(S) M	(S)M		Important

1.9.1 Spawning and Incubation Habitat

Observations to date suggest that there is only one spawning site in the Nechako River, which encompasses the braided section of river near Vanderhoof. The distribution of spawning locations may change from year to year depending on flow conditions. Some believe there may also be other spawning locations, at present or historically (i.e., prior to river regulation). It is possible that additional spawning and incubation sites could be identified in the future. Data indicate that white sturgeon eggs do not drift far, so incubation habitats are assumed to coincide with spawning habitats.

Critical habitat attributes for this life stage in the Nechako are as follows:

- Flows:
  - localized velocities in specific reaches can be the attractant or driver for spawning site selection
  - timing based on hydrograph: it is preferential for sturgeon to spawn at the timing of the historic freshet
- River flow interaction with river form (flow, substrate and sedimentation): creating appropriate morphological conditions for sturgeon to spawn.
- Temperature: increasing thermograph to near 13º C is the cue for initiating spawning.
- Turbidity: turbidity could possibly impact spawning site selection or habitat quality.
- Substrate: appropriate substrate is created by the interaction between flow and river morphology as well as bed load dynamics. Interstitial habitat must also be available.
- Water quality and chemistry: this includes oxygen, organics, pollutants and pathogens.
- Isolation from disruption and disturbance.

A number of key attributes have been identified for critical spawning habitat in the Nechako. Spawning is initiated after water temperatures reach a daily mean of about 13º C. White sturgeon require spawning sites that are isolated from disruption and disturbance. Appropriate spawning substrate is created by the interaction between flow and river morphology as well as bed load dynamics, and interstitial habitat must be available. Appropriate geomorphological conditions for sturgeon spawning are created by river flow interacting with river form (flow, substrate and sedimentation). Flow at the time of spawning must deliver localized velocities in specific reaches which can be the attractant or driver for spawning site selection, and timing during the historic freshet.

The Vanderhoof braided section of the Nechako River is recommended as critical habitat, with the primary supporting rationale being that this is the only known location for spawning in the Nechako system. Although this location is functioning as spawning habitat, it is believed to be non-functional as habitat for incubation and very early life stages. Various measures are being examined to restore the functionality of this habitat (Steve McAdam, pers. comm.).

This habitat is deemed critical on an annual basis during May and June, based on known timing of spawning and incubation. This period is sufficient to encompass known annual variability in onset of spawning.

The degree of certainty in this critical habitat determination is rated as high, based on repeated observations of spawning at this site.

1.9.2 Free Embryo and Larval Habitat

Little is known about this phase in the wild, but it is suspected to be a key phase in the recruitment failures observed in regulated systems. Only a single spawning site has been identified in the Nechako system, and this coupled with ongoing recruitment failure makes it difficult to identify the key components of viable habitat for this life stage. Key habitat for this life stage is assumed to be encompassed within known spawning and incubation habitat near Vanderhoof, and some distance downstream. At present there is insufficient information to precisely estimate the downstream limit of this habitat type.

Critical habitat attributes for this life stage in the Nechako are as follows:

- Flow: it is suspected that low velocity habitats are key, particularly for larvae.
- River flow interaction with river form (flow, substrate and sedimentation): creating appropriate morphological conditions for larval rearing.
- Temperature: this is a key attribute that affects growth rate and food abundance. Rapid fluctuations and temperature extremes could be detrimental to larvae
- Turbidity: turbidity could possibly affect larval survival by decreasing predation
- Substrate: appropriate substrate is created by the interaction between flow and river morphology as well as bed load dynamics. Interstitial habitat must also be available.
- Water quality and chemistry: this includes oxygen, organics, pollutants and pathogens, and in the case of larvae, this attribute is ranked higher than for other life stages since larvae represent the most sensitive life stage and are unable to move location.
- Food availability: fresh clean gravel with appropriate food. At present there is a lack of knowledge around habitat use for larvae at 12-40 days.
- Appropriate habitat (to avoid predation): includes both substrate and cover. Substrate is just one feature that allows larvae to escape predation. Other types of cover are also essential. Predation rates are probably high, so habitat attributes (i.e., edges, depth, velocity, interstitial spaces, vegetation, woody debris) that diminish predation are essential.
- Connectivity: connectivity between habitats is a key factor to larval survival.
- Isolation from disruption and disturbance.

Critical habitat for the free embryo and larval stages is the Vanderhoof braided section, the same habitat area noted as critical for spawning and incubation. This habitat is deemed critical on an annual basis during May, June and July, based on known timing of spawning and incubation. This period is sufficient to encompass known annual variability in onset of spawning. Critical habitat extends downstream beyond the boundaries of spawning and incubation habitat, but the downstream limit cannot be described accurately at this time. The overall degree of certainty in this critical habitat determination is rated as high, based on repeated observations of spawning at this site, although there is less certainty in the downstream limit of this habitat beyond that already defined for spawning and incubation.

1.9.3 Early Juvenile Habitat

Habitat needs within this two-year period may be considerably different than in the life stage immediately preceding it. In the Columbia and Kootenay Rivers fish younger than two years have been observed holding in habitats that are similar to adult habitat types, and in general it is believed that once white sturgeon are six months old they tend to occupy habitat that is similar to that preferred by adults. Very little is known about this life stage in the Nechako, yet survival at this stage may also limit recruitment. It is therefore a high priority for study.

Critical habitat attributes for this life stage in the Nechako are as follows:

- Flows: deep sites with low velocity.
- River flow interaction with river form (discharge and geomorphology): early juveniles seem to preferentially occupy deeper habitat (i.e., deep holes).
- Temperature: this attribute affects growth rate and food abundance. Rapid fluctuations and temperature extremes could be detrimental.

- Turbidity: turbidity could possibly decrease predation.
- Substrate: appropriate substrate is created by the interaction between flow and river morphology as well as bed load dynamics.
- Water quality and chemistry: this includes oxygen, organics, pollutants and pathogens.
- Food availability: sufficient food for rapid growth is important.
- Appropriate habitat to avoid predation: includes depth, cover and food abundance.
- Connectivity: connectivity between habitats is a key factor to juvenile survival.
- Isolation from disruption and disturbance.

No fish within this age class have been captured during the Recovery Team's course of studies on the Nechako, so any estimations of this habitat component are necessarily based on knowledge from other systems. Six high use areas for this life stage have been identified (RL&L 2000a):

- Keilor's Point (km 109.9-110.9)
- Leduc Ck confluence 125- Hole (km 124.4-126)
- Sinkut R–116 Hole (km 115.3-117.8)
- Nechako- Finmoore (km 91.1-98.6)
- Powerline Crossing- 129 Hole (km 129.4-130.1)

Additional holding and feeding areas include Sturgeon Point in the Stuart River (based on captures and historical information, (Toth and Yarmish 2003; Carrier Sekani Tribal Council 2005), confluence of Tachie and Middle rivers, and Pinchi Bay in Stuart Lake. Despite extensive sampling and telemetry, the area from Vanderhoof to Engen and Nadleh has been little used from 1995 to 1999, yet this continues to be an area where adult fish are observed in FSC fisheries and during helicopter flights. Other sites likely include the confluences of streams where sockeye concentrate.

Critical habitat for the 40 days to 2 years stage includes the six areas identified as high use areas for multiple life stages:

- Keilor's Point (km 109.9-110.9)
- Leduc Ck confluence 125- Hole (km 124.4-126)
- Sinkut R–116 Hole (km 115.3-117.8)
- Nechako- Finmoore (km 91.1-98.6)
- Powerline Crossing- 129 Hole (km 129.4-130.1)

The areas are shown in Section 1.9.8. This habitat is deemed critical year-round, based on knowledge of expected continuous occupation of these sites. The degree of certainty in this critical habitat determination is rated as moderate, based on repeated study of these sites and telemetry records of released juveniles in some of these habitats. Although other candidate sites have been identified there is insufficient certainty to define these as critical habitat at this time.

1.9.4 Late Juvenile and Adult Habitat

The late juvenile and adult stage is defined as occurring from 2 years onward. Diets of younger fish may be considerably different than those of large adult fish, but in general, all individuals in this class occupy the same habitats for the purposes of feeding, and presumably for overwintering.

Critical habitat attributes for this life stage in rivers in the Nechako system are as follows:

- Flows: adults and juveniles (over 2 years) show a preference for deep sites with low velocity.
- Food availability: sufficient quality and quantity of food for survival.
- Connectivity: connectivity between habitats is a key factor for juvenile and adult survival.
- Water quality and chemistry: this includes oxygen, organics, pollutants and pathogens
- Isolation from disruption and disturbance.

Critical habitat attributes for this life stage in lakes in the Nechako system are as follows:

- Food availability: Lakes are essential for providing food for white sturgeon. This includes mussels, salmon (particularly Sockeye) and other fishes. In addition, suitable escapement of sockeye salmon to ensure lake productivity is necessary.
- Connectivity: access to lakes is essential.
- Isolation from disruption and disturbance.

Juvenile and adult feeding habitat.

In the Nechako, feeding habitats are generally similar to overwintering habitat, as there appears to be an affinity for fish to hold in the same areas where they feed. The following high use areas have been identified for this life stage based on existing information (RL&L 2000a):

- Keilor's Point (km 109.9-110.9)
- Leduc Ck confluence 125- Hole (km 124.4-126)
- Sinkut R–116 Hole (km 115.3-117.8)
- Nechako- Finmoore (km 91.1-98.6)
- Stuart Lake (Tachie River confluence)
- Stuart Lake (Pinchi Bay)
- Lower half of Stuart Lake
- Trembleur Lake (Middle River confluence)
- Fraser Lake

Additional holding and feeding areas include Sturgeon Point in the Stuart River, Isle Pierre, and Francois, Takla, Trembleur and Tezzeron Lakes based on captures and historical information (Toth and Yarmish 2003; Carrier Sekani Tribal Council 2005). Despite extensive sampling and telemetry, the area from Vanderhoof to Engen and Nadleh has had little use from 1995 to 1999, yet this continues to be an area where fish are observed in FSC fisheries and during helicopter flights. Other sites include the confluences of streams where sockeye concentrate.

Winter habitat.

Overwintering habitat of white sturgeon is generally characterized as habitat where fish can maintain their position with minimal energy use. The deepest holes in the river are known to be used for overwintering. The specific locations noted as important overwintering areas include:

- Keilor's Point (km 109.9-110.9)
- Leduc Ck confluence 125- Hole (km 124.4-126)
- Sinkut R–116 Hole (km 115.3-117.8)
- Stuart Lake (Pinchi Bay)
- Stuart Lake (Tachie River confluence)
- Lower half of Stuart Lake
- Trembleur Lake (Middle River confluence)
- Fraser Lake

The recovery team has indicated confidence that the overwintering habitats identified are sufficient to support the population's needs at abundance levels up to the recovery target.

Critical habitat attributes for this life stage in rivers in the Nechako system are as follows:

- <u>Water quality and chemistry:</u> this includes oxygen, organics, pollutants and pathogens.
- <u>Depth</u>: deep holes.
- <u>Connectivity</u>: this may be particularly of issue during extreme low flows.
- <u>River flow interaction with river form</u>: interaction of discharge and river geomorphology.
- <u>Isolation from disruption and disturbance</u>.

Critical habitat attributes for this life stage in lakes in the Nechako system are currently unknown. However, it is assumed that lakes are used as over wintering habitat because radio-tagged white sturgeon have been observed making seasonal migrations to Stuart Lake and remain there for at least the following winter.

Adult Staging.

Nechako white sturgeon are known to "stage" in specific areas in April and May prior to spawning. Recent work observed mature fish staging in several areas from kilometre 115 to the lower limit of the Vanderhoof spawning site at kilometre 135 (Cory Williamson, BC Environment, pers. comm.). There are at least six deep holes in this river section used for staging and fish were observed to move frequently throughout the entire section (i.e., 115 – 135 km). Three of these areas were earlier identified as high use areas (RL & L 2000a):

- Leduc Ck confluence 125- Hole (km 124.4-126)
- Sinkut R–116 Hole (km 115.3-117.8)
- Nechako- Finmoore (km 91.1-98.6)

Fish were observed to move from these locations to the spawning site at or prior to the spawning period (RL & L 2000a; Golder 2003b).

Critical habitat attributes for this life stage in the Nechako system are as follows:

- Flows:
  - o localized velocities in specific reaches can be the attractant or driver for staging and subsequent spawning site selection.
  - o timing based on hydrograph: it is preferential for sturgeon to spawn at the timing of the historic freshet.
- Temperature: increasing thermograph to near 13º C instigates the cue for spawning, with staging initiated at lower temperature that has not yet been determined.
- Depth: precise depth criteria are not yet known, although sufficient depth to allow for sturgeon passage or access to spawning areas is essential.
- Connectivity: proximity to spawning and over wintering sites.
- Isolation from disruption and disturbance.

Combined stages.

Critical habitat features for staging are likely at least partly redundant to adult overwintering critical habitats, as staging fish commonly occupy adult habitats that are used for other purposes. Based on known habitat use, several areas are proposed as critical habitats for feeding, overwintering and staging. These areas are:

- Vanderhoof braided section (km 135.3-142)
- Keilor's Point (km 109.9-110.9)
- Leduc Ck confluence 125- Hole (km 124.4-126)
- Sinkut R–116 Hole (km 115.3-117.8)
- Nechako- Finmoore (km 91.1-98.6)
- Lower Half of Stuart Lake
- Stuart Lake (Pinchi Bay)
- Middle R Confluence- (Trembleur Lake)
- Fraser Lake
- Tachie R confluence (Stuart Lake)
- Sturgeon Point (Stuart River, km 47.6-51.6)

These habitats are deemed critical year-round. The degree of certainty in this critical habitat determination is rated as moderate, based on repeated observations of white sturgeon at these sites.

Other areas are deemed important habitats for rearing, overwintering and staging:

- Braeside (km 163.5-165.4)
- Francois, Takla, Trembleur and Tezzeron Lakes
- Isle Pierre- Nechako (km 67.2-81.5)

Additional work is required to support recommendations of these areas as critical habitat.

1.9.5 Critical Habitat Attributes and Timing

This section provides a compilation of all geographic locations that are proposed as critical and important, and provides the attributes of these areas that make them critical to white sturgeon. Also provided is the time of year that the critical habitat designation applies. The summary is provided in Table 6.

Table 6. Summary of attributes and timing for white sturgeon critical habitats in the Nechako system.

Location	Definition	Attributes & Rationale	Life Stages and Timing
Braided section at Vanderhoof (km 135.3-142)	Critical	The only confirmed location for spawning in the Nechako River system is the braided section of river near Vanderhoof. The precise locations of spawning in this area might change from year to year depending on flow conditions. Data indicate that white sturgeon eggs do not drift far, so incubation habitats are assumed to be coincident with spawning habitats. There is quite a bit of intervening habitat that may be suitable. Eggs have been captured at km 138.5. Tagged fish have also been observed above this point, however no eggs have been captured. At Km 141 there is another braided section that may also be suitable. Larval development includes the period from hatch to exogenous feeding (0 to 12 days). Critical habitat during this period will likely include the braided section of the Nechako River near Vanderhoof, extending downstream beyond the boundaries of the spawning and incubation area, though its lineal extent cannot be defined with certainty at this time. Although the braided area at Vanderhoof is functioning as spawning habitat, it is believed to be non-functional as habitat for incubation and very early life stages. At present we don't have enough information to differentiate 12-40 days from 0-12 days and the range may extend further for 12-40 days.	• spawning (√), late May to late Jul • free embryo and larvae (√), May to Jul • staging (√), Nov - Jul • composite timing: Nov - Jul
Sinkut River - 116 Hole (km 115.3-117.8)	Critical	See km 109-110.9	• early juvenile (√), all year • late juvenile and adult (√), all year • winter (√), Oct - May • staging (√), Nov - Jul • composite timing: all year

Location	Definition	Attributes & Rationale	Life Stages and Timing
Leduc Ck Confluence 125 Hole (km 124.4-126)	Critical	See km 109-110.9	• early juvenile (√), all year • late juvenile and adult (√), all year • winter (√), Oct - May • staging (√), Nov - Jul • composite timing: all year
Finmoore Nechako River (km 91.1-98.6)	Critical	Confirmed high use site	• late juvenile and adult (√), all year • composite timing: all year
Keilor's Point Nechako River (km 109.9-110.9)	Critical	Three critical areas have been identified between km 109 and the Vanderhoof spawning area - upstream and downstream of km 125, upstream and downstream of km 116 and upstream and downstream at km 110. Holes and the connecting environment between these holes (i.e., the entire reach) in these areas are key. There has been confirmed use of young juveniles at kms 110, 116 and 125.	• early juvenile (√), all year • late juvenile and adult (√), all year • winter (√), Oct - May • staging (√), Nov - Jul • composite timing: all year
Culvert Hole Nechako River (km 132.2 – 132.8)	Critical	Confirmed use of fish < 1m in length, This is the second available deep water site downstream of spawning area	• early juvenile, all year • staging (√), Nov - Jul • composite timing: all year
Powerline Crossing – 129 Hole Nechako River (km 129.4-130.1)	Critical	Confirmed use of fish < 1m in length, This is the first available deep water site downstream of spawning area	• early juvenile, all year • staging (√), Nov - Jul • composite timing: all year
Stuart Lake (Tachie River Confluence)	Critical	Confirmed high use site	• late juvenile and adult (√), all year • winter (√), Oct - May • composite timing: all year
Stuart Lake (Pinchi Bay)	Critical	Confirmed high use site	• late juvenile and adult (√), all year • winter (√), Oct - May • composite timing: all year

Location	Definition	Attributes & Rationale	Life Stages and Timing
Lower Half of Stuart Lake	Critical	An essential holding and feeding area (based on captures and historical information. The lower half of Stuart Lake is critical, but at this time we do not know about the rest of the lake. It should be noted however, that the whole lake has to be functional in order for there to be adequate productivity.	• late juvenile and adult (√), all year • winter (S), Oct - May • composite timing: all year
Middle River Confluence with Trembleur Lake	Critical	An essential holding and feeding area (based on captures and historical information.	• late juvenile and adult (√), all year • winter (S), Oct - May • composite timing: all year
Fraser Lake	Critical	Fraser Lake is an essential feeding area for white sturgeon. In addition, access and the productivity of the lakes are also essential to white sturgeon survival and recovery. Therefore, the designation takes into account both the direct use of the lake for feeding and the indirect, but equally significant, attribute of connectivity and food production/abundance. Fish spend significant time in these areas and usually do this in between spawning (however, this is not limited to spawners).	• late juvenile and adult (√), all year • winter (S), Oct - May • composite timing: all year
Stuart River (Sturgeon Point)	Critical	Sturgeon Point in the Stuart River is an essential holding and feeding area (based on captures and historical information.	• late juvenile and adult (√), all year • winter (S), Oct - May • composite timing: all year
Upstream of Nautley, near Diamond Island (km192.6-213)	Important	In 2007, mature males were staging in this area.	• spawning (?), late May to late Jul • free embryo and larvae (?), May to Jul composite timing: May - Jul
Isle Pierre (km 67.2-81.5)	Important	Confirmed high use site	• late juvenile and adult (√), all year • winter (S), Oct - May • composite timing: all year

Location	Definition	Attributes & Rationale	Life Stages and Timing
Braeside (km 163.5-165.4)	Important	This is a staging area and a potential spawning area based on data from 2007. Fish move here during times of higher water. Historically, this may have been an area that was just as significant as Vanderhoof. Mature fish were there at the same time spawning was occurring downstream in 2007 then dispersed in the same way –all the behaviours were similar to the fish spawning downstream. Since this is a potential spawning area based on data from 2007, it may also be important habitat for early juvenile white sturgeon. Following confirmation of this as a spawning area, this area could be designated critical habitat for early juvenile white sturgeon.	• spawning (S), late May to late Jul • free embryo and larvae (S), May to Jul • staging (√), Nov - Jul • composite timing: Nov - Jul
Upper half of Stuart Lake, Trembleur, Francois, Takla and Tezzeron Lakes	Important	Francois, Takla and Tezzeron Lakes are suspected for use but are also significant in terms of productivity. The productivity in these lakes ultimately affects food production in the lakes as well as food production in locations other than lakes. The attribute of productivity (i.e., salmon productivity) is critical to the recovery of the species.	• late juvenile and adult (S), all year • composite timing: all year
Nechako River (km 109.4-135.3	Important	This section of river is used annually by white sturgeon for staging prior to spawning. The specific function of this habitat is not clear, however fish appear to use the sediment dunes between deep areas at km 110, 116, 125, 129 and 132 to hold in as they gradually move up as a group over a period of a few weeks toward the braided reach at Vanderhoof for spawning.	• Staging, Nov - Jun • composite timing: all year

1.9.6 Activities Likely to Impact Critical Habitat

There are several activities that have the potential to impact critical habitats in the Nechako system. River regulation is believed to have had a significant influence on habitat quality at the spawning site, in particular by removing peak flows from the system. This has led to less frequent flooding of gravel bars, increased vegetation on bars and islands, and generally less movement of stream substrates (with concomitant decrease in substrate suitability for white sturgeon). Other activities such as gravel or sand dredging, linear developments, riparian, foreshore, floodplain alterations or developments, upstream land and water uses, and point and non-point source effluent discharges are possible concerns for all critical habitats in the watershed depending on details of the activities. These activities have been briefly reviewed and their threats prioritized by the basin-level recovery team (Table 7). Threats to white sturgeon and their habitats are discussed in more detail in Section 3 of the Recovery Strategy.

