HADD Compensation Project:
Restoration of Cantley Creek Fish Habitat

Submitted April 2005

Atlantic Coastal Action Program-Cape Breton

P.O. Box 28 Station A, Sydney, Nova Scotia, B1P 6G9;
Ph: 902-567-1628, Fax: 902-567-6282

Executive Summary

This project was done as compensation mandated under the federal Fisheries Act for "harmful alteration, disruption or destruction: (HADD) of fish habitat. DFO defines a HADD as "... any change in fish habitat that reduces its capacity to support one or more life processes of fish". The HADD addressed in this project was associated with ramp construction required for the twinning of Highway 125 at Coxheath (Figure 1). This work involved a culvert extension and realignment of a 170 m length of Cantley Creek which was assessed to result in loss of fish habitat downstream of the planned culvert extension and upstream of the waterways re-connection with Cantley Creek. To compensate for this impact ACAP-Cape Breton was contracted to develop and deliver a fish habitat enhancement project that would result in the creation of equivalent or better habitat at the level of approximately 3 to 1 enhanced habitat to replaced habitat. ACAP-Cape staff made a preliminary assessment of the fish habitat restoration needs of Cantley Creek in the spring of 2004. At this time it was determined that fish habitat within the creek is impaired due to embedded substrate and poor pool development throughout the entire length of the stream. Also, insufficient canopy cover and absence of bank stabilizing vegetation was found to occur along the lower portion of the creek that runs parallel to highway 125 and within the residential areas near the railroad tracks and the Cantley Village subdivision. ACAP-Cape Breton staff proposed a habitat restoration plan based on this assessment that included digger log installation throughout the lower 650 m of brook and the planting of bankside vegetation in areas identified in the assessment. Pre-restoration habitat assessments were carried out in August of 2004 in order to establish baseline data that could be used to quantify changes that result from the restoration work. The actual restoration work was carried out between August and 1 and October 31. Monitoring of restoration work will be carried out over a five-year period (from 2005-2009) to ensure proper functioning of digger logs, survival of bankside vegetation and to quantify changes in fish habitat and fish populations within Cantley Creek.

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1.0 Project Background

This project was carried out by the Atlantic Coastal Action Program of Cape Breton (ACAP-CB). ACAP-CB is a non-profit charitable organization that was set up in 1992 to develop and implement a Comprehensive Environmental Management Plan (CEMP) for the Sydney River watershed. The plan was developed over a five-year period through extensive public consultation. The end product was a document with eleven clearly stated goals providing a holistic vision of what the community is striving for: clean air and water, clean, safe and accessible spaces, protected habitats, properly managed waste, and a healthy community whose citizens make informed decisions. ACAP has spent the last six years implementing the plan through various projects. These projects have included ecological health assessments for over 100 km of freshwater fish habitat and restoration of over 40 km of fish habitat which has included the installation of 273 digger logs, extensive bankside planting, and the construction of 20 Fording sites aimed at remediating and mitigating the damage All Terrain Vehicles have on streams. Through the delivery of these projects, ACAP has developed extensive knowledge and skills related to freshwater fish habitat restoration and monitoring. This knowledge and skill set made ACAP-CB the logical choice to carry out this project.

This restoration project was done as compensation mandated under the federal Fisheries Act for "harmful alteration, disruption or destruction (HADD) of fish habitat. DFO defines a HADD as "... any change in fish habitat that reduces its capacity to support one or more life processes of fish". The HADD addressed in this project was associated with ramp construction required for the twinning of Highway 125 at Coxheath, near the town of Sydney, Nova Scotia (Dillon Consulting Limited, 2003).This work involved a culvert extension and realignment of approximately 170 m length of Cantley Creek which was assessed to result in loss of fish habitat downstream of the planned culvert extension and upstream of the waterways re-connection with Cantley Creek. To compensate for this impact ACAP-CB was contracted to develop and deliver a fish habitat enhancement project that would result in the creation of equivalent or better habitat at the level of approximately 3 to 1 enhanced habitat to replaced habitat.

Based on HADD compensation project guidelines preferred locations are those in which compensation results in the creation of similar habitat at or near the development site, within the same ecological unit that supports the same fish stock or species. Inspection by ACAP and DFO staff identified an appropriate location on Cantley Creek downstream of the footprint area. The location appeared to suffer from habitat degradation that was predicted to respond well to habitat enhancement. This degradation included a lack of riparian vegetation, poor pool development and stream bed siltation. This section of Cantley Creek was therefore targeted for restoration.

