DWB Consulting Services Ltd.

Williston Watershed Kokanee Spawner Distribution and Aerial Enumeration Surveys (2019)

FWCP Project No. PEA-F20-F-3359-DC-106374

Prepared for: BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development and The Fish and Wildlife Compensation Program (Peace Region)

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DWB Consulting Services Ltd. is pleased to submit this report for your review. This report has been prepared using sound technical and professional judgement, based on our knowledge and experience, applicable regulatory framework, industry best management practices, and current understanding of project conditions, design, and project setting.

REPORT TITLE: Williston Watershed Kokanee Spawner Distribution and Aerial Enumeration Survey (2019)

PREPARED FOR: The Ministry of Forests, Lands, Natural Resource Operations and Rural Development

The Fish and Wildlife Compensation Program (Peace-Williston Division)

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Executive Summary

Kokanee are the non-anadromous ecotype of sockeye salmon (*Oncorhynchus nerka*) and are widely distributed across Pacific watersheds. Although historically native to some lakes in the Williston Reservoir, Kokanee stocks from Arrow reservoir and Kootenay Lake were introduced from 1990 to 1998 into five Williston Reservoir tributary streams (Langston 2012). The goal of the introductions was to enhance the sport fisheries in the Williston Reservoir (Blackman and Jesson 1990).

In September 2019, aerial enumeration surveys were conducted over 28 tributaries across the four main sub-watersheds of the Williston Reservoir (the Finlay, Omineca, Peace and Parsnip). Results of these surveys were compared to spawner surveys conducted in six previous years: 2002, 2003, 2006, 2007 2010, and 2018. Kokanee spawner counts at the reservoir and sub-watershed scale in 2019 were compared to counts in 2003 and 2007 to highlight differences in spawner abundance in same Kokanee cohorts. Comparisons of spawner counts among these survey years assumes a 4-year life cycle, although 3- and 5-year life cycles are also known to occur in Kokanee populations. The project was designed to meet the following FWCP priority actions in the FWCP Peace Region Reservoirs Action Plan (Action 2a-1) to "Undertake a kokanee assessment study to summarize status, trends, and aquatic and terrestrial ecosystem impacts and potential risks of kokanee introductions. Develop appropriate recommendations for actions, as needed."

At the Reservoir-scale, substantial declines in the number of kokanee spawners have been observed since 2010. A 4.5-fold decrease in spawner abundance was observed in 2019 relative to 2018, followed by a comparable decrease (3.2-fold) in 2010 relative to 2018. Among the four sub-watersheds, the Omineca and Finlay Reaches had the highest proportion of Kokanee spawners enumerated from 2006 to 2019. Although the Parsnip Reach had the 2nd highest spawner abundance of the four sub-watersheds in 2002 and 2003, it has experienced an apparent decline in spawner abundance from 2006 onward and has had consistently low Kokanee counts in the last two survey years, with spawners documented in only a single tributary in each of the 2018 and 2019 survey years (the Lower and Upper Manson Rivers, respectively). Further, 2019 was the first year that kokanee spawners were documented in the Upper Manson River since formal aerial spawning surveys were initiated. The decline in spawner abundance in the Williston reservoir in 2019 relative to 2018 was reflected in all but two of the spawning tributaries surveyed. Silver Creek and the Swannell River were the only spawning sites where higher spawner counts were observed in 2019.

When comparing the 2019 count to the same cohort counts in 2003, an apparent reservoir-wide decline in Kokanee spawner abundance has occurred with counts 4.2-times lower in 2019 relative to 2003. These declines are reflected in three of four of the Reservoir's main sub-watersheds with 2003 counts for the Finlay, Omineca, and Parsnip Reaches being 5-times, 27-times, and 66-times lower relative to 2019 counts, respectively. The Peace Reach is the only sub-watershed where an increase in cohort spawner abundance has occurred, with 2019 counts being 74-times higher than counts in 2019. Although the same trends were apparent when comparing 2019 and 2007 cohort counts at both the reservoir and sub-watershed scale, the fact that a reduced number of streams were surveyed in 2007 (ten of twenty-eight) means counts are not directly comparable between these two survey years.

With respect to the upstream-most distribution of Kokanee spawners, there appeared to be no consistent directional trends within individual spawning tributaries among survey years (2002 to 2019), and in most

cases, within-stream Kokanee distribution has been comparable among survey years. At some sites however, Kokanee spawners appear to be distributed further downstream in 2018 and 2019 relative to the 2006 and/or 2010 survey years. Sites where there is an apparent downstream shift in spawner distribution include the Osilinka, Mesilinka, Germansen, and Swannell rivers, as well as Aley, Pelly, and Carbon creeks. The change in distribution at these sites may reflect density dependent effects of lower spawner numbers in 2018 and 2019 relative to previous years, resulting in reduced competition and increased availability of spawning habitat further downstream. The complete absence of Kokanee spawner observations in most survey streams of the Parsnip Reach in 2018 and 2019 prevented a full assessment of within-stream distribution among survey years for these sites.

Based on results from 2018 and 2019 surveys, we recommend annual Kokanee spawner surveys to continue over the next three years with a focus on aerial enumeration surveys. Increased frequency in spawner surveys will help determine how Kokanee populations are changing in the Williston Reservoir and identify any evidence of multiple non-overlapping Kokanee cohorts across the Reservoir's four primary sub-watersheds and their respective spawning tributaries.

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1.0 INTRODUCTION

1.1 BACKGROUND AND SCOPE

This report describes the work completed in 2019 by DWB Consulting Services Ltd. (DWB) for the BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development (MFLNRORD) in partnership with the Fish and Wildlife Compensation Program (FWCP). The work is part the FWCP project "*Studying Kokanee in our Peace Region*". FWCP is a partnership between BC Hydro, the Province of B.C., Fisheries and Oceans Canada, First Nations and Public Stakeholders to conserve and enhance fish and wildlife in watersheds impacted by BC Hydro dams. Kokanee spawner abundance and distribution was previously assessed between 2002 to 2006 (Langston 2012), in 2010 (Langston et al. *unpublished data*) and in 2018 (McDermot-Fouts and Robinson 2019). A smaller sample of streams ('index streams') were also surveyed from 2007 to 2009 (Langston et al., *unpublished data*). This report compares Kokanee spawner abundance and distribution data from the 2002, 2003, 2006, 2007, 2010, 2018, and 2019 survey years only. These years were selected to target individual, non-overlapping Kokanee cohorts across the Williston Reservoir. Cohorts or 'brood lines' represent individuals born in the same year within a population or stock. Specifically, the 2002, 2006, 2010, and 2018 survey years represent one line of related cohorts, while the 2019, 2007, and 2003 survey years represent another separate, non-overlapping line of cohorts. Kokanee spawners from one year are assumed to be the progeny of spawners from spawners four years previous. Comparisons between these survey years, and the cohorts they represent, is based on the assumption of a 4-year life cycle, although life cycles are known to vary between 3 and 5 years in Kokanee populations (Roberge et al. 2002).

Kokanee Biology and Life History

Kokanee are the non-anadromous ecotype of sockeye salmon (*Oncorhynchus nerka*) and are widely distributed across watersheds of the Pacific region (Taylor et al. 2000). Unlike their anadromous counterpart, Kokanee spawn and rear in freshwater habitats (rivers and lakes). Sockeye, like most pacific salmon species, mature in saltwater before migrating to freshwater streams to spawn (Nelson 1968). Morphologically, Kokanee mature at a much smaller body size than Sockeye salmon, reflecting their exclusive use of freshwater habitats (Wood and Foote 1996; McGurk 2000). Like most pacific salmon species, Kokanee and Sockeye are both semelparous, meaning they spawn only once before they die. Both ecotypes are planktivorous, feeding on zooplankton and other invertebrates. Kokanee are known to exhibit considerable variation in life history traits, particularly with respect to the types of spawning habitat used, and can utilize a variety of lentic (standing water) and lotic (flowing water) habitats for spawning (Taylor et al. 2000; Whitlock et al. 2018). As pelagic planktivores, Kokanee are well-suited to reservoir environments, where periodic water level changes (i.e. drawdowns) result in frequent disturbance to littoral (near-shore) habitats, and have shown to have been successful in other BC reservoirs (Blackman and Jesson 1990).

History of Kokanee in the Williston Reservoir

Prior to construction of the W.A.C. Bennett dam and formation of the Williston reservoir, several lakes were known to contain native Kokanee populations. These lakes included Thutade Lake, located within the Finlay River headwaters, and Arctic and Tacheeda Lakes, both tributaries of the Parsnip River (Figure 1). Aerial spawner surveys were first conducted in 1989 to locate and enumerate native Kokanee in the

Finlay River (McLean and Blackman 1991). The survey was expanded in the Finlay River and included 18 other tributaries in 1990, four of which were re-surveyed in 1994 (Langston and Zemlak 1998). The results of these early surveys (5,000 or fewer Kokanee observed) indicated that relatively low numbers of native Kokanee inhabited the Williston Reservoir (Langston 2012). Between 1990 and 1998, Kokanee were stocked in several streams of the Williston Reservoir to create a sport fishery, and to provide a food source for other piscivorous fish species. A total of 5 tributary systems were used for reintroduction: Carbon Creek, Davis Creek, Dunlevy Creek, Manson River, and Nation River (Langston 2012). Individuals used for introduction were sourced from Meadow Creek and Hill Creek in the Columbia River basin and were therefore genetically distinct from the native populations. Although stocked Kokanee populations potentially benefit sport fisheries and local First Nations, there has been ongoing concern that population expansion of stocked Kokanee from the Columbia River may pose a risk to local fish species such as Arctic Grayling (*Thymallus arcticus*), as well as native Kokanee populations in the Williston Reservoir (Langston 2012).

Kokanee spawner surveys were previously conducted between 2002 and 2006 inclusive (Langston 2012), in 2010 (Langston et al. *unpublished data*), and in 2018 (McDermot-Fouts and Robinson 2019). A smaller subset of streams was also surveyed from 2007 to 2009 (Langston et al., *unpublished data*). During the 2002 to 2006 surveys, Langston (2012) found that the peak spawning period for Williston Kokanee was mid-September. Surveys conducted in 2018 found that total spawner abundance in the reservoir had decreased between 2010 and 2018, with a total of 184,024 spawners enumerated in 2018, compared to 598,096 in 2010 (McDermot-Fouts and Robinson 2019). The 2002 to 2006 data indicated that Kokanee spawner abundance was highest in the Omineca (60-89% of spawners) and Finlay sub-watersheds (2-36%), depending on the study year. In comparison, spawner abundance in the Peace and Parsnip sub-watersheds was considerably lower in the same five year span, containing <1% and <8% of spawners, respectively (Langston 2012). However, staring in 2010, a reservoir-scale shift in Kokanee distribution was observed among the 4 sub-watersheds, with the highest proportion of spawners abundances observed in the Finlay Reach. In 2018, the Finlay Reach accounted for 53% of the total Kokanee spawners enumerated, followed closely by the Omineca Reach at 45%. The Peace and Parsnip Reaches made up a comparatively lower proportion of the total Kokanee spawners in 2018 at 2% and <1%, respectively (McDermot-Fouts and Robinson 2019).

Spawner enumeration surveys from 2002 to 2006 and in 2010 enumerated Kokanee in most of the tributaries within the four main sub-watersheds of the Williston Reservoir: the Finlay, Omineca, Peace and Parsnip River Reaches (Figure 1). In 2018 and 2019, a smaller representative sub-sample of these spawning tributaries (28 streams and rivers) were surveyed for Kokanee spawners.

1.2 Goals and Objectives

This project is directed under the **FWCP Reservoir Action Plan (Action 2a-1**) to "Undertake a Kokanee assessment study to summarize status, trends, and aquatic and terrestrial ecosystem impacts and potential risks of Kokanee introductions. Develop appropriate recommendations for actions, as needed." The ultimate goal is to better understand the abundance and distribution of Kokanee spawning populations across the Williston watershed to inform future management decisions and studies.

1.3 Study Area

The Williston Reservoir (56° N latitude, 124° W longitude) is located approximately 140 km north of Prince George, British Columbia (Figure 1) and represents the largest lentic freshwater system in BC. The reservoir was created in 1968 after construction was completed on the W.A.C. Bennett Dam, located on the upper Peace River near Hudson's Hope, B.C. The Peace River flows east to Lake Athabasca within the Mackenzie River drainage system, which flows north and discharges into the Arctic Ocean (Langston 2012). The reservoir has a mean depth of 44 m and a maximum depth of 166 m (BC Research 1977).

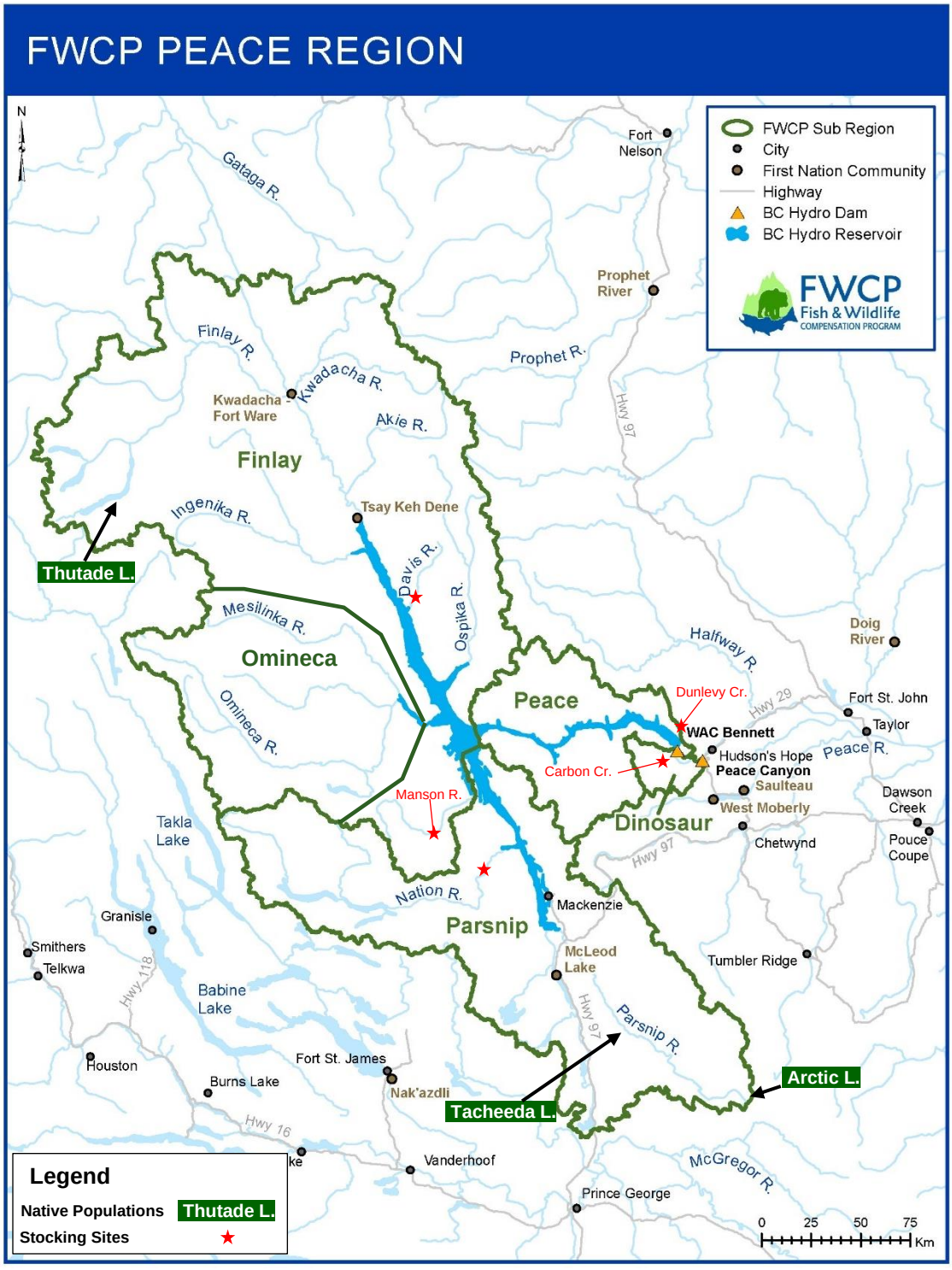

Figure 1. Williston Reservoir watershed showing the four main sub-watersheds relevant to Kokanee enumerations in bold (Parsnip, Peace, Omineca, and Finlay River systems). The Omineca sub-watershed is not an FWCP Sub Region but has always been treated as a distinct reach for the purpose of Kokanee enumerations. Lakes known to have had native Kokanee populations prior to introductions in the 1990's are highlighted in green. The approximate locations of five tributary systems targeted during the stocking programs between 1990-1998 are indicated by red stars.

2.0 METHODS

2.1 AERIAL ENUMERATION

The 2019 aerial enumeration surveys were conducted on 28 tributaries within the Williston Reservoir from 14 to 17 September, inclusive. The same spawning tributaries surveyed in 2018 were also surveyed in 2019, with only 2 modifications. In 2019, 11 Mile Creek was surveyed as a replacement for Gething Creek due to the absence of Kokanee spawner observations in Gething Creek in 2018. Further, the Parsnip River was surveyed in 2 separate sections. The first section ('Parsnip 1') began at the river mouth and ended at the confluence with Reynolds Creek, while the second section ('Parsnip 2') began at the outlet of Arctic Lake and ended 10 km upstream of the start point.

DWB used the same aerial enumeration methodology as described in Langston (2012) with additional refinements that were implemented in the 2010 surveys (Langston 2010 *unpublished data*). Aerial surveys were conducted from a Bell 206 Jet Ranger helicopter flying 30-50 m above water level. Spawner enumeration data was collected by two fisheries trained observers and a First Nations observer. The first observer acted as the primary spotter and made estimates on spawner abundance at 1-km intervals along the survey length by grouping fish into schools of 10, 50, 100, 500 and 1,000 individuals. The first observer also recorded GPS tracks of surveys lengths, potential fish barriers, and other relevant waypoints with a Garmin handheld GPS unit. The second observer recorded data on standardized field forms (Langston 2012), and acted as the secondary spotter, making independent estimates at each 1-km interval. Observers then conferred with one another until a mutual consensus on each estimate was reached. The First Nations observer provided guidance and assisted with various survey tasks as needed.

Modifications to the methodology in 2010 included the addition of an estimate of confidence that was assigned to every group of Kokanee that was counted, based on benchmark criteria (Table 1). The confidence in a count was categorized as very low, low, medium or high and corresponded to a measure of error. After the aerial enumeration was completed, the individual count estimates in each confidence rating category were subtotalled. A minimum and maximum value was calculated for each subtotal by subtracting and adding the error percentage of the count associated with that confidence rating (Table 1). The minimum, maximum and actual count subtotals for each confidence rating were summed to give a grand total of the minimum, maximum and actual count. The minimum and maximum values of the count estimates from 2010, 2018, and 2019 could be interpreted as the upper and lower limits of a confidence interval. These confidence intervals provide insight into whether a difference in spawner counts from 2010, 2018, and 2019 were precise enough to be considered truly different from estimates in other streams or survey years. For example, when comparing spawner count estimates among sites (e.g. sub-watershed, individual spawning streams), or the same site among different survey years, smaller confidence intervals surrounding estimates represent lower uncertainty on the part of the observer on counts made during an aerial survey (reflecting better survey conditions as described below). This ultimately provides a quantitative measure of confidence when comparing spawner counts between sites or years. When confidence intervals are large and overlapping between different count estimates, it tells the observer that counts made during those surveys were less precise and more strongly influenced by poor survey conditions. For example, when count estimates from two sites have different values, but large, overlapping confidence intervals, it means we have less confidence that there is a true difference between estimates.

Fish visibility factors such as turbidity, cloud cover, wind, canopy closure and precipitation during the survey were recorded on data sheets and influenced the choice of confidence rating for each grouping of fish counted. For example, if a group of spawners was observed in a stream with muddy or turbid water, where visibility was reduced or impaired, an observer's confidence in the group size would be expected to be lower than in less turbid waters. In such a case, the observer would assign a lower confidence rating to the observation (e.g. "low" or "very low").

Table 1. Benchmark criteria that defined the level of confidence in a count estimate of Kokanee and associated error for that count in the 2010, 2018, and 2019 aerial enumeration surveys (Langston 2010 *unpublished data*).

CONFIDENCE RATING	CRITERIA	ERROR (+ OR -)
Very Low	Counts of tight schools of large numbers of fish >5000.	35%
Low	Counts of tight schools of fish >100.	25%
Moderate	Counts of one or more large, spread out groups of at least 300 fish in each group.	20%
High	Counts of small, spread out groups of fish, cumulatively adding up to as much as 1000.	15%

Potential barriers to fish passage (e.g. waterfalls) were assessed visually from the helicopter during aerial enumeration surveys. Visual assessment of potential barriers was also supplemented by consulting previous years' survey data that detailed Kokanee spawner occurrence records above and below the barrier location. During surveys, observations of other non-Kokanee fish species were made and recorded if possible, but no counts or analyses were completed for this report. All data on incidental fish and wild wildlife observations made during aerial surveys can be found online on the BC Ecological Reports Catalogue (EcoCat) website (Government of BC, 2020).

2.2 Kokanee Distribution

The 2018 and 2019 surveys were the first years that Kokanee spawner distributions were described as a count of fish per stream kilometer surveyed. This component was added to the survey methodology to provide additional, finer-scale information on spawner distributions within individual streams. This information could in turn provide insight on potential relationships between spawner distribution and other within-stream variables such as location of suitable spawning habitats and barriers to fish passage. In 2018, stream kilometers were measured using a handheld GPS unit with a trip odometer that was reset to zero at the survey start location. A waypoint was created at each kilometer that was flown and the count of fish was subtotaled for each kilometer. In 2019, 1-km intervals for each survey stream were pre-loaded onto GPS units to improve survey efficiency. A series of large-scale, stream-specific maps were created that provide a visual comparison between Kokanee spawner counts made at 1-km intervals along of each survey stream in 2018 and 2019 (See Supplementary Maps, Appendix A).

2.3 Kokanee Collection

Kokanee were collected from four spawning tributaries and one lake for aging, fecundity, genetic and fish tissue analysis. Three spawning streams were located in the Finlay Reach (Russel Creek, Aley Creek, and Finlay River side channels), and one stream was located in the Omineca Reach (Germansen River). None

of the analyses associated with the Kokanee collections were included in the scope of this project and will be reported separately by another agency. Kokanee were collected by helicopter from the Russel Creek, Aley Creek, and Germansen River on the same days of aerial enumeration (helicopter access). Eighteen Kokanee were also collected from Arctic Lake on 28 June 2019 (ground/boat access). An additional 20 Kokanee were also collected from two locations on the Finlay River on 22 October 2019. Collection site coordinates and collection dates are summarized in Table B5 (Appendix B).

Kokanee were captured from spawning tributaries using a Smith-Root model L-24 backpack electrofisher. A crew member with an electrofisher walked downstream with the electricity on to stun the fish in the pool, which were then captured by the second crew member using a dip net. This method was efficient for quickly capturing a large number of fish and worked best on narrow and shallow streams where fish were concentrated, and stream velocities were slow enough to allow safe wading for crew members. Wider and deeper channels provided more escape routes for Kokanee, and large schools quickly dispersed when crews got close to them.

The Kokanee collected from Arctic Lake were captured with a sinking and floating experimental gill net that met the BC Resources Inventory Committee (RIC) standards for Lake Assessments (FFSCBC and BCMOE 2007). Both nets consisted of six panels, 15.2 m long and of different mesh sizes that were strung together in a "gang" to form a net 91.2 m long and 2.4 m deep. The mesh sizes (in order from panel one to panel six) were 25 mm, 76 mm, 51 mm, 89 mm, 38 mm, and 64 mm. Set times were no longer than two hours and every attempt was made to live release any bi-catch species.

Scientific Fish Collection Permits were obtained through the BC Ministry of Forests, Lands, Natural Resource Operations and Rural Development (MFLNRORD) in the Omineca Region (permit No. PG19-511197) before Kokanee were collected and all appropriate animal care protocols were followed. Kokanee were dispatched immediately after capture by using a hard object to inflict a lethal blow to the top of skull, just behind the eyes. Fish were then weighted using a scale that was accurate to one gram. Fork lengths were measured using a tape that was accurate to one millimetre. Fish were individually bagged and labeled with a unique identifier that corresponded to the stream they were captured from and their recorded weight and fork length. The collected Kokanee were frozen and kept frozen within two days of capture. All Kokanee were delivered to Dr. Mark Shrimpton at the University of Northern British Columbia in Prince George within a week from their capture date for further analysis (not addressed in this report). Collection site coordinates, as well as average fish lengths and weights for all 2019 collection sites are summarized in Table B5 (Appendix B).

2.4 Spatial and Temporal Analysis

Kokanee spawner abundance was compared at both the Reservoir-scale, and at the scale of its four main sub-watersheds (the Finlay, Omineca, Peace, and Parsnip Rivers - hereafter also referred to as "Reaches"). Spawner abundance was compared between the study years by comparing raw spawner abundance estimates (counts) gathered from aerial enumeration surveys. At the Reservoir-scale, abundance estimates were totaled across all tributary streams and rivers surveyed on a given year to gain total annual spawner abundance for the Williston reservoir. Similarly, for the four main sub-watersheds, abundance estimates from aerial surveys were summed to give a total annual abundance for each sub-watershed. The 2018 and 2019 data for the Finlay River were excluded from analysis since surveys began upstream of Cutoff Creek (not at the river mouth as in previous years). Any relevant trends within and between

individual study tributaries (streams and rivers targeted during aerial enumeration surveys) and how they related to their respective sub-watersheds, are also highlighted. Among study tributaries, a distinction is made between "index" and "non-index" streams. Index streams refer to the nine tributary systems recommended by Langston (2012) for annual Kokanee spawner monitoring, based on findings from initial surveys conducted between 2002 and 2006 (Table 2).

2.5 Within-Stream Spawner Distribution

The upstream-most extent of Kokanee spawner observations was recorded at each spawning tributary surveyed in 2018 and 2019. Data on the upstream extent exists for some, but not all, of the same 28 spawning streams for 2002, 2006, and 2010 (see Table B2, Appendix B). Based on precise 1-km intervals along spawning streams, the upstream-most extent of Kokanee spawners was summarized in table format to assess any potential changes in upstream-most distributions among survey years. A series of large-scale, stream-specific maps were created that show upstream extents for each spawning stream (See Supplementary Maps, Appendix A). These maps also show Kokanee spawner counts made at 1-km intervals along the length of each survey stream in 2018 and 2019. Although 1-km intervals in 2018 did not always coincide spatially with those in 2019, all stream-interval abundance counts were spatially referenced in maps so that spawner counts along stream lengths were comparable (see Section 4.4 for further discussion).

Table 2. Spawning tributaries (streams and rivers) and survey dates where aerial enumeration surveys were conducted in 2018 and 2019. Index streams as recommended by Langston (2012) for annual Kokanee spawner monitoring are highlighted in yellow. Note: 11 Mile Creek was a recent addition to survey streams in 2019, replacing Gething Creek, which was surveyed in 2018.

Sub-Watershed	Survey Tributary	Survey Date	
		2018	2019
Finlay Reach	Davis River	Sept 20	Sept 15
	Finlay River	Sept 19	Sept 14
	Bower Creek	**Sept 19**	**Sept 14**
	Cutoff Creek	Sept 19	Sept 14
	Russel Creek	**Sept 19**	**Sept 14**
	Tsaydiz Creek	**Sept 19**	**Sept 14**
	Pelly Creek	**Sept 19**	**Sept 15**
	Pelly Lake outlet stream (Zygadene Creek)	Sept 19	Sept 15
	Swannell River	**Sept 18**	**Sept 15**
	Aley Creek	Sept 18	Sept 15
Omineca Reach	Mesilinka River	Sept 18	Sept 15
	Germansen River	**Sept 20**	**Sept 16**
	Osilinka River	**Sept 20**	**Sept 15**
	Dead Bear Creek	Sept 20	Sept 15
	Silver Creek	Sept 20	Sept 16
Peace Reach	Carbon Creek	Sept 17	Sept 16
	Clearwater River	**Sept 20**	**Sept 16**
	Dunlevy Creek	Sept 17	Sept 15
	Nabesche River	Sept 17	Sept 15
	11 Mile Creek	Not Surveyed	Sept 16
Parsnip Reach	Cut Thumb Creek	Sept 17	Sept 14
	Scott Creek	Sept 17	Sept 14
	Philip Creek (2010 data)	Sept 21	Sept 17
	Upper Manson River (above lakes)	Sept 20	Sept 16
	Lower Manson River (downstream of lakes)	**Sept 21**	**Sept 16**
	Parsnip River	Sept 22	Sept 17
	Misinchinka River	Sept 22	Sept 17
	Reynolds Creek	Sept 22	Sept 17

2.6 Barriers to Fish Passage

The location and type of any potential barriers to fish passage (e.g. waterfalls) located during 2019 surveys or previous study years within study tributaries, are identified and briefly discussed in relation to the highest upstream locations where Kokanee spawners were detected during aerial surveys. Barrier locations within survey streams are georeferenced in Supplementary Maps (Appendix A). Potential barriers were defined as any obstruction within the channel of a spawning stream with the potential to

prevent passage of Kokanee spawners upstream of the obstruction. Potential barriers to fish passage included chutes, waterfalls (> 2-3 m in height), and log/debris jams.

3.0 RESULTS

3.1 TRENDS AT THE RESERVOIR LEVEL

At the Reservoir-scale, a substantial decline in the number of Kokanee spawners was observed between 2018 and 2019. A total of 40,670 Kokanee were enumerated in 2019, compared to 185,104 in 2018, which represents a 4.5-fold decrease in spawner abundance between these years (Figure 2). Total spawner abundance also decreased between 2010 and 2018, with a total of 598,096 spawners enumerated in 2010, which is approximately 3-times higher than the total abundance estimate in 2018. In contrast, the total number of Kokanee spawners increased between 2002 and 2006. A total of 65,714 and 171,016 spawners were enumerated in 2002 and 2003, respectively, representing a 2.6-fold increase between these two years. A total of 518,117 spawners were enumerated in 2006, which represents a 3-fold increase relative to 2003. In total, an 8-fold increase in spawner abundance was observed across the Williston Reservoir between 2002 and 2006, whereas a much smaller (1.2-fold) increase was observed between 2006 and 2010. Although, a total of 374,002 spawners were enumerated in 2007, only ten streams of the total twenty-eight were surveyed that year, which prevents standardized comparison with other survey years. When comparing the 2019 cohort to the same cohort counts in 2003, an apparent reservoir-wide decline in Kokanee spawner abundance has occurred with counts 4.2-times lower in 2019 relative to 2003. Although a similar decline was apparent when comparing 2019 to 2007 cohort counts, the fact that a reduced number of streams were surveyed in 2007 means counts are not directly comparable between these two survey years.

Spawner abundance varied considerably in 2019 among the four main sub-watersheds of the Williston Reservoir. The Finlay Reach had the overall highest count in 2019 at 33,810 total spawners, while the 2nd and 3rd highest spawner counts were observed in the Omineca and Peace Reaches, at 5,460 and 1,190 spawners, respectively (Figure 3). The lowest count was observed in the Parsnip Reach, with only 210 spawners enumerated, all within a single spawning tributary, the Upper Manson River. The low spawner count in 2019 was approximately value is the count for 2018 (270). The trends in relative spawner abundances observed among the four main sub-watersheds were similar in 2018, with the Finlay having highest count, followed by the Omineca, Peace, and Parsnip, respectively. With respect to long-term spawner abundance trends, the highest number of spawners have been consistently observed in either the Finlay or Omineca Reaches from 2006 to 2019 (Figure 3). From 2002 to 2007, the Omineca Reach had the highest number of spawners, but was surpassed by the Finlay starting in 2010, which has consistently had the highest spawner count for the past 3 survey years (2010, 2018, and 2019). From 2002 to 2003, the Parsnip Reach actually had the 2nd highest spawner abundance among the four sub-watersheds, but appears to have experienced consistent declines in spawner counts from 2006 to 2019. In contrast, the Finlay Reach has experienced an apparent increase in spawner counts, starting in 2006, when it surpassed the Parsnip Reach as the sub-watershed with the 2nd highest spawner abundance.

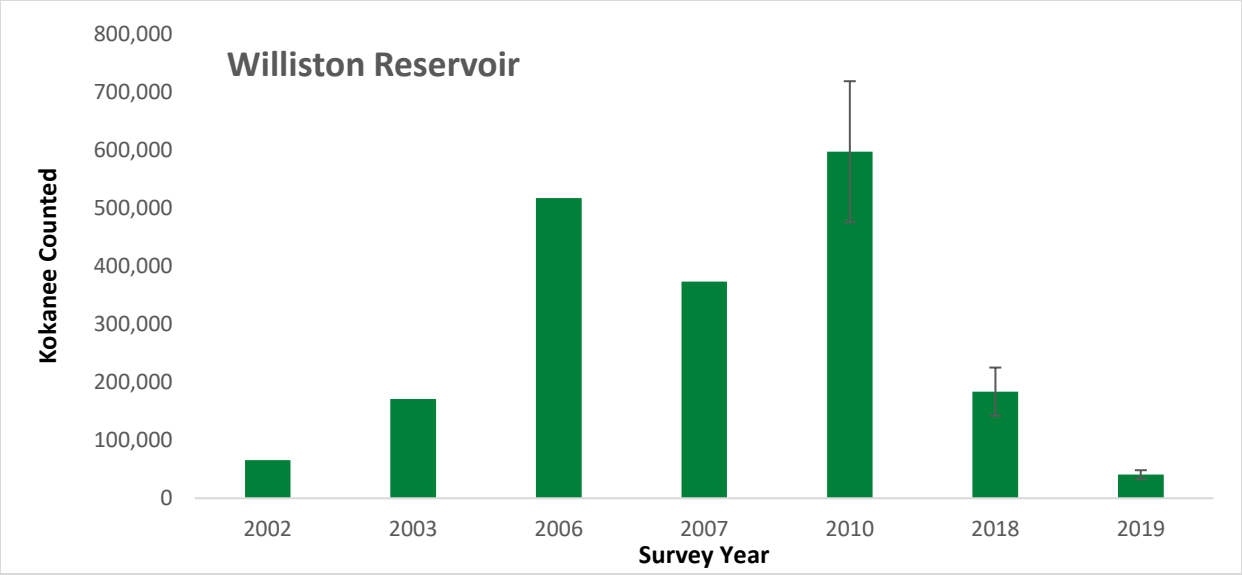

Figure 2. Number of Kokanee spawners counted in tributary streams of the Williston Reservoir from 2002 to 2019. The data included in the totals was limited to those stream counts that were comparable through all survey years. Although data from Bower and Tsaydiz Creeks were not available for 2002, Kokanee were assumed absent from those streams in that year. The error bars for 2010, 2018, and 2019 represent the confidence range for the data in those years. Note - Only ten streams surveyed in 2007 (8 index streams + Germansen and Upper Manson River).

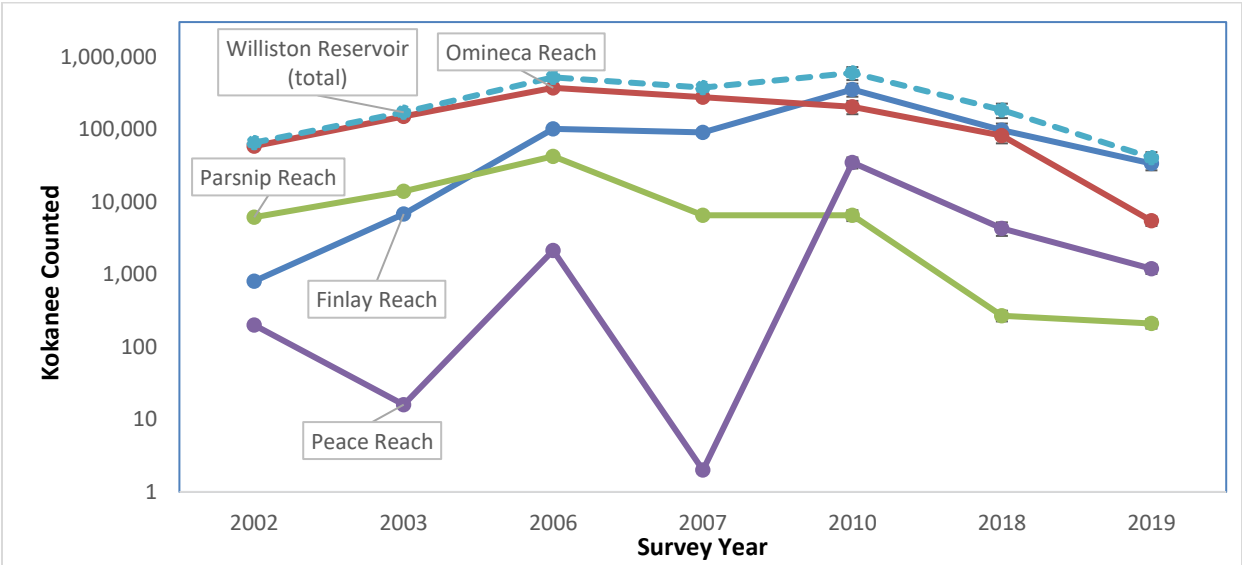

Figure 3. Trends in Kokanee spawner abundance from 2002 to 2019 in the four sub-watersheds of the Williston Reservoir compared to the reservoir total. Note - Only ten of twenty-eight streams were surveyed in 2007 (8 index streams + Germansen and Upper Manson Rivers), preventing standardized comparisons of 2007 with other years' counts.

3.2 Trends at the Sub-Watershed and Stream Level

In 2019, Kokanee spawners were observed in 19 of 28 spawning tributaries surveyed. Among the tributaries where no spawners were observed in 2019, 7 of 8 occurred in the Parsnip Reach, with fish only observed at a single tributary, the Upper Manson River (see Tables B2 and B3, *Appendix B*). Further, no Kokanee spawners were detected during aerial surveys in the section of Finlay River surveyed in 2019 (upstream of the confluence with Cutoff creek).

Finlay Reach

In the Finlay Reach, an apparent decline in spawner abundance was observed in 2019, with only 33,810 spawners enumerated during 2019 compared to 97,421 in 2018, representing a nearly 3-fold decrease in abundance. A similar decline was apparent in 2018 with only 97,421 spawners enumerated, reflecting a 3.6-fold decrease compared to 2010. In contrast, Kokanee spawner abundance increased dramatically from 2002 (804) to 2003 (6,800), and again in 2006 (101,293), representing 8.4-fold and 14.9-fold increases in spawner abundance in these two intervals (Figures 3 and 4). In 2010, a total of 353,269 spawners were enumerated, representing a 3.5-fold increase relative to 2006. In 2007, a total of 90,800 spawners were enumerated, though only 5 of 8 streams were surveyed that year, preventing direct comparisons among other years' counts. When comparing the 2019 cohort to the same cohort counts in 2003, an apparent decline in Kokanee spawner abundance has occurred with counts 5-times lower in 2019 relative to 2003. Although a similar decline was apparent when comparing 2019 and 2007 cohort counts, the fact that a reduced number of streams were surveyed in 2007 in the Finlay (five of ten) means counts were not directly comparable between these two survey years.

The overall trends in the Finlay Reach were consistent across all but one of its constituent survey tributaries. The Swannell River was the only site where spawner counts were higher in 2019 (570) relative to 2018 (210). Spawner abundance was lower in 2019 for all other survey streams relative to 2018. Among indexed streams (i.e. those recommended for monitoring by Langston 2012), Russel Creek has consistently had the highest number of spawners in all study years (Figure 5). Spawner abundance varied among the 5 non-indexed streams between study years. Spawner abundance was generally comparable among the non-indexed streams in 6 of 7 study years (2002, 2003, 2006, 2007, 2018, and 2019). In 2010 however, the Davis River and Cutoff Creek had considerably higher spawner abundances than Aley Creek (Figure 6). The Pelly Lake Outlet stream (AKA Zygadene Creek) was not surveyed in 2002, 2003, 2007 or 2010, precluding it from abundance comparisons in those study years.