Table 7. Activities that may impact Nechako white sturgeon critical habitat.

Impact Categories	Examples of Activities	Mechanism	Risk – Consequence (if it occurs)	Risk – Likelihood (that it will occur)	Uncertainty
Loss of habitat quantity and quality and fragmentation	▪ Instream works ▪ Land development ▪ Introduction of invasive species	▪ Physical removal of habitats ▪ Sedimentation ▪ Dewatering ▪ Render habitats unsuitable for use	Spawning and incubation – High Feeding - Moderate	Low – physical works in CH Moderate - sediment Low – altered flow	Moderately understood Impacts of invasive species not well understood
Altered hydrograph components	▪ Hydroelectric facility operations ▪ Pine Beetle Deforestation	▪ Temperature change ▪ Productivity change ▪ Habitat availability & suitability ▪ Spawning conditions	Spawning – High Feeding and overwintering – Moderate Juveniles - High	High to Moderate	Impact to juveniles unknown Impacts not fully understood
Pollution	▪ Non-point and point source discharges	▪ Deposition of substances ▪ Precludes use of habitat ▪ Damages food supply	High all life stages	Low	Low for ongoing discharges Spill event frequency and magnitude cannot be predicted
Alteration to food supply	▪ Fishing ▪ Invasive Species	▪ Lowering functionality of feeding areas impacting fitness of fish	Moderate	Moderate to Low	High uncertainty on this threat; impacts to population.
Climate change	▪ n/a at local level	▪ Temperature change ▪ Productivity change ▪ Habitat availability & suitability ▪ Dewatering	Moderate to High	Moderate	Uncertainty very high Compounded by pine beetle deforestation

1.9.7 <u>Data Gaps</u>

There are minor data gaps for determining the geographic boundaries of spawning and incubation critical habitat. Given the relatively small area of this habitat unit, the precision of boundaries is considered inconsequential at this time. There are significant uncertainties with respect to the qualities of habitat that are required to make this habitat unit functional for incubation and early life stages. Work is underway to assess these habitat variables (Steve McAdam, pers. comm.).

For many of the other life stages there are moderate data gaps for determining the geographic boundaries of critical habitat recommendations made here. For example, the river kilometres discussed here as boundaries are approximate. These areas are fairly broad, and are based on existing information of white sturgeon habitat use. Additional studies may increase the confidence in these boundaries and may permit greater precision in defining the geographic areas of interest.

1.9.8 <u>Maps of Critical Habitat</u>

Figure 14. Reference map for locations of Nechako white sturgeon critical habitats.

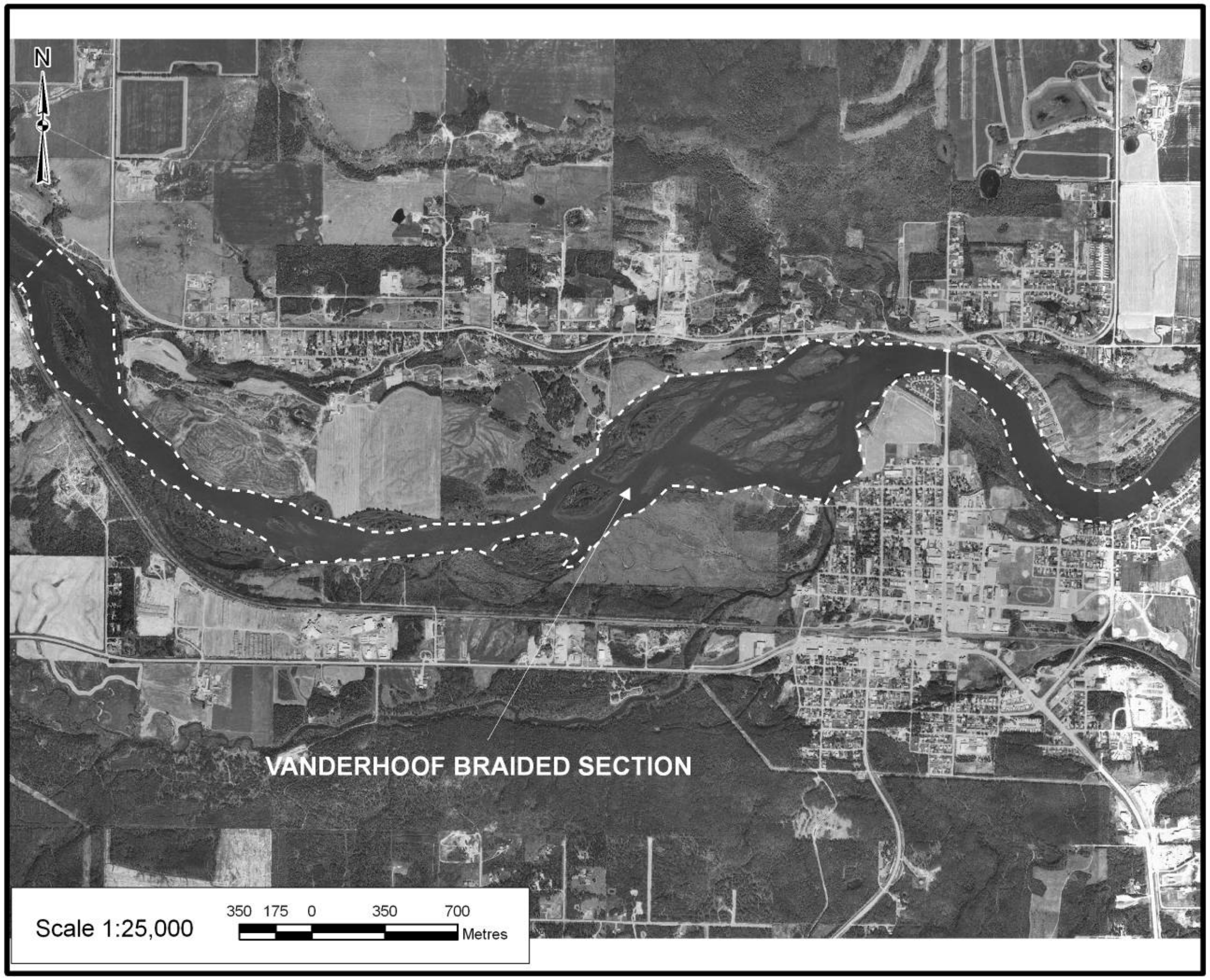

Figure 15. Map of critical habitat for Nechako white sturgeon: Vanderhoof braided section of the Nechako River.

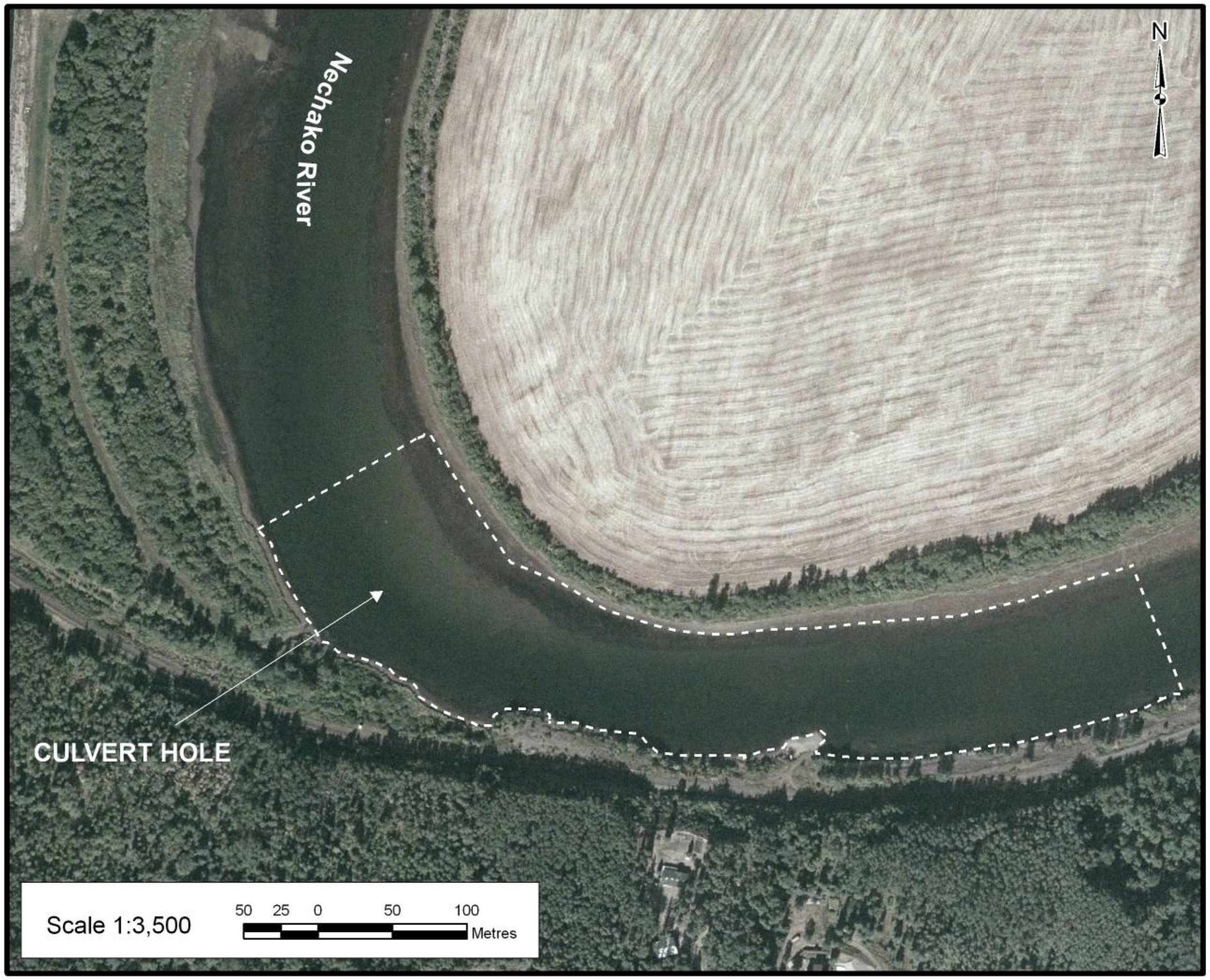

Figure 16. Map of critical habitat for Nechako white sturgeon: Culvert Hole site.

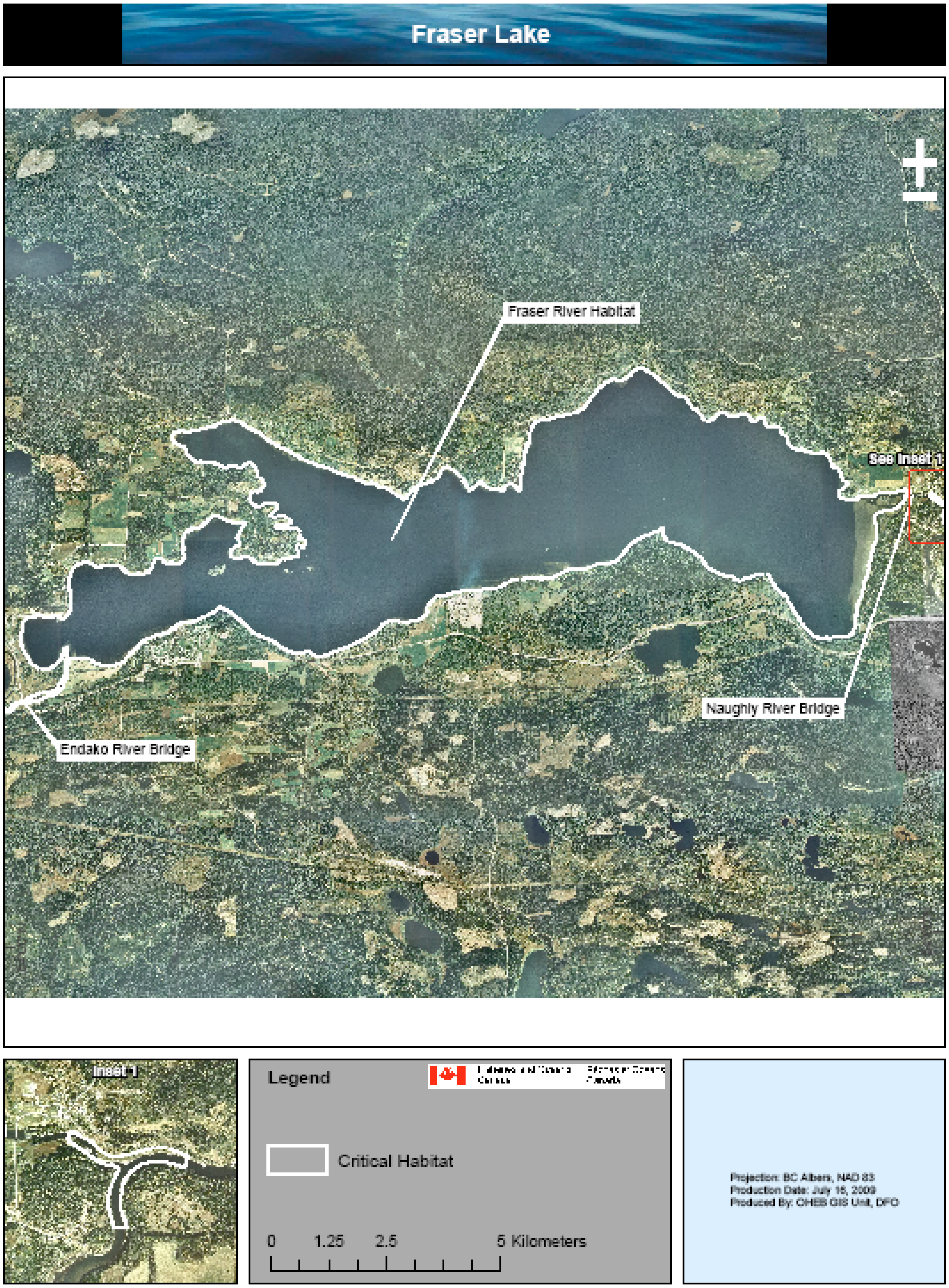

Figure 17. Map of critical habitat for Nechako white sturgeon: Fraser Lake and Nautley River confluence with the Nechako River.

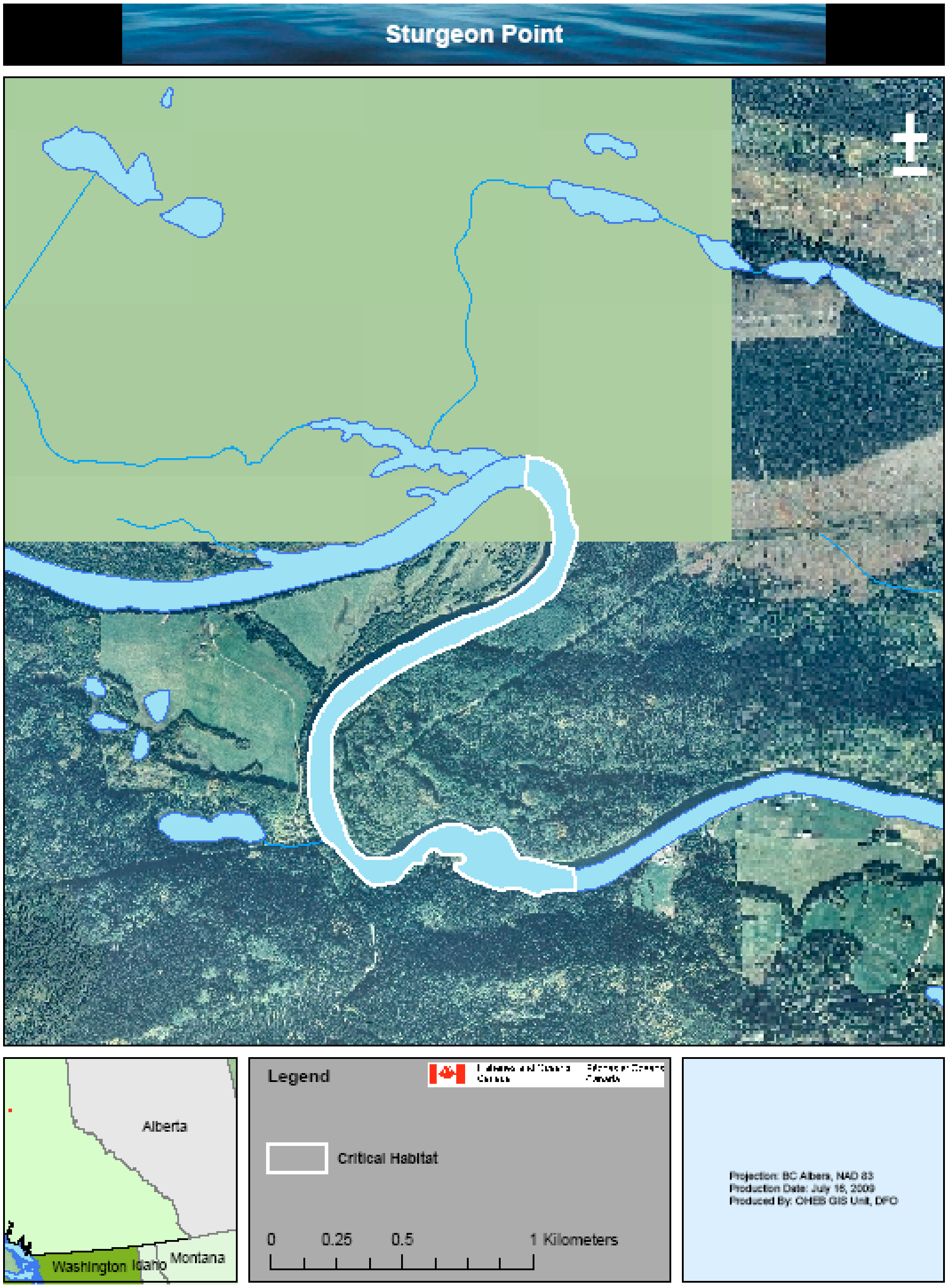

Figure 18. Map of critical habitat for Nechako white sturgeon: Sturgeon Point.

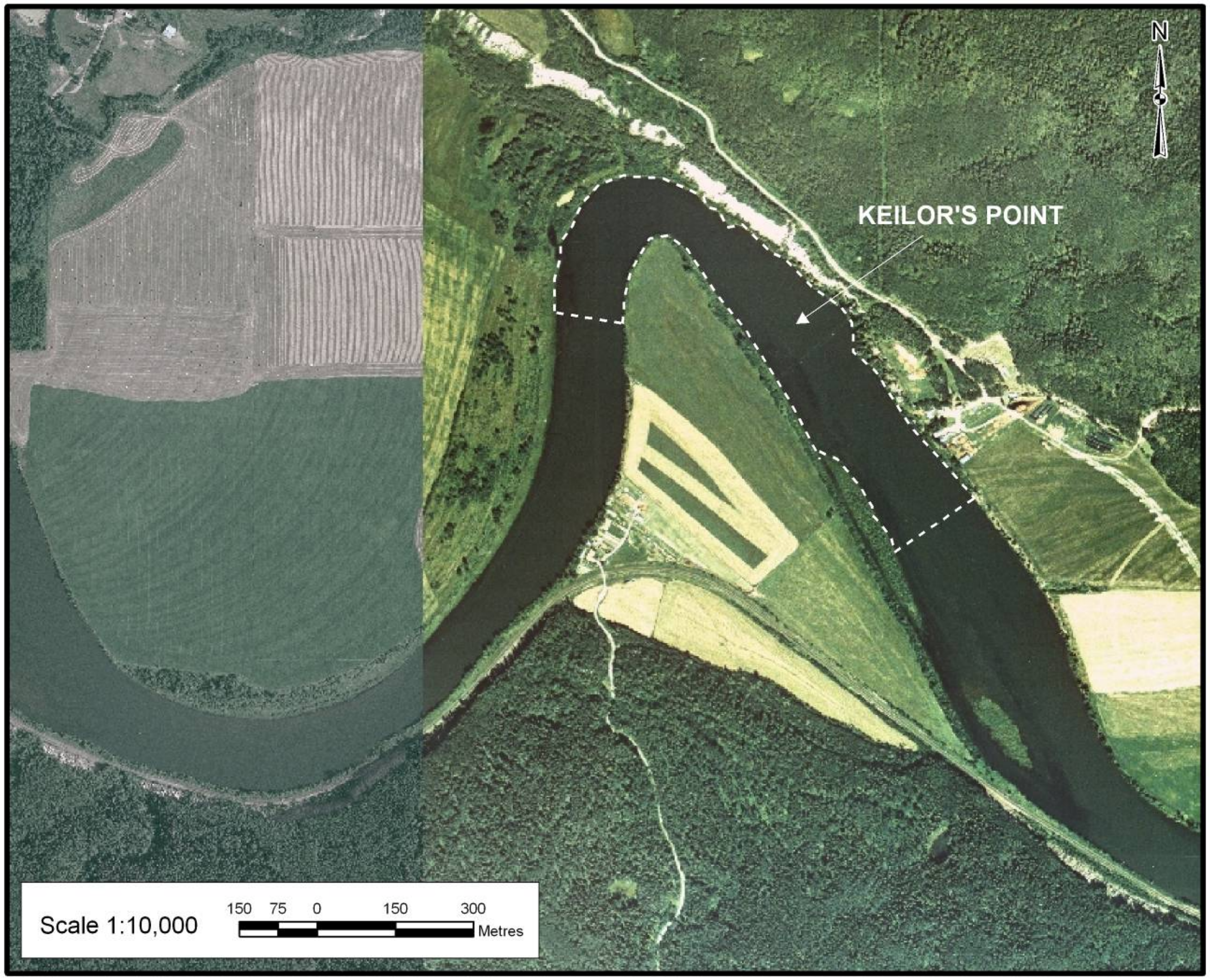

Figure 19. Map of critical habitat for Nechako white sturgeon: Keilor's Point site.

