Waterfall Creek Restoration Project
FsRBC Project #S-006-Y02-13

Submitted to: the District of New Hazelton

Submitted by: Nortec Consulting

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Abstract

The Waterfall/Station Creek system has historically been and continues to be impacted by transportation corridors, municipal and industrial developments and is subject to various diversions of flow. Through a consensus based stewardship program involving local communities, interest groups and Fisheries & Oceans Canada, numerous studies and works have been carried out in past years, towards enhancement of habitat and fish stocks, improved stewardship and stream rehabilitation.

Through Fisheries Renewal funding in 2000/01, a restoration/rehabilitation plan was prepared to attempt to address present and future impacts to fish and the aquatic environment present in the system. In fall of 2001 the FsRBC and the Bulkley/Morice Salmonid Preservation Group approved funding for restoration works through a contact (FsRBC #S-006-Y02-13) between Community Futures Development Corporation of Nadina and the District of New Hazelton. The prescribed works were based on previous contracts and reports (Waterfall Creek Enhancement Project 2000 – FsRBC Project #00-006-18 & Waterfall Creek Stream Rehabilitation Project 2000 – FsRBC).

The restoration/rehabilitation works carried out in late fall of 2001 consisted of:

- Removal of 6 culverts and replaced by a bridge
- Replacement of 2 culverts to improve fish passage
- Rehabilitation of stream substrates and development of spawning and rearing habitat for native and anadromus species.

The works took place in two sites of the stream over approximately 350 meters of the stream in the center of New Hazelton BC.

The project provided local employment and involved government agencies, interest groups and local community. The project provides an opportunity for ongoing community involvement through rehabilitation of the stream and fish stocks for future generations. Restoration works provided a direct benefit to fish habitat through improved access for fish, improved spawning habitat and increased rearing habitat for fish.

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1.0 Introduction

Waterfall Creek system is located near New Hazelton, British Columbia and is a principal tributary of the Station/Waterfall/Mission Creek system (WC460-007300), which flows into the Bulkley River (WC 460-000) approximately one kilometer above the Skeena/Bulkley river confluence.

The Waterfall/Station Creek system has historically been and continues to be impacted by transportation corridors, municipal and industrial developments and is subject to various diversions of flow. Local communities, interest groups and Fisheries & Oceans Canada have carried out numerous studies and works on the watershed in past years towards enhancement of habitat and fish stocks, improved stewardship and stream rehabilitation.

In June of 2001, a Fisheries Renewal Project was proposed and submitted for Waterfall Creek on behalf of the District of New Hazelton (DNH). The prescribed works were based on previous contracts and reports (Waterfall Creek Enhancement Project 2000 – FsRBC Project #00-006-18 & Waterfall Creek Stream Rehabilitation Project 2000 – FsRBC). The project was approved for funding in late fall of 2001 as FsRBC Project #S006-Y02-13 for a total of $107,933 with $71,922 allocated from FsRBC and the remainder as in-kind contributions from the District of New Hazelton.

The project was initiated in late October of 2001 and stream works were carried out in December 2001 during low winter flow conditions. This report details the restoration methodology employed, working conditions encountered, rehabilitation works completed and recommendations for future works and monitoring.

2.0 Objectives

The objectives of the project were to :

- Improve spawning habitat through establishment of spawning platforms with suitable substrate and flows to accommodate anadromus and native species present in the system.
- Provide enhanced rearing and overwintering habitat for resident and anadromus species.
- Improve fish passage and habitat through removal of two sets of problem culverts and replacement of one stream crossing with more suitable culverts.
- Carry out the works in and about the stream while minimizing siltation of the creek and with as little riparian disturbance as possible
- Develop a rehabilitation plan for riparian areas impacted by proposed works.

2.1 Restoration Rationale

The restoration rationale was provided by the *Waterfall Creek Enhancement Project 2000 Report (Nortec 2000)* – FsRBC#000006-18 and the *Chicago Creek Enhancement Society - Stream Restoration Report 2000/01 by Kingston & Assoc. Ltd. 2000.* The following components of stream habitat were prescribed for rehabilitation to benefit present and future fish stocks in the system:

1. Cover is important to fish to provide resting pools, rearing habitat and refuge from predators. It was conspicuous by its absence throughout Lower Waterfall Creek, particularly along the entire channelized section adjacent to the CNR tracks. Thermal protection is also vital for a proper functioning ecosystem, as stream temperatures should remain <20 degrees Celsius throughout the summer for fish species present. Restoration measures prescribed include:

- Installation of in stream structure such as large woody debris (LWD), root wads and boulders.
- Pool development by placement of in stream structure such as weirs, LWD, boulder clusters etc.
- Riparian planting of coniferous and deciduous species to provide thermal cover, future shade, leaf litter and food to the system, as well as a long term large woody debris source.

2. Spawning habitat requirements for coho, cutthroat and Dolly Varden char are similar in that their incubating eggs require clean, unsilted gravel 1 – 10 cm in diameter, with a flow of cool, clean oxygenated water. Restoration measures implemented include:

- In stream structures were placed in series with washed gravels from 1 – 10 cm in diameter, placed at depths of 70 – 100cm. in water depths varying from 15- 50 cm.
- Weirs and boulders will provide localized areas of scour and gravel cleaning to increase available areas for spawning.

3. Water Quality: Clean water is essential to the stream ecosystem for spawning and rearing fish, macro invertebrates and amphibians.

- Cleaning up of the terrestrial environment adjacent to the stream and removing contaminated sediments will assist in improving water quality.
- Public awareness, community education and stewardship are to be fostered through signage and public use of trails in rehabilitated areas of stream throughout the community.

4. Food sources for rearing fish will be improved through boulder, cobble and gravel placement in rehabilitated areas and riparian restoration. The construction of repeating riffles, spawning areas and improved rearing habitats should provide improved macro invertebrate food production for resident fish.

