Campbell River Gravel Post-Storm Assessment - 2024

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April 17, 2025
Final Report, Rev. 0

FWCP Project No. COA-F25-F-4152-DCA
NHC Reference No. 3009101.01

Prepared with financial support of 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.

DOCUMENT TRACKING

Date	Revision No.	Reviewer	Issued For
April 17, 2025	0	G. Hill	Final Report

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EGBC Permit to Practice Number: 1003221

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CREDITS AND ACKNOWLEDGEMENTS

The authors would like to thank the Fish & Wildlife Compensation Program for financial support on behalf of its program partners, and A-Tlegay Fisheries Society for initiating this study and for the support provided during the project, in particular:

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EXECUTIVE SUMMARY

The lower Campbell River has been strategically supplemented with chinook salmon spawning gravel since the 1990s because of a sediment deficit caused by the John Hart Dam (JHN). This gravel placement is a high priority action as part of the Fish & Wildlife Compensation Program (FWCP) Campbell River Watershed Action Plan.

Following post-storm monitoring in March 2024, A-Tlegay Fisheries Society (A-Tlegay) retained Northwest Hydraulic Consultants Ltd. (NHC) to perform a detailed chinook salmon spawning gravel assessment and hydrotechnical analysis for the lower Campbell River. This report presents the current quality and extents of the spawning gravel, and discussion regarding future monitoring and placement design. This monitoring and evaluation work aligns with action *CBR.RLR.ME.23.01 Conduct gravel monitoring in the lower Campbell River-P1* of the FWCP Campbell River Watershed Action Plan. The results of this work indicate a need for gravel placement for spawning salmonids under priority action *CBR.RLR.HB.13.01 Gravel placement in the lower Campbell River-P1*. This report provides details regarding urgency and recommended timing.

This project of a detailed spawning gravel assessment enabled estimation of specific habitat area quantities and quality of spawning gravel, the degree of erosion in previously surveyed areas, and the apparent urgency of spawning gravel requirements in the lower Campbell River. A comparison to the benefits of rapid spawning gravel assessments was discussed in this report. Rapid assessments are a lower-cost method of determining presence and movement of spawning gravel as well as forecasting needs for future gravel placement projects. The detailed spawning gravel assessments provide additional information on the gravel quality, and more accurate area estimates for spawning habitat.

NHC assessed gravel stability and discussed how different gravel placement methods, such as embedment strategies, could increase gravel retention in future designs. Future studies such as literature reviews of gravel placement projects, including past Campbell River projects, and gravel grainsize gradations would provide better insight into stable gravel pad designs. Additionally, a gravel tracing program would help evaluate the threshold for sediment entrainment, transport distances, and deposition locations of spawning gravels under varying flow conditions.

Previous hydrotechnical analyses identified a discharge of 225 m^3/s to be the approximate threshold for gravel mobilization (NHC, 2008). To provide stability to the spawning gravel, historic gradations included gravel with larger diameters to better retain gravel. A finer gradation was included in the mixture to reduce interstitial predation of salmon eggs. Past gravel gradations were within the preferred habitat suitability index (HSI) range for chinook salmon.

An analysis of historical flow data was used to present the changes in discharge management since the implementation of the November 2012 BC Hydro Water Use Plan (BC Hydro, 2012). In 2019, 2020, and 2021, spawning gravel was placed at sites 7, 9, and 5, respectively. There were five events since construction of Site 7 spawning pad in 2019. The peak discharges during these periods were likely reduced by the dam operations providing a longer event duration, rather than releasing a larger volume over a shorter timeframe, thereby reducing the volume of gravel mobilized. NHC anticipates that the BC Hydro ramp rates are sufficient for mitigating gravel mobilization, since mobilization is more impacted by duration and magnitude of flow.

A field assessment in August 2024 was completed concurrent with a topographic site survey. The survey showed that Site 5, the most recently constructed gravel pad, had undergone the least degradation. This survey also showed that the most degradation was located across Site 7, the oldest gravel placement site that was surveyed. Since Site 7 is the oldest project site, the location would have experienced the greatest number of high flow events.

A spawning gravel field assessment was completed to identify the location and quality of available spawning gravel in the study reach. Results of this assessment showed that Site 5 contained the highest quality spawning gravel and Site 7 contained the lowest quality. Site 9 had a greater percentage than Site 7 of unsuitable chinook spawning gravel across the original constructed gravel pad area. However, since the remaining spawning gravel at Site 9 is of greater quality than Site 7, a greater volume of gravel was mobilized from Site 7, and there is greater ease of access at Site 7, the next spawning gravel placement project is recommended to be at Site 7. The field assessment also identified areas of deposition outside of the spawning gravel pads.

Overall, Site 7 appeared to be the area most in need of supplemental spawning gravel. Information from the A-Tlegay report *Utilization of Spawning Gravel by Chinook within the Campbell River 2024* (Appendix A) indicated the constructed spawning gravel sites were being utilized by salmonids. The report did not indicate a requirement for urgent gravel placement. Based on the results of the detailed assessment, it was recommended that a gravel placement project be undertaken by the end of summer, 2026. Site 7 was identified as the most likely location.

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1 INTRODUCTION

A-Tlegay Fisheries Society (A-Tlegay) retained Northwest Hydraulic Consultants Ltd. (NHC) to perform a detailed chinook salmon spawning gravel assessment and hydrotechnical analysis for the lower Campbell River. This assessment involved a topographic site survey and spawning gravel field assessment. This monitoring and evaluation work aligns with High Priority Action *CBR.RLR.ME.23.01 Conduct gravel monitoring in the lower Campbell River-P1* of the FWCP Campbell River Watershed Action Plan.

This report presents an assessment of the quality and extents of the spawning gravel, a discussion regarding future monitoring and spawning gravel placement design, and details regarding urgency and timing for spawning gravel replacement.

1.1 Background

The lower Campell River, is a sediment-starved system that receives minimal gravel input due to the three dams upstream: Strathcona Dam, Ladore Dam, and John Hart Dam (JHN). Gravel supply is a limiting factor for chinook salmon reproduction. Spawning gravel must be supplemented in the river to maintain spawning habitat and support the yearly Campbell River chinook salmon escapement target of 2,000 pairs (Burt, 2004). DFO has an interim target of 1,000 pairs following direction from the Quinsam Campbell River Salmon Committee in 2023 (pers. comm. Derek LeBoeuf, April 9, 2024). Since the early 1990s, spawning gravel has been strategically placed in the lower Campbell River, with the three most recent placements being in 2019, 2020 and 2021, at Site 7, Site 9, and Site 5, respectively. In July 2018, spawning gravel was also sourced from the Second Island side channel, where it limited spawning and rearing habitat, and placed along the upstream third of Second Island in the Campbell River main channel (DFO and A-Tlegay, 2019).

Gravel placement is considered a High Priority Action (*CBR.RLR.HB.13.01 Gravel placement in the lower Campbell River-P1*) as part of the Fish & Wildlife Compensation Program (FWCP) Campbell River Watershed Action Plan (FWCP, 2018). To inform gravel placement, annual gravel monitoring assessments are undertaken (*CBR.RLR.ME.23.01 Conduct gravel monitoring in the lower Campbell River-P1*).

Twice in early 2024, flow exceeded the approximate threshold of 225 m^3/s for mobilizing gravel; designs for spawning gravel pads are based on this threshold. As a result of the high flow exceedances of 231 m^3/s on January 1, 2024 and 320 m^3/s on January 31, 2024, A-Tlegay performed a rapid assessment during flows of 70 m^3/s to 75 m^3/s in May 2024 to help assess whether works were urgently required for gravel placement in summer 2024 (LeBoeuf, 2025). This rapid assessment determined that urgent works were not required, and it prompted the detailed gravel assessment outlined in this report. The detailed gravel assessment provides planning guidance for future spawning gravel placements. As part of this detailed assessment,

the current quality and area of chinook salmon spawning gravel was estimated for the lower Campbell River. The A-Tlegay May 2024 gravel survey is provided in Appendix A.

1.2 Goals and Objectives

The objective of this project is to assess the quality and extents of spawning gravel in the study area, and to provide guidance for future gravel placement projects. This work is supported with discussions on spawning gravel gradation and design, frequency and duration of gravel mobilizing flows, future gravel monitoring, and the benefits of a rapid assessment compared to a detailed assessment of spawning gravel in the lower Campbell River.

1.3 Study Area

The project study area along the lower Campbell River, between the BC Hydro JHN Generating Station and the Logging Road Bridge, is shown in Figure 1.1. This study area includes three chinook salmon spawning gravel pads placed between 2019 and 2021. In future, the study area could be extended to the estuary for a more detailed review of depositional areas for gravel.

Figure 1.1 Project study area.

2 METHODS

The rapid assessment completed in May 2024 by A-Tlegay included drone and snorkel swim inspection of Site 5, Site 7, Site 9, and the upstream end of Second Island (LeBoeuf, 2025). Due to the high discharge of 70 m^3/s to 75 m^3/s during the time of snorkel survey, detailed field measurements could not be collected for gravel size, gravel pad width and length

measurements, and gravel depths. Visual surveys were used to estimate gravel pad characteristics. These details were quantified as part of the detailed assessment.

The main tasks completed for this detailed assessment included a site survey, spawning gravel field assessment, and hydrotechnical analyses. The methods for these tasks are outlined in the following sections; results are provided in Section 3.

2.1 Site Survey

Topographic surveys of the spawning gravel pads were performed by Underhill Geomatics on August 7, 2024 at gravel pad sites 5, 7, and 9. A minimum of three cross sections were taken across each gravel pad. At each site, results were used to estimate the amount of erosion since the spawning gravel was placed. This information was used to help assess the gravel quality for spawning.

2.2 Spawning Gravel Field Assessment

NHC performed a field assessment with members from A-Tlegay and Dave Ewart, retired Fisheries and Oceans Canada (DFO) hatchery manager, on August 7, 2024 to review gravel thickness and quality for chinook salmon spawning. The assessment extended from the tailrace of the JHN Generating Station at Site 5 near the mouth of the Elk Falls canyon to the downstream end of Second Island. Campbell River flow was approximately 34 m^3/s during the assessment.

The chinook spawning gravel quality assessment required qualitatively classifying and mapping the spawning gravel based on observations of the bed surface and checks on the gravel thickness at a limited number of locations. The gravel thickness was checked by digging down with a shovel to a maximum depth of approximately 0.3 m. Areas where gravel thickness was less than 0.3 m were not classified as effective spawning habitat. The degree of bed armouring and the approximate flow depth during the time of chinook spawning were considerations in assigning gravel quality. The flow depth was approximated using water level indicators on site such as moss growth and where it was worn off by typical higher flows.

The classification system used for the assessment is shown in Table 2.1. This system was used for a similar previous project (NHC, 2017a); however, the classification system for this project was modified such that Quality 1 habitat was still usable with a minimum of 10% spawning gravel coverage. Areas were assessed where chinook spawning gravel had been previously placed within the channel, and where obvious deposits were observed downstream of the placement sites. A sample of target quality spawning gravel was collected to perform a gradation analysis.

Table 2.1 Qualitative spawning gravel classification system applied to assessed areas.

Quality	Percent Spawning Gravel
1	10 to 20
2	20 to 40
3	40 to 60
4	60 to 80
5	80 to 100

2.3 Hydrotechnical Analysis

The hydrotechnical analysis for this project was performed as a desktop assessment and included the following:

- Review of spawning gravel field assessment and survey to map areas of with estimated spawning gravel quality
- Development of spawning gravel erosion and deposition mapping using survey data, demonstrating changes in bed elevations since previous spawning gravel placements
- Calculation of net erosion volumes between construction dates and August 7, 2024 using survey data
- Review of the basis and accuracy of the reported threshold for gravel mobilizing discharge for the spawning gravel pads
- Assessment of discharge records from BC Hydro and Water Survey of Canada relative to the gravel mobilizing discharge focussing on timing, frequency, and duration
- Review impact of BC Hydro flow ramp rates to gravel mobilization

3 RESULTS AND OUTCOMES

The rapid assessment completed by A-Tlegay in May 2024 indicated minor surface armouring of the gravel pads compared to the previous survey in 2022, and no noticeable complete washouts of gravel pads at Site 5, Site, 7 or Site 9 (LeBoeuf, 2025). This resulted in a recommendation to the Gravel Committee that urgent works were not required for summer 2024, and that a detailed assessment should be undertaken; the Gravel Committee agreed.

This section presents the results from the detailed assessment including the site survey, spawning gravel field assessment, and hydrotechnical analysis.

3.1 Site Survey

From the site survey, erosion-deposition maps were created to visualize the change in bed elevation at the three spawning gravel pad sites. Volume of gravel mobilized from each site was also estimated. The volumes are likely underestimates, since data was only available between surveyed sections, as the perimeter of the spawning gravel pad was not surveyed. Therefore, elevation differences are unknown within the area from the upstream-most surveyed section to the upstream gravel pad extent, and the downstream-most surveyed section to the downstream gravel pad extent. No volumetric or area corrections were applied to these volume estimates. Appendix B provides the full erosion and deposition map drawing set.

Sheet 001 in Appendix B presents a map of Site 5 showing the changes in bed elevation between gravel placement in 2021 and the 2024 survey. Site 5 was entirely embedded and constructed to be approximately level with the riverbed. The Site 5 gravel pad had some degree of erosion over most of its footprint, with as much as 0.7 m of erosion towards the middle of the Campbell River. Near the upstream center portion of the gravel pad there was an area of 0.4 m aggradation. From the survey, it was estimated that a minimum volume of 260 m^3 of gravel out of the original 1,200 m^3 placement has been mobilized from Site 5 since the 2021 placement (NHC, 2021).

Sheet 003 in Appendix B presents a map of Site 7 showing the changes in bed elevation between gravel placement in 2019 and the 2024 survey. The Site 7 gravel pad had eroded by as much as 1.3 m in depth, with most of the erosion across the gravel pad between 0.4 m and 0.7 m. There was some aggradation along the right bank with as much as a 0.7 m increase in bed elevation at the upstream half of the gravel pad. From the survey, it was estimated that a minimum volume of 1040 m^3 of gravel out of the original 1,980 m^3 placement has been mobilized from Site 7 since the 2019 placement (NHC, 2020a). Mobilized gravel appears to have deposited across from Site 9, though the deposited volume is unknown; see Section 3.2 for further details.

The Site 7 pad had been constructed with two embedded cells totalling an area of 300 m^2 where the riverbed was excavated and replaced with spawning gravel. The rest of the Site 7 pad consisted of gravel placed directly on the riverbed. There appeared to be less erosion in the areas of the embedded cells than the rest of the spawning gravel pad, which is consistent with the findings from the 2019 scour sensor study (NHC, 2020a). Since only four sensors were used in the 2019 study, two in the embedded cells, it was inconclusive whether the embedded cells made a difference in degree of scour.

Sheet 005 in Appendix B presents a map of Site 9 showing the changes in bed elevation between gravel placement in 2020 and the 2024 survey. Site 9 was constructed such that spawning gravel was placed on top of the riverbed without any being embedded. The Site 9 gravel pad was eroded by as much as 1.9 m, primarily in the upstream half of the pad. There was some aggradation: approximately 0.4 m of additional spawning gravel along the left bank. From

the survey, it was estimated that a minimum volume of 710 m^3 of gravel out of the 1,650 m^3 placement has been mobilized from Site 9 since the 2020 placement (NHC, 2020b).

Generally, results showed erosion of the spawning gravel pads placed between 2019 and 2021. Site 7 showed the most erosion and Site 5 showed the least, which corresponded to the relative age of the gravel pads. Older gravel pads would have been subjected to more flood seasons and high flow events therefore, a greater degree of erosion could be expected. Other factors such as embedding the gravel into the riverbed profile and differences in site characteristics, such as the hydraulic shear stress, also factor into the gravel mobilization.

3.2 Spawning Gravel Field Assessment

Based on the quality classification framework presented in Section 2.2, the overall quality of chinook spawning gravel in the lower Campbell River was observed to mostly be between Quality 1 and 3, with some Quality 4; there were no areas of Quality 5. Maps of the spawning gravel quality are provided in Appendix B, with a breakdown of quality by area assessed. Table 3.1 presents the total observed area of spawning gravel per quality classification. Table 3.2 presents a comparison of the original constructed gravel pad areas, and the updated estimated usable area. The quality of spawning gravel was assessed within the spawning gravel pad extents. Quality was only mapped and assigned when there was a minimum of 10% spawning gravel. Areas within the footprint of the spawning gravel pad extent without an assigned quality have zero chinook spawning habitat. Table provides the original constructed area, and the current available spawning area following this assessment.

Table 3.1 Summary of spawning gravel area and quality.

Quality	Percent Spawning Gravel	Total Area (m^2)
1	10 to 20	4,700
2	20 to 40	4,000
3	40 to 60	3,400
4	60 to 80	870
5	80 to 100	0

Table 3.2 Spawning gravel pad construction method, original constructed area, and updated spawning area for the three most recent gravel placement projects.

Site	Year of Most Recent Placement Project	Construction Method	Original Spawning Pad Area (m^2)	Current Spawning Pad Area (m^2)
5	2021	Mostly embedded, level with riverbed	2070	1850
7	2019	Placed on top of riverbed; two embedded cells	2360 (300 m^2 total embedded area)	1790
9	2020	Placed on top of riverbed	2100	1490

Map 1 shows the assessed spawning gravel quality at Site 5. Site 5 was observed to have the highest quality of all three pads. Approximately 45% of the area had a Quality 2, approximately 20% of the area had a Quality 3, and approximately 25% was Quality 4. Approximately 10% was considered unsuitable for chinook spawning. This spawning gravel pad was the most recently constructed, and showed the least erosion. From the drone imagery, gravel had been mobilized downstream towards First Island and the right flow split; this was confirmed during the field assessment.