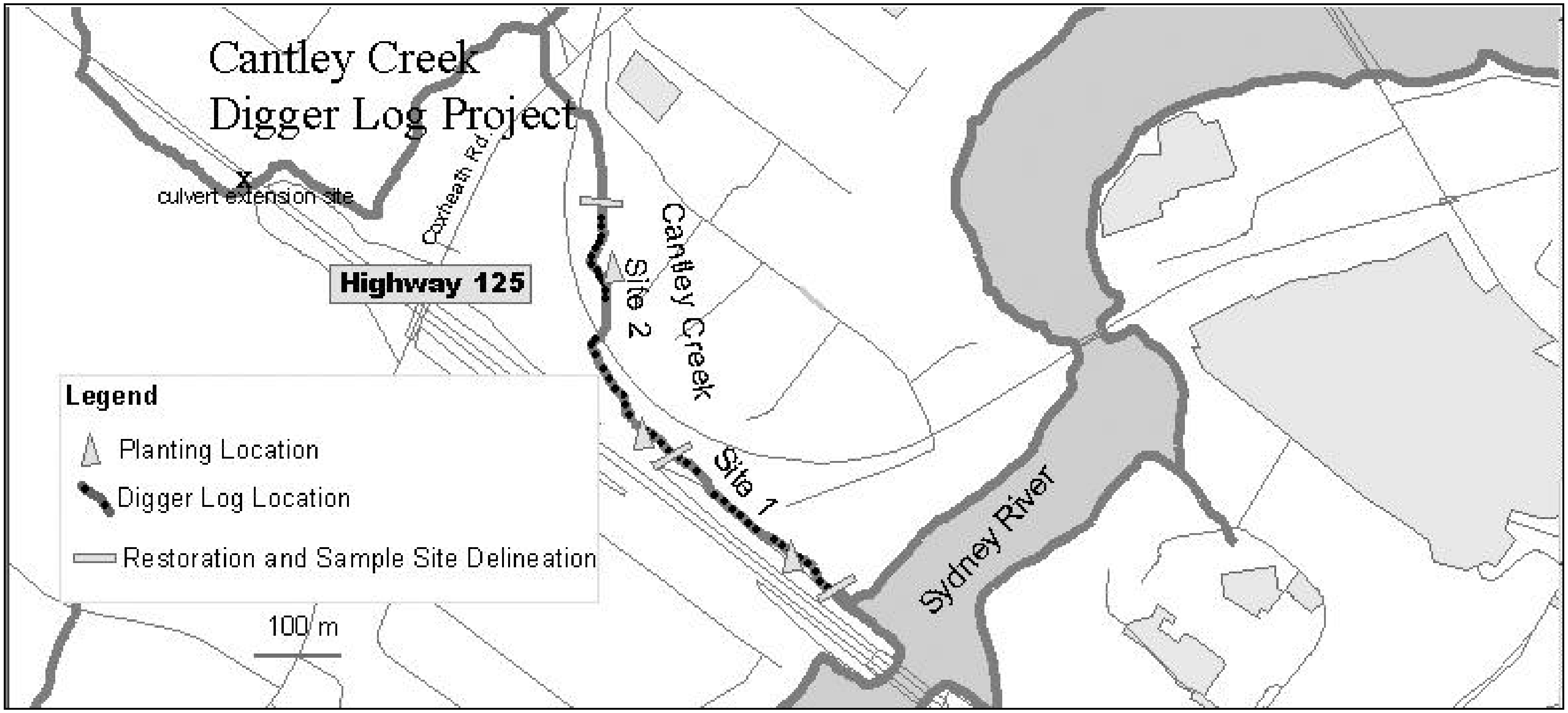

Figure 1. Map Restoration Site on Cantley Creek.

2.0 Habitat Restoration

Public Outreach

Prior to commencement of restoration work, all landowners along the banks of the lower Cantley Creek were identified (through landowner records) and informed by letter about the restoration project. The letter provided residents with information on the nature of the project including reason for the project, as well as dates and a description of the type of work that would be carried out. Landowners whose properties would have to be crossed in order to access work sites were also contacted in person to obtain permission. Additional contact with landowners occurred to obtain permission and assistance with maintenance of (e.g. not mowing down) bankside vegetation planted adjacent to their property.

Digger Logs

Digger logs were chosen to address the issues of poor pool development and siltation within the lower Cantley Creek. Digger logs represent low cost tools that can be installed by hand with minimal disturbance. Once installed, they mimic large organic debris, which embeds itself at the change in gradient from a riffle/run to a pool (Figure 2). These structures serve to create pools that provide fish protection from high summer water temperatures, increase stream oxygen levels and clean silt from spawning substrate.

An assessment of restoration potential by ACAP staff determined that the depth and rate of flow of Cantley Creek upstream of forks (where tributary joins stream) was insufficient to support digger log installation. However, it was felt that digger logs would effectively increase fish habitat in the portion of brook occurring approximately 100 m downstream of the culvert running under the railroad tracks (N 46° 06' 73.0" W 60° 14' 28.0) to the outflow into the Sydney harbour (N 46° 06' 44.6." W 60° 14' 02.3") (Figure 1). A field inspection by DFO staff confirmed these findings and gave the go ahead to proceed with HADD restoration work of the lower 650 meters of Cantley Creek. Permit applications were obtained from the Nova Scotia Department of Environment and Labour (NSDEL) and DFO's Navigatible Waters and Habitat divisions.

Figure 2. Digger Log installed by ACAP-Cape Breton on Cantley Creek August, 2004.

DFO Habitat Specialist, Darren Hiltz provided on-site consultation to determine digger log spacing and ensure that correct installation methods were followed. Placement sites for digger logs along the target 650 meters of Cantley Creek was determined using the "every 6-channel width" rule. Channel width was estimated to be 2 m on the lower section of Cantley making digger log placement every 12 m. On the upper section channel width decreased to 1.33 m making digger log placement every 8 m. A total of 43 logs were installed within the 650 m stream section.

All logs were sized on site to be no more than ¼ of the bank height and averaged 15 cm to 20 cm in diameter. They were placed across the stream on a 30° angle from the perpendicular. The upstream end of the log was set lower than the downstream end to direct flow on the pool-side of the brook and allow for improved fish passage. Logs were drilled every 2 m to tightly accommodate a 1.5 cm rebar 1.25 m long, which was driven through the log. Fifteen centimeters of the rod was bent over to keep the log from floating up. Both ends of the log were well rocked with stream cobble and small boulder to non-vegetated channel height (Figure 3). A cobble/small boulder ramp was constructed on the upstream side of the log on a 2:1 slope using material from the downstream side where the pool was to form. This ramp protects the log from ice and debris damage and forms a base upon which gravels, sorted by the flow over the next couple of years, collects to form spawning and fry nursery areas.

