





Huu-ay-aht First Nations

huu ay aht

ANCIENT SPIRIT, MODERN MIND

Sarita and Pachena Watershed Renewal:

AS-BUILT REPORT OF 2018 & 2019 FISH HABITAT REHABILITATION PROJECT IN THE PACHENA RIVER WATERSHED

Prepared by

Stefan Ochman

September 2019

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Prepared for:

LGL Limited
Environmental Research Associates
9768 Second Street
Sidney, BC
V8L 3Y8

Prepared by:

Stefan Ochman
210 Cultus Road
Bamfield, BC
V0R 1B0

September 2019

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ACKNOWLEDGMENTS

Many people participated in one way or another in the implementation of this construction project. A big thank you goes out to Marc Gaboury, who helped with locating and providing the design for the Large Woody Debris (LWD) structures. We thank Max Gerth from Roc-Star Enterprises Limited who coordinated the various components of this project such as rock blasting, transportation of rock and logs to the staging areas. Construction machinery (excavators, trucks, etc.) and operators (Ron Steinbach, Andrew Clappis and Kent McFarlane) were provided by Roc-Star Enterprises Limited. Brad Berry Ltd transported the old bridge timbers to the staging areas. The temporary bridge on Reach P6 of the Pachena River was provided by Coastal Bridge Limited. Richard H. Nookemus, Shannon Nookemus, Robert Seward, Linnea Bowes, Amber Bowes, Christopher Williams, Bruce Holland Sr., Bruce Holland Jr., Randall Holland, Barry Halverson, Wilson Tom Joe, Leonard Nookemis and Crystal Clappis drilled and glued cable into the rocks, and anchored the logs to large boulders and trees on the bank. Crystal Clappis helped plant grass seed in the disturbed areas. Scott McDonald from Meridian Forest Services was helpful in identifying areas where cedar trees with rootwads and where cedar timbers from old bridges were located as well transporting equipment from Port Alberni to the staging areas. Gary Gentile, Dave McMurdo and especially Bob Musselwhite from Canadian Air Crane were helpful in preparing the lifts and organizing the flying the LWD and rock bundles.

Funding for this project was provided by Huu-ay-aht First Nations from a watershed renewal fund provided by Steelhead LNG.

INTRODUCTION

Between 1998 and 2009, approximately $1.5M was spent on projects to restore fish habitat and populations in the Sarita, Pachena, Klanawa and Sugsaw watersheds. These restoration projects were focused on repairing or mitigating the habitat impacts to these watersheds caused by channel over-widening, loss of instream cover, bank instability and erosion, and degraded spawning, rearing and overwintering habitats. Restoration works in these watersheds followed from Overview, Level 1 and Level 2 fish habitat assessments conducted in these watersheds under the direction of the Huu-ay-aht First Nations (HFN) between 1997 and 2002 (Bocking et al. 1997; Ochman 1998; Ochman and Gaboury 1999; 2000; 2001; Gaboury 2000; Morgan 2002).

Restoration in the Pachena River watershed was limited to the construction in 2005 of 13 Large Woody Debris (LWD) structures with no rock ballast in Rousseau Creek. Two major log jams in Rousseau Creek were removed and falls on Reach P7 of the Pachena River were backwatered to help fish passage. Continuation of restoration work in the Pachena watershed was considered essential to the long-term survival and recovery of Coho and Chum salmon, as well as Steelhead, Rainbow Trout, and Cutthroat Trout within this watershed.

HFN proposed to implement aquatic rehabilitation projects at high priority sites within HFN territory to continue the historic work on watershed and fish population renewal (LGL Limited 2017). The goal of this rehabilitation project was to recover high-valued stream habitats to proper functioning condition. Habitat rehabilitation within HFN traditional territory is required to re-establish salmon and trout abundances to levels which were prevalent in the mid-20th century. As a means to properly implement protection measures and rehabilitation works leading to renewal of the Pachena River watershed, detailed design plans that identify structure types and locations, and prioritize and schedule construction activities were considered necessary by the HFN ʔuuʔałuk Watershed Renewal Technical Working Group (UTWG). Gaboury (2018) prepared the rehabilitation designs developed for the Sarita and Pachena River watersheds, including site location maps, typical structure drawings, implementation schedules, material specifications and quantities, and estimated construction costs. The following report describes LWD structures only constructed in the Pachena River watershed.

SITE LOCATION

The LWD sites described in this report are located in the Pachena River watershed. They include sites in the Pachena River mainstem (Reaches P2, P4 and P6), Tributary G, Rousseau Creek (Reach R1), and Tributary F (Figure 1 to Figure 4).

