Salmon River Aquatic Resources Integrated Management Report

March 2002
Final Report

Prepared For:

Oceans & Coastal Management Division
Department of Fisheries and Oceans
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East Coast Aquatics

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Introduction

In June 2000, the Department of Fisheries and Oceans (DFO) retained East Coast Aquatics on behalf of the Central Colchester Model Watershed to review the existing data, reports, air photos, and activities for the Salmon River Basin watershed, and develop the following Integrated Management Plan (IMP). The scope of this project was to focus primarily on the surface water resource and the land uses that impact upon that resource. The first objective was to identify the environmental quality guidelines that should act as a trigger for management activities, covering as wide a range of parameters as needed to ensure the health of the ecosystem within the project area. Furthermore, a target level has been defined as a future desired condition. The second objective was to compare all known information and data to the environmental quality guidelines to determine a prioritized list of activities to help guide future resource management activities within the watershed. The final objective was to identify information gaps that exist and impair the decision-making process of the IMP.

This IMP integrates social, economic and environmental aspects to the degree that they relate to the freshwater and estuary resources of the project area. It does not consider land based resource management that does not directly pertain to surface water resources. Although intimately linked, estuary and freshwater components have been presented separately in order to improve functionality of this report for community groups and government agencies that have greater jurisdictional interest in one component area over the other. An effort has been made to integrate the two in the prioritization of activities recommended for the project area.

The project area is all freshwater entering Cobequid Bay and the Salmon River, east of, and including, Beaver Brook at Old Barns and Chiganois River near Lower Onslow. It also includes the tidal area in a line from the mouth of the Chiganois River to the mouth of Beaver Brook. The watershed area as defined is approximately 965 km^2.

IMP Summary

Potential sources of impact to the Salmon River project area have been identified. They come from a wide variety of land uses and activities. Agriculture, gravel excavation, logging, and urban development have all had physical impact on the water resources. The most significant impacts are associated with the manner in which we have altered the riparian and stream channel functions in the lower reaches of the Salmon River and its tributaries. To comprehensively address this diverse array of impacts will at times require professional direction, and will always require strong community support. The impacts are generally manageable through a combination of changes in the manner in which land uses are carried out, and a moderate degree of rehabilitation activity.

It is recommended that the IMP call on professionals and local interest groups in the relevant fields to confirm, based on experienced judgment and a field visit, the suggested course of priority actions identified in this report. Such confirmation will allow rehabilitation, conservation, and protection oriented management activities to begin immediately for the 2002 field season in a manner that will address the most apparent and least complex ecosystem impacts. A total of seventy-one site specific issues have been identified for further action. As well, several other field reconnaissance and data collection exercises will help clarify and direct other IMP choices and decision making.

It is recommended that this IMP be treated as a dynamic document that will require future updating in order to remain valuable. One of the key components of accurate evaluation is the review of current air photos. This IMP is in part based

on review of 1994 photos, the most current at this date. The lack of current air photos is a weakness of this report. However, many of the observations are from long time operations or activities that are not likely to have changed much since the photos were taken, and, therefore, the observations are expected to be generally accurate. New air photo coverage is typically flown every ten years. Given this current data source, and given outstanding data collection that could provide valuable direction, user groups can target 2003/04 as a year to review and update this IMP.

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1.0 Issues and Key Questions

The Salmon River watershed, an area of some 960 km^2, flows from the Cobequid Highlands in Colchester County, Nova Scotia, through the town site of Truro and into Cobequid Bay (see Figure 1). The project area considered in this report includes the Salmon River and all its tributaries, including all that enter the estuary between Truro and the Chiganois River to the north, and Truro and Beaver Brook to the south (see Figure 2).

Figure 1: Provincial location of the Salmon River watershed, Colchester County, Nova Scotia.

Issues and key questions to be addressed through this report have been drawn from two sources. First, the author consulted many individuals interested in the watershed and the formation of the Central Colchester Model Watershed, who have been noted in the acknowledgements, as to their perception of key issues. Second, key issues were identified through a Cobequid Bay Watershed Management Initiative Workshop, where Workshop participants identified the need for an integrated management plan (IMP) to help resolve issues and impacts associated with water quality and habitat, and to identify information gaps or needs to the IMP process (Anonymous 2000). The result is this report, which attempts to identify those issues and questions that appear to be most important at this point in time to the residents and users of the Salmon River watershed. This report is limited in that it addresses impacts as they relate to the surface water resources of the watershed. Topics such as wildlife habitat, climate change, groundwater resources, and economic development have not been considered. The topics are not all encompassing, and therefore this report is to be read and discussed as a starting point for integrated watershed management of the Salmon River. As these priority key issues become resolved, new ones will come to the forefront. Therefore, the process is to be a dynamic one. There will be a long term need for the relationships that are currently being established, and for the IMP to be updated at some point in the future to reflect changes.

There are six main issues that have currently been identified within the project area (see Figure 2), through community group discussions, for which action and answers are desired:

- Water quality and habitat impacts associated with forestry activities
- Water quality and habitat impacts associated with agricultural activities
- Impacts to fish habitat and limitations to fish production
- Water quality and habitat impacts associated with urban/residential development
- Flood control impacts to habitat and stream function
- Effect of watershed activities on general hydrology and flood waters.

They are the current focus of this IMP. This report provides possible direction on how active management of the resource related issues can be carried forward.

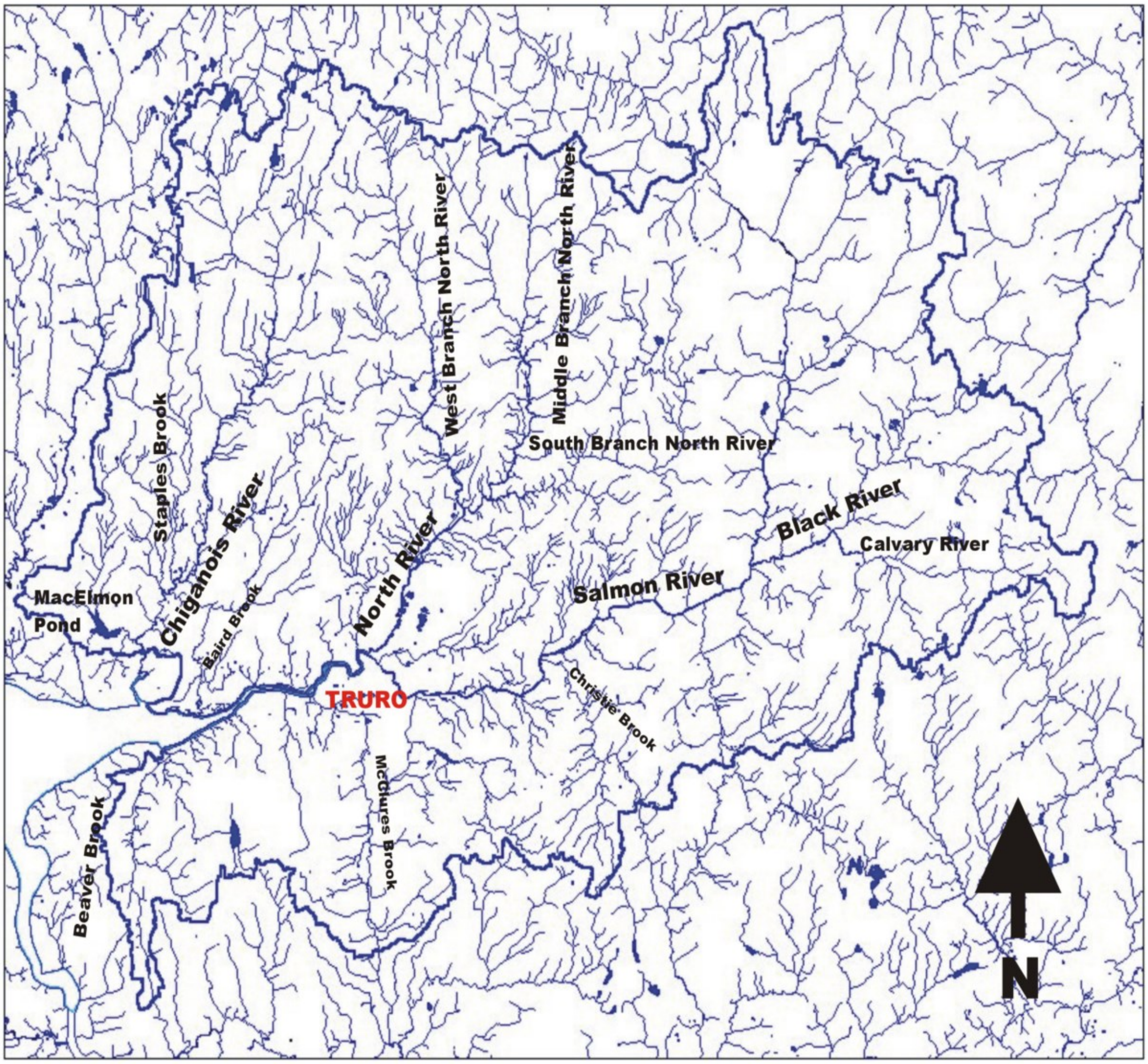

Figure 2: Map of the Salmon River watershed and its various tributaries as included in this integrated management report of surface water resources.

2.0 Historical Conditions

At the head of Cobequid Bay, the Salmon River is host to one of several local tidal bores. This 'wave' of marine water surges up the lower river as a result of the amplification of tidal waters in the Bay of Fundy (see Photo 1). This phenomenon has limited the use of the estuary for aquaculture and shellfish harvest, although some mud flats are harvested for clams. The lowlands of the valley allow for a long estuary, of which a part is considered in this report. In order to keep the incoming tide from flooding coastal marshlands, so valuable in providing hay and agricultural capacity to early settlers, dykes were constructed. In 1961 over 6000 acres of approximately 6500 acres of marshland area was protected by dykes (Canada, 1961). By this time, much of the dyking had been carried out not only to keep the tidal waters out, but to prevent flooding from the river as it entered the gentle gradient of the lower valley. Also in the late 1960's, Colchester County ranked second in the province in number of livestock (Hennigar 1968), further demonstrating the area's agricultural significance at that time.

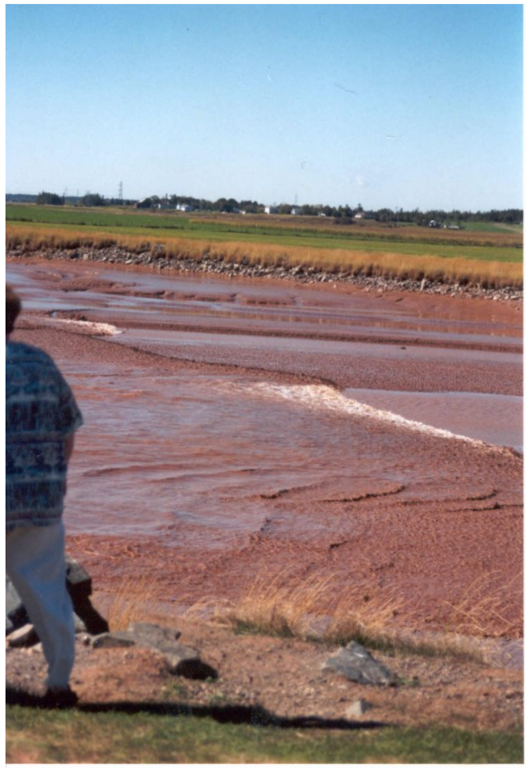

Photo 1: A tidal bore (moving from l to r) makes its way up the Salmon River near the highway 102 crossing. The tides in the Bay of Fundy come in with such surge that an upstream wave is created.

A Salmon River Dam Study was done by the Canada Dept. of Agriculture in 1961 (Canada, 1961). Three dam sites were evaluated to help keep ice and the resultant flooding out of the river. Lyons Head to Old Barns, Lower Truro, and Board Landing Bridge at that time were found to produce too small a reservoir to be viable. A small dam did exist on Farnham Brook at one time but has since been removed. In the nineteen sixties, 191,836 feet of dyke already existed along the river, and there had been 43,077 feet of bank protection works carried out. Over the years the lower reaches of the Salmon River, along with many of the tributaries, have been modified through channelization, mostly with the hopes of either draining marshlands for agricultural purposes, or reducing the probability and impact of ice jams and flooding. Flooding remains a key issue within the lower watershed, but is not addressed here, as numerous efforts and planning documents have been undertaken to try to manage this natural river function.

In 1968 it was noted that although there was an abundant quantity of surface water in the area, its chemical and sanitary quality rendered it unsuitable for most uses without treatment (Hennigar 1968). One of the oldest sites that remains a concern is the former Domtar site between Farnham Brook and the Salmon River. Years of railway tie treatment has contaminated the surrounding soils with the applied chemicals. Periodic sheens appear on the surface waters near the site, and ongoing management and monitoring will help contain to the impacts.

Historically the river had an ample fall run of Atlantic salmon and summer runs of sea trout. Fair numbers of parr and smolts were still found in the late 80's (Langill 1998). Today Salmon River is one of 33 inner Bay of Fundy rivers placed on the endangered species list in 2001 for the Atlantic Salmon. In total, returns to the Bay have fallen to 250 fish in 1999 from an average of 40,000 annually in the 1980's.

In the later 1980's, the Salmon River was one of 45 Nova Scotia rivers that were evaluated for eligibility as a national Heritage River designation (L. A. Rutherford 1987). The Salmon River's strongest assets in that review were those associated with Natural Heritage. The river ranked 16th of 45. Recreational value, in particular scoring for wilderness solitude, was very poor, landing the river last in the category. These categories simply reflected the existing or historic heritage value of the river. Unfortunately, management suitability in all categories was near, or at the lowest, score value. Remember this is a historic river context. Ease of management was determined by factors like Government ownership of adjacent lands, land uses, and industrial developments that may be hard to alter in the short term. Such issues that gave the river a low management score, also point to the importance of establishing and maintaining a multistakeholder watershed management group like the Central Colchester Model Watershed Association in order to be successful in the existing climate of diverse ownership and issues. The Salmon River did not meet the Canadian Heritage System integrity requirements to gain support of the program. The report cited 'heavily polluted waters from Truro to the river's mouth from municipal and industrial discharges'. This finding did not necessarily reflect quality along the majority of the length of the system. The report suggested that a tributary to the Salmon, the Chiganois, would be well suited as a provincially designated heritage river because of the 'very highly rated geology, pre-contact native history'(L. A. Rutherford, 1987).

The Salmon River valley is part of the Minas Basin lowland that is underlain mainly by the Wolfville Formation of the Upper Triassic Age. The river is bounded on the north by the Cobequid Highlands, and on the south by uplands underlain by rocks of the Horton Group (Miller and Milligan, undated). In Victoria Park, Truro, an ancient Triassic gorge is being re-eroded by Lepper Brook in grey sandstones and siltstones of the Early Carboniferous Horton Group. Under the road bridge in the park, the unconformity between the Horton Group and the younger Wolfville Formation is exposed (Donohoe and Grantham 1994). The Town of Truro is build upon the glacial outwash deposits of sand and gravel that were laid down in post-glacial times by the meandering rivers that drained the Cobequid Highlands. The soils around Cobequid Bay are similar to those found in the most productive areas of the Annapolis–Cornwallis Valley. The main difference between the two areas is climate, with the Salmon River area receiving cooler air from the Bay of Fundy, effectively shortening the growing season (Miller and Milligan, undated).

Much of the lower watershed has been cleared for agricultural purposes, and the upper watershed has been actively logged for over a century. The upper Chiganois River and North River have an abundance of roads from past logging activities, but much of these areas are regenerating and streams are stable. As of 1994, most recent cutblocks were around Black River, lower West Branch North River, and the upper sections of South Branch North River. Currently forestry operations like Kimberly – Clarke, and Irving operate in the watershed, and value added processes are carried out by Stella Jones Wood Preserving. Crown land makes up only 23% of the watershed, with the remainder being held privately.

Mining has played a minor role in the watershed, but most sites are currently inactive. Several current claims exist, primarily around Kempton and the estuary. Most recent activities are related to surface gravel extraction found primarily along the valley floor of the North River. However, Chiganois River, Salmon River, and McClure's Brook all have active operations adjacent to the waterways.

The Nova Scotia Department of Natural Resources (DNR) has developed preliminary guidelines for an integrated management plan of Crown lands in the Province. Currently, Crown lands have been classified into three broad use categories. Longer range plans of 4-5 years are being developed, and stand specific plans will be subsequently considered (Tattrie 2001). Although not specifically considered in this report, because of its preliminary development, the DNR integrated management plan should be considered in future works.

3.0 Land Based Evaluation

This component refers to all the fresh water resources and related land based resources within the watershed. Excluded is the estuary, although many of the land based components will affect the estuary and are, therefore, discussed as appropriate. Five aspects of the land based project area are discussed: water quality, sediment sources, freshwater ecosystem health, riparian, and hydrology.

Current conditions for each of these five review components have been analyzed and presented. The current information is then compared to relevant environmental quality guidelines that are derived either from regulatory requirements, or from best management practices. Both trigger levels and target levels are identified for various environmental quality parameters. Trigger levels are those below or above which a measure should not go, and that should 'trigger' management response if reached. Target levels are those that we expect to exist or that we would like to meet through integrated management activities to be confident our ecosystem parameter is properly functioning.

In order to assess the freshwater ecosystem, it is valuable to identify target species. Generally, recreationally or commercially important species will be the target species for an assessment. It is appropriate that a relatively environmentally sensitive species be used, as it will act as a better “indicator” of ecosystem health than a less sensitive species. Therefore, Atlantic salmon (*Salmo salar*), and both sea run and resident Brook trout (*Salvelinus fontinalis*), will be considered target species for the freshwater ecosystem of the Salmon River Watershed IMP.