Map 2 shows the assessed spawning gravel quality at Site 7. This site had the lowest quality of the three gravel placement locations. Quality 1 chinook spawning habitat covered approximately 50% of Site 7, with zero chinook spawning habitat over approximately 25%. Quality 2 habitat covered approximately 20%, and there was a small pocket of Quality 3 at the downstream end of the chinook spawning gravel pad; approximately 5% of Site 7. The low-quality habitat in this area was reasonable since Site 7 was the oldest spawning gravel project reviewed and had undergone the most erosion, due to withstanding the greatest number of high flow events. Just upstream of Site 7, there was an area of gravel deposition that was assigned Quality 2.

Map 3 shows the assessed spawning gravel quality at Site 9 and depositional areas downstream of Site 7 on the right half of Campbell River. At Site 9, the usable chinook spawning gravel was focussed along the left bank, and was approximately 25% Quality 3. There was a total area of approximately 10% Quality 1 and 5% Quality 2 chinook spawning gravel. This was consistent with the erosion-deposition map showing accumulation along the left bank and erosion of the outer gravel pad extent. Approximately 60% of the gravel pad was considered unsuitable for chinook spawning, mainly where the gravel pad had undergone erosion on the outer edge. Future designs for this area should consider reducing the extent into the river to retain gravel for a longer duration at Site 9.

Site 9 had a greater percentage than Site 7 of unsuitable chinook spawning gravel across the original constructed gravel pad area. However, since the remaining spawning gravel at Site 9 is of greater quality than Site 7, a greater volume of gravel was mobilized from Site 7, and there is

greater ease of access at Site 7, the next spawning gravel placement project is recommended to be at Site 7.

On the right bank, downstream of First Island, there was a large area of deposition extending to the upstream end of Second Island. Additional spawning gravel was sourced from the Second Island side channel in 2018 to improve spawning and rearing habitat in the side channel and increase the potential spawning area along the upstream third of Second Island in the Campbell River main channel (DFO and A-Tlegay, 2019). The total area was approximately 5,000 m^2, of which approximately 65% was Quality 1, 10% was Quality 3, 10% was Quality 4, and 15% was Quality 2. The Quality 3 and 4 areas were longitudinal strips in the center of the channel. The Quality 2 chinook spawning gravel was a more concentrated area at the downstream end of this depositional area. Gravel within this depositional area that was not suitable for chinook salmon is still suitable for other salmonids (pers. comm. Derek LeBoeuf, March 14, 2025).

Map 4 shows the assessed spawning gravel quality at depositional areas downstream of Site 9. There was Quality 2 and Quality 3 chinook spawning gravel in the side channel between Second Island and the right bank of Campbell River. There were two areas of Quality 2 spawning gravel in the main channel at the upstream end of Second Island. The downstream-most mapped area of chinook spawning gravel was a depositional area of Quality 2 gravel at the downstream end of Second Island on the left bank.

No areas downstream of Second Island were investigated during the field assessment. This was primarily due to the anticipation of minimal spawning habitat in those areas. Dave Ewart (pers. comm. August 7, 2024) mentioned low expectation of any significant quality spawning gravel between Second Island and the logging road bridge. LeBoeuf (2023) confirmed this with only one location of 10 m^2 spawning habitat observed.

From this assessment and the site survey, Site 7 appeared to be the location with the greatest need of additional chinook spawning gravel.

3.3 Field Observations of Spawning Chinook

A-Tlegay completed drone and snorkel swim surveys on October 10 and 24, 2025 to compare salmon spawning use to the gravel quality assessments undertaken for this study. Campbell River flow during the assessment was approximately 72 m^3/s and 114 m^3/s on October 10 and 24, respectively. The snorkel swim surveys observed the presence, species, and numbers of salmon using the spawning gravel. The study was to help determine whether a spawning gravel placement project was urgent and would require construction in 2025, or if construction could occur in 2026.

The study concluded that all spawning gravel sites were used by chinook salmon. Additionally, it was inconclusive whether utilization of spawning pads by chinook salmon was impacted by the high flow event in early 2024. The report does not indicate a requirement for urgent gravel

placement. The A-Tlegay report *Utilization of Spawning Gravel by Chinook within the Campbell River 2024* is provided in Appendix A.

Based on the results of the detailed assessment, a gravel placement project should be undertaken by the end of summer, 2026. With the lowest gravel quality, and the most widespread degradation, Site 7 was identified as the most likely location.

3.4 Hydrotechnical Analysis

Results of the hydrotechnical analysis are described in the following sections.

3.4.1 Gravel Mobilization Threshold

Since 2006, the gravel gradation for the gravel placement projects has been designed to be stable up to an approximate threshold of 225 m^3/s. Following the summer 2006 gravel placement at Site 7, a peak discharge of 265 m^3/s was recorded and a minor volume of gravel was mobilized (NHC, 2008). This indicated the approximate threshold of gravel mobilization was below 265 m^3/s.

NHC (2020a) completed a scour analysis at Site 7 using sensors installed during construction in 2019. These sensors recorded data from October 2019 to May 2020. The analysis noted that the maximum instantaneous discharge that caused movement in the Site 7 gravel pad was between 219 and 225 m^3/s. Additionally, the least amount of scour was recorded towards the centre of the spawning gravel pad in the upstream embedded cell.

Using Shield's Equation and shear stresses modelled at the pad sites, NHC (2008) found the stable particle diameter for a flow of 225 m^3/s to be 120 mm. Approximately 60% of the grainsize diameters are less than this for the chinook salmon spawning gravel mixtures used in past placement projects. Designs for spawning gravel pads target gravel stability for flows up to 225 m^3/s however, some of the finer grain size fraction will be mobilized at lower discharges. The analysis by NHC (2020a) indicates gravel may begin to mobilize at slightly lower discharges. While the gravel mobilizing flow threshold of 225 m^3/s is approximate, it is anticipated that discharge above this threshold will begin to mobilize gravel. Future work could involve investigating any modern design methodologies for gravel retention.

3.4.2 Spawning Gravel Gradations

Spawning gravel pad designs consider water depth, flow velocity, and substrate characteristics as key parameters. A habitat suitability index (HSI) relates each of these parameters to its suitability as habitat for a certain salmon species and life stage on a scale of 0 to 1. Zero indicates that the habitat is not suitable, and one indicates that it is ideal habitat. The limiting factor in calculating HSIs for chinook salmon in the lower Campbell River is the size of substrate.

NHC (2020a) provides further discussion on HIS curves and the appropriate range for chinook salmon.

During the spawning gravel field assessment, Dave Ewart visually identified an area of spawning gravel that was high quality. NHC collected a sample of this material from the downstream end of Site 7 on the right bank, and had a sieve test performed to determine its gradation. Figure 3.1 shows a grainsize distribution comparison between the spawning gravel sample and the material placed at sites 5, 7, and 9 between 2019 and 2021. This graph depicts how the chinook spawning gravel that was visually assessed to be of high quality has a narrower range in particle diameters compared to the material used for the gravel pads. The gravel sample quality fell within the ideal range (1.0) for chinook salmon HSI indices. For the placed gravel in 2019 to 2021, larger particle stone sizes were used to help provide stability to the placed gravel. Smaller stones were used to reduce void space to reduce interstitial predation of chinook eggs.

The gradations used in the spawning gravel placement projects were appropriate for chinook salmon, falling within the upper range of the HSI (0.73 to 1.0). The larger stone sizes create a sheltering effect and reduce the hydraulic forces on the smaller stones. This allows material with grainsize distributions including larger stones to remain stable at greater discharges. A reduction in the maximum gravel diameter would reduce the stability and allow gravel to mobilize at flows lower than the current approximate threshold of 225 m^3/s. A future project could include analysis and review of gravel gradations for other successful chinook spawning projects, considering interstitial predation and gravel retention mechanisms.

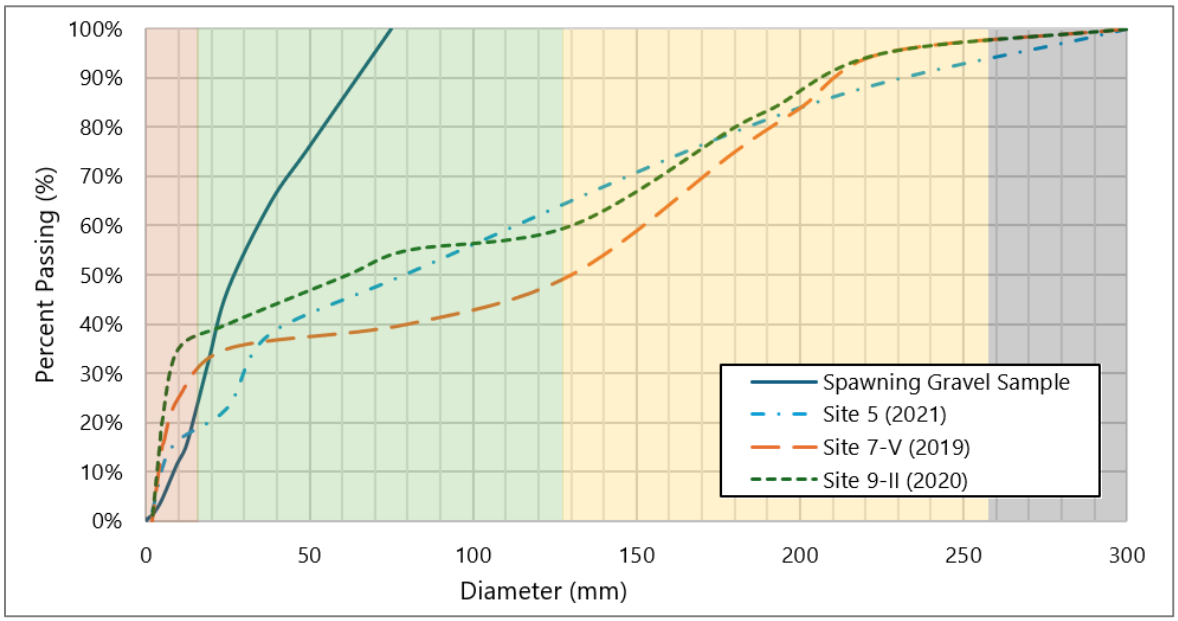

Figure 3.1 Grain size distribution of the obtained chinook spawning gravel sample and gradations used for past gravel placement projects. The zones of red, green, yellow, and black represent HSIs of 0.38, 1.0, 0.73, and 0, respectively.

3.4.3 Flow Data Analysis

In November 2012, BC Hydro adopted a Water Use Plan (WUP) to conduct operations to more positively affect fisheries and wildlife habitat, flood control, shoreline conditions, and recreational interests (BC Hydro, 2012). Flow events over 225 m^3/s in Campbell River were analyzed to present the changes in discharge management since the implementation of the WUP. Daily discharge datasets from Water Survey of Canada (WSC) and BC Hydro were reviewed. The WSC and BC Hydro data records were reviewed to provide comparison to changes and improvements in flow release management (Table 3.3). The WSC data was reviewed for 1949 to 1970 and 1992 to 2012, and the BC Hydro data records were reviewed from January 2012 to April 2024, inclusive. Based on the BC Hydro data, the gravel mobilization flow was exceeded five times between the last Site 7 gravel pad construction in August 2019 and summer 2024. These occurred as follows:

- February 1 to 5, 2020 – duration: 5 days | approx. discharge: 230 m^3/s
- November 5 to 15, 2021 – duration: 11 days | approx. discharge: 230 m^3/s to 250 m^3/s
- November 30 to December 6, 2021 – duration: 7 days | approx. discharge: 230 m^3/s to 250 m^3/s
- December 29, 2023 to January 2, 2024 – duration: 6 days | approx. discharge: 230 m^3/s
- January 30 to February 7, 2024 – duration: 9 days | approx. discharge: 230 m^3/s to 320 m^3/s

The peak discharges during these periods were likely reduced by the dam operations providing a longer event duration, rather than releasing a larger volume over a shorter timeframe. The longer event duration with lower peak discharge would have reduced shear stress on the riverbed, therefore mobilizing less spawning gravel. If the peak discharge for the events could be reduced by increasing the durations of the events, this would reduce the gravel mobilization.

Table 3.3 Changes in Discharge Management since implementing the BC Hydro Water Use Plan.

Parameter	Pre-WUP (1949 to 2012)	Post-WUP (2013 to 2024)
Number of Years of Record	43	12
Number of Events Where Flow Exceeded 225 m^3/s	105	10
Average Duration Where Flow Exceeded 225 m^3/s	2.5 to 5 Days[1]	8.5 Days[2]
Average Number of Flow Exceedance Events Per Year	3	1
Maximum Number of Flow Exceedance Events in One Year	10	2

1. Before the WUP was implemented, flow exceedances could occur in any month. Summer exceedances had lower durations, bringing down the annual average duration to 2.5 days. The winter high flow season had longer event durations. The average flow exceedance duration was 5 days in October through March.
2. Under the WUP, high flow releases have been limited to November through February.

3.4.4 Impact of BC Hydro John Hart Dam Ramp Rates on Gravel Mobilization

The impact of BC Hydro JHN ramp rates on gravel mobilization could not be determined, as hourly gravel mobilization data is not available. A gravel tracing program would provide better insight to this (Section 3.4.6). NHC anticipates that the ramp rates are sufficient for mitigating gravel mobilization, since mobilization is more impacted by duration and magnitude of flow. Additionally, the ramp rates do not allow for sudden releases of high discharge.

3.4.5 Stability of Spawning Gravel

The stability of the gravel pads was interpreted from the erosion-deposition maps presented in Section 3.1. The gravel pad degradation with minor relative accumulation is consistent with the sediment deficit in Campbell River. The upstream hydroelectric operations, and the five events of approximate gravel mobilizing flow exceedances of 225 m^3/s since 2019 contributed to erosion of spawning gravel in the lower Campbell River.

As noted in Section 3.1, the gravel placement project at Site 7 in 2019 included two embedded cells of spawning gravel. It is possible this design helped retain gravel for a longer timeframe by allowing gravel to remain stable during greater discharges, though more data would be required to have more certainty. The design of the spawning gravel pad and other factors such as the hydraulic shear stress at the site will affect gravel retention.

There are several design approaches to consider for future gravel placement including: full surface placement of spawning gravel, full gravel embedment, a series of smaller embedded pockets, or a surface-placed pad with smaller embedded pockets within.

The gradation of the spawning gravel should also be considered. To determine the optimal spawning gravel design and gradation for the lower Campbell River, further studies would be required. This would include literature reviews of other gravel pad placement projects and embedment methods, and reviews of gravel gradations that consider interstitial predation of eggs. A gravel tracing program to better understand the specific sediment transport behaviours and mechanisms in Campbell River would also be beneficial.

3.4.6 Gravel Tracing Program

A gravel tracer program could offer valuable insights into the movement of spawning gravels for varying grain sizes, helping to understand the processes of sediment entrainment, transport, and deposition. This program would involve tagging a sample of stones at each spawning pad with Radio Frequency Identification (RFID) Passive Integrated Transponders (PIT) tags. The tags would be embedded in small, drilled holes in the stones and sealed with epoxy, each tag carrying a unique RFID code recorded prior to deployment. By tagging a representative sample of the spawning gravel grain size distribution, the program could accurately reflect transport dynamics of different gravel sizes. After deployment, the tagged gravels would be exposed to river flows,

and their movements tracked by re-surveying the channel with an RFID antenna after a high flow event or following the winter high flow season.

The primary purpose of the gravel tracer program would be to evaluate the discharge associated with movement of individual grain sizes, transport distances, and deposition locations of spawning gravels under varying flow conditions. Additionally, burying some tracer gravels at varying depths would allow for estimation of scour depths and longevity of deeper spawning gravel.

The program could be designed with different levels of effort depending on the desired outcomes. A lower-effort version might involve deploying a reduced number of tracer stones at each spawning pad and conducting limited surveys after the winter high flow season. The surveys could be limited to the initial spawning pad footprint, providing a basic assessment of gravel movement by determining the presence or absence of tracer gravels at the spawning pads, thereby indicating whether the gravels were transported downstream. On the other hand, a more detailed and higher level-of-effort program could include multiple surveys throughout the winter to document gravel movements caused by individual high flow events. Such a program would allow for the identification of mobility thresholds for gravels of different sizes at different locations in the river, generating more detailed statistics on sediment transport. Expanding the survey area further downstream would also allow for relocation of mobile gravels, providing information on transport distances and observed depositional locations.

The gravel tracer program presents a flexible and scalable approach to studying sediment dynamics. This would provide additional guidance for planning and timing of future gravel placement projects by enabling estimation of the percentage of gravel mobilized for various grain sizes for given discharge each year.

An alternative method to the PIT tagging approach is the use of active tracers, which could provide real-time positions of the gravels as they move. The size of the active tracers would limit estimation to the coarser grain size fraction, however this would provide greater accuracy in defining the gravel mobilizing discharge, and the effect of BC Hydro ramp rates on gravel mobilisation.

While the gravel tracer program offers the potential for detailed and valuable data, the decision to implement the program will depend on the priorities of the Campbell River Gravel Committee and available resources.

4 DISCUSSION

This section presents a discussion on the values of the rapid spawning gravel assessments and the detailed assessments, and information about the sediment budget for the lower Campbell River.

