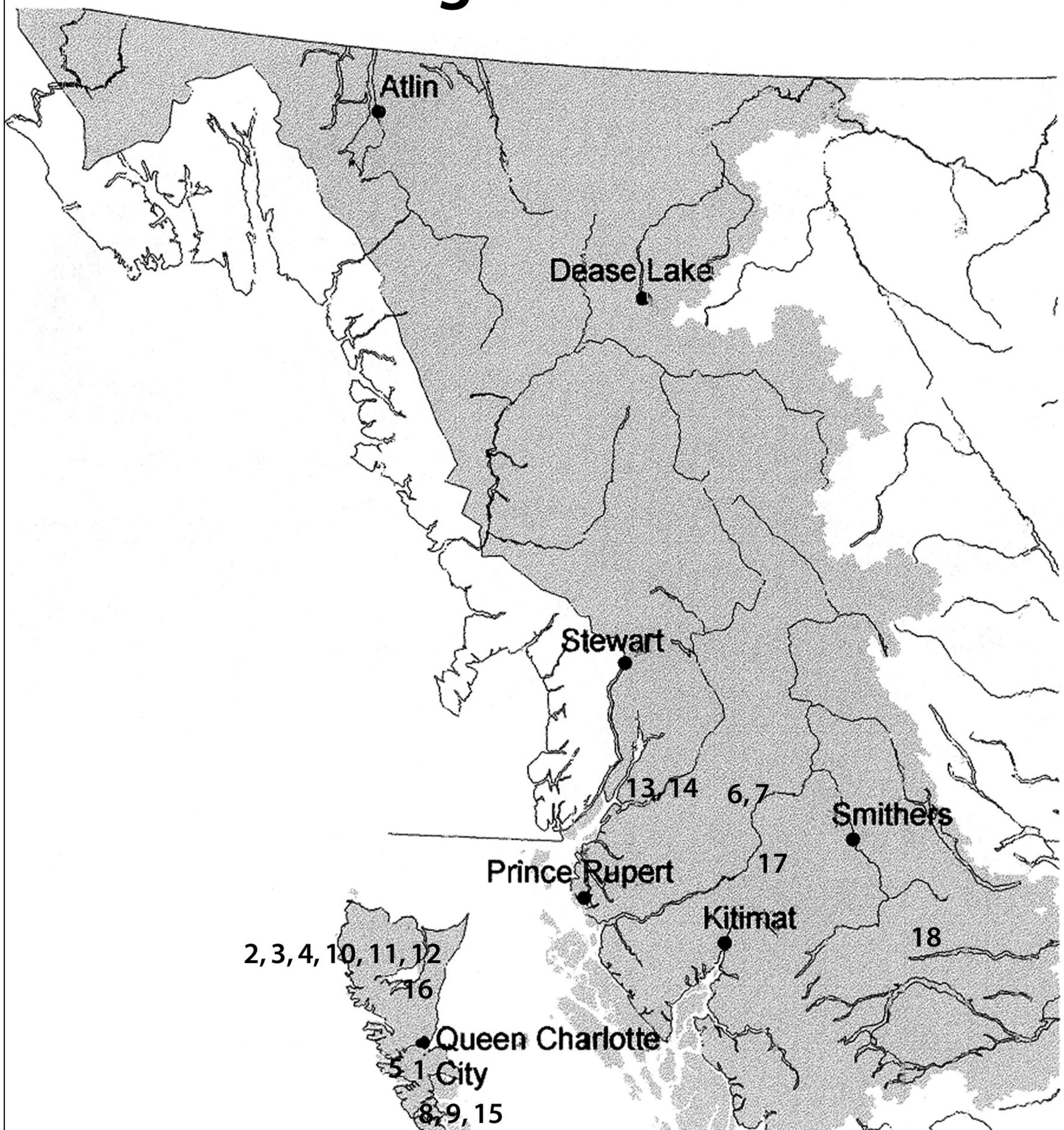
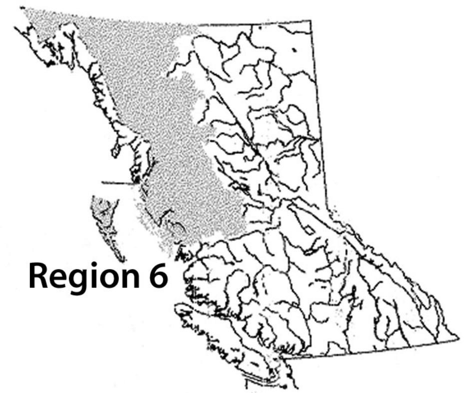
Skeena Region

Region 6. Skeena





WRP Projects

1	Copper Creek
2	15 Km Creek
3, 4	Torney Creek
5	Weeping Willy
6	Clear Creek
7	Glacier Creek
8	Clew Creek
9	Tributary 20 LB
10	Camp Creek
11, 12	Lower Naden River
13	Greenville Creek
14	Ginlulak Creek
15	Thorsen Creek
16	Clay Creek
17	Zymoetz River
18	Fenton Creek

UTM (NAD 83) zones, northings and eastings; watershed codes and waterbody identifiers for aquatic rehabilitation projects for Region 6, Skeena.

No.	Region	Watershed	WRP Projects	(NAD 83) UTM Zone	(NAD 83) UTM Northing	(NAD 83) UTM Easting	Watershed Code	Waterbody Identifier
1	Skeena	Copper Creek	Copper Creek Instream Restoration	9	5893871	312775	950–010400	00000MORI
2		Davidson Creek	15 Km Creek Slide Bioengineering	8	5980625	651944	940–661700	00000GRAI
3		Davidson Creek	Torney Creek Bar Stabilization	8	5980625	651944	940–661700	00000GRAI
4		Davidson Creek	Torney Creek Pond	8	5981000	652000	940–661700	00000GRAI
5		Deena Creek	Weeping Willy Creek Instream Restoration	8	5891558	690263	950–974300–17200	00000MORI
6		Kitsumkalum River	Clear Creek Side Channel	9	6075418	513248	430–465300	00000KLUM
7		Kitsumkalum River	Glacier Creek Fan Stabilization	9	6057514	517570	430–256600	00000KLUM
8		Mathers Creek	Clew Creek Instream Restoration	9	5877796	313760	955–018000–38300	00000MORI
9		Mathers Creek	Tributary 2.0 LB Instream Restoration	9			955–018000	00000MORI
10		Naden River	Camp Creek Instream Restoration	8	5978588	652175	940–665100	00000GRAI
11		Naden River	Lower Naden Reach 3–4 Instream Restoration	8	5978588	652175	940–665100	00000GRAI
12		Naden River	Lower Naden Reach 4–2 Instream Restoration	8	5978588	652175	940–665100	00000GRAI
13		Nass River	Greenville Creek Instream Restoration	9	6098674	463409	500–076200	00000LNAR
14		Nass River	Ginlulak Creek Instream Restoration	9	6099370	468612	500–090500	00000LNAR
15		Thorsen Creek	Thorsen Creek Off–channel and Instream Restoration	9	5862597	301569	950–105500	00000MORI
16		Yakoun River	Clay Creek Bioengineering	9			940–896100	00000GRAI
17		Zymoetz River	Zymoetz River Culvert Replacement	9	6044733	533524	440	00000ZYMO
18		Morice River	Fenton Creek Fish Access	9	6008368	637417	460–600600–26600	00000MORR

MAINSTEM COPPER RIVER LWD STRUCTURES

Objectives
The objective was to replenish LWD structures in the mainstem river to improve adult holding, juvenile rearing and overwintering habitat for salmonids (primarily coho as well as sockeye, steelhead and cutthroat) in the Copper River Mainstem.

FRBC Region/MELP Region/MOF Region
Pacific/Skeena/Vancouver

Author
Leandre Vigneault

Proponent/Implementing Partners
JS Jones Ltd.

Watershed/Stream
Copper River

Location
The Copper River is located on Haida Gwaii in the northern portion of Moresby Island. The work site can be reached by driving southeast from Sandspit along the JS Jones logging road (South Bay Mainline past the community of Copper Bay to the 17 mile mark. The two work sites are located within 300 meters of the 17–mile sign.

Introduction
The Copper River drains Skidegate Lake, a large lake located in the northern–central portion of Moresby Island. Both the Skidegate Lake Basin and the Copper River has been extensively logged since 1900. The Copper River and Skidegate Lake support important runs of coho, sockeye and pink salmon as well as steelhead and cutthroat trout. The Copper River mainstem has a stable, well–incised channel; however, the entire riparian zone was logged during the past 60 years and the South Bay Mainline was built within 100 m of the river for most of its length. The LWD structures that are found in the river are old and nearing the end of their functional life. The riparian forest is not yet capable of providing a natural source of LWD. The channel width in the vicinity of the proposed structures was about 20 m with 0.3 m bank height, and average channel gradient was 0.55%.

Assessments and Prescriptions
A modified Level 1/Level 2 assessment was conducted in March 1999 by LGL Ltd. and the Haida Fisheries Program (HFP) and a list of high, moderate and low priority sites was generated (LGL/HFP April, 1999). This report outlined general prescriptions (including typical structures) for 25 high priority sites for instream work. The prescriptions for the Copper River Mainstem focused on LWD placements to promote pool scour, stabilize banks and provide instream cover. Due to limited funds and the large size of the river, two sites with good road access, were selected as a pilot project for completion in the 1999 field season.