Figure 3. Installation of digger log by ACAP staff, August 2004.

Vegetation Enhancement of Stream Banks

Identification of bankside areas in need of re-vegetation and determination of the appropriate re-vegetation methods were determined and carried out in consultation with vegetation specialist Diane LaRue (Nova Scotia Department of Transportation and Public Works). A combination of waddles, live stakes and seedlings were used to stabilized banks and enhance stream cover within areas identified.

Waddles and Live Stakes

In October, 2004 18 waddles were placed on the steep eroding embankment occurring in the upper stream portion of the restoration area (Figure 1.). The waddles consisted of a bundle of branches belonging to a 'self-rooting' tree (Figure 4). These waddles act as barriers, stopping soil and water from running down into the stream during rainfall. The waddle structure also helps maintain bank stability by mechanically preventing erosion. Eventually, as the stakes and branches root, these structures will also provide biological protection against erosion with trees acting as buffers for runoff and their roots holding soil in place.

For this project willows were used to construct waddles. Branches were cut from trees near the site two days prior to planting (without damaging trees). Lengths of branches varied with the majority of branches being between 3 and 5 feet long. Bundles included a range of branch sizes that were tightly bound with twine at both ends (Figure 4). The branches chosen had growing tips pointing in both directions and were approximately 3 inches in diameter. In placing waddles, two live support stakes were pounded into the ground (Figure 4). Stakes were buried ¾ of the way into the ground with 2-4 nodes appearing above the soil. The waddle was placed behind the two stakes up the side of the slope. Another stake was pounded through the bundle into the soil to ensure the waddle stays in place until spring when the branches and stakes begin to root. Soil and detritus were used to cover the top of the waddle to help prevent the branches from drying out.

(A)

(B)

Figure 4. (A) Waddles placed on steep eroding bank of Cantley Creek; (B) binding of waddles. October 2004.

Seedling Planting

Black Spruce seedlings were planted in three separate treeless low-slope bank areas along the creek. Tree roots will act to stabilize the soil and prevent erosion, and once grown the trees will act as a barrier to help protect the creek from road salt splash coming from the highway situated in close proximity to the stream. Shade provided by these trees once mature, will also serve to enhance fish habitat by reducing summer water temperatures.

The spruce was planted using a dibble or a shovel and their root plugs were so that the top of the plug was either flush or slightly below the surface of the soil (Figure 5). Care was taken not to bury sapling laterals and to ensure that the trees plugs were vertical in the soil.

Trees were planted approximately 3 feet apart. Ninety trees were planted along the banks of the first site situated within the upper reach of Cantley (Figure 1). Two rows were planted along the mowed side of the creek, the opposite side was covered in brush and naturally seeded trees, this side was therefore planted more randomly, with trees placed only in areas with sufficient space and sunlight.

The second, and larger, planting site occurred at along the lower reach (Figure 1). A total of 160 trees were planted along this side of the creek bank which was in close proximity to the highway. Trees were planted along the bank in rows; sections with dense brush were avoided.

(A)

(B)

Figure 5. (A) Planting Black spruce seedling with dibble along lower section of Cantley Creek (silt fence from highway construction seen in background). (B) Black spruce seedling. October 2004.

3.0 Assessment & Monitoring

ACAP-Cape Breton staff collected data to determine pre-restoration conditions of Cantley Creek. This included the collection of information on fish populations, physical habitat quality, stream macro-invertebrates, and water quality. Subsequent post-restoration monitoring will be carried out to track changes that result from restoration. Two distinct sites or "reaches" were sampled within the lower Cantley Creek restoration site (Figure 1). These sites were chosen based on the assessment that they represented two distinct habitat areas. The lower site represented an area with very degraded fish habitat including very shallow water depths and an almost total lack of Riparian vegetation along the right bank. The second site represented a more upstream area with moderately degraded fish habitat which included sparse riparian vegetation and very poor pool development. Digger logs and riparian planting was carried out in both sections.

Habitat Assessment

A general evaluation of geographical and physical characteristics of the restoration locations on Cantley creek was made using the Ohio State Environmental Protection Agency's Qualitative Habitat Evaluation Index (QHEI) (Ohio-EPA, 1989). The QHEI is composed of an array of metrics that describe attributes of physical habitat that may be important in explaining the species presence, absence, and composition of fish communities in a stream. The field procedures and scoring criteria for the QHEI are described in Ohio EPA (1989). The field sheet for the QHEI consists of lists of qualitative descriptors that are checked as appropriate (Appendix A). Highest scores are assigned to the habitat parameters that have been shown to be correlated with streams that have high biological diversity and biological integrity with progressively lower scores assigned to less desirable habitat features. For example, a wide riparian width, > 50 m would be assigned a 4 and areas with narrower riparian width would be assigned progressively lower scores down to a score of zero for no riparian vegetation.

The overall QHEI scores for the two Cantley Creek reaches were 37 for the lower reach and 55 for the upper site (Table 1). The highest possible score is 100 and streams with scores >60 are considered to have "good to excellent fish habitat" (Ohio-EPA, 1989). The lower Cantley Creek scored receive a 0 for instream cover. This is due to the fact that there is insufficient water depth in this reach (<20 cm) to make instream cover useful. The lower site also scored low on Channel Quality and Pool/Riffle due to a complete lack of pool development. The upper reach also lacked pool development. Both sites scored low (5/10) in the Riparian/Erosion category due to a lack of bankside vegetation and presence of eroding banks (in upper section). Post restoration QHEI scores should rise due to the creation of pools by digger logs and the increase in bank stabilizing riparian vegetation.

