An Audit of Small Culvert Installations in Nova Scotia: Habitat Loss and Habitat Fragmentation

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By

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ABSTRACT

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This report evaluates fish habitat loss and fish habitat fragmentation with respect to the installation of small culverts in Nova Scotia. A random sample of fifty culvert notifications was selected for this study. The sample was taken from two seasons (1999 and 2000) and from four counties in Nova Scotia (Colchester, Cumberland, Halifax, and Hants). Details such as culvert design, dimensions, culvert bottom location, and slope were recorded. Observations such as siltation of stream substrate, erosion, fish passage problems, and culvert damage were documented. Photographs of the culvert and area were also taken.

Results indicate that a significant portion of the selected culvert installations contributed to both habitat loss and fragmentation. In most cases, habitat loss was evident for both the culvert footprint as well as adjacent habitat. Much of this loss and fragmentation could have been reduced or eliminated by redesign. Where losses were cumulative (i.e. several installations by the same proponent or the same stream), issuing a *Fisheries Act* section 35 authorization with compensation could have been an option to achieve the no net loss guiding principle for the management of fish habitat.

Results show the need for a monitoring program if development activities such as culvert installations are to be risk managed effectively and efficiently. This report recommends an annual random monitoring program that would audit these activities resulting in less habitat loss in order to fulfil the first strategy of "Protection and Compliance" outlined in the DFO Policy for the Management of Fish Habitat. The results of this monitoring program can also be used as a tool for applying other strategies in the Policy in order to achieve the objective of net gain of productive capacity for fisheries resources.

Key Words: audit, culvert, DFO Policy for the Management of Fish Habitat, fish passage, habitat fragmentation, habitat loss, monitoring, no net loss, net gain of productive capacity, risk management, slope

RÉSUMÉ

Langill, D.A., and P.J. Zamora. 2002. An audit of small culvert installations in Nova Scotia: habitat loss and habitat fragmentation. Can. Tech. Rep. Fish. Aquat. Sci. 2422: vii + 35p.

Le présent rapport évalue les pertes et fragmentations occasionnées à l'habitat du poisson par l'installation de petits ponceaux en Nouvelle-Écosse. Pour cette étude, on a échantillonné au hasard cinquante avis de pose de ponceau sur deux saisons (1999 et 2000) et dans quatre comtés de la Nouvelle-Écosse (Colchester, Cumberland, Halifax et Hants). On a relevé des données sur la conception des ponceaux, sur leurs dimensions, sur leur emplacement au fond et sur leur pente. On a également documenté des observations comme l'envasement du substrat des cours d'eau, l'érosion, les problèmes de passage du poisson et les dommages aux ponceaux. Des photos des ponceaux et de leurs alentours ont été prises.

Les résultats révèlent qu'une bonne partie des installations de ponceaux ont contribué à la fois à une perte d'habitat du poisson et à une fragmentation de cet habitat. Dans la plupart des cas, la perte d'habitat était manifeste tant à l'emplacement du ponceau que dans la zone adjacente. Une modification de la conception du ponceau aurait pu réduire en bonne part ou éliminer cette perte et fragmentation d'habitat. Dans le cas de pertes cumulées (dues à plusieurs installations par le même promoteur ou dans le même cours d'eau), l'octroi d'une autorisation portant compensation en vertu de l'article 35 de la *Loi sur les pêches* aurait pu permettre de respecter le principe d'absence de perte nette régissant la gestion de l'habitat du poisson.

Il ressort également des résultats qu'un programme de surveillance est nécessaire pour bien gérer les risques associés à des activités d'aménagement comme l'installation de ponceaux. Le présent rapport recommande un programme de surveillance annuelle aléatoire, qui consisterait à vérifier les activités aboutissant à une perte d'habitat, cela afin de satisfaire aux exigences de la première stratégie de « protection et respect des règlements » décrite dans la Politique de gestion de l'habitat du poisson du MPO. Les résultats de ce programme de surveillance pourraient aussi servir d'outil d'application des autres stratégies de la politique en vue d'attendre l'objet de gain net de la capacité de production pour les ressources halieutiques.

Mots-clés : vérification, ponceau, Politique de gestion de l'habitat du poisson du MPO, passage du poisson, fragmentation de l'habitat, perte d'habitat, surveillance, absence de perte nette, gain net de la capacité de production, gestion des risques, pente.

INTRODUCTION

The improper installation of culverts in streams and rivers can effect aquatic resources in several ways including the alteration of natural stream alignment, disruption of adjacent fish habitat, creation of a barrier to migration, and destruction of fish habitat at the installation footprint. Most culverts are installed in small streams of 1st or 2nd order. This is particularly important to Nova Scotia which has a predominance of 1st and 2nd order streams per unit area, second only to Prince Edward Island.

The Nova Scotia Department of Environment and Labour (NSDEL) uses a culvert notification system to regulate the installation of small culverts that tend to fit 1st and 2nd order streams (<1.0 m). These culverts must meet a set of stipulations outlined in the "Nova Scotia Watercourse Alteration Specifications" (1997), and are not subject to the referral process of Department of Fisheries and Oceans Canada (DFO) advice and NSDEL approval. Culvert notifications represent culverts installed without a permit from the Nova Scotia Department of Environment and Labour (NSDEL) through the exemption under Section 5(1)(d) of the *Activities Designation Regulations*. Installation of a culvert during the period June 1st to September 30th can currently proceed with a notification to NSDEL and does not require approval under the regulations. However, installation of a culvert inside this time frame must be preceded with the submission of a Notification of Culvert Installation form at the designated NSDEL office. These culverts are therefore not visited by inspectors before or after installations are completed.

Only single culverts can be installed using the notification process with maximum dimensions of 1800 mm in diameter for pipe culverts and 3.0 metres for arch culverts or open bottom box culverts. The maximum length for all notification culverts is 18.3 metres. Other requirements of the specifications state that the culvert will be installed during periods of low flow and in a manner to cause a minimum of siltation and disturbance to the adjacent and downstream areas. Details of culvert invert depth, gravel diameter, adequate protection from approach roads, adequate protection of culvert ends, rock apron protection of stream bottom and bank defined with length of protection required and size of rock to be used are all defined in the specifications (see appendix B). Minimum required storm flows, proper alignment with the stream, fish passage requirements, and maximum slopes are summarized for the proponent's benefit.

The notification method of managing activities that may have an impact on the environment is becoming a common strategy for regulatory risk management. An ever-increasing demand for development while government resources decrease has created a situation where risk management is necessary. However, the commitment to regulatory responsibility must be maintained. Auditing is the fifth procedural step in achieving the no net loss principle of the Policy for the Management of Fish Habitat (DFO, 1986). Auditing of small culverts in Nova Scotia is a step in maintaining the regulatory responsibility.

Fish habitat, as defined in the *Fisheries Act,* is any part of the environment "on which fish depend, directly or indirectly, in order to carry out their life process". The Department of Fisheries and Oceans (DFO) plays an important part in the environmental assessment and review of proposed activities that have the potential to have an impact on fish and fish habitat. Section 35(1) of the *Fisheries Act* prohibits any work or undertaking that results in the harmful alteration, disruption or destruction of fish habitat (HADD) of fish habitat.

Stream crossings represent a significant percentage of the potential impacts on fish habitat. To determine the appropriate type of stream crossing, a proponent should consider the need for a crossing structure, the hydrological conditions, the installation and maintenance costs, and the consequence to the natural resource value of the stream. The preferred alternative, from an environmental point of view is to bridge each stream, particularly if there is a known fisheries resource. However, there are many cases where a properly designed and installed culvert is appropriate as a water crossing, from both an environmental and economic point of view.