3.1 Water Quality

Water quality concerns exist for both humans, and for aquatic species within the watershed. Activities of the former may include irrigating crops, watering livestock, and drinking water. The latter, for land based evaluation, will focus on our target species of Atlantic salmon and anadromous trout, as their requirements are likely to address major water quality considerations for aquatic, terrestrial, and avian species that may interact with them or otherwise utilize the water resource and stream / riparian corridors (see Figure 3). Sediment related water quality issues are not discussed here, but under *Section 3.2 Sediment Sources*.

3.1.1 Current Conditions

Comparison of historical data (Horner 1989) and current data collected by the both the Department of Fisheries and Oceans and the Municipality of Colchester shows very little decrease in fecal coliform levels in the area of Truro railway bridge from 1987/88 summer averages of 775 and 900 MPN/100ml to 860 and 600 MNP/100ml in the summers of 2000 and 2001 (see Table 1). With the implementation of sewage treatment for the Town of Truro in 1996, many residential sources of coliform were eliminated. However, current coliform levels still preclude the use of the river water for nearly all activities, including irrigation, livestock watering, and recreation that may involve contact of the skin with the water. Bible Hill, Valley, Salmon River, part of East Mountain, Hilden, Truro Heights, part of North River, and Mingo's Corner are all serviced with sewage treatment.

Photo 2: A milky suspension clouds Lepper Brook on October 03, 2001, at the railway bridge in Truro. Source is unknown.

Two more locations have extremely high fecal coliform levels. Old Barns, Hwy 104 Bridge, and McClure’s Brook have had consistent counts in the 2000-4000 MNP/100ml range, and have also shown biological oxygen demand averages for the summer months above 6 mg/L. At Old Barns a significant jump in fecal levels occurred after 1998, from typical counts of 800 MNP/100ml to 5000+ MNP/100ml. Similarly, a significant jump occurred at McClure’s Brook after May 1998. Current fecal coliform levels on the North River (see Figure 4) mean that it, too, is unacceptable for irrigation of crops. Meat and poultry effluent entered McClure’s Brook and resulted in a charge under the Federal Fisheries Act in the early part of 2000 (Fitton 2000).

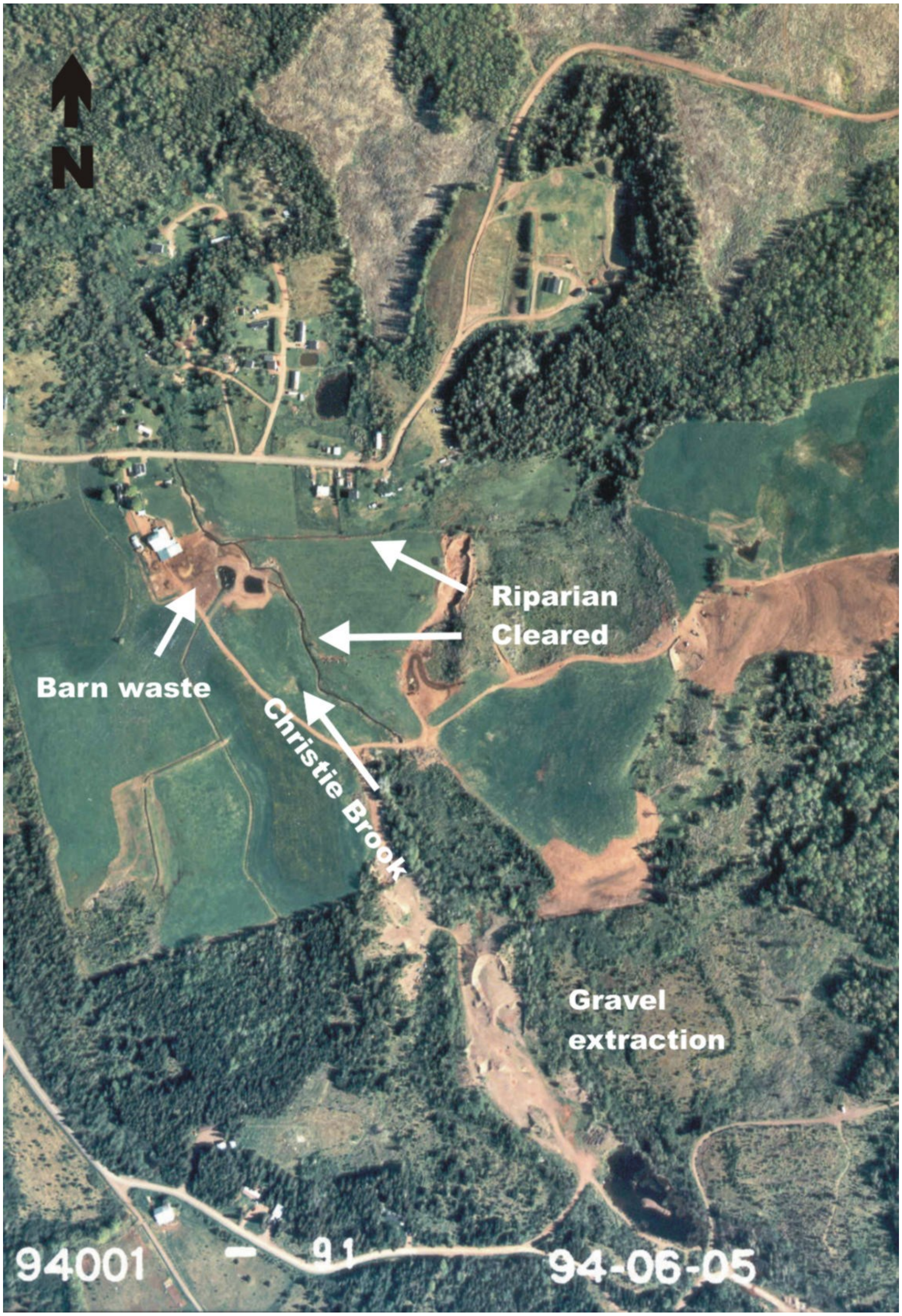

Figure 3: Christie Brook, a tributary to the Salmon River, has several visible impacts near the community of Harmony. Barnyard waste is in close proximity to the brook, and heavy animal traffic through the brook is apparent. These are likely sources of fecal contamination. As well, poor riparian corridors, and what appears to be an in-channel gravel extraction operation further impact local stream productivity and health

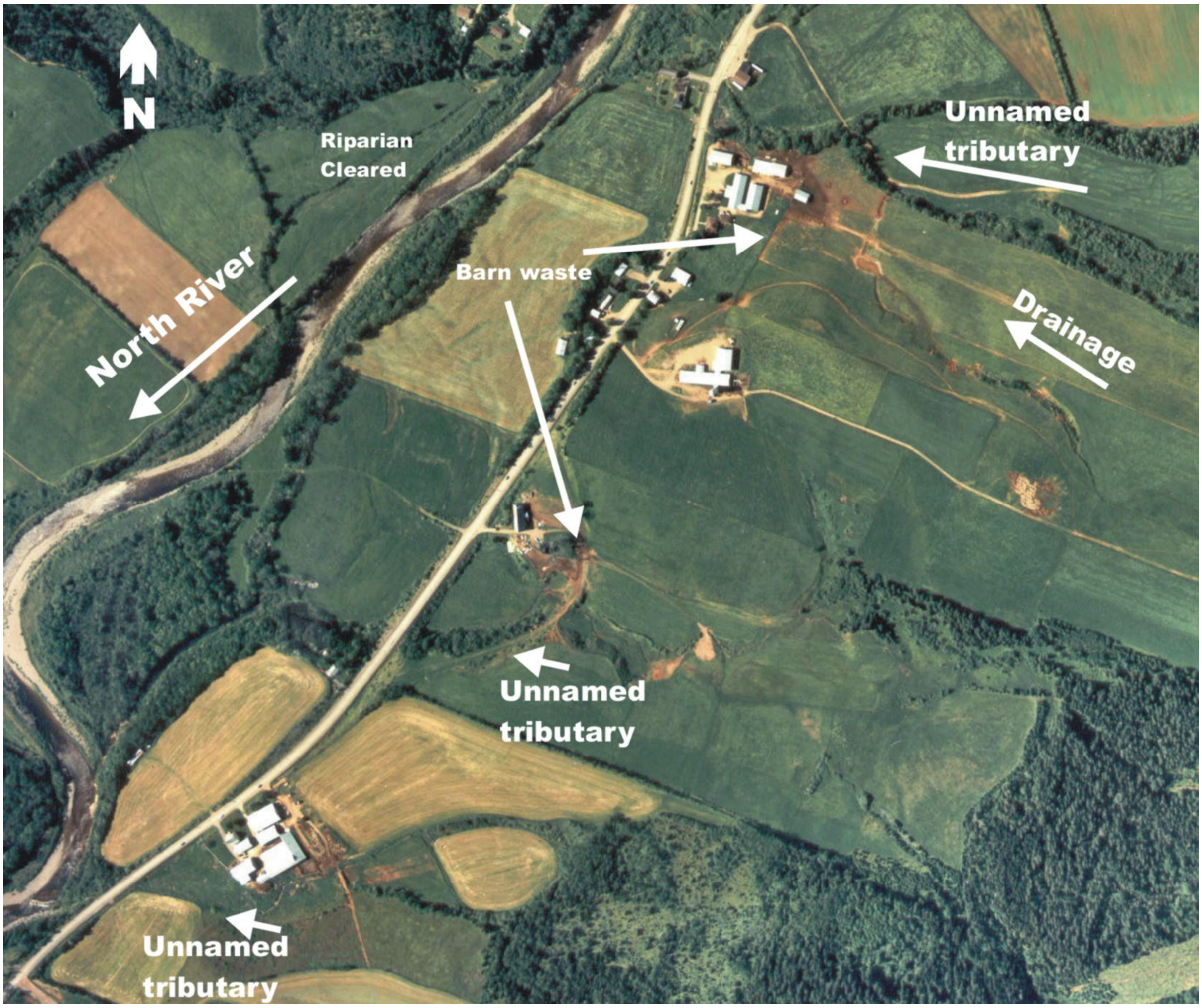

Figure 4: There appear to be several agricultural impacts associated with three small tributaries to the North River. Fecal coliform contamination is likely from barn wastes near the streams and livestock traffic.

Table 1: Comparison of selected water quality parameters in the Salmon River and adjacent tributaries between 1967 and 2001.

* Coliform counts in MPN/100ml and DO_2 in mg/L.

Site	Measure	1967[1]	1987/88[2]	1997[3]	2001[4]	2001[5]
Salmon River at Old Barns	Fecal coliform* (mean)	-	1240	150	4038	-
	Dissolved Oxygen* (mean)		8.75	-	-	-
Salmon River at Truro	Total coliform	1428	-	-	-	240
	Fecal coliform	-	612	105	600	80
	Dissolved Oxygen		10	-	-	
Salmon River near above Truro	Total coliform	118	-	-	-	1600
	Fecal coliform	-	-	-	255	32
Salmon River near Kemptown	Total coliform	35	-	-	-	>1600
	Fecal coliform	-	-	-	-	500
Black River near Riversdale	Total coliform	29	-	-	-	-
McClure's Brook	Total coliform	1450	-	-	-	-
	Fecal coliform	-	-	2586 (1998)	2652	-
Chiganois by Staples	Total coliform	-	-	-	-	500
	Fecal coliform	-	-	-	-	7
Chiganois at Lightbody	Total coliform	-	-	-	-	1600
	Fecal coliform	-	-	-	-	300
North River Middle Branch	Total coliform	-	-	-	-	>1600
	Fecal coliform	-	-	-	-	900
North River below West Branch	Total coliform	-	-	-	-	170
	Fecal coliform	-	-	-	-	60
North River near Hwy 104	Total coliform	184	-	-	-	>1600
	Fecal coliform	-	-	-	-	240
McCurdy Brook	Total coliform	770	-	-	-	-
Farnham Brook	Total coliform	1530	-	-	-	-

[1] Terry Hennigar thesis on Hydrogeology of the Salmon River. July to Nov. samples
[2] Horner and Associates Ltd. Sewage Treatment Requirements report of February 1989. Nov., Jun-Aug. 1987; June-Aug. 1988 samples
[3] Municipality of the County of Colchester ongoing water sampling program 1996-2001. July Aug. 1997 samples
[4] Municipality of the County of Colchester ongoing water sampling program 1996-2001. June-Aug. 2001 samples
[5] Department of Fisheries and Oceans spot sampling summer 2001. One sample date Aug. 2001.

The Lepper Brook drainage area contains the Town of Truro reservoir. As such, this basin should be carefully managed as an entity unto itself, possibly with standards separate from the remainder of the watershed. This action would ensure that both water quality and quantity are not affected. Both logging and other development take place in the Lepper Brook basin. Photo 2 documents a milky suspension in the lower brook in October of 2001, observed by chance by the author.

In 1988, the suspended solids at the CN Bridge in Truro averaged 50 mg/L over June – August (Horner 1989), at which time the Department of Environment receiving water quality standards was 10 mg/L. Current sampling by the County has shown typical monthly averages near the same site to be near 3 mg/L for several years. This is likely in part a result of the new sewage treatment facility becoming operational. The current levels are within acceptable standards.

A former Domtar site is located between Farnham Brook and the Salmon River. It has been reported that as much as 800,000 metric tonnes of contaminated soil is at the site. Chemicals such as pentachlorophenols and polycyclic aromatic hydrocarbons are found where railway ties used to be treated (MacIntyre 2001a). A bioremediation cell is on site; groundwater tests and air quality tests are carried out regularly in accordance with requirements of the Department of Environment. Sampling to determine if the contamination is moving toward the Salmon River were to have been completed by September 2001.

In the upper area of Farnham Brook, Nova Scotia Department of Environment issued a warning regarding the April 09, 2001 appearance of high nitrates (MacIntyre 2001b). Department of Transportation is doing groundwater testing for salt contamination near Farnham Brook. Farnham Brook had high total coliform levels in 1967. No testing since that date was available for comparison. A fish survey of Clifford Brook and Farnham brook in 1998 (LeBlanc 1998) showed good dissolved oxygen levels, between 11-12 mg/L. Farnham had a relatively high conductivity reading at 350µmols.

DFO water sampling conducted in August of 2001 showed that on the sample day, high levels of fecal coliform, and elevated levels of phosphates (0.37 mg/L) and nitrates (0.4 mg/L) were found in the upper area of Middle Branch North River near MacKenzie Settlement. Review of 1994 air photos did not reveal any obvious source for these higher than normal measures.

Broad sampling of pH around the watershed shows levels to be typically between 6.5 and 7.5. These levels are well within environmental guidelines for aquatic life, and significantly better than in other regions of the province where less buffering of acid rain impacts occurs.

In 2001, tributary water temperatures around the watershed rose to 25+ ^{o}C on occasion, and the Salmon River had average temperatures in June – August of 20-21 ^{o}C. Such temperatures are an undoubted stress to salmon and trout that may exist in the system, and observed highs would necessitate these species temporarily leaving those areas that crept past 24 ^{o}C. Warm water temperatures are likely related to poor riparian areas along large stretches of the main rivers as well as along several small tributaries (that typically are cool water refuge), and the generally observed over-widened and shallow river system. The Cobequid Salmon Association monitored water temperatures on Clifford Brook in 1998 and found it remained relatively cool throughout the summer. It is likely that Clifford would, therefore, be a cold water refuge when the larger channels begin to warm.

3.1.2 Target Levels

In Maritime fresh water systems phosphorous is usually the limiting nutrient to primary productivity. As little as 0.3-0.6 $\mu g/L^{-1}$ may be adequate for unicellular periphytic diatom growth and anything greater than 10 $\mu g/L^{-1}$ may cause excessive blooms (Bothwell cited in Mouldey Ewing, Ashley and Wilson 1998).

Table 2: Land based water quality trigger and target levels.

Parameter	Trigger Level	Target Level	Species of Limit / Source
PH	5.5	6.5-9.0	Canadian Water Quality Guideline – Protection of Aquatic Life
DO_2 – Dissolved Oxygen	early life stages 6000 $\mu g/L^{-1}$; other life stages 5500 $\mu g/L^{-1}$	Near saturation	Canadian Water Quality Guideline – Protection of Aquatic Life
Upper Temperature Limit	<20^0C extended <24^0C short term	14^0C - 16^0C	salmonids
Turbidity - consumption		1NTU	Canadian Drinking Water Quality Guidelines
Fecal coliform – Human consumption		0 MPN/100ml	Canadian Drinking Water Quality Guidelines
Fecal coliform – Irrigation	100 MPN/100ml	14 MPN/100ml	Canadian Water Quality Guidelines – Agricultural Uses
Fecal coliform – Human Contact	200 MPN/100ml	14 MPN/100ml	
Dissolved phosphorous	1 $\mu g/L^{-1}$	/ 3 $\mu g/L^{-1}$ <10 $\mu g/L^{-1}$	British Columbia Ministry of Environment
Nitrates – Human consumption		<45 mg/L (10 mg/L nitrate-nitrogen)	Canadian Drinking Water Quality Guidelines
Nitrogen		/ 20 $\mu g/L^{-1}$	British Columbia Ministry of Environment

3.1.3 Management Response

Several site specific recommendations have been made in Table 12. However, some management activities are at this point limited, awaiting the results of a more exploratory water sampling program that would move sample locations around the watershed to help locate sources of water contamination or quality issues, or that would simply be used to provide information from smaller tributaries for which current water quality is not known. Dissolved oxygen (DO_2), fecal and total coliforms, temperature (long term data logging through summer highs), and total suspended solids (TSS) should be the base parameters to be evaluated. Each site should be tested at least twice to help account for variation, and should be tested at the time of greatest potential impact, such as spring flood and summer low flows (post rain events if possible). If testing does not reveal water quality issues at the anticipated worst times, then we have greater confidence water quality issues do not exist at the sampled location. This sampling will produce results for several watershed locations, defining issues of water temperature and fecal coliform contamination. The results of exploratory sampling for fecal coliform should be used to determine if irrigation and livestock watering are permissible (see Appendix C for guidelines) in various areas of the watershed. It will also help to confirm sources of fecal contamination so that partnerships may be developed with relevant landowners to address source problems. Low dissolved oxygen results would add further priority to a critical site. Summer temperature data will quantify thermal warming impacts and determine the need for higher priority of riparian planting, as well as protection for cool water refuge areas (see Figure 5).