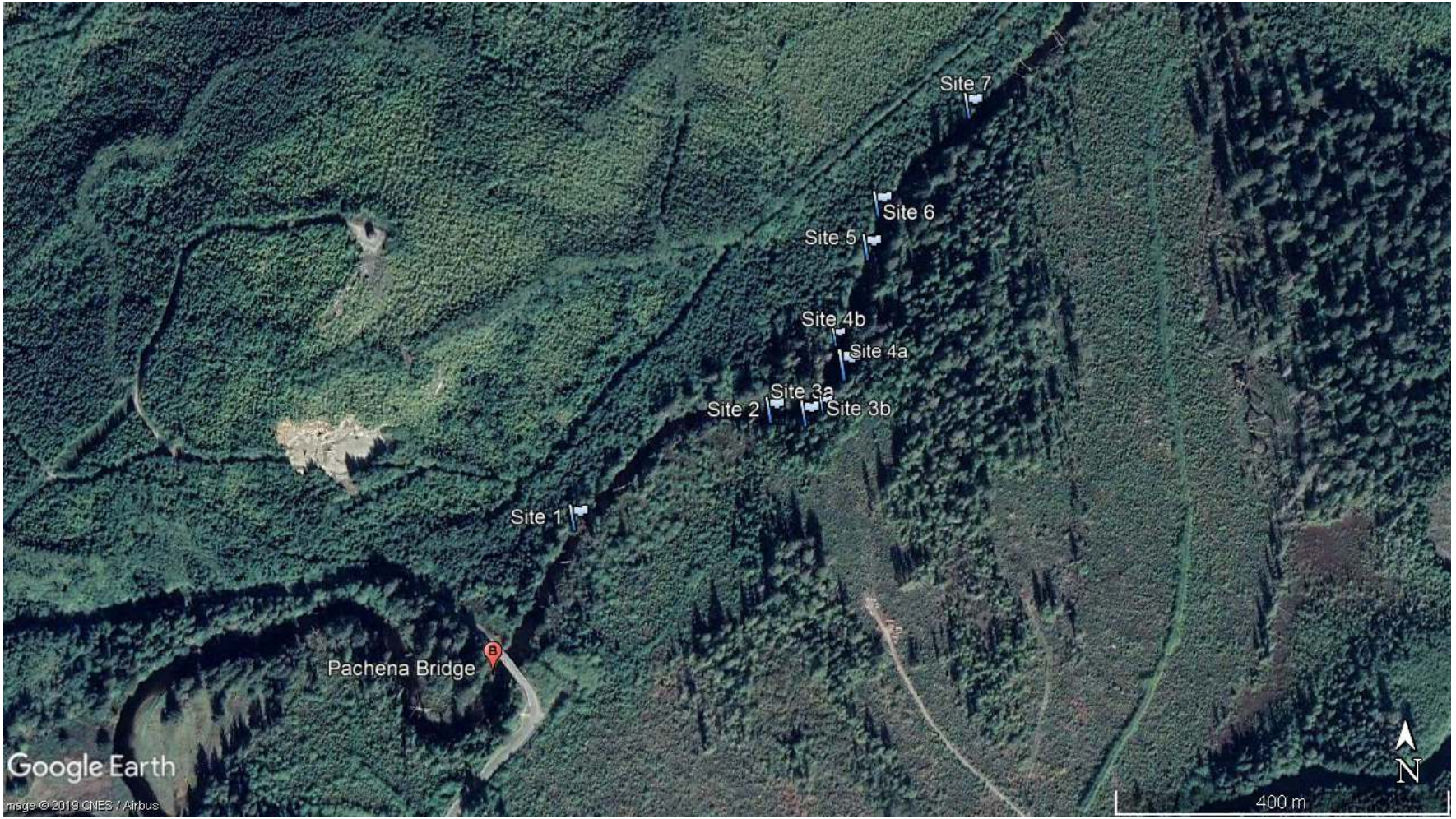


Figure 1. Location map for Sites 1-7, Pachena River, Reach P2.



Figure 2, Location map for Sites 8 - 9, Pachena River, Reach P4, Sites 35 - 46 & Sites 57 - 59, Rousseau Creek, Reach R1.

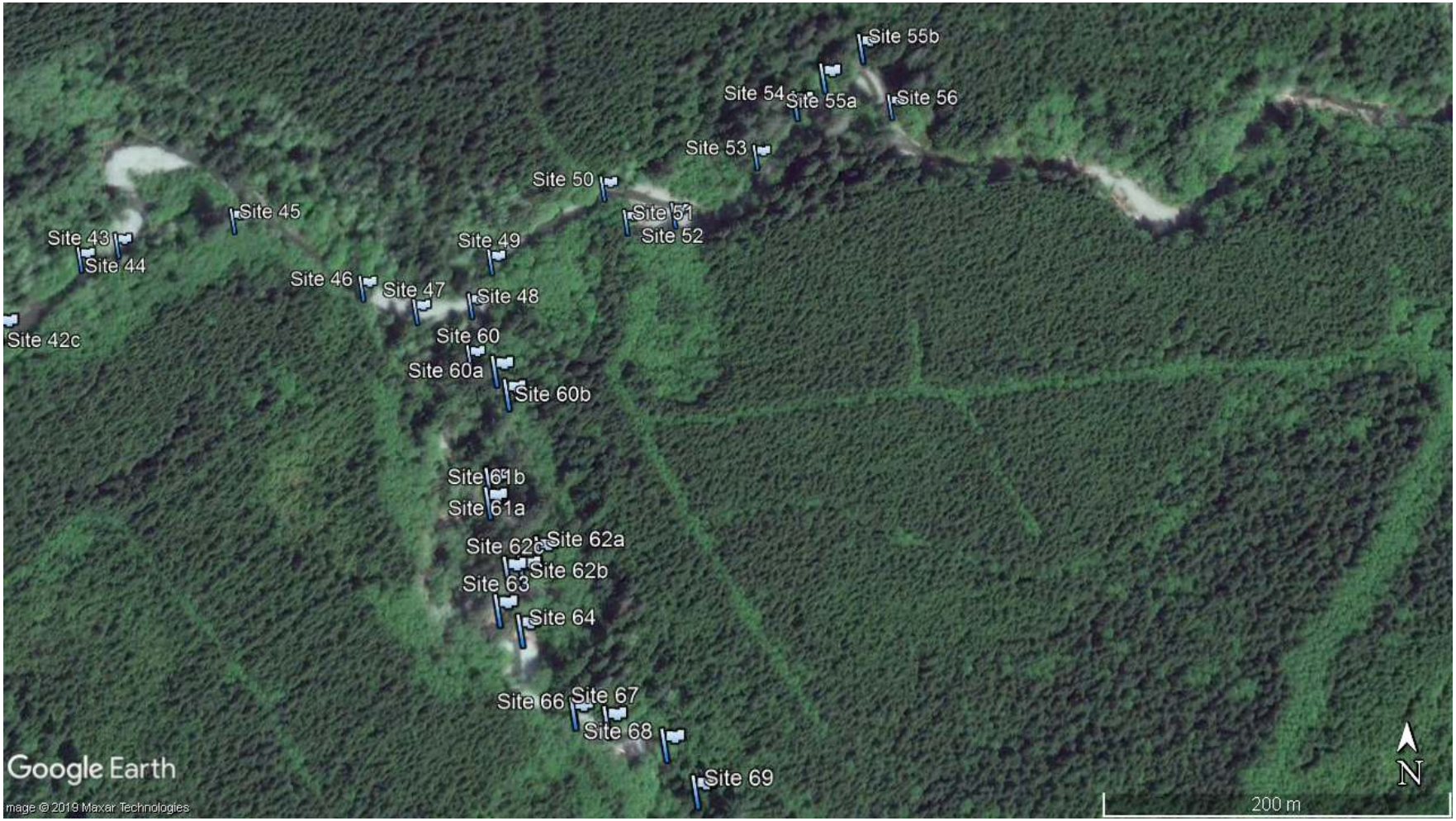


Figure 3. Location map for Sites 42 c - 56, Rousseau Creek, Reach R1, Sites 60 – 69, Tributary F.