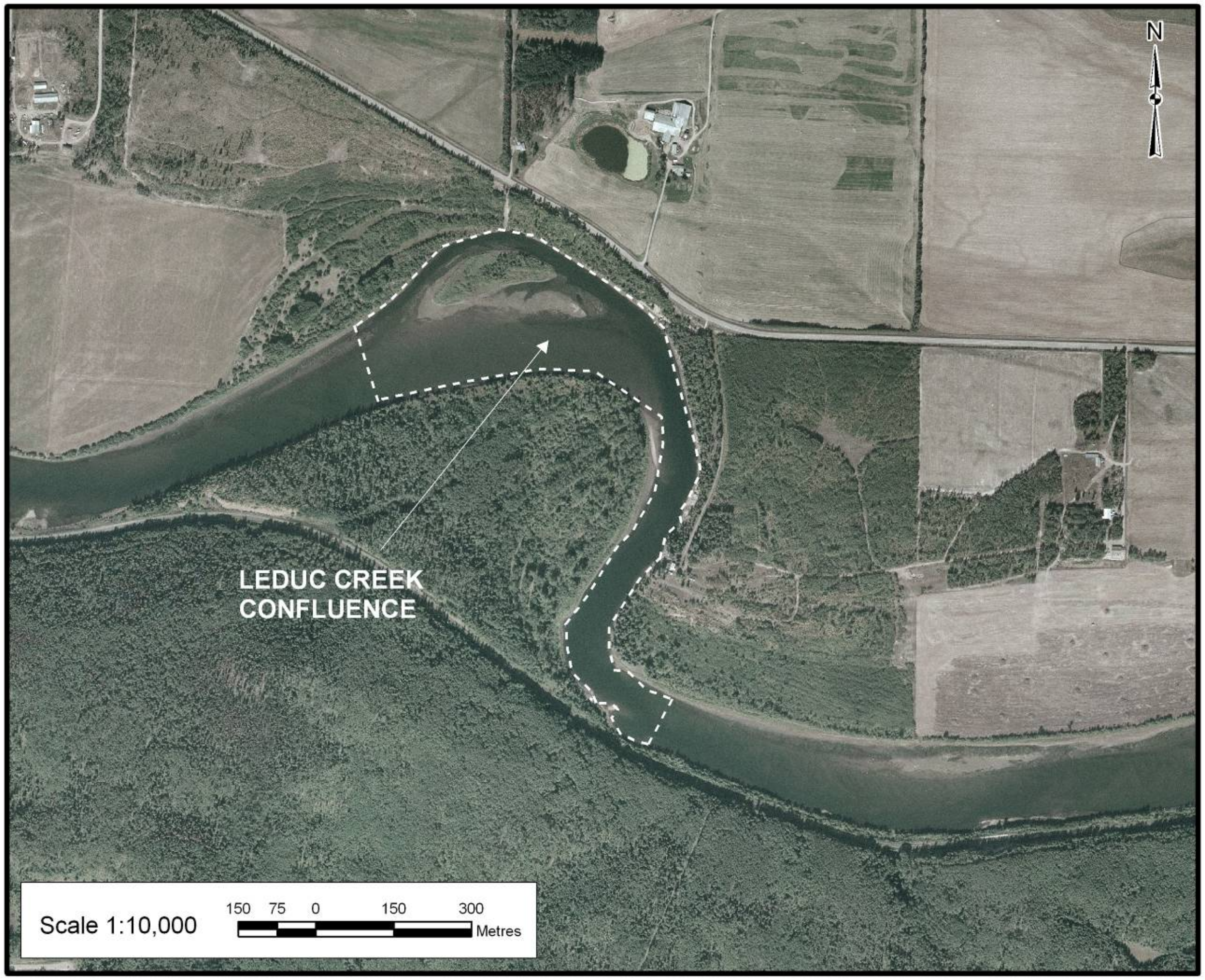

Figure 20. Map of critical habitat for Nechako white sturgeon: Leduc Creek confluence with the Nechako River.

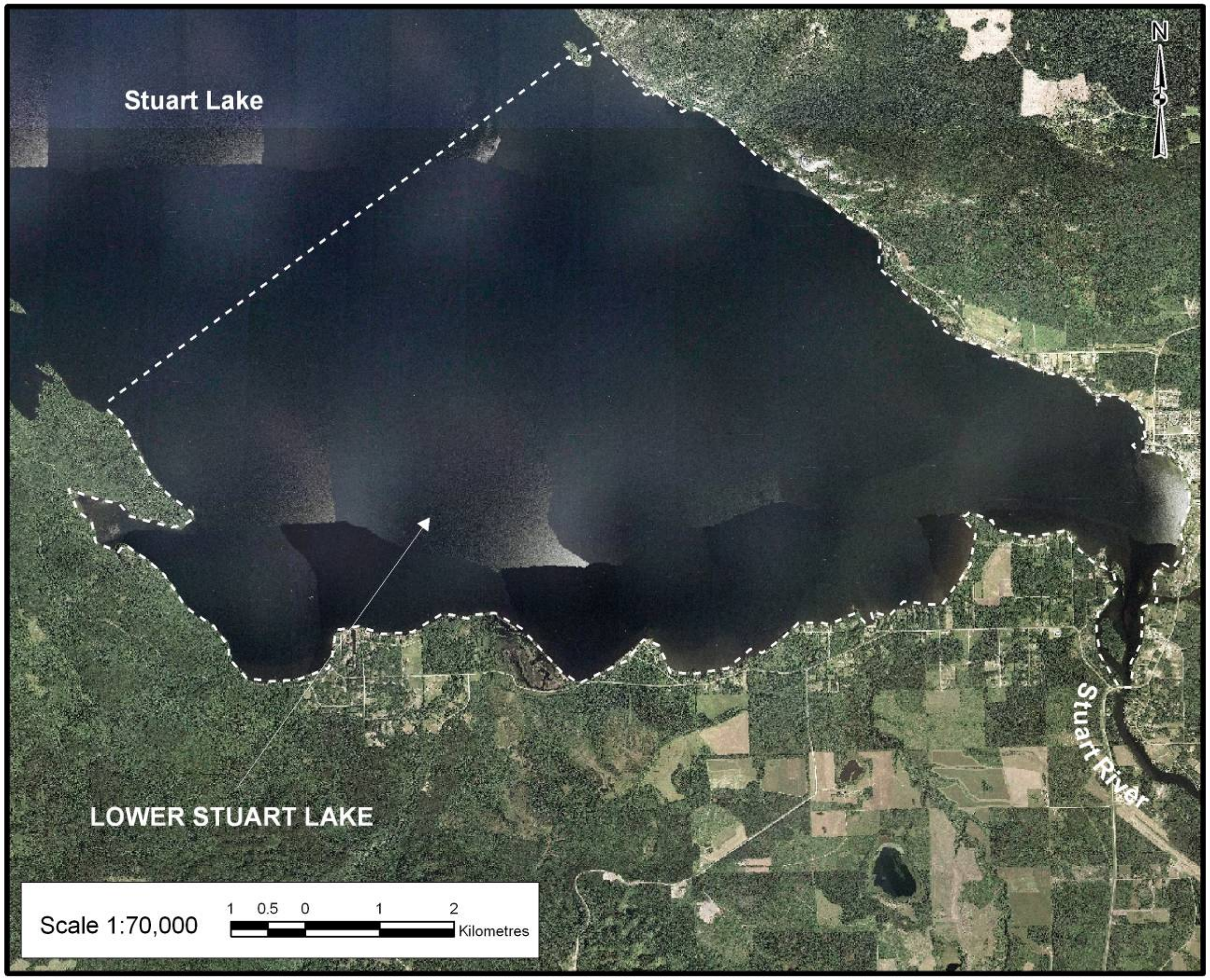

Figure 21. Map of critical habitat for Nechako white sturgeon: southern portion of Stuart Lake.

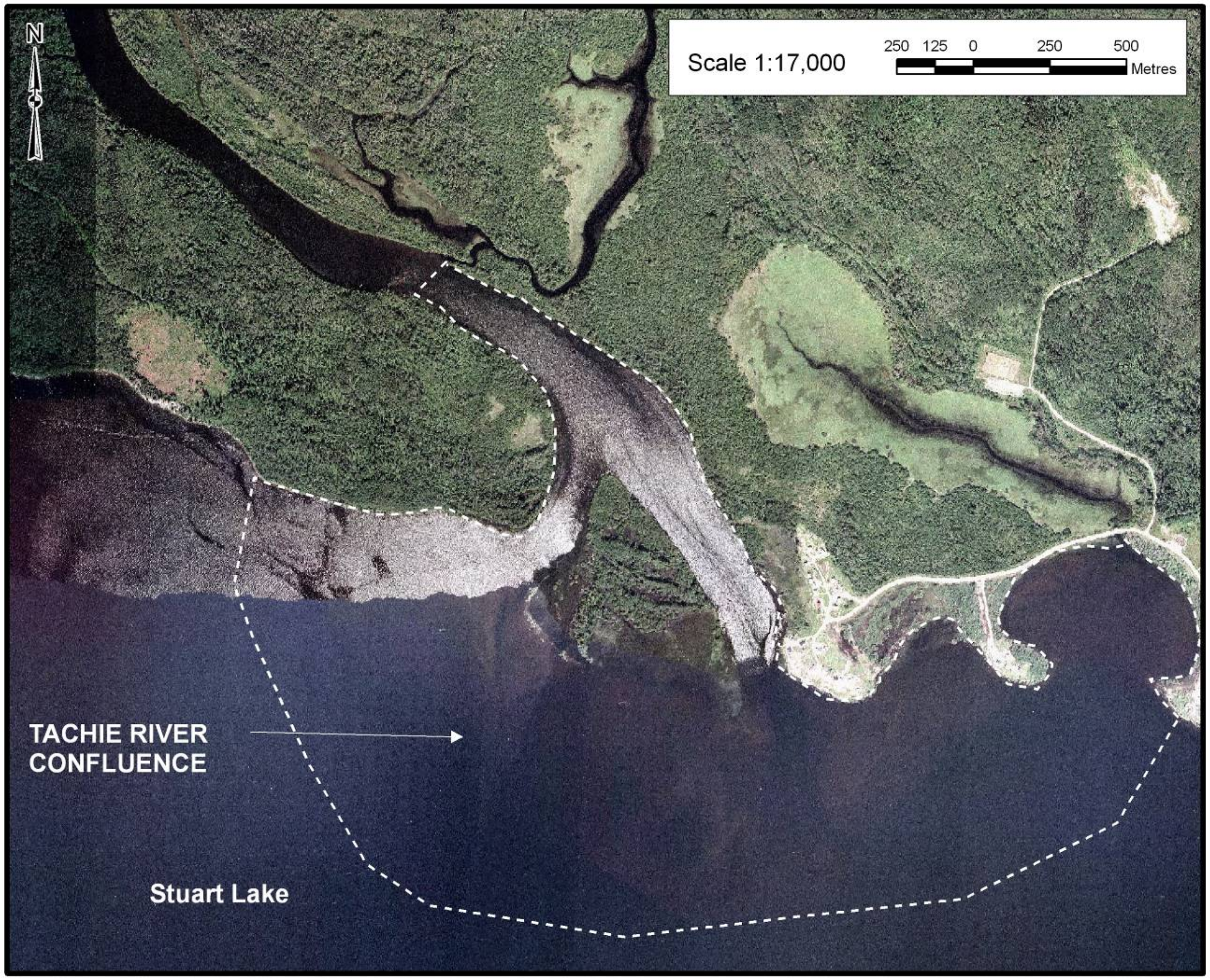

Figure 22. Map of critical habitat for Nechako white sturgeon: Tachie River confluence with Stuart Lake.

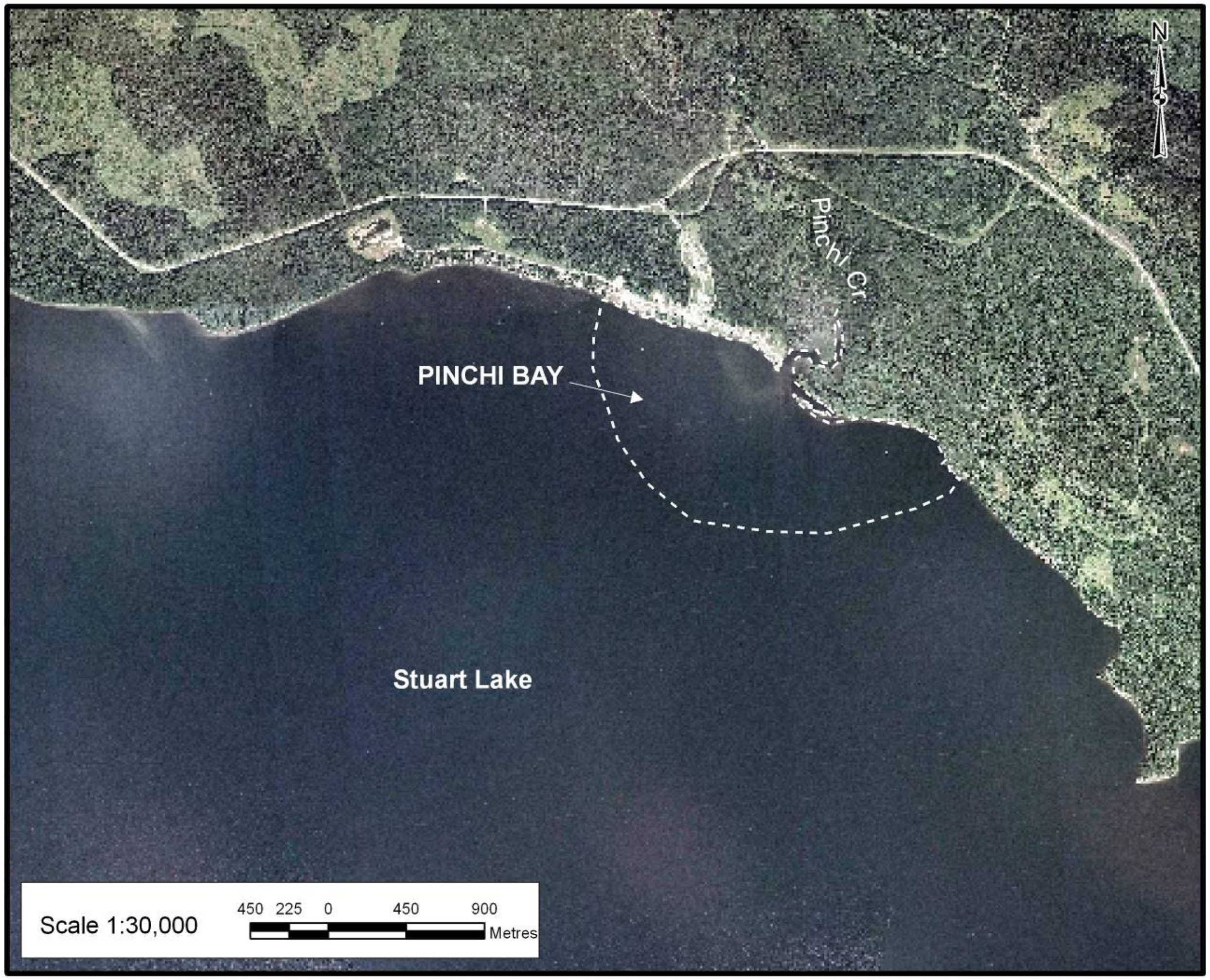

Figure 23. Map of critical habitat for Nechako white sturgeon: Pinchi Bay on Stuart Lake.

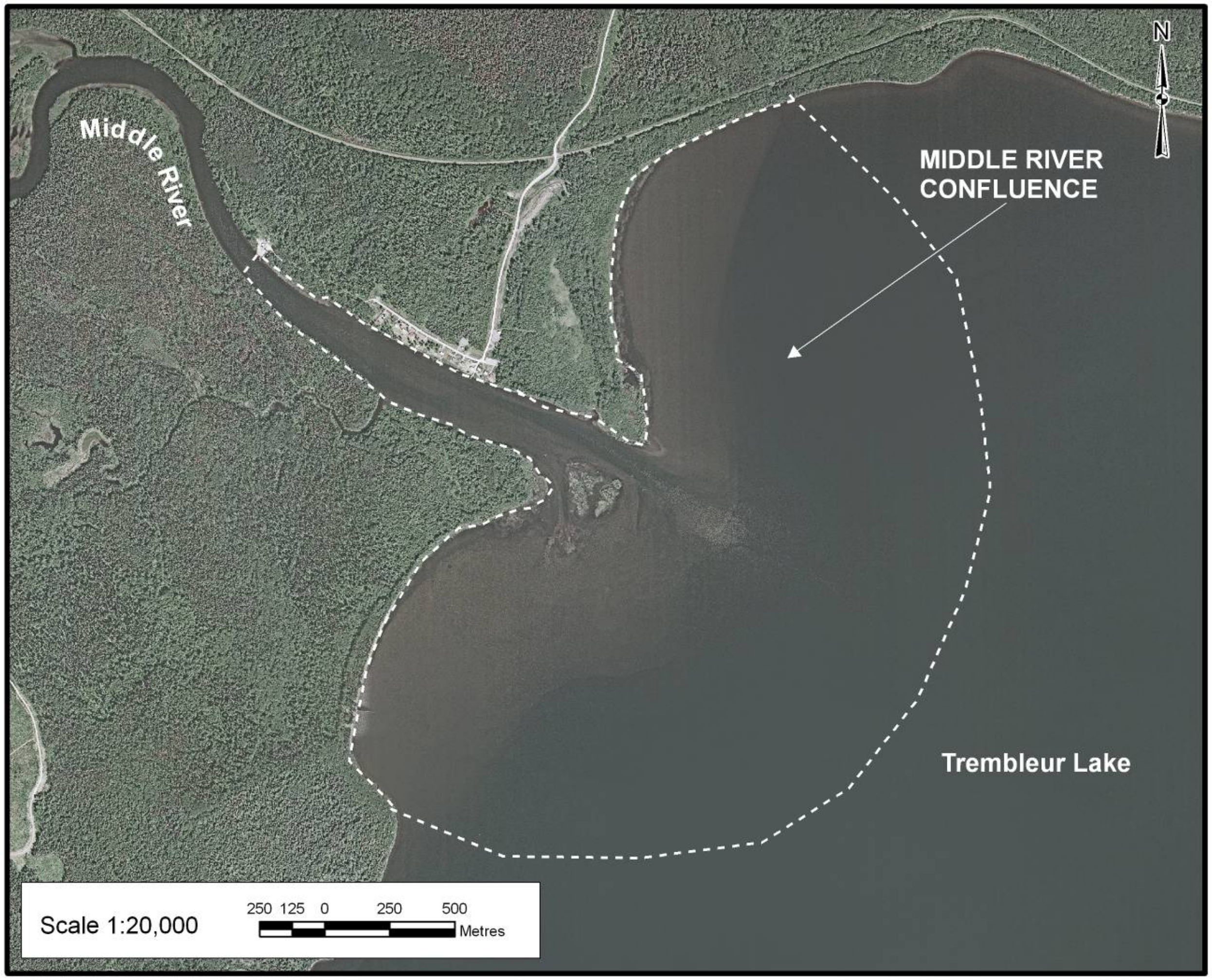

Figure 24. Map of critical habitat for Nechako white sturgeon: Middle River confluence with Trembleur Lake.

