ASSESSMENT OF GRAVEL QUANTITY/QUALITY/STABILITY AND STRANDING RISKS IN REACH 1 OF THE JORDAN RIVER

FWCP SEED PROJECT 13.JOR.02

Prepared For:

Fish and Wildlife Compensation Program

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EXECUTIVE SUMMARY

In 2013, D. Burt and Associates was awarded seed funding through the Fish and Wildlife Compensation Program (FWCP) to undertake an assessment of gravel quantity, quality, and stability in the reach downstream of the Jordan River Generating Station tailrace. Due to flow fluctuations associated with plant operation, the assessment also looked at stranding risks.

Field investigations included identification of habitat types, identification of potential stranding sites, visual assessment of substrate particle size distributions, quantification and georeference of existing gravel, level and rod surveys (2 cross-sections plus the study area thalweg), and a snorkel survey in November to enumerated adult returns.

The study area was found to have 2 large broad riffles separated by a section of pool and glide habitat, and was well wetted at base flow (0.3–0.4 m^3/s). The overall composition of the study area was 56% pool/glide habitat, and 44% riffle habitat. Given the historic spawning use of the area, gravel was anticipated to be found on the riffle habitats. However, visual assessment found the stream bed to be armoured and composed mainly of cobbles and boulders. Spawning gravels were absent with the exception of one location on the river right. It is speculated that tailrace flows are washing any recruited gravel out of this reach leaving an armoured layer of larger particle sizes.

The one site where gravel was found was located on the right side of the channel 80 downstream of the tailrace. This site has a region of continuous gravel amounting to 495 m^2, and an outer margin of patchy gravel amounting to 423 m^2. Quality of the gravel was considered moderate due to the presence of 15% fines and the shallowness of the layer. Potential spawning use was estimated at 395 pink pairs and 182 chum pairs. The occurrence of this gravel was attributed to the orientation of the tailrace, which directs flows obliquely to the opposite bank, which in turn redirects flows directly downstream. This leaves an inside semicircle that is protected from the full force of tailrace flows.

The thalweg profiles indicated gradients of 0.63% and 0.53% for the two riffles, however, the overall gradient of the study area was only 0.3%. Analysis of the cross-section profiles suggested that particle sizes of $\geq$ 4.1 cm should remain stable under tailrace flows of 57 m^3/s. However, given the visual observations, it would appear that tailrace flows are moving substrates larger than this, possibly from the repeated nature of their release, or possibly from a surge effect associated with the sudden release of a large amount of water.

Stranding risks have been reduced to some degree by the flow releases from Elliott Dam. For example, there is now sufficient wetted coverage at base flow that most eggs and alevins would remain wetted when turbine flows are turned off. The main concern now would be for rearing or downstream migrants that are lifted onto the higher locations of bars when turbine flows are released, and then left on these locations when the turbines are turned off. The main site of concern is the left portion of the bar associated with the lower riffle.

One snorkel survey was conducted (November 5, 2013) and found 6 adult coho (all in Reach 2), 1 dead jack coho (in the tailrace outlet pool), and 3 areas of redd digging (Reach 2).

Re-introduction of spawning gravel on the two riffle habitats was estimated to potentially provide habitat for 2,700 pink pairs and 1,250 chum pairs (structures would be required to retain the gravel).

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1. INTRODUCTION

Historically the Jordan River supported an abundance of anadromous salmon and trout runs with a species mix that included coho, chum, and pink salmon, and steelhead and searun cutthroat trout. Coho and Chum runs declined suddenly in the early 1950's and became extinct by the late 1950's – early 60's. Pink salmon were last observed in 1970, after which they too became extinct (Burt 2012 (draft)). Six years of monitoring by the Water Use Plan studies provided insight into the demise of these runs (summarised in Burt 2014). Foremost among factors, was that most of the anadromous portion of the river was contaminated with copper leaching in from the top end of the accessible section. While copper levels did not deter successful spawning and incubation, they completely prevented occurrence of the more sensitive freshwater rearing stage. Thus species such as coho and steelhead have been unable to complete their life history and produce outgoing smolts. It seems likely that copper contamination was the main reason for the abrupt decline in salmon runs in the 1950's and 60's. The stragglers that hung on for some time, as well as the pink runs, were likely sustained by the original tailrace channel, which was a 500 m long outflow channel for the original generating station located on the east side of the river. This 500 m long channel provided a section of aquatic habitat free of copper contamination. However, when BC Hydro moved the plant to the west side of the river in 1971, and then decommissioned the channel, this last freshwater refuge was lost thus sealing the fate of remaining salmon runs.

This grim situation was dramatically improved beginning in January 2008 when BC Hydro initiated fish flow releases from Elliott Dam. The terms of the Jordan WUP called for a release of 0.25 m^3/s, however, issues with the control mechanism necessitated locking the valve in the full open position, and this has resulted in release flows of roughly 0.30 – 0.40 m^3/s depending on water elevation in Elliott Headpond. For the anadromous portion of the Jordan River, these releases have provided sufficient dilution of copper that rearing fish have colonized this previously dead zone. Furthermore, sampling of juvenile trout found that fish condition factor (weight to length ratio) was comparable to fish sampled upstream of the copper impacted zone (Burt 2013). This turn around has opened the possibility for undertaking habitat restoration and related projects that help to restore salmon and trout runs back to the Jordan River.

The purpose of this seed fund project was to assess gravel quantity, quality, and stability in the reach downstream of the generating station tailrace, and to determine potential risks of stranding for both adults and emergent fry. This project was also intended to provide important baseline information to assist in future development of a restoration plan for anadromous reaches of the Jordan River.

2. STUDY AREA

The anadromous part of the Jordan River contains 3 distinct reaches (Figure 1). Reach 1 is tidal and extends from the mouth to just upstream of the current tailrace outlet, a distance of 970 m. Reach 2 extends from the top of Reach 1 upstream for 330 m to a partial barrier falls. The copper contamination mentioned in the Introduction emanates from an exposed section of the east bank at the top of this reach. Reach 3 is 325 m in length and terminates at a 4.6 m rock falls, considered to be a complete barrier to anadromous migration.

This reach is influenced by flows from the generating station, which exhibit wide fluctuations due to operation of the Jordan facility as a peaking power plant. The resultant flows appear to have scoured most gravels from this reach severely degrading its spawning capabilities.

The area of interest by this assessment was the section of Reach 1 from the tailrace downstream to the outlet of unnamed Creek 1 (Figure 1). This section contains 2 broad riffles and anecdotal information suggests that historically, this area was an important spawning ground for tidal spawning species such as pink and chum salmon. Until the current investigation, the status of habitat in this reach was largely unknown as the various WUP monitoring programs conducted from 2005 to 2011 focused on reaches upstream of the generating station tailrace. The viability of the area for fish was deemed uncertain due to extreme fluctuations in flow associated with operation of the Jordan facility (full generation can result in a release discharge of up to 57 m^3/s). Thus, when generation commences, the rapid increase in flows (there are no ramping requirements at the facility) has the potential to wash rearing fish out to the ocean (adults would likely seek shelter along the margins), and the decrease back to base levels when generation is turned off can leave juveniles stranded on exposed bars. Prior to the fish flow releases at Elliott Dam in January 2008, base levels were sometimes as low as 12 L/s. At this discharge, the river is basically a trickle and eggs and alevins in Reach 1 may be at risk, while any juveniles or adults present after cessation of generation would have had a high potential of being left stranded. After initiation of the flow release, base flows have increased to roughly 0.3 – 0.4 m^3/s. At this discharge there is substantially more water in the channel and stranding risks are reduced but still present in some areas.