4.1 Rapid and Detailed Spawning Gravel Assessments

The rapid assessment allows for an overview-level estimate of the available spawning gravel for relatively low effort and cost. Estimates for the amount of spawning gravel available do not consider the thickness of the gravel layer, and assume all available spawning habitat is high quality. The rapid assessment provides a general estimate of the available spawning habitat with the understanding that the estimated habitat area is likely of lower quality and may be an overestimate. The rapid assessment considers the estimated water depth during spawning.

The detailed assessment is useful to provide a more accurate estimate of the available spawning habitat. The detailed assessment considers the estimated water depth during spawning, the thickness of the spawning gravel layer, and the quality of the spawning gravel. The spawning habitat would be considered low quality or not usable if the water depth is too shallow, the gravel layer is too thin, or the grainsize distribution is not ideal (e.g., substrate is too coarse for fish to build their redds). The detailed assessment requires more effort and therefore is more costly; however, it is useful to verify the rapid assessments with additional data. For example, at Site 9 the rapid assessment showed useable spawning gravel across the full original constructed footprint, whereas the detailed assessment identified a considerably smaller area for usable spawning habitat. The rapid assessment identified potential spawning habitat, assumed to be of high quality. The detailed assessment indicated the usable chinook spawning habitat area and assigned a more accurate habitat quality.

Table 4.1 presents a quantitative comparison of spawning gravel areas identified by the 2022 rapid assessment and the 2024 detailed assessment. The rapid assessment completed in 2024 did not provide updates to the 2022 spawning habitat area tracking, since this was to be undertaken for the detailed assessment. The only events with discharge greater than 225 m^3/s following the 2022 rapid assessment were the two events that instigated the 2024 rapid assessment. The comparison in Table 4.1 does not consider the differences in spawning gravel quality identified as part of the detailed assessment. Site 9 shows the greatest variance between assessments. Variances were due to differences in methodology for the rapid assessment versus the detailed assessment.

Table 4.1 Spawning Gravel Area Comparison between 2022 Rapid Assessment and 2024 Detailed Assessment.

Location	2022 Rapid Assessment Area[1] (m^2)	2024 Detailed Assessment Area (m^2)	Change from Rapid to Detailed Assessment
Site 5	1,670	1,850	+180 m^2 (+11%)
Site 7	1,900	1,790	-110 (-6%)
Depositional area across from Site 9[2]	4,320	4,950	+630 (+15%)
Site 9	2,510	790	-1,720 m^2 (-69%)
Depositional area downstream of Site 9[3]	2,034	3,310	+1,276 m^2 (+63%)
Totals	12,434	12,690	+256 m^2 (2%)

1. Rapid assessment areas from LeBoeuf (2023).
2. Reported area for *Rapid Assessed area* from Zone 1 (LeBoeuf, 2023).
3. Reported area for *Rapid Assessed area* from Zone 2, Zone 3, Zone 4, and Second Island Channel (LeBoeuf, 2023).

Overall, the rapid assessment can effectively identify the mobilization and approximate locations of spawning gravel but does not distinguish spawning gravel quality. The primary benefit of the detailed assessment is information about the quality of available habitat, which informs the near-term needs for chinook spawning gravel projects.

4.2 Sediment Budget

Gravel has been placed in the Campbell River system for salmon spawning habitat restoration since 1997. An estimated 42,530 tonnes of spawning substrate has been introduced to the river downstream of Elk Falls. The average annual substrate introduction since 1997 is approximately 1,500 tonnes. NHC (2017b) estimated the average annual sediment yield in the lower Campbell River prior to construction of the JHT facility was 2,200 tonnes. Thus, there is an average deficit of 700 tonnes per year of spawning substrate since 1997, or 19,100 tonnes in the 28-year period.

5 CONCLUSIONS AND RECOMMENDATIONS

NHC has the following conclusions from results of the detailed site assessment including site survey, spawning gravel field assessment, and hydrotechnical analysis:

- Overall spawning gravel quality in the lower Campbell River was observed to mostly be between Quality 1 and 3, with some Quality 4; there were no areas of Quality 5 out of 5
- Each of the three spawning gravel placement locations underwent some erosion. Site 7 had the greatest eroded area, and Site 9 had the location with the greatest eroded depth. Site 5

had the least erosion and greatest overall gravel quality. The summation of depositional areas outside of Site 5, Site 7, and Site 9 totalled an area of 8,400 m^2.

- Designs for spawning gravel pads target gravel stability for flows up to 225 m^3/s however, some of the finer grain size fraction will be mobilized at lower discharges. The analysis by NHC (2020a) indicates gravel may begin to mobilize at slightly lower discharges. While the gravel mobilizing flow threshold of 225 m^3/s is approximate, it is anticipated that discharge above this threshold will begin to mobilize gravel.
- The approximate gravel mobilizing flow threshold of 225 m^3/s was exceeded approximately five times since the Site 7 gravel placement project was completed in summer 2019. Discharges for these events were 230 m^3/s to 320 m^3/s. The Site 7 gravel placement project was the oldest placement project reviewed for this detailed assessment and therefore was exposed to the most high flow events.
- NHC anticipates that the BC Hydro ramp rates are sufficient for mitigating gravel mobilization, since mobilization is more impacted by duration and magnitude of flow
- While the ideal (HSI of 1.0) chinook spawning gravel gradation is between 16 mm to 128 mm, greater grain sizes are required to keep the gravel pad stable for greater discharge events, and a smaller grain size is required to limit interstitial predation (NHC, 2020a). Grain sizes between 2 mm to 256 mm are within suitable HIS for chinook salmon spawning
- Rapid assessments can effectively identify the mobilization and approximate locations of spawning gravel but do not distinguish spawning gravel quality. The primary benefit of detailed assessments is information about the quality of available habitat, which informs the near-term needs for chinook spawning gravel projects. Both types of analysis provide valuable information
- Gravel placement projects in the lower Campbell River should be continued to replenish the chinook spawning habitat due to gravel being mobilized downstream

NHC recommends the following:

- Biological monitoring is conducted for the Campbell River gravel projects and should be continued, and potentially expanded. This monitoring work is conducted to address High Priority Actions in the FWCP (2018) Campbell River Watershed Action Plan: *assess success of habitat-based actions supported by FWCP* (CBR.ALL.ME.08.01), *conduct condition assessments and/or maintenance on habitat enhancements* (CBR.ALL.ME.09.01), and *conduct gravel monitoring in the lower Campbell River* (CBR.RLR.ME.23.01). As a minimum, annual snorkel swim surveys should continue to document Chinook spawning usage, and any additional benefits for fish.
- Habitat modelling and weighted usable area calculations, which require calculation of the HSI, should be considered to provide a more accurate estimation of the area required by each Chinook spawning pair. Comparison of the weighted usable area method and updated bio-standards would help assess, design, and monitor spawning gravel in the river

- Undertake a gravel tracing program to understand the processes of sediment entrainment, transport, and deposition. The primary purpose of the gravel tracer program would be to evaluate the threshold for sediment entrainment; transport distances, and deposition locations of spawning gravels under varying flow conditions. This would provide additional guidance for planning and timing of future gravel placement projects by enabling estimation of the percentage of gravel mobilized for various grain sizes for given discharge each year. The study area for gravel tracing should extend from the JHN Generating Station to the estuary.
- Complete a literature review of gravel placement projects in similar gravel bed systems to guide future gravel pad design in the Campbell River. Include previous literature reviews completed for the Campbell River. Include effective chinook spawning gravel size, stability methods, and predation factors. Use this information to guide design refinements for future gravel pads in the lower Campbell River
- Upgrade previous Site 7 chinook salmon spawning gravel pad designs in 2025 for spawning gravel placement at Site 7, which incorporates findings from the literature review
- Complete construction of a chinook spawning gravel pad at Site 7 by end of summer 2026

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APPENDIX A

A-TLEGAY REPORTS

A.1. Assessment of High Flow Impacts to Spawning Habitat in the Lower Campbell River, 2024

A.2. Report of Utilization of Spawning Gravel by Chinook within the Campbell River 2024

Assessment of High Flow Impacts to Spawning Habitat in the Lower Campbell River, 2024

Project Number: (COA-F25-F-4152-DCA)

Prepared with financial support of 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

Prepared for:
Fish and Wildlife Compensation Program

Prepared By:
A-Tlegay Fisheries Society
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Derek LeBoeuf, RPBio.

Stamped Version on File:
Final Report
March 26, 2025

Disclaimer:

This report was prepared by A-Tlegay Fisheries Society for the benefit of Fish and Wildlife Compensation Program. The information and material herein represents the best professional judgments in light of the information available at the time of preparation.

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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. Two releases at or above the threshold occurred with a peak release of 320 m^3/s for a couple days in January 2024. 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 including drone imagery collection and analysis. This assessment indicates that some gravel movement occurred as a result of the high flow releases in 2023/24 but the impacts to constructed gravel platforms were relatively minimal and the Committee was in agreement that emergency gravel pad work was not required this year. It was recommended a more detailed assessment methodology be conducted during lower summer flows.

For the Elk Falls Canyon section of the Lower Campbell River observations indicate that the gravel at the trolly deposition site is significantly reduced and therefore it would be our recommendation that additional gravel be added at the earliest opportunity.

The monitoring provided the Campbell River Spawning Habitat Roundtable with valuable information and allowed the Roundtable to make the informed decision to hold off on any emergency work and conduct a more detailed survey to provide results for the Roundtable's fall meeting.

Table of Contents

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 late December 2023, flow exceeded this threshold, reaching ~225 m^3/s for several days. A release occurred in mid-January through early February for which the flow release varied through this time. The flow release was started at 225 m^3/s for several days then increased to 320 m^3/s for 3 days then decreased to 225 m^3/s for several more days (pers. comm. Eva Wichmann of BC Hydro). Diversion flows through the canyon during this release would have peaked at around 190 m^3/s. 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. In 2022 a survey was conducted that followed these recommendations with some changes to the field portions mostly due to the survey occurring in the spring during higher flows. The 2022 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 naturally mobilized and deposited elsewhere in the Lower Campbell River thus providing additional spawning habitat. The 2024 survey followed the 2022 survey methodology (Laich Kwil-Tach Environmental Assessment Ltd. and Ecofish Research Ltd. 2022) with the exception that this year drone imagery was also collected on the canyon section from Elk Falls downstream to the tailrace. This imagery was collected for before after comparison to imagery collected in 2017 for the Water Use Study Monitor JHTMON-15 project.

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.

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 conducted included 1 day of snorkeling surveys and 2 days drone surveys in the spring of 2024. The snorkel surveys occurred on May 9, 2024, by A-Tlegay Fisheries Society biologist Derek LeBoeuf, R.P.Bio and technician Keanu Billy. Average daily discharge from the powerhouse during the survey was 75 m^3/s as reported by BC Hydro (Weekly Campbell System Forecast Update, email from Shayna Scott May 6, 2024), 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 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 snorkeled.

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 of the Lower Campbell River below the tailrace was conducted on May 2, 2024, by SuavAir. Average daily discharge from the powerhouse during the survey was 70 m^3/s as reported by BC Hydro (Weekly Campbell System Forecast Update, email from Shayna Scott April 30, 2024). 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 drone imagery flight of the Campbell River Canyon from Elk Falls downstream to the tailrace was conducted on May 9, 2024, by SuavAir. Average daily discharge within the canyon during the survey was 5 m^3/s as reported by BC Hydro (Weekly Campbell System Forecast Update, email from Shayna Scott May 6, 2024). Surveys were undertaken from Elk Falls waterfall to just upstream of the tailrace intake structure (Figure 1). Post processing of the images included the creation of two orthomosaic images (Figure 3).

The Lower Campbell River results from the snorkel surveys and SuavAir drone flights were compared and analyzed. The 2024 drone imagery was also compared with the 2022 drone imagery. Quantification, mapping, and spatial analysis was to occur as per the 2022 assessment; however, because of the triggering the more detailed survey this additional analysis was not conducted as it would occur as part of the detailed survey.

The canyon results of drone imagery were analyzed and compared with 2017 imagery.

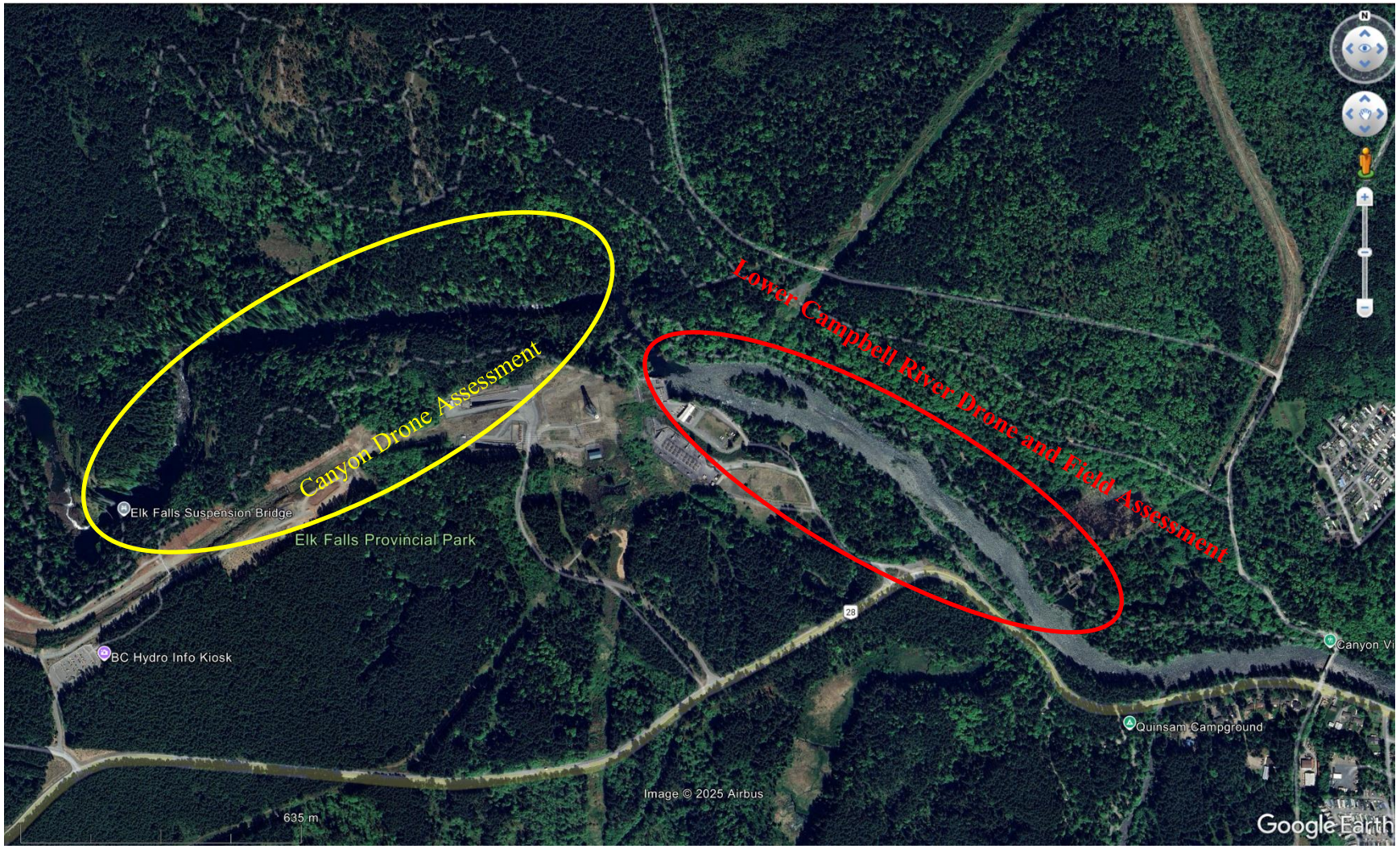

Figure 1: Overview map showing the area assessed by field crews and the area of drone assessment.

4 Results

The drone results of the Lower Campbell River are shown in Figure 2 (orthomosaic). The 2022 to 2024 comparison of individual sites are shown in Figure 4, Figure 5, and Figure 6. The canyon imagery is shown in full in Figure 2 and split into shorter sections for a closer perspective in Figures 7, 8, 9 and 10.

A preliminary analysis of the field assessment and drone imagery comparisons were quickly conducted. The key findings were:

- Flow was 70cms so both drone imagery and in water survey have their limitations however it is comparable to the 2022 surveys (80cms in 2022).
- Substrate in 2024 was noticeably more free/clean of algal growth compared to 2022.
- The substrate observed during the snorkel survey was mostly similar to 2022; however, there was a slightly higher composition of large gravel and small cobbles on the surface (0-5cm depth) than during the 2022 survey. This likely indicates that some fine sediment may have been washed away on the surface.
    - Subsurface most locations that were dug into showed sufficient gravel depths with a higher mix of fines and generally loose compaction.
- Imagery review – looking at the high-resolution imagery Suavair provided and comparing that to 2022 and our field observations, indicated that nothing stood out as drastically different.

Conclusions of the survey at this point are as follows:

- No noticeable complete wash outs of gravel pads 5, 7, 9,
- Maybe minor differences in substrate sizes on surface but still 20-30cm deep gravel/fines below surface material
- No noticeable changes in depositions zone substrate composition or depth.

The results were shared with the Gravel Committee members on May 28 (Spawning Gravel Update, email from Derek LeBoeuf May 28, 2024) with a recommendation to the committee that our opinion was that emergency mobilization was not needed at this time. However, that the planned two staged approach of a detailed survey in July 2024 when the flows are in the 30-40cms range should occur.

Several individuals from the committee responded in agreement with the recommendation of not needing an emergency gravel project but that a detailed survey as discussed in the April 10th meeting should proceed.