Figure 4. Location map for Sites 10 – 31, Pachena River, Reach P6, Sites 32 – 33, Tributary G.

REHABILITATION OBJECTIVES

Survival during early freshwater life stages is critical for the maintenance of Coho salmon and Steelhead populations. Lack of stable complex habitat in the Pachena River watershed is likely a limiting factor in the recovery of these species. The proposed LWD structures will increase hydraulic diversity, promote local scour and pool development. The LWD anchored in pools will also benefit the rearing habitat of juvenile Coho, Steelhead and resident trout that require cover for late summer rearing, stable overwintering rearing habitat, and lower velocity areas during freshets. The installation of LWD structures at eroding banks will help to reduce bank erosion rates and lead to a narrower, more stable channel over time.

Rehabilitation objectives for all 88 constructed sites were the same. The rehabilitation objectives for this project were to:

- improve instream habitat quality, quantity and diversity;
- provide critical overwinter and summer rearing habitats;
- provide instream LWD cover and promote pool scour by constructing LWD structures along the channel thalweg;
- improve gravel sorting and retention, thereby increasing the quality and quantity of gravels; and
- increase fry to smolt survival and smolt production per spawning pair.

CONSTRUCTED WORKS

The design for 69 Large Woody Debris (LWD) structures (Figure 5) in the Pachena watershed was completed by Marc Gaboury in May 2018 (Gaboury, 2018). Stefan Ochman submitted in early May a Section 11 Notification through Front Counter BC for changes in and about a stream for instream works relating to Section 39 g under Part 3 of the Water Sustainability Regulation. The Ministry accepted these works as a Notification since Huu-ay-aht First Nations is considered a local government under the Water Sustainability Regulation. The Notification was reviewed and accepted on forestry license N1A by Mary Toews on June 18, 2018. A Temporary Use Permit was obtained from Rita Johnson, Director of Lands and Natural Resources with Huu-ay-aht First Nations.

Roc-Star Enterprises Ltd. was the contractor chosen to provide the machinery and personnel to carry out this project. Max Gerth was the main coordinator for Roc-Star for this project. Ron Steinbach was the excavator operator in 2018. Andrew Clappis and Kent McFarlane were the excavator operators in 2019.

A permit was obtained from Island Timberlands Limited Partnership for the use of a quarry on its private lands. Since the rock was fractured, blasting provided only small boulders. This quarry was blasted only once. A Schedule B Land Interest and Temporary Permit was also submitted by Bill Coates from Roc-Star to Rita Johnson, HFN for a quarry on Treaty Settlement Lands. Development of this quarry produced appropriate-sized (0.8 m diameter) granite boulders.

Since the bridge crossing of the Pachena River at the upstream end of Reach P6 was rated for only 5 tons, a temporary bridge was installed by Coastal Bridge & Construction Ltd. for the

period from early July to early August 2018. This allowed rock trucks to make a shorter 12 km round trip from the HFN quarry to the staging areas. Ten meter long cedars 0.5 m diameter at breast height (DBH) with rootwads were pushed over by an excavator along the Sugsaw mainline road right-of-way. These cedars were also transported across the temporary bridge to the various staging areas. This route allowed trucks to avoid hauling oversized logs on the Bamfield Road.

All rock and logs were transported to 8 staging areas. A 16 mm diameter hole, 15 to 25 cm deep was drilled in each rock. Rocks were paired together by using Rockite to glue a 5 m long, 13 mm galvanized cable into the drilled holes (Figure 6). The weight of rocks was estimated by averaging the measurements for the three axes and using the formula of 3000 kg per meter cubed. A choker and/or cable sling with a farmer's eye was used to prepare bundles of rocks for the Air Crane to lift. The objective was to prepare lifts totaling a maximum of ~7000 kg. Trees with rootwads and those without rootwads at all staging areas and in the log jam area adjacent to Tributary F were placed by the excavator to allow the helicopter to pick them up using a grapple.

Once all rocks were drilled and cabled, rock bundles and LWD were ready to be airlifted. In early August 2018, each instream site was identified by placing a TYVEK plastic sheet with the painted Site Number on a gravel bar adjacent to the site. However, the extremely dry summer prevented airlifting of the rock and LWD as both Canadian Air-Crane Ltd S-64 helicopters were ordered by the Province of B.C. to go extinguish fires burning in the Zeballos and Burns Lake areas. The helicopters were released in early September but unfortunately this was too late in the season to work instream since the fisheries window closed on September 15. Consequently, the excavator had to return in the fall of 2018 to re-position the LWD at the log jam in Tributary F along the banks and to cable the LWD together and to live trees so that the LWD would not get swept away during winter flows.

On 12 and 13 June 2019, the Air Crane completed 114 lifts with rock bundles and 85 lifts with LWD in 9 hours. Table 1 summarizes the number of LWD structures prescribed and constructed in the Pachena watershed and Table 2 provides the coordinates of all sites.

Table 1. Fish habitat rehabilitation sites prescribed and constructed in the Pachena watershed.

Reach Name	Site Numbers	Number of Sites Prescribed	Number of Sites Constructed	UTM Zone	Easting	Northing
P2	1 to 7	7	9	10U	345155	5408276
P4	8 & 9	2	2	10U	348142	5409561
P6	10 to 30	21	32	10U	349027	5410409
P7	31	1	1	10U	349078	5410429
Trib G	32 & 33	2	2	10U	349092	5410454
Trib: Shaky Bill's	34	1	0	10U	346365	5408262
R1	35 to 59	25	28	10U	348499	5409576
Trib F	60 to 69	10	14	10U	349293	5409793
Total		69	88			

Table 2. Coordinates of LWD sites.