3. METHODS

Assessment of the study area was undertaken on August 22 and September 9, 2014 by Dave Burt (D. Burt and Associates), and Helen and Jeff Jones (Pacheedaht First Nation fisheries technicians). Activities undertaken during these field trips included the following:

- Visual assessment of the overall substrate composition on each of the two riffles (percentage per Wentworth scale size class, plus D_{50}, D_{90}, D_{max}, and roughness. Roughness was assessed by measuring height above the streambed of 6 representative particles sizes and taking their average).

- Identification of existing gravel sites that could potentially support spawning and collection of pertinent data including dimensions (m^2), size class composition, % fines, thickness, friability (looseness), and GPS coordinates (Garmin Oregon GPS).
- Assessment of potential stranding risks within the study area when the Jordan River generator is turned off and the flows recede.
- Completion of a channel cross-section profile on each of the 2 riffles, and a longitudinal thalweg profile from the generating station tailrace downstream to the bottom of the second riffle. Elevations at profile survey points were measured using and builder's level and rod. Horizontal distances were determined using a tape measure stretched between transect end points (spikes in the base of trees) for the cross-sections, and by a running hip chain for the thalweg profile. GPS coordinates were collected for cross-section end points and for every survey point on the thalweg profile.
- Collection of photographs of the cross-sections, potential spawning sites, potential stranding sites, and showing general features of the study area.

In addition to the above activities in Reach 1, the Pacheedaht Fisheries team also completed a snorkel survey on November 5, 2013 for the purpose of enumerating adult salmon returns to the lower river. The original intent was to survey Reaches 1 and 2, however, turbidity from an incoming tide necessitated that the survey be limited to Reach 2.

Other activities included providing a PowerPoint presentation to the Pacheedaht Chief and Council and Queesto Community Forest (current owners of logging and dryland sort operations on the Jordan River) in order to provide a summary of the current status of the Jordan River and to garner support for this and future projects on the river. As well, other land owners were contacted to discuss the project including CRD (Stephen Henderson, 250-360-3176) and Western Forest Products (Brian Marcus, 250-720-4226)

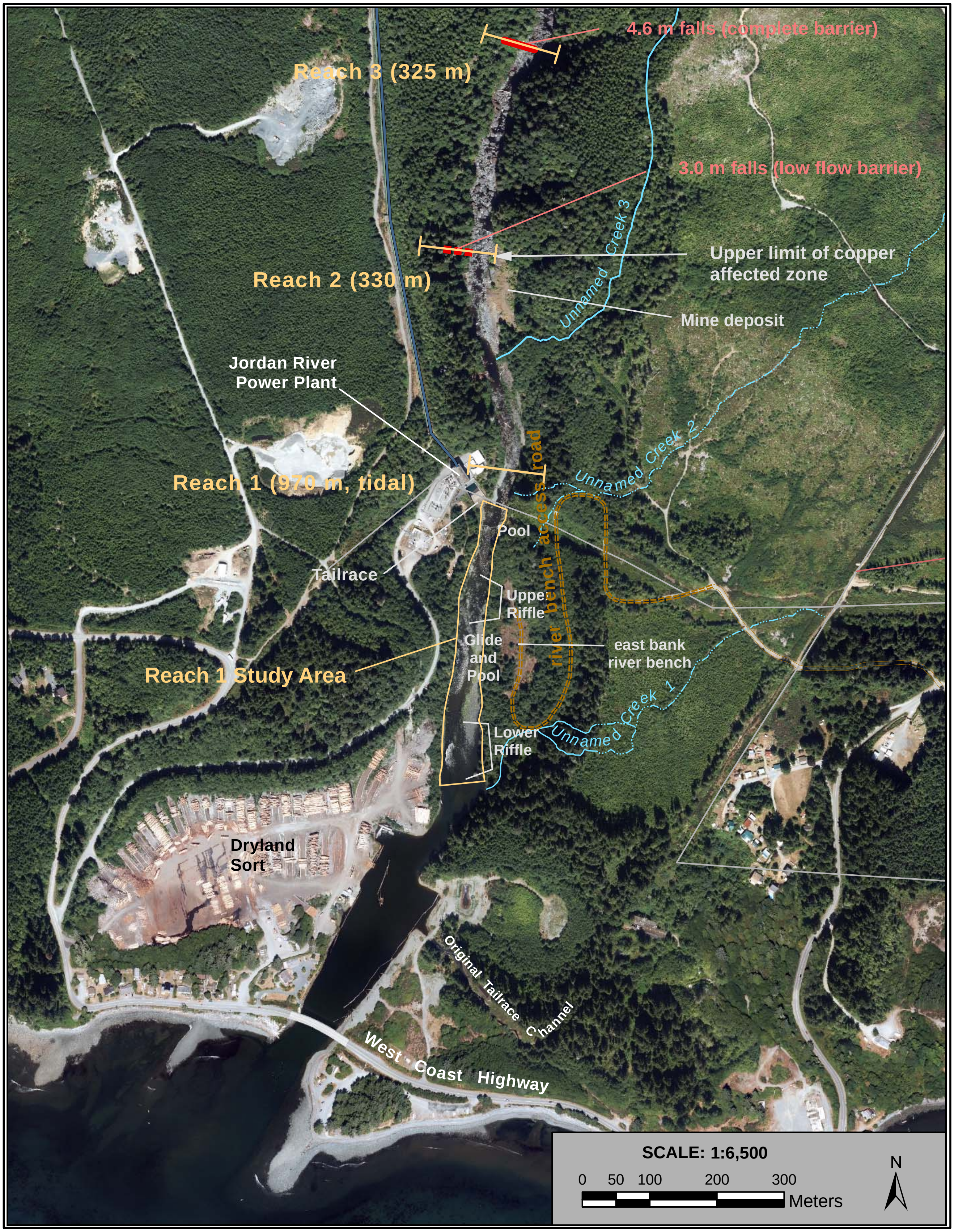

Figure 1. Map of the 3 anadromous reaches of the Jordan River and the study area in Reach 1. (May 2013 orthophoto courtesy of CRD's WMS server).

4. RESULTS

Description of Habitat

A 1:2000 scale map of the study area is shown in Figure 2. The area can be accessed by walking downstream from the generating station office parking lot, from the north end of the dryland sort (with permission), or by the access road to the river bench on the east side of the river. Habitat within the study area consist of a pool at the top where the tailrace flows enter the channel. This transitions into a riffle, followed by long stretch of glide and pool habitat, and then a second riffle at the bottom of the study area. Below the study area the gradient diminishes to near zero and the river becomes quite deep and slow moving. This zone is also subject to periodic dredging in order to maintain depths required to boom and barge log bundles from the dryland sort.