Table 1. Pre-restoration Cantley Creek (2004) habitat scoring for two sites assessed on Cantley Creek using Quality Habitat Evaluation Index. Metrics highest possible score in parentheses.

Metric	Site 1 Score	Site 2 Score
Substrate (max - 20 pts)	16	16
Instream Cover (max - 20 pts)	0	10
Channel Quality (max - 20 pts)	5	11
Riparian/Erosion (max- 10 pts)	5	5
Pool Riffle (max - 20 pts)	5	7
Gradient (max - 10 pts)	6	6
Total Score (100 pts)	**37**	**55**

Fish Population Assessment

Fish population assessment took place within the Cantley Creek restoration area. An upper and lower site was sampled within this area. The lower stream section was 26 meters in length and the upper stream section 29 meters in length. Permanent markers were placed at the sampling sites in order to allow for re-sampling in subsequent years. Nets were used to contain fish within these sections and fish surveys were conducted by electrofishing using a backpack Electrofisher on August 11, 2004. One person operated the backpack Electrofisher while two other individuals used dip nets to capture the stunned species. Sweep times ranged from 143-176 seconds. The captured specimens were placed into a five-gallon bucket containing stream water. When the survey time ended, aquatic species were enumerated, weighed using a hand scale and measured to total length. All fish were identified to the lowest possible taxonomic level. Water temperature at sampling time was 15 ° C.

No fish were found in two complete sweeps of the lower section. It required 5 sweeps to enumerate all fish within the upper section. This upper section contained a total of 28 Brook Trout. No other species of fish were found. The average length and weight of Brook Trout within the upper section of Cantley was 144.6 mm (± 42.8 SD) and 49.2 g (± 33.2) respectively. Size distributions are shown in Figure 6. Within two years of the restoration, we predict that fish will begin to utilize the lower reach of Cantley creek. We also predict an increase in the use of the upper reach.

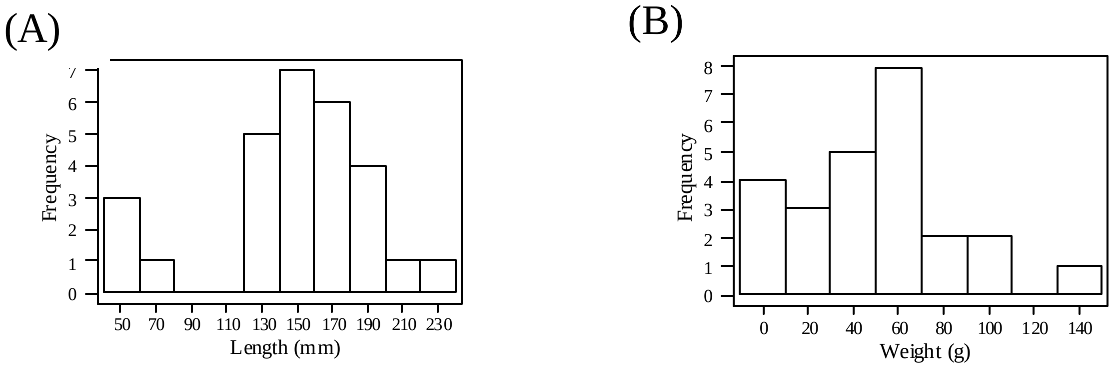

Figure 6. (A) Length and (B) weight distribution for Brook Trout electrofished in Cantley Creek August 11, 2004.

Macroinvertebrate Community.

Pre-restoration habitat quality of Cantley creek was further assessed using protocols outlined in the Canadian Aquatic Biomonitoring Network program. This is a program established by Environment Canada that provides standardized field protocols and analytical methods for the assessment of streams using benthic macroinvertebrates. The field protocols involve collection of benthic invertebrates via kick-net and the collection of a suite of biological, chemical and habitat data. Details of methods are outlined in (Reynoldson et al 1999). The data is analysed using the Reference Condition Approach (Bailey et al 2004) for assessing environmental health of streams. The Reference Condition Approach provides a technique that will allow us to compare the environmental health of Cantley Creek with an array of appropriate reference sites. We will use this method (with consultation from Environment Canada) to assess pre-restoration health of the stream and track remediation over a five year period. Baseline macroinvertebrate data along with a list of environmental variables collected are presented in Appendix B and C.

Water Chemistry

Pre-restoration water chemistry data was collected within the restoration area of Cantley Creek (Appendix C). No values exceeded those listed in the Canadian Environmental Quality Guidelines for protection of aquatic life (CCME 2003). Conductivity, total phosphorous, nitrate, and alkalinity/major ions will be utilized for predicting the invertebrate community characteristics as part of the Canadian Aquatic Biomonitoring Network stream assessment protocol. Additional baseline information is available in the Dillon-ADI (2003) environment assessment document that was prepared to support the HADD authorization (sample collected ~ 190 m downstream of Highway 125 on October 3, 2003; this sampling site is approximately 700 m upstream of the Restoration site).

With the exception of dissolved oxygen (which may increase due to increased water agitation and decreased water temperature in pools caused by digger logs) water chemistry is not expected to be altered by the restoration completed on Cantley Creek. However, some changes in water chemistry (e.g. nutrients, conductivity and acidity) may arise as a consequence of ongoing and future road construction in the upper portions of the watershed (> 800 m upstream of the restoration area). Specifically, the realignment of ~170 m of Cantley Creek near the Coxheath interchange and the alteration or infilling of three wetlands (Wetlands 4610602-515, -531, and 536; see Dillon-ADI (2002; 2003) environmental assessment screening report for further details).