5. Access for fish throughout the stream is critical to fish migration and movement between feeding and resting areas and suitable over wintering habitats. While this project

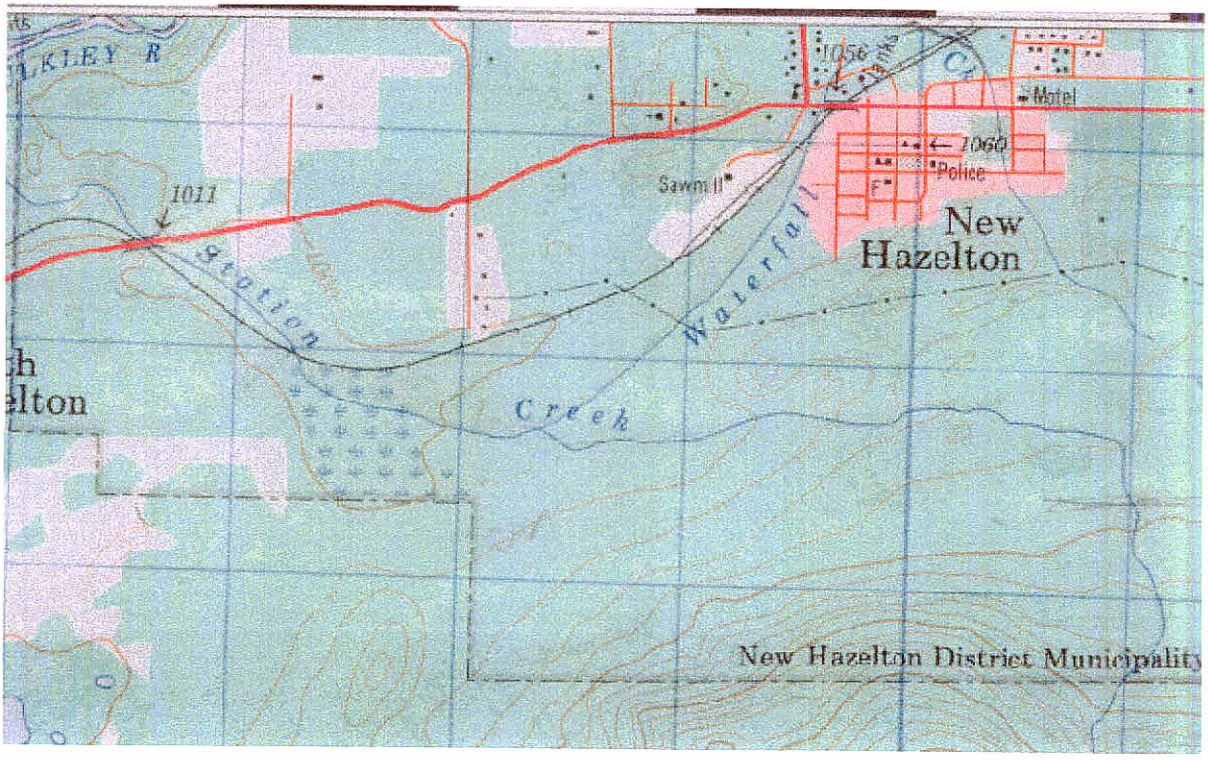
cannot address the primary constraint on fish movement (that being the Highway 16 culvert on Station creek) the removal of 3 sets of culverts and replacement of another set will improve access to available habitats currently utilized by fish.

3.0 Study Area

Waterfall Creek watershed falls primarily in the Interior-Cedar Hemlock Biogeoclimatic zone, best represented as the Hazelton Variant - ICHmc2 or moist cold sub-zone. Waterfall Creek arises in a series of swamps and drainage from a portion of the northeast face of the Roche de Boule Range of the Hazelton Mountains.

The creek is estimated to be 7 km long (*Mitchell 1998*) flowing from an area of approximately 9.5 square km. (*See Figure#1*) and joins Station/Mission Creek (WC460-007300) downstream of the District of New Hazelton, at approximately 314m of elevation above sea level, before flowing into the Bulkley River 1 kilometer above the Bulkley/Skeena confluence at Hazelton BC.

3.1 Figure 1 - Map of Project Area (93M/4) – District of New Hazelton



3.2 Summary of Stream Impacts

Waterfall Creek is heavily impacted by urban and industrial development prior to flowing into Station Creek (*Mitchell 1998*). These impacts include but are not limited to:

- Contaminated surface runoff from municipal streets, highway, CNR tracks, old bulk plant, gas stations, tire store, parking lots and a chipper mill.
- Clearing for highway and CNR right of way throughout the developed areas of the community and transportation corridors have resulted in riparian vegetation being removed.
- Channelization for stream crossings and adjacent to CNR, highway and municipal roads has resulted in loss of pool and riffle habitat in favor of homogeneous channel characteristics with primarily mud and silt substrates.
- Fourteen culverts exist on Waterfall Creek further channelizing flows and resulting in potential barriers to fish migration at various flows.
- New Hazelton sewage treatment plant discharges effluent into Waterfall Creek after treatment in aerated lagoons, and filtration though a wetland complex.
- Municipal litter and refuse such as tires, garbage etc.

The cumulative effect of the impacts to the creek have resulted in increased stream temperatures, decreased oxygen levels, degraded water quality through contaminants & effluent, lack of stream cover, habitat complexity and access for salmonids.

The primary impact to anadromus and resident fish species in Waterfall/Station Creek continues to be the Station Creek culvert under Highway 16, which is considered a barrier to upstream fish migration due to a >1.2m drop at the culvert outflow. It is also considered a velocity barrier, as it is approx. 60m long with a 2% gradient (Bustard 1986). This culvert has prevented fish passage to upstream reaches for an estimated 20 years and while scheduled for replacement by the Ministry of Transportation & Highways in future it continues to require mitigative measures in conjunction with the Chicago Creek Enhancement Society to ensure coho production from the creek.

