Assessment of High Flow Impacts to Spawning Habitat in the Lower Campbell River, 2022

Project Number: COA-F23-F-3768-DCA

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Disclaimer:

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Acknowledgements:

This project took place within the traditional territories of the Ligwilda'xw people on the unceded territory of the We Wai Kai and Wei Wai Kum First Nations.

This project was funded by the Fish & Wildlife Compensation Program on behalf of its program partners BC Hydro, the Province of BC, Fisheries and Oceans Canada, First Nations and Public Stakeholders FWCP.

Executive Summary

The Strategy for Spawning Habitat Enhancement and Monitoring in the Lower Campbell River (*Abell et al., 2019*) ("the Strategy") recommends that a High Flow Response Assessment (post-storm monitoring) is undertaken if flow in the Lower Campbell River exceeds an adaptive threshold of 225 m^3/s. The purpose of the monitoring is to provide a high-level assessment of the availability of gravel at spawning habitats in the river to inform if there is an immediate need to undertake works in the summer to urgently repair or replenish spawning habitat for salmon to use in the fall. In November 2021, flow exceeded this threshold, reaching ~260 m^3/s for 3 days and 276 m^3/s for 4 days and several more days between 230 m^3/s and 245 m^3/s (based on provisional data at WSC gauge 08HD003). Accordingly, FCWP-Coastal provided funds to support post-storm monitoring of salmonid spawning habitat in the lower Campbell River with the additional scope of assessing and quantifying non-priority sites or sites where gravel has become deposited that may now be functional spawning habitat.

This project addresses three Priority 1 actions in the Campbell River Watershed Action Plan (FWCP 2020); CBR.ALL.ME.08.01 Assess success of habitat-based actions supported by FWCP, CBR.ALL.ME.09.01 Conduct condition assessments and/or maintenance on habitat enhancements, and CBR.RLR.ME.23.01 Conduct gravel monitoring in the lower Campbell River.

Post-storm spawning habitat monitoring was completed successfully utilizing previously identified methods but also adding the use of drone imagery, and a drone RSAP survey. This assessment indicates that some gravel movement occurred as a result of the high flow releases in 2021 but the impacts to constructed gravel platforms were relatively minimal. The total area of Chinook spawning habitat, priority and other identified areas, measured in spring 2022 was identified to be 14,587 m^2.

The monitoring provided the Campbell River Spawning Habitat Roundtable with valuable information regarding the quality and quantity of salmonid spawning habitat in the lower Campbell River. This information was used by the Roundtable to make informed decisions during their fall meeting.

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1 Introduction

The Strategy for Spawning Habitat Enhancement and Monitoring in the Lower Campbell River (*Abell et al., 2019*) ("the Strategy") recommends that a High Flow Response Assessment (post-storm monitoring) is undertaken if flow in the Lower Campbell River exceeds an adaptive threshold of 225 m^3/s during fall through spring. The purpose of the monitoring is to provide a high-level assessment of the availability of gravel at spawning habitats in the river to inform if there is an immediate need to undertake works in the summer to urgently repair or replenish spawning habitat for salmon to use in the fall. In November 2021, flow exceeded this threshold, reaching ~260 m^3/s for 3 days and 276 m^3/s for 4 days and several more days between 230 m^3/s and 245 m^3/s (based on provisional data at WSC gauge 08HD003). Accordingly, FCWP-Coastal provided funds to support post-storm monitoring of salmonid spawning habitat in the lower Campbell River.

The Strategy and the 2019 post-storm assessment (Laich Kwil-Tach Environmental Assessment Ltd. and Ecofish Research Ltd. 2019) outlined methods and recommendations for the post-storm assessments. The 2022 survey followed these recommendations with some changes to the field portions mostly due to the survey occurring in the spring during higher flows. This survey also incorporated additional efforts in the form of complimentary drone imagery and video as well as increasing the area of focus to include not just the priority sites but to identify total suitable spawning habitat by assessing gravel depositional areas. These gravel depositional areas are areas where previously placed gravels from priority sites have been mobilized and then deposited elsewhere in the Lower Campbell River. These depositional areas have the potential to provide spawning habitat as a consequence of previous gravel placement efforts.

In addition, a georeferenced RPAS (remotely piloted aerial system[1]) overflight survey of the lower Campbell River was conducted. The survey covered the same area that was RPAS surveyed in 2021 under the BC Hydro JHTMON-13 project. The RPAS overflight was proposed as it presented an opportunity to collect data regarding gravel abundance and distribution to potentially compare results between years

[1] We use the term "drone" to refer to the instrument that was used to collect aerial imagery in spring 2022, whereas we use the term "RPAS" to refer to the more technologically advanced instrument that was used in fall 2022 and featured built-in RTK GPS technology that enabled the data to be georeferenced.

before and after a high flow event to better understand the effect of high flows on gravel mobilization and transport in the river. The JHTMON-13 RPAS survey was conducted in September 2021 after a few gravel projects had been completed in consecutive years without a high-flow event[2]. The September 2021 results could be compared to the results of the 2022 RPAS survey that occurred after high flows (~276 m^3/s) in late 2021. Note that the drone survey was timed for spring 2022 to collect imagery to support high-level assessment prior to the summer least risk instream works timing window. By contrast, the RPAS survey was timed for September 2022 when lower flows meant that superior georeferenced data relating to channel morphometry and gravel location could be collected that could be directly compared with data collected in September 2021. RPAS data processing and analysis were not proposed to occur within the scope of this work but collecting the data allows for future analysis if the opportunity or need arises. The data from this survey will therefore be secured and stored for processing at a future time.