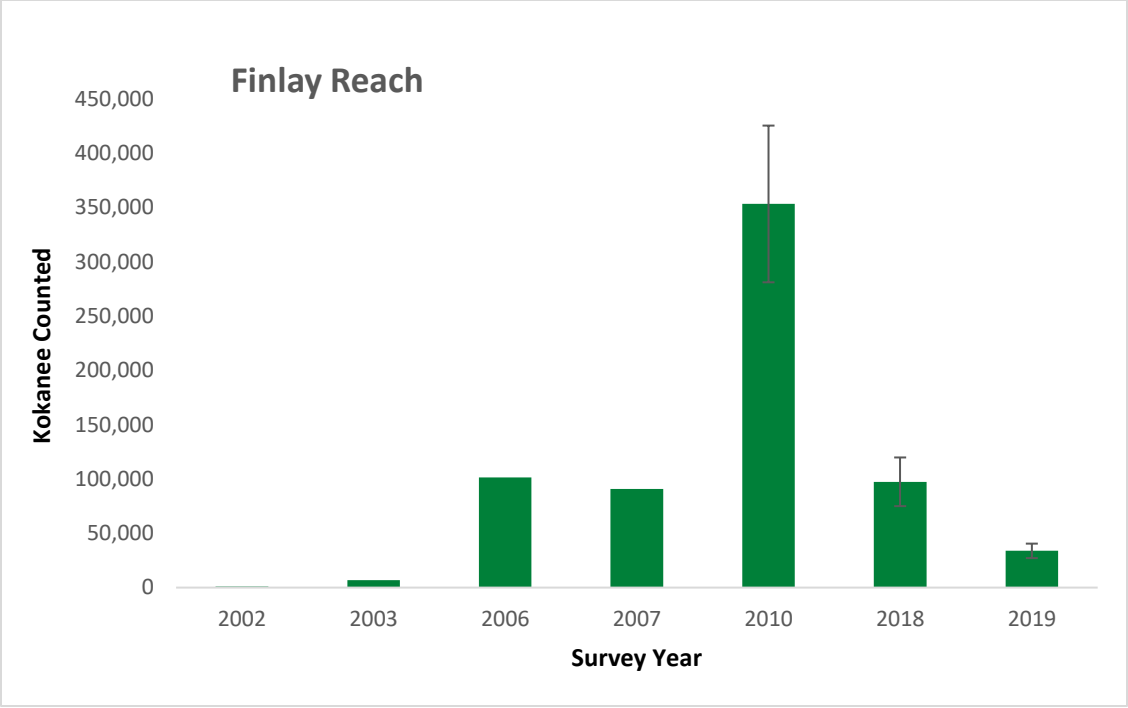

Figure 4. Number of Kokanee spawners counted in nine tributary streams of the Finlay Reach of the Williston Reservoir from 2002 to 2019. The Finlay River was only enumerated upstream of Cutoff Creek in 2018 and 2019 and was not comparable to previous years. The data shown does not include the Finlay River counts in any of the four survey years. The error bars for 2010, 2018, and 2019 represent the confidence range for the data in those years. Note - Only five of eight streams were surveyed in the Finlay Reach during 2007.

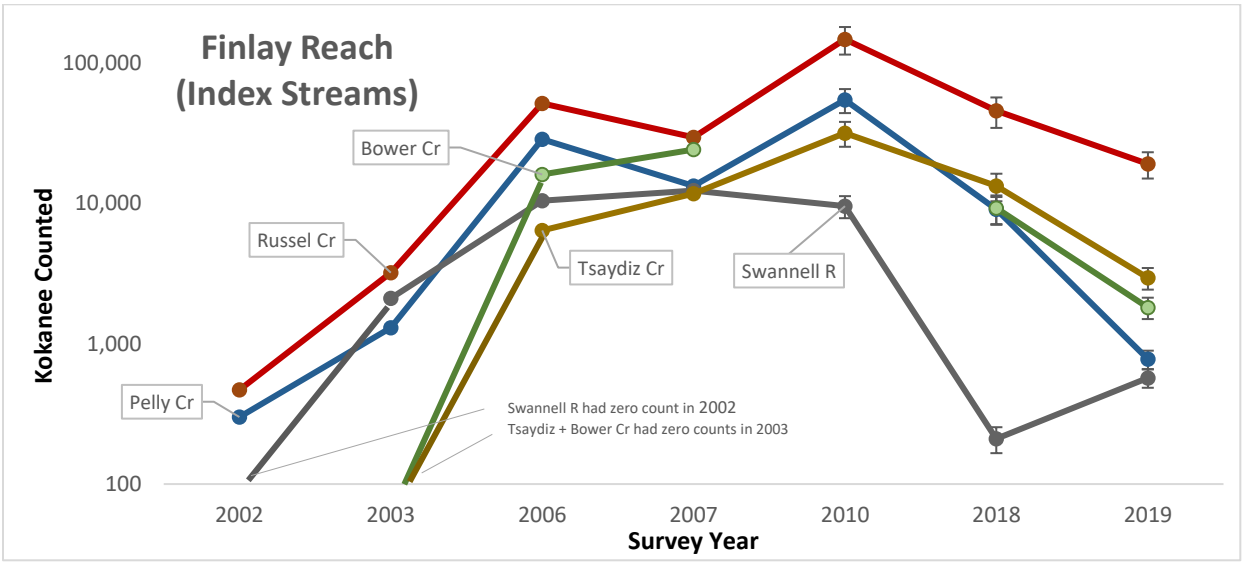

Figure 5. Trends in Kokanee spawner abundance from 2002 to 2019 for indexed streams in the Finlay Reach. Tsaydiz Creek was not enumerated in 2002. Bower Creek was not enumerated in 2010. The error bars for 2010, 2018, and 2019 represent the confidence range for the data in those years.

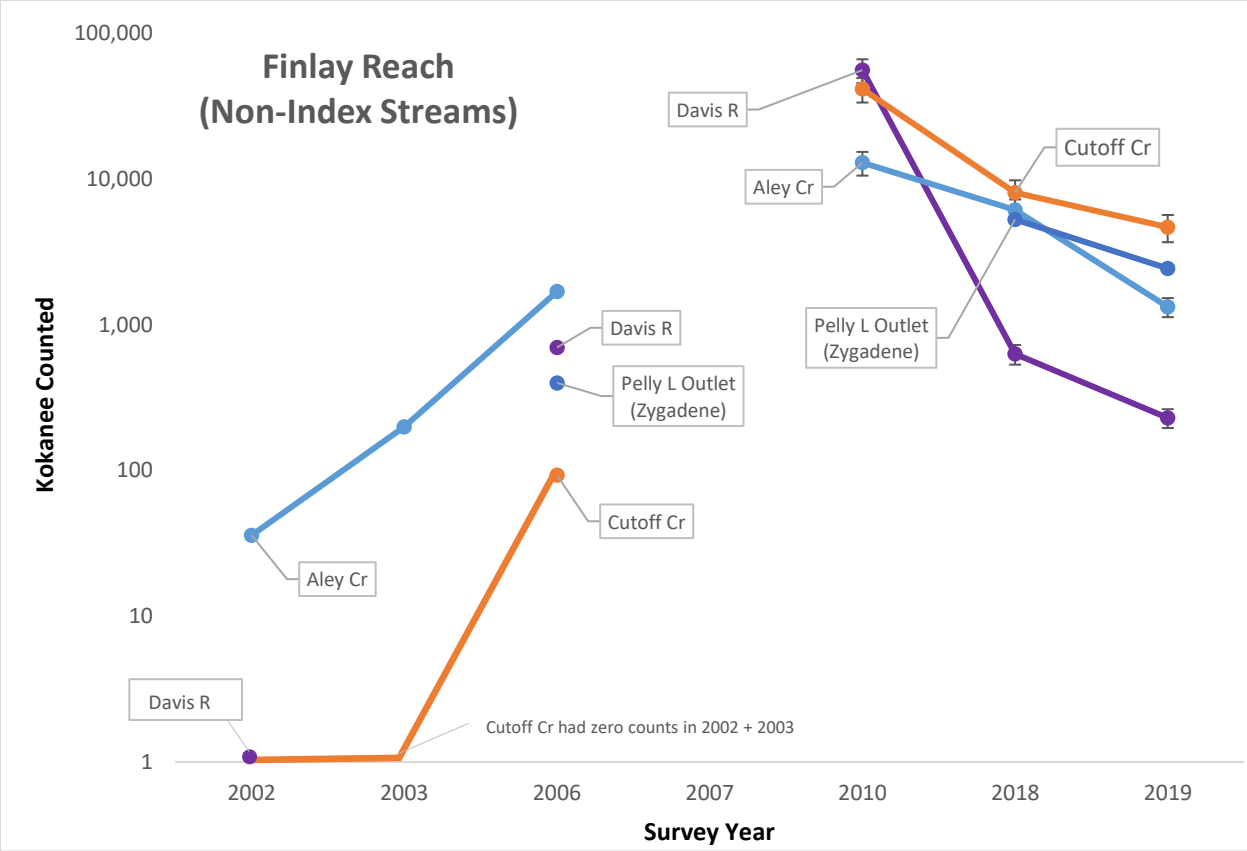

Figure 6. Trends in Kokanee spawner abundance from 2002 to 2019 for non-indexed streams in the Finlay Reach. The Pelly Lake outlet stream (Zygadene Creek) was not enumerated in 2002, 2003, or 2010. Note – Not all streams were surveyed every year.

Omineca Reach

In the Omineca Reach, a large apparent decline in Kokanee spawner abundance was observed in 2019, with only 5,460 spawners enumerated compared to 82,036 in 2018 (Figure 7). This represents a 15-fold difference in spawners enumerated between 2019 and 2018, and also represents the largest difference in spawner abundance between 2019 and 2018 among the 4 sub-watersheds. In comparison, relatively smaller declines in spawner abundance were apparent in both 2010 (203,473) and 2018 (82,036), representing 1.8-fold and 2.5 decreases in abundance for those two study periods, respectively. In contrast, spawner abundance increased between 2002 (58,600) and 2003 (150,300), and again between 2003 and 2006 (372,300), representing 2.6- and 2.5-fold increases in abundance between these two intervals, respectively. A total of 276,000 spawners were enumerated in the Omineca Reach in 2007, though only 2 of 6 streams were surveyed that year (Germansen and Osilinka Rivers). When comparing the 2019 cohort to the same cohort counts in 2003, an apparent decline in Kokanee spawner abundance has occurred with counts 27.5-times lower in 2019 relative to 2003. Although a similar decline was apparent when comparing 2019 and 2007 cohort counts, the fact that a reduced number of streams were surveyed in 2007 in the Omineca Reach (two of five) means counts were not directly comparable between these two survey years.

The overall trends in abundance observed in the Omineca Reach between study years were consistent among all but one the streams surveyed. Silver Creek was the only spawning tributary to show an increase

in spawner abundance in 2019, with 1900 spawners enumerated, compared to only 705 in 2018 (Figure 8). Abundance decreased in all other spawning tributaries in 2019 relative to 2018. Declines in abundance were especially notable in the Mesilinka River, where only 20 spawners were enumerated in 2019, compared to 49,352 in 2018. The Osilinka and Germansen Rivers have had the highest and 2nd highest spawner abundances, respectively, among all Omineca Tributaries surveyed for most years between 2002 and 2019. The two exceptions are 2010 and 2018, when the Mesilinka River had the 2nd highest and highest spawner counts, respectively (Figure 8).

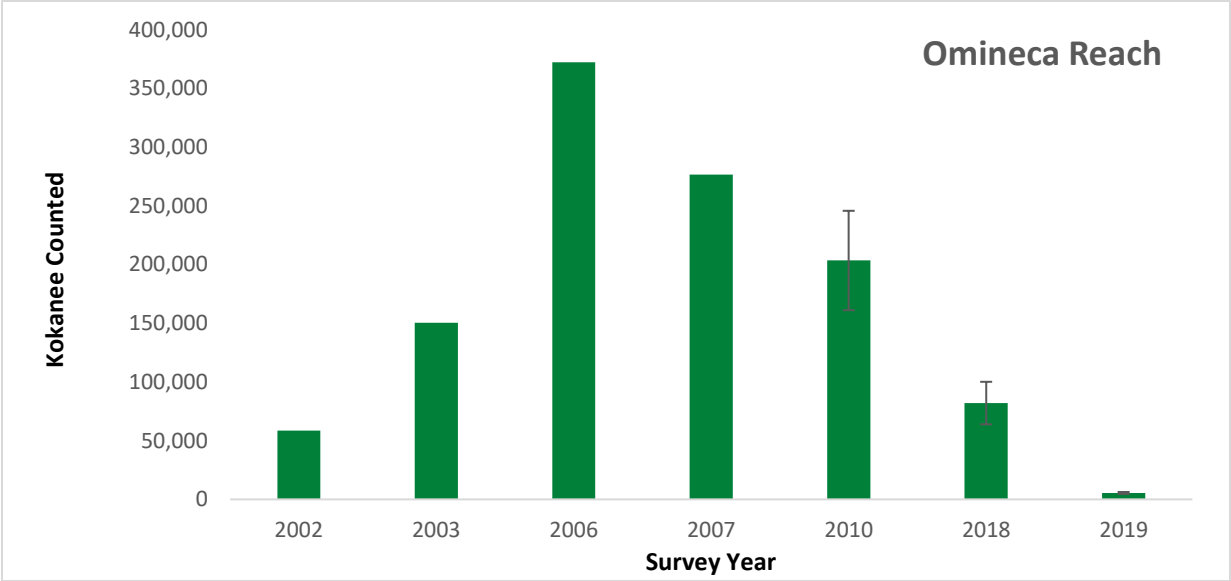

Figure 7. Comparison of the number of Kokanee spawners counted in five tributary streams of the Omineca Reach of the Williston Reservoir from 2002 to 2019. The error bars for 2010, 2018 and 2019 represent the confidence ranges for the data in those years. Note: only two of six streams surveyed in the Omineca in 2007.

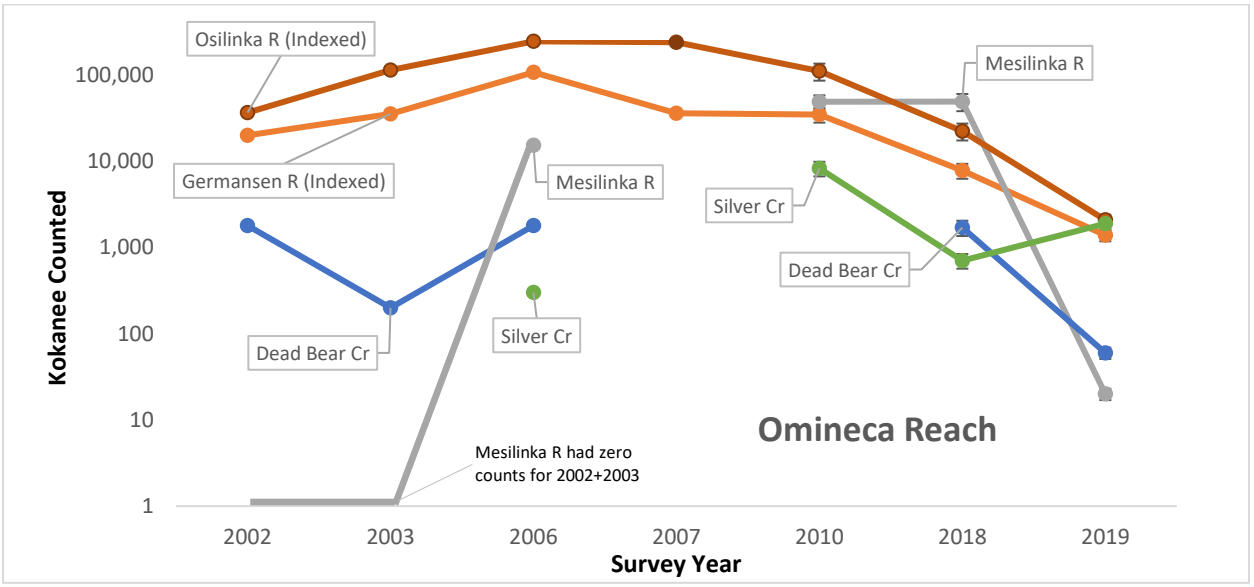

Figure 8. Trends in Kokanee spawner abundance from 2002 to 2019 for five streams in the Omineca Reach. Error bars for 2010, 2018 and 2019 represent the confidence range for the data in those years. Note: Not all streams were surveyed every year.

Peace Reach

In the Peace Reach, an apparent decline in spawner abundance was observed in 2019 with 1,190 spawners enumerated compared to 4,297 in 2018 (Figure 9), representing a 3.6-fold decrease between 2019 and 2018. A more substantial decrease in abundance was apparent in 2018 (4,297), representing an 8-fold decrease from the 2010 study year. Spawner abundance also decreased 12.5-fold between 2002 (200) and 2003 (16), but then increased by large margin (132-fold) between 2003 and 2006 (2,124). Although only 2 spawners were enumerated in 2007, the Clearwater River was the only spawning tributary surveyed that year. Spawner abundance again increased between 2006 and 2010 study years, with a total of 34,823 spawners enumerated in 2010, representing a 16.4-fold increase during this 4-year interval. When comparing the 2019 cohort to the same cohort counts in 2003, an apparent increase in Kokanee spawner abundance has occurred with counts 74-times higher in 2019 relative to 2003. Although a similar increase was apparent when comparing 2019 and 2007 cohort counts, the fact that only a reduced number of streams were surveyed in 2007 in the Peace Reach (one of five) means counts were not directly comparable between these two survey years.

The overall trends in spawner abundance observed in the Peace Reach were consistent among most of its constituent tributaries, including the single indexed stream, the Clearwater River (Figure 10). Among tributary streams, abundance was generally comparable in four of seven study years (2002, 2003, 2006, and 2019). No fish were observed during 2002 or 2003 surveys in Carbon Creek, and the Clearwater and Nabesche Rivers. Further, only a single spawning site, the, Clearwater River, was surveyed in 2007. In the year with the highest overall spawner abundance (2010), Dunlevy Creek and the Nabesche River had the highest and 2nd highest spawner abundance by a considerable margin compared to the other two study tributaries (Carbon Creek and the Clearwater River) (Figure 10). The highest counts in 2019 were observed in the Nabesche River and Dunlevy Creek, at 650 and 375 fish, respectively. Comparatively lower counts were observed in Carbon Creek and the Clearwater River (135 and 15 fish, respectively). Only 15 spawners were enumerated at 11-Mile Creek in 2019, a new addition to survey streams in 2019. All spawners in 11-Mile Creek were observed within the first several hundred meters upstream of the stream mouth. Kokanee spawner passage appeared to be obstructed by several barriers along the first two kilometers of stream (See Section 3.4 for further details).

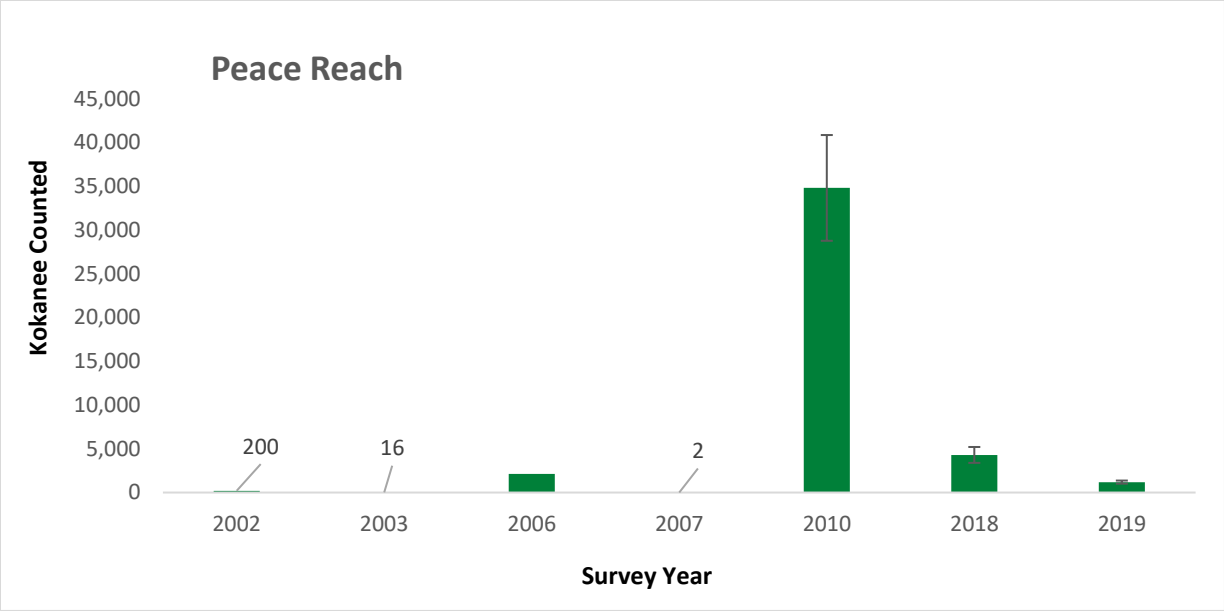

Figure 9. Comparison of the number of Kokanee spawners counted in four tributary streams to the Peace Reach of the Williston Reservoir from 2002 to 2019. The error bars for 2010, 2018 and 2019 represent the confidence range for the data in those years. Note: only one spawning tributary (Clearwater River) was surveyed in 2007.

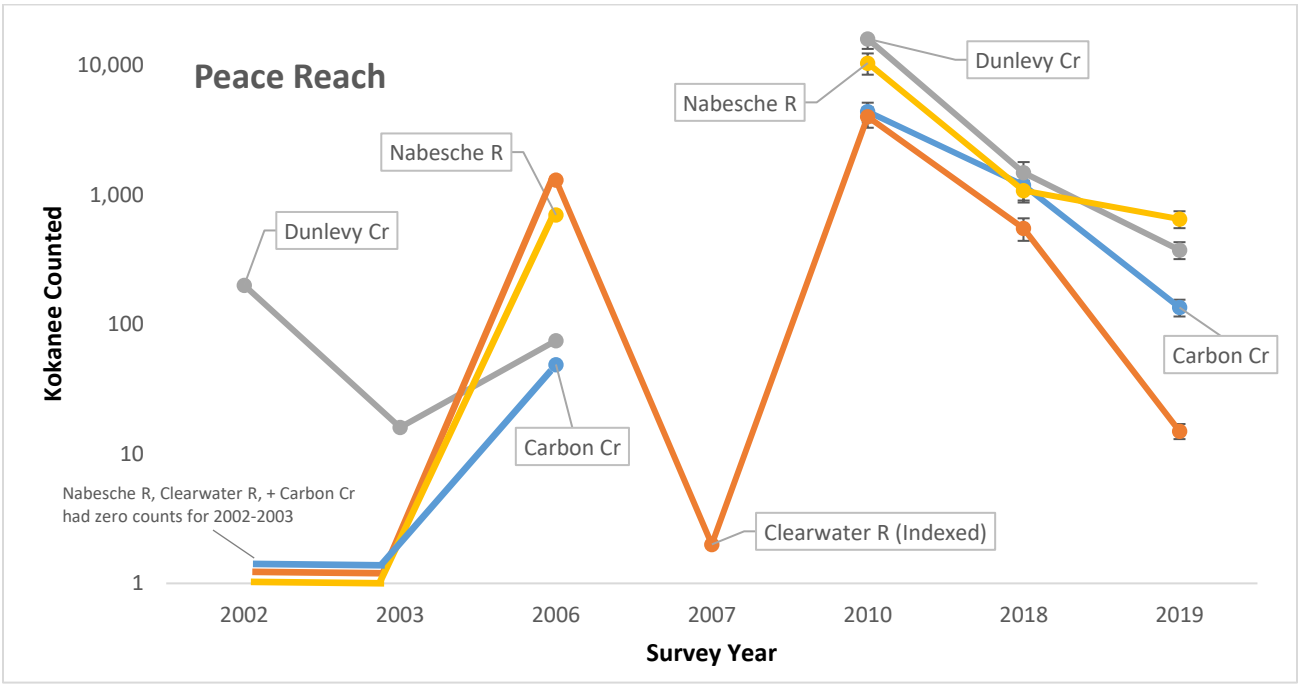

Figure 10. Trends in Kokanee spawner abundance from 2002 to 2019 in four streams of the Peace Reach. Error bars represent confidence ranges for the data in those years. Note: 11-Mile Creek not shown; only 15 fish observed in 2019 (see Section 3.4 for further details). Not all streams were surveyed every year.

Parsnip Reach

For the Parsnip Reach, there were a comparable number of spawners observed between 2019 and 2018, with 270 and 210 spawners enumerated during these two years, respectively. These number also represent the lowest Kokanee spawner numbers among the four sub-watersheds of Williston Reservoir. In 2019, Kokanee spawners were only observed in one of seven tributaries surveyed, the Upper Manson River, located upstream (north) of the Manson Lakes (see Tables B2 and B3, Appendix B). The 2019 survey represents the first year that Kokanee spawners were documented in the Upper Manson River. With respect to historic abundance trends, spawner abundance increased between 2002 (6,110) and 2003 (13,900), and again between 2003 and 2006 (42,400), representing 2.3- and 3.1-fold increases between these two intervals, respectively. A total of 6,500 spawners were enumerated in the Parsnip Reach in 2007, although only two spawning tributaries (Lower and Upper Manson Rivers) were surveyed during that year. When comparing the 2019 cohort to the same cohort counts in 2003, an apparent decline in Kokanee spawner abundance has occurred with counts 66-times lower in 2019 relative to 2003. Although a similar decline was apparent when comparing 2019 and 2007 cohort counts, the fact that a reduced number of streams were surveyed in 2007 in the Parsnip Reach (two of eight) means counts were not directly comparable between these two survey years.

The trends in spawner abundance observed in the Parsnip Reach among survey years were generally reflected in all of its constituent spawning tributaries. Prior to 2019, the Lower Manson River, located downstream (south) of the Manson Lakes, consistently had the highest spawner abundance among all survey streams, except in 2010 when the Misinchinka River and Scott Creek had the highest spawner counts, though only by a relatively small margin (approximately 1.5 times higher than Lower Manson spawner count).

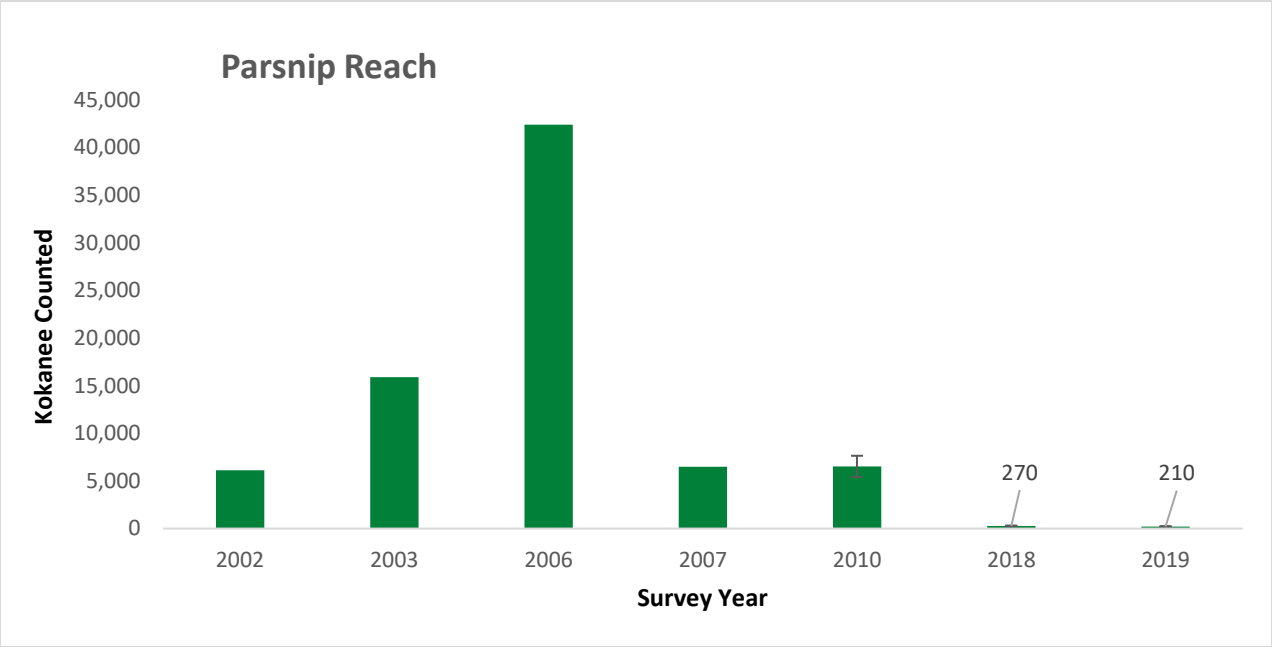

Figure 11. Comparison of the number of Kokanee spawners counted in ten tributary streams of the Parsnip Reach in the Williston Reservoir from 2002 to 2019. The error bars for 2010, 2018, and 2019 represent the confidence range for the data in those years. Note – Only two streams surveyed in 2007 (Lower and Upper Manson Rivers).

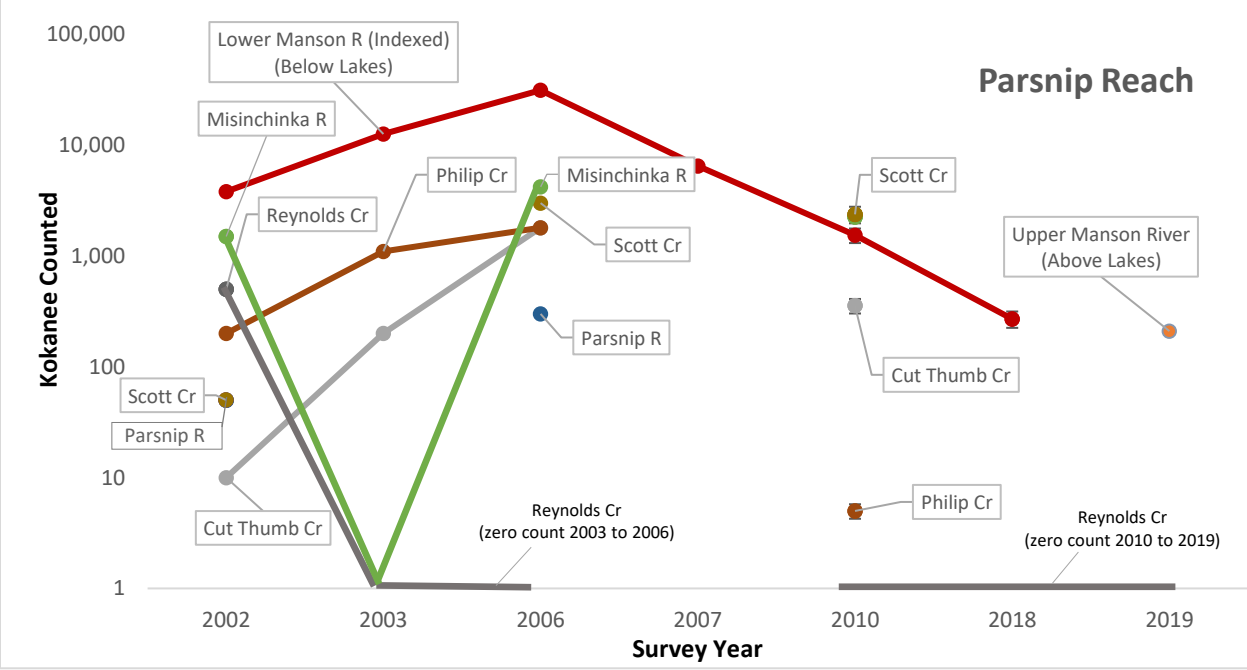

Figure 12. Trends in Kokanee spawner abundance from 2002 to 2019 for seven streams in the Parsnip Reach. The Upper Manson River was the only tributary where Kokanee spawners were observed in 2019.

3.3 Upstream Kokanee Distribution

With respect to the upstream-most distribution of Kokanee spawners, there appeared to be no consistent directional trends among individual spawning tributaries. In most cases, upstream Kokanee distribution was comparable among survey years. A few notable exceptions are the Osilinka, Mesilinka, and Germansen rivers, as well as Aley, Pelly, Swannell, and Carbon creeks, where Kokanee spawners appear to be distributed further downstream in 2018 and 2019 relative to the 2006 and/or 2010 survey years (Table 3). The complete absence of Kokanee spawner observations in many survey streams of the Parsnip Reach in 2018 and 2019 prevented a full assessment of within-stream distribution among survey years for these sites. Eight of the twenty-eight streams assessed had no Kokanee observations in either 2018 or 2019.

Table 3. Highest upstream km marker of Kokanee spawner observations from 2002 to 2019. Except where indicated, km intervals began at the survey start point (km 0). Each sub-watershed is sorted by the highest km of 2019 survey Kokanee extent to reflect current greatest use by spawners among tributaries. Orange cells indicate stream was not surveyed and green cells indicate stream was surveyed, but no data exists for upstream-most extent of spawners. Cells with zeros indicate no fish were observed on a given survey year. Spawning streams highlighted in red indicate an apparent decrease in upstream spawner distribution.

Sub-Watershed	Stream	Highest Km Kokanee Spawners Observed				
		2002	2006	2010	2018	2019
Finlay	Russel Creek	No Data	No Data	22	22	19
	Bower Creek	0	15	No Survey	20.5	16
	Cutoff Creek	0	2	16	11	15
	Davis River	0	0.5	No Data	11	10
	Pelly Creek	No Data	14	21	17	10
	Tsaydiz	No Survey	7	9	7	8
	Swannell River	0	18	18	3.5	5
	Pelly Lake Outlet (Zygadene)	No Survey	5	No Survey	3	4
	Aley Creek	No Data	No Data	12.5	4	3
	Finlay River*	0	6 km south of Cutoff Creek	7.5	8	0
Omineca	Osilinka River	No Data	69	71	34	31
	Mesilinka River	0	No Data	78.5	107.5	10
	Germansen River	No Data	7	10	7	6
	Silver Creek	No Survey	4	3	3	3
	Dead Bear	No Data	1	No Survey	3	1
Parsnip	Upper Manson River (above lakes)	No Survey	0	0	0	7
	Lower Manson River** (below lakes)	No Data	Above Lakes	No Data	82	0
	Misinchinka River	No Data	16	11	0	0
	Cut Thumb	No Data	6	4.5	0	0
	Parsnip River***	No Data	25	0	0	0
	Philip Creek	No Data	9.5	6	0	0
	Reynolds Creek	No Data	4	0	0	0
	Scott Creek	No Data	No Data	6	0	0
Peace	Nabesche River	0	6	14	12	14
	Carbon Creek	0	0	13	8	8
	Dunlevy Creek	No Data	2.5	7.5	7.5	7.5
	Clearwater River	0	4.5	7.5	8	3
	11 Mile Creek	No Survey	No Survey	No Survey	No Survey	0.2
	Gething Creek	No Survey	No Survey	No Survey	0	No Survey

* In 2018 and 2019, **Finlay River** only surveyed upstream of mouth of Cutoff Creek. Entire river length surveyed in previous years. Except 2006, 1-km intervals began at the mouth of Cutoff Creek (km 0).
****** Upstream extent for **Lower Manson** in 2006 located above Manson Lakes in Upper Manson River (10U 410076 6170891)
*** In 2019, the **Parsnip River** was surveyed in two separate sections: the first section ('Parsnip 1') began at the river mouth and ended at the confluence with Reynolds Creek, while the second section ('Parsnip 2') began at the outlet of Arctic Lake and ended 10 km upstream of the start point. Km marker for 2006 Kokanee extent measured from the river mouth.

3.4 Upstream Barriers to fish Passage

In total, potential physical barriers to fish passage have been identified in 8 tributaries surveyed between 2018 and 2019, mostly consisting of waterfalls (Table 4). The only additional barriers identified in 2019 were on 11-Mile Creek and Phillip Creek. Potential barriers on 11-Mile Creek consisted of a series of waterfalls within the first 1.5 km of the stream. All the falls were estimated to be 3-5 meters in height and no Kokanee were observed upstream of the first waterfall located just upstream of the mouth and below the bridge crossing (Figure 13). On Phillip Creek, a chute was identified approximately half way between km 5 and km 6.

Among the four main sub-watersheds, the Peace Reach had the most tributaries with potential barriers identified between 2018 and 2019 (five of six tributaries surveyed: Carbon Creek, Dunlevy Creek, Gething Creek, 11 Mile Creek, and Nabesche River). The Parsnip Reach had two tributaries with a potential barrier identified (Cut Thumb and Phillip Creek), while the Finlay Reach had only a single tributary with a potential barrier (Swannell River). No potential barriers were located in any of the tributaries surveyed within the Omineca Reach.

Of the tributaries where potential barriers were identified, the upstream-most location where Kokanee spawners were observed on any of the five survey years was downstream of the potential barrier in all tributaries except Carbon Creek in the Peace Reach and Phillip Creek in the Parsnip Reach (See Supplementary maps, Appendix A). For Carbon Creek, Kokanee spawners were located several kilometers upstream of the potential barrier in both 2002 (~ 16 km) and 2010 (~ 4 km), but the upstream limit of spawner detection in 2018 and 2019 occurred at the barrier itself. No surveys were conducted in Carbon Creek in 2006. For Phillip Creek, although no Kokanee spawners were observed during 2018 or 2019 surveys, spawners were observed upstream of this location in both 2006 and 2010 (at km 9.5 and 6, respectively), suggesting this feature is not a barrier to Kokanee spawner passage.

Table 4. Location and type of potential barriers to fish passage identified during surveys conducted between 2002-2019 among 29 tributaries in the Williston Reservoir. Only tributaries where barriers were identified are shown. Also indicated is whether upstream-most location of Kokanee spawner observation for any survey year occurred upstream of the potential barrier. No barriers were identified within Omineca Reach tributaries.

Sub-Watershed	Stream	Barrier Location	Km Marker	Barrier type	Kokanee Spawners Upstream of Barrier	
					2018	2019
Finlay	Swannell River	10U 368290 6278830	19.5	Falls	No	No
Peace	Carbon Creek	10U 521943 6199539	8.1	Chute/Cascade	Yes*	No
	Dunlevy Creek	10U 537127 6228534	7.5	Falls	No	No
	Nabesche River	10U 492813 6228608	14.2	Falls	No	No
	11 Mile Creek	10U 521286 6199581	0.2	Falls	No Survey	No
		10U 521245 6199468	0.4			
		10U 521103 6199231	0.6			
		10U 521090 6199095	0.8			
		10U 520868 6198896	1			
	Gething Creek	10U 547192 6206584	0.7	Falls	No	No Survey
Parsnip	Cut Thumb Creek	10U 481662 6156594	6.1	Falls	No	No
	Phillip Creek	10U 460266, 6128480	5.2	Chute	No	No

***Spawners were only detected upstream of the barrier in Carbon Creek in 2002 and 2010 survey years.**

****No Kokanee spawners were observed in Gething Creek in 2018 (not surveyed in previous years and replaced with 11 Mile Creek in 2019).**

Figure 13. First of five waterfalls observed on 11 Mile Creek during the 2019 aerial survey. This waterfall was located within 200 m of stream mouth just downstream of the bridge crossing. All Kokanee were observed downstream of this feature.

3.5 Survey Conditions

Overall, conditions experienced during 2019 aerial surveys were good for observing spawners, with visibility classified as either high or medium in most streams (Table 5). Some notable exceptions where poor survey conditions were experienced included Dead Bear Creek, Dunlevy Creek, and the Nabesche River, all of which were surveyed in the late afternoon of September 15th between 3:30 and 5:00 pm. Survey conditions at all three sites were characterized by low light levels and dark stream substrates, resulting in poor visibility for observing spawners. In addition, Dead Bear and Dunlevy Creeks are characterized by high, dense canopy closure on either side of the stream, creating shade over large sections of these streams and resulting in higher than normal flying heights. Poor conditions were also experienced along some sections of the Finlay River survey on September 14th, 2019. Rain impact on the

water surface, combined with low light, and deep turbulent water in sections of the first 10 km north of the survey start point (mouth of Cutoff Creek), as well as a narrow canyon section between km 10 and 13 with deep water, resulted in reduced visibility for observers. Although spawning fish were visible and successfully enumerated at these sites, it is likely that counts were underestimated due to the survey conditions experienced. Survey conditions along the Parsnip River were also poor and were characterized by deep and turbid (muddy) water. The turbid water conditions of the Parsnip River have been also been observed in previous years' surveys with no Kokanee spawners having been observed in this river during aerial surveys since 2006. A summary of survey conditions and visibility ratings for 2010, 2018, and 2019 are provided in Table 5.