Figure 5: The golf course on McClure's Brook is a potential source of thermal warming because of the lack of riparian, and several ponds that may drain into the brook. As well, partnering with course management should be undertaken to ensure fertilizers are not used in a manner that would affect the brook, creating algal blooms and consuming stream oxygen.

Confirmation and reduction of fecal coliform sources at Old Barns and McClure's will greatly increase the probability of opening shellfish areas for clam digging. Although it is difficult to say with complete confidence, it appears that most estuary contamination comes from McClure's and the numerous small tributaries that directly enter the estuary. Fecal contaminants from the area of Truro and upstream exist, but appear both relatively small and inconsistent based on existing data. Because of significant fecal coliform count increases at McClure's and Old Barns, both occurring in 1998, evaluation of development occurrences and management practice changes that may be linked to resource users located in those two areas should be carried out. Successful identification of a significant resources activity change could provide a high priority target for improved practices that would result in marked improvements in fecal coliform contaminant levels in these two locations.

Temperature profiles through the summer will help identify high priority cool fish refuge areas, and provide magnitude comparison to thermally warmed waters in cleared areas. The Municipality of Colchester, which is doing the greatest volume of regular sampling, should consider dropping (if cost of analysis is an issue) measures, such as TSS, that are not proving to be an issue, and adding dissolved oxygen (DO_2). The reason for measuring DO_2 is twofold. First, there is comparable historic data from 1967 and 1987. Second, DO_2 is a generally collected and comparable parameter for aquatic life considerations. A separate nitrogen and phosphorous analysis would also help track productivity and could be related to observed algal blooms. Furthermore, if feasible, the county, or some other party, should reduce the number of sites on the Salmon River, and establish, or add, seasonal sites on the main branches of the Chiganois, North River, and Black River.

Farnham Brook should be tested for fecal coliform, DO_2, conductivity / salinity, and nitrate,s as issues associated with all of these parameters have existed at one time, and current evaluation would determine the present state of such parameters. Similarly, the Middle Branch of North River near Mackenzie's Settlement should be tested for fecal coliform and DO_2 because of previously observed high levels.

Several different events in the Salmon River River watershed in the past year (Fitton 2000, MacIntyre 2001a, MacIntyre 2001b) demonstrate that human activities in the area remain a threat to the water resources. Therefore, the need to maintain a regular water quality monitoring program, such as the Municipality of the County of Colchester has undertaken since 1996, should remain a high priority. Such a system will provide a means of tracking critical events, as well as providing comparison data to potentially determine the magnitude of adverse effects that may occur.

3.2 Sediment Sources

Significant sediment problems tend to be from a few core sources. They include roads and ditches, stream crossings, stream bank erosion, and open areas such as cut blocks and agricultural lands. Stream bank erosion can be a significant source, but it is usually an effect caused by some other activity that needs to be addressed (see Figure 6). Sediment sources can be classed as those that are fine particulate and suspend in the water column for a period of time, and a heavier fraction that primarily moves along the bottom of a stream. For a short period of time mobile species will often leave areas where there is suspended sediment. The heavier fraction can significantly alter or eliminate species' habitat, causing a long term or permanent avoidance of the area impacted.

In evaluating these sources, we need to assess the proximity of lakes and wetlands where settling and filtration may occur, the erodibility of the soils, and the connectivity to the stream channel. Connectivity refers to how directly sediment can be carried from a source to the stream channel by natural processes. For example, an eroding ditch line that dumps straight into a brook has high connectivity. In contrast, a large open pit area on steep ground may have low connectivity if water running off the site drains into a brush and treed flat area a long distance from the open stream channel.

Target levels of sediment related concentrations tell us in general if sediment delivery needs to be addressed. Ongoing sediment delivery must be identified and stopped prior to undertaking any in-channel activities to reduce the impacts of past sedimentation.

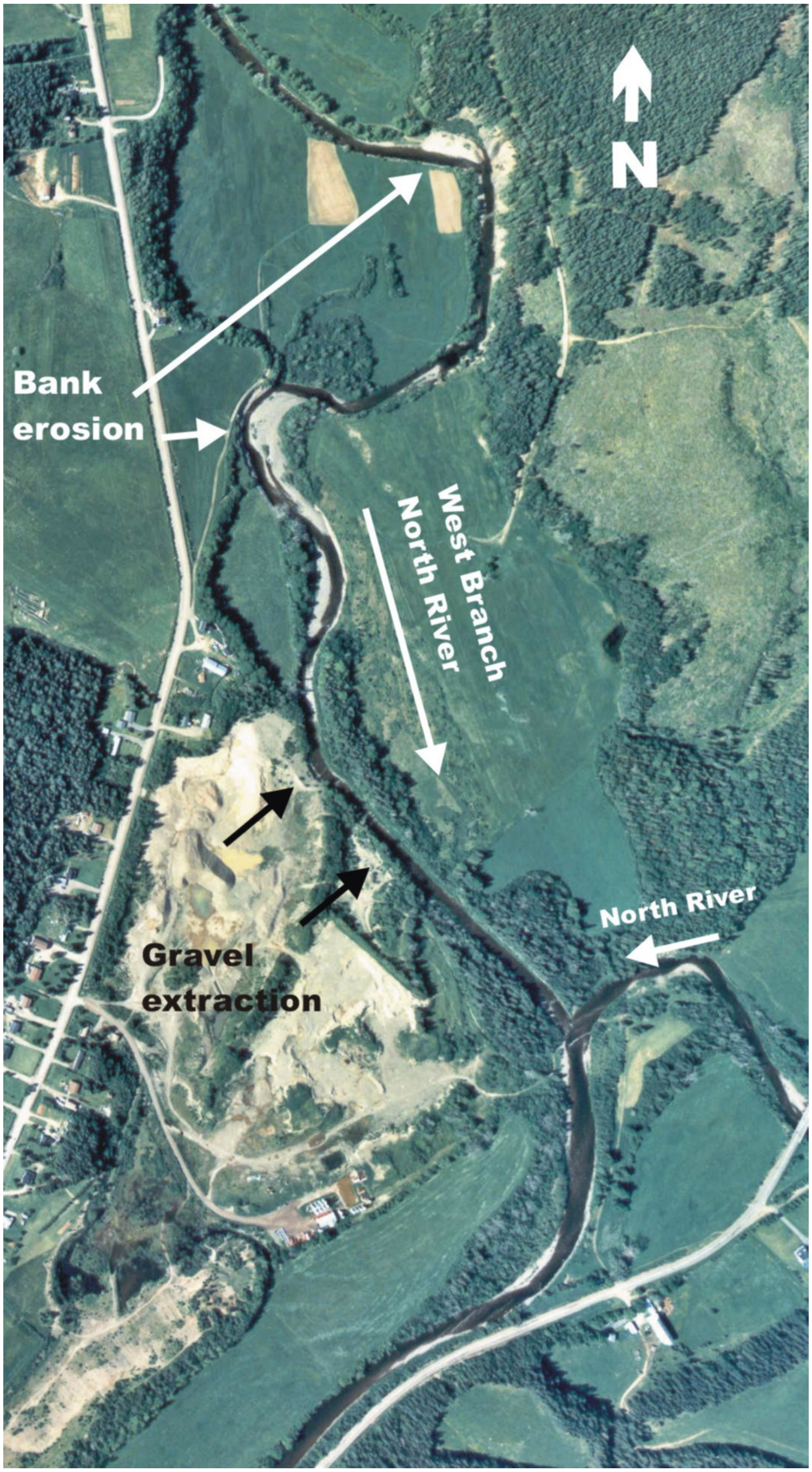

Figure 6: A gravel extraction operation at the confluence of the West Branch North River and the North River is a potential sediment source as minimal, to no, riparian is left between the exposed ground and the river. Upstream, two sections of eroding bank contribute to the bedload and point bars observed in the channel. The banks and the bars should be stabilized.

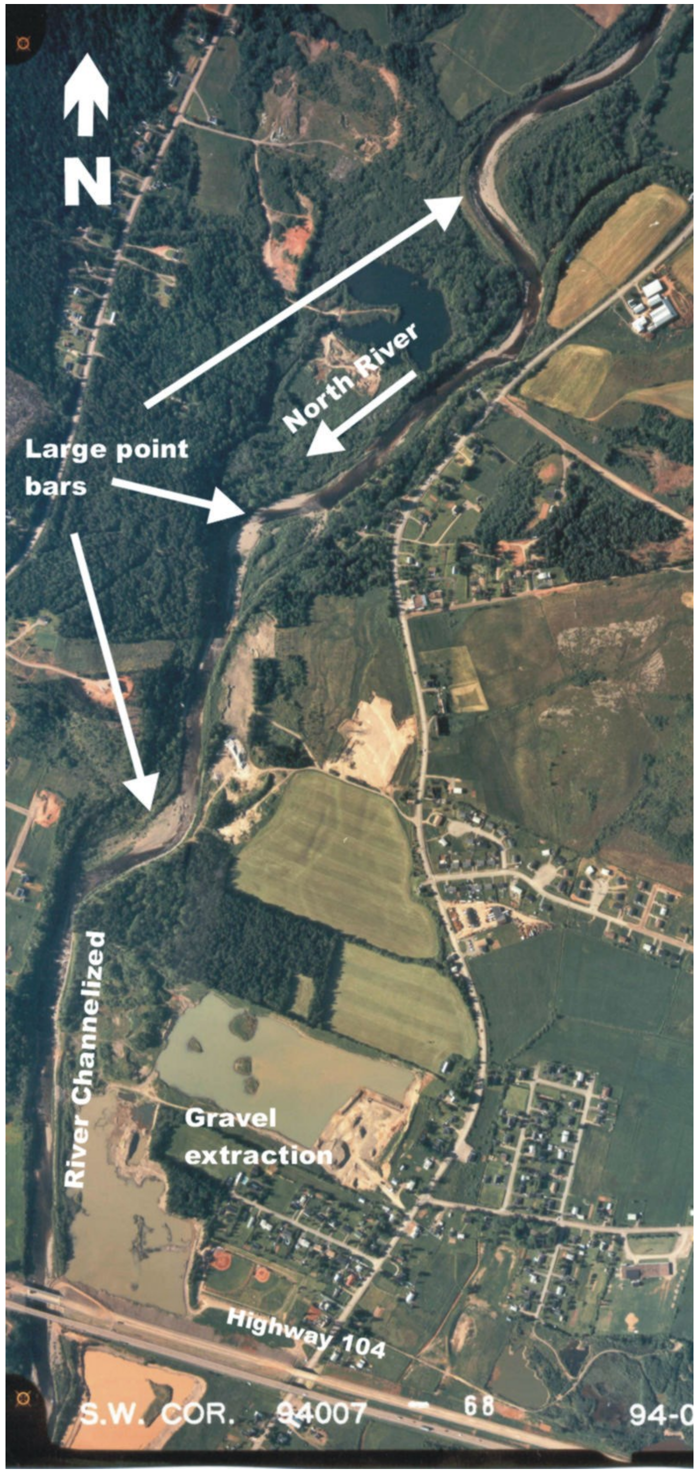

Figure 7: Along with riparian restoration and rehabilitation of gravel extraction sites, this reach of the North River needs stabilization of large point bars to allow for the future improvement of in-stream habitats. Constructed lateral debris jams would work well in this substrate for improving habitat.

3.2.1 Current Conditions

In general, sediment delivery does not appear to be significant in the Salmon River around Truro, based on the sampling conducted by the county since 1996. However, current sampling does not identify impact to habitats from past sedimentation, and it does not measure the movement of more typical substrate materials. There are several locations, particularly on the Chiganois and North Rivers (see Figure 7), where the channel appears unstable based on the presence of large point bars. In most of these locations, potential heavy fraction sediment sources were observed on the 1994 air photos. As well, the area of the watershed south of the Salmon River appears to be on highly erodible soils, and the potential for erosion of disturbed surfaces is greater in those areas.

Lepper Brook is the Town of Truro reservoir, and as such should be carefully managed as an entity unto itself to ensure that both water quality and quantity are not affected. This is in part being done through a forest harvest management plan. In their proposed 2000/01 Lepper Brook Watershed management plan, Kimberly-Clark suggested creating extra take off ditches to ensure proper filtration of run off water (Kimberly – Clarke, 2000), although it was not numerically stated how many per length of ditch, or what distance from a stream crossing these should be implemented. They also proposed the removal of blowdown, as not harvesting will result in "potential siltation problems…which is already occurring." However, if siltation is a concern, the impact of soils exposed by tree blowdown must be carefully weighed against the exposure of soils and channeling of surface drainage that is likely to occur in removing those trees. Ground cover type vegetation serves a primary function in surface runoff filtration, and most undisturbed areas should adequately prevent siltation of streams. Furthermore, there are benefits to leaving blowdown, as coarse woody debris is generally a characteristic only of mature old growth forests (Lynds and LeDuc 1995), and with less than 0.6% old growth stands existing in the province, the habitats, nutrient cycling, and other functions associated with coarse woody debris has generally been impaired. The 1994 air photo review showed a moderate area of Lepper Brook had exposed soils associated with urban development close to the town reservoir. Both development and future potential impacts, such as a residential area with lawn fertilizers or pavement runoff carrying incidental petroleum products from vehicles, must be weighed relative to protecting the water supply.

There are a minimum of six key gravel extraction operations (in the project area watershed) that were observed on the 1994 air photos (see Figures 7 and 8), and that appear to impact the local water resources. The nature of all of these operations is to be in very close proximity to the river channels themselves. Excavation quickly puts the pits below the water table and the sites fill with a combination of surface and groundwater. This factor greatly increases the existence of sediments in water at the excavation site, as surface runoff and excavation operation suspend sediments in the water, and the ponding at the sites. Their close proximity to the rivers means there is a high connectivity to the rivers, and a related high risk of sediments entering the stream channel, particularly during heavy rain and flood events. The North River is the location of greatest gravel extraction activity, but sites of concern also have been identified on Chiganois, and Christie Brook.

There is a Town dump site on a small tributary to McClure's brook (see Figure 9) that appears to be a sediment source. Although a settling pond exists, the existence of downstream sediment bars would indicate the pond is inadequate. There is also significant potential for leachate from the dump to directly enter the watercourse.

Preliminary habitat surveys conducted by DFO at sites on the main branches of the Chiganois, North and Salmon Rivers during the summer of 2001 indicated moderate to high levels of embeddedness of substrates at all locations. As some of these sites were upstream of current resource use activities, but adjacent to historic areas of logging, it is possible that past practices delivered sediments that remain embedded in the streams.

Based on a GIS assessment of digital map coverage, there are some 2.6 km/km^2 of road and rail bed, and 0.67 stream crossings/km^2 estimated within the 967 km^2 project area watershed. Both numbers are high, approaching the trigger levels. Although this alone is not cause for concern, this GIS assessment in combination with review of the 1994 air photos indicates there are two potential issues to be addressed. Many roads are in old logging areas, and left unattended for many years could fail, preventing fish passage and creating localized sediment sources. Secondly, there are roads very close to the main channels of the Chiganois, North, and Salmon rivers, often on both sides of the river, and sometimes with a rail line paralleling the river as well. This means that if any of the road or rail crossings is a barrier to fish migration, it occurs at the lowest point of the tributaries to these main rivers. Whether for general fish population productivity, or access to the cool tributaries for seasonal spawning and cold water refuge, it is important to ensure access exists at these crossings. Access is of particular importance in the lower reaches of individual tributaries.

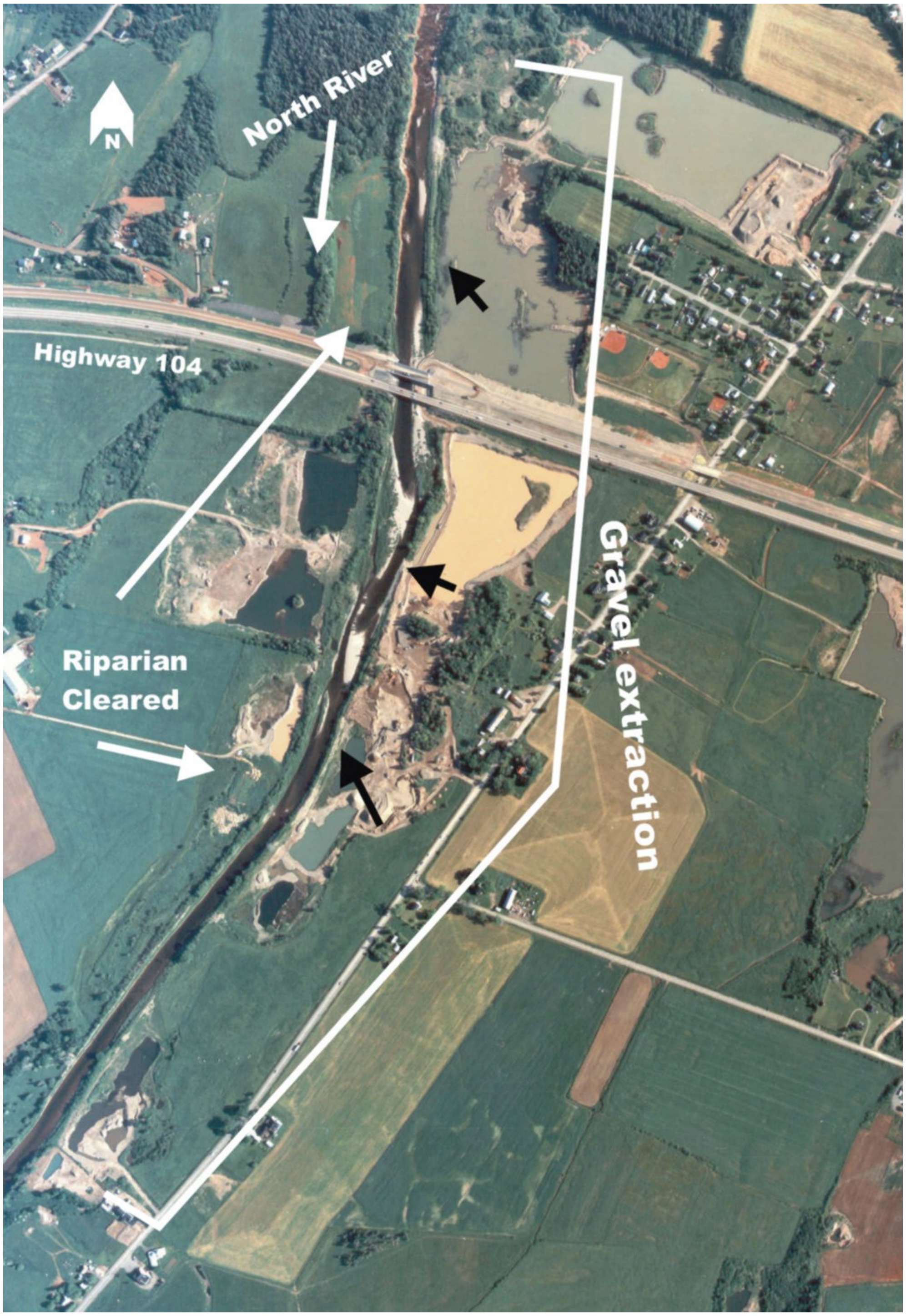

Figure 8: Numerous gravel extraction operations exist immediately adjacent to both sides of the lower North River near Highway 104. Resulting ponds exhibit suspended sediments. Thermal warming and sedimentation may be an issue if these channels drain directly to the river. The North River has been channelized all along this reach (see also Photo 3), and completely lacks habitat diversity.