The results of this survey will be utilized by DFO, the Wei Wai Kum and We Wai Kai First Nations and the Campbell River Spawning Habitat Roundtable to inform conservation and management decisions on the Campbell River.

2 Goals and Objectives and Linkage of FWCP Action Plans and Specific Actions

This project addresses the following three Priority 1 actions in the Campbell River Watershed Action Plan (FWCP 2020):

CBR.ALL.ME.08.01 Assess success of habitat-based actions supported by FWCP: Assess success of habitat-based actions supported by the FWCP. Success could be assessed through monitoring of biological and/or physical habitat responses. Success could be assessed on a graduated schedule such as every 1, 3, 5 and 10 years or based on high flow events or other natural or human caused disturbances.

[2] For context, flow exceeded the 225 m^3/s threshold in January 2019 (maximum ~ 255 m^3/s), prompting monitoring in summer 2019. However, flow generally remained below the 225 m^3/s threshold from February 2019 through to September 2021 when the JHTMON-13 RPAS survey was completed, with the minor exception of a small exceedance (~233 m^3/s) of the target in February 2020. Flow information is based on Water Survey of Canada data for gauge 08HD003.

CBR.ALL.ME.09.01 Conduct condition assessments and/or maintenance on habitat enhancements: Conduct condition assessments and/or maintenance on habitat enhancements supported by the FWCP. This could include the development of an inspection and maintenance schedule if required. If part of a multi-year study, provide information about future objectives and actions.

***CBR.RLR.ME.23.01 Conduct gravel monitoring in the lower Campbell River*:** Conduct gravel monitoring in the lower Campbell River mainstem including Elk Falls Canyon. Gravel monitoring should follow from a gravel placement and monitoring plan (under Action 10) and should inform the quantity and locations for gravel placement on annual basis.

3 Methods

Field work was conducted on April 29, 2022 by A-Tlegay Fisheries Society biologist Derek LeBoeuf, R.P.Bio and technician Zach Everson. Average daily discharge from the powerhouse during the survey was 80 m^3/s as reported by BC Hydro (Weekly Campbell System Forecast Update, email from Edgar Lazarte April 25, 2022), and weather was clear and sunny. Snorkel surveys were undertaken from the powerhouse tailrace downstream to the Highway 19 bridge (Figure 1). Priority sites inspected were Site 7, Site 5, Site 9, Upstream End of Second Island, Ebert Road and additional deposition zones as identified in Figure 2 (maps of the sites are also presented in the Strategy). Elk Canyon (priority 5) was the only priority site that was not surveyed.

Due to the survey occurring during high water, detailed field measurements (gravel size, width and length measurements of gravel platforms, and gravel depths) could not be collected. Data collection included visual surveys to estimate gravel patch surface area, approximate gravel size and gradation. Approximate gravel depth was estimated, supported by field measurements where feasible.

The drone imagery flight was conducted on April 22, 2022, by SuavAir. Average daily discharge from the powerhouse during the survey was 80 m^3/s as reported by BC Hydro (Weekly Campbell System Forecast Update, email from Edgar Lazarte April 19, 2022). Surveys were undertaken from the powerhouse tailrace downstream to the Elk Falls Mill water intake structure (Figure 1). Post processing of the images included the creation of an orthomosaic image and input of georeferenced spatial data of the as-built dimensions of Site 7, Site 9 and Site 5 gravel pads.

The RPAS overflight survey of the lower Campbell River was conducted on September 8, 2022. Average daily discharge from the powerhouse during the survey was 42 m^3/s as reported by BC Hydro (Weekly

Campbell System Forecast Update, email from Edgar Lazarte September 26, 2022), and weather was clear and sunny. Survey methods matched those of the September 2021 survey, described in Greenacre *et al*. (2023).

The results from the field survey and SuavAir drone flight were compared. The 2022 drone imagery was also compared with earlier imagery to as accurately as possible identify and map any changes as a result of high flows and identify current suitable spawning habitat. Area of spawning habitat (m^2) was determined utilizing GIS measurement tools.