Table 5. Stream visibility ratings for aerial enumeration surveys conducted in 2010, 2018, and 2019. Visibility was rated as high, medium, or low by observers based on conditions experienced at the time of survey (e.g. light levels, weather, stream substrates, canopy closure, flight speed). Specific observer comments are noted where applicable for some streams regarding conditions experienced that may have impaired observer ability to observe spawners during survey. Observer comments were taken from original survey datasheets for 2010 (Langston et al., *unpublished data*), 2018 and 2019.

Sub-Watershed	Stream	2010		2018		2019	
		Visibility	Observer Comments	Visibility	Observer Comments	Visibility	Observer Comments
Finlay	Russel Creek	High		Med	Many areas with big trees and shade	High	
	Bower Creek	No Survey		Med	Trees and shade made in some areas	High	
	Cutoff Creek	High		Med	Low early morning light, tight trees	High	
	Davis River	Med		High		Med	
	Pelly Creek	High		Med	Heavy shade in some canyon sections near mouth	Low	Low light, dark substrates, turbulent water km 8 to 11
	Tsaydiz	Med		Med		Med	
	Swannell River	High		Med	Afternoon sun; lots of shadows and glare	Med	
	Pelly Lk Outlet (Zygadene)	No Survey		Low	Windy with some shadows. Full on fuel and had to fly fast	High	
	Aley Creek	High		High		High	
	Finlay River	Med	Some very deep pools where fish not visible (i.e. long canyon)	Med	Dark substrate and green stain with many deep sections	Low	Poor light, rain impact, deep turbulent water from km 0 to 10
Omineca	Osilinka River	High		High		Med	
	Mesilinka River					High	
	Germansen River	Med		High		High	
	Silver Creek	Med		Med	Some locations with tight canopy/shadows near mouth	High	
	Dead Bear Creek	No Survey		Low	Dark substrate, tight canopy (shadows), had to fly high	Low	Poor light, dark substrate, high crown closure

Sub-Watershed	Stream	2010		2018		2019	
		Visibility	Observer Comments	Visibility	Observer Comments	Visibility	Observer Comments
Parsnip	Upper Manson River	Med	Some shadows and dark pockets	Med	Dark substrate, lots of large woody debris	Med	
	Lower Manson River	High		Med		Med	
	Misinchinka River	Med	Some dark pockets and very dark spots	High		High	
	Cut Thumb	High		Med	High	High	
	Parsnip River	Low	Very turbid	Low	High turbidity	Low	Deep, turbid water
	Philip Creek	Med		Med		High	
	Reynolds Creek	High		High		High	
	Scott Creek	High		Med		Med	
Peace	Nabesche River	High		Low	Low and thick clouds (low light), lightly snowing.	Low	Poor light, dark substrate
	Carbon Creek	High		Med		Low	Glare from sun
	Dunlevy Creek	High		Med	Lots of cottonwoods, large trees near banks	Med	Poor light, dark substrate, high crown closure
	Clearwater River	High		Med	Afternoon light in steep-sided stream valley; lots of shadows	High	
	11 Mile Creek	No Survey		No Survey		High	
	Gething Creek	No Survey		Med	Low, thick clouds (low light), lightly snowing. Moderately turbid water. Had to fly high due to steep canyon	No Survey	

4.0 DISCUSSION

4.1 Changes in Abundance and Distribution at the Reservoir and Sub-Reservoir Level

The sharp decline in spawner abundance in 2019 provides some evidence that 2018 may have been a peak spawner return year in the Williston Reservoir, though additional surveys over the next 3 years are needed to provide stronger support. Due to low counts in 2018 relative to the last previous survey in 2010, it was previously suspected that 2018 may not have represented a peak spawner return year in the Williston Reservoir. The period between 2010 and 2018 represented an 8-year timespan, which potentially encompasses 2 generations or life cycles of one Kokanee cohort (group of individuals hatched during same year). Although Kokanee typically have a 4-year life cycle on average, this period can vary between 3-5 years (Roberge et al. 2002). Based on the 8-year span between surveys, it was suggested in the 2018 report that the peak year in spawner abundance was not captured in the 2018 surveys possibly because

the introduced Kokanee have deviated from a 4-year life cycle (McDermot-Fouts and Robinson 2019). The Williston Reservoir encompasses a large and diverse watershed, and salmonids (including Kokanee) are known to exhibit considerable variability in their life history. This is particularly true with respect to generation time and adaptation of populations to local conditions and habitats (Milner et al. 2003; Whitlock et al. 2018). It is therefore conceivable that multiple non-overlapping spawning cohorts exist across the Williston watershed after 20+ years since their introduction. During this period a steady increase in spawner abundance was observed each year across the reservoir leading to a peak abundance year in 2006. The 2018 and 2019 surveys represent the first time Kokanee spawner enumeration surveys have been conducted in consecutive years since surveys were performed consecutively between 2002 and 2006. The last time Kokanee spawner enumeration surveys were conducted across multiple consecutive years was between 2002 and 2006. If 2018 was indeed a peak spawner year, we might expect to see a similar pattern of increasing spawner counts across successive years as surveys continue past 2020.

Although the 2019 decline in spawner abundance in the Williston reservoir was reflected in most of the individual spawning tributaries surveyed, both Silver Creek and the Swannell River were notable exceptions. In contrast to most survey streams, both these sites had higher spawner counts in 2019, with both having nearly 3-times as many spawners enumerated in 2019 relative to 2018. The survey crew in 2019 experienced favorable conditions during the surveys at Silver Creek with good lighting (mix of sun and clouds) and clear, shallow water which resulted in a high confidence rating for 2019 spawner counts. The fact that confidence intervals on both Silver Creek and Swannell spawner counts in 2018 and 2019 do not overlap provides support that higher counts observed in 2019 represent precise (low uncertainty) estimates and were not obscured by poor survey conditions. This variation in inter-annual-spawner counts among survey streams also lends some support to the possibility of multiple non-overlapping Kokanee cohort across the Williston reservoir and its spawning tributaries. However, more data from future survey years are needed to provide stronger support for this hypothesis. Another FWCP-funded project being conducted by UNBC (PEA-F20-F-3143-DCA; Kokanee Genetics and Demographics) is currently in progress and will provide genetic and aging data that is expected to help answer these outstanding questions regarding Kokanee life cycle and spawning phenology in the Williston Reservoir.

The previous two surveys years have seen a near absence of Kokanee spawners in the Parsnip Reach tributaries. This was an expected result based on low spawner counts in the Parsnip Reach during previous years, and appears to been part of a longer-term decline in spawner abundance that's been observed in the tributaries of the Parsnip Reach since 2006. Although the Parsnip Reach had the 2nd highest spawner abundance of the four sub-watersheds in 2002 and 2003, it has experienced an apparent decline in spawner abundance from 2006 onward and has had consistently low Kokanee counts in the last two years, with spawners documented in only a single tributary in each of the 2018 and 2019 survey years (the Lower and Upper Manson Rivers, respectively). Furthermore, 2019 was the first year that Kokanee spawners were observed during aerial surveys in the Upper Manson River. Habitat observations from 2010 (Langston et al. *unpublished data*) and 2018 noted an abundance of fines and mud in the substrate, and poor overall spawning potential upstream of the Manson Lakes. It was initially thought to be unlikely that Kokanee would ever be observed spawning in the Upper Manson River and the site was considered for removal from future surveys (McDermot-Fouts and Robinson 2019). The explanation for the recent appearance of Kokanee spawning in the Upper Manson River is unknown at this time. One possible explanation is that the spawners observed here in 2019 represent an isolated population residing the

Manson lakes and that individuals in this population have life cycle phenology that varies from other populations in the reservoir (i.e. spawner return years). This could potentially explain the lack of observations of spawners in this tributary in previous surveys years, as survey timing may have missed spawner returns for such a population. Future surveys will reveal if Kokanee continue to spawn within this area, and if their numbers increase.

4.2 Within-stream abundance and Distribution

There appeared to be no consistent changes in upstream distribution for most spawning tributaries from 2002 to 2019. For some sites however, an apparent change in upstream distribution was observed where upstream-most spawners were seen further downstream in 2018 and 2019 relative to previous survey years. The sites where changes in spawner distribution were most pronounced, tended to be longer streams and rivers such as the Mesilinka, Osilinka, and Swannell Rivers. The change in distribution at these sites may reflect density dependent effects of the lower spawner numbers in 2018 and 2019 relative to previous years resulting in reduced competition for, and increased availability of spawning sites at downstream sections.

Previous surveys have observed that Kokanee appear to select the first available spawning habitat they encounter, and that spawners tended to be distributed only as far upstream as spawning numbers and available habitat require (Langston 2012). The fact that the tributaries showing a downstream shift in spawner distribution were located in the Finlay and Omineca Reaches, which have consistently had the highest number of spawners in the reservoir, provides some support for this hypothesis. The absence of upstream-extent data for some streams during previous survey years (2002, 2006 and 2010) makes discerning apparent changes in upstream spawner distribution difficult.

4.3 Fish Collections

Fish were easily located and collected from three of five collections sites in 2019. Locations of relatively high densities of spawners were identified from the air during aerial enumeration surveys at Russel Creek, Aley Creek, and Germansen River. Narrow, slow flowing reaches and side channels were targeted for collections. Higher concentrations of spawners at such sites facilitated rapid collection of fish utilizing a 2 to 3-person crew electrofishing and dip-netting. Collections took about an hour on average at these sites.

Fish collection at Arctic Lake took place earlier in the season in 2019 rather than in September. This timing window was selected to target higher early-season water levels and allow jet boat access to the lake via the Parsnip River. Low, late-season water levels prevented boat access and fish collections here in 2018. Though crews were able to successfully access the lake, only a single day was allocated for fish collections, including mobilization and demobilization from the lake via Jetboat. The large size of the lake proved challenging for finding concentrations of large schools of Kokanee. As a result, we were only able to collect a total of 18 fish instead our initial target of 30. In future years, an additional day should be allocated for fish collections at Arctic Lake to allow for more time to locate and sample fish. Camping sites exist at the lake that would allow a crew to stay overnight and reduce time constraints for completion of fish collections within a short, single-day window.

Fish collection at the Finlay River side channels occurred in late October 2019, approximately one month after aerial surveys had been completed. This later timing window was selected to target fish from native Kokanee stock at the north end of the reservoir, which have been hypothesized to spawn later in the

season than the introduced Columbia stock (Mark Shrimpton, personal communication). The survey crew had difficulty locating spawners during the October 22 collection date despite experiencing excellent survey conditions for observing fish. The survey flew over all side channels in an effort to locate fish. Historic locations of Kokanee spawner observations were also searched.

Kokanee were eventually observed and collected from two locations: a side channel of the Finlay River located approximately 8 km north of the Akie River Mouth (7 fish), and approximately 3 km upstream of the Akie River itself (13 fish). The Akie River was recommended by Kwadacha first nations partners during Oct 22 flights after exhausting search of the historical locations of Kokanee spawner observations in the Finlay side channels. At the first site, Kokanee carcasses and redds were identified from the air and a small school of Kokanee (20-25 fish) were located on ground during a reconnaissance. On the Akie River, a school of 30-40 fish was identified from the air in non-flowing side channel of the river. A thin layer of ice (2-3 cm) on the water surface made Kokanee capture challenging. Further, since fish were not located until later in the afternoon, time constraints meant that only about 20 minutes could be allocated to fish capture at the last site (Akie River). No Kokanee spawners were observed in the main channel of the Finlay River during fish collections (October 22) nor aerial enumeration survey. (September 14). Given these observations, future collections efforts should be focused on locating slow or non-flowing pools or side channels, as Kokanee spawners appear to favor these habitats.

4.4 Uncertainty Analysis

Observing and accurately enumerating Kokanee spawners from rotary aircraft is highly dependant on survey conditions. These include the prevailing weather conditions at the time of survey (e.g. sunny vs. overcast), as well as the physical characteristics of the spawning stream (e.g. depth, turbulence, turbidity, forest cover). In some smaller streams, such as Dead Bear creek, mature trees close to the stream channel made safely flying close to the stream difficult. This combined with overcast conditions and turbulent water made observing Kokanee spawners more challenging in some streams (e.g. Dunlevy Creek and Nabesche River). However, overall the 2019 survey crew experienced excellent conditions for spotting and enumerating spawners during aerial surveys, and as such, confidence in spawners counts across the reservoir as a whole were high.

The low numbers of Kokanee observed in 2018 relative to the 2010 and 2006 surveys initially raised concerns about the timing of the enumeration flights relative to peak Kokanee returns. Spawner counts were even lower in 2019, which might raise concerns about the survey timing and potentially missing peak spawning periods (i.e. surveys scheduled too early or too late in the run of Kokanee spawners to capture the peak return). In both 2018 and 2019, surveys occurred in the window recommended by Langston (2012) and overlapped the dates flown in 2010 (12 to 18 September - Langston 2010 *unpublished data*).

No Kokanee carcasses were observed in any of the streams during the 2019 surveys suggests that the survey timing was not too late. The condition of the Kokanee spawners that were collected from Russel Creek, Aley Creek and Germansen River during enumeration flights provided assurances that the timing was appropriate. The Kokanee collected were in relatively good condition with few signs of fin or tissue damage associated with redd construction or rapid senescence. Females were observed that appeared to still have most or all of their eggs intact (pre-spawn or actively spawning) while others were observed that appeared to have spent their eggs (post-spawn). Males were also observed producing varying amounts of milt upon collection, suggesting that they were yet to spawn or were in the process of fertilizing eggs.

Kokanee were collected from the Finlay River side channels and the Akie River (a tributary of the Finlay River) approximately 4 weeks after the enumeration flights on October 22, 2019 and condition of those fish suggested that spawning in that location was nearing completion. It is suspected that fish collected from the Finlay and Akie Rivers may be late fish from the Columbia run but genetic analyses on collected specimens an adjunct project by UNBC (PEA-F20-F-3143-DCA) will be needed to confirm this.

The conditions observed during the 2019 spawner surveys provides evidence that surveys were well timed and that the counts accurately estimated the peak in Kokanee returns to spawning grounds.

Interpretations of the enumeration data from 2002, 2006, 2010, 2018 and 2019 are based on a number of critical assumptions. Key assumptions include the 4-year life cycle of Kokanee and that the observed changes in the selected cohort are representative of all Kokanee in the reservoir. Aging the Kokanee spawners collected in the 2018 survey will provide useful information that will support or discredit the assumption of a 4-year life cycle. Considerable variation in population size appears to have occurred in the study cohort since 2002 but little is known about the variation in the other cohorts that were enumerated from 2003 to 2005. Enumerating Kokanee returns in 2020, 2021, and 2022, would provide a more complete and accurate interpretation of Kokanee population dynamics in the reservoir.

5.0 RECOMMENDATIONS

Based on the findings from this study, we recommend continued annual Kokanee spawner surveys over an additional 3 years. This includes an additional year than what was proposed following 2018 surveys (McDermot-Fouts and Robinson 2019). Enumerating spawners annually over a 5-year period (including 2018 and 2019) will help achieve the following objectives: (i) determine if Kokanee spawning abundances increase or continue to decline, and (ii) identify any evidence of multiple overlapping Kokanee cohorts across the Williston watershed, sub-watersheds, and spawning tributaries. Spawner surveys should focus on the same tributaries surveyed in 2019, with the exception of 11-Mile Creek in the Peace Reach. Despite lack of observations in the Parsnip River over the years, there is still interest in surveying the river due to conservation concerns with the native Kokanee population in Arctic Lake. We recommend continuing with the modified survey approach used in 2019 where the assessment is split into two reaches with the first reach being the confluence with the reservoir to the confluence with Reynolds Creek and the second from the outlet of Arctic Lake downstream for 10 km (approximately Lat: 54.52296 N, Lon: 121.92229 W).

Survey methods should continue to follow those used during previous study years, with a primary focus on aerial enumeration surveys. Aerial surveys should continue to include confidence estimates on spawner counts to allow robust comparisons in future years. In addition, given that the 9 index streams recommended by Langston (2012) showed interannual trends in spawner abundance that consistently reflected those seen at the reservoir-scale, and at each sub-watershed, these sites should continue to be included in future surveys. We also recommended that Kokanee spawners continue to be quantified at 1-km intervals along survey streams during aerial surveys. To maintain spatial consistency, surveys should continue to use the same 1-km intervals as established in 2019 which were calculated precisely using GIS software. Further, 1-km interval waypoints should be pre-loaded into GPS units prior to the onset of surveys to increase survey efficiency.

If genetic and demographic research with UNBC continues into 2021 (FWCP project: PEA-F20-F-3143-DCA) we recommend Kokanee spawner collections at the same five sites sampled in 2019: Russel Creek,

Germansen River, Aley Creek, Finlay River side channels, and Arctic Lake. Additional sites may be added or removed in consultation with UNBC researchers, FWCP, and other project partners. Due to difficulty locating fish during Finlay River collections in 2019, and the complete absence of spawner observations in the Finlay during aerial surveys, collection sites should be focused near the same sites where fish were located during collections in 2019 i.e. side channel of the Finlay and Akie Rivers). Kokanee have been observed in these locations later than the typical aerial surveys would be completed, and therefore the recommended timing is mid to late October. Genetic analyses on fish collected from the Finlay and Akie Rivers in 2019 will determine whether these fish were late spawners from the introduced Columbia-origin stock. If this is the case, collections are recommended for the last week of October to potentially target native stock spawners. Collection at Arctic Lake should again occur during June 2020, but 2 days should be allocated for the collection to allow sufficient time to mobilize to and from the site by jet boat, and to capture a sufficient sample of fish.

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Appendix A
Maps

LIST OF MAPS

Overview Maps

Overview Map 1 – Overview map of Finlay North

Overview Map 2 – Overview map of Finlay South and Omineca North

Overview Map 3 – Overview map of Omineca South and Parsnip Northwest

Overview Map 4 – Overview map of Peace and Parsnip Northwest

Overview Map 5 – Overview map of Parsnip South

Stream Maps

Finlay River (North of Cutoff Creek)	Upper Manson River
Cutoff Creek	Germansen River
Bower Creek 1: km 1 - 12	Silver Creek
Bower Creek 2: km 13 – 22	Nabesche River
Russel Creek	Dunlevy Creek
Tsaydiz Creek	Carbon Creek
Swannell River	11-Mile Creek
Pelly Creek	Clearwater River
Zygadene Creek (Pelly Lake Outlet)	Scott Creek
Davis River	Cut Thumb Creek
Aley Creek	Phillip Creek
Mesilinka River 1: km 1 -12	Misinchinka River
Mesilinka River 2: km 13 -22	Reynolds Creek
Mesilinka River 3: km 23 -34	Parsnip River 1: km 1 - 19
Mesilinka River 4: km 35 - 48	Parsnip River 2: km 20 - 36
Mesilinka River 5: km 49 - 60	Parsnip River 3: km 37 - 51
Mesilinka River 6: km 61 - 90	Parsnip River 4: km 52 - 62
Mesilinka River 7: km 91 - 116	
Osilinka River 1: km 1-17	
Osilinka River 2: km 18-39	
Dead Bear Creek	
Lower Manson River 1: km 1 - 17	
Lower Manson River 2: km 18 - 35	

Overview Map 1
2019 Kokanee Spawner Surveys
Region: Finlay North

Scale: 1:150,000

0 1.25 2.5 5 7.5 10 12.5 15 km

Date: December 03, 2019

Map Datum: NAD 1983 UTM Zone 10N

MFLNRORD_19380-334_KokaneeSurvey2019.mxd

DWB Consulting Services Ltd.

Start Survey

End Survey (2019)

Furthest Upstream Kokanee Observation

Potential Barriers

Chute/Cascade

Chute/Falls

Falls

Fish Abundance Labels

2002: 157 KO *(Year: Abundance Value, Species)*

Data labels show the survey year and the number of Kokanee counted. The point associated with the label represents the furthest upstream location that Kokanee were observed in that year.

2002: 157 KO *(Year: Abundance Value, Species (survey end location))*

In years where the furthest upstream Kokanee observation was not known, the data label points to the furthest upstream extent of the survey. Data labels that point to survey end points rather than the furthest upstream Kokanee observation are clearly identified.

280000 300000 320000 340000 360000 380000

6400000 6380000 6360000 6340000 6320000 6300000

Weissener Lake
Esri Lake
Pulpit Lake
Fishing Lakes
Culvert C
2018: 2,250 KO
2010: 268,756 KO
2019:4,690 KO
2010: 41,555 KO
2018: 8,090 KO
2006: 93 KO
Cutoff C
Finlay R (2018)
2006: 33,200 KO
2019: 1,810 KO
2006: 16,000 KO
2018: 9,230 KO
Bower C
Bower C
Rainbow Lake
Fort Ware
Suczou Lake
Jack Lake
Foot Lake
Budd Lake
2019: 19,025 KO
2010: 147,080 KO
2018: 45,510 KO
Stellauz Lake
Russel C
Russel C
2002: 468 KO (survey end location)
2006: 51,500 KO (survey end location)
*Suspected waypoint error in 2002 & 2006 survey end location (provided by other)
Finlay R
Kemess Lake
Fredrikson Lake
McConnell Lakes
Thorne Lake
2006: 6,400 KO
2019: 2,940 KO
Tsaydiz C
Tsaydiz C
2010: 31,590 KO
2018: 13,270 KO
Finlay R (2002, 2006, 2010)
Estella Lakes
Ed Bird Lake
Tsay Keh Dene
Pelly Lake Inlet
Tutuchi Lake
Pelly C
Tucha Lake
2019: 2,440 KO
Pelly Lake
2010: 54,406 KO
2018: 9,040 KO
2006: 400 KO (survey end location)
2018: 5,295 KO
2006: 28,500 KO
Zygadene C
Zygadene C
2002: 300 KO (survey end location)
2019: 775 KO
Little Dismal Lake
Goldeneye Lake
Pelly C
Williston Lake
Swannell R

Overview Map 2
2019 Kokanee Spawner Surveys
Region: Finlay South & Omineca North

Scale: 1:150,000

0 1.25 2.5 5 7.5 10 12.5 15 km

Date: December 03, 2019

Map Datum: NAD 1983 UTM Zone 10N

MFLNRORD_19380-334_KokaneeSurvey2019.mxd

DWB Consulting Services Ltd.

Start Survey

End Survey (2019)

Furthest Upstream Kokanee Observation

Potential Barriers

Chute/Cascade

Chute/Falls

Falls

Fish Abundance Labels

2002: 157 ND *(Year: Abundance Value, Species)*

Data labels show the survey year and the number of Kokanee counted. The point associated with the label represents the furthest upstream location that Kokanee were observed in that year.

2002: 157 ND *(Year: Abundance Value, Species (survey end location))*

In years where the furthest upstream Kokanee observation was not known, the data label points to the furthest upstream extent of the survey. Data labels that point to survey end points rather than the furthest upstream Kokanee observation are clearly identified.

320000 340000 360000 380000 400000 420000

6300000 6280000 6260000 6240000 6220000 6200000

2010: 54,406 KO
2018: 9,040 KO
2006: 28,500 KO
2002: 300 KO (survey end location)
Pelly Lake
Pelly Lake Inlet
2006: 400 KO (survey end location)
2018: 5,295 KO
Zygadene C
2019: 775 KO
Little Dismal Lake
Golgoneye Lake
Pelly C
Swannell R
2018: 210 KO
2019: 570 KO
Ingenika Mine
Delkitz Lake
2006: 10,400 KO
2010: 9,526 KO
Swannell R
2010: 56,120 KO (survey end location)
Johanson Lake
Darb Lake
2018: 631 KO
2019: 230 KO
2006: 700 KO
Davis R
Tomias Lake
Carina Lake
Lafferty Lake
Aiken Lake
2006: 15,400 KO
2010: 49,156 KO
Williston Lake
Blackpoint Lake
2018: 49,352 KO
Mesilinka R.
Tobin Lake
Tuhizzi Lake
Genlyd Lake
Tenaktu Lakes
Dead Bear C.
2019: 20 KO
2019: 60 KO
2002: 1,800 KO (survey end location)
2006: 1,800 KO
Dead Bear C
2010: 111,236 KO
2006: 246,800 KO
2018: 1,704 KO
2019: 2,090 KO
Mesilinka R
Osilinka R.
2018: 22,450 KO
Osilinka R
Uslika Lake
2002: 36,800 KO (survey end location)
Misti Lake
Chuddiatsa Lake
Otter Lakes
Crater Lake
Echo Lake
Nina Lake
Muscovite Lakes
Blue Lake
Johns Lake

Overview Map 3
2019 Kokanee Spawner Surveys
Region: Omineca South & Parsnip Northwest

Scale: 1:150,000

0 1.25 2.5 5 7.5 10 12.5 15 km

Date: December 03, 2019

Map Datum: NAD 1983 UTM Zone 10N

MFLNRORD_19380-334_KokaneeSurvey2019.mxd

DWB Consulting Services Ltd.

Start Survey

End Survey (2019)

Furthest Upstream Kokanee Observation

Potential Barriers

Chute/Cascade

Chute/Falls

Falls

Fish Abundance Labels

2002: 157 ND *(Year: Abundance Value, Species)*

Data labels show the survey year and the number of Kokanee counted. The point associated with the label represents the furthest upstream location that Kokanee were observed in that year.

2002: 157 ND *(Year: Abundance Value, Species (survey end location))*

In years where the furthest upstream Kokanee observation was not known, the data label points to the furthest upstream extent of the survey. Data labels that point to survey end points rather than the furthest upstream Kokanee observation are clearly identified.

360000 380000 400000 420000 440000 460000

6200000 6180000 6160000 6140000 6120000 6100000

Otter Lakes
Crater Lake
Echo Lake
Nina Lake
Lakes Muscd
Blue Lake
Shoal Lakes
12 Mile
Germansen Landing
Germansen R
2018: 7,825 KO
2006: 108,000 KO
2019: 1,390 KO
2010: 34,789 KO
2002: 20,000 KO (survey end location)
Ah Lock Lake
Wessie Lake
Germansen R
Germansen Lake
2019: 1,900 KO
Old Hogem
Silver C
2010: 8,292 KO
2018: 705 KO
2006: 300 KO
Teegee Lake
Silver Lake
Silver C
2019: 210 KO
Manson Creek
Upper Manson R
Wolverine Lakes
Upper Manson R
Manson Lakes
Lower Manson R
Carter Lake
Lower Manson R
Scott C
2010:
Scott C
2002: 3,800 KO (survey end location)
2010: 1,538 KO (survey end location)
2006: 31,300 KO
2018: 270 KO
Christine Lake
Head Lake
Maybelline Lake
Duncan Lake
Blackwater Lake
Connaghan Lake
Calais Lake
Dukaitoonli Lake
Albert Lake
Dia Lake
Electra Lake
Wudtsi Lake
Tsaydaychi Lake
Ahdatay Lake
Klawli Lake
Skunk Lake
Speng Lake
Fulcroe Lake
Munro Lake
Finger Lake
Phillip C
2002: 200 KO
2010: 5 KO
2006: 1,800 KO
Klawdetelle Lake
Nation Lakes
Punnis Lake
MacDonald Lake
Glaucers Lake
Tamaiscale Lake
Izgay Lake
Witter Lake
Phillip C
Thutsacho Lake
Takatoot Lake
Aldine Lake
Witch Lake
Choyazi Lake
Webberly Lake
Gogagindli Lake
Philip Lakes
Chidhonajih Lake
Elliott Lake
Dan Mine Lake
Kloch Lake
Mudzenchoot Lake
Abas Lake
Natazuto Lake
Kazchek Lake
Chu Lake
Sheshenadji Lake
Kalder Lake
Benoit Lakes
Inzana Lake

Overview Map 4
2019 Kokanee Spawner Surveys
Region: Peace and Parsnip Northeast

Scale: 1:150,000

0 1.25 2.5 5 7.5 10 12.5 15 km

Date: December 04, 2019

Map Datum: NAD 1983 UTM Zone 10N

MFLNRORD_19380-334_KokaneeSurvey2019.mxd

DWB Consulting Services Ltd.

Start Survey

End Survey (2019)

Furthest Upstream Kokanee Observation

Potential Barriers

Chute/Cascade

Chute/Falls

Falls

Fish Abundance Labels

2002: 157 KO *(Year: Abundance Value, Species)*

Data labels show the survey year and the number of Kokanee counted. The point associated with the label represents the furthest upstream location that Kokanee were observed in that year.

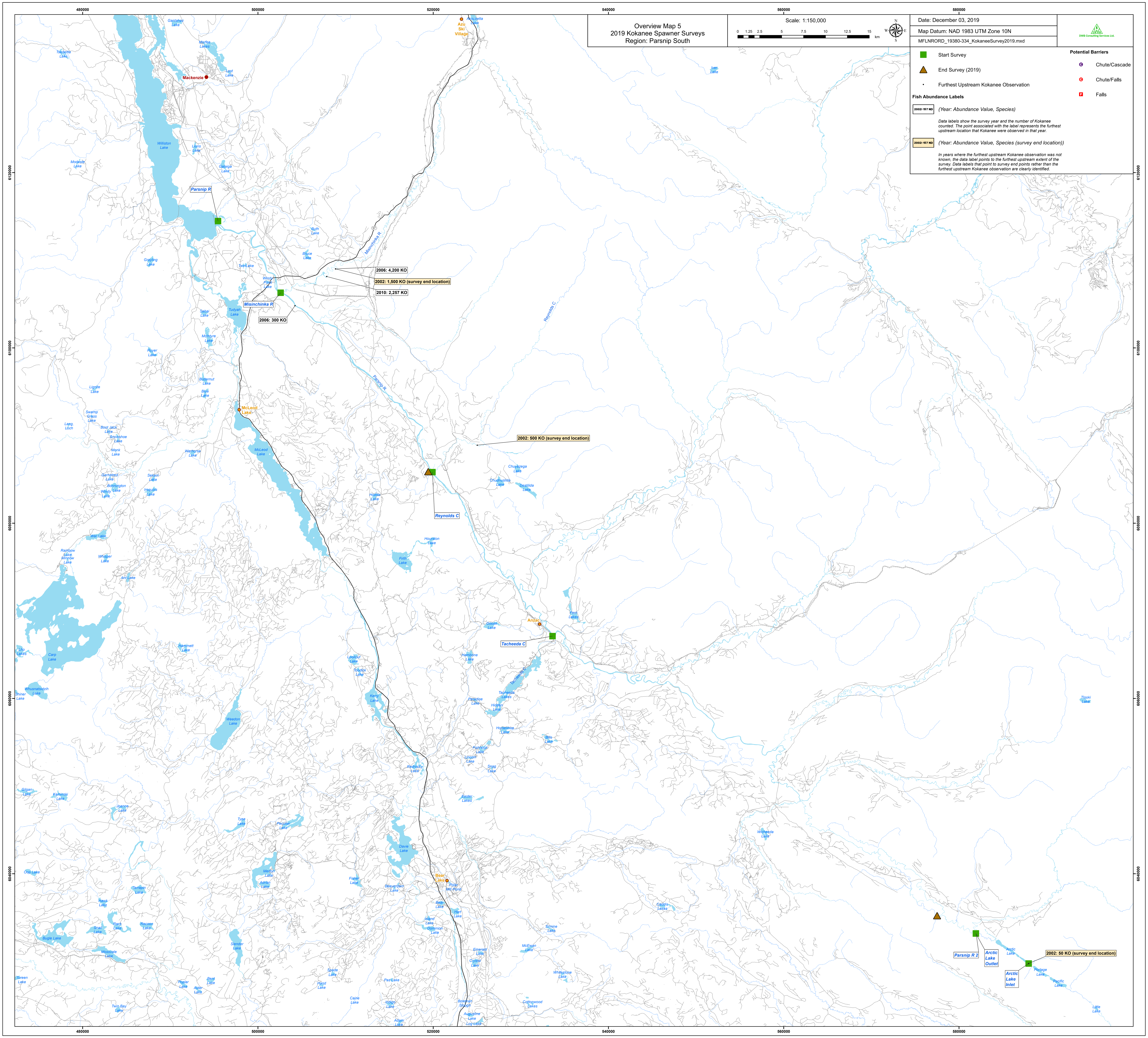
2002: 157 KO *(Year: Abundance Value, Species (survey end location))*

In years where the furthest upstream Kokanee observation was not known, the data label points to the furthest upstream extent of the survey. Data labels that point to survey end points rather than the furthest upstream Kokanee observation are clearly identified.

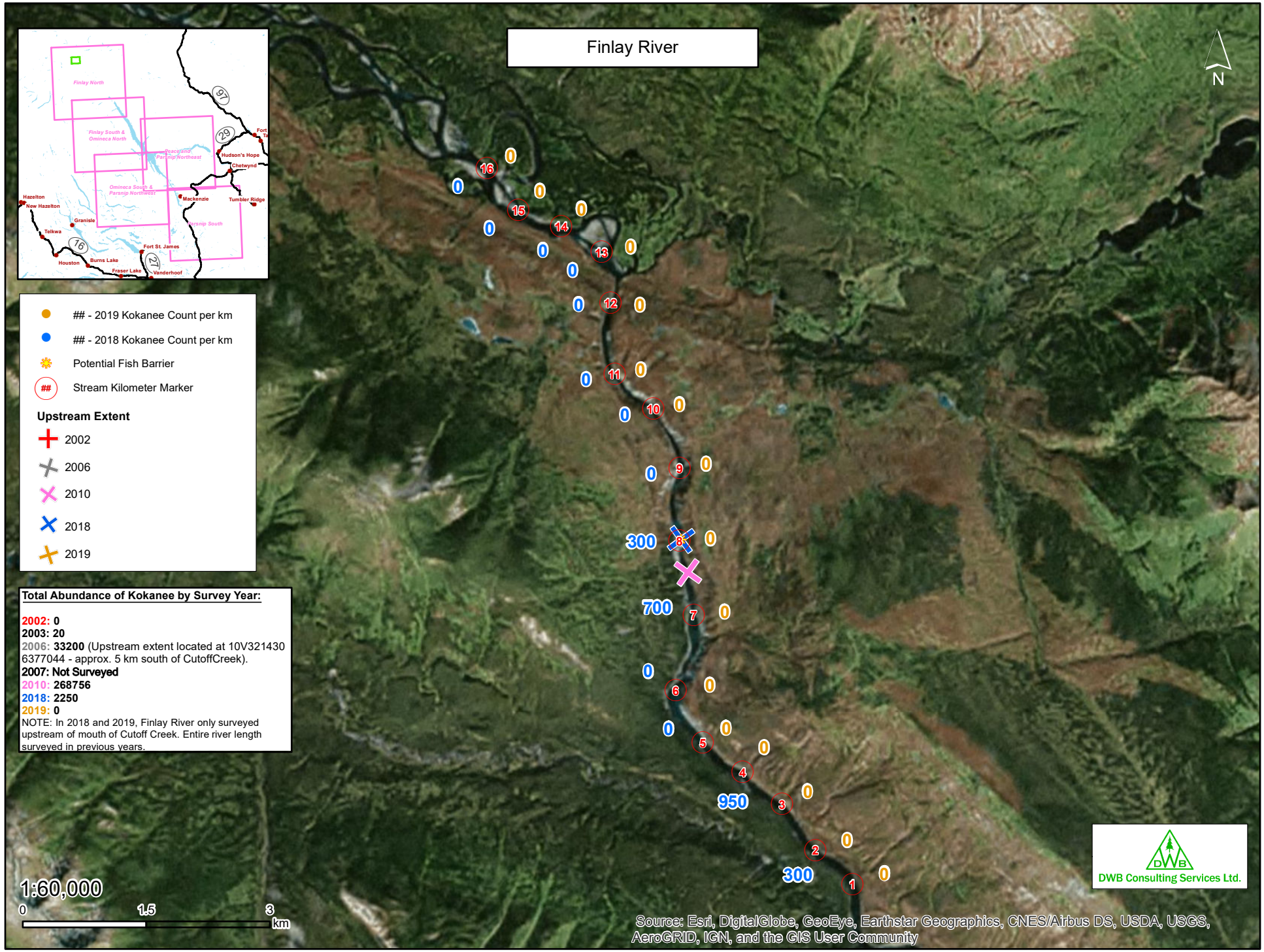
440000 460000 480000 500000 520000 540000

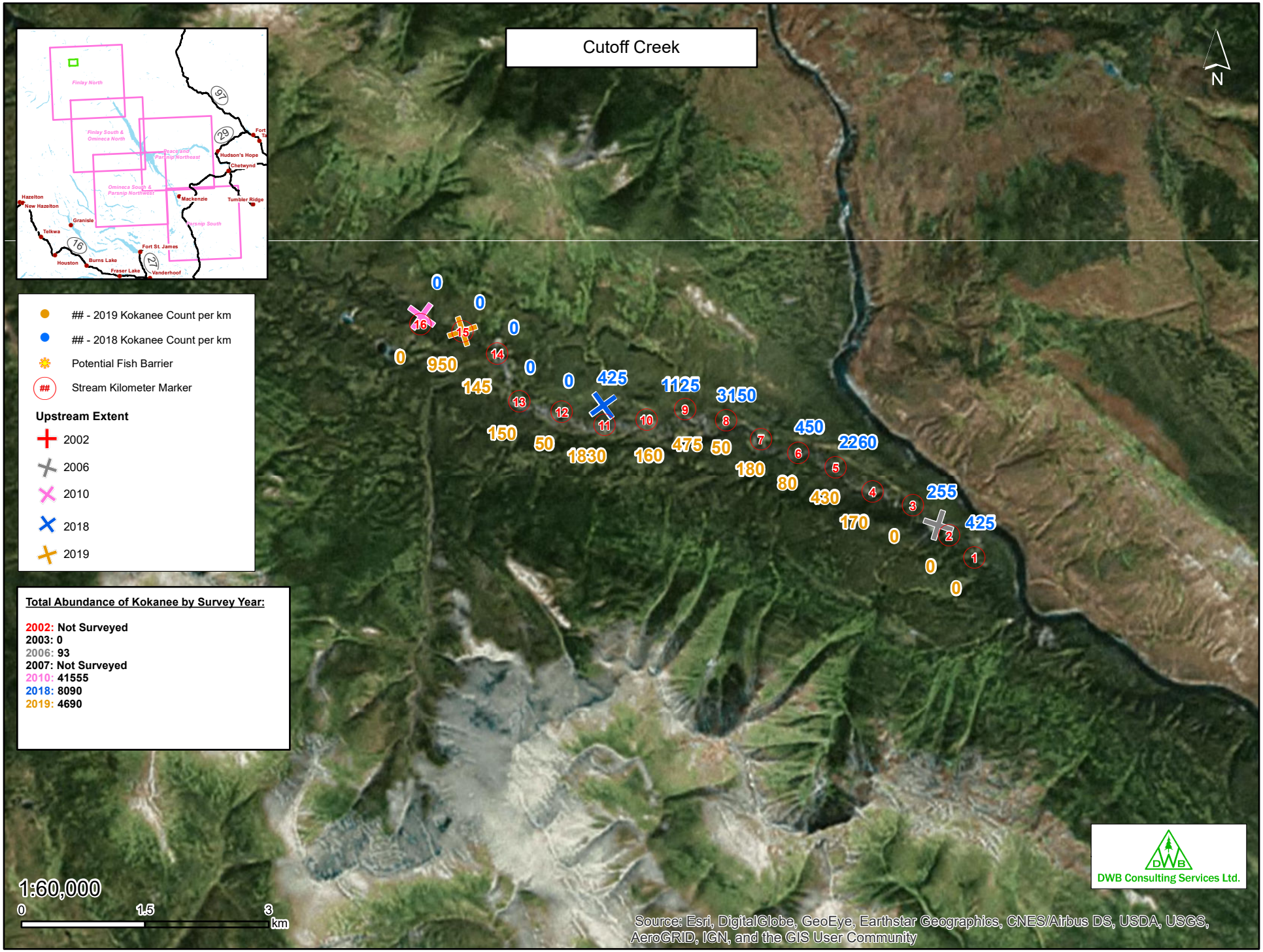
6260000 6240000 6220000 6200000 6180000 6160000