Biological, engineering, and hydraulic factors should be considered when constructing or replacing a culvert crossing. Biological considerations include the species of fish potentially effected, age, velocity tolerances of fish over the design culvert length, time of migration, and allowable delays in migration runs. The quality and quantity of upstream habitat, presence of fish barriers upstream and downstream, upstream channel stability and debris potential, and upstream management activities that may effect or have an impact on fisheries must also be examined. If the barriers are man-made, then fish passage is often requested in the new structure on the assumption the existing culvert barrier will ultimately be removed. Engineering considerations include details of the road profile, road cross section, proposed culvert parameters including culvert length, type of inlet, and proposed culvert alignment. Factors such as streambed foundation, site access, regulatory and arbitrary constraints (flood plains and allowable headwater depth), and the desired life expectancy of the structure need to determined. Site specific factors to be considered may include corrosive soils, streambed loads, and options for repairing and/or replacing a culvert once it is installed. Hydraulic considerations include design peak flows, streambed parameters such as particle size, gradient, cross section, roughness coefficient, hydrograph, and bedload quantity. A key hydraulic feature for such installations is the immediate upstream and downstream natural water level control points which will remain in place after the culvert is installed. These points are key to fish passage design. Other considerations include debris (amount, type, and ice build up), upstream water storage, and upstream and downstream conditions that could effect culvert performance.

Culverts are the main method of construction for stream crossings in the Maritimes. Culvert installations consist of a variety of structures, including corrugated metal pipes, box culverts, and natural bottom arches. It is important to differentiate between drainage culverts and stream culverts. Drainage culverts are installed in a road grade to allow passage of surface runoff water which has been collected and channelled by the road way ditches. A drainage culvert should not direct water flow to fish habitat without proper erosion control structures (e.g. check dam, take off ditch, settling pond, vegetation for natural filtration). Stream culverts are installed where a road crosses a watercourse that contains fish habitat. Although impacts on fish habitat from poorly installed drainage culverts were observed during the audit, only those impacts for stream crossings were assessed in this project.

There has been an increasing recognition by habitat biologists that small culvert crossings should not only be engineered for alignment and slope but also to allow unhindered fish passage. Improperly selected and placed culverts can be barriers to fish passage and adversely effect fish production and populations. The interconnection of various fish habitats is fundamental to supporting the abundance of fish species and their life stages. Ensuring that the different habitat areas remain connected for the free migration of spawning adults and rearing juvenile fish is critical in maintaining healthy populations. Culverts are potential barriers to fish migration and therefore may greatly reduce the productive capacity of habitats in some systems. Poorly planned, designed, or constructed culverts may become serious problems to the production of fish runs and in some cases the survival of fish species.

The most common problems are associated with excessive water velocities due to undersized structures or vertical barriers to fish passage. Other problems can include the velocity of water through a given length of structure in relation to the ability of fish to swim; depth of water in the structure at high, moderate, or low flows; icing and debris problems; design flows in relation to annual hydrographic and seasonal time of fish passage; and the size and species of fish passing through the structure. Properly installed baffles and open bottom structures are two examples of mitigation designed to overcome these common problems. If an open bottom structure is used in place of a pipe culvert, the size must be substantially increased to reduce water velocities during high flow periods in order to prevent streambed unravelling.

In conducting this audit a random sample of culvert notification installations was made in four counties of Nova Scotia to measure habitat loss and fragmentation. Physical parameters of the culvert imprint and observed areas of impact were measured at each culvert. This data was used to quantify the amount of habitat loss to determine the effect of culvert installations on fish habitat. The report provides a quantitative assessment of habitat loss from culvert installations in the region and useful recommendations for the development of new guidelines, improving existing guidelines, and developing audit protocols.

MATERIALS AND METHODS

Information from the DFO's Habitat Referral Tracking System (HRTS) database was used to obtain basic site data. The DFO and Provincial File Number, Notification Date, Waterway, Map & Grid Reference, County, Installation Date, and Proponent information were obtained from the HRTS file and recorded before leaving the office. Not all information was available from the HRTS files if the original notification was not complete when submitted. The relevant map areas were identified when possible for field reference. Co-ordinates were not always given in the original notification and the proponent was contacted for further information. Industry contacts were supplied with a list of relevant culverts and a meeting was requested for them to guide the field review. This opportunity for discussion of the current system helped to form the recommendations for further improvement.

All culvert notifications identified in the sample set were subject to assessment. However, after a site visit it became clear that some crossings had been changed to another type of crossing (i.e. bridge) or were not completed. Culverts not completed were still listed in the HRTS system and were not distinguished from those that had been completed. The type of fish habitat that existed at each site was recorded. If there was no viable fish habitat, this was recorded and the site was assessed, but not all categories were applicable.

The proponent was categorized as private citizen, industry, or government. The road where the culvert resides was also categorized as private, public, or forestry. A site number was assigned in a chronological sequence. The following were characteristics particular to the culvert and include measurements to determine how much, if any, fish habitat was lost. General comments on culvert characteristics were also recorded.

The culvert diameter and length were recorded. The diameter represented the diameter of a round culvert, the widest portion of an oval culvert, or the width of a box culvert. Measurements were recorded in millimeters. The length of the culvert was the distance, measured in meters to one decimal point, from one end of the culvert to the other.

The material of the culvert was noted, differentiating between plastic, steel, concrete, and wood. Design features such as smooth verses corrugated, and indicating if there were baffles installed in the culvert were also noted. Smooth walled culverts require additional care to ensure fish passage due to an increased velocity of discharge. The appropriate culvert shape was recorded to aid in determining habitat impact. It was noted if the culvert had an open bottom, or if the bottom of the culvert was covered by natural substrate.

The percent slope was determined using a surveyor's level. To do this, the relative elevation of the upper and lower ends of the culvert bottom were measured. Care was taken to measure from the bottom of the culvert and not the stream itself. Raw data were recorded on the field form and the difference between inlet and outlet was divided by the culvert length to determine the slope. This value was multiplied by 100 to convert to percent.

The culvert outfall drop was measured in centimenters by measuring the vertical drop between the bottom of the culvert to the surface of the stream or pool at the outflow. If the culvert being assessed required maintenance, it was noted. Many sites were assessed with the proponent present and issues of maintenance were discussed on site. This emphasized the need for routine, random, monitoring and in most cases, was appreciated by the proponent for feed back on their current techniques and practices.

The following characteristics of the stream were recorded to determine how the culverts might have an impact on the system. In particular, this determined whether there was biological evidence of a barrier, and how the morphology of the stream may have adapted to the culvert. General comments on stream characteristics were recorded on the field form. An area of three culvert lengths above and three culvert lengths below the culvert site provided information with respect to impact on fish habitat. Procedures used to collect and measure were consistent with those outlined by Johnston and Slaney (1996) and Sooley *et al.* (1998) (see appendix A).

The sediment source and degree of sedimentation was an observation made as part of the site assessment. If there was presence or absence of sediment directly related to the culvert and/or road it was indicated, as well as the nature of the sediment source. The comment section was used to explain the evaluation of the sediment source further.

The depth of the pool immediately downstream of where the culvert water plunges into the stream at the outlet was measured in centimeters. Both water depth and distance from culvert to water were recorded. The wetted width of the stream was the wetted stream width on the day of the assessment and was measured in meters. The width was measured at a minimum of five places above and/or below the culvert and averaged. These measurements were taken a minimum of one culvert length above and below the culvert to avoid influence of the culvert on channel width.

The water depth of the stream was the water depth on the day of assessment and was measured in centimeters. The depth was measured at a minimum of five locations above and/or below the culvert and averaged. These measurements were also taken a minimum of one culvert length above and below the culvert to avoid influence of the culvert channel depth.

The observed presence of fish above or below the culvert was indicated on the field form. Species were identified when possible. Noticeable activity of other animal presence such as current signs of beaver activity within sight of the culvert or other animal signs such as tracks, scat, or sightings were noted for each site. Details such as structure identification (dam, house, and culvert blockage) and if the structure was a fish passage barrier were also noted.