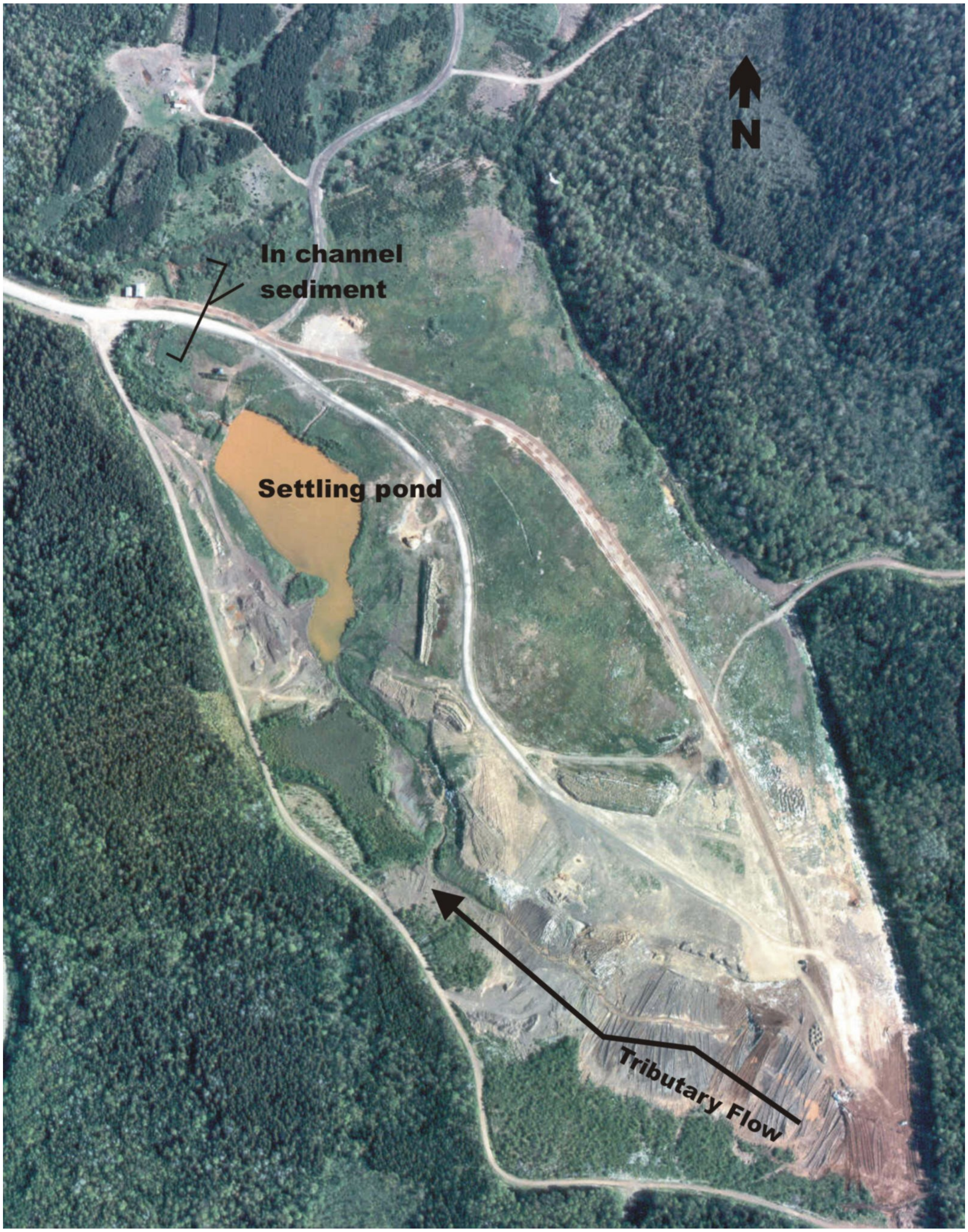

Figure 9: This small unnamed tributary to McClure's brook is the location of the Town of Truro dump. The settling pond appears inadequate based on visible sediments in the channel below the pond. There is good stream habitat and riparian for some distance downstream.

An additional sediment source of undetermined magnitude in the Salmon River Watershed is the somewhat widespread practice of fording rivers with vehicles. Based on air photo review, some fourteen fords were found at seven locations in the watershed (see Table 12).

3.2.2 Target Levels

Targets presented in Table 3 for road lengths help confirm if roads are likely a primary source of sediments or if other sources are likely larger contributors. Unfortunately, no target levels exist for other types of sediment sources typically found in Nova Scotia. Use of this table will help focus management activities on the greatest sediment sources within the basin.

Table 3: Sedimentation trigger and target levels.

Parameter	Trigger Levels	Target Levels	Species of Limit / Source
Total suspended solids		<25mg/L	Salmonid feeding and growth
Turbidity - consumption		1NTU	Canadian Drinking Water Quality Guidelines
Roads within 100m of stream	>0.45 km/km^2	<0.3km/km^2	BC Ministry of Environment – Interior Watershed Assessment Procedure
No. of stream crossings	>0.9/ km^2	< 0.6/km^2	BC Ministry of Environment – Interior Watershed Assessment Procedure
Roads within basin	>2.6 km/km^2	<1.94km/km^2	BC Ministry of Environment – Interior Watershed Assessment Procedure
Stream Bank Erosion	<50% stability total length of both banks	>80% stability total length of both banks	Department of Fisheries and Oceans

3.2.3 Management Response

The degree of current sediment delivery from various potential sources is unknown, as is the long term impact from past sources. The first step in quantifying whether potential problems with sediment sources exists has been completed by a review of aerial photos of the basin. Several key sites have been identified in Table 12 of the recommendations (see also Figures 10 and 11). The next step will require ground truthing of the identified sources to determine if they still exist, and evaluation of the long lasting impacts in areas where historic sedimentation is suspected.

The key is first to stop significant sediment sources before any rehabilitation work in the channel takes place. All sites identified in this report should be visited to confirm current status of these sediment sources, and connectivity to the stream network. The sites should be photo documented, and a description written about the current state, physical dimensions, and stability trends (whether the site is beginning to recover or continuing to destabilize). Finally, a recommendation as to what stabilization activities, if any, should be undertaken. Stabilization activities should begin immediately once the site is confirmed and an appropriate method determined.

The second step is to determine the level of channel impact from current and past sediment sources. A broad survey of stream substrate should be conducted to help confirm the type of sedimentation impact that exists. There are two primary types of impact. Either a fine suspended particulate, or a heavier particulate that settles into the substrates of the stream, will usually be observed. The former means that stopping the source will likely improve stream conditions in a reasonable period without further intervention. Displaced stream invertebrates and other mobile species will likely recolonize the affected area through drift and active migration. If the impact has existed for a long period of time, or in a headwater area where recolonization by drift is not possible, or within an area where riparian vegetation is lacking, then a significantly

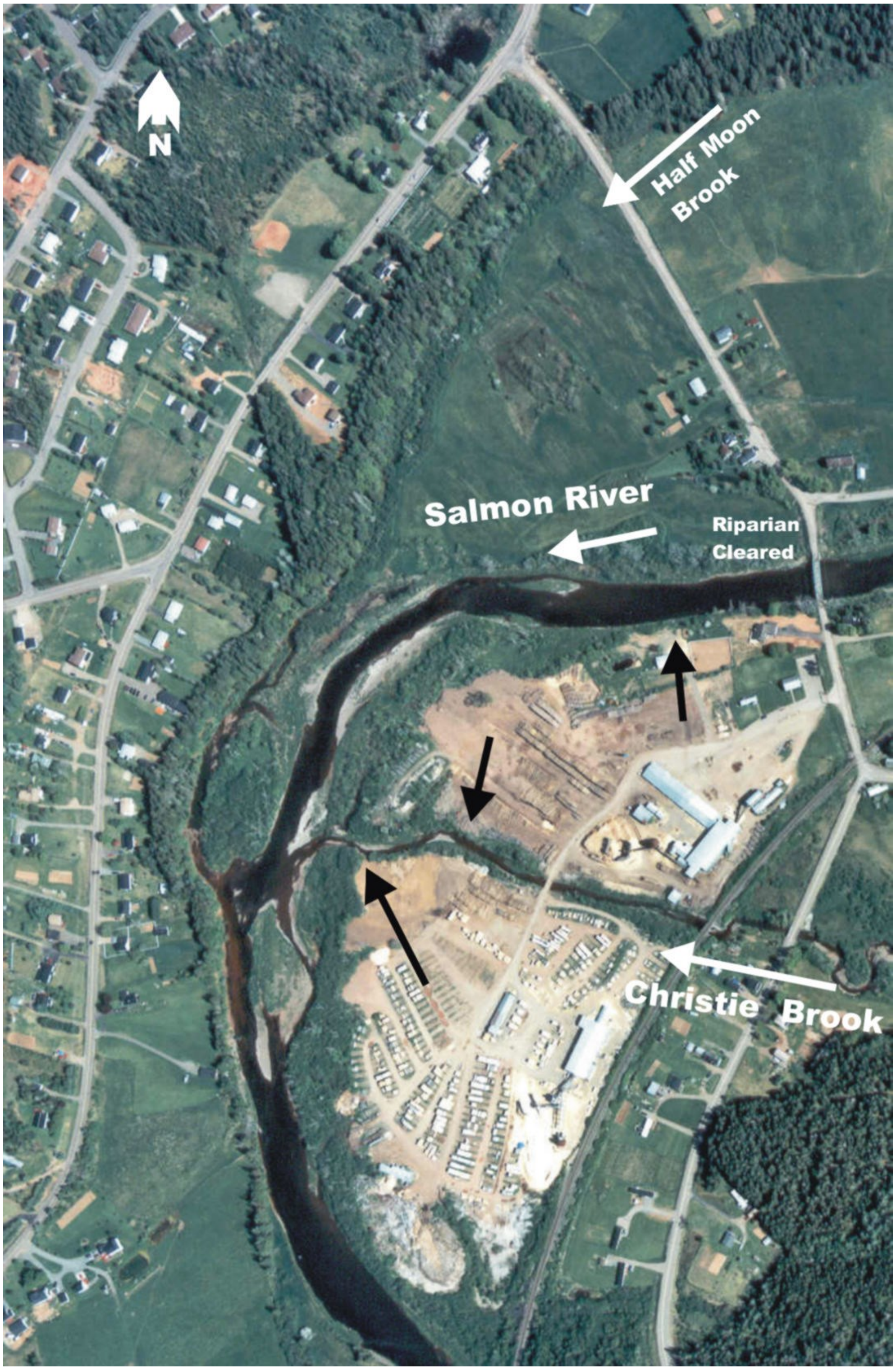

Figure 10: A lumber yard at the confluence of Christie Brook and Salmon River encroaches both systems. As the yard is likely a high traffic area, the potential is great for sediment runoff to the streams through the minimal riparian.

Figure 11: Fourteen ditches drain a field directly to lower Farnham Brook, and are a likely source of sediment. Almost all riparian is lacking from the confluence with the Salmon River upstream to Farnham Road.

longer time may be required for natural increases in productivity to occur. Given impacts from a heavier fraction, interstitial spaces may have become filled with sediments. Aquatic insects that live in the substrate can therefore no longer exist. Stream organics do not become trapped and therefore do not have the chance to provide nutrients to the system. Spawning habitat is greatly compromised, and the ability of the channel to provide complex microhabitats is all but eliminated. In an embedded system only a major run off event will likely improve the impaired habitats. The stream must also be relatively stable and complex to facilitate natural recovery.

Of the larger channels in the watershed, the upper Chiganois and North Rivers are good candidates to be evaluated for stream channel embeddedness and complexity because of the existence of past resource use, current apparent stability, and low human activity. If impacts are identified, rehabilitation efforts will have greater likelihood of success than other areas of the watershed where resource use and channel stability may be ongoing issues.

Once sediment sources have been arrested, consideration should be given to a large scale bar stabilization program at several locations to stabilize stream channels. Bar stabilization for smaller systems is best accomplished by a program of heavily staking exposed bars with willow, alder, or other appropriate species. Although they are not likely the desired final riparian vegetation, they are the most effective in quickly stabilizing a channel and moving toward productive habitat. The relatively low cost of this type of program is appropriate given the risk of failure of any program if a heavy flood season follows the first year of implementation. This project can be done with locally sourced materials and labour. For larger systems, anchored large wood structures on bars can be installed in conjunction with staking. These structures help fines drop out on the bars, further building their height. Their roughness catches additional wood from the system that promotes stabilization / protection of the bar.

The final recommended activity is to provide a system of monitoring and evaluation. In order to determine the degree of sedimentation currently occurring in Salmon River and its tributaries, a sedimentation indicator should be established. It is recommended that a low cost effective means follow that utilized by the British Columbia Watershed Restoration Program (Larkin and Slaney 1996). This techniques uses plastic containers filled with graded gravels embedded in the permanently wetted portion of the main river and several major tributaries. After a period of time the buckets are removed and all sediments from the buckets captured and weighed to determine the volume of material being delivered by the channel. When compared to a standards table, and the other local streams, the resulrts can highlight the magnitude of sediment loads. Furthermore, early collection of this data will allow for future comparison in order to evaluate a measurable objective for sediment reduction. This plan should be implemented prior to spring freshet, as this typically is the period when highest suspended sediment loads are found. Collection and analysis of water samples for total suspended solids is another viable alternative. However, it requires more active personnel participation and laboratory analysis. Such samples should be taken at peak events to supplement and calibrate other data. Similarly, establishment of benthic invertebrate density plots would also provide a sound means of measuring habitat productivity. At this level of the food chain, clean substrates directly affect stream productivity and the resulting correlation would help determine the trend of recovery.

Table 4: Key sediment evaluation activities and locations.

System	Sediment Source Confirmation	Sediment Impact Evaluation	System sediment monitoring
Upper Chiganois	✔	✔	
Lower Chiganois		✔	✔
Farnham Brook	✔	✔	✔
North River	✔	✔	
West Branch North River		✔	
Middle Branch North River	✔	✔	✔
Christie's Brook	✔	✔	✔
Sooley's Brook	✔	✔	✔
McClure's Brook	✔	✔	✔

Table 4 outlines general activities to be undertaken regarding sedimentation and Table 12 highlights specific sites for which some of these activities should be implemented. At a minimum, each of these key sites should be evaluated for sediment impact to stream substrate, and potential sources of sediment identified in Table 12 should be confirmed.

3.3 Freshwater Ecosystem Health

It is often difficult to objectively determine the limiting factors of production of stream dwelling salmonids. However, quantitative comparison of observed physical conditions to some biostandard or conditions in undisturbed systems is one of the best methods available. Physical habitat assessment, in this case for our target species of salmonids, is most valuable when completed during low flow periods. An overview assessment of recent air photos will help target high priority areas for stream assessments. Most high fish value streams will contain a close ratio of riffle to pool habitats, an abundance of large woody debris within the active channel, adequate residual pool depth, and good overhead cover.

3.3.1 Current Conditions

The habitat value of much of the Salmon River watershed has been greatly impaired by years of human alteration. Extraordinarily long stretches of river have been denuded of riparian, channelized or ditched, bermed or dyked (see Photo 3). Natural floodplain functions have been severely impaired. Instability in the river channels was observed on several of the main systems of the watershed. None of the higher order systems exhibit the channel and habitat complexity associated with productive fish streams, and many of the smaller tributaries in the lower elevations of the watershed have been similarly impacted. Associated with these physical changes to the river environment are the observed problems of channel erosion, hydrological impacts, and warm river temperatures (discussed elsewhere in this report).

Photo 3: The North River looking upstream from near the confluence with the Salmon River. The channel has been straightened, bermed, and stripped of all significant riparian growth. Lack of in-stream complexity is apparent.

Hydrologic regimes are affected by lack of channel diversity and large organic debris that allow rivers to become more efficient conduits for water to leave the land base. Related to this lack of complexity are the simplification of local stream hydraulics, and the poor diversity of microhabitats that are targeted by a variety of species. The resulting trend is fewer types of organisms within the channel.