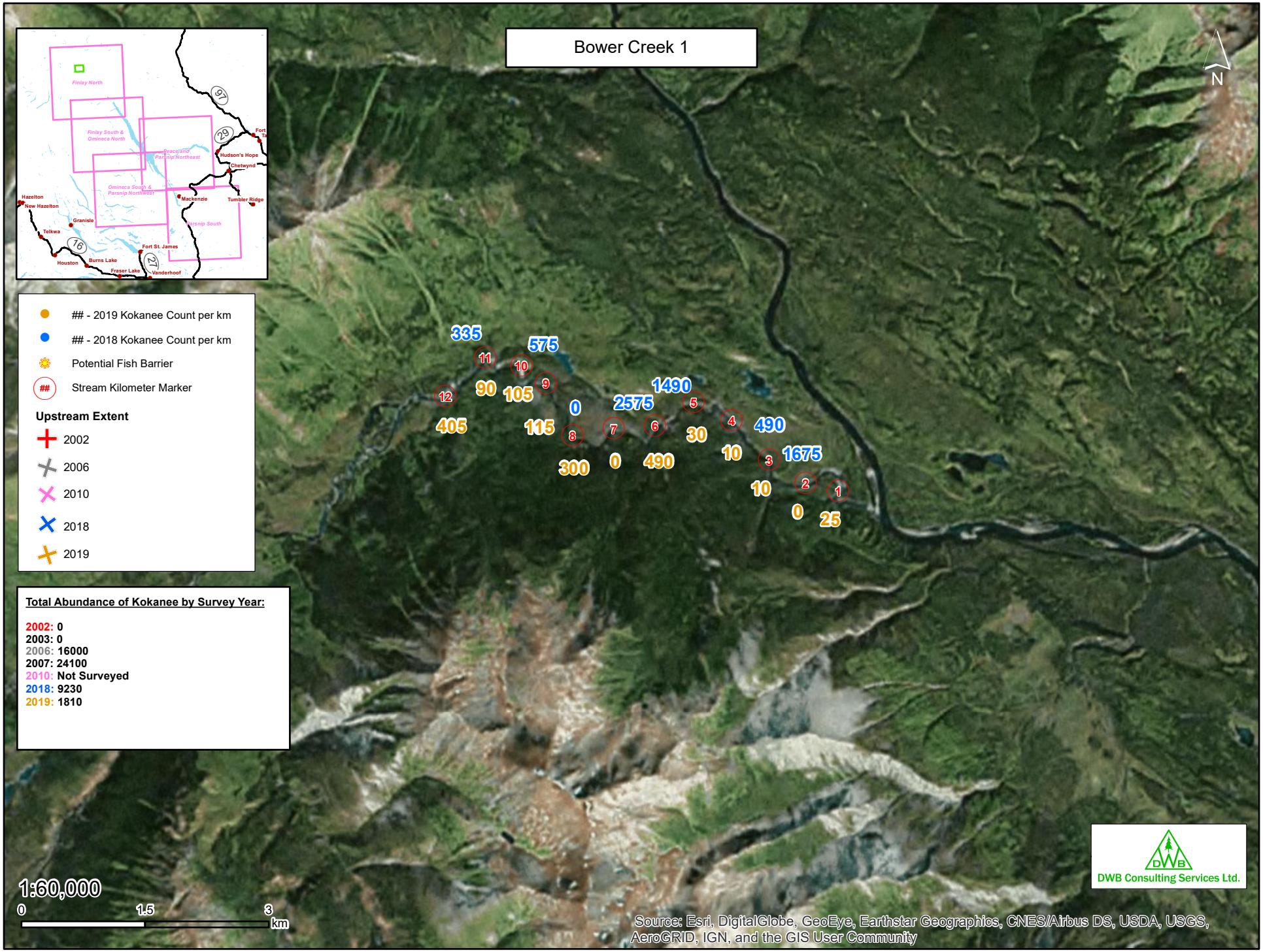
2006: 1,700 KO (survey end location)
2002: 36 KO (survey end location)
2010: 12,992 KO
2018: 6,145 KO
Aley C
2019: 1,330 KO
Aley C
Emerald Lakes
Wicked Lake
Nabesche R
2010: 10,409 KO
2019: 650 KO
2018: 1,080 KO
2006: 700 KO
Nabesche R
Dunlevy C
2018: 1,481 KO
2002: 200 KO (survey end location)
2019: 375 KO
2010: 16,014 KO
2006: 75 KO
Dunlevy C
Dunlevy Lake
Williston Lake
Canty Lake
Carbon C
Carbon Lake
2018: 1,186 KO
2019: 15 KO
11 Mile C
2019: 135 KO
Gething C
Gething C
Dinosaur Lake
Moosecall Lake
Wright Lake
2010: 4,388 KO
Carbon C
Rete Lake
2019: 15 KO
Clearwater R
2006: 1,300 KO
2010: 4,012 KO
2018: 550 KO
2006: 49 KO (survey end location)
Snoal Lakes
Scott C
Clearwater R
2010: 2,375 KO
2002: 50 KO (survey end location)
2006: 3,000 KO (survey end location)
Lower Manson R
Scott C
Carve Lake
Lower Manson R
Cut Thumb C
Christina Lake
2002: 10 KO (survey end location)
2006: 1,800 KO
Pothole Lakes
Cut Thumb C
Head Lake
Maycolme Lake
2010: 356 KO
Dina Lakes
Burden Lake
Heather Lake
Clearwater Lake
Bickford Lake
Pine Valley
Lemoray
Coonan Lake
Simpson Lake

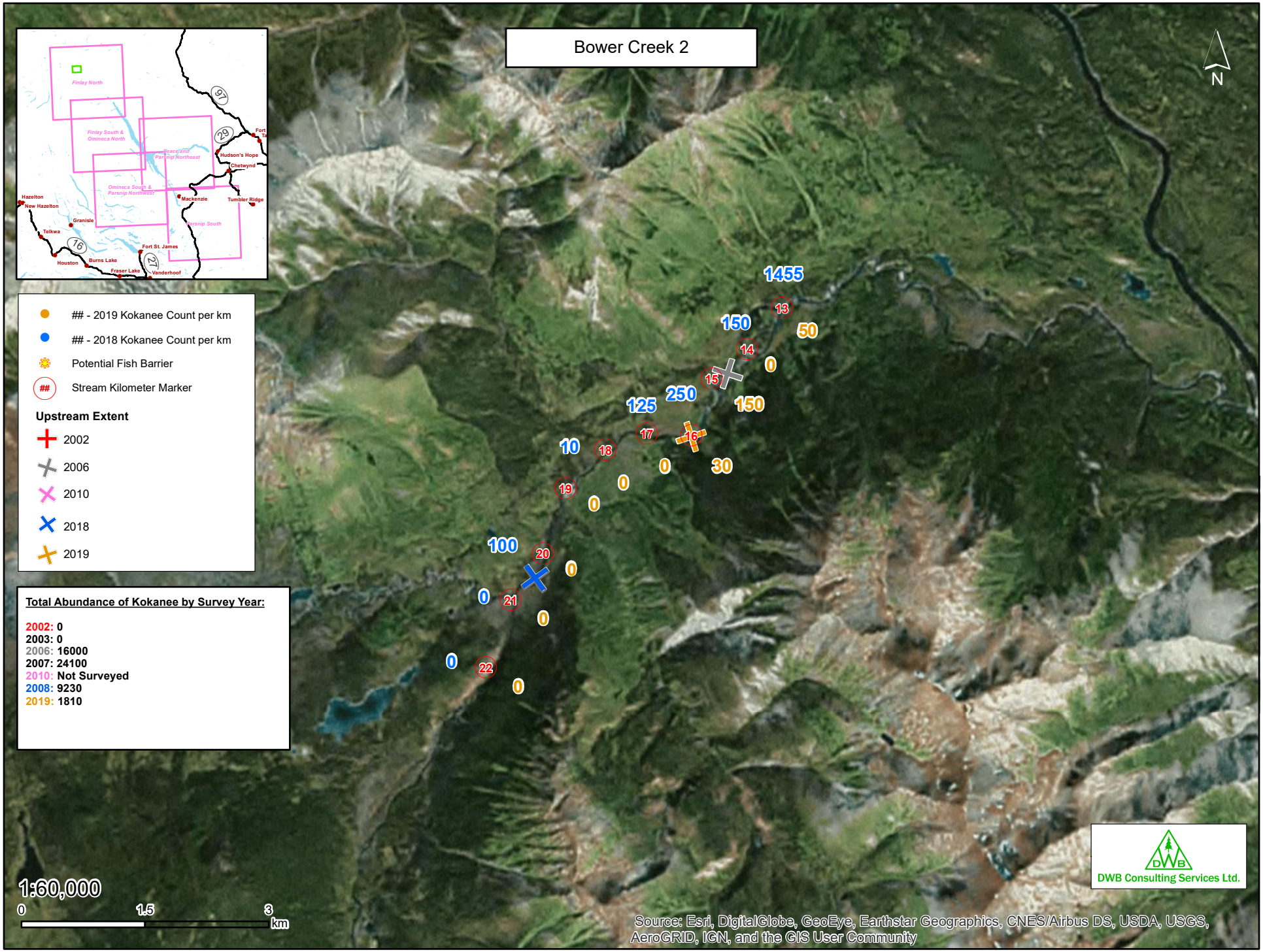


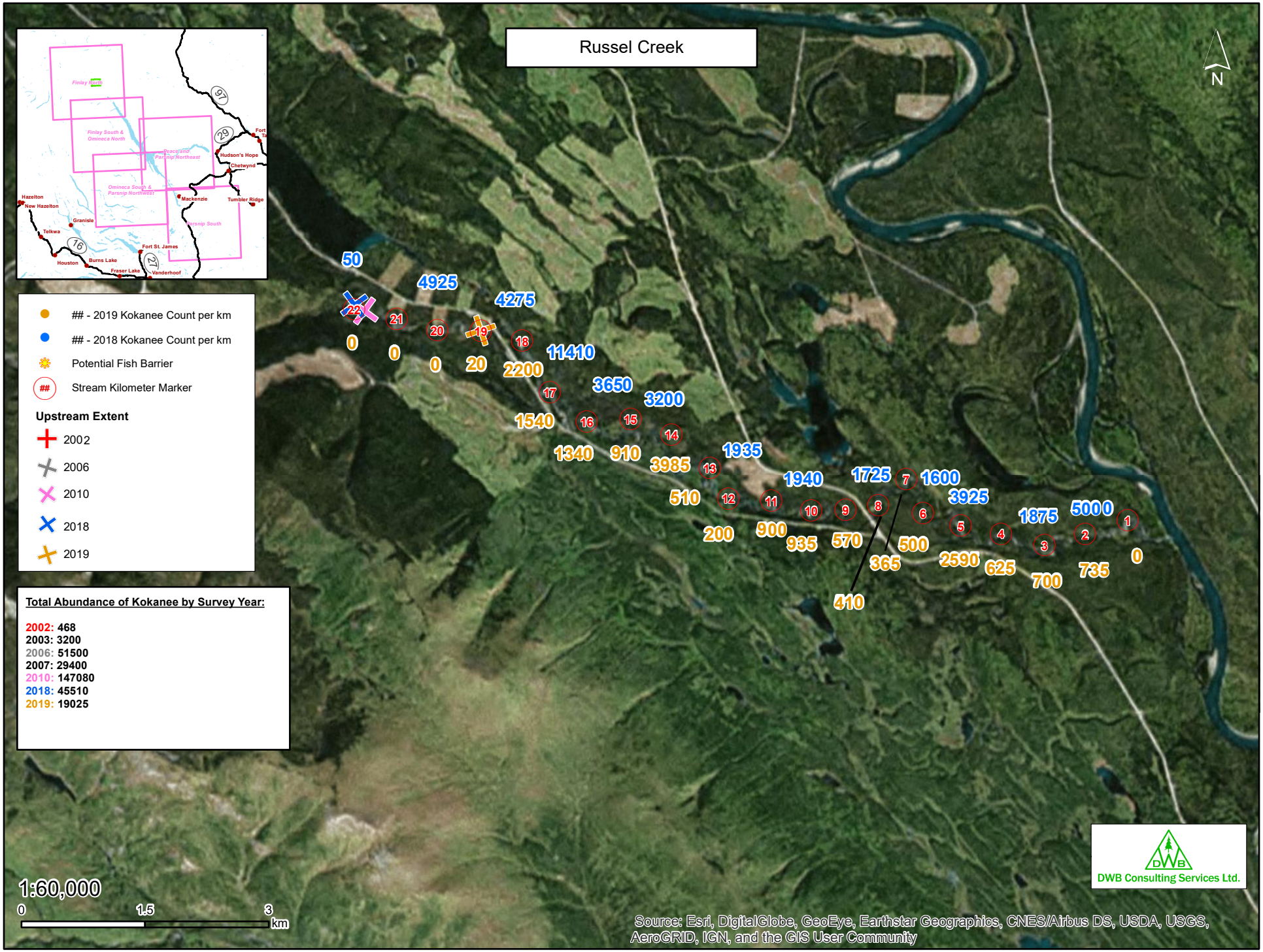
Overview Map 5
2019 Kokanee Spawner Surveys
Region: Parsnip South
Scale: 1:150,000
0 1.25 2.5 5 7.5 10 12.5 15
km
Date: December 03, 2019
Map Datum: NAD 1983 UTM Zone 10N
MFLNRORD_19380-334_KokaneeSurvey2019.mxd
DWB Consulting Services Ltd.
Start Survey
End Survey (2019)
Furthest Upstream Kokanee Observation
Fish Abundance Labels
2002: 157 KO
(Year: Abundance Value, Species)
Data labels show the survey year and the number of Kokanee counted. The point associated with the label represents the furthest upstream location that Kokanee were observed in that year.
2002: 157 KO
(Year: Abundance Value, Species (survey end location))
In years where the furthest upstream Kokanee observation was not known, the data label points to the furthest upstream extent of the survey. Data labels that point to survey end points rather than the furthest upstream Kokanee observation are clearly identified.
Potential Barriers
Chute/Cascade
Chute/Falls
Falls
Parsnip R
Misinchinka R
Reynolds C
Tacheeda C
Parsnip R 2
Arctic Lake Outlet
Arctic Lake Inlet
2006: 4,200 KO
2002: 1,500 KO (survey end location)
2010: 2,257 KO
2006: 300 KO
2002: 500 KO (survey end location)
2002: 50 KO (survey end location)
Mackenzie
Azu Ski Village
McLeod Lake
Anzac
Bear Lake
Williston Lake
McLeod Lake
Tudyah Lake
Carp Lake
Weedon Lake
Davie Lake
Parsnip R
Misinchinka R
Reynolds C
480000
500000
520000
540000
560000
580000
6120000
6100000
6080000
6060000
6040000

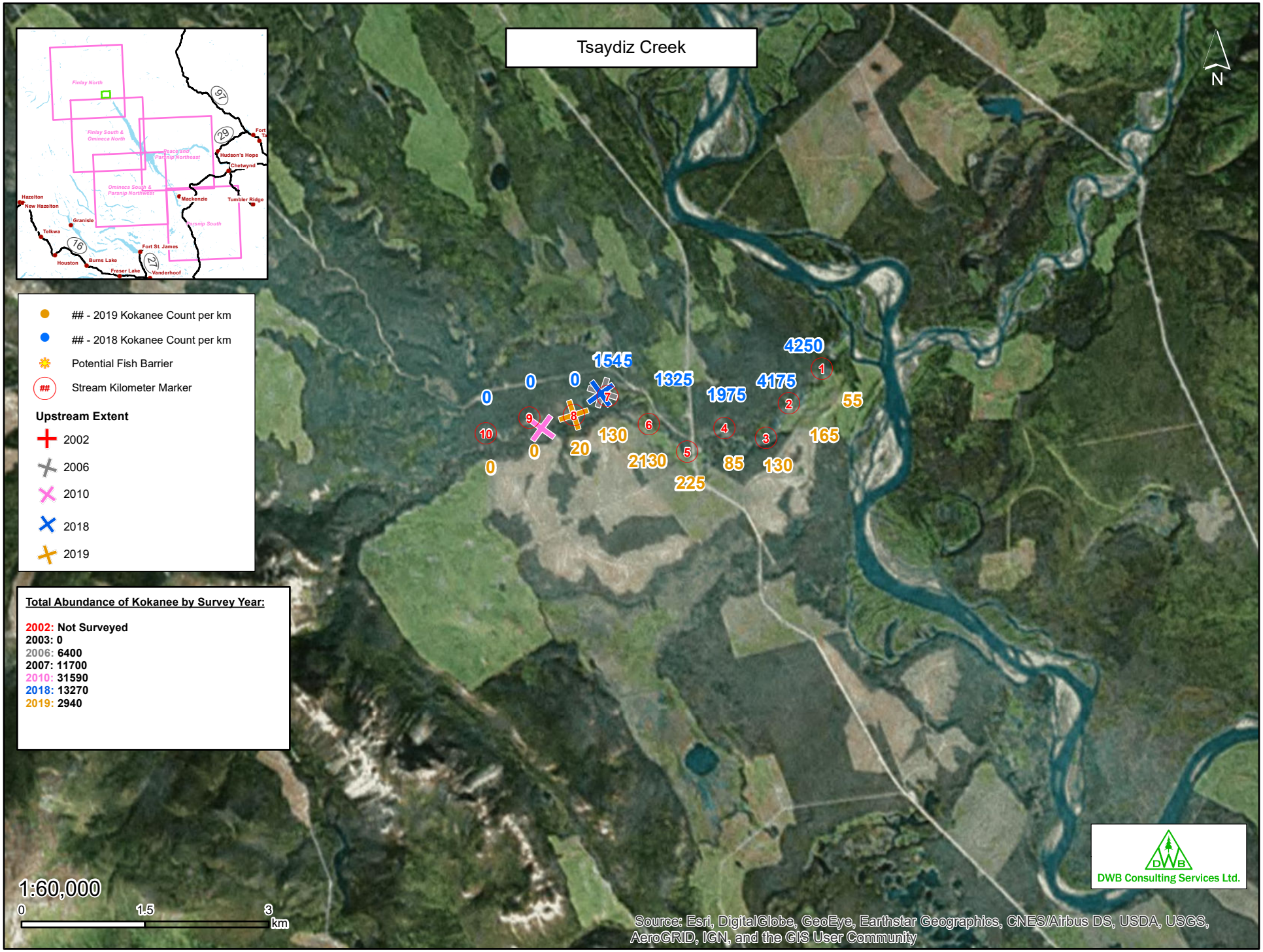

Finlay River
N
Finlay North
Finlay South & Omineca North
Peace/Liard Parsnip Northeast
Omineca South & Parsnip Northwest
Parsnip South
Hudson's Hope
Chetwynd
Mackenzie
Tumbler Ridge
Hazelton
New Hazelton
Granisle
Telkwa
Houston
Burns Lake
Fraser Lake
Fort St. James
Vanderhoof
97
29
16
27
- 2019 Kokanee Count per km
- 2018 Kokanee Count per km
Potential Fish Barrier
Stream Kilometer Marker
Upstream Extent
2002
2006
2010
2018
2019
Total Abundance of Kokanee by Survey Year:
2002: 0
2003: 20
2006: 33200 (Upstream extent located at 10V321430 6377044 - approx. 5 km south of CutoffCreek).
2007: Not Surveyed
2010: 268756
2018: 2250
2019: 0
NOTE: In 2018 and 2019, Finlay River only surveyed upstream of mouth of Cutoff Creek. Entire river length surveyed in previous years.
1:60,000
0
1.5
3
km
DWB Consulting Services Ltd.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

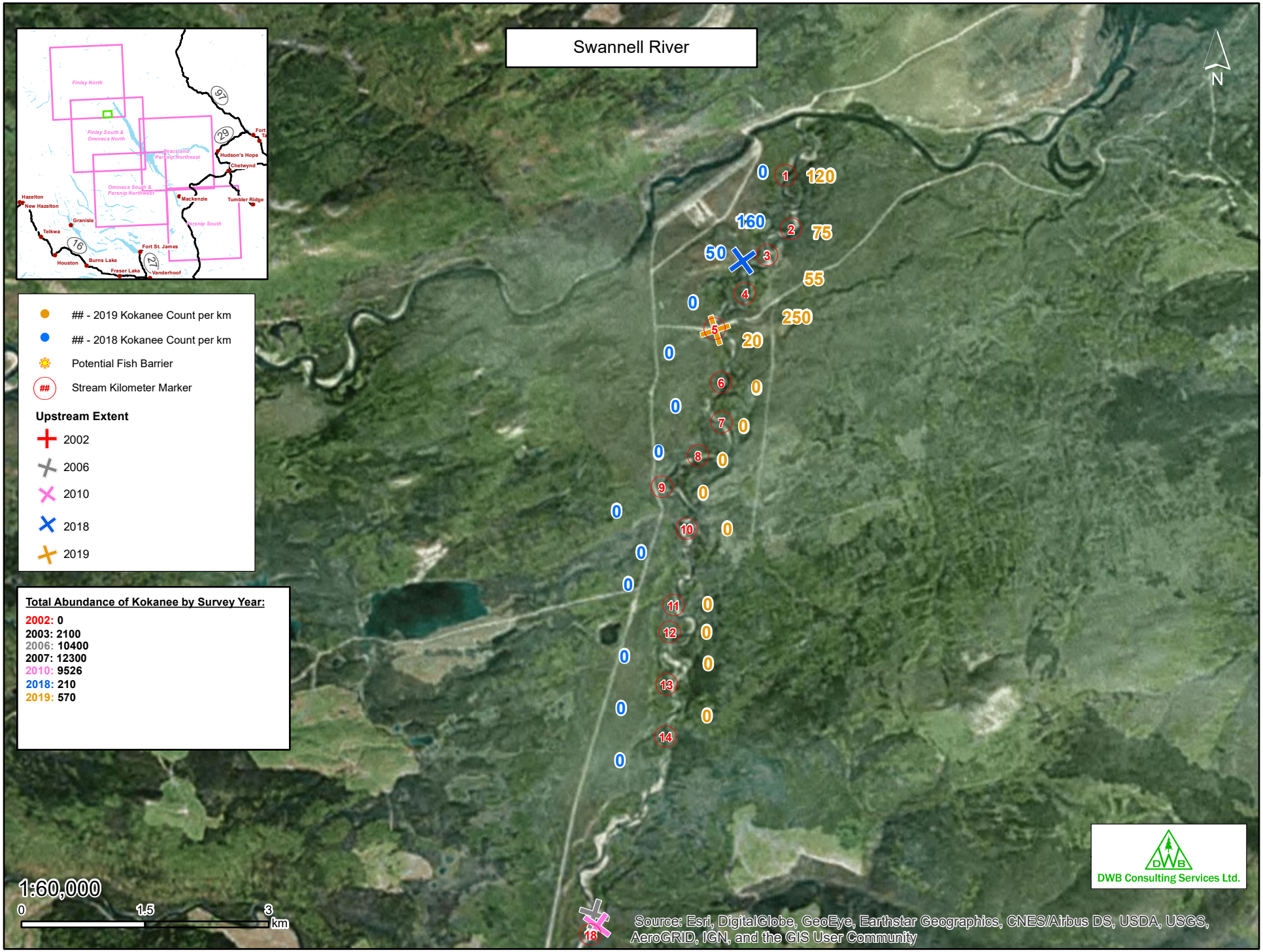

Cutoff Creek
N
Finlay North
Finlay South & Omineca North
Peace/Parsnip Northeast
Omineca South & Parsnip Northwest
Parsnip South
Hudson's Hope
Chetwynd
Mackenzie
Tumbler Ridge
Hazelton
New Hazelton
Granisle
Telkwa
Houston
Burns Lake
Fraser Lake
Fort St. James
Vanderhoof
97
29
16
27
- 2019 Kokanee Count per km
- 2018 Kokanee Count per km
Potential Fish Barrier
Stream Kilometer Marker
Upstream Extent
2002
2006
2010
2018
2019
Total Abundance of Kokanee by Survey Year:
2002: Not Surveyed
2003: 0
2006: 93
2007: Not Surveyed
2010: 41555
2018: 8090
2019: 4690
0
0
0
0
950
145
0
0
425
1125
3150
150
50
1830
160
475
50
180
450
2260
80
430
255
170
0
425
0
0
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
1:60,000
0
1.5
3
km
DWB Consulting Services Ltd.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

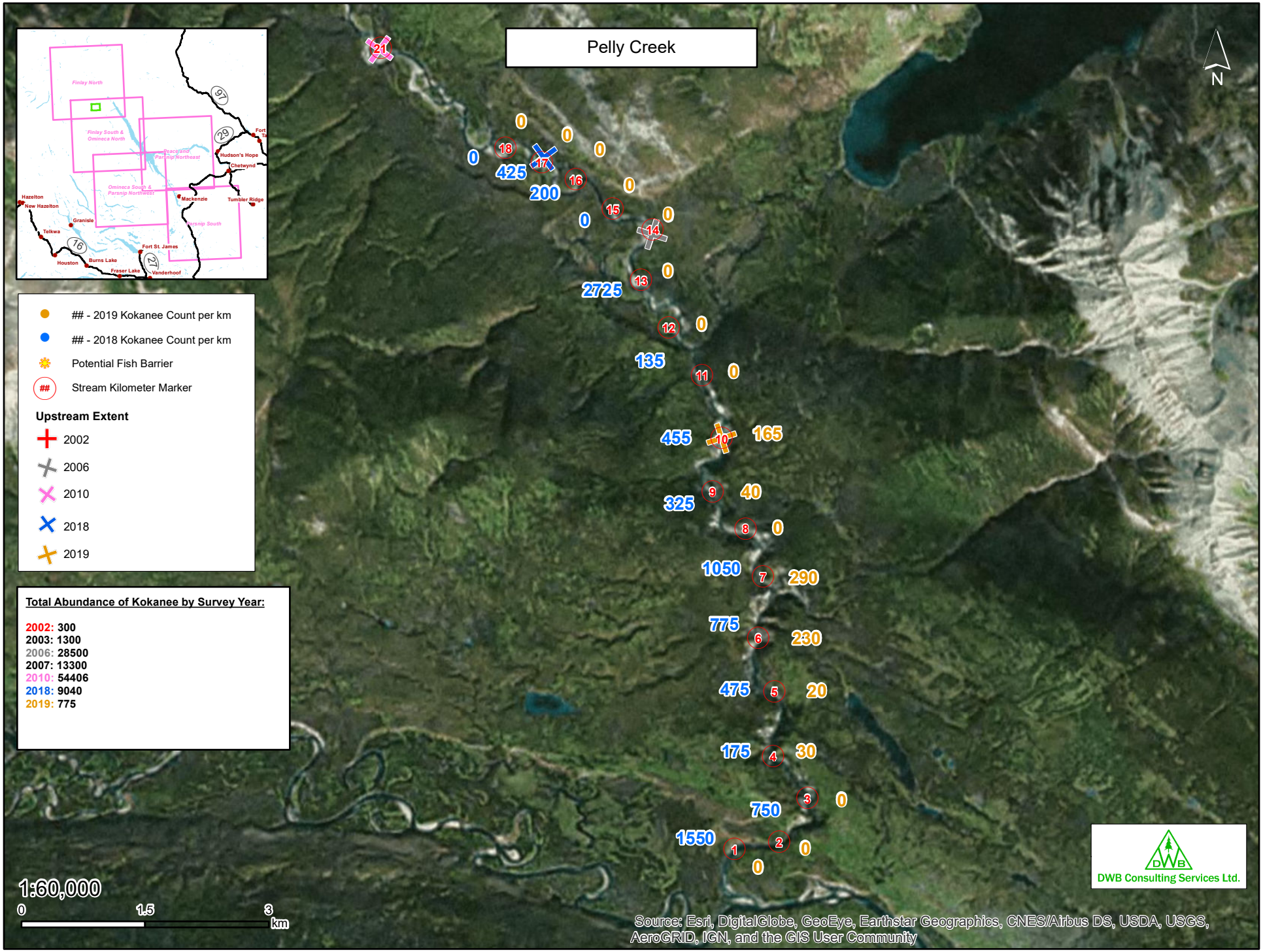

Bower Creek 1
N
Finlay North
Finlay South & Ominica North
Peace/Parsnip Northeast
Ominica South & Parsnip Northeast
Parsnip South
Hudson's Hope
Chetwynd
Mackenzie
Tumbler Ridge
Hazelton
New Hazelton
Granisle
Telkwa
Houston
Burns Lake
Fraser Lake
Fort St. James
Vanderhoof
97
29
16
27
- 2019 Kokanee Count per km
- 2018 Kokanee Count per km
Potential Fish Barrier
Stream Kilometer Marker
Upstream Extent
2002
2006
2010
2018
2019
335
575
1490
11
10
9
12
90
105
0
2575
5
4
490
405
115
8
7
6
30
10
1675
300
0
490
3
2
1
10
0
25
Total Abundance of Kokanee by Survey Year:
2002: 0
2003: 0
2006: 16000
2007: 24100
2010: Not Surveyed
2018: 9230
2019: 1810
1:60,000
0
1.5
3
km
DWB Consulting Services Ltd.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

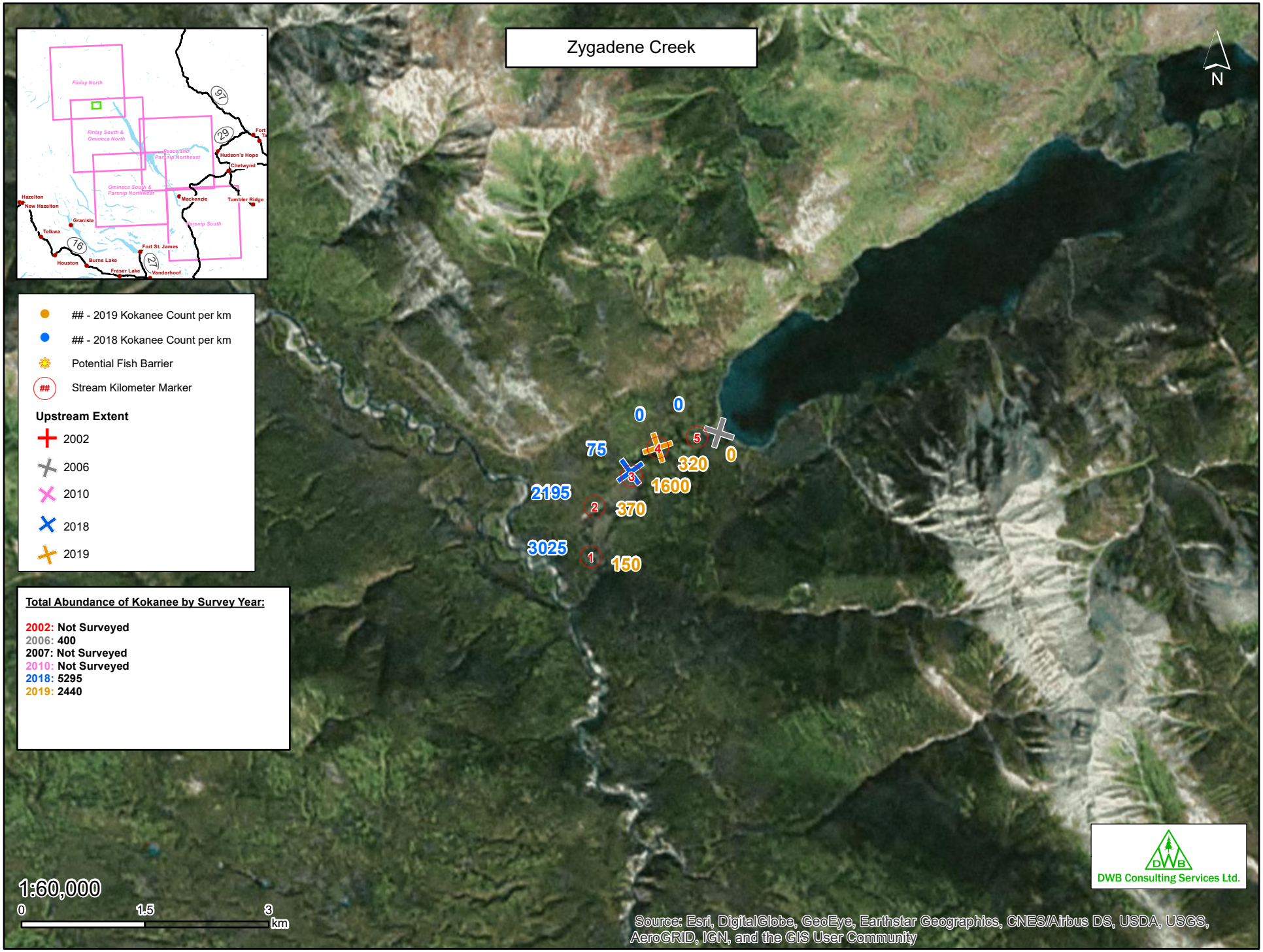

Bower Creek 2
N
Finlay North
Finlay South & Ominece North
Peace/Land Parsnip Northeast
Ominece South & Parsnip Northeast
Parsnip South
Hudson's Hope
Chetwynd
Mackenzie
Tumbler Ridge
Hazelton
New Hazelton
Granisle
Telkwa
Houston
Burns Lake
Fraser Lake
Fort St. James
Vanderhoof
97
29
16
27
- 2019 Kokanee Count per km
- 2018 Kokanee Count per km
Potential Fish Barrier
Stream Kilometer Marker
Upstream Extent
2002
2006
2010
2018
2019
Total Abundance of Kokanee by Survey Year:
2002: 0
2003: 0
2006: 16000
2007: 24100
2010: Not Surveyed
2008: 9230
2019: 1810
1455
13
150
50
14
0
15
250
125
150
17
16
10
18
0
30
0
19
0
100
20
0
0
21
0
0
22
0
1:60,000
0
1.5
3
km
DWB Consulting Services Ltd.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

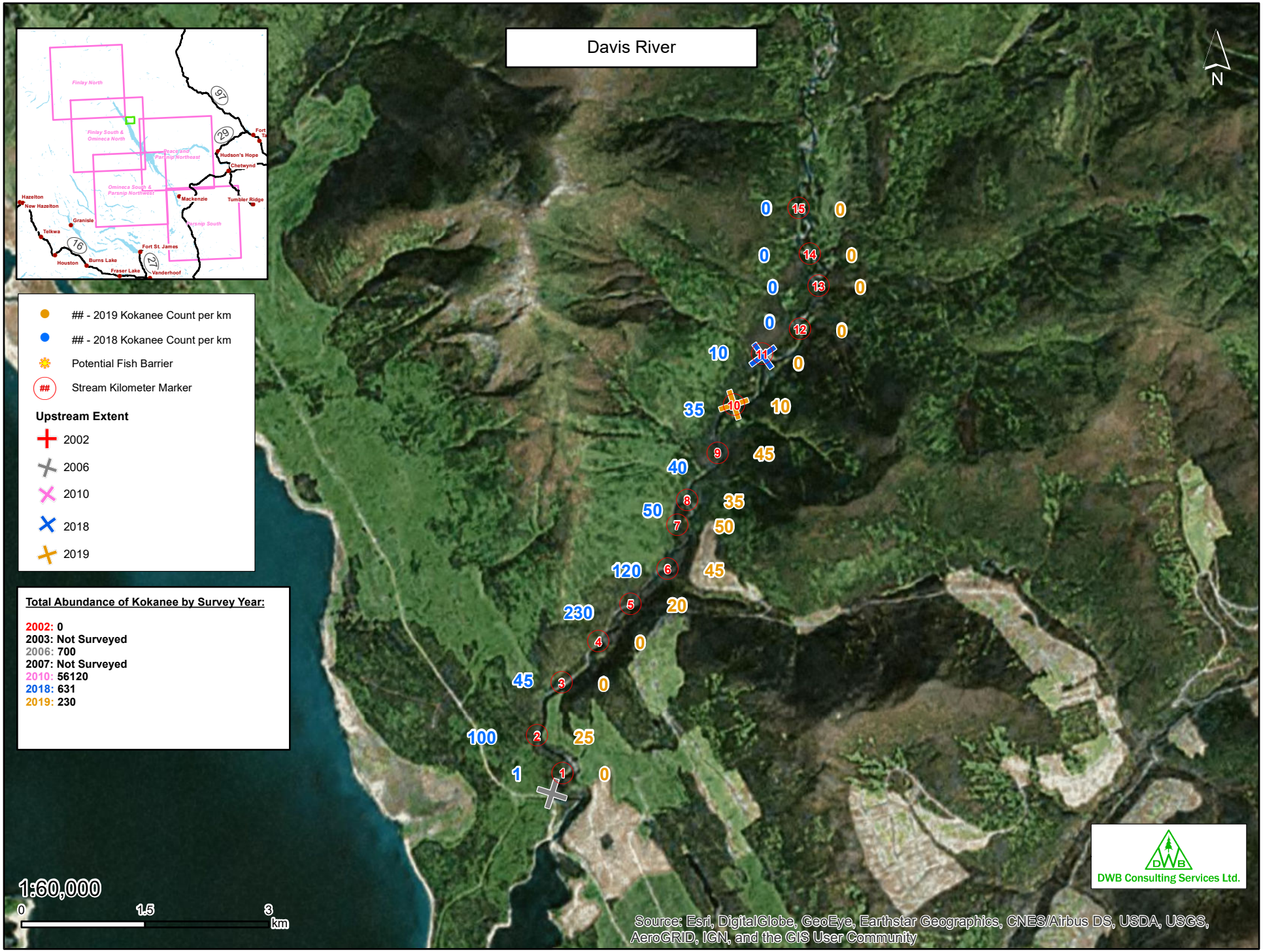

Russel Creek
N
Finlay South
Finlay South & Omineca North
Peace/Parsnip Northeast
Omineca South & Parsnip Northwest
Parsnip South
Hudson's Hope
Chetwynd
Mackenzie
Tumbler Ridge
Hazelton
New Hazelton
Granisle
Telkwa
Houston
Burns Lake
Fraser Lake
Fort St. James
Vanderhoof
97
29
16
27
- 2019 Kokanee Count per km
- 2018 Kokanee Count per km
Potential Fish Barrier
Stream Kilometer Marker
Upstream Extent
2002
2006
2010
2018
2019
Total Abundance of Kokanee by Survey Year:
2002: 468
2003: 3200
2006: 51500
2007: 29400
2010: 147080
2018: 45510
2019: 19025
50
4925
4275
11410
3650
3200
1935
1940
1725
1600
3925
5000
1875
0
0
0
20
2200
1540
1340
910
3985
510
200
900
935
570
500
365
410
2590
625
700
735
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
1:60,000
0
1.5
3
km
DWB Consulting Services Ltd.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

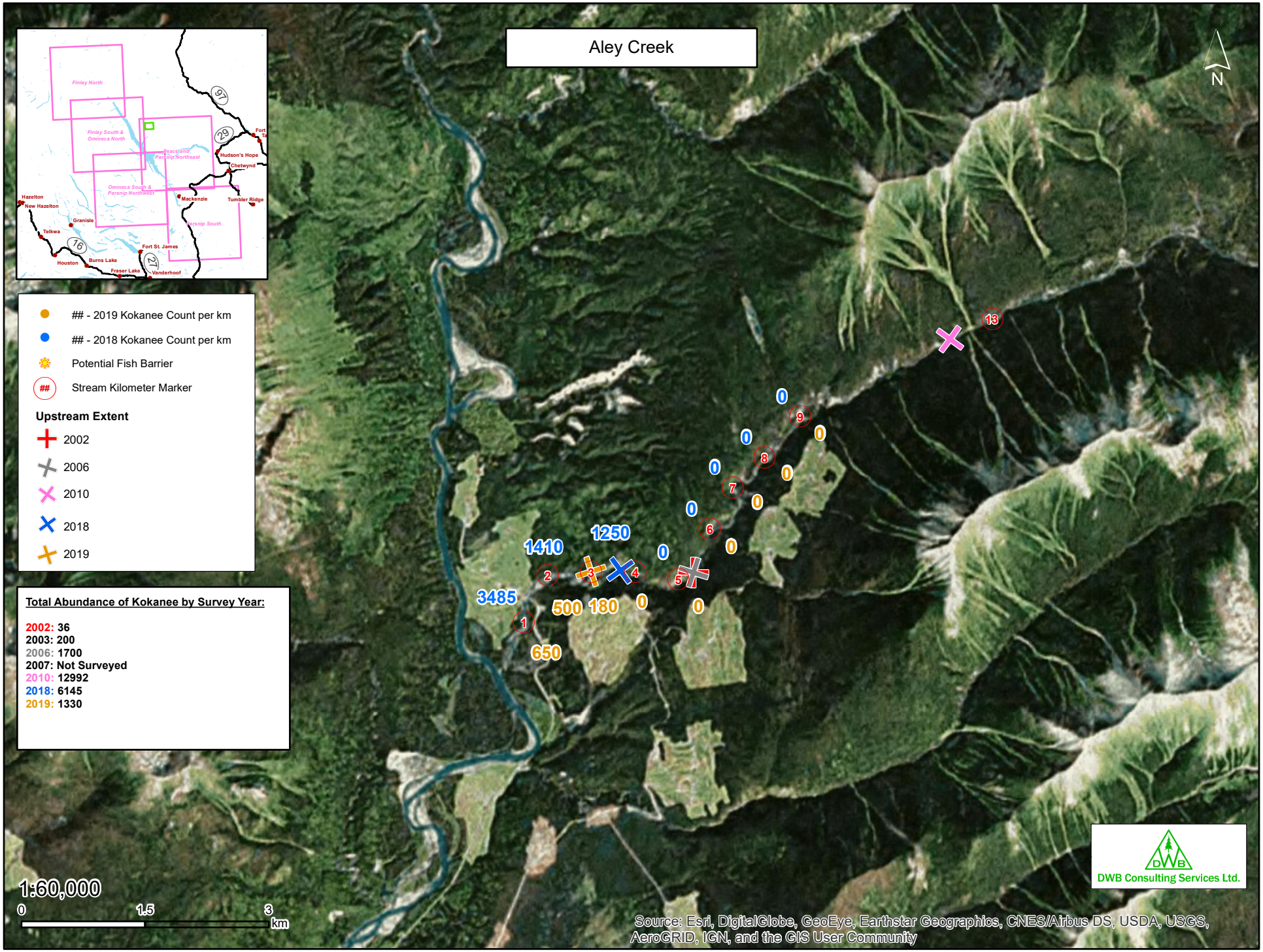

Tsaydiz Creek
N
Finlay North
Finlay South & Omineca North
Peace/Liard Parsnip Northeast
Omineca South & Parsnip Northeast
Parsnip South
Hazelton
New Hazelton
Granisle
Telkwa
Houston
Burns Lake
Fraser Lake
Fort St. James
Vanderhoof
Mackenzie
Hudson's Hope
Chetwynd
Tumbler Ridge
97
29
16
27
- 2019 Kokanee Count per km
- 2018 Kokanee Count per km
Potential Fish Barrier
Stream Kilometer Marker
Upstream Extent
2002
2006
2010
2018
2019
Total Abundance of Kokanee by Survey Year:
2002: Not Surveyed
2003: 0
2006: 6400
2007: 11700
2010: 31590
2018: 13270
2019: 2940
1545
0
0
0
0
0
20
130
2130
225
1325
1975
85
4250
4175
130
55
165
1
2
3
4
5
6
7
8
9
10
1:60,000
0
1.5
3
km
DWB Consulting Services Ltd.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