Rehabilitation Work
The two sites (sites 3 and 4) selected for instream work in 1999 were located approximately 600 m apart. Both sites were located within 20 m of the South Bay Mainline. At site 3, eight large red cedar and cypress (*Chamaecyparis nootkatensis*) logs, 4 with rootwads attached, and six spruce stumps were used to create a structure on an outside bend. Most of the stems had one end attached to live trees on the bank while the other end on the riverbed was ballasted with rocks attached by cable and epoxy (Fig. 6–1).

At site 4, eight large red cedar and cypress logs were used to create a floating logjam that provides instream cover at the tailout of a large pool. This structure was constructed using four logs that had one end attached to live trees on the bank. The remaining four logs were placed over and under these logs at an angle to form a series of triangles with the logs pinned together using rebar (Fig. 6–2). At both sites a Hitachi EX150 excavator was used to place the LWD and boulders. The LWD used for this project was salvaged from a clearcut and delivered using a self–loading logging truck.

Cost Summary

Supervision and Reporting	$ 4,400
Labour	1,400
Materials and Equipment	5,000
Total Cost	$10,800

Outputs
The two structures are providing good cover for both adult and juvenile salmonids with juvenile fish observed around both structures within a few hours of completion. The

structure at site 3 is also creating some scour and should result in the formation of a good low water holding and rearing area.

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Figure 6–1. In Copper River mainstem, rocks attached by cable and epoxy ballasted the structures.

Figure 6–2. The triangulated structures were formed by using a series of triangles with the logs pinned together using rebar.

15K CREEK SLIDE BIOENGINEERING

Objectives
The objective of the 15K Creek Slide Project was to rehabilitate seven slides that contribute excessive amounts of sediment and debris into 15K Creek.

FRBC Region/MELP Region/MOF Region
Pacific/Skeena/Vancouver

Author
Ian Dodd, R.P.Bio.

Proponent/Implementing Partners
Husby Forest Products Ltd.

Watershed/Stream
Davidson Creek/Torney Creek

Location
Davidson Creek is located in the northwest corner of Graham Island, the northernmost island of the Queen Charlotte group. 15K Creek is a large S2 creek that flows east into Davidson Creek. The slides can be accessed from the Eden Lake Logging Camp by travelling to the km 12.5 mark on the Davidson mainline then exiting onto Branch 50 and travelling to the km 14 marker.

Introduction
The Davidson Creek Watershed (wet hypermaritime Coastal Western Hemlock (CWHwh1 and CWHwh2) ecosystem) has sustained logging for the last 30 years. The watershed has been extensively logged during this time. Logging practices have initiated slides that impact fish streams and therefore rehabilitation measures have been investigated.

Assessments and Prescriptions
After completing a Level 1 Detailed Field Fish, Fish Habitat and Riparian Zone Assessment in 1998, the 15K Creek Reach 1 Section 2 slides were selected as possible restoration sites. The slides are located on side slopes to the creek. The top section of the slide slopes has been harvested in the past 15 years. Logging debris was left at a couple of landings located on the break in the slope. In a number of cases the logging debris initiated the slides. The slides have created logjams and sediment wedges in the creek. The slide paths have not revegetated and fine sediment continues to be deposited into the creek.

In 1998 bioengineering was conducted on four of the slides. This year bioengineering techniques were applied to slides 15K–2 and 15K–3; the two larger slides which were not addressed in 1998.

Rehabilitation Work
Works were initiated in July of 1999, and the following steps were taken:

- The spur road above the slides was deactivated in 1998. During the deactivation, logging debris was pulled back from the break in the slope below the road.
- Rebar, boards, Sitka alder (*Alnus sinuata*) plugs and fertilizer were carried to the slides. Willow was not used because it is scarce in this area.
- Modified Brush Layers (MBL) were rebarred into place on the steeper sections of the slide (Figs. 6–3, 6–4 and 6–5). The brush layer consisted of Sitka alder plugs that were planted 30 cm apart. Sitka alder plugs were also planted on the slope between the MBLs. Live gully breaks were not used. The MBLs were extended into the gullied section of the slide to prevent further gully development. The MBL in the gullied section contained only cobbles to allow water passage.

Cost Summary

Personnel	$14,000
Equipment	1,000
Materials	1,000
Total Cost	$16,000

Outputs
Reach 1 Sections 1 and 2 of 15K Creek provide high quality rearing and spawning habitat for coho, pink, cutthroat and Dolly Varden. The slides have terminated in the creek creating large jams and sediment wedges. The jams do not prohibit fish passage. Downstream the channel is moderately to severely aggraded with dewatered channels during low flows. The bioengineering will reduce the amount of further sediment delivery to the creek. Bioengineering techniques were used on 0.4 ha of slide area.

Proposed Work

In the spring of 2000 re–seed exposed soils and repair damaged structures.

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Figure 6–3. Construction view of bioengineered landslide.

Figure 6–4. Construction view of bioengineered landslide.

Figure 6–5. Construction view of bioengineered landslide.

LOWER DAVIDSON OFF–CHANNEL CONSTRUCTION

Objectives
The objective of this project was to improve summer and winter rearing habitat for coho in a gravel pit pond.

FRBC Region/MELP Region
Pacific/Skeena/Vancouver

Author
Ian Dodd, R.P.Bio.

Proponent/Implementing Partners
Husby Forest Products Ltd.

Watershed/Stream
Davidson Creek/Torney Creek

Location
Davidson Creek is located in the northwest corner of Graham Island, the northernmost island of the Queen Charlotte group. The pond in the gravel pit drains into Torney Creek close to the confluence of Torney and Davidson Creeks. Rehabilitation works were conducted within the confines of the abandoned gravel pit.

Introduction
The Davidson Creek Watershed (wet hypermaritime Coastal Western Hemlock (CWHwh1 and CWHwh2) ecosystem) has sustained logging for the last 30 years. The watershed has been extensively logged during this time. Logging practices have impacted coho off–channel habitat and therefore rehabilitation measures have been investigated.

Assessments and Prescriptions
After completing a Level 1 Detailed Field Fish, Fish Habitat and Riparian Zone Assessment in 1998, the Lower Davidson gravel pit pond was selected as a possible restoration site. Currently the pond provides rearing habitat but lacks depth and adequate fish cover.

The pond is tidal; U–shaped, 250–m long and 18–m wide. The pond is shallow with a low water depth averaging less than 40 cm and no overhead cover. Coho fry, stickleback (*Gasterosteus spp.*) and sculpin have been fish–trapped. Summer water temperatures have exceeded 25°C resulting in coho fry mortality.

Lister and Finnigan (1997) recommend developing ponds with a depth greater than 1.1 m, a surface area of less than 0.3 ha, and providing overhead cover.

Rehabilitation Work
The pond was excavated to a depth of between 1.5 and 2 m below the low water mark (Figs. 6–6, 6–7 and 6–8). The two ends of the pond were left at a depth of 40 cm to provide a variety of habitat depths. Three long slender islands were built to increase the edge area in the pond. The side slopes on the pond excavation have 1 horizontal to 1 vertical slope in an attempt to provide bank stability. Fifteen rootwads and 60 logs were placed in the pond for cover. Small trees and branches collected from a previous tree spacing project were added to the pond as cover. Following the excavation the exposed soils were grass seeded.

The following steps were taken to excavate the pond and add the LWD:
- The LWD was stockpiled at the landing to the south of the pit.
- The site was flagged indicating excavation limits, islands and the centreline.
- A large sandbag dam was placed at the mouth to the pond to prevent tidal water from entering the pond.
- Fish were removed by fry trapping, pole seining, beach seining and electrofishing.
- Using the Hitachi 200 excavator, a road was built into the pit for gravel truck access.
- Three gravel trucks were used to transport the material to two dumping sites.
- The LWD was put in place as the excavation progressed throughout the pond.

Cost Summary

Personnel	$10,300
Equipment	9,080
Materials	9,400
Total Cost	$28,780

Outputs
This project has created approximately 4500 m^2 of high quality rearing and overwintering habitat.

Production Estimates

Keeley *et al.* (1996) provided predictions of 69 coho smolt per 100 m^2 off–channel ponds. The pond is expected to produce approximately 3105 coho smolts annually. Keeley *et al.* (1996) provided predictions of 6.8 adult coho salmon per 100 m^2 off–channel ponds. Expected production of adults is approximately 306 coho.

Proposed Work

Re–seed exposed soils and add additional slash and branches for fish cover.

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Figure 6–6. Post–construction view of off–channel pond (prior to dam removal).

Figure 6–7. Post–construction view of off–channel pond (prior to dam removal).

Figure 6–8. Post–construction view of off–channel pond (prior to dam removal).

UPPER DAVIDSON GRAVEL BAR STABILIZATION

Objectives
The objective of this project was to stabilize gravel bars by planting red alder plugs. Windthrow had caused bank disturbance and sediment accumulation on gravel bars of the channel.

FRBC Region/MELP Region/MOF Region
Pacific/Skeena/Vancouver

Author
Ian Dodd, R.P.Bio.

Proponent/Implementing Partners
Husby Forest Products Ltd.