4.0 Post-restoration monitoring and maintenance plan

Monitoring will be carried out to ensure proper functioning of digger logs, survival of bankside vegetation and to quantify changes in fish habitat and fish populations within Cantley Creek. What follows is a summary description of proposed monitoring plan including dates and times the work will take place. A detailed monitoring and maintenance schedule with budget allocations can be found in Appendix D.

Digger Logs Monitoring and Maintenance

Digger logs will be checked on an annual basis (from 2005-2009) during low flow periods (July-August) to determine if they are functioning as intended (visual inspection and photographs). Any instability observed in digger logs will be repaired as soon as possible. ACAP-Cape Breton will obtain approvals.

Vegetation Enhancement Monitoring and Maintenance

Riparian vegetation maintenance will occur as often as deemed necessary to ensure survivorship. This may include, but is not limited to, watering and cutting back of competitive weeds.

The 18 waddles installed along the steep embankment were monitored into midwinter, 2004 to ensure that the waddle structures were stable and strong enough to support the winter snowfall. No waddles were found to have broken or dislodged. In the spring, 2005 the structures will once again be observed to determine the rate at which the structures were able to root and grow. ACAP will continue to monitor the waddle structures periodically throughout the summer of 2005, and over the following years (2006-2007) to observe the growth and beneficial effects provided by these structures.

The 300 Black spruce seedlings will be monitored in the spring of 2005, 2006 and 2007. Trees not surviving the winter will be replaced at this time. Survival rate will be assessed throughout the coming years with reference to seedling site, seedling proximity to creek and other competition.

Monitoring Fish Population and Habitat Changes

Changes in fish habitat and number of fish population within the portion of Cantley Creek targeted for restoration will be quantified by re-assessing the brook using QHEI habitat protocols in 2005 and 2006 with a potential repeat in 2008. In addition, changes in the overall water quality and overall stream health will be tracked using Canadian Aquatic Biomonitoring Network protocols (Reynoldson et al. 1999) with re-sampling to occur in 2006. Fish biomass will be resurveyed in 2006 and 2009 to quantify any changes in fish populations that occur once enhanced habitat has been created. Pre-restoration sampling protocols will be strictly replicated for all post-restoration monitoring. This will allow for meaningful comparisons over time.

Appendix A: QHEI habitat assessment data sheet.

Ohio EPA Site Description Sheet for evaluating the geographical and physical characteristics of fish sampling locations. This is used to record information for the calculation of the Qualitative Habitat Evaluation Index (QHEI).

Ohio EPA Site Description Sheet - Fish QHEI SCORE: [ ]

Stream______ RM______ Date______ River Code______

Location______ Crew:______

1] SUBSTRATE (Check *ONLY* Two Substrate *TYPE BOXES; Check all types present*); SUBSTRATE SCORE: [ ]

TYPE POOL RIFFLE — POOL RIFFLE — SUBSTRATE QUALITY

- □□-BLDER /SLABS[10]-____ ____ □□-GRAVEL [7]- ____ ____
- □□-BOULDER [9] ____ ____ □□-SAND [6] ____ ____
- □□-COBBLE [8] ____ ____ □□-BEDROCK[5] ____ ____
- □□-HARDPAN [4] ____ ____ □□-DETRITUS[3] ____ ____
- □□-MUCK [2] ____ ____ □□-ARTIFIC.[0] ____ ____

Substrate Origin (Check all): □-LIMESTONE [1] □-RIP/RAP [0] □-TILLS [1] □-HARDPAN [0] □-SANDSTONE [0] □-SHALE [-1] □-COAL FINES [-2]

Silt Cover (Check One): □-SILT HEAVY [-2] □-SILT MODERATE [-1] □-SILT NORMAL [0] □-SILT FREE [1]

Extent Of Embeddness (Check One): □—EXTENSIVE [-2] □—MODERATE[-1] □—LOW[0] □—NONE[1]

TOTAL NUMBER OF SUBSTRATE TYPES: □> 4 [2] □— <= 4 [0]

NOTE: (Ignore sludge that originates from point-sources; score is based on natural substrates)

COMMENTS______

2] INSTREAM COVER COVER SCORE: [ ]

TYPE (Check *All* That Apply)

- □-UNDERCUT BANKS [1] □-DEEP POOLS [2] □-OXBOWS [1]
- □-OVERHANGING VEGETATION [1] □-ROOTWADS [1] □-AQUATIC MACROPHYTES [1]
- □-SHALLOWS (IN SLOW WATER) [1] □-BOULDERS [1] □-LOGS OR WOODY DEBRIS [1]

AMOUNT(Check *ONLY* One or check 2 and *AVERAGE*): □- EXTENSIVE > 75% [11] □- MODERATE 25-75% [7] □- SPARSE 5-25% [3] □- NEARLY ABSENT < 5%[1]

COMMENTS:______

3] CHANNEL MORPHOLOGY: (Check *ONLY* One PER Category OR check 2 and *AVERAGE*) CHANNEL: [ ]

SINUOSITY	DEVELOPMENT	CHANNELIZATION	STABILITY	MODIFICATIONS/OTHER	
□- HIGH [4]	□- EXCELLENT [7]	□- NONE [6]	□- HIGH [3]	□- SNAGGING	□- IMPOUND.
□- MODERATE [3]	□- GOOD [5]	□- RECOVERED [4]	□- MODERATE [2]	□- RELOCATION	□- ISLANDS
□- LOW [2]	□- FAIR [3]	□- RECOVERING [3]	□- LOW [1]	□- CANOPY REMOVAL	□- LEVEED
□- NONE [1]	□- POOR [1]	□- RECENT OR NO RECOVERY [1]		□- DREDGING	□- BANK SHAPING
				□- ONE SIDE CHANNEL MODIFICATIONS	