Basic habitat evaluation measures, completed by Department of Fisheries and Oceans summer students in 2001, were carried out on portions of the North River, Salmon River, and Chiganois River. A comparison of DFO estimated river widths (based on the size of the watershed) and the existing river widths as sampled, showed over-widening of the channel from 1.2 to 1.4 times the estimated width. Their August survey also showed both the Salmon River and North River mainstems were reaching 26 ^{0}C at several locations. A total of 2.4 km of habitat was surveyed on the three systems. Not one significant pool was found. A similar observation was made of these systems through the 1994 air photo review. Snorkel surveys for salmon in the system show the fish tend to be holding behind individual boulders in the stream (Longard 2001). Lack of deep holding and over wintering pools for both adult salmon and trout within the basin seems to be one potential limiting factor to fish production. Lack of pools can also increase stress and predation of fish during summer low flows. Finally, it could impair salmon migration and the ability of fish to enter and hold in the river much prior to spawning. With Atlantic salmon numbers being as low as they currently are, holding habitat may not be limiting to that species, but may still be important for resident and anadromous trout. The limited primary pool habitat is likely limiting to successful migration of these anadromous species.

Photo 4: A cement cap helps protect a pipeline crossing of the Salmon River at Truro. At low flows, such as in the photo, it could inhibit some fish passage.

A final result of degraded channel habitat is that food webs are affected. The ability of the natural system to be as diverse as it was in historic times becomes restricted. As organics are flushed through the system, primary producers and invertebrate scraper and shredder organisms become suppressed. With a simplification of habitats through removal of in-stream and riparian wood, and infilling of pools (to name a few), the physical habitat of the organisms that make up the base of the food chain become smaller and less productive. The basis of stream nutrient cycling in Eastern Canada is largely leaf litter and streamside organics that must be held within the river system long enough to support primary production

Lastly, a quick review of the watershed roads shows there to be at least 1600 stream crossings. Healthy habitat is of little use if the target species cannot access it. Recent evaluation of culverted road crossings in the interior of British Columbia has shown as many as 40% of old installations are either full or partial barriers to fish (Parker pers. comm. 2001). In a system like Salmon River, where large portions of habitat exist in first, second, and third order streams, the potential for significant habitat loss because of culvert barriers exists. Standard methodology (Parker 2000) allows for evaluation and prioritization of culverts for fish passage. Salmon fry have demonstrated a preference for streams, 2.5 meters wide (Scruton and Gibson 1993), and it is this same magnitude of stream that is more likely to have a culvert than a bridge at any road crossing. Maintaining fish passage for fry and young parr at culverts is difficult because of their poor swimming and jumping abilities. Because of low mobility of fry, it is critical to ensure spawner passage high up into the systems to the preferred habitat of young fish.

The number of stream crossings per unit area of watershed for the Salmon River basin is high. Given a project area of approximately 966 km^2, and some 1600+ crossings within that area, the target level of 0.6 crossings per km^2 is approached. Therefore, the potential for both sediment sources and fish barriers associated with crossings may be of concern. Although an assessment of crossings by sub-basin was not conducted, it is expected that Chiganois, West Branch North River, and Black River all exceed the target levels.

Farnham Brook used to have a dam on it. At Crowes Mills, Baird Brook is dammed to form Higgins Pond. It used to be for a mill operation. A large dam on Lepper Brook creates a reservoir for the Town water supply. A small dam at McElmon's Pond, at the Department of Natural Resources Game Sanctuary off the Chiganois River, has a six step straight fish ladder. Department of Natural Resources has noted a productive trout population in the headwaters of McElmon's (pers. comm. MacLennan 2001). Although the dam at McElmon's has a fish ladder, the others do not, and the potential for expirtation of resident trout populations from a locally significant impact is increased. Dams have the potential to flood key spawning or rearing areas for fish, although these types of habitat do not appear limiting in the project area, and this issue is of little concern.

Early in 1998, a broad survey of the Salmon River Watershed was completed by Cobequid Salmon Association members to identify areas for urgent repair and restoration (Cobequid Salmon Association 1998), but the results of that survey have not been available as part of this report. The Association has carried out stream rehabilitation activities at several locations in the Salmon River watershed, including Clifford Brook, Farnham Brook (see Photo 5), McClure's Brook, Steele Run, and the South Branch North River. Nova Scotia Fisheries staff recently carried out fish surveys on Clifford's and Farnham's Brook, and found good numbers of Brook trout (*Salvelinus fontinalis*) in both sites. Larger fish, but fewer age classes are being observed in Farnham. A possible fish barrier exists on Clifford's Brook at Highway 104. Both systems are second order streams (LeBlanc 1998). A greater number of American eel, *Anguilla rostrata*, found in Farnham may be an indication of poorer quality habitat and sedimentation. Based on a data logger Cobequid Salmon Association had in Clifford Brook, maximum water temperature in 1999 was 23 ^{0}C, and very few days reached above 20 ^{0}C. These measures further indicate the value for both rearing and cool water refuge.

Photo 5: Two photos of Farnham Brook. The one on the left shows recent stream improvements conducted below Vimy Rd. The right photo shows an up stream stretch with good riparian function, although the channel lacks structure and complexity**.**

3.3.2 Target Levels

River systems are all so unique that it is difficult to provide general target guidelines that can consistently be applied. Therefore, the following targets deserve strong consideration, but ultimately need to be applied by a habitat professional who can make the necessary judgments on application of the targets to individual systems. Four major components are highlighted here for ecosystem target levels: large woody debris (LWD); riffle – pool frequency; residual pool depth; and overhead stream cover. Many more indicators exist that can be used by a professional to further diagnose degraded habitat; however, if these basic elements are not met, then further intervention is necessary. More detailed explanation of parameters is presented in Appendix A.

Table 5: Summary Freshwater Ecosystem Trigger and Target Levels

Habitat Parameter	Trigger Levels	Target Quality Guideline
Pool Riffle Ratio (area)		>1:2 for channels <15 m bank full width and <5% gradient
Pool Riffle Ratio (habitat unit)		~1:1 for channels <15 m bank full width and <5% gradient
Residual Pool Depth	<30 cm for primary pools	/50 cm for primary pools
Functional Large Woody Debris Tally		/1 piece per bank full channel width
Over-stream Cover	< 10%	/10 % cover within 1 meter of bank full water surface area
No. of stream crossings	< 0.6/km^2	>0.90/km^2

3.3.3 Management Response

All tributaries greater than 2 meters bank full width that do not have a survey of primary habitat units[*] within the length of stream that is potentially fish bearing should have a 'Level 1 Fish Habitat Assessment Procedure (FHAP)' conducted (Johnston and Slaney 1996). The assessment requires the careful measurement, over a representative length of channel, of the primary habitat units, LWD within each unit, and degree of overhead cover as described and recorded on the form in Appendix A: *Level 1 FHAP Form*, or some similar format. Results should then be analyzed relative to Table 5 and the guidelines. Comparison of primary habitat unit ratios and LWD tallies should also be done with any low or non-impact reaches within the watershed, to help determine local target levels for those features.

An evaluation of fish passage at all watershed stream crossings that exist on 1^{st} to 3^{rd} order streams, based on 1:50,000 mapping, should be carried out. These selection criteria will include streams that are big enough to represent significant fish habitat, but small enough to have been spanned with a culvert, as opposed to a bridge. Evaluations, and any necessary fish access restoration, should begin in the lower reaches of individual systems first, and proceed toward the headwaters. This ensures tributaries are linked to the larger systems for fish access. Maintenance and sediment source issues should also be noted at each crossing, even if fish passage is not an issue. Such information can be forwarded to those responsible for maintenance of the road, be it forestry, private landowners, or Department of Highways. A form, and method, similar to that found in Appendix E: *Fish Passage Culvert Inspection Form* should be used (Parker 2000).

[*] Primary habitat units are the riffles, pools, and glides that dominate channel morphology. They must be greater than 50% of the wetted width, and at least one average bank full width in length to be considered primary features. Pools must also maintain a minimum residual depth at low flows.

For the mainstems of the Salmon, North, and Chiganois Rivers, fish habitat rehabilitation is necessary, but as a lower priority to riparian and channel stability activities. Focus should be on the continued improvement of tributary habitats, as the Cobequid Salmon Association has been undertaking. In particular, Farnham, McClure's and McElmon's warrant further examination. Tributaries that are lower in a watershed provide valuable high water refuge, as well as rearing, for anadromous species. Each of these systems has good trout populations that should be protected. Additional complexing should be considered on Farnham Brook in the area of Vimy Road (see Photo 5). Boulder clusters and large woody debris structures would improve cover and habitat complexity until riparian areas regenerate. Upstream, there is dense riparian vegetation that provides good small organic debris, shading, and cover. However, consideration should be given to installing some large wood structures, and creating a few openings along the riparian that would allow for planting or release of conifers or other larger growing species. As well, there is an opportunity to partner with the Nova Scotia Agricultural College in restoring the lower reach of Farnham Brook, from Farnham Road to the mouth of the brook that runs across College property. This section has moderate riparian functions, but lacks maturing riparian growth, and in-stream habitat has been impacted by channelization. Possible sedimentation issues exist in the lowest portion of this reach below Highway 311. Improving channel morphology diversity will provide better connectivity of this system, which appears to have good fish productivity in the upper reaches, to the Salmon River.

It is recommended that concurrently, a few large wood structures be designed and installed in the Chiganois (above Staples Brook) and Middle Branch North River (lower reaches), and be monitored in order to determine effectiveness and stability within these systems as potentially large benefits could be achieved. If shown to be successful, the relative priority of mainstem habitat restoration could be increased.

In general, mainstem works should focus on those areas, identified in Table 12, that are in need of bar stabilization and riparian work. It is recommended that an extensive program of staking large point bars with fast growing, native, moisture tolerant, deciduous species be initiated as soon as possible. A staking program will serve to stabilize lateral movement, as well as narrow and deepen the targeted reaches. Once stability is achieved, additional habitat rehabilitation can be considered to increase complexity. Large wood structures may be needed at the head of some of the largest bars to provide roughness, and promote accumulation of additional substrate.

The Clifford Brook culvert crossing identified in Table 12 should be evaluated to ensure fish passage, as there are good trout densities confirmed, relatively cool summer waters, and past rehabilitation works on the brook. If passage is an issue, a structure similar to those in Appendix F: *Fish Passage restoration techniques* could be considered.

3.4 Riparian Assessment

Riparian and wetland areas serve several major functions to a stream system. These functions can usually be grouped into the following five categories: surface sediment filtration, bank and channel stability, stream shading, large woody debris recruitment, and small organic debris contribution (i.e., leaf litter, twigs, terrestrial insects). What we want to concern ourselves with is whether or not these streamside areas are carrying out each of these functions, and in which direction they are tending if not functioning properly. Those tending away from proper functioning condition are of greater concern than those areas that are recovering well, and beginning to once again adequately carry out the above noted functions (Prichard, D. H. et. al. 1998).

3.4.1 Current Conditions.

Riparian functions of the lower reaches of the Salmon River (see Figure 12), and all the tributaries entering these lower reaches (see Figure 13), have been severely impaired. Table 12 outlines, at a great underestimate, more than 24 km of river channel that is almost completely devoid of riparian vegetation and function. Stretches of river up to 3 km long have little or no riparian areas. The severely degraded, or lacking, riparian functions makes restoration the second most important priority for this watershed behind water quality. It is also the single most important long term IMP issue to address for the future health of the aquatic ecosystem, because of the length of time necessary to establish a fully functional riparian area in a location where none currently exists.

Figure 12: The riparian corridor along the Salmon River is lacking for 3km through Truro, along both banks of the river. It appears likely there are only a couple of landowners with whom to address this high priority issue.

Figure 13: Over 3.5 km of the lower Chiganois River has no mature riparian vegetation. The resulting lack of habitat complexity is apparent, and other functions of the riparian are severely impaired. The importance of this reach makes it a high priority for extensive riparian restoration.

During a 2001 summer survey of the Chiganois, Salmon, and North Rivers by Department of Fisheries and Oceans summer students, riparian areas were found to be lacking. In particular, their sampling sites on the Salmon River typically ranged from 5% to 15% tree cover. Review of 1994 air photos confirmed several large, key locations to have poorly established riparian areas. These include the lower reaches of the Chiganois and Salmon Rivers, as well as Beaver Brook, Farnham Brook, McClure's brook, and several smaller tributaries to all of these systems as outlined in Table 12 of the recommendations.

Table 6: Potential level of riparian functioning (from Koning, C.W. Ed. 1999).

Structural Stage	LWD	SOD*	Stream Shading	Surface sediment filtering	Bank and channel stability
Initial	L	L	L	L	L
Shrub herb	L	M-H	L-M	M	L
Pole sapling	L	H	L-M	M	L
Young forest	L	H	M-H	H	L-H
Mature forest	H	H	H	H	H
Old forest	H	H	H	H	H

*Small organic debris (leaf litter, twigs, terrestrial insects)

An overall riparian assessment for the watershed has not been conducted, nor is it known which way the individual functions are tending. But the need for wide scale riparian restoration is very apparent based on air photo review and consideration of observed conditions and their ability to function (as displayed in Table 6). The key question is whether the areas are repairing naturally, or still in a phase of becoming less functional. An example demonstrates that not all is apparent at first glance.

If an area of stream bank was logged 15-20 years ago, it could very well be overgrown with good size trees that look as if they meet most functions reasonably well, and can only get better. However, a look at the stream may show that the large woody debris in the same reach is almost all gone. Either it has rotted away or washed away in floods. As the streamside vegetation is still young, we will not expect any of it to fall naturally into the channel (natural recruitment) for another 50-80 years. LWD, then, is tending away from proper functioning condition even though other functions currently may be improving (see Table 6). As the LWD becomes depleted, the channel may loose stability, habitat value, in-stream cover, substrate sorting ability, and pool formation. Therefore, it may be a key site for placing in-stream LWD structures that will help until natural wood recruitment can begin again from the riparian area. To reiterate, it is important to determine not only what functions are impaired, but also which way they are tending relative to their proper functioning condition.

In 1995, 4% of Nova Scotia forests were over 80 years of age, and only 0.6% were over 100 years. A small 0.4 hectare site of old sugar maple and elm identified on a private lot near Kemptown in the Salmon River Watershed, and a 52 hectare old forest on Crown land near Montrose, Colchester County (Lynds and LeDuc 1995), are the only local sites identified as old growth. As large trees do not generally mature and die any sooner than 80 years in Nova Scotia, the presence of naturally falling wood (recruitment) to Nova Scotia streams is all but non-existent, even if a riparian of relatively old trees exists. Significant amounts of large wood do not fall naturally to the ground until a mature old growth stage exists at 120-150 years stand maturity (Lynds and LeDuc 1995). Given that many of our rivers are gravel and cobble based, wood is an integral part of not only bank stability, but also stream morphology. Without naturally recruited trees entering a river system, habitat complexity is greatly reduced. Installing log structures in the streams and leaving riparian buffers to mature and naturally recruit to the rivers is a sound short and long term strategy for stabilizing our rivers and improving habitat and complexity. Installed structures can be expected to give 10-50 years of service, at which time riparian areas will hopefully be able to begin a natural supply of wood to the rivers.

Lepper Brook was not observed to be a highly impacted area based on 1994 air photo review. However, some impacts were observed, and as a water supply for Truro it needs to be given careful attention. In the Lepper Brook watershed

Kimberly-Clark proposed to follow a machine exclusion zone within 10m of streams (Kimberly –Clark, 2000). However, it did not specify a buffer zone, or no cut zone, nor did it specify the exclusion zone would apply to all streams. They do note, however, that in one proposed Provincial Crown block a corridor of 35m on each side of the brook is to be left. They also proposed to allow natural regeneration 'to encourage species diversity', and to plant only areas where adequate regeneration was not occurring. Cut areas were to be limited to 25 acres, except where insects, disease, over maturity or blowdown damage occur. This criterion would typically leave many opportunities to justify larger cut areas, and, in fact, two of the three proposed blocks for the current harvest year exceeded the guideline of 25 acres. The management plan is currently only for one year, after the original 10 year agreement expired in 1999.

3.4.2 Target Levels

In early 2002, DNR implemented new regulations for the protection of wildlife habitats and watercourses (Nova Scotia Department of Justice 2001). The regulations serve to limit logging activity on both private and Crown lands. The primary regulation protecting watercourses is the establishment of a riparian buffer on streams greater than 50cm wide (see Figure 14).

Over 70 % of the Salmon River watershed is privately owned. The old regulations protecting Crown Lands were infrequently applied to private holdings both, intentionally and unintentionally. The new regulations to protect wildlife habitat and watercourses should address this shortcoming to some extent, as they apply not only to Crown lands but also private holdings, such as industrial woodlots or small woodlots. All lands in this report have been evaluated based on the same standards, regardless of ownership, and provincial guidelines were used to evaluate and identify resource management opportunities.

Riparian function is difficult to quantify and the targets presented are only general guidelines. Those presented are for a watershed scale analysis, as a site evaluation is very different. Although watershed scale impacts are expected, they are difficult to quantify. There are many stream sections for which riparian functions desperately need to be addressed, as presented in Table 12 of the recommendations. Table 7 presents trigger levels to determine likely impairment of riparian functions within the Salmon River basin, and can be completed through an air photo review using a map wheel or GIS to measure relevant distances.