Any known species at risk (fishes, fresh water mussels, plants, birds, mammals, reptiles, amphibians, butterflies, and dragonflies) that were sighted were recorded in the notes section (species, number, and location).

An important component of the fish habitat survey involved reporting the presence or absence of invertebrate species. This provided an indication of specific environmental parameters and conditions, acted as a monitor for ecological health, and indicated food source for fish. It also was used as a tool in identifying indirect habitat required for any stage of the lifecycle for fish as defined in the *Fisheries Act*. Observations of invertebrates were recorded as present or absent.

The percent area of streamside vegetation types was detailed. Submerged plants and substrate type were also noted. All subjective analysis was completed using uniform methods and a consistent approach. This included using a consistent area for examination of the habitat for three culvert lengths above and below the culvert (refer to details on the classification schemes used in qualitative fish habitat surveys attached in the appendix A). As well, consistency was ensured by using the same auditor for all sites involved.

Each site was photographed as part of the stream assessments. These photos not only say more, but with greater impact than any data table or graph might possibly or adequately explain. A minimum of four photos were taken upstream and downstream, both above and below the culvert. Photos of the inlet and outlet of the culvert were also taken. The film roll number and frames were recorded for each site. Pictures taken were indicated in the comments section. The purpose of the photos was to document such factors as substrate, height of road fill over the culvert, and to visually present the structure where the measurements were taken.

RESULTS AND DISCUSSION

Using the data from DFO's Habitat Referral Tracking System (HRTS), a summary of all culvert notifications for Nova Scotia from 1996 to 2000 inclusive was compiled in order to identify potential study sites. This step provided a starting point by quantifying the maximum number of sites that could have been assessed and provided site locations (see Table 1). Using the HRTS program ensured all notifications were initially considered.

Table 1: Summary of culvert notification files from 1996 to 2000 for Nova Scotia.

	1996	1997	1998	1999	2000	**Total**	%
Annapolis	2	2	2	6	3	15	2.8
Antigonish	0	1	0	1	12	14	2.6
Cape Breton	4	1	6	0	1	12	2.3
Colchester	21	6	3	15	47	92	17.4
Cumberland	12	10	10	5	11	48	9.1
Digby	15	7	3	0	0	25	4.7
Guysborough	18	10	6	16	10	60	11.3
Halifax	17	9	18	17	16	77	14.6
Hants	33	14	11	15	19	92	17.4
Inverness	0	0	0	6	9	15	2.8
Kings	1	2	2	0	0	5	0.9
Lunenburg	2	1	3	0	5	11	2.2
Pictou	0	0	0	0	14	14	2.6
Queens	0	1	1	3	2	7	1.3
Richmond	5	0	4	3	0	12	2.3
Shelburne	2	3	2	0	0	7	1.3
Victoria	1	0	2	0	0	3	0.6
Yarmouth	8	4	1	0	0	13	2.5
Unknown	0	0	1	0	6	7	1.3
Annual Total	141	71	75	87	155	**529**	

A total of 529 records were found for the 1996 to 2000 period. The counties most active were Colchester and Hants with 17.4% each of the total over the five year period accounting for 34.8%. Activity in Halifax, Guysborough, Cumberland, and Digby counties account for 14.6, 11.3, 9.1, and 4.7% respectively. These six counties represent 74.5%. The remaining counties range from 2.8% to 0.6% representing 25.5%. This analysis of culvert notifications provided an overview for county selections. On the basis of available resources and time, the counties of Colchester, Cumberland, Halifax, and Hants were selected for this audit. All user groups were represented in these counties. The culvert notifications in these four counties represents 58.5% of all those in the province from 1996 to 2000 (see Figures 1 and 2).

A random sample of 50 culverts was selected from two field seasons (1999 and 2000). Selecting from the two most recent years was an attempt at eliminating the variable of culvert degradation due to ageing. This sample set represented 9.5% of the total culvert notifications from 1996 to 2000 (see Table 2).

Table 2: Total number of culvert notifications for Colchester, Cumberland, Halifax, and Hants counties for the field seasons of 1999 and 2000.

	1999		2000
Government	4		15
Industry	32		55
Private Citizen	16		23
Totals per year	52		93
Total		145	

A random selection of sites was done within each category and year. The selection criterion was set as 50% of category sites selected. Two exceptions to this were (1) if the number of sites within a category was less than 5, then all sites were sampled and (2), if the number of sites was greater than 10, then no more than 10 sites per category were selected. Categories in excess of ten were randomly selected using a number system and a random drawing of values (see Table 3). Figures 3 and 4 illustrate proponent and sector classification of the selected culvert notifications.

Table 3: Selected number of culvert notification sites for study from Colchester, Cumberland, Halifax, and Hants counties for the field seasons of 1999 and 2000.

Random Selection	1999		2000
Government	4		8
Industry	10		10
Private Citizen	8		10
Totals per year	22		28
Total		50	

Tables 2 and 3 establish that the selected sample of 50 culverts represent 34.5% of all notifications from the four counties in 1999 and 2000. This provided a suitable number of culvert sites for a representative sample. Also, from this representative sample, extrapolation may be made to all culvert notifications for the entire province. See Table 4 for a summary of selected culvert sites and Figure 5 for a map of the sites audited.

A culvert slope of 0.5% was used as the limit for determining effective fish passage. It is generally accepted in the Maritime region that fish passage is impaired with a culvert slope greater than 0.5% (Conrad & Jansen, 1994). Exceptions to the 0.5% slope for fish passage do exist for short corrugated metal culverts properly recessed into the stream bottom. However, provincial specifications require the culvert slope to be less than 0.5%.