Dimensions of the channel and its habitat types within the study area based on digitizing in ArcGIS are as follows:

Channel area:	18,400 m^2
Channel length:	428 m
Mean channel width:	43 m
Pool and glide area:	10,923 m^2 (56%)
Upper riffle area:	3,707 m^2
Lower riffle area:	4,400 m^2
Total riffle area:	8,107 m^2 (44%)

Anecdotal information from First Nation interviews (Recreation Resources Ltd 2001) suggests that the study area once supported extensive salmon spawning, most likely by pink and chum salmon as they are known to spawn in tidal zones. However, our surveys found that most of this area can no longer support spawning as substrates are now dominated by cobbles and boulders. Some pockets of gravel were found but these tended to be less than 0.25 m^2 in size. The exception was a 60 m long section of gravel on the right side of the channel 80 m downstream of the tailrace outlet. This patch of gravel will be described in detail below.

Average composition of substrates on the upper and lower riffles from visual assessment are given in Table 1. Cobbles formed 40–45% of the bed material and boulders 25–30%. With the exception of the patch of gravel mentioned above, the small and large gravel fractions were located in the spaces between the cobbles and boulders. Also, the greater percentage of gravel in the upper riffle (30% for small and large gravel combined) was due to the influence of this gravel patch on the overall composition. The overall impression of the streambed in Reach 1 was that gravel sized substrates appear to have been scoured away leaving an armoured layer of cobbles and boulders.

Table 1. Summary of substrate size composition for the two riffle habitats and the site with existing gravel based on visual assessment.

	Percentage Per Size Category									
	Fines (< 2 mm)	Small Gravel (2-16 mm)	Large Gravel (16-64 mm)	Small Cobble (64-128 mm)	Large Cobble (128-256 mm)	Boulder (> 256 mm)	D_{50} (cm)	D_{90} (cm)	D_{max} (cm)	Roughness (cm)
Upper Riffle	5	20	10	20	20	25	52	86	150	29
Lower Riffle	5	15	5	15	30	30	60	65	83	34
Existing gravel site	15	35	15	15	5	15	–	–	–	–

The third row in Table 1 shows the substrate composition of the one location in Reach 1 where a continuous patch of gravel was found. Composition of this site is unique with 50% of materials composed of small and large gravel. The site begins 80 m downstream of the tailrace, extends downstream by roughly 60 m, and has a width ranging from 12 – 21 m (Figure 2). The site was subdivided into a section with continuous gravel located along the right side, and a section where the gravel was patchier, located on the thalweg side. GIS computation indicated an area of 495 m^2 for the continuous gravel portion, and 423 m^2 for the patchy portion, for a combined area of 918 m^2. Quality of the gravel was judged to be only fair due to shallowness of the layer, and a moderate level of compaction as a result of intrusion of fines (15%). Nevertheless, generating station staff have observed spawning and salmon eggs at this site in previous years (Dwayne Walsh, Jordan River Generating Station, pers. comm.). Photos of the area and its gravel are included in Appendix II (Photos 1, 3, and 4).

Longitudinal and Cross-Section Profiles

Field surveys included a level and rod survey of one cross-section profile on each riffle, and a longitudinal thalweg profile from the top to the bottom of the study area. Locations of these profiles are shown in Figure 2, while results are illustrated in Figure 3. Channel geometry statistics generated using survey data and WINXSPro software are provided in Appendix I. Photos of upper and lower transects are given in Appendix II (Photos 1 and 2).

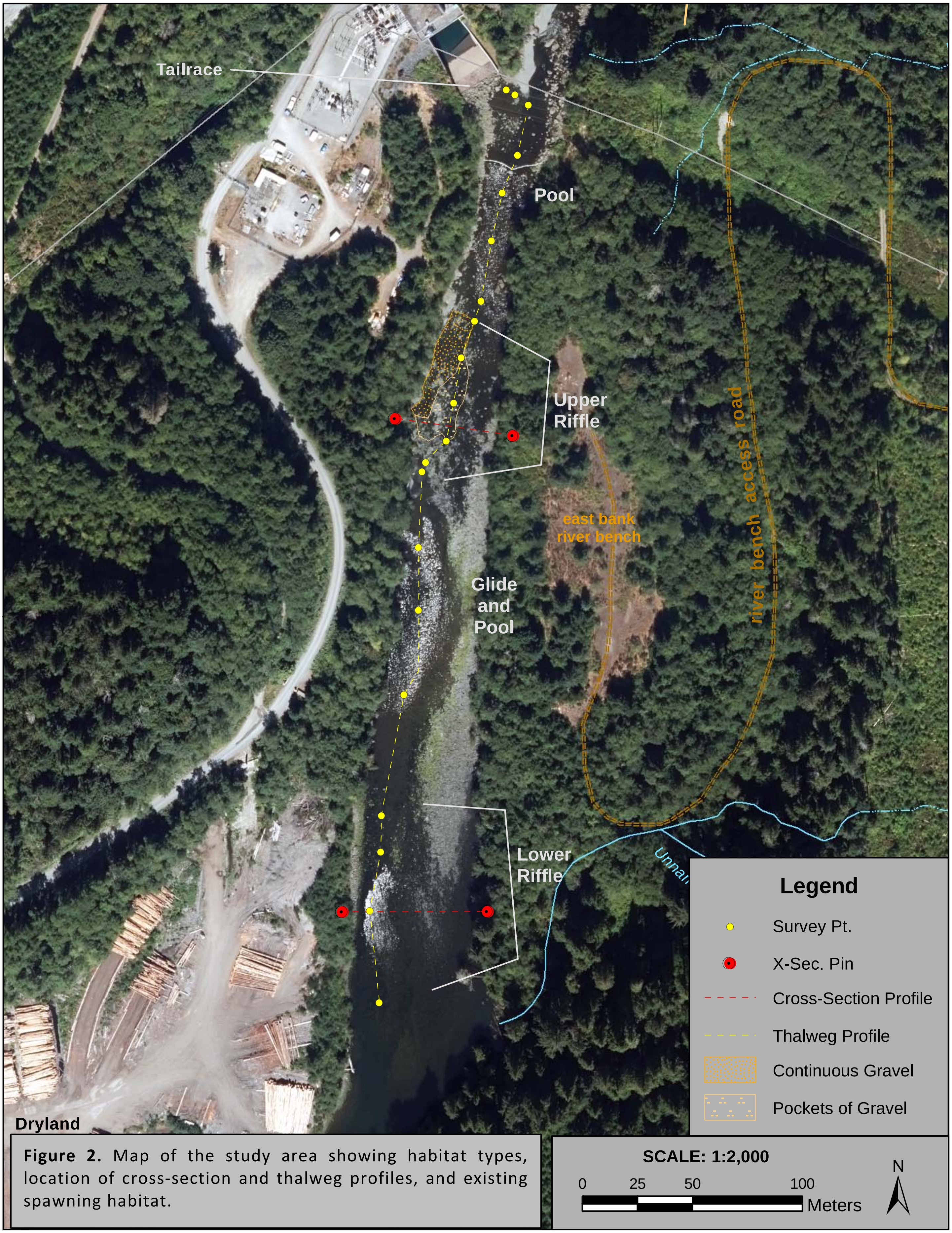

Figure 2. Map of the study area showing habitat types, location of cross-section and thalweg profiles, and existing spawning habitat.