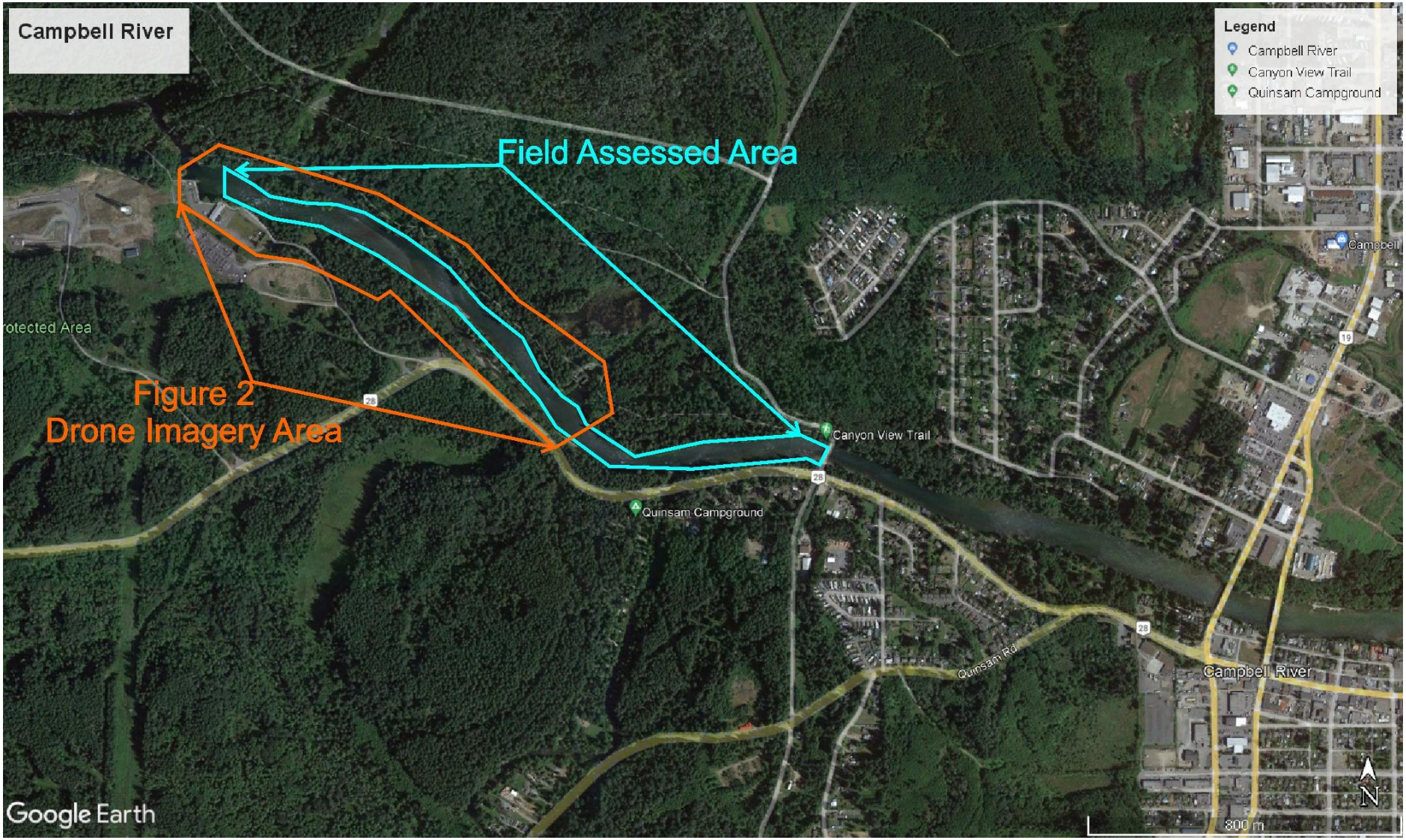


Figure 1: Overview map showing the area assessed by field crews and the area of drone assessment.

4 Results

The results are shown in Figure 2 (orthomosaic) and Table 1 (spawning habitat tracking table). These results are based on professional interpretation of observations, and analysis of the data collected during this survey, aerial imagery comparisons and previous reports. It must be noted that the intent of the survey was to provide a coarse level examination and estimate of available spawning habitat and the results are to be utilized with these limitations in mind.

Figure 2 highlights differences between the as-built surveys of previous gravel enhancement projects (pink), changed gravel distribution due to gravel transport from the original adjacent constructed area (yellow and orange dashed lines), and depositional areas that represent potentially suitable spawning habitat formed by transport of gravel from separate areas upstream (green line). Table 1 provides the current (summer 2022) estimated spawning area for each identified site as well as additional information for some sites including the year(s) and sizes of previous gravel placement projects. The estimates of habitat area focus on Chinook salmon (a high priority species, as described in the Strategy), although at least some areas of the habitat are expected to be suitable for spawning by other salmonid species.

For context, the area of Chinook spawning habitat measured in spring 2022 (14,587 m^2) substantially exceeded an estimate presented in the Strategy for 2017 (1,700 m^2), presumably reflecting the success of multiple gravel enhancement projects conducted between 2017 and 2022. Additionally, the area of Chinook spawning habitat measured at individual priority sites in 2022 was either greater or similar to areas at comparable sites surveyed in 2019 (Laich Kwil-Tach Environmental Assessment Ltd. and Ecofish Research Ltd. 2019). Thus, there has been an apparent increase in spawning habitat availability in the last 5 years. The estimated area of Chinook spawning habitat is still lower than the long-term target of 24,000 m^2 of high-quality Chinook Salmon spawning habitat presented in the Strategy, although that target is aspirational in the sense that it is expected to exceed the habitat requirements of the number of salmon that currently return to the river.