An in-depth comparison of drone imagery of the High Flow Assessment was not conducted. Further analysis was to be conducted during the detailed survey.

Analysis and comparison of the canyon drone imagery from 2017 with the drone imagery taken in 2024 was conducted. Analysis showed that gravel has moved between the two imagery dates, however, no significant new gravel deposition zones were noted. The biggest change was at the location where the gravel gets deposited by the trolly system just below the Elk Falls suspension bridge. Downstream of that, analysis showed that the main gravel areas appeared to be similar. Minor increases of inter-boulder accumulation of gravel could be observed in 2024, these slight changes of inter-boulder gravel accumulation were only observed to approximately 100m downstream of the dogleg shown in Figure 8. Further downstream of that location, no notable gravel could be observed. Based on this observation, the canyon has a large deficit of gravel and could use additional gravel inputs.

5 Conclusion

As noted, both during the field assessment and drone imagery comparison, no significant or obvious large-scale erosion of gravel sites or depositional areas within the Lower Campbell River had occurred. However, this assessment did indicated that some gravel movement at the Lower Campbell River sites occurred as a result of the high flow releases in 2024. Specifically, algae was noticeably absent indicating scouring processes and comparative notes between the 2022 and 2024 surveys indicated that smaller surface gravel appeared to be less prevalent which also suggests some level of scouring processes occurred. In summary, between 2022 to 2024, it was concluded that impacts or changes to constructed gravel platforms were relatively minimal.

Within the Canyon, observations have indicated that the gravel at the trolly deposition site is significantly reduced. Our recommendation is that additional gravel be added at the earliest opportunity.

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.

The information collected was utilized to inform decision making in 2024 by the Roundtable and initiate a more detailed survey that was utilized to further inform decision making in the fall Gravel Committee meeting.

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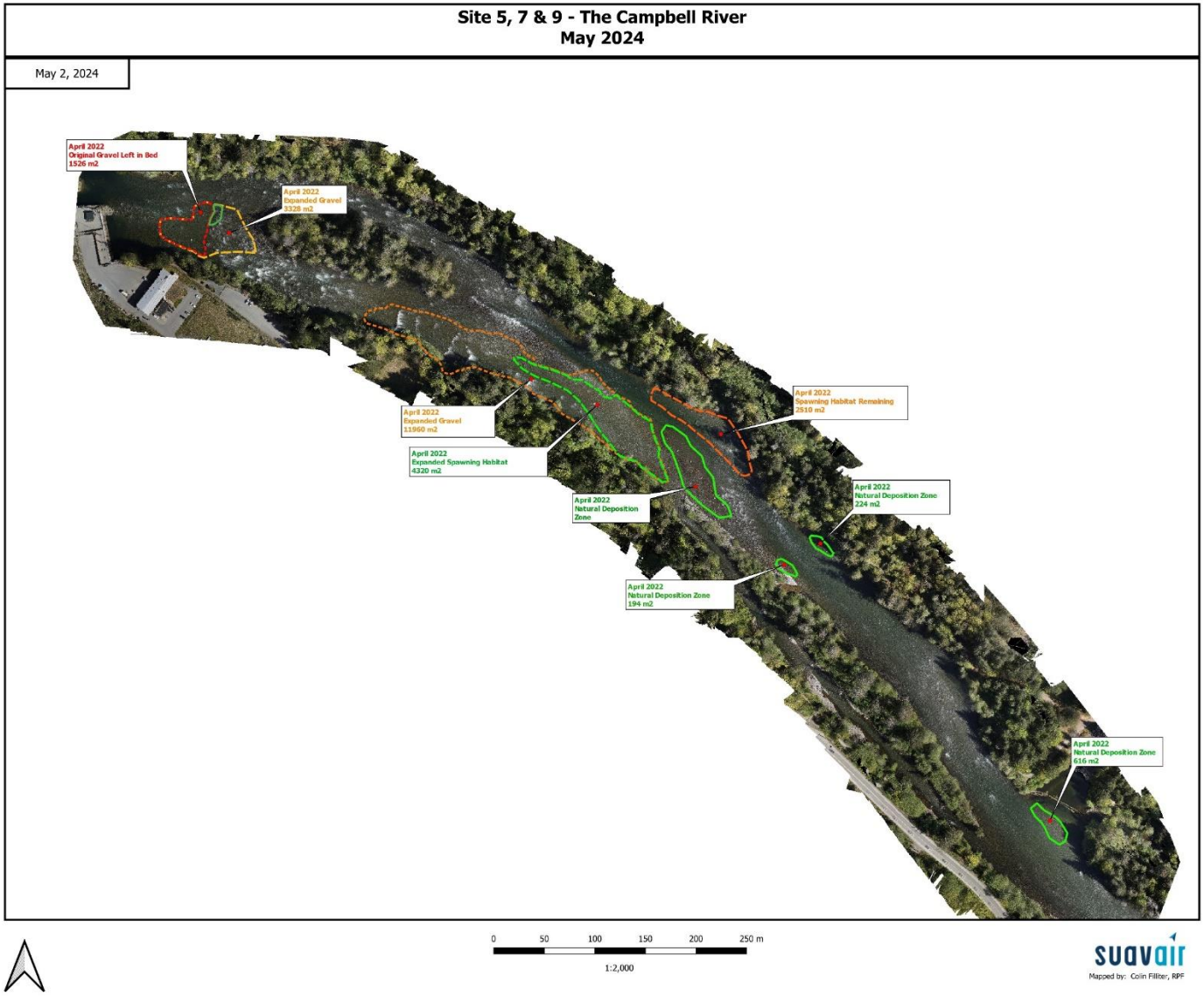


Figure 2: Orthomosaic of the upper reach of the Lower Campbell River from the powerhouse to the Elk Falls water intake with details of gravel restoration projects and depositional zones that have suitable spawning habitat.

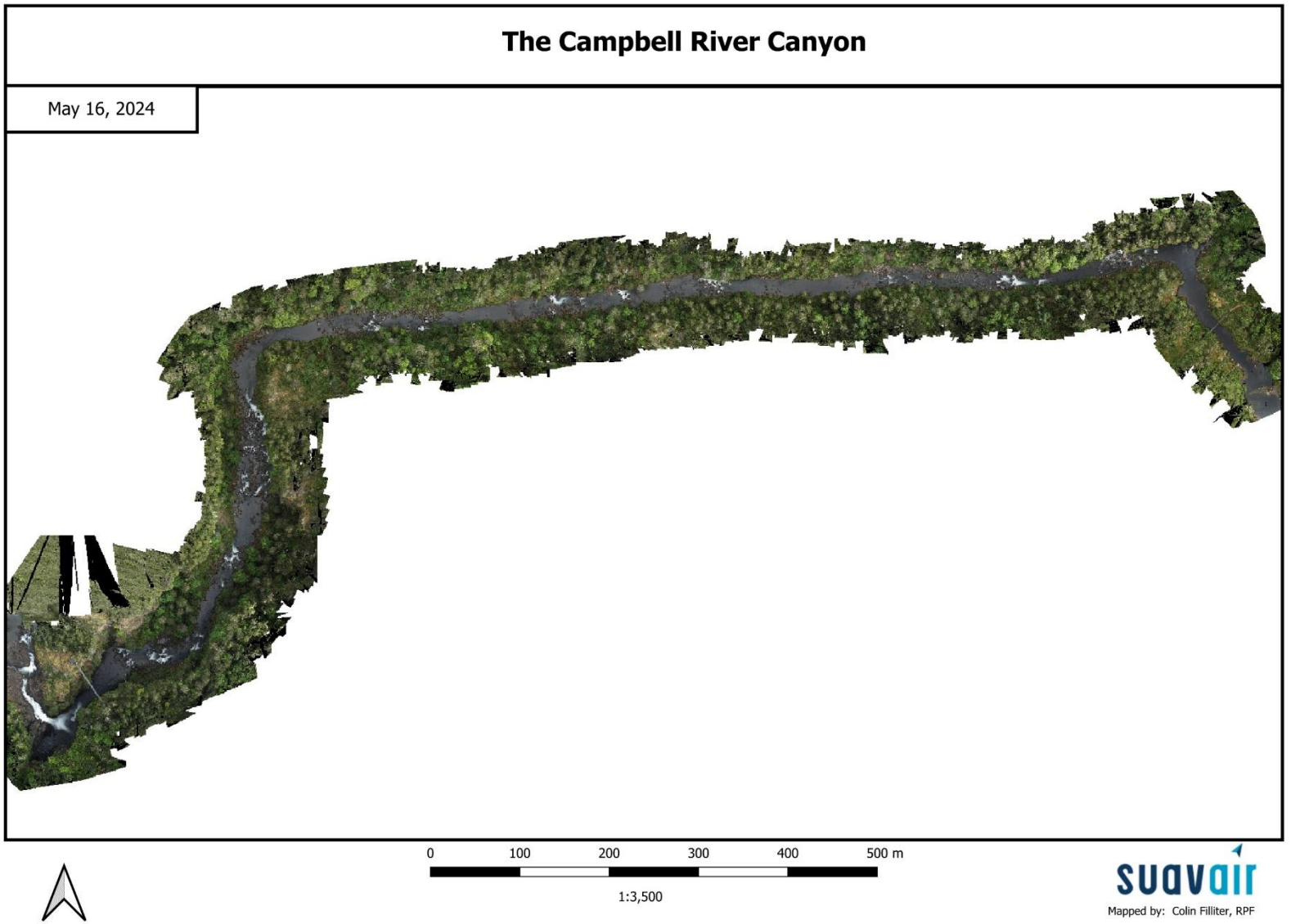


Figure 3: Orthomosaic of the entire canyon reach of the Campbell River that was flown by drone in 2024.

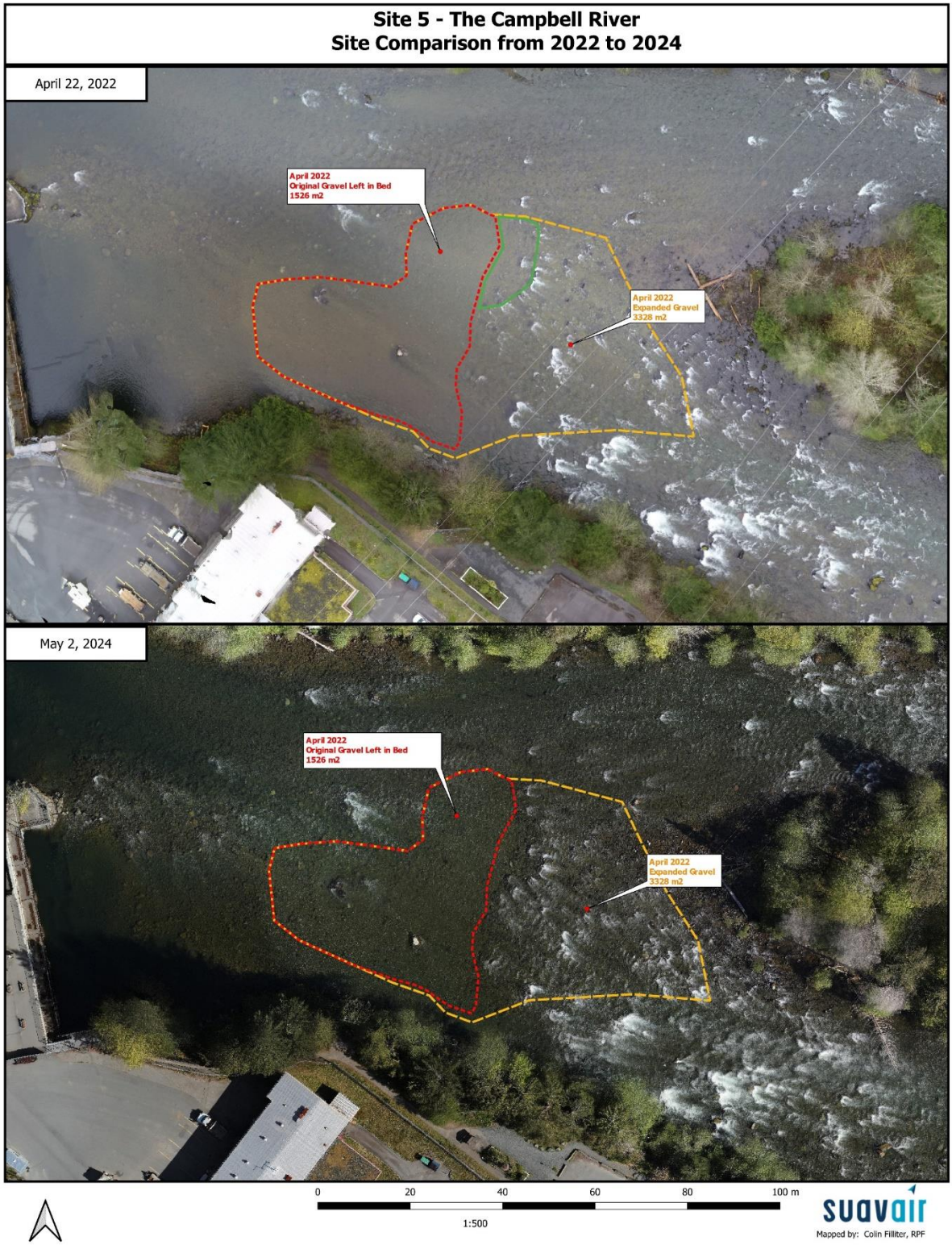


Figure 4: Orthomosaic close up of Site 5 with details of gravel restoration projects and depositional zones that aid comparisons between survey years 2022 and 2024.

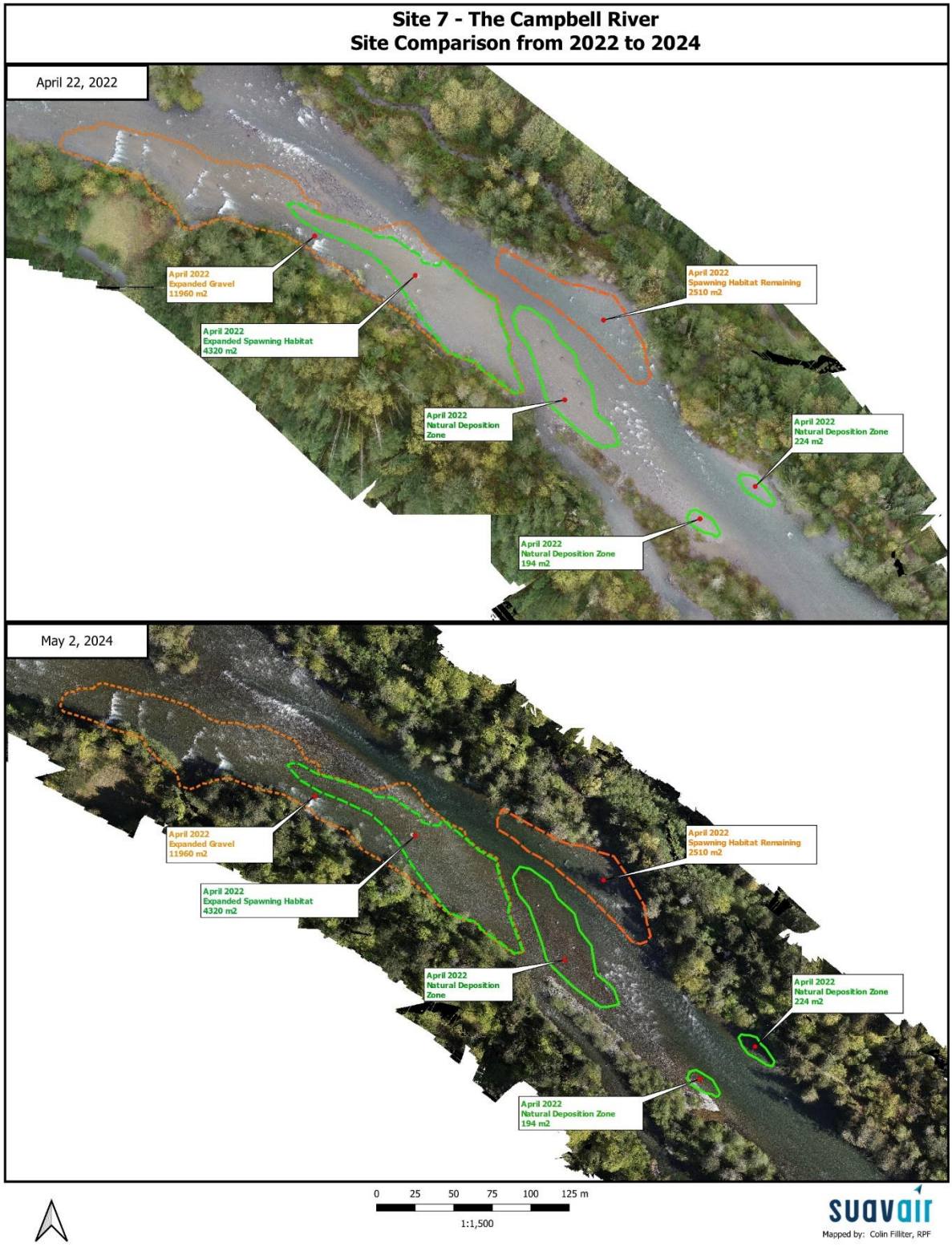


Figure 5: Orthomosaic close up of Site 7 with details of gravel restoration projects and depositional zones that aid comparisons between survey years 2022 and 2024.