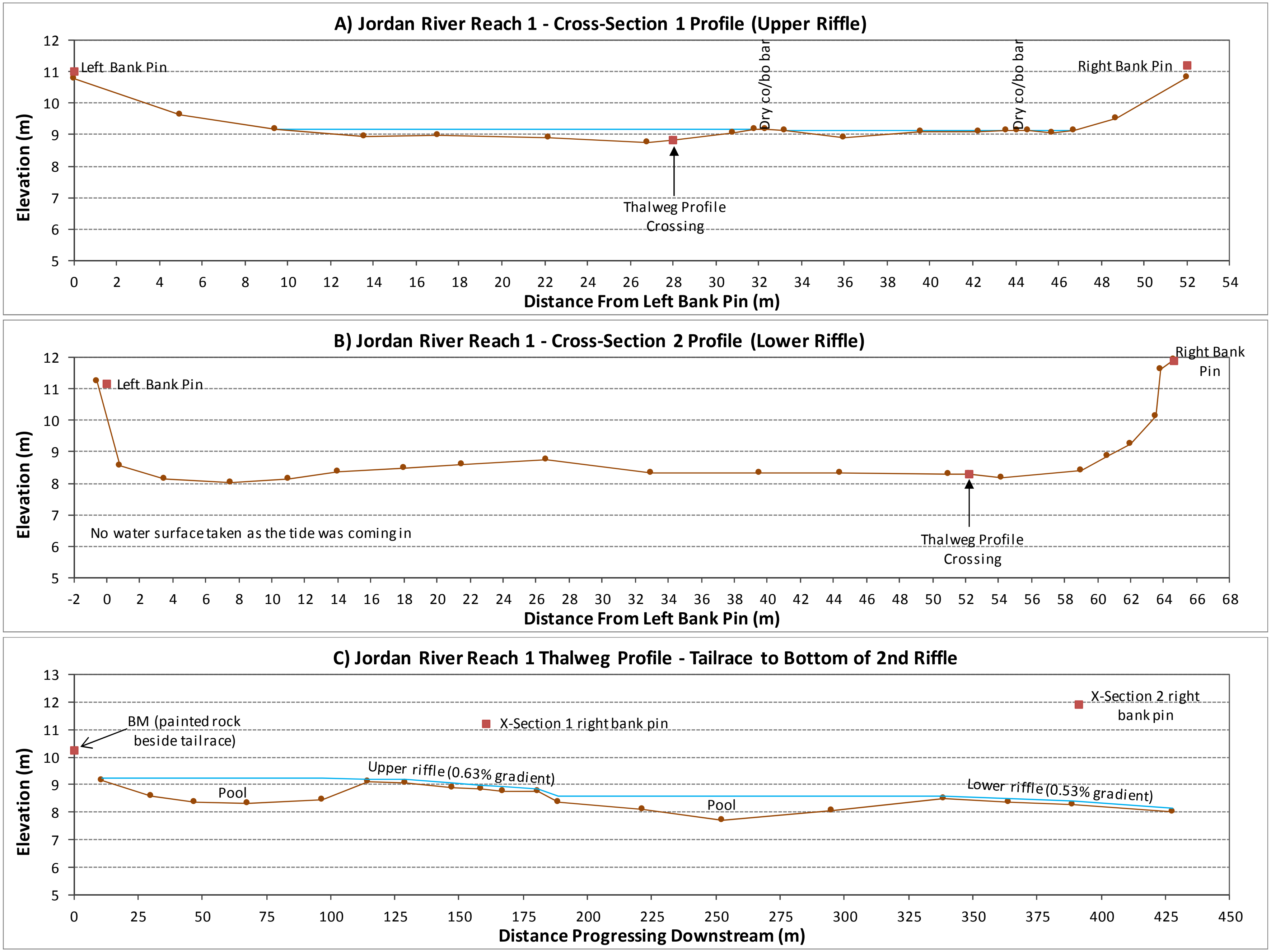

Figure 3. Channel cross-section profiles for the upper and lower riffles (Charts A and B, respectively), and for the longitudinal thalweg profile (Chart C).

Substrate Stability

As mentioned above, gravel sized substrates appear to have been scoured from Reach 1 leaving an armoured layer of mostly cobbles and boulders. Given that habitats upstream of the tailrace have pockets of gravel and larger particles are not armoured, it is likely that the state of habitat in Reach 1 is due to the scour action of peaking flows from the Jordan River Generating Station. At full generation, these flows amount to 57 m^3/s. Analysis of the cross-section data in WINXSPro suggests that the tractive force on the stream bed at this discharge is 4.1 kg/m^2 at XS1 and 3.9 kg/m^2 at XS2 (Appendix I). According to Newbury and Gaboury (1993), for non-cohesive bed materials greater than 1 cm in diameter, tractive force is equal to incipient diameter (the size in cm at which a particle is mobilized). Thus, a discharge of 57 m^3/s is estimated to mobilize substrates ≤ 4.1 cm as XS1 and ≤ 3.9 cm at XS2. Figure 4 shows incipient diameter as a Figure 3function of discharge for each cross-section (based on data from Appendix I). Visual observations suggest that these incipient diameters may be an underestimation of particle sizes mobilized by generation flows. Possible explanations for this are the repeating nature of generation flows, or perhaps a surge effect from the sudden release of a large amount of water.

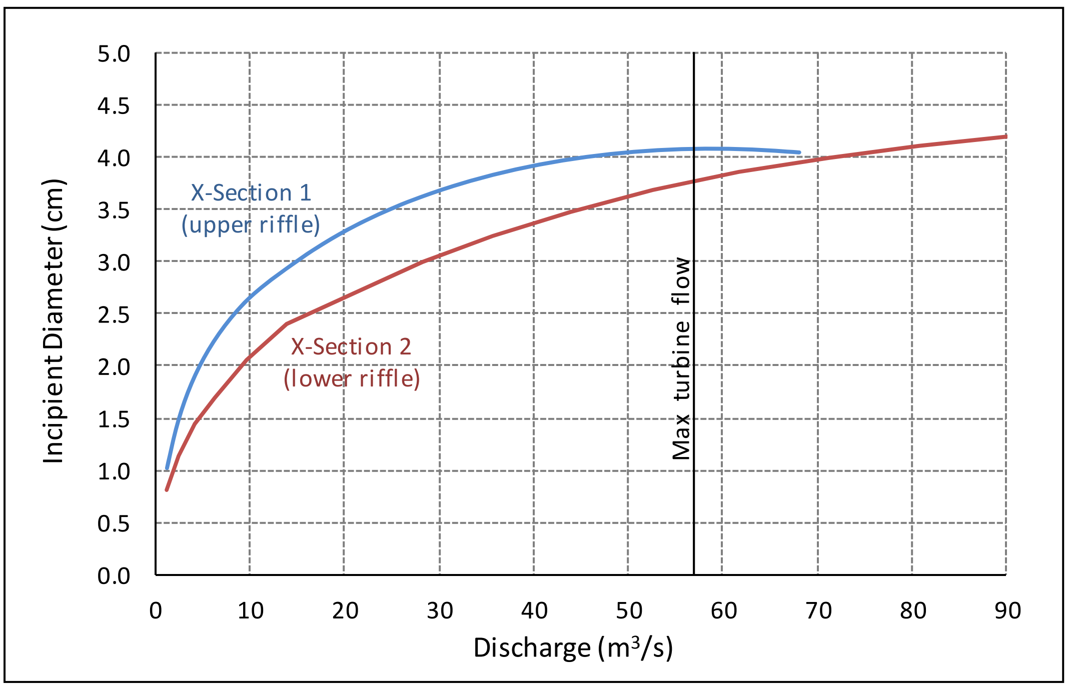

Figure 4. Incipient particle diameter as a function of discharge for Cross-Sections 1 (upper riffle) and 2 (lower riffle).