Watershed/Stream
Davidson Creek/Torney Creek

Location
Davidson Creek is located in the northwest corner of Graham Island, the northernmost island of the Queen Charlotte group. The upper part of Davidson Creek is a medium sized S2 creek that flows northeast. The affected stream section is approximately 1500 m long. The stream section can be accessed by travelling southwest on the Davidson Mainline and turning left onto the branch road that enters Cutblock 413 Block 1. Follow the branch, cross the first bridge, and park at the first vehicle pull–out on the left hand side. The downstream end of the treated stream section is located by walking approximately 70 m to the east of the vehicle pull–out. The treated area is approximately 500 m long.

Introduction
The Davidson Creek Watershed (wet hypermaritime Coastal Western Hemlock (CWHwh1 and CWHwh2) ecosystem) has sustained logging for the last 30 years. The watershed has been extensively logged during this time. Within Cutblock 413 the riparian buffer along the west side of Davidson Creek is not wide enough resulting in windthrow.

Assessments and Prescriptions
After completing a Level 1 Detailed Field Fish, Fish Habitat and Riparian Zone Assessment in 1998, the Upper Davidson Reach 4 was selected as a restoration site. The following is the stream description:

- S2 stream (average width = 7.9 m), riffle–pool morphology, average gradient 2.3%, gravel dominated substrate.
- Cutthroat and Dolly Varden trapped.
- Streamside harvesting on the west bank leaving a one tree width riparian strip.
- Significant windthrow impact, bank erosion, and sediment accumulation in sediment bars.
- Lacks pool area and frequency.

This prescription involved the planting of large alder plugs on the exposed sediment bars.

Rehabilitation Work
Works were initiated in July of 1999. The red alder plugs were planted during summer low flows. The alder were planted 1 metre apart. Alder was also planted on any exposed and eroding banks.

Cost Summary

Personnel	$4,000
Materials	1,000
Total Cost	$5,000

Outputs
Approximately 600 red alder plugs planted along 500 m of stream.

Proposed Work
In the year 2000 the percentage of alder survival will be assessed. If the survival rate is high, another 1200 red alder plugs will be planted in the remaining 1000 m of disturbed channel.

For Further Information

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DEENA RIVER LWD PLACEMENT

Objectives
This project will improve spawning, rearing and overwintering habitat for salmonids (primarily coho as well as pink, chum and steelhead) in Weeping Willy Creek, a major tributary to the Deena River.

FRBC Region/MELP Region/MOF Region
Pacific/Skeena/Vancouver

Author
Leandre Vigneault

Proponent/Implementing Partners
JS Jones Ltd.

Watershed/Stream
Deena River/Weeping Willy Creek

Location
The Deena River is located on Haida Gwaii in the southwest corner of Skidegate Inlet on Moresby Island. The work site can be reached by travelling the JS Jones logging roads to West Deena Mainline. The work site is located on a major tributary (Weeping Willy Creek), which crosses the West Deena Mainline at 5.0 mile.

Introduction
The Deena River has been extensively logged over the past 40 years. Approximately 90% of the Weeping Willy sub–basin has been logged since the late 1960s. A combination of high annual rainfall, unstable terrain and extensive timber harvesting have caused numerous landslides and significant channel instability in both the tributaries and the mainstem. Changes in the main channel and numerous small tributaries have resulted in the loss of rearing and overwintering fish habitat. Coho salmon, important to the commercial and recreational fisheries, is the primary target species for rehabilitation.

Restoration works were conducted on three upper tributaries of the Deena in 1997 and 1998. The reach had a channel width of 8 m, an average bankfull depth of 0.7 m, and average slope of 1.7%.

Assessments and Prescriptions
Level 1 assessments were conducted in 1998 by LGL Ltd. and the Haida Fisheries Program (HFP) resulting in a list of high, moderate and low priority sites for rehabilitation (HFP/LGL 1999). In January 1999 Level 2 surveys were conducted for most of the high priority sites by NHC Ltd. and HFP. Prescriptions were generated following these surveys and then summarized in a Level 2 prescription report (NHC/LGL 1999). For Weeping Willy Creek the prescription was to restore a natural meander pattern to the reach and to promote the formation of scour pools, stabilize banks and provide instream cover by placing LWD.

Rehabilitation Work
The 1999 works occurred on the lower 700 m of Weeping Willy Creek. Construction of 31 LWD structures and the manipulation of one LWD jam were proposed. The construction of LWD structures was implemented in four stages:

- Collection and delivery of logs and rootwads (LWD) from a clearcut approximately 10 km away. Wood was pulled to the roadside using a Hitachi EX150 excavator with an 8 m choker, then to the worksite using a self-loading truck. Rootwads were transported by a dump truck.
- Four short tote roads were built from nearby logging roads to the stream access points using an EX150 excavator. The routes for tote roads were selected to minimize impacts to the riparian zone. No conifers were removed, and when trees were removed they were felled by hand. Wherever possible the stumps were cut low and left in place to reduce ground disturbance.
- Approximate placement of LWD and rocks at the proposed structure locations used a skyline system. The skyline consisted of either a 60 m or 100 m length of 9/16–inch diameter galvanized steel cable securely anchored to a tree or stump at the far end, as close to the ground as possible. The near end of the cable was attached to the bucket of the EX150 excavator. Logs, rootwads and rocks were suspended from one or two pulleys. With the skyline cable tight and sloping down, the load was moved along by gravity. Once the load reached the designated location, the excavator boom was lowered to the ground. Rootwads were the most difficult to move in this way because of their tendency to get caught on surrounding trees.
- Construction of LWD structures was carried out by a crew of four workers. A single grip puller (Tirfor Jack) with a 1500 kg lifting capacity rating was used to pull the logs and rocks into place. In total, nine V–

shaped lateral spurs (Figs. 6–9 and 6–10), 10 cross stream sills and three rootwad cover features were installed. In addition, an LWD jam was manipulated to allow better fish passage and reduce lateral scour and potential avulsions. These structures were constructed and anchored using techniques described in Watershed Restoration Technical Circular No. 9.

Figure 6–9. Placing instream structures in Weeping Willow Creek is expected to increase the scour and cover for fish.

Cost Summary

Supervision, Monitoring and Reporting	$23,000
Labour	6,800
Materials and Equipment	15,300
Total Cost	$45,100

Outputs

The instream structures have already increased the number of adult and juvenile holding areas throughout the lower 700 m of Weeping Willy Creek by creating areas of scour and cover around the LWD structures.

Figure 6–10. V–shaped lateral LWD spurs were placed in 11 locations in Weeping Willow Creek.

Proposed Work

An additional 11 V–shaped lateral LWD spurs and one log and rootwad bank protector/lateral debris jam will be constructed during 2000. For the structures which could not be completed because of time and budget constraints in 1999, the logs were either moved onto the banks or secured to live trees with rope or cable. The structures constructed during 1999 will be assessed and any necessary adjustments will also be made.

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CLEAR CREEK SIDE CHANNEL

Objectives

The objective of this project was to improve and increase the fish habitat in a small stream that had formed in an old roadbed. This development was aimed especially at rearing habitat for coho, Dolly Varden and cutthroat trout.

FRBC Region/MELP Region/MOF Region

Skeena–Bulkley/Skeena/Prince Rupert

Authors

Lyle Bolton, Project Manager
Glenn Grieve, R.P. Bio.

Proponent/Implementing Partners

Kitsumkalum Band Council.

Watershed/Stream

Kitsumkalum River/Clear Creek

Location

The site is located near the village of Rosswood, approximately 50 km north of Terrace, BC on the Nisga'a Highway. The site can be reached by turning northeast from the highway onto Egan Road, travelling approximately 2.5 km and turning east onto Geier Road. From the end of Geier Road turn north along the old main logging road to Clear Creek. From there it is necessary to wade the creek and proceed north along the old road approximately 1 km to the site.

Introduction

This is the fourth year of what has become a five–year project. Work began in 1995 with a Level 1 overview study of the Kitsumkalum River Watershed which was followed by a Level 1 detailed assessment of the Clear Creek Watershed in 1996 and a feasibility study of this site in 1997. The project is focused on extending and improving the habitat in a 1.25–km long, groundwater–fed, sidewall channel that occupies the eroded bed of what used to be the mainline logging road. Water levels have varied less than 0.5 m, and water has flowed throughout the winter during the last two years of monitoring. Sediment size and water level fluctuations suggested that the side channel did not need to dissipate much energy even in relatively high water events in the watershed when it probably carries floodwaters distributary from the mainstem. The channel had very little complexity, and virtually no wood. Since the entire area had been greatly influenced by past logging activities, and due to its location, energetics and stable water supply, the project represented a relatively low risk with a significant potential to produce fish. This conclusion was apparently shared by all of the fisheries personnel who visited the area before construction began, including staff from the Ministry of Environment, Lands and Parks, Fisheries and Oceans Canada and the U.S. Forest Service.

Assessments and Prescriptions

A Level 1 field assessment and a feasibility study were completed in 1996–97. Construction design prescribed extension of the channel headward, using the excavation spoil to build a berm between the mainstem creek and the side channel development, and complexing most of the existing eroded stream channel with deep pools and LWD placement. As part of the feasibility study the entire floodplain topography was mapped using a total station, and a series of 46 benchmarks were established near the channel. The specific design of the lowest 250 m of the side channel has been postponed to date in order to assess the significance of a large beaver dam–wetland complex to fish passage over three years. As one of the beaver dams does appear to be blocking upstream migration of adult coho, this design will be prepared for construction next year, when the 1.25 km of habitat we've improved or created will finally be connected to the mainstem of Clear Creek. This Type III Site Survey and Design will require additional fieldwork and topographic surveys.