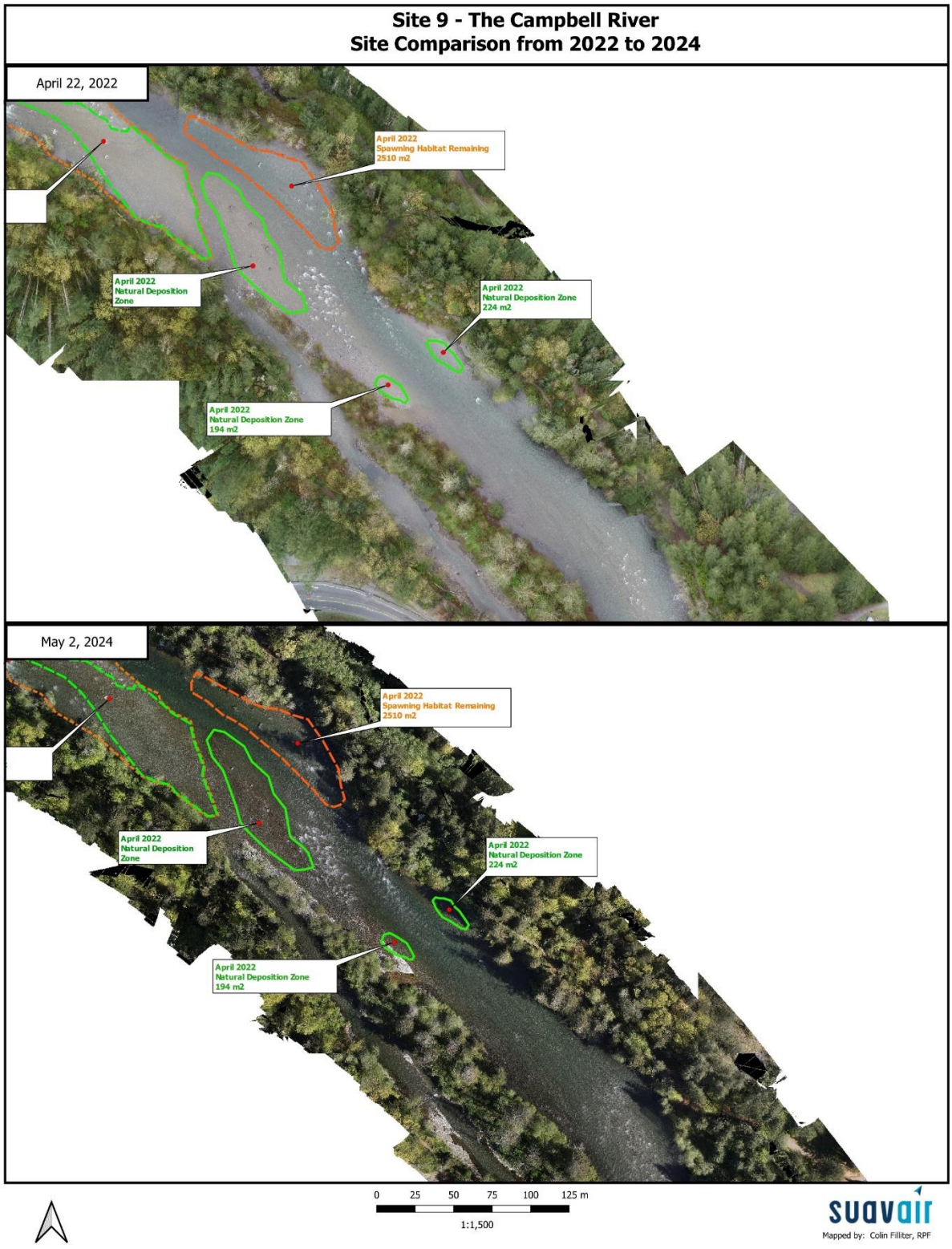


Figure 6: Orthomosaic of Site 9 with details of gravel restoration projects and depositional zones that aid comparisons between survey years 2022 and 2024.

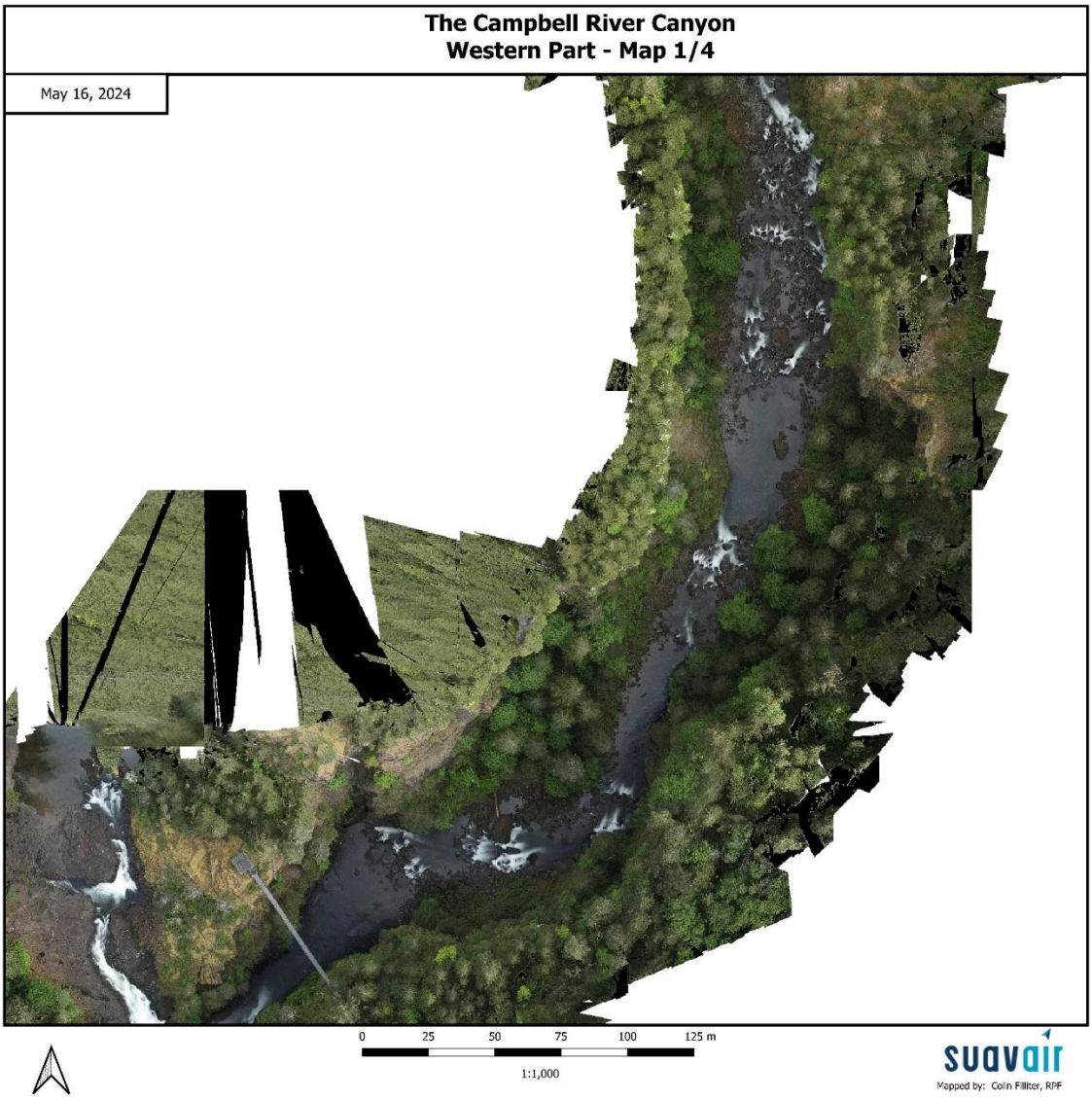


Figure 7: Orthomosaic close up of the canyon section part 1 of 4.

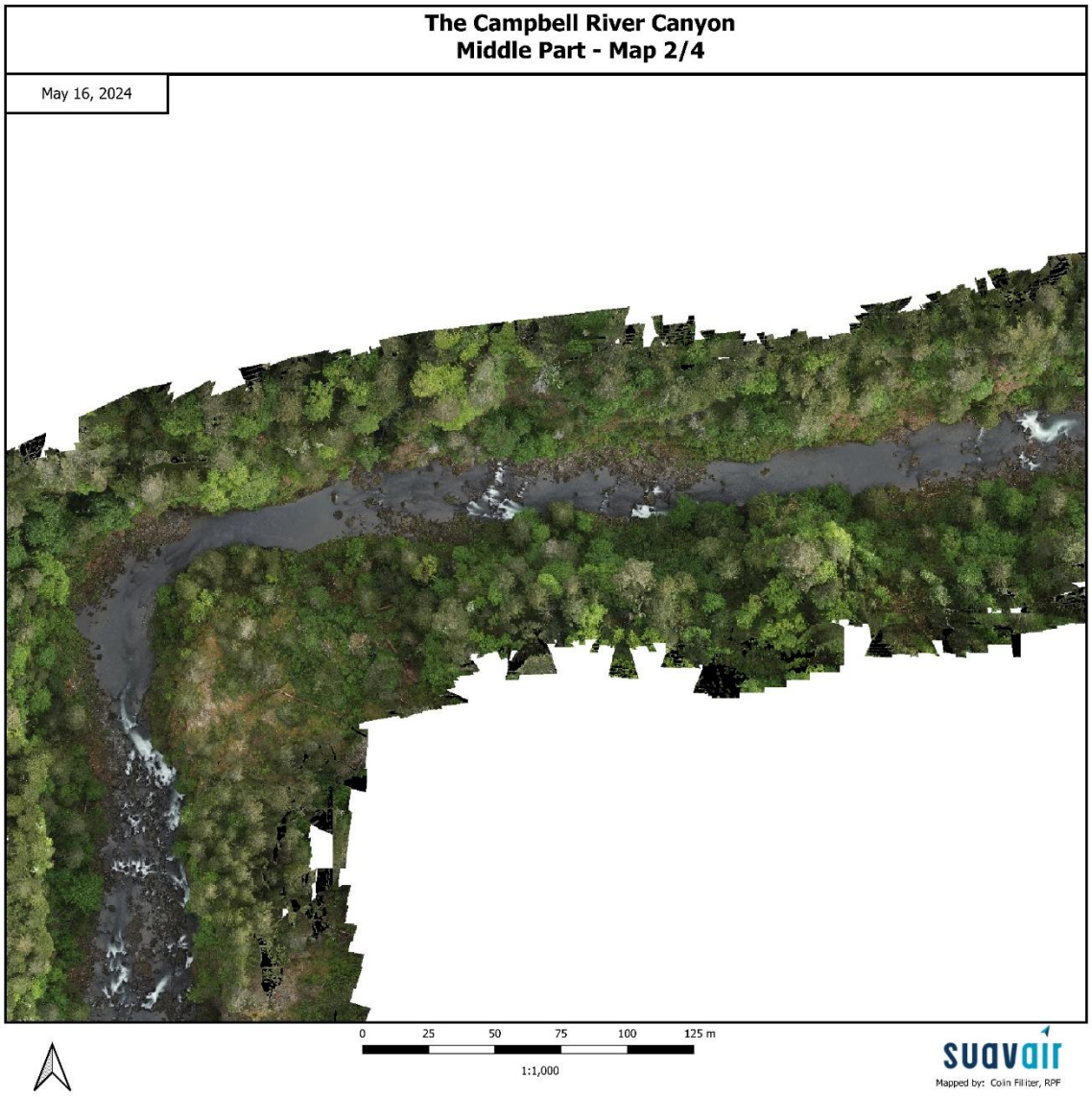


Figure 8: Orthomosaic close up of the canyon section part 2 of 4.

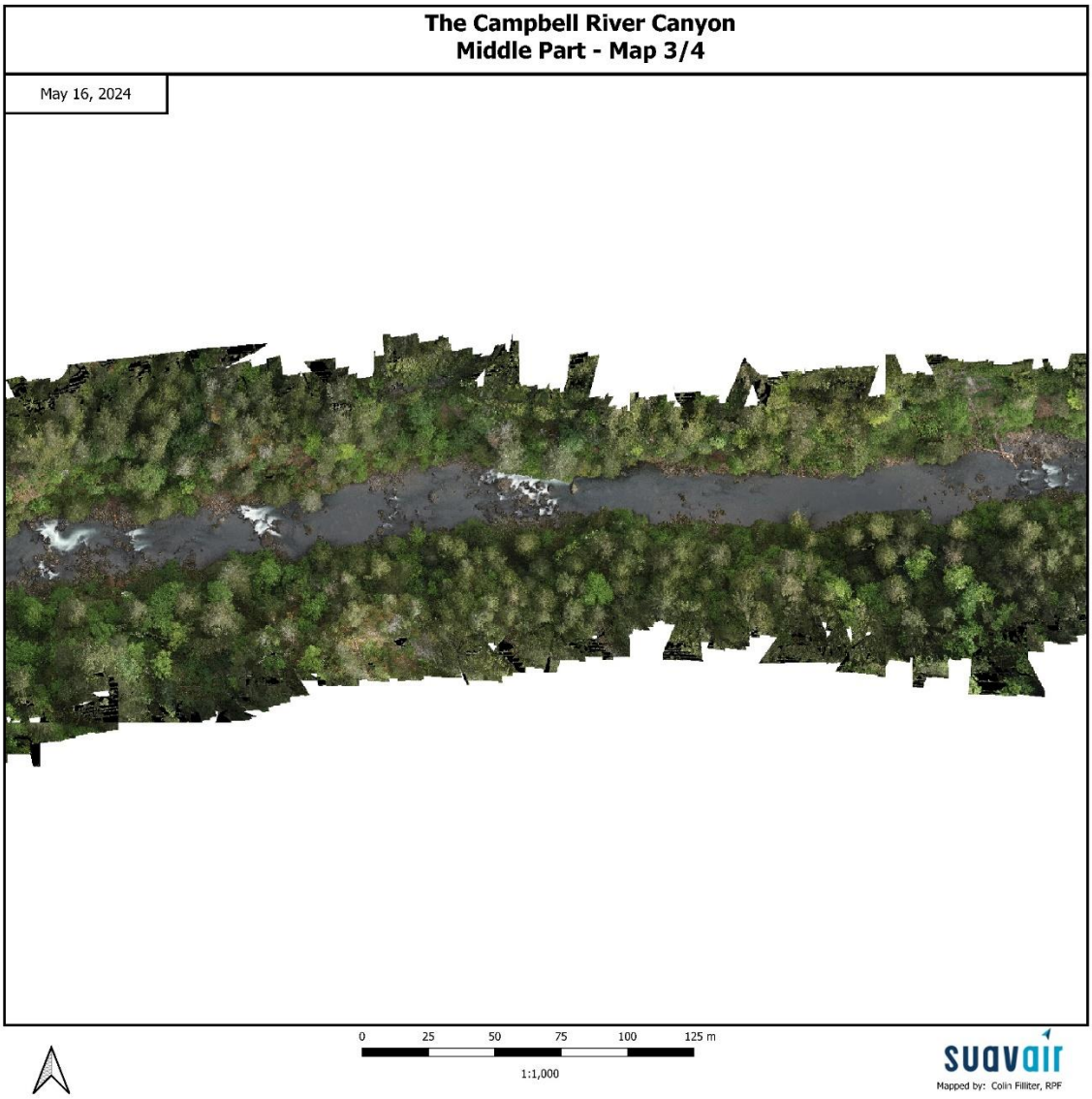


Figure 9: Orthomosaic close up of the canyon section part 3 of 4.

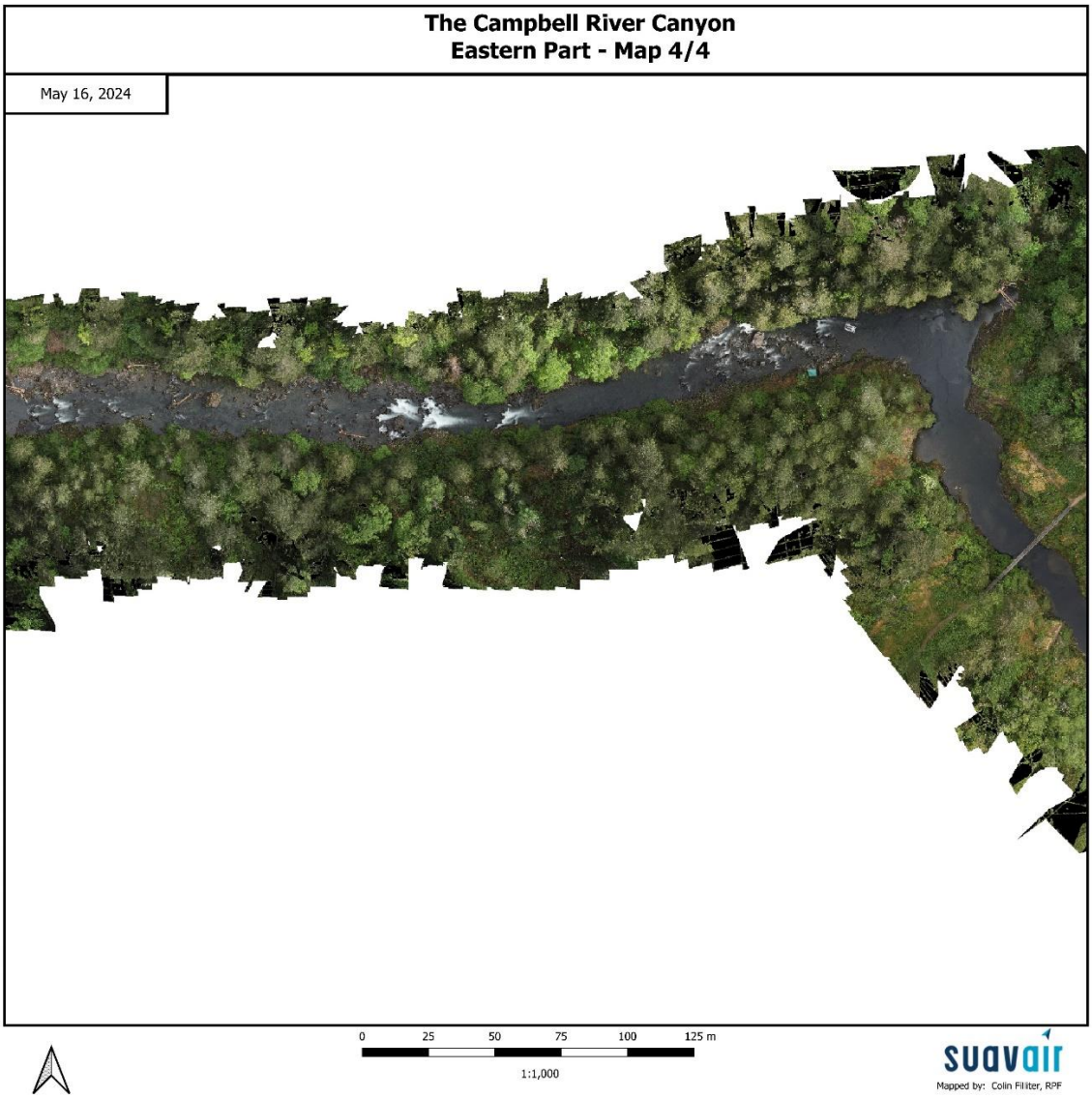


Figure 10: Orthomosaic close up of the canyon section part 4 of 4.