COMMENTS:______

4] RIPARIAN ZONE AND BANK EROSION - (check ONE box per bank or check 2 and AVERAGE per bank) RIPARIAN: [ ]

River Right Looking Downstream

RIPARIAN WIDTH — L R (Per Bank)

- □□-WIDE>50m [4]
- □□-MODERATE 10-50 [3]
- □□-NARROW 5-10m [2]
- □□-VERY NARROW 1-5m [1]
- □□-NONE[0]

EROSION/RUNOFF - FLOOD PLAIN QUALITY — L R (Most Predominant Per Bank) L R (Per Bank)

- □□-FOREST, SWAMP [3] □□-URBAN OR INDUSTRIAL[0]
- □□-OPEN PASTURE/ ROWCROP[0] □□-SHRUB OR OLD FIELD[2]
- □□- RESID.,PARK,NEW FIELD [1] □□-CONSERV. TILLAGE [1]
- □□-FENCED PASTURE [1] □□-MINING/CONSTRUCTION [0]

BANK EROSION

- □ □-NONE OR LITTLE [3]
- □ □-MODERATE [2]
- □ □-HEAVY OR SEVERE[1]

COMMENTS:______

POOL/GLIDE AND RIFFLE/RUN QUALITY POOL: [ ]

MAX. DEPTH (Check 1)

- □- >1m [6]
- □- 0.7-1m [4]
- □- 0.4-0.7m [2]
- □- < 0.4m [1]
- □—<0.2m [Pool = 0]

MORPHOLOGY (Check 1)

- □-POOL WIDTH > RIFFLE WIDTH [2]
- □-POOL WIDTH = RIFFLE WIDTH [1]
- □-POOL WIDTH < RIFFLE W. [0]

POOL/RUN/RIFFLE CURRENT VELOCITY (Check *All* That Apply)

- □-TORRENTIAL[-1] □-EDDIES[1]
- □-FAST[1] □-INTERSTITIAL[-1]
- □-MODERATE [1] □-INTERMITTENT[-2]
- □-SLOW [1]

[□-NO POOL[0]]

COMMENTS:______ RIFFLE: [ ]

RIFFLE/RUN DEPTH

- □- GENERALLY >10 cm,MAX>50 [4]
- □- GENERALLY >10 cm,MAX<50 [3]
- □- GENERALLY 5-10 cm [1]
- □- GENERALLY < 5 cm [Riffle = 0]

RIFFLE/RUN SUBSTRATE

- □-STABLE (e.g.,Cobble, Boulder) [2]
- □-MOD. STABLE (e.g.,Pea Gravel) [1]
- □-UNSTABLE (Gravel,Sand) [0]

RIFFLE/RUN EMBEDDEDNESS

- □-EXTENSIVE [-1] □-MODERATE[0]
- □-LOW. [1] □-NONE[2]

[□-NO RIFFLE[0]]

COMMENTS______ GRADIENT: [ ]

5] Gradient (feet/mile):______ %POOL:______ %RIFFLE:______ %RUN:______

EPA 4520

V-4-19

Appendix B: Stream invertebrate Data

	Cantley Site 1	Cantley Site 2
TAXA		
MOLLUSCA		
Gastropoda-Physidae	1	
Gastropoda-Planorbidae		
Gastropoda-Pleuroceridae		
Gastropoda-Limnaeidae		
ANNELIDA		
Oligochaeta		
Tubificida-Naididae	1	
Lumbricina (earthworms)	2	
INSECTA		
Coleptera		
Elmidae	147	87
Elmidae (adults)	1	2
Dytiscidae (adults)	7	
Diptera		
Ceratopogonidae		
Chironomidae	8	24
Dolichopodidae	1	
Empididae		
Psychodidae		3
Simuliidae		
Tipulidae	7	2
Diptera Adult		
Ephemeroptera		1
Heptageneidae	7	3
Ephemerellidae	2	5
Baetidae	10	30
Leptophlebiidae	6	3
Unidentified and Casts	8	79
Megaloptera		
Sialidae		
Odonata		
Gomphidae		
Plecoptera		
Chloroperlidae	1	4
Leuctridae		2
Perlidae	7	1
Perlodidae	40	46
Taeniopterygidae	4	12
Trichoptera		
Brachycentridae	1	
Glossosomatidae		
Hydroptilidae		
Hydropsychidae	2	
Lepidostomatidae		
Philopotamidae		2

Continued……		
Polycentropidae	5	
Rhyacophilidae		3
COLLEMBOLA		
Isotomidae		
Poduridae		
CRUSTACEA -Isopoda		
Asellidae		1
Oniscidae (*Philoscia vittata*)	2	
Oniscidae (*Porcellio* sp)-Terrestrial		
Unid. Family		1
HYDRACARINA	1	2
Tick/Spider		
TOTAL	**271**	**313**

Appendix C: Water Chemistry Results

Creating a New Kind of Company...