Site Number	Latitude	Longitude
1	48.808294	-125.108839
2	48.809506	-125.10675
3a	48.8095	-125.105939
3b	48.809511	-125.105693
4a	48.809696	-125.104964
4b	48.809836	-125.104829
5	48.809789	-125.104741
6	48.811709	-125.103781
7	48.812713	-125.102306
8	48.820962	-125.068634
9	48.820714	-125.068929
10	48.828226	-125.056937
11	48.828067	-125.057115
12	48.827821	-125.057472
13	48.827684	-125.057806
14	48.827757	-125.058091
15	48.827641	-125.058254
16a	48.827598	-125.058485
16b	48.827337	-125.058632
16c	48.827312	-125.05878
16d	48.827151	-125.058783
16e	48.827054	-125.058834
17	48.82688	-125.058992
18a	48.82678	-125.05897
18b	48.826749	-125.05916
19	48.826688	-125.059678
20	48.826229	-125.060216
21a	48.826229	-125.060279
21b	48.826121	-125.060396
22a	48.82608	-125.060542
22c	48.82601	-125.060499
23	48.82599	-125.060853
24	48.82568	-125.061571
25	48.82553	-125.06193
26b	48.82545	-125.061979
27a	48.82524	-125.062295
27b	48.82517	-125.062431
28	48.8252	-125.062523
29	48.82478	-125.062826
30	48.82453	-125.063144
30a	48.82408	-125.063394
31	48.82847	-125.056205
32	48.82863	-125.056298
33	48.8289	-125.05612
35	48.82063	-125.064022
37	48.82098	-125.063374
38	48.8213	-125.062884
39	48.82149	-125.062424
40a	48.82178	-125.061333
40b	48.82176	-125.061027
40c	48.82153	-125.060902
40d	48.82171	-125.060649
40e	48.82176	-125.060123
41	48.82267	-125.058788
42a	48.82278	-125.058379
42b	48.82284	-125.058236
42c	48.82295	-125.058013
43	48.8234	-125.057235
44	48.82369	-125.056859
45	48.82396	-125.055378
46	48.82345	-125.054588
47	48.82327	-125.053769
49	48.82354	-125.053526
50	48.82416	-125.052091
51	48.82403	-125.051618
52	48.82391	-125.050836
53	48.82406	-125.050551
54	48.82445	-125.050048
55a	48.82468	-125.04989
55b	48.82469	-125.049634
56	48.82435	-125.049127
57	48.821	-125.066032
58	48.82162	-125.066439
59	48.82206	-125.066944
60	48.82283	-125.053048
60A	48.82277	-125.052861
60B	48.82254	-125.052774
61A	48.82198	-125.052892
61B	48.82189	-125.052957
62A	48.82148	-125.052731
62B	48.82134	-125.052833
62C	48.82136	-125.052859
63	48.82124	-125.05279
64	48.82105	-125.052568
66	48.82074	-125.052094
67	48.82062	-125.051483
68	48.82012	-125.051502
69	48.81996	-125.050605

A total of 69 LWD sites were prescribed and a total of 88 sites were constructed (Photo 1 to Photo 88). Table 3 shows the number of LWD with and without rootwads, the number and diameter of boulders, and the number of anchor trees used in each structure.

A total of 590 LWD (341 without rootwads and 249 with rootwads) were used to build the 88 structures. LWD structures projected 3 to 7 m from the bank. At 3 sites, a sill log across the entire channel was incorporated into the LWD structure. The length of the LWD along the banks varied from 0.5 m (sill log at sites 16e) to 25 m (site 42c) with the length of most structures being approximately 10 m. The total length along the bank of all 88 structures was 1023.5 m.

The 53 sites in Reaches P2, P4, R1 and Tributary F were constructed in 64 hours from June 17 to 28, 2019 using a 290 track excavator. The 33 sites in Reach P6 and Tributary G were built in 80 hours from July 3 to 22, 2019 using a smaller 160 track excavator.

Site 34 on Shaky Bill's Creek was not constructed because this site is located on Mosaic Forest Management LP (formerly Island Timberlands LP) private lands. Permitting would have required a letter of support from the company and involved a more complicated approval process from the Ministry.

Site 48 was not built and Site 49 was built in a new location on the Left Bank 20 m downstream as a result of a cross channel log jam that formed during the winter of 2017-2018. Site 62 was dropped since Tributary F was no longer flowing in this direction following the toppling of a massive spruce across the channel.

A coastal grass mixture was spread in all disturbed areas, such as access trails for the excavator. Tree and shrub plantings have not been undertaken at the time of writing but are planned for spring 2020.

ENVIRONMENTAL MONITORING

The construction of the LWD structures was undertaken in a manner to have minimal impact on fish and fish habitat. As much as possible, natural riparian vegetation and streambanks were protected and/or rehabilitated during and after construction. This was especially challenging in Reach P6 and in Tributary G, where a lot of vegetation had to be removed for the excavator to just access the sites and sort the rock bundles and LWD.

The environmental monitor had daily 'tailgate' meetings with the excavator operator and technicians to communicate issues related to environmental protection. There were no shut downs for rainfall.

Before the excavators accessed the sites, they were clean, in good operating condition and free of excess oil and grease. The excavators were inspected daily for leaks and areas of damage on hoses etc. Twenty-five liter jerry cans were used to re-fuel the excavators.

On July 3, 2019, within the first hour after accessing Reach P6, the 130 excavator broke off a valve on the fuel tank. Approximately 70 liters of diesel fuel were spilt into the River. Immediately following this and for a week following the leak, spill pads and booms were deployed to contain and remove the fuel. An environmental effects monitoring program was implemented after the spill. Stream walks downstream of the spill site found no dead fish. Water and sediment samples were collected and analyzed. Only negligible amounts of fuel were detected in the water samples one week after the leak.

During construction of the LWD structures, sediment generation was minimized but no physical sediment control measures were installed. Flows were maintained to aquatic habitats downstream of the work sites during construction. Fish were not salvaged before construction of the LWD structures.

Table 3. Summary of materials used in LWD structures in Pachena Watershed. Photos taken on September 5 & 6, 2019.