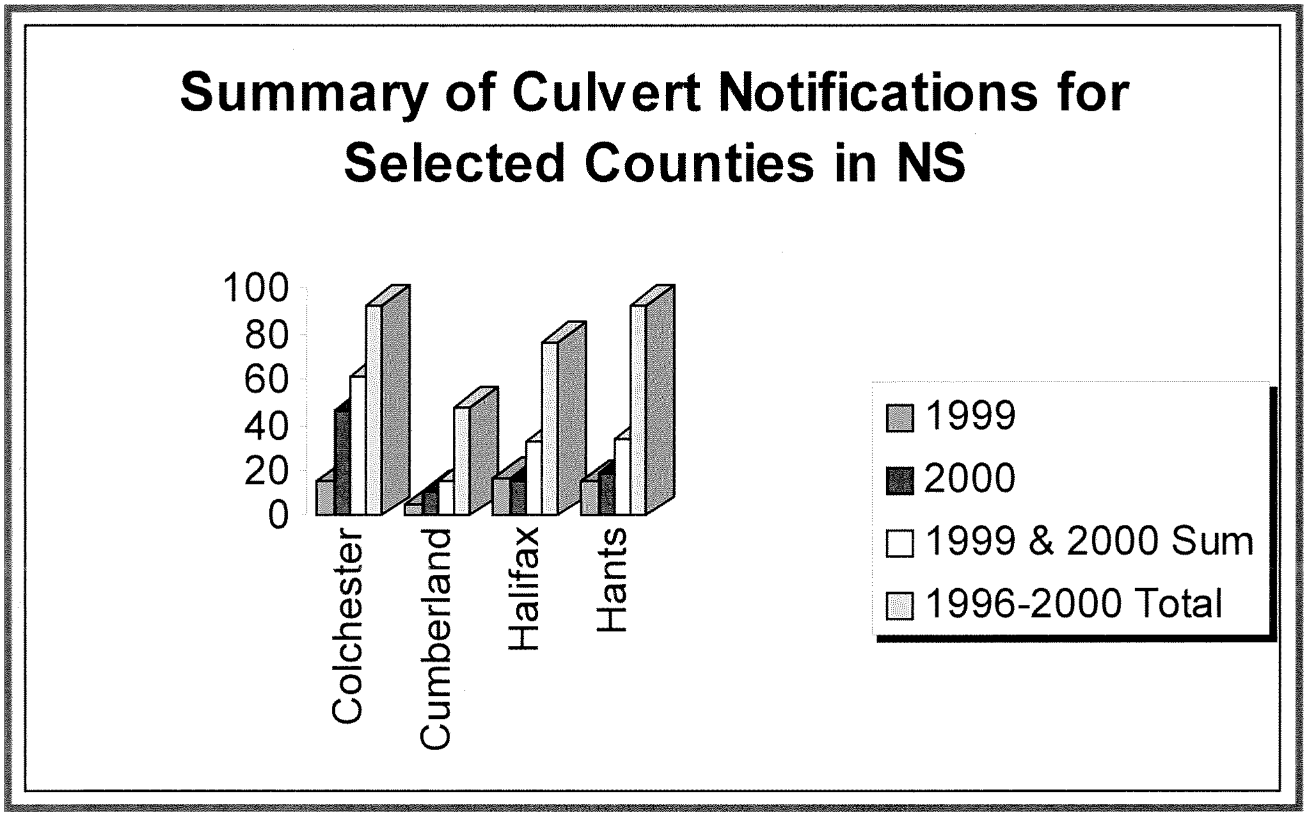

Figure 1: Summary of culvert notifications for selected counties in Nova Scotia.

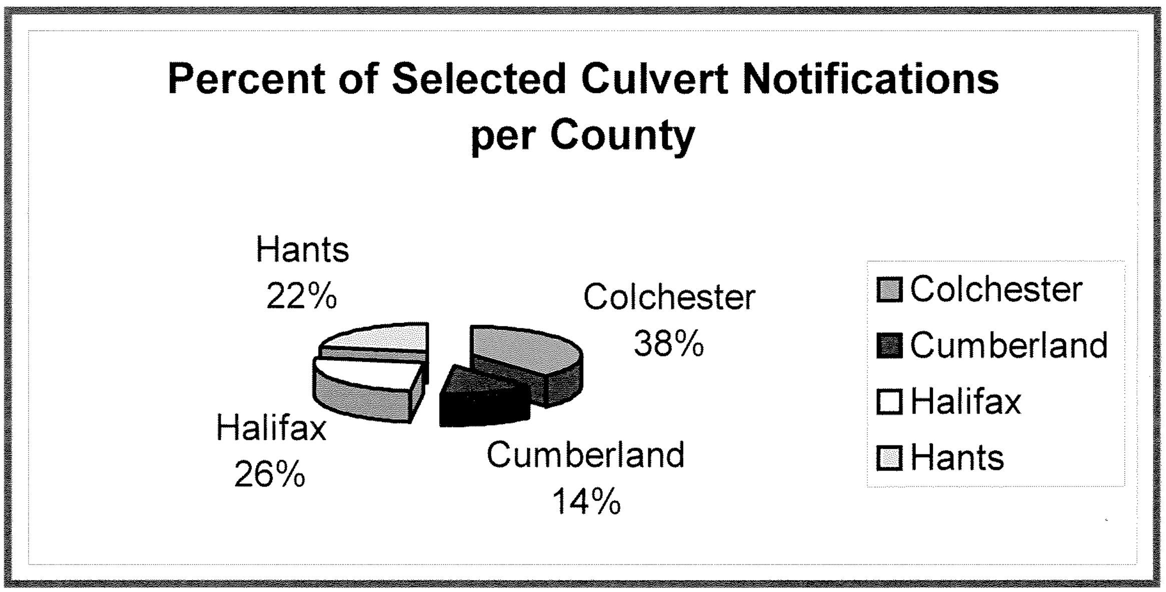

Figure 2: Percent of selected culvert notifications per county.

Table 4: Summary of selected culvert sites assessed.

Site	Year	County	Sector	Proponent
1	1999	Colchester	Forestry	Industry
2	1999	Colchester	Forestry	Industry
3	1999	Colchester	Forestry	Industry
4	1999	Colchester	Forestry	Industry
5	1999	Colchester	Forestry	Industry
6	2000	Colchester	Forestry	Industry
7	2000	Colchester	Forestry	Industry
8	2000	Colchester	Forestry	Industry
9	2000	Colchester	Forestry	Industry
10	2000	Colchester	Public Roads	Government
11	1999	Colchester	Private Business	Industry
12	1999	Colchester	Agriculture	Industry
13	1999	Colchester	Private Business	Industry
14	2000	Colchester	Forestry	Industry
15	2000	Colchester	Forestry	Industry
16	2000	Colchester	Golf	Industry
17	2000	Colchester	Golf	Industry
18	2000	Colchester	Golf	Industry
19	2000	Colchester	Mining	Industry
20	1999	Cumberland	Forestry	Industry
21	2000	Cumberland	Forestry	Industry
22	1999	Cumberland	Public Roads	Government
23	2000	Cumberland	Public Roads	Government
24	2000	Cumberland	Public Roads	Government
25	2000	Cumberland	Public Roads	Government
26	2000	Cumberland	Private Citizen	Private Citizen
27	1999	Halifax	Public Roads	Government
28	1999	Halifax	Public Roads	Government
29	2000	Halifax	Public Roads	Government
30	2000	Halifax	Public Roads	Government
31	2000	Halifax	Public Roads	Government
32	2000	Halifax	Public Roads	Government
33	1999	Halifax	Private Business	Industry
34	1999	Halifax	Energy Industry	Industry
35	1999	Halifax	Private Citizen	Private Citizen
36	1999	Halifax	Private Citizen	Private Citizen
37	1999	Halifax	Private Citizen	Private Citizen
38	2000	Halifax	Private Citizen	Private Citizen
39	2000	Halifax	Private Citizen	Private Citizen
40	1999	Hants	Forestry	Industry
41	1999	Hants	Forestry	Industry
42	1999	Hants	Forestry	Industry
43	1999	Hants	Forestry	Industry
44	2000	Hants	Forestry	Industry
45	2000	Hants	Forestry	Industry
46	2000	Hants	Forestry	Industry
47	2000	Hants	Forestry	Industry
48	2000	Hants	Forestry	Industry
49	1999	Hants	Public Roads	Government
50	2000	Hants	Private Citizen	Private Citizen