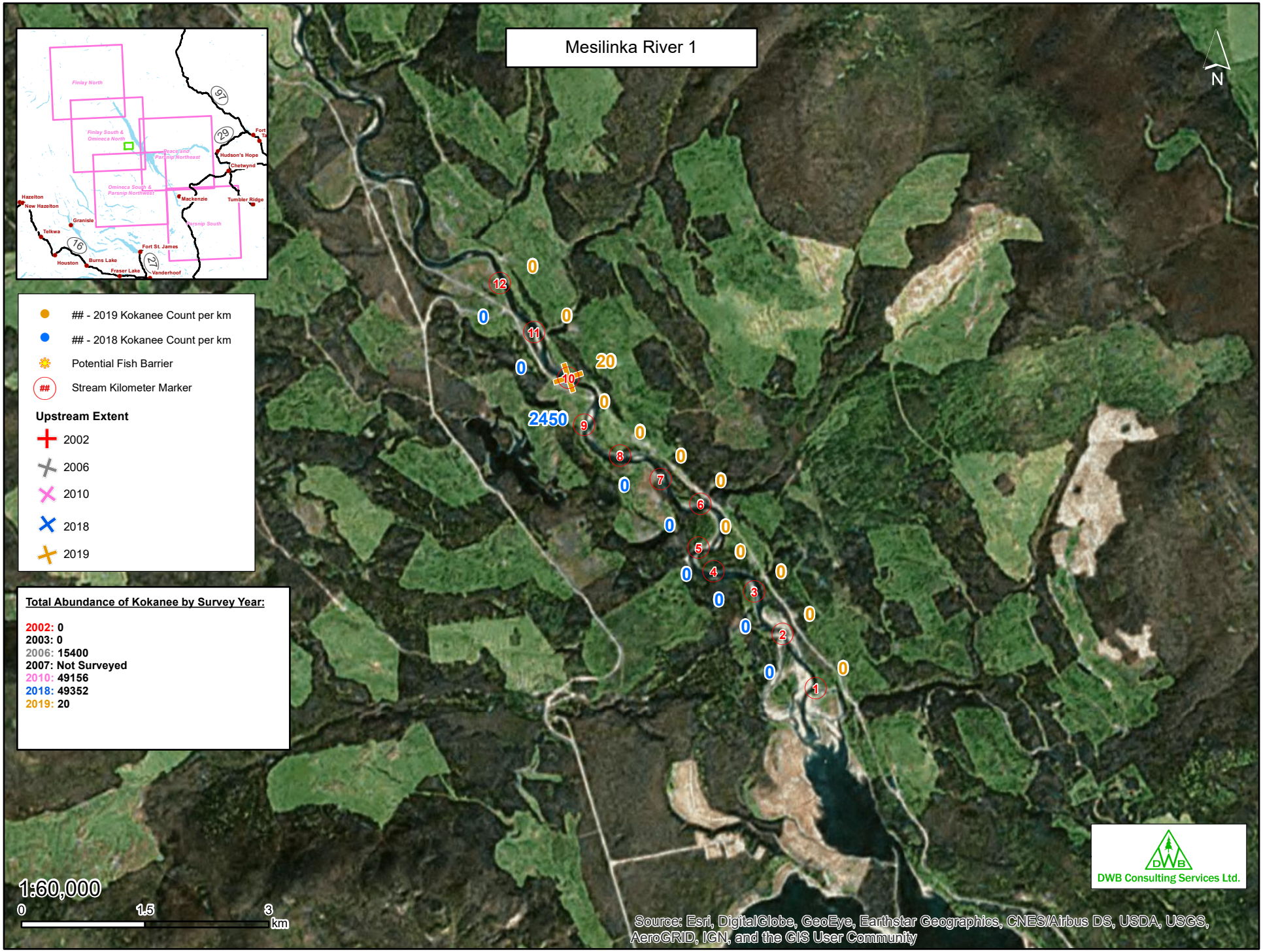

Swannell River
N
Finlay North
Finlay South & Ominece North
Peace/Land Parsnip Northeast
Ominece South & Parsnip Northeast
Parsnip South
Hazelton
New Hazelton
Granisle
Telkwa
Houston
Burns Lake
Fraser Lake
Fort St. James
Vanderhoof
Mackenzie
Tumbler Ridge
Chetwynd
Hudson's Hope
97
29
16
27
- 2019 Kokanee Count per km
- 2018 Kokanee Count per km
Potential Fish Barrier
Stream Kilometer Marker
Upstream Extent
2002
2006
2010
2018
2019
Total Abundance of Kokanee by Survey Year:
2002: 0
2003: 2100
2006: 10400
2007: 12300
2010: 9526
2018: 210
2019: 570
0 1 120
160 2 75
50 3
55
4 0
250
5
20
0
6 0
0
7 0
0
8 0
9 0
0
10 0
0
0
11 0
12 0
0
0
13
0
0
14
0
18
1:60,000
0 1.5 3 km
DWB Consulting Services Ltd.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

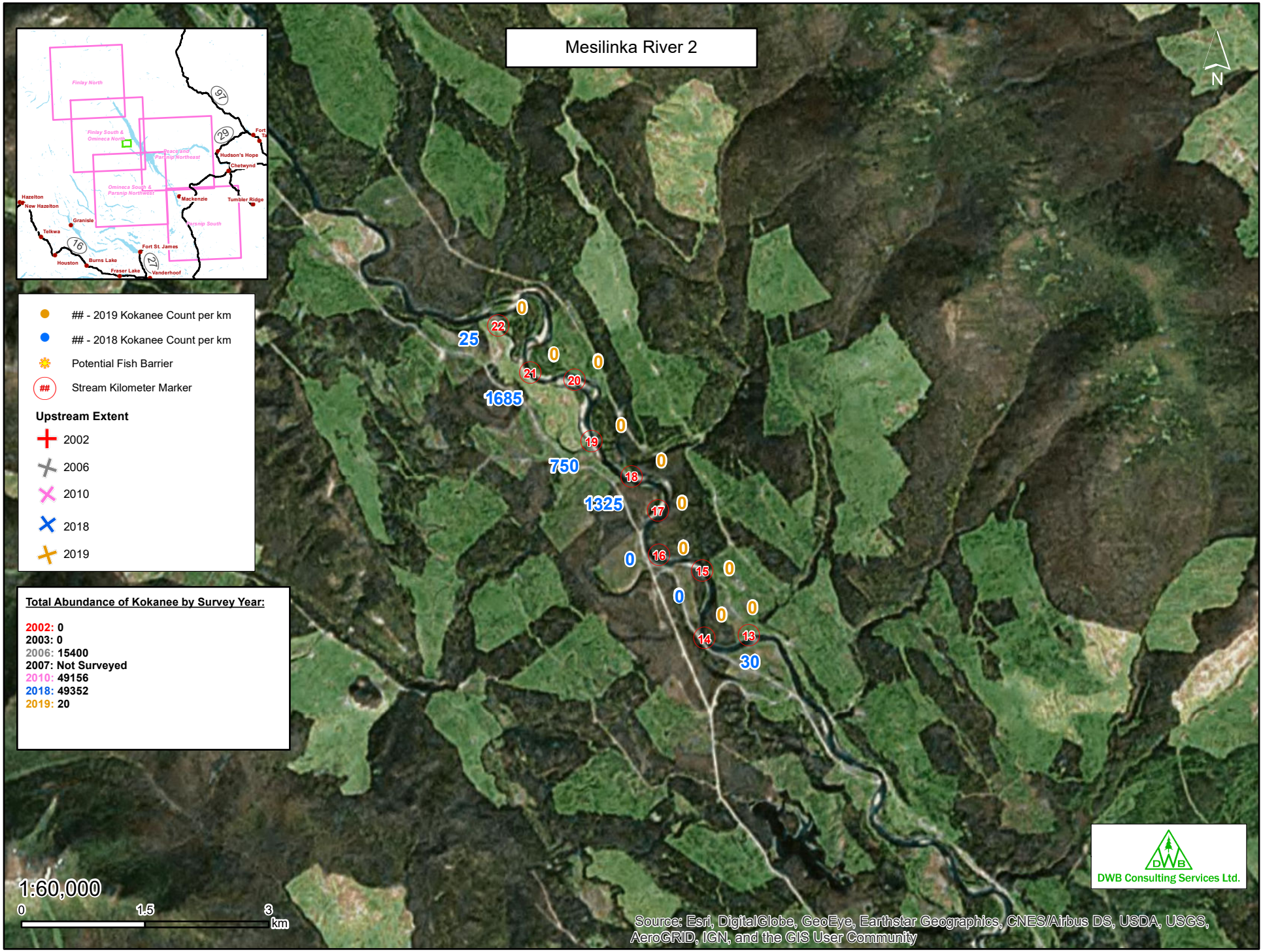

Pelly Creek
N
Finlay North
Finlay South & Omineca North
Peace/Parsnip Northeast
Omineca South & Parsnip Northwest
Parsnip South
Hudson's Hope
Chetwynd
Mackenzie
Tumbler Ridge
Hazelton
New Hazelton
Granisle
Telkwa
Houston
Burns Lake
Fraser Lake
Fort St. James
Vanderhoof
97
29
16
27
- 2019 Kokanee Count per km
- 2018 Kokanee Count per km
Potential Fish Barrier
Stream Kilometer Marker
Upstream Extent
2002
2006
2010
2018
2019
Total Abundance of Kokanee by Survey Year:
2002: 300
2003: 1300
2006: 28500
2007: 13300
2010: 54406
2018: 9040
2019: 775
0
425
200
2725
135
455
165
325
40
1050
290
775
230
475
20
175
30
750
1550
1:60,000
0
1.5
3
km
DWB Consulting Services Ltd.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

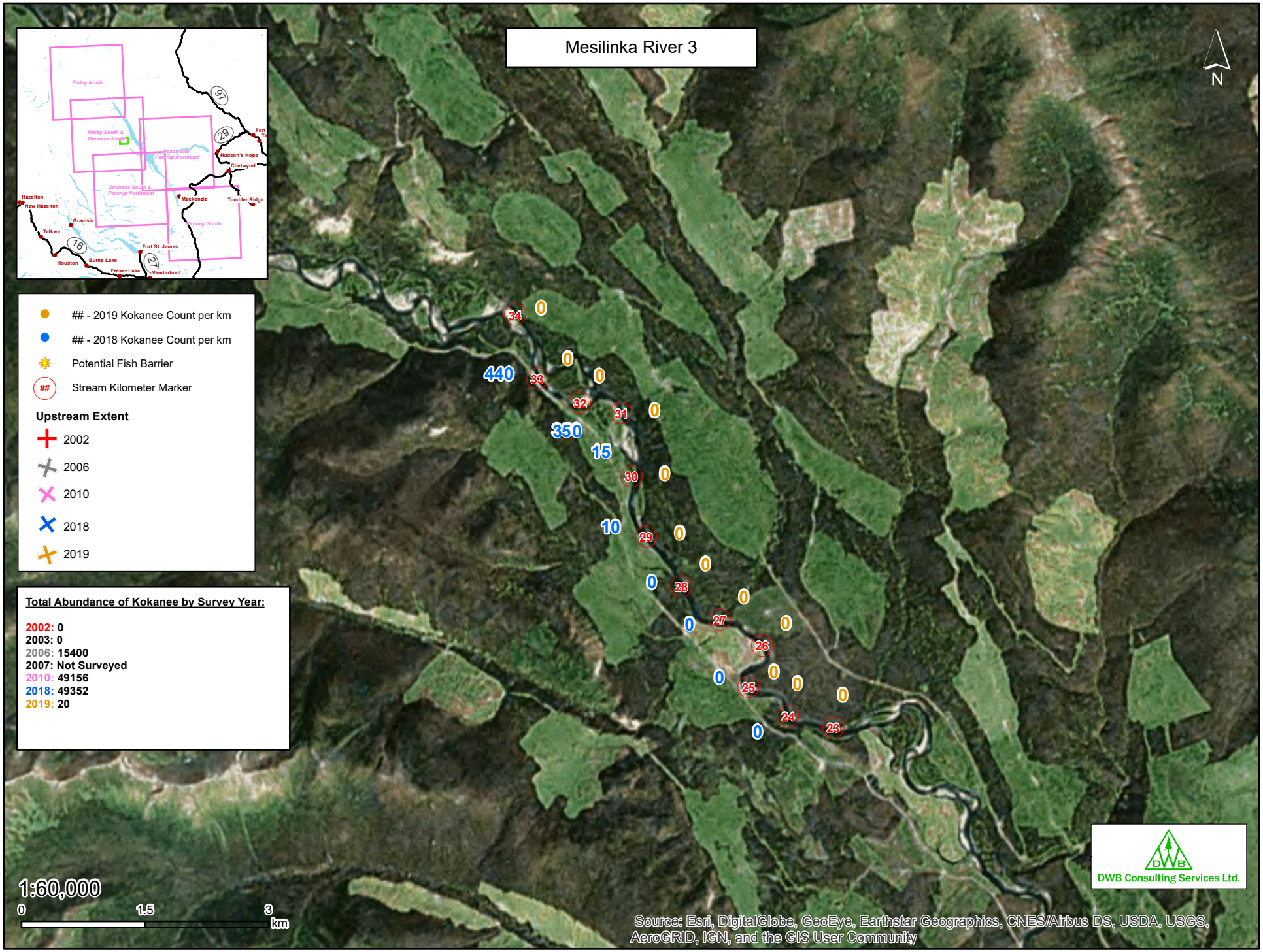

Zygadene Creek
N
Finlay North
Finlay South & Ominica North
Peace/Land Parsnip Northeast
Ominica South & Parsnip Northeast
Parsnip South
Hudson's Hope
Chetwynd
Mackenzie
Tumbler Ridge
Hazelton
New Hazelton
Granisle
Telkwa
Houston
Burns Lake
Fraser Lake
Fort St. James
Vanderhoof
97
29
16
27
- 2019 Kokanee Count per km
- 2018 Kokanee Count per km
Potential Fish Barrier
Stream Kilometer Marker
Upstream Extent
2002
2006
2010
2018
2019
0
0
0
75
320
1600
2195
370
3025
150
1
2
3
4
5
Total Abundance of Kokanee by Survey Year:
2002: Not Surveyed
2006: 400
2007: Not Surveyed
2010: Not Surveyed
2018: 5295
2019: 2440
1:60,000
0
1.5
3
km
DWB Consulting Services Ltd.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

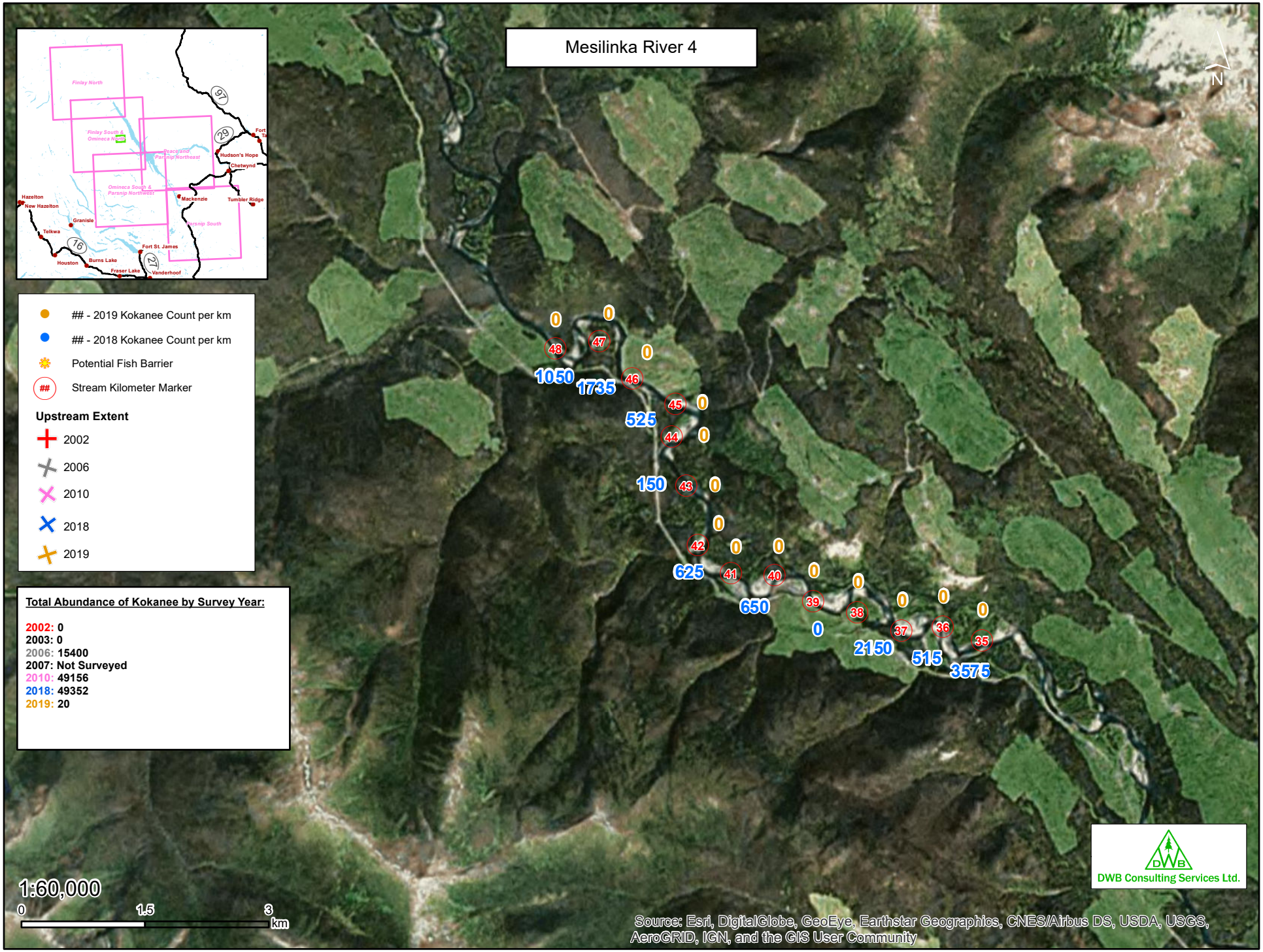

Davis River
N
Finlay North
Finlay South & Ominece North
Peace/Land Parsnip Northeast
Ominece South & Parsnip Northeast
Parsnip South
Hudson's Hope
Chetwynd
Mackenzie
Tumbler Ridge
Hazelton
New Hazelton
Granisle
Telkwa
Houston
Burns Lake
Fraser Lake
Fort St. James
Vanderhoof
97
29
16
27
- 2019 Kokanee Count per km
- 2018 Kokanee Count per km
Potential Fish Barrier
Stream Kilometer Marker
Upstream Extent
2002
2006
2010
2018
2019
Total Abundance of Kokanee by Survey Year:
2002: 0
2003: Not Surveyed
2006: 700
2007: Not Surveyed
2010: 56120
2018: 631
2019: 230
0 15 0
0 14 0
0 13 0
0 12 0
10 11 0
35 10 10
9 45
40
8 35
50 7 50
120 6 45
5 20
230
4 0
45 3 0
100 2 25
1 1 0
1:60,000
0 1.5 3 km
DWB Consulting Services Ltd.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

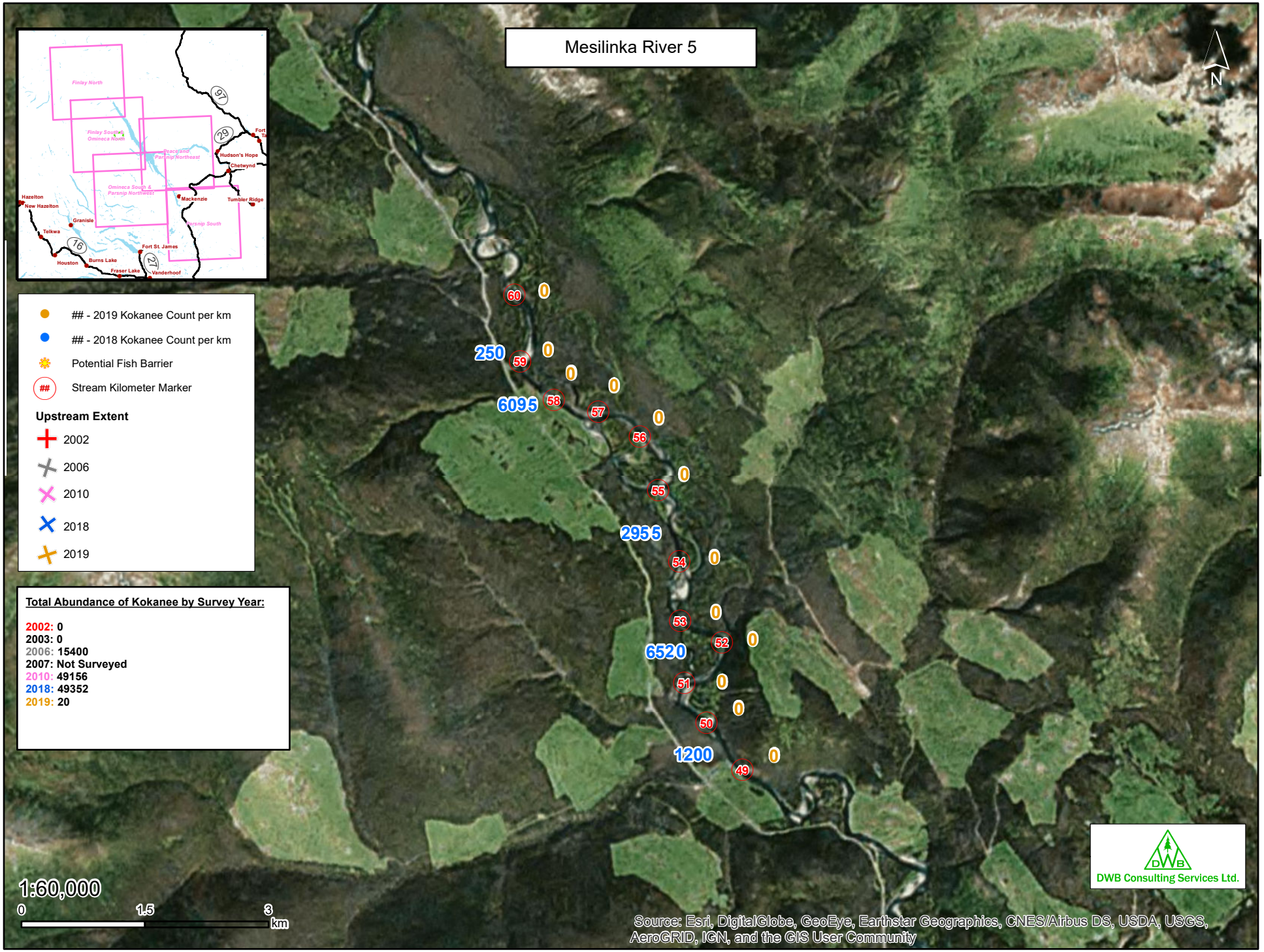

Aley Creek
N
Finlay North
Finlay South & Ominece North
Peace/Land Parsnip Northeast
Ominece South & Parsnip Northeast
Parsnip South
Hudson's Hope
Chetwynd
Mackenzie
Tumbler Ridge
Hazelton
New Hazelton
Granisle
Telkwa
Houston
Burns Lake
Fraser Lake
Fort St. James
Vanderhoof
97
29
16
27
- 2019 Kokanee Count per km
- 2018 Kokanee Count per km
Potential Fish Barrier
Stream Kilometer Marker
Upstream Extent
2002
2006
2010
2018
2019
Total Abundance of Kokanee by Survey Year:
2002: 36
2003: 200
2006: 1700
2007: Not Surveyed
2010: 12992
2018: 6145
2019: 1330
1:60,000
0
1.5
3
km
DWB Consulting Services Ltd.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

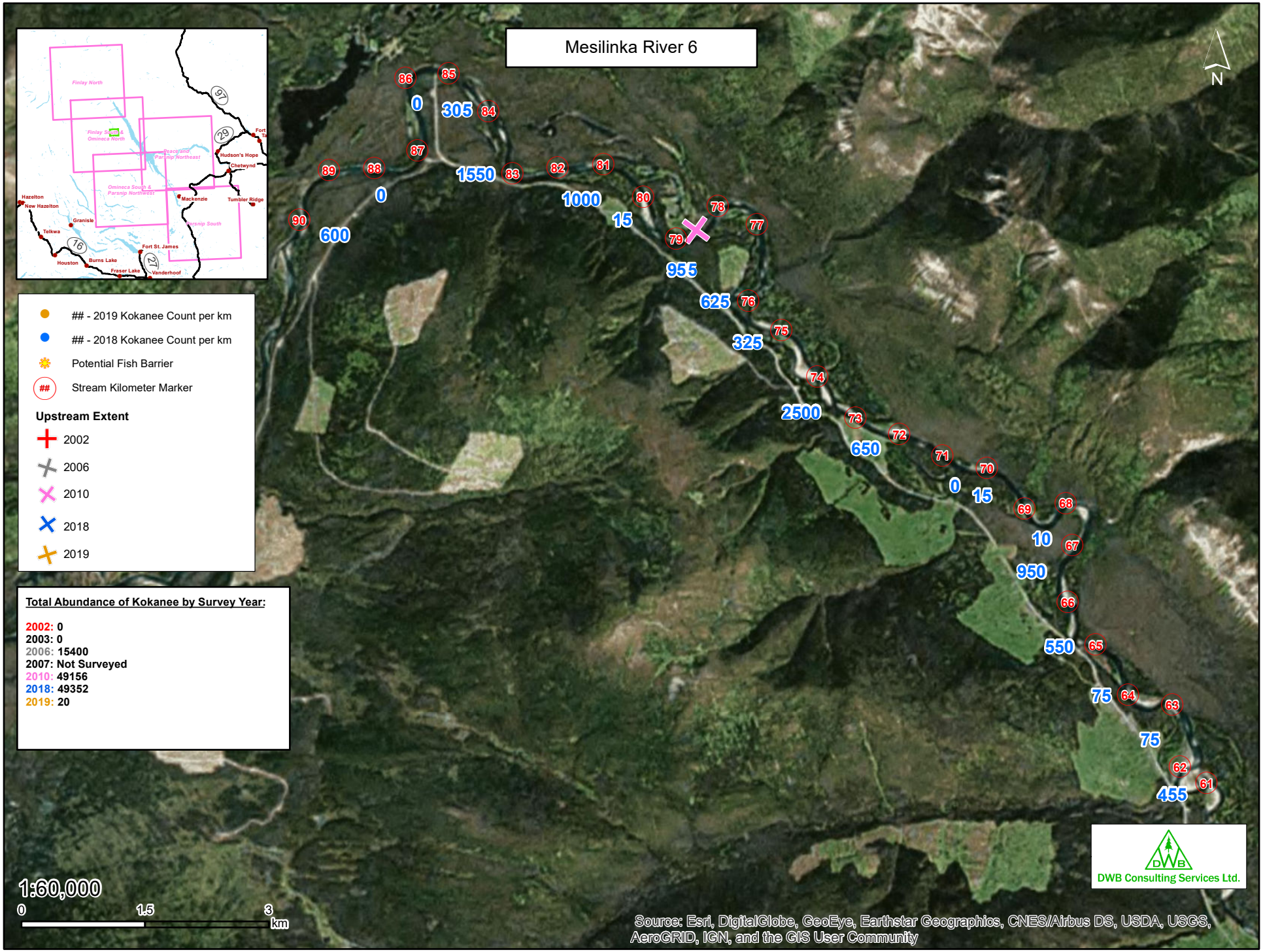

Mesilinka River 1
N
Finlay North
Finlay South & Ominica North
Peace/Liard Parsnip Northeast
Ominica South & Parsnip Northeast
Parsnip South
Fort St. John
Hudson's Hope
Chetwynd
Mackenzie
Tumbler Ridge
Hazelton
New Hazelton
Granisle
Telkwa
Houston
Burns Lake
Fraser Lake
Fort St. James
Vanderhoof
97
29
16
27
- 2019 Kokanee Count per km
- 2018 Kokanee Count per km
Potential Fish Barrier
Stream Kilometer Marker
Upstream Extent
2002
2006
2010
2018
2019
Total Abundance of Kokanee by Survey Year:
2002: 0
2003: 0
2006: 15400
2007: Not Surveyed
2010: 49156
2018: 49352
2019: 20
0
12
11
10
9
8
7
6
5
4
3
2
1
20
2450
1:60,000
0
1.5
3
km
DWB Consulting Services Ltd.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

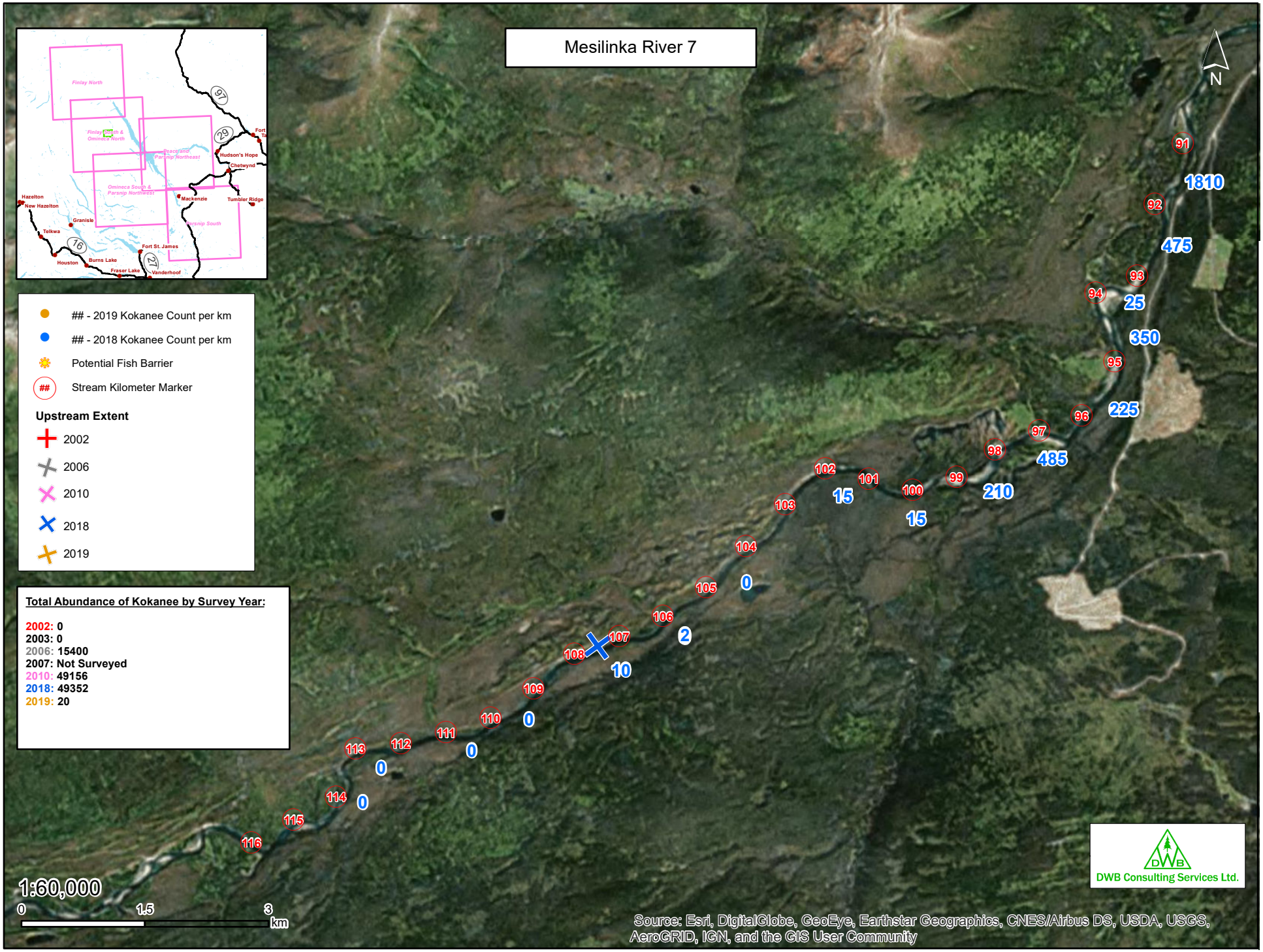

Mesilinka River 2
N
Finlay North
Finlay South & Omineca North
Peace/Parsnip Northeast
Omineca South & Parsnip Northwest
Parsnip South
Hudson's Hope
Chetwynd
Mackenzie
Tumbler Ridge
Hazelton
New Hazelton
Granisle
Telkwa
Houston
Burns Lake
Fraser Lake
Fort St. James
Vanderhoof
97
29
16
27
- 2019 Kokanee Count per km
- 2018 Kokanee Count per km
Potential Fish Barrier
Stream Kilometer Marker
Upstream Extent
2002
2006
2010
2018
2019
Total Abundance of Kokanee by Survey Year:
2002: 0
2003: 0
2006: 15400
2007: Not Surveyed
2010: 49156
2018: 49352
2019: 20
0
22
25
0
21
0
20
1685
19
0
750
18
0
1325
17
0
16
0
0
15
0
0
0
0
14
13
30
1:60,000
0
1.5
3
km
DWB Consulting Services Ltd.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

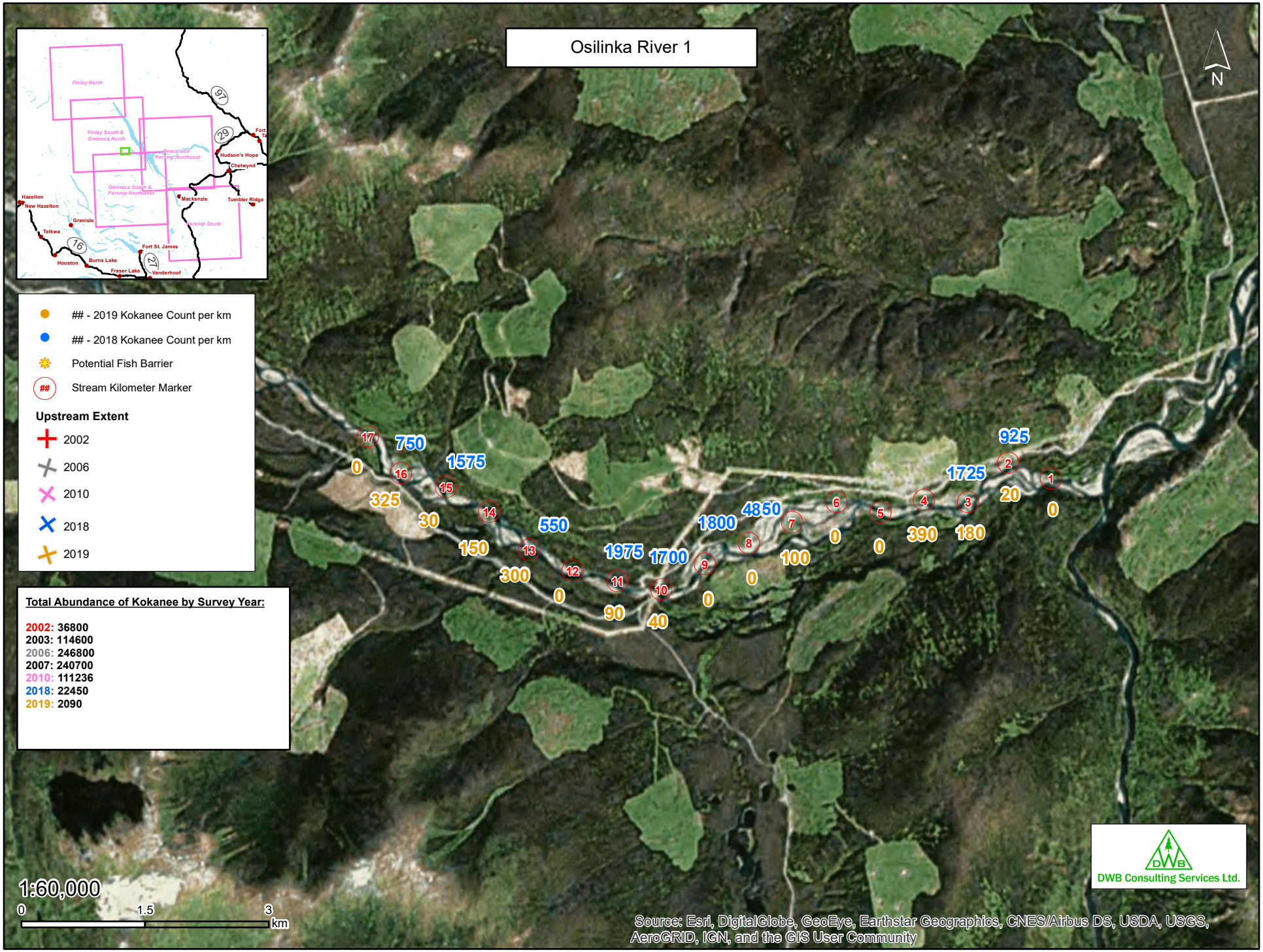

Mesilinka River 3
N
Finlay North
Finlay South & Omineca North
Peace/Land Parsnip Northeast
Omineca South & Parsnip Northwest
Parsnip South
Hudson's Hope
Chetwynd
Mackenzie
Tumbler Ridge
Hazelton
New Hazelton
Granisle
Telkwa
Houston
Burns Lake
Fraser Lake
Fort St. James
Vanderhoof
97
29
16
27
- 2019 Kokanee Count per km
- 2018 Kokanee Count per km
Potential Fish Barrier
Stream Kilometer Marker
Upstream Extent
2002
2006
2010
2018
2019
Total Abundance of Kokanee by Survey Year:
2002: 0
2003: 0
2006: 15400
2007: Not Surveyed
2010: 49156
2018: 49352
2019: 20
0
34
0
440
33
0
32
31
0
350
15
30
0
10
29
0
0
28
0
0
27
0
26
0
0
25
0
0
24
0
23
1:60,000
0
1.5
3
km
DWB Consulting Services Ltd.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

