

# Deadman Creek Chinook Restoration and Instream Incubation Project (Year 3)



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Down to Earth Biology

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## EXECUTIVE SUMMARY

This project continued to test the use of instream egg incubation to restore a Chinook spawning population to Deadman Creek, a tributary of Teslin Lake in the Teslin River watershed. Local knowledge indicates that Deadman Creek historically had a small spawning population; however, the specific reason why spawning no longer occurs in the stream or the size of the former run are unknown. The 2018 project involved the following components: water temperature monitoring, hydrometric monitoring, juvenile monitoring, instream egg incubation and success monitoring.

The juvenile monitoring was conducted during June, July and September 2018 to expand baseline information of juvenile habitat utilization in the stream. Capture rates for juvenile Chinook salmon increased during July and September with the greatest number captured during September. Non-natal juvenile Chinook migrate into Deadman Creek during the mid- to late summer and it is unclear whether smaller juveniles captured during July to September originated from eggs planted in the stream during August 2017. The instream egg incubation component involved site preparations in both Deadman Creek and the control stream (Morley River) to construct artificial redds with stream substrate to mimic natural conditions. Brood stock for the project was collected in Morley River and eggs and milt were transported to Deadman Creek. A cumulative total of 22,604 eggs were planted at 11 discrete sites in Deadman Creek and 13,325 eggs were planted at four sites in Morley River in the vicinity of the Alaska Highway crossing to serve as controls. Eggs were planted in Deadman Creek and Morley River from August 12 to 17, 2018, using three methods: Whitlock-Vibert boxes to determine hatching success, closed mesh bags (insertion pipe in a bag) to determine emergence success, and egg insertion pipes to increase the number of eggs planted. Hatching success as determined by Whitlock-Vibert boxes was generally high in Morley River with mean survival of 75% and a range of 34-97%. Hatching data from Deadman Creek was highly variable between sites; however, the overall average was 44% with a range of 5-97%. Through the use of specially designed closed mesh bags, it was possible to determine survival through to the emergence stage. In Morley River, the mean emergence rate was 69% with a range of 29-90% and in Deadman Creek a mean of 11% with a range of 0-37%. However, two of the egg planting sites in Deadman Creek froze to bed and if these two sites are removed, the mean emergence would be 14%. Caution should be taken when comparing these results given that the incubation conditions at the Morley River egg planting sites are very good and may not be representative of most spawning areas in the Yukon River watershed. Water temperatures and associated accumulated thermal units (ATU) data were considerably different between Morley River and Deadman Creek. Egg development was considerably quicker in Morley River, with egg hatching taking place during early to mid October and emergence during March/April. Due to colder water temperatures, egg hatching occurred in Deadman Creek during mid-January and at ATUs which were considerably lower than what is published for this species in the literature. Fry emergence occurred in Deadman Creek during June 2018. Analysis of ATU data indicates that at cold temperatures, the eggs and alevin in Deadman Creek continue to develop at a rate equivalent to approximately 1.6 temperature units per day.

The methods used for this trial project and the results gathered suggest that the approach used has merit for reintroducing a spawning population to Deadman Creek. The 2018/2019 project was done much more efficiently due to the lessons learned over the duration of the 2017/2018 project.



## ACKNOWLEDGEMENTS

Gillian Rourke and James McGrath of the Teslin Tlingit Council contributed significantly to all aspects of this project and assisted with the planning and field components of the project. Trix Tanner (Salmonid Enhancement Program - Fisheries and Oceans Canada) assisted with project permitting and provided advice on overall project direction. Teslin Tlingit Council Salmon Steward Cordell Jules and Environment Yukon summer students Justine Benjamin and Luka van Randen provided valuable field assistance to the instream egg incubation portion of the project. Funding for this project was provided by the Yukon River Panel's Restoration and Enhancement Fund.

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## TABLE OF CONTENTS

<b>1</b>	<b>INTRODUCTION .....</b>	<b>1</b>
1.1	OBJECTIVES.....	2
<b>2</b>	<b>METHODS.....</b>	<b>4</b>
2.1	WATER TEMPERATURE MONITORING .....	4
2.2	HYDROMETRIC MONITORING.....	4
2.2.1	Stream Discharge .....	4
2.2.2	Water Surface Elevation Survey.....	5
2.2.3	Continuous Record.....	5
2.3	JUVENILE MONITORING .....	6
2.4	INSTREAM EGG INCUBATION.....	9
2.4.1	Site Selection and Preparation.....	9
2.4.2	Broodstock Collection .....	12
2.4.3	Egg Fertilization.....	12
2.4.4	Egg Deployment.....	12
2.4.5	Spot Velocity Measurements.....	13
2.5	SUCCESS MONITORING .....	13
2.5.1	Morley River.....	13
2.5.2	Deadman Creek .....	14
<b>3</b>	<b>RESULTS.....</b>	<b>15</b>
3.1	WATER TEMPERATURE MONITORING .....	15
3.2	HYDROMETRIC MONITORING.....	17
3.3	JUVENILE MONITORING .....	19
3.4	INSTREAM EGG INCUBATION.....	24
3.4.1	Site Preparation .....	24
3.4.2	Broodstock Collection .....	24
3.4.3	Egg Fertilization and Deployment .....	24
3.4.4	Spot Velocity Measurements.....	26
3.5	SUCCESS MONITORING .....	27
3.5.1.1	Morley River.....	27
3.5.1.2	Deadman Creek .....	28
<b>4</b>	<b>DISCUSSION.....</b>	<b>31</b>
<b>5</b>	<b>CONCLUSION.....</b>	<b>33</b>
<b>6</b>	<b>LITERATURE CITED.....</b>	<b>34</b>

## LIST OF APPENDICES

### APPENDIX A. PHOTOGRAPHS



## LIST OF TABLES

Table 1.	Stage-discharge measurements for at Site DC02 in Deadman Creek from June 8, 2018 to June 5, 2019.....	18
Table 2.	Summary of Deadman Creek juvenile Chinook monitoring during 2018. ....	19
Table 3.	Summary of egg planting in Deadman Creek and Morley River.....	25
Table 4.	Spot velocity measurements collected at all artificial redds and four natural redds using a Swoffer velocimeter, August 2018.....	26
Table 5.	Summary of Morley River Whitlock-Vibert box hatching results (October 3, 2018).....	27
Table 6.	Summary of Morley River closed mesh bag emergence results (February and April 2019). ....	28
Table 7.	Summary of Deadman Creek Whitlock-Vibert box hatching results (April and June 2019). ....	29
Table 8.	Summary of Deadman Creek emergence success as determined by closed mesh bags (June 29, 2019).....	30

## LIST OF FIGURES

Figure 1.	Water temperatures at egg planting sites in Deadman Creek and Morley River from the timing of egg planting through to fry emergence. ....	16
Figure 2.	Stage-discharge hydrograph at Site DC02 in Deadman Creek from June 8, 2018 to June 5, 2019.....	18
Figure 3.	Deadman Creek juvenile Chinook fork length frequencies from June, July and September 2018.....	23
Figure 4.	Accumulated thermal units (ATUs) at egg planting sites in Deadman Creek during the 2018/2019 incubation period.....	32
Figure 5.	Accumulated thermal units (ATUs) using a minimum base rate development of 1.6 °C per day at egg planting sites in Deadman Creek during the 2018/2019 incubation period. ....	32



## 1 INTRODUCTION

Chinook salmon are a vitally important resource for Teslin Tlingit citizens, being both culturally significant and important for subsistence. Chinook salmon must successfully migrate through all fisheries on the mainstem Yukon River in both Alaska and Yukon to return to the Teslin River watershed; additionally there are environmental threats such as predators and changing river conditions (e.g., temperature, rainfall) along the length of the river. Given the length of the Chinook salmon migration back to the Teslin River watershed, the health of this run has long been understood by the Teslin Tlingit as an important indicator of the overall health and strength of the Yukon River Chinook salmon run. In response to alarming and enduring declines in returning Chinook salmon, Teslin Tlingit Council (TTC) has been taking action for over 15 years, on a local, territorial, and international scale to conserve the Chinook run for future generations, the health of the environment, and for all fishers throughout the watershed.

Chinook salmon in the Teslin River watershed have one of the longest salmon migrations in North America with the headwaters of the Teslin River being nearly 3,000 km upstream from the Bering Sea. During the 2002 and 2003 drainage-wide Chinook telemetry project, the longest distance travelled by a tagged Chinook was located in the Teslin River watershed (Mercer and Eiler 2004). This individual was relocated in the McNeil River, a tributary of the upper Nisutlin River and had travelled nearly 2,700 km upstream from the tagging site on the lower Yukon River (Mercer and Eiler 2004). The Teslin River watershed is also a major spawning destination for Canadian-origin Chinook; the results from the in-season genetic analysis at Eagle, AK during 2016 indicated that 35% of the 2016 Canadian Chinook escapement were of Teslin River origin (JTC 2017).

Deadman Creek is a clear water tributary of Teslin Lake which flows into the lake 30 km north of the community of Teslin, YT (Map 1). The total drainage area of the watershed is approximately 150 km<sup>2</sup> and the stream is relatively accessible with the lower reaches accessed from the Alaska Highway crossing and an adjacent gravel pit access road. Adult Chinook salmon have not been observed in the creek in recent years (Wilson 2003), although local knowledge indicates that the stream once had a spawning population. Chinook carcasses were observed in the stream and had been incidentally caught by local fishers before large beaver dams began populating the creek. It is presumed that when the lower 10-15 kms of the creek were burned by a forest fire that this created ideal habitat for beaver due to the regrowth of deciduous vegetation (Wilson 2003). The creek was the focus of active beaver management and monitoring of juvenile Chinook utilization by TTC between 2001 and 2006 (Wilson 2003, 2004, 2005). This monitoring indicated various beaver dams in varying conditions; juvenile Chinook were, however, captured upstream of all dams including the uppermost sampling station located 8 km upstream of Teslin Lake. At the time of these surveys, the creek was actively forming a new channel around the largest beaver dam located in the lower reaches of the creek. Recent observations indicate that during periods of low flow, beavers are capable of establishing dams in the stream; however, the majority of current beaver activity is located outside of the main channel. Previous reports consistently recommended that methods to restore a spawning Chinook population to Deadman Creek be investigated (Wilson 2003, 2004, 2005).

The current project was designed to build on a 2015 project funded by a Yukon River Panel Restoration & Enhancement project to identify a Chinook salmon stock restoration project in the Teslin River watershed.





The 2015 project identified Deadman Creek as a suitable candidate for such a project due to the current lack of a spawning population and local/traditional knowledge which indicated that this was once a spawning stream. Habitat observations made during 2015 indicated appropriate flow and substrate for Chinook spawning and highly suitable juvenile rearing habitat. Consideration of this information resulted in the development of the 2016 and 2017 projects to re-introduce a spawning population of Chinook salmon using in-stream egg incubation methods, and to establish control sites in Morley River, which is a spawning area currently used by Chinook. The inclusion of the egg deployment sites in Morley River allowed for the same methods used in Deadman Creek to be tested in a location with habitat currently known to be suitable for spawning and egg incubation, providing additional perspective on the effectiveness of these methods as a restoration tool.