Reach Number	Site Number	Location (m)	Right or Left Bank	Maximum Projection from Bank (m)	Total Length of Structure (m)	LWD without Rootwad			LWD with Rootwad			Number of Anchor Trees	Boulder Ballast			Photo Number	View of Photo
						Number	Mean Diameter (m)	Mean Length (m)	Number	Mean Diameter (m)	Mean Length (m)		Number	Mean Diameter (m)	Range in Diameter (m)		
Chainage increasing upstream from concrete Pachena Bridge																	
P2	1	175	Right	5	12	5	0.4	10	5	0.4	10	1	24	0.5	0.3-1.1	1	RB
P2	2	410	Right	4	10	1	0.3	7	3	0.5	10	1	12	0.6	0.3-1.0	2	RB
P2	3a	465	Left	3	5	5	0.3	5	1	0.3	3	1	0	0	0	3	LB
P2	3b	480	Left	8	8	3	0.5	9	2	0.3	10	2	10	0.6	0.4-1.1	4	LB
P2	4a	540	Left	5	10	2	0.4	8	1	0.6	10	1	6	0.6	0.3-1.0	5	LB
P2	4b	555	Left	5	10	4	0.5	10	0	0	0	1	6	0.5	0.4-0.7	6	LB
P2	5	570	Right	5	12	5	0.6	7	2	0.4	10	2	20	0.6	0.3-1.0	7	RB
P2	6	780	Right	5	14	1	0.3	6	4	0.5	10	1	16	0.6	0.3-1.0	8	RB
P2	7	930	Right	4	12	3	0.5	8	5	0.6	7	2	14	0.6	0.3-0.8	9	RB
Chainage increasing downstream of Rousseau Bridge																	
R1	57	25	Left	8	6	4	0.5	6	5	0.5	9	2	24	0.5	0.3-0.7	10	LB
R1	58	145	Right	6	15	2	0.4	8	4	0.5	10	3	12	0.5	0.4-0.7	11	RB
R1	59	200	Left	4	12	3	0.3	10	5	0.5	10	3	14	0.5	0.4-0.8	12	LB
Chainage increasing downstream of Rousseau Bridge																	
P4	8	500	Left	5	16	1	0.3	6	5	0.4	10	3	10	0.7	0.4-1.2	13	LB
P4	9	535	Left	6	14	2	0.4	7	8	0.5	10	4	18	0.6	0.4-1.0	14	LB
Chainage increasing upstream of Rousseau Bridge																	
R1	35	108	Left	6	15	5	0.4	10	6	0.5	10	2	14	0.7	0.5-1.1	15	LB
R1	36	144	Not built														
R1	37	185	Left	10	12	7	0.5	10	3	0.5	10	2	14	0.6	0.5-1.2	16	UP
R1	38	230	Left	5	10	1	0.3	10	3	0.5	8	1	12	0.6	0.3-0.9	17	LB
R1	39	263	Right	6	10	3	0.3	10	3	0.5	10	2	16	0.7	0.5-1.2	18	RB
R1	40a	344	Left	7	7	6	0.4	7	3	0.5	8	1	14	0.5	0.4-0.9	19	DS
R1	40b	365	Left	6	10	5	0.6	8	2	0.6	7	1	5	0.6	0.5-0.9	20	LB
R1	40c	375	Right/Stum	7	5	4	0.7	7	2	0.7	4	1	4	0.4	0.3-0.6	21	UP
R1	40d	405	Left	6	8	6	0.4	6	1	1.2	12	2	14	0.8	0.5-1.4	22	LB
R1	40e	440	Fulllspan	10	12	4	0.6	6	3	0.6	9	2	10	0.5	0.4-0.8	23	DS
R1	41	600	Fulllspan	7	8	2	0.4	6	3	0.6	10	2	16	0.7	0.6-1.0	24	DS
R1	42a	625	Left	5	10	6	0.4	7	2	0.5	10	2	10	0.6	0.4-0.8	25	DS
R1	42b	635	Left	8	5	3	0.6	8	1	0.6	10	0	6	0.6	0.4-0.8	26	LB
R1	42c	650	Left	3	25	14	0.9	12	2	0.8	5	1	38	0.7	0.4-1.2	27	DS
R1	43	740	Right	8	10	5	0.3	8	4	0.4	10	2	18	0.6	0.4-1.0	28	RB
R1	44	770	Left	7	10	4	0.4	8	6	0.5	10	2	18	0.6	0.5-0.8	29	LB

Reach Number	Site Number	Location (m)	Right or Left Bank	Maximum Projection from Bank (m)	Total Length of Structure (m)	LWD without Rootwad			LWD with Rootwad			Number of Anchor Trees	Boulder Ballast			Photo Number	View of Photo
						Number	Mean Diameter (m)	Mean Length (m)	Number	Mean Diameter (m)	Mean Length (m)		Number	Mean Diameter (m)	Range in Diameter (m)		
R1	45	875	Left	4	7	3	0.4	8	3	0.5	8	1	4	0.5	0.4-0.8	30	LB
R1	46	980	Left	6	14	2	0.4	6	3	0.4	7	1	30	0.4	0.2-0.7	31	LB
R1	47	1020	Left	8	12	5	0.4	7	6	0.5	10	1	14	0.6	0.3-1.0	32	LB
R1	48	1060	Not Built														
R1	49	1080	Right	6	14	8	0.5	7	2	0.4	8	2	10	0.6	0.4-1.0	33	RB
R1	50	1175	Right	5	7	6	0.5	7	2	0.4	8	2	10	0.6	0.4-0.8	55	RB
R1	51	1220	Left	4	10	6	0.4	7	2	0.4	10	3	10	0.4	0.3-0.6	48	LB
R1	52	1265	Left	12	7	6	0.6	10	1	1.2	12	1	12	0.5	0.4-0.8	49	DS
R1	53	1300	Right	4	14	7	0.6	7	0	0	0	0	8	0.4	0.3-0.7	50	RB
R1	54	1380	Left	4	6	3	0.4	7	1	0.5	6	0	4	0.5	0.3-0.7	51	LB
R1	55a	1415	Right	6	7	4	0.5	7	2	0.4	6	0	8	0.4	0.3-0.7	52	RB
R1	55b	1450	Right	5	15	12	0.6	10	3	0.5	10	1	16	0.5	0.4-0.8	53	DS
R1	56	1480	Left	6	17	9	0.8	8	1	0.3	5	0	12	0.6	0.3-1.0	54	DS
Chainage increasing upstream from confluence of R1 and Trib F.																	
Trb F	60	19	Left	4	6	6	0.4	7	0	0	0	2	10	0.4	0.3-0.7	34	DS
Trb F	60a	45	Right	2	10	5	0.5	7	0	0	0	1	12	0.4	0.3-0.8	35	RB
Trb F	60b	60	Right	2	5	4	0.5	6	0	In side channel		1	0	0	0	36	RB
Trb F	61a	117	Left	4	10	7	0.5	8	3	0.7	7	1	4	0.6	0.4-0.8	37	LB
Trb F	61b	130	Left	3	8	5	0.4	7	2	0.5	12	0	0	0	0	38	LB
Channel 2 m wide through 2 fallen spruce rootwads @ 135 m.																	
Trib F	62a	185	Left	6	7	4	0.5	8	2	0.5	6	2	8	0.5	0.3-0.8	39	LB
Trib F	62b	200	Left	3	13	8	0.5	7	3	0.3	5	Deadman	6	0.5	0.4-0.6	40	LB
Trib F	62c	210	Left	4	8	1	0.9	9	3	0.6	9	To log	6	0.6	0.5-0.8	41	LB
Trib F	63	220	Right	6	15	8	0.5	10	4	0.3	7	To log	4	0.5	0.4-0.8	42	RB
Trib F	64	235	Left	4	13	7	0.6	7	3	0.5	10	2	6	0.8	0.6-1.2	43	LB
Trib F	65	266	Not built														
Trib F	66	312	Left	5	10	3	0.5	8	3	0.7	9	1	10	0.6	0.4-0.8	44	LB
Trib F	67	360	Right	5	20	3	0.5	8	2	0.7	10	2	14	0.6	0.5-0.9	45	RB
Trib F	68	405	Right	3	7	3	0.4	7	1	0.6	6	2	10	0.4	0.3-0.6	46	RB
Trib F	69	460	Right	6	12	3	0.5	7	2	0.6	8	2	6	0.5	0.4-0.7	47	RB
Chainage increasing upstream of small Pachena Bridge																	
P7	31	20	Right	6	16	4	0.4	5	5	0.4	10	2	6	0.6	0.4-1.0	56	RB
Trib G	32	50	Right	7	7	2	0.3	12	1	0.8	5	2	8	0.8	0.5-1.2	57	DS
Trib G	33	80	Left	4	17	6	0.4	7	2	0.2	10	3	8	0.5	0.4-0.8	58	LB