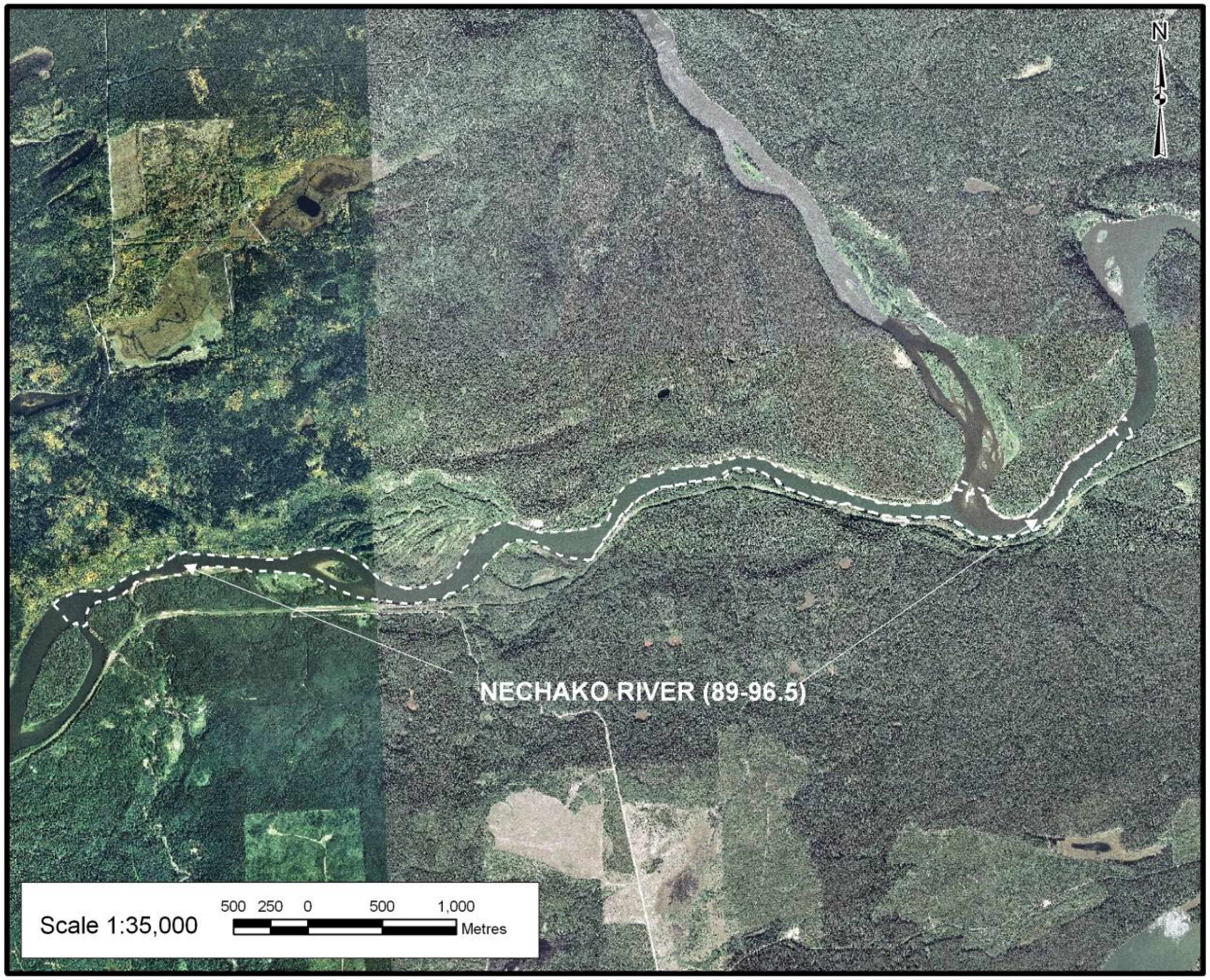

Figure 25. Map of critical habitat for Nechako white sturgeon: Finmoore (Nechako River km 89 to 96.5).

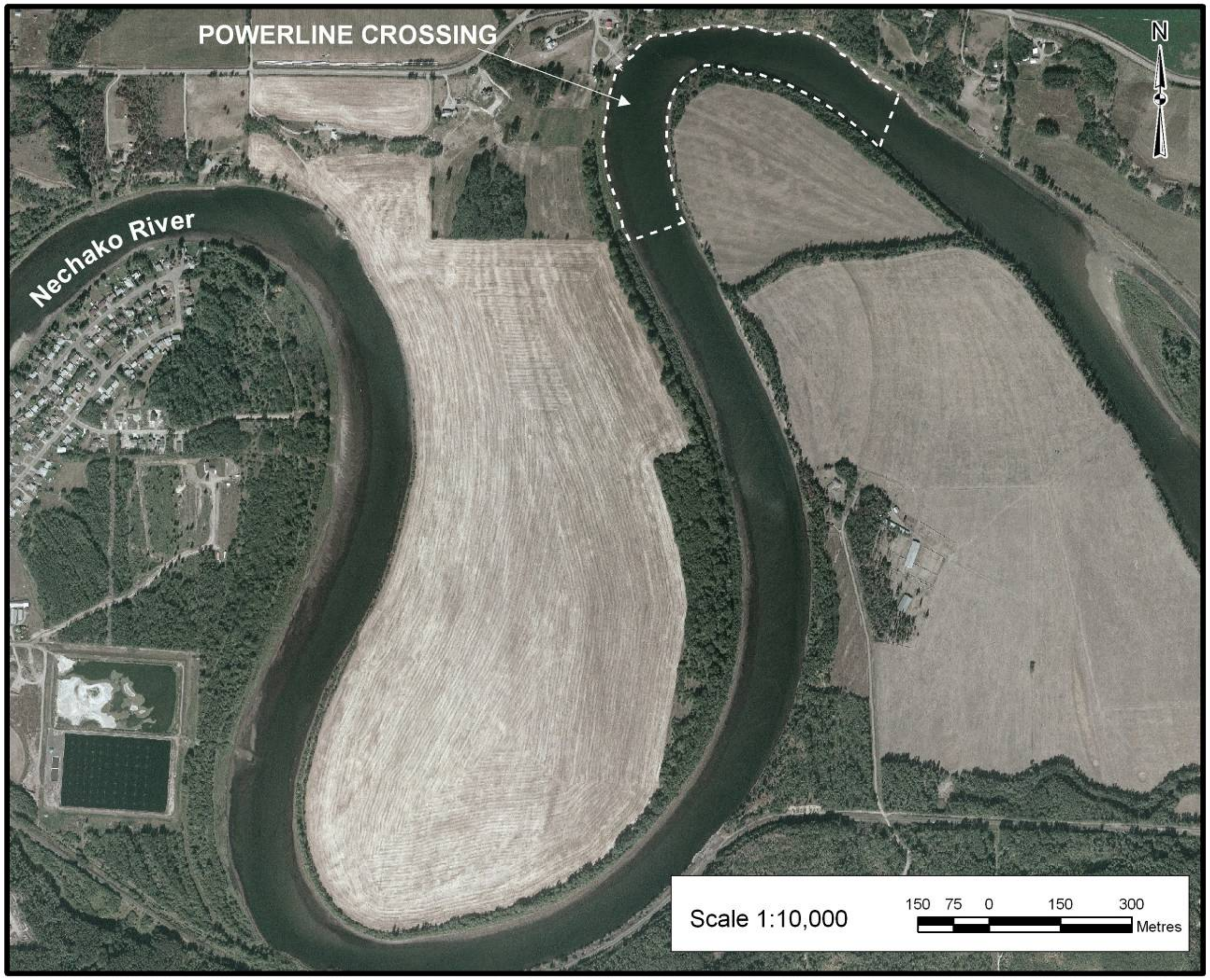

Figure 26. Map of critical habitat for Nechako white sturgeon: Powerline site on the Nechako River.

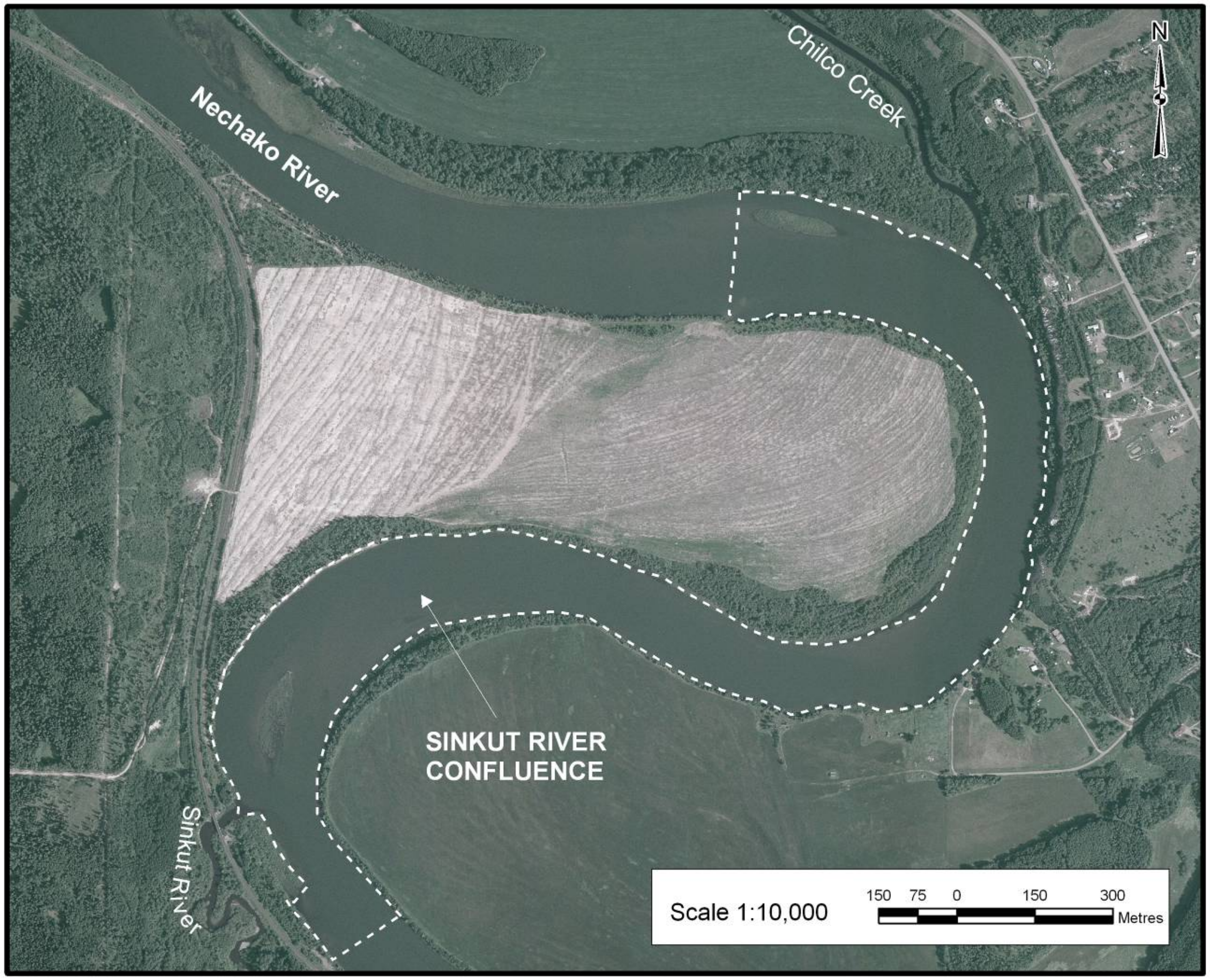

Figure 27. Map of critical habitat for Nechako white sturgeon: Sinkut River confluence with the Nechako River.

1.10 COLUMBIA

White sturgeon historically had access from the ocean all the way to Columbia Lake in the upper Columbia and Shoshone Falls in the upper Snake River. Populations in the upper reaches of the basin were most likely resident but benefited from the seasonal availability of anadromous salmon. White sturgeon inhabited the upper Columbia mainstem, lower Spokane River, lower Pend d'Oreille River, and lower Kootenay River to Bonnington Falls, and probably also used portions of smaller tributaries including the Sanpoil, Kettle, Slocan, and Salmo Rivers (Hildebrand and Birch 1996; Prince 2001). Distribution was probably patchy with fish concentrated in areas of favourable habitat. Significant concentrations of white sturgeon were reported during the early 1900s in the mainstem downstream from Castlegar, the lower Kootenay River, Arrow Lakes, Big Eddy near Revelstoke, and the present site of Mica Dam (Prince 2001).

For the purposes of recovery planning, the upper Columbia sturgeon population extends from Grand Coulee Dam in the US, upstream past HLK and Arrow Lakes Reservoir (ALR) to the Revelstoke Dam (REV). Remnant population components consisting of a few individuals occur, or are suspected, throughout other portions of the historic range. Genetic substructure possibly occurs within this population (Nelson and McAdam 2004) and further research on this topic is underway (S. McAdam, pers. comm.).

The largest component of this population resides in the free-flowing transboundary reach between HLK and Roosevelt Reservoir (FDR). Individuals in the transboundary reach have access to approximately 180 km of river from HLK to Grand Coulee Dam, including FDR. Habitats within this reach include large, deep, eddy areas that are "preferred" areas for both white sturgeon and their prey items (UCWSRI 2002). Aggregations of adult white sturgeon have been observed mostly between HLK (i.e., in HLK eddy) and Norns Creek (~7 km downstream of HLK), and Fort Shepherd eddy, Waneta eddy, and in the lower portion of the Kootenay River below Brilliant dam.

Less is known about sturgeon distribution and density in the approximately 40 km section of river between the border and FDR. In this reach they spawn at two locations near Northport, show clear recruitment failure, and appear somewhat distinct based on current genetics and movement (Nelson and McAdam 2004). Most adult sturgeon occur in the transition zone of the FDR and the river upstream to the border. Density is much lower in FDR main pool. Based on recapture data, 26% of tagged fish made forays into Canada within a 2 year study period, indicating some movement and mixing of sturgeon throughout the transboundary reach (Howell and McLellan 2007a, b).

Since 2002, more than 81500 sub-yearling cultured juveniles bred from Columbia stock have been released into the Columbia River downstream of HLK (Beamesderfer and Justice 2008; R. Ek, Manager, Kootenay Sturgeon Conservation Hatchery, Fort Steele, BC, pers. comm.). These fish are concentrated in the Robson reach between HLK and the Norns Creek fan, and in a series of smaller eddies downstream to Waneta Eddy at the border where they forage and overwinter. Released juveniles have also been observed in the US, especially around the mouths of the Kettle and Colville rivers and Marcus Flats. Many of the observations of habitat use by young juveniles are based on hatchery fish and there is an assumption (untested) that wild fish would behave similarly.

second component of this white sturgeon population currently inhabits ALR, upstream of the HLK. It is believed that HLK divided a contiguous population, but it is unclear whether the primary spawning grounds were historically upstream or downstream of HLK. There is thus debate about the extent to which either component can be self-supporting. The majority of the

ALR component are found in the Beaton Flats area of ALR through most of the year. Abundance of the ALR component is substantially lower than the component in the transboundary reach Table1.

Since 2007, more than 10,800 cultured Columbia sub-yearling juveniles and about 500,000 free embryos have been released near the Revelstoke spawning site in an attempt to determine the suitability and availability of early life stage and juvenile habitat, and to collect data on survival of juveniles (Beamesderfer and Justice 2008; R. Ek, pers. comm.). While the studies are still preliminary in nature, early indications suggest the area between Greenslide and Mulvehill creek confluences supports a concentration of those juveniles found to remain in the river below REV (G. Birch, pers. comm.). As noted above, there is an untested assumption that wild fish would behave similarly to hatchery fish. This concentration may reflect the influence of reservoir backwatering at the time the juveniles were released, which could result in juveniles establishing localised territories (G. Birch, pers. comm.).

Prince (2001) reported First Nations and anecdotal sightings of white sturgeon in upper portions of the mainstem Columbia, however, adult sturgeon have not been collected above REV during investigations in Kinbasket Reservoir, and Revelstoke Reservoir (RL&L 1996b, 1996c, 2000b). Recently, over 51,000 hook-hours of set line effort was expended during July and September 2008 in Kinbasket Reservoir with no captures (A. Prince, Biologist, Westslope Consulting Ltd, pers. comm.). Given the large size of these reservoirs and limited sampling effort, the failure to catch a white sturgeon does not necessarily preclude their existence, but would suggest that population densities are likely to be very low (RL&L 2000b).

The transboundary nature of this population requires that recovery efforts be coordinated across multiple jurisdictions. Designation of critical habitat will be complicated by different jurisdictions and legal requirements. To recover this population will require critical habitats to be designated and managed in both countries in a coordinated manner. Since SARA is Canadian legislation, this document will only address habitats in Canada.

In the following sections, the transboundary component and the ALR component are discussed separately.

Table 8. Summary of information base for white sturgeon habitats in the ALR area of the Columbia River. A blank cell means that the life stage does not consistently use the habitat.

Area	Confirmed (√), Suspected (S), or Possible (?) Use by Life Stage and Degree of Use (H=High, M=Moderate, L=Low)						
	Spawn	**Larval Rearing**	**Juvenile Rearing**	**Adult Feeding**	**Over wintering**	**Staging**	**Overall Assessment**
Golf course spawning area	√ (M)	S (L)		√ (L)			critical
Big Eddy		?		√ (L)		√ (M)	critical
Salmon Rocks		?		√ (L)		√ (M)	critical
Beaton Reach			√ (M)	√ (H)	√ (H)		critical
Narrows Reach			S (L)	√ (M)			critical
REV to Beaton Flats excluding areas mentioned above			S (L)	√ (L)			important
Confluence areas of the following creeks: Halfway Kuskanax MacDonald Deer Mosquito Taite			?	√ (L)	?		important

Table 9. Summary of information base for white sturgeon habitats in the transboundary area of the Columbia River. A blank cell means that the life stage does not consistently use the habitat.

Area	Confirmed (√), Suspected (S), or Possible (?) Use by Life Stage and Degree of Use (H=High, M=Moderate, L=Low)						
	Spawn	**Larval Rearing**	**Juvenile Rearing**	**Adult Feeding**	**Winter**	**Staging**	**Overall Assessment**
Robson Reach			√ (H)	√ (H)	√ (H)	√ (M)	critical
Kootenay Eddy			√ (M)	√ (H)	√ (M)	√ (L-M)	critical
Ft. Shepherd Eddy			√ (H)	√ (H)	√ (H)	√ (H)	critical
Waneta Eddy			√ (H)	√ (H)	√ (H)	√ (H)	critical
Pend d'Oreille – Columbia Confluence	√ (H)	√ (H)	√ (L)	√ (M)		√ (H)	critical
Bridge Hole			S (L)	√ (M)	√ (M)		critical
Brilliant Tailrace			S (L)	√ (M)	√ (M)		critical
Norns Creek confluence to downstream of Genelle Islands	√ (L)	√ (L)	√ (L)	√ (L)	? (L)		important
Rock Is to US border			√ (L)	√ (L)	? (L)		important

1.10.1 Spawning and Incubation Habitat - ALR

ALR component.— Spawning presently occurs at a site located adjacent to the Revelstoke golf course. Spawning occurs naturally, although intermittently and at low numbers. Extensive sampling over several years (Golder 2006a) has confirmed that there has been no recruitment from these spawning events. This suggests that some factor(s) within spawning and incubation habitats are not functional at present, although the majority of mortality could also occur during a later life stage (e.g., juveniles). There are a variety of competing hypotheses to explain the lack of recruitment at this site (National Recovery Team for White Sturgeon 2009).

Critical Habitat.— All spawning and incubation habitat for the ALR component is located in the Columbia River adjacent to the Revelstoke golf course. This is a single location and there is therefore no substitutability for this component of critical habitat. The spawning site is a short distance downstream from REV, and can be affected by flow releases from REV and backwatering from ALR. Several studies have been proposed to assess the requirements for recruitment from this spawning site (BC Hydro 2007).

This habitat is deemed critical on an annual basis from mid-July and to early September based on known timing of spawning and incubation (Golder 2006a). The degree of certainty in this critical habitat determination is rated as high, based on repeated observations of spawning at this site and absence of other spawning habitat for the ALR population component. However, there was lack of consensus on this recommendation within the Columbia TWG.

1.10.2 Spawning and Incubation Habitat - Transboundary

Transboundary component.— The area downstream of Waneta dam in the Pend d'Oreille plume is the location in the Canadian section of the Columbia River downstream of HLK where spawning has been repeatedly detected since 1993. The Waneta spawning site is located less then 1 km upstream of the Canada-USA border. An additional Canadian spawning site has been identified based on the recent capture of a small number of larvae near Kinnaird, however this second site remains poorly defined. An additional spawning site for the transboundary component occurs in the US at Northport. Management of critical habitat for this component of the Columbia River population will require a coordinated approach with US jurisdictions.

Spawning occurs naturally at spawning sites in the transboundary reach, but there has been little recruitment from these spawning events. The limited recruitment detected is insufficient to sustain this population. Some attributes of the spawning and incubation habitat are not functional at present, and there are a variety of competing hypotheses to explain the lack of recruitment at this site (National Recovery Team for White Sturgeon 2009).