Rehabilitation Work

After erecting a temporary steel bridge, borrowed from the MOF, over the mainstem creek, the existing eroded channel was extended headward in 1998 by excavation of an additional 250 m of channel to a depth of 2 m below grade and an average wetted width of 5 m. The spoil from this excavation was used to construct a 1.5–m high, 5–m wide and 300–m long berm between the mainstem creek and the side channel. Before pulling out before the heavy fall rains, disturbed areas were seeded, silt control structures were built and the temporary bridge was removed.

In 1999 the mainstem creek had braided, necessitating the installation of two temporary bridges for access to the eastern side channel. The newly excavated channel, along with 120 m of the original, eroded former roadbed, were complexed by embedding 31 single–log, channel spanning, LWD weirs, excavation of deep pools, increasing the sinuosity of the channel and the placement of 139 other LWD pieces as cover and for bank protection. Disturbed areas have again been seeded, silt control has been established and the bridges have again been removed. As the project is not yet complete, only a preliminary survey of the location and orientation of installed structures was done using a hip chain, compass and clinometer, so that gross movements will be detectable.

All of the work to date has occurred in the headwater area of the side channel. We have approximately 900 m to go and are gradually working our way downstream.

Equipment

We used an EX200 Hitachi with a thumb, a Hitachi 160 and a John Deere 490 on the project this year. All three excavators had biodegradable hydraulic fluid. We found the largest machine to be most efficient for the complexing work. The bridge construction required approximately 41 hours and the placement work took approximately 62 hours. LWD was delivered using a single–axle flat deck truck with a Hiab crane.

Cost Summary

Equipment	
Access	$24,881
Complexing	16,188
Materials (170 pieces LWD)	1,500
Project Management/Reports	3,400
Total Cost	$45,969

Production Estimates

Approximately 1250 m^2 of new habitat was created and improved in the channel extension and an additional 480 m^2 of habitat was created and improved in the existing eroded channel. A conservative interpretation of bio–standards (Koning and Keeley, 1997) suggests that there is a potential for the work to date to result in the return of 103 adult coho, along with a 1.5–fold increase in production of cutthroat trout and Dolly Varden char.

Proposed Work

It is recommended that the complexing be continued and that the modifications near the mouth be designed and implemented. Any of the LWD that could float should be anchored to embedded LWD using manila rope.

The anchoring should be completed during the fall of 1999. The site survey and design will be completed in the spring of 2000, with continued complexing of the channel and the construction to provide fish access near the mouth slated for later that summer.

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GLACIER CREEK FAN STABILIZATION

Objectives
The objective of this project is to improve and stabilize the Glacier Creek fan located at the confluence of the Kitsumkalum River and Glacier Creek.

FRBC Region/MELP Region/MOF Region
Skeena–Bulkley/Skeena/Prince Rupert

Author
Lyle Bolton

Proponent/Implementing Partners
Kitsumkalum Band Council (KBC).

Watershed/Stream
Kitsumkalum River/Glacier Creek

Location
Glacier Creek is a small tributary that flows into the Kitsumkalum River 10 km south of Kitsumkalum Lake. The creek crosses the Nisga'a Hwy approximately 25 km north of Terrace.

Introduction
Glacier Creek flows west into the lower Kitsumkalum River approximately 26 km upstream from the Skeena–Kitsumkalum confluence. The watershed drains approximately 15.5 km^2 of the western slopes of the Hazelton Mountains in the Nass Range. The mainstem is approximately 10 km long. An upstream migration barrier (~350 m from the confluence) limits anadromous fish from using the upper reaches of the creek.

Assessments and Prescriptions
Glacier Creek was included in the Kitsumkalum Watershed Restoration Program. Initial biophysical planning and assessment (J&S Outdoor Ventures Ltd., 1996), stream inventory and a Level 1 fish habitat assessment were conducted by Jim Culp. The WRP Level 1 fish habitat assessment identified coho and Dolly Varden at the highway bridge. Cover features (i.e., LWD, boulders, off–channel and overhanging vegetation) in this reach rated poor to fair (J&S Outdoor Ventures Ltd., 1996).

Rehabilitation Work
The restoration of Glacier Creek occurred largely at the section below the Nisga'a Hwy bridge. This section of the creek appeared to have been channelized and severely lacked habitat diversity (Fig. 6–11).

LWD was placed at approximately 16 locations along the lower part of the creek fan. A EX200 excavator was utilized in the placement of the LWD. After the wood was put in place they were then pinned together with 5/8–inch rebar and tied together with biodegradable (manila) rope. The completed project has created pools for fish habitat.

The fan stabilization at this site will improve access upstream from the confluence of the Kitsumkalum River and Glacier Creek and prevent degradation of the channel bed.

Stabilizing the lower part of Glacier Creek has created more diversity and habitat conditions (Fig. 6–12). It also provides more water depth during low flow periods. The works will be monitored over an extensive period of time by taking photographs of the area. The pools will provide holding cover for spawners and rearing habitat for juvenile and resident salmonids.

Cost Summary

Labour	$7,213
Equipment and Materials	1,918
Total Cost	$9,131

Outputs
0.5 km of stream was restored.

Production Estimates
Production estimates for this project have not yet been determined.

Proposed Work
Glacier Creek is the site of a potential fish habitat area that is in the initial working stages. The work as mentioned earlier will be monitored with photos over the next several years.

For Further Information

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Figure 6–11. Complexing at Glacier Creek in progress.

Figure 6–12. Placement of LWD at Glacier Creek.

MATHERS CREEK TRIBUTARY RESTORATION

Objectives
Improve adult holding and juvenile rearing and over wintering habitat for salmonids (primarily coho as well as sockeye, chum, pink and steelhead) in lower Mathers Creek.

FRBC Region/MELP Region/MOF Region
Pacific/Skeena/Vancouver

Author
Leandre Vigneault

Proponent/Implementing Partners
MacMillan Bloedel Ltd.

Watershed/Stream
Mathers Creek/Clew Creek

Location
Mathers Creek is located on Haida Gwaii on the north side of Louise Island. The work site can be reached by driving east from Beattie Camp along the Louise Mainline to the junction with spur L300. Some of the work was conducted immediately adjacent to this junction (Clew Creek) and some at the 7–mile mark on L300 (Tributary 2.0 LB).

Introduction
Mathers Creek flows east from the northern–central part of Louise Island and empties into Cumshewa Inlet southeast of Kitson Point. Mathers Creek is the largest watershed on Louise Island with a drainage area of 84.2 km^2. The watershed supports runs of coho, sockeye, chum and pink salmon as well as steelhead and cutthroat trout and Dolly Varden char. Approximately 26 km^2 (30%) of the watershed has been logged with most of the logging concentrated in the lower mainstem and the two major tributaries. Most of this logging was done prior to the 1970s and has resulted in loss of most of the old growth riparian forest along the lower mainstem. A combination of increased sediment loads and reduced LWD input has resulted in a loss of good adult holding and juvenile rearing habitat in the Mathers Creek mainstem and tributaries. Clew Creek has an 8 m channel width, 2 m depth, and average slope of 2.3%. Tributary 2.0 LB was considerably smaller with an average channel width of about 3 m.

Assessments and Prescriptions
Level 1 assessments were conducted in August 1998 by LGL Ltd. and the Haida Fisheries Program (HFP) resulting in a list of high, moderate and low priority sites for rehabilitation (LGL/HFP March, 1999). Level 2 surveys were conducted for most of the high priority sites in January 1999 by NHC Ltd. and HFP. Prescriptions were generated following these surveys and then summarized in a Level 2 prescription report (NHC/LGL, 1999).

Rehabilitation Work
Recommended rehabilitation works for Mathers Creek focused on restoring off–channel areas and adding LWD cover elements. Work in the 1999 field season focused mainly on two sites, Clew Creek and Tributary 2.0 LB. As well, two large trees that had slumped into the mainstem from an eroding bank were moved and securely anchored alongside the bank so as to continue to provide cover while limiting any threat to a bridge.

Clew Creek
Instream work was conducted in the lowest reach of this creek, downstream of the Louise Mainline road crossing. The lower 175 m of this reach had only a few pieces of LWD, primarily clumps of alder fallen from the stream bank and was characterized by mid–channel bars, eroding banks and multiple flow channels. The objective was to return the creek to its previous channel alignment, add LWD to scour pools and provide instream cover as well as prevent further bank erosion. A Hitachi EX300 excavator was used to excavate and re–establish the original channel, construct a large woody debris (LWD) jam to block off an avulsion channel, bury LWD sills to maintain grade control and place LWD for scour and bank protection. A four person crew assisted to install 8 LWD structures including V–shaped structures on the bank to deflect flow and create scour, sill logs to control the grade of the streambed (Fig. 6–13 and 6–14), and other log structures to block avulsion channels and maintain the preferred channel alignment.

Tributary 2.0 LB

Instream work was conducted by hand in the lower 400 m meters of this creek. A four–person crew worked with hand tools to excavate pools, install LWD sills to backwater pools and construct LWD structures to provide instream cover (Fig. 6–15).

Cost summary

Supervision, Monitoring and Reporting	$33,200
Labour	10,400
Materials and Equipment	27,355
Total Cost	$70,955

Outputs

The instream work completed at the two sites resulted in improved fish access as well as direct fish habitat improvements to 575 m of stream channel.