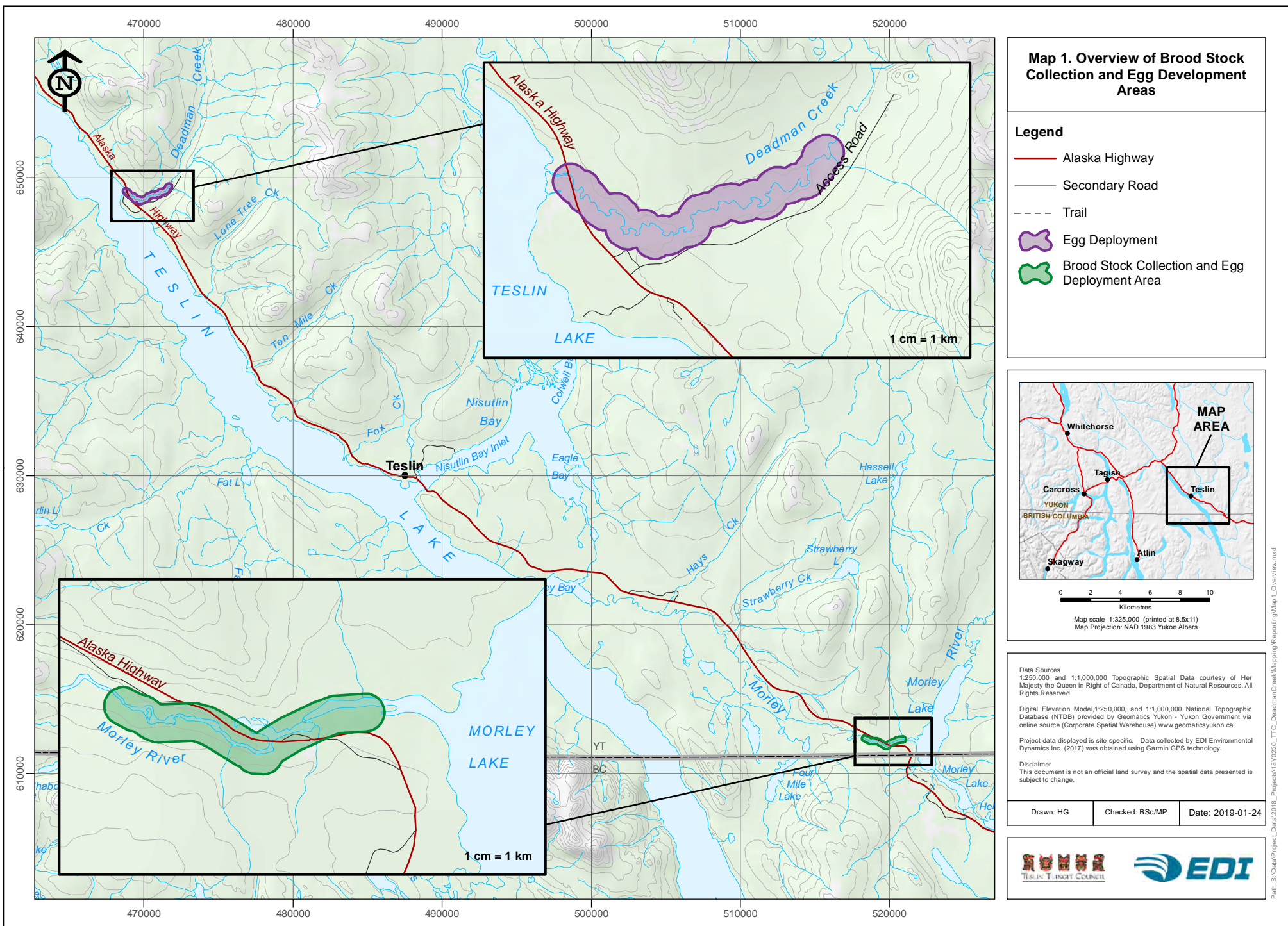
The 2016 project planted a total of 6,524 fertilized eggs in Deadman Creek and 5,957 in Morley River with a mean hatching rate of 55% on Deadman Creek and 87% on Morley River (EDI 2017). During 2017, the number of eggs planted was increased to 27,712 in Deadman Creek and 7,513 in Morley River. Hatching success was very similar to the 2016 project with a mean of 56% in Deadman Creek and 85% in Morley River (EDI 2018). During both years, survival was variable both with and between sites. The 2017 project involved the development of a custom designed closed mesh bag which allows the alevin to be contained and provide a survival estimate through to the emergence period. A small number of such bags were used in each stream and ranged from 91-94% survival to emergence in Morley River and 2-60% in Deadman Creek.

## 1.1 OBJECTIVES

The overall objective of this project is to begin to restore a self-sustaining Chinook spawning population to Deadman Creek through the use of egg planting which is a culturally appropriate method for the TTC. The 2018 project built upon the 2016 and 2017 projects and increase planting efficiency, with many improvements from lessons learned in previous years. The project also provided a unique learning opportunity to test the egg planting methods to determine the utility of this method for restoring Chinook stocks elsewhere in the Yukon River watershed. The specific objectives of the project were as follows:

- Deploy up to 60,000 fertilized Chinook eggs into Deadman Creek and Morley River (combined) to test the feasibility of egg planting methods to restore Chinook stocks in the Teslin River watershed.
- Conduct follow up monitoring during the winter and spring to determine the fate of the planted eggs in both streams.
- Conduct a juvenile Chinook sampling program during the summer of 2018 to collect data on habitat utilization by non-natal juveniles and the current status of beaver dams and/or other barriers to fish passage.
- Provide local capacity building and technical training/employment for TTC staff and local field assistants.







## 2 METHODS

### 2.1 WATER TEMPERATURE MONITORING

Water temperature monitoring during 2018 involved the retrieval and redeployment of surface water temperature loggers originally deployed during 2015 and 2016 (EDI 2016, 2017) in Deadman Creek and Morley River. New loggers were also deployed during 2018 in conjunction with the egg planting sites in each of Deadman Creek and Morley River (see Section 2.4.4 below for additional information). All temperature loggers used with Tidbit V2 loggers programmed to record hourly water temperature data.

### 2.2 HYDROMETRIC MONITORING

Hydrometric monitoring for this project (Deadman Creek) is comprised of three components: continuous water level monitoring, water level surveys and discharge measurements. The objective of this monitoring is to monitor changes in water levels during the egg incubation period (short term) and, over the longer term, establish a continuous record of water levels and discharge at site 2 to inform the characterization of the aquatic habitat throughout the year.

EDI staff re-installed the Deadman Creek hydrometric station on June 8, 2018 at a new, more secure location. The station consists of a stilling well, continuous water level logger, continuous barometric pressure logger, staff gauge and water level survey benchmarks.

Open water season water level surveys and discharge measurements have been conducted in 2017 (three data points), in 2018 (one data point) and 2019 (two data points). Winter discharge was also measured in February 2018 and February 2019.

Additional water level surveys and discharge measurements in high and low flow conditions during open water season are required in order to develop a rating curve (water level – discharge relationship) and derive a continuous discharge based on the water level logger continuous record.

#### 2.2.1 STREAM DISCHARGE

The velocity-area mid-section method will be used to determine discharge at hydrometric stations where channel criteria meet those outlined in standard guidance documents (RISC 2009; WSC 1999). Cross-section locations are located in close proximity to continuous data logger installations. The current meter used to obtain the velocity measurements is a 2-dimensional, side looking, FlowTracker2 Handheld Acoustic Doppler Velocimeter (ADV) (Sontek/Xylem 2016) or alternatively a Swiffer Model 2100 Current Velocity Meter. Discharge results are reported in  $\text{m}^3/\text{s}$ .



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## 2.2.2 WATER SURFACE ELEVATION SURVEY

Typically, an elevation survey is completed during each hydrometric station visit in open water season. The purpose of these surveys is to tie the data logger water levels to the local station datum. The station has a local, relative datum defined by benchmarks in close proximity to the data logger and stilling well. Three benchmarks are installed at each continuous station as per RISC (2009) Data Grade A guidelines. Each survey includes a survey with a level and rod for Benchmark 1 (BM1), Benchmark 2 (BM2), Benchmark 3 (BM3), the top of the staff gauge (TOS), the water surface elevation (WATER) and the elevation of the fixed-length logger apparatus (TOR). The elevation of Benchmark 1 at every station defines a local elevation of 100.000 m above datum. The local datum is always located below the elevation of zero flow.

The benchmarks and the top of the staff gauge are regularly checked for shifting as a result of periglacial processes and survey error. While there is some apparent movement in the benchmark elevations and occasionally anomalous survey data, the water surface elevation data will be carefully reviewed using staff gauge readings and the field records of stilling well maintenance (logger or staff gauge shifts) before applying local datum offsets to the raw data logger record. All suspect data is excluded from the corrected data. All stage (i.e. water surface elevation) data is presented in metres referenced to the local datum unless otherwise noted.

Surveys are not completed during the winter because stage elevations are affected by ice, changing the relationship between stage and discharge; rating curves are not developed for the winter period.

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## 2.2.3 CONTINUOUS RECORD

One Solinst Edge Levellogger pressure transducer was installed in the stilling well of the hydrometric station. One Solinst Edge Barologger barometric pressure transducer is installed on a tree near the station to compensate the water level loggers for atmospheric pressure. Readings are set at 15-minute intervals to create a continuous record. The pressure transducers are downloaded on each site visit. Pressure in water is recorded in metres of water column, atmospheric pressure in kPa and converted in metre of water column equivalent using a factor of 0.101972. Continuous stage is the result of total pressure in water minus the atmospheric pressure, which result is offset to match water surface elevation surveyed with the local datum. Continuous discharge is calculated using the stage-discharge rating curve developed for the rating period. The continuous stage record (rather than discharge record) is presented until a reliable rating curve can be developed.

The barometric pressure transducer did not log data from February 26, 2019 to June 3, 2019 due to a programming error. This data gap is filled with the atmospheric pressure hourly record in kPa from the Teslin Airport meteorological station operated by Environment and Climate Change Canada - Meteorological Service of Canada.



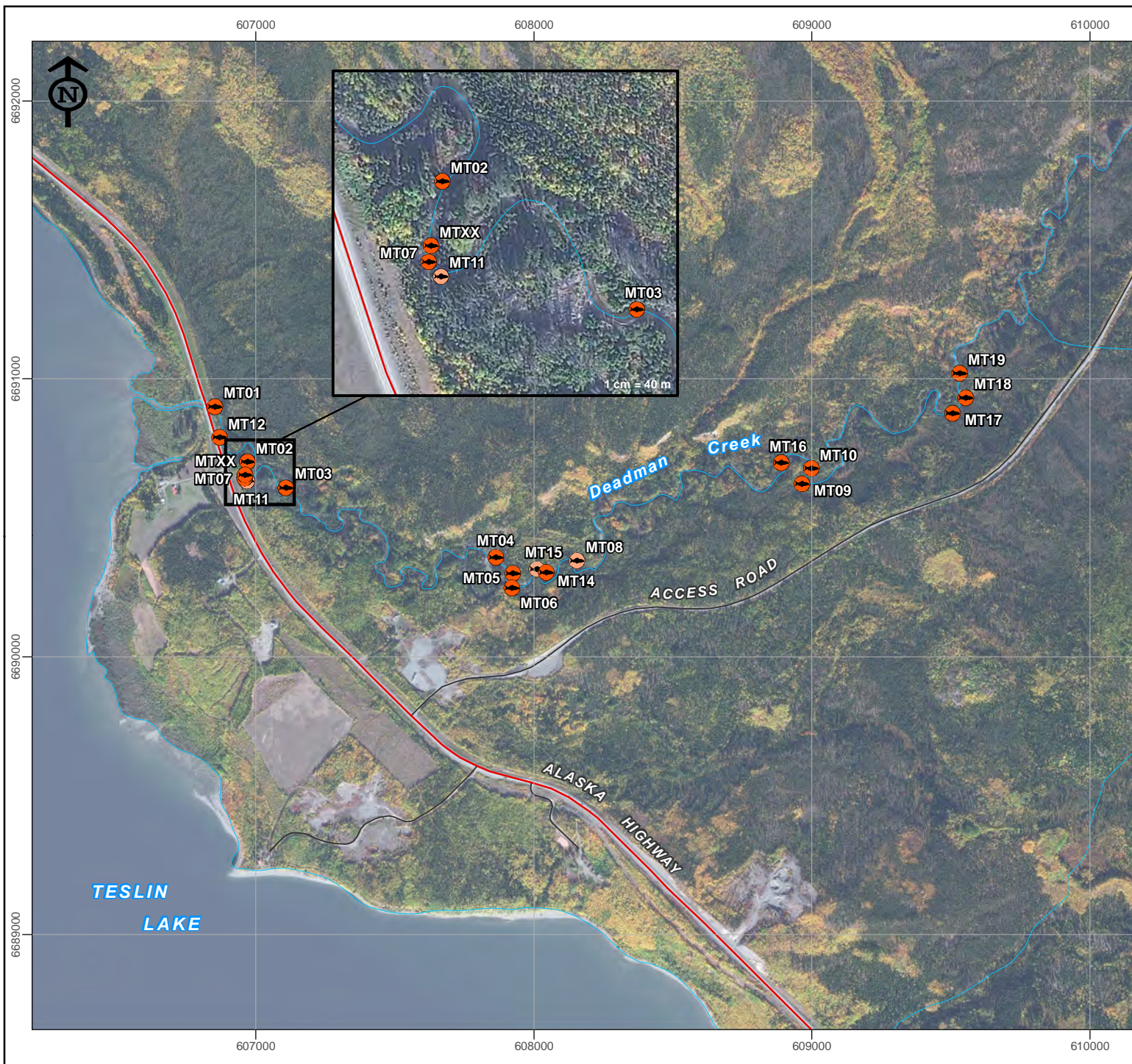
## 2.3 JUVENILE MONITORING

Sampling for juvenile Chinook was conducted in Deadman Creek on five occasions and Morley River on two occasions under a Scientific Fish Collection License issued by the Department of Fisheries and Oceans (DFO). Sampling occurred on June 7-8, June 19-22, July 16-18, July 29-31 and September 5-7, 2018 at Deadman Creek and June 19-20 and July 30-31 at Morley River (Map 2, Map 3).

Previous work conducted in the watershed noted that non-natal Chinook did not appear to be present during June and started to arrive in early July with numbers increasing later in the summer. The June sampling event was intended to confirm these previous observations and determine if sampling during the early summer may be able to provide an indication of fry hatched from eggs planted during August 2017. The July, August and September sampling events were intended to coincide with higher non-natal juvenile Chinook abundance in the stream and to build the existing data set of relative abundance and extent of habitat utilization in the stream.

All minnow trapping conducted consisted of 3-4 traps set at each station and all traps were baited with Yukon River origin salmon roe following Yukon River Panel (2007) protocols and left to soak overnight. Field crews measured water quality parameters (water temperature, pH, specific conductance and dissolved oxygen) collected for each station along with water depth and a general description of habitat. Digital photos were collected for all sampling stations along with GPS co-ordinates and set/pull times. Upon retrieval of the traps, all fish were counted and identified to species with a minimum of 10 individuals of each species from each trap measured for fork length. Across all sampling events, 206 trap sets were completed in Deadman Creek and 24 were completed in Morley River. Observations of the status of beaver dams and other potential barriers to fish passage in Deadman Creek were also recorded during the June and August sampling events.