Critical Habitat.— Critical spawning and incubation habitat for the transboundary component is the Waneta spawning site, which includes the Pend d'Oreille River from the Highway 22A bridge to the confluence with the Columbia, and the Columbia River from the Pend d'Oreille confluence to the international border. Due to uncertainty in the identification of the spawning site associated with larval captures at Kinnaird, critical habitat is not proposed associated with that spawning site. The Waneta spawning site is the only spawning site in Canada currently proposed for the transboundary component.

The Waneta spawning site is deemed critical on an annual basis during June, July and the first week of August, based on known timing of spawning and incubation. This period is sufficient to encompass known annual variability in onset of spawning. The degree of certainty in this critical habitat determination is rated as high, based on repeated observations of spawning at this site.

1.10.3 Early Juvenile Habitat - ALR

0 - 40 days.— This life stage is considered a key recruitment bottleneck and is therefore a high priority for conservation.

For the ALR component this stage may last somewhat longer than in other locations due to the low water temperatures found at the spawning site during spawning and early rearing (Tiley 2004). Adhesive eggs are normally retained within the spawning site, but after hatching larvae are mobile and may move downstream. The location of larvae at this stage is not known for the ALR component. It is assumed that habitat for this stage includes the spawning site, as well as habitat downstream, though the extent of the downstream boundary is not known.

40 days to 2 years.— For the ALR component this stage has not been observed in the wild, as a result of ongoing recruitment failure. The location of habitat suitable for this life stage is therefore uncertain. During the early part of this phase it is expected that juvenile white sturgeon use a range of mainstem and off-channel habitats, as well as the deltaic habitats at the northern end of Arrow Reservoir. However, the precise locations of this use and its downstream extent are not clear at this time.

Critical Habitat.— For the ALR component the precise location of habitat for the 0 – 40 day life stage is not known, due in large part to ongoing recruitment failure. Critical habitat is therefore identified based on known spawning occurrences. Critical habitat includes the spawning site below REV and extends downstream some distance, though the downstream boundary cannot be defined at this time. This habitat is deemed critical on an annual basis during July through September, based on known timing of spawning and incubation. This period is sufficient to encompass known annual variability in onset of spawning. The degree of certainty in this critical habitat determination is rated as high, based on repeated observations of spawning at this site, although there is insufficient certainty to define the downstream limit of this habitat beyond that already defined for spawning and incubation. Several studies have been devised to assess suitable habitat for this life stage (BC Hydro 2007).

Critical habitat for the 40 days to 2 years stage is expected to include a range of mainstem and off-channel habitats, as well as deltaic habitats at the northern end of Arrow Reservoir. Uncertainty regarding the boundaries of this habitat unit are sufficiently high that critical habitat is not being proposed at this time.

1.10.4 Early Juvenile Habitat – Transboundary

***0 - 40 days.*—** This life stage is considered a key recruitment bottleneck and is therefore a high priority for conservation.

For the transboundary component, the habitat for the early portions of this stage (incubation to 12 days) is similar to habitat used for spawning. At the Waneta location, habitat for this stage extends downstream beyond the international border. The distribution of spawning and incubation habitats is understood fairly well for this location, and the distribution of post-hatch larvae began receiving significant study in 2008 (Golder 2009).

***40 days to 2 years.*—** For the transboundary component, habitat occupied during the early portion of this life stage is unknown. This is partly due to ongoing recruitment failure, as well as the difficulty in sampling within the large river environment. Habitat use by sub-yearling sturgeon released from conservation aquaculture work in this area suggests that all the main habitats (Waneta Eddy, Fort Shepherd Eddy, Kootenay Eddy and the Robson Reach) are occupied by later portions of this life stage (e.g., Golder 2006b). Additional sites where juveniles have been detected occur at a number of sites along the river margin, and these should be considered for future designation as critical.

***Critical Habitat.*—** Critical habitat for the transboundary component 0 – 40 days stage is defined as the same habitat unit as that used for spawning. The habitat extends downstream at least as far as the U.S. border. Thus, the recommendation for critical habitat for this life stage is the same as the spawning and incubation habitat.

Critical habitat for the transboundary component 40 days to 2 years stage includes the following habitats: Waneta Eddy, Fort Shepherd Eddy, Kootenay Eddy and the Robson Reach. Additional rearing sites for the early juveniles life stage may be defined in the future with additional data.

1.10.5 Late Juvenile and Adult Habitat - ALR

***General*. —** For the ALR component, there is uncertainty about habitat use during portions of this life stage. However, good evidence has been gathered to show that adult white sturgeon reside in the Revelstoke Reach as well as the Beaton Flats area of Upper Arrow Reservoir, as well as at key feeding sites at the mouths of key kokanee spawning streams (Golder 2006b). It is expected that older juveniles occupy similar habitats. Further study is needed to increase confidence in these assessments.

Adult Feeding Habitat. — Adults have been found more often in the upper basin of Arrow Reservoir. Within that basin they are generally concentrated near the north end, and most consistently in the Beaton Flats area. The Revelstoke Reach is also used as feeding and staging habitat, but further work is needed to clarify the importance of this location.

A vital function of the reservoir is to provide feeding habitat to white sturgeon. Kokanee are the predominant food resource of adult white sturgeon, and therefore creek mouths where kokanee congregate are important habitats. Beaton Flats and Beaton Arm are identified as especially important. Creek mouths and lower reaches of the following streams are also identified as important, based on mean annual escapements of more than 5000 kokanee (MoE, data on file):

- Halfway
- Kuskanax
- MacDonald
- Deer
- Mosquito
- Taite

Adult Winter Habitat. — Winter habitat of white sturgeon can be characterized as habitat where fish can maintain their position with minimal energy use. Within the Arrow Reservoir overwintering habitats are identified based on past fish capture, and are generally located in the northern end of Arrow Reservoir, at or near Beaton Flats.

Adult Staging. — Prior to spawning, white sturgeon often stage in areas directly adjacent to a spawning area. Given the limited information available about spawning for the ALR component, precise description of staging areas is challenging. The most likely areas occur upstream of the Highway #1 bridge, extending upstream to the spawning site by the Revelstoke golf course. Of particular importance within this area is the large eddy referred to locally as Big Eddy.

Critical Habitat.— For the ALR component critical habitat for the late juvenile and adult life stage is as follows. For feeding, it is the Beaton Flats area, based on year round use and consistently high densities of adults. Other areas (e.g., kokanee spawning stream outlets) are identified as important, but additional work is required to clarify whether they should be classified as critical. For overwintering, Beaton Flats area is also identified, based on past fish captures. For staging, Big Eddy is identified as critical habitat, although additional area is identified as important. Big Eddy and the Beaton Flats area are deemed critical on a year-round basis, based on known timing of feeding, staging and overwintering. The degree of certainty in this critical habitat determination is rated as moderate to high, based on repeated observations of white sturgeon activities at these sites, although there is some uncertainty regarding the geographic boundaries of this habitat. Several studies have been devised to improve confidence in the assessment of these boundaries.

1.10.6 Late Juvenile and Adult Habitat - Transboundary

General. — For the transboundary component, there is uncertainty regarding habitat use by late juveniles and adults, due principally to rarity of young white sturgeon in this portion of the river. It is anticipated that critical habitat for this life stage is the same as for juveniles of 1 - 2 years age. The latter portions of this life stage reside primarily in the four large main river eddies, however, the timing of this transition is unclear. It is also unclear whether this would still be true if abundance was greater than it is at present. There is a high level of confidence in the location of most adults within this reach, based on years of telemetry and sampling.

***Adult Feeding Habitat.* —**In the transboundary area, the reach from Norns Creek confluence to Genelle Islands appears to be used for foraging by sturgeon residing in the upper part of this area, although this use has yet to be fully documented. As well, habitats immediately below HLK (Robson Reach) and Brilliant Dam (Brilliant Tailrace and Bridge Hole) likely provide excellent feeding opportunities, specifically feeding on fishes entrained through those facilities. Fort Shepherd and Waneta Eddies are used year round by large numbers of adults, and are assumed to provide a consistent food supply based on the ability of these areas to slow and trap organic material in the drift.

***Adult Winter Habitat.* —** For the transboundary component, there are four main locations of high importance as overwintering habitat: Waneta Eddy, Fort Shepherd Eddy, Kootenay Eddy, and the Robson Reach.

***Adult Staging.* —** For the transboundary component, the main staging areas associated with the Waneta spawning site are Fort Shepherd Eddy and Waneta Eddy, and this is well-documented.

***Critical Habitat.*—** Critical habitat is defined as follows for the transboundary component during the late juvenile and adult life stage. As in the case of the ALR component, areas have been identified as critical feeding habitat based on frequency of use and abundance. These are Waneta Eddy, Fort Shepherd Eddy, Kootenay Eddy, Brilliant Tailrace, Bridge Hole and the Robson Reach. The same six locations have also been identified as critical overwintering habitat. Waneta and Fort Shepherd Eddies have been further identified as critical habitats for staging. These habitats are deemed critical on an annual basis because of their combined value as feeding, overwintering and staging habitat. However, Brilliant Tailrace is not used when spilling occurs during freshet, which typically runs from April to July. The degree of certainty in this critical habitat determination is rated as high, based on repeated observations of white sturgeon activities in these areas. However, there was lack of consensus on the Brilliant Tailrace and Bridge Hole recommendations within the Columbia TWG.

1.10.7 Connectivity – ALR

For the ALR component in the Columbia River, connectivity is required for the segment upstream from the Highway 1 Bridge to Big Eddy, and from Big Eddy to the spawning site at the golf course. Connectivity is identified specifically for those locations because flow releases from REV are a prerequisite for connectivity. The proposed minimum flow from REV may provide such connectivity; however, this must be evaluated once the flow is implemented. For the transboundary component in the Columbia River, connectivity is also an issue. Based on preliminary genetic data, it is believed that HLK currently divides a formerly contiguous population. The limited ability to alter present levels of connectivity at HLK is acknowledged, however, connectivity was likely critical prior to dam construction. At a minimum the present levels of connectivity within the transboundary reach should be maintained.

1.10.8 Critical Habitat Attributes and Timing

This section provides a compilation of all geographic locations that are proposed as critical and important, and provides the attributes of these areas that make them critical to white sturgeon. Also provided is the time of year that the critical habitat designation applies. The summary is provided in Table 10 and Table 11.

Table 10. Summary of attributes and timing for white sturgeon critical habitats in the Columbia ALR area.

Location	Definition	Attributes & Rationale	Life Stages and Timing
Revelstoke Golf Course	critical	This is the only confirmed spawning area for white sturgeon in the mid- Columbia River between REV and HLK. Spawning has been detected sporadically at this location since 1999 with at least 2 spawning events estimated in those years when spawning has been documented. Spawning has occurred over a variety of flow conditions, in late July and in some years there is another event in mid-late August. Spawning generally occurs during period of summer water temperature maxima (within a range of 9-12º C), in thalweg depths of 4 - 5 m depth, at maximum dam discharge and ALR at full pool. Based on the locations of captured eggs, low flows during years with low summer ALR levels could expose incubating eggs at night on bars downstream of the spawning area. In years with high ALR summer levels, incubating eggs would be within backwater effect of reservoir and may be more vulnerable to predation.	• spawning and incubation (√), mid Jul - early Sep • free embryo and larvae (S),late Jul - early Sep • adult (√), summer • composite timing: spring and summer
Big Eddy	critical	Represents locations selected by pre spawning females (and possibly pre spawning males) that provide suitable low velocity holding areas near spawning habitats; higher use of these areas may reflect depths >20 m at these location, though staging requirements poorly understood. Changes in flow or temperature conditions during the staging period have been shown to impact spawning behaviour and success in other sturgeon species. There is transitional use by juveniles.	• free embryo and larvae (?),late Jul - early Sep • adult (√), summer • staging (√), Jun - Jul • composite timing: spring and summer
Salmon Rocks	critical	see comments for Big Eddy	• free embryo and larvae (?),late Jul - early Sep • adult (√), summer • staging (√), Jun - Jul • composite timing: spring and summer
Beaton Reach	critical	In all seasons Beaton Flats is the most preferred area for adult feeding. This is a depositional area near the historical river-lake interface, with depths over 15 m and low velocities. All individuals captured and aged pre-date Keenleyside Dam closure (pre-1968). Adults range throughout the Narrows and Upper Arrow Lakes area and into the mid Columbia as far upstream as REV. Some suggestion of an upstream feeding movement by some individuals in spring and early summer as reservoir fills. Individuals tend to select the reservoir-river interface area. There is no indication of shallow water habitat use although study effort has been limited. In winter, fish tend to be found in deeper portions (>15 m depth) within Beaton Flats. Since regulation of the river, winter flows and water temperatures have increased. Whether this has increased or decreased the suitability of overwintering habitats is	• juvenile (√), all year • adult (√), all year • winter (√), Nov - Mar • composite timing: all year

Location	Definition	Attributes & Rationale	Life Stages and Timing
		unknown. Deep near-bottom areas in Beaton Flats exhibit velocities < 0.5 m/s. Evidence from other sturgeon species indicates unsuitable overwintering conditions can lead to atresia of oocytes.	
Narrows Reach	critical	Feeding area with depths over 15m and low velocities, depositional area by river lake interface. Potential juvenile rearing.	• juvenile (S), all year • adult (√), all year • composite timing: all year
REV to Beaton Flats excluding areas mentioned above	important	No evidence to suggest differential habitat uses by juveniles. Low use of shallow water habitats. In LCR, up to age-6, main food item appears to be Mysis relicta for hatchery juveniles. Availability of this food item in MCR is unknown. Adults range throughout the Narrows and Upper Arrow Lakes area and into the mid Columbia as far upstream as REV. Some suggestion of an upstream feeding movement by some individuals in spring and early summer as reservoir fills. Tend to select the reservoir-river interface area. No indication of shallow water habitat use although tracking has not been intensive. Sturgeon are generalist opportunistic feeders; fish likely form important component of diet. Feeding success likely plays a key role in age-at-maturity, fecundity, and spawning frequency.	• juvenile (S), all year • adult (√), all year • composite timing: all year
Confluence areas of the following creeks: Halfway Kuskanax MacDonald Deer Mosquito Taite	important	These are important feeding areas, particularly for adults. The primary food item is kokanee.	• juvenile (?), all year • adult (√), all year • winter (?), Nov - Mar • composite timing: all year

Table 11. Summary of attributes and timing for white sturgeon critical habitats in the Columbia transboundary area.

Location	Definition	Attributes	Life Stages and Timing
Pend d'Oreille-Columbia confluence to US border	Critical	This is the primary confirmed spawning area for white sturgeon in the Columbia River between HLK and the Border. Spawning has occurred annually at this location since 1993 with an estimated minimum 3 to 12 spawning events per year. Spawning has occurred over a wide variety of flow conditions (no correlation with flow), but always on the descending limb of freshet and after water temperature reaches 14C. Modelling by CPC indicates that majority of egg incubation area is located upstream of the border and in the influence of both the Pend d'Oreille and Columbia Rivers. Suitable flow conditions for successful hatching are present in most years throughout the majority of the spawning period.	• spawning and incubation (√), Jun – early Aug • free embryo and larvae (√), mid Jun - mid Aug • late juvenile and adult (√), all year • staging (√), Nov - Jul • composite timing: all year
Kootenay Eddy	Critical	Adult feeding area; highest selection for all seasons is for depositional areas with depths greater than 15m and lower velocities relative to thalweg flows. Adults range throughout these areas, but also frequently use adjacent shallower habitats. In recent years they have been documented in shallow water habitats adjacent to known rainbow trout spawning areas. Some evidence of predation on spawning mountain whitefish suggests use of shallower areas for feeding in late fall and early winter. In winter, fish tend to be found in deeper portions >20m; since river regulation winter flows and water temperatures have increased, effect on overwintering habitat is unknown. Winter water temperatures rarely decrease below 4^{0}C. Evidence from other sturgeon species indicates unsuitable overwintering conditions can lead to atresia. There is an apparent low level of spawning in the vicinity of these sites, based on observations in the past two years. The exact location of spawning is unknown. Also unknown is whether this represents a new spawning area or whether it has always been used at a low level by some fish that reside in the upper section of this river segment. Investigations in these areas in early to mid 1990s did not indicate any spawning use at that time. Low use for staging, low velocity holding areas near spawning habitats.	• early juvenile (√), mid Jun - mid Aug • late juvenile and adult (√), all year • winter (√), Nov - Mar • staging (√), Nov - Jul • composite timing: all year
Ft. Shepherd Eddy	Critical	see first two paragraphs for Kootenay Eddy High use of area for staging likely due to depths >50m; low velocity holding areas near spawning habitats. Staging requirements are poorly understood, but changes in flow or temperature have been shown to affect spawning behaviour and success in other sturgeon species.	• early juvenile (√), mid Jun - mid Aug • late juvenile and adult (√), all year • winter (√), Nov - Mar • staging (√), Nov - Jul • composite timing: all year

Location	Definition	Attributes	Life Stages and Timing
Waneta Eddy	Critical	see first two paragraphs for Kootenay Eddy Staging requirements are poorly understood, but changes in flow or temperature have been shown to affect spawning behaviour and success in other sturgeon species. Low velocity holding areas near spawning habitats.	• early juvenile (√), mid Jun - mid Aug • late juvenile and adult (√), all year • winter (√), Nov - Mar • staging (√), Nov - Jul • composite timing: all year
Robson Reach	Critical	see first two paragraphs for Kootenay Eddy Staging requirements are poorly understood, but changes in flow or temperature have been shown to affect spawning behaviour and success in other sturgeon species.	• early juvenile (√), mid Jun - mid Aug • late juvenile and adult (√), all year • winter (√), Nov - Mar • staging (√), Nov - Jul • composite timing: all year
Bridge Hole	Critical	Consistent use as a feeding and holding area throughout the year. Disproportionate use by fish that preferentially reside within the lower Kootenay River. Relative to other critical habitats, low numbers of fish have been detected in this area.	• late juvenile and adult (√), all year • composite timing: during non-spill periods
Brilliant Tailrace	Critical	Consistent use as a feeding and holding area throughout the year. Disproportionate use by fish that preferentially reside within the lower Kootenay River. Relative to other critical habitats, low numbers of fish have been detected in this area. Some individuals appear to show fidelity to this area.	• late juvenile and adult (√), all year • composite timing: during non-spill periods
Norns Creek confluence to downstream of Genelle Islands	Important	Precise spawning, larval and free embryo dispersal patterns are unknown. For sub adults (20 to 25 years old) and mature adults (generally older than age 25) highest selection in all seasons is for depositional areas with depths over 15 m and lower velocities relative to thalweg flows. Adults range throughout these areas but also frequently use adjacent shallower water habitats. In recent years have been documented in shallow water habitats adjacent to known rainbow trout spawning areas. Some evidence of predation on spawning mountain whitefish suggests use of shallower water areas for feeding in late fall and early winter. In winter, fish tend to be found in deeper portions (>20 m depth) of the four main feeding areas. Winter water temperatures rarely decrease below 4C; fish remain relatively active in wintering areas relative to populations in other northerly systems.	• free embryo and larvae (?), mid Jun - mid Aug • late juvenile and adult (√), all year • composite timing: all year
Rock Is to US border	Important	see Norns to Genelle	• late juvenile and adult (√), all year • winter (√), Nov - Mar • composite timing: all year

1.10.9 Activities Likely to Impact Critical Habitat

There are several activities that have the potential to impact white sturgeon critical habitats in the Columbia River. These activities have been briefly reviewed and their threats prioritized by the basin-level recovery team (Table 12). Risk is usually defined as a product of probability of occurrence and consequence. In this table, risk primarily describes consequence alone. Probability of occurrence in most cases is presumed to be low because current regulatory restrictions would preclude many of these activities in critical habitat. Threats to white sturgeon and their habitats are discussed in more detail in Section 3 of the Recovery Strategy.

ALR component.— The spawning site for the ALR component is downstream from REV, which is currently operated as a load-following facility. Although spawning appears to occur naturally, operations of REV are believed to influence the viability of incubation habitat by stranding eggs and embryos. Hypolimnetic releases (i.e., from deep, cold water) from REV have altered water temperatures and are believed to influence timing of spawning and duration of embryo development. Elevation of ALR is believed to alter flows below REV due to a backwatering effect, which may influence suitability of spawning and incubation habitats.

Operations at REV can also limit connectivity among habitats from Arrow Reservoir to the spawning site at the golf course. The proposed minimum flow from REV may provide such connectivity; however, this must be evaluated once the flow is implemented.

Transboundary component.— The Waneta spawning area is influenced by load-following and water storage associated with a series of dams on Pend d'Oreille River, including Seven Mile and Waneta Dams within Canada and additional facilities upstream in the U.S. Spawning occurs primarily beyond the Pend d'Oreille channel, into the confluence with the Columbia mainstem and downstream a short distance. Thus, Columbia and Kootenay River dams further impact spawning and incubation habitats, again as a result of both load-following and storage. Contaminant impacts are also of concern.