For Further Information

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Figure 6–13. View looking upstream at a typical V–shaped log spur on Clew Creek.

Figure 6–14. View looking upstream at a typical V–shaped log spur on Clew Creek.

Figure 6–15. View looking upstream at a rock riffle and two LWD structures constructed by hand in Tributary 2.0 LB.

CAMP CREEK INSTREAM STRUCTURES

Objectives
The purpose of the Camp Creek project was to increase habitat complexity for coho by adding functional large woody debris (LWD).

FRBC Region/MELP Region/MOF Region
Pacific/Skeena/Vancouver

Author
Ian Dodd, R.P.Bio.

Proponent/Implementing Partners
Naden Harbour Timber Ltd.

Watershed/Stream
Naden River/Camp Creek

Location
Naden River is located in the northwest corner of Graham Island, the northernmost island of the Queen Charlotte group. Camp Creek is a small S2 creek that flows east into Eden Lake. The creek can be accessed from the Eden Lake Logging Camp by walking south 50 m. The instream structures are located approximately 70 m downstream of the camp.

Introduction
The Naden River Watershed (wet hypermaritime Coastal Western Hemlock (CWHwh1 and CWHwh2) ecosystems has sustained logging for approximately the last 35 years. The watershed has been logged extensively during this time. Logging has affected fish habitat in a number of locations.

Assessments and Prescriptions
Camp Creek was harvested to the banks between 1977 and 1979. The creek now consists of sections of long riffles and lacks LWD and LWD recruitment. Fish utilization was low based on a pre–project assessment using minnow traps.

The project consisted of adding six triangle logjams/deflectors to a 150 m section of the creek (Figs. 6–16, 6–17). The structures were positioned to enhance existing shallow pools. A backhoe was used to place the logs and boulders in the creek.

Rehabilitation Work
Works were initiated in August of 1999, and the following steps were taken:

- Cedar logs were salvaged from roadsides and transported to a landing located close to the creek. Boulders from a quarry were transported to the landing site using a gravel truck. The logs weighed between 2000 and 3000 lbs and each boulder weighed between 400 and 700 lbs.
- A generator, an electric wood auger, and an electric rock drill were used at the landing to prepare the rock and logs for transport into the creek. Holes were drilled through both ends of the logs. Two 8–inch long holes were drilled into the boulders. The two ends of a 1/2–inch galvanized metal cable were fastened into the holes of two separate boulders using epoxy.
- The logs and rocks were transported to each creek site, where the hoe was used to place the structures. The hoe could access the stream at these sites with minimal damage to the riparian vegetation.
- For the next three days, the logs were re–positioned in the creek using hand winches. The logs and boulders were then cabled together in the creek.
- The logs do not extend more than 40% into the channel bankfull width. In most cases the logs were positioned in a low profile to prevent bank scour.

Cost Summary

Personnel	$8,000
Equipment	2,000
Materials	500
Total Cost	$10,500

Outputs
This project has created approximately 240 m^2 of high quality pool habitat. The 150 m section of complexed fish habitat is expected to produce approximately 500 0+ coho.

Proposed Work
Perform maintenance on structures. Remove large boulders from pools to deepen pools. At one location, build a sill log structure to hold back gravel.

For Further Information

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Figure 6–16. Post–construction view of a triangular logjam.

Figure 6–17. Post–construction view of a triangular logjam.

LOWER NADEN REACH 3–4 INSTREAM STRUCTURES

Objectives

The purpose of the Lower Naden Reach 3–4 Project was to increase habitat complexity for coho by adding functional large woody debris.

FRBC Region/MELP Region/MOF Region

Pacific/Skeena/Vancouver

Author

Ian Dodd, R.P.Bio.

Proponent/Implementing Partners

Naden Harbour Timber Ltd.

Watershed/Stream

Naden River/Lower Naden Reach 3–4 Creek

Location

Naden River is located in the northwest corner of Graham Island, the northernmost island of the Queen Charlotte group. Lower Naden Reach 3–4 is a small S2 creek which flows north east into Naden River. The creek can be accessed from the Eden Lake Logging Camp by travelling north five kilometres on the Naden Mainline to the 10 km road sign. The road crosses the stream at this location. The instream structures are located immediately upstream and downstream of the stream crossing.

Introduction

The Naden River Watershed (wet hypermaritime Coastal Western Hemlock (CWHwh1 and CWHwh2) ecosystem) has sustained logging for approximately the last 35 years. The watershed has been extensively logged during this time. Fish habitat has been negatively affected by past logging practices in a number of locations.

Assessments and Prescriptions

Lower Naden Reach 3–4 creek was harvested to the banks between 1974 and 1977. The creek now consists of sections of long riffles and lacks LWD and LWD recruitment. Fish utilization was low based on pre–project assessment using minnow traps.

The project consisted of adding eight triangle log jams/ deflectors to a 200 m section of creek. The logjams were positioned to enhance existing shallow pools. For the four structures upstream of the stream crossing, a helicopter was used to place the logs and boulders in the creek. For the four structures downstream of the stream crossing, a backhoe was used to place the logs and boulders in the creek.

Rehabilitation Work

Works were initiated in August of 1999, and the following steps were taken:

- The riparian zone is dominated by pole–sapling conifer, which provides 50% crown closure of the creek. Several conifers were removed from selected sites to provide a hole in the canopy for the logs and rocks to be lowered to the creek.
- Cedar logs were salvaged from roadsides and transported to a landing located close to the creek. Boulders from a quarry were transported to the landing site using a gravel truck. The logs used weighed between 1000 and 2500 pounds and each boulder used weighed between 300 and 700 pounds.
- A generator, an electric wood auger, and an electric rock drill were used at the landing to prepare the rock and logs for transport into the creek. Holes were drilled through both ends of the logs. Two 8 inch–long holes were drilled into the boulders. The two ends of a 1/2” galvanized metal cable were fastened into the holes of two separate boulders using epoxy.
- The logs and rocks were transported to the creek sites. A backhoe placed the structures at the four sites located downstream of the road crossing. The backhoe could access the stream at these sites with minimal damage to the riparian vegetation.
- A helicopter transported the material to the 4 sites located upstream of the road crossing. A Hughes 400 helicopter was used to transport the logs and boulders. The helicopter pilot was directed to each site by the radio–person in the creek. Good communication between the pilot and the radio–person was imperative since the pilot can not see the creek and the radio–person in the creek can not see the helicopter.
- For the next three days the logs were re–positioned in the creek by using hand winches. The logs and boulders were then cabled together in the creek.
- The logs do not extend more than 40% into the channel bankfull width (Figs. 6–18, 6–19, 6–20). In most cases the logs were positioned in a low profile to prevent bank scour.

Cost Summary

Personnel	$11,500
Equipment	3,500
Materials	1,000
Total Cost	$16,000

Outputs

This project has created approximately 320 m^2 of high quality pool habitat. The 200 m section of complexed fish habitat is expected to produce approximately 900 0+ coho.

Proposed Work

During 2000, it is proposed that maintenance be performed on the structures; the large boulders from pools should be removed to deepen pools; and two or three riffle structures upstream of existing structures are to be constructed.

For Further Information

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Figure 6–18. Post–construction view of a triangular logjam.

Figure 6–19. Post–construction view of log deflectors.

Figure 6–20. Post–construction view of log deflectors.

LOWER NADEN REACH 4–2 UPGRADE TO INSTREAM STRUCTURES

Objectives

The purpose of the Lower Naden Reach 4–2 Upgrade to Instream Structures Project was to secure and adjust the 1998 triangular logjam structures and to add five more large woody debris structures to increase habitat complexity for coho.

FRBC Region/MELP Region/MOF Region

Pacific/Skeena/Vancouver

Author

Ian Dodd, R.P.Bio.

Proponent/Implementing Partners

Naden Harbour Timber Ltd.

Watershed/Stream

Naden River/Lowre Naden Reach 4–2 Creek

Location

Naden River is located in the northwest corner of Graham Island, the northernmost island of the Queen Charlotte group. Lower Naden Reach 4–2 is a small S2 creek that flows east into Naden River. The creek can be accessed from the Eden Lake Logging Camp by travelling north 0.5 km on the Naden Mainline to the first bridge crossing. The instream structures are located immediately upstream of the stream crossing.

Introduction

The Naden River Watershed (wet hypermaritime Coastal Western Hemlock (CWHwh1 and CWHwh2) ecosystem) has sustained logging for approximately the last 35 years. The watershed has been extensively logged during this time. Logging has negatively affected fish habitat in a number of locations.

Assessments and Prescriptions

Lower Naden Reach 4–2 creek was harvested to the banks between 1974 and 1979. The creek now consists of sections of long riffles and lacks LWD and LWD recruitment. Fish utilization was low based on pre–project assessment using minnow traps.

The project consisted of securing and adjusting five existing triangle logjam structures and adding five more structures to a 400 m section of creek (Figs. 6–21, 6–22, 6–23). The logjams were positioned to enhance existing shallow pools. A helicopter was used to place the logs and boulders in the creek.

Rehabilitation Work

Works were initiated in August of 1999, and the following steps were taken to adjust five of the existing structures:

- The existing structures were adjusted to enhance pool development. Hand winches were used to reposition the logs. Logs were not extended more than 40% into the channel bankfull width. Ballast rock was brought in by helicopter in order to support several structures.