The presence of a 918 m^2 bed of gravel with a relatively high percentage of particle sizes less than 4.1 cm is likely due to its location on the inside of curvature of the turbine outflows. The behaviour of these outflows is to shoot across to the opposite bank at a slight downstream angle. The opposite bank then redirects the flows downstream. This configuration leaves an inside semicircle that does not experience the full forces of the turbine flows.

Stranding Risks

Stranding risks in Reach 1 have been reduced to some degree by initiation of the fish flow releases from Elliott Dam in January 2008. Prior to these releases, summer base flows in the anadromous portion of the river were in the range of 0.012–0.017 m^3/s, and riffle habitats were reduced to a few centimetres of water trickling among the rocks. After initiation of the fish flow releases, base flows increased to 0.3–0.4 m^3/s, and riffle habitats were greatly improved in wetted coverage and thalweg depths. An example of post-flow release riffle conditions is in Cross-Section 1 (Figure 3, Chart A), which had a wetted width of 37 m, a mean depth of 0.17 m, and a maximum depth of 0.4 m under a base flow of 0.37 m^3/s.

It is the impression of the author that the new base flows alleviate stranding concerns for eggs and alevins in the substrate. However, there are still likely to be stranding risks for rearing or downstream migrant juveniles that are swept onto higher elevation portions of bars when generation is turned on, and potentially left there when generation is turned off. The primarily location of concern for this scenario is the cobble/boulder bar on the left (east) side of the lower riffle. This risk would only occur when tide heights are below the elevation of potential stranding sites. Field observations suggest that stranding would only be an issue at tidal heights of roughly $\leq$ 2 m. Adult stages are less likely to become stranded as they can more readily move to deeper habitats as flow recede. Photo 5 in Appendix II provides a view of the lower riffle bar area.

Naturally, stranding would only be an issue if fish are using the area for rearing, or downstream migration timing window. To date, there have been no studies to assess rearing use of Reach 1 or the population characteristics of downstream migration (species, migrant population size, and timing). Also unknown, is how quickly the water in Reach 1 empties once the generator is turned off, which can influence stranding rates.

If in the future, stranding is deemed to be an issue, there are various means of minimizing impacts. Examples include: 1) introducing a ramp-down rate for the Jordan River generator, 2) timing the cessation of generation with higher tides, and 3) at the cessation of generation, maintain a small load so as to supply sufficient water until high tide.

Snorkel Survey Results

The snorkel survey was conducted by Helen and Jeff Jones of the Pacheedaht First Nation fisheries section on November 5, 2013 from 9:40 to 11:40 am. The area surveyed included the lower 60 m of Reach 3, all of Reach 2, and the upper 230 m of Reach 1, for a total distance of about 600 m. The weather was overcast with light rain, and water visibility was estimated at 3–5 m. Discharge at the gauging station above the generating station was 0.497 m^3/s. A total of 6 adult coho and 1 dead jack coho were observed, and signs of redd digging were observed at 3 locations. All 6 live coho were found in Reach 2, four of which were observed in association with some large LWD on the right bank opposite Unnamed Creek 3. The dead jack coho was found in the pool at the tailrace outflow (Reach 1). Photo 6 shows and adult coho holding over an area of digging while Photo 7 shows an adult holding among the rocks (Appendix II).

5. DISCUSSION

Reach 1 is a part of the Jordan River where the gradient diminishes and the channel widens, and as such, would normally be a depositional zone for smaller substrates. Anecdotal information from First Nation interviews (Recreation Resources Ltd 2001) suggest the reach once supported extensive spawning which infers an abundance of gravel sized substrates. The general lack of smaller particle sizes found by this seed project, and observations of habitat in Reach 2, suggests that smaller substrates are being scoured from Reach 1 by the frequent high flows associated with peaking operation of the Jordan River electrical facility. The one area of continuous gravel identified appears to be the result of its location on the inside curvature of the path of turbine flows, which offers a measure of protection from the energy of these flows.

The identified gravel site had a region of continuous gravel amounting to 495 m^2 in area, and a patchy portion of 423 m^2 in area. In terms of pink spawning potential, if it is assumed that 70% and 30% of these regions are suitable for spawning (respectively), and the usable portion were recruited at density of one spawner pair per 1.2 m^2, this existing gravel site could support a total of 395 pink pairs, or an escapement of 970 pinks (Table 2). Similarly, if the site were utilized by chum salmon, the above usage assumptions, and a spawning biostandard of 2.6 m^2 per spawning pair, then the gravel site could potentially support 182 chum spawning pairs, or an escapement of 364 adults (Table 2).

Future investigations on the Jordan River will involve development of a comprehensive restoration plan for anadromous reaches of the river. One important option will be to explore methods for trapping or encouraging gravel to remain in the riffle zones assessed by this seed project. A preliminary projection of spawning potential for these two riffles is given in Table 2. Under the assumptions shown, reintroduction of gravel to these 2 riffles could potentially provide spawning habitat for around 2,700 pink pairs (escapement 5,400), and 1,250 chum pairs (escapement 2,500).

Table 2. Potential number of adult pink and chum salmon supported by existing gravel in Reach 1, and if gravel were restored to existing riffle habitats.

Site	Area of Site (m^2)	Assumed % Usable	Usable Area (m^2)	Area per Spawning Pair Biostandard (m^2)	# of Spawning Pairs Supported
Pink Salmon					
Existing gravel site – continuous portion	495	70%	347	1.2	289
Existing gravel site – patchy portion	423	30%	127	1.2	106
Total			474		395
Upper riffle – if gravel restored	3,707	40%	1,483	1.2	1,236
Lower riffle – if gravel restored	4,400	40%	1,760	1.2	1,467
Total			3,243		2,703
Chum Salmon					
Existing gravel site – continuous portion	495	70%	347	2.6	133
Existing gravel site – patchy portion	423	30%	127	2.6	49
Total			474		182
Upper riffle – if gravel restored	3,707	40%	1,483	2.6	570
Lower riffle – if gravel restored	4,400	40%	1,760	2.6	677
Total			3,243		1247

Note: area per spawning pair biostandards are from Table 2 in Burt (2004).

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7. ACKNOWLEDGEMENTS

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APPENDICES

Appendix I. Cross-Section Hydraulic Data Generated by WINXSPro 3.0 software

Appendix II. Selected Photos.

Appendix III. Financial Statement (Statement of income and expenditures-form attached

Appendix IV. Confirmation of FWCP Recognition

a) Presentation to Pacheedaht Chief and Council

Appendix I. Cross-section hydraulic data generated by WINXSPro 3.0 software.