Kent Moeller
President
Campbell River Salmon Foundation

December 5, 2024

RE: Utilization of Spawning Gravel by Chinook within the Campbell River 2024

Dear Kent Moeller,

This report is intended to summarize the field work conducted for the project titled "Utilization of Spawning Gravel by Chinook within the Campbell River 2024". Drone and accompanying snorkel surveys occurred in the Campbell River during Chinook spawning at the beginning and middle of October 2024. This project was funded by the Campbell River Salmon Foundation and the results presented will be used to aid in determining gravel needs of spawning salmonids within the Campbell River.

Background

The Campbell River watershed has multiple dams which impact the lower Campbell River. Recruitment of sediment occurs naturally, however, with the dam's obstruction the only substantial gravel accruement within the lower Campell River is from human intervention. The continued loss of natural gravel over years has resulted in the loss of spawning gravel for salmonids. Work has been funded by CRSF, BC Hydro's Fish and Wildlife Compensation Program (FWCP) and others to add spawning gravel to multiple sites within the Campbell River to provide spawning habitats for all Pacific salmonid species with the target species being Chinook salmon. Through high flow events, the placed gravel is mobilized and has formed additional gravel beds, expanding the spawning habitat from the original sites while also reducing the quality and availability of the constructed gravel beds thus resulting in the need for continued monitor and future intervention through additional gravel placement to those existing sites.

In the winter of 2023 and spring of 2024, extensive rain falls resulted in an increase in water being released from the John Hart dam above the lower Campbell River. Discharge from the dam exceeded typical winter flows over multiple days and could have resulted in mobilization of spawning gravel throughout the Campbell River. Work funded by the Fish and Wildlife Conservation Program (FWCP) was conducted in the spring and summer of 2024 to determine if emergency action needed to occur to supplement the gravel within the river, including gravel quality surveys and mapping of gravel beds. While immediate action was not deemed necessary, movement of gravel was observed and so it was concluded that conducting observations of spawning fish on the gravel beds would help determine if fish were still utilizing the constructed spawning beds. This information

combined with the FWCP work would all be utilized for planning the need and next phases of gravel addition to the Campbell River.

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

Methodology followed and improved upon the 2022 study titled "Campbell River Salmon Utilization of Spawning Gravel". Timing for peak Chinook spawning was advised by the Quinsam hatchery dead pitch, snorkel surveys from the fall of 2024 and the results from the drone surveys that were conducted in 2022. Two drone flights were conducted by SuavAir on October 10th and October 24th, immediately following the drone surveys, two A-Tlegay Fisheries technicians snorkeled the areas following guidance from the drone survey to determine species identification. The surveys included four 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).

Drone footage was reviewed, and snorkel survey results (counts and species identification) were combined to give an estimate of number of each salmonid species observed within the spawning areas. Species were identified from video review and snorkel surveys 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.

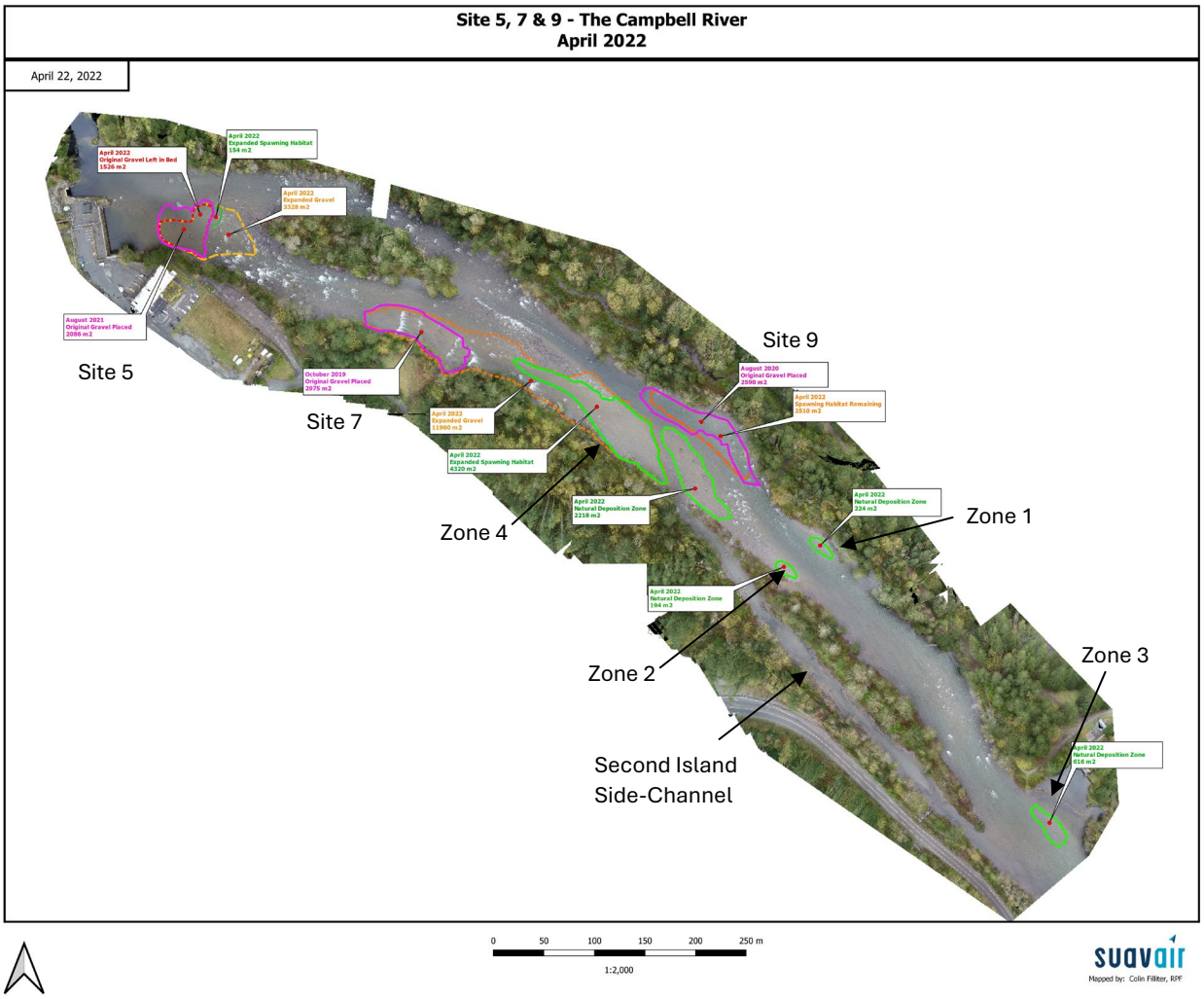


Figure 1. Map of the Campbell River spawning gravel sites from 2022, the same sites were surveyed in 2024.

Results

Initial plans to utilize this project as a training exercise for an A-Tlegay Fisheries technician for drone flight experience were not realized due to an incident in September that resulted in the sudden loss of the A-Tlegay drone and the pre-flight in early October was not able to be conducted.

The below table combines snorkel survey numbers and drone survey numbers, giving a more accurate representation of the species present and in what abundance. Issues encountered in the last drone imagery survey that occurred in 2022 were mitigated this year with the joint snorkel

surveys, reducing the need to rely on the drone imagery for species identification while still utilizing it for a more accurate count, especially of areas that were not easily accessed.

While the joint snorkel/drone surveys provided an increase reliability in estimates, several factors can influence both. Drone footage review was influenced by glare on the water, shadows from bank vegetation, direction of flight, flight height and speed. Both drone footage review and snorkel survey species identification increased in difficulty by a mixture in salmon species present. Chinook, Chum and Coho salmon are all within the same size range, with variations. This year in particular an increase in both Chum and Coho salmon have been observed, making it more difficult to separate out Chinook salmon. Depending on water speed, snorkelers may have difficulties determining species when not relying on size estimates.

Table 1. Observed number of salmonids in gravel areas in the Campbell River during drone flight video and snorkel surveys, 2024.

Site	Date	Species				Comments
		Chinook	Pink	Coho	Chum	
Natural deposited placed gravel - Zone 1	10-Oct-24	8	10	70	0	
	24-Oct-24	3	0	0	110	
Natural deposited placed gravel - Zone 2	10-Oct-24	0	30	25	0	
	24-Oct-24	0	0	0	400	
Natural deposited placed gravel - Zone 3	10-Oct-24	30	180	30	0	
	24-Oct-24	5	0	0	600	
Natural deposited placed gravel - Zone 4	10-Oct-24	4	516	32	16	
	24-Oct-24	39	0	0	1230	
Second Island Channel	10-Oct-24	1	415	21	0	
	24-Oct-24	33	0	0	1555	
Site 5	10-Oct-24	15	275	170	0	75 Coho observed above Site 5
	24-Oct-24	10	4	1	68	
Site 7	10-Oct-24	0	48	58	0	
	24-Oct-24	25	12	0	38	
Site 9	10-Oct-24	31	40	175	2	
	24-Oct-24	2	0	0	230	

Spawning redds can be identified in drone video footage throughout the study area. 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. The goal of each drone flight was primarily fish counts, with inconsistencies in flight heights, sun exposure and camera angles direct comparisons of spawning gravel was difficult between the two flight days. Images of each gravel site and visible spawning redds were saved from drone video footage to provide visual evidence of salmonid spawning (Appendix A). Site 9 was the only site where direct comparison between the two images were able to occur, while a slight increase in redds can be observed on October 24th (85-90% "cleaned"), by the October 10th survey date a large portion of the gravel was already visibly lighter (80-85% "cleaned").

Conclusion

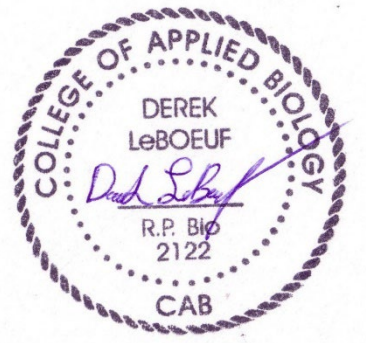
All spawning gravel sites were observed via drone and snorkel surveys to be utilized by salmonids. This was confirmed by both drone and snorkel observations and the presence and evidence of redds. Chinook were observed in all four constructed sites, as well as the natural deposition zones except Zone 2. This project was successful in determining the utilization of the spawning gravel sites throughout the Campbell River by salmonids; however, this assessment did not allow for conclusive determination if Chinook utilization of the constructed gravel pads had been impacted by increased flow or gravel mobilization.

Sincerely,

Sarah Unrau

Reviewed by,

Derek LeBoeuf, R.P.Bio.



Appendix 1. Site Pictures

Figure 2. Site 5 October 24, 2024, drone image.

Figure 3. Part of Site 7 October 10, 2024, drone image.

Figure 4. Part of Site 7 October 10, 2024, drone image.

Figure 5. Site 9 October 10, 2024, drone image.

Figure 6. Site 9 October 24, 2024, drone image.

Figure 7. Part of Second Island channel October 10, 2024, drone image.

Figure 8. Part of naturally deposited gravel Zone 1, October 10, 2024, drone image.

Figure 9. Part of naturally deposited gravel Zone 1, October 10, 2024, drone image.

Figure 10. Naturally deposited gravel Zone 2 October 10, 2024, drone image.

Figure 11. Part of naturally deposited gravel Zone 3, October 10, 2024, drone image.

Figure 12. Part of naturally deposited gravel Zone 3, October 10, 2024, drone image.

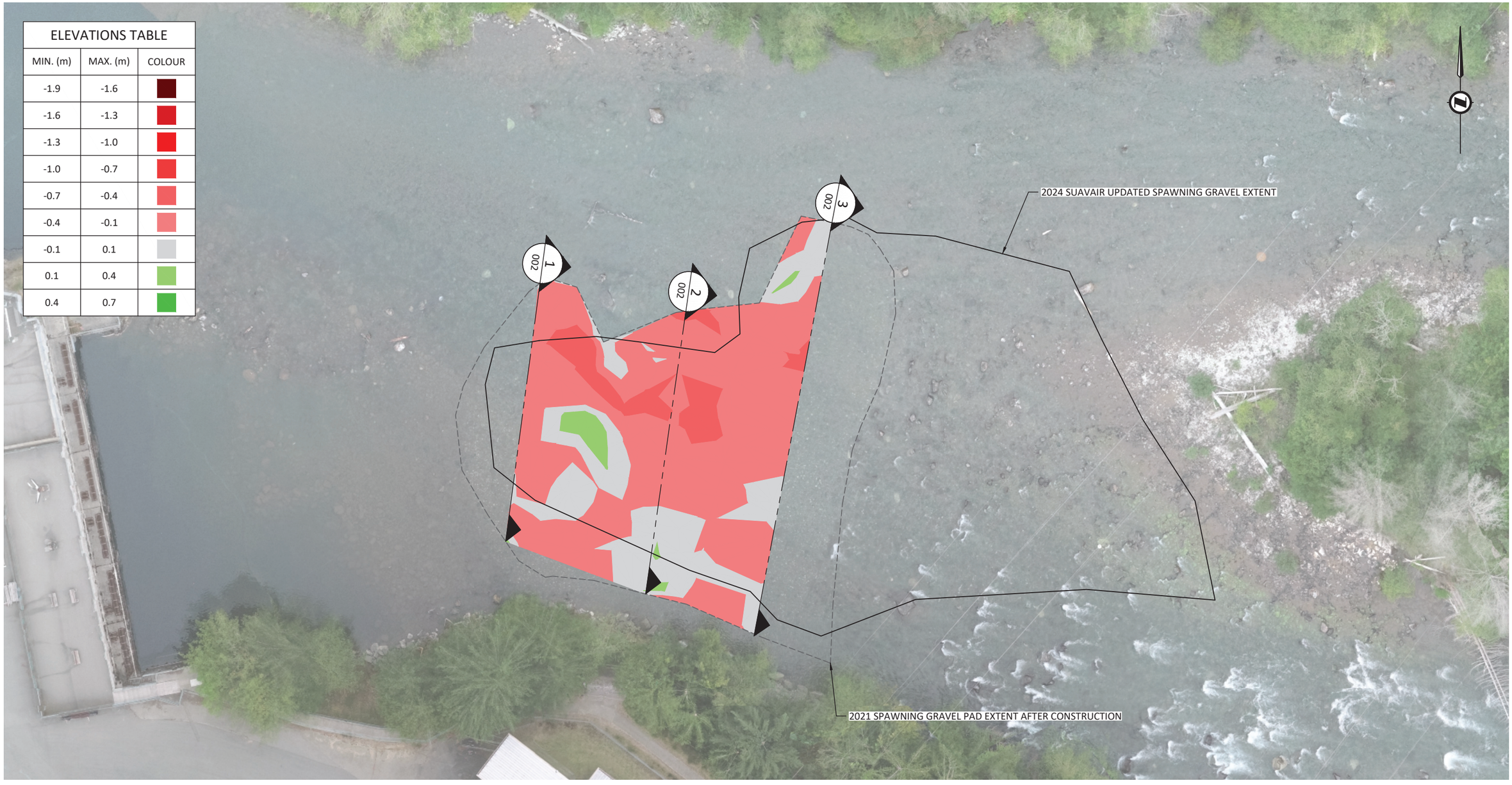
Figure 13. Zone 4 towards First Island, October 10, 2024, drone image.