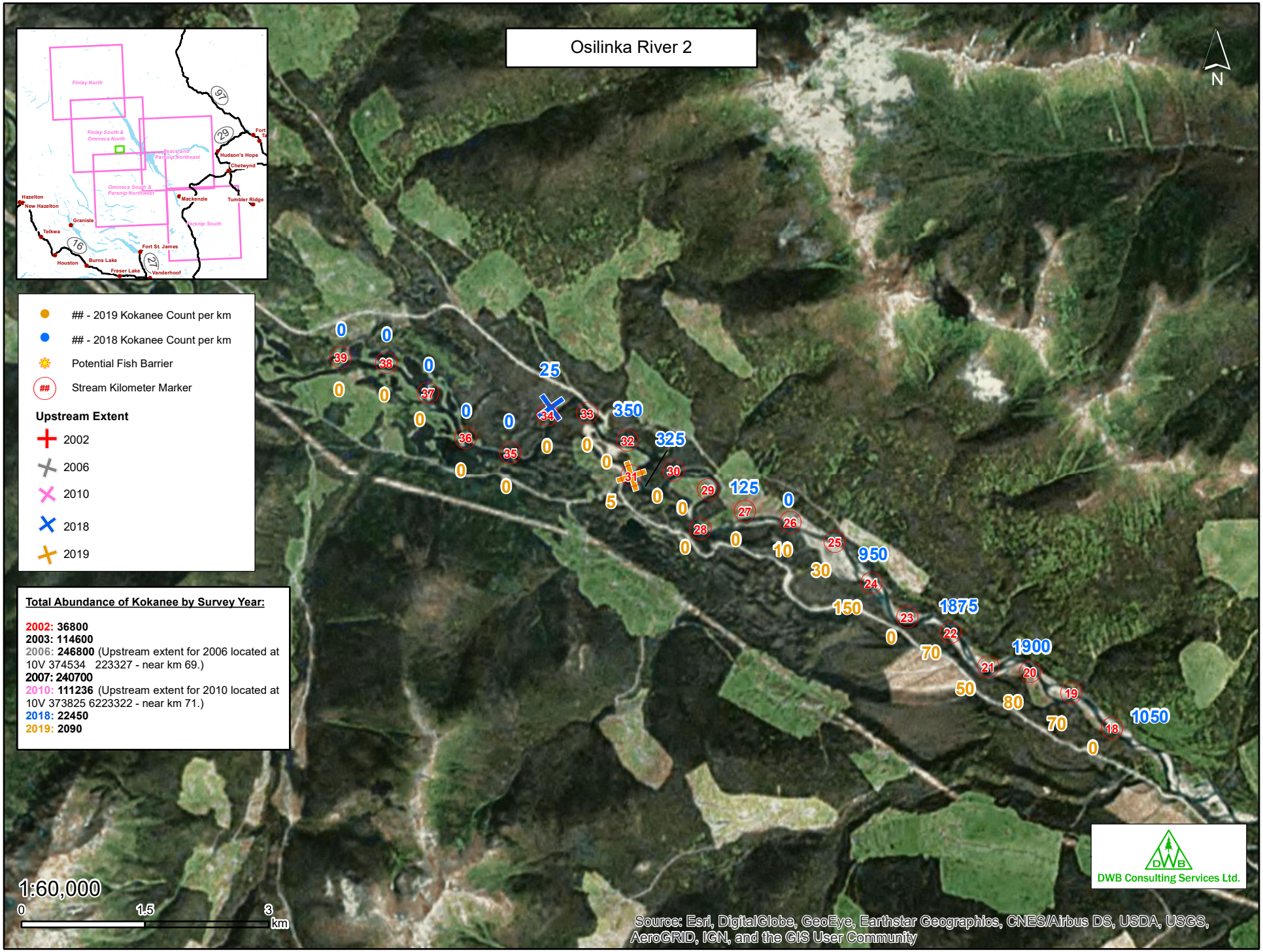

Mesilinka River 4
N
Finlay North
Finlay South & Omineca North
Peace/Liard Parsnip Northeast
Omineca South & Parsnip Northwest
Parsnip South
Fort St. John
Hudson's Hope
Chetwynd
Mackenzie
Tumbler Ridge
Hazelton
New Hazelton
Granisle
Telkwa
Houston
Burns Lake
Fraser Lake
Fort St. James
Vanderhoof
97
29
16
27
- 2019 Kokanee Count per km
- 2018 Kokanee Count per km
Potential Fish Barrier
Stream Kilometer Marker
Upstream Extent
2002
2006
2010
2018
2019
Total Abundance of Kokanee by Survey Year:
2002: 0
2003: 0
2006: 15400
2007: Not Surveyed
2010: 49156
2018: 49352
2019: 20
0
0
48
47
0
1050
1735
46
45
0
525
44
0
150
43
0
0
42
0
0
625
41
40
0
0
650
39
38
0
0
0
0
2150
37
36
35
515
3575
DWB Consulting Services Ltd.
1:60,000
0
1.5
3
km
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

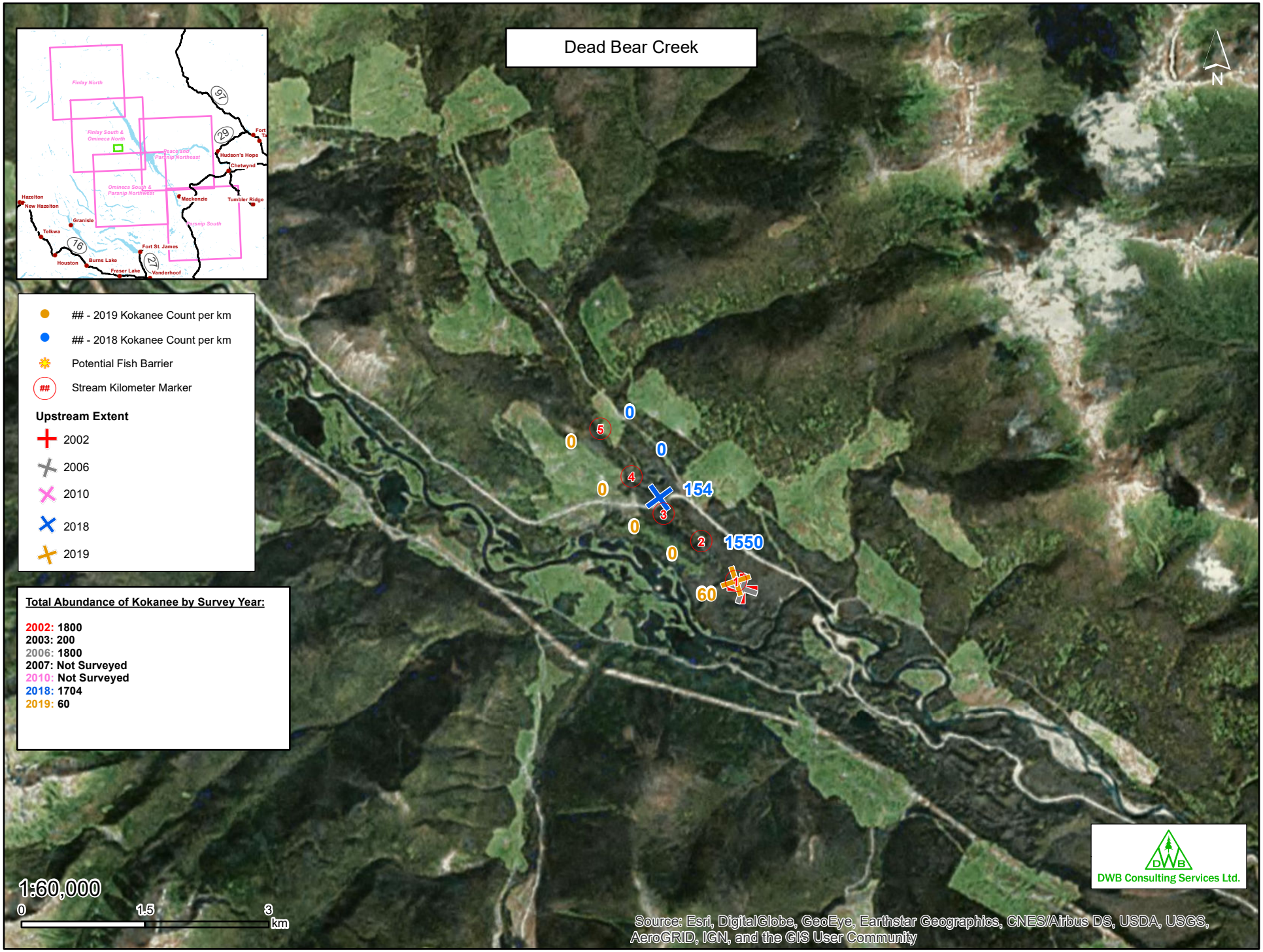

Mesilinka River 5
N
Finlay North
Finlay South &
Omineca North
Peace and
Parsnip Northeast
Omineca South &
Parsnip Northwest
Parsnip South
Fort
Hudson's Hope
Chetwynd
Mackenzie
Tumbler Ridge
Hazelton
New Hazelton
Granisle
Telkwa
Houston
Burns Lake
Fraser Lake
Fort St. James
Vanderhoof
97
29
16
27
- 2019 Kokanee Count per km
- 2018 Kokanee Count per km
Potential Fish Barrier
Stream Kilometer Marker
Upstream Extent
2002
2006
2010
2018
2019
Total Abundance of Kokanee by Survey Year:
2002: 0
2003: 0
2006: 15400
2007: Not Surveyed
2010: 49156
2018: 49352
2019: 20
60
0
250
59
0
0
6095
58
57
0
56
0
55
2955
54
0
0
53
52
0
6520
51
0
0
50
1200
0
49
DWB Consulting Services Ltd.
1:60,000
0
1.5
3
km
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

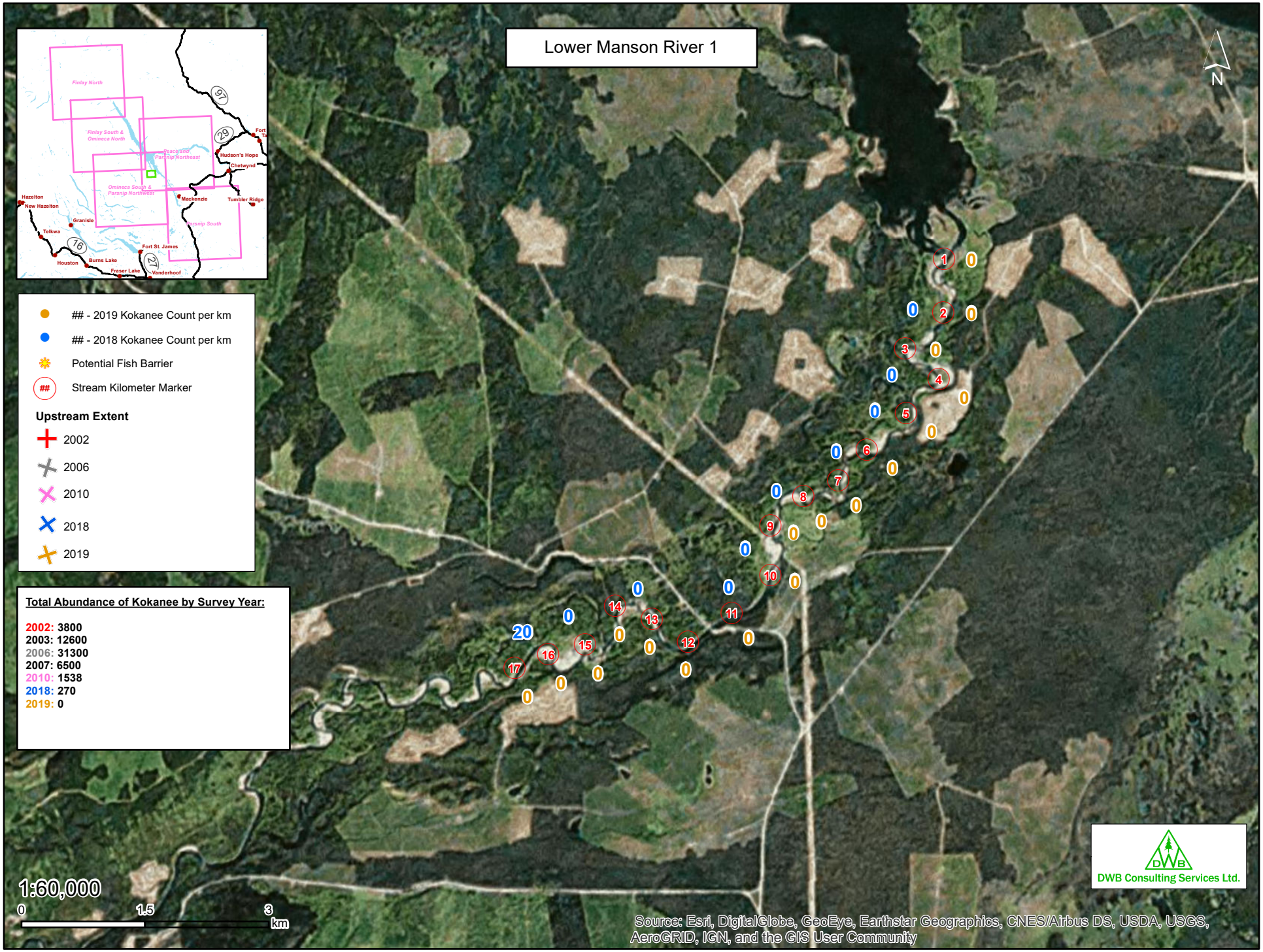

Mesilinka River 6
N
Finlay North
Finlay South & Omineca North
Peace/Parsnip Northeast
Omineca South & Parsnip Northwest
Parsnip South
Hudson's Hope
Chetwynd
Mackenzie
Tumbler Ridge
Hazelton
New Hazelton
Granisle
Telkwa
Houston
Burns Lake
Fraser Lake
Fort St. James
Vanderhoof
97
29
16
27
- 2019 Kokanee Count per km
- 2018 Kokanee Count per km
Potential Fish Barrier
Stream Kilometer Marker
Upstream Extent
2002
2006
2010
2018
2019
Total Abundance of Kokanee by Survey Year:
2002: 0
2003: 0
2006: 15400
2007: Not Surveyed
2010: 49156
2018: 49352
2019: 20
86 85 0 305 84 87 1550 83 82 81 89 88 0 1000 80 78 90 600 15 77 79 955 625 76 75 325 74 2500 73 72 650 71 70 0 15 69 68 10 67 950 66 550 65 75 64 63 75 62 61 455
1:60,000
0 1.5 3 km
DWB Consulting Services Ltd.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

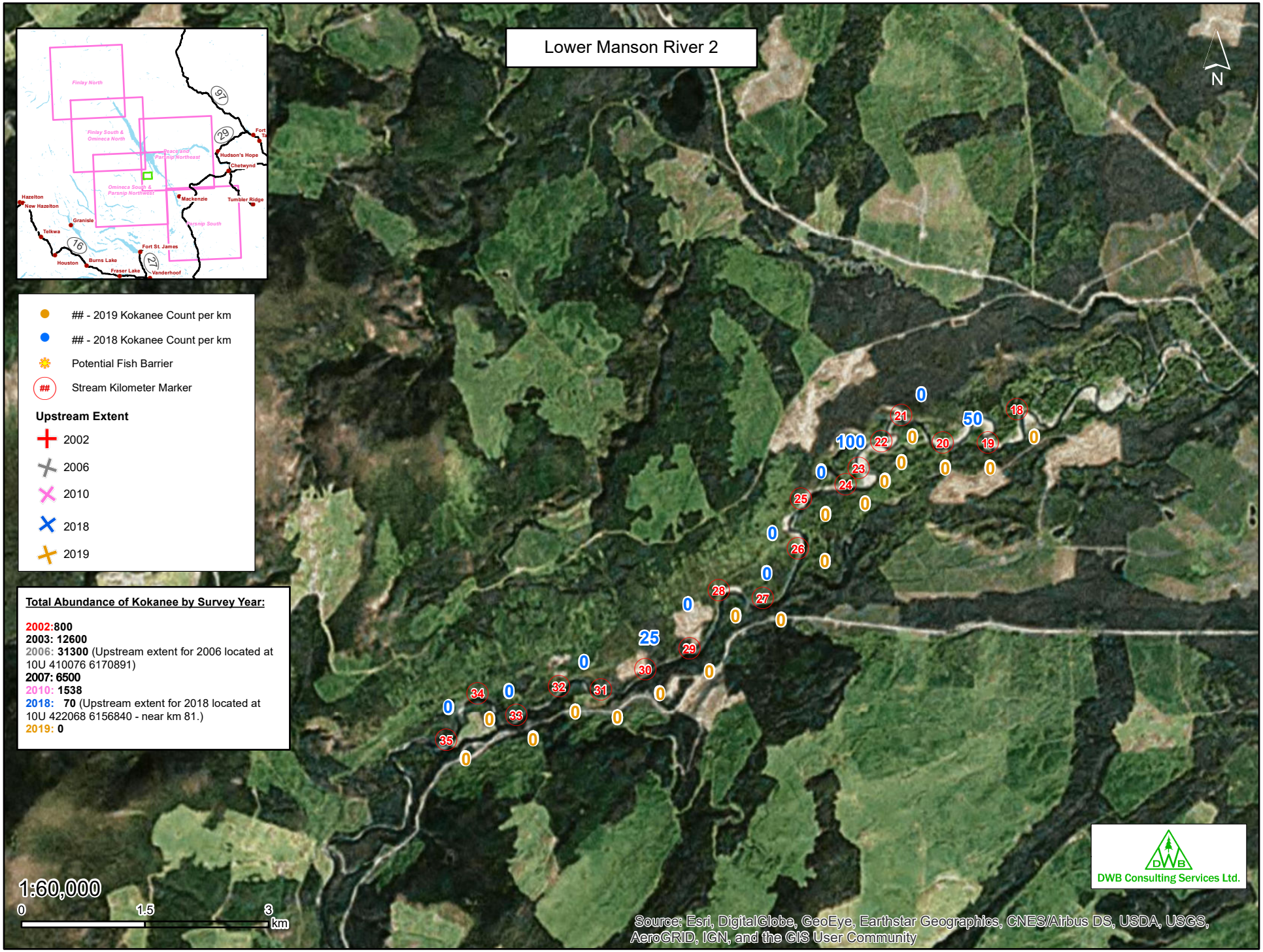

Mesilinka River 7
N
Finlay North
Finlay South & Omineca North
Peace/Land Parsnip Northeast
Omineca South & Parsnip Northwest
Parsnip South
Hudson's Hope
Chetwynd
Mackenzie
Tumbler Ridge
Hazelton
New Hazelton
Granisle
Telkwa
Houston
Burns Lake
Fraser Lake
Fort St. James
Vanderhoof
97
29
16
27
- 2019 Kokanee Count per km
- 2018 Kokanee Count per km
Potential Fish Barrier
Stream Kilometer Marker
Upstream Extent
2002
2006
2010
2018
2019
Total Abundance of Kokanee by Survey Year:
2002: 0
2003: 0
2006: 15400
2007: Not Surveyed
2010: 49156
2018: 49352
2019: 20
91
1810
92
475
93
94
25
350
95
225
96
97
98
485
102
101
100
99
210
103
15
15
104
105
0
106
2
107
108
10
109
110
0
111
0
112
113
0
114
0
115
116
1:60,000
0
1.5
3
km
DWB Consulting Services Ltd.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

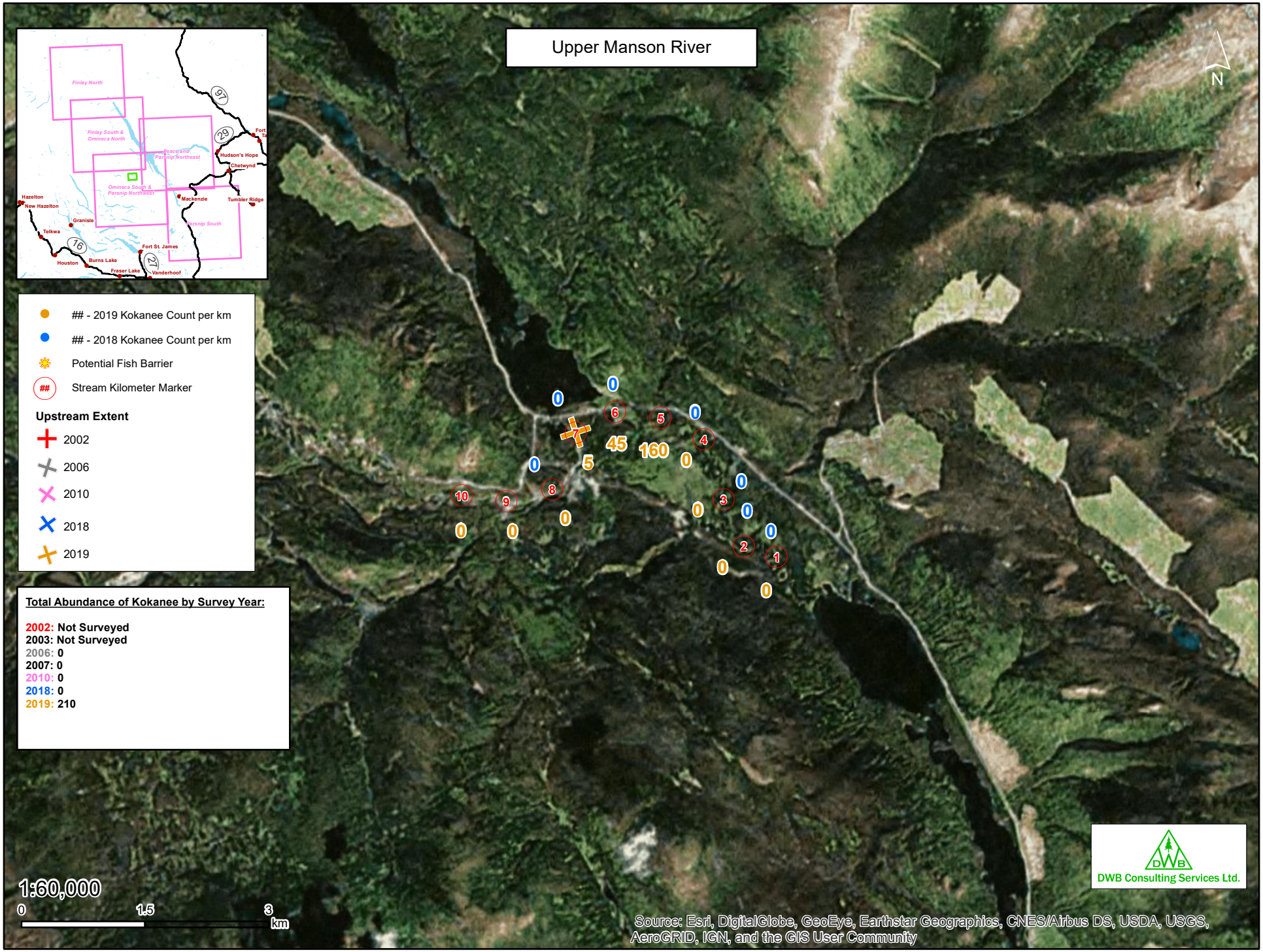

Osilinka River 1
N
Finlay North
Finlay South & Ominica North
Peace/Land Parsnip Northeast
Ominica South & Parsnip Northeast
Parsnip South
Hudson's Hope
Chetwynd
Mackenzie
Tumbler Ridge
Hazelton
New Hazelton
Granisle
Telkwa
Houston
Burns Lake
Fraser Lake
Fort St. James
Vanderhoof
97
29
16
27
- 2019 Kokanee Count per km
- 2018 Kokanee Count per km
Potential Fish Barrier
Stream Kilometer Marker
Upstream Extent
2002
2006
2010
2018
2019
Total Abundance of Kokanee by Survey Year:
2002: 36800
2003: 114600
2006: 246800
2007: 240700
2010: 111236
2018: 22450
2019: 2090
17
750
0
16
1575
325
15
30
14
550
150
13
1975
300
12
1700
0
11
1800
90
10
40
4850
9
0
8
100
7
0
6
0
5
390
4
180
3
1725
925
20
2
0
1
DWB Consulting Services Ltd.
1:60,000
0
1.5
3
km
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

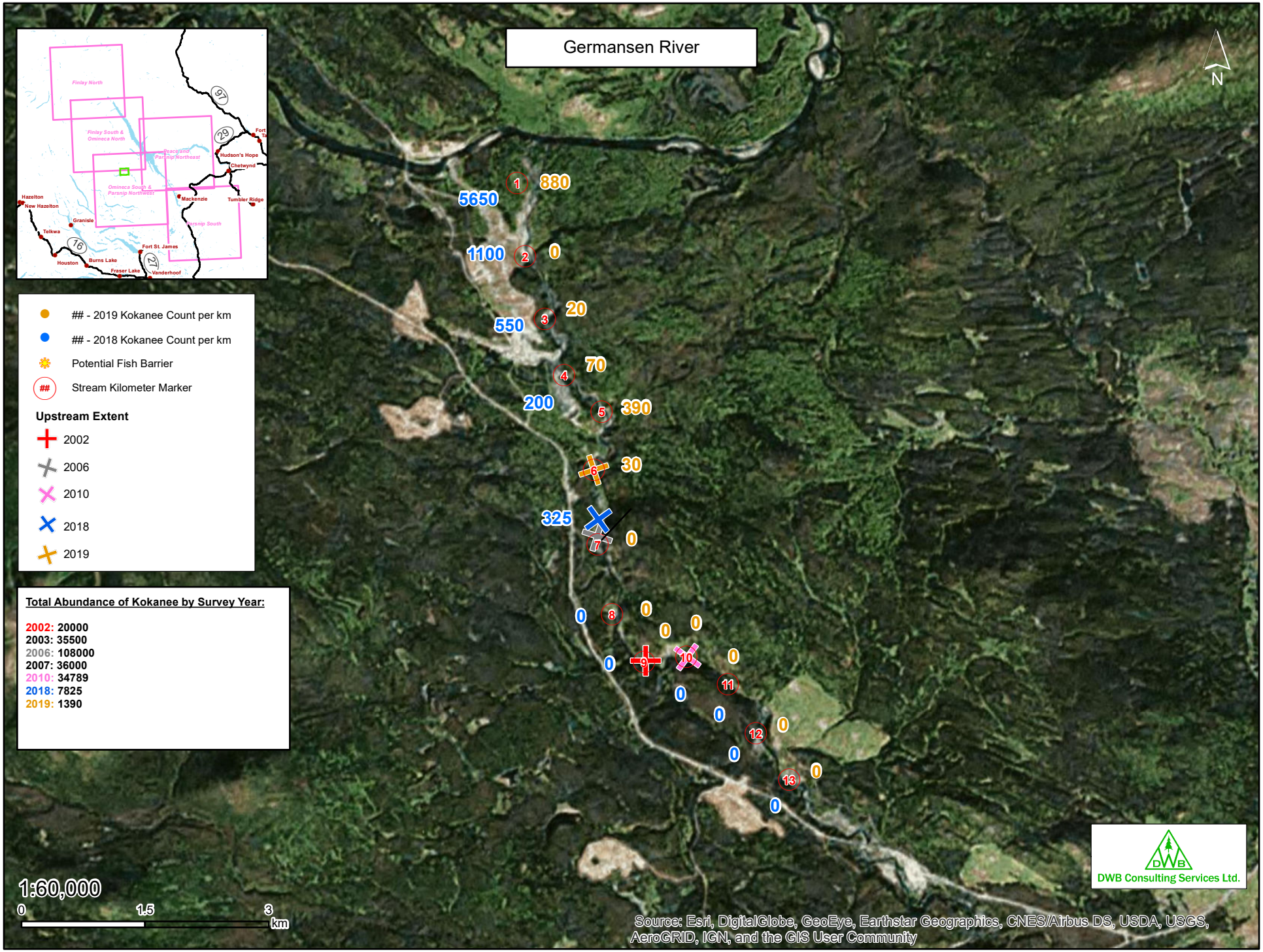

Osilinka River 2
N
Finlay North
Finlay South & Ominica North
Peace/Parsnip Northeast
Ominica South & Parsnip Northwest
Parsnip South
Hudson's Hope
Chetwynd
Mackenzie
Tumbler Ridge
Hazelton
New Hazelton
Granisle
Telkwa
Houston
Burns Lake
Fraser Lake
Fort St. James
Vanderhoof
97
29
16
27
- 2019 Kokanee Count per km
- 2018 Kokanee Count per km
Potential Fish Barrier
Stream Kilometer Marker
Upstream Extent
2002
2006
2010
2018
2019
Total Abundance of Kokanee by Survey Year:
2002: 36800
2003: 114600
2006: 246800 (Upstream extent for 2006 located at 10V 374534 223327 - near km 69.)
2007: 240700
2010: 111236 (Upstream extent for 2010 located at 10V 373825 6223322 - near km 71.)
2018: 22450
2019: 2090
1:60,000
0
1.5
3
km
DWB Consulting Services Ltd.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

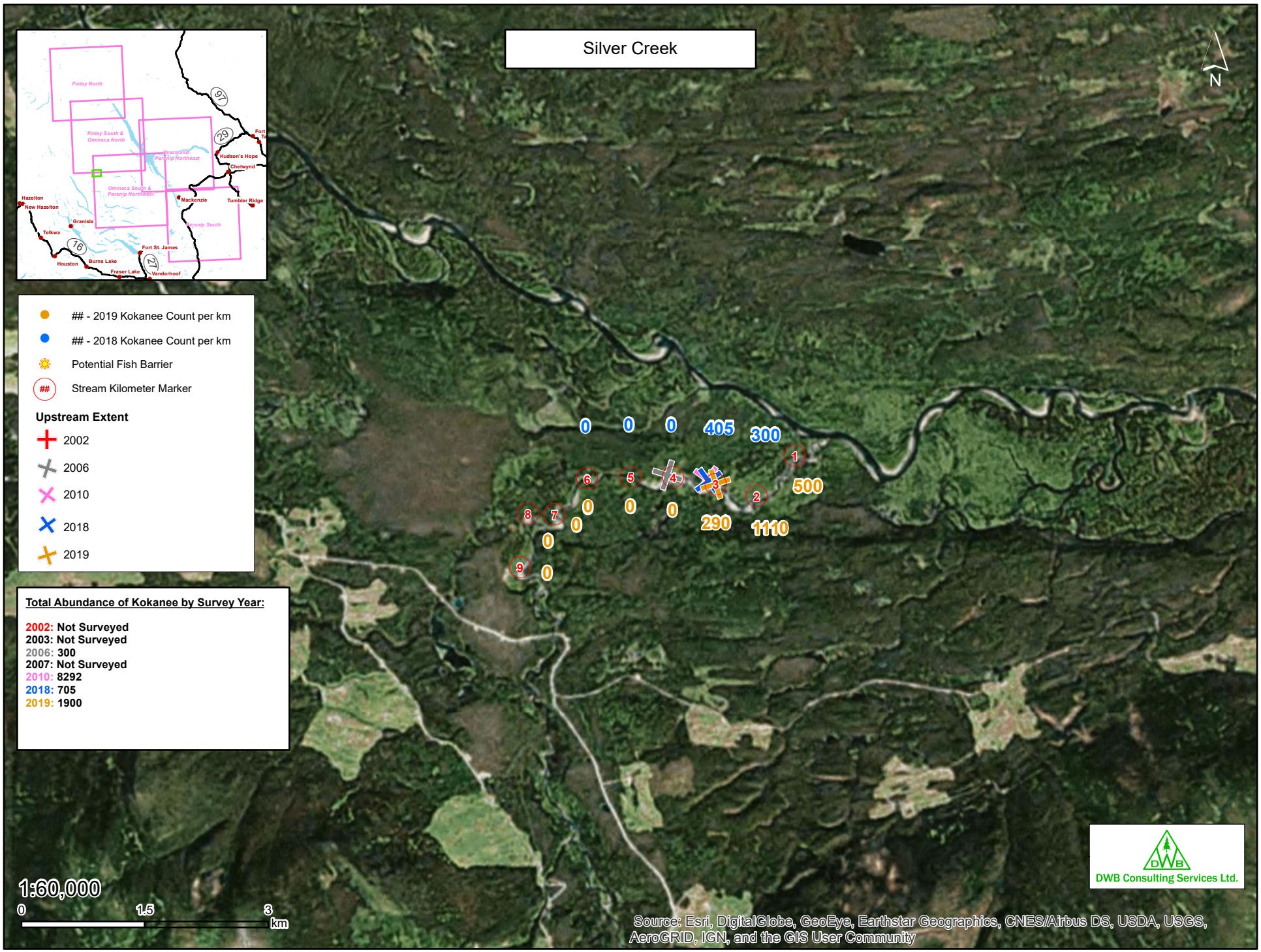

Dead Bear Creek
N
Finlay North
Finlay South & Ominica North
Peace/Land Parsnip Northeast
Ominica South & Parsnip Northeast
Parsnip South
Hudson's Hope
Chetwynd
Mackenzie
Tumbler Ridge
Hazelton
New Hazelton
Granisle
Telkwa
Houston
Burns Lake
Fraser Lake
Fort St. James
Vanderhoof
97
29
16
27
- 2019 Kokanee Count per km
- 2018 Kokanee Count per km
Potential Fish Barrier
Stream Kilometer Marker
Upstream Extent
2002
2006
2010
2018
2019
Total Abundance of Kokanee by Survey Year:
2002: 1800
2003: 200
2006: 1800
2007: Not Surveyed
2010: Not Surveyed
2018: 1704
2019: 60
0
0
0
0
0
0
154
1550
60
5
4
3
2
1:60,000
0
1.5
3
km
DWB Consulting Services Ltd.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

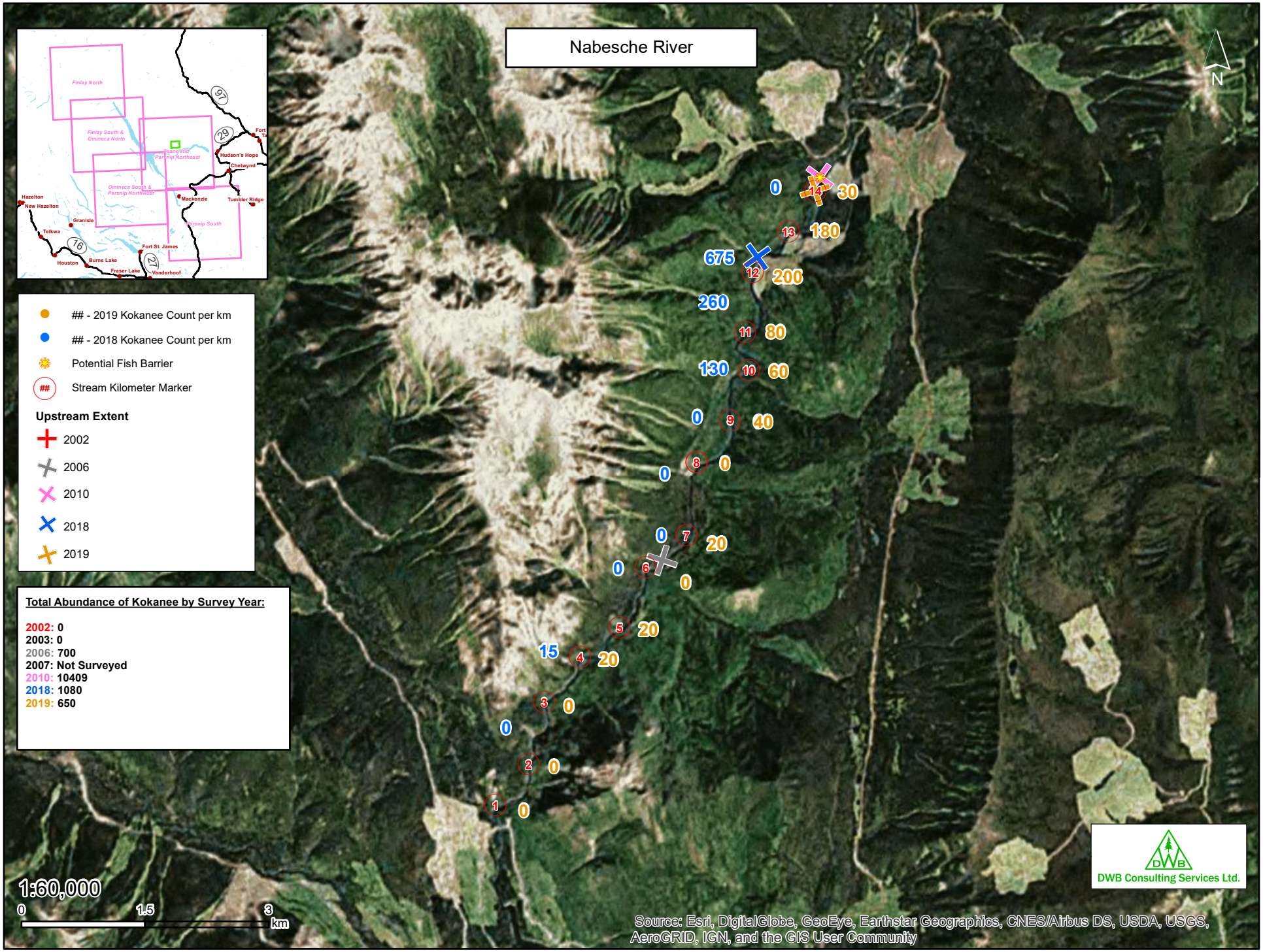

Lower Manson River 1
N
Finlay North
Finlay South & Ominica North
Peace/Parsnip Northeast
Ominica South & Parsnip Northeast
Parsnip South
Hazelton
New Hazelton
Granisle
Telkwa
Houston
Burns Lake
Fraser Lake
Fort St. James
Vanderhoof
Mackenzie
Tumbler Ridge
Chetwynd
Hudson's Hope
97
29
16
27
- 2019 Kokanee Count per km
- 2018 Kokanee Count per km
Potential Fish Barrier
Stream Kilometer Marker
Upstream Extent
2002
2006
2010
2018
2019
Total Abundance of Kokanee by Survey Year:
2002: 3800
2003: 12600
2006: 31300
2007: 6500
2010: 1538
2018: 270
2019: 0
1:60,000
0
1.5
3
km
DWB Consulting Services Ltd.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

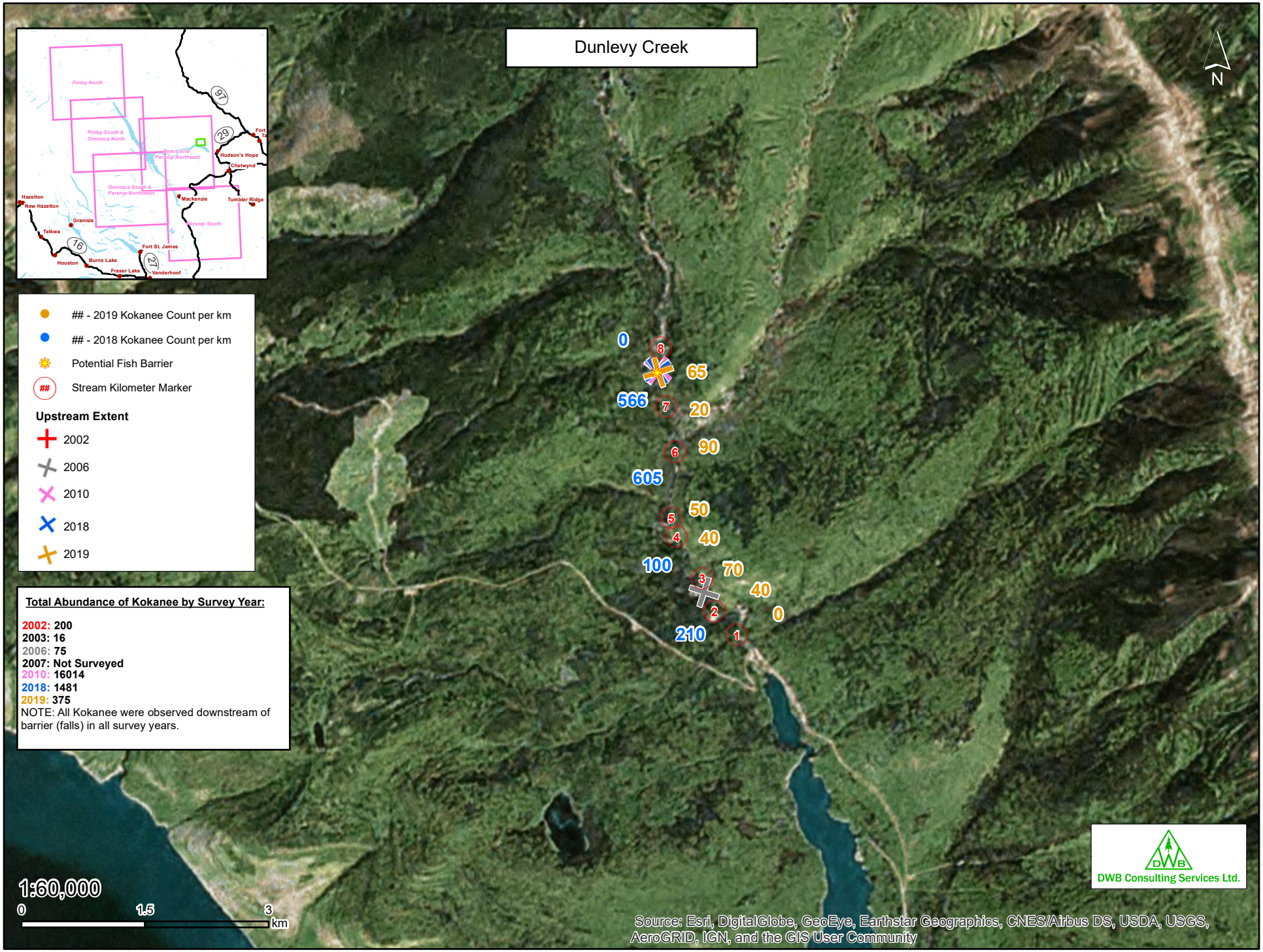

Lower Manson River 2
N
Finlay North
Finlay South & Omineca North
Peace/Liard Parsnip Northeast
Omineca South & Parsnip Northwest
Parsnip South
Hudson's Hope
Chetwynd
Mackenzie
Tumbler Ridge
Hazelton
New Hazelton
Granisle
Telkwa
Houston
Burns Lake
Fraser Lake
Fort St. James
Vanderhoof
97
29
16
27
- 2019 Kokanee Count per km
- 2018 Kokanee Count per km
Potential Fish Barrier
Stream Kilometer Marker
Upstream Extent
2002
2006
2010
2018
2019
Total Abundance of Kokanee by Survey Year:
2002:800
2003: 12600
2006: 31300 (Upstream extent for 2006 located at 10U 410076 6170891)
2007: 6500
2010: 1538
2018: 70 (Upstream extent for 2018 located at 10U 422068 6156840 - near km 81.)
2019: 0
1:60,000
0
1.5
3
km
DWB Consulting Services Ltd.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