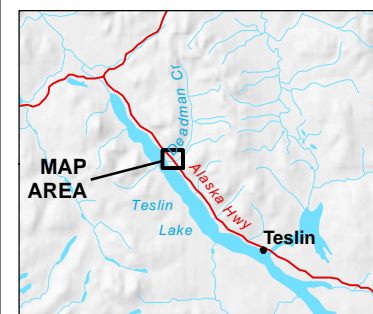


## Map 2. Juvenile Chinook Monitoring Locations in Deadman Creek

### Legend

#### Juvenile Chinook Monitoring Locations

-  2018
-  pre 2018
-  Alaska Highway
-  Secondary Road



Map scale 1:20,000 (printed at 8.5x11)  
Map Projection: NAD 1983 UTM Zone 8N

Data Sources  
Digital Elevation Model, 1:50,000, and 1:1,000,000 National Topographic Database (NTDB) provided by Geomatics Yukon - Yukon Government via online source (Corporate Spatial Warehouse) [www.geomatics.yukon.ca](http://www.geomatics.yukon.ca).

High Resolution Imagery provided by Geomatics Yukon - Yukon Government.

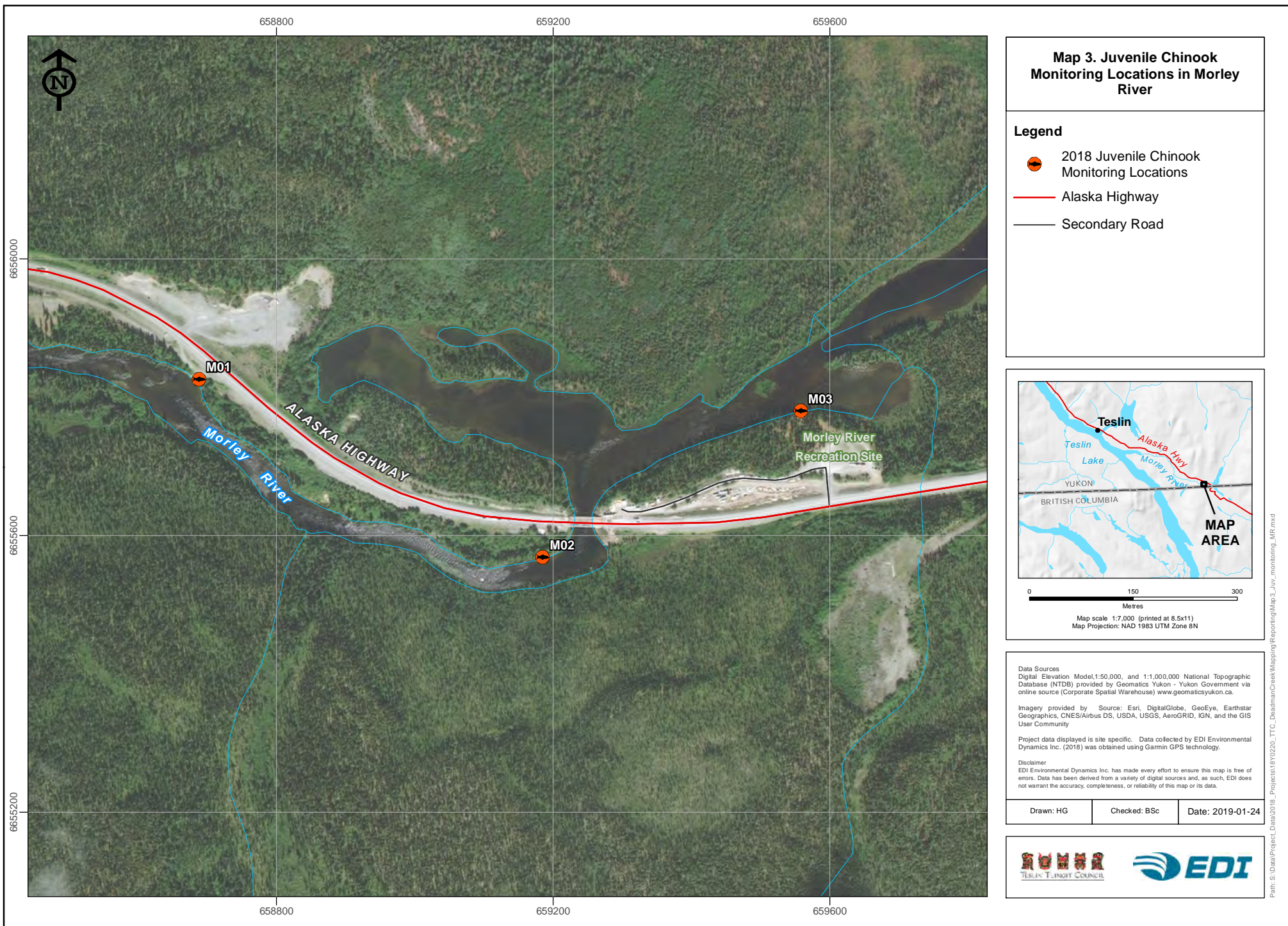
Project data displayed is site specific. Data collected by EDI Environmental Dynamics Inc. (2018) was obtained using Garmin GPS technology.

Disclaimer  
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## 2.4 INSTREAM EGG INCUBATION

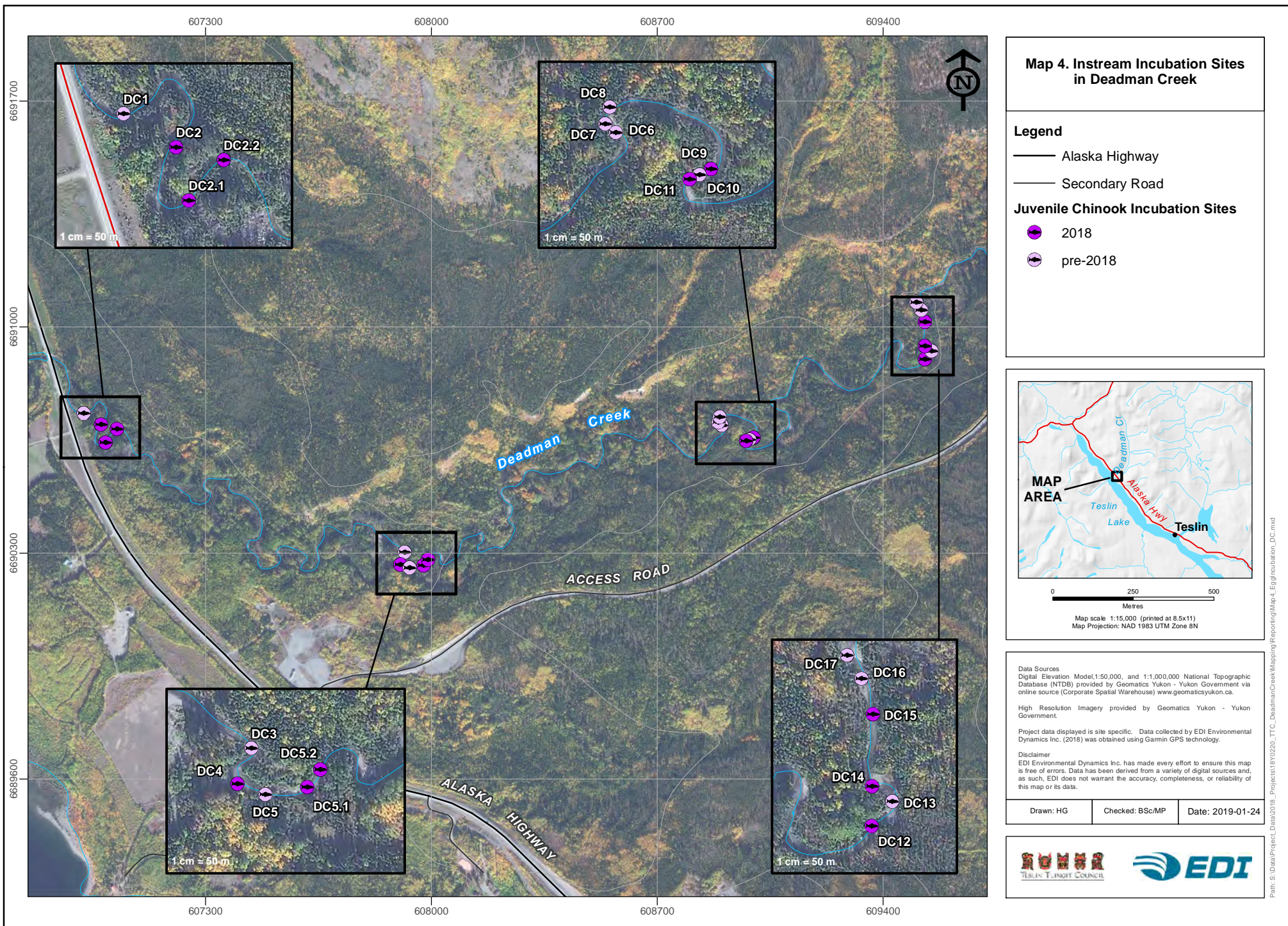
The project underwent a YESAB project review during the summer of 2017 was inclusive of the 2018 scope of work for the project. Permits were issued by DFO for the 2018 works and included a Scientific Fish Collection License for the brood stock collection and an Introduction, Transplant and Transport (ITT) permit for the egg planting in Deadman Creek and Morley River. The instream egg incubation (egg planting) component of the project involved the following components: site selection and preparation, brood stock collection, egg fertilization, egg deployment and spot velocity measurements.

### 2.4.1 SITE SELECTION AND PREPARATION

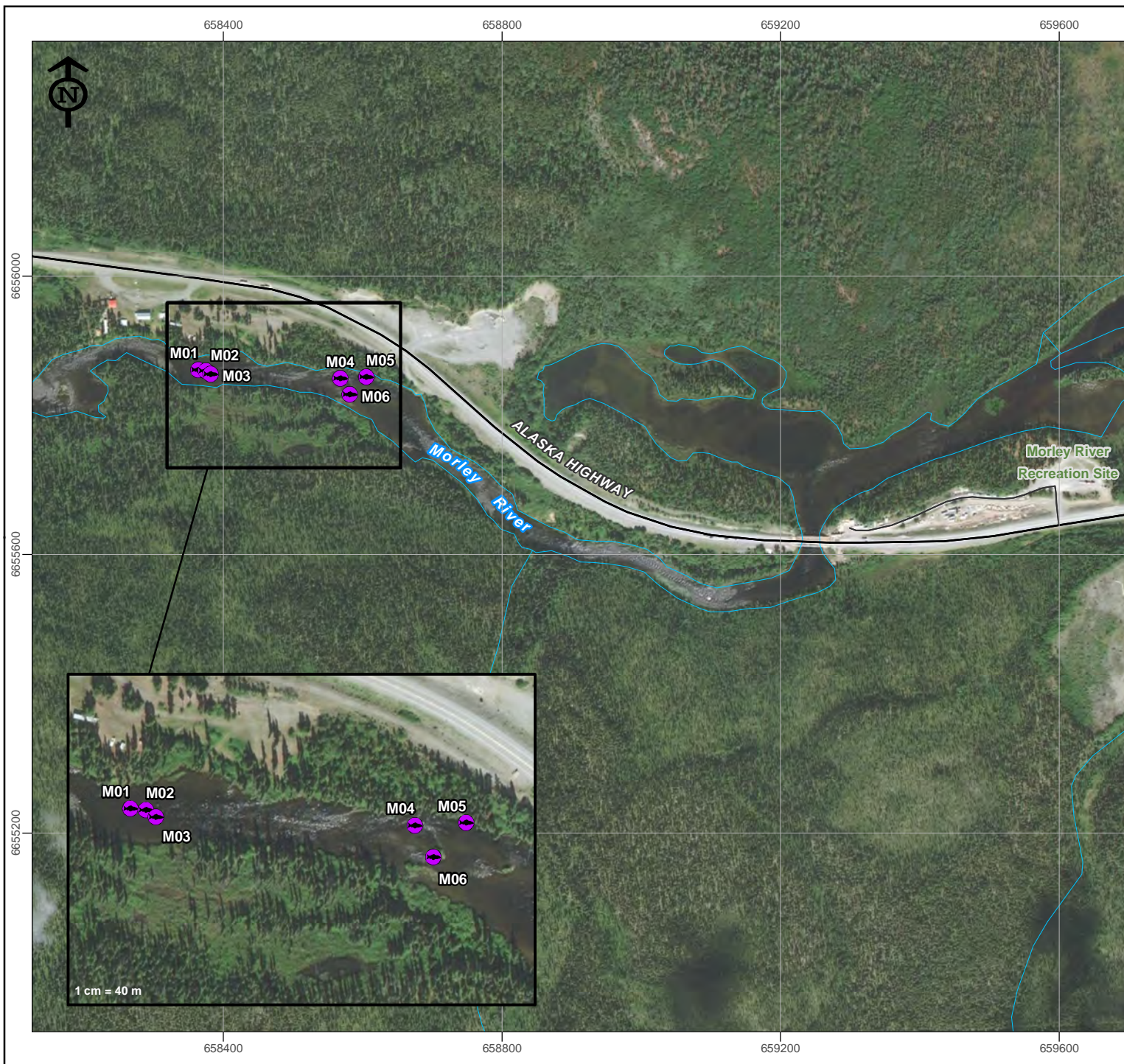
During the site selection process, 7 of the sites used during 2017/2018 were chosen for planting and four new sites were established (Map 4). Some of the older sites not planted were 2017/2018 were excluded due to less than ideal site conditions (DC01, DC03 and DC05) or an insufficient number of eggs available for planting. The four new sites were established due to their ease of accessibility and similarity of site conditions (water velocity and substrate) to sites which have had relatively high survival during previous years. In Morley River, all five of the egg planting sites used in previous years were once again used during 2018/2019 and a new, sixth site was established (Map 5).