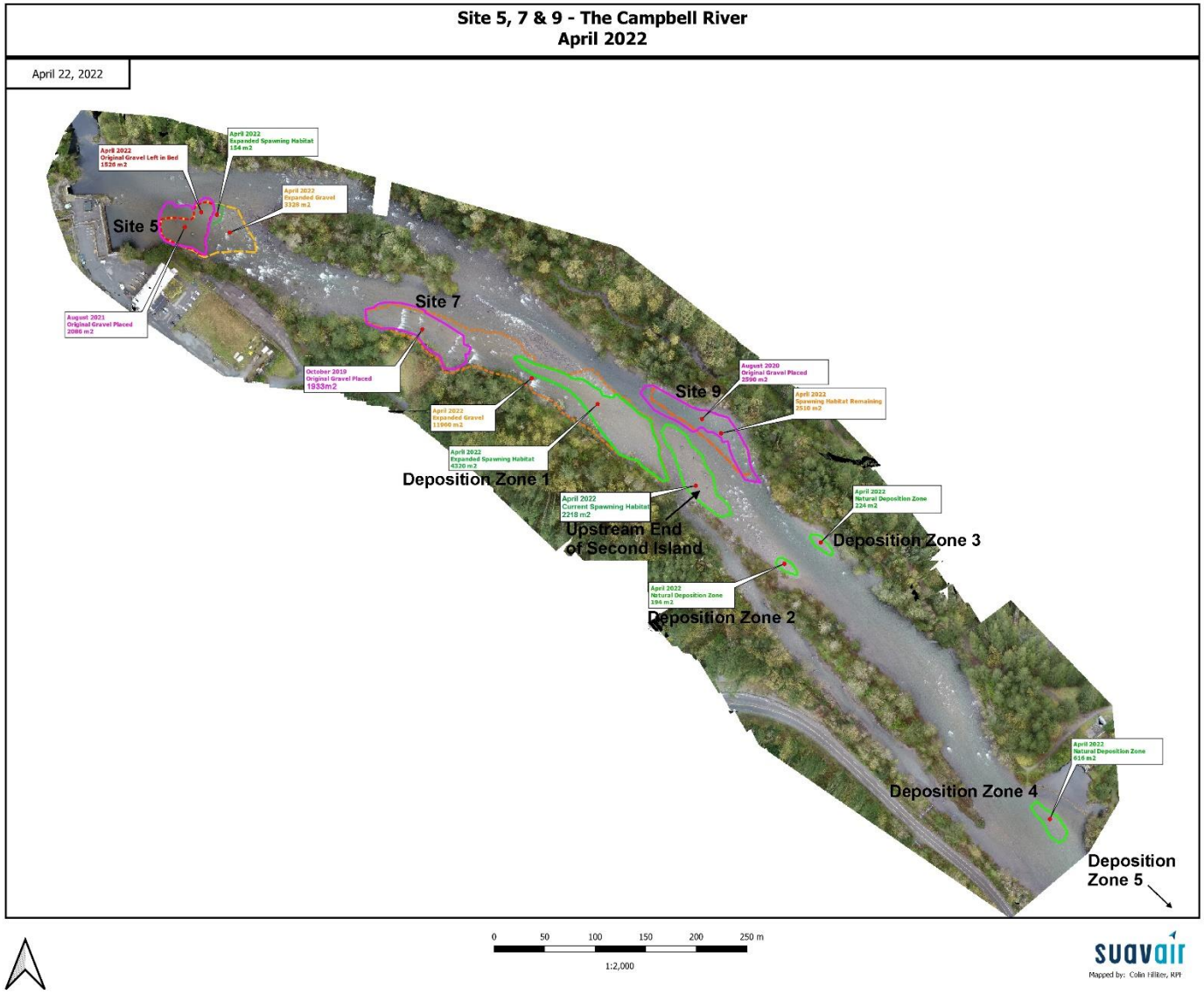


Figure 2: Orthomosaic of the upper reach of the Campbell River from the powerhouse to the Elk Falls water intake with details of gravel restoration projects and depositional zones that have suitable spawning habitat.

Table 1: Spawning Habitat Tracking Table

Post Storm Assessment Ranking of Priority Sites	**Last Built Habitat Created Year – Area**	**2022 Chinook spawning area**	Comments
1. Site 7	1. 2019 – 1933m^2	1. 1900m^2	
2. Site 5	2. 2021 – 2086m^2	2. 1670m^2	
3. Site 9	3. 2020 – 2100m^2	3. 2510m^2	The as-built did not include the temporary gravel access road.
4. Upstream End of Second Island (Reach 4) and	4. 2018 – 4000m^2	4. 1463m^2	Not assessed in 2022. The 2019 post storm assessment area is utilized
Second Island Channel	2018 - 1000m^2	1000m^2	Not assessed in 2022. 2019 restoration report area utilized
5. Elk Canyon (Reach 5)	5. 2017 – 400m^2	5. 400m^2	
6. Ebert Road (Reach 2)	6. 2005 – 5929m^2	6. 190m^2	Not for Chinook anymore, more chum
Created Habitat Total as of March 2022		9,133m^2	
Deposition Sites with Suitable Spawning Habitat		**Area**	Comments
Deposition Zone 1		4320m^2	
Deposition Zone 2		194m^2	
Deposition Zone 3		224m^2	
Deposition Zone 4		616m^2	
Deposition Zone 5		100m^2	
2022 Suitable Spawning Habitat Deposition Total		5,454m^2	
Total Habitat Measured (m^2)		Sum of Chinook spawning area 9,133 + 5,454= **14,587m^2 total habitat measured**	

The field observations are presented from an upstream to downstream direction.

4.1 Site 5 (Priority Site #2) – Upstream End of First island on River Right

Site 5 was characterized by uniform suitably sized spawning gravels. Several small pits were dug and the gravels were uncompacted and at least 30cm deep. An area from near the river center of the site was observed to be washed almost clean of gravels and consisted of large boulders. Gravel deposition was observed in depths likely suitable for spawning downstream and river center. Gravel deposition continued downstream but wasn't in depths or quantities deemed sufficient to support spawning.

The drone imagery analysis confirmed what was observed in the field. Observations have been mapped in Figure 2.

4.2 Site 7 (Priority Site #1) – Downstream End of First island on River Right

Site 7 was characterized by the placed submerged boulders with a uniform suitably sized spawning gravels. Several small pits were dug and the gravels were uncompacted and at least 20cm deep. Field crew felt that suitable spawning habitat was present within the entirety of the constructed gravel pad. Downstream of the gravel pad the substrate consisted of varying depths of gravel mixed with cobble and boulders. Flow was too fast through this section to properly assess but it was thought that minimal suitable spawning gravel depth or area was present for Chinook. Gravel at this area was mobilized by the 2019 high water event that occurred after the construction of Site 7.