The following steps were followed for adding the five additional structures:

- The riparian zone is dominated by pole–sapling red alder, which provides 100% crown closure of the creek. Alder was removed from each site to provide a hole in the canopy for the logs and rocks to be lowered to the creek.
- Red cedar logs with attached rootwads were salvaged from roadsides and transported to a landing located close to the creek. Boulders from a quarry were transported to the landing site using a gravel truck. The logs used weighed less than 1200 pounds and each boulder used weighed between 300 and 450 pounds.
- A generator, an electric wood auger, and an electric rock drill were used at the landing to prepare the rock and logs for transport into the creek. Holes were drilled through both ends of the logs. Two 8–inch long holes will be drilled into the boulders. The two ends of a 1/2” galvanized metal cable will be fastened into the holes of two separate boulders using epoxy.
- The logs and rocks were transported by helicopter to the creek sites. The helicopter pilot was directed to each site by the radio–person in the creek. Good communication between the pilot and the radio–person was imperative because the pilot could not see the creek and the radio–person in the creek could not see the helicopter.
- For the next three days the logs were re–positioned in the creek by using hand winches. The Hughes 500 helicopter then transported the boulders in pairs to each of the sites. The logs and boulders were then cabled together in the creek.

Cost Summary

Personnel	$9,000
Equipment	3,000
Materials	1,000
Total Cost	$13,000

Outputs

This project has created approximately 200 m^2 of high quality pool habitat. The 400–m section of complexed fish habitat is expected to produce approximately 1800 0+ coho.

Proposed Work

Perform maintenance on structures. Remove large boulders from pools in order to deepen the pools.

For Further Information

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Figure 6–21. Post–construction view of a triangular logjams.

Figure 6–22. Post–construction view of a logjam.

Figure 6–23. Post–construction view of a log deflector.

GREENVILLE CREEK INSTREAM RESTORATION

Objectives
The objectives of this project are to restore holding, rearing and spawning habitats for salmonids in Greenville Creek.

FRBC Region/MELP Region/MOF Region
Skeena–Bulkley/Skeena/Prince Rupert

Author
Bruce Murray

Proponent/Implementing Partners
Nisga'a Tribal Council.

Watershed/Stream
Nass River/Greenville Creek

Location
Greenville Creek enters the west side of the Nass River at the village of Lakalzap (Greenville). The 1999 restoration works are located in the west sub–basin of Greenville Creek, 1300–1700 m upstream of the Nisga'a Highway bridge crossing of Greenville Creek at the north entrance to the village of Lakalzap.

Introduction
Greenville Creek supports several salmonid species including coho, pink and chum salmon, Dolly Varden char and cutthroat trout. The drainage area of the west sub–basin is 26.5 km, of which 7.4% has been logged (NTC, 1996). Most of this logging occurred in readily accessible, riparian areas. Channel instability has limited both the quality and quantity of historic salmon, trout and char habitats used for spawning, egg incubation and juvenile rearing. Channel aggradation results in long periods of subsurface flow. This functions to reduce fish production by increasing juvenile mortality and delaying spawning run timing.

Assessments and Prescriptions
The Level 1 Fish Habitat Assessment (NTC, 1998) identified that riparian logging, stream channelization, dyking, and aggradation negatively impacted Reach 6b. Similarly, riparian logging, hill slope and channel instability and aggradation negatively impacted Reach 6c. Both reaches are over widened, have very poor pool area (<6%) and pool frequency (1 in 12 B_w), low numbers of functional large woody debris and are often subject to subsurface flows due to sediment aggradation.

The Level 2 Fish Habitat Restoration Prescriptions (NTC, 1999) addressed habitat impacts identified in the Level 1 assessment and targeted salmonid spawning, rearing and holding life stages. A total of 17 prescription sites were proposed; restoration activities were to:

- construct LWD and boulder structures at six sites in Reach 6c that would help realign the channel and maintain flows up to a bankfull stage within a single channel;
- establish a radius of curvature on the meanders of approximately 2.3–fold the bankfull width;
- re–establish a single channel in Reach 6b by constructing pool and riffle sequences at 11 sites;
- establish cover by constructing LWD structures in 18 newly established pools in Reaches 6b and 6c; and,
- revegetate the abandoned overflow channels in Reaches 6b and 6c with natural vegetation.

Rehabilitation Work
Two prescription sites were completed during the 1999 construction window. At Site 17 and Site 16, multiple LWD and boulders structures were constructed to realign the channel and provide overhead cover (Figs. 6–24, 6–25). At Site 17, a 14 x 8 m pool was excavated along the right bank meander to provide a residual depth of 0.8 m. The right bank was then reinforced with nine rootwads, eight cover logs and epoxy cabled to 42 boulders. All rootwads were positioned into the channel and oriented in a manner to smooth the radius of curvature; while, the bole ends were entrenched 12 m into the right bank. The factor of safety (FS_B) to compensate for LWD buoyancy was 3.41 (D'Aoust and Millar, 1999).

At Site 16, the channel was realigned and downstream sedimentation from an active slide extending above the left bank was reduced. A total of 23 rootwads and 7 cut–logs were epoxy cabled to 36 boulders and arranged to form 10 triangular structures, over a distance of 58 m along the toe of the slide. All rootwads were placed in the channel and oriented in a manner to smooth the radius of curvature; while, the bole ends were entrenched 10 m into the face of the slide. Terracing the toe of the slide and armouring it with boulder material excavated from the realigned channel further reduced active channel sedimentation. The

FS_B to compensate for LWD buoyancy among the 10 triangular structures ranged from 1.5 to 4.9 (D'Aoust and Millar, 1999).

All machine work was conducted with a Cat 315L excavator. To complete this project within the construction window required a crew of five people.

Cost Summary

Construction and Materials	$24,420
Supervision, Design and Labour	24,786
Total Cost	$49,206

Outputs

0.1 km of fish access was restored
0.1 km of stream was restored.

Production Estimates

Successful completion of this project will potentially restore summer surface flow to approximately 3 km of channel. Biostandards are not well founded for complex projects of this scope and can only be properly evaluated through effectiveness monitoring. In the interim, a review of the literature suggests that a 100 to 200% increase (i.e., a 1– to 2–fold increase) in fish biomass is not unreasonable (Koning and Keeley, 1997).

Proposed Work

Prescription work outlined above is targeted for completion in 2003.

For Further Information

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Figure 6–24. Post–construction view of Site 17, Greenville Creek.

Figure 6–25. Post–construction view of Site 16, Greenville Creek.

GINLULAK CREEK INSTREAM RESTORATION

Objectives
The primary objective of this project is to control head cutting, thereby reducing streambank and streambed erosion. The secondary objective is to improve fish habitat.

FRBC Region/MELP Region/MOF Region
Skeena–Bulkley/Skeena/Prince Rupert

Author
Bruce Murray

Proponent/Implementing Partners
Nisga'a Tribal Council.

Watershed/Stream
Nass River/Ginlulak East Creek

Location
Ginlulak Creek is approximately 9.2 km long and drains a 43 km^2 watershed. Restoration work was restricted to the 15 km^2 Ginlulak East sub–basin. Ginlulak East Creek drains into the west side of a carex (*Carex spp.*) marsh from where it flows into the mainstem of Ginlulak Creek and then into the Nass River.

Introduction
Historically, the Ginlulak system supported annual runs of pink salmon, chum salmon, and coho. Dolly Varden char and cutthroat trout also inhabited the system. Pink and chum are rarely observed in the system, while coho salmon are still prevalent. Juvenile coho rearing habitat is replete; however, the most critical spawning habitat for the watershed is on the alluvial fan area of East Ginlulak Creek. This fan has been heavily impacted by past riparian logging practices. The majority of logging took place in the Ginlulak Watershed between 1954 and 1973. Logging in the Ginlulak East sub–basin accounts for 74% of all historic logging in Ginlulak Creek Watershed. To date, 37% of Ginlulak East sub–basin has been logged.

Assessments and Prescriptions
Logging of the fan has resulted in destabilization of the channel, formation of sediment wedges and frequent avulsions. A restoration plan proposed by nhc (1995) and implemented in 1996 re–established the creek in one main channel near the apex of the fan by:

- constructing a dyke to prevent the flows from continuing down a recent avulsion channel; and,
- removing a large sediment wedge from the main channel.

In 1997, the mainstem and off–channel habitat in the lower section of the fan was complexed with LWD and boulder structures (NTC, 1998). In 1998, coho escapement in this lower section of the fan was approximately 400 individuals, representing a 15–fold increase from 1997 (Bruce Baxter, pers. comm.).

A Level 2 Assessment conducted in 1998 (NTC, 1999) concluded that construction of pool and riffle sequences near the apex of the alluvial fan would:

- control channel head cutting and reduce the extent of bed and bank erosion during floods;
- extend the period of time the flow is on the surface of the streambed, rather than subsurface; and
- help stabilize and improve the quantity and quality or rearing, holding and spawning habitat for coho, Dolly Varden char and cutthroat trout.