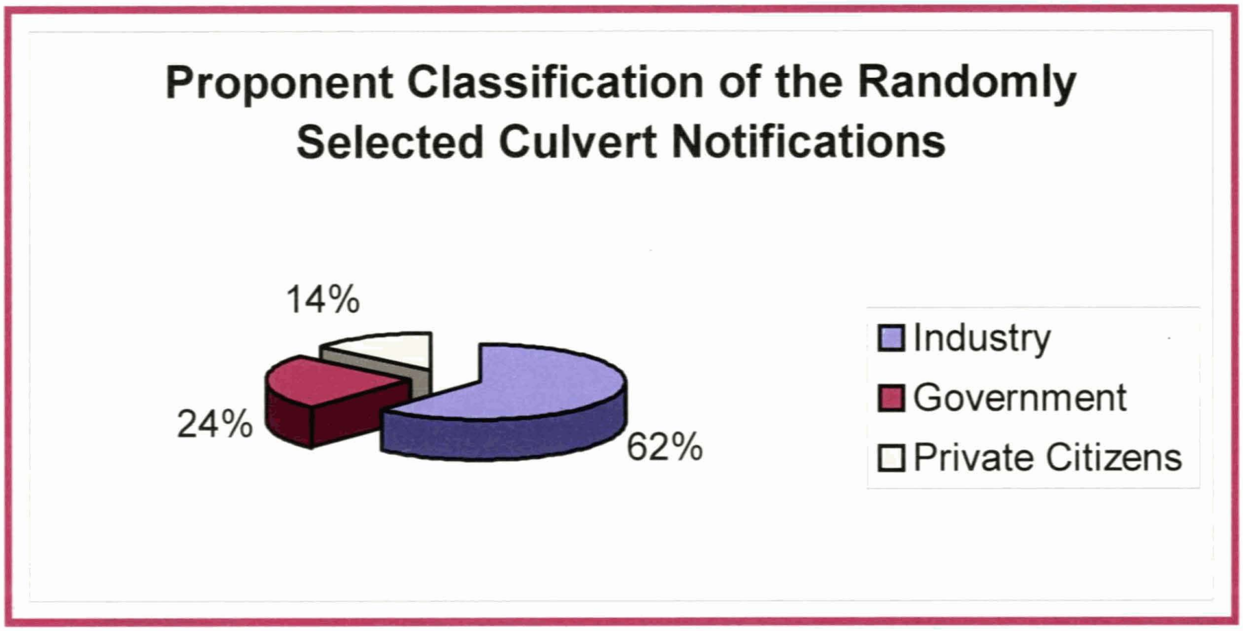

Figure 3: Proponent classification of the randomly selected culvert notifications

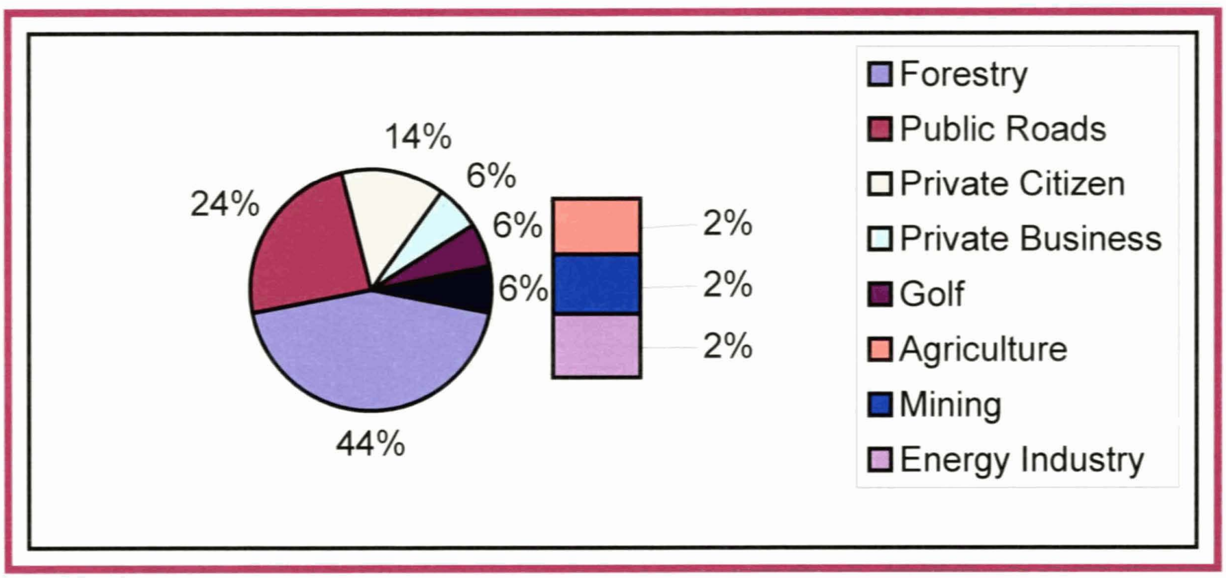

Figure 4: Sectors characterized by the randomly selected culvert notifications

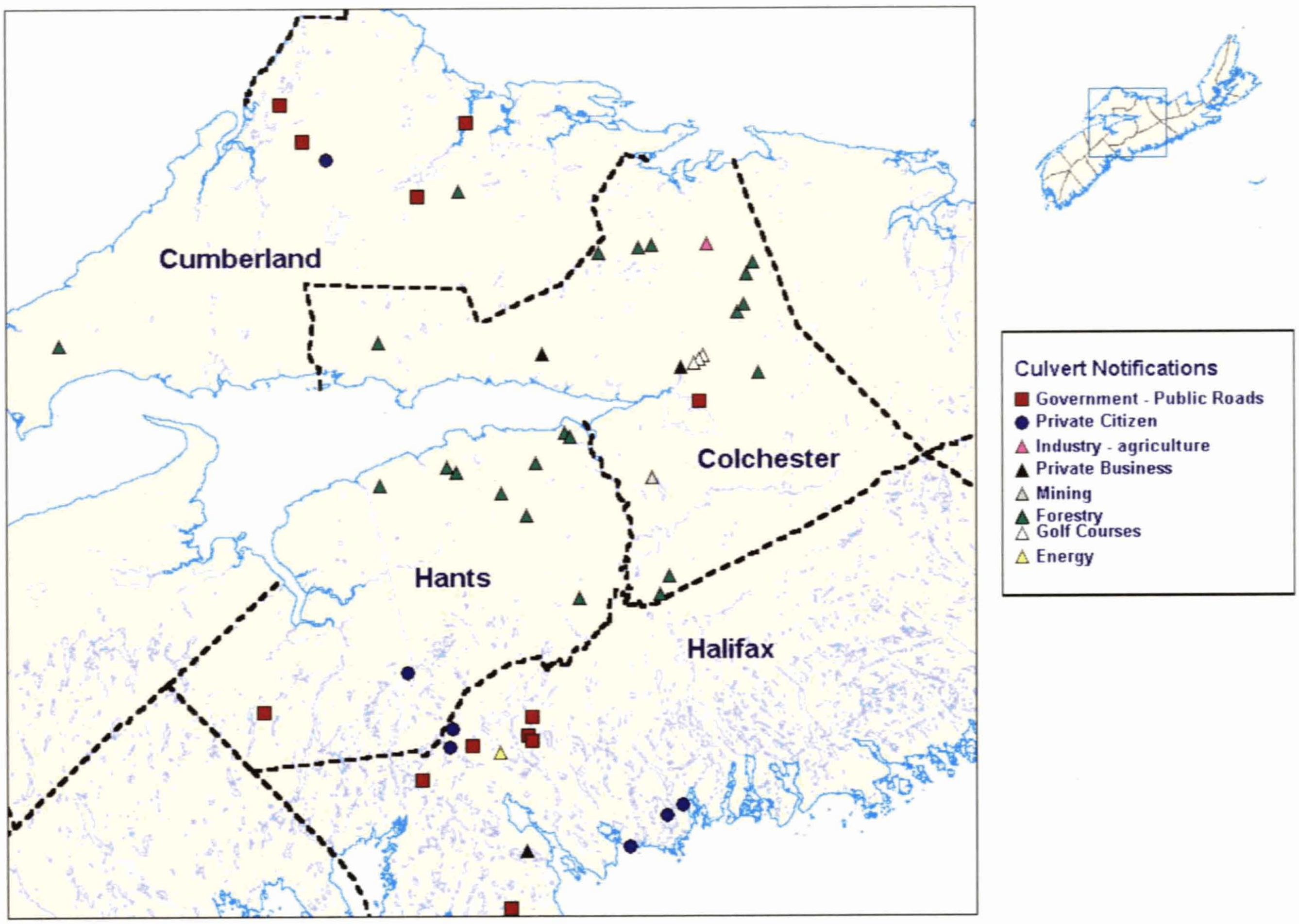

Figure 5: Map of Nova Scotia with assessed culvert sites and sector identified

Forestry roads had the largest number of culverts installed by notification followed by private roads, then public roads with 40%, 34%, and 26% respectively (see Table 5). A total of 12% of the assessed sites did not have the proposed culvert installed. Of the remaining sites, 29.5% were not considered fish habitat and the remaining 58.5% had varying degrees of habitat loss and fragmentation resulting from culvert footprint, impacts on adjacent habitat, and lack of fish passage (see appendix C).