The drone imagery analysis confirmed what was observed in the field. Observations have been mapped in Figure 2.

4.3 Deposition Zone 1– Downstream of Site 5

Deposition Zone 1 was characterized by the gravel mobilized by the 2019 high water event that occurred after the construction of Site 7. Uniform suitably sized spawning gravel was present where the flow slowed down and water depth decreased. Several small pits were dug and the gravels were uncompacted and at least 20cm deep. The field crew thought that this area consisted of suitable spawning gravel but water level and flow were of low suitability for Chinook spawning.

The drone imagery analysis and field assessment were utilized to map the suitable spawning habitat. Observations have been mapped in Figure 2.

4.4 Site 9 (Priority Site #3)

Site 9 was characterized by uniform suitably sized spawning gravels within the footprint of the constructed gravel pad. Several small pits were dug and the gravels were uncompacted and at least 15cm deep but due to the flow deeper pits could not be dug. It appeared that a small portion of the upstream, stream center side of the constructed pad had been mobilized.

The drone imagery indicated that some gravel from the top end had moved slightly and been deposited slightly downstream. This analysis when compared to field observations showed that slight changes had likely occurred, but the area of the original pad and the area of adjacent re-deposited gravels that are suitable spawning habitat were very similar. Observations have been mapped in Figure 2.

4.5 Upstream End of Second Island (Priority Site #4) and Second Island Channel

This site was not assessed by field crews during this survey but had been walked during low water levels in the previous summer and was observed to have suitable sized uncompacted gravels. The Second Island Channel was not assessed by field crews. Observations from bank walks indicated minimal change has occurred in this area since construction.

The drone imagery, current and 2019, was analyzed and no changes appeared to have occurred since the previous post-storm assessment. As such the area identified in the 2019 post storm survey (Laich Kwil-Tach Environmental Assessment Ltd. and Ecofish Research Ltd. *2019*) was utilized. The Second Island Channel area identified in the 2019 restoration report (*Fisheries & Oceans Canada and A-Tlegay Fisheries Society, 2019*) has therefore been utilized in the calculation.

4.6 Deposition Zone 2

Deposition Zone 2 was characterized by the suitably sized spawning gravels. The area was small and likely originated from gravels from the upstream end of Second Island Site.

The drone imagery analysis and field assessment were utilized to map the suitable spawning habitat. Observations have been mapped in Figure 2.

4.7 Deposition Zone 3

Deposition Zone 3 was characterized by the suitably sized uncompacted spawning gravels that were at least 15cm deep. The area was small and likely originated from gravels from Site 9.

The drone imagery analysis and field assessment were utilized to map the suitable spawning habitat. Observations have been mapped in Figure 2.

4.8 Deposition Zone 4 – Mill Intake

Deposition Zone 4 was characterized by the suitably sized uncompacted spawning gravels, some in slower moving water and some in deeper faster water. Several pits indicated uncompacted gravel at least 30cm deep.

The drone imagery analysis compared to current and previous surveys indicate this area has continued to accumulate gravel and expand in area. Field and drone imagery were utilized to map the suitable spawning habitat. Observations have been mapped in Figure 2.

4.9 Deposition Zone 5 – Upstream of the Quinsam River Confluence

A small gravel depositional zone, Deposition Zone 3, was observed in the center left of the channel approximately 100m upstream of the confluence of the Quinsam River. This patch was approximately 10m x 10m and was characterized by the suitably sized uncompacted spawning gravels that were at least 20cm deep. The area was small and likely originated from gravels from Site 9.

No drone imagery was captured at this site so the field assessment size was applied to this site.

4.10 Ebert Road (Priority Site #6)

This area consisted predominantly of boulder and large cobble material in riffle habitat with a mix of small 1-5m^2 patches of suitable gravel. Similar to the 2019 survey a few suitable gravel patches were observed that were of sufficient size 10m^2 or greater with uncompacted appropriately sized gravels.

No drone imagery was captured at this site and field observations were comparable to the 2019 survey so the area measurements as determined in the 2019 survey were applied to this site.

5 Recommendations

- We are of the opinion that incorporating the use of a drone survey with the results obtained from the field survey benefited the ability to quantify any impacts or changes that would have or could occur during high flow events. In future years both components should be incorporated to improve resolution.
- A more formal quantification of spawning habitat at the Second Island and Second Island Channel should be undertaken to confirm the assumptions made in this report and to provide a more accurate measurement of suitable spawning area.
- There is no confirmed funding to analyze the fall 2022 RPAS data. However, if the appropriate project arises, comparing the 2021 and 2022 RPAS surveys could help to better understand the effect of high flows on gravel mobilization and transport in the river. For example, as part of the JHTMON-13 study, BC Hydro is working with Laich Kwil-Tach Environmental Assessment Ltd. to develop a hydraulic model of the lower model. Potentially, the RPAS data could be used as part of a separate project to develop and validate a gravel transport component of the model. Such work could provide a decision support tool to evaluate scenarios and understand where, when, and how much gravel should be applied to optimize spawning habitat in the river."

6 Conclusion

This assessment indicates that some gravel movement occurred as a result of the high flow releases in 2021 but the impacts to constructed gravel platforms were relatively minimal. The biggest change occurred in the newly constructed Site 5 with an approximate change (loss) of 416m^2.