Table 7: Summary Riparian Target Levels

Habitat Parameter	Trigger Level	Target Level	Source
Portion of stream riparian cleared		<0.15 km/km	British Columbia Ministry of Environment
Portion of fish bearing stream riparian cleared		<0.25 km/km	British Columbia Ministry of Environment
Riparian buffers - <50 cm stream width	< 5 m	No unnecessary shrub; herbaceous veg. removal within 20 meters. No vehicle machinery within 5m.	Nova Scotia Department of Natural Resources
Riparian buffers – >50cm stream width	< 20 m	Leave a living basal area of trees no less than $20m^2$ per hectare within 20 meters. No canopy opening greater than 15 m. No vehicle within 7 m.	Nova Scotia Department of Natural Resources

3.4.3 Management Response

Riparian restoration, involving a variety of techniques, is the second greatest priority for the Salmon River Watershed. Table 12 highlights over 24 km of channel that is of primary importance for this work. It is recommended that NSDNR riparian guidelines be followed, and a 20 meter riparian zone be created. A riparian specialist should be involved in determining species mix and planting densities. In some areas that exhibit a pole sapling growth, a silviculture

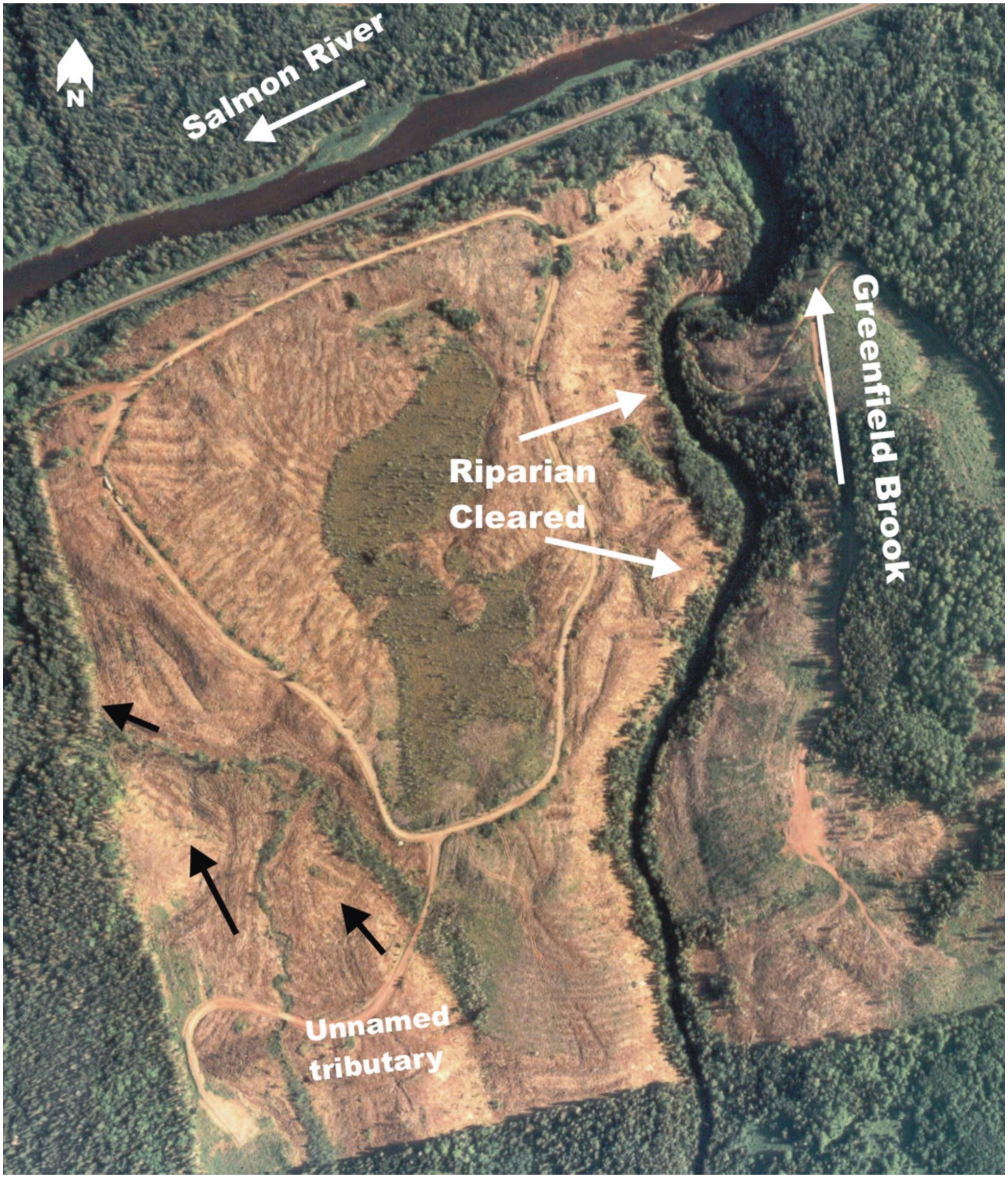

Figure 14: A small unnamed tributary next to Greenfield Brook has been logged over and has no riparian left. Minimal to no riparian remains along much of both sides of the lower reach of Greenfield Brook. No immediate impacts are apparent, yet future impacts to stream stability, habitat, and shading could be an issue.

prescription may be appropriate to release desired species and improve growth. Any lower river sections that have been cleared of vegetation to the stream bank should receive revegetation to help restore natural riparian function, and planting should begin immediately in areas identified in Table 12. A specialist would provide valuable input in helping ensure success. Too often the wrong species are planted in a site and success is poor. Furthermore, the species planted may not help address the most impaired function of the riparian area. For example, staking a bank area with willow and alder can provide quick dense cover that may address bank stability, surface filtering and small organic debris input. However, this species will not usually provide long term large woody debris, bank protection from heavy ice scour, or stream shading to larger systems. Another common error is planting some species in open areas when they are the desired long term species. Unfortunately, such species are often not pioneer plants and can be intolerant to the direct sun and its heat, or too much water often associated with a cleared stream bank. The result is a good intentioned project that fails. Mixed planting and identification of micro sites by a specialist can often overcome these problems and protect the capital investment made.

Efforts should be made to work with the landowners of impaired riparian areas, and areas of active land clearing, to make them aware of the new Forest Act Regulations (Department of Justice 2001), and to encourage their partnership in the establishment of riparian areas.

The Town of Truro should seek a variety of opinions on land use activities in the Lepper Brook sub-basin in order to make the best informed decisions possible for the protection of the Town water supply. New regulations for forestry management (Department of Justice 2001) will further help protect water resources on both Crown and private lands. However, these regulations do allow management options within riparian areas, and the Town may wish to have the most protective definition applied to the Lepper Brook basin.

In general, the Nova Scotia Agricultural College should be encouraged to promote establishment of full riparian buffers, composed of a 'free to grow' to maturity stand, on all their operational lands. The opportunities to the college to reach new agricultural managers, and promote education of the value of riparian resources from both ecological and agricultural perspectives, are greater than through other available mechanisms and form a valuable part of long term IMP strategies.

3.5 Hydrology

Hydrology and hydraulics are often confused, in part because of their interrelationship. Hydrology deals with the large scale of the water cycle, how water lands on, runs off, sinks into, and otherwise leaves the earth's surface. Hydraulics tends to deal more with how surface water acts as it tumbles over logs and rocks, goes through culverts, and babbles along a stream bed. The scale is smaller than that of hydrology, focusing on a localized area. Hydraulics is indirectly considered in section *3.3 Freshwater Ecosystem Health.* Here we will discuss the larger scale hydrology of the watershed and the impact of human activity on it. Hydrologically unstable systems have poorly developed riparian vegetation and experience episodes of stream bank erosion and siltation, often resulting in poor quality habitat conditions (Scruton and Gibson 1993). There are two major areas of hydrological influence discussed in the IMP, vegetation removal and drainage alteration.

Removal of mature tree vegetation within a watershed can alter the snowfall accumulation, spring peak floods, summer low flows and other hydrological processes. Therefore, in order to determine if there is potentially altered hydrology within a basin because of this factor, it is important to estimate the Equivalent Clear-cut Area (ECA) within the watershed. Note that this is equivalent clear-cut, not actual, and therefore includes cultivated lands, burn sites, and hydro lines as being "equivalent" to a clear cut. Furthermore, equivalent refers to the area that would be clear-cut after considering a reduction for forest regeneration within historically denuded areas.

A second factor that contributes to a change in system hydrology is drainage alteration because of road construction. The higher the density of roads, the greater the likelihood natural drainage patterns have been altered. Ditches redirect water to quickly exit a hill slope, and the road surface itself drains more quickly toward those ditches than does a heavily vegetated forest of equivalent surface area. As the water quickly drains off the land, it enters the river system faster, creating greater "peak" flows. This effect puts more water in a river than it was "designed" for by mother nature and can cause excessive erosion, greater bed load and sediment movement, and increased loss of wood from the channel than in historic times.

3.5.1 Current Condition

The ECA, density of roads, and number of stream crossings have been estimated for the project area. Approximately 2488 kilometers of roads and rail beds exist in the Salmon River Watershed. Given the watershed area of 966 km^2, there are 2.6 km/km^2 of road beds, and some large tracts of cleared lands in the Salmon River watershed. Agriculture has cleared much of the lower elevations of the watershed. With the exception of the Black River sub-basin, areas outside of the lower Salmon River valley appear only moderately impacted by land clearing, and logging activities.

The ECA of the Black River sub-basin appears high based on review of 1994 air photos that showed large areas of logging. This observation was not quantified.

An average road density of 2.6 km/km^2 in the whole project area does not imply hydrological impact, although it is in excess of the target level outlined in Table 8. However, particular sub-basins appear to have higher road densities than the average, and could very well exceed trigger levels. Chiganois, West Branch North River, and Black River all appear to have higher than average road densities.

There is a great amount of ditching in the lower elevations of the watershed, likely to promote the quick drainage of agricultural areas established in the flood plain. However, the practice is double edged in that it also means lands are more quickly drained during periods of flooding, adding to the magnitude of the flood. The lower Chiganois, Farnham Brook, Baird Brook Beaver Brook, Higgins Brook, and McCurdy’s Brook all exhibit a high degree of ditching and channelization to drain lands. Historic drainage densities (km stream / km^2 of basin area) were calculated for a few of these areas (Hennigar 1968). The alteration of drainage density is likely to have affected the local hydrology of some of these basins.

3.5.2 Target Levels

When the ECA of a watershed is above 25%, it almost certainly affects the system hydrology. The greater the proportion of ECA in the upper elevations of the watershed (in the upper 60% of the hydrosymetric curve), the more likely the hydrologic regime will be altered (Anonymous 1995). The second component being evaluated by this IMP in regard to hydrology is the density of roads within the watershed because of the relationship between road density and altered drainage.

Table 8: Summary Hydrology Target Levels

Habitat Parameter	Trigger level	Target Level
Equivalent Clear Cut Area (ECA)		< 25% of watershed area
Road density for entire sub basin	>3.0 km/km^2 of watershed area	<2.1 km/km^2 of watershed area

3.5.3 Management Response

Flooding in the lower valley is an ongoing concern that is largely not addressed within this report. However, hydrological impacts will only further exacerbate the problems associated with flooding, and therefore should be a relatively high IMP priority. Removal of vegetation, the issues of ECA and water retention, roads and their ditches altering natural drainage patterns, and development of industrial park areas that remove vegetation hardens ground surfaces and creates drainage alterations. Soil compaction, loss of wetlands, and dyking are all things found in abundance in the Salmon River watershed, and all things that cumulatively will alter hydrology. Peak flows are higher and summer low flows are lower when critical thresholds, some of which are outlined in the trigger levels Table 8, are exceeded. Therefore, it is recommended that a comprehensive GIS evaluation of ECA, road densities, and drainage densities be conducted within the watershed to further identify the priority that should be associated with carrying out activities such as road deactivation, block and riparian planting, or silviculture and water management within industrial areas. These should be carried out at a sub-basin scale to further highlight priority areas. Additionally, a review of flood reports and hydrometric station data for the watershed would further support or refute the concept of hydrology being impacted, based on the observed changes in flood return rates and discharge rates. Historic precipitation and discharge station data exist from the 1930's and 1960's respectively for comparative analysis (Hennigar 1968).

A GIS analysis of land use polygons and regeneration is needed to quantify and support the relative priorities of addressing cleared areas within the watershed on a sub-basin scale. The Department of Natural Resources has current forest cover data and satellite imagery showing cleared lands (as opposed to the dated 1994 air photos) that would aid accuracy and timeliness of this process. Accurate analysis of current data sources for the following parameters would be of great benefit to hydrological, and other resource, evaluation.

- Equivalent Clear Cut area by sub-basin.
- Equivalent Clear Cut area above the 60% hydrosometric curve by sub-basin.
- Road densities by type and by sub-basin (km/km^2 of watershed).
- Roads within 100m of streams by sub-basin (km roads/km^2 of watershed)
- Number of stream crossings by sub-basin (crossings/km^2 of watershed)
- Length of stream riparian cleared by sub-basin (km/km of stream)
- Length of fish bearing stream riparian cleared (km/km of stream < 20% gradient).

This GIS analysis is the best manner in which to confirm with confidence the level of priority that should be given to addressing local impacts that affect hydrology.

4.0 Estuary Based Evaluation

This component covers all estuary base resources relevant to the identified *Key Issues and Questions in Section 1*. Two components of the estuary based project area are discussed: water quality, and estuary ecosystem health.

Current conditions of each of the two review components have been analyzed and presented. The current information has then been compared to relevant environmental quality guidelines derived either from regulatory requirements, or best management practices. Both trigger levels, those below or above which a measure should not go, and target levels, those that we would like to meet through integrated management activities to be confident our ecosystem parameter is properly functioning, are presented.

4.1 Water Quality

The primary issue related to water quality in the estuary portion of the project area is one of fecal coliform contamination. High levels of fecal coliform contamination has resulted in the closure of the whole estuary project area for shellfish harvest.

4.1.1 Current Conditions

The county of Colchester has been regularly sampling estuary water quality since 1996. These samples, collected at Old Barns, have shown degrading quality of estuary water. Fecal coliform and biological oxygen demand averages for 2001 were 4000+ MPN/100ml and 6 mg/L respectively. In 1997, approximately 200,000 hectares of coastal waters in Atlantic Canada have been closed to the harvesting of shellfish because of fecal bacterial contamination, representing 33 % of the total classified shellfish growing area (Menon undated). All of the estuary area included in the project area for this report is closed for shellfish harvest because of high fecal coliform levels.

Turbidity is naturally high in the estuary, with total suspended solids being 300-400 mg/L on a regular basis, far in excess of the 25 mg/L target level for freshwater aquatic habitat. This level of turbidity, and the strong tidal currents, naturally limit the use of the estuary for spawning and rearing of most marine species. Clams are found in some areas and have been historically harvested recreationally.

4.1.2 Target Levels

As the Salmon River estuary is not a high use area, typical target species were not used to define target levels for the several key parameters. The estuary target levels are generally established by taking the species with the greatest sensitivity to a particular parameter and using it to establish estuary target levels. However, more general targets are presented in Table 9, as no key species in the project area has been identified. Additional marine environmental quality guidelines are presented in Appendix D for reader reference.

Table 9: Estuary water quality target levels.

Parameter	Trigger	Target Level	Species of Limit
PH		7.0-8.7	Canadian Water Quality Guidelines
DO_2 – dissolved oxygen	5.0 mg/L	>8.0 mg/L (early life stages >9500 μg/L^{-1})	General (Canadian Water Quality Guidelines)
Lower temperature limit	+ or – 10% of seasonal ambient		
Upper temperature limit	+ or – 10% of seasonal ambient		
Fecal coliform – shellfish harvest	Mean is] 14 MPN/100ml or 10% of samples above 43MPN/100ml	]14 MPN/100 ml	Canadian Shellfish Sanitation Program
Fecal coliform – human contact		<200 MPN/100 ml	Background Level

4.1.3 Management Response

There is only one objective for estuary water quality improvement that is recommended for consideration. It is the reduction of fecal coliform contamination to allow for local shellfish harvest. Several sites, identified in Table 12, need to be evaluated in order to confirm, and reduce, fecal contamination sites adjacent to the estuary. Air photo review revealed several locations, mostly on the southern boundary of the estuary between, and including, Mill Brook and Beaver Brook, which appear to have likely sources of fecal contamination. Furthermore, review of the County of Colchester water sampling data from 1996-2001 revealed a marked increase in fecal coliform at Old Barns since 1998. Land use development and management changes around that time should be examined to determine if a link to the higher counts can be identified.

Remediation activities have been successful in re-opening a portion of the productive shellfish growing areas in Yarmouth Harbour, NS; Caraquet, NB; and Murray River, PEI. A total of 2485 hectares of shellfish closures have been reopened for commercial shellfish harvesting as a result of pollution remediation since 1990 (Menon undated).

4.2 Marine Ecosystem Health

As with the fresh water evaluation, target species ought to be identified. Usually a shellfish or fin fish would be used for an estuary area. However, limited use of the estuary by such species precluded the selection of a target species in this case.

4.2.1 Current Conditions

High turbidity and strong tidal currents preclude development of aquaculture and commercial fish harvest in the estuary of the project area. These natural characteristics limit the productivity of the estuary. Commercially or recreationally important species would primarily use the estuary as a migration corridor. Estuary habitats have remained unaltered for a long period of time. However, there has been a significant loss of salt marsh type habitats to agricultural through dyking. In 1961, approximately 92 % of the estimated 6500 acres of marshland had been converted to agricultural lands (Canada Department of Agriculture 1961).

4.2.2 Target Levels
Target levels have not been set for the most impaired estuary habitat, salt marshes. This is currently an information gap that needs to be addressed.

Table 9: Estuary ecosystem health target levels.

Parameter	Target Level	Source
Salt marsh areas		Historic level estimate, 6500 acres

4.2.3 Management Response
The recommendations for ecosystem health are focused on addressing existing information gaps, instead of specific habitat related issues. They are focused on finding out more about the most obviously altered habitat, salt marshes. It is expected that addressing this information gap will allow IMP decision makers to consider the establishment of active management activities for the estuary within the project area.

A scientific literature search regarding salt marshes should be conducted to compile the necessary information to make management decisions regarding this habitat as it exists in the project area. Minimum viable salt marsh dimensions and characteristics, target levels for monitoring and reclamation, identification of potential benefits of reclamation to flood relief, and identification of salt marshes to mitigate fecal contamination impacts should all be components of the literature review and information gathering process. An inventory of local salt marsh species is recommended. The inventory will help identify a relevant target species and, thus, guide application of marine environmental quality guidelines and any reclamation efforts.