At all sites in both streams, working/cleaning of the substrate was required to mimic the natural redd construction and to prepare each of these sites for the egg planting. This was accomplished by digging/raking of the streambed with hand tools. In Morley River, care was taken to avoid disturbance to natural Chinook redds of which a number were observed in the vicinity of the deployment sites. GPS co-ordinates were collected for all sites and a rock with a unique combination of colored flagging tape was placed on each prepared site to facilitate relocation of the sites. The final step of site preparation was to move all cleaned substrate to the sides of the deployment area thus leaving a trench. It was within this trench that the Whitlock-Vibert boxes, closed mesh bags and egg insertion pipes were placed during the egg deployment. After being planted into the stream, the incubation media were covered with the previously moved substrate and supplemented with additional stream substrate as needed.










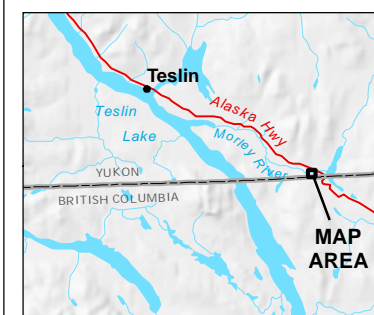
**Map 5. Instream Incubation Sites  
in Morley River**

**Legend**

- Alaska Highway
- Secondary Road

**Juvenile Chinook Incubation  
Sites**

-  2018



0 150 300  
Metres

Map scale: 1:8,000 (printed at 8.5x11)  
Map Projection: NAD 1983 UTM Zone 8N

Data Sources  
Digital Elevation Model, 1:50,000, and 1:1,000,000 National Topographic Database (NTDB) provided by Geomatics Yukon - Yukon Government via online source (Corporate Spatial Warehouse) [www.geomatics.yukon.ca](http://www.geomatics.yukon.ca)

Imagery provided by Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

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## 2.4.2 BROODSTOCK COLLECTION

Brood stock collection was conducted on Morley River in the vicinity of the Alaska Highway crossing from August 11-16, 2018. All fish handled were captured by angling/snagging, and visual observation counts of redds and spawning females were collected during the brood stock collection week to determine the number of spawners and redds present. A follow up site was conducted on August 25, 2018 to obtain a final count of the number of redds present within the portion of the river where brood stock was collected (Morley River downstream to the old lodge).

A step ladder was used in the river and on the river banks to assist field crews in obtaining a better view to observe Chinook. All Chinook salmon captured were measured from mid-eye to fork and snout to fork length, sexed, sampled for scales and genetics (paired auxiliary processes); scale and genetic samples were provided to DFO for analysis. Fish not suitable for brood stock (condition, ripeness, etc.) were released promptly and those to be used for brood stock were temporarily placed in holding tubes or bags to allow for eggs and milt to be collected simultaneously. All Chinook salmon captured were tagged with a brightly colored Floy tag near the base of the dorsal fin. Each tag had a unique identifier and different colors were used for males and females to make identification possible without having to recapture fish.

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## 2.4.3 EGG FERTILIZATION

When a sufficient number of males and females were captured to conduct an egg take, each fish had its vent carefully wiped dry and the eggs/milt were placed in new, dry plastic containers. Eggs were enumerated by weight to obtain an estimate of the total number collected. Eggs and milt were kept in a clean dark cooler with an ice pack to keep cool until fertilization.

Egg fertilization was conducted in close proximity to each egg planting site to reduce the amount of handling and transport into the stream. An umbrella was set up over the fertilization site to provide shelter from the rain and sun during the fertilization and water hardening process. Prior to fertilization, all eggs were mixed such that individual sites had a mix of eggs from various females. The fertilization was done in batches with only enough eggs to fertilize one to three sites to reduce the amount of egg holding time between fertilization and planting into the stream. Eggs were weighed to estimate the number required for each site(s) and milt from three males was used for each batch of fertilization. After being fertilized, the eggs were placed in the strainer to water harden and flush for 20 minutes before being loaded into the various incubation media for planting in the stream.

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## 2.4.4 EGG DEPLOYMENT

The egg deployment at each site involved the use of three methods including Whitlock-Vibert boxes, closed mesh bags and egg insertion pipes. Whitlock-Vibert boxes are a commercially available incubator of which each were loaded with 200 fertilized eggs and buried in the planting site. The closed mesh bags were 30 cm by 15 cm fine mesh bags filled with substrate using a shovel and buried in the planting site. An egg insertion pipe was used to deploy a predetermined number of eggs into the bag in an effort to mimic natural conditions





and provide a surrogate for monitoring the survival of eggs planted using an egg insertion pipes. Once the eggs were planted into the bag, the pipe was carefully removed, the zipper on the bag closed and the whole bag buried within the site. The mesh bags were constructed of fine mesh and were designed to hold either rocks to allow for the fate of all eggs/alevin to be determined following retrieval. Three to five egg insertion pipes were used at each site and provide a more rapid method of planting eggs; however, they are not contained and therefore obtaining a quantitative estimate of survival is not possible. The number of eggs planted using the pipes was dependent upon substrate conditions with larger amount of substrate (deeper) allowing for more eggs to be planted. Half of the eggs were placed into the pipe at a depth of approximately 25 cm below the surface of the bed, with the remainder deposited 5-10 cm closer to the bed surface. All incubation media were marked with a color combination of flagging tape unique to each planting site and sketched onto a site plan to facilitate success monitoring. Following the placement of all eggs at each site, previously cleaned substrate was piled into a mound to protect the eggs and mimic the construction of a natural Chinook redd.

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#### 2.4.5 SPOT VELOCITY MEASUREMENTS

Spot velocities were collected using a Swiffer velocity meter at all egg planting sites as well as on four natural redds in Morley River at the time of egg planting and also during the late winter success monitoring events. Measurements were collected at 60% of the water depth (standard for stream discharge measurements) and all directly above the bed with the latter providing a more adequate representation of intra-substrate flow. The spot velocities were collected to determine what flow rates Chinook salmon are spawning in and if this is a limiting factor in site selection. This information will also be used to compare success rates of each planting site to see if there is a correlation with flow rates.

### 2.5 SUCCESS MONITORING

Success monitoring was conducted from November 2018 through to June 2019 in Deadman Creek and October 2018 to April 2019 in Morley River. The primary objective of this monitoring was to determine survival to the alevin stage (Whitlock-Vibert boxes) and fry emergence stage (closed mesh bags).

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#### 2.5.1 MORLEY RIVER

The first monitoring event in Morley River was conducted on October 3, 2018 and was intended to retrieve all Whitlock-Vibert boxes to obtain a measure of hatching success. All boxes and incubators were removed from the substrate and brought to shore to process the contents. The contents were placed into a container with water, and the fate of all individuals was determined. Following counting, any dead eggs/alevin were removed and the live alevins were placed back into the substrate of the initial egg planting site using an egg insertion pipe. A portion of the egg insertion pipe sites were also investigated via snorkeling and hand



excavation to obtain a qualitative estimate of egg survival in relation to the quantitative results to the Whitlock-Vibert boxes.

The second monitoring event was conducted in Morley River on February 24, 2019 with the objective of checking on the development status of the alevin in the closed incubation media. Three of the six closed mesh bags were retrieved; however, it was determined that the alevin/fry were not quite at the emergence stage and therefore the final three sites were left in place until April 11, 2019. Each bag was excavated from the site and brought to the shoreline. The rocks within the bag were carefully removed and any live emergent fry placed into a container of water. Enumerating dead eggs and alevin with the bag is often not possible; however, efforts were made to quantify these occurrences as well. Following being counted, measured and photographed, the free-swimming fry were released into a slack water area along the shoreline.

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### 2.5.2 DEADMAN CREEK

Based upon the results of previous year's monitoring (EDI 2017), it is known that hatching in Deadman Creek occurs during the winter months and is delayed compared to Morley River due to colder water temperatures. For this reason, comprehensive monitoring of egg survival was not conducted in Deadman Creek late winter. Past monitoring events have indicated that the removal of ice at the planting sites during the mid-winter results in changes to flow/ice conditions and may adversely affect egg survival.

A site visit was completed to site DC04 on November 2, 2018 to retrieve a Whitlock-Vibert box as a source of eggs for the Salmon in the Classroom project at Teslin School as per Introduction, Transplant and Transfer permit TL-18-21. A second interim site visit was conducted at this same site on January 12, 2019 to check on the development stage of the planted eggs. A winter site investigation was conducted at all egg planting sites on February 25 and 26, 2019 to collect information on ice characteristics, water temperature and dissolved oxygen. All egg planting sites were again visited on April 11 and 12, 2019 at which time as many of the Whitlock-Vibert boxes were retrieved as ice conditions allowed. Upon retrieval, the contents of the boxes were determined and the live alevin re-planted back into the stream.

The final site visit was planned to retrieve the closed mesh bags and any remaining Whitlock-Vibert boxes on June 5, 2019; however, after retrieving the remaining Whitlock-Vibert boxes and a single closed mesh bag, it was determined that the alevin had not yet fully developed into emergent fry. Based on these findings. The retrieval of the remaining closed mesh bags was postponed until June 29, 2019.



## 3 RESULTS

### 3.1 WATER TEMPERATURE MONITORING

Surface water temperature loggers in Deadman Creek and Morley River were retrieved, downloaded and redeployed during the 2018/2019 egg incubation period. Water temperatures in Morley River are warmer than those in Deadman Creek for the entire record period (Figure 1). At egg planting sites in Morley River, the water temperature varied between 1.3 and 0.2 °C during the winter months but began to warm steadily in late March to a high just above 2 °C by early April (Figure 1). These trends were very similar across all planting sites, likely due to their close proximity. In Deadman Creek, temperatures at all egg planting sites decreased steadily from mid-August through to the early winter and remained very close to freezing for the duration of the winter months until mid-May when temperatures began to steadily rise (Figure 1). There were slight differences in winter water temperatures at the egg planting sites in Deadman Creek. The highest temperatures during the winter months were recorded at Site DC15 where temperatures were typically within the range of 0.2 to 0.4 °C. A single site (DC11) recorded temperatures below freezing, thus indicating that this site was at least frozen to the bed during the mid to late winter.

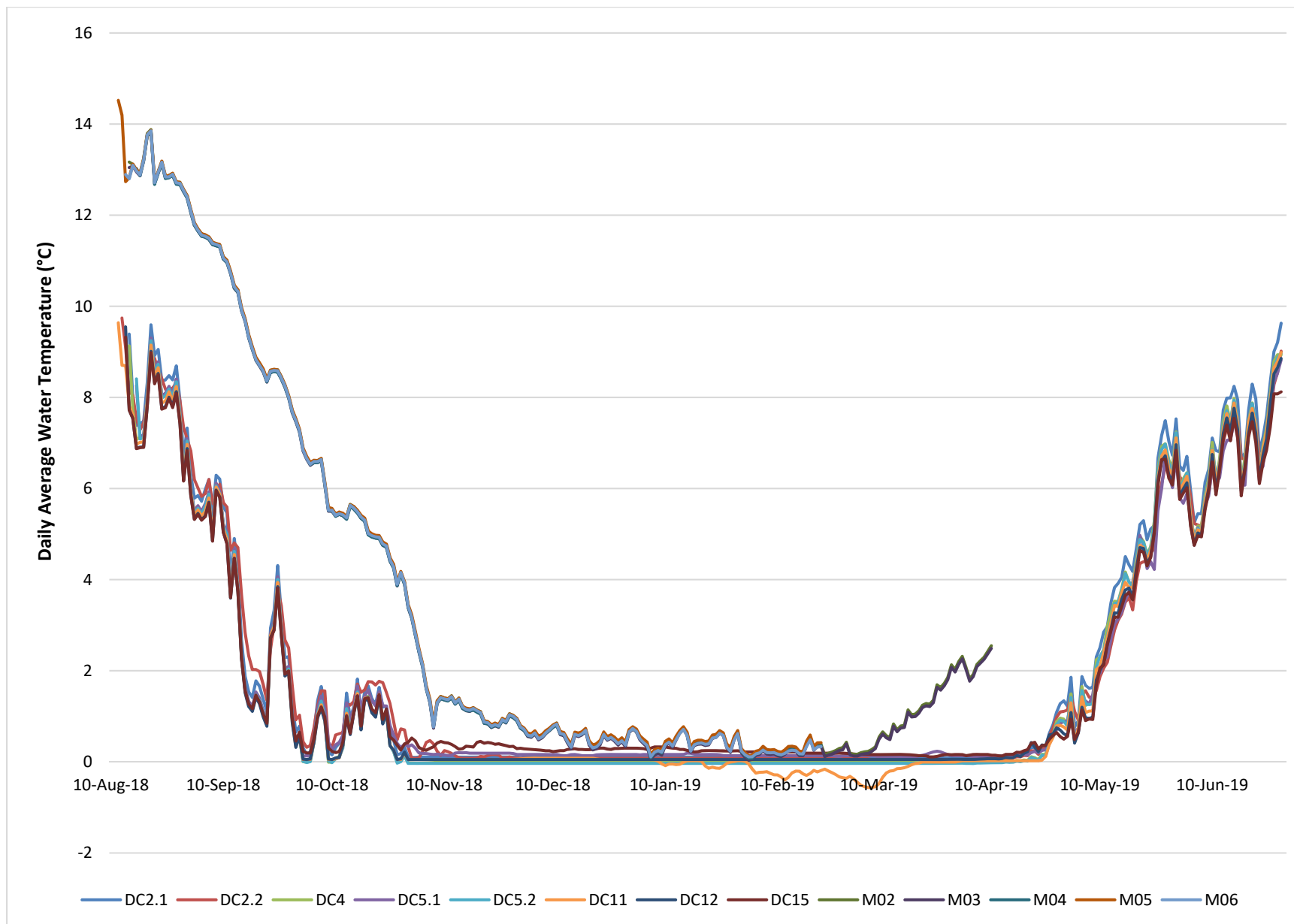


Figure 1. Water temperatures at egg planting sites in Deadman Creek and Morley River from the timing of egg planting through to fry emergence.