An important limitation to note is that the field snorkel survey occurred during flows of 80cms which seemed to be the upper limit of flows suitable to gather appropriate data. For instance, attempting to dig pits to measure the depth of the gravel was made difficult as the flow would cause the pit to fill in as it was dug which is why the gravel depths in this report are approximations or communicated as “at least”. The other limitation of high flows was the restricted ability for the snorkelers to stop and stand in place to take field measurements.

This report documents that the addition of gravel and subsequent mobilization of gravel from constructed platforms results in deposition of these gravels at downstream locations in suitable depths and sufficient area that are likely to support spawning Chinook and other salmon species. The conclusions and

recommendations of this report were found to be supported when in the fall of 2022 the Campbell River Salmon Foundation supported an assessment utilizing a drone to determine utilization of returning salmon of the areas identified within this report. The report titled Campbell River Salmon Utilization of Spawning Gravel is included as Appendix A. The report concludes that "Although species identification and exact numbers could not accurately be determined by drone media, the use of spawning gravel can definitively be confirmed. Spawning redds were visible within all sites and actively spawning fish were seen during video review and bank walks/snorkel". The drone survey could confirm that Chinook did utilize the sites and active spawning was observed but the differentiation between each fish observed could not accurately be determined and therefore exact counts of each species could not be achieved.

Although methods were changed slightly from the methods identified in the 2019 High Flow Response Assessment (post-storm monitoring), the goal of achieving a high-level assessment of the availability of gravel at spawning habitats in the river to determine whether directed works are required in the summer to urgently provide sufficient spawning habitat for salmon to use in the fall was effectively achieved, while using the drone allowed additional information to be collected in a cost effective way.

Although this report has been written after summer 2022, the information collected was utilized to inform decision making in 2022 by the Roundtable, which includes First Nations, regulators, and stakeholders. In addition, the quantification of gravel deposition zones and the subsequent spawning habitat survey provide a more complete quantification of available spawning habitat for Chinook and other salmon species in the Campbell River.

7 References

Abell, J., J. Krogh, M. Sheng, J. Meldrum, D. West, and T. Hatfield. 2019. Strategy for Spawning Habitat Enhancement and Monitoring in the Lower Campbell River. Consultant's report prepared for the Fish & Wildlife Compensation Program by Laich-Kwil Tach Environmental Assessment Ltd. Partnership and Ecofish Research Ltd., June 14, 2019.

Fisheries & Oceans Canada and A-Tlegay Fisheries Society. 2019. Campbell River Second Island Channel Restoration. Report prepared for the Fish & Wildlife Compensation Program, May 14, 2019.

FWCP [Fish & Wildlife Compensation Program]. 2020. Campbell River Watershed Action Plan. Final version issued after administrative update July 21, 2020. 37 p.

Greenacre, D., N. Nahirnick, K. Healey, and J. Abell. 2023. JHTMON-6 Component 3: Flow-Habitat Analysis of Lower Campbell River – Year 2 Annual Report. Draft V1. Consultant's report prepared for BC Hydro by Laich-Kwil-Tach Environmental Assessment Ltd. Partnership and Ecofish Research Ltd., February 2, 2023.

Laich Kwil-Tach Environmental Assessment Ltd. and Ecofish Research Ltd. 2019. Lower Campbell River Spawning Habitat Monitoring – July 2019. Memo prepared for the Campbell River Spawning Habitat Roundtable. 10 p.

Lewis, A., T. Hatfield, B. Chilibeck, and C. Roberts. 2004. Assessment Methods for Aquatic Habitat and Instream Flow Characteristics in Support of Applications to Dam, Divert, or Extract Water from Streams in British Columbia. Report prepared for the Ministry of Water, Land and Air Protection and the Ministry of Sustainable Resource Management.

RIC (Resources Inventory Committee). 2001. Reconnaissance (1:20 000) Fish and Fish Habitat Inventory Standards and Procedures. Prepared for BC Fisheries Information Services Branch. April 2001 Version 2.0. 170 p.

Wil Hilsen, 2017. Campbell River Chinook Spawning Gravel Assessment August 2017 Mapping Program. Northwest Hydraulic Consultants Ltd.

8 Appendix 1

Kent Moeller
President
Campbell River Salmon Foundation

December 2, 2022

Re: Campbell River Salmon Utilization of Spawning Gravel Report

Dear Kent Moeller,

This report is intended to provide a summary of the results of three drone flights, stream walks/snorkel, and subsequent video review for the purpose of determining salmon spawning utilization of the constructed gravel pads and identified gravel deposition areas within the Campbell River. The surveys were conducted in October 2022 and funded through the Campbell River Salmon Foundation (CRSF).

Background

The lower Campbell River has been intensively impacted by the placement of the John Hart Dam. The dam inhibits the natural recruitment and distribution of sediment, including gravels, from further up the watershed. This disruption for an extended period of time results in the loss of spawning gravel for salmonids. Over the years works funded by CRSF, BC Hydro's Fish and Wildlife Compensation Program (FWCP) and others have resulted in the addition of spawning gravel to multiple sites within the Campbell River. The placed gravel from these sites have periodically been mobilized during high flow events and as a result portions of the placed gravels have slowly moved to other parts of the river and been naturally deposited, potentially expanding spawning habitat from the original sites. The Campbell River hosts all Pacific salmonid species, however the targeted species for the addition of spawning gravel was Chinook salmon.

This project aims to confirm and quantify salmonid spawning within both the created spawning habitats and the naturally deposited placed gravel spawning habitats to determine if these habitats are being utilized and to what degree.