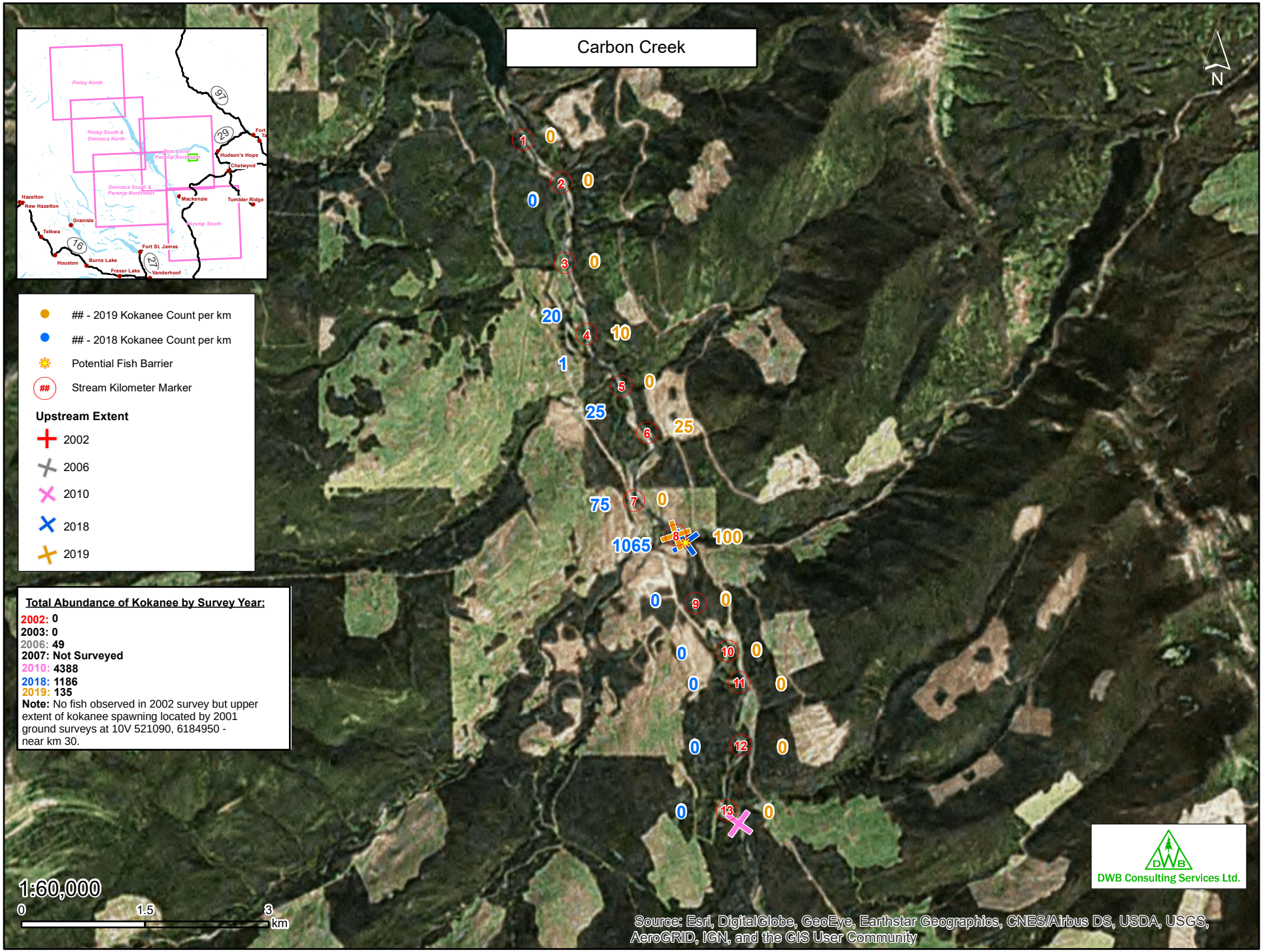

Upper Manson River
N
Finlay North
Finlay South & Omineca North
Peace/Parsnip Northeast
Omineca South & Parsnip Northwest
Parsnip South
Hudson's Hope
Chetwynd
Mackenzie
Tumbler Ridge
Hazelton
New Hazelton
Granisle
Telkwa
Houston
Burns Lake
Fraser Lake
Fort St. James
Vanderhoof
97
29
16
27
- 2019 Kokanee Count per km
- 2018 Kokanee Count per km
Potential Fish Barrier
Stream Kilometer Marker
Upstream Extent
2002
2006
2010
2018
2019
Total Abundance of Kokanee by Survey Year:
2002: Not Surveyed
2003: Not Surveyed
2006: 0
2007: 0
2010: 0
2018: 0
2019: 210
0 0 0 6 5 0 4 7 45 160 0 5 0 8 10 9 0 0 0 3 0 0 2 1 0 0
1:60,000
0 1.5 3 km
DWB Consulting Services Ltd.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

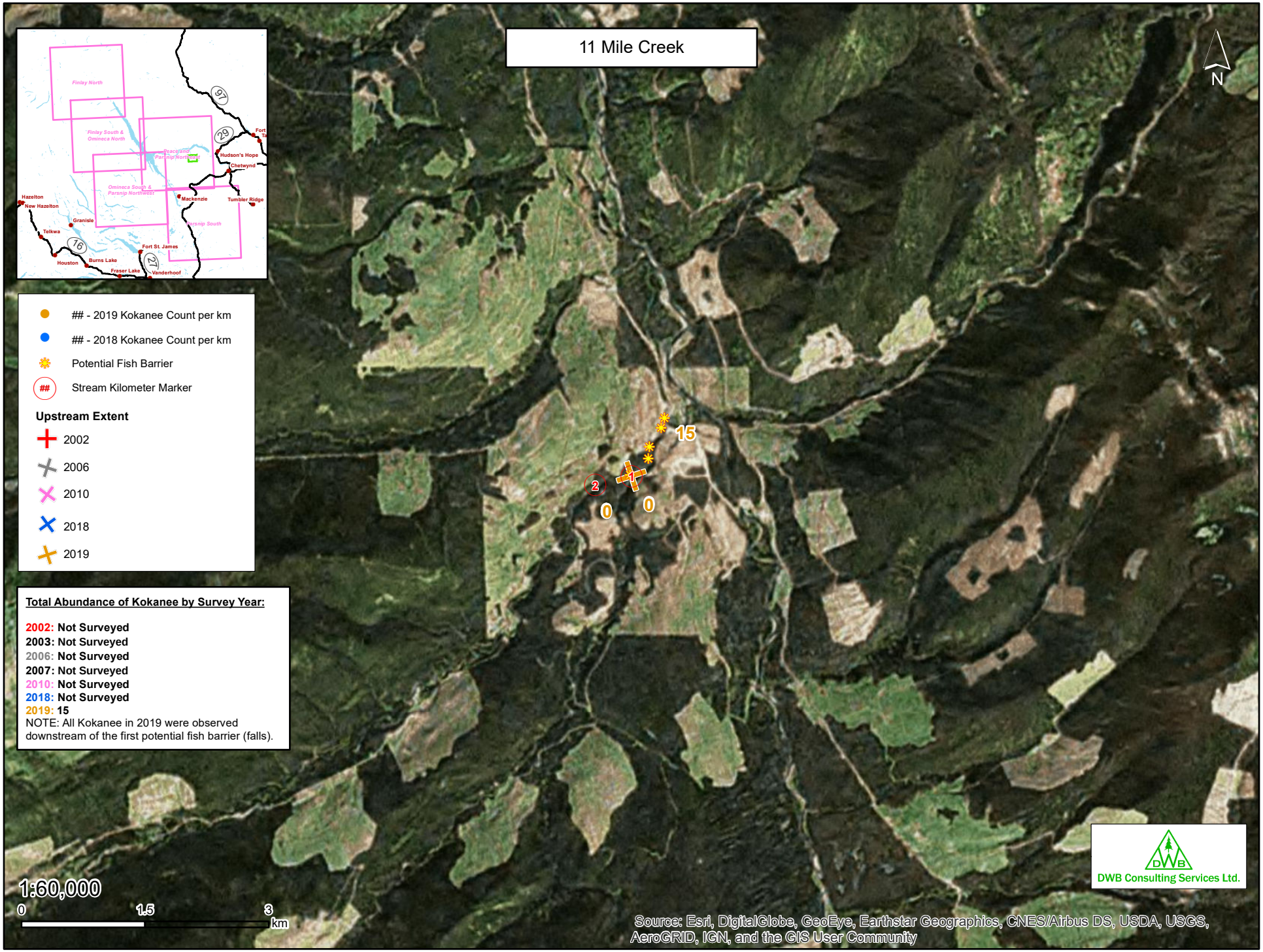

Germansen River
N
Finlay North
Finlay South & Omineca North
Peace/Parsnip Northeast
Omineca South & Parsnip Northeast
Parsnip South
Hudson's Hope
Chetwynd
Mackenzie
Tumbler Ridge
Hazelton
New Hazelton
Granisle
Telkwa
Houston
Burns Lake
Fraser Lake
Fort St. James
Vanderhoof
97
29
16
27
- 2019 Kokanee Count per km
- 2018 Kokanee Count per km
Potential Fish Barrier
Stream Kilometer Marker
Upstream Extent
2002
2006
2010
2018
2019
Total Abundance of Kokanee by Survey Year:
2002: 20000
2003: 35500
2006: 108000
2007: 36000
2010: 34789
2018: 7825
2019: 1390
1 880 5650
2 0 1100
3 20 550
4 70 200
5 390
6 30
7 325 0
8 0 0
9 0 0 0
10 0 0
11 0 0
12 0 0
13 0 0
1:60,000
0 1.5 3 km
DWB Consulting Services Ltd.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

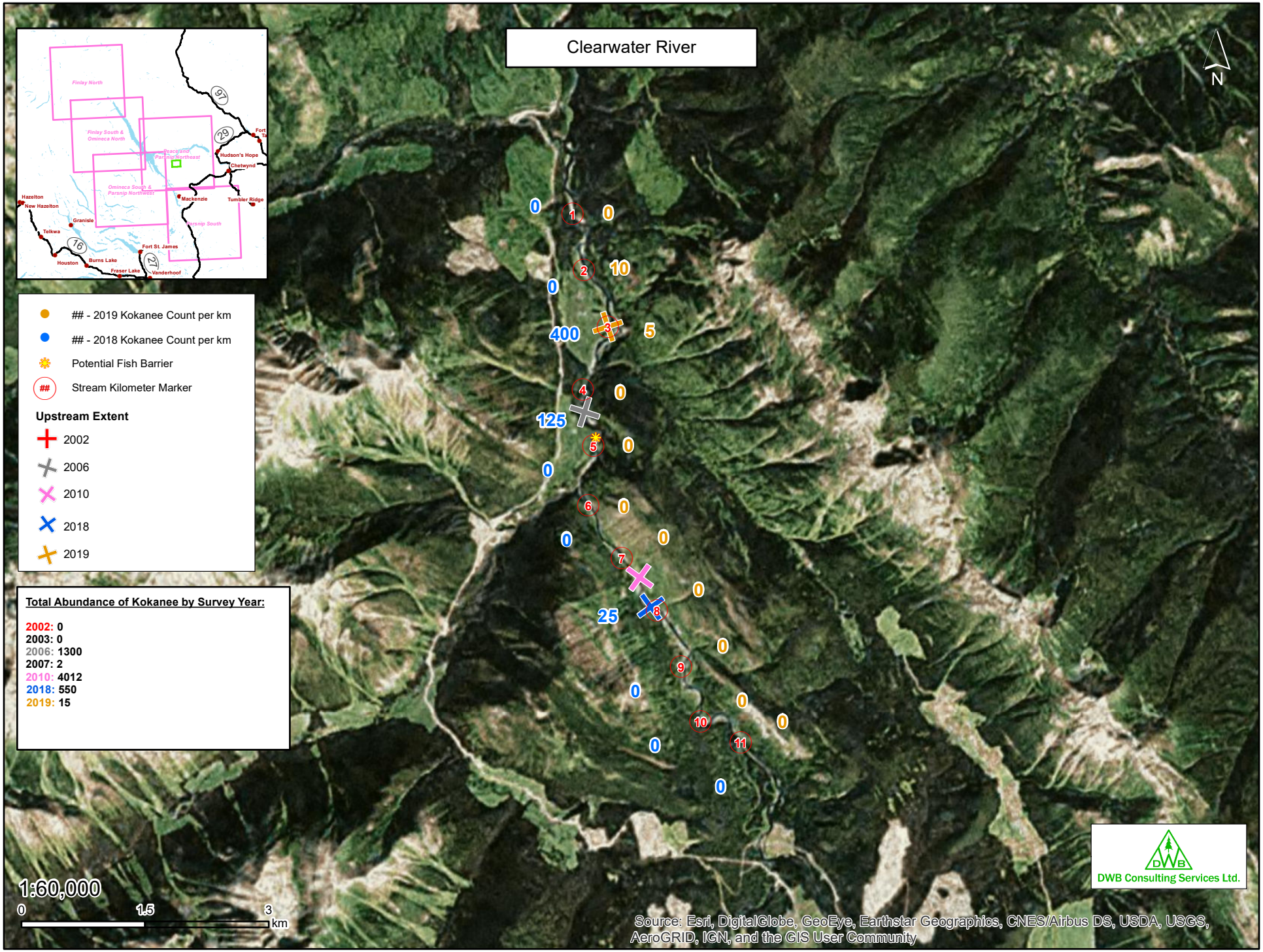

Silver Creek
N
Finlay North
Finlay South & Ominica North
Peace/Parsnip Northeast
Ominica South & Parsnip Northeast
Parsnip South
Fort Ta
Hudson's Hope
Chetwynd
Mackenzie
Tumbler Ridge
Hazelton
New Hazelton
Granisle
Telkwa
Houston
Burns Lake
Fraser Lake
Fort St. James
Vanderhoof
97
29
16
27
- 2019 Kokanee Count per km
- 2018 Kokanee Count per km
Potential Fish Barrier
Stream Kilometer Marker
Upstream Extent
2002
2006
2010
2018
2019
Total Abundance of Kokanee by Survey Year:
2002: Not Surveyed
2003: Not Surveyed
2006: 300
2007: Not Surveyed
2010: 8292
2018: 705
2019: 1900
0 0 0 405 300
1
500
2
1110
290
0 0 0
6 5 4 3
0 0
8 7
0
0
9
0
1:60,000
0 1.5 3 km
DWB Consulting Services Ltd.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

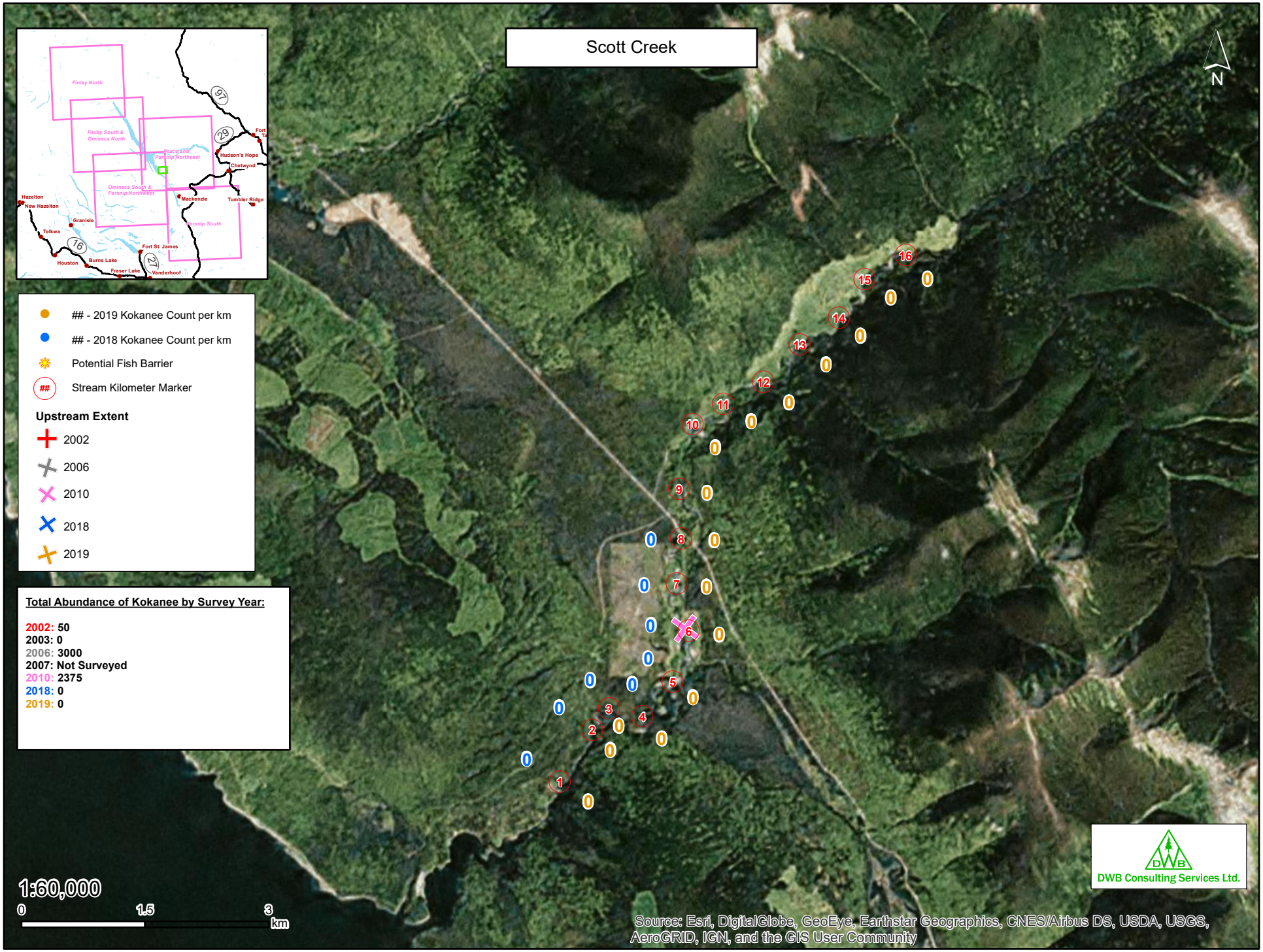

Nabesche River
N
Finlay North
Finlay South & Ominica North
Ominica South & Parsnip Northeast
Parsnip South
Hudson's Hope
Chetwynd
Mackenzie
Tumbler Ridge
Hazelton
New Hazelton
Granisle
Telkwa
Houston
Burns Lake
Fraser Lake
Fort St. James
Vanderhoof
97
29
16
27
- 2019 Kokanee Count per km
- 2018 Kokanee Count per km
Potential Fish Barrier
Stream Kilometer Marker
Upstream Extent
2002
2006
2010
2018
2019
Total Abundance of Kokanee by Survey Year:
2002: 0
2003: 0
2006: 700
2007: Not Surveyed
2010: 10409
2018: 1080
2019: 650
0 30
14
13 180
675
12 200
260
11 80
130
10 60
0
9 40
0
8 0
0
0 7 20
0
6
0
5 20
15
4 20
3 0
0
2 0
1 0
DWB Consulting Services Ltd.
1:60,000
0 1.5 3
km
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

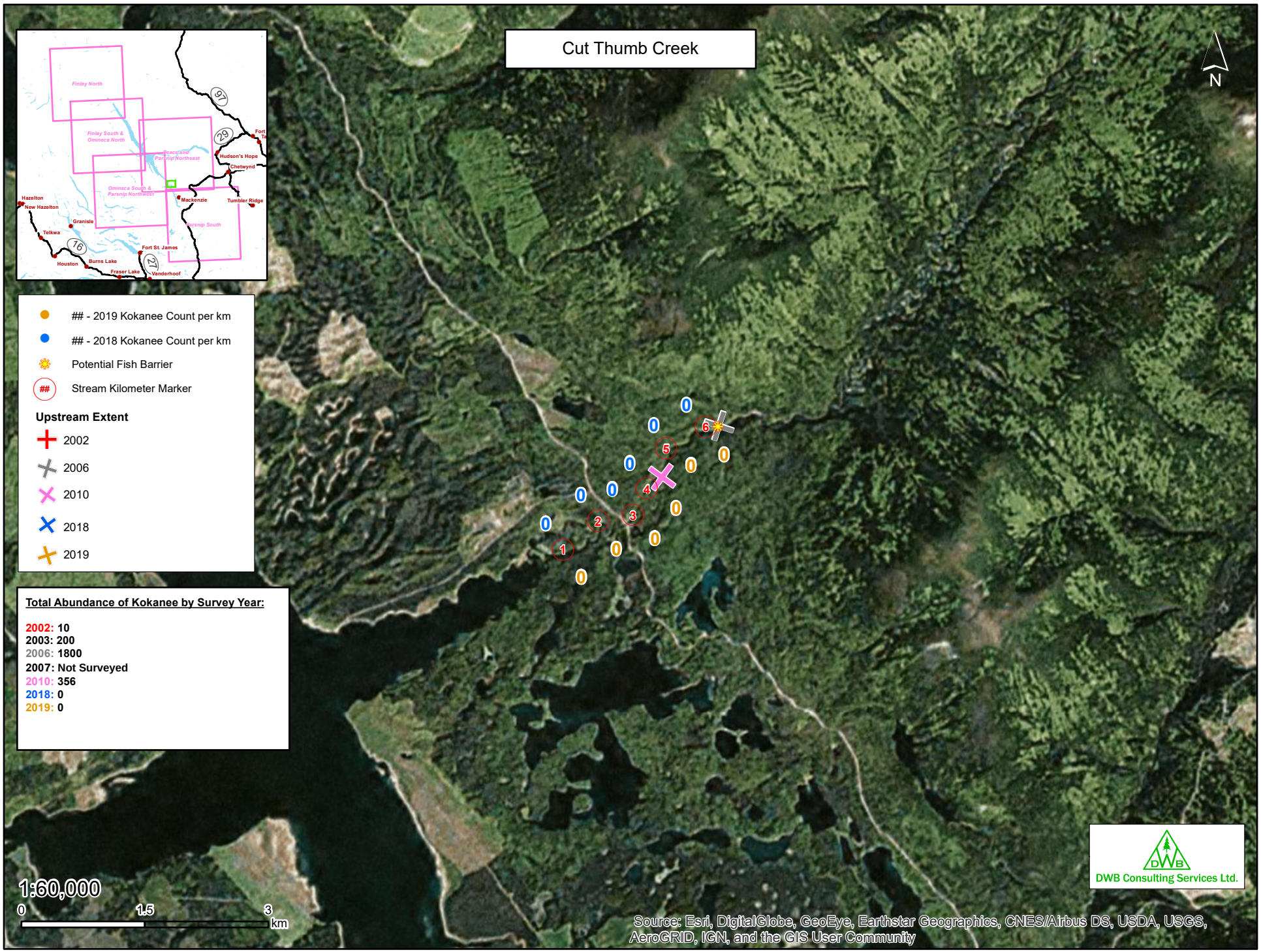

Dunlevy Creek
N
Finlay North
Finlay South & Omineca North
Peace/Liard Parsnip/Northeast
Omineca South & Parsnip Northeast
Parsnip South
Hudson's Hope
Chetwynd
Mackenzie
Tumbler Ridge
Hazelton
New Hazelton
Granisle
Telkwa
Houston
Burns Lake
Fraser Lake
Fort St. James
Vanderhoof
97
29
16
27
- 2019 Kokanee Count per km
- 2018 Kokanee Count per km
Potential Fish Barrier
Stream Kilometer Marker
Upstream Extent
2002
2006
2010
2018
2019
0
65
566
20
90
605
50
40
100
70
40
0
210
8
7
6
5
4
3
2
1
Total Abundance of Kokanee by Survey Year:
2002: 200
2003: 16
2006: 75
2007: Not Surveyed
2010: 16014
2018: 1481
2019: 375
NOTE: All Kokanee were observed downstream of barrier (falls) in all survey years.
1:60,000
0
1.5
3
km
DWB Consulting Services Ltd.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

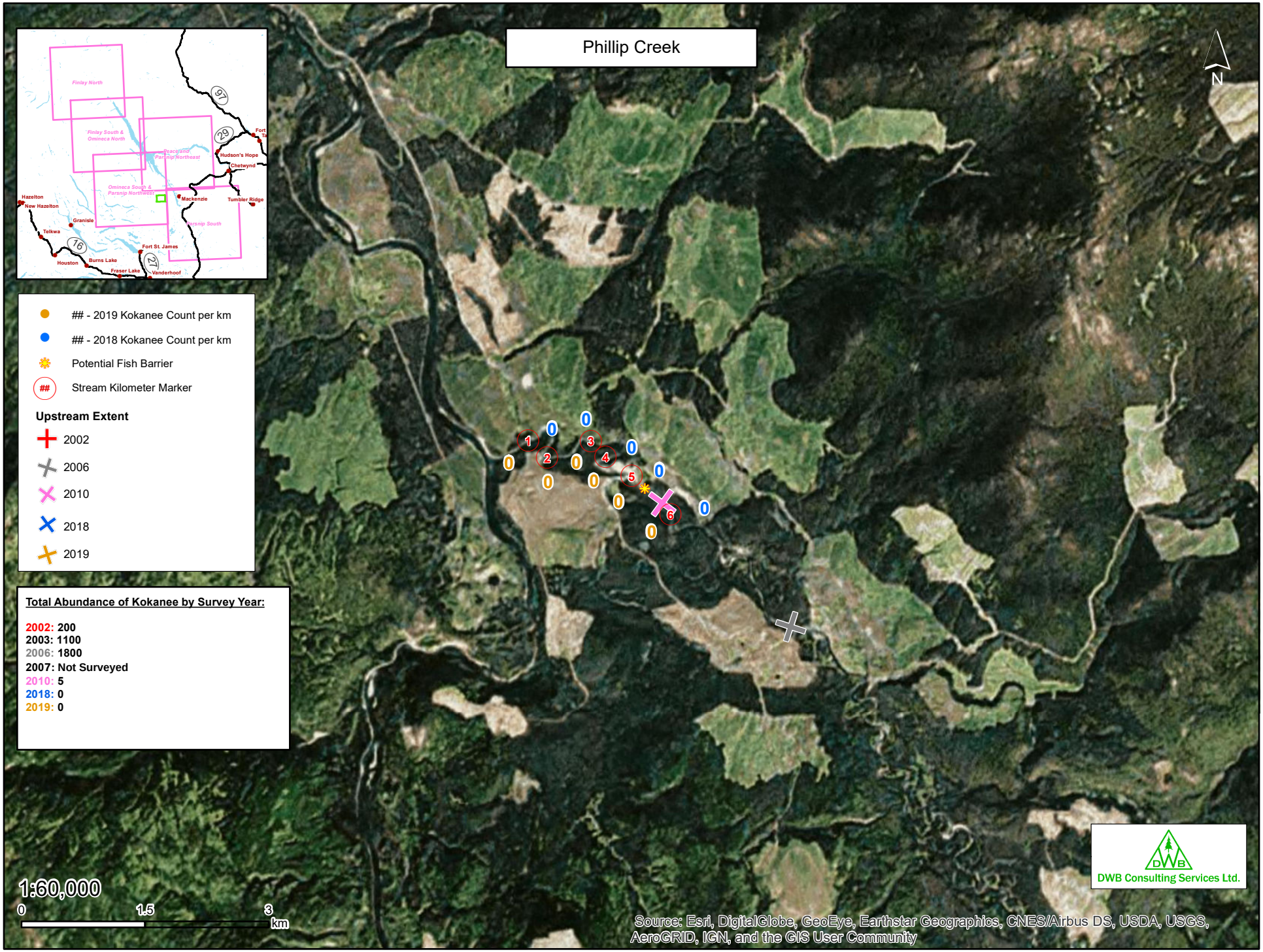

Carbon Creek
N
Finlay North
Finlay South & Omineca North
Peace/Liard Parsnip Northeast
Omineca South & Parsnip Northwest
Parsnip South
Hudson's Hope
Chetwynd
Mackenzie
Tumbler Ridge
Hazelton
New Hazelton
Granisle
Telkwa
Houston
Burns Lake
Fraser Lake
Fort St. James
Vanderhoof
97
29
16
27
- 2019 Kokanee Count per km
- 2018 Kokanee Count per km
Potential Fish Barrier
Stream Kilometer Marker
Upstream Extent
2002
2006
2010
2018
2019
Total Abundance of Kokanee by Survey Year:
2002: 0
2003: 0
2006: 49
2007: Not Surveyed
2010: 4388
2018: 1186
2019: 135
Note: No fish observed in 2002 survey but upper extent of kokanee spawning located by 2001 ground surveys at 10V 521090, 6184950 - near km 30.
1:60,000
0
1.5
3
km
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
DWB Consulting Services Ltd.

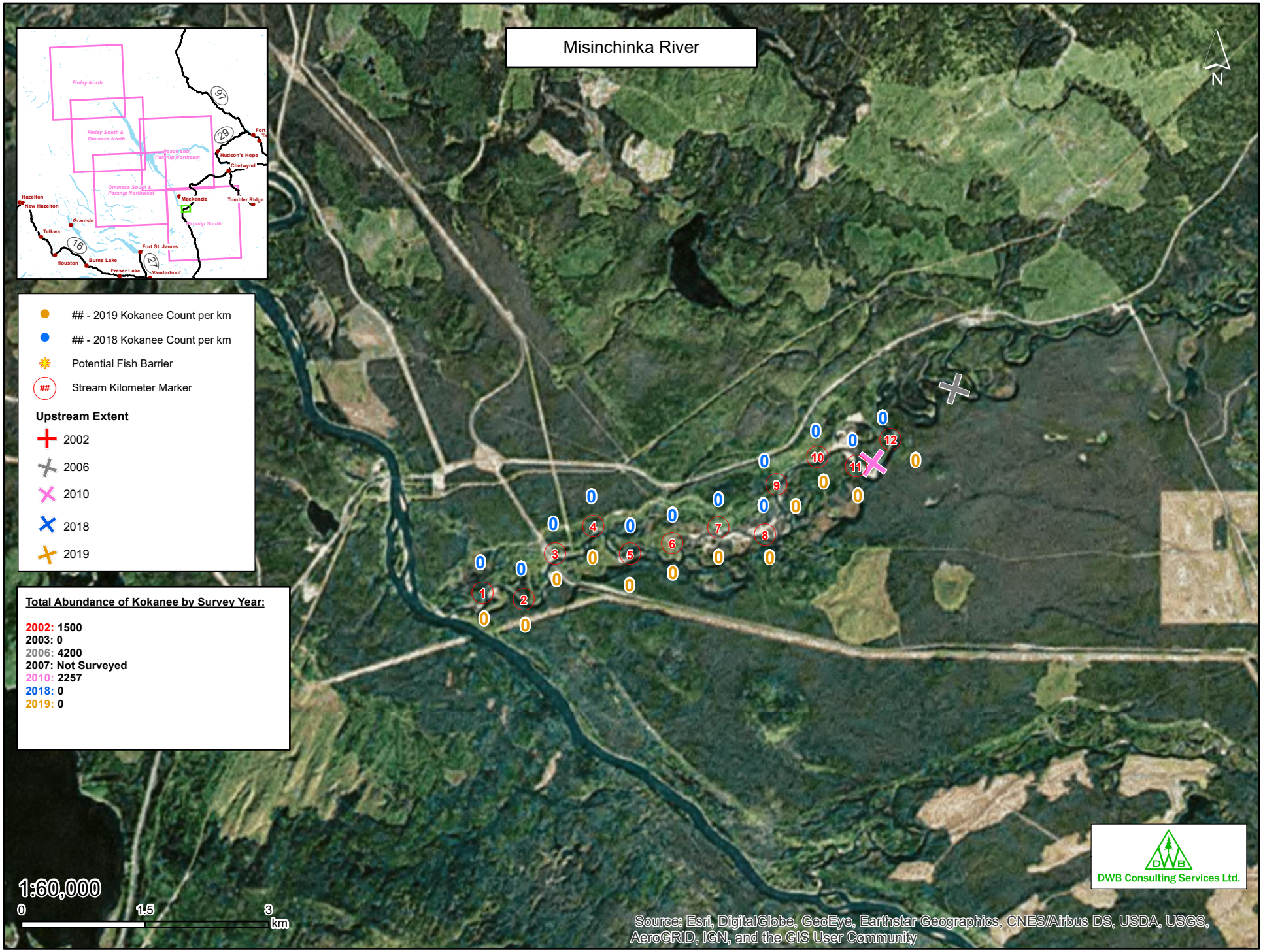

11 Mile Creek
N
Finlay North
Finlay South & Omineca North
Omineca South & Parsnip Northwest
Parsnip South
Hudson's Hope
Chetwynd
Mackenzie
Tumbler Ridge
Hazelton
New Hazelton
Granisle
Telkwa
Houston
Burns Lake
Fraser Lake
Fort St. James
Vanderhoof
97
29
16
27
- 2019 Kokanee Count per km
- 2018 Kokanee Count per km
Potential Fish Barrier
Stream Kilometer Marker
Upstream Extent
2002
2006
2010
2018
2019
15
2
1
0
0
Total Abundance of Kokanee by Survey Year:
2002: Not Surveyed
2003: Not Surveyed
2006: Not Surveyed
2007: Not Surveyed
2010: Not Surveyed
2018: Not Surveyed
2019: 15
NOTE: All Kokanee in 2019 were observed downstream of the first potential fish barrier (falls).
1:60,000
0
1.5
3
km
DWB Consulting Services Ltd.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

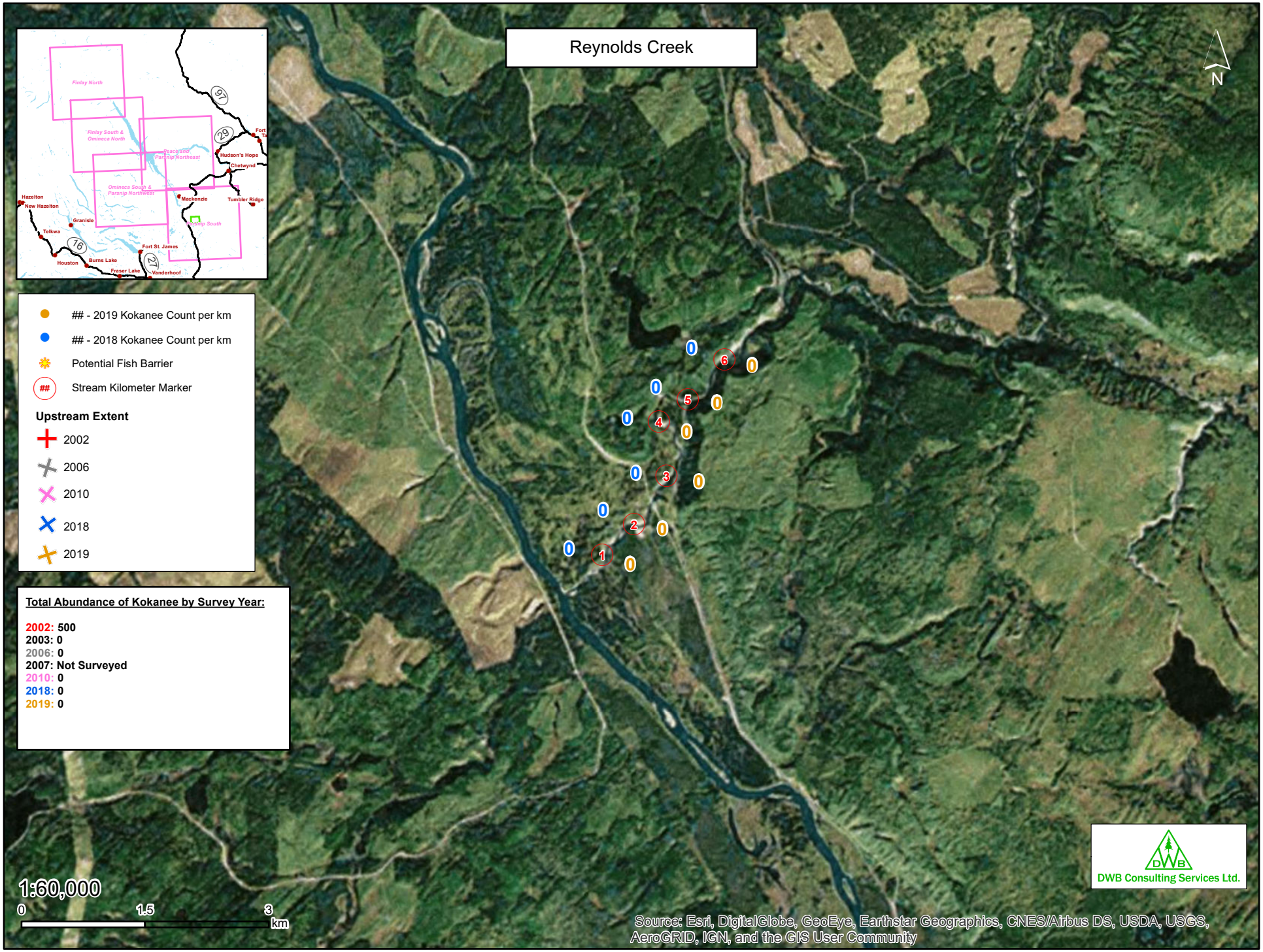

Clearwater River
N
Finlay North
Finlay South & Omineca North
Peace/Liard Parsnip Northeast
Omineca South & Parsnip Northwest
Parsnip South
Hazelton
New Hazelton
Granisle
Telkwa
Houston
Burns Lake
Fraser Lake
Fort St. James
Vanderhoof
Mackenzie
Hudson's Hope
Chetwynd
Tumbler Ridge
97
29
16
27
- 2019 Kokanee Count per km
- 2018 Kokanee Count per km
Potential Fish Barrier
Stream Kilometer Marker
Upstream Extent
2002
2006
2010
2018
2019
Total Abundance of Kokanee by Survey Year:
2002: 0
2003: 0
2006: 1300
2007: 2
2010: 4012
2018: 550
2019: 15
0
1
0
2
10
0
400
3
5
4
0
125
5
0
0
6
0
0
0
7
0
25
8
0
9
0
0
10
0
11
0
0
1:60,000
0
1.5
3
km
DWB Consulting Services Ltd.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