### 3.2 HYDROMETRIC MONITORING

Deadman Creek is a mountain stream with no lake storage upstream of the hydrometric station at Site 2 near the mouth of the creek (Teslin Lake). Flow patterns at Site DC02 are dynamic and sensitive to seasonal variations, weather events and ice effects (Table 1, Figure 2).

Annual peak flows generally occur in response to the spring snowmelt. However, in 2018, peak flow was not fully recorded since the station was removed from the stream on May 8 after the well was damaged by ice movement triggered by spring thaw. In 2019, dry spring conditions did not result in substantial freshet flows. Instead, snowmelt runoff occurred gradually, and the flow response was moderate through May 2019, with peaks recorded on May 10, May 18 and May 22. Discharge measurements during spring freshet peak flows have not been collected to date.

Summer and fall high flows also occur in response to rainfall events. Examples in 2018 include June 10 and 15, August 10 and October 15. In 2019, high flows ( $3.487 \text{ m}^3/\text{s}$ ) were measured on June 5 following a rainfall event.

Freeze up likely occurred around October 31, 2018 and winter ice conditions prevailed until April 30, 2019. These dates are estimated from observations of the continuous record of water levels and water temperatures. Water levels recorded by the instrument between late October and late April are affected by ice forming at the surface and on the streambed (i.e. backwater effects) and the changing of the channel morphology. Therefore, water level recorded in the winter is not a reliable indicator of discharge. Typically, there is an elevated water level due to ice effects for a corresponding low discharge. Winter discharge was measured on February 26, 2019 at low flow ( $0.259 \text{ m}^3/\text{s}$ ) and the ice cover was approximately 40 cm thick.

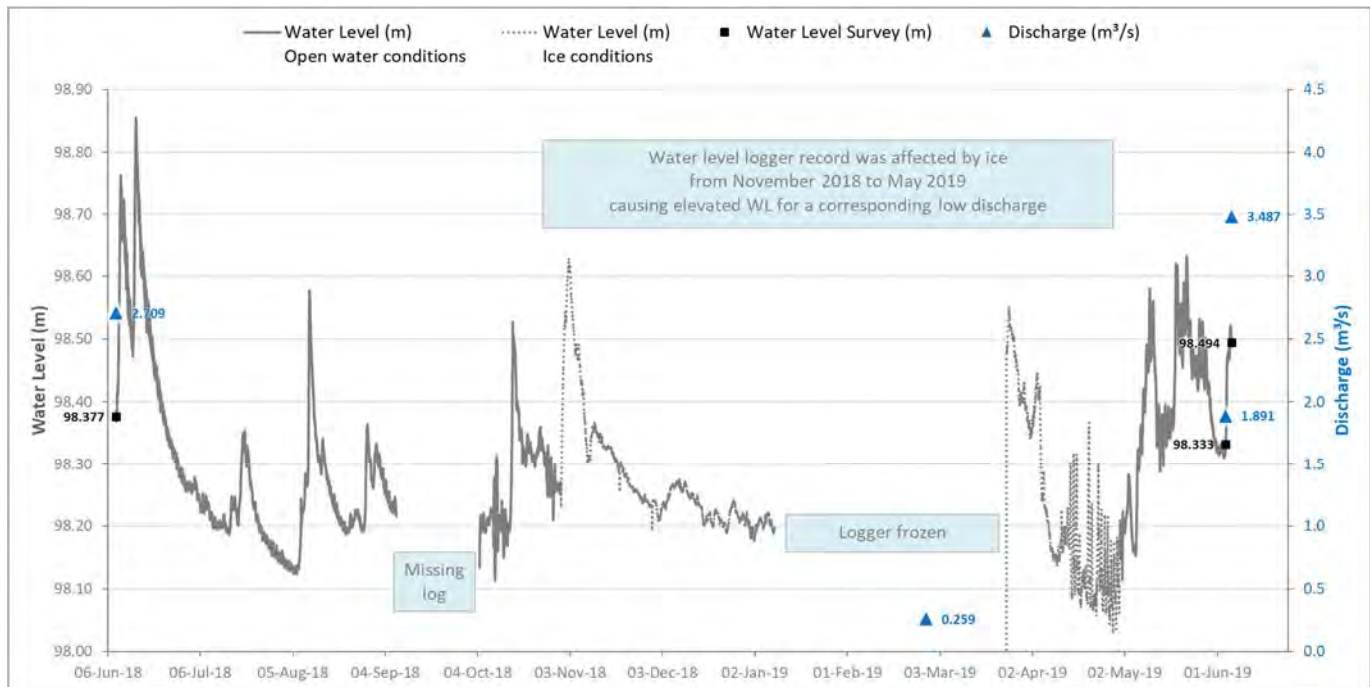


Figure 2. Stage-discharge hydrograph at Site DC02 in Deadman Creek from June 8, 2018 to June 5, 2019.

Table 1. Stage-discharge measurements for at Site DC02 in Deadman Creek from June 8, 2018 to June 5, 2019.

Date and Time	Water Surface Elevation (m; local datum)	Water Surface Elevation (m; staff gauge)	Discharge (m³/s)	Method	Notes
08/06/2018 17:45	98.377	0.560	2.709-	Velocity-area, mid-section. Instrument: ADV	Station re-installed downstream of 2017-2018 location.
26/02/2019 15:00	-	-	0.259	Velocity-area, mid-section. Instr.: Swoffer	Winter low flow, ice 40 cm thick
03/06/2019 18:45	98.333	0.543	1.891	Velocity-area, mid-section. Instr.: ADV	Moderate flow
05/06/2019 17:15	98.494	0.700	3.487	Velocity-area, mid-section. Instr.: ADV	High flow in response to rainfall



### 3.3 JUVENILE MONITORING

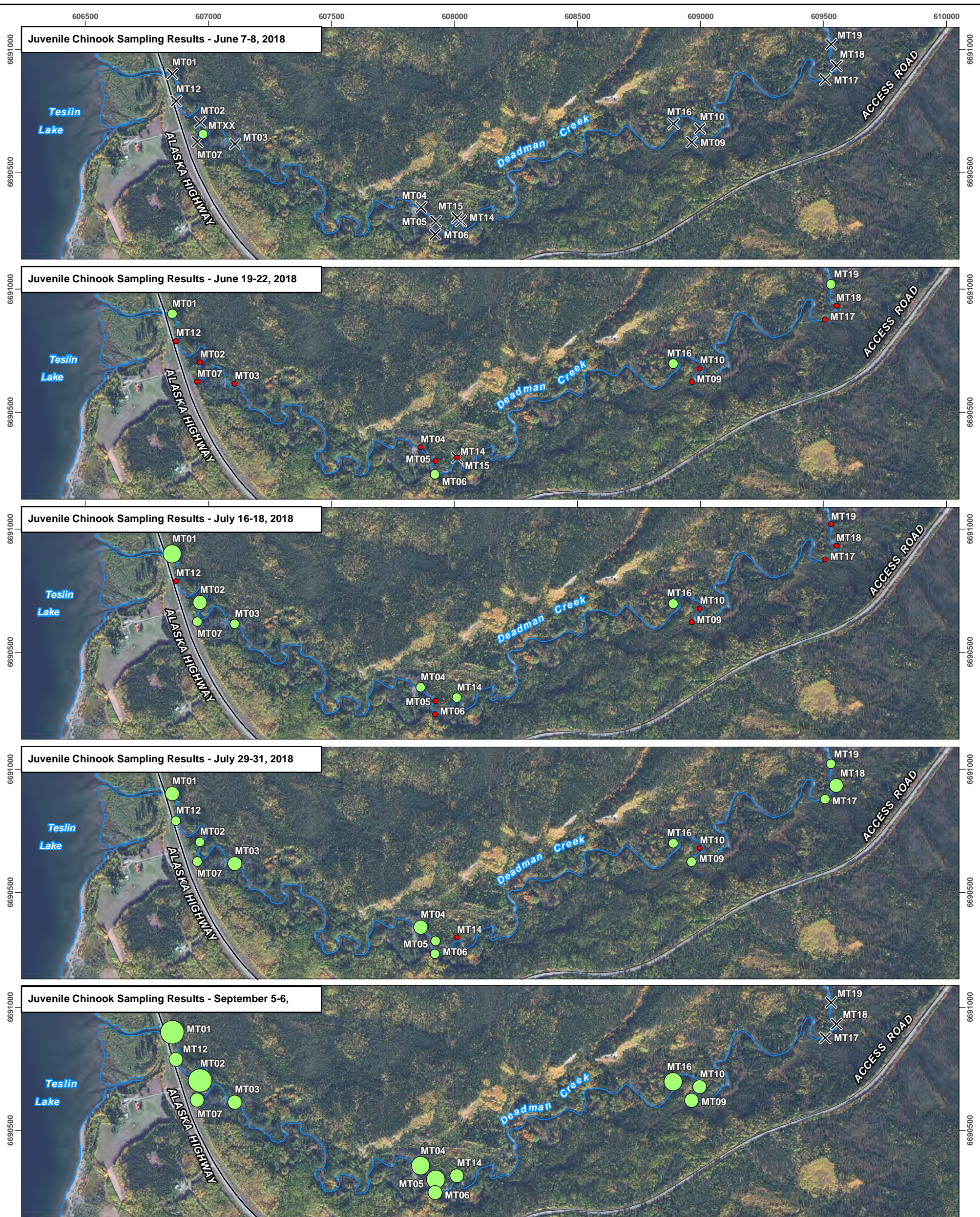
The juvenile Chinook sampling events captured 546 fish of 4 species with the catch dominated by slimy sculpin during June and juvenile Chinook during July and September in Deadman Creek (Table 2; Map 6). Interestingly, 2018 was the first year juvenile Chinook salmon were captured in Deadman Creek during the June sampling events with a total of 12 individuals captured. These individuals appeared to be of the 1+ year class and based upon their size, may be originated from eggs planted in the stream during August 2016.

Juvenile Chinook salmon were captured in Morley River during the June sampling event, (23 in total), but none were captured during the July sampling event (Map 7). A number of juvenile Chinook were observed during both sampling events; however, it is likely that the effectiveness of the minnow traps is diminished in the large river channel and the relative abundance of juveniles may be under represented by this sampling method.

**Table 2. Summary of Deadman Creek juvenile Chinook monitoring during 2018.**

Sampling Event	Species	Traps Captured	Average CPUE (#/12 trap hours)	Total Individuals Captured
June 7-8 (10 traps set)	Chinook salmon	5	0.36	7
June 19-22 (54 traps set)	Chinook salmon	4	0.05	5
	slimy sculpin	17	0.35	32
	burbot	2	0.02	2
	Arctic grayling	1	<0.01	1
July 16-18 (55 traps set)	Chinook salmon	13	0.46	44
	slimy sculpin	18	0.42	43
July 29-31 (64 traps set)	Chinook salmon	35	0.56	65
	slimy sculpin	50	0.80	95
	burbot	1	<0.01	1
September (49 traps set)	Chinook salmon	35	2.56	242
	slimy sculpin	7	0.07	7
	burbot	2	0.02	2
Total (232 traps set)	Chinook salmon	84	0.83	363
	slimy sculpin	74	0.42	177
	burbot	5	0.01	5
	Arctic grayling	1	<0.01	1





#### Legend

- Alaska Highway
- Secondary Road

#### Juvenile Chinook Sampling Results

- ✕ Not Sampled
- 0
- >0 - 1
- 1 - 3
- 3 - 5
- 5 +



### Map 6. Juvenile Chinook monitoring results in Deadman Creek

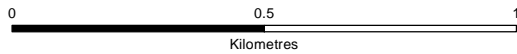
Data Sources  
Digital Elevation Model, 1:50,000, and 1:1,000,000 National Topographic Database (NTDB) provided by Geomatics Yukon - Yukon Government via online source (Corporate Spatial Warehouse) [www.geomaticsyukon.ca](http://www.geomaticsyukon.ca).