3.3 Waterfall Creek Aquatic Resources

Waterfall Creek contains populations of enhanced coho salmon (*Oncorhynchus kitsuch*) in the fry and juvenile stages, Cutthroat trout (*O. clarkii*) ranging from 33 – 90mm and Dolly Varden char (*Salvelinus malma*) ranging from 40 – 192mm (Mitchell 1998 & Bustard 1986). The creek also supports other aquatic life (i.e. aquatic invertebrates, amphibians).

The creek flows through and is adjacent to numerous wetland complexes that have a unique and valuable role in supporting diverse food chains, providing fish and wildlife resources and maintaining natural hydrologic systems.

3.4 Enhancement Activities

Over the past 10 years, coho stocks to the Station/Waterfall Creek system have been enhanced through the efforts of the Salmonid Enhancement Program, in conjunction with a New Hazelton Elementary School Group and the Chicago Creek Enhancement Society. Initially the school group released small numbers of fry into the creek from classroom incubators/aquariums, and efforts were made annually to cleanup debris and garbage accumulating in the creek.

In recent years coho juveniles and smolts from lower Station Creek stocks have been incubated and reared at the Chicago Creek Hatchery and released into upstream Station/Waterfall locations to seed available habitat in the areas inaccessible to anadromus species. While a formal enhancement plan has not been developed, the Chicago Creek Environmental Enhancement Society has been releasing between 12,000 – 17,000 coho yearlings for the past 5 years (*B.Donas, FOC, personal communication*).

Approximately 400 adult coho are expected back in the fall of 2002 from enhancement activities in past years (*B. Donas FOC pers com*). The development of spawning and rearing habitat suitable for these fish was a major consideration of the restoration plan and subsequent works. Monitoring of results of these initiatives in the coming years will determine the success of the combined enhancement and restoration activities.

3.5 Waterfall Creek Flows

RECORDED FLOWS AND FLOW ESTIMATE SUMMARY

RECORDED MONTHLY AVERAGE FLOWS (CUBIC METRES PER DAY)

YEAR	MONTH									
	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
1994	NR	NR	NR	21,306	27,484	16,185	9,046	9,621	10,904	7,018
1995	F	F	4,439	13,122	12,556	12,398	13,849	10,768	7,100	5,620
1996	F	5,072	10,135	10,383	NR	NR	NR	17,652	16,874	8,459
1997	F	12,416	15,222	16,589	14,689	27,829	20,776	9,392	12,949	7,995
1998	F	5,045	8,292	25,384	18,545	15,163	9,207	9,865	9,235	5,231
1999	F	4,006	8,238	13,452	10,910	12,467	10,528	11,210	6,060	6,168
2000	F	F	5,673	6,938	7,858	6,413	3,339	NR	NR	3,676
2001	F	F	2,359	13,868	18,147	15,466	13,090	8,940	4,192	4,445
TOTALS	F	6,635	7,765	15,130	15,741	15,132	11,405	11,064	9,616	6,077

NOTES: LOWS RECORDED BY DISTRICT OF NEW HAZELTON AT TWO CULVERTS AT LOG SORT UPSTREAM OF CN CROSSING
JUNE AND JULY 1997 FLOWS ARE ESTIMATES ONLY
F = FROZEN CONDITIONS ON STREAM
NR = NO RECORD

3.6 FLOW ESTIMATE SUMMARY

RECORDED AVERAGE MONTHLY FLOW (1995, 1997 THROUGH 1999, 2001)
-10,926 CUBIC METRES PER DAY
-126 LITRES PER SEC.

ESTIMATED MAXIMUM MONTHLY FLOW
-27,829 CUBIC METRES PER DAY
-322 LITRES PER SEC

ESTIMATED MINIMUM MONTHLY FLOW
-3,500 CUBIC METRES PER DAY
-41 LITRES PER SEC.

4.0 Fish Survey & Trapping Summary

4.1 Permits

A component of stream restoration requires the removal of fish prior to initiating instream works. Permits are required from agencies for any works in and about a stream. Application for fish collection permits were submitted in November when the approval process for restoration was pending. A Fish Collection Permit (#309003K) was issued on November 23, 2001 from the Ministry of Water, Land & Air Protection (WLAP) to remove fish from the sites proposed for works on Waterfall Creek. A Scientific Licence (#2001-093) was also issued from Fisheries & Oceans Canada (FOC) to allow capture of fish present on site through Gee Trapping and seine.

A requirement of the permit and licence is for a summary report of activities to be submitted to the respective agencies on completion. This report is intended to fulfill that requirement, as copies will be submitted to the agencies involved.

4.2 Adult Survey

During discussions with FOC, concerns were expressed that there may be coho spawning in the area of proposed works or downstream that could be affected by siltation during construction. Stream surveys were suggested to determine if adult coho were present or spawning redds were visible in the sites or immediately downstream.

On November 22, 2001, the area in question was surveyed for coho or redds and 3 adult coho were observed. One female was situated below the Site 2 culverts but no digging was visible. Two adult coho were observed immediately upstream of the upper boundary of Site 3B. No redds or evidence of digging was observed in the sites proposed for works. A subsequent survey was carried out on November 30, 2001 and again no fish were observed in the sites proposed for works. Approximately 20 adult coho were observed spawning in the area upstream of HWY 16, above Kal Tire during the Nov. 30 stream walk.

4.3.0 Fish Collection and Removal

Fish Collection Permits allowed for the use of Gee trapping for capture of fish or seining. Gee trap sites were selected on the basis of water depth and flow characteristics with depth being the primary requirement and due to low winter flows few areas held enough water to submerge a Gee trap sufficiently to capture fish. Due to ice cover of the stream seining was not feasible initially, although a small seine and dipnets were utilized to try and capture any remaining fish once the water level was reduced and the ice was removed.