Reach Number	Site Number	Location (m)	Right or Left Bank	Maximum Projection from Bank (m)	Total Length of Structure (m)	LWD without Rootwad			LWD with Rootwad			Number of Anchor Trees	Boulder Ballast			Photo Number	View of Photo
						Number	Mean Diameter (m)	Mean Length (m)	Number	Mean Diameter (m)	Mean Length (m)		Number	Mean Diameter (m)	Range in Diameter (m)		
Chainage increasing downstream from small Pachena Bridge																	
P6	10	34	Right	5	12	2	0.8	7	3	0.4	12	2	8	0.5	0.3-0.7	59	RB
P6	11	68	Left	6	25	7	0.6	7	3	0.3	10	3	12	0.8	0.6-1.2	60	DS
P6	12	101	Right	7	7	1	0.5	8	3	0.4	10	1	6	0.8	0.6-1.2	61	RB
P6	13	128	Left	7	15	3	0.4	7	2	0.6	12	2	14	0.6	0.5-0.8	62	LB
P6	14	152	Left	7	20	6	0.4	8	2	0.4	12	2	8	0.6	0.5-0.8	63	LB
P6	15	167	Left	6	8	4	0.4	7	1	0.4	10	1	8	0.6	0.5-0.8	64	LB
P6	16a	185	Right	4	7	4	0.4	7	1	0.3	10	1	4	0.6	0.5-0.8	65	RB
P6	16b	215	Right	4	7	1	0.4	7	4	0.4	10	1	6	0.6	0.4-0.7	66	RB
P6	16c	240	Right	4	12	1	0.4	9	3	0.4	10	2	8	0.5	0.4-0.8	67	RB
P6	16d	255	Right	6	8	2	0.4	8	1	0.4	10	1	6	0.4	0.3-.08	68	RB
P6	16e	260	Sill log	1	0.5	1	1.2	4	0	0	0	buried	0	0	0	69	DS
P6	17	290	Left	3	7	3	0.5	7	1	0.3	11	1	6	0.5	0.4-0.8	70	LB
P6	18a	310	Left	4	25	4	0.4	9	6	0.4	11	3	18	0.5	0.4-0.8	71	DS
P6	18b	320	Left	7	8	4	0.6	8	2	0.4	10	1	14	0.5	0.4-0.6	72	LB
P6	19	355	Right	4	15	3	0.7	4	5	0.3	11	1	22	0.5	0.3-1.0	73	DS
P6	20	390	Left	6	25	2	0.6	4	5	0.3	12	2	22	0.5	0.3-1.0	74	UP
P6	21a	415	Sill log	15	1	3	0.6	10	0	0	0	1	4	0.4	0.3-0.5	75	DS
P6	21b	420	Left	7	15	0	0	0	3	0.3	10	0	6	0.5	0.4-1.0	76	LB
P6	22a	450	Right	15	7	0	0	0	2	0.4	12	0	6	0.7	0.6-0.8	77	DS
P6	22b	460	Instream	3	1	1	0.3	6	0	0	0	0	2	1.1	0.9-1.2		
P6	22c	470	Left	10	20	0	0	0	8	0.5	11	3	12	0.6	0.5-0.8	78	DS
P6	23	490	Right	6	15	3	0.7	6	4	0.4	10	1	8	0.6	0.4-0.8	79	DS
P6		510	Natural Logjam														
P6	24	550	Right	3	20	0	0	0	5	0.4	10	1	10	0.5	0.4-0.8	80	RB
P6	25	580	Left	4	15	2	0.3	5	2	0.4	10	2	6	0.5	0.4-0.8	81	DS
P6	26a	600	Fullspan	15	1	1	0.4	14	0	0	0	0	0	0	0		
P6	26b	610	Right	4	18	6	0.4	7	4	0.4	8	1	26	0.5	0.4-0.8	82	DS
P6	27a	630	Left	4	12	0	0	0	2	0.6	10	1	20	0.5	0.4-0.8	83	DS
P6	27b	640	Left	3	10	0	0	0	2	0.4	10	1	12	0.4	0.3-0.5	84	LB
P6	28	655	Right	5	16	0	0	0	9	0.4	10	2	26	0.5	0.4--1.0	85	DS
P6	29	700	Right	3	20	2	0.3	5	3	0.4	10	2	18	0.4	0.3-0.5	86	DS
P6	30	730	Right	6	12	5	0.5	7	5	0.4	10	2	36	0.4	0.3-0.8	87	DS
P6	30a	790	Left	3	12	4	0.5	10	2	0.7	14	3	0	0	0	88	LB