Project data displayed is site specific. Data collected by EDI Environmental Dynamics Inc. (2018) was obtained using Garmin GPS technology.

High Resolution Imagery provided by Geomatics Yukon - Yukon Government.

Disclaimer  
This document is not an official land survey and the spatial data presented is subject to change.

Disclaimer  
EDI Environmental Dynamics Inc. has made every effort to ensure this map is free of errors. Data has been derived from a variety of digital sources and, as such, EDI does not warrant the accuracy, completeness, or reliability of this map or its data.

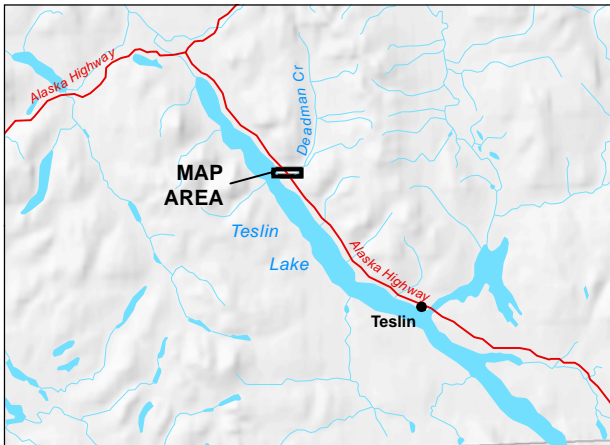


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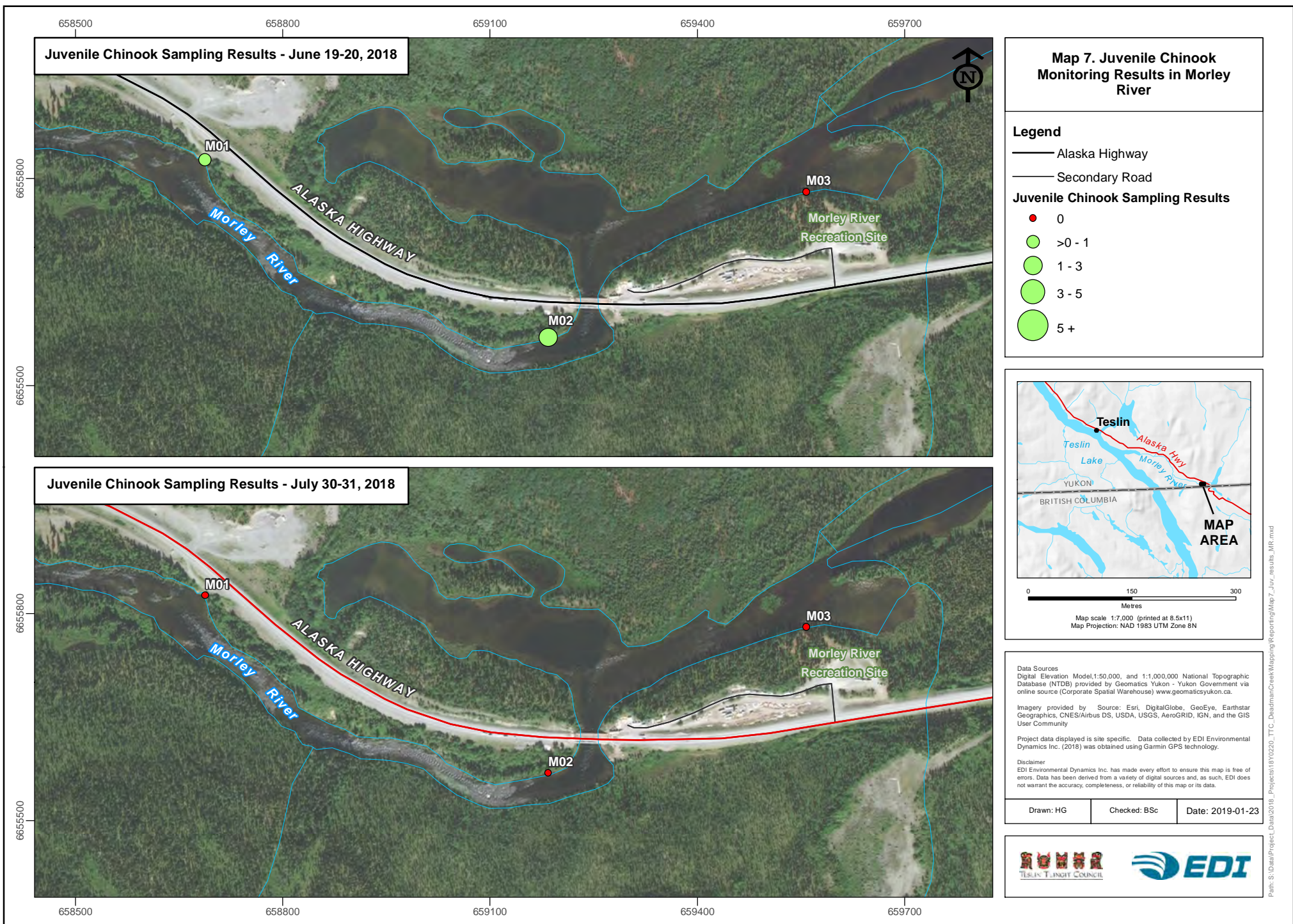
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Date: 2019-01-23









The juvenile Chinook salmon captured during the June events that are believed to be 1+ juveniles based upon their size (Duncan and Bradford 2006) with average fork lengths of 85 mm during the June 7-8 sampling event and 88 mm during the June 19-22 sampling event. To provide perspective, the 0+ juveniles captured in Morley River from June 19-22 were relatively small (average of 45 mm fork length). Given that past sampling efforts have documented non-natal juveniles migrating into Deadman Creek in larger numbers during the late summer (Wilson 2004, 2005), it is probable that these individuals captured during June overwintered in the stream. A primary goal of the juvenile monitoring is to determine if the relative abundance of juveniles in the stream may be changing as a result of egg planting activities. Although further sampling is required during June of future years, the presence of these juveniles may represent juveniles originating from egg planting the previous year. Deadman is a relatively cold water stream and therefore juveniles originating from planted eggs may be smaller than non-natal juveniles using the stream. A comparison of fork length data during sampling events in Deadman shows an increase in fork lengths as would be expected (Figure 3); however, there is not a clear bimodal distribution which would indicate the presence of non-natal juveniles and juveniles originating from eggs planted the previous summer. It is possible that there is too much variation to expect such a distribution and that other spawning areas in the upper Teslin River watershed may actually show a similar temperature regime to Deadman Creek. Relatively warm, lake-headed areas such as Morley River are uncommon and other known spawning areas such as the mainstem Nisutlin River may in fact also be more similar to Deadman Creek.

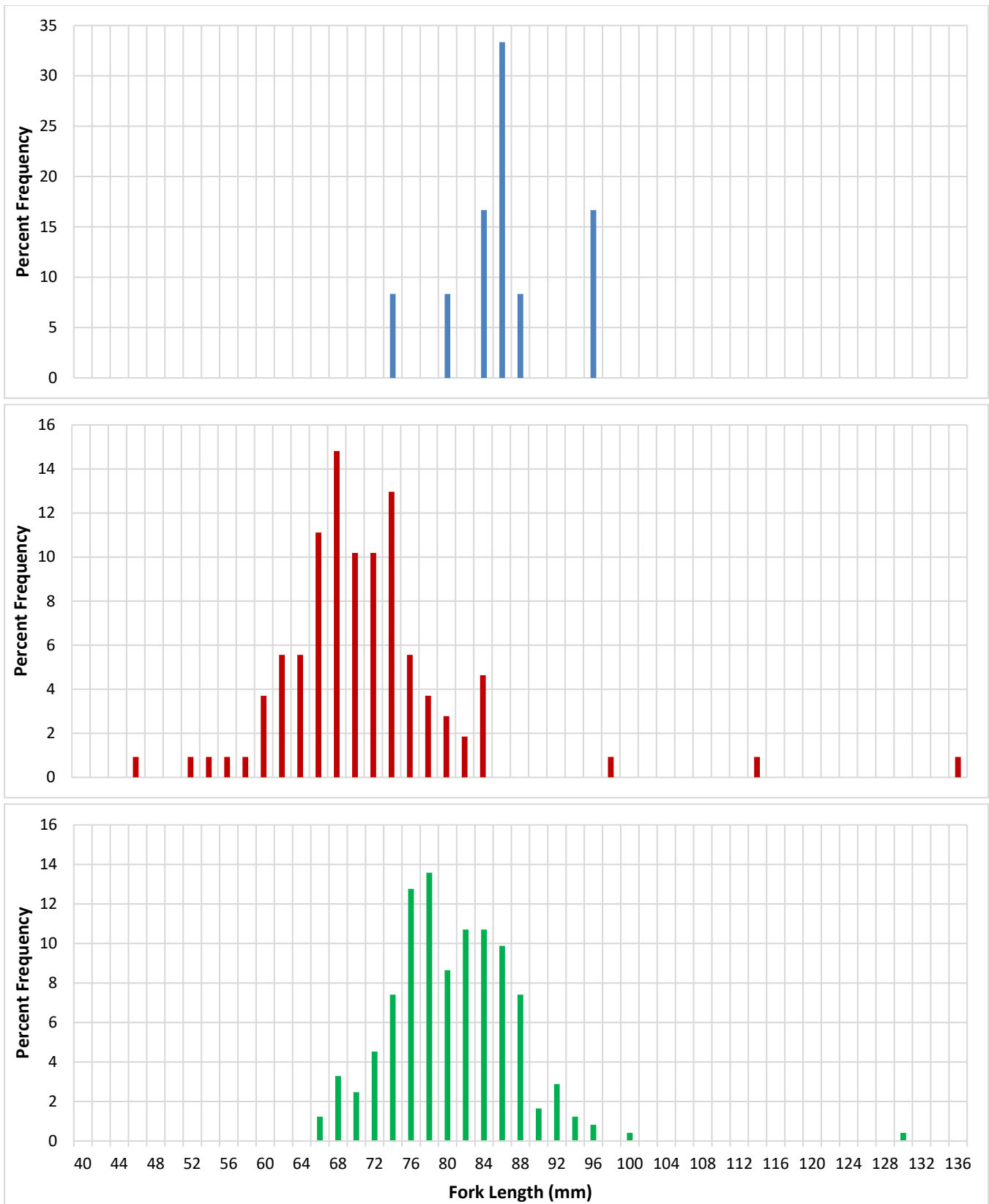


Figure 3. Deadman Creek juvenile Chinook fork length frequencies from June, July and September 2018.





## 3.4 INSTREAM EGG INCUBATION

### 3.4.1 SITE PREPARATION

The preparation of the 17 egg planting sites required more time during the 2018 project as crews were much smaller in size with two to five people as compared to 5-10 of people in previous years. On August 10, 2018 a highwater event in Deadman Creek compromised most of the prep work done up to that date. From August 11 to the end of the project, sites were either prepped/fixed while egg enumeration and fertilization occurred or the night before they were planned to be planted.

### 3.4.2 BROODSTOCK COLLECTION

The brood stock collection and egg fertilization was conducted in batches to allow for sufficient time to plant the eggs within a given day and thus minimize egg handling time. A total of 33 spawning Chinook salmon were captured while attempting to obtain brood stock with the majority of these fish ripe and suitable for the collection of eggs or milt. Milt was collected from a total of 18 males and 12 females were live spawned for brood stock. Four of these females were complete egg takes and yielded 4,307 to 6,578 eggs; the remaining seven females were partially spent and yielded between 271-3,308 eggs. In addition to the four females which were used as brood stock, two spent females were captured and released.

Age, sex and length data along with genetic samples were collected from all 33 captured Chinook and were provided to DFO for analysis. Scale samples from 24 individuals were analyzed by the Pacific Biological Station (PBS) and provided complete ages with results indicating that the majority of Chinook aged were from the 2013 brood year (58%) with the remainder from the 2012 brood year (42%). The remaining 10 individuals yielded partial ages and are not presented here. The Chinook salmon sampled during brood stock collection had fork lengths ranging from 735 to 1003 mm with an average of 860 mm. Average fork lengths for males and females was very close with males being slightly larger than females on average (863 mm and 860 mm respectively).

### 3.4.3 EGG FERTILIZATION AND DEPLOYMENT

A total of 35,929 eggs were planted during 2018 including 22,604 eggs in Deadman Creek and 13,325 eggs in Morley River (Table 3). The total number of eggs planted is higher, but comparable to the total number of eggs planted in 2017 (35,225). However, the number of eggs planted in Morley River was much higher in 2018 compared to 2017 (7,513). The increase in eggs planted in Morley River was to offset the number of eggs taken out of the river with the high artificial fertilization success compared to (assumed) wild fertilization success.