ACAP
P.O. Box 28, Stn A
Sydney, N.S. B1P 6G9
Tel/Fax: 567-6282

Sample Number: 9966778-02
Date Received: 11/15/04 13:22
Date Reported: 11/24/2004
Date Sampled:
Matrix: Water

Project Number: c/o Kellie White

Requested Analysis

Analysis	Method	Results	Units	Date
CAN0204				
Acidity	AWWA 2310 B.	<5	mg/l	11/17/2004
Alkalinity	AWWA 2320 B.	98	mg/l	11/16/2004
Sulfate	AWWA 4110 B.	18	mg/l	11/16/2004
Chloride	AWWA 4110 B.	70	mg/l	11/17/2004
Silica	AWWA 3500-Si.	9.1	mg/l	11/17/2004
Ortho Phosphorous	AWWA 4110 B.	<0.3	mg/l	11/16/2004
Nitrate/Nitrite	AWWA 4110 B.	0.27	mg/l	11/16/2004
Ammonia (N)	AWWA 4500-NH3	<0.1	mg/l	11/16/2004
Total Organic Carbon	AWWA 5310 B.	9.8	mg/l	11/17/2004
Colour (Apparent)	AWWA 2120 B.	33	TCU	11/16/2004
Turbidity	AWWA 2130 B.	0.6	NTU	11/16/2004
Conductivity	AWWA 2510 B.	530	umho/cm	11/16/2004
pH	AWWA 4500-H+	8.0	pH Units	11/16/2004
Aluminum	EPA 6020	0.019	mg/l	11/17/2004
Antimony	EPA 6020	<0.0004	mg/l	11/17/2004
Barium	EPA 6020	0.364	mg/l	11/17/2004
Beryllium	EPA 6020	<0.0005	mg/l	11/17/2004
Boron	EPA 6020	0.13	mg/l	11/17/2004
Cadmium	EPA 6020	<0.0003	mg/l	11/17/2004
Chromium	EPA 6020	<0.001	mg/l	11/17/2004
Cobalt	EPA 6020	<0.001	mg/l	11/17/2004
Calcium	EPA 6020	55.8	mg/l	11/17/2004
Copper	EPA 6020	<0.002	mg/l	11/17/2004
Iron	EPA 6020	<0.10	mg/l	11/17/2004
Lead	EPA 6020	<0.001	mg/l	11/17/2004
Lithium	EPA 6020	0.007	mg/l	11/17/2004

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Requested Analysis

9966778-02

Analysis	Method	Results	Units	Date
Manganese	EPA 6020	0.013	mg/l	11/17/2004
Molybdenum	EPA 6020	<0.004	mg/l	11/17/2004
Nickel	EPA 6020	<0.003	mg/l	11/17/2004
Silver	EPA 6020	<0.002	mg/l	11/17/2004
Sodium	EPA 6020	43.7	mg/l	11/17/2004
Thallium	EPA 6020	<0.0008	mg/l	11/17/2004
Tin	EPA 6020	<0.02	mg/l	11/17/2004
Uranium	EPA 6020	0.00112	mg/l	11/17/2004
Vanadium	EPA 6020	<0.002	mg/l	11/17/2004
Zinc	EPA 6020	<0.002	mg/l	11/17/2004
Strontium	EPA 6020	0.398	mg/l	11/17/2004
Magnesium	EPA 6020	4.70	mg/l	11/17/2004
Potassium	EPA 6020	1.7	mg/l	11/17/2004
Sulfur	EPA 6020	6.5	mg/l	11/17/2004
Arsenic	AWWA 3114 B.	0.0007	mg/l	11/17/2004
Selenium	AWWA 3114 B.	<0.001	mg/l	11/17/2004
Mercury	AWWA 4500-Hg	<0.001	mg/l	11/17/2004
TKN	AWWA 4500-Norg.	0.2	mg/l	11/23/2004
TPO4	AWWA 4500-P F.	0.02	mg/l	11/23/2004

TKN and TPO4 analysis was subcontracted to PSC-Bedford.

EAP Calculated Parameters

Hardness	158.69	mg/L	Cation Sum	5.13	meq/L
Bicarbonate	97.04	mg/L	Anion Sum	4.22	meq/L
Carbonate	0.91	mg/L	% Difference	9.76	%
Sat. pH	7.69	units	Ion Sum	9.34	meq/L
Sat. Index	0.31		Theo. Cond.	457.10	umhos/cm
TDS (Calc)	262.07				

Approved By: M. Mombourquette

Michelle Mombourquette
Lab Manager

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QAQC Results

ACAP
P.O. Box 28, Stn A
Sydney, N.S. B1P 6G9
Tel/Fax: 567-6282

Lab Number: **9966778**

24-Nov-04

Project ID: **c/o Kellie White**

Analysis		Units	Blank	Matrix Spike (%)	Initial Result	Duplicate Result	RPD Duplicate
Acidity							
122282	Acidity	mg/l	<5		<5	<5	0.0
EAP							
122416	Silica	mg/l	<0.2	115.9	0.6	0.5	18.2
122272	Alkalinity	mg/l	<1.0	91.5	61	62	1.6
122393	Sulfate	mg/l	<2.0	101.5	46	47	2.2
122390	Chloride	mg/l	<1.0	100.8	98	99	1.0
122392	Ortho Phosphorous	mg/l	<0.3	95.8	<0.3	<0.3	0.0
122391	Nitrate/Nitrite	mg/l	<0.06	103.8	<0.06	<0.06	0.0
122275	Ammonia (N)	mg/l	<0.1	97.7	<0.1	<0.1	0.0
122374	Total Organic Carbon	mg/l	<0.5	90.6	2.9	2.8	3.5
122273	Conductivity	umho/cm	<5.0	90.7	540	543	0.6
122274	pH	pH Units	5.4	99.6	7.2	7.2	0.0
122269	Colour (Apparent)	TCU	<5	96.7	>1000	>1000	0.0
122270	Turbidity	NTU	<0.1	105.0	300	300	0.0
Metal Scan - CCME (Water)							
122417	Aluminum	mg/l	<0.005	96.8	0.19	0.188	1.1
122418	Antimony	mg/l	<0.0004	105.3	<0.0004	<0.0004	0.0
122419	Barium	mg/l	<0.0004	122.9	0.0155	0.0145	6.7
122420	Beryllium	mg/l	<0.0005	123.0	<0.0005	<0.0005	0.0
122421	Boron	mg/l	<0.10	91.4	<0.1	<0.1	0.0
122422	Cadmium	mg/l	<0.0003	112.7	<0.000017	<0.000017	0.0
122423	Chromium	mg/l	<0.001	114.0	0.002	0.002	0.0
122424	Cobalt	mg/l	<0.001	115.6	0.002	0.002	0.0
122425	Calcium	mg/l	<0.10	104.8	498	484	2.9
122426	Copper	mg/l	<0.002	104.7	0.003	0.003	0.0
122427	Iron	mg/l	<0.10	112.0	<0.1	<0.1	0.0
122428	Lead	mg/l	<0.001	114.4	<0.001	<0.001	0.0