APPENDIX B

NHC DRAWING SETS

B.1. Erosion and Deposition Drawings
B.2. Spawning Gravel Quality Maps

ELEVATIONS TABLE		
MIN. (m)	MAX. (m)	COLOUR
-1.9	-1.6	
-1.6	-1.3	
-1.3	-1.0	
-1.0	-0.7	
-0.7	-0.4	
-0.4	-0.1	
-0.1	0.1	
0.1	0.4	
0.4	0.7	



NOTES:
1. SITE 5 RECORD SURVEY CONDUCTED AUGUST 11, 2021 BY NHC.
2. SITE 5 MONITORING SURVEY CONDUCTED AUGUST 7, 2024 BY UNDERHILL GEOMATICS LTD.
3. BACKGROUND AERIAL IMAGERY DRONE SURVEY COMPLETED AUGUST 14, 2024 BY SUAVAIR.
4. SPAWNING GRAVEL EXTENT FOR 2024 APPROXIMATED BY SUAVAIR AND PROVIDED TO NHC. USABLE SPAWNING HABITAT IS A SUBSET WITHIN THIS AREA AND IS NOT INDICATED.
5. APPROXIMATE VOLUME MOBILIZED FROM SITE 5: 260 m^3. VOLUME ESTIMATE PROVIDED FOR AREA BETWEEN UPSTREAM-MOST AND DOWNSTREAM-MOST SURVEYED SECTIONS WHERE ELEVATION COLOUR CONTOURS ARE DEPICTED.

SITE 5 - PLAN
SCALE 1:500

0 5 10 15 20 25m
SCALE = 1:500

CLIENT:

A-TLEGAY FISHERIES SOCIETY
1441 A Old Island Highway
Campbell River, BC
V9W 2E4

nhc northwest hydraulic consultants

CAMPBELL RIVER SPAWNING GRAVEL MONITORING 2024

SITE 5 - PLAN

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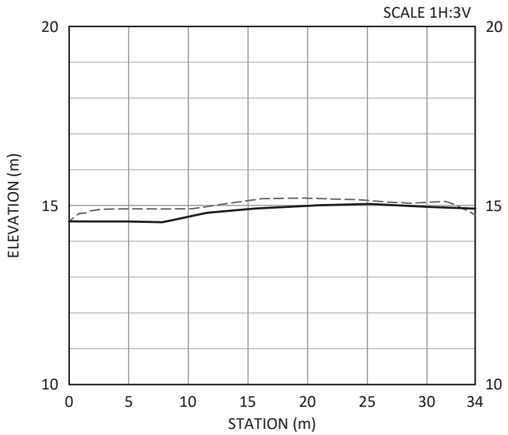
CHECKED:	KEK	SCALE:	AS SHOWN WHEN PLOTTED B SIZE		
APPROVED:	KEK	DATE:	12 MAR 2025	REV No:	R1

SUPERSEDES ALL REVISIONS WITH NUMBER PRECEDING



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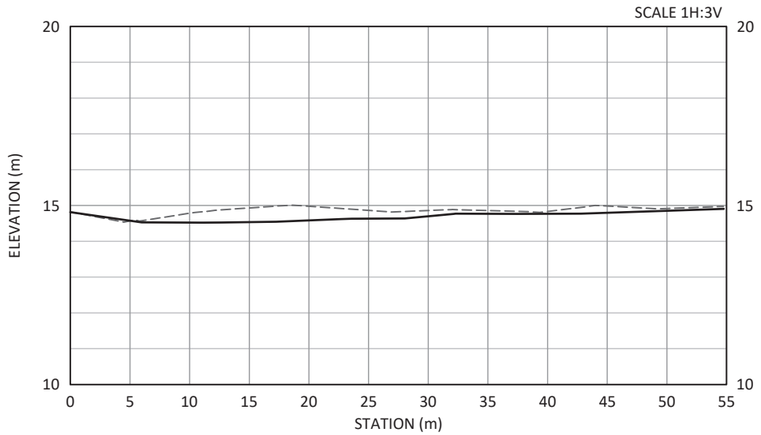

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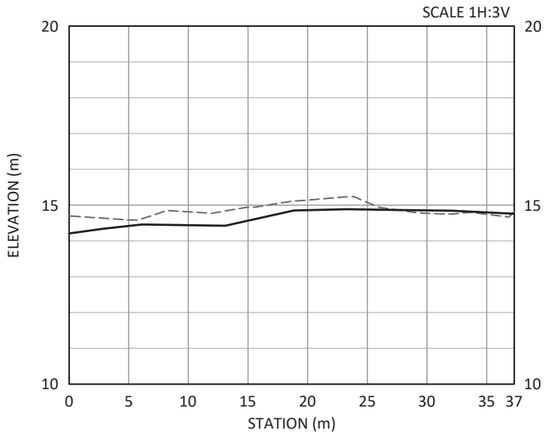

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LEGEND

2021 RECORD SURVEY – – – – – – – – – – –

2024 MONITORING SURVEY ———————

CLIENT:

A-TLEGAY FISHERIES SOCIETY
1441 A Old Island Highway
Campbell River, BC
V9W 2E4

nhc northwest hydraulic consultants

CAMPBELL RIVER SPAWNING GRAVEL MONITORING 2024

SITE 5 - SECTIONS

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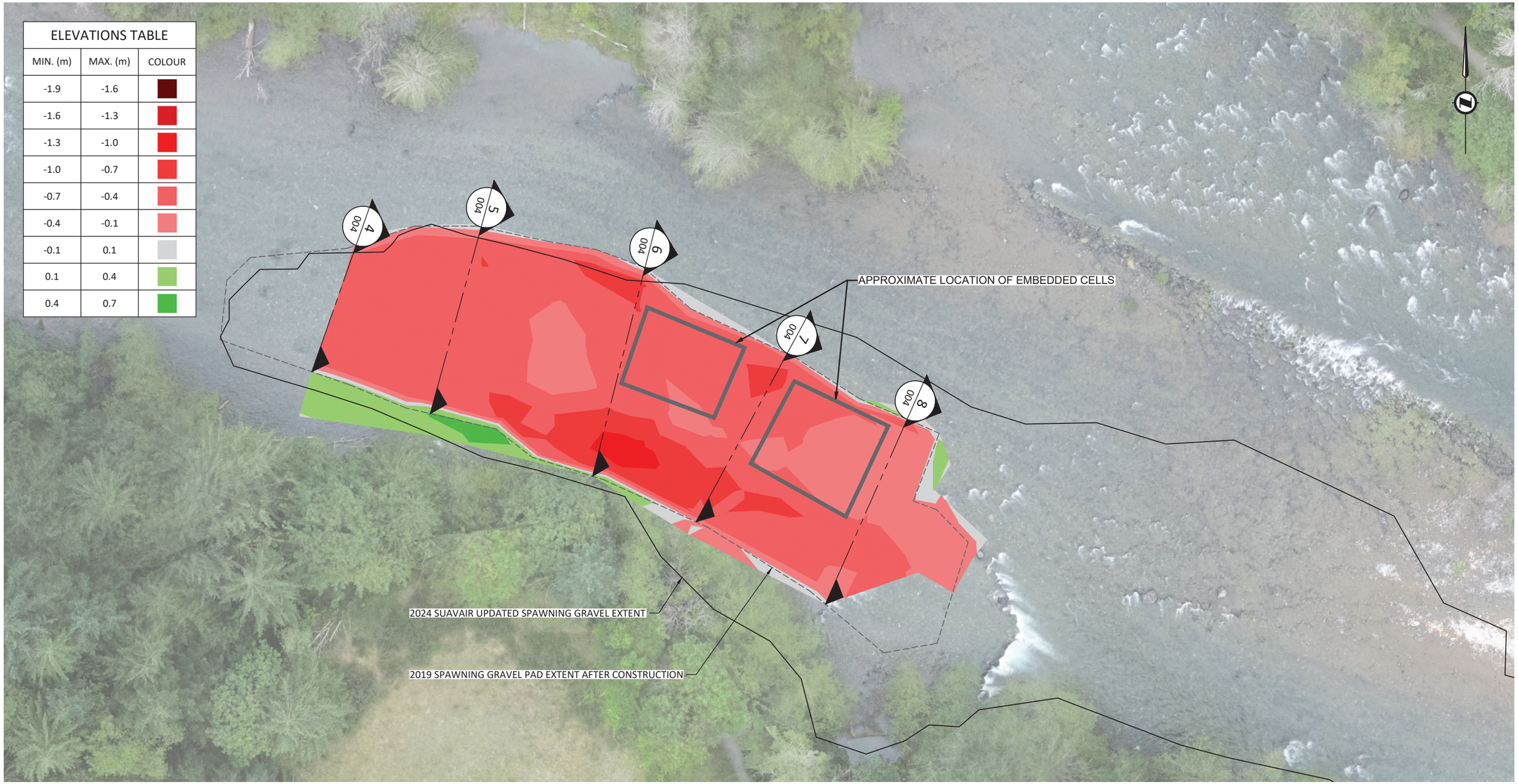
CHECKED: KEK	SCALE: AS SHOWN WHEN PLOTTED B SIZE	
APPROVED: KEK	DATE: 12 MAR 2025	REV No: R1

SUPERSEDES ALL REVISIONS WITH NUMBER PRECEDING

ELEVATIONS TABLE		
MIN. (m)	MAX. (m)	COLOUR
-1.9	-1.6	
-1.6	-1.3	
-1.3	-1.0	
-1.0	-0.7	
-0.7	-0.4	
-0.4	-0.1	
-0.1	0.1	
0.1	0.4	
0.4	0.7	



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2. SITE 7 MONITORING SURVEY CONDUCTED AUGUST 7, 2024 BY UNDERHILL GEOMATICS LTD.
3. BACKGROUND AERIAL IMAGERY DRONE SURVEY COMPLETED AUGUST 14, 2024 BY SUAVAIR.
4. SPAWNING GRAVEL EXTENT FOR 2024 APPROXIMATED BY SUAVAIR AND PROVIDED TO NHC. USABLE SPAWNING HABITAT IS A SUBSET WITHIN THIS AREA AND IS NOT INDICATED.
5. APPROXIMATE VOLUME MOBILIZED FROM SITE 7: 1040 m^3. VOLUME ESTIMATE PROVIDED FOR AREA BETWEEN UPSTREAM-MOST AND DOWNSTREAM-MOST SURVEYED SECTIONS WHERE ELEVATION COLOUR CONTOURS ARE DEPICTED.

SITE 7 - PLAN
SCALE 1:500

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SCALE = 1:500

CLIENT:

A-TLEGAY FISHERIES SOCIETY
1441 A Old Island Highway
Campbell River, BC
V9W 2E4

nhc northwest hydraulic consultants

CAMPBELL RIVER SPAWNING GRAVEL MONITORING 2024

SITE 7 - PLAN

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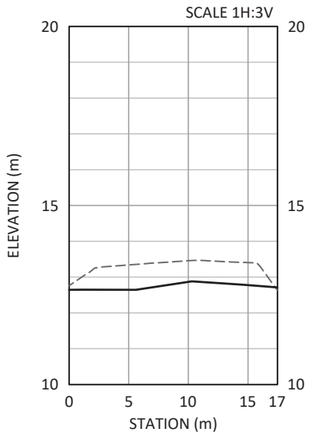
CHECKED:	KEK	SCALE:	AS SHOWN WHEN PLOTTED B SIZE		
APPROVED:	KEK	DATE:	12 MAR 2025	REV No:	R1

SUPERSEDES ALL REVISIONS WITH NUMBER PRECEDING



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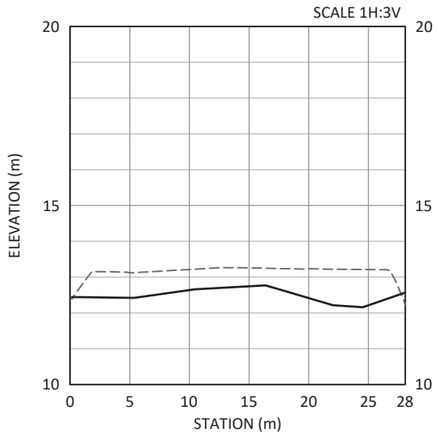

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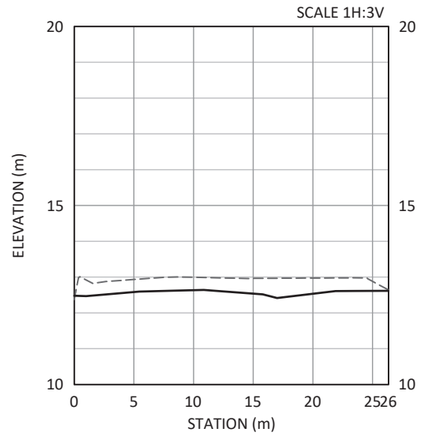

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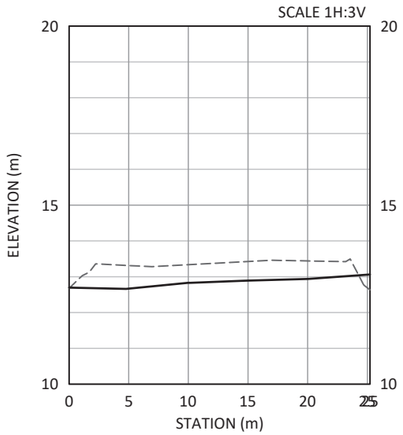

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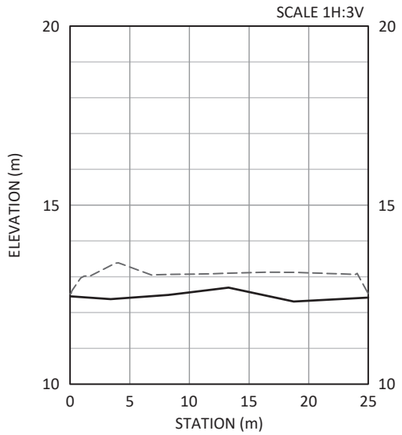

SECTION 7
SCALE 1:500

LEGEND

2019 RECORD SURVEY

2024 MONITORING SURVEY

CLIENT:

A-TLEGAY FISHERIES SOCIETY
1441 A Old Island Highway
Campbell River, BC
V9W 2E4

CAMPBELL RIVER SPAWNING GRAVEL MONITORING 2024

SITE 7 - SECTIONS

DESIGNED: N/A	SHEET ID: 3009101-5-IFR-SET-STUDY-R1B-004 R1	SHEET No: 004
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CHECKED: KEK	SCALE: AS SHOWN WHEN PLOTTED B SIZE	
APPROVED: KEK	DATE: 12 MAR 2025	REV No: R1

SUPERSEDES ALL REVISIONS WITH NUMBER PRECEDING

ELEVATIONS TABLE		
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-1.6	-1.3	
-1.3	-1.0	
-1.0	-0.7	
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-0.4	-0.1	
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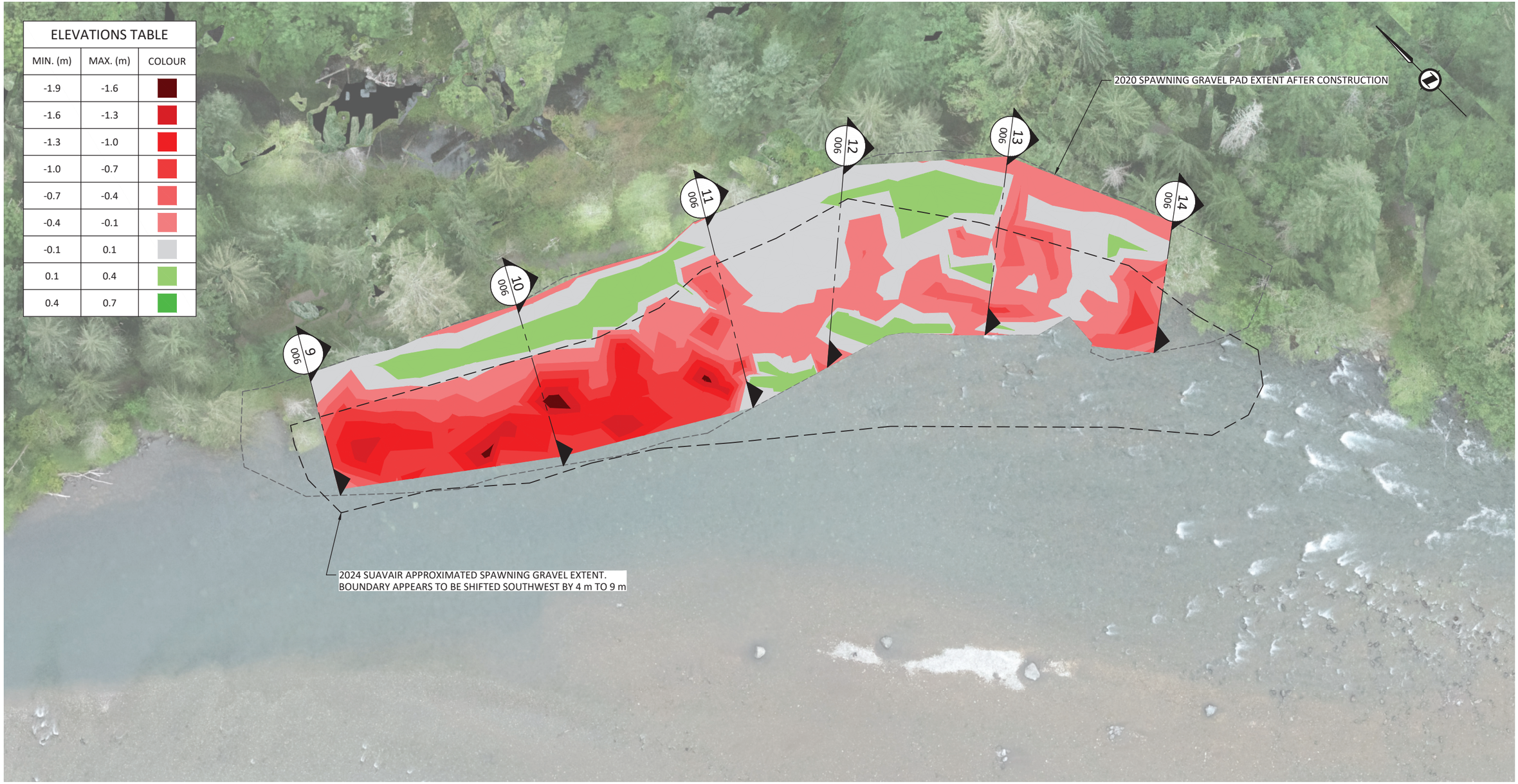

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2. SITE 9 MONITORING SURVEY CONDUCTED AUGUST 7, 2024 BY UNDERHILL GEOMATICS LTD.
3. BACKGROUND AERIAL IMAGERY DRONE SURVEY COMPLETED AUGUST 14, 2024 BY SUAVAIR.
4. SPAWNING GRAVEL EXTENT FOR 2024 APPROXIMATED BY SUAVAIR AND PROVIDED TO NHC. USABLE SPAWNING HABITAT IS A SUBSET WITHIN THIS AREA AND IS NOT INDICATED.
5. APPROXIMATE VOLUME MOBILIZED FROM SITE 9: 710 m^3. VOLUME ESTIMATE PROVIDED FOR AREA BETWEEN UPSTREAM-MOST AND DOWNSTREAM-MOST SURVEYED SECTIONS WHERE ELEVATION COLOUR CONTOURS ARE DEPICTED.