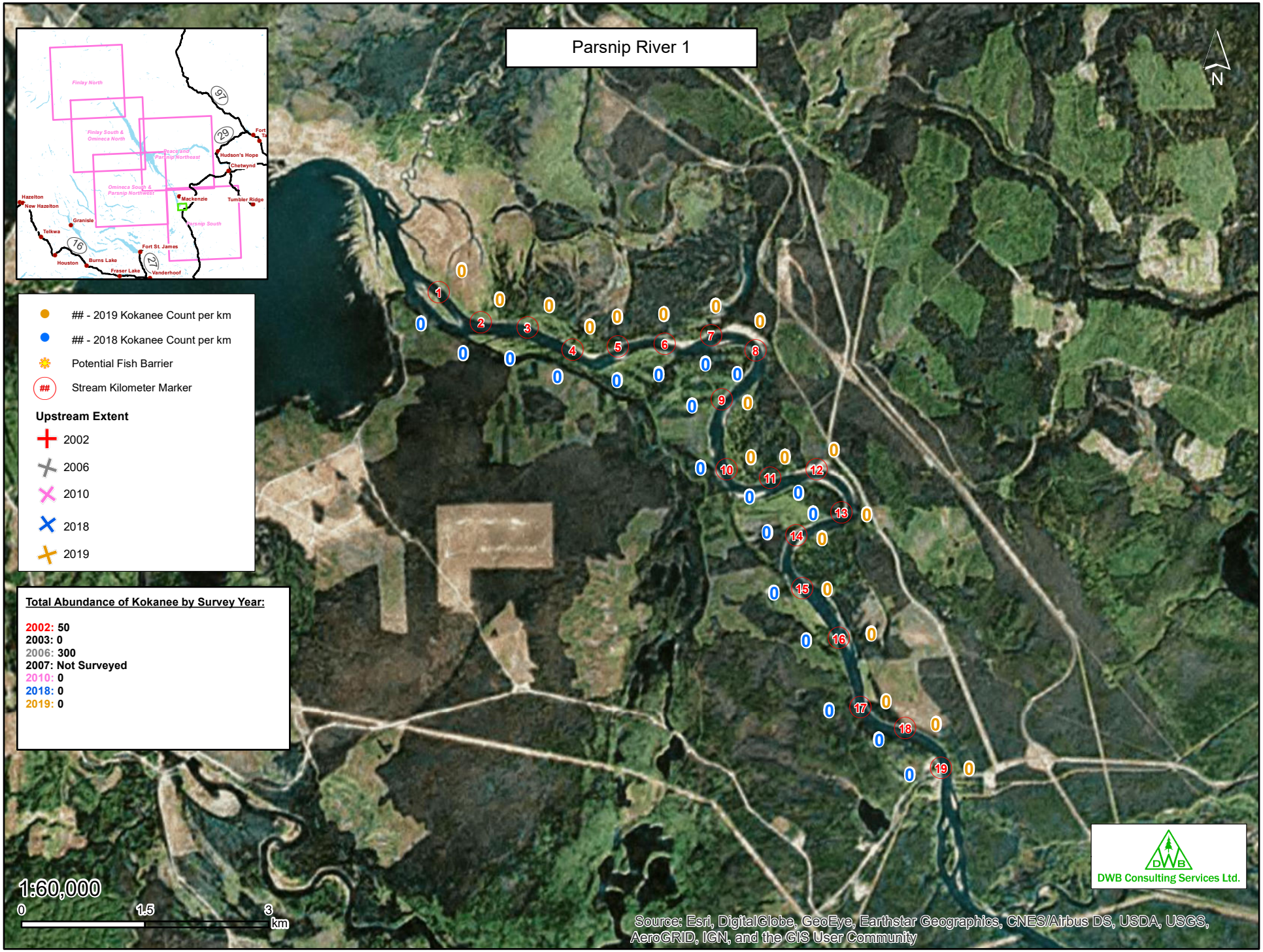

Scott Creek
N
Finlay North
Finlay South & Omineca North
Peace/Parsnip Northeast
Omineca South & Parsnip Northwest
Parsnip South
Hudson's Hope
Chetwynd
Mackenzie
Tumbler Ridge
Hazelton
New Hazelton
Granisle
Telkwa
Houston
Burns Lake
Fraser Lake
Fort St. James
Vanderhoof
97
29
16
27
- 2019 Kokanee Count per km
- 2018 Kokanee Count per km
Potential Fish Barrier
Stream Kilometer Marker
Upstream Extent
2002
2006
2010
2018
2019
Total Abundance of Kokanee by Survey Year:
2002: 50
2003: 0
2006: 3000
2007: Not Surveyed
2010: 2375
2018: 0
2019: 0
1:60,000
0
1.5
3
km
DWB Consulting Services Ltd.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

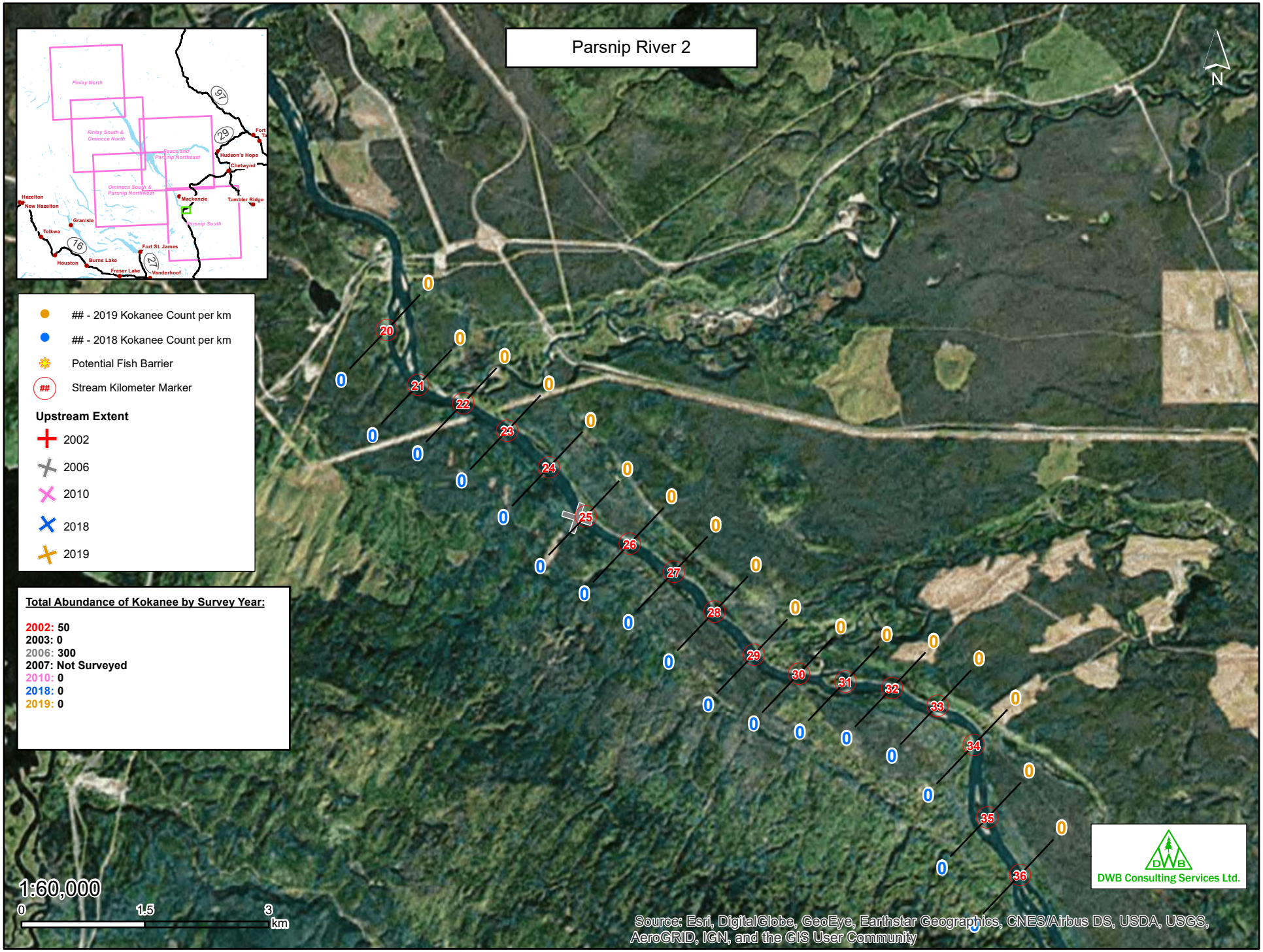

Cut Thumb Creek
N
Finlay North
Finlay South & Omineca North
Peace/Liard Parsnip Northeast
Omineca South & Parsnip Northeast
Parsnip South
Fort Ta
Hudson's Hope
Chetwynd
Mackenzie
Tumbler Ridge
Hazelton
New Hazelton
Granisle
Telkwa
Houston
Burns Lake
Fraser Lake
Fort St. James
Vanderhoof
97
29
16
27
- 2019 Kokanee Count per km
- 2018 Kokanee Count per km
Potential Fish Barrier
Stream Kilometer Marker
Upstream Extent
2002
2006
2010
2018
2019
Total Abundance of Kokanee by Survey Year:
2002: 10
2003: 200
2006: 1800
2007: Not Surveyed
2010: 356
2018: 0
2019: 0
1:60,000
0
1.5
3
km
DWB Consulting Services Ltd.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

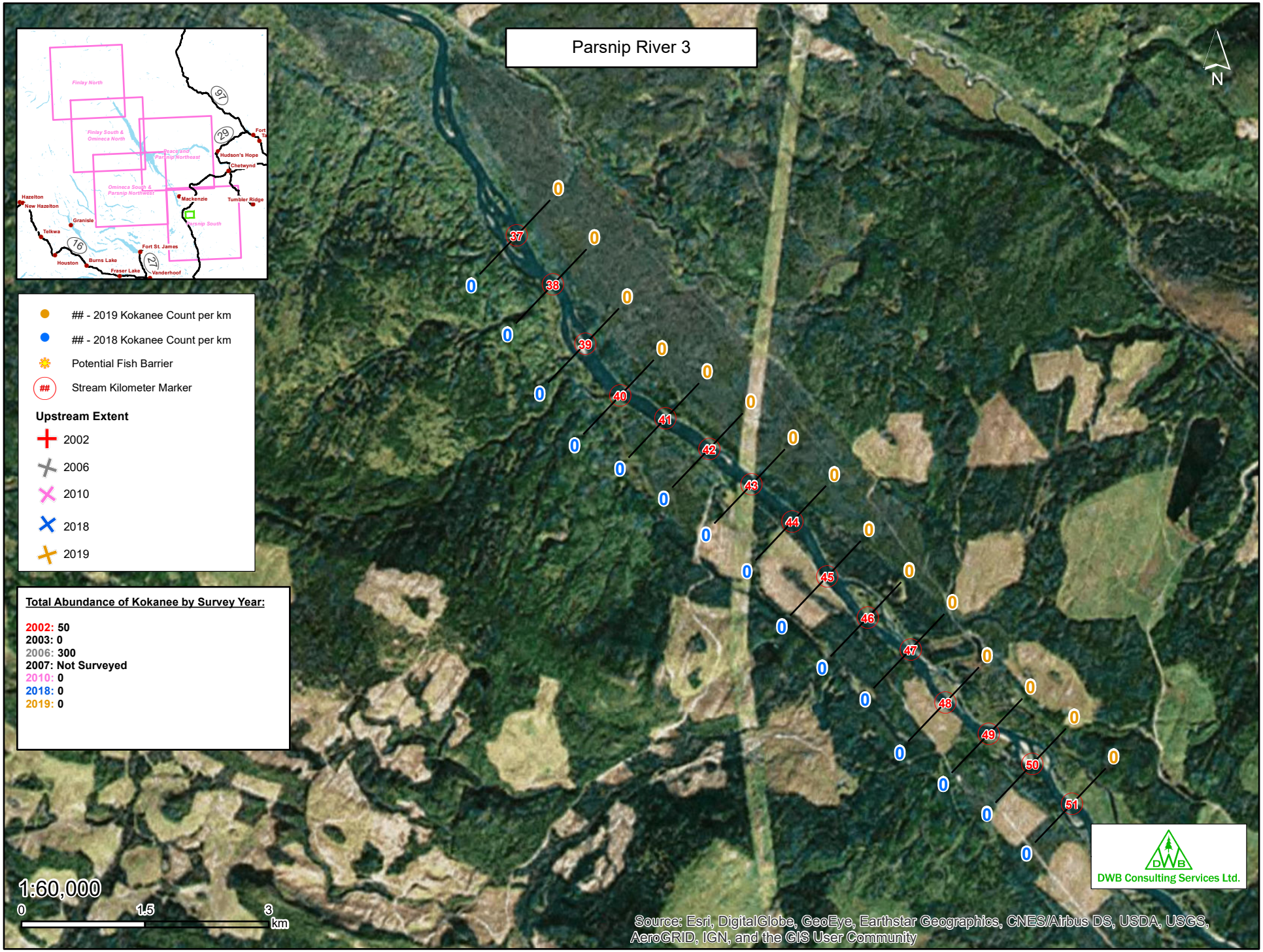

Phillip Creek
N
Finlay North
Finlay South & Ominica North
Peace/Land Parsnip Northeast
Ominica South & Parsnip Northwest
Parsnip South
Hudson's Hope
Chetwynd
Mackenzie
Tumbler Ridge
Hazelton
New Hazelton
Granisle
Telkwa
Houston
Burns Lake
Fraser Lake
Fort St. James
Vanderhoof
97
29
16
27
- 2019 Kokanee Count per km
- 2018 Kokanee Count per km
Potential Fish Barrier
Stream Kilometer Marker
Upstream Extent
2002
2006
2010
2018
2019
Total Abundance of Kokanee by Survey Year:
2002: 200
2003: 1100
2006: 1800
2007: Not Surveyed
2010: 5
2018: 0
2019: 0
1:60,000
0
1.5
3
km
DWB Consulting Services Ltd.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

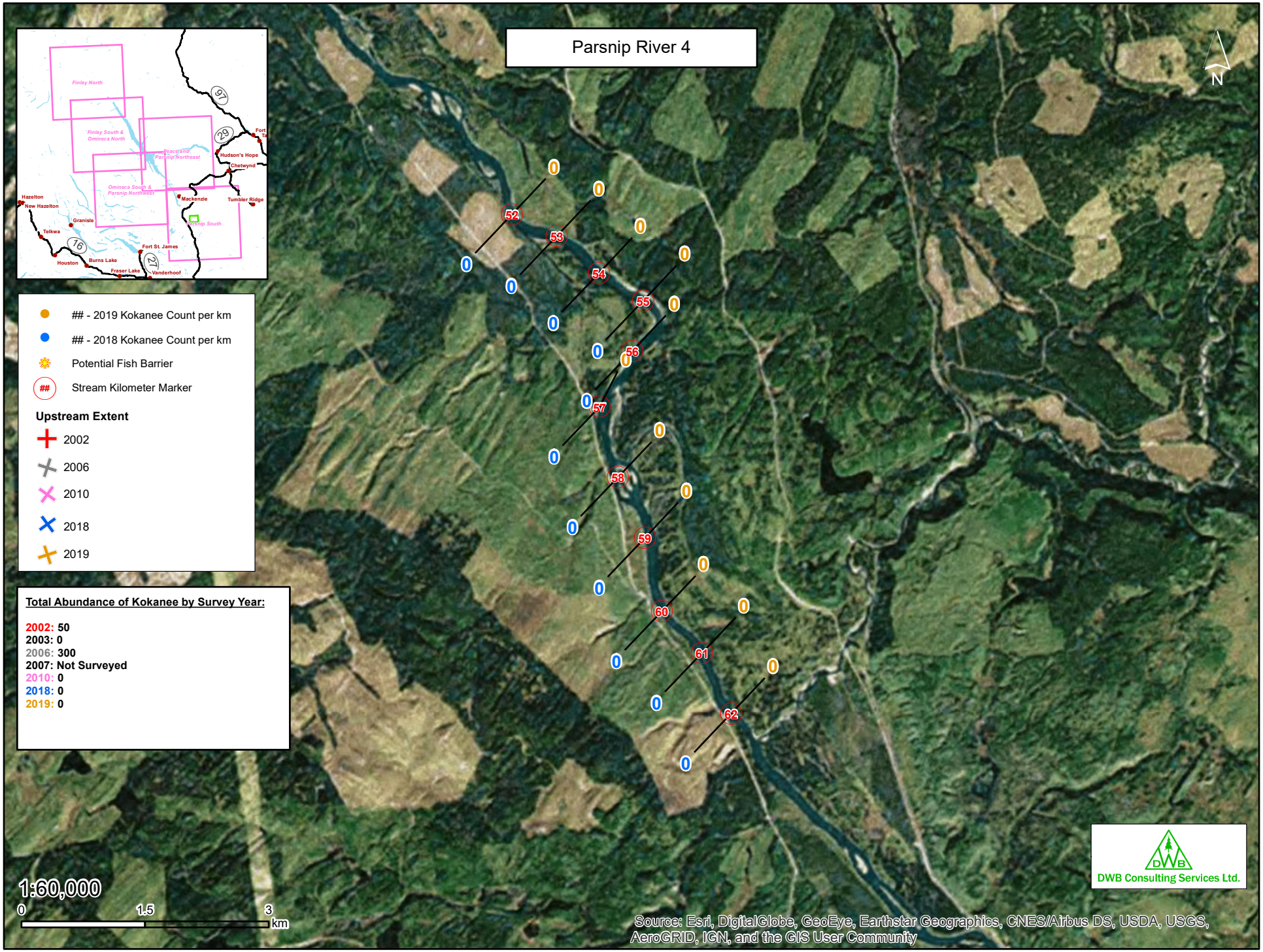

Misinchinka River
N
Finlay North
Finlay South & Ominica North
Peace/Parsnip Northeast
Ominica South & Parsnip Northeast
Parsnip South
Hudson's Hope
Chetwynd
Mackenzie
Tumbler Ridge
Hazelton
New Hazelton
Granisle
Telkwa
Houston
Burns Lake
Fraser Lake
Fort St. James
Vanderhoof
97
29
16
27
- 2019 Kokanee Count per km
- 2018 Kokanee Count per km
Potential Fish Barrier
Stream Kilometer Marker
Upstream Extent
2002
2006
2010
2018
2019
Total Abundance of Kokanee by Survey Year:
2002: 1500
2003: 0
2006: 4200
2007: Not Surveyed
2010: 2257
2018: 0
2019: 0
1:60,000
0
1.5
3
km
DWB Consulting Services Ltd.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community


Reynolds Creek
N
Finlay North
Finlay South & Omineca North
Peace/Liard Parsnip Northeast
Omineca South & Parsnip Northwest
Hudson's Hope
Chetwynd
Mackenzie
Tumbler Ridge
Hazelton
New Hazelton
Granisle
Telkwa
Houston
Burns Lake
Fraser Lake
Fort St. James
Vanderhoof
97
29
16
27
- 2019 Kokanee Count per km
- 2018 Kokanee Count per km
Potential Fish Barrier
Stream Kilometer Marker
Upstream Extent
2002
2006
2010
2018
2019
Total Abundance of Kokanee by Survey Year:
2002: 500
2003: 0
2006: 0
2007: Not Surveyed
2010: 0
2018: 0
2019: 0
1:60,000
0
1.5
3
km
DWB Consulting Services Ltd.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community


Parsnip River 1
N
Finlay North
Finlay South & Omineca North
Peace/Liard Parsnip Northeast
Omineca South & Parsnip Northwest
Parsnip South
Hudson's Hope
Chetwynd
Mackenzie
Tumbler Ridge
Hazelton
New Hazelton
Granisle
Telkwa
Houston
Burns Lake
Fraser Lake
Fort St. James
Vanderhoof
97
29
16
27
- 2019 Kokanee Count per km
- 2018 Kokanee Count per km
Potential Fish Barrier
Stream Kilometer Marker
Upstream Extent
2002
2006
2010
2018
2019
Total Abundance of Kokanee by Survey Year:
2002: 50
2003: 0
2006: 300
2007: Not Surveyed
2010: 0
2018: 0
2019: 0
1:60,000
0
1.5
3
km
DWB Consulting Services Ltd.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community


Parsnip River 2
N
Finlay North
Finlay South & Omineca North
Peace/Lend Parsnip Northeast
Omineca South & Parsnip Northeast
Parsnip South
Hudson's Hope
Chetwynd
Mackenzie
Tumbler Ridge
Hazelton
New Hazelton
Granisle
Telkwa
Houston
Burns Lake
Fraser Lake
Fort St. James
Vanderhoof
97
29
16
27
- 2019 Kokanee Count per km
- 2018 Kokanee Count per km
Potential Fish Barrier
Stream Kilometer Marker
Upstream Extent
2002
2006
2010
2018
2019
Total Abundance of Kokanee by Survey Year:
2002: 50
2003: 0
2006: 300
2007: Not Surveyed
2010: 0
2018: 0
2019: 0
1:60,000
0
1.5
3
km
DWB Consulting Services Ltd.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community


Parsnip River 3
N
Finlay North
Finlay South & Omineca North
Peace/Parsnip Northeast
Omineca South & Parsnip Northwest
Parsnip South
Hudson's Hope
Chetwynd
Mackenzie
Tumbler Ridge
Hazelton
New Hazelton
Granisle
Telkwa
Houston
Burns Lake
Fraser Lake
Fort St. James
Vanderhoof
97
29
16
27
- 2019 Kokanee Count per km
- 2018 Kokanee Count per km
Potential Fish Barrier
Stream Kilometer Marker
Upstream Extent
2002
2006
2010
2018
2019
Total Abundance of Kokanee by Survey Year:
2002: 50
2003: 0
2006: 300
2007: Not Surveyed
2010: 0
2018: 0
2019: 0
1:60,000
0
1.5
3
km
DWB Consulting Services Ltd.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community


Parsnip River 4
N
Finlay North
Finlay South & Omineca North
Peace/Omineca Parsnip Northeast
Omineca South & Parsnip Northwest
Parsnip South
97
29
27
16
Fort Ta
Hudson's Hope
Chetwynd
Mackenzie
Tumbler Ridge
Hazelton
New Hazelton
Granisle
Telkwa
Houston
Burns Lake
Fraser Lake
Fort St. James
Vanderhoof
- 2019 Kokanee Count per km
- 2018 Kokanee Count per km
Potential Fish Barrier
Stream Kilometer Marker
Upstream Extent
2002
2006
2010
2018
2019
Total Abundance of Kokanee by Survey Year:
2002: 50
2003: 0
2006: 300
2007: Not Surveyed
2010: 0
2018: 0
2019: 0
52
53
54
55
56
57
58
59
60
61
62
1:60,000
0
1.5
3
km
DWB Consulting Services Ltd.
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Appendix B
Data Tables

Table B1. UTM coordinates for start and end points of aerial enumeration surveys conducted in 2002, 2006, 2010, 2018, and 2019 in 28 spawning tributaries of the Williston Reservoir. Not all streams were surveyed every year.

			Survey End				
Sub-Watershed	**Stream**	**Survey Start**	**2002**	**2006**	**2010**	**2018**	**2019**
Finlay	Davis River	10U 409740 6268587	10U 411406 6283144	10U 411406 6283144	10U 412132 6283820	10U 412894 6277655	10 412450 6275741
	Finlay River	10U 376713 6316052	9U 626764 6330417	9U 626764 6330417	9U 673145 6383941	9U 670453 6388539	9U 670279 6388621
	Bower Creek	10U 324801 6370015	9U 678082 6369629	9U 678082 6369629	**No Survey**	9U 675804 6366585	9U 675810 6366587
	Cutoff Creek	9U 675443 6380017	10 674285 6380630	10 674285 6380630	9U 666083 6383151	9U 667901 6382583	10U 667996 6382470
	Russel Creek	10U 357499 6342941	10U 357535 6342937	10U 357535 6342937	10U 345987 6345394	10U 346851 6345706	10U 347572 6345710
	Tsaydiz Creek	10U 370755 6322856	**No Survey**	10U 367046 6321753	10U 366022 6321472	10U 366274 6321570	10U 366345 6321675
	Pelly Creek	10U 350034 6293856	10U 348670 6301820	10U 348670 6301820	10U 344183 6305421	10U 345097 6305106	10U 347052 6302977
	Pelly LK. outlet (Zygadene Creek)	10U 349285 6300589	**No Survey**	10U 351135 6302672	**No Survey**	10U 349292 6300602	10U 350870 6302614
	Swannell River	10U 371674 6289552	10U 366767 6278529	10U 366767 6278529	1U0 367355 6278698	10U 369115 6279864	10U 370014 6281977
	Aley Creek	10U 442799 6258212	10U 445206 6259428	10U 445206 6259428	10U 448850 6262505	10U 447183 6261644	10U 446503 6261324
Omineca	Mesilinka River	10U 408033 6222765	10U 332074 6255964	10U 332074 6255964	10U 378361 6256207	10 365621 6246227	10U 387199 6247517
	Germansen River	10U 394482 6183985	10U 395835 6177595	10U 395835 6177595	10U 397114 6177120	10 397217 6176601	10U 397572 6176148
	Osilinka River	10U 404251 6216805	10U 360488 6215118	10U 360488 6215118	10U 371300 6223295	10U 371378 6223445	10 U 385513 6222260
	Dead Bear Creek	10U 387972 6221477	10U 387604 6221759	10U 387604 6221759	**No Survey**	10U 385456 6224435	10U 385880 6223699
	Silver Creek	10U 348097 6181799	**No Survey**	10U 346180 6181292	10U 346395 6181334	10U 344988 6181108	10U 344389 6180170
Peace	Carbon Creek	10U 519586 6205293	10U 512075 6181409	10U 512075 6181409	10U 522905 6194816	10U 522765 6195091	10U 522447 522447
	Clearwater River	10U 489828 6194512	10U 506904 6163649	10U 506904 6163649	10U 490002 6195158	10U 492325 6186844	10 492041 6187129
	Dunlevy Creek	10U 538523 6224798	10U 537127 6228534	10U 537127 6228534	10U 537172 6228582	10U 537266 6229632	10 537268 6228525
	Nabesche River	10U 488869 6220139	10U 490878 6223936	10U 490878 6223936	10U 492882 6228679	10U 493141 6229476	10 492886 6228639

			Survey End				
Sub-Watershed	**Stream**	**Survey Start**	**2002**	**2006**	**2010**	**2018**	**2019**
	Gething Creek	10U 538385 6224897	**No Survey**	**No survey**	**No Survey**	10U 547001 6206369	**No Survey**
	11 Mile Creek	10U 521502 6199827	**No Survey**	**No survey**	**No Survey**	**No Survey**	10 520694 6198634
Parsnip	Cut Thumb Creek	10U 479367 6154909	10U 481643 6129946	10U 481643 6129946	10U 481314 6156524	10U 481662 6156594	10 481786 6156681
	Scott Creek	10U 464419 6175528	10U 465275 6176956	10U 465275 6176956	10U 466235 6178557	10U 466150 6178896	10 469638 6182763
	Philip Creek (2010 data)	10U 458282 6128886	No Data	No Data	10U 461217 6127620	10U 461344 6127679	10 460565 6128118
	Upper Manson River (above lakes)	10U 412305 6168756	**No Survey**	10U 410017 6170926	10U 411365 6169391	10U 409128 6170039	10 4077769 6169934
	Lower Manson River (downstream of lakes)	10U 448217 6177096	10U 416773 6160421	10U 416773 6160421	10U 416817 6160433	10U 417414 6159716	10 435606 6167498
	Parsnip River	10U 495440 6114475	10U 584155 6032398	10U 584155 6032398	10U 581935 6033178	10U 581928 6033185	10 519828 6085878
	Misinchinka River	10U 502588 6106299	10U 508856 6109016	10U 508856 6109016	10U 509494 6032319	10U 508805 6109564	10 507967 6108638
	Reynolds Creek	10U 519907 6085825	10U 525021 6088910	10 525021 6088910	10U 522003 6088566	10U 522197 6088861	10 522052 6088554

Table B2. UTM coordinates for the uppermost extent of Kokanee spawner observations during aerial enumeration surveys conducted in 2002, 2006, 2010, 2018, and 2019 in 28 spawning tributaries of the Williston Reservoir.

		Uppermost location Kokanee observed						
Sub-Watershed	**Stream**	**2002**	**2006**	**2010**	**2018**	**2019**	**Barrier Location**	**Barrier type**
Finlay	Davis R	No Fish	10U 409456 6268631	No Data	10U 412017 6273944	10U 411666, 6273351	-	-
	Finlay R	No Fish	10U 320519 6378020	9U 673145 6383941	9U 673027 6384331	No Fish	9U 673027 6384331	Chute/Falls
	Bower C	No Fish	9U 678417 6370402	No Survey	9U 676274 6367730	9U 678045 6369612	-	-
	Cutoff C	No Fish	9U 674474 6380592	9 668002 6382562	9U 669577 6381585	9U 668511 6382426	-	-
	Russel C	No Data	No data	10U 347697 6345684	10U 347575 6345757	10U 349111 6345447	-	-
	Tsaydiz C	No Survey	10U 367761 6322172	10U 367023 6321735	10U 367741 6322157	10U 367413 6321897	-	-
	Pelly C	No Data	10U 348670 6301820	10 345523 6304169	10U 347517 6302859	10U 349678 6299451	-	-
	Pelly Lake outlet (Zygadene Creek)	No Survey	10U 351135 6302271	No Survey	10U 350060 6302190	10U 350394 6302489	-	-
	Swannell R	No Fish	10U 369154 6279820	10U 369186 6279670	10U 370951 6287752	10U 370692 6286281	10U 368290 6278830	Falls
	Aley C	No Data	No data	10U 448321 6262260	10U 444319 6259449	10U 443963 6259437	-	-
Omineca	Mesilinka R	No Fish	10U 379102 625551	10U 380855 6254783	10V 368755 6247991	10U 404896 6227379	-	-
	Germansen R	No Data	10U 395242 6179108	10U 396341 6177637	10U 395257 6179308	10U 395202 6179911	-	-
	Osilinka R	No Data	10U 374534 6223328	10U 373826 6223322	10U 388061 6221646	10U 389043 6220816	-	-
	Dead Bear C	No Data	10U 387604 6221759	Not Surveyed	10U 386595 6222859	10U 387523 6221847	-	-
	Silver C	No Survey	10U 346180 6181292	10U 346666 6181233	10U 346680 6181213	10U 346769 6181182	-	-
Peace	Carbon C	No Fish	No Data	10U 522594 6196123	10U 521943 6199539	10U 521829 6199627	10U 521943 6199539	Chute/Cascade

		Uppermost location Kokanee observed						
Sub-Watershed	**Stream**	**2002**	**2006**	**2010**	**2018**	**2019**	**Barrier Location**	**Barrier type**
	Clearwater R	No Fish	10U 490095 6191235	10U 490766 6189219	10U 490900 6188861	10U 490378 6192267	-	-
	Dunlevy C	No Data	10U 537699 6225870	10U 537127 6228534	10U 537153 6228541	10U 537134 6228459	10U 537127 6228534	-
	Nabesche R	No Fish	10U 490878 6223936	10U 492813 6228608	10U 492050 6227637		10U 492813 6228608	Falls
	Gething Creek	No Survey	No Survey	Not Surveyed	No Fish	No Survey	10U 547192 6206584	-
	11 Mile Creek	No Survey	No Survey	Not Surveyed	No Survey	10U 521518 6199521	10U 521286 6199581	Falls
Parsnip	Cut Thumb C	No Data	10U 481643 6156589	10U 480984 6155972	No Fish	No Fish	10U 481662 6156594	-
	Scott C	No Data	No data	10U 466342 6177932	No Fish	No Fish	-	-
	Philip Creek	No Data	10U 462037 6126802	10U 460479 6128299	No Fish	No Fish	-	-
	Upper Manson R (above lakes)	No Survey	No Fish	No Fish	No Fish	10U 409863 6170949	-	-
	Lower Manson R (below lakes)	No Data	10U 410076 6170891	No data	10U 459094 6129079	No Fish	-	-
	Parsnip River	No Data	10U 504225 6104817	No Fish	No Fish	No Fish	-	-
	Misinchinka R	No Data	10U 508856 6109016	10U 507844 6108148	No Fish	No Fish	-	-
	Reynolds C	10U 521308 6087799	No Fish	No Fish	No Fish	No Fish	-	-

Table B3. Kokanee spawner abundance for each of the 29 tributaries surveyed in 2002, 2006, 2010, 2018 and 2019 in the Williston Reservoir. Index streams recommended for annual spawner monitoring by Langston (2012) are highlighted in yellow. Note - not all streams were surveyed every year (NS = Not surveyed). *Data for the Finlay River from 2018 and 2019 were excluded from analysis since surveys began upstream of Cutoff Creek (not at river mouth as in previous years). **No data for 2002 so 2003 data used to allow comparisons.

Sub-Watershed	Stream	2002	2003	2006	2007	2010	2018	2019
		Total	Total	Total	Total	Total	Total	Total
Finlay	Aley Creek	36	200	1,700	NS	12,992	6,145	1,330
	Cutoff Creek	NS	0	93	NS	41555	8090	4690
	Bower Creek	**0**	**0**	**16,000**	**24,100**	**NS**	**9,230**	1,810
	Davis River	0	NS	700	NS	56,120	631	230
	Finlay River*	0	20	33,200	NS	26,8756	2,250	0
	Pelly Lake Outlet (Zygadene)	NS	NS	400	NS	NS	5,295	2,440
	Pelly Creek	**300**	**1,300**	**28,500**	**13,300**	**54,406**	**9,040**	**775**
	Russel Creek	**468**	**3,200**	**51,500**	**29,400**	**147,080**	**45,510**	**19,025**
	Swannell River	**0**	**2,100**	**10,400**	**12,300**	**9,526**	**210**	**570**
	Tsaydiz**	**0**	**0**	**6,400**	**11,700**	**31,590**	**13270**	**2940**
Omineca	**Germansen River**	**20,000**	**35,500**	**108,000**	**36,000**	**34,789**	**7,825**	**1,390**
	Mesilinka River	0	0	15,400	NS	49156	49352	20
	Osilinka River	**36,800**	**114,600**	**246,800**	**240,700**	**11,1236**	**22,450**	**2,090**
	Dead Bear	1,800	200	1,800	NS	NS	1,704	60
	Silver Creek	NS	NS	300	NS	8,292	705	1,900
Parsnip	Cut Thumb	10	200	1,800	NS	356	0	0
	Manson River (below lakes)	**3,800**	**12,600**	**31,300**	**6,500**	**1,538**	**270**	**0**
	Manson River (above lakes)	NS	NS	0	0	0	0	210
	Misinchinka River	1500	0	4200	NS	2257	0	0
	Parsnip River	50	0	300	NS	0	0	0
	Philip Creek	200	1,100	1800	NS	5	0	0
	Reynolds Creek	500	0	0	NS	0	0	0
	Scott Creek	50	0	3000	NS	2375	0	0
Peace	Carbon Creek	0	0	49	NS	4388	1186	135
	Clearwater River	**0**	**0**	**1,300**	**2**	**4,012**	**550**	**15**
	Dunlevy Creek	200	16	75	NS	16,014	1,481	375
	Nabesche River	0	0	700	NS	10,409	10,80	650
	Gething Creek	NS	NS	NS	NS	NS	0	NS
	11 Mile Creek	NS	NS	NS	NS	NS	NS	15
	Total Kokanee	**65,714**	**171,016**	**518,117**	**374,002**	**598,096**	**184,024**	**46,470**

Table B4. Kokanee spawner abundance for each of the all spawning tributaries surveyed in 2010, 2018 and 2019 with minimum and maximum values calculated based on confidence ratings (see Table 1). Index streams recommended for annual spawner monitoring by Langston (2012) are highlighted in yellow. Note - not all streams were surveyed every year (NS = Not surveyed). *2018 and 2019 data for the Finlay River were excluded from analysis since 2018 survey began upstream of Cutoff Creek (not at river mouth as in previous years).

Sub-Watershed	Stream	2010			2018			2019		
		Total	Min	Max	Total	Min	Max	Total	Min	Max
Finlay	Aley Creek	12,992	10,587	15,397	6,145	5,030	7,261	1,330	1,131	1,530
	Cutoff Creek	41,555	33,587	49,523	8,090	6,350	9,830	4,690	3,696	5,684
	Bower Creek**	**NS**			**9,230**	**7,100**	**11,360**	**1,810**	**1,496**	**2,124**
	Davis River	56,120	45,685	66,556	631	534	728	230	196	265
	Finlay River*	268,756	211,893	325,619	2,250	1,733	2,768	0	0	0
	Pelly Lake Outlet (Zygadene)	NS			5,295	4,126	6,464	2,440	2,074	2,806
	Pelly Creek	**54,406**	**43,830**	**64,982**	**9,040**	**7,014**	**11,066**	**775**	**659**	**891**
	Russel Creek	**147,080**	**114,386**	**179,775**	**45,510**	**34,379**	**56,642**	**19,025**	**14,894**	**23,066**
	Swannell River	**9,526**	**7,822**	**11,230**	**210**	**166**	**254**	**570**	**485**	**656**
	Tsaydiz**	**31,590**	**25,232**	**37,949**	**13,270**	**10,323**	**16,217**	**2,940**	**2,424**	**3,456**
Omineca	**Germansen River**	**34,789**	**28,156**	**41,422**	**7,825**	**6,285**	**9,365**	**1,390**	**1,182**	**1,599**
	Mesilinka River	49,156	39,959	58,353	49,352	38,235	60,469	20	17	23
	Osilinka River	**111,236**	**86,338**	**136,134**	**22,450**	**17,468**	**27,433**	**2,090**	**1,777**	**2,404**
	Dead Bear	NS			1,704	1,361	2,047	60	51	69
	Silver Creek	8,292	6,693	9,891	705	569	841	1,900	1,615	2,185
Parsnip	Cut Thumb	356	303	409	0	0	0	0	0	0
	Lower Manson River (below lakes)	**1,538**	**1,307**	**1,769**	**270**	**225**	**316**	**0**	**0**	**0**
	Upper Manson River (above lakes)	0	0	0	0	0	0	210	179	242
	Misinchinka River	2,257	1,837	2,677	0	0	0	0	0	0
	Parsnip River	0	0	0	0	0	0	0	0	0
	Philip Creek	5	4	6	0	0	0	0	0	0
	Reynolds Creek	0	0	0	0	0	0	0	0	0
	Scott Creek	2,375	1,969	2,781	0	0	0	0	0	0
Peace	Carbon Creek	4,388	3,630	5,146	1,186	904	1,468	135	115	155
	Clearwater River	**4,012**	**3,295**	**4,729**	**550**	**441**	**659**	**15**	**13**	**17**
	Dunlevy Creek	16,014	13,387	18,641	1,481	1,171	1,791	375	319	431
	Nabesche River	10,409	8,466	12,352	1,080	872	1,288	650	553	748
	Gething Creek	NS			0	0	0	NS		
	Total Kokanee	**598,096**	**476,472**	**719,720**	**184,024**	**142,553**	**225,495**	**40,670**	**32,979**	**48,368**

Table B5. Site coordinates, number of fish sampled, collection date, and average length (fork length) and weight of Kokanee from all sites where collections were conducted in 2019. Average values represent the mean ± standard deviation. All Kokanee were transferred to project collaborators at UNBC for detailed analysis as directed by MFLNRORD.

COLLECTION SITE	STREAM	COLLECTION DATE	FISH COLLECTED	AVERAGE LENGTH (CM)	AVERAGE WEIGHT (G)	UTM CORRDINATES
Russel Creek	Russel Creek	Sept 14, 2019	40	22.2 ± 1.0	107.5 ± 16.4	10 353084, 6343305
Aley Creek	Russel Creek	Sept 15, 2019	43	21.9 ± 1.0	124.3 ± 23.9	10 443205, 6259285
Germansen River		Sept 16, 2019	40	21.3 ± 1.0	106.9 ± 14.9	10 394374, 6183287
*Finlay River Site 1	Finlay Side Channel	Oct 22, 2019	7	20.8 ± 0.95	87.9 ± 14.6	10 368846, 6328585
*Finlay River Site 2	Akie River	Oct 22, 2019	13			10 373436, 6323873
Arctic Lake	Arctic Lake	June 28, 2019	18	18.5 ± 0.72	74.7 ± 6.3	10 584966, 6031854

* Note – Kokanee were collected from two locations along the Finlay River in 2019. Site 1 consisted of a side channel of the Finlay River located approximately 8 km north of the Akie River mouth, while Site 2 was located approximately 3 km upstream on the Akie River itself. Fish data were combined between the two sites for body length and weight averages (n = 20 fish total).