Methods

Timing for peak Chinook spawning was advised by the Quinsam hatchery. Three drone flights were conducted by SauvAir on October 12th, October 21st, and October 28th, 2022, covering three naturally deposited placed gravel zones, and four constructed gravel pads; Second Island side-channel (gravel added in 2015), Site 5 (gravel added in 2021), Site 7 (gravel added in 2016 and 2019), and Site 9 (gravel added in 2020) (Figure 1). Stream walks were conducted on October 12th and October 28th, and a snorkel was conducted on October 20th to aid in species identification during video review.

Species were identified from video review by A-Tlegay Fisheries Technicians and Biologist based on past experience in salmonid identification, species composition determined during stream walks/snorkel, perceived size and behaviour in the videos, as well as schooling behaviours.

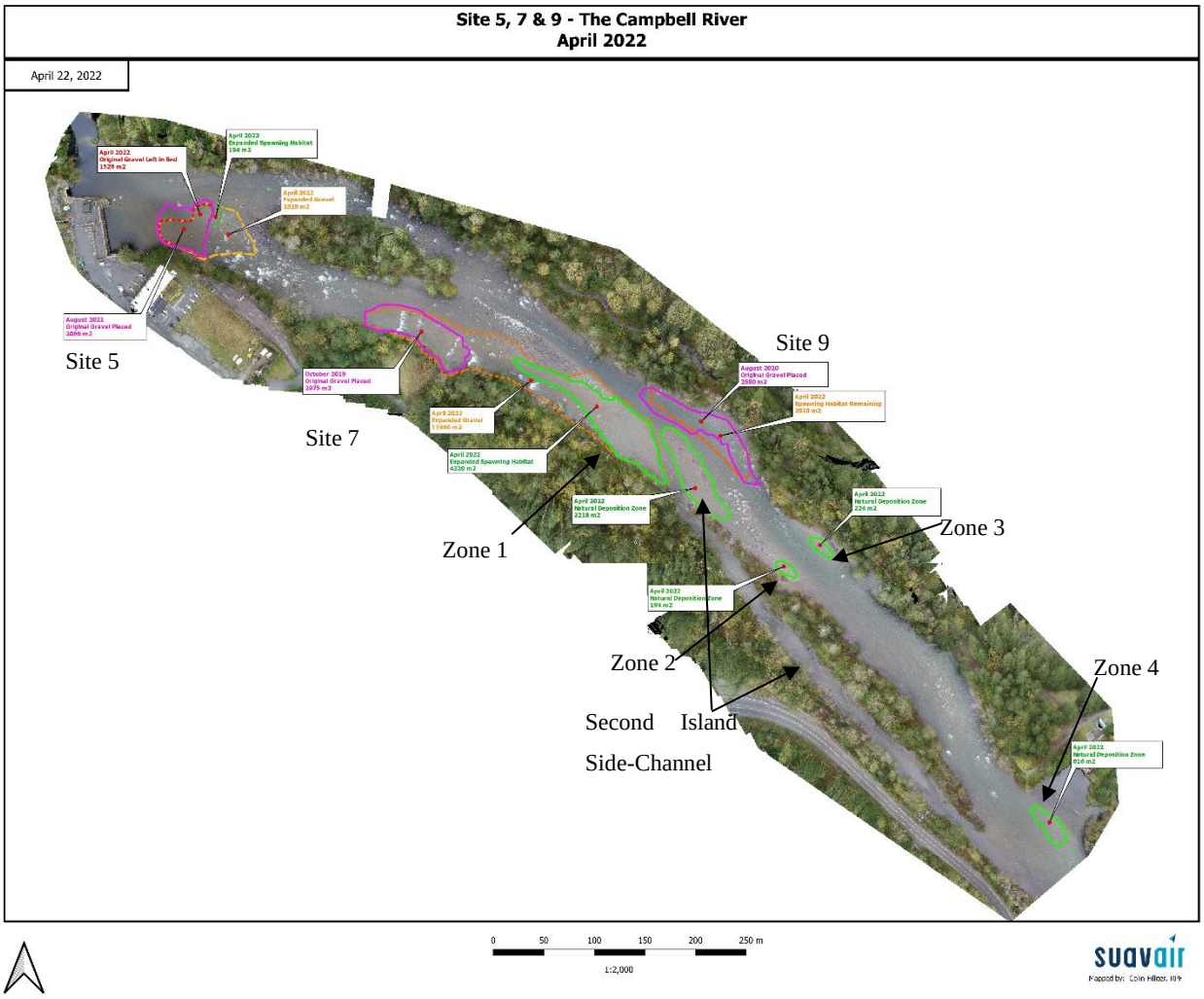


Figure 1. Map of the Campbell River spawning gravel sites.

Results

Video footage review was conducted, and the results were recorded in Table 1. The numbers presented in Table 1 are estimates and may not accurately represent the population structure within these spawning habitats. Many factors influenced the ability to accurately determine species and number of salmonids within the Campbell River including glare from sunshine, shadows from bank vegetation, upstream vs downstream video footage, variation of

height of drone in relation to fish, speed of drone while filming, the inability to accurately measure fish size, and having multiple species within the same area. Chinook, Chum and Coho salmon can all vary within the same size range, with Pink salmon typically being smaller, however jacks from all species can easily be mistaken as Pink salmon, thus identification by size is not a reliable indicator.