General activities that would impact critical habitat for juvenile and adult life stages include several aspects of river regulation, fish community changes, gravel or sand dredging, linear developments, riparian, foreshore, floodplain alterations or developments, upstream land and water uses, and point and non-point source effluent discharges. The exact concerns vary depending on details of the activities. General threats to white sturgeon habitat are discussed in the Recovery Strategy.

It is the presence of HLK rather than an activity per se that limits connectivity for the transboundary component. Resolution of this issue is complex, however, as HLK also affects the movement of non-native walleye and potentially other exotics, hindering expansion of their range into Arrow Reservoir.

Table 12. Activities likely to impact Columbia white sturgeon critical habitat.

Impact Categories	Examples of Activities	Mechanism	Risk – Consequence (if it occurs)	Risk – Likelihood (that it will occur)	Uncertainty
Loss of habitat quantity and quality and fragmentation	▪ Instream works ▪ Land development ▪ Introduction of invasive species	▪ Physical removal of habitats ▪ Sedimentation ▪ Dewatering ▪ Render habitats unsuitable for use	Spawning and incubation – High Feeding - Low	Low – physical works in CH Moderate - sediment low – altered flow	Generally well understood except impacts to large eddies Impacts of invasive species not well understood
Altered hydrograph components	▪ Hydroelectric facility operations	▪ Temperature change ▪ Productivity change ▪ Habitat availability & suitability ▪ Spawning conditions	Spawning and incubation – High Feeding – Moderate	High to Moderate	Impact to juveniles unknown Impacts not fully understood
Pollution	▪ Non-point and point source discharges	▪ Deposition of substances ▪ Precludes use of habitat ▪ Damages food supply	High all life stages	Low	Low for ongoing discharges Spill event frequency and magnitude cannot be predicted
Alteration to food supply	▪ Fishing ▪ Invasive Species	▪ Lowering functionality of feeding areas impacting fitness of fish	Moderate	Moderate to Low	High uncertainty on this threat; impacts to population.
Climate change	▪ n/a at local level	▪ Temperature change ▪ Productivity change ▪ Habitat availability & suitability ▪ Dewatering	Moderate to High	Moderate	Uncertainty very high

1.10.10 Data Gaps

Minor data gaps exist for determining the geographic boundaries of critical spawning and incubation habitat for both the ALR and transboundary population components. In the case of the Kinnaird spawning site, the data gaps are substantial. However, with respect to the other two sites the habitat units are relatively small and quite well-defined, so any increase in the precision of the habitat boundaries is considered inconsequential at this time. There remain significant uncertainties with respect to the qualities of habitat that are required to make these habitat units functional for incubation and early life stages. Work is underway to assess these habitat variables (Steve McAdam, BC Ministry of Environment, pers. comm.).

There are moderate data gaps for determining the geographic boundaries of critical habitat for early life stages. The areas defined in this document as critical habitat are based on existing information of white sturgeon habitat use. Additional studies may increase the confidence in these boundaries and may permit greater precision in defining the geographic areas of interest. There are significant data gaps with respect to specific qualities of habitat that would allow some of these sites to become fully functional.

There are some data gaps for determining the geographic boundaries for critical habitats for the late juvenile and adult life stage. The eddies described are fairly small, and it is unlikely that additional confidence is required to better define these boundaries. The Beaton Flats area is considerably broader, and there may be benefits in trying to better define the geographic boundaries of this site.

The single biggest data gap is with respect to determining the causes of ongoing recruitment failure, and how to make critical habitat functional. Other data gaps include knowledge of historic spawning sites and connectivity to those sites. Data gaps also exist with respect to water quality parameters and limits to sturgeon production.

1.10.11 Maps of Critical Habitat

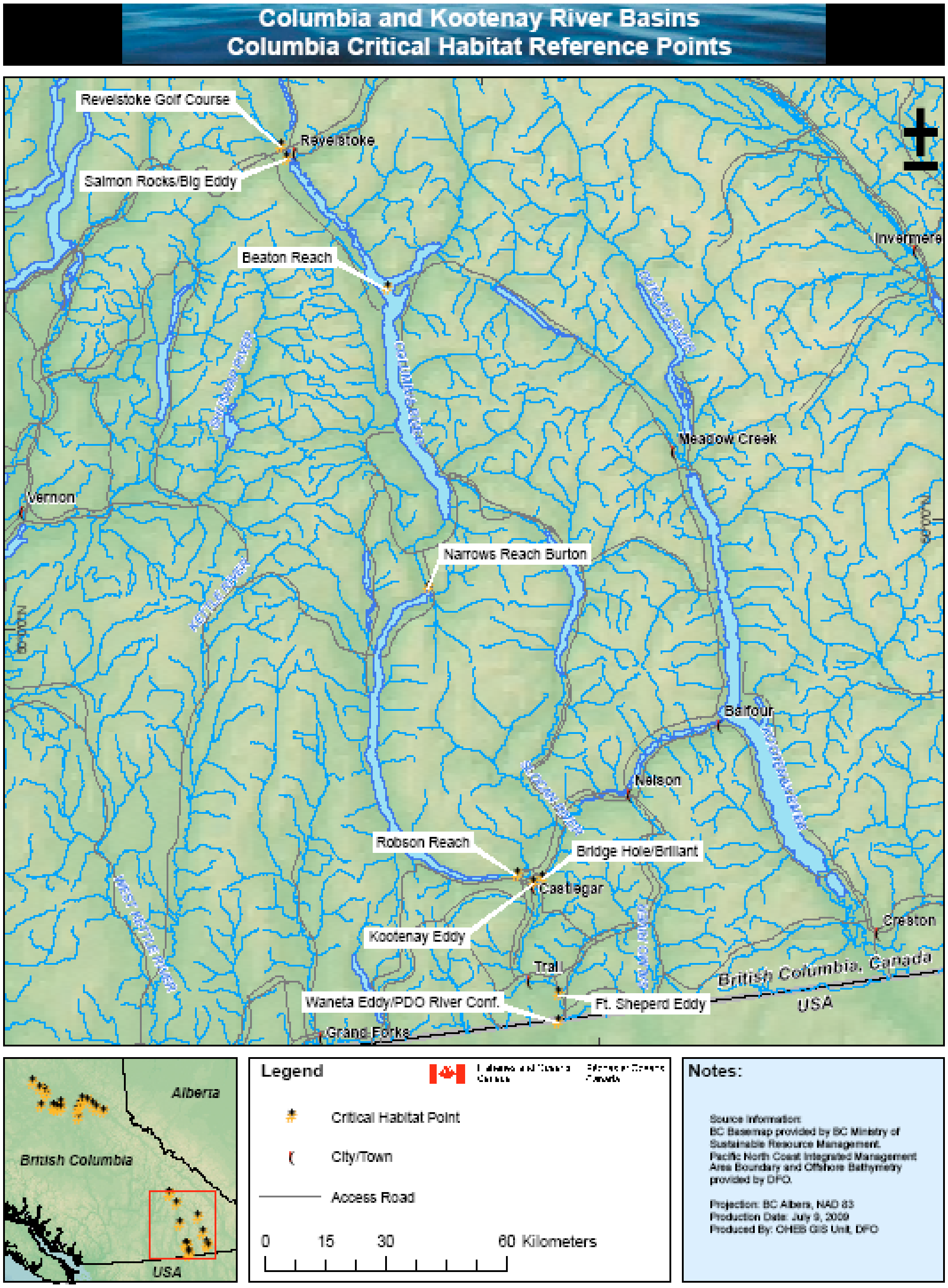

Figure 28. Reference map for locations of Columbia white sturgeon critical habitats.

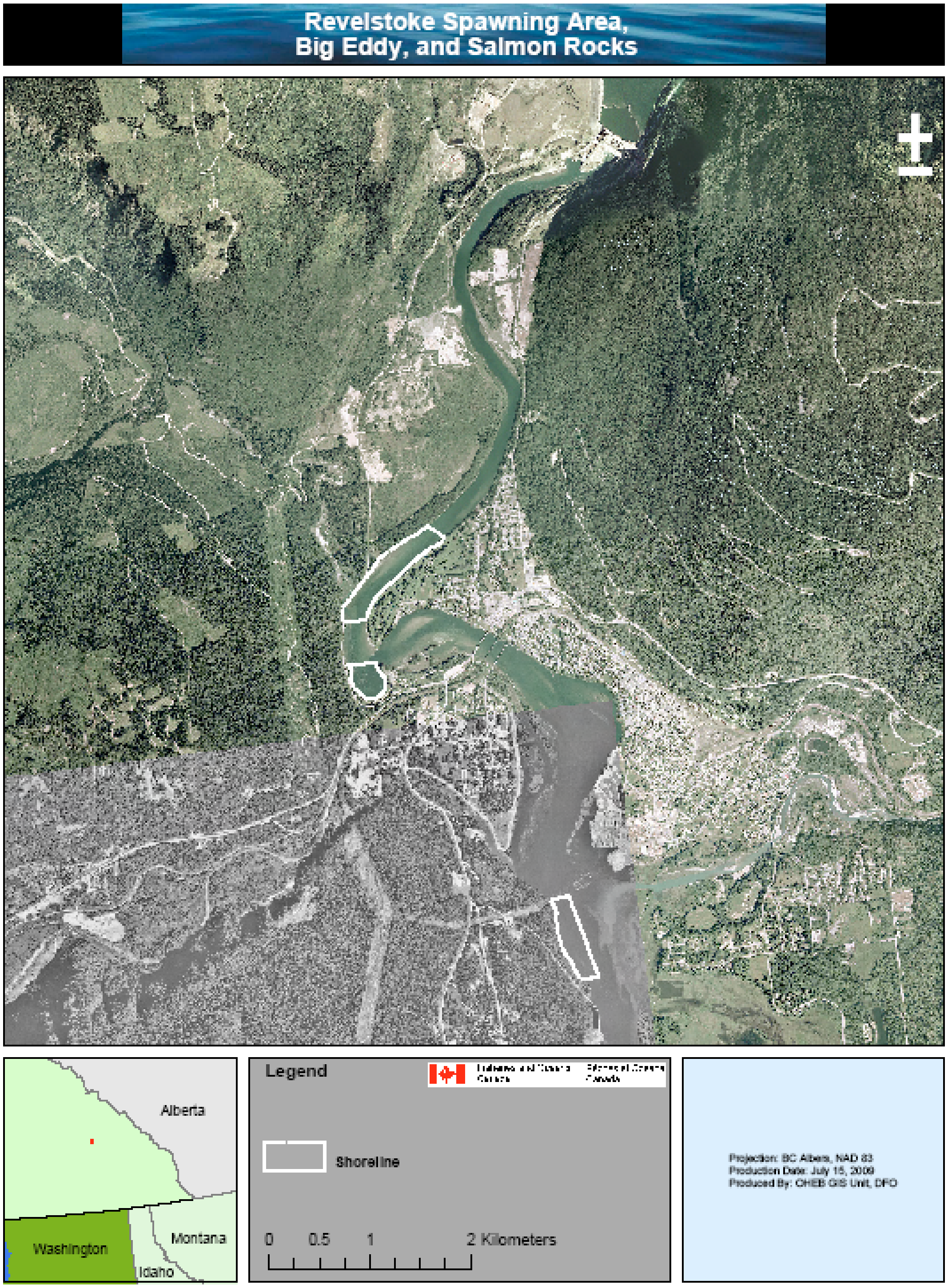

Figure 29. Map of critical habitat for Columbia white sturgeon: Revelstoke Golf Course, Big Eddy and Salmon Rocks.

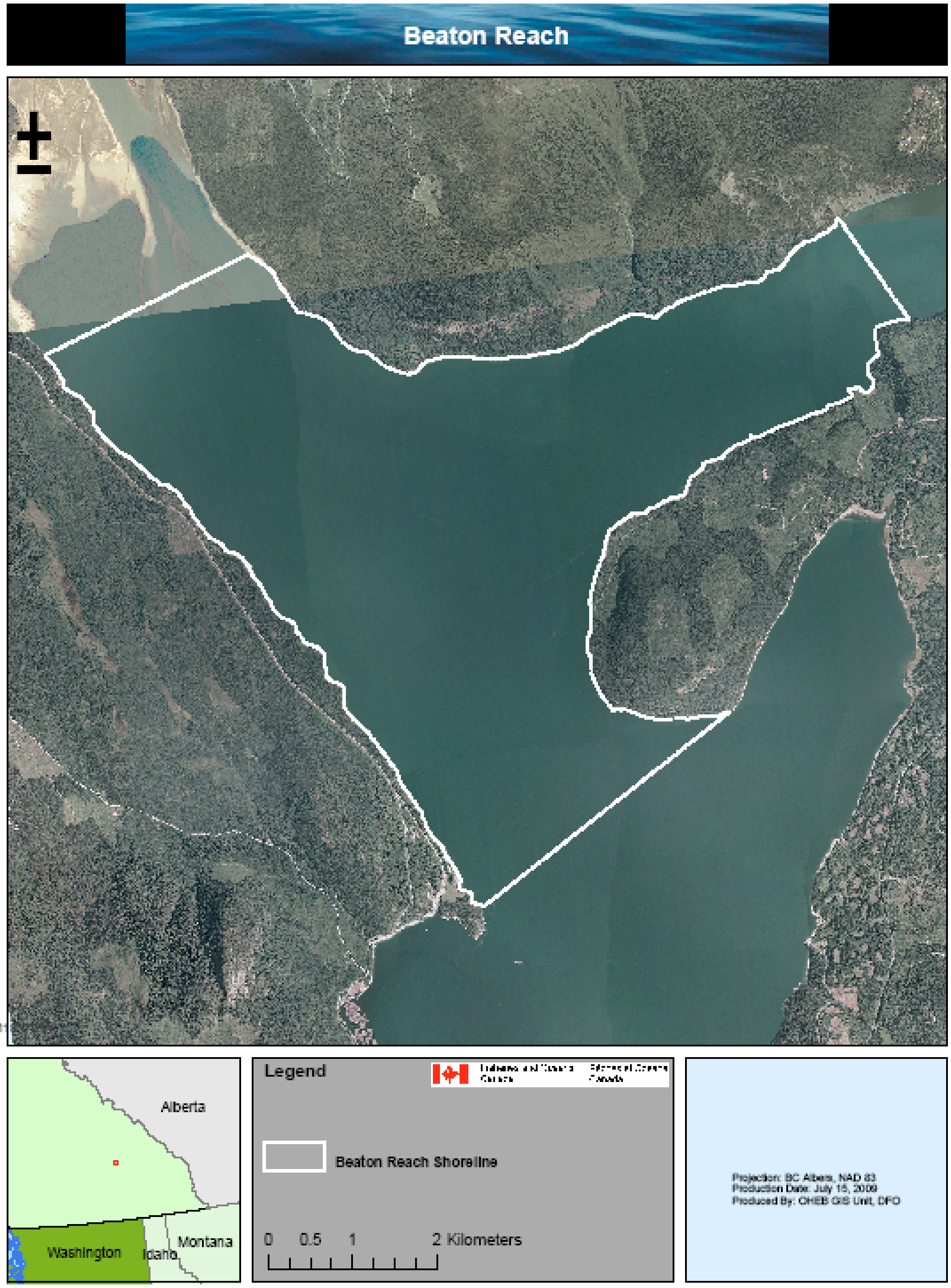

Figure 30. Map of critical habitat for Columbia white sturgeon: Beaton Reach.

Figure 31. Map of critical habitat for Columbia white sturgeon: Narrows Reach.

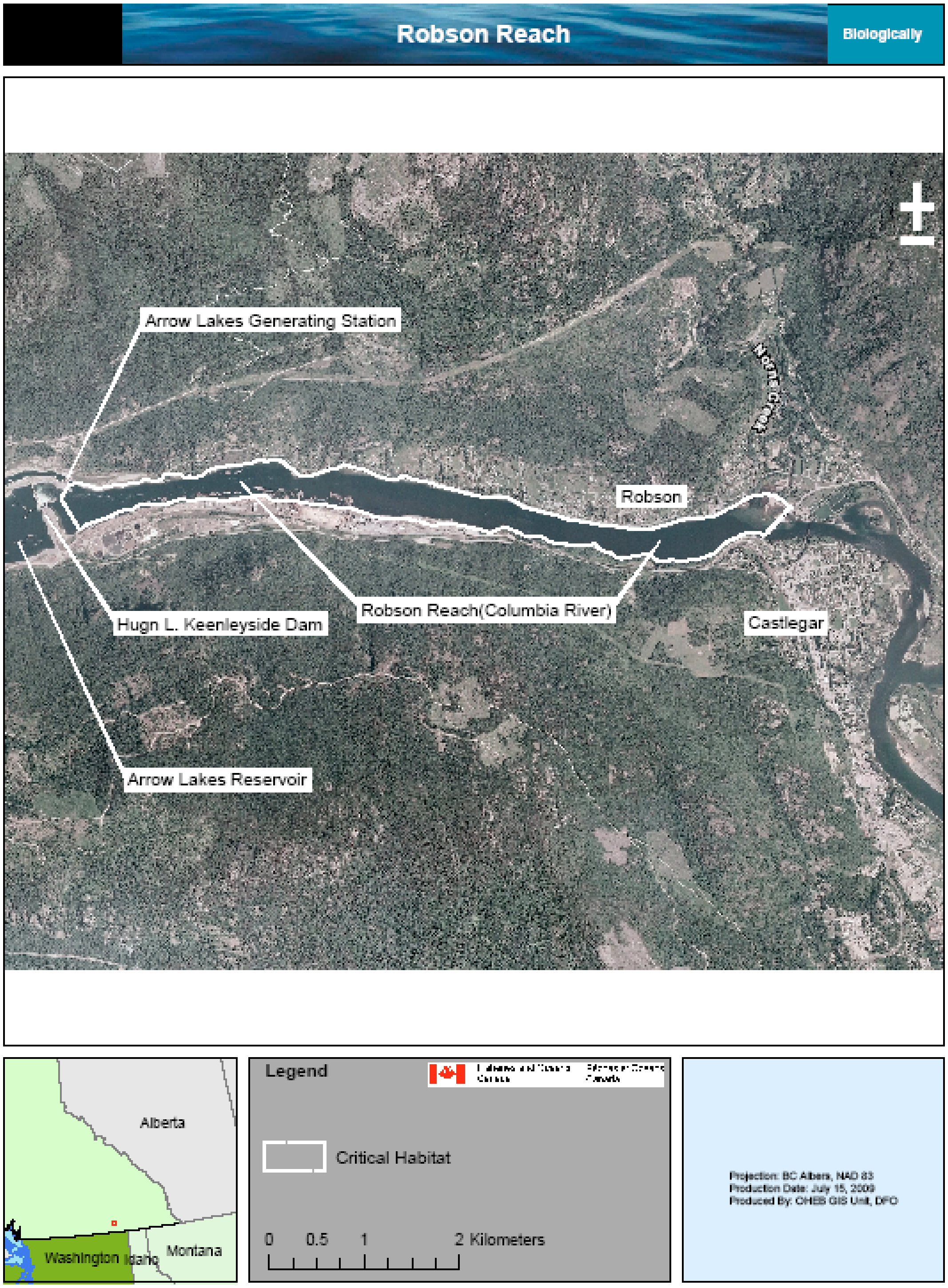

Figure 32. Map of critical habitat for Columbia white sturgeon: Robson Reach below HLK.