Rehabilitation Work
Four boulder riffles structures were constructed with riffle spacing between 42 and 45 m or about four times the estimated bankfull channel width (Figs. 6–26, 6–27, 6–28, 6–29). Riffles were constructed with a 15 to 1 downstream face and featured a high roughness factor. Riffle crest heights ranged from 0.48 to 1.04 m. The riffle structures were built from a range of rock sizes (0.3 to 1.2 m mean ϕ). The largest rocks were selected to be stable at the maximum annual flood stage. Riffle crests were keyed into the streambed 0.2 to 0.5 m. Maximum depth of channel excavation of each scour pool, located at the toe of each riffle, was 1.4 m. Residual pool depth after armouring ranged from 0.85 to 1.2 m; while, residual depths in the four upstream dammed pools ranged from 0.96 to 1.4 m. A total volume of 530 m^2 of rock was used to construct four riffle structures.

Cost Summary

Labour	$ 8,137
Equipment and Materials	16,110
Total Cost	$24,247

Outputs

0.15 km of stream was restored.

Production Estimates

Biostandards for pool–riffle sequences are not well formulated. Pool and riffle sequences constructed in Ginlulak Creek in 1999 increased pool area approximately 4.5–fold, which parallels figures reported by Newbury *et al.* (1997) for pool–riffle construction in Oulette Creek on the Sunshine Coast. Fish biomass also increased 5.4–fold after restoration (Newbury *et al.*, 1997).

For Further Information

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Figure 6–26. Downstream, pre–construction view from chainage 0+850 m at riffle crest site 1 (crest at 0+836 m) and riffle crest site 2 (crest in photo background at 0+791 m).

Figure 6–27. Upstream view of riffle and pool sequence at Site 1. Riffle crest is at chainage 0+836 m.

Figure 6–28. Upstream view of riffle and pool sequence at Site 2. Riffle crest is at chainage 0+791 m.

Figure 6–29. Upstream view of riffle and pool sequence at Site 3. Riffle crest is at chainage 0+746 m.

THORSEN CREEK RESTORATION PROJECT

Objectives

- Implement non–intrusive, cost–effective restoration strategies emulating existing natural processes and ensuring continuation of natural restorative processes occurring in the watershed;
- Implement restoration strategies acknowledging limiting factors to production of target species (coho, chum, pink, steelhead residents, respectively).

FRBC Region/MELP Region/MOF Region

Pacific/Skeena/Vancouver

Author

David Loewen

Proponent/Implementing Partners

Western Forest Products Ltd., Hecate Strait Streamkeepers.

Watershed

Thorsen Creek

Location

Sewell Inlet Moresby Island, Queen Charlotte Islands/ Haida Gwaii

Introduction

Thorsen Creek is a 1600 ha, fourth–order stream located in the submontane wet hypermaritime Coastal Western Hemlock (CWHwh1) ecosystem. Logging commenced in the watershed in the 1940s and continues today. Approximately 45% of the watershed has been logged with extensive logging and road building in the upper watershed. The combination of high precipitation (average 3,665 mm/year), steep valley walls, extensive logging and road building has led to extreme periods of flooding and mass wasting events throughout the watershed. A 15–m high logjam 1.84 km from the mouth (formed in 1984) has blocked all downstream migration of gravel and LWD and upstream migration of anadromous fish. A road parallels the lower 800 m of stream cutting off access to historical off–channel rearing areas.

Assessments and Prescriptions

Extensive local knowledge and assessments identified the following limiting factors:

- a lack of adequate spawning habitat;
- a lack of low velocity rearing/overwintering habitat;
- an increase in high water events; and
- a loss of accessible habitat.

Off–channel development was prescribed for four separate areas in reaches one and two to create rearing/ overwintering habitat, LWD placement at two sites in reach two to create rearing and spawning habitat, and boulder weir construction throughout reaches three and four to create spawning habitat and low–velocity rearing areas.

Rehabilitation Work

Work commenced in June 1999. Work included:

- A rearing/spawning channel constructed on the lower floodplain. A small tributary was utilized—lengthened by 75 m, widened over 50 m with a rearing pond (130 m^2) developed at the base of the valley wall (Off–channel #1) (Figs. 6–30, 6–31).
- A small rearing pond (130 m^2) was constructed immediately adjacent to a small tributary 765 m upstream of the mouth (Off–channel #2).
- An 800 m^2 rearing channel was excavated in an old filled–in back channel 811 m upstream of the mouth (Off–channel #3).
- Numerous boulder weirs were constructed throughout reaches 3 and 4 (Fig. 6–32).
- Two LWD structures were constructed in reach two, 0+374 m and 0+434 m (Fig. 6–33).
- Steps were taken to limit sediment input from the Metric M/L into Thorsen mainstem.

Cost Summary

Assessments and Prescriptions	$23,000
Construction, Supervision, Labour and Materials	62,000
Total Cost	$85,000

Production Estimates

Koning and Keeley (1997) suggest an 8.5–fold increase may be expected in chum and pink densities following mainstem spawning habitat restoration. It is difficult to apply a number to habitat created by the LWD structures and boulder weirs. Thorsen Creek is a very powerful stream during high water events; this winter will test the stability of the structures and dictate how many rearing and spawning habitats are created.

Koning and Keeley (1997) also suggests no other instream factors or bottlenecks should limit fish productivity. The 15–m high logjam at 1.84 km stops downstream migration of gravel therefore slowing development of spawning habitat. Ongoing monitoring of the mainstem structures would provide an accurate measure of habitat creation.

Off–channel development during this project created approximately 1500 m^2 of rearing/overwintering habitat. As coho numbers are currently very low in Thorsen Creek, the biostandards estimate of 6.8 adult coho per 100 m^2 off–channel pond or 102 adult coho for this project may be optimistic. Similar to the mainstem work, an ongoing monitoring program would provide an accurate measure of fish production from the developed off–channels.

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Figure 6–30. The downstream end of Off–channel #1. Depth in this area is approximately 1.5 m.

Figure 6–31. The upstream end of Off–channel #1. Any trees knocked down during construction were utilized to provide cover.

Figure 6–32. This boulder weir was constructed in reach 3. The main objective is to capture gravel moving downstream, however low velocity rearing habitat has also been created. The majority of the weirs were cabled together for much needed stability.

Figure 6–33. This LWD structure was constructed in reach two, 375 m upstream of the mouth.

CLAY CREEK BIOENGINEERING

Objectives
The objective was to reduce sedimentation occurring from a 405 m ditchline that couples into Clay Creek, a major spawning/rearing tributary of the Yakoun River Watershed, Queen Charlotte Islands. The project focused on the construction and installation of several bioengineering methods utilizing a broad cross–section of plant species.

FRBC Region/MELP Region/MOF Region
Pacific/Skeena/Prince Rupert

Author
Darren Hebert, DWH & Associates

Proponent/Implementing Partners
Weyerhaeuser Canada Ltd.

Watershed
Yakoun River, Queen Charlotte Islands

Location
Clay Creek sub–basin, 25 minutes due south of Port Clemens, BC along East Yakoun Main road within TFL 39.

Introduction
In general, Clay Creek downstream of the ditchline is subject to high degrees of sedimentation and aggradation resulting from the erosion of lacustrine soils within the ditchline. The ditchline is highly prone to perennial surface and rill erosion, as evidenced by the numerous sediment wedges found throughout the downstream portion of Clay Creek. To that end, this site was proposed for rehabilitative works during the 1999/2000 field season.

Assessments and Prescriptions
The initial assessment of this site involved a determination of site elevation, exposure (aspect), as well as nutrient availability (based on soil type/biogeoclimatic zone type) and presence of indicator plant species. Based on this initial assessment, a restoration strategy involved an initial planting using pioneering woody species to restore slope stability. It is then recommended to underplant in later seasons using later successional conifer species such as western red cedar or Sitka spruce.

Methodology
In total, 230 m of ditchline will be treated with a combination of live smiles and wattle installations. All bioengineering works were constructed and installed employing hand labour. Live smiles were built and installed in the lower 37 m of the ditchline, while modified brush layers and wattle installations will occur from 37 m to 230 m upslope through the ditchline. The general strategy for this site involves halting further erosion of lacustrine soils into Clay Creek by protecting the exposed soils (wattles), and reducing the slope length and steepness (wattles and live smiles) through the ditchline. The lacustrine soils hold moisture well and are therefore conducive to the establishment of pioneering plant species (i.e., willow).

The plant species used for initial slope stabilization were varied, with the site restoration being viewed largely as an experimental trial at site propagation employing a wide variety of plant species. To that end, the prescription included the propagation of Pacific willow (*Salix lasiandra*), salal (*Gaultheria shallon*), kinnikinnick (*Arctostaphylos uva–ursi*), hardhack (*Spiraea douglasii*), salmonberry (*Rubus spectabilis*), Sitka willow (*Salix sitchensis*), red elder (*Sambucus racemosa*), and snowberry (*Symphoricarpos albus*). Each structure was tagged and recorded and will be assessed in 2000/2001.

Equipment
The project tools and handtools included: shovelnose shovels, planting shovels, swede saws, chainsaw, single–handed pruning shears, two–handed pruning shears, deadblow sledgehammers, hardhats, bailing twine, wattle sawhorses, dibbles, workglove, 10–gallon buckets, watering cans, safety equipment (hardhats, workgloves, eye shields/ear protection, hi–vis vests, level 1 first–aid kit, hand–held radios.

Rehabilitation Work
This bioengineering project, including site preparation, construction of structures, and installation spanned 14 days from October 12 to October 29, 1999.