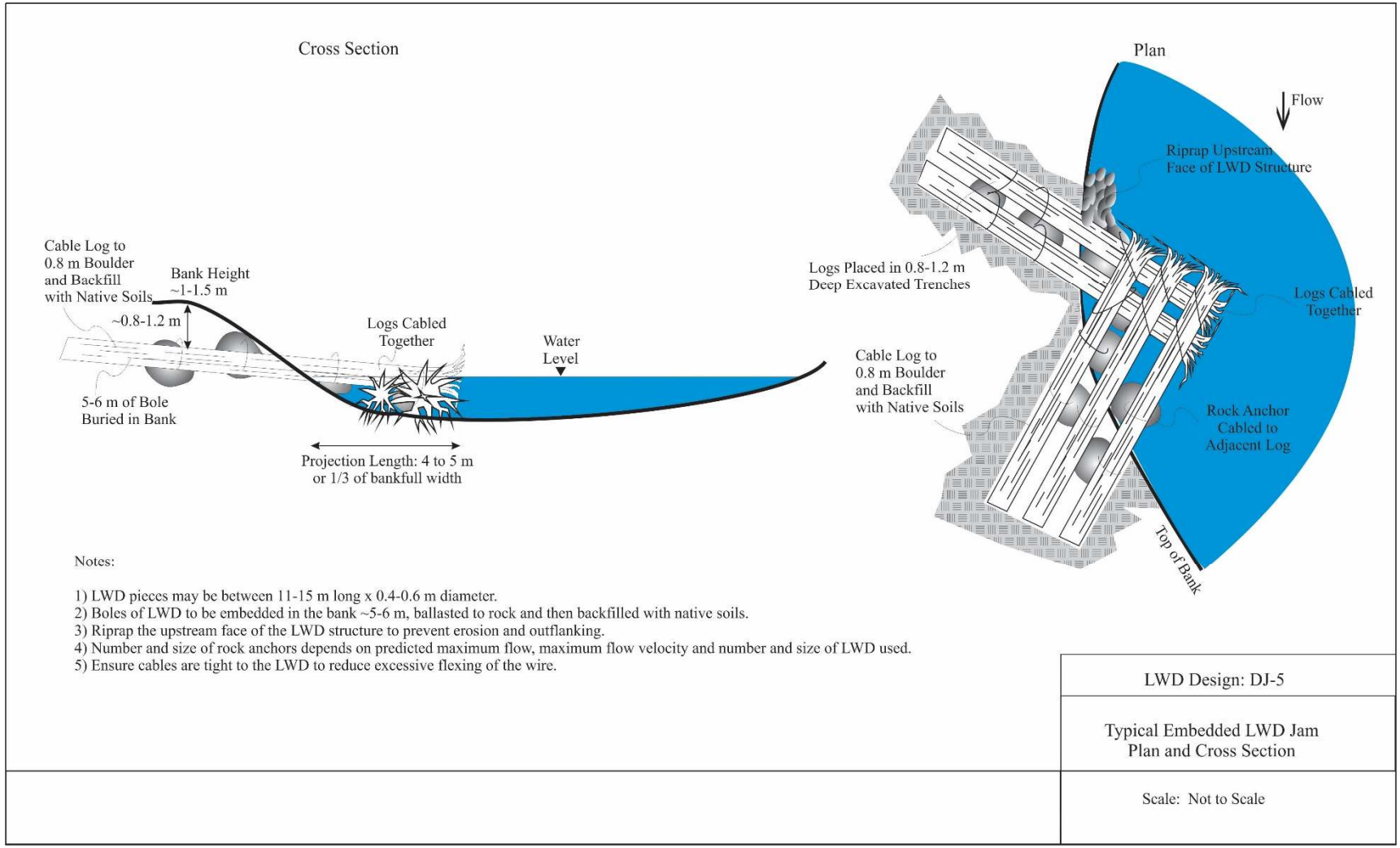


Figure 5. Typical plan and cross section views of large woody debris (LWD) structure.

Method of Cabling LWD to Boulder Ballast

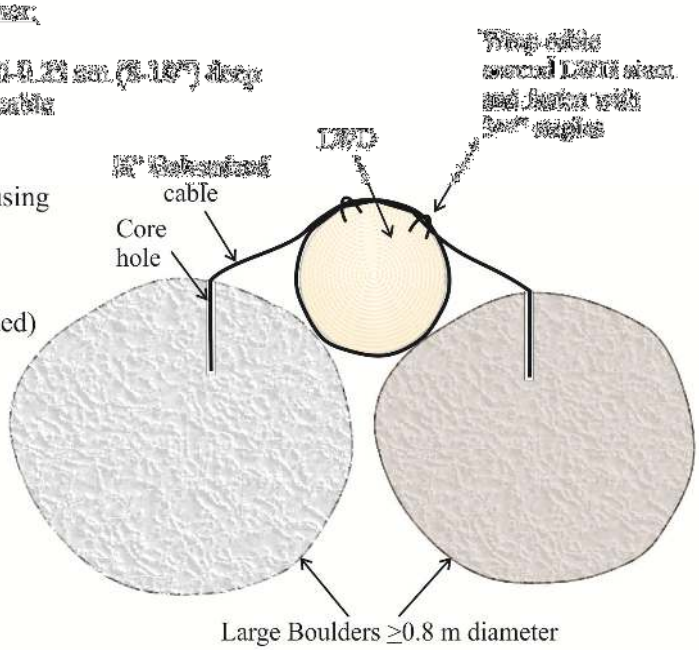
Attach cable to boulder in following manner:

1- drill hole in large diameter boulder (>0.8 m diameter) deep with drill bit 1/8" larger in diameter than cable diameter (5/8" hole recommended).

2- clean drilled holes thoroughly of dust using wire brush and water. Ensure holes are completely clean.

3- wrap cable (½" galvanized recommended) around LWD and tighten.

4- pour Rockite into drilled hole and insert cable.



For additional information, refer to Slaney and Zaldokas (1997) FRP technical circular number 2, chapter 5, page 55.

	Detail for Attaching Boulders to Large Woody Debris (LWD)
	Scale: Not to scale

Figure 6. Detail for attaching boulders to large woody debris.

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PHOTO PLATES



Photo 1. Reach P2, Site 1 - 175 m, Right Bank.



Photo 2. Reach P2, Site 2 - 410 m, Right Bank.



Photo 3. Reach P2, Site 3a - 465 m, Left Bank.



Photo 4. Reach P2, Site 3b - 480 m, Left Bank.



Photo 5. Reach P2, Site 4a - 540 m, Left Bank.



Photo 6. Reach P2, Site 4b - 555 m, Left Bank.



Photo 7. Reach P2, Site 5 - 570 m, Right Bank.