QAQC Results

ACAP
P.O. Box 28, Stn A
Sydney, N.S. B1P 6G9
Tel/Fax: 567-6282

Lab Number: **9966778**

24-Nov-04

Project ID: **c/o Kellie White**

Analysis		**Units**	**Blank**	**Matrix Spike (%)**	**Initial Result**	**Duplicate Result**	**RPD Duplicate**
122429	Lithium	mg/l	<0.001	79.8	0.069	0.071	2.9
122430	Manganese	mg/l	<0.004	115.0	7.54	7.85	4.0
122431	Molybdenum	mg/l	<0.004	109.3	<0.004	<0.004	0.0
122432	Nickel	mg/l	<0.003	108.7	0.005	0.005	0.0
122433	Silver	mg/l	<0.002	99.5	<0.0001	<0.0001	0.0
122434	Sodium	mg/l	<0.30	119.9	172	168	2.4
122435	Thallium	mg/l	<0.0008	117.5	<0.0008	<0.0008	0.0
122436	Tin	mg/l	<0.02	107.4	<0.02	<0.02	0.0
122437	Uranium	mg/l	<0.00015	106.0	<0.00015	<0.00015	0.0
122438	Vanadium	mg/l	<0.002	118.0	<0.002	<0.002	0.0
122439	Zinc	mg/l	<0.002	110.6	0.007	0.008	13.3
122440	Strontium	mg/l	<0.002	112.0	2.21	2.16	2.3
122441	Magnesium	mg/l	<0.06	115.0	105	103	1.9
122442	Potassium	mg/l	<0.6	114.0	4.6	4.7	2.2
122443	Sulfur	mg/l	<3.7	94.4	588	591	0.5
122444	Arsenic	mg/l	<0.0006	107.0	0.0007	0.001	35.3
122445	Selenium	mg/l	<0.001	110.0	0.004	0.005	22.2
122446	Mercury	mg/l	<0.001	84.0	<0.0001	<0.0001	0.0

Note: Quality Control samples are processed with every batch of 15-20 samples and are not client specific.

M. Mmbourgeois

Alison Wilson, P. Eng.
Quality Supervisor

Appendix D: Monitoring and Maintenance Schedule/Budget

Post Compensation Monitoring & Maintenance Schedule
&
Budget Allocation

(for remainder of project)

Monitoring	**Dates & Time Required**	**Costs Remaining**
Habitat structure inspection - Digger logs checked to determine if they are functioning as intended (visual inspection and photographs)	2005 -2009 Coordinator - 1 day for 5 years (1 week)	$105/yr (total $525)
Fish habitat survey - Development of rearing/feeding and potential spawning habitat assessed using DFO protocols within the compensation area. Consistent with pre-construction survey. Work involved field data collection, data entry, analysis and report writing.	2005, 2006 Coordinator - 3 days/year for 3 years (9 days) Assistant – 2 days/year for 3 years (6 days) -	$315/yr (total $1365)
Fish biomass survey - Using same protocols and same locations as pre-construction survey - quantify net gain in productive capacity using a before/after, control/impact design. Work would include identification of appropriate control streams. Data entry, analysis, report preparation.	2006, 2009 Coordinator 1 week/ year for 3 years (3 weeks) -	$787/yr (total $1575)
Track changes in water quality and overall stream health using **C**anadian **A**quatic **Bi**omonitoring **N**etwork (CABIN) protocols (Reynoldson et al. 1999). For Cantley Creek and appropriate reference stream.	2006 Coordinator (2 days) - Assistant (2 days) -	$350/yr (labour) $1950/yr (analysis) total ($2300)
Riparian vegetation monitoring Assessment of survival rates will be made by counts of plantings. Goal is 90% survival.	2005-2008 Coordinator 1 day/ year for 4 years (4 days) -	$105/yr total ($420)

Maintenance	Dates & Time Required	Costs
Digger Logs – Any instability observed in digger logs will be repaired as soon as possible. ACAP-Cape Breton will obtain approvals	2005-2009 Coordinator 1 day for permit prep for 5 years (1 week) - Restoration staff 3 days/ year for 5 years (3 weeks) -	$640/yr total ($3202)
Riparian vegetation – maintenance will occur as often as deemed necessary to ensure survivorship. This may include, but is not limited to, watering and cutting back of competitive weeds. Details of riparian vegetation maintenance plan will be developed in consultation with Diane LaRue (TPW's vegetation specialist).	2005-2007 Restoration staff 2 days/year for 3 years (~1 week)	$357/yr total ($1071)

Budget Breakdown by Year

	2004	**2005-2009**
	$22,833	$10,458

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