5.0 Watershed Condition Summary
The Salmon River watershed surface water resources have been significantly and negatively impacted by past and present land use practices. The extreme alteration of functions associated with riparian areas, salt marshes, and surface drainage in the lower watershed in order to achieve human resource use objectives has impaired those natural ecosystem functions to the point of limiting species productivity and ecosystem capacity. Fortunately, the impacts to the upper reaches of this watershed have not been as severe or sustained, and, therefore, species viability and ecosystem functions remain relatively stable and productive on a whole watershed scale. There is little indication that negative impacts are being mitigated. Therefore, there is a real and urgent need for stakeholders of this watershed to become actively involved in the integrated management of its resources to ensure future productivity and viability of the Salmon River's species and ecological functions.

6.0 Prioritization and Recommendations
There are three principles that should be considered in prioritizing future management activities within the Salmon River basin. They are not strict rules, but very well founded guidelines learned from other programs. They are the following:

- **Preservation of remaining environmental assets as the most important concept**– Australian Rehabilitation Manual.

This concept seems simple at first glance, but inevitably ends up being one of the most difficult to enact. Because of the intricacies of food webs, water cycles, nutrient cycles and so on, we can never duplicate through restoration an ecosystem that is undisturbed. The best that we can do is also extremely expensive. Usually, inhibitively so. Even if we can satisfactorily rebuild affected watersheds and coastal areas, our works have arrived too late for a species that has been extirpated or driven to extinction. Therefore, it is of utmost importance to preserve those remaining environmental assets to the best of our ability. The effort requires protection of undisturbed, or minimally disturbed, areas and better management of those lands and water bodies already impacted.

- **Best first, worst last approach** - US Forest Service Pacific Northwest Region.

This concept is based on the notion that we often want to go and fix what is most visibly damaged. Unfortunately, we are often tackling the most expensive job with the greatest chance of failure because of the inherent risks that are associated with a badly degraded environmental asset. Therefore, consideration should be given to beginning the rehabilitation effort with the easier and cheaper activities that are bound to be successful. A positive effect is almost immediate, unstable or high risk areas have a little more time for natural recovery, and a system in which the small issues have been addressed is more likely to accommodate the larger failure impacts. This principle may not always be appropriate if, for example, the risk associated with not addressing the worst factors early on jeopardizes all other activities beyond an acceptable limit. However, it is another sound consideration in determining the proper course of action.

- **Start at the top and work down** - British Columbia Watershed Restoration Program.

Whether trying to improve fish habitat, water quality or some other ecosystem components, it is a good general practice to work from high ground toward the lowest areas in the project location. Estuary projects to create new hard substrates for shellfish are compromised if the sediment sources in the watershed above are not fixed first. Planting riparian vegetation in the lower areas of a watershed to cool water temperatures does not work effectively if temperatures are already elevated from passing through exposed areas upstream. Fixing sources of coliform in an estuary will not yield desired results if sources in the river that enters the basin are not eliminated first. The one exception is in strict habitat improvements for anadromous fish. The stream is like a ladder and if the lower rungs do not exist the fish cannot reach the rehabilitated habitat in the headwaters. However, extreme care must be used in this example, for if upstream issues are not adequately addressed the risk of impact to downstream investments still reflects the general rule of thumb, to work from the top of the watershed down to the estuary.

There must be two levels of priority setting for future activities in the Salmon River basin. The first is at the watershed level perspective and answers questions such as: Should stream habitat or water quality be addressed first? These watershed level priorities are presented in Table 10. Although they are presented as ‘very high – low’ priority, the designations are relative, as all issues are significantly important to warrant activity. The results are based on the three guiding principles laid out above and the ability of an action to address the key issues and questions presented in *Section 1 Key Issues and Questions*. A commentary on the justification for ranking an activity is provided so that the reader can further evaluate whether all factors have been adequately considered. For details on each activity refer back to the relevant section in the preceding report.

A group of local persons interested in the Cobequid Bay watershed met to discuss management initiatives in December 2000 (Anonymous 2000) and was in part an initiating factor for this report. The participants identified several key issues that they felt needed to be addressed, and this IMP further supports those conclusions. There is a need to implement best management practices in resource and development sectors, for widespread use of best practice is not apparent from the review conducted. There is a desire to focus on water quality enhancement and protection as a management objective. This is important, for as the highlighted priorities indicate, there are numerous impacts to water quality, from many sectors, that continue to mask the successful implementation of other improvement activities such as the Town of Truro sewage treatment facility. Finally, the workshop concluded that there was desire for a total ecosystem approach. When a group manages a watershed, political boundaries must be largely forgotten and the waters that cycle through the ecosystem must define its boundaries. This report has focused on the surface water resources of the Salmon River watershed, a starting point directed by the Central Colchester Model Watershed committee and the workshop participants. However, to be truly integrated, one cannot ignore the other social, economic and ecological components.

The 2000 workshop on integrated management for the Cobequid Bay watershed highlighted forestry, agriculture and urban/residential development as the three main impacts within the watershed (Anonymous 2000). Not surprisingly, the review conducted herein further confirms that finding through air photo review, and report and data analysis. The workshop participants also indicated that cost was the greatest perceived limitation to finding or implementing solutions to these impacts. Although not completely wrong, the cost of not improving our practices and reducing our impacts will far outweigh the costs currently faced. Best management practices have inherent financial benefit to resource productivity and sustainability, and most often are operationally beneficial to the users as well. 'An ounce of prevention is worth a pound of cure' is very real when considering resource impacts. For example, at $50,000 - $100,000/km for stream restoration, it is much more cost effective to leave riparian buffers, and ensure proper road construction and crossing practices are followed to prevent the degradation of the habitat. The cost of establishing a riparian area on cattle farms and providing a clean water source to animals is likely much less than the loss of revenue from shellfish area closures because of fecal coliform contamination, and the loss of dairy cattle productivity from health impacts associated with poor water quality and muddy wallows. We must work as a group, with multi-sectoral expertise, to develop, implement, and share the cost of best resource management for the ecosystem, because the benefits will be multi-sectoral.

Table 10 is the first of two levels of priority setting presented. It reflects the relative priority, and justification, of the seven freshwaters and estuary components discussed at length in this report.

Table 10: Summary table of watershed level priorities.

Rank	Activity	Justification
1 – Very high	**Water Quality - Freshwater**	Unless water quality is unimpaired, it is always the highest priority for all living things, including ourselves. We need a consistent high quality and quantity of water to survive. If water quality does not exist, the management of the remaining parameters is of little benefit.
2 – Very high	**Riparian areas**	Riparian areas and their five primary functions are so severely impacted in the lower Salmon River watershed that addressing the other issues presented will necessitate active restoration of these riparian areas and their functions in order to be successful.
3 - High	**Hydrology**	The priority of addressing potential hydrological impacts is in response to mitigating floodplain alterations that negatively affect flooding, and the importance of the issue to the health and public safety of residents in the lower Salmon River floodplain. Hydrological impact does not appear to be having as significant an ecological impact as some of the remaining factors presented below.
4 – High	**Sedimentation – Freshwater**	Sedimentation is a higher priority than freshwater habitat only in those areas identified in Table 12 as having potential sedimentation and channel stability issues. It is difficult to address habitat issues in an unstable channel. Overall, current sedimentation does not appear significant, although past impacts may exist in the form of embedded channel substrates and reduced residual pool depths.
5 - Moderate	**Habitat – Fresh Water**	Freshwater habitats of the larger channels in the watershed are extremely poor because of past and current activities. They need to be improved. Ranked fifth, other issues that need to be addressed in order for habitat work to be successful ought to be completed or underway. Protection needs to be given to smaller streams to conserve their quality, which is currently supporting much of the freshwater productivity.
6 - Moderate	**Water Quality - Estuary**	Fecal coliform contamination is extremely elevated in this high flushing estuary, indicating very poor management practices that need to be addressed for the benefit of estuary health and potential shellfish openings.
7 – Low	**Habitat – Estuary**	A severely reduced volume of salt marsh habitat needs to be the focus of estuary based habitat evaluation. This evaluation will help provide IMP decision makers with the information necessary to properly prioritize future estuary habitat activities.

The second level of priority setting is at the ecological parameter level, and addresses questions such as: To reduce sedimentation in the watershed, should we fix road related sources or stream bank erosion problems first? These parameter level priorities are presented in Table 11 and site specific priority locations are presented in Table 12. Details of these activities are further explained in the relevant sections of the preceding report.

Table 11: Summary Table of general priority activities for Salmon River project Area.

Rank	Activity	Explanation
1	**Water Quality – Freshwater**	
1-1	Establish exploratory water quality sampling.	Establish exploratory water sampling program in the watershed to try and locate specific sources, and areas of greater water quality impact. Sample for DO_2, temperature, fecal and total coliform, and total suspended sediments as basic suite of parameters. Add others in areas where additional impacts may be anticipated.
1-2	Establish sanitary shoreline survey.	Walk along the shoreline of the lower Salmon River and lower Chiganois River to map and identify pipe and ditch bound effluents to the systems. Use data in conjunction with ongoing exploratory water sampling program to determine potential negative impacts that will need integrated management activity. Mimic Environment Canada sanitary shoreline survey program.
1-3	Reduce confirmed water quality impacts.	Water quality issues that are confirmed in 1-1 and 1-2 above should be remediated. Areas where improvement is anticipated include Farnham Brook, McClure's Brook, Chiganois, and Middle Branch North River.
1-4	Develop a list of activities to address water quality issues.	When the three activities above are completed, a list of activities can be developed to address any identified issues that arise. In the case of stream temperature, and suspended solids, activities may already be implemented under other recommendations presented here, or simply require that those activities become higher priority.
2	**Riparian areas**	
2-1	Carry out mainstem /major tributary riparian planting.	Areas that do not meet NSDNR Forest Act regulations for riparian buffers should be planted immediately. Planting will need cooperation of private landowners and be based on the prescription of a riparian specialist. The main target areas are the Salmon River from Hwy 102 upstream through Truro; the lower reaches of Farnham, McClure's, Baird, McCurdy's, McElmon's, and Beaver Brooks; the mainstem of Chiganois River, from the head of tide to Staples Brook.
2-2	Carry out riparian assessment of pole/sapling areas.	A riparian specialist should make an on-site assessment of any riparian areas that currently are in a pole/sapling stage. There is potential that stand modification could greatly speed the stand change to the desired mature mix through activities such as releasing conifers, girdling, and patch planting. These activities should be high priority for areas where all riparian functions are not currently being met, high fisheries values exist, and landowners are supportive of stand modification.
2-3	Carry out riparian modification.	Rehabilitation prescriptions from 2-2 for stand modification could be initiated immediately based on identified priorities. Prescriptions should be developed by a riparian specialist.
3	**Sedimentation – Freshwater**	
3-1	Ground truth identifying sources of sediment.	Conduct site visits of potential sediment source sites identified in Table 12. Document site characteristics such as dimensions of source, connectivity to the stream, and type of sediments and soils. Photo document.
3-2	Rehabilitate confirmed sediment sources.	Those sites in 3-1 that are confirmed sediment sources should immediately undergo rehabilitation.
3-3	Conduct a stream impact survey.	A survey of Salmon River and its major tributaries should be undertaken to determine the impact of past and current sediment sources of habitat and channel stability. North River, Chiganois, Christie Brook, and McClure's Brook are key locations to be surveyed. Refer to others in Table 4.
3-4	Stabilize bars in over-widened stream segments.	Carry out mainstem bar stabilization at key sites (identified in Table 12) on the Chiganois, North, and Salmon Rivers
3-5	Monitor / evaluate	Install plastic bucket sediment traps in Salmon River and major tributaries identified in

	sediment reduction.	Table 4; to quantify level of sedimentation and serve as a long-term means of monitoring and evaluation.
4	**Hydrology**	
4-1	Conduct a GIS analysis of hydrological impacts.	There appear to be good GIS capacity and resources within the watershed that would allow for an accurate and current evaluation of factors that may impact watershed hydrology. Carrying out such an evaluation is important for confirming what priority should be given to hydrology based management activities.
4-2	Begin replanting and road deactivation.	If GIS analysis suggests watershed level hydrological impacts having occurred, begin projects of drainage realignment, road deactivation, and open-area planting to mitigate those impacts.
5	**Ecosystem Health – Fresh Water**	
5-1	Conduct a watershed level assessment of fish habitat.	Determine degree of habitat quality and prioritize areas for rehabilitative work based primarily on importance to limiting habitat of target species, anticipated likelihood of success, and acceptable limits of risk and cost.
5-2	Carry out stream rehabilitation test activities.	Establishing primary habitat units within the Salmon River, Chiganois, and North River mainstems is a high priority to providing access for anadromous species of trout and salmon. However, limited structures should be tested to determine effectivness and stability within these somewhat unstable, channelized reaches.
5-3	Carry out stream rehabilitation activities.	Start by establishing primary habitat units in high priority areas. Do not go into high risk areas that are unstable or extremely high energy if less risky alternatives exist. Later revisit initial project areas to determine if greater habitat and hydraulic complexity can be achieved by additional in-stream works. High priority candidates include Farnham's, McClure's, McElmon's pond outlet, Clifford's brook culvert.
5-4	Assess fish passage at watershed culverts.	Culverted road crossings should be assessed in the watershed for passage of juvenile Atlantic salmon and Brook trout. A priority list of sites to restore access should be created. Evaluate tributaries directly entering Chiganois, North River, and Salmon River first.
5-5	Restore fish passage at culverts.	Based on the assessment in 4-3, priority culverted road crossings should be removed, replaced, or modified to ensure juvenile passage. Begin at bottom and work upstream.
6	**Water Quality – Estuary**	
6-1	Confirm 'key' fecal coliform sources.	Review Table 12 locations and conduct field survey and sampling to determine if effluent problems exist at identified locations.
6-2	Reduce fecal input from identified coastal sources.	Any sites confirmed in 6-1 should immediately be targeted for reduction. Key target areas are the small streams between Mill Brook west to Beaver Brook on the southern side of the estuary.
6-3	Conduct Sanitary Shoreline Survey.	Walk along the shoreline of the estuary to map and identify pipe and ditch bound effluents to the systems. Can be conducted at same time as 1-2. Use in conjunction with ongoing exploratory water sampling program to determine potential negative impacts that will need integrated management activity.
7	**Ecosystem Health – Estuary**	
7-1	Conduct scientific literature search.	Conduct a review of scientific literature to identify relevant facts and concerns associated with the significant loss of salt marsh habitat that has occurred in the Salmon River estuary.
7-2	Establish local priorities and targets.	Complete a local inventory of the estuary to identify relevant target species and marine environmental quality guidelines.

7-3	Develop estuary IMP strategy.	With the information collected in 7-1 and 7-2, a watershed committee should consider the information and formulate an integrated management plan strategy for the estuary area that could not be adequately completed as part of this report.

Project activities to be undertaken.
Data gaps to be filled by information collection.

Table 12 outlines over seventy specific sites of impact or suspected impact throughout the Salmon River watershed. As much of the information presented in the table was derived from 1994 air photo review, it is possible the impacts no longer exist or have naturally rehabilitated; therefore, field confirmation of all sites is recommended prior to undertaking planning and fund raising to address identified issues. Furthermore, as the last visual aid available for consideration in the development of this report was the 1994 photos, many watershed activities could have subsequently been undertaken that have caused impacts, or those sites viewed could have trended away from the desired condition. Continued observation around the watershed is necessary to ensure that current sites of concern are identified and confirmed. This listing is not to be considered all inclusive, but a starting point for what are anticipated to be key sites with known or suspected watershed issues.

Those involved in using this report to carry out IMP activities need to consider the relevant section of text in the preceding pages, as well as the listed priorities of Tables 10-12 since these are not reiterations of the same issues but contain different information that needs to be considered.

Table 12: Specific Impacts to the Salmon River Watershed and Priorities for Integrated Management Activities.