Only two sites assessed were box culverts, one of these was open bottom. This was the only site assessed where a footprint was not left by the culvert installation. The remaining installed culverts were all pipe culverts. Single culvert installations accounted for 38 of the 42 pipe culvert sites with no diameter greater than 1800mm. Plastic corrugated pipes were used at 15 sites of which 7 of these were considered to be fish habitat.

Table 5: Summary of general statistics of culvert sites assessed.

Parameter	Number (out of 50 sites)	%
Year Installed - 1999	22	44
Year Installed - 2000	28	56
County - Colchester	19	38
County - Cumberland	7	14
County - Halifax	13	26
County - Hants	11	22
Proponent - Industry	31	62
Proponent - Government	12	24
Proponent - Private	7	14
Road Type - Forestry	21	42
Road Type - Permanent	29	58
Culvert Installed	44	88
Pipe Culvert	41	82
Arch Culvert	2	4
Open Bottom Arch Culvert	1	2
Culvert Material - Wood	2	4
Culvert Material - Steel	19	38
Culvert Material - Concrete	8	16
Culvert Material - Plastic	15	30
Corrugated Design	34	68
Baffles Present	0	0
Statistics		
Average Diameter of Culvert Pipes	770 mm	
Maximum Diameter of Culvert Pipes	1800 mm	
Minimum Diameter of Culvert Pipes	400 mm	
Average Length	11.3 m	
Maximum Length	40.0 m	

Table 6: Summary of fish habitat measurements of culvert sites assessed.

Parameter	Number (out of 50 sites)	%
Fish Habitat	31	62
Culvert Ends Protected	19	38
Approach Roads Protected	17	34
Inset to stream bed 75 mm - 150 mm	24	48
Problems with Alignment to Stream	7	14
Requiring Maintenance	19	38
Erosion Problems	27	54
Habitat Loss - Non Fish Passage - slope > 0.5%	19	38
Habitat Loss - Non Fish Passage - Outfalls (dropped or perched culvert)	13	26
Habitat Loss - Footprint	30	60

The culvert footprint was calculated using the average stream width multiply by the culvert length. Total fish habitat loss from the culvert footprint of the 50 assessed sites was 363 square meters. A conservative measure of the habitat degradation from adjacent areas due to siltation was an additional 310 square meters. Only the assessed area of three culvert lengths below the culvert installation site was included in this figure. A conservative measure of the habitat fragmentation from adjacent areas due to fish passage problems was an additional 950 square meters. Only the assessed area of three culvert lengths above the installation site was included in this number. In reality, all fish habitat above a barrier would be unavailable to migratory fish. Determining an accurate estimate of fragmentation loss was difficult given the lack of 1st and 2nd order stream detail on current maps.

The loss due to the culvert footprint can be extrapolated to a potential annual loss of fish habitat in the province of Nova Scotia of 769 square meters resulting from the installation of small culverts. Additional habitat degradation and fragmentation can be extrapolated to a potential annual loss of fish habitat in the province of Nova Scotia of 657 and 2010 square meters respectively. Total habitat loss, degradation, and fragmentation could potentially be as high as 3436 square meters annually for the province of Nova Scotia.

Fragmentation of fish habitat occurred when the culvert slope exceeded 0.5% and/or when a perched culvert existed (see figure 7). Slope was an issue with 25 of 50 assessed sites where a measured slope was greater than 0.5% and 14 of 50 assessed sites had outfalls preventing fish passage (see Table 6). Both slope and outfall were obstacles at 10 of these sites. No baffles were installed at any of these sites.

Bank stabilization data indicate high levels of unstable banks associated with culvert installations on forestry roads. Forest roads also tended to be highly eroded. This compounded the bank erosion problems evident in the stream surveys and resulted in highly silted fish habitat downstream of the adjacent culvert. In addition, forestry operations tend to have several culverts in close proximity in the same stream. The cumulative effects of these culverts often complicated the assessment of a particular culvert. Although only one open bottom culvert was selected in the random sampling, several were observed during the audit. Arch culverts and half pipes of this nature eliminate the footprint of habitat loss that pipe culverts leave. Fish passage is not compromised in open bottom installations since the natural stream grade is maintained, as well as the original stream substrate. However, proper design of open bottomed culverts is essential for a reduced risk of habitat loss and habitat fragmentation.

Culvert notifications relating to some sectors, such as agriculture, mining, and the energy industry, appeared only once in the sample set. Reasons may include alternate water crossing methods requiring provincial permits (large culverts, bridges, fords, etc.) and therefore do not require the use of the culvert notification system.

Maintenance was an issue with 19 culverts of the 50 assessed sites (see figures 6 through 16). If the culvert being assessed was in a state that required maintenance, this was noted. Problems included poor condition through cracking or bending such that it was likely to effect the function of the culvert. Debris accumulation was the cause of culvert failure for at least one site assessed. Many sites were assessed with the proponent present and issues of maintenance were discussed on site. This interaction is a benefit of an audit program and facilitates other strategies of the Habitat Policy such as public education, integrated resource planning, and even monitoring. This was appreciated by proponents for feed back on their current techniques and practices. Figures 17 and 18 illustrate innovative ideas used in the field as well as, fish and fish habitat friendly designs.

Figure 6: Improperly installed silt fence.