Although species identification and exact numbers were not accurately determined by these methods, the use of spawning gravel can definitively be confirmed. Spawning redds were visible within all sites and actively spawning fish were seen during video review and bank walks/snorkel (Appendix 1). A spawning redd is typically lighter in colour than the surrounding gravel, caused by the fish using its tail to clear a spot to spawn. Comparing images of the gravel pads prior to peak spawning, October 12, 2022 with images (Figures 2, 3 and 4) of the gravel pads taken October 28, 2022, we were able to determine an approximate percentage of disturbed (cleaned gravels) during spawning behaviour. Site 5 had approximately 70-80% of gravel that was "cleaned", indicating spawning/spawning behaviours; Site 7 had approximately 80-90% of gravel that was "cleaned", indicating spawning/spawning behaviours; and Site 9 had approximately 80-90% of gravel that was "cleaned", indicating spawning/spawning behaviours.

All sites, the created and the naturally deposited placed gravel, throughout October had evidence of spawning by salmonids, it can be definitively determined by this assessment that the spawning gravel from projects are being utilized by salmonids for spawning at all created sites including the expanded areas of naturally deposited placed gravel.

Table 1. Salmonid counts at determined gravel sites within the Campbell River based on video review from drone flights October 12th, 21st and 28th, 2022.

Date	Site	Salmonid Estimated Counts					Comments
		Chinook	Pink	Coho	Chum	Unknown	
Oct. 12	Naturally deposited placed gravel – **Zone 3**	0	115	0	0	0	Tightly grouped

Oct. 12	Naturally deposited placed gravel – **Zone 2**	102	0	0	0	0	Extreme visibility issues
Oct. 12	Naturally deposited placed gravel – **Zone 4**	100	0	15	0	0	
Oct. 12	Naturally deposited placed gravel – **Zone 1**	30	0	0	0	0	
Oct. 12	Second Island Side-Channel	100	0	50	0	0	
Oct. 12	Site 5	100	0	45	0	0	
Oct. 12	Site 7	50	0	35	0	0	Man fishing
Oct. 12	Site 9	85	0	30	0	0	
Oct. 21	Naturally deposited placed gravel – **Zone 3**	50	48	0	10	0	
Oct. 21	Naturally deposited placed gravel – **Zone 2**	100	0	30	20	0	Hard to ID, lots of movement and lots of glare
Oct. 21	Naturally deposited placed gravel – **Zone 4**	90	0	50	10	0	
Oct. 21	Naturally deposited placed gravel – **Zone 1**	50	0	10	0	0	
Oct. 21	Second Island Side-Channel	45	0	2	10	0	
Oct. 21	Site 5	0	0	0	0	200	Mix of Coho, Chum, and Chinook
Oct. 21	Site 7	100	10	40	10	0	
Oct. 21	Site 9	115	0	25	10	0	

Oct. 28	Naturally deposited placed gravel – **Zone 3**	40	0	115	0	0
Oct. 28	Naturally deposited placed gravel – **Zone 2**	60	0	50	0	0
Oct. 28	Naturally deposited placed gravel – **Zone 4**	50	0	70	20	0
Oct. 28	Naturally deposited placed gravel – **Zone 1**	30	0	10	0	0
Oct. 28	Second Island Side-Channel	40	0	15	10	0
Oct. 28	Site 5	80	0	50	10	0
Oct. 28	Site 7	60	0	30	20	0
Oct. 28	Site 9	130	0	50	10	0

Conclusion

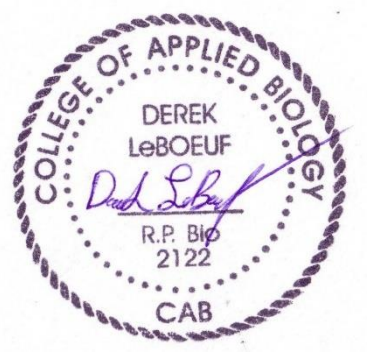
All spawning gravel sites were observed to be utilized by salmonids throughout the three surveys. Chinook and pink salmon were observed spawning within both the created sites and the naturally deposited placed gravel sites. Drone flight video was useful in confirming salmonid utilization of the two types of habitats, created pads and depositional zones, for spawning. However, the use of a drone for species identification proved to be extremely difficult and inaccurate and therefore is not recommended for further investigations if exact species determination is needed. Use of a drone to enumerate fish numbers without identification to species was relatively effective but depended highly on conditions such as river depth, sun angle, and

glare. This project was successful in confirming the utilization of spawning gravel within the Campbell River and will help inform decisions regarding future spawning habitat restoration.

Sincerely,

Sarah Unrau

Reviewed by,



Derek LeBoeuf, R.P.Bio.

Appendix 1. Site Pictures

Figure 2. Site 5 October 28th, 2022, lighter coloured gravel indicates spawning has occurred.

Figure 3. Site 7 October 28th, 2022, lighter coloured gravel indicates spawning has occurred.

Figure 4. Site 9, picture on left from October 12 and picture on right from October 28, 2022, lighter coloured gravel indicates spawning has occurred.

Figure 5. Natural Deposition Zone *3* October 28, 2022.

Figure 6. Natural Deposition Zone 2 October 28, 2022.

Figure 7. Natural Deposition Zone *4* October 28, 2022.

Figure 8. Natural Deposition Zone *1* October 28, 2022, lighter coloured gravel indicate spawning has occurred. Shadowing from trees on the shoreline make this site more difficult to determine utilization.

Figure 9. Underwater image of mixed salmonid species within the Second Island Side-Channel, October 28, 2022.

Figure 10. Actively spawning salmonids within the Second Island Side-Channel, October 28, 2022.

Figure 11. Drone image from Natural Deposition Zone *3* October 12, 2022, highlighting issues in identification and counting from drone footage.