**Table 3. Summary of egg planting in Deadman Creek and Morley River.**

Stream	Sub Area	Site	WVB				Closed Mesh Bag	Egg Insertion Pipe				TOTAL
			1	2	3	4	1	1	2	3	4	
Morley	Lodge	M01	200	200			193	513	513	386		2005
		M02	200	200			200	320	464	396		1780
		M03	200	200			200	640	640	640		2520
	Islands	M04	200	200	200		200	660	804	660		2924
		M05	200	200			250	568	603			1821
		M06	200	200			200	800	604	271		2275
	<b>TOTAL</b>		<b>2600</b>				<b>1243</b>	<b>9482</b>				<b>13325</b>
Deadman	Highway	DC02	200	200				504	540	495	522	2461
		DC02.1	200	200			200	605	605	605	605	3020
		DC02.2	200	200			200	454	795			1849
	Gravel Pit	DC04	200	200	200	200	200	393	393	393		2179
		DC05.1	200	200	200		190	480	480	480		2230
		DC05.2	200	200			200	375	375	375		1725
	Upper Access A (Chilkoot)	DC09	200	200			200	464	464			1528
		DC11	200	200			200	628	628			1856
	Upper Access B (Glissade)	DC12	200	200			200	528	436	416		1980
		DC14	200	200				544	532	524		2000
		DC15	200	200			200	588	588			1776
	<b>TOTAL</b>		<b>5000</b>				<b>1790</b>	<b>15814</b>				<b>22604</b>



### 3.4.4 SPOT VELOCITY MEASUREMENTS

Spot velocities were collected at all egg planting sites in both streams and four natural Chinook redds in Morley River. Three areas of the water column were measured for water velocity: just above the substrate (best indication of intra-gravel flow), 10 cm above the substrate, and at 60% of the total water depth. When considering the measurements just above the bed, the four natural redds ranged from 0.21 to 0.68 m/s with an average of 0.41 m/s (Table 4). The artificial egg planting sites in Morley River had similar spot velocities to the natural redds but the natural redds encompassed a broader range of velocities ranging from 0.18 to 0.64 m/s, with an average of 0.37 m/s. In Deadman Creek, the egg planting sites had a very similar average velocity as compared to natural redd sites in Morley River (range = 0.32 to 0.63 m/s, average = 0.48 m/s).

All spot velocities measured during the April monitoring event showed a decreased velocity compared to the August measurements with the exception of site M06 in Morley River (Table 4). This site is located adjacent to a small island and even at the lower water levels was observed to have maintained a velocity very similar to that of higher water levels due to the channel morphology.

**Table 4. Spot velocity measurements collected at all artificial redds and four natural redds using a Swoffer velocimeter, August 2018.**

Stream	Site	Velocity just above bed (m/s)	
		August 2018 (egg planting)	April 2018 (monitoring)
Deadman Creek	DC02	0.53	0.31
	DC02.1	0.63	0.20
	DC02.2	0.48	0.27
	DC04	0.60	0.24
	DC05.1	0.48	-
	DC05.2	0.41	0.20
	DC09	0.49	-
	DC11	0.61	-
	DC12	0.33	0.18
	DC14	0.32	0.10
	DC15	0.37	0.21
Morley River	M01	0.27	0.20
	M02	0.18	0.08
	M03	0.25	0.17
	M04	0.29	0.29
	M05	0.58	0.46
	M06	0.64	0.65
	M02 - Natural Redd	0.21	-
	M04 - Natural Redd	0.31	-
	M04 - Natural Redd	0.42	-
	M04 - Natural Redd	0.68	-



### 3.5 SUCCESS MONITORING

The success monitoring results are presented separately in the following sections for Morley River and Deadman Creek. These two streams have different water temperature regimes, with Deadman Creek being cooler, and therefore the timing of the success monitoring differs.

#### 3.5.1.1 Morley River

The Whitlock-Vibert boxes were retrieved from Morley River on October 3, 2018 and across all sites, had a mean hatching success of 75% and a range of 33.5 to 96.5 % (Table 5). Average survival was highest at site M06 (92%), followed by sites M03 (87%) and M02 (82%). The lowest mean survival was at site M01 (44%) which interestingly has had relatively low survival in past years. The alevins which remained in the incubators in all sites were relatively small and appeared to be recently hatched (Photo A1 in Appendix A). ATUs at the three sites ranged from 510 (Site M04) to 580 (Site M05) at the time of retrieval. This variation is due to differing dates of egg deployment rather than a difference in temperatures between sites.

**Table 5. Summary of Morley River Whitlock-Vibert box hatching results (October 3, 2018).**

Site	Total Eggs Planted	ATUs	Dead Eggs	Dead Alevin	Inferred Survival <sup>A</sup> (%)
M01	200	-	132	1	33.5
	200		90	2	54.0
M02	200	538	17	4	89.5
	200		45	5	75.0
M03	200	536	25	2	86.5
	200		23	3	87.0
M04	200	510	85		55.0
	200		56		72.0
	200		25	1	87.0
M05	200	580	42	1	78.5
	200		66	2	66.0
M06	200	550	21	3	88.0
	200		6	1	96.5

<sup>A</sup> Inferred survival assumes that a large proportion of the alevins had already exited the incubators.

The monitoring of emergence success was conducted on two site visits (February 22 and April 10) at which time the closed mesh bags were retrieved from all sites. Although a total of 6 bags had been planted, two had been partially exposed and are excluded from the results presented here given that exposed bags do not provide an accurate representation of survival. The four remaining bags had an average emergence success of 69.3% with a range of 29 to 95.5% (Table 6). The site with the lowest emergence success (M01) also had the lowest hatching success as determined by the Whitlock-Vibert boxes despite being in close proximity and having very similar characteristics to sites M02 and M03. All 6 egg planting sites in Morley River were free of ice during both winter site visits (Photos A2 and A3 in Appendix A).

The emergent fry retrieved from the bags during April were more developed than those retrieved in February despite being advanced by only 30-40 ATUs (Photos A4 and A5 in Appendix A). The more advanced fry



observed in April appeared to be more advanced than would be expected based upon their ATUs (771 to 814).

**Table 6. Summary of Morley River closed mesh bag emergence results (February and April 2019).**

Site	Date Retrieved	Total Eggs Planted	ATUs	Live Fry	Survival (%)
M01	April 10, 2019	193	-	56	29.0
M02		200	814	191	95.5
M03		200	803	139	70.5
M06	February 22, 2019	200	771	164	82.0

### 3.5.1.2 Deadman Creek

During the interim site visit to Deadman Creek on November 2, 2018, a considerable amount of was observed in the lower reaches of the stream, in particular in areas with faster flows such as riffles (Photos A6 and A7 in Appendix A). It is not known if this is a regular occurrence on the stream or if this was caused by unique circumstances. A portion of the anchor ice was removed from the bed at site DC04 and a single Whitlock-Vibert box was retrieved to provide a source of eggs for the Salmon in the Classroom at Teslin School.

A site visit to site DC04 in Deadman Creek on January 12, 2019 indicated the presence of mostly very advanced eyed eggs with a small number of recently hatched alevins (Photo A8 in Appendix A); this site is used for interim monitoring given that it is relatively accessible and typically has minimal ice cover. The ATUS at this site at the time of the site visit were 257.

A winter site visit to Deadman Creek was conducted on February 25 and 26, 2019 to document ice conditions, water temperature and dissolved oxygen. All sites were ice covered at this time, although the majority had very thin ice coverage and/or snow bridges present (Photo A9 in Appendix A). Incubation media were not retrieved at this time given that past observations have indicated that the disruption of the ice coverage can result in changes to winter flow conditions which may adversely affect egg survival. All egg planting sites were again visited on April 11 and 12, 2019 at which time as many of the Whitlock-Vibert boxes were retrieved as ice conditions allowed. Upon retrieval, the contents of the boxes were determined and the live alevin re-planted back into the stream. Due to ice conditions, not all of the boxes could be removed during the April site visit and this was delayed until early June 2019. On June 6, 2019, the contents of the mesh bags indicated that the alevin were not yet emerged (Photo A10 in Appendix A) and the bags were left in place until later in June to allow for a more complete indication of emergence success to be obtained. On June 29, 2019, the contents of the mesh bags indicated that the alevin had emerged (Photo A11 in Appendix A) and all remaining incubation media were retrieved.

The mean hatching rate as indicated by the Whitlock-Vibert boxes was 44%; however, there was variation between sites (Table 5). The highest hatching rate (97%) was the highest recorded to date at Deadman Creek and occurred at site DC4 which has consistently had relatively high survival compared to other sites in the



stream. The lowest survival was recorded at site DC5.1 (5.0%) and DC2 (6.5%; Table 7). This low survival at site DC2 is interesting given that a second box within the same site (with 0.5 m of each other) had a hatching success of 60%.

**Table 7. Summary of Deadman Creek Whitlock-Vibert box hatching results (April and June 2019).**

Site	Total Eggs Planted	Dead Eggs	Dead Alevin	Inferred Survival <sup>A</sup> (%)
DC2	200	187		6.5
	200	76	4	60.0
DC2.1	200	171	3	13.0
	200	78	13	54.5
DC2.2	200	145	2	26.5
	200	94	37	34.5
DC4	200	55		71.5
	200	6		97.0
DC5.1	200	183	7	5.0
DC5.2	200	159	6	17.5
	200	83	2	57.5
DC09	200	24	1	87.5
	200	33	0	83.5
DC11	200	152	21	13.5
	200	93	0	53.5
DC12	200	77	7	58.0
	200	55	1	72.0
DC14	200	127	4	34.5
	200	120	6	37.0
DC15	200	164	4	16.0
	200	175	2	11.5

<sup>A</sup> Inferred survival assumes that a large proportion of the alevins had already exited the incubators.

Data on fry emergence in Deadman Creek was collected through the retrieval of closed mesh bags on June 29, 2019; ATUs for the egg planting sites ranged from 551 to 636 at the time of retrieval. Mean emergence success was 11% (SE = 4.3, n = 9) and similar to hatching success, was variable between sites with a range of 0% at DC2.2 to a high of 36.5% at DC2.1. Winter observations at DC2.2 indicated that the substrate at the site was frozen (despite continual water flow) and therefore this resulted in a lack of emergence at this site. Similar conditions were likely present at site DC11 during the late winter when the water temperature logger at this site recorded freezing temperatures for an extended period. During the late winter visit to this site, the channel showed extensive overflow with the streamflow flowing through the vegetation along the north streambank; these observations provide further evidence that the site froze to bed during the winter months. All of the remaining mesh bags appeared to be located in sites with suitable winter conditions for incubation and were well covered upon retrieval.



**Table 8. Summary of Deadman Creek emergence success as determined by closed mesh bags (June 29, 2019).**

Site	Total Eggs Planted	ATUs	Dead Eggs	Dead Alevin	Live Fry	Inferred Emergence (%) <sup>A</sup>
DC2.1	200	636	15	0	73	36.5
DC2.2	200	629	180	0	0	0.0
DC4	200	575	25	4	56	28.0
DC5.1	190	576	25	0	6	3.2
DC5.2	200	551	35	0	14	7.0
DC9	200	-	12	11	27	13.5
DC11	200	580	185	15	0	0.0
DC12	200	572	13	8	21	10.5
DC15	200	600	150	7	3	1.5

<sup>A</sup> Inferred survival incorporates the number of live emergent fry observed and the total number of eggs initially planted. In many instances, the fate of individual dead eggs/alevin could not be determined.

Accumulated thermal unit data from Deadman Creek indicate that the rate of development was considerably different than the typical development for Chinook salmon (Alexco 2017). Yukon River Chinook typically become eyed eggs around 280 ATUs and hatch into alevin at 480 to 540 ATUs. The Deadman Creek eggs (site DC4) appeared to be very nearing hatching on January 12, 2019 at 257 ATUs which is far less than is typical for Chinook. Emergence as fry typically occurs from 900-1000 ATUs; however, very well-advanced emergent fry were retrieved from the closed mesh bags on June 29, 2019 at 551 to 636 ATUs.





## 4 DISCUSSION

The juvenile Chinook sampling component of the project continues to provide information on the relative abundance of juveniles in Deadman Creek. It was theorized that fry originating from the eggs planted in Deadman Creek could be smaller than non-natal juveniles due to differing water temperature regimes (Deadman is relatively cold). However, due to considerable variation in fork length of the juveniles captured, it has not yet been possible to definitively determine which juveniles are originating from eggs planted in the stream. To provide more conclusive results on this topic, future years of the project should considerable genetics analysis such as the parentage based tagging approach as outlined by (Beacham et al. 2018 and Steele et al. 2019).

The Whitlock-Vibert boxes and closed mesh bags in Deadman Creek and Morley River are used to provide a measure of hatching success and emergence success, respectively. These are the primary methods of determining the success of the project as the survival data provides a direct measure of egg survival in the two streams. In both streams, the hatching and emergence success during 2018/2019 was lower than during 2017/2018 and 2016/2017. For example, the mean hatching success in Morley River was 85% during 2017/2018 and 83% during 2016/2017 (EDI 2018). In Deadman Creek, hatching success was 56% during 2017/2018 and 71% during 2016/2017. Other than the testing of methods (closed mesh bags), 2018/2019 was the first year of substantial effort in determining success monitoring and therefore a comparison to past years is not yet feasible.