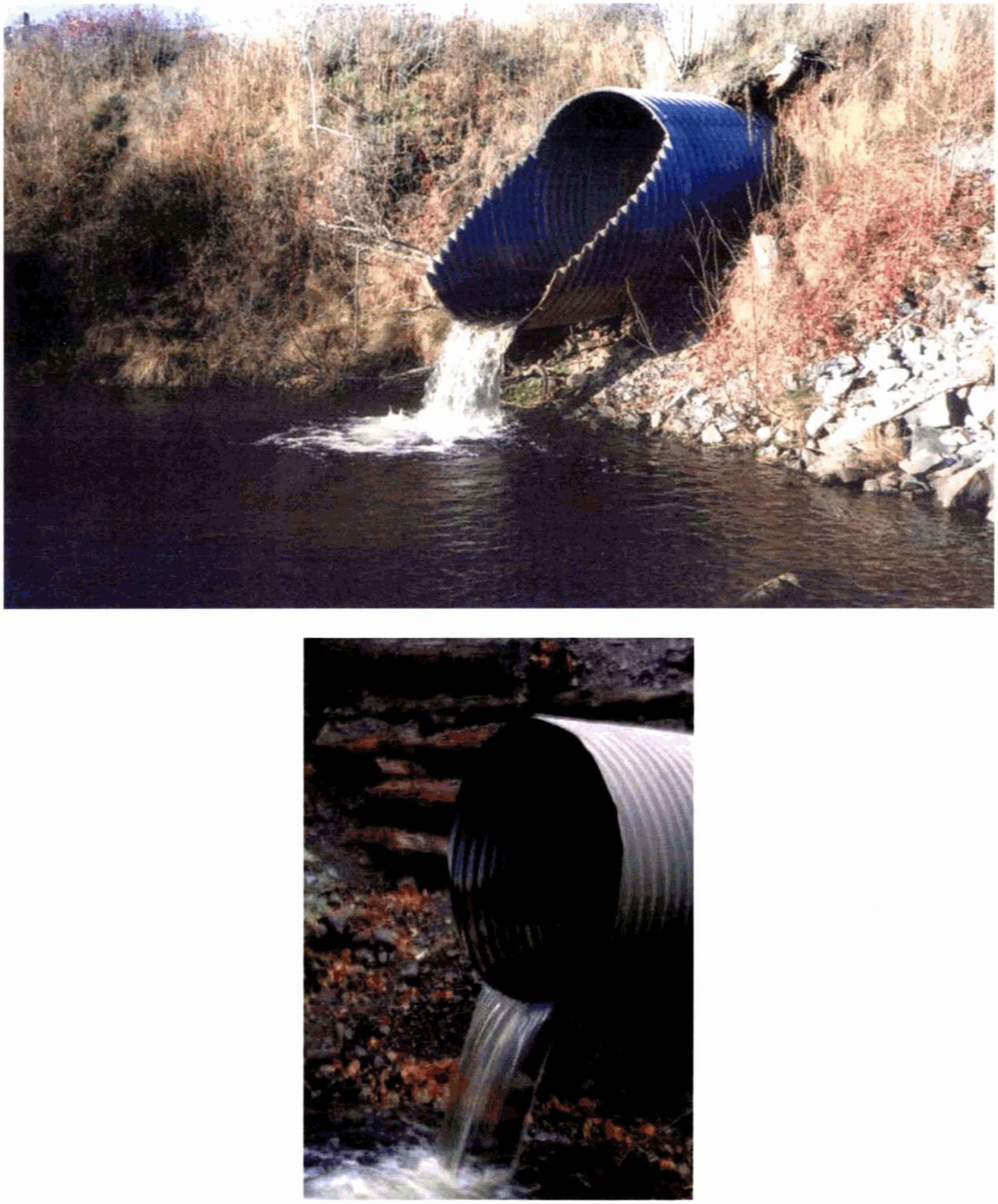

Figure 7: Improperly installed culverts leading to perched culverts and impediment to fish passage.

Figure 8: Debris blockage obstructing fish passage.

Figure 9: Culvert end not properly protected.

Figure 10: Culverts not installed as indicated in original notifications.

Figure 11: Typical forestry road and culvert crossing in Nova Scotia.

Figure 12: Private forest road and culvert construction with resulting siltation.

Figure 13: Riparian vegetation not re-established as required.

Figure 14: Inappropriately installed culvert resulting in road failure.

Figure 15: Streambed covered by road gravel.

Figure 16: Culvert being filled by bed load material from above culvert site.

Figure 17: Innovative ideas for stabilization in difficult soils.

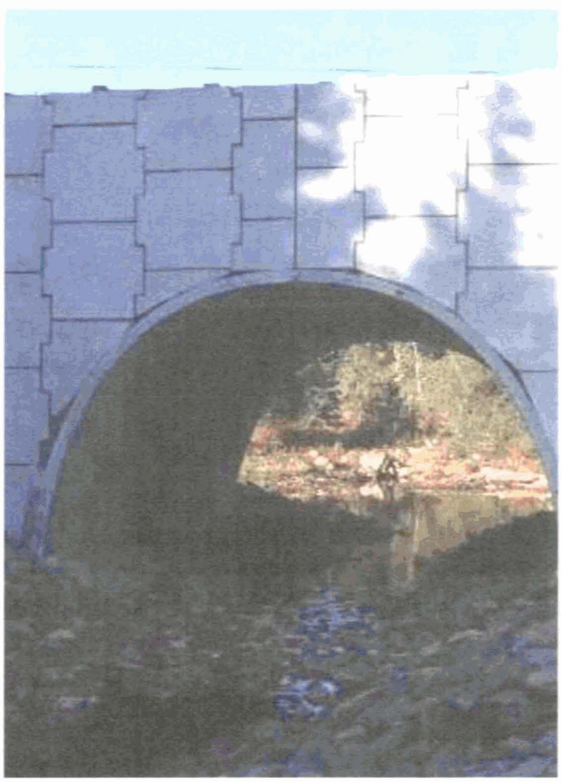

Figure 18: Fish and fish habitat friendly designs.

CONCLUSION

The audit documents that there are many sub standard practices of current small culvert installations in Nova Scotia with regard to habitat loss and fragmentation. This was especially significant regarding fish passage problems. Excessive culvert slope, outfall problems, and erosion were identified as the main causes. Also documented were many instances of habitat loss resulting from the culvert footprint, an unavoidable consequence of pipe culvert installations that can be avoided only by redesign.

Audits such as this are essential if development activities are to be risk managed effectively. Risk management is best achieved by frequent process review resulting in appropriate revision of guidelines. Audit reports may also help address other key strategies for achieving the "No Net Loss" principle of the DFO Policy for the Management of Fish Habitat, such as Co-operative Action, Habitat Improvement and Habitat Monitoring.

RECOMMENDATIONS

This report recommends the following steps to resolve the current sub standard practices used in small culvert installations.

i. DFO should work with provincial agencies to revise guidelines to ensure proponent's *Fisheries Act* responsibilities will be met with regard to habitat protection.

ii. DFO should audit on a regular basis to ensure proponent's *Fisheries Act* responsibilities have been met with regard to habitat protection. The need for a reliable audit program that will place culvert installations in the "low risk" category of referral management is required. The public's awareness of an audit program will provide motivation for improved compliance through education, increased installation care, and accountability.

iii. Guidelines for small culverts should be revised to include natural stream slope as a criterion for determining if a pipe culvert is appropriate for a particular stream crossing. Many of the pipe culverts examined in this study were installed at sites where natural stream slope was so steep that either an excessive culvert slope or a hung culvert outfall was inevitable. Guidelines should include what is required for the design and number of baffles needed for a given natural stream slope.

iv. DFO and other regulatory agencies should use the meetings and workshops that industrial sectors organize annually as opportunities, through presentations and information sheets, to inform the industry of proper installation techniques and of new technology and options. The interaction with representatives of the various sectors during this study was positive and suggested that the industries would be very open to this type of exchange.

v. This study should be used as a starting point for developing a monitoring protocol to be used on randomly selected culverts that are installed under guidelines. It should also be beneficial for developing monitoring protocols for other guidelined activities that require a risk management approach to their regulation.

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APPENDIX A- CLASSIFICATION METHOD FOR QUALITATIVE HABITAT SURVEYS

Adapted from Standard Methods Guide for Freshwater Fish and Fish Habitat Surveys in Newfoundland and Labrador: Rivers and Streams (Sooley *et al.* 1998)

Qualitative Fish Habitat Surveys

Qualitative fish habitat surveys were conducted as part of the culvert site visits. The purpose was to provide a meaningful description of the habitat conditions at the time of the assessment. For each assessment, the following items to be recorded:

habitat area and physical measurements
photos
substrate type and relative percentage
stream bank erosion and stability
riparian and in-stream cover
riparian vegetation
general habitat classification
type of habitat present

General Habitat Types

The proportion of each habitat type within the section is estimated using the following terminology (Gibson *et al.* 1987, Scruton and Gibson 1995, Scruton *et al.* 1992 and McCain *et al.* 1990, as cited by Sooley *et al.* 1998):

Run - Swiftly flowing water with some surface agitation but no major flow obstructions, coarser substrate (gravel, cobble and boulders).
Riffle - Shallower section with swiftly flowing, turbulent water with some partially exposed substrate (usually cobble or gravel dominated).
Pool - Deeper area comprising full or partial width of stream, due to the depth or width flow is reduced. Pool has rounded surface on bottom.
Wetland - Water surface is smooth and substrate is made up of organic matter, sand, mud, and fine gravel. This habitat differs from a pool due to the length, associated with low gradient. This habitat generally has a flat bottom.

Substrate

The substrate composition for the entire section is noted for a total of 100%, and is based upon Sooley *et al.* (1998) classification.

Organic Matter - Fine, usually dark in color, derived from the decay of living organisms.