A fish barrier was placed at the upstream site of diversion on Site 3B prior to diverting flows through the wetland, to ensure fish would not move into the wetland complex. A fish barrier was also placed in Waterfall Creek immediately downstream of the outflow from the wetland diversion to ensure there was no emigration of fish into the wetland or Site 3B. Barriers were constructed using a vexar material over a wooden frame with wire mesh attachments on the side and bottom to allow for sandbags to be placed on the bottom of the stream and against the stream bank. The barriers were removed once the flows were redirected back into the main channel following construction.

4.3.1 Site 3B Summary

Although areas of sufficient depth for trapping were rare, 6 sites of suitable flow and depth were selected for location of traps. Trapping was initiated on the morning of Dec. 3, 2001. Traps were numbered and labeled using survey ribbon, baited with salmon roe and checked daily over the period from Dec. 3 – 10/01.

Eighty-four Dolly Varden were captured from the site, 82 through Gee trapping and 2 using dipnet and small seine following ice removal and reduced flows. Size range was from 40 – 140mm with the majority of the fish being 80 – 120mm. Fish condition was good and all fish were released to below the CNR culverts in Site 1.

Eight juvenile coho were captured, all through Gee trapping. Size range was 70 – 100mm and fish condition was good. The coho were also released to Site 1. Two frogs of undetermined species were recovered and released from the site during seining. Two juvenile fish were observed in the restored area of Site 3B on Dec. 20, two days after the flow was returned to the main channel.

4.3.2 Site 2 Summary

At Site 2 the priority for fish removal was the small pool immediately upstream of the existing culverts. This was the only area to be impacted by construction, and fish access from downstream was not considered to be feasible due to low winter flow conditions. Two Gee traps were set on Dec. 11, 2001 and fished consecutively until Dec. 17, 2001 when construction was commenced in Site 2. A total of seven fish were captured: 4 coho and 3 Dolly Varden. Size range was 100 – 140mm and 80 – 120 respectively. Fish

District of New Hazelton provided project coordination, materials and labor and was the proponent of the FsRBC project.

5.2.0 Schedule of Activities & Construction Works

5.2.1 Site 3B Approved Works – Culvert removal, pool and spawning riffles development

1. Stream walks were carried out on Nov. 22nd & Nov. 30th to determine if any adult coho were present or if spawning of adult coho had taken place. No spawning activity was visible within the sites prescribed for works.
2. Vexar stop nets were constructed and placed upstream and downstream of the site to eliminate opportunity for juvenile emigration into the site while the site was having fish removed and during the construction phase. Fish on site were removed through extensive gee trapping and finally beach seining. Juveniles captured were recorded and transported and released well downstream in Site 1.
3. On Dec. 7/01 a culvert was replaced from the wetland complex to the main channel below Site 2B on Pugsley Ave. A culvert was installed upstream of the proposed berm site to divert flows into the wetland and around the works location of Site 3B.. A sandbag/poly berm was constructed at the upstream end of the site to divert flows through the culvert to the adjacent wetland complex and around the proposed work site (*See Figure #5*).
4. Flows were diverted over a two day period to move any fish remaining in the area proposed for works into remaining pool habitat for ease of trapping and capture. A sandbag/poly berm was constructed at the downstream end of the site to capture any siltation or flows coming from the restoration site. Captured flows were minimal and pumped to an adjacent wetland as required.
5. Culvert removal and pool development in upper Site 3B was carried out in the dry channel from Dec. 10 – 11/01 (*See Figure #6)*. Substrate sediments were removed and replaced with cobble and gravel and the banks armored where culverts were removed. Silt fencing was utilized below pool development sites and pumped out to the adjacent wetlands as silty waters accumulated.
6. Construction of the spawning pads and placement of abutments and gravels in lower 3B began on Dec. 12/01 (*See Figure #7*). Excavation and works were carried out from the road to minimize impact to stream banks and riparian areas as much as possible. Abutments were constructed using marine grade plywood versus treated materials and a cedar log was placed on top spanning the channel *(See Figure #8)*. During excavation a pipeline was broken during excavation and repaired by district crew immediately.
7. Care was taken to maintain riparian structure on the south side of the stream while substrate sediments were excavated. Contaminated sediments were encountered in substrate materials below the old bulk plant and substantially removed resulting in a wider channel than originally designed.
8. On Dec. 13/01, the spawning channel was completed. Discussion for revisions with a FOC Habitat representative allowed the remaining two culverts to be

removed and replaced with a bridge abutment, which was carried out the same day.

9. On Dec. 14th, the new bridge site was rip rapped with suitable materials and cobble, boulder and gravels were placed in the excavated channel.
10. On Dec. 17th the site was re-watered. The siltation was monitored closely and minimized through pumping initial flows to an adjacent wetland. Siltation was minimal due to low flows and cleaned materials used in channel restoration. A berm was placed at the site of the wetland diversion prior to removal of the temporary culvert and silt fencing and the downstream berm were removed.

5.2.2 Site 2 Approved works – Culvert replacement, Pool development and Boulder placement

1. Site 2 and downstream sections were surveyed for any spawning activity on Nov. 22nd and Nov. 30th. No adults or digging were observed.
2. Fish removal was carried out in Site 2 through gee trapping from Dec. 11th – 17th prior to any works. Stop nets were considered not to be required as few fish were found in the area.
3. On Dec. 14th , a sandbag and poly berm was established above the culverts on Site 2 to isolate the excavation site for the replacement culverts from flows.
4. On Dec. 17th , the FOC Habitat representative was on site and the work plan was revised to allow excavation and placement of the new culverts adjacent to the existing culverts, prior to their removal. The intent was to minimize downstream siltation.
5. A sandbag and poly berm, as well as hay bales, were used to isolate the excavation area downstream of the culverts and monitored and maintained during works (*Figure #2)*. Pumping of silted water seeping into the site was carried out as required.
6. On Dec. 18th, installation of the new culverts, pool construction and lining of the pools above and below the culverts were completed. Flows were diverted through the new channel to allow removal of the old culverts. Siltation was present for approximately 20 minutes and was moderated by silt fencing and hay bales below the outfall.
7. The old culverts were removed on Dec. 19th; banks were stabilized and pulled back to a 2/1 slope (*Figures #3 & 4*). Excavated materials were hauled off site for disposal.
8. On Dec. 20th , the sites were cleaned up and LWD debris was hauled in, placed and rocked into pools.