SITE 9 - PLAN
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SCALE = 1:500

CLIENT:

A-TLEGAY FISHERIES SOCIETY
1441 A Old Island Highway
Campbell River, BC
V9W 2E4

nhc northwest hydraulic consultants

CAMPBELL RIVER SPAWNING GRAVEL MONITORING 2024

SITE 9 - PLAN

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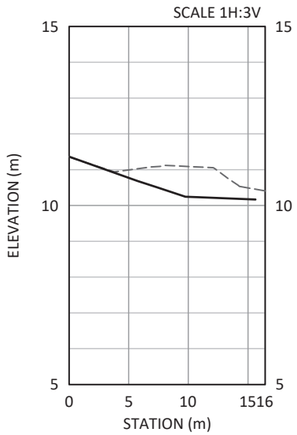
CHECKED:	KEK	SCALE:	AS SHOWN WHEN PLOTTED B SIZE		
APPROVED:	KEK	DATE:	12 MAR 2025	REV No:	R1

SUPERSEDES ALL REVISIONS WITH NUMBER PRECEDING



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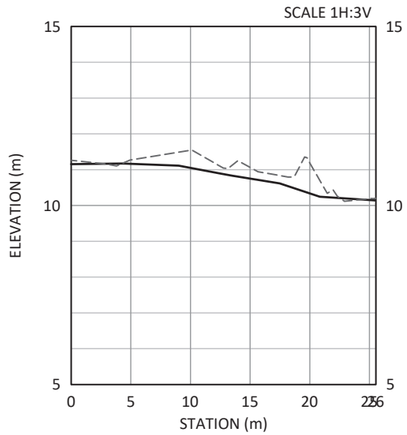

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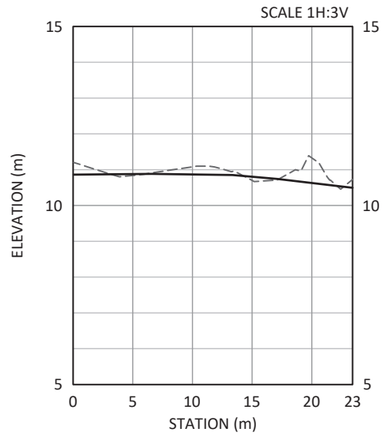

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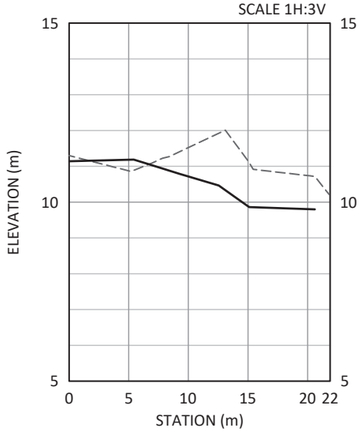

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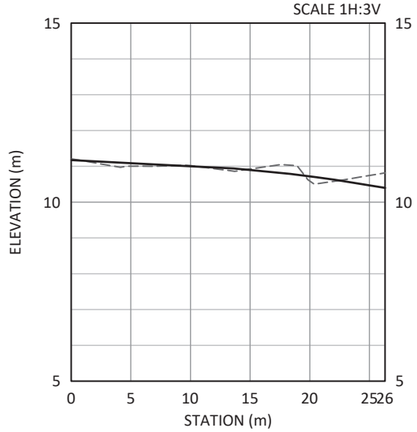

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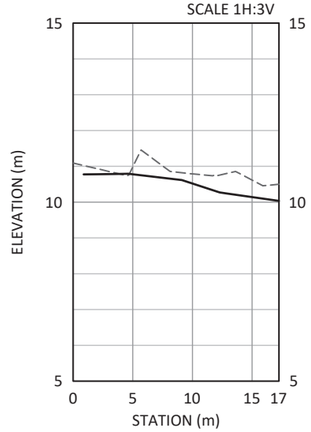


SECTION 14
SCALE 1:500

LEGEND

2020 RECORD SURVEY

2024 MONITORING SURVEY

CLIENT:

A-TLEGAY FISHERIES SOCIETY
1441 A Old Island Highway
Campbell River, BC
V9W 2E4

nhc northwest hydraulic consultants

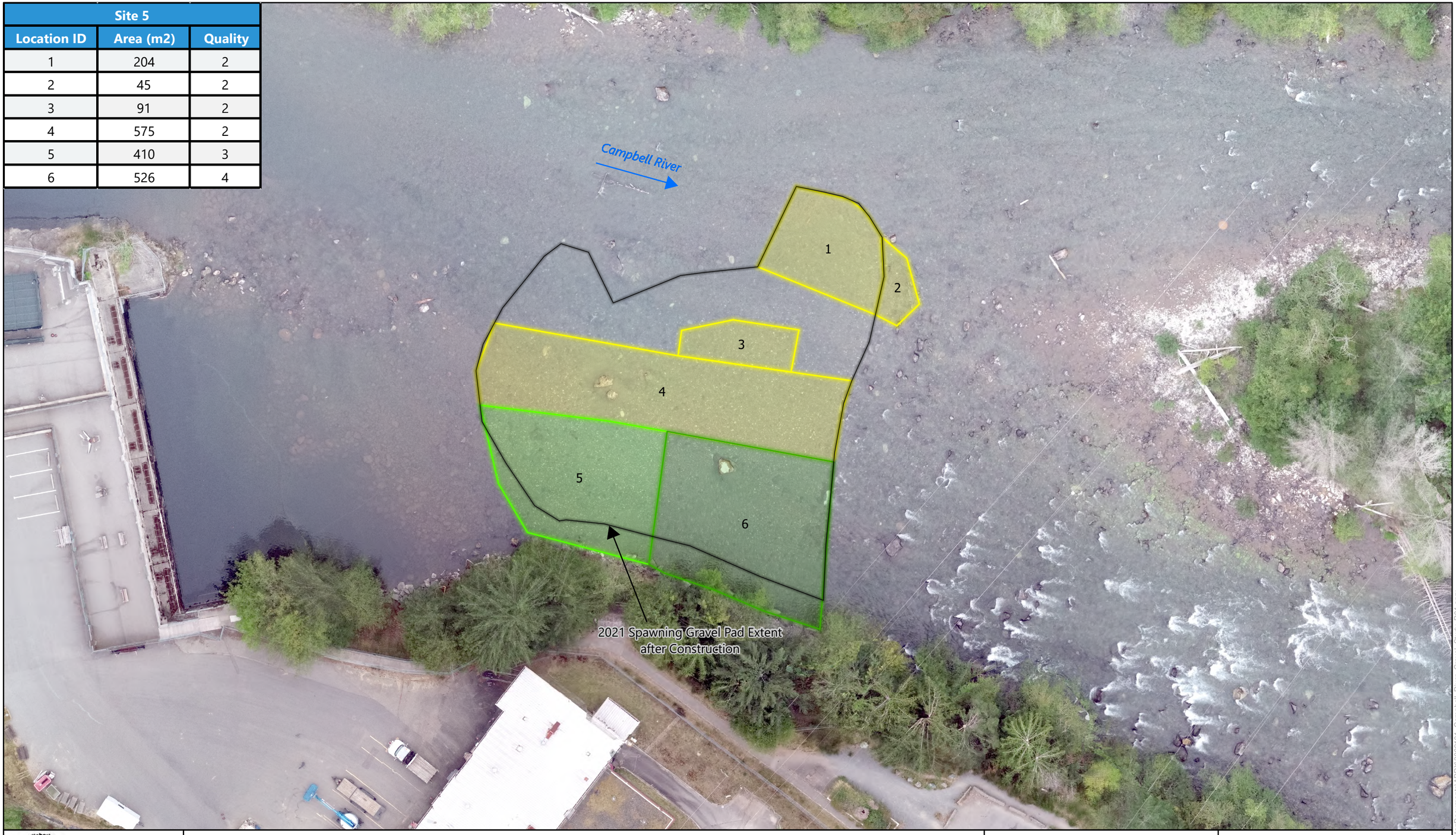
CAMPBELL RIVER SPAWNING GRAVEL MONITORING 2024

SITE 9 - SECTIONS

DESIGNED:	N/A	SHEET ID:	3009101-5-IFR-SET-STUDY-R1B-006 R1	SHEET No: 006
DRAFTED:	BXH	STATUS:	ISSUED FOR REVIEW	
CHECKED:	KEK	SCALE:	AS SHOWN WHEN PLOTTED B SIZE	
APPROVED:	KEK	DATE:	12 MAR 2025	REV No: R1

SUPERSEDES ALL REVISIONS WITH NUMBER PRECEDING

Site 5		
Location ID	**Area (m2)**	**Quality**
1	204	2
2	45	2
3	91	2
4	575	2
5	410	3
6	526	4



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Legend
- Spawning Gravel Quality 1/5
- Spawning Gravel Quality 2/5
- Spawning Gravel Quality 3/5
- Spawning Gravel Quality 4/5

DATA SOURCES:
Orthoimagery courtesy of SuavAir Aerial Imaging, 8/14/2024.

NOTES:
Spawning gravel quality ranked out of five, with five representing the highest quality. Spawning gravel quality assessed August 7, 2024 by Dave Ewart during field visit, with input from A-Tlegay Fisheries Society, and NHC.

SCALE - 1:500
0 5 10 15 Meters
N

Coordinate System: WGS 1984 UTM ZONE 10N
Units: METRES; Vertical Datum: FILL THIS IN!

Job: 3009109 | *Date: 06-SEP-2024*

Campbell River Spawning Gravel Study Spawning Gravel Usability at Site 5

MAP 1

ABC, P:\3009\101\95_GIS\00_MapDocuments\APRX\3009101_Campbell_River_Gravel_Study_R01.aprx

Site 7		
Location ID	**Area (m2)**	**Quality**
8	112	2
9	133	1
10	134	2
11	108	1
12	115	1
13	816	1
14	108	3
15	58	2
16	210	2

Gravel Deposition		
Location ID	**Area (m2)**	**Quality**
7	164	2

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Legend

- Spawning Gravel Quality 1/5
- Spawning Gravel Quality 2/5
- Spawning Gravel Quality 3/5
- Spawning Gravel Quality 4/5

DATA SOURCES:
Orthoimagery courtesy of SuavAir Aerial Imaging, 8/14/2024.

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SCALE - 1:500
0 5 10 15 Meters
N

Coordinate System: WGS 1984 UTM ZONE 10N
Units: METRES; Vertical Datum: FILL THIS IN!

Job: 3009109 | *Date: 06-SEP-2024*

Campbell River Spawning Gravel Study Spawning Gravel Usability at Site 7

MAP 2

Site 9		
Location ID	**Area (m2)**	**Quality**
21	9	1
22	54	1
23	60	2
24	566	3
25	101	1
Gravel Deposition		
Location ID	**Area (m2)**	**Quality**
17	343	4
18	535	3
19	3325	1
20	749	2

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Legend
- Spawning Gravel Quality 1/5
- Spawning Gravel Quality 2/5
- Spawning Gravel Quality 3/5
- Spawning Gravel Quality 4/5

DATA SOURCES:
Orthoimagery courtesy of SuavAir Aerial Imaging, 8/14/2024.

NOTES:
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SCALE - 1:700
0 5 10 15 20 Meters
N

Coordinate System: WGS 1984 UTM ZONE 10N
Units: METRES; Vertical Datum: FILL THIS IN!

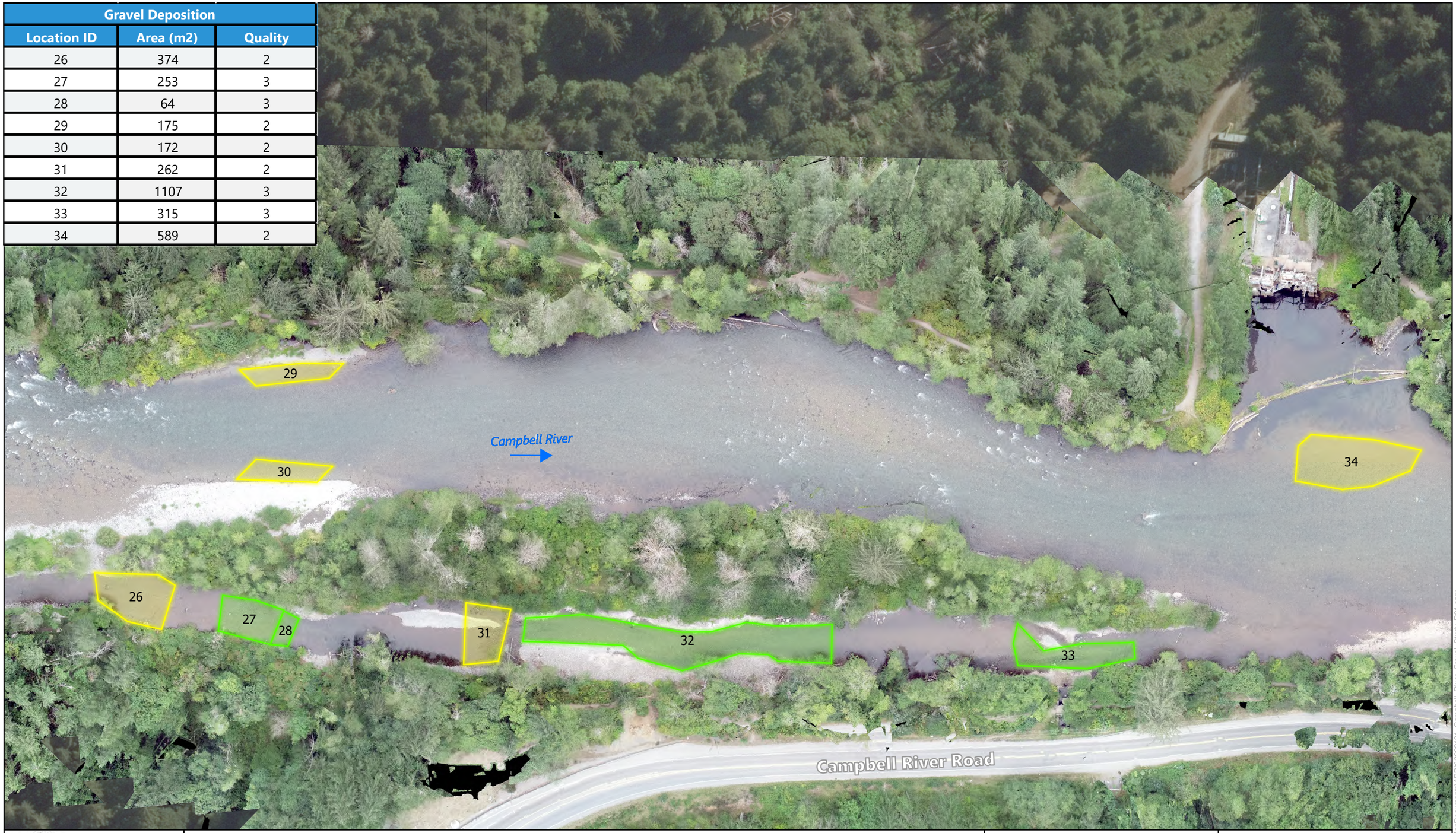
Job: 3009109 | *Date: 06-SEP-2024*

Campbell River Spawning Gravel Study Spawning Gravel Usability at Site 9

MAP 3

ABC, P:\3009101\195_GIS\00_MapDocuments\APRX\3009101_Campbell_River_Gravel_Study_R01.aprx

Gravel Deposition		
Location ID	Area (m2)	Quality
26	374	2
27	253	3
28	64	3
29	175	2
30	172	2
31	262	2
32	1107	3
33	315	3
34	589	2



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Legend

- Spawning Gravel Quality 1/5
- Spawning Gravel Quality 2/5
- Spawning Gravel Quality 3/5
- Spawning Gravel Quality 4/5

DATA SOURCES:
Orthoimagery courtesy of SuavAir Aerial Imaging, 8/14/2024.

NOTES:
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SCALE - 1:1,200
0 5 10 15 20 25 30 35 40 Meters

Coordinate System: WGS 1984 UTM ZONE 10N
Units: METRES; Vertical Datum: FILL THIS IN!

Job: 3009109 | *Date: 06-SEP-2024*

Campbell River Spawning Gravel Study Spawning Gravel Usability

MAP 4

ABC: P:\3009101\95_GIS\00_MapDocuments\APRX\3009101_Campbell_River_Gravel_Study_R01.aprx