Main System	Tributary	Main Issue	Issue	Air photo	Map Identifier	Priority
Black River	***Calvary River***	Several high use fords across the mouth of the Calvary River immediately above the Black River are contributing sediment and habitat impacts.	Fords	94006-189	AA	**Mod.**
Black River	***Three Lakes***	The Three Lakes area has been extensively logged with no to minimal riparian left around the lakes and small streams. Unknown fish values, but only a few lakes in the system. Do water chemistry and fish survey to confirm priority for works.	Logging	94003-175	FF	**Mod.**
Chiganois River	***Chiganois River***	Gravel mining adjacent to the main river with direct runoff channels to the river. Just off the Blackburn Road below Belmont. Heavy riverbed load visible in main river adjacent to the site. Sediment Control and stabilization needed	Gravel pit	94006-161	DD	**High**
Chiganois River	***Chiganois River***	Mainstem riparian is needed. None exists on both sides of the river for 2 km through agricultural lands. Channel is stable laterally. Some bar stabilization is needed as well. High priority for these works from Hwy 2 north for 1.5 km to Hwy 102 and another 2 km north to the next road crossing.	Agricultural	94009-55/57	L	**High**
Chiganois River	***Chiganois River***	Main stem bar stabilization through staking and large wood structures to create roughness and promote deposit and vegetation is needed. Small site on McCully Brook.	Other-channel stabil	94007-57	S	**High**
Chiganois River	***Lower Chiganois***	Some nice riffle areas exist, but there is no riparian. System is laterally stable. There is no woody debris or boulder. Lateral habitat structures should work very well. Plant riparian.	Agricultural	94009-57 94002-66	Gen.	**High**
Chiganois River	***Chiganois River***	The upper channel has no habitat complexity / pools, likely because of past logging that was extensive in the area. The channel appears to be stabilizing / stable and is a good candidate for works. No woody debris or boulders visible. Many roads allow access.	Other - Habitat need	94004-87	Gen.	**Mod./ High**
Chiganois River	***Chiganois River***	A couple of fords on the upper river. Channel appears to be stabilizing in this area that has been previously heavily logged. Planting main stem bars would help speed this stabilization. This channel section is along the Graham Road, north of community of Staples Brook.	Logging / Fords	94003-145/.147	II	**Mod.**
Chiganois River	***MacElmon Pond***	Little stream out of MacElmon's Pond needs to be planted with a riparian corridor. Confirm water quality and ensure fish passage to pond exists as it is one of only a few ponds/lakes in the system and is the lowest in the system.	Agricultural	94009-54	Gen.	**High**
Chiganois River	***Staples Brook***	Bed load movement on Staples Brook. No apparent source. Should be examined to reduce impact to Chiganois. Frog Lake, the headwaters of Staples, holds a population of Brook Trout, and the stream is likely spawning habitat. Excessive bedload and fine sediments would impact the quality of spawning.	Other - Channel Stability	94006-161	EE	**Mod.**
Chiganois River	***Unnamed tributary***	Small channel through a farm has no riparian but does have stable banks. It appears to be carrying significant bed load. Drains in part from adjacent tilled field. Source should be identified and arrested.	Agricultural	94007-57	U	**High**
Chiganois River	***Unnamed tributary***	Farm impacts within a fenced area of the stream. Heavy animal traffic over the creek.	Agricultural	94006-64	W	**High**

Main System	Tributary	Main Issue	Issue	Air photo	Map Identifier	Priority
Chiganois River	***McCully Brook***	Fecal inputs from two farms. Sediment input also likely from most northerly farm.	Agricultural	94007-57	T	High
Chiganois River	***Unnamed tributary***	This farm in the lower reaches of the system has a small channel dammed to create a pond that is a high cattle use area near the barnyard. There may also be drainage from a manure pile to a small adjacent system. Likely source of fecal inputs.	Agricultural	94002-66	A	Mod. / High
Chiganois River	***Unnamed tributary***	Cut block over a small tributary that flows directly into the Chiganois. Minimum to no riparian buffer left on the Chiganois. Likely some sediment source. East side of river, north of Belmont.	Logging	94006-62	X	Mod.
Chiganois River	***McCully Brook***	No riparian on approximately 750m of stream through farmland likely contributes to thermal warming. Just off the Staples Brook Road.	Agricultural	94005-60	JJ	Mod.
Chiganois River	***Unnamed tributary***	Chiganois appears unstable, and to have deposited (or eroded ?) gravels on a large field adjacent to the river. Some bank has been rip rapped downstream of this location. East side of Chiganois, north of Belmont.	Other - Channel Stability	94006-62	Y	Eval.
Chiganois River	***McCully Brook***	Logging related surface drainage impacts within the cutblock are related to skid roads and logged ephemeral streams. Hydrology and natural drainage of this localized area appear impacted. Possible sediment sources.	Logging	94006-60	Z	Eval.
North River	***Middle Branch North River***	Three fords of the main river and one tributary in close proximity contribute sediments. A bridge is nearby. Point bars have developed downstream. Eliminate the crossings and use the bridge. Stabilize bars.	Fords	94003-159	HH	High
North River	***North River***	Gravel extraction adjacent to the main river channel. Potential sediment source during floods or heavy rains. Thermal warming from shallow ponds. River has been channelized with no habitat characteristics. Ponds need rehabilitation. River needs stabilization and habitat complexity.	Gravel Pit	94009-67	J	High
North River	***North River***	Main channel bar stabilization is needed through massive staking and large woody debris structures on the bars to create roughness and promote deposition, colonization. Lateral debris jams would work well in this substrate. Two small farms with manure piles next to small tributaries likely contribute fecal inputs.	Other - Channel stability/ Agricultural	94007-68	P	Mod.
North River	***North River***	Old gravel pits should be rehabilitated. Determine where original duff layer was taken. Add organics to the sites to promote vegetation cover. Plant aquatic vegetation in pond areas. May be a location to put highways ditch diggings along the shores of these ponds to promote vegetation growth. Monitor water temperature and sediments at outlets.	Gravel Pits	94007-68	P	Mod.
North River	***South Branch North River***	Small direct tributary to the South Branch has been both logged and skidded over. Likely a direct input of sediment. Approximately 250m of channel.	Logging	94006-82	V	Mod.

Main System	Tributary	Main Issue	Issue	Air photo	Map Identifier	Priority
North River	***South Branch North River***	Some braiding and two river fords on the South Branch. The river appears to be stabilizing from past disturbance. Planting bars to speed this process would be beneficial.	Fords / Other	94006-78/76	W	**Mod.**
North River	***Unnamed tributary***	Heavy cattle use and manure pile runoff into three small tributaries from four operations that directly enter the North River south of the community of North River on Hwy 311. DFO sampling shows a significant increase in fecal coliform contamination occurs as the river passes this location.	Agricultural	94006-172	CC	**High**
North River	***West Branch North River***	Gravel pit with small sections of no buffer on the West Branch North River. Likely a sediment source. Large actively eroding stream banks adjacent to two different sections of road and a small tributary. Large point bars immediately downstream. All these sources need stabilization.	Gravel pit / Other – erosion	94006-72	U	**Very High**
North River	***West Branch North River***	The upper channel has no habitat complexity / pools, likely because of past logging that was extensive in the area. The channel appears to be stabilizing / stable and is a good candidate for works. No woody debris or boulders visible. Many roads allow access.	Other – Habitat need	94004-94	Gen.	**Mod./ High**
Salmon River	***Baird Brook***	A poorly contained manure pile exists next to a small tributary to Baird Brook in Central Onslow and is a likely fecal source.	Agricultural	94002-70	C	**High**
Salmon River	***Baird Brook***	Dam at a road crossing in Crowes Mills. Review to determine if it is needed. System is stable and likely productive. Conduct fish survey. Higgins Pond water could contribute to thermal warming, but may help regulate summer flows. Determine fish access at site, and develop management options.	Other	94009-59	M	**Mod.**
Salmon River	***Baird Brook***	Logged over section on approximately 250m of upper Baird Brook. May be some channel instability at the site. Appears to be a perched culvert blocking fish passage at the rail line crossing. East of Higgins Mill Road and north of Crowe Mills.	Logging/ Other – culvert	94007-60	R	**Mod.**
Salmon River	***Baird Brook***	Logging impact on a tributary of Baird Brook. In block drainage is following roads. A road is damming flow into a pond. Overflow is eroding road surface to lower channel. West of Onslow Mountain.	Logging	94006-66	V	**Mod.**
Salmon River	***Baird Brook***	This system is highly channelized and ditched in the lower 500m. No riparian exists. Although stable, very poor fish habitat values without rehabilitation.	Agricultural	94002-68	B	**Mod.**
Salmon River	***Beaver Brook***	This tributary by Old Barns has 3 culverts in the lower 600meters that may limit fish access. There is nearly no riparian on the both sides of the lower 3km of channel, and the channel has been extensively modified by agriculture.	Agricultural	94001-71/129	1	**High**
Salmon River	***Beaver Brook***	An upper Beaver Brook tributary has been completely logged and turned into an agricultural field with no riparian. Approximately 1.2km in total on two branches. Likely a sediment source. East of community of Beaver Brook.	Agricultural	94011-75	MM	**Mod.**

Main System	Tributary	Main Issue	Issue	Air photo	Map Identifier	Priority
Salmon River	***Christie Brook***	This system in Lower Harmony has been impacted by several activities, apparently on one property. There are likely fecal inputs from a barnyard directly to the creek. There is no riparian through much of the agriculturally developed portion of the property. There had been much recent logging in 1994 air photos, although no direct impacts observed. Several areas of exposed soils from various activities, and a gravel mining operation in a small drainage likely contribute sediment sources. Numerous poor management practices that should be improved.	Logging/ Agricultural /Gravel pit	94001-91	9	**High**
Salmon River	***Christie Brook***	A lumber yard at the confluence of the Salmon River and Christie Brook encroaches both the brook and river with little to no buffer between the yard and the watercourses. A likely source of river sediments.	Other - Industrial	94002-84	G	**High**
Salmon River	***Christie Brook***	Large cut block, approx. 500 m x 800 m, with a small tributary to Christie Brook in the middle. All riparian is removed. No apparent sedimentation. Thermal warming likely.	Logging	94002-27	18	**Mod.**
Salmon River	***Farnham Brook***	There is likely sediment source from approximately 14 drainage ditches that directly enter the lower reach of the brook from a tilled field near Upper Onslow. Sediments are apparent in the channel. There is no riparian in this lower reach. A settling pond may be necessary between ditching and the brook. There is poor fish habitat for access to the upper stream, that appears to have good fish values. Work should be undertaken from the dyke along the Salmon River upstream to the Farnham Road crossing in partnership with the Agricultural College, who manage this stretch of property. Things to consider are riparian, in-stream habitat and consolidation of the flow from several ditched areas farther upstream to help augment flows. Approximately 1.5 km.	Agricultural	94002-76/78	E	**V. High**
Salmon River	***Farnham Brook***	Two or three farms with very close approximation to a tributary of Farnham have likely manure and animal related fecal and sediment inputs.	Agricultural	94007-70	O	**High**
Salmon River	***Farnham Brook***	Recent stream rehabilitation works on Farnham Brook in the area of Vimy Road should be augmented with additional in-stream structures to increase complexity. In particular large wood structures at any created pools, and on outside bends (parallel to the bank). This will provide cover while riparian in the disturbed area grows.	Other – development	94002-78	Gen.	**High**
Salmon River	***Farnham Brook***	Approximately 500 m of channel has no riparian on the north side. A general riparian prescription is needed for approximately 1 km in the downstream direction.	Other - development	94002-80	F	**High**
Salmon River	***Farnham Brook***	Approximately 500 m of channel with little or no riparian adjacent to a roadway and tilled field, although connectivity is not fully apparent. Stream is carrying bed load. Sources should be evaluated.	Other	94007-73	N	**Mod.**

Main System	Tributary	Main Issue	Issue	Air photo	Map Identifier	Priority
Salmon River	***Lepper Brook***	Land clearing and residential development in the watershed area above the dam on Lepper. As this dam is a water supply, it is generally a poor management practice to allow development. Occurring on the North side of the reservoir it is very close to the open water. Residents, developers, and the community levels of government need to be careful in this area because of highly erodible soils. If the water supply becomes negatively impacted, the cost of treatment could increase.	Other - development	94001-83	7	**High**
Salmon River	***Lepper Brook***	Channelized portion of lower Lepper by the park has little riparian and poor habitat. Stream and riparian works would improve both.	Other	94001-81	6	**Mod**
Salmon River	***McClure's***	Golf course on McClure's is a potential source of fertilizers / nutrients that could prompt algal growths and consume oxygen in the stream. There is very poor riparian throughout this stretch, and several ponds may contribute to thermal warming if they are linked with the stream. Needs further onsite evaluation.	Other - development	94001-79	5	**High**
Salmon River	***McClure's Brook***	Lower McClure's has poor habitat and riparian, yet, based on the 1994 photos there is little true encroachment on the stream channel. Cleared areas could be replanted, and stream rehabilitated for a successful in-town project. Possible location for protective covenants with landowners, including golf course, before additional development takes place. A good opportunity currently exists here.	Other - development	94001-25	12	**High**
Salmon River	***McClure's***	A small unnamed tributary to McClure's has been a source of gravel excavation. Settling pond appears inadequate as there are in-channel deposits a short distance downstream from the pond. Otherwise, there is a good riparian and channel for a distance downstream, so this impact could be significant to reducing the local productivity.	Gravel pit	94001-141	11	**Mod./ High**
Salmon River	***McClure's Brook***	In the industrial park area large portions of land have been cleared, paved, and ditched. Given the size of the area, the clearing, paving and ditching is likely to have hydrological impacts on McClure's Brook. Better management practices could be implemented.	Other - industrial	94001-141	10	**Mod.**
Salmon River	***McClure's Brook***	A 100m and two 300m sections of McClure's with patchy and highly impacted riparian, resulting in apparent bank instability.	Other – rural clearing	94002-17	17	**Mod.**
Salmon River	***McClure's Brook***	In this area of McClure's near Hilden over 2 km of stream has very little and patchy riparian. Increased thermal warming. The brook is stable in this area except for a couple of small sections where mineral soils are visible, possibly because of animal access.	Other - Rural clearing	94011-84	LL	**Mod**
Salmon River	***McCurdy's Brook***	Riparian restoration is needed in the lower 1km of this system to improve fish values and reduce thermal warming. The brook appears to be a good candidate for stream restoration as well.	Agricultural	94009-65	K	**Mod./ High**
Salmon River	***McCurdy's Brook***	Logging impacts on upper McCurdy's where stream was logged to both sides of approximately 300m+ of channel. May be road related sediments in this block as well.	Logging	94007-64	Q	**Mod**

Main System	Tributary	Main Issue	Issue	Air photo	Map Identifier	Priority
Salmon River	***Salmon River***	Main river riparian is severely lacking in town for a 3 km stretch, both sides of the river from the Park St. bridge upstream. It would appear these lands belong to only a few landowners with agricultural plots, and such limited owners may facilitate implementation of a riparian planting project.	Agricultural	94001-29, 94002-78	13	**High**
Salmon River	***Salmon River***	There appear to be two active fords within the boundaries of Truro. Unnecessary impact, sediment source.	Ford	94001-29	14	**Mod**
Salmon River	***Salmon River***	Vehicle tracks in the Salmon River and along the bars are apparent on the north side of the river near valley station. No apparent destination for these tracks was observed.	Ford	94009-74/76	I	**Low**
Salmon River	***Unnamed tributary***	Three tributaries that enter the south side of the river between Old Barns and Lower Truro run through barnyards with manure piles and high animal use visible. Likely source of fecal contamination.	Agricultural	94001-73	2	**High**
Salmon River	***Clifford Brook***	Agricultural impacts from two operations. Approximately 450+ m of land clearing over the brook and tilled lands adjacent to the brook. CSA did stream clearing in 1998, but need to confirm these are the same sites. Small watering pond draining to brook. All potential sediment sources. At a second site there is a manure pile runoff to the brook. CSA worked on Hwy 104 culvert in 1998. Passage should be confirmed.	Agricultural	94006-180	BB	**High**
Salmon River	***Campbell Brook***	This agricultural operation at the eastern edge of Truro appears to be manipulating the stream, although, the reason for manipulation is not clear from the 94 air photos. Looks as if channel may have been dammed temporarily to direct flow into adjacent field, and then channel reopened. There is a large section of stream that has been ditched.	Agricultural	94001-31	15	**Mod./ High**
Salmon River	***Unnamed tributary***	Two small tributaries. To the Salmon River near Kemptown have no riparian remaining on both sides of the streams for over 450 m of channel because of logging. Likely thermal warming just prior to reaching the main river. Main River needs complexity added to channel, in-stream structures.	Logging	94003-171	GG	**Mod / High**
Salmon River	***Greenfield Brook***	A small tributary has been logged and skidded over. All riparian has been removed along approximately 900 m of channel.	Logging	94009-80	H	**Mod/ High**
Salmon River	***Unnamed tributary***	Over 800 m of channel on this tributary near Kemptown has no riparian and would contribute to thermal warming.	Logging	94004-14	KK	**Mod. / High**
Salmon River	***Mill Brook***	There are logging related impacts to this tributary of Mill Brook. The site is near to where there are two stream crossings. There has been no riparian left and there are skid trails through the channel.	Logging	94002-9	16	**Mod**
Salmon River	***Unnamed tributary***	This small tributary appears to flow into McClure's just upstream of the confluence with the Salmon River. It appears that a small riparian area that has been logged is heavily compacted and a potential sediment source. As well, a soil removal operation is in a draw that may carry sediments to the stream. The site is West of Old Halifax Road.	Logging/ Other – soil removal	94001-77	4	**Mod**

Main System	Tributary	Main Issue	Issue	Air photo	Map Identifier	Priority
Salmon River	***Unnamed Tributary***	Logging on this small system and exposed soils adjacent to the creek are likely sediment sources.	Logging	94001-31	8	**Mod**
Salmon River	***McCurdy's Brook***	Although the lower system has been heavily logged, it appears decent buffers were left around streams. Channel appears stable.	Logging	94007-66	Gen.	**Low**
Salmon River	***Steele Run***	The Steele Run above Kemptown has an old ford crossing and a nearby road crossing that must have failed and is damming water. Water has been flowing over the road causing erosion. Sediment sources. Just off Hwy 4.	Fords	94004-210	NN	**Low**
Salmon River	***Unnamed tributary***	Old logging impacts. A little used ford of the Salmon River and two small tributaries that have followed old roads out of blocks to the Salmon River likely carried sediments in the past. Appear largely stable now but should be confirmed.	Logging	94004-206	OO	**Low**
Salmon River	***Sooley Brook***	This small tributary from the south has an apparent soil removal operation adjacent to the stream that may be a sediment source. East Lower Truro.	Other – soil removal	94001-75	3	**Low**
Salmon River	***McNutt Brook***	This southerly tributary has good riparian for streams in this area. Ensure there is fish access to the lower reaches.	Other – road crossing	94001-73	Gen.	**Low**
Salmon River	***Higgins Brook***	The whole lower reach of this system is ditched and diverted for agricultural purposes. Possible issues could be thermal warming and sediment source. No fish values exist in present form.	Agricultural	94002-72/74	D	**Low/ Mod.**

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8.0 Appendices

Appendix A: Level 1 FHAP Form
Appendix B: Canadian Water Quality Guidelines for the Protection of Aquatic Life: Summary Table
Appendix C: Canadian Water Quality Guidelines for the Protection of Agricultural Water Uses: Summary Table
Appendix D: Marine Environmental Quality Guidelines for Blue Mussels in the Bras d'Or
Appendix E: Fish Passage Culvert Inspection Form
Appendix F: Fish Passage Restoration Techniques