A) Cross-section 1 (upper riffle), resistance method: Thorne and Zevenbergen, D_{84}: 600 mm

STAGE (m)	X-Section Area (sq m)	X-Section Perimeter (m)	Width (m)	Hydraulic Radius (m)	Hydraulic Depth (m)	Slope (m/m)	Mannings n	Average Velocity (m/s)	Discharge (cms)	Shear (N/sq m)	Tractive Force (kg/sq m)	Alpha	Froude Number
0.42	6.18	36.33	36.28	0.17	0.17	0.0060	0.115	0.21	1.28	10.00	1.02	1.00	0.16040
0.52	9.98	38.88	38.82	0.26	0.26	0.0058	0.123	0.25	2.51	14.55	1.48	1.00	0.15834
0.62	13.93	40.38	40.30	0.35	0.35	0.0056	0.119	0.31	4.31	18.82	1.92	1.00	0.16804
0.72	18.04	41.88	41.79	0.43	0.43	0.0053	0.112	0.37	6.76	22.58	2.30	1.00	0.18206
0.82	22.29	43.22	43.11	0.52	0.52	0.0051	0.103	0.45	9.95	25.93	2.65	1.00	0.19835
0.92	26.65	44.31	44.18	0.60	0.60	0.0049	0.093	0.54	14.29	28.97	2.96	1.00	0.22044
1.02	31.11	45.03	44.86	0.69	0.69	0.0047	0.087	0.62	19.20	31.80	3.24	1.00	0.23671
1.12	35.63	45.74	45.54	0.78	0.78	0.0045	0.082	0.69	24.59	34.19	3.49	1.00	0.24929
1.22	40.21	46.46	46.23	0.87	0.87	0.0043	0.079	0.76	30.40	36.15	3.69	1.00	0.25888
1.32	44.87	47.17	46.91	0.95	0.96	0.0040	0.076	0.81	36.54	37.70	3.85	1.00	0.26597
1.42	49.60	47.89	47.59	1.04	1.04	0.0038	0.073	0.87	42.94	38.84	3.96	1.00	0.27088
1.52	54.39	48.60	48.28	1.12	1.13	0.0036	0.071	0.91	49.51	39.59	4.04	1.00	0.27389
1.62	59.25	49.31	48.96	1.20	1.21	0.0034	0.070	0.95	56.16	39.94	4.08	1.00	0.27518
1.72	64.18	50.03	49.64	1.28	1.29	0.0032	0.068	0.98	62.81	39.91	4.07	1.00	0.27489
1.80	68.17	50.60	50.19	1.35	1.36	0.0030	0.067	1.00	68.06	39.62	4.04	1.00	0.27357

B) Cross-section 2 (lower riffle), resistance method: Thorne and Zevenbergen, D_{84}: 620 mm

STAGE (m)	X-Section Area (sq m)	X-Section Perimeter (m)	Width (m)	Hydraulic Radius (m)	Hydraulic Depth (m)	Slope (m/m)	Mannings n	Average Velocity (m/s)	Discharge (cms)	Shear (N/sq m)	Tractive Force (kg/sq m)	Alpha	Froude Number
0.40	6.81	42.14	42.09	0.16	0.16	0.0050	0.109	0.19	1.32	7.93	0.81	1.00	0.15391
0.50	11.32	48.08	48.01	0.24	0.24	0.0049	0.120	0.22	2.52	11.21	1.14	1.00	0.14665
0.60	16.40	53.69	53.54	0.31	0.31	0.0047	0.122	0.26	4.20	14.11	1.44	1.00	0.14766
0.70	22.04	59.48	59.23	0.37	0.37	0.0046	0.121	0.29	6.35	16.60	1.69	1.00	0.15078
0.80	27.99	60.11	59.78	0.47	0.47	0.0044	0.116	0.34	9.65	20.22	2.06	1.00	0.16094
0.90	33.99	60.59	60.17	0.56	0.56	0.0043	0.109	0.41	13.96	23.57	2.41	1.00	0.17456
1.00	40.03	61.07	60.57	0.66	0.66	0.0041	0.091	0.53	21.40	26.62	2.72	1.00	0.21007
1.10	46.10	61.56	60.96	0.75	0.76	0.0040	0.085	0.61	28.24	29.37	3.00	1.00	0.22494
1.20	52.22	62.04	61.36	0.84	0.85	0.0039	0.081	0.68	35.74	31.82	3.25	1.00	0.23694
1.30	58.37	62.37	61.58	0.94	0.95	0.0037	0.078	0.75	43.91	34.07	3.48	1.00	0.24680
1.40	64.54	62.67	61.79	1.03	1.04	0.0036	0.075	0.81	52.59	36.05	3.68	1.00	0.25469
1.50	70.72	62.97	61.99	1.12	1.14	0.0034	0.073	0.87	61.70	37.74	3.85	1.00	0.26086
1.60	76.93	63.28	62.19	1.22	1.24	0.0033	0.071	0.92	71.14	39.16	4.00	1.00	0.26553
1.70	83.16	63.58	62.40	1.31	1.33	0.0031	0.069	0.97	80.82	40.30	4.11	1.00	0.26888
1.80	89.41	63.89	62.60	1.40	1.43	0.0030	0.068	1.01	90.67	41.16	4.20	1.00	0.27102

Appendix II. Selected Photos.