6.0 Construction Revisions

During construction of in stream works a number of revisions to the plan were required due to existent conditions and materials supplied.

1. On site 3B two sets of culverts were planned for removal with one set to remain for access to private lands south of the stream. During construction an agreement was

reached with FOC Habitat representatives for the removal of the third set of culverts with a concrete bridge abutment to be placed for future access to private properties.

2. During excavation of the channel in the lower section of site 3B, care was taken to maintain the riparian structure present on the south side of the stream. During excavation of the channel contaminated sediments were encountered in the area below the old bulk plant requiring more material to be taken out. Substrate sediments were contaminated with oil and fuel residue that was visible during excavation. As a result of the effort to retain the riparian and remove contaminants the width of the stream channel excavated was more than the site plans required. This required more gravels and boulder than planned to bring the streambed to grade and may require future remedial works to confine flows for the desired velocity for spawning.

3. Cleaned gravel sources for suitable spawning substrate were inspected at two sites prior to start of construction. A source of material in Smithers was selected due to quantity available and lack of fines present. When delivered to the site it was apparent the gravel delivered was of larger diameter than selected and a request was made for addition of smaller material in subsequent loads.

4. Since the channel in this area may require a narrowing of channel width as discussed two paragraphs above, it is proposed that with a minimal amount of effort and disturbance that the channel could be modified to confine flows.

5. Due to ice cover, stream flow was directed to the sides of the stream and sides of the abutments placed in the spawning riffles. This eroded the clay seal on the right bank of the two middle abutments and required resealing.

7.0 Working Conditions

Working in stream during winter and freezing temperatures offered a number of challenges and benefits. For future reference the following aspects of winter works bear consideration:

1. Stream flows were dramatically reduced from those present during the normal work window of late August. Waterfall Creek average flows during December are 5,089 cubic meters per day while during August and September the average flows are >11,000 cubic meters per day. A >50% reduction in flows facilitated instream works such as sandbagging berms, channeling flows and subsequently reduced siltation significantly. On Site 3B the stream flow was low enough to allow for a diversion of flow through a wetland complex while culvert removal, substrate placement and spawning riffles were constructed over the 270m of dry channel.
2. Minimal flows reduced the demand for large berms and associated materials for silt control as well as pumping of silt laden waters. Cold weather and firm stream banks may have also reduced the amount of bank seepage and sloughing present during summer conditions. Removal of berms and structures was marginally more

difficult due to freezing as a small portion of silt fence and sand bags were not able to be removed following works and were taken out in spring.

3. Pump and hose monitoring and maintenance is essential to maintain during severe cold conditions although no problems were encountered during works on the stream in this project.
4. While ice cover was a problem initially for removal of fish, it proved to be insignificant as only 3 fish were recovered from sections where excavation was carried out after the ice cover was removed. Gradually dewatering the channel also assisted in ensuring as many fish as possible were removed prior to works. While ice cover would not always be present in streams, ice and shore ice conditions are worthy of consideration when planning fish removal from sites during similar conditions.
5. Excavation of culverts and roadways in December proved more difficult as frost was approximately .5 m deep making it necessary to use a smaller bucket with teeth on the excavator to break through or chip away at the frozen ground. Stream banks posed similar problems but the frost level was not deep and the soils less compacted than the roadways. Time required for excavation on traveled roads for culvert removal was probably double that of conditions with no frost present.
6. Snow cover did not prove to be a problem and removal of brush was easier in frozen ground and did not disturb roots and surface soils to the extent expected in summer conditions.
7. One area of the stream bank in lower Site 3B has slumped and required silt fence. This was the area where a pipeline was broken by the excavator and the stream banks had to be excavated back further than planned to repair the section of pipe. While the pipeline break itself had no impact to the stream, the excavation of the stream bank will require wattles and bank restoration on that location.

8.0 Riparian Restoration Plan

8.1 Previous Site Conditions

The sites subject to works on Waterfall Creek were adjacent to existing roadways and road crossings, and as such the existent riparian areas provided minimal bank stability and shade to the stream. Throughout this section of the stream the original stream canopy had been significantly removed through road construction and culvert placement in the project area during past development. The existent riparian area was narrow, averaging approximately 2.5m in width adjacent to the roadways and was broken by the culvert crossings in the 4 locations on site. The banks varied from 1.5 – 2m in height and the slopes were approximately 30%.

The existent vegetation on disturbed sites prior to initiation of restoration works was comprised of primarily deciduous growth at the shrub/herb stage. The first layer contained no coniferous species and was predominately alder willow that varied from 3-5 m in height offering crown closure from 1 –40%. The second layer was comprised of a mix of red osier dogwood, black twinberry, red elderberry and prickly rose. These shrubs

varied from 1 - 2m in height and offered minimal stream shading. The last layer was primarily grass species with some spirea providing ground cover and nutrient filtering.

8.2 Riparian Restoration Methodology

During stream channel restoration works in Dec. 2001, riparian vegetation was removed from selected sections of Sites 2 and 3B to facilitate access for instream works. Consistent with rehabilitation techniques for stream channel and fish habitat restoration activities a plan for restoration of the riparian zone is required for impacted riparian areas as part of an integrated rehabilitation strategy.

Riparian vegetation communities are generally characterized by high plant species diversity, high structural heterogenicity and high productivity. The primary goal of riparian restoration is to establish a diverse and complex vegetation community to provide stream shading, large and small organic debris to streams, stream bank stability, surface sediment and subsoil nutrient filtering, invertebrate production for fish consumption, organic inputs into streams including leaf litter and to provide feeding, resting and breeding sites for wildlife.