Morley River is intended to serve as a control for Deadman Creek; however, recent findings have indicated the incubation conditions are extremely good and may not provide a realistic indication of survival for most Yukon River Chinook spawning areas. For this reason, the results from Morley River serve as a control for the success monitoring methods but it is not realistic to expect the eggs planted in Deadman Creek to have survival which is comparable to Morley River. To provide some perspective, the results of an instream egg incubation trial on the Klondike River by EDI and Tr'ondëk Hwëch'in (EDI 2019) found a mean hatching success of 61% and a range of 16 to 95%. Although this hatching success is higher than was documented in Deadman Creek during 2018/2019, it is comparable to the results from previous years.

As supported by data from previous years, the ATU data collected in combination with the egg planting sites during 2018/2019 suggests that the rate of development in Deadman Creek is more accelerated than would be suggested by the literature and existing knowledge of Yukon River Chinook. Our findings indicate that eggs/alevin continue to develop at some minimum rate, despite very cold temperatures. Based upon our observations of alevin and emergent fry and available ATU information, the base rate development of 1.6 ATUs per day as found during 2017/2018 was consistent with the results found during 2018/2019 (refer to Figure 4, Figure 5 and Photo A11 in Appendix A). These findings suggest that Yukon River Chinook are specially adapted to allow for survival despite temperatures which are just above freezing for a prolonged period during the incubation period.

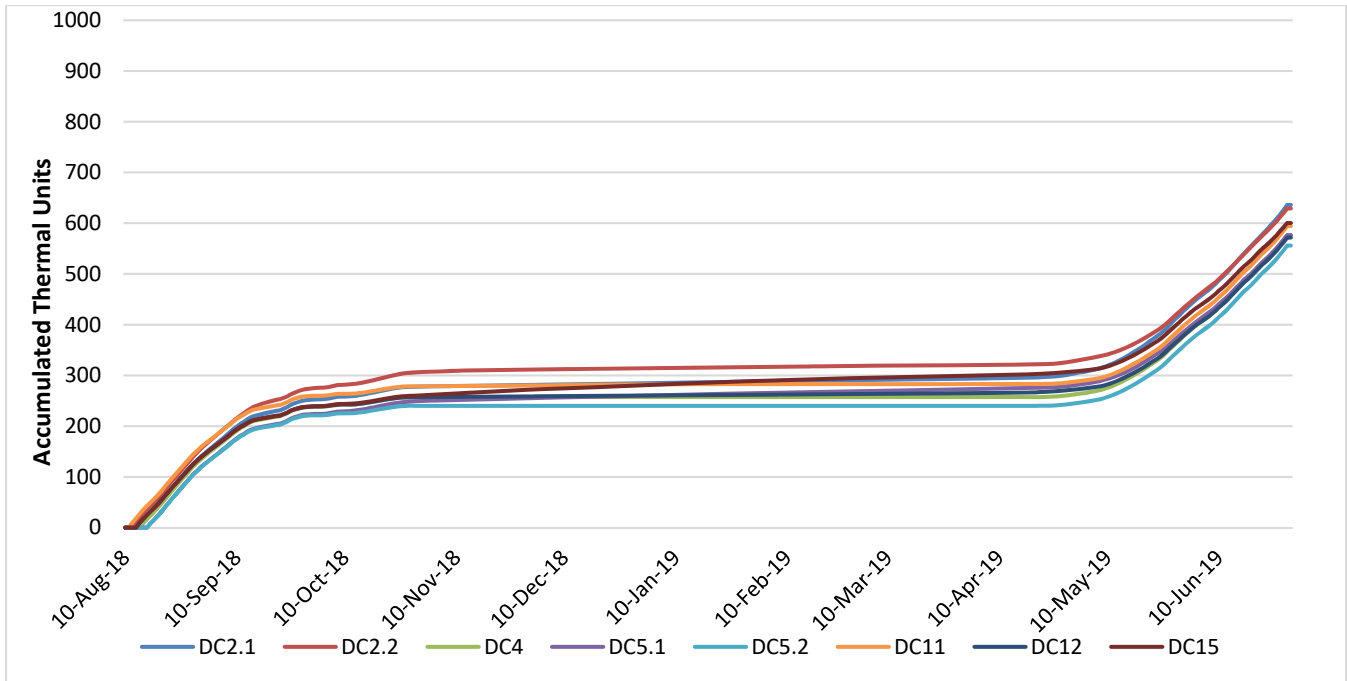


Figure 4. Accumulated thermal units (ATUs) at egg planting sites in Deadman Creek during the 2018/2019 incubation period.

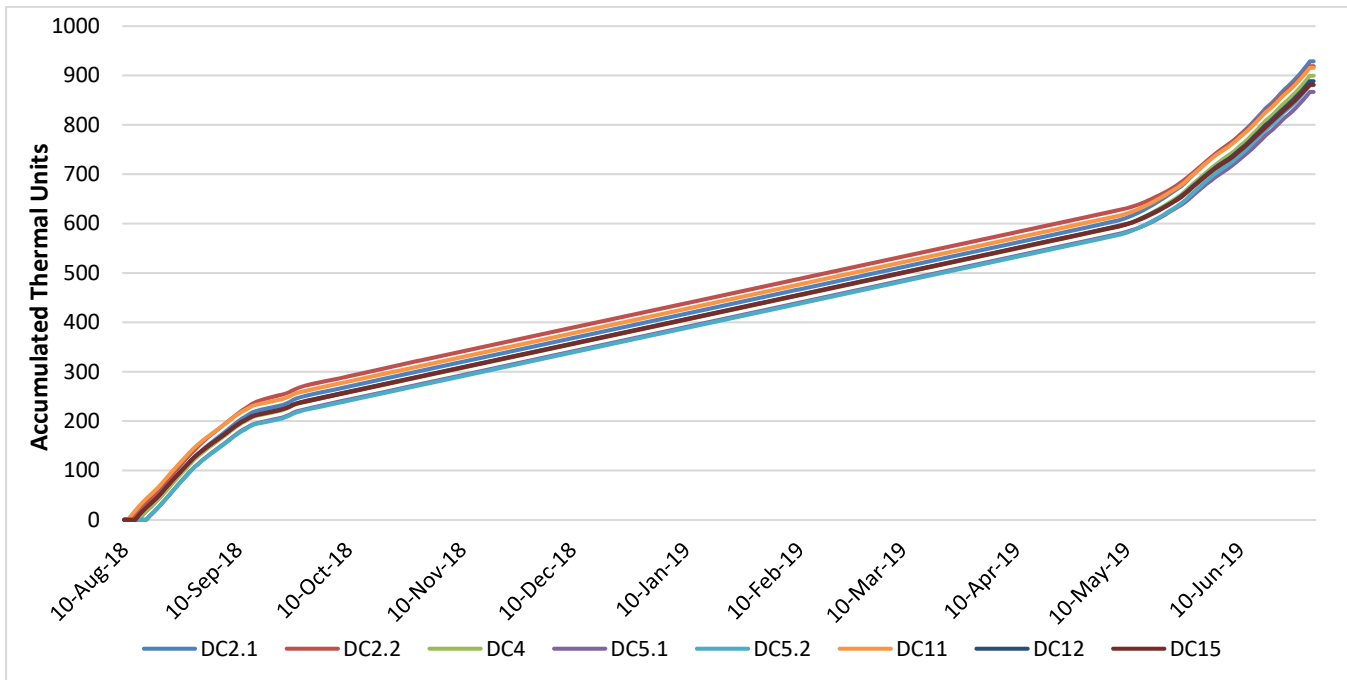


Figure 5. Accumulated thermal units (ATUs) using a minimum base rate development of 1.6 °C per day at egg planting sites in Deadman Creek during the 2018/2019 incubation period.



## 5 CONCLUSION

The current project continued to refine the methods used for restoring a Chinook stock to Deadman Creek through the use of egg planting. Over the previous three years, the ability to successfully collect brood stock and plant fertilized eggs has been confirmed; as have been the methods for monitoring survival through to hatching and emergence. Morley River provides a suitable control for testing such monitoring methods given the highly suitable incubation conditions present, and future years of the project should continue to utilize this control area for this purpose. Hatching and emergence success was quite variable in Deadman Creek during 2018/2019; however, the presence of some sites with high survival is promising for the long-term success of this project. In future years of the project, the following items are recommended to be incorporated into the project:

- Utilize a parentage based tagging approach (genetics analysis) to determine the presence of fry (and future adults) originating from eggs planted in Deadman Creek.
- Depending on the availability to sufficient numbers of brood stock, increase the number of eggs planted into Deadman Creek in order to achieve the goal of restoration a small, but self-sustaining spawning population in the stream.
- Collect additional information on the distribution and number of spawning Chinook in Morley River to better inform the use of this stream as a source of brood stock or for future stock restoration initiatives in this watershed.
- Collect information on wild egg survival in Morley River in order to provide a benchmark to which the success of egg planting efforts can be compared in both Deadman Creek and Morley River.





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## APPENDIX A. PHOTOGRAPHS



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Photo A1. Recently hatched alevin and very advanced eye-eggs at Morley River, October 9, 2018 (510 ATUs).



Photo A2. Overview of winter conditions at Morley River on February 27, 2019. Sites M04 and M05 are located on the right side of the photo.



Photo A3. Overview of winter conditions at Morley River on February 27, 2019. Site M06 is located in the foreground of the photo.

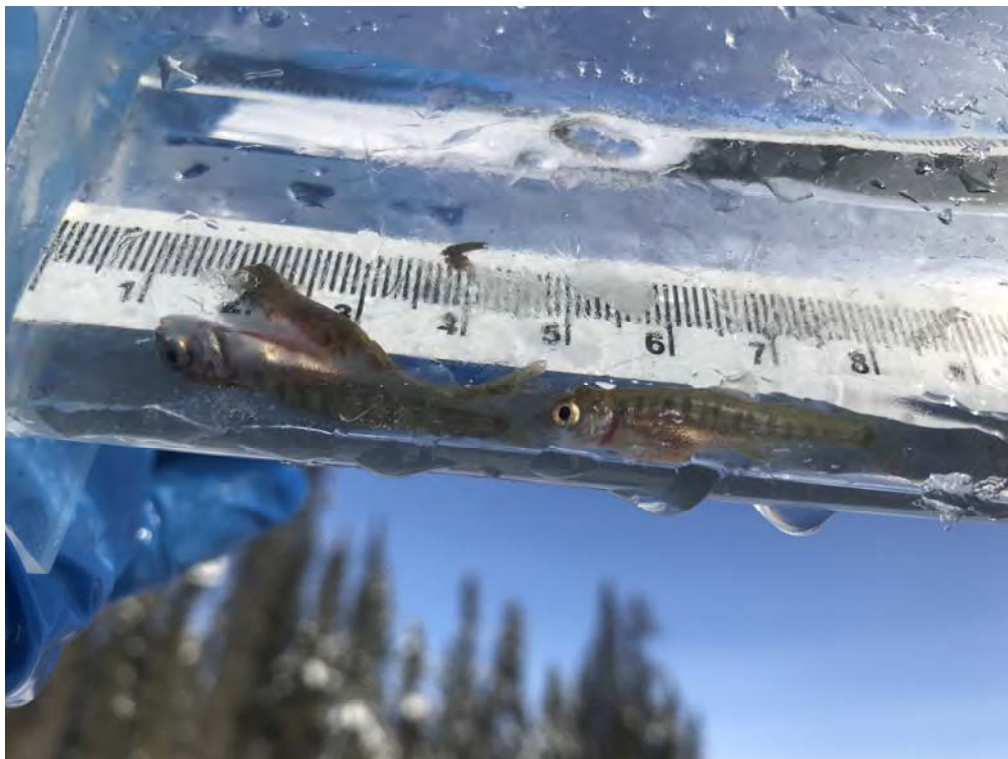


Photo A4. Emergent fry retrieved from a closed mesh bag at Site M06 on Morley River, February 27, 2019 (771 ATUs).





Photo A5. Emergent fry retrieved from a closed mesh bag at Site M02 on Morley River, April 10, 2019 (814 ATUs; photo provided by James McGrath).



Photo A6. Anchor ice formation on Deadman Creek directly downstream of site DC4 (November 2, 2018).



Photo A7. Anchor ice formation on the streambed of Deadman Creek at site DC4 (the clear patch is where the ice was removed to retrieve a Whitlock-Vibert box; November 2, 2018).



Photo A8. Recently hatched alevin and advanced eyed-eggs at site DC4 on Deadman Creek, January 12, 2019 (257 ATUs).





Photo A9. Example of typical winter conditions on Deadman Creek, not the presence of thin ice and snow bridges (February 26, 2019).



Photo A10. Well developed alevin retrieved from a mesh bag at site DC9 on Deadman Creek (410 ATUs, June 6, 2019).





Photo A11. Emergent fry retrieved from a closed mesh bag at site DC15 on Deadman Creek (600 ATUs, June 29, 2019)