The total area of treatment was 0.23 km or 2025 m^2 of ditchline and associated hillslopes (Figs. 6–34, 6–35). The project employed four technicians for a total of 56 person–

days. The project site was comprised of four separate rehabilitation sites (sites A, B, C, D). Total number of structures built and installed:

Site A:
Live Smiles: eight installed, each is comprised of 20, four–foot lengths of Pacific willow cuttings, 0.05 to 0.2 m in diameter. Cuttings all have side branches removed at trunk base. Total number of four foot cuttings: 160.

Rebar stakes: 32, 1 m lengths of _ inch rebar. Rebar posts are spaced 0.75 m apart in concave formation (facing open "upstream" in the ditchline).

Site B:
Total wattles installed: 9, 2 m in length, 0.15 m in diameter. Three rows of wattles, 1 m apart laterally, 2 m apart longitudinally. Each wattle row spans the length of the Site B sidewall failure. Fifty–four stakes were required. Total modified brush layers: 22, each 1 m length (faceplate) with >10, 1 m length cuttings.

Site C:
Total wattles installed: 9, 2 m in length, 0.15 m in diameter. Three rows of wattles, 1 m apart laterally, 2 m apart longitudinally, starting at 0+41. Each row spans the length of the Site C sidewall failure. Twenty–seven stakes were required. Total modified brush layers: 9, each 1 m length (faceplate) with >10, 1 m length cuttings.

Site D:
Total wattles needed: 120, 2 m in length, 0.15 m in diameter. Two rows of wattles, 1 m apart laterally, 2 m apart longitudinally, starting at 0+56. Each row spans the length of the Site D sidewall failure. Three–hundred and sixty stakes were required. Total modified brush layers: 33, each 1 m length (faceplate) with >10 1 m length cuttings.

Cost Estimates

Four Technicians	$ 7,616
One Project Manager	4,900
Two vehicles	2,800
Field Supplies	500
Total Cost	$15,816

Monitoring

Maintenance is proposed for the 2000/2001 field season. In particular, an assessment of each plant species tagged during construction/installation will be carried out. General site maintenance and protection will also be conducted during the next fiscal year.

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Figure 6–34. Panoramic view of Clay Creek (Y–1900) debris slump pre–work, August, 1999.

Figure 6–35. Panoramic view of Clay Creek (Y–1400) ditchline post–construction, December, 1999.

ZYMOETZ RIVER CULVERT REPLACEMENT (SITE 77)

Objectives
The objective was to re–establish juvenile fish access to a 1500 m^2 off–channel slough, used as rearing and overwintering habitat by juvenile coho, which was isolated from the river by two perched culverts in the road.

FRBC Region/MELP Region/MOF Region
Pacific/Skeena/Vancouver

Author
Steve Jennings

Proponent/Implementing Partners
Skeena Cellulose Inc.

Watershed/Stream
Zymoetz (Copper) River

Location
The culvert replacement occurred at 28 km on the Copper River Forest Service Mainline, approximately 45 km southeast of Terrace.

Introduction
The Copper River drains a 3000 km^2 watershed, which contains substantial fisheries values along with powerlines, pipelines, roads and forestry development. In conjunction with floodplain logging and road construction over the past 35 years, large floods caused substantial channel changes and impacted fish habitat, particularly off–channel habitat amount and fish access.

Assessments and Prescriptions
The slough at Site 77 is an isolated relic flood channel of the river, 200 m length and 7 m wide, located against the hillside and isolated from the river by the mainline road (Fig. 6–36). A small tributary and groundwater seepage maintains water levels in the slough.

The problem consisted of two culverts, perched 50 cm above the floodplain on the upstream and downstream ends, which were accessible to juvenile fish only when backwatered during river high flows (Fig. 6–37). Hundreds of juvenile coho were observed holding in the slack water below the culvert outfall during high runoff with no access to the off–channel habitat. Minnow trapping in the slough captured several coho smolts (160 to 180 mm in length) which were likely 3 years old and not able to exit the slough due to dispersed flow through the roadbed and perched culvert inlet. In addition to the metal culverts, an obstructed wooden box culvert was found during excavation, which dispersed water into the roadbed and prevented fish movement.

Rehabilitation Work
In August of 1999, we replaced the two perched culverts with a 1500 mm culvert that ensured up and downstream fish passage and removed the box culvert to maintain adequate water depth in the slough upstream (Figs. 6–38, 6–39).

The two 40 ft culverts were removed with an excavator working from the road. The roadbed was excavated an additional three feet lower to accommodate the 1500 mm baffled culvert (55 feet in length). The new pipe was installed at 1% slope and clean gravel and riprap armoring was placed around the inlet and outlets. Beaver grating will be installed.

Cost Summary

Labour	$ 5,000
Machinery and Materials	7,000
Total Cost	$12,000

Production Estimates
Overall the slough appears suitable as off–channel rearing habitat and we anticipate high use of the slough by coho fry which will be monitored. Average production is estimated at 375 smolts, using 0.25 smolts/m^2, similar to Telkwa River off–channel habitat production figures (A. Baxter, pers. comm.).

Proposed Work
Future work includes development of an outlet channel, 50 m in length, which will confine the culvert outflow across the floodplain to the river channel and ensure year–round access to the culvert exists for juvenile fish.

For Further Information

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Figure 6–36. Isolated off–channel slough located upstream of perched culverts at 28 km.

Figure 6–37. Outlet of two culverts perched 50 cm above the bed and only accessible at high flood river flows (inlet to left culvert buried).

Figure 6–38. Installation of new 1500 mm culvert.

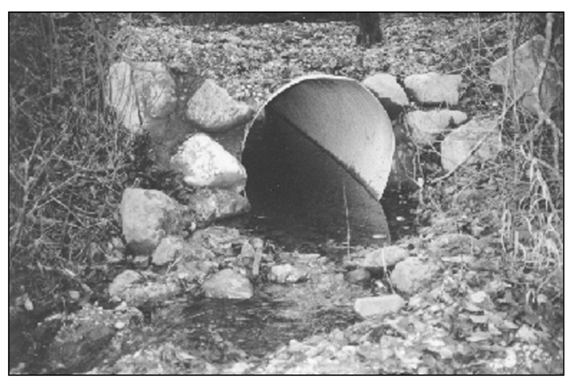

Figure 6–39. The new culvert provides upstream access to off–channel habitat and enables downstream migration of smolts.

FENTON CREEK FISH ACCESS PROJECT

Objectives
The objective of this project was to re–establish fish access to the middle and upper reaches of Fenton creek that were cut off by a wooden stave culvert constructed in the early 1960s.

FRBC Region/MELP Region/MOF Region
Skeena–Bulkley/Skeena/Prince Rupert

Author
Jeff Lough

Proponent/Implementing Partners
Houston Forest Products

Watershed/Stream
Morice River/Fenton Creek

Location
Fenton Creek is a tributary of the Morice River. It flows into the Morice at approximately km 30 on the Morice River Mainline

Introduction
Fenton Creek currently contributes 500 m of summer run steelhead and coho habitat in its lower–most reach. A mainline logging road culvert located approximately 500 m upstream of the confluence has been blocking all fish passage to approximately seven kilometres of stream since the early 1960s. Fish sampling downstream of the culvert has identified significant densities of provincially significant Upper Skeena coho and regionally significant summer run steelhead. Fish sampling upstream of the culvert has identified fish use by resident Dolly Varden and rainbow trout only. This sampling confirmed initial suspicions of the structure being a full barrier to anadromous fish passage in addition to restricting resident fish migration patterns. In the summer of 1999, the mainline road culvert was removed and an arch culvert was installed that re–established access to the upper reaches for the target populations of steelhead and coho.

Assessments and Prescriptions
The initial assessment of the Fenton Creek culvert was completed by Morris and Eccles (1975). The culvert was identified as a potential barrier to fish passage (Fig. 6–40). In 1999 Bustard (1998) identified the road structure as a barrier to fish passage due to the outlet drop and very fast water velocities that combine to stop fish passage for both coho and steelhead.

These assessments in addition to recommendations from the MELP and DFO) identified the Fenton Creek culvert as one of the highest priority restorative projects in the Morice Watershed as the habitats for targeted upper Skeena River coho and steelhead would be the primary beneficiary.

Rehabilitation Work
The wooden stave culvert on lower Fenton Creek was removed and replaced with a large arch culvert during a compressed two–week implementation schedule. The entire flow of Fenton Creek had to be rerouted around the deactivation and construction site for approximately 100 m upstream and downstream of the site for the construction period. Fish in the immediate project area were salvaged and placed downstream of the construction site. The arch culvert was placed on embedded concrete footings that allowed the natural stream bed to be re–established at the appropriate gradient (Figs. 6–41, 6–42).

Cost Summary

Labour and Equipment	$ 230,000
Materials	25,000
Total Cost	$255,000

Outputs
Access to over 7 km of spawning and rearing habitat was re–established.

Proposed Work
Both adult and juvenile fish were moving through the new structure in the fall of 1999 and both juvenile coho and steelhead have been sampled upstream of the arch culvert.

These findings suggest spawning and subsequent juvenile rearing in the upper reaches of Fenton Creek has been re–established. An ongoing routine monitoring program that will be completed annually to evaluate the long–term effectiveness of the structure.

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Figure 6–40. "Before" photo of 1960s constructed wooden stave culvert creating a full fish passage barrier on lower Fenton Creek.

Figure 6–41. Placement of new arch culvert on concrete footings.

Figure 6–42 . Arch culvert installed with flows re–established. The final construction stage was to replace road fill over the arch.