Replanting efforts can accelerate the process to restore riparian function in the riparian zones complementing in stream restoration activities. Therefore planting a mix of deciduous tress such as cottonwood, willow and coniferous trees as well as ground cover will assist in achieving this objective. Timely replanting of streamside areas is essential to the overall success of restoration projects through providing reduced erosion potential and stream shading and cover for fish habitat.

Consistent with the above, the objective for the riparian restoration on Sites 2 & 3B are to initiate riparian works in early April of 2002. A combination of techniques is proposed that will establish the bank protection required to reduce erosion potential and provide the diversity of species similar to that existent prior to restoration works. Coniferous stock is proposed to provide stream shading and a potential long-term source for LWD.

Riparian rehabilitation techniques proposed are:

- The planting larger, rooted, stock of Mountain alder (*Alnus incana)*, willow (*varied salix species*) and Red-osier Dogwood *Cornus stoloniferaas* well as a mix of coniferous species including white spruce (*Picea glauca x engelmannii),* Lodgepole pine (*pineus contorta latifolia*) in suitable locations. Stock size will vary from 1 – 3m in height, hence a backhoe and dumptruck will be used to remove, transport selected stock from locations in close proximity to the restoration sites. Planting sites will be prepared to receive stock with a suitable sized depression and soil and fertilizer added.
- A combination of wattles, live banks and modified brush layers of alder, willow and red osier will be utilized in immediate stream side areas to provide erosion protection and allow vegetation to become established. Wattles will be short retaining walls built of live cuttings and backfilled with soil and woody debris. Modified brush layers will be utilized above wattles where feasible to provide soil

stability and establish brush and ground cover along the roadside. These will be constructed using deciduous stakes and small logs from the adjacent wetland.

- Whips cut from Black Cottonwood (*Populous balsamifera)* and Willow (*varied salix species*) during February 2002 in the Two Mile area will be planted at a spacing of 1 per square meter of stream bank in sections immediately adjacent to the stream.
- Natural seed from native shrubs (if available) and grass seed will be broadcast for ground cover in disturbed areas between live plantings and wattles and on the top of the stream bank. The grass mixture proposed is "Enviroturf" from the Dawson Seed Company from Surrey BC and consists of red fescue, creeping red fescue, ryegrass and hard fescue.
- Soil will be transported to the site by the District for use in covering wattles and brush layers and to establish grass along the top of the bank.
- Fertilizer to be used is a purely organic fish bone meal produced in Prince Rupert with approx. 17%calcium, 8% phosphorous, 45% ash and <30% nitrogen or protein. The bone meal with a nitrogen component will assist in establishing plants and ground cover quickly with no adverse effect to the stream.

8.3 Riparian Works Plan

8.3.1 Site 2 Recommendations

At Site 2 two culverts were placed adjacent to the two faulty culverts scheduled for replacement. A section of stream channel upstream of the culverts was constructed and flows were diverted into the new culverts to facilitate removal of the old culverts while minimizing siltation to the stream. As a result approximately 30 m of riparian vegetation was removed from the east bank of the stream and 15 m from the west bank to facilitate stream channel works, pool development and culvert removal.

The vegetation existent on site was consistent with the description above with predominantly alder, willow and red osier providing a stream shading function with a mixture of prickly rose, twinberry and grasses in the understory.

Recommendations for riparian revegetation in this site include:

- The planting of 4 alder and 3 red osier dogwood clumps using a backhoe
- Planting 4 conifers (1-3m high) using a backhoe as well as planting 30 of a smaller coniferous stock (.2-.5m high) by hand from a district source utilized in past projects. The survival of planted conifers from the previous years project is evident on the west side of waterfall Creek in Site 2 and the south side of the stream in Site 3b.
- Whip planting of a mix of Black Cottonwood (20) and Willow whips (20) at a spacing of 1 per square meter of stream bank.
- A combination of live bank construction and modified brush layers of alder, willow and red osier will be utilized in selected stream side areas to provide erosion protection and allow vegetation to become established.

- Grass seed will be planted for ground cover in disturbed areas between live plantings and the stream bank. The grass mixture proposed is "Enviroturf" from the Dawson Seed Company from Surrey BC and consists of red fescue, creeping red fescue, ryegrass and hard fescue.
- Natural regeneration of shrubs and herbs species is anticipated in areas where root mass remains and surface soils are relatively undisturbed.
- Replanted areas will be watered and monitored for moisture for a minimum of one month following planting.

8.3.2 Site 3B Recommendations

On this site the section of stream undergoing restoration runs immediately adjacent to an existing roadway and the stream was crossed by 3 dual sets of culverts. Plans were for the removal of two sets of culverts, the establishment of two pools and construction of spawning riffles over approximately 75 meters of stream. Due to on site revisions the remaining set of culverts was removed and bridge abutments were put in place to improve access for fish.

The works required removal of the majority of the riparian vegetation from the north bank over 270m to facilitate in stream works and approximately 30m of the riparian structure from the south bank during culvert removal and lining of the stream channel and bank with suitable materials. The riparian structure on the south bank of the stream that offers solar insolation was retained over the majority of the site and throughout the spawning riffle section.

The riparian structure in the 200m eastern section of Site 3B was sparse and predominantly low brush and grasses that was further compromised by the 3 access roads over the stream. The willow, alder and red osier present provided little shade to the stream due to aspect and height, although the brush combined with grasses and herbs did provide some sediment control and nutrient filtering to the stream in this area.