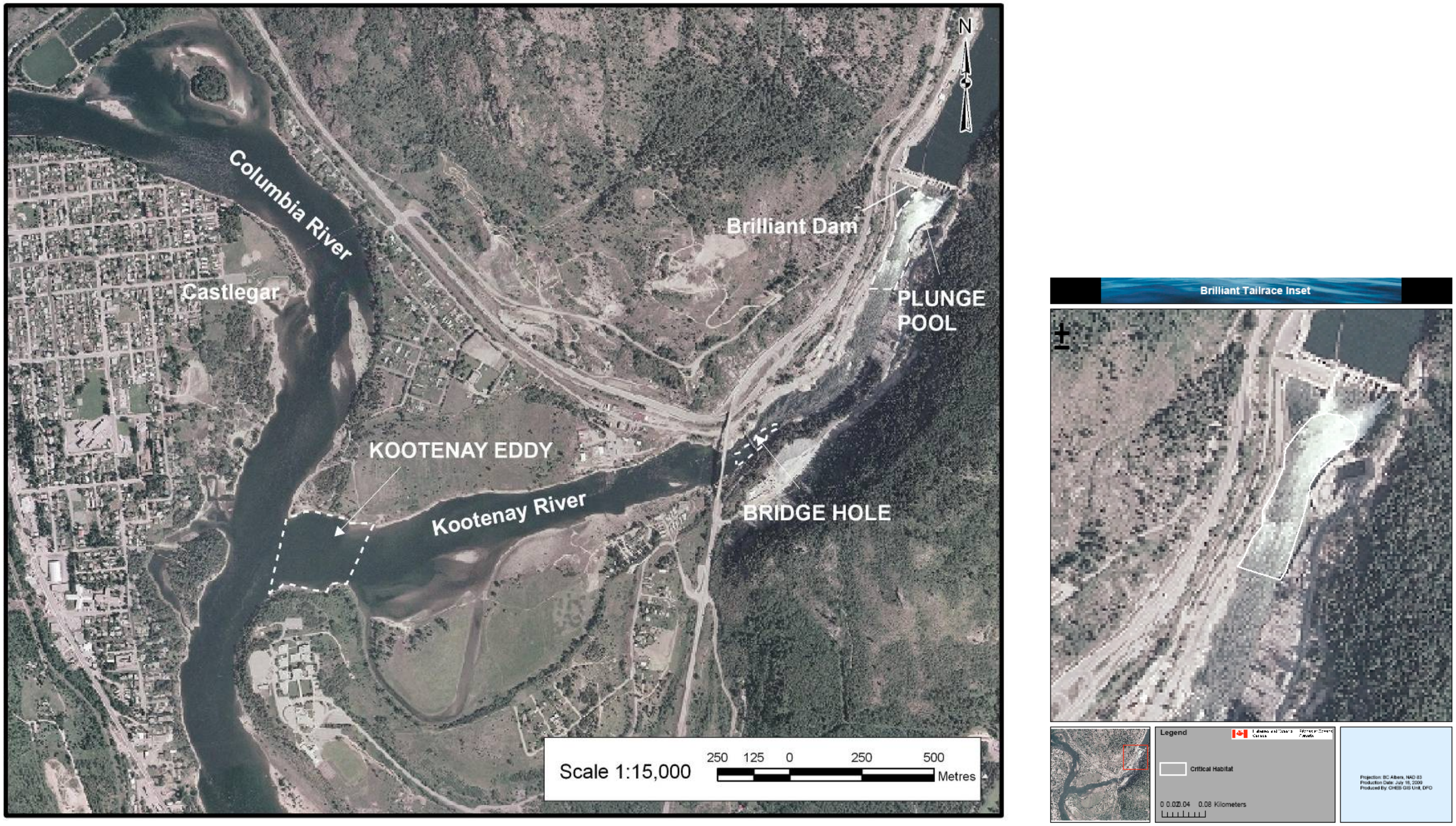

Figure 33. Map of critical habitat for Columbia white sturgeon: Kootenay Eddy, Bridge Hole and Brilliant Tailrace.

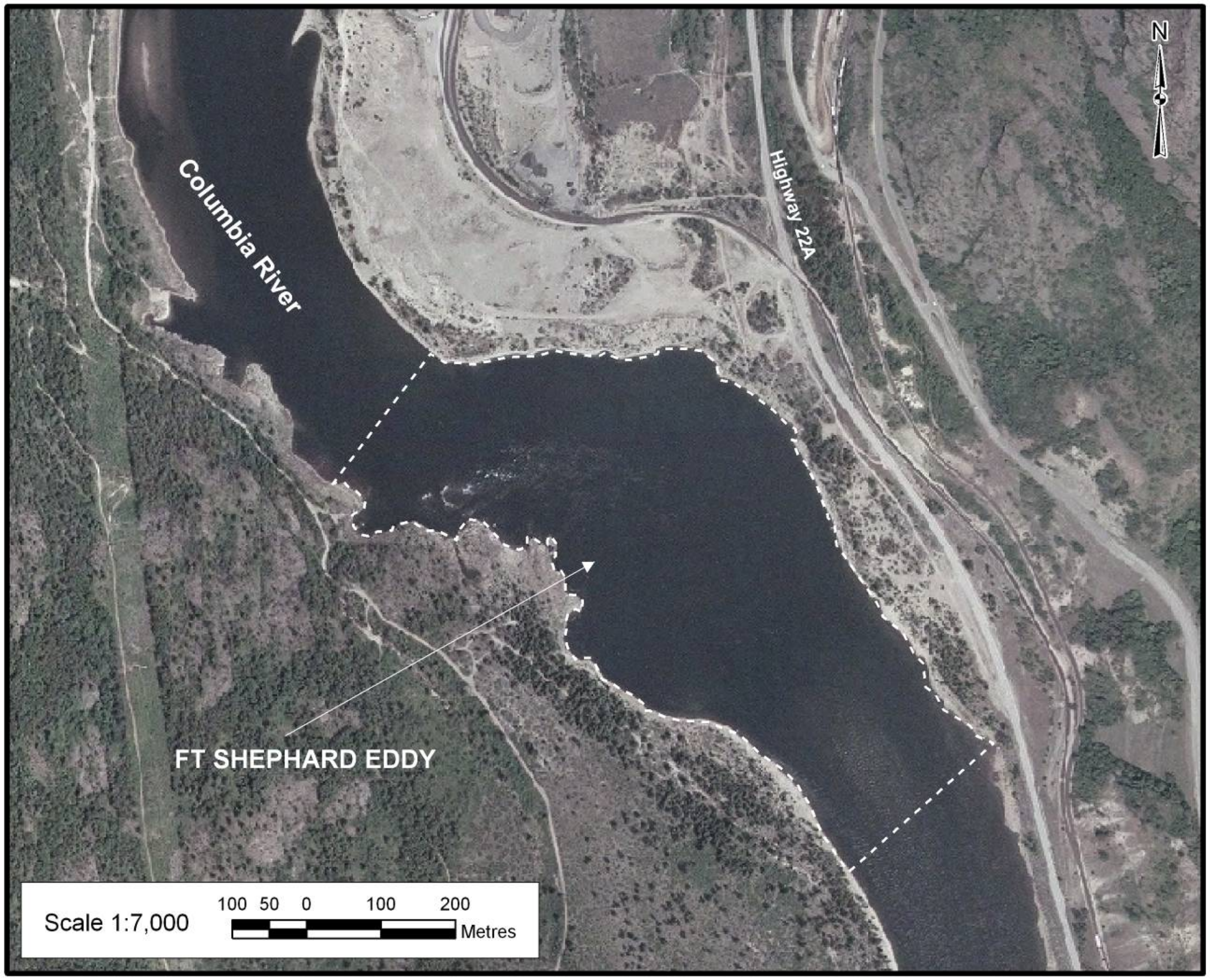

Figure 34. Map of critical habitat for Columbia white sturgeon: Fort Shepherd Eddy.

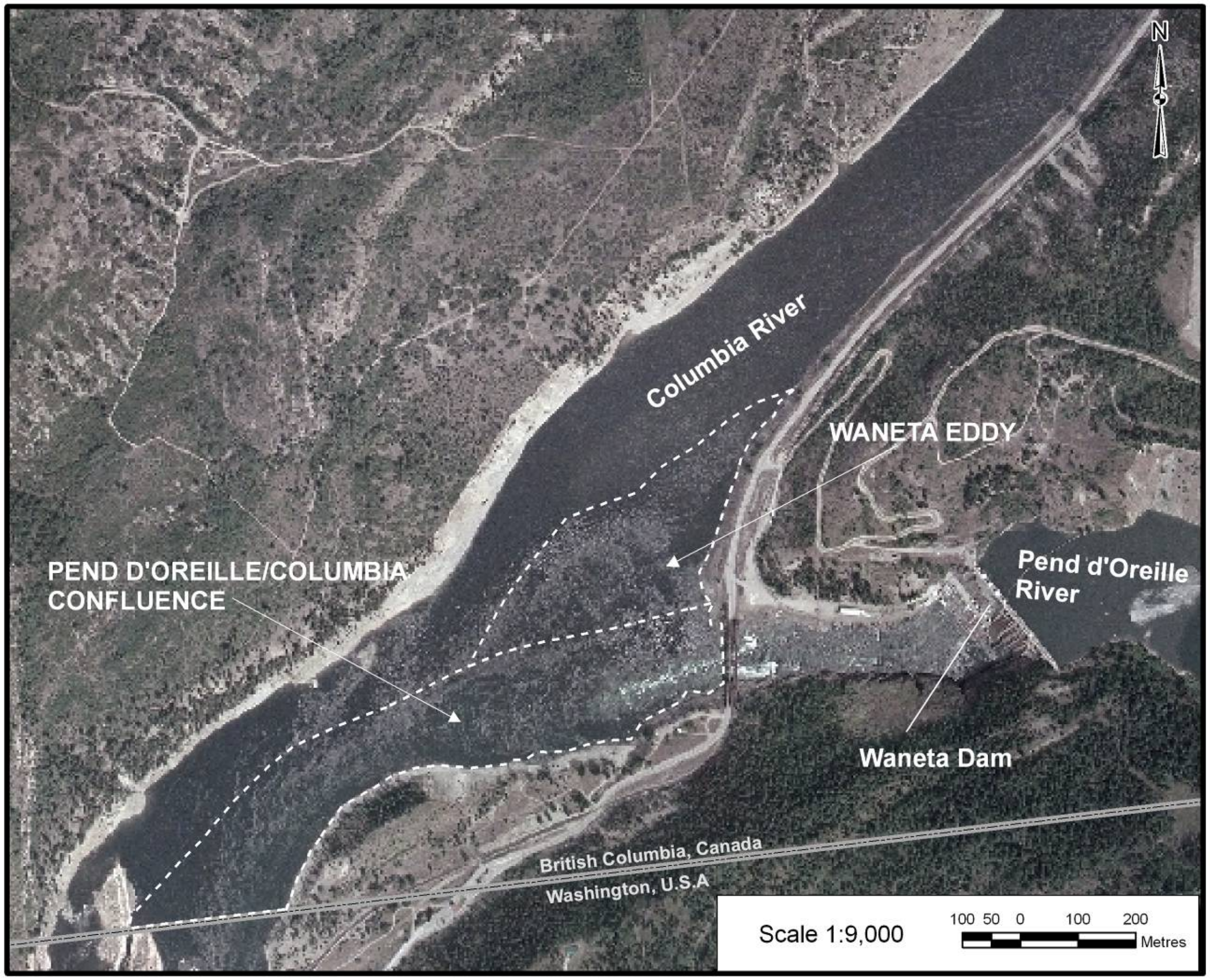

Figure 35. Map of critical habitat for Columbia white sturgeon: Waneta Eddy and Pend d'Oreille confluence with the Columbia River.

1.11 KOOTENAY

The Kootenay River population of white sturgeon extends from Kootenai Falls, Montana, located 50 river-kilometres downstream of Libby Dam, through Kootenay Lake to Corra Linn Dam on the lower West Arm of Kootenay Lake, British Columbia. Kootenai Falls likely represents an impassable natural barrier to the upstream migration of white sturgeon, although anecdotal evidence suggests the historic presence of white sturgeon upstream of Kootenai Falls in Montana and British Columbia. A natural barrier at Bonnington Falls downstream of Kootenay Lake has isolated Kootenay white sturgeon from the Columbia River population since the end of the Pleistocene, approximately 10,000 years ago (Northcote 1973). Spawning habitat is located in the US, whereas much of the adult and juvenile rearing habitat is located in the Canadian portion of Kootenay River plus Kootenay Lake (e.g., Kootenay delta and tributary creek mouths). Offchannel wetland habitat is likely valuable for early life stages, and historically was in greater abundance than at present.

White sturgeon are also found in very small numbers in Duncan Reservoir and Slocan Lake (RL&L 1998b, 1998c). The Slocan River is a tributary of the Kootenay River and white sturgeon in the Slocan are genetically most similar to the Kootenay population. Since the Slocan is downstream of Bonnington Falls any white sturgeon here would have been unable to return to the Kootenay. Five adult sturgeon from the Kootenay population were transplanted into Koocanusa Reservoir, upstream of Kootenai Falls, by BC and Montana government staff in the mid-1970s.

The transboundary nature of the Kootenay River population requires that recovery efforts be coordinated across multiple jurisdictions. Designation of critical habitat is complicated by different jurisdictions and legal requirements. Recovery of this population will require critical habitats to be designated and managed in both countries in a coordinated manner.

The information base for the Kootenay white sturgeon population is substantial, based on many years of intensive study, although relatively more information is available for habitats in the US than in Canada. High use habitats within the Canadian portion of its range have been identified for all life stages, and this information is summarized in Table 13. As additional information is collected, it will become possible to refine recommendation for designating critical habitat.

Table 13. Summary of information base for Kootenay white sturgeon habitats. A blank cell means that the life stage does not consistently use the habitat.

Area	Confirmed (√), Suspected (S), or Possible (?) Use by Life Stage and Relative Density (H=High, M=Moderate, L=Low, U=Unknown)						
	Spawn	**Free embryo and larvae (0 – 40 days)**	**Early juvenile (40 days – 2 yrs)**	**Late Juvenile and Adult**	**Winter**	**Staging**	**Overall Assessment**
Kootenay River (km 122-132.5)		S (U)	√ (M)	√ (M)	√ (M)	√ (M)	critical
Kootenay River Delta (km 117-121.9)		? (U)	√ (H)	√ (H)	√ (H)	√ (M)	critical
Lardeau Delta (km 17-18)			S (L)	√ (H)	√ (M)	√ (L)	critical
Crawford Creek Delta (km 75-80)			√ (L)	√ (M)	√ (M)	√ (L)	critical
Kootenay River (km 132.6-170)		S (U)	√ (M)	√ (L)	√ (L)	√ (L)	important
Kootenay Lake (All other parts with the exception of the West Arm)	See text re: lake levels	? (U)	√ (L)	√ (L)	√ (L)	√ (L)	important

1.11.1 Spawning and Incubation Habitat

No spawning sites have been identified in Canada. Current spawning habitat is located in the US in the Deep Creek - Shorty's Island reach, within Idaho (Paragamian et al. 2002). Some white sturgeon in spawning condition have been documented above Bonners Ferry but only for short (2 – 12 hour) periods (IDFG in prep.). Substrates in the main spawning area are dominated by fines, providing unsuitable incubation conditions (Kock et al. 2006), and are considered a central cause of recruitment failure. Historic spawning sites were likely located at and upstream of Bonners Ferry, where there are rocky substrates and high water velocities. Paragamian et al. (2002) suggest that there is a correlation between lake elevation and location within the Kootenai River where spawning is located, and this relationship seems to be due more to river depth than to velocity (Berenbrock 2006). Thus, although spawning and incubation habitats are geographically within the US, an influence on this habitat is the elevation of Kootenay Lake, in Canada. All egg incubation sites are located within the US. Kootenay Lake elevations are believed to influence incubation success indirectly, through selection of appropriate spawning sites.

Within Canada, no critical habitat is identified for this life stage. The US spawning habitat is influenced by releases from Libby Dam and water levels in Kootenay Lake. However, while Kootenay Lake is physically located in Canada, its water levels are managed subject to agreements under the International Joint Commission (IJC). Additionally, it is important to note that at this time there is still some uncertainty regarding the required operations of water levels as a component of critical habitat.

1.11.2 Free Embryo and Larval Habitat

There is uncertainty about whether these life stages occur or could occur in Canada. This uncertainty is principally related to the lack of understanding of larval drift, such as the duration and distance of drift, as well as a more general understanding of the role of drift within the life history of white sturgeon. Recent laboratory work on larval drift (Kynard and Parker 2006) implies that some larvae may drift from spawning areas in the US to rearing areas in Canada, but this is unverified in the field. Habitats that may be used are main and off channel habitats in the lower end of the Kootenay River, and possibly the river delta at the south end of Kootenay Lake. There is a relatively high level of uncertainty about whether such use occurs.

1.11.3 Early Juvenile Habitat

There is greater certainty that fish of this age class use habitats located in Canada (Neufeld and Spence 2002, 2004a, 2004b; Neufeld 2005, 2006). Habitats include main channel habitats in the lower end of the Kootenay River, and the south end of Kootenay Lake (Neufeld 2006). One year old hatchery fish are known to use lake habitat and it is therefore assumed that fish throughout this stage use a range of habitats in the lower portion of the Kootenay River and the Kootenay River delta (Neufeld 2005, 2006).

Given the existing uncertainties, no critical habitat is proposed at this time for the earliest part of this life stage. For the latter part of this life stage, critical habitat includes portions of the Kootenay River and the Kootenay River delta. This habitat is deemed critical year-round, based on habitat needs of white sturgeon during this life stage. The level of confidence in this critical habitat recommendation is moderate, but there remains considerable uncertainty regarding the geographic boundaries of this habitat unit.

1.11.4 Late Juvenile and Adult Habitat

Both juvenile and adult life stages use Kootenay Lake and Kootenay River as essential rearing habitat. Telemetry data and fish sampling show that white sturgeon are commonly located at the Kootenay River delta at the south end of Kootenay Lake, the Duncan River delta at the north end of Kootenay Lake, and the Crawford Creek delta on the east side of Kootenay Lake (RL&L 1999a; Neufeld 2006). These delta areas are extensively used by white sturgeon (Andrusak 1982; RL&L 1999a; Neufeld 2005, 2006); a depth of 100 m has been selected to represent the transition from delta to where fine substrates exist to regular lake bottom. On the Kootenay River delta, this habitat includes the lower kilometre of the river below the railway bridge. These areas are considered key feeding habitat for all these age groups and should be considered for designation as critical habitat. The key feature of rearing habitat in the lake appears to be abundance of food resources, especially kokanee, mountain whitefish and *Mysis*. Kokanee abundance should be considered in critical habitat assessments since they are a key prey species, and bays at creek mouths where kokanee aggregations occur are recommended for designation as critical habitat.

The following locations are key kokanee areas:

- Boulder Creek – from the mouth upstream to velocity barrier located 10 m upstream of Hwy 3A bridge;
- Crawford Creek – from mouth upstream 4.4 km to velocity chute;

- Summit Creek – from mouth upstream to the confluence with Topaz Creek;
- Goat River – from mouth to deactivated dam located east of Creston, immediately downstream of Sullivan Creek;
- Duncan River – from outlet to lower end the Duncan Dam tailrace;
- Lardeau River – from outlet to Trout Lake;
- Meadow Creek – from mouth to falls located approximately 6 km upstream or Meadow Creek spawning channel.

There is moderate uncertainty in the relative importance of some of these habitats due to the unknown extent of white sturgeon dependence on kokanee, however there is high certainty that the Kootenay River delta is essential for these larger fish.

Portions of the Lower Kootenay River and the Kootenay River delta, the Crawford Creek delta and the Lardeau delta are proposed as critical habitat for this life stage. This habitat is deemed critical year-round, based on habitat needs of white sturgeon during this life stage and others. The level of confidence in this critical habitat recommendation is high, but there remains considerable uncertainty regarding the geographic boundaries of this habitat unit. Other areas have been identified as key feeding areas, particularly for kokanee, but the information base is insufficient to identify them as critical at this time.

1.11.5 Critical Habitat Attributes and Timing

This section provides a compilation of all geographic locations that are proposed as critical and important, and provides the attributes of these areas that make them critical to white sturgeon. Also provided is the time of year that the critical habitat designation applies. The summary is provided in Table 14.

Table 14. Summary of attributes and timing for white sturgeon critical habitats in the Kootenay River.