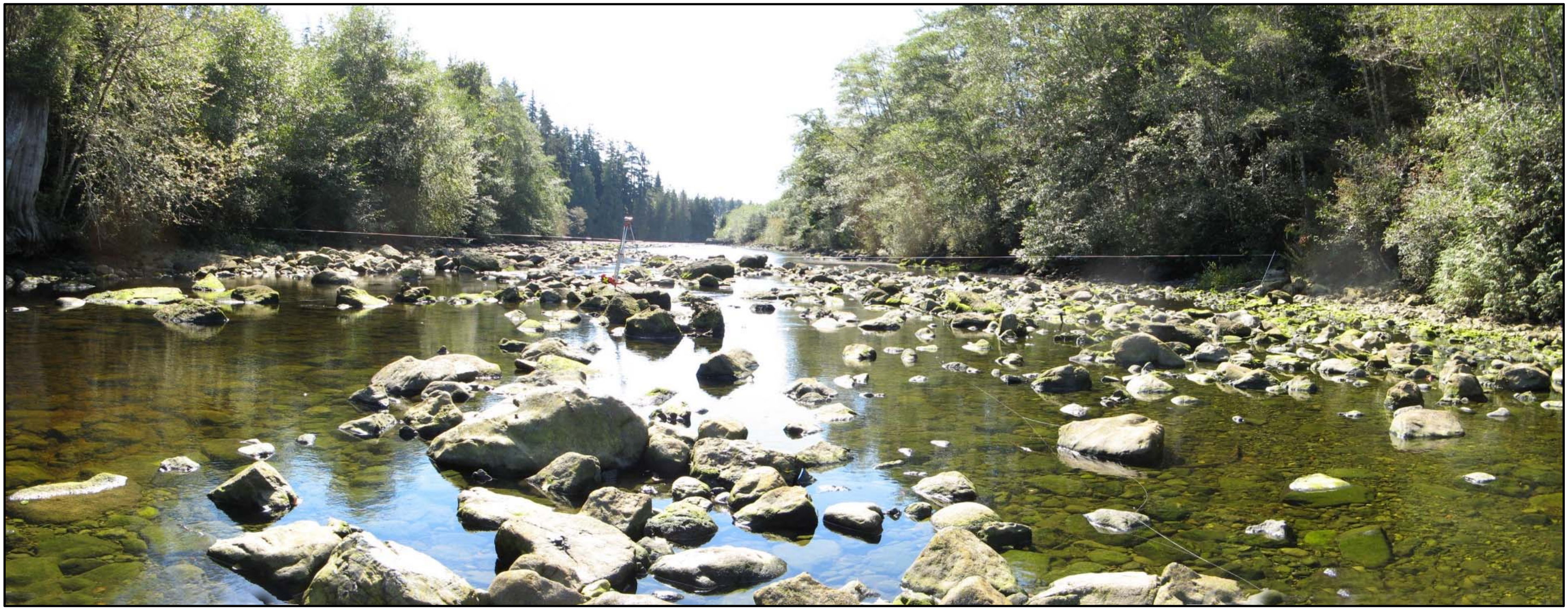

Photo 1. View looking downstream at Cross-Section 1 (upper riffle) (September 9, 203, discharge 0.37 m^3/s). The only location with any significant quantity of gravel in Reach 1 can be seen in the lower right of the photo. This section of gravel begins at the transect line and extends along the right side of the channel upstream for 60 m.

Photo 2. View looking upstream at Cross-Section 2 (lower riffle) (August 14, 2013). Unfortunately, an incoming tide had inundated the riffle by the time the photos were taken.

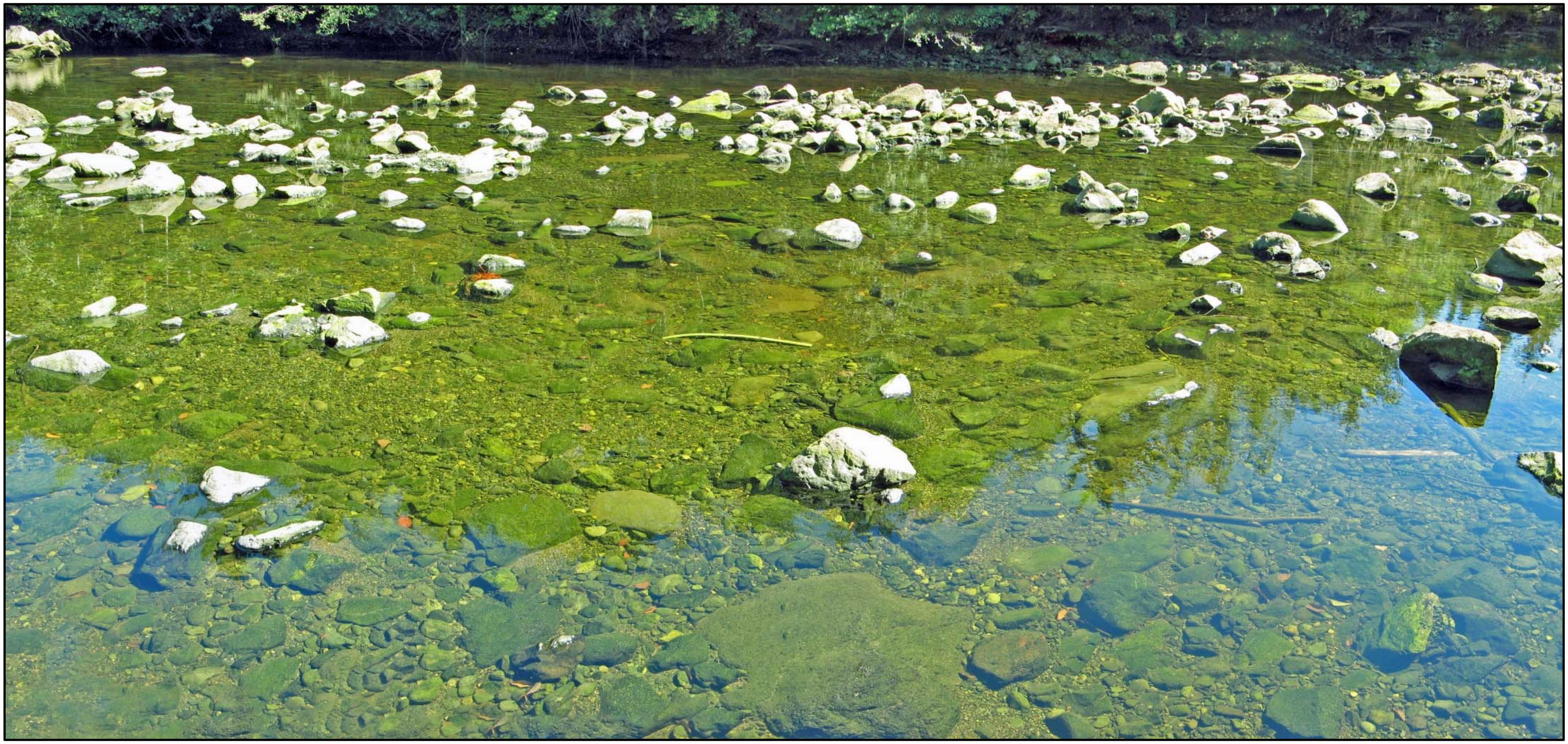

Photo 3. View of the section of continuous gravel from mid channel looking toward the right bank (September 9, 2013). Some spawning has been observed in this gravel in past years by the generating station staff.

Photo 4. Close-up view of gravel composition of the continuous gravel pad (September 9, 2013). White bands on the walking stick are 2.5 cm.

Photo 5. View looking upstream at the lower riffle on an incoming tide (September 9, 2013). On the east side of the channel (river left facing downstream) is a cobble/boulder bar that may pose stranding issues when the Jordan turbine is turned off and flows drop (if fish are in the river and if the tide is less than 2 m).