Recommendations for riparian restoration in Site 3B include:

- Planting of 4 alder/willow clumps and 3 red osier dogwood clumps using a backhoe as outlined above.
- Planting 8 conifers (1-3m high) using a backhoe as well as planting 60 of a smaller coniferous stock (.2-.5m high) by hand from a district source utilized in past projects. The survival of planted conifers from the previous years project is evident on the west side of waterfall Creek in Site 2 and the south side of the stream in Site 3b.
- Whip planting of a mix of Black Cottonwood (80) and Willow whips (80) at a spacing of 1 per square meter of stream bank.
- A combination of wattles and modified brush layers of alder, willow and red osier will be utilized in stream side areas to reduce the slope, provide erosion protection and allow vegetation to become established.
- Grass seed will be planted for ground cover in disturbed areas between live plantings and wattles and on the top of the stream bank. The grass mixture

proposed is "Enviroturf" from the Dawson Seed Company from Surrey BC and consists of red fescue, creeping red fescue, ryegrass and hard fescue.

- Soil and fertilizer will be transported to the site for use in covering wattles and brush layers and to establish grass along the top of the bank.
- Replanted areas will be watered and monitored to maintain moisture for a minimum of one month following planting.

8.4 Riparian/Mitigative Works Schedule - April 2002

- Stabilize slumps or surface erosion sites prior to riparian works
- Develop site plan and layout for areas requiring wattles, alder clumps etc.
- Select and collect materials required for restoration
- Access suitable LWD for potential placement should this be recommended.
- Establish timing and permit requirements with agencies for remedial works required.
- Coordinate with volunteers for planting and riparian rehabilitation activities.

9.0 Monitoring of Restoration/Rehabilitation Works

Monitoring of restoration activities in a stream is an important component of any rehabilitation project. To determine the benefit of works carried out in and about the stream, it is imperative to implement a monitoring program to track results of changes in habitat components, water quality and the relative benefits to aquatic organisms utilizing the habitat created or improved.

9.1. Flow Monitoring Sites

Flow monitoring on Waterfall Creek is carried out by the District of New Hazelton at Site 2, approximately 90 m downstream of Highway 16 culverts. Monitoring at this site will be maintained to determine flows prior to the addition of flows from the District sewage out fall downstream. The intent is to determine dilution factors from the District waste treatment facility.

The District of New Hazelton further proposes to monitor pipe flow and over flow to their impoundment, measure flow at the intake weir at the original site of the Water Survey Canada Station 0EE028, and measure flows of Waterfall Creek at the historical site downstream of HWY 16. Flows will be recorded on a weekly basis until ice conditions preclude accurate readings, as has been the case in past years. Water level gauges have been placed in the above locations and in Station Creek, approximately 1 km continuing south from Pugsley Street.

Location of Monitoring Sites

1. Original site of Water Survey Canada Station 0EE028 above flow control weir on Station Creek.
2. District of New Hazelton historical flow monitoring site approximately 90m downstream of HWY 16.
3. Station Creek water gauge approximately 1 km south of Pugsley Street.

9.2 Aquatic Resource Monitoring

Fish resource monitoring will be facilitated by the juvenile fish information to be collected in summer 2002 by B. Donas, FOC and Bridie O'Brien, and monitoring of spawning activity following transport of coho to Waterfall Creek in fall 2002. A monitoring plan using similar methodology in future years will greatly assist in determining effectiveness of restoration works carried out.

9.3 Monitoring of Riparian Rehabilitation Sites

The District of New Hazelton proposes to monitor and maintain riparian rehabilitation sites through the summer/fall 2002. Site assessments will be carried out by district staff on a bi-monthly basis to monitor survivals, site maintenance will be carried out as required to try and ensure survival of planted stock. Brushing around conifers planted in fall of 2000 in riparian and trail locations will also be carried out.

10.0 Recommendations

- Completion of remedial works and riparian restoration works in spring 2002.
- Monitoring of rehabilitation works on an ongoing basis by the District.
- In order to ensure minimum flows in Waterfall Creek, it was recommended that more water be diverted to the creek from the swamps located south of the District impoundment.
- Re-calibrate flows at Site 2 and continue to monitor Waterfall and Station Creek flows on a weekly basis.
- Roundtable meetings of the Mission Creek Steering Committee should continue to discuss future options and provide comment and concerns on an ongoing basis.
- Completion of the Water Use Planning process to ensure concerns of participants are being met, and that a process exists for dispute resolution on an ongoing basis.
- Signage should be established that reflects the efforts of all groups involved and the stewardship objectives of the projects. Signage was also recommended for the trail system and has yet to be completed.
- Efforts must be continued towards having the culvert barrier issue on Highway 16 resolved. The expense and benefit of restoration works and continued enhancement remain questionable should this issue not be resolved in a timely fashion.

11.0 Acknowledgements

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13.0 Appendix Contents:

Figure 1.0 - Site Map

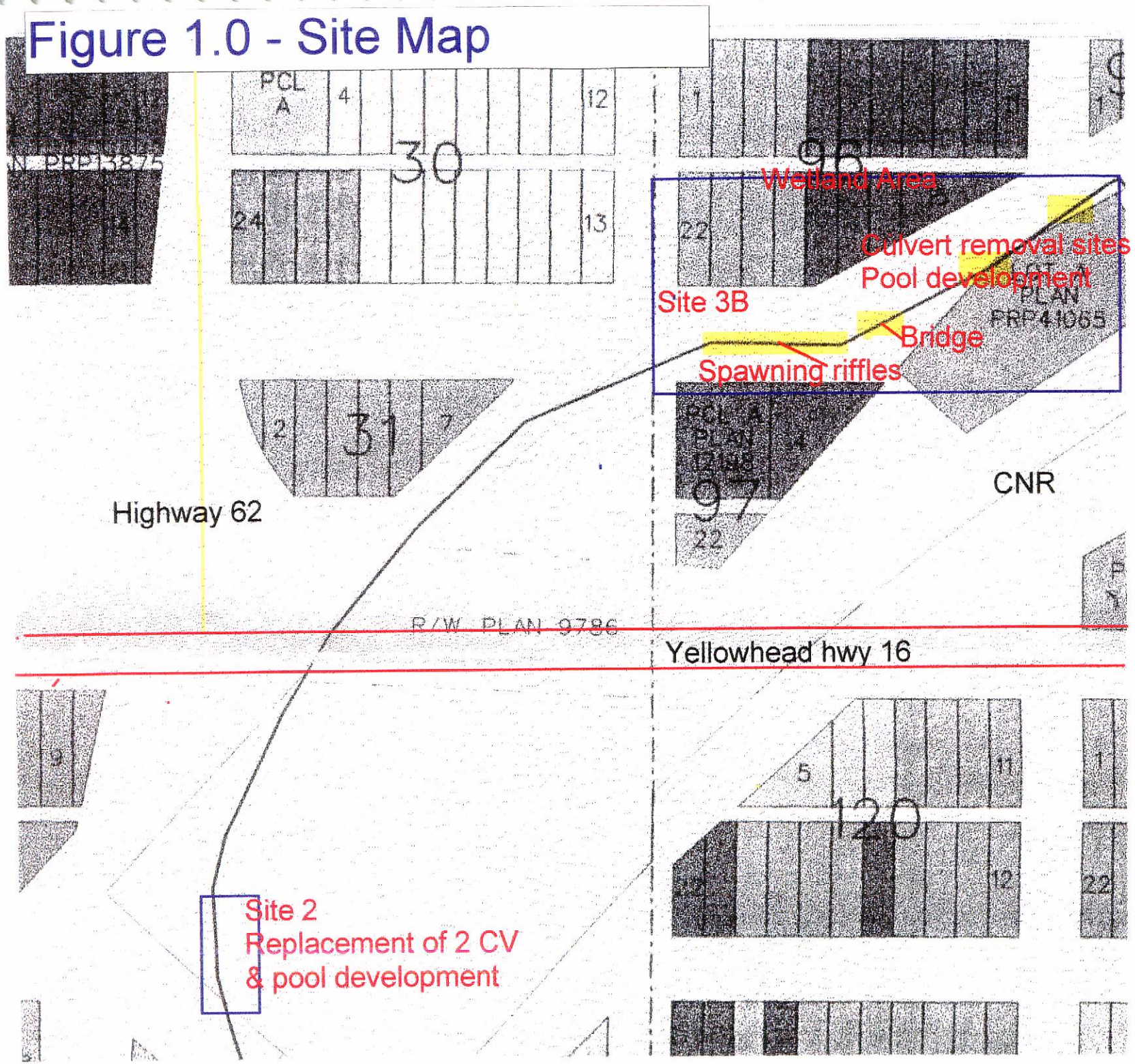

Figure #2 – Upstream view of Site 2 – Installation of culverts & pool development

Figure #3 – Site 2- Downstream view

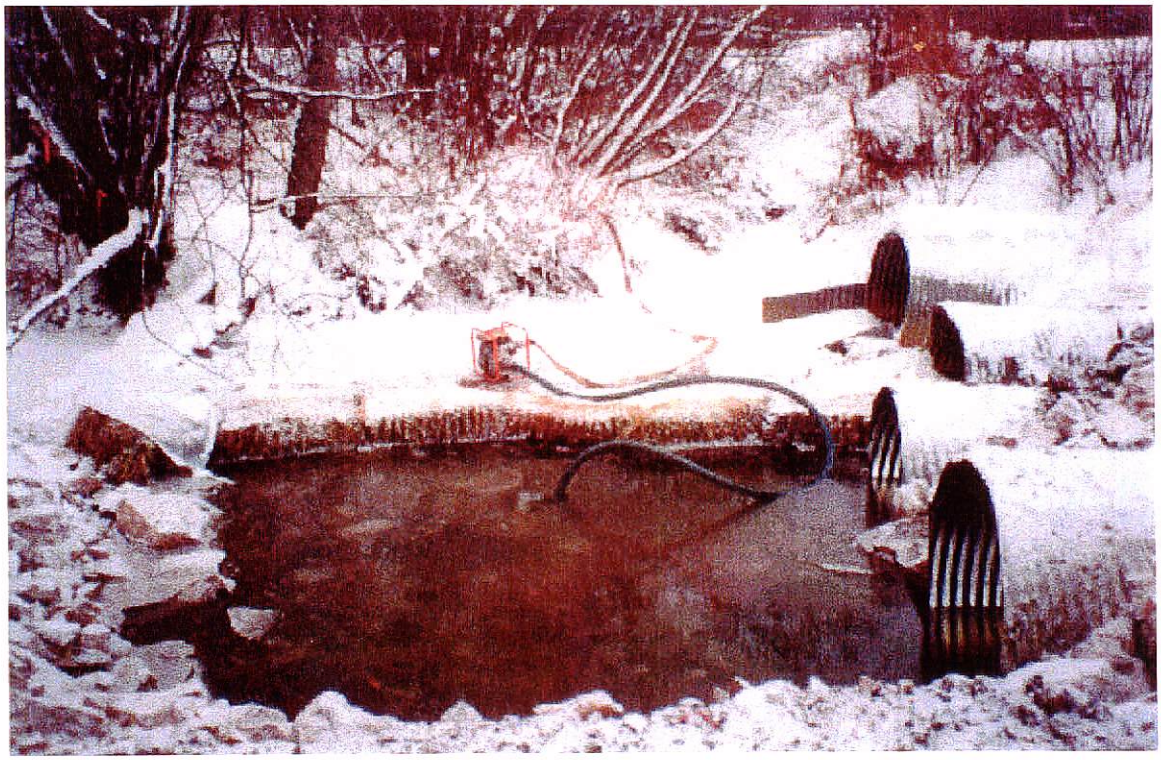

Figure #4 – Site 2 – Upstream view – Pool development

Figure #5 – Site 3B – Upstream diversion site and berm

Figure #6 – Upper Site 3B – Channel reconstruction

Figure #7 – Site 3B – Spawning riffles with substrates restored

Figure #8 – Site 3B – Abutment placement in spawning channel