Location	Definition	Attributes & Rationale	Life Stages and Timing
Kootenay River (km 122-132.5)	Critical	The lower Kootenay River is of moderate importance to all life stages of white sturgeon though all seasons. The use of this reach by all life stages, as well as its proximity to the Kootenay River Delta and to upstream staging and spawning sites, forms the basis for the importance of this reach. The habitat is characterized by low gradient (<1%), fine (silt and sand) substrates, meander channel morphology, occasional eddies with depths exceeding 20 m, and cutbank riparian habitat with cottonwood forests. Surrounding wetland complexes (seasonally flooded before impoundment and the operation of Libby Dam) may have historically been significant for sturgeon, both directly as habitat and/or as a contributor to river productivity. The area is defined as the regular high water mark (533 m elevation) in the Kootenay River from the Kootenay River Delta (boundary defined as the CP train bridge near RKM 122) upstream to River Kilometre 132.5.	• free embryo and larvae (S) • early juvenile (√) • late juvenile and adult (√) • winter (√) • staging (√) • composite timing: all year
Kootenay River Delta (Kootenay Lake)	Critical	The Kootenay River Delta is an essential feeding, over-wintering and staging area for white sturgeon. The large depositional area, fine substrates and high availability of benthic food organisms found here are the main features that make this site key. Proximity to spawning sites upstream in the US contributes to the importance of this habitat. The area is defined as the regular high water mark (533 m elevation) at the extreme south end of Kootenay Lake to a depth of 100 m (the transition from depositional delta to regular lake bottom). This area includes the Kootenay River downstream from the CP train bridge near RKM 122.	• free embryo and larvae (?) • early juvenile (√) • late juvenile and adult (√) • winter (√) • staging (√) • composite timing: all year
Lardeau Delta (Kootenay Lake)	Critical	The Lardeau Delta is an essential feeding and over-wintering area for many adult white sturgeon in this population. The characteristics of the habitat are similar to those in the Kootenay River delta. The proximity of this habitat to two key kokanee producing streams forms the basis for its importance as a feeding site, and the large depositional area and related habitat and food source form an essential over-wintering area. Timing of use is currently being investigated, however past evidence suggests the greatest use occurs between August and November. The area is defined as the regular high water mark (533 m elevation) at the extreme north end of Kootenay Lake and offshore to a depth of 100 m (the transition from depositional delta to regular lake bottom.	• early juvenile (S) • late juvenile and adult (√) • winter (√) • staging (√) • composite timing: all year, highest use Aug - Nov

Location	Definition	Attributes & Rationale	Life Stages and Timing
Crawford Creek Delta (Kootenay Lake)	Critical	The Crawford Creek Delta is an essential feeding and over-wintering area for adult white sturgeon in this population. The characteristics of the habitat are similar to those found on the Kootenay and Duncan river deltas. The large depositional area and food source, the proximity of this habitat to a key kokanee producing stream as well as the differentially higher use of this location than other parts of Kootenay Lake contribute to the recommendation of this habitat as Critical. Timing of use for this habitat is currently being investigated but past evidence suggests the highest use during the winter months. The area is defined as the regular high water mark (533 m elevation) at the extreme north end of Crawford Bay and offshore to a depth of 100 m (approximately the mouth of Gray Creek; the transition from depositional delta to regular lake bottom.	• early juvenile (√) • late juvenile and adult (√) • winter (√) • staging (√) • composite timing: all year, highest use Aug - Oct
Kootenay River (km 132.6-170)	Important	similar to Kootenay River (km 122 - 132.5)	• free embryo and larvae (S) early juvenile (√) • late juvenile and adult (√) • winter (√) • staging (√) • composite timing: all year
Kootenay Lake	Important	Includes all other habitats, such as key food production areas.	• spawning (see text) • free embryo and larvae (?) • early juvenile (√) • late juvenile and adult (√) • winter (√) • staging (√) • composite timing: all year

1.11.6 Activities Likely to Impact Critical Habitat

Activities that could impact critical habitat include flow regulation, instream activities such as gravel or sand dredging, linear developments, alterations or developments to instream and adjacent habitats, upstream land and water uses, and point and non-point source pollution. These activities have been briefly reviewed and their threats prioritized by the basin-level recovery team (Table 15). Threats to white sturgeon and their habitats are discussed in more detail in Section 3 of the Recovery Strategy.

Table 15. Activities that may impact Kootenay white sturgeon critical habitat.

Impact Categories	Examples of Activities	Mechanism	Risk – Consequence (if it occurs)	Risk – Likelihood (that it will occur)	Uncertainty
Loss of habitat quantity and quality and fragmentation	▪ Instream works ▪ Land development ▪ Introduction of invasive species	▪ Physical removal of habitats ▪ Sedimentation ▪ Dewatering ▪ Render habitats unsuitable for use	Late juveniles and feeding - High	Low to moderate – physical works in CH Moderate – altered flow, sediment	Generally well understood, except early juveniles Impacts of invasive species not well understood
Altered hydrograph components	▪ Hydroelectric facility operations	▪ Temperature change ▪ Productivity change ▪ Habitat availability & suitability ▪ Spawning conditions	Spawning in US – High Feeding – Moderate Juveniles – High?	Moderate	Impacts not fully understood, especially for juveniles and spawning in the US
Pollution	▪ Non-point and point source discharges	▪ Deposition of substances ▪ Precludes use of habitat ▪ Damages food supply	High all life stages	Moderate	Low for ongoing discharges Spill event frequency and magnitude cannot be predicted
Alteration to food supply	▪ Fishing ▪ Invasive Species	▪ Lowering functionality of feeding areas impacting fitness of fish	Moderate	Low	High uncertainty on this threat; impacts to population.
Climate change	▪ n/a at local level	▪ Temperature change ▪ Productivity change ▪ Habitat availability & suitability ▪ Dewatering	Moderate to High	Moderate	Uncertainty very high

1.11.7 Data Gaps

A key data gap is the precise relation between Kootenay Lake levels and viability of white sturgeon spawning and incubation habitat. Studies have been defined and are underway to assess this relationship.

1.11.8 <u>Maps of Critical Habitat</u>

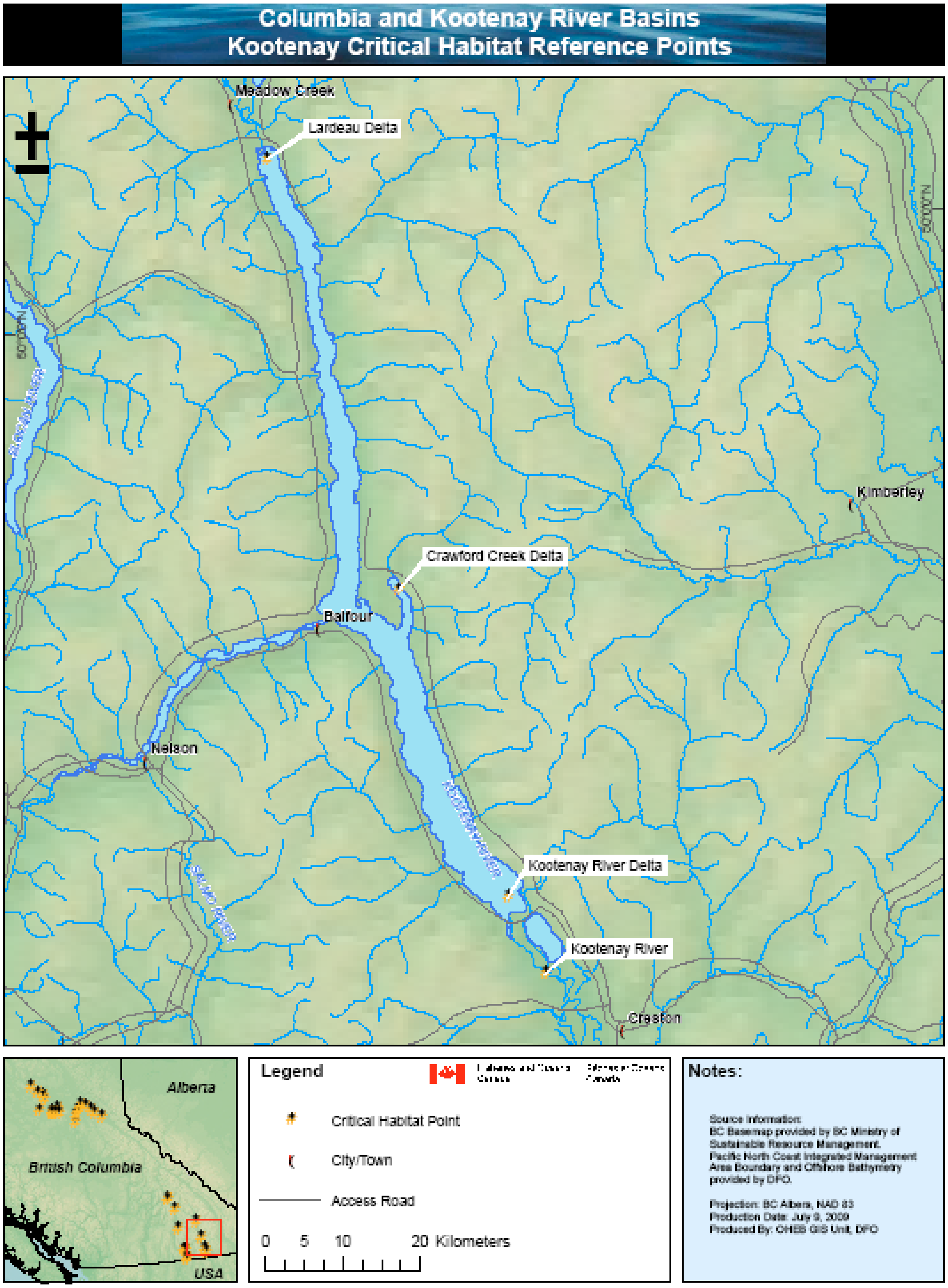

Figure 36. Reference map for locations of Kootenay white sturgeon critical habitats.

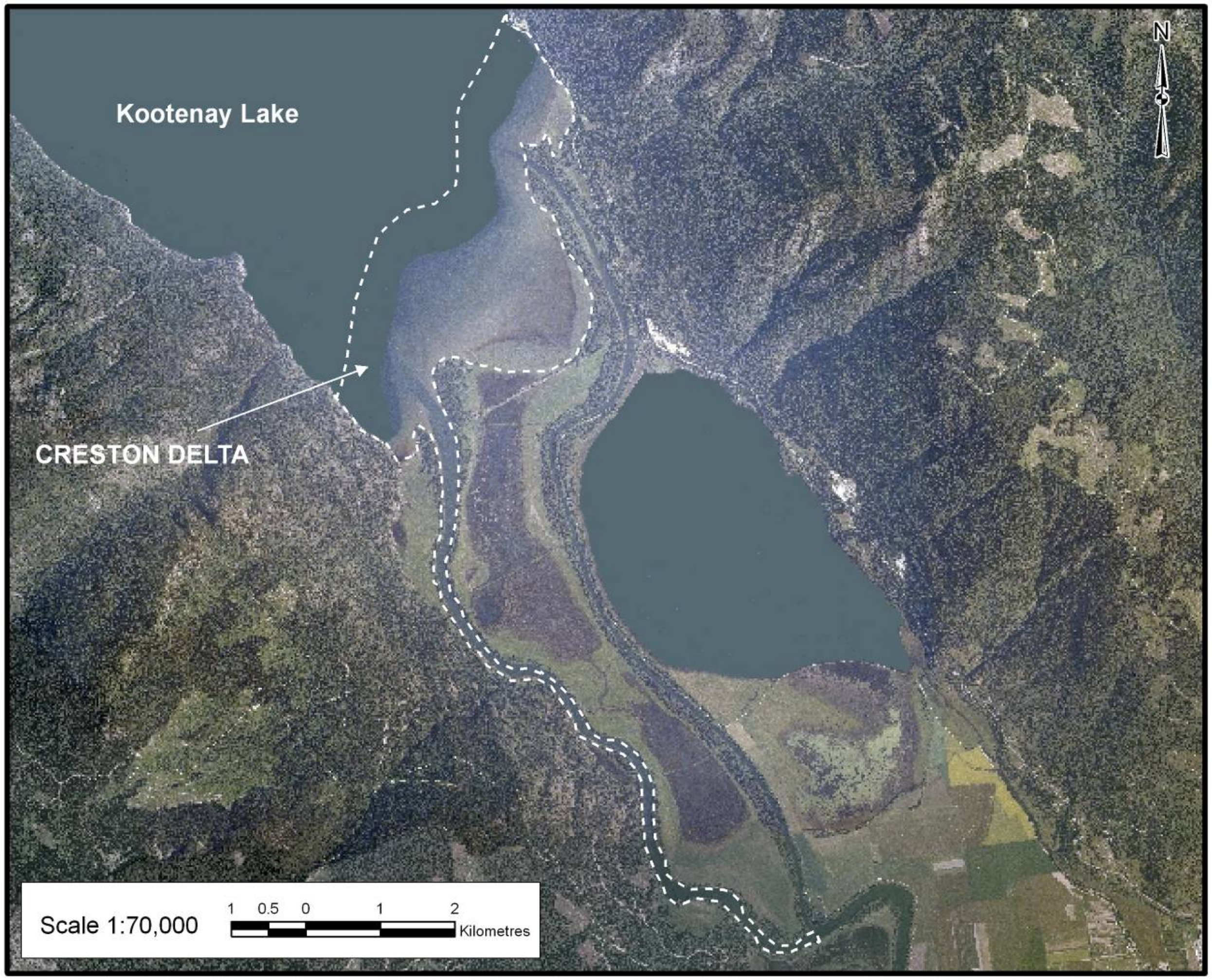

Figure 37. Map of critical habitat for Kootenay white sturgeon: Creston Delta and lower Kootenay River.

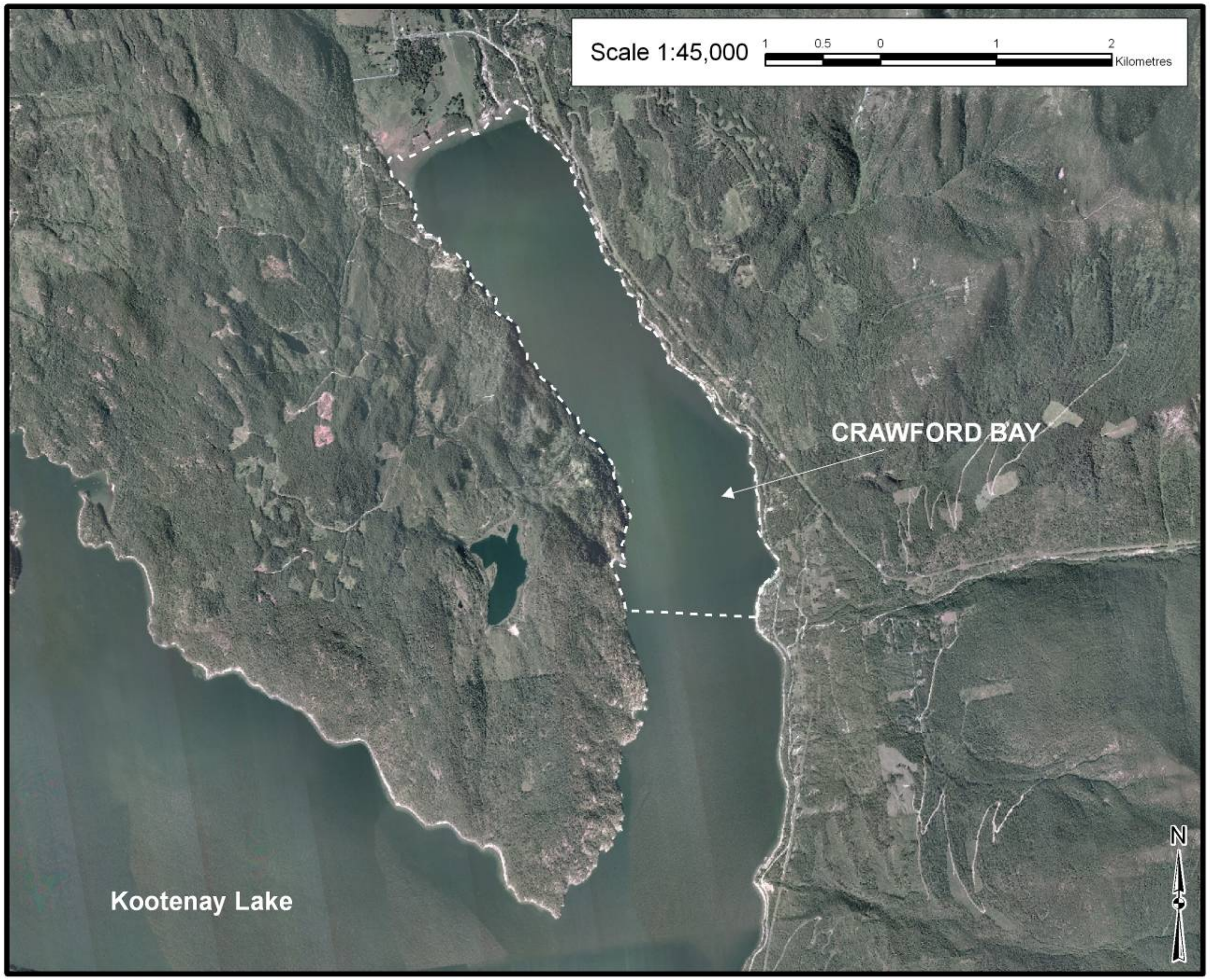

Figure 38. Map of critical habitat for Kootenay white sturgeon: Crawford Bay on Kootenay Lake.

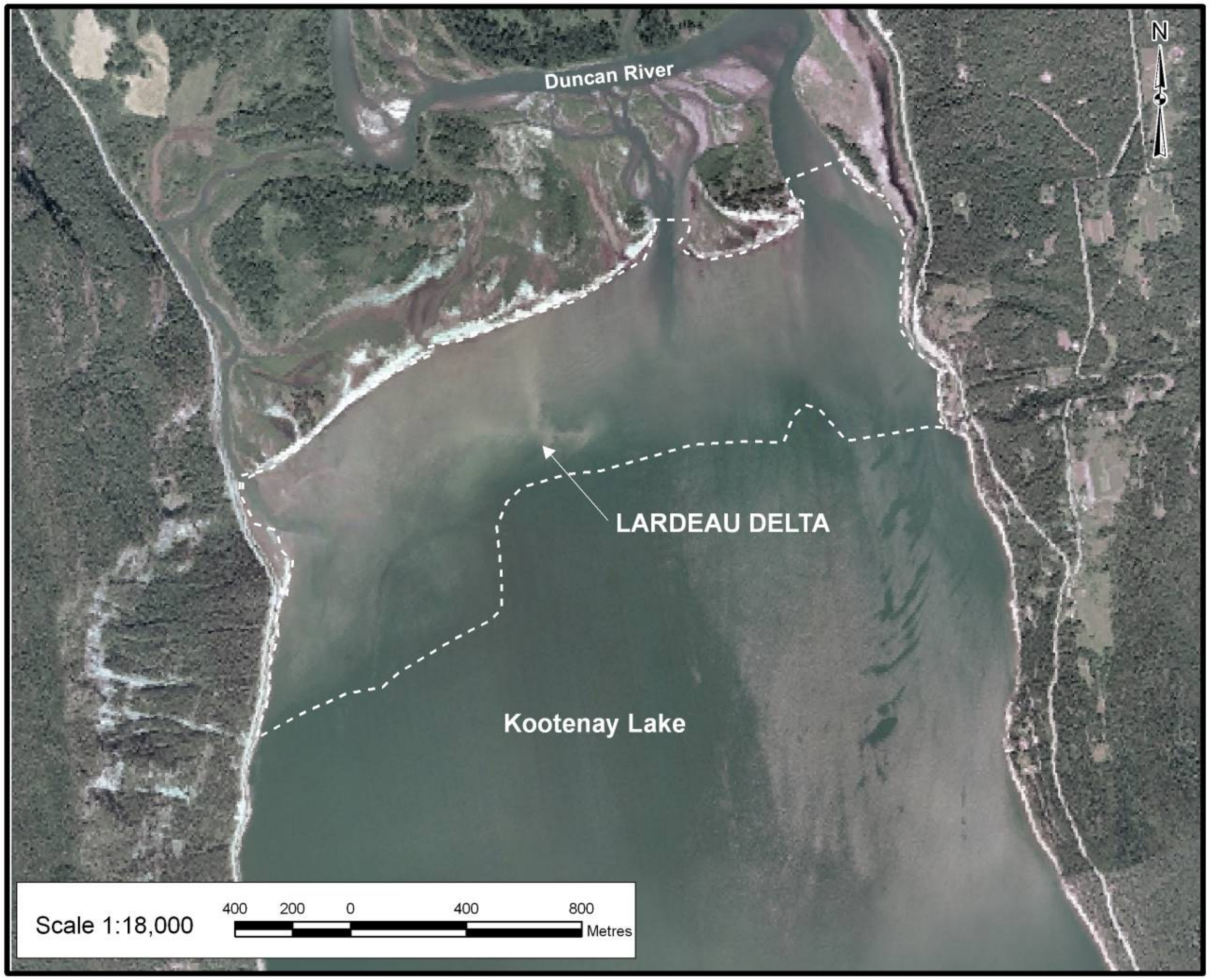

Figure 39. Map of critical habitat for Kootenay white sturgeon: Lardeau Delta on Kootenay Lake.

SCHEDULE OF STUDIES

Critical habitats defined in this document, when combined with functioning recruitment in each population, should provide the initial basis for population recovery. Although there remains some uncertainty regarding factors such as the precise timing and spatial location of some specific critical habitats proposed here, the greater uncertainty is the cause of persistent recruitment failure and identification of a feasible means of restoration. This focus is reflected in the knowledge gaps identified in the recovery strategy, which provides a guide to future studies with a strong focus on recruitment failure diagnosis and restoration. While some studies conducted on the species biology and movement may provide further information on definition of particular critical habitats, such studies should not supersede investigations of recruitment failure and its restoration because doing so may not be in the best interest of the species.

Despite the foregoing emphasis on the need to examine the cause of recruitment failure, and finding a feasible means of restoration, two areas stand out as needing further evaluation with respect to critical habitat. First is the ALR component of Columbia white sturgeon, since evaluations of the recoverability of this population segment will influence future decisions about maintaining critical habitat in this area. Current studies, including examinations of the historic and contemporary genetic population structure of the Columbia River population, historic movement patterns, and the effects of different thermal regimes on the growth potential of white sturgeon, will provide crucial insights. These same studies should be informative with respect to the group of fish that regularly occupy the lower Kootenay River, and identification of any unique characteristics of fish that occupies these habitats at low density. The presence or absence of any such unique characters may influence future decisions about the critical habitats in this portion of the species' range (e.g., Brilliant tailrace).

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