Photo 8. Reach P2, Site 6 - 780 m, Right Bank.



Photo 9. Reach P2, Site 7 - 930 m, Right Bank.



Photo 10. Reach R1, Site 57 - 25 m, Left Bank.



Photo 11. Reach R1, Site 58 - 145 m, Right Bank.



Photo 12. Reach R1, Site 59 - 200 m, Left Bank.



Photo 13. Reach P4, Site 8 – 500 m, Left Bank.



Photo 14. Reach P4, Site 9 – 535 m, Left Bank.



Photo 15. Reach R1, Site 35 – 110 m, Left Bank.



Photo 16. Reach R1, Site 37 - 185 m, Left Bank. Looking Upstream.



Photo 17. Reach R1, Site 38 - 230 m, Left Bank.



Photo 18. Reach R1, Site 39 - 263 m, Right Bank.



Photo 19. Reach R1, Site 40a - 344 m, Left Bank. DS.



Photo 20. Reach R1, Site 40b - 365 m, Left Bank.



Photo 21. Reach R1, Site 40c - 375 m, Right/Stump. DS.



Photo 22. Reach R1, Site 40d - 405 m, Left Bank. US.



Photo 23. Reach R1, Site 40e - 440, Left Bank. DS.



Photo 24. Reach R1, Site 41, 600, Right Bank. DS.



Photo 25. Reach R1, Site 42a - 625 m, Left Bank. DS.



Photo 26. Reach R1, Site 42b - 635 m, Left Bank.



Photo 27. Reach R1, Site 42c - 650 m, Left Bank. DS.



Photo 28. Reach R1, Site 43 - 740 m, Right Bank. DS.



Photo 29. Reach R1, Site 44 - 770 m, Left Bank.



Photo 30. Reach R1, Site 45 - 875 m, Left Bank.



Photo 31. Reach R1, Site 46 - 980 m, Left Bank. DS.



Photo 32. Reach R1, Site 47 - 1020 m, Left Bank. DS.



Photo 33. Reach R1, Site 49 - 1080 m, Right Bank. US.



Photo 34. Trib F, Site 60 - 19 m, Left Bank. DS.



Photo 35. Trib F, Site 60A - Site 45 m, Right Bank. DS.



Photo 36. Trib F, Site 60B - 60 m, Right Bank. In Side Channel.



Photo 37. Trib F, Site 61A - 117 m, Left Bank. DS.



Photo 38. Trib F, Site 61B - 130 m, Left Bank.



Photo 39. Trib F Site 62A, - 185 m, Left Bank. DS.



Photo 40. Trib F, Site 62B - 200 m, Left Bank.



Photo 41. Trib F , Site 62C - 210 m, Left Bank.



Photo 42. Trib F, Site 63 - 220 m, Right Bank.



Photo 43. Trib F, Site 64 - 235 m, Left Bank. DS.



Photo 44. Trib F, Site 66 - 312 m, Left Bank. DS.



Photo 45. Trib F, Site 67 - 360 m, Right Bank.



Photo 46. Trib F, Site 68 - 405 m, Right Bank.



Photo 47. Trib F, Site 69 – 460 m, Right Bank.



Photo 48. Reach R1, Site 51 - 1220 m, Left Bank.



Photo 49. Reach R1, Site 52 - 1265 m, Left Bank. DS.



Photo 50. Reach R1, Site 53 - 1300 m, Right Bank.



Photo 51. Reach R1, Site 54 - 1380 m, Left Bank.



Photo 52. Reach R1, Site 55a - 1415 m, Right Bank.



Photo 53. Reach R1, Site 55b - 1450 m, Right Bank. DS.



Photo 54. Reach R1, Site 56 - 1480 m, Left Bank, DS.



Photo 55. Reach 1, Site 50 – 1175 m, Right Bank.



Photo 56. Reach P7, Site 31 - 20 m, Right Bank.



Photo 57. Trib G, Site 32 - 50 m, Right Bank. US.



Photo 58. Trib G, Site 33 - 80 m, Left Bank. US.



Photo 59. Reach P6, Site 10 – 34 m, Right Bank.



Photo 60. Reach P6, Site 11 – 68 m, Left Bank. DS.



Photo 61. Reach P6, Site 12 – 101 m, Right Bank.



Photo 62. Reach P6, Site 13 – 128 m, Left Bank.



Photo 63. Reach P6, Site 14 - 152 m, Left Bank. DS.



Photo 64. Reach P6, Site 15 - 167 m, Left Bank.



Photo 65. Reach P6, Site 16a - 185 m, Right Bank.



Photo 66. Reach P6, Site 16b - 215 m, Right Bank.



Photo 67. Reach P6, Site 16c - 240 m, Right Bank.



Photo 68. Reach P6, Site 16d - 255 m, Right Bank.



Photo 69. Reach P6, Site 16e - 260 m, Sill log. DS.



Photo 70. Reach P6, Site 17 - 290 m, Left Bank.



Photo 71. Reach P6, Site 18a - 310 m, Left Bank. DS.



Photo 72. Reach P6, Site 18b - 320 m, Left Bank.



Photo 73. Reach P6, Site 19 - 355 m, Right Bank. DS.



Photo 74. Reach P6, Site 20 - 390 m, Left Bank. US.



Photo 75. Reach P6, Site 21a - 415 m, Sill log. DS.



Photo 76. Reach P6, Site 21b - 420 m, Left Bank.



Photo 77. Reach P6, Site 22a - 450 m, Right Bank. DS.



Photo 78. Reach P6, Site 22c - 470 m, Left Bank. DS.



Photo 79. Reach P6, Site 23 - 490 m, Right Bank. DS.



Photo 80. Reach P6, Site 24 - 550 m, Right Bank.



Photo 81. Reach P6, Site 25 - 580 m, Left Bank. DS.



Photo 82. Reach P6, Site 26b - 610 m, Right Bank. DS. With sill log cabled between sites 25 & 26.



Photo 83. Reach P6, Site 27a - 630 m, Left Bank. DS.



Photo 84. Reach P6, Site 27b - 640 m, Left Bank.



Photo 85. Reach P6, Site 28 - 655 m, Right Bank. DS.



Photo 86. Reach P6, Site 29 - 700 m, Right Bank. DS.



Photo 87. Reach P6, Site 30 - 730 m, Right Bank. DS.



Photo 88. Reach P6, Site 30a - 790 m, Left Bank.