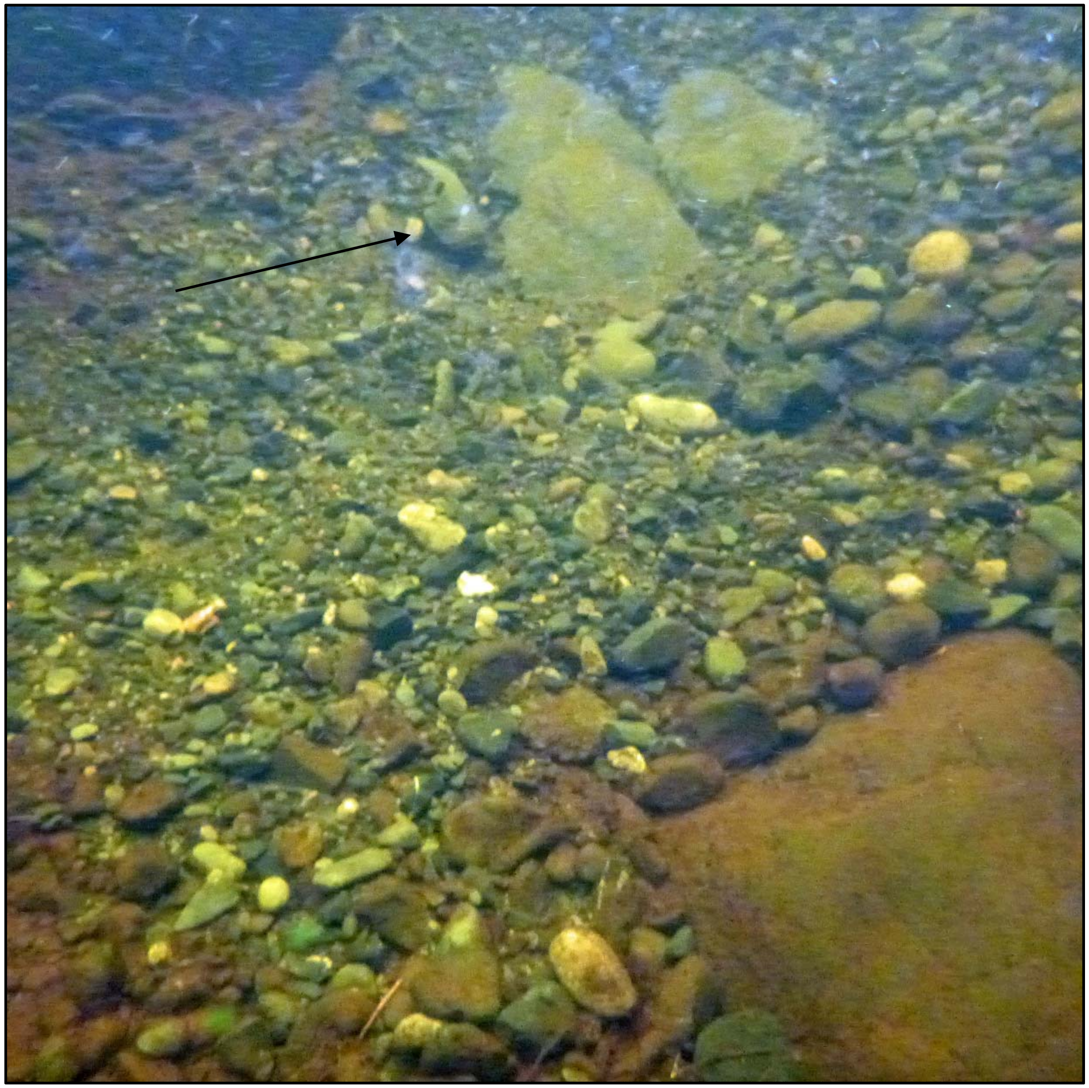

Photo 6. View of adult coho holding over an area of digging in Reach 2 (November 9, 2013 snorkel survey).

Photo 7. Adult coho holding among rocks in reach 2 (November 9, 2013 snorkel survey).

FISH AND WILDLIFE
COMPENSATION PROGRAM

Financial Statement Form

Project # 13.JOR.02

	BUDGET		ACTUAL	
	FWCP	Other	FWCP	Other
INCOME				
Total Income by Source	$4,986.40	$900.00	$4,986.40	$1,452.80
Grand Total Income (FWCP + other)	$5,886.40		$6,439.20	
	BUDGET		**ACTUAL**	
	FWCP	Other	FWCP	Other
EXPENSES				
Consultant Fees	$1,164.80		$1,606.80	$140.40
(List others as required)				
Pacheedaht Fisheries Technicians	$560.00		$560.00	$280.00
Adult enumeration survey (Pacheedaht)		$900.00		$450.00
Biologist - Reporting	$2,329.60		$2,329.60	$582.40
Pacheedaht - Report assistance	$140.00		$0.00	
MATERIALS & EQUIPMENT				
Equipment Rental				
Materials Purchased				
Travel Expenses	$392.00		$490.00	
Permits				
(List others as required)				
Water Quality Analysis	$400.00		$0.00	

FISH AND WILDLIFE
COMPENSATION PROGRAM

Financial Statement Form – Continued

ADMINISTRATION				
Office Supplies				
Photocopies & printing				
Postage				
(List others as required)				
Total Expenses	$4,986.40	$900.00	$4,986.40	$1,452.80
Grand Total Expenses (FWCP + other)	$5,886.40		$6,439.20	
BALANCE (Grand Total Income – Grand Total Expenses)	$0.00		$0.00	
	The budget balance should equal $0		*The actual balance might not equal $0*	

** Any unspent FWCP financial contributions are to be returned to:*

Fish and Wildlife Compensation Program
c/o BC Hydro
11th floor
6911 Southpoint Drive
Burnaby, BC
V3N 4X8
Attention: Lorraine Ens

For more information visit fwcp.ca.

The FWCP is a partnership of:

BC hydro FOR GENERATIONS
British Columbia
Canada
Fisheries and Oceans Canada
Pêches et Océans Canada

GDS12-288

Performance Measures

Using the performance measures applicable to your project, please indicate the amount of habitat anticipated to be restored/enhanced for each of the specified areas (e.g. riparian, tributary, mainstream). The same table will be used in the final report to summarize project results.

Performance Measures – Target Outcomes

Project Type	Primary habitat benefit targeted of project (sq.m.)	Primary Target Species	Estuarine	In-stream Habitat – Mainstream	In-stream Habitat – Tributary	Riparian	Reservoir Shoreline Complexes	Riverine	Lowland Deciduous	Lowland Coniferous	Upland	Wetland	Other
Impact Mitigation													
Fish passage technologies	Area of habitat made available to target species		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
Drawdown zone revegetation/ stabilization	Area turned into productive habitat		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
Wildlife migration improvement	Area of habitat made available to target species		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
Prevention of drowning of nests, nestlings	Area of wetland habitat created outside expected flood level (1:10 year)		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
Habitat Conservation													
Habitat conserved – general	Functional habitat conserved/replaced through acquisition and management	Pink, chum, coho, and steelhead	☐	☒	☐	☐	☐	☐	☐	☐	☐	☐	Possible options for management of the Jordan facility to minimize stranding (e.g.,
Habitat conserved - general	Functional habitat conserved by other measures (e.g. riprapping)	Pink and possibly chum salmon	☐	☒	☐	☐	☐	☐	☐	☐	☐	☐	Future works to explore structures that may help retain naturally recruited gravel
Designated rare/special habitat (subset)	Rare/special habitat protected		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	

Performance Measures – Target Outcomes - Continued														
Project Type	**Primary habitat benefit targeted of project (sq.m.)**	**Primary Target Species**	Estuarine	In-stream Habitat – Mainstream	In-stream Habitat – Tributary	Riparian	Reservoir Shoreline Complexes	Riverine	Lowland Deciduous	Lowland Coniferous	Upland	Wetland	**Other**
Maintain or Restore Habitat forming process													
Artificial gravel recruitment	Area of stream habitat improved by gravel placement	Pink and possibly chum salmon	☐	☒	☐	☐	☐	☐	☐	☐	☐	☐	Potential future installation of spawning gravel and structures to help retain gravel.
Artificial wood debris recruitment	Area of stream habitat improved by LWD placement		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
Small-scale complexing in existing habitats	Area increase in functional habitat through complexing		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
Prescribed burns or other upland habitat enhancement for wildlife	Functional area of habitat improved		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
Habitat Development													
New habitat created	Functional area created		☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
Other													
Development of a comprehensive		Pink, chum, coho, steelhead, anadromc	☒	☒	☒	☐	☐	☐	☐	☐	☐	☐	This project assisted in gathering information
			☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
			☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	
			☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	