Siltation - The relative degree of siltation in the section should be described and it should be determined if there is much silt deposit on top of and between other substrate rocks. This could be either descriptive or defined as a percentage of the substrate by silt and to what depth.
Mud/clay - Very fine deposits from mud to silt on stream margins, between rocks, and on top of other substrates.
Sand - Sand sized deposits frequently found on margins of streams or between rocks and stones, from 0.06 to 2 mm in diameter.
Gravel - Small stones from 2 mm to 3 cm in diameter.
Cobble - Moderate to small sized rocks from 6 13 cm in diameter.
Boulder - Boulder sized rocks from 25 cm up in diameter.
Bedrock - Continuous rocks exposed by the scouring forces of the river/stream

Cover

Cover provides a hiding place for fish as well as an area to rest or feed. There are five types of cover which can be subdivided into two categories (Scruton *et al.* 1992, cited by Sooley *et al.* 1998). Estimation of each type of cover is done separately and expressed as a percent. The proportion of each type of riparian cover is also noted for both the left and right banks.

Riparian Cover

Overhanging - cover provided by riparian grasses and shrubs up to I m in height. This type of vegetation is found along the stream edge or hangs out over the stream.

Canopy - cover which is provided by mature hardwood and softwood trees growing along the riparian zone (within a 5 m distance of both stream banks). This only includes trees which have branches/foliage hanging over the stream.

Instream Cover

Cover (substrate, logs, debris, etc.) - cover that is in the streambed. This includes fallen trees and logs, rocks and boulders and other accumulated debris as well as undercut banks.

Vegetation - aquatic vegetation which is growing in the streambed. This includes grasses, macrophytes, waterweeds, mosses, algae and other stream plants.

Deep Pool - the portion of a pool with a depth greater than 1 m.

Riparian Vegetation

According to MacDonald *et al.* (1991), riparian vegetation includes vegetation growing on or near the banks of a water body that display some wetness characteristics during part of the growing season. The percent of riparian vegetation growing within a 5 m distance of both stream banks is recorded. The vegetation types that are used in this estimate include the following:

Hardwood - mature deciduous trees, including maples, birch, oak.
Softwood - mature coniferous trees, including spruce, pine, fir.
Alders - larger, hardwood shrubs such as mountain ash (dogwood), willow, aspen, etc. up to 2 m in height.
Shrubs - for example, steeplebush, blueberry, fireweed, ferns, etc.
Grasses - all natural grasses on the stream edge and in association with surrounding vegetation.
Bog - all surrounding wetland vegetation including sphagnum moss and sedges.

Erosion

As well as a food source, vegetation provides bank stability, thereby preventing erosion and subsequent silt deposit into the stream. The percent of bank erosion within the section is estimated, and both banks are taken into account when recording this estimate. For instance, if the entire section of the left bank is recorded as 100% stable bank whereas the right bank does not exhibit this particular characteristic (i.e. 0%), then the amount of stable bank is recorded as 50% for this site. The banks on each side of the survey area are classified according to the terminology below (Sooley *et al.* 1998):

Stable Bank - area of well vegetated ground with adequate root systems and no visible signs of eroding soil.
Bare-stable Bank - area of rock or other non-vegetative material which is not easily erodible.
Eroding Bank - area of slumping and loss of bank material. Do not confuse with undercut bank. While erosional forces create undercut banks they tend to be stable due to an established root system.
Eroding Road - area of slumping and loss of road material.

APPENDIX B- NS WATERCOURSE ALTERATION SPECIFICATIONS (1997)

Nova Scotia Department of Environment and Labour

Culverts

The following applies to culvert construction or maintenance.

C1. The exemption under Section 5(1)(d) of the *Activities Designation Regulations* applies to the installation of a culvert during the period June 1 to September 30 only. Installation of a culvert outside this time frame will require formal approval and will require approval from the Department of Fisheries and Oceans. Installation of a culvert inside this time frame must be preceded with the submission of a Notification of Culvert Installation form at the designated Regional Office, Nova Scotia Department of the Environment.

C2. The exemption applies to a single culvert installation with the following maximum dimensions:

a) 1.8 metres (6 feet) in diameter in the case of a pipe culvert;
b) 3.0 metres (10 feet) in span in the case of an arch or open bottom box culvert;
c) 18.3 metres (60 feet) in length in all cases.

C3. Whenever possible, culverts shall be installed during periods of low flow. All work operations are to be conducted in a manner to cause a minimum of siltation and disturbance to the adjacent and downstream areas.

C4. The size of the culvert should be based on a minimum of 1:25 year estimated storm flows for forest roads and on a minimum of 1:100 year estimated storm flows for all other permanent installations.

C5. The culvert is to be aligned with the stream.

C6. Where fish passage is required, the maximum slope of the culvert is not to exceed 0.5%.

C7. The stream is not to be disturbed outside the area to be covered by the culvert and rock apron. Depending on the size of culvert, the bottom of the culvert should be set from 75 mm to 150 mm (3 inches to 6 inches) below the stream bed. The bottom of a 450 mm (18 inch) culvert should be about 75 mm (3 inches) below the stream bed and a 1200 mm (48 inch) culvert about 150 mm (6 inches) below the stream bed.

C8. If two or more culverts are to be set side by side, only one needs to be set below the stream bottom. The culverts are to be placed a minimum of one meter apart. The space between the culverts is to be adequately compacted to prevent washout.

C9. Culvert pipe should be set on a firm level bottom, preferably on a bed of gravel. If the stream channel contains rocks larger than 150 mm to 200 mm (6 to 8 inches) in diameter, the rocks are to be removed.

C10. The road fill at each end of a culvert must be adequately protected from erosion by applying rock or other non-erodible materials to the top of the road bank. All materials are to be placed on a good footing to prevent collapse.

C11. When more than one length of corrugated steel culvert is required the culverts are to be connected with couplings provided by the manufacturer.

C12. The stream bottom and banks at the outlet of culverts are to be protected from scour by the water that flows through the culvert. If rock is not naturally present, rock protection is to be placed on the stream banks and the stream bottom for a specified distance downstream of culverts. The rock is to be a minimum of 150mm (6 inches) in diameter and be placed at the culvert outlet for the distances indicated in the following table. The rock must be non-ore bearing and non-toxic to aquatic life.

Culvert Size-Length of Rock Protection

Culvert Size	Length of Rock Protection
450 mm (18 inch) dia.	2.1 m (7 feet)
600 mm (24 inch) dia.	2.7 m (9 feet)
760 mm (30 inch) dia.	3.3 m (11 feet)
900 mm (36 inch) dia.	4.0 m (13 feet)
1200 mm (48 inch) dia.	5.5 m (18 feet)

C13. All excavated material and construction debris shall be disposed of away from the stream so that rain or high flow conditions will not return the debris to the stream.

C14. Water control is to be accomplished using one of the following methods:
- a) Installing the new culvert beside the watercourse and diverting the stream flow into the culvert following completion of the installation.
- b) Diverting the watercourse, temporarily, through a diversionary channel.
- c) Pumping the stream flow around the installation.

C15. Excavation of diversionary channels is to be carried out in the dry from the downstream end. Diversionary channels constructed in erodible or silt-forming materials are to be stabilized with protective rock, plastic sheeting, or other approved materials before any flow is diverted.

C16. The following uniformly-graded, stone-riprap material is to be used for embankment protection unless alternate materials have been approved by the Nova Scotia Department of the Environment.

Class 1

Local velocity up to 3 m per second (10 feet per second)	At least 70% of the riprap shall be between 200mm and 450mm (8 inches and 18 inches).

Class 2

Local velocity up to 4 m per second (13 feet per second)	At least 70% of the riprap shall be between 300mm and 760mm (12 inches and 30 inches).

Class 3

Local velocity up to 4.5 m per second (15 feet per second)	At least 70% of the riprap shall be between 500mm and 1200mm (20 inches and 48 inches).

C17. Culverts are to be installed prior to grubbing.

C18. During construction, temporary access roads and working areas around the site must be adequately surfaced with clean gravel and maintained to prevent siltation of the watercourse.